Italian Society for Climate Sciences
SISC

7th Annual Conference
Trento, 23-25 Oct 2019

CLIMRISK19

Climate Risk: Implications for Ecosystem Services and Society, Challenges, Solutions

Book of Abstracts

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About SISC Conference

"ClimRisk19 | Climate Risk: implications for ecosystem services and society, challenges, solutions" is the title of the SISC Seventh Annual Conference, held on October 23rd-25th, 2019 in Trento, Italy, at Autonomous Province of Trento premises.
The SISC Conference series aim at connecting leading scientists, researchers, economists, practitioners, business leaders, and policy makers, whose activities are focused on different aspects of climate change, its impacts and related policies.
The Conference was an important interdisciplinary platform for the presentation of new advances and research results in the fields of science and management of climate change.

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About SISC

The Italian Society for Climate Sciences (Società Italiana per le Scienze del Clima - SISC) is a non-profit and non-advocacy association, which aims at contributing to scientific progress and the innovation of climatic sciences in Italy by promoting the convergence of disciplines and multidisciplinary research. SISC aims to be a reference point for all scholars dealing with climate-related sciences and their applications.

SISC was created to serve as a meeting point for scientists from different disciplines, who use climate information for their research: from climatologists to physicists and chemists, geographers to agronomists, economists to political scientists, and all scholars that deal with climate-related sciences and their applications.

The Italian Society for Climate Sciences aims at contributing to scientific progress and innovation of climatic sciences in Italy by promoting the convergence of disciplines and multidisciplinary research.

The institutional purposes of the SISC are:

a) to the world of research:

- to foster the exchange of ideas, the creativity and the development of new interdisciplinary research;

- to promote communication and cooperation between universities and research institutions in Italy, strengthening the presence of climatic sciences in both Italian universities as well as higher education systems;
- to attract young talents to build a new interdisciplinary scientific community and increase overall productivity;
- to stimulate and coordinate the Italian contributions to the International programs in the field of climate sciences;
- to become the reference point and the meeting place for Italian scientists living abroad.

b) to the society:

- to increase the impact of the studies and of the debate on climate issues, giving scientific rigour to the analysis of climate policies for mitigation and adaptation;
- to promote the dialogue among scientists, policy makers, businesses and citizens to support actions in the interests of the society and the environment;
- to provide research results to institutions, businesses and citizens

The SISC association is non-profit and non-advocacy, acts according to ethical principles and promotes policies for equal opportunities.

The aims of the Association are pursued in particular through the organization of conferences and debates addressed to the scientific and policy communities, the implementation of web-communications, the promotion of training courses for young graduates, and collaboration with multidisciplinary doctoral courses on climate science.

Plenary lectures

ORAL

Communicating risk and uncertainty via the media

James PAINTER

Reuters Institute for the Study of Journalism and Department of Politics and International Relations, University of Oxford, UK

Most people in most countries get most of their information about climate science from the media, but communication now takes place in fragmented and rapidly changing media landscapes, including that of Italy. Audience trust in mainstream media is declining, media usage is increasingly polarized, social and mobile platforms continue to grow, and the sources of climate information are more diverse. In this context, many journalists continue to find the accurate portrayal of uncertainties in climate science a challenge. This presentation will review the latest literature on the nexus between uncertainties, the media and audiences, and consider the possible advantages of framing uncertainties as risk management. Case studies of media treatments of extreme weather attribution and the 'deadline narrative' of 2030 will be included.

ORAL

Climate services in Europe: Current challenges and future perspectives

Carlo BUONTEMPO

European Centre for Medium-Range Weather Forecasts, UK

Climate service has now become an essential element to include in any research proposal on climate. But how we got to this point? Following a rather personal trajectory this presentation wants to explore the last 15 years of climate service history in Europe.
Starting from this historical account the paper highlights some of the key lessons that have been learnt in the process and try to identify some of the stumbling blocks that are preventing a further technological development and the adoption of climate services by a broader set of users.

ORAL

Climate change and health: Emerging zoonoses

Anna Paola RIZZOLI

Fondazione Edmund Mach, Italy

Climate change can affect human health either directly (e.g., impacts of heat waves or consequences of floods and storms) and indirectly through changes in disease vectors distribution in space and time (e.g. ticks, mosquitoes), or changes in the risk for food and water-borne diseases.
The impact of climate change on health is also dependent by regional environmental condition and socio-economical settings which affect the capacity to implement adaptation strategies. So far, studies on the impact of climate change have focused mainly on the direct impact, while the consequences related to ecosystems services alteration caused by climatic stressor represent a significant knowledge gap. The effects of climate variability on infectious diseases is determined mainly by their mode of transmission. Pathogens that require a vector or a wildlife reservoir are more susceptible to climate change influence. Climate can affect all the component of the disease transmission, including the pathogen, the vector, the reservoirs, the environmental condition and the human host. Zoonoses are infectious diseases caused by micro or macro parasites that spread between vertebrate animals and humans. 60% of the human diseases are zoonoses. It is estimate that more than 6 out of every 10 known infectious diseases in humans are spread from animals, and 3 out of every 4 new or emerging infectious diseases in humans are spread from animals (WHO). As well as being a public health problem, many of the major zoonotic diseases prevent the efficient production of food of animal origin and create obstacles to international trade in animal products.
In this presentation an overview on the impact of climate change and other co-driving factors on zoonotic diseases emergence will be given. Case studies for directly and indirectly transmitted

zoonoses using as example diseases which are associated to forest ecosystema are taken, including tick borne diseases such as Lyme disease and TBE, or directly transmitted pathogens such as hantaviruses and Ebola virus.

Explore, predict and project climate variations and extremes

ORAL

Climate change, glaciers melting, and risks perception on the Mont Blanc region. An overview from the anthropological perspective

Elisabetta DALL'Ò

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The aim of this paper is to describe the preliminary results of an ethnographical research I've been conducting on the Mont Blanc region, concerning the impacts of climate change and glaciers melting on the Alps, and local communities responses. The alpine environments are tackling a set of complex changes, due to climate change impacts, such as glacier and permafrost melting, slopes instability, rock falls, avalanches and extreme rainfall variability, which are playing an increasingly crucial role for the future of those who inhabit there. Increasingly, however, it is being recognized that science, technology, and engineering may not hold all the answers to cope with the main modern environmental challenges (Jones 2016). This is dramatically true for glaciers' melting and its consequences (floods, water scarcity, avalanches, permafrost loss, rockfalls), one of the most meaningful threat now facing Alps and Mountain regions all over the world, as the result of rising global temperatures and climatic instability. Nowadays diverse disciplines — included humanities — are increasingly turning attention to "climate change", and to its related events and impacts. Especially, particular emphasis has been given to how local and global communities respond to global warming, climatic changes, and their related hazards, with pointed focus on perception (memory, history, culture) and on practices carried out in order to mitigate the potential devastating effects. Regardless of other impending changes to its disciplinary practice, the future of Anthropology, which

is the “science of culture”, is one that cannot ignore climate change and its effects on humankind. In the geological, cultural and social age in which we are living — the so- called Anthropocene, the age of Anthropos — humans, through the choices they have made as a species, which means cultural decisions, have become the main agents of change.
The Mont Blanc region is characterized by a huge variety of biodiversity, habitats, environments, in which human and wildlife species coexist, coping with extreme natural phenomena, due to specific weather conditions and local topography. In this area there is a widespread and multifaceted risk. In addition to some certainties — we have knowledge of the forms of this risk: avalanches, rockfalls, landslides, and mainly mud slides, and we know the places in which they occur, and will occur — still coexist some incertitudes of temporal order and intensity. In fact, we don’t know about the time this phenomena will appear, we can only assume about which intensity they will keep. They could appear simultaneously and amplifying the consequences the ones on the others, or to appear in different moments or ages. For sure the outgoing climate change makes less predictable future scenarios, and therefore be less manageable and more impacting. The ethnographical research was carried out with some alpine communities of the Mont Blanc region which have experienced a transformation of livelihoods mainly due to “mountain’s urbanization” since late 60s and 70s, cementification, building speculation, massive tourism, motorway construction, ski resorts, and to the construction of the Mount Blanc tunnel between France and Italy. Among this changing we have to claim a progressive abandonment of pastoralism and cultivation in a large part of the territory. In this “cultural, natural, and environmental” context a serious phenomenon takes place: the glaciers retreat. As the anthropologist Ben Orlove states, we humans have much to learn from glaciers, and the world we live in can benefit from our learning about them. Glaciers are found on every continent, in some of the world’s richest countries and some of the poorest. For residents of many high-elevated regions, glaciers give mountain homelands their distinctive character. For people who live further downslopes, glaciers supply valuable water and can be sources of floods and landslides, reminding us of our dependence on the natural world. For both groups, and for those who live further away as well, glaciers are precious as well for their transcendent beauty. And glaciers are endangered. In all areas of our warming world, they are shrinking, as winter snows are no longer sufficient to replenish their melting. So glaciers can become a theme for people who are trying to make sense of our changing world. As people search for ways to comprehend and address climate change, glaciers often come forward as potent elements in thought and action (Orlove 2008). It became clear that many of the glaciers that had seemed permanent features of the landscape for millennia will not survive for many decades. This is the case of Mont Blanc. The most frequently discussed impact of glacier melting on global environmental change is its contribution to sea-level rise, but this is only a part of a very global issue. Permafrost melting is probably one of the most dramatic consequences of this phenomenon. In the frozen core of the Alps scientists have measured startling temperature increases, with jumps of as much as half a degree Celsius in just a decade, 20 feet deep into the rocks. On Svalbard, an Arctic island north of Norway, similar warming has been measured more than 100 feet deep in the permafrost. It is well known that permafrost, on the mountain slopes, holds together rocks; continued warming and the thawing of permafrost also increases the occur for big mudslides and debris flows. More the frozen soil thaws, more it can easily be set into motion by rain. The “domino effect” (e.g. the melting of the permafrost which provokes rockfalls on the glacier, they, on

turn, cause avalanches) boosts every single phenomenon, consequently emphasizes and implements a disruptive chain.
mechanism. Moreover, locked into permafrost there is an estimated 1.7 trillion tonnes of carbon in the form of frozen organic matter. When permafrost thaws, this matter warms up and decomposes, releasing carbon dioxide (CO_2) and methane, gases. Despite the urgency of the problem, we are actually observing a disconnection between the seriousness of this phenomenon and its perception. Perception of mountain environment does not rest on physical visibility alone. Cultural framing can also shape the ways in which places are perceived, both by influencing the patterns of movement that can bring people close to them and by shaping their understandings. In the Mont Blanc area, local residents and tourists may not see by the naked human eye the nearby glacier retiring, but they are quite conscious of glacier retreat and express concern about it. The residents recognize other aspects of local climate change, such as drier summers, as well. They are relatively untroubled by possible local repercussions such as the genuine risk that the reservoir of the power plant would receive insufficient inflow as glacier retreat increases. Nor do they attribute the increased number of rockfalls and landslides to glacier retreat, since the phenomena that most affect them do not come from the area near the glacier. Local perceptions are rather more influenced by global, political discourses, than would result from its physical visibility alone. In general, the study of physical processes associated with glacier retreat is more advanced than the study of the impacts of these processes on human societies; indeed, the question of impacts constitutes an important gap in our knowledge. That's why to include the ethno-anthropological studies in a multidisciplinary frame of research can be a way to better understand the ongoing environmental challenges.

ORAL

The white heart of Trentino is tired

Christian CASAROTTO

Muse, Museum of Science of Trento

Currently, in Trentino, there are about 150 glaciers; their cover an area of 32 km2 (Casarotto & Trenti, 2015), a white heart which, at the maximum of the Little Ice Age (LIA, mid-nineteenth century), extended for 102 km2. (Zanoner et al., 2017). From the end of the LIA to today, the surface has been reduced by 70%. The marked retreat observed in recent decades, has led the Autonomous Province of Trento to start activities and studies to monitor the evolution of the glacial heritage in the province. Since 2012, the Autonomous Province of Trento, with the Muse - Museum of Science of Trento, organizes and plans the necessary activities to calculate the mass balance of 6 glaciers, considered example, distributed on the main glacialized mountain groups of the province.

The mass balances are determined for these glaciers: Adamello and Lobbia in the Adamello Groups, La Mare and Careser in the Cevedale Group, Agola in the Brenta Dolomites and the Principale della Marmolada in the homonymous group.

The balances are determined using the glaciological and geodetic methods. In order to calculate the balance using the glaciological method, at the end of the winter (winter balance) hundreds of manual measurements of snow depth are carried out to determine the thickness of the snow cover. After, known the density of the snow, the snow depth is transformed into millimetres of equivalent water. At the end of summer (summer balance), however, we measure, previously inserted in the ice; the protrusion of the stakes, during the summer, increases due to the melting. The difference between winter balance (accumulation) and summer balance (melting, or ablation) determines the net balance for that year.

The geodetic balance is calculated as altitude differences measured with GPS Rover.

From 2012 to today (2018) the net balances have been negative: the summer loss due to melting is greater than the winter snow accumulation over the entire surface of the glacier. This means that the equilibrium line, where the accumulation corresponds with ablation (and the balance is zero), is rising above the maximum altitude of the Trentino glaciers, preventing the glaciers from preserving snow and, therefore, to form new ice.

The net balances calculated for the period 2012-2018 fluctuate between -2,000 and -4,000 mm of water equivalent, corresponding to losses between 2 and 4 meters of ice each year. Due to the strong loss of mass that every year is recorded, we observe the expression of the following morphological manifestations:

- fragmentation of glaciers, with isolation of smaller glaciers located within small glacial cirques and isolated from the main glacier;
- surfacing of rocky islands (nunatak), especially in correspondence of increases in slope, which leads to the division, even at lower altitudes, of the glacial tongue;
- increase of the debris cover. The debris that covers the glacier has a protective effect against solar radiation and therefore significantly slows down the melting;
- formation of epiglacial water bodies;
- formation of deep epiglacial channels (bedieres).

The glaciers present in Trentino are therefore experiencing a phase of marked degradation, in line with what happens at the national alpine level. Trentino's glaciers are at mountain groups with lower altitudes, if compared to the altitudes of the Western Alps mountains. Due to global warming, therefore, the equilibrium line starts to be constantly above the maximum altitude of our glaciers, leading to melting, over the entire surface, the ice.

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ORAL

Drought characterization over Trentino – South Tyrol: assessment of trends in meteorological indices and impacts on vegetation from optical remote sensing imagery

Alice CRESPI[a], Paulina Bartkowiak[a,b], Felix Greifeneder[a], Claudia Notarnicola[a], Luca Pasolli[a], Marc Zebisch[a], Mariapina Castellia[a] Marcello Petitta[c]

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Variations in hydrological regimes triggered by warming conditions are expected to occur in the future at global scale. In particular, higher temperatures could increase the frequency and severity of extreme events, in terms of both intense precipitation and droughts, with relevant negative impacts on human activities and community safety. Since the magnitude and features of climate change and impacts could be highly spatially variable, high-resolution studies are essential to evaluate local current trends in the climate signals extracted from long records of meteorological observations and to assess their influence on specific regions of interest.

In particular, the Alps have experienced a temperature arise of around 2°C between the late 19th and the early 21st century, which is twice as much the global average warming, enhancing the potential impacts on local ecosystems and socio-economic sectors. Trentino – South Tyrol is the northernmost Italian region, largely characterized by the Alpine mountain environment. Agriculture represents a key regional sector which rely on water resources and is managed over a large grassland variety extending over broad elevation ranges. The drought of summer 2003 revealed the vulnerability of the sector to water scarcity during which relevant production losses where registered.

The present contribution analyzes the evolution of temperature and precipitation together with that of two of the most used meteorological drought indices, the Standardized Precipitation Index (SPI) and the Standardized Precipitation Evapotranspiration Index (SPEI), for Trentino – South Tyrol to evaluate long and short-term variations of the hydrological cycle over the last 60 years. To this aim a large database of meteorological observations, from the station networks managed by the Provinces of Trento and Bolzano, was set up and all the series were checked for quality and homogeneity. In order to analyze the spatial variability of the climate signal over the complex orography of the territory, monthly temperature and precipitation data from stations were interpolated onto a regular grid of 750 m resolution by means of an anomaly-based spatialization approach. SPI and SPEI series were then computed for each grid cell and for different aggregation periods. Theil-Sen trends and Mann-Kendall significance of the series were assessed at both mean regional and grid cell levels. While no significant trends in the SPI and SPEI regional series were pointed out for the whole 60-year period, a greater variability was depicted by exploiting trends over shorter time moving windows. Moreover, the trend assessment over the gridded values allowed pointing out the features of the different climatic zones which were masked in the regional averages.

Furthermore, variations in drought characteristics such as frequency, severity and duration over the whole period will be discussed.

Finally, time series of remotely-sensed data, including Leaf-Area-Index (LAI), acted as a basis for the investigation of the impact of meteorological variability and extremes, such as drought, on Alpine grasslands. LAI was retrieved from the Moderate Resolution Imaging Spectroradiometer (MODIS) bands in visible and infrared electromagnetic regions at 250 m spatial resolution, and an optimized (for mountainous terrains) inversion of the radiative transfer model PROSAIL. LAI time-series corresponding to grasslands were compared to water stress evolution derived from meteorological indices and observations over the period 2004–2019.

ORAL

Climatic monitoring in an Alpine long term socio-ecological research site

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In complex landscapes, such as mountain areas, topography (elevation, inclination, and exposition) determines highly heterogeneous climatic conditions. Data collection started in 2009, and in 2014 the Val Mazia/Matschertal was accepted as a Long Term (Socio-) Ecological Research LT(S)ER site. The LT(S)ER IT25 - Val Mazia/Matschertal is a closed catchment covering an elevation range between 900 and 3700m a.s.l.. The site is particularly interesting as it is relatively dry (ca. 500mm at 1500m a.s.l.) and therefore appropriate to study potential future impacts of climate change. For a better understanding of the ecological, hydrological and climatic processes in the catchment, a spatially distributed micro-meteorological network has been installed. The measurement infrastructure consists of 18 stations among all dominant land-use types (grassland, forest, river, proglacial area) covering an elevation range from 1000 to 2700 m a.s.l.. The parameters monitored are mainly related to the 1) Microclimate (air temperature, humidity, wind) 2) Hydrological cycle (soil moisture, soil water potential, runoff, evapotranspiration, solid/liquid precipitation) 3) Energy balance (short/longwave/net radiation, surface heat fluxes) 4) Optical reflectance (Phenocam, NDVI/PRI Sensors). We will present here an overview of the dataset, exploiting the dependence of climatic extremes from mountain elevation. We would like to highlight the potential of the dataset to understand the impact of climatic and land use changes on mountain ecosystem services.

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http://lter.eurac.edu/en

POSTER

The valley glaciers of the Italian Eastern Alps may survive beyond this century?

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A recent work (Serandrei-Barbero et al, 2019) carried out on the Western Tauri glaciers (Eastern Alps), shows, to the end of this century, glacier length reductions between 20% and 35% for valley glaciers and between 30% and 60% for mountain glaciers, representing 95% of the Italian Alps glaciers. Their consequent surface area loss of more than 60%, with a probable fragmentation in smaller units, leads to the possibility that 95% of the living glaciers will disappear by the end of this century.

These results were obtained by a linear model (Leclercq and Oerlemans, 2012, Zecchetto et al., 2017) forced by the temperature increase according to the A1B scenario (Nakicenovic et al., 2000), which indicates an increase of temperature of 0.25° C per decade until the mid of the 21st century and of 0.36° C per decade in the second half of the century. These temperature projections have been used by Gobiet et al., 2014 for their analysis of the future climate change in the European Alps.

To extend this analysis to other valley glaciers of the Italian Eastern Alps, we have used the same linear model to investigate the behaviour of seven valley glaciers, pertaining to South Tirol, as a result of the same temperature expected by the A1B scenario. To six glaciers, the only ones considered as valley glaciers in the Nuovo Catasto dei Ghiacciai Italiani (Smiraglia and Diolaiuti, 2015), we added the Lana glacier, a typical complex valley glacier with a tongue derived from the confluence of three different accumulation basins, the fourth one being now suspended on the tongue that feeds with collapses and avalanches.

In 1980, the areas of these 7 glaciers were between 6,5 km2 and 1,7 km2, in 2008 between 5,5 km2 and 1.3 km2. In 1980 the lengths of these glaciers were between 4200 m and 2900 m, in 2016 between 4035 m and 2585 m with percent shortenings between 4% and 25%.

The results show that the valley glaciers experience lower retreat rates than those of the mountain glaciers.

These results have to be considered as a lower bound value since progressive glacier shrinkage and fragmentation will lead to increasing glacier melt even under the same climatic conditions because glacier dynamics and response times cause a condition of glacier disequilibrium. Despite this, and given the measured and modelled retreats, the valley glaciers seem to be the only glaciers possibly reaching the next century.

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POSTER

Analysis of the evolution of Fradusta Glacier – "Pale di San Martino" 1994-2019

Cristian FERRARI[a], Gino Taufer[a,b], Matteo Zumiani[a,c], Elena Bertoni[a,c], Silvano Adami[a]

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The Glaciological group of the S.A.T. since 1990 has activated a systematic monitoring action of the Trentino glaciers, linking on the work already carried out by the Italian Glaciological Group (C.G.I.).

Since 1994 the monitoring of the Fradusta glacier in the dolomite group of the Pale di San Martino has been carried out by the Glaciological Group of the SAT togheter with the technicians of Paneveggio Pale di San Martino Natural Park.

The Fradusta glacier (Code C.G.I. 950) was already mapped since 1888 when it presented an indicative surface detected by a map of about 225Ha.

During the climatic evolution of the 20th century, the Fradusta glacier was photographed and mapped several times and it was therefore possible to detect the extent of the glacial cover;

With the first orthophotos from 1950 ca. it was possible to measure the surface occupied by the glacial mass with more precision. The recent researches related to in-depth geomorphological studies on the territory with the relief of the morainic cords also with the use of LiDAR technologies give instead an estimated surface around the PEG of approximately one hundred Ha.

From 1962 the first surface calculation by the Italian Glaciological Group (C.G.I.) began that confirmed an extension of the glacial body of around 65Ha, successive measures to half of the years 70 indicated a halving of the occupied surface with consequent decrease of the thickness of the ice.

Since 1994, surface measurements have been performed more accurately with precision instrumentation.

The tendency of the reduction of the surface compared with the trend of snowfall on the ground measured in detection stations nearby to the Fradusta glacier, shows however an accelerated trend of the reduction of surface and mass evidently correlated to seasons in which the ablation of the mass glacial is less and less compensated by winter precipitation as already observed on other glacial bodies of the Alpine arc.

POSTER

Inventory of Trentino glacier and their evolution from Little Ice Age

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In occasion of the preparation of a new inventory for Trentino glaciers, all historically available data were digitized in a geographic information system (GIS) with the aim to reconstruct their evolution from the end of the Little Ice Age (LIA) up to date.

At the maximum of the LIA (around 1850) were defined in GIS. the maximum of the LIA (around 1850) glaciers filled an area of about 102 km2 distributed in the mountain groups of Presanella, Cevedale, Brenta, Marmolada and Pale di San Martino, where many of them still remain albeit much reduced. In the early 1900s, however, some glaciers disappeared mainly because of the adverse conditions of altitude and/or orientation (for example on Monzoni and Lagorai mountain groups).

Other digitized inventories were those dating back to 1954 (survey American Aeronautical), 1958 (CGI, Italian Glaciological Committee), to 1987 (SAT, Mountaineering and Climbing Federation Trento), 2003 (PAT, Autonomous Province of Trento) and 2015 (PAT). The last one counts 140 glaciers with total area of about 28 km2.

The inventories of 1954 were completed by ortorectify of aerial imagery. The inventories of 1958 and 1987, instead, were completed using location surveys and compilation of maps with scale 1:25 000; the other two were completed on the basis of LiDAR surveys from which the perimeters scale 1:1 000 and digital surface models (DSM) were adopted. Despite the different accuracy for the inventory, the total areas can be compared with sufficient reliability, assuming that measure errors cancel each other out.

The average annual losses of glacial surface were compared for each of the considered four time periods. We have noticed that these losses have grown exponentially.

With the three-dimensional analysis of the 2003 and 2015 inventories, the average annual reduction in thickness was determined for the glaciers representative of the main mountain groups, and it has been observed to achieve values up to 4.000 mm. Additionally, the number of glaciers is increasing and with the retreat the glaciers are dividing into smaller, separate units. The surface of the glaciers from the maximum of the LIA to date has been reduced by 72% (from 102 km^2 to 28). In 1954 the surface was 54 km^2, in 1987 was 51 km^2 and in 2003 was 39 km^2.

ORAL

Convective clustering and climate sensitivity

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Cloud resolving models examining states of radiative convective equilibrium have shown the potential for convection to strongly cluster through feedbacks between clouds, water vapour and radiation. The way such clustering may change in the future and the relationship to sea surface temperature (SST) is still poorly understood, but if clustering proofs to increase over warmer SSTs, leading to relative drier states, this could represent a negative feedback on climate. In addition to summarizing recent work with convection permitting models, recent results using longwave radiation and GPM rainfall data will be shown to examine how the interannual changes in clustering impact the dryness of the tropical troposphere, and together with low level static stability, can explain variations in top of atmosphere net radiative fluxes.

ORAL

Time of emergence of climate change in West Africa: precipitation metrics

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The time of emergence (TOE) of climate change is defined as the time when a new climate state emerges from a prior one. In the context of present climate change, reliable prevision of TOE is highly valuable in prioritising mitigation and adaptation measures. Although evidences show that global temperature has already emerged from preindustrial natural variability, regional scale TOE assessment of climate variables other than temperature is still affected by uncertainty. Assessing climate change emergence is particularly relevant in West Africa, a region highly threatened by climate change and urging trustworthy climate predictions.

West African climate is dominated by the dynamics of the West African monsoon, which is characterised by large natural variability at decadal time scales, and by large uncertainties in future projections, with no consensus among climate models on the sign of future change in monsoonal precipitation. Therefore, in West Africa the TOE determination is challenged by robustness issues. In this paper, the TOE of climate change in West Africa is assessed for the first time, by applying 3

detection methods to future projections of 6 precipitation metrics computed from bias-corrected output of 29 state-of-the-art climate models.

Results show that, at the end of the 21st century, cumulated monsoonal precipitation is characterised by a negative trend in West Sahel (-6%), dominated by the decrease in the number of wet days (-19%), and a positive trend in East Sahel (+21%), dominated by the doubling of very wet days (+110%). The rainy season is projected to start 7 days later, and be 5 days shorter. The TOE of climate change for cumulated precipitation reproduces the same pattern, with a shift towards a dryer climate in the early 2060s in West Sahel, and a shift into wetter conditions simulated for the first half of the century in East Sahel, between late 2020s and late 2050s depending on the method. In West Sahel, the dry shift is anticipated by the shift in the number of wet days in the 2030s. In East Sahel, a shift in the number of very wet days in the 2030s anticipates the shift into wetter conditions. Conversely, the climate shift in precipitation regime is not associated with changes in the onset and length of the rainy season, both showing no shift into new climate state. In general, the TOE determination is more robust for the number of wet and very wet days than for cumulated precipitation.

Although uncertainty in climate model future projections limits the robust determination of TOE at the sub-regional and local scales, this assessment study provides reliable time constraints to the expected climate shift in West Africa, supporting the adaptation to the future change in precipitation regime.

ORAL

Northern hemisphere monsoon response to mid-Holocene orbital forcing and greenhouse gas-induced global warming

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Precipitation and circulation patterns of Northern Hemisphere monsoons are investigated in Coupled Model Intercomparison Project phase 5 simulations for mid-Holocene and future climatescenario rcp8.5. Although both climates exhibit Northern Hemisphere warming and enhanced interhemispheric thermal contrast in boreal summer, changes in the spatial extent and rainfall intensity in future climate are smaller than in mid-Holocene for all Northern Hemisphere monsoons except the Indian monsoon. A decomposition of the moisture budget in thermodynamic and dynamic contributions suggests that under future global warming, the weaker response of the African, Indian, and North American monsoons results from a compensation between both components. The dynamic component, primarily constrained by changes in net energy input over land, determines instead most of the mid-Holocene land monsoonal rainfall response.

ORAL

Is natural variability really natural? The case of Atlantic Multidecadal Oscillation

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As well known, the climate system is endowed with a complex dynamics, characterized by both internal natural variability and interactions with external (natural and anthropogenic) forcings. Attribution studies of the recent global warming show that the global temperature has been mainly driven by external anthropogenic forcings, even if internal variability can have a role in determining temperature values at short time scales (interannual to multidecadal ones).

If El Niño Sothern Oscillation clearly contributes to interannual variability, decadal "modulations" of the global temperature curve have not been strictly attributed to atmospheric or oceanic (possibly coupled) patterns. Nevertheless, an unforced internal component that varies on multidecadal time scales has been identified in the temperature record (DelSole et al., 2011) and it has been noted that the warming and cooling of this component matches that of the Atlantic Multidecadal Oscillation (AMO).

Thus, could AMO have a role in modulating global temperature? Or are the forcings which drive the global temperature that lead also the AMO behaviour? This dilemma can hopefully be solved by attribution studies of the AMO behaviour itself.

As a matter of fact, several studies face this problem: see, for instance, Otterå et al. (2010), Booth et al. (2012), Zhang et al. (2013), Knudsen et al. (2014), Clement et al. (2015), Bellucci et al. (2017), Cane et al. (2017), Murphy et al. (2017), Bellomo et al. (2018), Kim et al. (2018). Even if many papers emphasize the role that sulphate aerosols could have in driving the AMO curve, others claim to a role of ocean dynamics and internal factors of the climate system. All these studies have been performed by runs of Global Climate Models (GCMs).

In this framework, following a first attempt briefly described in Pasini et al. (2017), here we address this problem via a neural network (NN) model specifically developed for modelling relationships among variables in small datasets (Pasini, 2015). This nonlinear data-driven model allows us to perform an attribution activity by NNs in which we consider data of external forcings (solar radiation, volcanic activity, GHGs radiative forcing, sulphates forcing) as inputs/predictors and the AMO index as target/predictand.

First of all, we modify our previous NN model by considering a quasi-Newton backpropagation method, which is more suitable for handling small datasets with respect to our previous learning technique. Then, the results show that we are able to reconstruct the "shape" of the AMO curve when all the inputs are considered with their real observed values, with a high variance explained (R2 = 0.59), while a multilinear regression model shows quite poor results (R2 = 0.26). Then, if sulphates

are considered constant and fixed at their value of 1866, the oscillating signal of AMO disappears, so claiming to a big role of these anthropogenic aerosols for driving AMO behaviour. At the same time, however, when GHGs are considered constant at their preindustrial values only a small oscillation is visible in the simulated AMO signal.

We can conclude that, as a matter of fact, the AMO signal is modulated especially by the sulphates forcing, but a component of GHGs forcing is needed for determining well its observed form. No role has been detected for external natural forcings.

In short, for the case of AMO, natural variability seems not to be really natural.

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ORAL

Decadal predictability in the North Atlantic: The impact of the Atlantic multidecadal variability on the Atlantic storm track

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The seminar discusses the link between the Atlantic Multidecadal Variability (AMV) and the variability of the Atlantic storm track and eddy-driven jet on the decadal time scale via a coordinated analysis of idealised simulations with state-of-the-art coupled models. The rationale for the approach is that the modulation of sea surface temperature by the AMV modifies temperature gradient and land-sea thermal contrast in the core of the Atlantic extratropical storm track region. The data used are obtained from a multi-model ensemble of AMV± experiments conducted under the framework of the Decadal Climate Prediction Project component C (DCPP-C). These experiments are performed nudging the surface of the Atlantic Ocean (temperature and salinity) to states defined by imposing observed (ERSST) AMV± anomalies onto the respective model climatology. Most model experiments indicate an equatorward shift of the jet and of the transient eddy kinetic energy and a deceleration of the jet by the transient eddies in response to AMV+. A robust finding is the reduction of the meridional heat flux (v'T') in the region of strong baroclinicity. The potential outcome of this analysis is informative of the potential combination of dynamical (jet displacement) and thermodynamic (advection of thermal anomalies) AMV impacts on Europe and of processes generating uncertainty in the multi-model DCPP-C framework.

ORAL

Seasonal sources of predictability for the Euro-Mediterranean sector from different earth system components

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Seasonal forecasts are essential to offer early-warning decision support systems that can help to reduce the socio-economics related risk associated to some anomalous events.

Seasonal predictability comes from the slowly evolving components of the climate system, as the ocean and the land surface. The state of the equatorial Pacific and its variability linked to El-Nino Southern Oscillation (ENSO) convey local and remote predictability, due to the strong air-sea coupling

that spreads information in several regions of the globe. However, the detection of the ENSO influences over the Euro-Mediterranean domain is made difficult by the large variability of the atmospheric circulation on the North Atlantic-European sector. We want to assess the role of low frequency sea surface temperature variability in shaping the ENSO fingerprint over the Euro-Mediterranean region. Indeed, the different processes involved in the propagation of ENSO signal remotely, as the propagation of planetary waves, may be affected by the background sea surface temperature (SST) state. In the detail, we focus our attention on how the North Pacific low frequency SST variability, due to different phases of the Pacific Decadal Oscillation (PDO), may interact with the teleconnection of different phases of ENSO. The modulation of the ENSO teleconnection under different PDO phases is discussed and a possible tropospheric pathway is explored, accounting for the sensitivity to the basic state of the planetary wave propagation.

On the other hand, we aim to investigate also local processes, representing potential sources of predictability at the seasonal time scale. Feedbacks between soil moisture state and the atmosphere are known to play a crucial role in shaping the duration and the intensity of summer heat waves. The atmospheric response over the Mediterranean region to extremely dry and extremely wet soil conditions is examined, with a special focus on the role of land surface model initialization. Our results show that the coupling between land surface and atmosphere enhances feedback processes, and hence higher temperatures and longer heat waves.

ORAL

Aggregation of convection in RCE simulations and their possible implications for climate

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Recently idealized experiments on the development and structural organization of convection in environments at radiative-convective equilibrium have been performed in the literature using both convective resolving models and global models. The experiments shown performed with two CRMs, are modeled as other similar experiments that aim to study the aggregation of convection and its variability as in Bretherton et al. (2005). These simulations show spontaneous spatial aggregation of convection of radiative-convective equilibrium despite homogeneous boundary conditions and forcing (Wing et al. 2017). The aggregation observed is due to interactions between convection, radiation, environmental moisture, surface fluxes, and circulation. Since similar processes (i.e. moisture convection feedbacks, radiation feedbacks, surface fluxes feedbacks) are important for observed phenomena (see Holloway et al. 2017) such as the Madden-Julian oscillation, the Intertropical Convergence Zone and tropical cyclogenesis, the implications of such states are discussed with respect to the potential effects they may have on the climate.

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ORAL

The Vaia storm event of 27-30 October 2018 in the Eastern Italian Alps: Forcing mechanisms and sensitivity to boundary conditions

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The aim of this study is to identify the main mesoscale features and mechanisms responsible for the generation of an extreme precipitation and windstorm event that affected the eastern Italian Alps on 27-30 October 2018 (the so called “Vaia” event). The event was characterised by extreme cumulated precipitation (up to 850 mm in three days) and wind (wind gusts up to 200 km/h), causing severe floods, landslides, extended damages to growing stock, interruption of traffic and electricity supply, as well as other infrastructural damages.

The synoptic situation was characterized by a trough, which deepened on the eastern flank of a blocking ridge in the Atlantic, extending to France and Spain. At the surface, cyclogenesis started on the poleward part of the jet stream, east of the trough axis, over the western Mediterranean, and moved, deepening, towards north-western Italy. Two consecutive precipitation phases can be identified, both fed by intense moist southerly flow: the first was associated with the almost stationary warm front and was characterized mainly by stratiform orographic rainfall; in the second phase, intense convective activity was associated with the subsequent passage of the cold front.

The mechanisms responsible for the strong winds and extreme precipitations are analysed by means of a combination of ground observations, satellite and radar data, and numerical simulations performed by two convection permitting models: WRF and MOLOCH. Model results are first validated against observations, highlighting that both models are able to well capture the temporal and spatial distribution of precipitations and extreme winds. Both measurements and numerical results are then analysed to identify the precipitation systems and the wind field associated with the different phases of the storm and to evaluate the role of the orography of the eastern Alps in locating the precipitation maximum over the mountainous hinterland. Furthermore, numerical sensitivity experiments are performed to investigate the role of the sea surface temperature anomalies in modulating the precipitation over the Alps, as well as the intensity of the Mediterranean cyclone.

ORAL

The role of data in understanding changes in hydrologic extremes

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Whether extreme rainfall events are increasing in frequency and intensity is a major concern all over the world. Thanks to a recent database for short-duration rainfall extremes in Italy (Libertino et al., 2018), a country-wide analysis has been undertaken, that investigates trends in the sub-daily precipitation annual maxima.

Considering the country as a unique study area, our analyses shows neither significant changes in extreme rainfall frequency, nor in their intensity.

This outcome appear justified by the high geographic, climatic and topographic non-uniformity of the country. On the other hand, data used display a notable variability in their uniformity and density, and this has been the subject of specific attention during the analyses. In a spatially significant kind of trend assessment, it was deemed necessary to increase the resolution of the analysis in the Italian peninsula. At this closer look, well-defined areas with a positive or a negative significant trend in the rainfall amounts emerged and the spatial clustering of trend results in the same direction (either increase or decrese) was considered to help defining areas with a coherent behavior. Clues for a slight increase in frequency are also observed, though statistically still non-significant. It is observed that the direction and the significance of trends show also to depend on the duration of the extreme rainfall considered. Different durations (e.g. 1h vs. 24 h) show a different degree or sign of change. This can depend on the different underlying rainfall generation mechanisms, and highlight the importance of analyzing sub-daily rainfall data at large spatial scales, which is not common in the literature.

The mapping of areas with coherent trends and of stations with significant increasing trends represents the first data-based answer, with complex non-uniform results, to the common-sense and widespread thinking about the increase in intensity and frequency of severe thunderstorms in Italy.

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ORAL

Trends in the severe weather events simulated by SPHERA, a convection-permitting reanalysis over Italy

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This study presents the potential in climate applications of SPHERA (High Resolution REAnalysis over Italy), the novel convection-permitting regional reanalysis centred over Italy, which has been developed by ARPAE-SIMC. SPHERA domain covers Italy and the surrounding seas with a horizontal resolution of 2.2km, with a hourly temporal frequency. It is nested in ERA5, the global reanalysis from ECWMF, and it is based on the limited area COSMO model. A nudging data assimilation scheme is applied in order to steer the model simulation towards observations. SPHERA is currently in production and when completed it will cover the period 1995-2020.

In SPHERA, the higher horizontal resolution and the explicit solution of deep convection lead to a net gain against other coarser reanalyses, especially for weather events directly associated to convection processes (e.g. thunderstorms, heavy precipitation, hail, supercells, ..). We present here the validation of SPHERA against near surface observations over the Italian area also in comparison with other reanalysis datasets (ERA5, MERIDA, MOLOCH-rianalysis, COSMO-REA6). Evaluation is presented for the total precipitation and temperature at 2m. Moreover, we report the temporal signal of some extreme weather events that can be extracted from SPHERA for the period already produced. Focus will be on heavy precipitation events and heat/cold spells.

ORAL

Investigating about climate-change hazards that might impact electric infrastructures

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There is an urgent need for an effective and harmonized framework to develop climate resilient solutions to ensure the necessary level of security in energy production and supply.

To support the development of national adaptation policies and measures addressing climate change impacts on Italian energy sector, this work aims to analyze the projected changes of some extreme events such as droughts, floods, wet-snow over Italy, even if incremental changes of meteorological variable (in particular, temperature and precipitations) are not to be neglected. In fact they also represents important hazards for infrastructures, i.e. thermoelectric power generation facilities are at risk if water availability decreases or ambient air temperature increase; hydropower

can be affected by changing in precipitation patterns. Among extreme events, heat-waves and drought conditions represent serious hazards for the energetic/electric system (as well as environmental and social ones). Thinking about thermoelectric power generation facilities, they are at risk if water availability decreases and/or ambient air and water temperatures increase. In fact, these meteorological conditions reduce the efficiency of cooling, increase the likelihood of exceeding water thermal intake as well as the effluent limits to protect local ecology, and increase the risk of partial or full shutdowns of generation facilities. Such situations may become even more critical by an increasing electricity demand for cooling related with a warmer climate.

The climate change investigations are made on the basis of high-resolution climate models results provided by EU-funded Projects Euro-CORDEX (horizontal resolution of 0.11°, about 12 km) under two different radiative forcings (RCP8.5 and RCP2.6) to infer quantitative assessments about the danger of climate change impacts under different socio-economic pathways (Detlef et al, 2011): very high baseline emission scenarios (RCP8.5) and mitigation scenario leading to a very low forcing level (RCP2.6).

Following the recommendations stated in the Program for Climate Model Diagnosis and Intercomparison (Meehl, 2005), multi-model ensemble means have been computed to improve the accuracy and reliability of probabilistic projections compared to single model realizations. Moreover the Wilcoxon rank-sum test has been applied to identify the area affected by significant climate changes.

After filtering the models with limited performances in reconstructing the current climate inferred from reference data-base (E-OBS and MESAN), the multi-model climate change scenarios have been characterized by comparing the base-line period (1971–2000) with short (FUT1=2021-2050), medium (2041-2070) and long term (FUT2=2051-2080) future scenarios.

A sub-set of the ETCCDI indexes (WMO, 2009), specifically designed to describe extreme weather and climate events, has been considered to investigate the extreme events above mentioned: SUmmer days (SU), Tropical Nights (TR), Consecutive Dry Days (CDD), extreme precipitations (R99PTOT), Frost Days (FD). Moreover WSF (Wet Snow Frequency) index has been computed. It is an ad hoc index to characterize wet-snow events, phenomena that may cause serious problems for the safety and operation of the Electric System when wet snow sleeves on overhead lines reach weights exceeding the design criteria.

Without mitigation actions, the more significant results highlight a warming of about 2°C in the next decades, 3°C in the mid of the century, and more than 5°C in the last thirty-years period; a decreasing of total precipitations, with significant reduction in the summer ranging between 10 and 20% in the first half of the century, until 50% at the end of it.

Hot days and extreme precipitations show the most dramatic changes both in frequencies and intensities. Consistently with a warming climate, the hot days are expected to intensify over the century: the SU added events will be likely about 10 days in the summer season of the next decades, 40 more days in the last part of the XXI century. Tropical nights will also increase: TR scenarios point out an increase ranging from 10 to 40 events along the century with high confidence.

Moreover CDD are expected to increase significantly with further episodes ranging from 2 to 10 over the century during the warm months, specially over peninsular Italy.

Extreme precipitations are projected to increase more likely over coast areas, depending on the season. The R99P scenarios point out with some confidence increased risks for extreme precipitation over Northern Adriatic Coasts and Gulf of Genoa in spring, Tyrrhenian and Adriatic Coasts in fall season.

Wet-snow events are projected to decrease considerably in the areas nowadays affected by these phenomena, whereas they are likely to increase significantly over Alps, kept free of wet-snow until now. Larger uncertainties characterize the Central and Northern Apennines where the WSF signal is almost absent and no useful information can be inferred for these areas.

On the assumption of mitigation pathways compatible with 1.5°C increase of the mean air temperature, in the context of sustainable development (RCP2.6), climate changes are projected to be much lower.

In fact combined with a warming under 1.5°C, the precipitation scenarios show lower changes. In particular, under RCP2.6 it is avoided the significant precipitation reduction expected in RCP8.5 in summer. Indeed an increase of 10% over Po Valley is expected with some confidence.

However it is worth noting that some climate impacts can no longer be avoided. In facts, the future scenarios elaborate for the ETCCDI index R99P point out that extreme precipitations are expected to increase during the winter and spring even in RCP2.6 configuration, instead their growth could be partially avoided in autumn. Actually some uncertainties characterize these results.

No significant changes in consecutive dry days are inferred from future scenarios elaborated with RCP2.6, in comparison with the reference scenario 1971-2000.

In line with a smaller warming under the hypothesis of low green-house gases emissions pathway, a lower but significant hot-days increasing is projected along all the century: SU maps highlight an average increase between 2 and 5 episodes in summer season. Tropical nights will also increase: about 5 more events are expected in the three future scenarios but there is some confidence in the results only at short term (FUT1), whereas under RCP8.5 configurations there is a great agreement among the models in highlighting a significant increasing of this meteorological condition.

Frost days are likely to decrease also in RCP2.6, too, but the phenomenon is considerably less pronounced in comparison with the scenarios expected in RCP8.5. It is worth noting than under the hypothesis of low green-house gas emissions, the Alpine area are likely to be free from significant reductions. In facts, no significant changes are expected in RCP2.6 over high elevation areas.

Lastly wet-snow events are projected to change with the same patterns characterizing the RCP8.5 scenarios but the variations expected are significantly reduced.

To summarize the results, Energetic Sector will have to adapt not only to changes in mean climate, it also has to cope with an increased climate variability whose effects could hamper the security in energy production and supply with remarkable social and economic impacts.

In the case of a socio-economic pathways RCP8.5, despite some uncertainties (because of discrepancies among the models), heat-waves and drought conditions will likely exacerbate in the coming decades, revealing a trend toward increasing impacts from weather related hazards and, therefore, increasing risk to enhance critical conditions for the Italian energetic/electric system. Such conditions will be much less critical if mitigation actions will be undertaken.

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ORAL

Metrology for Meteorology and Climate

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As stated by the Global Climate Observing System (GCOS) "Long-term, high-quality and uninterrupted observations of the atmosphere, land and ocean are vital for all countries, as their economies and societies become increasingly affected by climate variability and change". High-quality observation is possible only if based on a sustained traceability to the System of Units (SI) and with documented uncertainties associated to the measured values.

Over the last decade, an increasing collaboration has been established between the metrology and the meteorology and climate communities. The International Committee for Weights and Measures (CIPM) and the World Meteorological Organization (WMO) of the United Nations are jointly cooperating and driving the growing liaisons between National Institutes of Metrology (NMIs) and National Meteorological and Hydrological Services (NMHSs).

Following the signature of the Mutual Recognition Arrangement (MRA) by the World Meteorological Organization, in April 2010, the Comité consultatif de thermométrie (Committee Consultative for Thermometry) of the CIPM submitted a recommendation to CIPM. The document motivated the reasons to encourage National Metrology Institutes (NMIs) [...] to face new perspectives, needs, projects and activities related to the traceability, quality assurance, calibration procedures and definitions for those quantities involved in climate studies and meteorological observations and to support a strong cooperation between NMIs and Meteorological Institutions at local, national and international levels.

Both the key world institution representing meteorology and metrology, WMOand CIPM, created new working groups: the CCT created the Working Group for Environment and the WMO Commission of Instrument and Methods of Observations (CIMO) and Commission of Climatology (CCl) launched expert teams on metrology, uncertainty and reference observations . These new groups are now active, following a well defined workplan and include experts in thermal metrology and external members representing international institutions such as the International Surface Temperature Initiative and the Global Cryosphere Watch programme.

As a key topic, air temperature measurement still requires deep understanding and research both in terms of guidelines for the calibration of thermometers in air as well as for the evaluation of the complete uncertainty budget for field measurements, taking into account the absence of thermodynamic equilibrium and the numerous quantities of influence. Being temperature one of the key variables in climate studies and earth observations, as stated by the GCOS, several members of the CCT WG-ENV, were officially asked to join expert teams of WMO Commissions of Instrument and Methods of Observation (WMO - CIMO) and of Climatology (WMO – CCl), working group of the International Surface Temperature Initiative, of the GCOS Reference Upper Air Network (GRUAN) and other. The liaisons so established were effective since the beginning in terms of mutual attendance to meetings, conferences, workshops, conference calls. The involvement of metrologists is now extended also to other international initiatives such as ISTI, WMO-GCW GCOS Atmospheric Obseravtion Panel for Climate (AOPC) and focused teams such as expert team on Arctic environment.

Since 2010, EURAMET launched calls for projects in the field on environmental metrology, through its European Metrology Research Programme (EMRP, now EMPIR). The objective is to improve calibration procedures and measurement techniques for some Essential Climate Variables (ECVs).

MeteoMet, the larger EMRP consortium of NMIs, collaborators, universities, meteorological agencies, research institutes and manufacturers is operative since 2011 and is focussing especially on temperature, pressure and water vapour dealing with near surface, soil and cryosphere observations. MeteoMet activities evolved from developing novel instruments and methods, improving calibration procedures and establishing documented traceability, towards a more challenging vision: the full evaluation of measurement uncertainties. Such scope requires a number of activities and studies, both in laboratory and in field, including long lasting measurements, use of dedicated facilities, investigations of sensor characteristics and the improvement of measurement devices. All of them under performed with methods following a rigorous metrological approach.

The overall aim is to make a further step towards establishing full data comparability, consistency and long-term continuity, through a comprehensive evaluation of the measurement uncertainties for the quantities involved in the global climate observations. The improvement of quality of ECVs records, through the inclusion of measurement uncertainty budgets, will also highlight possible strategies for the reduction of the uncertainty.

This contribution reviews the main ongoing activities, the structure and terms of reference of the CIPM and WMO Working Groups and expert teams, the outreaches of MeteoMet key objectives, and outcomes of international events and conferences.

The common vision, linking projects scopes and discussion within task groups is to establish a permanent bridge between metrologists and climatologists, through which to strengthen and develop collaborations, joint activities/projects and results dissemination to the whole society.

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Climate related impacts on natural and human systems

ORAL

Mosquito-borne infections in Europe: Assessment of public health risks via temperature-driven mathematical models

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Climatological variables are critical drivers in infections transmitted by mosquitoes, acting at multiple levels on the biology of the mosquito life cycles but also on epidemiological traits of the viruses such as the incubation times and transmissibility. Therefore, the impact of climate change on the risks for public health can be profound. Mosquito-borne infections represent a significant fraction of disease burden worldwide and are emerging or re-emerging as an important threat for human health. Diseases such as chikungunya and dengue are rapidly expanding their geographic range well beyond the tropical and subtropical belt. In Europe, the first recorded episode of chikungunya transmission occurred in Emilia Romagna, Italy, in 2007, and resulted in a large outbreak involving over 200 patients; in the summer of 2017, another outbreak of more than 400 cases originated in Anzio, involving neighboring cities including Rome, and seeding an additional outbreak of over 100 cases in Guardavalle Marina, Calabria. Sporadic transmission of chikungunya has also been recorded in

Southern France in 2010, 2014 and 2017. Dengue had been absent from Europe since 1928 until the summer of 2010, when small outbreaks took place in France and Croatia. In 2012, the Portuguese island of Madeira witnessed a major outbreak with over 2000 cases; further sporadic cases of autochthonous dengue were more recently reported in France. Meanwhile, in the rest of the world, Zika has emerged as a new pandemic threat with severe congenital syndromes; outbreaks of Zika appeared in 2007 and 2014 in insular countries of the Pacific, then in 2015 it reached Brazil from which it spread explosively to most areas of Central and South America. Although Zika infection in humans is generally asymptomatic or very mild, it is capable of causing Guillain-Barre' syndrome in adults and congenital neuronal defects in newborns from mothers infected during pregnancy. Finally, large and deadly yellow fever outbreaks have occurred in Angola, Democratic Republic of Congo and Brazil since 2016, in spite of the major reductions achieved with the introduction of an effective vaccine since the '90s.

Mathematical and computational models can play an important role to assist public health systems and decision makers, by allowing the estimation of potential transmission risks to humans and the cost-effectiveness of preventive interventions under a range of temperature scenarios. In this presentation, we will showcase a number of practical applications of models to mosquito-borne infections accounting for temperature changes over time and under different scenarios of temperature change.

To estimate transmission risks of tropical diseases in Northern Italy, we developed a mathematical model representing the dynamics of Aedes albopictus populations throughout the whole developmental cycle (eggs, larvae, pupae, female adults). The model was fitted to mosquito capture data from ten municipalities in the provinces of Trento and Belluno across the mosquito seasons of 2014 and 2015. We found a significant risk of chikungunya outbreaks in most sites if a case was imported from endemic areas between the beginning of summer and up to mid-November, with an average outbreak probability between 4.9% and 25%, depending on the site. A lower risk was predicted for dengue, with an average probability between 4.2% and 10.8% in a restricted window of importation (between mid-July and mid-September). These risks would be enhanced by potential rises in temperatures, doubling for scenarios envisioning a 2-degrees daily increase, furthermore, the time span of the year where outbreaks could occur would also increase significantly, with large site-specific variations. We later used the same estimates on mosquito abundance to provide a timely risk assessment during the Zika pandemics in 2016, highlighting a consistently low risk of autochthonous mosquito-borne transmission in Northern Italy (as long as the vector competence of Aedes albopictus remains at the currently measured levels). In a separate study, we then moved on from the assessment of transmission probabilities to estimate the potential size of chikungunya and dengue outbreaks. We also evaluated the ability of preventive approaches to reduce transmission risks and outbreak sizes and we analyzed its cost-effectiveness. We found that routine larviciding of public catch basins can limit both the risk of autochthonous transmission and the size of potential epidemics. Ideal larvicide interventions should be timed in such a way to cover the month of July. Optimally timed larviciding can reduce locally transmitted cases of chikungunya by 20%-33% for a single application (dengue: 18-22%) and up to 43%-65% if treatment is repeated four times throughout the season (dengue: 31-51%). In larger municipalities (>35,000 inhabitants), the cost of comprehensive larviciding over the whole urban area overcomes potential health benefits related to

preventing cases of disease, suggesting the adoption of more localized interventions. Small/medium sized towns with high mosquito abundance will likely have a positive cost-benefit balance. Involvement of private citizens in routine larviciding activities further reduces transmission risks but with disproportionate costs of intervention.

Similar approaches were applied to analyze in real-time an actual outbreak, namely the 2017 chikungunya outbreak in Anzio. Using entomological capture data collected in 2012 from 18 sites along a 70 km-transect from the Lazio coast (four sites) to rural inland areas, and temperature data from 2017, we estimated the mosquito population densities. We coupled these estimates with data on human landing captures to estimate the mosquito biting rate and computed the probability of outbreak and outbreak size for different time of the year in the region. We identified the time of likely introduction of the index case (first week of June in Anzio, range: 21 May-18 June; early July in Rome, range: 28 May-16 July). We estimated a higher risk of large outbreaks in coastal and rural sites than in urban sites, despite the high vector abundance in some urban areas, and a significant probability of observing additional transmission up to mid-November (later confirmed by observations). We also quantified the probability that infected blood donations might have been occurred during the outbreak and total health and economic burden for the outbreak in Lazio. Based on the same mosquito abundance estimates in Lazio, we evaluated the probability of yellow fever outbreaks transmitted by Ae. albopictus in case of importation of an index case from areas of the world with active transmission. We found that the risk of transmission is generally low and limited to sporadic cases. However, for some coastal and rural sites there is a nonnegligible potential for large outbreaks, especially if importation occurs during the second half of July.

These applications elucidate the different ways in which data-driven modeling can contribute to decision making in public health, in order to face the growing threats of mosquito-borne infections and to assess the potential impact of climate change on these estimates. The extraction of valuable information from data and temperature projections is critical for preparedness and optimal resource assessment.

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ORAL

Quantitative impacts of temperature on mosquito dynamics and their transmitted pathogens: A modelling approach

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Zoonotic pathogens cause about three quarters of human emerging infectious diseases, many of which are spread by vectors such as mosquitoes. Thus, mosquito-borne pathogens transmission is shaped by vector abundance, which ultimately is mostly driven by environmental temperature. In fact, it is well known that temperature significantly affects mosquito dynamics; for instance, warmer conditions might decrease survival but also hasten the development of the immature aquatic stages.

Mathematical models provide a powerful tool to quantitatively investigate how different weather conditions could influence mosquito population dynamics. We developed mechanistic models tailored to different mosquito species, taking into account existing knowledge gathered through laboratory experiments, to assess how temperature affects their abundance and seasonal dynamics. We focussed both on indigenous Culex species (eg. Culex pipiens) and alien invasive Aedes species (eg. Aedes albopictus and Aedes koreicus). We found that warmer seasonal temperatures usually cause an upper shift of the Aedes abundance curve, while very hot conditions might extremely decrease Cx. pipiens population size during summer.

Finally, using an epidemiological model, we evaluated the impact of temperature on the transmission dynamics of Chikungunya virus, transmitted by Aedes albopictus, in an urban context. We found that temperature plays an important role in the magnitude of transmission potential as well as in the timing of disease transmission.

ORAL

Mosquito extremes: How warmer climate and extremes precipitation change freshwater ecology and increase human health risks

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Rise of temperature in temperate and alpine region have anticipate of almost one month the reproduction and metamorphosis of amphibians and many freshwater invertebrates, such as dragonflies.

That means that now in august many ponds, pools and agricultural channels can be void of

predators and competitors of mosquitoes larvae. This use to be normal in south Mediterranean, but in these area we have very few or no rain during summer, so many little freshwater habitats (typical of mosquitoes) dry out.

In more temperate climate we (luckily) still have precipitation is summer that maintain some water for mosquitoes or, even worse, the alternation of drought and short extreme precipitation create many ephemeral and hot water bodies that are just ideal for mosquitoes. Mainly for new alien/tropical mosquitoes now in Europe such as the Tiger Mosquito.

This big amount of mosquitoes creates of course problems for life quality of the people that reacts increasing the number of pesticides sprayed in nature. This brings results al short terms but, at distances, produces: 1) a biodiversity loss, with an ulterior decrease of mosquitoes predator and competitors; 2) and adaptation of mosquitoes to pesticides.

Both factors, in a sort of chain reaction, increases mosquitoes number and heal risk for population, by the possible diseases the mosquitoes can bring and by the exposure to pesticides.

ORAL

Potentialities from airborne allergenic pollen phenology to track climate change effects

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The effects of climate change on ecosystems are largely evident and documented (EEA 2016). Changes in physiology, phenology and distribution of species are also reported. Phenological events occurring in spring, both for animals and plants, tend to anticipate by 2.3 days every decade (Parmesan and Yohe, 2003). Such phenomena have been observed also on the flowering phase (Walthers, 2010).

It is well know that climatic variables in general, and temperature in particular, influence – among other factors- plants phenology. Consequently flowering time is a frequently observed phenological phase in the context of climate change research.

These investigations can be conducted with direct observations or indirectly, e.g.for anemophilous plants by analyzing pollen in the atmosphere. In this case, pollen is a proxy for flowering phenophase and is considered a good indicator of climate change.

Data on airborne pollen phenology (timing of release in atmosphere and amounts related to different pollen species) can be obtained by the aerobiological monitoring networks that work in several Countries across Europe (e.g., POLLnet in Italy; http://www.pollnet.it/default_it.asp); they are of great importance because permit to document changes in the presence of allergenic pollen in the air.

Allergic diseases are nowadays a remarkable and growing public health problem (WAO 2013). Among the various causes, global warming is considered a key factor in increasing the prevalence of

these diseases (D'Amato et al. 2018). The rising temperatures are linked both to the increase in pollen quantities (Ziello et al 2012) and to the lengthening of the pollen season (Ziska 2016).

It is therefore important to monitor the situation, since the effects of climate change on vegetation may ultimately have negative consequences on human health.

The objective of this study is to analyze the temporal trend of daily airborne pollen concentration data of the last 30 years, collected at the aerobiological monitoring center in San Michele all'Adige (Trentino, North Italy) and the relations with meteorological parameters. The possible implications for pollinosis will be discussed.

Material and Method The aerobiological monitoring center of San Michele all'Adige is located at the bottom of an alpine valley, at 228 m a.s.l. The surrounding vegetation is characterized by a high biodiversity, which is reflected in the pollen spectrum, composed by more than 60 taxa.

Data are obtained using a volumetric Hirst-type sampler, following a standardized procedure adopted at national level (Bucher et al 2017), in compliance with the European rule (UNI 11108:2004) and quality procedures (Galan et al 2014).

For the data analysis, 24 pollen taxa – both arboreal and herbaceous – were selected considering the prevalence in the spectrum, the allergenicity and the rappresentativity of both arboreal and erbaceous plants.

Starting from the daily pollen concentration in air [P m-3], the following pollen descriptors were calculated for each year: (i) start and (ii) end date (defined as the days in which the 2.5% and 97.5% of total annual pollen concentrations are reached, respectively); (iii) peak date (day in which the maximum concentration occurs); (iv) total pollen amount (=Pollen Index; sum of the daily concentrations in a year).

The temporal trend of each pollen season descriptor was analyzed by non-parametric statistic using aeRobilogy (Rojo et al 2018), to check if a general advance or delay signal exists, with a special focus on pollen season start date. In addition, pollen season descriptors were analyzed in relation to meteorological parameters.

Results Time course of yearly pollen season start results to anticipate for 15 out of 24 taxa, significantly (p

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ORAL

Modeling crop-specific impact of heat waves by deep learning: Wine production in Trentino (Italy)

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In the last century heat waves have increasingly affected public health and the environment, with substantial impact on the agricultural sector in terms of severe drought, unsustainable irrigation and loss of yield. In July/August 2013, an extreme high temperature event in East China caused a devastating drought impacting 1.610 billion people and crops in an area of 18720km2; more than 350 million people were in shortage of drinking water; 3520km2 crops had no harvest, with direct economic losses in excess of 14 billion Yuan (~ 1.8 billion Euro). The potential for damage by heat waves is high and distributed at any latitude, with recurrent drought affecting maize yield in the USA or causing wildfires in Sweden forests (as in 2018). It is thus urgent to adopt solutions to provide both global preparation and high precision in modeling heat waves and the consequent impact on crop phenology and yield. In order to tackle these two challenges, we propose EHWP-HR and HW-CRP. EHWP-HR is an high-resolution version of the European Heat Wave Forecast System described in Gobbi et al, 2017, while HW-CRP is a framework for assessing the impact of heatwaves on crops using Machine/Deep learning models and agronomic expertise. These two modules are based on high-resolution temperature maps obtained using UNetDS: a deep learning model based on U-Net (Ronneberger et al, 2015) implemented in HW-CRP.

HWP-HR and HW-CRP are two powerful tools which apply artificial intelligence models for monitoring and understanding the impact heat waves have on crops on a high-resolution geo-localized level, since we can take in consideration different type of varieties and micro-climates. Micro-climates are especially of concern in a mountainous area such as the Province of Trentino in Italy, where agriculture sector is one of the major economic resources, but at the same time meteorological conditions are highly variable.

Plant response to high temperature varies according to temperature, duration and plant type. Heat stress affects all aspects of plant processes as germination, growth, development, reproduction and yield. These phases have been coded using the BBCH index (Zadoks et al, 1974). During the phenological stage of flowering the plant is highly susceptible to heat, wind and water stress. Heat stress can cause poor yield due to poor fruit set. For example, during the two last growth stages of grapevines phenology, veraison until harvest, heat stress can cause softening of the fruit. Berries may

shrivel or be sunburnt (Hayman et al., 2012). At the same time, the temperature rise due to climate change is shifting the occurrences of the phenological stages and major changes are expected in the growth season length (Alikadic, et al., 2019). Furthermore, heat stress influences major physiological processes and creates metabolic imbalance (Hasanuzzaman et al, 2013). Over the past three decades (1980-2008), heat stress caused a decrease of 5.5% and 3.8% in the world yields of wheat and maize, respectively (Lobel et al., 2011). Since BBCH is a key parameter describing the phase of a plant, we enriched HW-CRP with PhenoCNN: a deep learning model for vine phenology predicting daily BBCH values based on temperature and GIS-features (under validation at national scale).

Furthermore, HW-CRP contains flexible modules for the case study of wine production in the Province of Trento: i) assessment of specific stages during growth where heat waves are more frequent, ii) how heatwaves relate to the total yield, iii) how heatwaves relate to the quality of wine production and iv) how they affect the plant in different geographical environments. Notice that grape growth is also impacted by the meteorological conditions of the previous year, thus the correlation of occurrence of heat waves in the relevant growth stages with the yield of the following year is also taken into consideration.

HW-CRP contains also UNetDS: a deep learning downscaling model based on U-Net with GIS-based features (terrain data as DTM, slope and aspect) that shows promising results (RMSE

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ORAL

FLOOD-MAGE: Climate modelling of flood risk (CLARA CS)

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FLOOD-MAGE is a DRM climate service aimed to estimate the potential economic losses triggered by flood events of different kinds (pluvial, fluvial and coastal). The risk information produced by the service is key for setting appropriate climate adaptation priorities and strategies. The service can adapt to different spatial scales and builds upon advanced seasonal meteo-climatic downscaling, high resolution exposure mapping, hydrodynamic and hydrostatic hazard modelling, multi-variable vulnerability assessment, and macro-economic modelling of labour and capital. The service is oriented to a variety of users, including the public administration, river basin authorities, land reclamation boards, asset managers, and insurers. FLOOD-MAGE provides insights on the economic and financial impacts linked to extreme event scenarios and draws a comprehensive outlook on how such impacts may change due to increased climate variability.

The pilot area chosen to demonstrate the application of the service consists of one municipality (Rimini) located on the coast of the Emilia-Romagna region, on the outlet of the Marecchia river. It hosts about 150 thousand people and has a strong seasonal touristic vocation, with hundreds of hotels developing along the 15 km long, 200 m wide seaside sand stripe. Rimini is today subject to pluvial and coastal flood events, while in the past suffered river flood events, thus it is an ideal candidate to be a pilot for the evaluation of the service performances.

FLOOD-MAGE hazard downscaling procedure looks for the most detailed and updated data available for the area of application. The service combines georeferenced information describing the meteorological forcing (precipitation intensity), the land morphology (high-resolution terrain model, LiDAR) and land cover (buildings and areas categories), water network (both natural and artificial features such as drainage networks and retention areas), and the value of exposed assets. In addition, hydro-meteorological records (precipitation, discharge volumes) are used to calibrate the flood hazard model so to obtain important statistics regarding past flood events, such as an estimate of return periods for extreme events.

POSTER

Impact of climate change on society in Mongolia. Herders' families case study

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For centuries, nomadic culture has been the essence of Mongol lifestyle. Nowadays, Mongols are facing a rapid shift from a Soviet-style one-party state and command economy to a chaotic democracy and free-market economy, and from a nomadic culture to a modern, urban lifestyle. Every year, thousands of shepherds move with their gers to the capital of the country Ulaanbaatar, which now holds half the nation's population. Climate change seems an important culprit, and Mongolia, landlocked and far from the moderating effects of the ocean, is suffering more than most parts of the world. The climate in Mongolia is characterized by warm summers and long, dry and very cold winters. Drought summer paves the way for the harsh winter with dzud. Often more than a million cattle, sheep and goats, weakened by a dry summer, died, while nomads' precious horses froze to death on their feet. In years with dzud, the situation is even worse. In order to avoid these extreme conditions, more and more herders are dismantling their gers and abandoning the vast grasslands of the steppes to settle in the capital, Ulaanbaatar.

The aim of this paper is to examine the influence of the global climate change, combined with local environment mismanagement on the quality of life of Mongol nomads. A questionnaire survey was carried out in the spring and summer of 2019 to collect data on Mongol household's current life satisfaction with regard to climate change. The sample consisted of 170 randomly selected herders living now in gers around Ulaanbaatar, who abandoned their nomadic lifestyle because of loss of livestock and/or access to water and pastures. The reason of such dramatic changes in their lifestyle may also result from the expansion of mining with all negative environmental consequences. Because of this, an additional research goal is also to determine if the shepherds are aware of climate change in Mongolia and its impact on natural environment including pastures. Questionnaires were handed out directly to herdsmen by the Pen-and-Paper Personal Interview (PAPI) method. Questions in the survey questionnaire dealt with herdsmen demographic and economic characteristics and environmental issues.

Environmental situation of Mongol Aimags in the time span 2000-2018 was considered. Descriptive analysis like non-parametric tests and the multinomial logistic regression was used to identify the relationship between dependent variable (life satisfaction of respondents) and independent variables (household characteristics, household conditions, welfare status, declared effects of extreme climate phenomena, previous, actual livelihood activities and regional observed constrains). The multinomial logistic regression was applied, because the dependent variable is composed of a polytomous category having multiple choices. In regression model, the estimates for the parameter was identified, and compared to a baseline category (in this study, non change in the quality of life was a baseline category). The model was validated by: significant test of the overall

model, tests of regression coefficients, goodness-of-fit measures and validation of predicted probabilities.

Results show that in the city, living conditions are tough. The nomads have to deal with unemployment and poverty, as well as shortages of water, sanitary infrastructure and electricity. Lack of space is also a major issue. They miss the sense of freedom that accompanied life in the steppe.

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POSTER

Glacier retreating driving changes in downstream freshwater systems: Evidences from Italian Alps

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Glacier retreating will alter hydrological regimes, sediment transport, biogeochemical and contamin ant fluxes from rivers to oceans. This will influence the natural environment, including biodiversity and the ecosystem services that glacier-fed rivers provide to humans. Among these the provision of water for agriculture and livestock, hydropower, and potable use. Understanding how climate change and, specifically, glacier retreat affect aquatic biodiversity in glacier-fed streams represents a future research challenge.

A long term study was carried out to highlight the main ecological predictors driving invertebrate distribution in glacier-fed streams in the Italian Alps (Trentino and Lombardy). More than 40 sites belonging to four main stream types were sampled for two decades. Among these, the Careser stream (Trentino, Italy) will be taken as case study to highlight implication of air temperature variation on thermal and hydrological regime of a glacier-fed stream fed by a shrinking glacier. Site's "glaciality level" was quantified using: distance from the snout and % of glacier cover in the catchment; isotopic and geochemical parameters [e.g. δD and δ18O composition, conductivity and chemical content of surface water]; channel stability and water temperature; food availability (estimated as epilithic chlorophyll a and BPOM); food web structure [e.g. relative importance of allochthonous and autochthonous food sources using stable carbon (δ13C) and nitrogen (δ15N) isotopes]; % of Diamesa spp. (Diptera Chironomidae) and the presence of Diamesa steinboecki. Altogether the environmental parameters define the 'glacial influence' on biota.

High 'glaciality level' was associated mainly with low maximum water temperature (Tmax), high Glacial Index (calculated as a function of glacier area and distance from the glacier), high discharge, high channel instability, low food availability for consumers, low structural and functional diversity of the animal communities dominated by few Diamesa species. These obligate glacial river invertebrates disappear at glacier cover (GCC) < 30% and Tmax > 6 °C and can be considered as sentinel species of climate change.

Spatio-temporal changes in the community structure were highlighted in sites fed by glaciers under different retreat rates. Tipping points were highlighted, where the most cold-stenothermal kryal inhabitants (e.g. Diamesa steinboecki) disappeared or survived only as brachypterous populati ons, whereas other Chironomidae (Diamesinae and Orthocladiinae), Limoniidae, Baetidae, Nemouridae, Limnephilidae and non-insect taxa (e.g. Oligochaeta, Hydracarina) became more abundant. Upstream migration was observed in Diamesa spp. which conquered new stream reaches left free by the retreating glacier, and euriecious taxa which colonized reaches with ameliorated

environmental conditions, no longer the exclusive habitat of Diamesa spp. Consequently, functional diversity and community traits compositions changed, e.g. arrival of predators and taxa with incomplete metamorphosis or no pupation. Changes in macroinvertebrate community structure and functions will have implication on self-purification capacity of rivers and cascade effects on the food web and the species list and the relative abundance of each of them give us information on the ecological and "health" status of glacial ecosystems.

Even the isotopic signature of the water appears an appropriate tool to provide a snapshot of the evolving climatic conditions associated to changing icemelt contribution resulting in distinct regression lines δD-δ18O River Water Lines.

Rapid glacier retreating reveals stream macroinvertebrate community assembly processes with stochastic and deterministic components, that represent «early warning indicators» of the effects of climate change occurring in the Alps.

Long-term standardized monitoring of environmental parameters and biological communities will be essential to understand the degree of vulnerability of these systems to climate warming, to predict impacts on glacial biodiversity and ecosystem services and to improve water resources management in the Alps.

The research project was co-funded by the Autonomous Province of Trento (Italy) (2001-2003, HIGH-EST project, no. 1060/2001; 2003- 2006, VETTA project, no. 3402/2002), the protected areas Adamello-Brenta (2017-2019) Natural Park and Stelvio National Park (1999-2004) and the EC (AASER project, 1996-1999, European Union Environment and Climate Programme, contract no. ENV4-CT95-0164).

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POSTER

Development of a forest land suitability model for Lebanon reforestation under climate change conditions

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In the heart of the Mediterranean Basin, the world's most threatened biodiversity hotspot, at the Eastern end of the Mediterranean Sea (33°50' North and 35°50' East), falls the small country of Lebanon, covering a total of 10,452 km² of surface area. Lebanon's topography is characterized by the high mountains of the Mount Lebanon and the Anti-Lebanon ranges, separated by the Beqaa Valley. Along its territory, Lebanon witnesses an extreme variability in altitude, exposition and topography, defining a diversity of climatic conditions from Mediterranean climate along the coast and the mid altitude of the mountain ranges, from sub alpine and mountain Mediterranean climate on the highest slopes to arid/sub-desert in the northern plains. This geographic and climatic diversity is reflected trough a set of ecological systems largely varying from one region to another, generating, over a small scaled country, a unique biodiversity and hence, a true biological hotspot.

So far, in Lebanon, the land suitability tools are limited, and research for an effective and active suitability map for forest species is in process. Previous works analyze the range of species distribution according to altitude, vegetation levels or bedrock type for some key species and examine the relationship between the distribution of the Lebanese forest types and the conditions of climatic indicators and soil characteristics. These studies did not consider the introduction of pioneer species, which have a pivotal role in increasing the forest cover in the country to mitigate the negative effects of climate change.

The present study aims to perform a holistic evaluation of forest land potentialities of Lebanon under present and future climatic conditions, including the introduction of pioneer species in degraded land. This study will provide an important reference to limit the loss of forest in Lebanon and to guide a development of a suitable and productive forestry system, under climate changes.

For this purpose, a GIS-model was developed to combine forest species requirements, in terms of soil and climate conditions, into land suitability classes. Existing geographic database of climate and soil information were used to produce the land suitability maps for a selection of native and autochthonous forest species in Lebanon. Highly suitable or Optimal (S1), moderately suitable (S2), marginally suitable (S3) and not suitable classes (N) were created, according to altitude and soil type and present and projected values of temperature and precipitation.

The preliminary results of land suitability analysis show a general critical situation in terms of forests species distribution under future climate change scenarios compared to the current situation. In fact, the distribution of thermophile species, which growth best in high temperature is projected to expand in higher locations respect to the current situation and the non-suitable classes are expected to disappear. On the contrary, the expansion of cold adapted species may be limited by

future climate change conditions. The results of land suitability analysis show not only the level of suitability for forestry land use but also the limitations for forest distribution, providing useful information to optimize the reforestation of the study area.

ORAL

Climate disasters, income inequality and poverty: A panel analysis

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In the era of accelerated climate change when climate disasters are expected to occur more often and with greater intensity, the consequences of climate change on economic and social outcomes need to be anticipated to inform public policy. One of these important outcomes is income inequality. Evidence on the effect of disasters on inequality is still inconclusive. Some argue that the effect of climate change, including the effect of disasters, increases inequality in the US (Hsiang et al, 2017), while others confirm this effect through the displacement of middle-income families leaving rich and poor people in the location of the disaster, which increases income inequality (Smith et al, 2006). The indirect effect or the effect of reconstruction, that takes place months or years after disasters occur mostly benefits the influential groups in society (i.e., those with political connexions or lobbying capacity) which also increases inequality (Mutter, 2015). Alternatively, when the consequences of disasters are broad and affect everyone in society, inequality is expected to decrease.

This paper looks at the effect of climate disasters on income inequality considering the case of Ecuador, a middle-income country characterized by high levels of inequality and frequent natural disasters. Moreover, Ecuador is a highly fragmented country in geographic terms according to a geographic fragmentation index of 0.8 compared to 0.3 of OECD countries, which indicates that the probability of randomly choosing two people in a country and living in different ecological zones is 80% (Lora et al, 2003). This level of geographic fragmentation implies that climate conditions, and therefore the propensity to suffer disasters related to climate, vary greatly across provinces and municipalities. I combine quarterly data from the employment survey and records of climate disasters in Ecuador for the period 2007 - 2016. The employment survey provides extensive information about the socioeconomic characteristics of the Ecuadorian population, whereas disaster records include not only to the number of disasters in a specific place, but also to the consequences of these disasters measured by human losses and economic costs.

I calculate measures of income inequality (i.e., the Gini coefficient, the Atkinson Index, and the coefficient of variation), and aggregate individual socioeconomic information at the provincial and municipal levels. I construct a panel for 24 provinces and 219 municipalities (8,760 observations), and employ a panel fixed effects methodology. The identification strategy is aimed at controlling for unobservable characteristics of local jurisdictions, such as people's average level of risk aversion that can influence their decisions where to live, or local preparedness to face disasters that can determine the extent of their impacts and recovery. The resulting correlation between preparedness or location

choices and unobserved characteristics may cause an endogeneity problem in the econometric estimation and biases OLS estimates. A panel fixed-effect model is adopted aiming to control for unobserved characteristics at the municipal level.

My results suggest that climate disasters increase income inequality in the short (i.e., less than a year) and medium run (i.e., more than a year), although factors such as institutional quality regarding the functioning of labour markets can partially mitigate this effect. At the same time, municipalities with a higher proportion of indigenous groups are characterized by higher levels of income inequality. Moreover, the relationship between disasters and inequality is stronger in local jurisdictions with higher average income levels and when disasters are of greater magnitude. I also test the effect of climate disasters on the inequality of the population regarding other social outcomes, such as poverty levels, and find similar patterns. This paper contributes to the rapidly growing literature in the economics of climate change and, to the best of my knowledge, it constitutes the first paper that generates evidence of the relationship between climate disasters and income inequality in a developing country and that takes advantage of the local variation in climate conditions and socioeconomic characteristics of the population.

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ORAL

The Climate Report 2018 for South Tyrol: an interdisciplinary approach for communicating local climate change impacts and adaptation strategies

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The Climate Report 2018 for South Tyrol was produced within an internal project of Eurac Research together with the support of other experts from universities, the Research Center of Laimburg and the Province of Bolzano. The main purpose of the report is to communicate the latest scientific evidence on potential consequences of climate change for South Tyrol and analyze options for mitigating greenhouse gas emissions and adapting to the expected impacts of climate change. The goal was achieved by means of a very interdisciplinary approach, since a team of more than 40 researchers of different Eurac institutes spent a year in collecting and analyzing data and exchanging knowledges encompassing a broad spectrum of fields. The final text was edited by the Eurac department of science communication which allowed to effectively disseminate the content to a wide range of public, e.g. decision makers, schools and interested citizens, and to provide to the authorities a scientific document which could be easily consulted to support the local planning.

The 120 pages of the report are structured in four main sections: evidences of climate change and assessment of main greenhouse gas sources for the Province, climate change impacts on natural system, impacts on society, and possible mitigation and adaptation strategies.

The climate change signal was assessed at local scale by exploiting the longest past weather observations and by extracting the downscaled future scenarios relative to different Representative Concentration Pathways (RCP4.5 and RCP8.5) from a bias-corrected ensemble of climate model outputs of Euro-Cordex database. Daily temperature and precipitation series spanning the last 50 years and projected, together with model uncertainty, to 2100 were constructed for the historical weather sites in South Tyrol and used to propose specific climate indicators, such as number of tropical nights or length of growing season, and to evaluate their trends and variability.

Potential climate change impacts were discussed for each of the most meaningful natural components for South Tyrol, i.e. water and snow, biodiversity and natural hazards, such as avalanches and landslides, by exploiting current data, other existing studies and by analyzing the past and future projections of the specific climate indicators, e.g. the mean annual cycle of Adige river catchment runoff to assess possible variations in water availability.

By following the same approach, the climate change impacts on society are discussed by individually focusing on the most vulnerable sectors: water management and hydropower production, agriculture and forestry, infrastructures, mountain and urban settlements, tourism and health. The report provides for each sector the currently evident impacts retrieved from observations and indicators, the possible future scenarios and suggests specific mitigation and adaptation measures.

In the closing section, the overview of adopted actions and plans at local, regional and national scales in the framework of climate change allows to highlight the increasing need of more comprehensive and intersectoral strategies in the near future and to suggest possible approaches. In addition, examples of good practices to reduce individual impacts on greenhouse gas emissions are addressed to the large public, e.g. enterprises, schools, researchers and citizens, in order to promote individual awareness and the exchange between scientific community and society.

ORAL

Electricity demand and climate adaptation in Brazil: Estimation and cross validation of sectoral demand shocks

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MOTIVATION. The study aims to disentangle the relation between weather variations and electricity consumption in Brazil by adopting a panel study of 27 Brazilian federal regions using sectoral data and monthly observation for a 12 years period.

Providing a detailed analysis of the elasticities of energy demand to weather shocks is an important element for the analysis of the impacts of more frequent high temperature extremes and a long-run increase in global temperatures. Furthermore, the empirical framework allows to take multiple empirical gaps into account. First, available empirical estimations of the weather-energy relation mainly focus on developed countries characterized by temperate climates, while fewer empirical studies exist as for developing or emerging economies in tropical areas (Akpinar-Ferrand and Singh, 2010; Trotter et al., 2016). Secondly, monthly electricity demand series allow to gain insight in the inter-annual variations of the weather-energy response. Furthermore, the sectoral decomposition of the electricity demand allows to consider the specific impacts on the residential as well as on the commercial and industrial sectors, the latter being generally disregarded by the empirical literature (Auffhammer and Mansur, 2014).

The paper seeks to shed light on the possible impact of different key modeling aspects on the empirical results. As underscored by Newell et al. (2018) in the case of the theories relating climate change damages to temperature shocks, when estimable forms of the relationship cannot be unequivocally prescribed, empirical works are faced with discretion over their results and considerable model uncertainty. Such discretion exists also within the studies looking at the impact of climate change on energy demand, as empirical frameworks often differ both on the choice of the weather variable measuring thermal stress and on the functional form of the relation between weather and energy demand (Bigano et al. 2006; De Cian et al. 2013; Deschenes and Greenstone, 2014; De Cian and Sue Wing, 2019). Previous studies assessing the impact of weather on electricity demand in Brazil adopted only Cooling Degree Days variable (Schaeffer et al., 2008; Trotter et al., 2016). To this aim, four weather variables are alternatively adopted and the out-of-sample predictive

accuracy of more than 70 different variants the of the panel econometric model are assessed for each sector by adopting a model cross validation technique.

METHODS. The availability of a dataset of monthly data for 27 federal regions covering a time period of 12 years allows to adopt panel econometric techniques. Different fixed effects regression models are performed and compared. Furthermore, both the impacts of weather variations on the electricity demand level and on electricity demand growth is tested. The combination between the modeling of the dependent variable, the type of fixed effect model, the presence of interaction terms between the weather-related shocks and seasonal and climatic conditions of the federal regions leads to the evaluation of 18 different econometric specification for each weather independent variable.

Four different thermal stress-related weather variables are tested: Cooling Degree Days (number of degrees that surpass the thermal comport threshold, measured day by day), calculated both with a 18°C and a 24°C threshold (Minstry, 2019a;2019b); regional monthly temperature, calculated from the grid-cell monthly average surface air temperature (NOAA, 2019); temperature 'bins', the monthly count of daily temperatures falling in a given set of temperature ranges, calculated based on the daily mean surface air temperatures (NOAA, 2019).

A set of covariates is included in order to improve the models' estimations: a regional monthly GDP index is constructed by weighting the national monthly seasonally adjusted GDP series for Brazil by the share of federal region's yearly GDP over total national yearly GDP (both available from OECD, 2019a; 2019b); the monthly population series are constructed by a linear interpolation of the yearly population series available at the regional level (OECD, 2019b). The dependent variable is obtained from the Resenha Mensal do Mercado de Energia Elétrica (EPE, 2019).

As data coverage spans from January 2004 to December 2016, the series is split between an in-sample and an out-of-sample series, the former going from 2004 to 2014 and the latter from 2015 to 2016.

In total, 72 models for each sector are compared by adopting a forecast cross validation and evaluating model's results through the root-mean-square error (RMSE) between the predicted values and the actual values of electricity demand in the out-of-sample period.

MAIN RESULTS AND CONCLUSIONS. As for the residential and commercial sectors' estimations, the coefficients obtained using the CDDs, the direct temperature (quadratic) and the temperature bins are significant and correctly signed across the different econometric specifications, pointing to the need of a cross validation analysis to assess the best performing model. The industrial sector's demand is not sensitive to weather shocks in most models, coherently with previous empirical evidence. The results may be both due to strong composition effects and because the most relevant Brazilian industrial activities may not require building cooling services (Schaeffer et. al, 2014). Studying industrial energy demand at a more disaggregated level is therefore identified as a relevant research area.

The cross-validation results show that the models adopting direct temperature are generally preferred to the models adopting temperature bins and CDDs. Both in the residential and commercial sectors the models including a quadratic function of temperature have in fact the lowest RMSE. In turn, models with temperature bins perform better than models with CDDs. Furthermore, the RMSE across most of the commercial sectors' estimations is lower than the residential sectors' estimations.

The choice of the threshold value for CDDs influences the results, with the higher threshold (24°C) models being a more accurate measure for assessing the temperature-related electricity shocks than lower threshold ones (18°C). This underscores that the 18°C threshold, often adopted by global studies providing projections of the climate change impacts on energy demand (Isaac and van Vuuren 2009; Park et al., 2018), may be less suitable than higher thresholds for tropical counties.

Overall, the results confirm that adopting a variable that estimates directly the threshold level at which energy consuming behavior would change (direct temperature and temperature bins), rather than assuming it ex-ante (CDDs), may decrease estimation uncertainty.

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ORAL

Impact of warming climate and changes of precipitation intensity on early grape-harvest of premium wine in Italy

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Climate changes are effecting global agriculture, influencing the growth stages of wine grape and of many other crops, worldwide. Temperature is the key factor and its last decades' positive trend drives the harvest earliness of the wine grape affecting quality and quantity of premium wine. The characteristics of precipitation like intensity, duration and frequency of rain, more than the total amount of rainfall, are threatened by global warming, with evidence of increase of heavy rain events and reduction of precipitation frequency. Although the impact of precipitation amount and drought on wine grape phenology have been investigate, the role of precipitation characteristics is unknown. Here we show that the precipitation intensity, which is the precipitation amount divided by the number of the rainy days, plays a key role, after temperature, in the advance of the harvest date of wine grape. Using harvest dates of the last 200 years of two premium wines (white and red), made by a vinery that have been keeping the cultivation techniques unchanged since 1650, we found that the annual harvest dates have been getting early as temperature increases (−5.92 days °C−1) and more intense precipitation events occur (−1.51 days/ (mm/rainy days)). Our results are consistent with the hypothesis that the vulnerability of some premium wine to global warming could be worsened by the increase of precipitation intensity.

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POSTER

An integrated system dynamics model for multi-risk assessment for water scarcity in the Noce river catchment (Province of Trento, Italy)

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Mountain regions are facing multiple impacts due to climate change and anthropogenic activities. One aspect of these impacts with cross-sectorial importance is the modification of available water quantity due to shifts in precipitation and temperature. This change of water availability will influence a variety of economic activities that still rely on large quantities of water (e.g. ski tourism, energy production, agriculture).

The Alps are among those areas where recent events of decreased water availability triggered emerging water disputes and spread of economic impacts across multiple sectors. In order to make our water management systems more resilient, there is a need to unravel the interplays and dependencies that can lead to multiple impacts across interdependent sectors. However, current assessments dealing with climate change usually account for a mono sectoral and single risk perspective.

This study shows an integrative assessment of multi-risk processes across strategic sectors of the Alpine economy. System dynamics modelling (SDM) is applied as a powerful tool to evaluate the multiple impacts stemming from interactions and feedbacks among water-food-energy economic sectors of the Noce river catchment in the Province of Trento (Italy).

The SDM developed for the Noce catchment represents an innovative multi-risk tool, combining outputs from physically based models and probabilistic assessments of water flows. Moreover, this study simulated the water demand from three main sectors relying on the same resource: (i) apple orchards cultivation, (ii) water releases from large dam reservoirs for hydropower production and (iii) domestic and seasonal tourism activities.

Hydrological results have been validated on historical time series (i.e. 2009-2017) and projected in the future considering RCP 4.5 and 8.5 climate change scenarios for 2021-2050 medium term and 2041-2070 long term. By doing so, it has been possible to explore future unsustainable conditions of water supply and demand. Finally, SDM can be used to identify possible adaptation strategies (e.g. water pricing, drip irrigation and regulation) and integrate decision policies scenarios to tackle climate-related water scarcity.

POSTER

Climate migrations: A review of the social and ethic impacts of climate change on human systems

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Climate affects all the ecosystems on Earth and its changes modifies them causing the extinction of some species or the birth and evolution of others. Usually these changes take place over a very long period of time, but today it is no longer the case. Some scientists blame the man, whose activities, has led to produce more and more greenhouse gases, impacting on the climate system that characterized the different areas of the planet.

Other scientists, a small percentage, but important for its political implications, do not believe in the anthropogenic origin of climate change. In fact, they think that it is all in the normal order of things, or rather of nature: they are the negationists, on which governments have reclined in order not to feel the need or urgency to take actions with regard to this case.

After all is said and done, it is not important to know who is to blame and it is not even in the interest of climate: it changes inexorably. Every summer becomes warmer, every winter becomes less cold; nowadays the ices melt more and more and the desertification advances and leads, together with other causes, entire populations to escape from their home or their native territory. History teaches us that this phenomenon happens when your place of origin is no longer hospitable or it is not adapted to life. Other responsibilities come out that we will have to face. One of them is climate migration, a category that is not included among those entitled to asylum in international agreements, without home and no possibility of welcoming, they find themselves trapped in a limbo.

How to react? What to do? How can states that can still survive climate change help them? Can they do it?

Experts refers to a 'moral responsibility' that richer countries have towards the poor ones, which are most affected by the effects of climate change. Here the ethical discussion arises, because climate change does not only affect the present generation, but also and above all the future ones and the 'non-sentient nature'. This calls into question our classical ethical parameters and a new discipline is brought to light: climate justice, a branch of the better-known environmental justice.

Climate change and migration are strongly correlated natural phenomena, which have always existed on Earth for all living beings. Because of their slowness in the reactions, institutions and political systems are not ready to face them due to the complexity of both phenomena in progress.

We know that all animal species have always moved because it is a need, but they are often prevented due to artificial barriers. As for animal species it has been proposed to break down these barriers or modify them and allow their movement: why not do it for humans too? In this case impediments are the cultural ones, because we still do not understand that migration is a phenomenon of adaptation and has always been the case.

Climate migration cannot be stopped or judged, it would be like judging nature itself, of which it is a part. We have to find the values that allows us to live with it, like the duty to respect nature and therefore also to respect ourselves. Climate change will lead us to rethink our entire system and reflect on the relationship we once had with the ecosystem, the environment and ultimately nature. The aim of this work is analyzing deeply the problem and trying to give solutions and make proposals. It is no longer possible to hide behind 'the game of faults', it is time to act together, realizing that the principles guiding our lives on Earth should be modified in order to let life continue on this planet, perhaps in a different way, but still live.

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POSTER

Projecting conflict under a changing climate: An artificial intelligence application

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Although the number of wars has generally declined after the end of the Cold War, intra-national conflict in developing and emerging countries still represents one of the major threats to global security and will continue to lead to massive displacement of people, increased poverty, and higher undernourishment. In the framework of the Sustainable Development Goals, global leaders committed to promoting "peace, justice and strong institutions". However, the challenges of preventing, mitigating, and adapting to violence are daunting, especially when new conflicts erupt in areas of the world where they were not expected. A long research tradition has been trying to explain the main drivers of conflict, while a much more limited effort has addressed the task of conflict predictions. Yet, attempts to forecast conflicts have generally produced grim results. Our work fills this gap introducing a Machine Learning framework that targets these challenges in forecasting conflict onset at the grid-cell level. The framework takes advantage of Artificial Neural Networks to learn from a massive and sparse multidimensional historical dataset and project the outbreak of conflict in the long-term. We used three orders of drivers to train the predictive model: socio-economic characteristics, temporal and spatial contiguity and climatic and environmental conditions.

To the best of our knowledge, the present work is the first attempt to build a framework that applies Machine Learning algorithms to long-term projections with the aim of forecasting conflict onset at the grid-cell level, by including a number of different drivers, not in the least climatic anomalies. The results show that the model can reach the highest possible accuracy in detecting conflict episodes in the historic time-series and suggest that Machine-Learning models far overcome the performance of previously-applied techniques in forecasting violence.

POSTER

Delivering essential lake climate variables: An update from ESA CCI Lakes

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Lakes and enclosed inland seas are integrators of environmental and climatic changes occurring within their contributing basins. The factors that drive lake conditions vary widely across space and time, and lakes, in turn, impact their surrounding environments in important and diverse ways. As a result, lakes are important to our understanding of climate change as sentinels of change, as actors in influencing change, and as integrators of their surrounding basins. They constitute essential components of the hydrological and biogeochemical water cycles due to their basic ability to store, retain, clean, and provide water. The geographical distribution of the world's lakes is very irregular, with most lakes located at high latitudes in the Northern Hemisphere and in currently or formerly glaciated areas. Their global distribution is of special interest for large-scale studies of environment, biodiversity, health (spread of water-borne diseases), agricultural suitability, climate change modeling, and for assessments of present and future water resources. Their temperature and thermal structure is strongly influenced by incoming radiation. They have significant chemical variation in terms of nutrients, major ions, and contaminants. Biomass, population numbers, and growth rates are also impacted by climate changes. They vary in terms of water quantity. Lakes also have a broader influence on many facets of terrestrial ecology, biodiversity, economy, and human welfare. It is recognized that lakes also play also a substantial role in greenhouse gases flux exchanges with the atmosphere.

Nonetheless, in situ lake observations are scarce in many areas of the globe, especially geographically remote, lake-rich regions such as the Canadian and Siberian Arctic. Existing and forthcoming remote sensing technologies have exhibited intriguing potential to address this deficiency in several areas. Current altimeters provide dense time series of water surface elevation measurements for large lakes, and multispectral optical and thermal sensors can be used to measure lake area, water quality, temperature, and ice cover (e.g., Woolway and Merchant, 2019; Wang et al., 2018; Duguay and Lafleur P. M., 2003; O'Reilly, C. M., et al. 2015, Pekel et al., 2016).

In the future, wide-swath altimeters like the upcoming SWOT (Surface Water and Ocean Topography) mission can provide more robust measurements of height on much smaller lakes. Hyperspectral satellite imagers such as the recently launched PRISMA (Precursore Iperspettrale della Missione Applicativa) mission will have the potential to provide more nuanced views of sediment, carbon, phytoplankton and other constituents of lake water. High resolution thermal imagery will allow to better quantify and extensively map lake water temperature. Much work remains, however, to realize a robust, global dataset of lake water quantity and quality that can be used to understand how lakes are changing in response to climate and other human impacts, and how lakes influence the climate.

The GCOS (Global Climate Observing System), in response to an invitation from the UNFCCC (United Nations Framework Convention on Climate Change), have identified 'required actions to reduce gaps in knowledge to improve monitoring and prediction, to support mitigation, and to help meet increasingly urgent needs for information on impacts, adaptation and vulnerability' (implementation plan document of the GCOS).

To reach this goal, GCOS has defined a set of variables representative of the different components of the Earth system and its climate. These comprise the Essential Climate Variables (ECVs), long-term observations of the atmosphere, the continental surface and sub surface, and the ocean. On each of these compartments GCOS has identified the data essential for climate analysis, prediction and change detection. Lakes are considered by GCOS as one of the main components of the water cycle linked to the climate system and have considered that lakes long term and perennial observations are crucial in this context. Several variables have been defined with strict requirements.

To respond to this UNFCCC and GCOS need for climate data, the European Space Agency (ESA) has undertaken the Climate Change Initiative (CCI) programme. The objective of the ESA CCI is to realize the full potential of the long-term global Earth Observation archives. The ESA Climate Change Initiative comprises 23 parallel projects, of which, the most recent focuses on lakes.

The ESA CCI Lakes project, started in February 2019, is three-years long and will provide the first consistent dataset of essential climate variables for a global selection of lakes, in response to the updated GCOS definition of the Lakes ECV. The CCI Lakes is a multi-disciplinary project combining expertise in the remote observation of lake water extent, lake level, ice cover, surface water temperature and surface water reflectance. The project is challenging as data records acquired from 23 different satellite sensors with different resolutions has to be processed. This implies that a crucial point is to reach consistency between the individual parameters, which are observable at varying spatial resolutions and temporal intervals, and available from sensor records which do not always overlap in time. More than 1000 lakes will be considered for the data production, while specific studies in per-defined use cases will be developed by the project team. The use cases will focus on multiple topics such as the analysis of brownification in Scandinavian lakes, or the analysis and interpretation of ECVs in Greenland larges lakes. The CCI Lakes products will be of course open-public and accessible so that it firmly presents an opportunity for lake scientists and climate modellers worldwide to perform studies on these five key lake variables. In this workshop we will present the project overview along with progress and an outlook on the work that lies ahead. In particular, the contribution will discuss preliminary results in retrieving phytoplankton phenology and trends in subalpine lakes.

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POSTER

Impact of agricultural drought resilience on the welfare of smallholder livestock farming households

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The recurring agricultural drought is a major challenge to livestock smallholder farmers in Sub-Saharan Africa. The aim of this study is to determine the impact of agricultural drought resilience on the welfare of smallholder livestock farming households in Northern Cape Province of South Africa using a survey by interviewing 207 smallholder livestock farmers and a stochastic production function model. By focusing on the 2015-2016 drought event, this study will contribute to the existing literature by constructing Agricultural Drought Resilience Index (ADRI) as independent variable for the outcome variable welfare (measured by income from livestock production) and determine the impact of drought resilience on the welfare of smallholder livestock farming households to agricultural drought in the Northern Cape province of South Africa. The results showed that feed cost, other farming operational expenses, and labour have a significant impact on the farming household's welfare. This implies that smallholder's farmers who spend much money in buying feed, in medication, in water for their livestock are more likely to improve their welfare as compared to those who spend less on feed, medication, and water. Furthermore, farmers' household members who spent long hours on their farm tend to enhance their welfare. On the other hand, land and agricultural drought Index found that insignificant, this could be because of most of the farmer's farm on communal farms, which are owned by the municipality or Department of Rural Development and Land Reform; and during dry periods most farmers do not have any strategic plan in place except selling their livestock to be able to buy feed. The farmers also indicating that the assistance received from the government and different stakeholder is not in time and the assistance reach them when farmers already lost their livestock due to agricultural drought and utilized their coping and adapting capacity by selling their livestock. The study recommends the government and different stakeholders develop a policy intervention through delivering their assistance on time and helping them to get title

deed for land in order to enhance their resilience to agricultural drought by accessing credit using their title dead as collateral and charge them a low premium when a drought strike.

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POSTER

Natural hazard risk reduction in the Alpine region: An assessment of alternative protection measures under different environmental scenarios

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Natural hazards have always affected human settlements, causing damage and fatalities and forcing people to adapt and to protect themselves. In recent years, the number of affected people and the economic impacts connected to natural hazards has significantly increased, mainly due to bigger investments in hazard prone areas. Moreover, climate-related natural hazards are expected to rise in the future triggered by climate change.

The Alps constitute a representative example of this phenomenon. The occurrence of natural hazards in populated areas, characterised by widespread tourism activities and highly valuable infrastructure, generates a high demand for risk management. Risk can be tackled by reducing the risk-exposed areas through limitation on settlements or by adopting grey or green protection measures, one of this being ecosystem-based solutions. Ecosystems such as forests can act as natural modifiers of hazard processes. In mountain environments, forested areas have been managed for a long time due to their protection effect against gravitational natural hazards such as avalanches, landslides and rock falls. Well managed forests are able to reduce both frequency and magnitude of certain hazardous processes and also their potential consequences on humans and their belongings. It is often argued that, although green measures are not immediately effective, they can adapt to different natural hazard conditions over time. Moreover, they are often less costly to install and to maintain compared to technical measures.

Nevertheless, the efficiency of forests in natural hazard regulation could be affected by climate change. Variations in precipitation and increasing temperatures can have a direct impact on forests, modifying their current composition and spatial distribution. The failure or decrease of the protective role of forests could eventually lead to indirect impacts to human settlements. Therefore, climate change may have a two-fold impact connected to gravitational natural hazards: it can affect not only

the processes themselves, but it can also influence the extent to which assets and people are exposed to natural hazards by impacting protection forest characteristics.

In this context, the Interreg Alpine Space project "GreenRisk4Alps" aims at implementing an ecosystem-based risk management strategy for natural hazards in the Alpine region, assessing the risk posed by gravitational natural hazards under different environmental scenarios. Thus, the costs, the protective effects and the acceptance of technical and forestry-based protection measures are analysed and compared, also considering the effects of climate change to protection forests.

This poster contribution will highlight the risk assessment methodological framework adopted in the "GreenRisk4Alps" project. Firstly, a multi-level exposure assessment evaluates the difference in exposure of assets under different forest scenarios. The spatially explicit analysis is complemented by a stakeholder workshop through which local knowledge on natural hazard risks and their management is acquired. This serves to locate risk hotspots where an economic evaluation of different risk reduction measures is carried out. Moreover, climate scenarios are calculated and used to evaluate how the forest and its protection function will be modified in the future due to climate change, complementing the risk assessment workflow. All this aims at providing recommendations for a forestry-based risk management strategy which considers current and future, social and environmental conditions.

POSTER

Reducing the scatterometer-model sea surface wind bias in the Mediterranean Sea for storm-surge forecast application: The operational system of the Tide Forecasting Center in Venice

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With one third of the EU population living within 50 km of the coast, and one hundred thousand people annually exposed to coastal flooding in Europe [Vousdoukas et al., 2018], the combined effects of sea level rise and potential increment in the frequency and intensity of storm surges require innovative and effective monitoring and protection stategies. In recent years, substantial research effort has been dedicated to improve initial and boundary conditions of storm surge models in order to obtain more accurate sea level forecasts [De Biasio et al., 2016; De Biasio et al., 2017; Bajo et al., 2017].

The accuracy of numerical storm surge model simulations depends critically on the quality of the atmospheric forcing, i.e. the surface boundary conditions used to drive the simulation. The forcing – usually supplied to operational storm surge models by atmospheric model forecasts – is dictated by the physical variables producing the surge and determining its evolution. The wind at the sea surface

has a key role, as the surge elevation depends on the wind stress, which is proportional to the squared wind speed.

Zecchetto et al. [2015] have demonstrated that It is possible to improve the description of the model wind field at the sea surface using satellite scatterometer data, reducing the bias between global model forecasts and observations. The method, called wind bias mitigation (WBM), supplies a "mitigated model wind" wm' obtained by multiplication of the "standard model wind" field wm by a factor (1+Δws): wm' = (1+Δws) wm. After a period of transition, dedicated to fine-tuning the procedure algorithm [De Biasio and Zecchetto, 2017], an operational system has been set up at the Tide Forecasting and Early Warning Center of the Venice Municipality, which is in charge of providing the sea level forecast for Venice and the surrounding lagoon.

The system relies on the availability of sea surface wind observations over the Mediterranean Sea coming from four satellite scatterometer: MetOp-A/B/C of EUMETSAT and ScatSat-1 of ISRO. The first three scatterometers rely on the C-band ASCAT instrument with fixed antenna geometry, while the fourth carries the Ku-band Pencil Beam scatterometer (rotating dish antenna). The four datasets are provided by the Eumetsat Satellite Application Facility on Ocean and Sea Ice (OSI-SAF) Wind subsystem, under the responsibility of the Royal Netherlands Meteorological Institute (KNMI).

The data collected in one year of operation allow us to delineate a statistics of the scatterometer-model wind bias. They also permit to outline the spatial and temporal features of the sea surface wind over the Mediterranean Sea as seen by the four scatterometers, both alone and with respect to the European Centre for Medium-Range Weather Forecasts (ECMWF) high resolution deterministic model simulations.

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POSTER

Representing Water-Land-Energy-Food-Climate Nexus in Sardinia with System Dynamics Modelling

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Water use in the Mediterranean has been often pushed beyond sustainability (Souissi et al., 2013). Heavy depletion of water sources, under agricultural water demand and droughts, is leading to water degradation and deterioration of ecosystem services (Huang et al., 2013; Mosley, 2015). Furthermore, exploitation of deteriorated water resources comes with high energy costs (e.g. groundwater abstraction, pumping for distribution, desalination, water purification, etc.). Thus, water use is strongly linked to energy use, with obvious implications on GHG emissions and environment, but also to important values associated to Mediterranean agricultural systems, such as food security and employment. It is then evident that different factors are interlinked with water management within a dynamically complex system (i.e. the Nexus, WEF, 2016) characterized by many feedbacks, trade-offs and high complexity of socioeconomic and environmental agents inducing non-linear responses that are hard to predict (Helbing, 2010; Landis et al., 2013). Within this system, each sector cannot be considered in isolation as it impacts other system sectors (Feng et al. 2016). Systemic approaches for integrated management and governance of water resources and interconnected sectors (i.e. the Water-Energy-Food-Climate-Land use-Nexus) are increasingly considered, but several challenges remain for an effective operationalization of such frameworks into practice (Sperotto et al., 2017). Understanding such complex nexus systems requires innovative methodologies able to integrate different domains (e.g. hydrology, economics, planning, environmental and social sciences) and potential responses/feedbacks, to infer how actions on one component may trigger unwanted responses on other components. To support effective and targeted adaptation measures, planning should make use of results based on solid scientific research that takes into consideration measures of the uncertainty of climate change forecasts and the impacts associated with it.

In this respect, the ongoing EC Horizon 2020 project SIM4NEXUS (www.sim4nexus.eu) is developing system dynamics models (SDMs; cf. Ford, 2010) for 12 case studies ranging in scale from sub-national to global. For each case study, a detailed mapping of the nexus system, and of the relevant policy objectives, goals and measures was completed in order to inform quantitative SDM nexus model development. Both of these steps were carried out in consultation with local expert stakeholder groups. In particular we are here representing water-land-energy-food-climate nexus links with system dynamics modelling for Sardinia. Sardinia, as many other Mediterranean regions, must implement a sustainable approach to water management, focused on water conservation and more efficient use to reduce conflicts between sectors. This approach must take into account an

equitable distribution of water resources between different sectors, economic needs and social priorities, but also the need to preserve the ecology of freshwater ecosystems. In many river basins, water resources are already widely exploited and their reliability is threatened by the decline induced by climate change in recharging inland waters and by the increase in irrigation demand.

For the Sardinia case study, the main focus was the representation of the reservoir water balance for the island, accounting predominantly for water supply and for water demand related to agricultural, energy-related, and domestic/tourist consumption. On the water supply side, the model accounts for inflows to the reservoirs based on precipitation partitioning to runoff over the catchment area upstream of reservoirs. The final model disaggregates the water supplies and multiple demands in seven hydrological districts. For water demand, the model considers: 1) open-water evaporation from reservoir surfaces; 2) discharges for hydroelectric generation; 3) spillways in times of overflow; 4) irrigation requirements; 5) industrial demand; 6) domestic and tourist water requirements and; 7) environmental flows (i.e. the minimum amount of water needed to preserve ecological functions and values in watercourses). With irrigated agriculture being the largest water consumer, this sector was modelled in more detail. The crop water requirements per unit-area, and the area planted, were taken into consideration for 13 major crops on Sardinia as a function of current and changing climatic conditions. Touristic fluxes, and relative water demands, are modelled based on a Touristic Climate Index and socio-economic scenarios.

While water is the central focus, this model is not only concerned with Sardinian hydrology and is not a hydrological model, but considers other nexus sectors including energy, climate, food and land use. Energy generation and consumption were also important along with the mode of generation and sector of consumption, as was modelling the change in crop types (i.e. land use and food production changes) and the crop water requirements associated with potential crop and cropped area changes, and in response to change in the local climate. Energy production is modelled from sources including oil, coal and methane, solar, wind and hydropower, while energy demand comes from the agricultural, domestic, industrial and service sectors (including transportation). The production of energy, especially related to non renewable energy sources, have a direct implication on land uses both because energy farms imply land appropriation and also because the use of hydropower “limit” water availability that can indirectly sustain hydrological and physiological processes of ecosystem and reduce land degradation. The use of energy from the different sectors and using different energy sources, either renewable and not renewable, have different implication ad loading to emission of GreenHouse Gasses with specific impacts on climate change.

While driven by strong interests to secure food provisions, an increase in irrigation in the Mediterranean may not be totally sustainable. Irrigation requirements in Sardinia are projected to increase between 4 and 18% for 2050 compared to present conditions. Over the same period the inflow in the reservoirs can decrease between 5 and 20% and the evaporation losses from the water surface bodies in the reservoirs increase by about 10%. Policy rules are tested and highlight how optimal allocation should be tested and enforced in order to safeguard sustainability of natural resources over time, especially when considering climate variability which will enforce critical conditions. Optimal quality of natural resources are necessarily preserved if allocation of uses are displaced in order to avoid strong peaks following seasonal (i.e. summer) conflicts from multiple sectors. To meet these criticalities, new infrastructures and investments should increase for more

efficient systems. All this would require changes in institutional and market conditions with a more cautious water management that includes prices and recycling policies to ensure adequate future water supply and prevent tensions between different sectors.

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POSTER

The Sim4nexus approach to policy-relevant Nexus research: From system concept to serious game

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There is growing interest in the water-energy-food-land-climate nexus where interactions in one sector can lead to impacts in other sectors. These sectors exist in a 'hyperconnected' system (WEF, 2016), bound together in a complex way in which each sector cannot be considered in isolation. The use of serious games could help erode these silos, fostering efforts towards holistic policy making accounting for systemic impacts of policy decisions. One major criticism of some serious games is their lack of policy relevance. Better understanding of the nexus and characterization of its internal feedbacks is required in order to be able to make informed, meaningful policy decisions. However many studies either 1) consider only some nexus sectors, neglecting impacts on the others (Feng et al. 2016) or 2) consider more sectors, but only for very local, specific case studies that lack wider applicability (Valek et al. 2017). Efforts are required to consider many nexus sectors together at a

range of scales to develop a more general understanding of nexus behaviour, and the potential impact of climate, socio-economic and policy changes. Such knowledge aims to improve the current perception of serious games as lacking policy relevance.

This work refers to an ongoing (2016–2020) Horizon2020 project 'Sustainable Integrated Management FOR the NEXUS of water-land-food-energy-climate for a resource-efficient Europe (SIM4NEXUS; www.sim4nexus.eu)'. SIM4NEXUS aims at developing policy-relevant serious games for 12 case studies. The serious games in SIM4NEXUS will be operable at scales from regional to national, to continental, to global. While previous efforts have considered nexus elements either in complete isolation or only in 'partial integration' (i.e., considering only a few nexus elements at one time), SIM4NEXUS addresses all nexus elements together and to account for the possible impact on these elements in response to climate and policy changes. This is being achieved by close case study stakeholder involvement at every step in the process, from qualitative system design and conceptualisation, policy analysis, quantitative model development and serious game testing and playing. SIM4NEXUS addresses both research and knowledge gaps regarding the global nexus at multiple scales and communicating critical results to policy-makers via a state-of-the-art serious game built on robust science. SIM4NEXUS integrates thematic models within a system dynamics modelling framework to integrate the knowledge and data from thematic models and local experts. SIM4NEXUS adds the learning from playing the serious game, itself built on the SD models, and testing nexus-compliant policies. System-wide trade-offs and synergies can be sought, with benefits for multi-sectoral policy development and planning. There are five main steps in the model and serious game development process: Step 1. Case study nexus system description, framing and conceptualis ation; Step 2. Thematic data identification and collection; Step 3. System dynamics integration modelling and conversion to Python; Step 4. Communication of model output to the Knowledge Elicitation Engine; Step 5. Design and development of the serious game front-end. Steps 1 and 2 are concerned with framing the key nexus issue(s) to be explored in each case study, in which the main case study nexus issue(s) is identified. For example, in Sardinia, the central issue is the long-term resilience of reservoir water supply to changes in climate and agricultural factors, while in the Netherlands, it is centered on biomass generation and a switch to a low-carbon economy. From the central theme, interactions with other nexus sectors are identified, including feedback processes. The central theme identified can be cross-checked with the policy analysis to begin to identify policy scenarios to be modelled so as to have relevance for local players. Even at this early stage, stakeholder involvement is critical, and input is taken from case study-level policy analysis. The end product of this process is a conceptual (qualitative) diagram that defines the central nexus issue and that elaborates the key interactions with other nexus sectors. Key policies to potentially be played in the final game are identified, subject to change. Data requirements for quantitative modelling are identified at this stage, and data are gathered. In Step 3, a System Dynamics Model (SDM) is developed for each SIM4NEXUS case study using STELLA (SDM; Ford, 2010) software that allows for the exploration of complex systems. SDM is ideal for modelling complex systems governed by feedback, delay and cross-disciplinary problems. STELLA can integrate data from many disciplines. SDM is ideally suited to studying the trajectory of system parameters under change and for dealing with uncertainty. SDM is proven in modelling complex systems in a diverse range of disciplines and for communicating with non-expert stakeholders. In Step 4, the Knowledge Elicitation Engine (KEE)

focuses on integrating knowledge and strategies at different spatial and temporal scales. The KEE enables the analysis of interactions within existing regulatory frameworks and barriers to implementation (Steps 1 and 2). The KEE provides the SG with the system-wide impact of each action implemented under a case study or specific scenario, considering the interactions modelled in the SDM (Step 3). Moreover, the KEE permits a top-down learning approach based on serious game front-end user decisions and a bottom-up approach based on classical machine learning methodologies applied to data. All learning and relevant knowledge are stored in a semantic repository, which is supported by a cross-domain ontology, simplifying information exchange between nexus components and fosters better understanding of nexus interactions from a holistic point of view. The last step of the process (Step 5) is the development of the serious game which aims at bridging the gap between science and policy stakeholders by translating complex modelling results into an interactive virtual world. The main content in the serious game is provided both through the interfaces and the logics that the game contains, as well as through the KEE (Step 4). The identification and formalization of the content to be imparted is important for the game logics requirements definition, as the logics behind the game must guide the user through these contents in order to impart the knowledge to be conveyed. This identification is required for the construction of the KEE, as well as the way both the game and the KEE architecture will communicate the knowledge and information. Therefore, Steps 4 and 5 are critically linked. As a player, you represent decision makers in the various sectors in a particular nexus sector. Your aim is to achieve the nexus targets (objectives) set out by the national or international bodies by changing or adapting new policies and to implement practices to comply with local policy objectives. To succeed in the game, you should learn how to achieve these targets by mixing and matching various cross-sectoral policies without compromising the existing 'goal attainment' of the other sectors.

The models developed in SIM4NEXUS, and as a result the serious games, are the most comprehensive examples yet developed, and will advance nexus science. In addition, because of the close link with local stakeholder groups, and the novel addition of specific policy objectives within the models and games, it is anticipated that the SIM4NEXUS output will have real-world impact on how cross sectoral policy decisions are made. At the same time, the games can be used in educational settings to inform students about real world nexus issues and challenges.

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POSTER

The impact of climate change in a rural agricultural system: A case study from Alto Huallaga Valley (Perú)

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Climate change is affecting the whole Earth, modifying the balance of ecosystems. Among the human activities, which are more vulnerable to climate change consequences, agriculture is the most affected one. During 1940-1970 period, the "green revolution", as described by Evenson (2003) , radically transformed the global agricultural system by improving agricultural technologies in different aspects, such as pesticides and chemicals, irrigation, genetic selections and their monocultural production. Nowadays, it is not easy to recognize the impact of the implementation of these technologies onto the environment. Agriculture does not only exploit the same main resources of natural ecosystems (e.g. water, nitrogen and phosphorus) and, in addition, it releases pesticides and occupies large areas of uncontaminated places increasing CO_2 and greenhouse gases (GHG) production. Therefore, agricultural activities are both drivers and subject to climate change.

In 2006, the Socioeconomic Data and Applications Center (SEDAC) of NASA reported that emerging countries are more prone to climate change than the industrialised ones [SEDAC, 2006] . Moreover, according to Cline (2007) , the predicted impact of climate change on agricultural yields shows the same difference among countries. Many studies have developed forecasting model at global scale to predict how the climate change will impact countries starting from the Atmosphere-Ocean General Circulation Models (AOGCMs) and the Earth System Models of Intermediate Complexity (EMICs) [Randall, 2007] . These models are extremely useful in those countries where few consistent data are available. For this reason, to better approximate the global data to the local scale, a re-scaling procedure is needed. More precisely, this procedure aims at assessing local scale, although the scarce and not always reliable database makes the calibration not robust. Furthermore, the phenomena related to local morphology are completely neglected.

The general purpose of the project research is to develop a local scale model which simulates the occurrence of weather extreme events in tropical areas. The present study is carried out in the emerging context of the Alto Huallaga basin, located in the Amazon region of Perú (South America). The characterization of the area is fundamental for the assessment of weather events strictly related to the morphology. According to the Holdridge diagram [Holdridge, 1947] , it is possible to classify the basin as a premontane zone characterised by a tropical wet climate. Here, the agro-system strictly depends on weather and climate conditions because of the low local technification. Indeed, the tropical context makes the Huallaga basin a flourishing ecosystem due to several local factors, such as its regime of tropical rainfall (3000 mm per year), the scarce seasonal variation, the high moisture of the air and the general high minimum temperature. Nevertheless, in recent years the agricultural system has extremely changed due to a different management of crop-fields passing from a familiar

scale, where crops were cultivated for self-nourishment, to global agricultural industry. In this frame, small producers, who have not access to agricultural technologies, are the most vulnerable persons to climate change and extreme weather events.

The local quantification of climate change and trends of climate variables are still not well documented due to the limited number of the weather stations within the area and the scarce maintenance of them. The main study conducted in the area concerns the Huallaga basin and the near Ucayali basin [Lavado, 2012] . This study stated that rainfall did not show a consistent variation from 1965 to 2007, while the mean, maximum and minimum values of temperature increased 0.09 °C/decade, 0.07 °C/decade and 0.11°C/decade, respectively.

The current research is conducted in the framework of a fair-trade project whose aim is to enhance the adaptation strategies to climate change of local little farmers of Moquicho, also known as baby banana (Musa Acuminata). They are particularly prone to extreme weather events due to the low, or absent, implementation of agro-techniques, as explained before. It was decided to spread a social survey among local inhabitants to understand which weather events cause more damages to banana production. From the preliminary results, it was found that the most endangering weather events are related to the increasing of wind gusts, in terms of frequency and magnitude, and the lengthening of dry season, because the monthly cumulated rainfall occurs in just few days. The weakly and short root structure of banana (25 cm), cannot contrast the quickly convective gusts, provoking plants lodging. In order to solve the local lack of data and to design the local model for simulating the occurrence of convective winds, two weather stations were installed in the area of Huallaga basin (Shiringal 9°08’02.7”S 76°03’27.0”W and Pendencia 9°08’40.2”S 75°57’41.7”W).

To estimate the climate change trends, the available data from two stations were analysed, i.e. Tingo Maria, in the southern part (9°18'36.6"S 76°00'01.6"W, 1941-2007) and Tocache in the northern part of the basin (8°11’23.81”S 76°32’58.27”W, 1964-2011), respectively. First of all, both of them have been tested with the Standard Normal Homogeneity Test (SNHT), developed by Alexandersson (1986) , to detect the potential breaking points and to homogenize the data according to the “referred period”, which is intended to be the most reliable one. Then, the data series have been tested by the Mann-Kendall test [Kendall, 1948] in order to assess the occurrence of trends. Preliminary results of Tingo Maria station, for instance, show that minimum and mean values of temperature do not have a significant trend, while the maximum temperature, the relative humidity and precipitation show an increase. These outcomes partly are not consistent with the results of Lavado (2007)3, where rainfall doesn’t show a consistent trend and the values of mean, minimum and maximum temperatures increase. A possible reason of this difference can be reconducted to the quantity of data, these results were obtained by averaging 13 stations concerning the rainfall and 11 concerning temperatures, indeed.

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Urban areas: Assessing, predicting and managing the current and future risk

ORAL

Adaptation to climate change in urban areas: The use of specific climatology by professionals and local stakeholders involved in urban planning and management

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What about climate change in Italian urban cities in recent decades? What's possible to do about climate mitigation and adaptation in daily urban design, management and planning activities?

Some answers are expected to come from the Italian project ClimaMi 'Climatology for professional activities and adaptation to urban climate change in the Milano area', co-funded by Fondazione Cariplo in 2019. The project aims to involve professionals, such as engineers and architects, who work in public and private organisations concerned with energy, construction and plant design, building renovations, meteoric runoff management, urban planning and regulation. It will provide them with knowledge basis and suitable local data about urban climate to address the problem of climate change in the specific territorial context.

Within the end of 2019, a Climatic Database and its Guidelines will be released in open source as an integrated urban climate information tool (SIC-U). The database is referred to twenty automatic urban meteorological stations (AWSs) belong to Climate Network of Fondazione OMD, that have been monitoring weather since 2011/2012 in Milano (8 stations) and surrounding minor urban centres. Climate Network accounts for 50 AWSs specialised to measures meteorological variables at the top of Urban Canopy Layer in the main Italian cities.

ClimaMi database, beside most of the usual climatological statistics, implements the climate parameters and indicators that can be used directly by professionals in design calculations or as decision support. Most of these parameters are contemplated by sector legislation or technical standards; other climatic parameters introduced are quite new in professional sectors, such as Humidex and Heat Index suitable to quantify both cooling energy demand and outdoor microclimate comfort. Frequency and intensity of extreme events are accounted for: hot heatwaves, Humidex and Heat Index threshold exceeds, heavy precipitations and strong winds. The database includes data uncertainties and AWSs metadata too.

The associated Guideline is intended to give consciousness of local urban climate, its characteristics and phenomena that are going to be exacerbated by climate change, such as Urban Heat Island (UHI). Urban climate change is in fact the sum of global warming and local anthropogenic contributions. The professionals have to pay great attention on interactions between buildings, infrastructure, energy consumption and microclimate of public space: the influences are in both directions. The use of correct climate temporal and spatial scales is fundamental to properly evaluate result performances of projects, urban planning and management in relation to local microclimate comfort and adaptation to urban climate change impacts.

ClimaMi project includes capacity building courses for professionals, designed to give them the suited climatological bases to understand characteristics and implications of different climate data and statistics, to evaluate associated uncertainties and to choose the data more suitable to their purposes.

ClimaMi project also includes an experimental action: the application of SIC-U to update the Territorial Government Plan (PGT) of Melzo, a little town near Milano where a Climate Network AWS is located. The purpose is to use SIC-U to characterise local climate and to quantify outdoor microclimate comfort, UHI intensity, extreme events frequency and intensity (heatwaves), warming and cooling degree days. All these information will be used as a decision support for regeneration of city districts planning and as a monitoring system of PGT implementation: every year the dashboard of climate indicators will be updated.

ClimaMi has an experimental value in its overall perspective. Firstly a multidisciplinary technical committee was created to bring together climatologists, engineers, architects and urbanists to work on the various issues of urban climate change. A preliminary training on applied climatology and the creation of a common language were necessary inside the technical committee itself. They are the groundwork of the Guidelines and of the Glossary included.

The technical committee had stringent and constant dialogue with the project stakeholders, belonging to public administration, energy and water utilities, Universities, industry. They expressed specific applications, practical needs and a common perception: a significant variation of climatic patterns in the last decade, that make inadequate their usual and consolidated approaches.

Comparison among different CLINOs in Milano Centro AWS, the only weather station in Milano downtown for which pluridecadal data series is available, confirmed stakeholders' perception. Considering yearly mean temperature series since 1900 onwards, performing Thiel-Sen statistic with Mann-Kendall test and asking for three change points, the statistical analysis identifies 1980, 1999 and 2010 as change points with an average annual temperature increase of about 2°C. The last change point makes sense to use the period 2012-2018 in ClimaMi database, i.e. data from Climate Network for application purposes.

Another goal of ClimaMi is the determination of the more useful updating period of a climatological statistic in relation to practical applications: a fixed interval or a variable period function of temperature increase rate?

Another issue could be the choice of the reference period to calculate extreme events occurrences, such as heatwaves as defined by WMO-WHO Guidelines (2015): because of climate instability, the choice of different though close CLINOs as reference (e.g. 1981-2010 instead of 1961-1990) implies different occurrence counting of heatwaves referring to the same period.

Professionals and decision makers have to be able to properly choose climatic statistics in relationships with their usage.

ClimaMi database makes awareness of spatial distribution of climatic parameters in Milano metropolitan area and particularly inside Milano city. Such a distribution will be presented and discussed referring to the following climatic indicators: warming and cooling degree days (Energy sector), Humidex and Heat Index thresholds exceeds (both as counting of moist heatwaves and outdoor microclimate comfort metric - Health, urban planning), dry heatwaves occurrences, frequency/intensity/duration of precipitation events (urban management).

Structure of ClimaMi database and guidelines will be also presented.

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ORAL

Adapting to climate change in Hungarian cities: Reviewing lessons of the Mediterranean area to avoid negative lock-ins

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Hungary is facing huge challenges regarding climate change through rising temperature and changing precipitation patterns. Anticipated weather forecasts for the Carpathian basin pointed out that climatic conditions will be almost the same as in the Mediterranean region nowadays. Current and future weather extremes threaten all of the national assets, therefore effective adaptation goals and actions are unquestionably needed. The increasing number of regional and local climate strategies

and action plans have been developed for the last years, while more and more Hungarian cities decide to elaborate their own mitigation and/or adaptation targets in order to tackle climate-related challenges. Present study has two main aims. Firstly, collecting best practices and options regarding climate change adaptation on urban level from the Mediterranean region. For this purpose, a detailed and comprehensive literature review is conducted by using main scientific databases. It is widely acknowledged that different scale of cities require different adaptation actions, consequently effective and progressive adaptation options are grouped by the size of cities. Secondly, a qualitative assessment of selected climate actions and practices is making in order to reveal and avoid negative lock-ins in elaborating development strategies. The impacts of climate change on Mediterranean region are well examined, as future climate predictions of Carpathian basin are also properly investigated, whereas feasibility analysis of the application of benefit transfer method in climate-related strategy-making has less attention by now. For bridging the gap between methodological bias and the need for applying best practices thousands of kilometres from their origin, an evaluation framework is designed to define negative lock-ins. Based on different features of Hungarian cities, some good practices running well in Italy, Spain or Greece could be completely impracticable due to their long-term negative consequences. The developed and applied methodology shall be used by strategy-making actors to make Hungarian cities more climate adaptive and to avoid adverse effects of actions that deemed previously appropriate.

ORAL

Assessment of direct and indirect impacts of urban flood in Monza

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Context. Due to the climate change and urbanization processes in progress, which are causing the growth of rain event intensities and water discharges, urban flooding occurs today with increasingly rapid dynamics. Therefore, urban flooding events are also called flash floods. Considering on the one hand the high social and economic value exposed in urban area, due to people and goods presence, and on the other, the difficulties in implementing preventive and mitigation measurements, it is extremely important to assess properly the risk associated with these events. Risk Assessment (RA) is a fundamental step in the Disaster Risk Management (DRM) cycle, particular when taking a holistic approach to linking Disaster Risk Reduction (DRR) with national development strategies and moving from mere emergency assistance into a DRR framework. The research community concerned with DRR, particularly physical and environmental science, has agreed to a common approach to the calculation of risk (R) (Balbi et al., 2010), as a function of hazard (H), vulnerability - mainly physical - (V) and exposure (E): R = f (H, V, E). Hazard represents the likelihood that an event will occur; vulnerability links the intensity of a hazard to potential losses, while exposure indicates the value, often in monetary terms, of the exposed assets (Arrighi et al., 2013; Bazzurro and Luco, 2005).

In a changing society which increasingly relies on interconnections, the links between elements are crucial, especially considering the urbanization and technological trends that modern-day society is strongly promoting. Urban population growth means that people are depending more and more on critical facilities, and there is an increasing interdependency between infrastructures. Complex socio-technological networks, which increase the impact of local events on broader crises, characterize the modern technology of present-day urban society (Pescaroli and Alexander, 2018). Lhomme et al., (2013) showed that the 'city has to be considered as an entity composed by different elements and not merely as a set of concrete buildings'.

In this respect, the traditional risk assessment approach has the drawback of considering all exposed elements independent from each other. This assumption does not hold in urban areas because of the thick network of interconnections that requires a more comprehensive approach than the traditional reductionist one, as it needs to involve 'whole systems' and 'whole life' thinking (Albano et al., 2014). The reductionist approach, in which the ìrisks are an additive product of their constituent parts' (Clark-Ginsberg et al., 2018) accounts only the direct and physical damage.

Aim. The aim of this research is to promote a paradigm shift in collective risk assessments: from a reductionist approach, where the total risk is the combination of the risk of elements individually, to a holistic approach that considers the whole systems as unique entities of parts connected between themselves. To support this paradigm shift, this work shows the urban flood impact assessment in the city of Monza based on both traditional approach and on a Graph Theory approach.

Case study: city of Monza

Monza is a city 15 kilometres north-northeast of Milan, it is the capital of the Province of Monza and Brianza and it is about 40 km from Lecco and Como. Monza is the most important economic, industrial and administrative centre of the Brianza area, supporting a textile industry and a publishing trade. The territory of the Municipality of Monza is crossed by the River Lambro and it has some specificities such that even flood hazard with low probability can generate high value of damage, and therefore of risk. There is an important anthropic present, with more than120.000 inhabitants on 33km^2 of surface (an average density of more than 3,700 inhabitants/km^2), many economic activities and important historical-artistic-environmental building exposed.

Methodology

The case study chosen has a high level of flood hazard. In fact, besides problems related to the insufficiency of the urban drainage system, Monza suffers from periodic inundations due to the flooding of the rivers Lambro and Lambretto, which cross the urban center. As a prerequisite to risk assessment, the hazard maps for different return periods were obtained in this work, following construction of the Urban Flash Flood Model of Monza, which is made up of the following components: intensity- duration- frequency (IDF) curves, hydrographs of rivers Lambro and Lambre tto, rainfall/runoff transformation in the urban centre, 2D flow routing of inundations.

Beyond the hazard model, it has been necessary to collect all the data necessary to set up the exposure database with the necessary physical characteristics of the buildings useful for the vulnerability assessment. In fact, for the traditional risk assessment it has been considered the physical and direct economic flood damages by adopting the INSYDE model (Dottori et al., 2016), a synthetic flood damage model based on a component-by-component analysis of physical damage to buildings.

In parallel to the INSYDE model, this research developed a graph-based model (GRAM) based on Graph Theory, the mathematics branch for the treatment of networks, for the case study of Monza. GRAM comprises four main steps: (1) network conceptualization, (2) graph construction, (3) analysis of graph properties and (4) impact propagation in the network (Arosio et al., 2018a, 2018b). In the first, the typologies of the elements to be included in the risk analysis are identified (e.g. population, fire stations, schools etc.), as well as the connections and interdependencies among them. In the second, the graph is built according to the conceptualized network and the information on the actual nodes collected in the case study. In the third, the graph properties are computed and analysed, which provide useful information to characterize the exposed system. In the fourth, the hazard information is utilized to initial perturbate the graph and according to the losses of connections, the impact is propagated into the graph.

Preliminary results

The results of the proposed analysis are presented in two steps: in the first the traditional risk due to the physical direct damage and second the system characteristic and indirect impacts. For the first case the analysis will show the total amount of risk associated to physical direct damage due to flood related to insufficient of the drainage system and the Lambro river, in both case for three different return periods (T10, T100 and T200). In this case, it will be possible to compute the annual average loss for the two independent types of flood in the study area. In the second case, it will be possible to highlight the characteristic of the systems (e.g. presence of critical elements) and shows how the indirect impacts are propagate according to the different return periods.

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ORAL

Chemoresistive gas-sensor technology for detecting and mapping greenhouse and pollutant gases: Is it a viable solution?

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With the dizzying increase in the world's population, a sustainable economy is the only way to avoid compromising the global health and earth resources. In fact, the reports of national and transnational agencies in recent years have underlined a drastic and constant deterioration in the health of our ecosystem, due to an immoderate use of natural resources [1]. Among the various problems that have emerged, those of global warming and climate change are among the most alarming, as they would directly affect both the ecosystem in which we live and the survival for the mankind [2]. One of the causes of these changes is due to gaseous emissions resulting from human activity, which in recent centuries, due to industrial development and urbanization, have increased to exponential levels. Among the effects of these polluting gases are photochemical smog, acid rain, death of forests, reduced atmospheric visibility and the greenhouse effect. In particular, the greenhouse effect is one of the main causes of global warming and climate change [3]. Nowadays, the gases that are still particularly under strict control are CO_2, N_2O, CH_4, O_3 and fluorocarbons, as they cause the greenhouse effect, and CO, SO_2 and NO_2, as they are particularly toxic directly for humans and the environment. Global agreements from various countries were signed to the aim of limiting the emission of these polluting gases [4], by introducing legislation to has proved to be increasingly stringent, and on an annual basis national and supranational organization, such as the UN and the European Union, issue updated reports on the situation.

In recent years, research has focused not only on the use of renewable energy sources for sustainable development, but also on increasingly simple and reliable methods for detecting and mapping the concentration of toxic and polluting gases [5]. To achieve this goal, it is essential to develop sensors capable of easily acquiring and providing data in real time. In the EU, certified environmental gas monitoring systems are based on optical methods of light-matter interaction [6]. The most commonly used instruments are IR or chemiluminescent spectroscopes, depending on the type of gas analysed. These analyzers are particularly reliable, having both a high selectivity with respect to the type of gas analyzed and low detection limits. Nevertheless, these detectors showed drawbacks that limit their sustainable widespread use, including the high cost (over 50 thousand euros) and the large size and weight that render them particularly cumbersome. They are also

instruments that require ongoing calibrations and to operate under controlled temperature and humidity conditions.

For this reason, in recent decades, researchers have paid considerable attention on the development of gas sensors that could overcome these limitations, satisfying the sustainable development and the market demand. These researches have led to the development of increasingly compact and low-cost gas sensors, which exploited different physical-chemical principles compared to light-matter interaction. The most investigated are solid state gas sensors, which are divided into four broad categories: pellistors, quartz microbalance, electrochemical gas sensors and chemoresistive gas sensors [7]. Each type of solid-state gas sensor has its advantages and disadvantages, but it is undeniable that, at the state of the art, the literature has focused more on chemoresistive gas sensors because of their great versatility [8]. These devices are based on the use of a nanostructured semiconductor (usually metal oxide) thermo-activated. This semiconductor acts both as a receptor, interacting chemically with gases in the atmosphere, and as a transducer, since the chemical interaction with gas molecules leads to a change in one the semiconductor physical properties, i.e. the electrical resistance [9]. These sensors are particularly low cost, small, stable, highly sensitive, showed the advantage of higher throughput and amenability for large-scale integration. These characteristics turn this sensor type into the ideal candidate for developing sensing systems that deployed in a widespread way, with the possibility of mapping in real time the presence of toxic and polluting gases on a dedicated area. However, over the years, they have also shown disadvantages, including low selectivity and signal drift over time. The possibility of synthesizing various types of nanostructured semiconductors with different sensitivity to atmospheric gases has allowed to partially overcome the problem of low selectivity. By combining new sensing materials to realize sensor arrays with specific algorithms to manage the read-out signal it is now approaching the time to achieve an electronic nose like solution with high selectivity.

In this work we present the results obtained in the project CHEARIA, a collaborative project between Bruno Kessler Foundation of Trento and several high schools of the Trentino-Alto Adige Region (I.T.E. 'Tambosi', Trento; I.T.T. 'G. Marconi', Rovereto; I.T.T. 'M. Buonarroti-Pozzo', Trento; Ist. di Istruzione 'M. Curie', Pergine; Ist. di Istruzione 'M. Martini', Mezzolombardo; Istituto Rainerum, Bolzano; Liceo Artistico 'A. Vittoria', Trento; Liceo Classico 'G. Prati', Trento; Liceo Scientifico 'G. Galilei', Trento), as part of the national training program 'work-based learning'. The target of this project was to get young generation acquainted on the air quality theme by taking them involved in a program of gas sensors development and their use to the purpose. The program was focused on chemoresistive gas sensors and it went through two separate actions. The former was targeted to verify the reliability of low-cost commercial gas sensors, the latter to evaluate state of the art solutions developed at FBK. The obtained results were compared with those obtained with the certified systems made available by the environmental protection agency (APPA) of the Autonomous Province of Trento (PAT). The investigation has shown that commercial systems dedicated to a generic air quality control are quite far to be reliable to asses outdoor air quality. These systems, in fact, equipped with a single chemoresistive gas sensor, have a very low selectivity and the calibration to be performed for their use does not take into account several parameters that are critical for the implementation of a sufficiently reliable system. On the other hand, the solutions based on new sensing material prepared at FBK and tested in the lab shows quite promising improvements and

their on-field test are ongoing in order to provide the right basis to develop dedicated algorithms and to provide a step further towards a low cost high reliable solutions for a capillary air quality control.

From the student's viewpoint, beside the direct experience with a research environment, they have the opportunity to have an insight in three critical aspects of pollution detection: the sampling methodology, the dependence of the results from the ambient conditions and the meaning as well as handling of the acquired data. A correct management of these aspects is required to draw any conclusions.

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Climate policies and mitigation strategies for ambitious climate targets

ORAL

Life Cycle Assessment of a Carbon Negative Emission Process Based on Ocean Liming and CO_2 Storage

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The interest for Negative Emissions Technologies (NET) is growing, since around 100-1.000 Gt of CO_2 should be removed from the atmosphere over the 21st century for limiting the global temperature increase to 1.5°C (IPCC, 2018). To reach this removal level , further research on NETs is needed in order to overcome their main limiting factors (large energy requirement, land availability, etc.; Fuss et al., 2018). Caserini et al. (2019) have proposed a new Carbon Dioxide Removal (CDR) process that combines available technologies (biomass gasification, limestone calcination, water-gas shift, CO_2/H_2 separation) with technologies still under development, such as CO_2 storage and ocean alkalinization by calcium hydroxide spreading (ocean liming).

The process consists in the exploitation of the enthalpy of a hot syngas, produced by the gasification of biomass or coal, for the calcination of limestone; the CO_2 is separated and safely stored, whereas the other by-product of the process, a gas rich in hydrogen, is used to produce electricity for self-consumption or for supplying the electricity grid; the latter is assumed to replace

the production of the same quantity of electricity from fossil sources, avoiding the impacts related to its production.

In the configuration with biomass gasification, the removal of CO_2 from the atmosphere also occurs thanks to the uptake of CO_2 during its growth, while in the case of coal the removal is related only to the ocean liming, which allows an increase in the uptake of atmospheric CO_2 by the oceans and its storage in the form of bicarbonates (Renforth et al., 2013; Keller et al., 2014; Lenton et al., 2018).

This work evaluates, through the Life Cycle Assessment (LCA) methodology, the effectiveness of this process in removing CO_2 from the atmosphere, considering all the potential environmental impacts evaluated with a cradle-to-grave approach. The LCA is applied to four configurations of the system, which combine two types of fuels (biomass or coal) and two types of CO_2 storage, Geological Storage (GS) and Confined Submarine Carbon Storage (CSCS, i.e. in glass capsules on the seabed, as described in Caserini et al., 2017).

The implemented LCA methodology is based on ISO standards (ISO, 2006; ISO, 2018); the Functional Unit (FU) of the system is 1 kg of Ca(OH)2 produced by limestone calcination and discharged into the ocean.

The data used to feed the Life Cycle Inventory (LCI) are mainly derive from the preliminary design of the process and the scientific literature, as well as the ecoinvent database (version 3.4). The system is modelled with the SimaPro (version 8.5) software. Fourteen impact categories representing different impacts on the environment and human are evaluated, with a particular focus on Climate change, Ozone depletion, Marine eutrophication, Land use, Mineral, fossil and renewable resources depletion. The Cumulative Energy Demand (CED) indicator, that evaluates the direct and energy consumptions, is also included in the LCA. The impacts are calculated with ILCD method (version 1.10) for all categories except for CED indicator that is calculated with CED method (version 1.10).

The results show that for all the analysed configurations, the process has a negative potential impact on the Climate change category, i.e. there is a benefit for the environment in terms of CO_2 removal from the atmosphere. When using the geological storage, the process avoids respectively 3.0 $kgCO_2eq/FU$ in the biomass configuration and 1.7 $kgCO_2eq/FU$ in the coal configuration (3.7 $kgCO_2eq/kg$ biomass and 2.6 $kgCO_2eq/kg$ coal respectively). With CSCS, the benefit is slightly reduced (by only 0.02 $kgCO_2eq/FU$). It is worth noting that these CO_2 benefits are higher than those assessed by the carbon balance in Caserini et al. (2019), 3.0 $kgCO_2eq/kg$ biomass, because a different source (i.e. a different CO_2 emission factor) was assumed for the electricity avoided production.

Thanks to the electricity avoided production, the biomass configuration with geological storage has a total negative impact, that is a benefit for the environment, in 12 impact categories (11 in the case of storage in capsules) while there are 7 categories with negative impact in both configurations with coal. Since the avoided impacts are related to the electricity source, the type of avoided electricity source has a relevant role and is subjected to a sensitivity analysis.

The biomass configurations have a higher impact than those based on coal in the Land-use category, due to the biomass supply, that is the most impacting process for this category. This result demonstrates the trade-off between Climate change and Land use in biomass cases, i.e. the climate change benefit is in contrast with the land requirement for biomass production. Indeed, studies in the literature have identified land availability as limiting factor of Bio-energy carbon capture and

storage (BECCS) that will compete with food production in the future (Creutzig, 2014; Fuss et al., 2018).

A sensitivity analysis is then performed, considering the impact on the results of the variations of 5 parameters: the discharge rate of Ca(OH)2, the transport distance for the biomass to the plant, the transport distance for the calcium carbonate to the plant, the transport distance for Ca(OH)2 from the plant to the port, and the type of avoided electricity. Three operating conditions (best, most likely, and worst for CO_2 removal) are considered.

In all the operating conditions, all configurations have a benefit on climate change, i.e. a total negative impact. This conclusion is robust against the variation of the parameters considered in the assessment. Thanks to the removal of CO_2 through the ocean liming, the configurations based on coal allow removing CO_2 from the atmosphere even without considering the avoided impacts of electricity production.

Further research (e.g. on different feedstocks, on hydrogen utilization for ammonia production) is needed to better understand the potential impacts for other configurations of this process, as well as a climate modelling simulation to verify the effectiveness of ocean liming in increasing the uptake of atmospheric carbon dioxide by the oceans and in reducing their acidification.

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ORAL

Alkalinisation strategies in the Mediterranean Sea for an efficient removal of atmospheric CO_2 and the mitigation of ocean acidification

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Recent scientific findings and policy recommendations have underlined the importance to limit global warming to 1.5 degrees above pre-industrial levels (Paris agreement, IPPC SR 1.5 degrees). Beyond

the effort to dramatically cut the carbon emissions at an unprecedented pace, this goal requires the development and implementation of active Carbon Dioxide Removal (CDR) strategies.

While a number of options exist, relatively few studies have assessed the mitigation capacity of Negative Emission Technologies (NET) on a larger scale in order to support efficient implementation strategies of carbon dioxide removal. Among the CDR strategies, ocean alkalinization has the additional potential of contrasting ocean acidification resulting from increased uptake of atmospheric CO_2 by the ocean.

In this work we present an analysis of different strategies of ocean alkalinization across the Mediterranean Sea taking into consideration the regional heterogeneity of the basin. While the Mediterranean system shows clear trends of warming and acidification across virtually the entire basin, the strength of these trends is subject to a high regional variability depending on physical (stratification, overturning) and biogeochemical features (productivity, alkalinity). A set of numerical simulations was carried out to quantitatively address the alkalinization effort through a coupled physical-biogeochemical model (NEMO-BFM) for the Mediterranean sea at 1/16 degree horizontal resolution (~6 Km) under RCP4.5 emissions scenario over the next decades. In particular, the analyses compare the effectiveness of different alkalinisation strategies on both spatial and temporal scales in order to estimate the mitigation potential in terms of CDR and contrasting ocean acidification as well as to address the required time-scale of action.

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ORAL

Climate Change Action in a Large University: Methodologies and Results of the CO_2 Mitigation Plan of Politecnico di Milano

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Interventions involving all political and administrative levels and strong participation of a high number of parties are required to meet the ambitious targets of the Paris Agreement, aiming at keeping the global temperature rise well below 2°C (above pre-industrial levels) and to pursue efforts to limit the temperature increase even further to 1.5°C. Accordingly, subnational institutions (Regions, Municipalities) and stakeholders like companies, investors and civil society organizations have signed other commitments, in addition to the Agreement at the national level. The Non-State Actor Zone for Climate Action (NAZCA) portal, launched by the UNFCCC, displays more than 12,000 commitments undertaken by non-state actors, among which 13 commitments belong to Universities in USA, Canada and Australia (UNFCCC, 2019).

Many Universities all around the globe have been working for years on issues related to the reduction of CO_2 emissions (Leal Filho and Leal-Arcas, 2018). The survey carried out in 2017 by the Climate Change Working Group of the Italian University Network for Sustainable Development shows that two out of the 52 Italian Universities involved in the survey have developed an Emission Mitigation Plan, while six more are in the drafting process. Moreover, other Universities are implementing actions to lower their emissions and setting reduction targets.

As a contribution to the global effort for the mitigation of climate change, the Politecnico di Milano has developed a CO_2 Emissions Mitigation Plan to outline the methodological framework for defining and undertaking formal commitments aimed at the reduction of the University emissions.

The activities taken into account in the Mitigation Plan and in the reduction targets are the same accounted for in the Politecnico CO_2 Emissions Inventory (Caserini and Baglione, 2016): electricity consumption, gas consumption (excluding the one related to the production of electricity externally purchased), electricity consumption from external district heating and cooling networks, transports related to business travels, daily commuting to the University campuses of the whole community (students, professors, technical and administrative personnel, PhD students, research fellows, …), international mobility for students exchange programmes and fuel consumption of the Politecnico vehicles.

The Mitigation Plan assesses, with specific methodologies based on detailed local data and average emission factor at the national scale, the CO_2 emission reduction of different interventions in the energy and mobility fields: 1) installation of a new tri-generator and optimization of the existing

one; 2) replacement of lighting equipment with LED technology; 3) installation of photovoltaic equipment; 4) replacement of the refrigeration equipment to increase efficiency; 5) retrofitting of existing buildings for upgrading energy efficiency; 6) regulation of heating and cooling systems; 7) further promotion of sustainable mobility in order to reduce motorised private transport, both through infrastructural measures (such as the installation of bike shelters and charging station for electric cars) and management policies (such as discounts on subscriptions for public transport and shared mobility services). The emission reduction targets obtainable have been indicated for each intervention, taking into account two different time horizons: 2025 and 2030. Moreover, CO_2 emissions reduction related to national and European policies for the reduction of the average emission factor for electricity network (MATTM, 2018) and cars (CdUE, 2018), taken into account in the University Emission Inventory, have also been considered. Some methodological aspects are also discussed in the Mitigation Plan, since they are required to evaluate the impact of each action or to set the reduction targets.

The estimated impact of the planned intervention results in a 24% overall emissions reductions by 2025, compared to the 2015 value, which will rise to 29% by 2030.

The Mitigation Plan, officially approved by the University on February 2019, therefore proposes the following emission reduction commitments: -25% by 2025 and -35% by 2030, both compared to the reference year 2015.

Finally, the document outlines the main advantages and obstacles linked to each proposed action, together with a preliminary assessment of the economical effort needed.

The design and implementation of the interventions will be based on more accurate evaluations and technical and economical details; the Mitigation Plan is the necessary strategic framework to streamline the strong mitigation effort undertaken.

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ORAL

Potential of Maritime Transport in the Mediterranean Sea for Ocean Liming and CO_2 removal

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The issue of increased carbon dioxide (CO_2) emissions, leading to climate change and ocean-acidification, has been identified as one of the essential problems of human society to be urgently addressed over the next years to decades. Since greenhouse gases (GHG) are still increasing and the most ambitious mitigation policies already approved or under discussion are not able to reduce to zero GHG emissions within the middle of the century, Negative Emission Technologies (NETs) have been invoked as necessary to achieve the aspirational 1.5°C target of the Paris Agreement (EASAC, 2018). Environmental policy is thus increasingly acknowledging the issue and encouraging research on NETs.

Among the NETs, ocean liming has a clear potential of mitigation for both issues, ocean acidification and the increase of atmospheric CO_2, via the formation of bicarbonate, leading to increased uptake of atmospheric carbon dioxide by the oceans and a reduction of their acidification. Many authors (Keller et al., 2014; Renforth and Henderson, 2017; Lenton et al., 2018) indicate a large potential of carbon removal by ocean liming, as well as technological challenges and potential side effects (Renforth et al., 2013).

Artificial ocean liming can be seen as a massive acceleration of the natural processes of chemical weathering of minerals that have played a role in modulating the climate on geological timescales (Archer e Brovkin, 1998; Colbourn et al., 2015). While these processes highlight theoretically viable pathways of mitigation, little is known about feasibility of ocean liming as a large-scale NET.

In the framework of the DESARC-MARESANUS Project, an analysis of the potential of existing ships to discharge slaked lime in the Mediterranean Sea has been evaluated.

IMO data (IMO, 2014) have been used to analyse global vessel traffic, in particular the number and type of vessels, the average tonnage and speed for each category, and the average number of days of navigation. Average CO_2 emission factors and fuel consumption for each vessel category have been also calculated, comparing the results with the IPCC guidelines (IPCC, 2006).

Data on vessel traffic in the Mediterranean Sea have been obtained from the EMODnet (EMODnet, 2017) database. Traffic density data for the 12 months of year 2017 have been processed for the Cargo, Passenger and Tanker categories of vessels. To eliminate the hours related to the stationarity of ships, the maximum number of monthly hours of cells has been limited to 10; hours of navigation at a distance lower than 5 km from the coast hasn't been considered. The total amount of hours of navigation have been assessed as 5.155.684 and 2.297.837 for cargo ships and tankers, respectively.

From the comparison between the naval traffic (in terms of days of navigation) in the Mediterranean Sea (EMODnet data) and at the global level (IMO data), the naval traffic in the

Mediterranean Sea is assessed on average as the 6% of world traffic, although the Mediterranean Sea constitutes only 0.7% of the total surface of the oceans.

A first evaluation of the potential ocean liming in the Mediterranean Sea of CO_2 removal has been realized considering a conservative value of discharge rate of slaked lime of 30 kg/s for cargo ships and tankers, a rate about 33 times lower than that of 1 ton/s assumed by Renforth et al. (2013). On the basis of the hours of navigation, this rate results in a potential annual discharge in the Mediterranean Sea of 805 Mt/year of Ca(OH)2. Assuming a conservative value of 1.4 moles of CO_2 absorbed by the surface of the sea per each mole of $Ca(OH)_2$ added (Keller et al., 201), this is equivalent to the potential removal from the atmosphere of CO_2 equal to 670 Mt/year. As a comparison, this removal is about 10 times the amount of CO_2 absorbed yearly by the Mediterranean Sea, assessed considering a uniform global average of CO_2 removal by the ocean (25%, Le Quéré et al., 2018). The real effectiveness of ocean liming for CO_2 removal and reducing ocean acidification will be evaluated through an Earth System Model.

With this discharge rate, the unloading of a 30,000 tons vessel would take place in about 12 days. Different logistic scenarios for the discharge of slaked lime are considered:

- new dedicated ships, with calcium hydroxide being loaded in some ports in the Mediterranean Sea created on purpose. In this scenario, a discharge rate up to 100 kg/s could be considered; the unloading of a 60,000 tons vessel would take place in about 1 day (550 km with an average speed of 22 km/h).
- modified existing ships, with loading logistics and discharge rate similar to the previous scenario; the average size of existing cargo ships and tankers is 43.500 and 62.600 tons, respectively.
- partial load on existing ships: in this case assuming a discharge rate of 30 kg/s and 15% of the existing ships' average load available for slaked lime transport, the complete unloading takes place in about 6 days for the cargo ships and 3.6 days for tankers.
- use of ballast water: ballast water is sea water carried by vessel in its ballast tanks to ensure its trim, stability and structural integrity. Ballast tanks are built in ships with piping systems and high capacity ballast pumps to carry out the operation. A discharge rate of about 30 kg/s is compatible with the daily discharge of the ballast water load (10:1 dilution) of existing cargo ships and tankers. This option has the advantages of avoiding the ballast water management, since ballast water discharge typically contains a variety of biological materials, including plants, animals, viruses, and bacteria; these materials often include non-native and exotic species that can cause extensive ecological and economic damage to aquatic ecosystems and human health issues.

Although the high density of vessel traffic in the Mediterranean Sea makes it possible to use existing vessel traffic for the technique of ocean liming, further research on the logistic of the spreading and material management are needed to identify the best strategy, as well as modeling of the benefits for the ocean.

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ORAL

Vulnerability and risk assessment at regional scale: The Sardinia case study

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Adaptation to climate change is now a priority for policies development. According to recent studies, it is urgent to develop options and actions for local administrations to strengthen climate resilience, reduce negative impacts due to climate change, and enable more effective management opportunities.

This study, performed in the framework of the Sardinia Region Adaptation Strategy to Climate Change and in collaboration with the LIFE Project Master-ADAPT, focused on the assessment of vulnerability and risk due to climate change in three sectors: the agricultural-forestry sector, the inland water systems and the hydrogeological component.

The analysis was performed based on the innovative approach of developing "Impact Chains", recently proposed at international level (GIZ, 2014, 2017), which need to be specific for the territory, the phenomenon under study, and the relevant sector analyzed.

This approach is based on the selection of indicators to be used as proxy to: 1) describe a phenomenon and/or specific characteristics of the territory, 2) identify and evaluate the main factors and assets most exposed to climate change, 3) assess the susceptibility to damage and 4) have information on the capability of the territory to respond and/or adapt to such changes. Furthermore, this approach is based on the new concept of vulnerability and risk proposed by the last IPCC report (2014), which considers the risk as the result of three components (hazard, exposure and

vulnerability). For each of the three sectors under consideration, individual impact chains have been developed to provide a more detailed understanding of the relevant climate risk per sector (at municipal level and for all the regional territory).

In order to assess the vulnerability and risk to climate change for Sardinia, an accurate analysis of the observed climate conditions and future scenarios have been performed. The E-OBS (Haylock et al., 2008) observation grid dataset (28 km of spatial resolution) was used for reproducing the current climate (for the thirty-year climate reference period 1981-2010), while the optimized configuration over Italy (Bucchignani et al., 2016) of the regional model COSMO-CLM (at about 8 km spatial resolution) was used to define the impact of climate change over the 2021-2050 period, according to the RCP4.5 and RCP8.5 IPCC scenarios, compared to a baseline (1981-2010).

In addition, elements such as population, infrastructure, goods and services, which can be exposed to damage due to climate change, as well as the physical, socio-economic, and cultural elements that can determine a greater or lesser sensitivity to the climate risk and the ability of the region to respond and face negative impacts, have been considered in the analysis.

The analysis of all these elements, in the framework of the impact chain, allowed to better understand climate vulnerability and risk components (i.e. hazard, exposure, sensitivity, adaptation capacity), and to have useful information, at local scale, for the identification of adaptation objectives and options to face climate risk for each analyzed sectors.

This analysis represents the knowledge base required by local administrations in developing adaptation policies to climate change. A correct land management and planning, aimed to both preserve and/or enhance local resources and to reduce the critical issues due to climate change, requires sound knowledge of all the environmental, social and economic elements determining local vulnerability and risk.

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POSTER

Climate risk mitigation: How finance works?

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The attention to the impact of climate change in economic contexts has grown significantly in recent years. Globally, the 193 UN member states have developed the 2030 Agenda, outlining the so-called Sustainable Development Goals (SDGs), as fundamental objectives to be respected to promote sustainable development. Among the most ambitious objectives is the maintenance of the global temperature increase by 2 ° Celsius (European Commission, 2015).

In this context, finance is framed as a fundamental lever to support responsible economic actions aimed at protecting environmental balances and the market is considered the key channel for allocating resources to eco-sustainable projects. In the framework of environmental finance, this contribution focuses on the tool of Green Bonds, framing the regulators' perspective and the principles of self-regulation that describe the process of issuing, evaluating and reporting for the transparency and efficiency of the financial market. Green Bonds are bonds whose issue is linked to the financing of projects that have a positive impact on the environment and they have assumed a key role in ensuring the achievement of the objectives of the 2030 Agenda.

From the companies' point of view, Green Bonds facilitate the assumption of ethical and responsible behavior, towards which managers are increasingly sensitive and who find their first theoretical foundation in the theory of stakeholders. The latter, in contrast to the neoclassical vision, based exclusively on the maximization of profit, believes that the objectives of the company must take into account the interests of all stakeholders, among which is the reference context and, therefore, the environment (Freeman, 1984). With the stakeholder theory, the issue of corporate social responsibility is dealt with for the first time, which is now completely incorporated into corporate strategies.

The relevance of sustainable finance on the international scene is emphasized by the creation of a network (Network for Greening the Financial System) established at the end of 2017 among some of the world's leading central banks and supervisory authorities, with the aim of coordinating the initiatives in theme of environmental and climate risk management in the financial sector. Furthermore, starting in 2015, the Financial Stability Board set up a task force on climate-related financial information (TCFD) (FSB, 2015) in order to create information on climate change and promote informed investments. The Junker Commission has also urged the international community to mobilize large volumes of public and private capital in the direction of sustainable development, calculating that, to reach the SDGs by 2030, 180 billion euros a year would have to be allocated to climate and power.

The theme of the GB was treated by the International Capital Market Association, which intervened by introducing some rules of self-regulation at international level (so-called Green Bond Principles), which do not represent a mandatory normative document (ICMA, 2018). In fact, considering that the risk and yield characteristics of Green Bonds do not differ from those of an ordinary obligation, they do not represent an autonomous and independent category of instruments with their own discipline. Currently, the international frame of reference, which allows the definition of a "green" bond, is made up of the GBP and the sectoral criteria issued by the Climate Bond Initiative (CBI, 2019). Moreover, the European Commission, in March 2018, launched its Action Plan aimed at defining a strategy that includes finance as a tool to support sustainable growth and, in June 2019, it published a report containing the proposal to introduce common criteria for issuing green bonds in Europe: the European Green Bond Standards.

From an analysis of the literature on sustainable finance and Green Bond, it was possible to identify three different strands. The first strand of literature, to which the less recent works belong, has dealt with the role of finance in support of the environment, the development of environmental sensitivity in corporate contexts and CSR. These are almost always theoretical studies, which provided the basis for the subsequent development of more detailed studies on financial instruments. In fact, even if they don't precisely mention Green Bonds, they investigated the presence of the conditions for the spread of Green Bond in the market (Cumming & Johan, 2007) (Jansson & Biel, 2011). A second line, starting in 2010, focused on the analysis of the main features of Green Bonds, as an opportunity to attract capital to support environmental protection initiatives (Reichelt, 2010) (Tang & Zhang, 2019). Finally, most of the financial literature has developed econometric analysis aimed at comparing the yield of green securities with that of ordinary bonds (Zerbib, 2019) (Ehlers, T., & Packer, 2017) (Baker et al, 2018). To date, no author has clearly described the regulatory framework of the Green Bonds, despite the fact that, for the theory of market efficiency, transparency is fundamental for the protection of investors and to guarantee the efficiency of the market (Fama & Eugene, 1998).

In this context, the contribution of this study is framed, which aims to define the Green Bond regulations, the developments that have characterized them and the future developments that are expected. In fact, knowing the regulatory framework makes possible to highlight the system of incentives and protections for issuers and investors in the segment of listing and trading of securities. From our analysis, it emerged that the current voluntary regulatory system is still far from ensuring an adequate level of transparency to investors. However, the poposal report published by the EU Commission, seems to promote greater protection for the underwriters, leaving more room for the development of green investments. The present study concerns a preliminary analysis, necessary for subsequent investigations aimed at evaluating the convenience of Green Bonds compared to other segments of bonds listed on the European market.

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ORAL

Certified wood price premium harvested from Borneo's rainforest with biodiversity conservation and carbon storage

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Climate risk has a close relationship with the coverage of forest on earth. Deforestation would release the stored carbon there, and accelerate global warming. One way to mitigate deforestation is to incentivize the owner of the forest to utilize their forest in a sustainable way by using various roles of the forest. Forest certification is a measure to pay a premium for the timbers harvested from the forests that are managed sustainably. The aim of our research is to examine how much consumers in Japan would evaluate the timber from a sustainable forest in Indonesia and derive how much the consumers would be willing to pay for the role of carbon sequestration as well as other aspects such as biodiversity conservation.

We employed the choice experiment to estimate the willingness to pay (premium) for four types of timber with different certifications. Here, the certifications refer to Forest Stewardship Council (FSC) certification and ecosystem services certification which guarantees zero carbon emissions and/or zero biodiversity loss. To verify the possibility that the respondents' evaluation differs depending on the information provided, four types of information (ver. 1 to ver. 4) on the richness of the ecosystem in a forest in Borneo concerning ecosystem services certification were provided to the respondents and the willingness to pay in each version was compared. Four types of information are: 1) Data on the number of species inhabiting in the forest, 2) pictures and videos of the various species inhabiting in the forest, 3) the video of Sumatran rhinoceros, an endangered species living in the forest, and 4) photos and videos of Clouded leopard, the largest carnivore on Borneo, living in the forest were presented in ver.1, 2, 3 and 4, respectively.

In addition to the choice experiment, the best-worst scaling (BWS) was used to verify the reliability of the results of the choice experiment in terms of convergent validity. In the BWS, we asked

respondents to assume that they were choosing a wooden desk to buy and to consider which of the following five wooden desks they would like to purchase; 1) wooden desk made from the timber that is FSC certified and ecosystem service certified based on both zero carbon emissions and zero loss of biodiversity (FSC + carbon storage and biodiversity), 2) timber that is FSC certified and ecosystem service certified based on zero loss of biodiversity (FSC + biodiversity), 3) timber that is FSC certified and ecosystem service certified based on zero carbon emissions (FSC + carbon storage), 4) timber that is FSC certified but not ecosystem service certified (FSC), and 5) timber without any certification (no certification).

Following the pilot survey conducted in August 2018, the actual survey was conducted in October 2018 and 3774 responses were obtained. Results of the choice experiment show that, regardless of the information provided, the willingness to pay (premium) for the certification is higher in the order of “FSC + carbon storage and biodiversity”, “FSC + biodiversity”, “FSC + carbon storage”, “FSC" and "no certification". On the other hand, the results of BWS show that respondents would like to buy more in the order of 1) wooden desk made from "FSC + carbon storage and biodiversity", 2) wooden desk made from "FSC + biodiversity", 3) wooden desk made from "FSC + carbon storage", 4) wooden desk made from "FSC", and 5) wooden desk made from "no certification". The results obtained in this study are considered to be reliable since similar results were obtained from the choice experiment and BWS.

ORAL

Sustainable development, agriculture and climate change in the EU post-2020 policy pathways

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Sustainable development is enshrined in the European Union treaties, being at the heart of the European policy for a long time. Notwithstanding that, many critics have been raised regarding the lack of a coherent and comprehensive strategy in implementing Sustainable Development Goals (SDGs) at the EU level, in the more than three years that have passed since the adoption of the SDGs. Even if limited, the intervention of the EU has been shaped by the common efforts of reaching the ambitious goals set by the 2030 Agenda for Sustainable Development, adopted by the UN General Assembly on 25 September 2015 with Resolution A/RES/70/1. By 2030, we shall inter alia (a) implement resilient agricultural practices that increase productivity and production - under Goal 2; (b) substantially increase water-use efficiency across all sectors - under Goal 6; (c) integrate climate change measures into national policies, strategies and planning, (d) strengthen institutional capacity on climate change mitigation, adaptation, impact reduction and early warning – under Goal 13; (e) protect, restore and promote sustainable use of terrestrial ecosystems – under Goal 15. Within these goals, the UN Environment Assembly of the United Nations Environment Programme encourages to

pursue synergies and co-benefits among different policy areas (e.g. climate change, agriculture, water, air, energy access) and to take advantage of the resulting synergistic effects.

While sustainable development involves multifaceted perspectives, climate change has been identified as one of the new threats for the achievement of SDGs according to the 2019 High-level Political Forum (HLPF) that concluded in July. Climate change and agriculture are interrelated in many ways on multiple scales: agriculture both contributes to and is affected by climate change. On the one hand, food security and safety are particularly affected by climate change. As recent studies suggest, climate change would influence both the nutrient intakes of food - due to a "great nutrient collapse" caused by increasing carbon dioxide in the atmosphere – and its safety (since diseases spread by insects and pathogens were found to be climate-sensitive). Furthermore, the loss of crop varieties due to the adverse effects of climate change could affect the cultural dimension of food security. On the other hand, agriculture is an important contributor to climate change. As farming activities directly depend on climatic conditions, changing in the rainfall and temperature patterns, and extreme events such as droughts and heatwaves drive farmers to increase their use of pesticides and fertilizers increasing the potential for pollution and adverse impact on human health. The EU policy framework recognises a set of measures to mitigate its impact, i.e. agronomic measures (aiming at reducing the need for nitrogen fertilisers), livestock measures (closed storage of manure, improved application of manure and urea fertiliser, improved livestock feeding strategies so that animals produce less ammonia-rich manure, as well as anaerobic digestion for large farms), or energy measures (such as developing photovoltaic installations or reducing fuel consumption).

Within this context, the Common Agricultural Policy (CAP) instruments for climate change mitigation and adaptation and environmental protection may play a key role. The entry into force of the new Common Agricultural Policy in the European Union (expected in 2021) may provide room for analysing further its impact and potential for contributing to the achievement of Sustainable Development Goals, thanks also to the change in the institutional set-up as a result of the EU election in May 2019. This analysis implies a reconsideration of the role of law and its tools, which should address the need for improving agricultural productivity while ensuring climate resilience and the effectiveness of sustainable development. While agri-environmental-climate measures under the second pillar of the Common Agricultural Policy has been widely explored and considered to"fill a lacuna" in integrating environmental protection within agricultural policy, other instruments (e.g. land management contracts, organic farming support, capital investment measures in physical assets, support action to technological transfer) are less researched in their potential to enhance adaptation to and mitigation of climate change. Within the legal studies, the nexus between climate change, sustainable development and the need to achieve food and nutritional security in all parts of the world is under scrutiny from the specific discipline of "agricultural law", which also includes food and environmental legal issues. Law has a direct influence on how to approach and understand such nexus since policies and legal rules influence and/or determine the decisions and behaviors of the actors involved at multiple levels in climate change.

Against this background, this paper aims at examining the governance framework put in place for SDGs implementation at EU level. In particular, it investigates how EU institutions are dealing with agricultural adaptation to climate change and the extent to which climate variability is addressed under the Common Agricultural Policy (CAP). In this regard, the paper will briefly review the 2014-

2020 CAP that is currently in place. After that, the CAP reform under negotiation will be taken into consideration in order to understand if and how climate change is given priority for the period 2021-2027 and to what extent it can be deemed to be compliant with sustainable development objectives. Indeed, the post-2020 CAP needs to be assessed against several SD goals and targets, such as SDG 2 "Zero Hunger"; SDG 6 "Clean Water and sanitation"; SDG 13 "Climate action"; and SDG 15 "Life on land". Renewed governance arrangements are increasingly considered crucial in order to achieve desirable results from the implementation of a Sustainable Development Goals (SDGs) strategy at EU level.

In conclusion, the paper will evaluate the relationships among the EU sustainable development strategy, the current and future Common Agricultural Policy and the EU transition pathways to climate resilience, thus distilling what can be learned on the state of policy coherence and the extent to which a realignment is necessary.

The paper will use a mix method approach that includes content analysis of primary policy and legal documents, and review of secondary literature about policy interventions on climate change and the agricultural sector in the light of sustainable development. Primary documents include both hard and soft law and may involve international legal instruments (UN protocols, agreements, declarations, and action plans), EU legislation (i.e. regulations, directives, decisions), EU communications, roadmaps, green and white papers. The methodological approach follows three steps: (1) Collection of primary and secondary documents for each policy and legal domains at international, national and local level; (2) Content analysis of primary documents and mapping of the key policy and legal areas; (3) Selection of the policy and legal objectives and assessment of their coherence and interactions.

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ORAL

Effects of climate change on the opportunity cost of health risk and value of time: a household production approach

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The greenhouse effects had been well addressed in literature. This paper specifically focuses on the effect of climate change on human health. While the individual's health could be affected exogenously by such factors as climate change and environmental quality, it could be endogenously produced by individual behavior as well. As such, a deterministic health production function (HPF) is commonly specified in literature. In reality, however, the individual health condition is stochastic due to a wide range of uncertainties, including the effect of climate change, environmental quality, productivity of health care, individual characteristics, etc.

Health condition affects not only the individual's welfare directly, but also the individual's allocation of time among alternative uses (e.g., work, leisure, sickness, outdoor recreation, etc.) indirectly. Accordingly, the time constraint is no longer deterministic in the sense that all uses are random variables. With such a property, the conventional theory of time allocation and value of time require innovative modification.

In light of the linkage between climate risk and health risk, we developed a model that incorporates both a stochastic health production function (HPF) and a stochastic time constraint that allows us to redefine the opportunity cost of health risk and value of time. We modify the deterministic HPF in literature structurally such that the illness-time is stochastic with such arguments as medical treatment expenditure, prevention expenditure, and environmental quality. The results deviate from the literature in terms of the household's budget allocation between medical treatment and prevention expenditures, time values of alternative uses, and the social damage cost (SDC) of pollution. The underlying policy implications are then discussed, with particular focus on the double dividends hypothesis of green tax reform.

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ORAL

SDG compliance and climate finance as implementative driver for adaptation policies

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Currently the framework of the SDGs is composed by 17 goals, 117 target and 241 indicators. Indicators are though to be the backbone, for monitoring the progress towards the SDGs at thelocal, national, regional,and global levels.

A sound indicator framework will turn the SDGs and their targets into a management tool to help countries develop implementation strategies and allocate resources accordingly, as well as a report card to measure progress towards sustainable development and help ensure the accountability of all stakeholders for achieving the SDGs.

The indicators are universal, sustainable and ambitious in order to reach the goals by 2030.

In such a framework SDGs became a strong tecnical matter where measurement andmonitoring of the impact of SDGs has a strong role. Indicators can monitor also actions indeed investments and policies, In the SDG discourse, finance has great importance to reach the compliance: finance leverages project. actions and policies that can traduce SDGs on the ground.

However investments on SDGs are nowaday not still so attractive, as they are long term rewarding and thus not so profitable in a short run. Financial incentives and finance engineer actions are needed in to mainstream SDGs in the economy: one example is blending the investment with public finance.

Usually mutual funds are classified by their investment style, meaning growth or value, but they are also classified by their market capitalization, also known as "market cap," which is the size of a business or corporation equal to the share price times the number of outstanding shares. Mutual funds are generally categorized as large-cap, mid-cap, or small-cap. Next comes the growth, value or blend descriptor.

For example a large blend fund would be one that primarily invests in a blend of growth and value stocks that are large in by capitalization (or simply "large-cap stocks"). A blend fund is a type of equity mutual fund that includes a mix of value and growth stocks. These funds offer investors diversification among value and growth investments in a single portfolio. In this sense climate finance can help to foster SDGs and adaptation measures. Finance strategies need to be coupled to certification procedures.

SDG compliance can be induced if it is convenient in terms of image, brend and reputation, Certified label as ISO should drive this process. This mechanism has been worked as instance for child labour exploitation with big companies. The concet will be: bad reputation given by the unreception

of SDGs reflects on loss of markets. Indeed economic actors are encouraged to follow SDG compliance.Beside finance, also access to information and measurement methodology are crucial for the implementation of the SDG. For, example – Roberto explains – FAO is custodian of some incators. Custodians in the SDGs framework are responsible to monitor and upgrade the indicators: they manage the "science behind the indicators". Every 4 month indeed the United Nations Statistical Commission updates and refine the set of indicators. To Achieve SDGs is necessary to have them compliant at the all scales, and big data and statistic has a strong role. On this vision indicators, became part of a statistical infrastructure (Fig.3) for monitor SDGs progress.

However not always data for indicators are available,and furthermore there is not yet full consensus on indicators measurement methodologies. In conclusion, SDG compliance is for prosperity, and their are a real action on reality. Indicators reduce the complexity of reality in a measurable way, and SDG compliance can be facilitated by tools for the actor, that helps their management and monitoring.

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POSTER

Estimating the Forest Carbon Budget: A Key Challenge in Implementing the Paris Agreement in Russia

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The Earth's climate has changed throughout its geophysical history, but since the 1950s, the planet has experienced changes that are significantly different from those observed previously: atmospheric and ocean temperatures have increased, snow and ice have decreased, and sea levels have risen. Comprehensive studies conducted by the Intergovernmental Panel on Climate Change (IPCC, 2014) have shown that over the period from 1880 to 2012, the average surface temperature of the ocean and land has increased by 0.85±0.2°C and is described by a steady linear trend, which may lead to even more pronounced warming.

In accordance with the most common hypothesis explaining this trend, the changes are caused by a sharp increase in the concentration of anthropogenic greenhouse gas emissions (in particular, carbon dioxide) in the atmosphere, caused by the intensive development of industry in the second half of the XX century (Cook et al., 2016).

Our focus is on the current agenda of the UNFCCC Paris Climate Agreement, adopted in 2015 to develop and implement measures to limit global temperature increases to two degrees below pre-industrial levels. Thus, the member countries of the agreement have recognized the need to reduce existing emissions by 2030 and to eliminate them completely by 2050. In particular, Russia confirmed its intention to reduce emissions throughout the national economy by 2030 by 25-30% compared to 1990.

Forests play an important role in the global carbon cycle, providing the bulk of the carbon flow into plant ecosystems and thus balancing the Earth's climate system. It is the responsibility of the world's forests to store excess carbon from the atmosphere. The most important element of the global carbon budget is the forest ecosystems located on the territory of Russia, which is explained by its vast territory, where 21% of the world's forest covered land area is concentrated.

According to the Paris Agreement (2015), the information base for the development of national climate strategies should be reporting on greenhouse gas emissions, taking into account the land use, land-use change and forestry (LULUCF) sector, which has been regularly provided under the UNFCCC for more than twenty years.

Although Russian forest carbon budget studies have been intensively conducted over the past few decades, the relevant estimates made by different research teams differ too much to suggest that a clear consensus can be reached on the volume of carbon sinks from the land use sector, land use change and forestry (LULUCF) in Russia. There are at least three independent research groups whose results provide fundamentally different estimates of Russia's forest carbon budget. The results of the work of these groups give fundamentally different estimates of the carbon budget of forests in Russia. Zamolodchikov et al. (2011) have developed the Regional Forest Carbon Budget Assessment (ROBUL) methodology, which is now used for Russia's official reporting to the UNFCCC, and gives an estimate

of 230-240 Tg C per year. The staff of the All-Russian Research Institute of Forestry and Mechanization (VNIILM), responsible for Russia's reporting to FAO, estimates the same indicator at 630±110 Tg C per year (Filipchuk et al., 2018). An independent international team based on IIASA (Laxenburg, Austria), having conducted numerous multimodel studies, claims that the carbon flow into the forests of Russia is 546±120 Tg C per year (Pan et al., 2011; Shvidenko, Schepaschenko, 2014).

Thus, each of these approaches is intended to solve its own rather narrow task and, in a sense, does not compete, but complements each other. Nevertheless, the harmonization of these approaches is unlikely to be possible from both a methodological and a political point of view. Rather, efforts should be made to address the key constraint on the development of Russian forest carbon-absorption potential assessment - the poor quality of data contained in the Forest Resource Register. It is the reconstruction of the system of comprehensive forest inventory in the country that could become the most important impulse for solving not only the task under discussion, but also significantly improve the quality of forest management in general.

Work needs to be done on two fronts: (a) creating economic incentives to reduce anthropogenic greenhouse gas emissions, while at the same time (b) increasing the potential absorption capacity of forests.

To solve the first problem, it is necessary to pay attention to the complex development of renewable energy sources, the level of implementation of which is still significantly lower than in the leading countries of the world. The creation and implementation of measures to stimulate the development of this energy sector can lay the foundation for a major technological modernization of the internal energy supply system. The first roles in the implementation of such projects should belong to the companies that are now engaged in the traditional use of natural resources (primarily, oil and gas, coal) and metallurgy, which will not only significantly increase the level of diversification of their businesses, but also to ensure sustainable socio-economic development of their dependent areas.

The second task is being solved through a sharp increase in the area and quality of Russian forests. In this sense, an important, though obviously a side effect of the federal project "Forest Conservation" implemented as part of the national project "Ecology" is a significant increase in the area of reforestation (Pyzhev, 2018). Some of these projects in the format of public-private partnership have already started with the active participation of RUSAL. In addition, artificial (plantation) reforestation provides up to 40 times less absorption of greenhouse gases than natural forests (Lewis et al., 2019).

Thus, in order to achieve the objective of increasing the actual absorption capacity of Russian forests, it is necessary, first of all, to focus on the allocation of as much area as possible under the promotion of natural regeneration of forests with appropriate forest management activities, with appropriate economic and legal protection of these areas from use in other economic needs. As the calculations presented in the above paper show, new natural forests can provide additional absorption of up to 116 t C per 1 ha by 2100.

Considering the economic and environmental aspects of the role of Russian forests in the implementation of national commitments to reduce greenhouse gas emissions, we can conclude that it is necessary to create a comprehensive strategy for Russia's participation in the Paris Initiative. It seems that such a strategy should take into account at least three key areas. Firstly, the development of renewable energy within the country for the purpose of technological modernization of the

Russian economy and flexible integration into the global trends of changing the energy consumption balance. Secondly, it is necessary to significantly increase the area and improve the quality of Russian forests by creating conditions for the natural regeneration of forests and strengthening the work on artificial reforestation, which is already being carried out by companies issuing greenhouse gases and the Federal Forestry Agency within the framework of the federal project "Conservation of Forests".

Third, it is equally important to ensure the improvement of the forest information system, which should eventually provide a much more accurate and scientifically sound knowledge of the actual absorption capacity of Russian forests.

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POSTER

Seasonal variability in the South Asian monsoon dynamics

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Here, we analyze seasonal changes in the dynamics and thermodynamics of the South Asian summer monsoon (SASM) in atmospheric reanalysis data using a threshold-independent index of monsoon onset we have recently introduced (Walker and Bordoni 2016). We seek to evaluate the extent to which emerging theoretical frameworks are consistent with the observed monsoon. Climatological composites reveal that at monsoon onset, an abrupt strengthening and northward migration of the maximum in sub-cloud equivalent potential temperature accompany the rapid northward movement of the monsoon rainbelt. These changes are driven by changes in near-surface specific humidity, rather than changes in near-surface temperature, whose gradient actually decreases at monsoon onset. These findings are inconsistent with the traditional paradigm of the monsoon as a sea breeze circulation and confirm the convectively coupled view of the SASM circulation as an energetically-direct overturning circulation as more fundamental for the understanding of monsoon dynamics.

Providing further support to this emerging view, we show that the SASM sector mean circulation at monsoon onset undergoes a rapid transition from an equinox circulation with a pair of tropical overturning cells, to a solstice circulation dominated by a strong cross-equatorial monsoonal cell and negligible overturning cell in the northern hemisphere. This transition corresponds to a transition in

the leading order momentum budget, from an eddy-dominated equinox regime to a highly nonlinear monsoon regime which approaches conservation of angular momentum. These transitions are similar to those seen in idealized zonally symmetric studies of aquaplanet monsoons,, suggesting that eddy-mean flow feedbacks identified in those studies may be acting in the SASM sector, and may contribute to the abruptness of the SASM onset. Our findings highlight the importance of nonlinear dynamics in the seasonal evolution of the SASM circulation and suggest that some fundamental aspects of the observed monsoon can be understood in the absence of land-sea contrast or other zonal asymmetries.

POSTER

Atmospheric circulation errors in the CMCC-SPSv3 model: climate drift dynamics and impact on seasonal forecasts

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CMCC-SPSv3 is a fully-coupled climate model developed at Centro EuroMediterraneo sui Cambiamenti Climatici (CMCC), currently used in operational mode to produce global seasonal forecasts. The atmospheric component of CMCC-SPSv3 is the Community Atmosphere Model version 5.3 [CAM5.3, Neale et al. 2012] with a horizontal resolution of about 110 km. The coupled ocean model is based on NEMO 3.4 [Madec et al. 2008], with a horizontal resolution of about 25 km. The sea ice component is the Community Ice CodE version 4 [CICE4, Hunke and Lipscomb 2008] which uses the same horizontal grid of the ocean model, and land processes are taken into account using the Community Land Model [CLM4.5, Oleson et al., 2013]. Previous assessments on model performances [Sanna et al., 2017] classified the CMCC-SPSv3 as a state-of-the-art seasonal prediction system. Forecasts are provided each month to a variety of users, included the Copernicus Climate Change Service.

Any general circulation model suffers from climate drift, a problem which is ultimately due to errors in the models themselves. From the point of view of dynamical systems, climate drift consists on the fact that the model and the real climate system have two different attractors, implying that, starting from realistic initial conditions, the model integration produces trajectories asymptotically drifting to a mean state (the model's own climate) that is different from the observed one. Practically speaking this means that, in the end, the model has a tendency to produce biased forecasts, which limits their usefulness. Characterize climate drift dynamics is therefore very important for many applications, ranging from the implementation of bias correction methods to the identifications of the model errors determining the drift, guiding the development of the next generation of models. Thus, the aim of this work is to study the climate drift of the CMCC-SPSv3 model, with a focus on Northern Hemisphere mid-latitude atmospheric dynamics.

This is made possible comparing a set of hindcasts (or re-forecasts, that is a series of forecasts starting and ending in the past) with Era-Interim reanalysis [Dee et al. 2011]. For the CMCC-SPSv3

model a set of 6-months monthly hindcasts spanning the period 1993-2016, ran in a 40-members ensemble mode is available. In this work, we consider prediction for the winter season (DJF) obtained with integrations started on 1st November. Both forecasts and Era Interim daily data are interpolated to a common 2.5 degree resolution grid to allow for a direct comparison.

Ensemble mean geopotential height at 500 mb (z500) and zonal wind at 850 mb (u850) show the larger biases over Eurasia and North Pacific Ocean. An interesting feature of the model error on the meridional wind at 850 mb (v850) is present over the Rockies, indicating a possible misrepresentation of the interaction between the orography and the atmospheric flow in this region; the temperature at 850 mb (t850) shows a warm bias over the Arctic and a cold bias at midlatitudes. Vertical cross-sections of zonal mean temperature and wind corroborate the previous findings, showing a cold bias present in the whole troposphere except that at high latitudes, and too strong zonal winds. The Jet Latitude Index [Woollings et al. 2010] indicates that the model maximum zonal velocity is often located in a too narrow latitude band compared to the distribution found in Era-Interim, in particular over the Atlantic sector.

Comparing DJF mean errors with the average error on the first five days of the hindcasts (1st-5th November) is possible to notice some similarities, suggesting that some systematic errors can arise from “fast physics” processes, and thus that they can be diagnosed looking at the error evolution in the first forecast steps, following the approach originally proposed by [Klinker and Sardeshmukh, 1992].

Finally, we focus our attention on atmospheric blocking. Due to its quasi-stationary nature, this phenomenon is often associated with anomalous meteorological conditions in mid-latitudes. Therefore, a correct representation of blocking dynamics and statistics in numerical models is crucial, from short-range weather forecasts to climate predictions.

Since the ‘90s it is known that models have limited skills in representing blocking [Tibaldi and Molteni, 1990], but even nowadays most GCMs show substantial biases [Davini and D’Andrea 2016].

The ability of CMCC-SPSv3 in reproducing blocking is assessed using two objective indices. In particular, we used both the one-dimensional index proposed by [Tibaldi and Molteni, 1990], based on the gradient reversal of the daily 500mb geopotential field, and its two-dimensional extension proposed by [Davini et al. 2012]. In the first (second) case, every event detected at a given latitude (point) is defined as Istantaneous Blocking (IB); if a given latitude (point) is blocked for 5 consecutive days, a Persistent Blocking (PB) is occurring. The simulation of blocking is particularly poor in the Euro-Atlantic sector, where the simulated frequency of IB at a given latitude can be underestimated by 50%. The two-dimensional analysis shows that the most problematic region extends from southern Greenland to Scandinavia and the British Isles. Actually, the North Atlantic region show a lower intermediate frequency (5-15 days) variability compared to reanalysis.

In order to inspect in greater detail the model deficiencies in simulating Euro-Atlantic blocking, we constructed composites of hemispheric daily fields on the occurrence of PB within the area 40W-40E;40N-75N. The sector is defined as blocked if PB is detected in at least one grid point inside it, non-blocked otherwise. The most apparent difference between model hindcasts and reanalysis, in the blocked state, is the too strong simulated zonal wind over North Atlantic and an eastward displacement of the location of the jet maximum velocity.

Moreover, in order to study the mutual interaction between total systematic error and blocking bias, and the impact of the wrong representation of Euro-Atlantic PB on the quality of seasonal forecasts, we followed the strategy suggested by [Davini and D'Andrea 2016], adapted to our case. Considering a given variable, the total systematic error can be mathematically decomposed into three terms: one indicating the part of the systematic error due to a bias in the frequency of blocking, one representing the error due to the wrong simulation of the blocking spatial pattern, and one due to the systematic error when blocking is not occurring. Results show that, over the North Atlantic ocean, a considerable portion of the zonal wind and geopotential height errors are associated with blocking. On the eastern North American continent, both geopotential and temperature fields show opposite errors in blocked and non-blocked situations. Furthermore, also the geopotential anticyclonic bias over North Pacific is apparently associated with Atlantic blocking.

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POSTER

Seasonal forecast in the winter stratosphere

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Variability in the stratosphere is ascribable to upward propagating waves with a wave source in the troposphere. Waves modulate the intensity of the polar vortex and can lead to sudden stratospheric warmings (SSW), i.e. a reversal of the westerly flow. Progress in understanding and modelling these phenomena has been stimulated also by potential impacts of stratospheric variability on surface weather. In this study we present an assessment of the prediction skill for the winter stratosphere in a multi-model ensemble of 5 state-of-the-art seasonal forecast systems taking part in the Copernicus Climate Change Service. The analysis is based on hindcasts initialised at the beginning of November available through the Copernicus Climate Data Store. We assess model bias in the mean stratospheric flow and its variability, and in reproducing the observed relationship between heat fluxes at the tropopause and the zonal wind in the mid-stratosphere. Potential predictability and the deterministic skill in predicting the circulation in the tropical and extratropical stratosphere are quantified. Models indicate a range of skills that is comparable with state-of-the-art predictions of the tropospheric North Atlantic Oscillation. A framework for probabilistic seasonal predictions of the strength of the polar vortex, and specifically the occurrence of SSWs, is also established. Finally, we look at the role of the initialisation of stratospheric wind in the tropics and the way models reproduce the impact of the Quasi-Biennial-Oscillation on the polar vortex and on the near surface circulation. Results indicate a potential predictability of short-term climate variability of the stratosphere that appears to be uncorrelated with model bias. Further research on the relation between seasonal predictability and extreme events in the extratropical stratosphere is envisaged.

Climate trends: Changes in means and extreme events in observations, simulations and projections

POSTER

Analysis of temperature climate trends in Puglia and Basilicata

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The knowledge of the hydrological variables, particularly the temperature, and of their variations over time assumes strong relevance, especially in extreme values, for the definition of strategies for adapting to climate change, being often the cause of significant negative impacts on the territory, on the environment, on society and economic activities in general.

The study work had the main objective of analyzing any gradual or sudden changes in the maximum and minimum, annual and monthly, temperature, referring to the thermometric stations of the regions of Puglia and Basilicata (and related river basins), in the period of time from 1950 to 2010.

The thermometric data used in the analysis have been incorporated into the Hydrological Annals available online: since these historical series are incomplete, a process of completing the time series has been necessary through a punctual spatial interpolation method, "Inverse Distance Weight (IDW) ", a deterministic method for multivariate interpolation which consists in assigning the value to

unknown points by calculating it with a weighted average of the values available in the known points, giving greater weight to the neighboring points rather than to distant points.

Subsequently, in the Matlab software, a statistical analysis was carried out, using the non-parametric Mann-Kendall test in its sequential form, very suitable for assessing significant in the hydro-meteorological field of the time series, gradual (mostly due to general climate change) or sudden trends (mostly due to human impact interventions).

At the end of the process, in the examined study area (50 most important stations in the territory of Puglia and Basilicata), a slight increase in the annual maximum temperature value emerged, on average equal to +0.61 °C, and a more significant one positive trend of the minimum annual temperature value, on average equal to +1.47 °C.

This tendency, is estimated to start from the 1990s for both variables, with peaks in recent years. However, points representing sudden changes ("change points") attributable to anthropic factors are not particularly evident. Statistical analyzes have confirmed this trend also at the monthly level, especially being more important for the months of May and January.

Finally, from the spatial point of view, the geostatistical method of Kriging was used, through the Q-Gis software, which assumes the presence of a spatial correlation between the measured values and attempts to make predictions taking into account the distance and the correlation by means of the variogram. The analysis showed a slight statistical homogeneity only in the northern and mostly flat part of Puglia, partially excluding the altitude factor from the trend.

Concluding, comparing with the published literature, the study showed a concordant result in establishing a general increase in the temperature value, starting from the 1980s, but of complicated understanding in the causes. A difference between the Puglia and Basilicata trends compared to the national ones concerns the extreme climate that increases the most, since, in the regions analyzed, it concerns the minimum temperature.

POSTER

Are the short and intense precipitations in North of Italy affected by a significant trend?

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In recent years, climate change and the consequences attached to it are gathering increasingly attention in the scientific community. Climate models confirm that increase in temperatures will lead to a surge in climate and weather extremes. In several regions of the globe, change in intensity and frequency of heavy precipitation are expected as well as period of drought and precipitation deficits (IPCC, 2018).

The upward trend of temperatures is acknowledged and well documented, both in Italy (Desiato, et al., 2017) and at the global level (Hansen, Ruedy, Sato, & Lo, 2010), this increase in temperature is strictly connected to the rate of change in saturation vapour pressure as described by the Clausius-Clapeyron equation. According to this relationship for every rise of 1°C in the temperature, 7% more

water vapour is contained in the saturated air that under the right circumstances may turn into rainfall, enhancing an increase in precipitation intensity (Berg, Moseley, & O. Haerter, 2013). The surge in precipitation intensity along with the decreasing trend in the accumulated annual rainfall (Brunetti, Maugeri, Monti, & Nanni, 2006) might imply fewer but more intense rainfall in the future (Trenberth et al, 2003).

The impact of climate change on extreme rainfall is reason for concern for human livelihood since change in the frequency and intensity of these extremes may lead to flood events, landslide or simple malfunctioning of urban drainage system. Particular attention should be paid to rain induced floods. Worldwide during the period 1980-2009 they were responsible for more than half-million of casualties and billions of dollars of damages every year (Doocy, Daniels, Murray, & Kirsch, 2013). Moreover, precipitation at sub-daily scale are intensifying more rapidly than daily rainfall (Westra, et al., 2014), this might involve especially the urban environment where floods induced by this short-duration rainfall (i.e. flash floods) are more hazardous than slower-onset floods. The comprehension of this phenomenon could lead to a better design of infrastructures and more appropriate risk mitigation strategies.

The purpose of this study is to identify any statistically significant trend in extreme rainfall and its spatial and temporal patterns and detect which morphological and climatic variables are the main drivers of the variation in the frequency and intensity of extreme rainfall events. The study was carried out in the northern part of Italy over six regions, namely Piemonte, Lombardia, Veneto, Emilia-Romagna, Trentino and Friuli Venezia Giulia. The region selected is of particular interest given by the diversity of the landscape. In fact, in this patch of land there are two different mountain ranges, that is the Alps and the Apennines. The Po valley with the Po river and all its tributaries and the glacial lakes at the foots of the Alps. After a few quality check, 382 meteorological stations were selected that provided annual maximum rainfall series (AMS) for different durations, 1,3,6,12 and 24 hours over the period spanning from 1930 to 2017. Also, for each observation the corresponding date of occurrence was retrieved enabling the possibility to perform a seasonality analysis on the precipitation extremes.

We decided to perform the analysis on the 1960 – 2017 period, during which the global warming seems to rise markedly. For each duration, the presence and the significance of trends was investigated through a modified version of the non-parametric test Mann-Kendall (Hamed & Rao, 1998) that takes into account the effect of autocorrelation in the time series. The magnitude of the trend is instead quantified with the Theil -Sen estimator, a reliable method insensitive to outliers.

A preliminary assessment of the results returned by the Mann-Kendall test displayed an overall larger presence of stations exhibiting increasing trend rather than decreasing (ratio 4:1), this is especially true in the north-eastern region (i.e. Trentino-Alto Adige, Veneto and Friuli- Venezia Giulia). Moreover, the difference between the number of statistically significant increasing and decreasing trends seems to grow with the duration.

The relationship between trend and elevation of the stations was investigated through means of scatterplots and non linear tools, such as distance correlation coefficient and the maximal information coefficient. Every technique adopted confirmed that there is no correlation between the two variables.

The seasonality was studied through boxplots and by observing the frequency of occurrences in each month for every decade. At first look, there is no clear trend or shift in the period of occurrence of annual maximum during the time span observed. Instead, it is pretty clear how the date of occurrence of shorter events (i.e. 1,3 hours) are concentrated in the summer months (convective events), while for longer events the distribution is wider with the higher frequencies moving towards the autumn months.

Moving forward, we would like to refine the dataset created increasing the number of station at our disposal so as to provide a more homogeneous spatial density all over the study area. Then, throughout a weighted clustering might be of interest the classification of 'climatic zones' that share similar morphological and trend features in order to perform a regional analysis able to exploit the variability of the landscape. Finally, we believe is utterly important in the evaluation of trend in precipitation extremes, to find and study the geomorphological/hydrological covariates (e.g. temperature, relative humidity etc.) that might help us capture the reasons behind the changes in the frequency and intensity of rainfall extremes.

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Assessment of Extreme drought episodes over Po Plain (Italy)

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Drought is a normal and recurrent climate feature, but one of the most important climate hazard that can produce negative effects on natural and socioeconomic systems. Its frequency has increased in the last decades affecting also the Po Plain, a region historically rich in water resources. Past (1965-2017), near future (2020-2049) and far future (2070-2099) weakly drought events for the Po Plain region, based on 60 weather stations and 5 EURO-CORDEX Regional Climate Models (collected for the RCP 4.5 and 8.5 scenario) were expressed and mapped. Firstly, a quality control was performed on the climatic series and all unreasonable values were removed. Subsequently daily values were converted to weekly and the homogeneity of the series was checked. Finally, the obtained weekly homogenised data were reconstructed in order to remove gaps. Subsequently in order to facilitate the spatial analysis of drought events, weekly temperature and precipitation series were interpolated by means of the Universal Kriging and auxiliary variables as latitude, longitude, distance to shoreline and elevation. Reference evapotranspiration (ETo) was estimated using of the Hargreaves ETo equation. Then the model validation was performed. For each model 10 precipitation and temperature daily series were extracted and compared with the respective quality controlled series recorded at the ground. The statistical comparison was developed by means of Co.Temp and Co.Rain software classifying episodes in weak, mean, heavy and extreme. Subsequently, severe and extreme drought episodes were detected by means of two drought indices (SPI and SPEI) calculated at 12, 24 and 36 months. Trends were analysed and the results of the two indices were compared in order to individuate all the possible triggering factors. Subsequently main drought events were characterised, identifying duration, magnitude and length, considering episodes that affect at least 25% of the study area and longer than 3 consecutive weeks.

The results figured out that drought becomes more frequent and longer after the 2000s. In the future more frequent extreme precipitation events and longer dry spells will be observed, which will lead to an intensification of drought in terms of length and percentage of interested area.

POSTER

Evaluation of a convection permitting model simulation and comparison with EURO-CORDEX ensemble

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Regional climate models (RCMs) at few kilometers of resolutions are powerful tools for understanding the evolution of the climate system at local levels, in response to the changing concentrations of greenhouse gases. RCMs are very effective for the study of climate change, seeking to represent, in an improved way, the local-scale atmospheric phenomena and the climate system with a high quality of details, through dynamical downscaling. Moreover, RCMs show the capability to provide a detailed description of climate extremes. The recognized prerequisite that RCMs have to satisfy, in order to provide reliable future climate projections, is the ability in realistically simulating the present-day climate (Kim et al., 2014). This phase is defined as "model evaluation" (Airey and Hulme, 1995). In other words, evaluation consists in an assessment of model quality and deficiencies by means of the comparison of model outputs and observations (Flato et al., 2013; Lenderink, 2010; Kotlarski et al., 2014).

The importance of Regional Modelling has been recognized by the establishment of several international projects in the last twenty years. In particular, the World Climate Research Program Coordinated Regional Downscaling Experiment (CORDEX) has been established in order to provide a global coordination of regional climate downscaling for improved climate change adaptation and impact assessment. Within CORDEX, a RCM ensemble for Europe (EURO-CORDEX) has been completed at grid resolutions of 12 km. Even if EURO-CORDEX represent a valuable dataset for impact studies, it is widely recognized that grid meshes of about 10 km are not sufficient to resolve the complex dynamics of convective systems. For this reason, Convection-Permitting Regional Climate Models (CP-RCM) have been developed and applied in recent years (Prein et al 2015, Coppola et al 2018, Lenderink et al 2019), running at a considerably finer grid spacing, typically between 1.5 and 4 km. CP-RCM enhances the representation of local climate by better resolving the regional forcings and processes, associated with topography and land cover, in response to variability in the large-scale atmospheric circulation. In the context of climate change, limited evidence exists of the added value of these CP-RCM s. A number of studies have found that changes in precipitation extremes obtained with CP-RCM s are different from those obtained with RCMs – mostly for short duration, local scale and in summer—while in others changes in the CPRCMs were similar to the RCM-derived changes (Kendon et al 2017, Ban et al 2015).

A simulation with the RCM COSMO-CLM is presented in the present work. COSMO-CLM is the climate version of the operational, non-hydrostatic mesoscale weather forecast model COSMO-LM developed by the German Weather Service (DWD). The mathematical formulation of COSMO-CLM is made up of the equations for a compressible flow. The unresolved scale phenomena are taken into

account in a statistical manner through a number of parameterizations. The current version of the model includes the urban land use scheme TERRA-URB, which parametrises the effects of buildings, streets and other man-made impervious surfaces. The latest version of TERRA-URB implements the Semi-empirical Urban canopy parametrisation (SURY), which translates urban canopy parameters (with 3D information) into bulk parameters while preserving the low computational cost.

More specifically, this study focuses on the results of a very high-resolution COSMO-CLM simulation over the Extended Alpine Region (GAR) performed over the period 2000-2009, driven by ERA-Interim Reanalysis (about 80 km) in order to perform a simulation under perfect boundary conditions. A first downscaling has been performed at the intermediate resolution of 0.11° (about 12 km) over the EURO-CORDEX domain, and then further downscaling over GAR has been performed at the resolution of 0.0275° (about 3 km). The simulation has been developed in the frame of the European Climate Prediction system (EUCP) project, with the aims of developing a simulation strategy for validating CP-RCMs. EUCP is going to generate a comprehensive portfolio of extreme event simulations for the historical period (1980-2015) and the near term future (~1-40 years), assessing also changes in the characteristics and frequency of high impact events for the next decades.

In a first phase, model evaluation has been performed comparing the COSMO-CLM outputs in terms of 2-meter temperature and precipitation against several gridded observations data, specifically:

- E-OBS is a daily gridded data set, which spans the entire European continent (land only) at about 28 km of horizontal resolution (Haylock et al., 2008). This data set was constructed through interpolation of station data variables.
- EURO4M-APGD is a gridded daily Alpine precipitation data set (5 km resolution) based on rain gauge measurements across the European Alps and adjacent flatland regions (Isotta et al., 2013).
- SAFRAN is a sub-daily gridded data set of precipitation and temperature over France (Vidal et al., 2010). It has a horizontal resolution of 8 km.
- HYRAS REGINE is a daily gridded precipitation data set over Germany (Rauthe et al., 2013) with a horizontal resolution of 1 km.

Moreover, evaluation of wind speed is proposed comparing the results of the very high resolution climate simulation against new ERA5 reanalysis, characterized by a horizontal resolution of around 31 km.

Preliminary results highlight the good capability of the model in reproducing the main climate features especially for areas with not very complex orography, such as the Southern Germany and Northern France. The coarse resolution of E-OBS dataset allows only qualitative evaluations by the comparison of patterns, while observational datasets at very high resolution (SAFRAN, HYRAS REGNIE, EURO4M) allow performing also quantitative bias evaluations. In this view, the analysis of results over GAR compared with the aforementioned observational datasets, highlights that the adopted RCM configuration has a very good capability to catch the 2m temperature values despite temperatures are generally overestimated during summer. The positive temperature bias, for the case of E-OBS, may partially be a consequence of an underestimation of observational data with respect to the real temperature, but a possible explanation is the shortcoming of the model in reproducing atmospheric dynamics typical of the considered area. Precipitation is well reproduced over France and Germany, even if, over Alps, the total seasonal precipitation of the model is generally

higher than observations. This is due to the complex orography, as already stated in similar works (Montesarchio et al., 2014), where the effects of the different horizontal resolution of the datasets are more evident and errors on the estimation of the precipitation registered by the stations occurred, being often the measurement stations not at the same altitudes as the model grid points.

It is also interesting to verify if the proposed approach produces remarkable improvements with respect to state-of-art regional simulations. For this reason, an extraction of data from the EURO-CORDEX simulations (driven by ERA-Interim) and relative ensemble mean have been evaluated over the same GAR domain and the same time period in order to find common ground.

This approach for evaluation allows comparing the results of the convection permitting RCM with the available state of the art. Similar patterns of temperature, precipitation and wind are expected at the large-scale with differences in regional details, which can be related to the coarse resolution in EURO-CORDEX.

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POSTER

Heat Events in the Indian Subcontinent under a warming climate scenario: Detection and its Drivers

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Global temperatures have shown a warming trend over the last century, mainly as a result of anthropogenic activities. Rising temperatures are a potential cause for increase of extreme climate events, such as heat waves, both in severity and frequency. Heat waves are anomalous episodes, characterized by extremely high surface air temperatures that usually last up to several days and have serious consequences. Over India, the most impacting heat waves occur during the months of March to June and can affect various sectors including health, agriculture, ecosystems and the national economy. In May 2015, a severe heat wave due to the delayed onset of southwest monsoon affected parts of south-eastern India, which claimed more than 2500 lives.

Heatwaves over India are known to be linked with the climate mode such as El-Niño-Southern Oscillation or ENSO. Some studies indicated that the processes generating heat waves over northwest-central and coastal eastern India could be different. They link the heat waves of northwest-central India to anomalous blocking over North Atlantic and to the cooling over central and east equatorial Pacific for eastern Indian coast. Other studies demonstrated that anomalous persistent high-pressure systems, supplemented with clear skies and depleted soil moisture, are primarily responsible for the occurrence of heat waves over India.

Here we focus on the study of the drivers associated with major heat events in the recent years. Preliminary results show the prevalence of Heat events in North-West, Central and South-Eastern regions of India during the pre-monsoon (March, April, May) and transitional (May, June, July) months. Heat Index (HI), a combination of temperature and relative humidity, gives an insight into the discomfort. Heat stress reduces the efficiency of the body's cooling mechanism as it blocks evaporation. Thus, along with temperature anomalies, humidity also plays role in transitional period.

POSTER

Local climate change analysis as support of adaptation plan: experience from ADRIADAPT project

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The coastal areas are particularly exposed to extreme events and climate change impacts. ADRIADAPT is a project in the framework of INTERREG Italy-Croatia that aims to develop climate knowledge and tools to support the analysis of vulnerability, decision making and improve policy in relation to climate change of the cities that belong to Adriatic coast. A bilingual platform (Italian and Croatian) including information and guidance, adaptation tools, training courses tailored to the needs of local stakeholders will be developed.

In order to reach these objectives the first action is to produce a complete Local Climate Profile over the case studies of the project, namely: Udine, Cervia, Union of the Municipalities of the Savio Valley, Vodice, Sibenik and Split, present and future periods.

This work is focused on Local Climate Profile of two areas: Cervia and Union of the Municipalities of the Savio Valley. Minimum, maximum temperature, 90th, 95th and 99th percentile of maximum temperature, heat wave duration, tropical nights, total amount of precipitation, consecutive dry days, are the main climatic indices selected to be analysed at seasonal and annual time scale.

Trends and changes of these indices, with focus on the different thresholds, are tested from the statistical point of view and, the results are presented over 1961-2018 period. Daily minimum, maximum temperature and precipitation from Eraclito data set (version 4.2), the resolution 5x5km, are used in order to study the present climate variability and, to underlines the main vulnerabilities of the territories. Future climate scenarios of some indices will be then presented at local level. A statistical downscaling techniques (CCAReg scheme) applied to large scale fields from global climate models of CMIP5 experiments will be used in order to construct the future climate projections for Cervia and Union of the Municipalities of the Savio Valley. The local scenarios are constructed in the framework of RCP4.5 and RCP8.5-Representative Concentration Pathways, and are referred to 2021-2040 and 2061-2080.

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POSTER

Precipitation patterns on Mount Baldo (Italy): climatological analysis and dependence on synoptic conditions

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A precipitation dataset composed of measurements from 31 weather stations disseminated in the area of Mount Baldo (Italy) is analysed, in order to produce a climatological analysis and to evaluate the influence of synoptic conditions on precipitation patterns in the area. The dataset covers 140 years (1879-2018), although the various stations have been operated discontinuously during this period. Mount Baldo is an extremely interesting case study, as it is the southernmost Alpine massif facing the Po Plain, and it is thus directly influenced by orographic precipitation caused by moist southerly flows from the Mediterranean.

The first part of the work focuses on the analysis of monthly data, which have been homogenized using the Standard Normal Homeogeneity Test (SNHT), in order to obtain an overview of typical annual and seasonal mean values along with their climatological trends. Furthermore, climatological representative values have been spatialized using the kriging with external drift (KED), adopting latitudinal, longitudinal and altitudinal trends as external parameters.

In the second part of the work, the relation between synoptic circulation types and precipitation distribution in the Mount Baldo area is investigated, by classifying daily precipitation data covering a total of 18 years according to the degree of zonality and meridionality of 500-hPa geopotential fields. Specific features of each synoptic situation are discussed, evaluating in particular the relation between the spatial distribution of precipitation and geostrophic wind direction.

POSTER

Satellite altimetry and in situ observations: Estimating Relative and absolute sea level rise in Northern Adriatic Sea (Venice and Trieste)

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Climate-related disasters are highly demanding in terms of life land economic losses. Among them, storms are the costliest type of disaster: their impact on coastal zones strongly depend on the relative sea level, and on its changes, that thus deserve special attention particularly where people, industrial settlements and cultural heritage coexist. In the Mediterranean basin the most exposed area to this risk is the Adriatic Sea, and in particular Venice, whose high vulnerability has determined the need to realize one of the most impressive hydraulic engineering works: the MOSE barriers. In this context, the long term implications of rising sea levels have not been exhaustively investigated yet, and the contributions from the various mechanisms impacting on sea level have not been clearly quantified. The European Space Agency (ESA) Climate Change Initiative (CCI) project on "Sea Level" has produced an improved set of satellite-based sea level gridded products by reprocessing altimeter data over 1993-2015. Recently, CTOH within the project has released a new version of the dataset which includes along track high resolution (i.e., around 300 m spaced) Jason-1 and Jason-2 data. Our contribution aims at assessing the quality of the current Sea Level CCI products in the Adriatic Sea - in particular around the cities of Venice and Trieste, how close to the coast the actual Sea Level CCI products can be considered reliable, and what are the main differences between gridded and along track data. Near Trieste we also can rely on Jason-1 and Jason-2 track data reprocessed at 20 Hz. For a better understanding of the role played by subsidence on the local sea level rise, the latest CCI gridded products and the new along-track high resolution observations at the nearest suitable measurement points are compared with tide gauge data, thanks to the very short distance between the tide gauges and the coast in those two cities (4 km in Venice and 0 km in Trieste). From in-situ measurements a relative sea level rise trend of about +6.3 mm/yr has been determined in Venice, while for Trieste we got +4.7 mm/yr. The difference between in-situ data and altimetry observations supplies an estimate of the subsidence contribution in both cities [Vignudelli et al., 2019]. A partial validation of these estimates has been made against GPS-derived values, in order to distinguish the contributions of subsidence and eustatism, and in view of the possible closure of the sea level budget in those two cities. Subsidence data, when available, are derived from local permanent GPS stations. We investigate also the role of the varying surface pressure in the relative sea level rise local budget: pressure data are taken from affordable time series of meteorological data at Venice and Trieste, as well as from the ECMWF ERA INTERIM reanalysis project. This work will contribute to identify problems and challenges to extend the sea level climate record to the coastal zone with quality

comparable to the open ocean, and also to assess the suitability of altimeter- derived absolute sea levels as a tool to estimate subsidence from tide gauge measurement in places where permanent GPS receivers are not available.

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POSTER

The influence of CO_2 forcing on North American monsoon moisture surges and precipitation intensity in the southwestern United States

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Widespread multiday convective bursts in the southwestern United States during the North American monsoon are often triggered by Gulf of California moisture surges (GoC surges). However, how GoC surges, and the amount and intensity of associated precipitation, will change in response to CO_2-induced warming remains little known, not least because the most widely available climate models do not currently resolve the relevant mesoscale dynamics because of their coarse resolution (100 km or more). In this study, a 50-km-resolution global coupled model is used to address this question. It is found that the mean number of GoC surge events remains unchanged under CO_2 doubling, but intermediate-to-high intensity surge- related precipitation tends to become less frequent, thus reducing the mean summertime rainfall. Low- level moisture fluxes associated with GoC surges as well as their convergence over land to the east of the GoC intensify, but the increases in low-level moisture are not matched by the larger increments in the near-surface saturation specific humidity because of amplified land warming. This results in a more unsaturated low-level atmospheric environment that disfavors moist convection. These thermodynamic changes are accompanied by dynamic changes that are also detrimental to convective activity, with the midlevel monsoonal ridge projected to expand and move to the west of its present-day climatological maximum. Despite the overall reduction in precipitation, the frequency of very intense, localized daily surge-related precipitation in Arizona and surrounding areas is projected to increase with increased precipitable water.

POSTER

Two hundred years of Temperature Observations in the City of Trento, Alps (1816-2018)

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Starting from 1816, regular measurements of air temperature were performed in Trento, a mid-sized city in the Italian Alps. However, during this period, locations of the observatories, instruments and observers have often changed, resulting in a variety of short series. Metadata about methods of observation, locations of measurements and observers were carefully collected in order to reconstruct the history of the observations. Thanks to this work, a continuous long record of monthly mean temperature was obtained by merging the short single series. Such a long series inevitably contains inhomogeneities due to external factors such as changes in the observers, procedures or instrumentation. These inhomogeneities were detected, when possible related to metadata and corrected through the application of homogenization techniques, resulting in a homogeneous series. The homogeneous series was analyzed to evaluate statistically significant trends in annual mean data. This analysis highlighted a significant positive trend of annual mean temperatures, especially in the last 30 years, a result confirmed by other long-term series. Moreover, the homogeneous series of monthly mean temperatures were also analyzed to investigate trends season by season, resulting in Summer being the season with the most pronounced increase in temperature.

Risks and adaptation options in a warmer world

ORAL

A multiscale perspective in Green Infrastructures planning to foster climate change adaptation in urban areas

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Urban environments are playing a key role in social and economic development at global, national and local scale, constituting both one of the major challenges and opportunities of the XXI century. With more than half of world population currently urbanized (UN, 2018), cities are among the main causes of climate change, suffering the negative consequences on economic, socio-cultural, political and environmental dimensions (World Bank, 2010; EU, 2011). On the other hand, urban areas are strongly threatened by climate change: they are highly vulnerable to the extreme weather and climate-related phenomena due to their inherent characteristics, which are independent from potential climate variations.

Given the climate projections developed for Europe (EEA, 2017) and the projected population growth in urban areas (UN, 2018), there is then an urgent need to ensure a proper functioning of cities, which must be able to cope with the impacts of climate change in the short and long-term avoiding negative consequences for society, economy and environment. In such a scenario, urban

planning and design play a crucial role in identifying critical issues and defining the interventions on the built environment through the implementation of adaptation policies and actions aimed at promoting a rational use of resources and improving the quality of life.

The limited extent, fragmentation and lack of adequate maintenance of green areas represent a serious threat to natural ecosystems, increasingly unable to fulfill their role and provide benefits to the urban communities. Recently, the European Union has identified the ecosystem approach as a strategy to foster the development of innovative and sustainable actions for climate change adaptation. The target 2 of EU Biodiversity Strategy focuses on maintaining and enhancing ecosystem services and restoring degraded ecosystems by incorporating green infrastructure (GI) in spatial planning (EC, 2011). Such a concept, developed in the mid-90s in the USA and for which there is not a universally valid definition, has recently spread across Europe through the adoption of the EU Strategy on Green Infrastructure in 2013. According to the definition provided by the European Commission (EC, 2013a), the concept of GI is strictly related to that of ecosystem, seen as the complex of biotic and abiotic components, their physical environment and all their interactions in a particular unit of space. However, just some of the multiple processes that characterize ecosystems deliver direct benefits to human beings. In order to identify them, ecosystem services (ESs) must be evaluated in relation to four categories: provisioning, regulating, cultural and supporting services (MEA, 2005).

To clarify the role of ecosystems in developing green infrastructures for climate adaptation, the additional concepts of natural capital, Ecosystem-based Adaptation (EbA) and Nature-Based Solutions (NBSs) have to be considered. Specifically, natural capital represents the biophysical basis of GI, being an extension of the economic notion of capital to environmental services and goods provided by natural ecosystems that generate direct and indirect benefits for people (UK NCC, 2013; CCN, 2018). To operationalize the concept of natural capital and strengthen its role in local decisional processes, other approaches have emerged. EbA identify natural elements that contribute to the enhancement of adaptive capacity and resilience of community (Andrade Pérez, et al., 2010), while NBSs encompass all the actions which are inspired by, supported by or copied from nature that allow to reduce disaster risk, improve human well-being and promote a socially inclusive green growth (EC-DGRI, 2015).

The four concepts of GI, ES, EbA and NBSs are closely interrelated, partly overlapping and partly complementing each other (Pauleit et al., 2017). While EbA and ES refer to a strategic and evaluation dimension respectively, GI represents an operational approach that support the integration of NBSs in territorial and urban development processes by quantifying the benefits of natural capital in adapting cities to climate change. Moving from a conceptual to an operational level, GI represents the optimal planning of green measures to ensure the supply of a wide range of ecosystem services across multiple spatial scales.

The great amount and range of GI components (EC, 2013b), their contribution to adaptation and the existing relationships with the anthropic elements require the adoption of some key principles for guiding their planning and implementation (Benedict & McMahon, 2006; Naumann et al., 2011; Pauleit et al., 2011; Hansen & Pauleit, 2014). Planning the territorial transformations requires a multiscale perspective, from the regional, through urban and neighborhood level to single block and vice versa, and a synchronic vision, which does not follow a top-down approach but a cyclical path,

able to seize and analyze the mutual relationships of complex urban systems. According to the principle of multiscalarity, GIs should be implemented on multiple scales, acting synergically and simultaneously on different levels in providing regulation services (climate and water quantity and quality) with benefits connected to the outdoor cooling, peak flow and volume reduction and filtering of potentially harmful substances.

Within this framework, the study presents a critical analysis of the main components and key principles of GI as a planning approach aimed at fostering climate change adaptation in the urban environment through the integration and promotion of biodiversity with interventions on multiple spatial scales and the creation of an interlinked system of green areas. A preliminary comparison with the other concepts (ES, EbA and NBSs) for ecologically-oriented urban development is carried out through a desk review to highlight differences, commonalities and relationships existing between them, clarifying the specific role of green infrastructure planning in managing natural resources. Three case studies (green belt in Vitoria-Gasteiz, Spain; Urban Development Plan "StEP Klima Konkret" in Berlin, Germany; stormwater management plan in New Orleans, USA) of GIs planned and/or implemented on different spatial scales (metropolitan, district/neighborhood and block/building) in different geographical locations are introduced to clarify the role of GI in urban planning and its benefits. The analysis emphasizes:

(i) the effectiveness of top-down approach in systematizing critical issues and resources within the traditional planning tools and the ability of local governments in turning challenges into opportunities for sustainable development (Vitoria-Gasteiz and Berlin);

(ii) the crucial role of community in bottom-up approach to promote a urban regeneration process through the search of funding and dialogue with local authorities (New Orleans).

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ORAL

Addressing climate change adaptation governance in mountain regions: the application of the Budoia Charter as a regional case-study for local adaptation action in the Alps

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Sub-regional adaptation to climate change has received much attention in theory and practice (Laukkonen et al., 2009; Nalau et al., 2015; Rauken et al., 2015). However the many governance issues that arise when adaptation actions are to be planned and applied have not yet been convincingly solved (Hanssen et al., 2013; Masson et al., 2014; Masud et al., 2016; Hamilton & Lubell, 2018) – notwithstanding the growing amount of practice available from different world regions and for different sectors (Geneletti & Zardo, 2016; Aguiar et al., 2018; Picketts, 2018).

When climate change adaptation policies are concerned, mountain regions deserve to be dealt with as a separate territorial case. Studies show that mountains hold special vulnerabilities and are subject to specific impacts of climate change. As a consequence, a selection of adaptation actions can reveal the ones being particularly suitable to be applied in mountain regions (Beniston, 2003;

Beniston, 2005; Palomo, 2017). Notwithstanding the outcomes of research and policy practice in several mountain regions (Ingty, 2017) and particularly in the Alps (Bonzanigo et al., 2016), as well as the acknowledgement of mountain zones in larger scale adaptation strategies and plans, a comprehensive approach dedicated to addressing climate change adaptation governance in mountain areas has not been framed yet (Terzi et al., 2019).

This paper aims to provide a contribution to address the issues raised by planning sub-regional adaptation measures to climate change (Reckien et al., 2018; Pietrapertosa et al., 2019) and to identify a tailored-approach for mountain areas.

We aim in particular to set up a workable framework of a standard procedure for identifying suitable adaptation actions for sub-regional geographical units (municipalities and their groupings, according to territorial or administrative criteria) in a mountain environment, assuming that current institutional governance structures will not be subject to any dramatic change in the short run.

The units under investigation differ from each other for a set of regular characteristics, including: geographical characterization, available sources of knowledge, local climate context, climate impacts, governance schemes, resources and key planning/programming instruments, sector-bound and integrated vulnerabilities, preparedness on identified vulnerabilities, and public awareness and political voice on climate change in general and climate change adaptation in particular.

The resulting procedure intends to use existing figures and information and elicited regional and local stakeholders' assessments for selecting and identifying appropriate adaptation measures for the areas under investigation and for mountain areas more in general.

Measures will be selected from existing consolidated collections based on an assessment of: their institutional significance (e.g. national/regional/local adaptation strategies and plans); geographical scope of application (e.g. mountain areas); scientific contents (e.g. results of research and cooperation projects focused on the investigated regions or on comparable ones); experience with concrete outcomes after implementation (e.g. projects and experience from the EU Climate-Adapt Platform); and other relevant dimensions.

Moreover, a consistency analysis is performed on such measures in order to assess their alignment to overarching and/or legally binding plans. This analysis is expected to allow for integrating existing formal adaptation plans (PNACC, 2017) with coherent mountain and site-specific adaptation measures from other reliable sources.

The resulting mixed approach (qualitative and quantitative) used to combine technically sound measures and sub-regional demands aims to strike the balance between a reasonable scientific assessment of impacts and affected sectors in the regions (DARACC of Lombardy, 2016; AdaPT Mont-Blanc, 2018; ARPA-FVG, 2018; RSA of Piemonte, 2019), and the local perceptions and prevailing priorities in the sub-regional units under investigation – taking note also of local constraints in terms of competences and finance.

As a result, we expect to identify a modular procedure suitable to be refined by use in other locations and supported by a set of quantitative and qualitative indicators aimed to frame a background acting as a Decision Support System (DSS) for actual decision making concerning adaptation policies and measures at the appropriate level.

The procedure stems from the experience with the Budoia Charter – a voluntary political declaration, promoted in the framework of the Alpine Convention and the international Network of

municipalities "Alliance in the Alps" on the initiative of Italy and the Italian branch of the Network (2017), in line with the Guidelines on local adaptation to CC in the Alps (2014).

In particular, the procedure is being tested in five pilot-areas at the sub-regional level across the Italian Alps ranging from Valle d'Aosta to Friuli Venezia-Giulia, from Western to Eastern Italian Alps, and is planned to be further extended to other mountain regions in Italy and worldwide.

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ORAL

Option value and the social cost of carbon: What are we waiting for?

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Scientists and economists have long recognized that significant uncertainties and irreversibility characterize climate change. And yet, the social cost of carbon (SCC), the preeminent policy tool to address climate change, does not include the option value (OV) that arises due to these characteristics. We demonstrate a simple methodology for approximating the OV underlying the SCC using the Bachelier formula. Applying this methodology to the official U.S. SCC estimates , we find that these estimates increase by 71% to 81% depending on the discount rate. Conducting a sensitivity analysis, we find that OV increases with the thorough the representation of uncertainty in the underlying climate-economic model. Given the large magnitude of OV, we believe that official U.S. SCC estimates and the next generation of climate-economic models must account for OV. As these newer models promise to more fully represent uncertainty, OV will increase in importance in the future along with its relative value.

Policy is made with substantial uncertainty underlying the benefits and costs of climate action. These uncertainties permeate each step of the climate-economic modeling process: socio-economic and emissions scenarios; climate models; climate damage functions; and social welfare functions. Using various methodologies, economists have developed an extensive literature studying the impacts of this uncertainty on climate policy. Despite recent advances in stochastic dynamic programming (SDP), the expected value approach is still the dominant approach to cost-benefit analysis in the climate context. Specifically, due to SDP's complexity, state space limitations, and focus on optimal emissions pathways instead of most likely or Business as Usual (BAU) pathways, applying Monte Carlo simulations within the framework of "deterministic" integrated assessment models

(IAMs) is still the most policy-relevant methodology for modeling uncertainty. Irreversibility of greenhouse gas (GHG) emissions adds additional complications for SDP.

In the expected utility framework, irreversible decisions modify the expected net present value (ENPV) rule for optimal decision-making. Under irreversibility, the simple ENPV rule may lead decision makers to take undesirable risks. Essentially, it fails to account for option value (OV): the value to the decision maker of future flexibility from postponing an irreversible decision under uncertainty and learning. By adjusting the ENPV to include this valuation of preservation, irreversible investments require higher returns to pass a cost-benefit test than a similar certain or reversible investment. While there are two definitions of OV and corresponding modifications to the ENPV rule, we focus on real (Dixit-Pindyck) OV instead of quasi-option value (Arrow-Fisher-Henry-Hanemann OV) as the two concepts are strongly related in the context of discrete investment (i.e., marginal emission) decisions and an extensive set of option price formulas have been developed in the literature for the former. This OV adjustment of the ENPV is separate from any risk premium adjustments, as it applies even when the central planner is risk neutral.

We apply real options analysis using output from the 2016 Interagency Working Group on Social Cost of Greenhouse Gases (IWG) to demonstrate the simplicity of our approximation method for OV. Specifically, we downloaded the output from IWG (2016)'s Monte Carlo simulations that produced three distributions of 150,000 SCC estimates for three constant discount rates: 2.5%, 3%, and 5%. Focusing on our main result using all model runs for the 3% discount rate, we then assume there exists a financial asset (e.g., a stock) with identical moments as the SCC distribution where the asset's spot price equals our central SCC estimate. The current SCC valuation is society's best available knowledge (i.e., distribution of damage) to calculate a fair value of future regrets. Society is essentially short-selling climate change (i.e., making policy decisions that are only optimal if the true marginal cost of climate change turns out to be below the mean SCC), and must purchase a call option hedge against the resulting risk of uncompensated future damages.

Using the model runs of the 2016 IWG, we roughly approximate the portion of the SCC corresponding to OV. To calculate the SCC, the IWG ran 45 Monte Carlo simulations of 10,000 model runs for three IAMs (DICE, FUND, and PAGE), five socio-economic scenarios from EMF-22 (IMAGE, MERGE Optimistic, MESSAGE, MiniCAM, 550 ppm average), and three discount rates (2.5%, 3%, and 5%.). Using the mean and variance of the 150,000 SCC estimates (Figure 1) corresponding to the 3% discount rate, we approximate OV using the Bachelier model of $36 corresponding to a 2020 SCC of $50 in 2018 USD (see Table 1). This result strongly implies that the omission of OV leads to a serious underestimation of the SCC.

Using the IWG (2016) runs, [4] we conduct a sensitivity analysis to determine the impact of various modeling components (scenarios, model structure, and discount rates) on the SCC's OV. We find significant variation in the OV as a percent of the SCC between the models from 21% in DICE to 79% in FUND. The much higher ratio of OV to SCC in FUND and PAGE (at 69%) is the result of these models using a significant number of stochastic variables relative to DICE. Treated as a separate uncertain ethical parameter, the discount rate has a significant impact on the magnitude of the OV, but its relative value to the SCC only changes slightly, from 71% of the SCC for a 2.5% rate to 81% for a 5% rate. Given the prominence of IAM choice in determining OV, it is critical that IAMs truly model the full spectrum of parametric uncertainty, including tipping points. Finally, to address skewness and

kurtosis, we use the Edgeworth binomial tree to account for higher order moments finding that the Bachelier model underestimates OV by assuming normality.

Using a rough approximation of the OV portion of the SCC, we find evidence that current SCC estimates represent significant underestimates due to a failure to model the irreversibility of marginal GHG emissions. We demonstrated that OV is a significant portion of the official U.S. SCC estimate at 72%. The SCC share is more sensitive to the choice of IAM model than to IWG's other key modeling assumptions. As the SCC's OV is part of the SCC, not a separate value to be treated independently, climate economics can no longer ignore this large part of the marginal cost of GHG emissions.

The approximation method applied here can also be used in alternative policy contexts, such as oil and gas leasing decisions in the outer continental shelf. Currently, the Bureau of Ocean and Energy Management (BOEM) accounts for the OV corresponding to oil price uncertainty . However, they exclude the OV corresponding to catastrophic oil spills even as the agency increases environmental risks by opening the Arctic National Wildlife Refuge for drilling. A 2015 D.C. Circuit ruling (Center for Sustainable Economy v. Jewell) supports BOEM's omission, unless a numerical methodology to estimate OV corresponding to non-market risks becomes readily available in the literature. This paper demonstrates a potential methodology.

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ORAL

Exploring Machine learning potential for climate change risk assessment and adaptation planning

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Disasters are on the rise, both in terms of frequency and magnitude. The increase of disasters is mainly due to the impact of climate change which is leading to exacerbate weather (e.g. tropical storms, cyclones) and hydrological events (e.g. floods, landslides). Based on the last IPCC report, more severe compound climate-related risks are projected to increase with global warming of 1.5°C and rise further with 2°C. Moreover, multi-sector risks are expected to overlap spatially and temporally, creating new (and aggravating current) hazards that will affect, in turn, an increasing numbers of people and regions. The multiplicity of human and climate-related agents and stressors, the complexity of relations and responses, and the related high degree of uncertainty involved, make the assessment of climate change impacts notoriously difficult.

Current risk assessment procedures fail in characterizing the complexity and dynamic component of risk, not considering spatio-temporal changes in exposure and vulnerability patterns (i.e. no time-dependent vulnerabilities, no changes among exposed elements), as well as synergies between physic, environmental and socio-economic systems. Recent advancements in climate change risk assessment (CCRA) have been prompted thanks to the increase in volume, variety, and velocity of spatio-temporal data for environmental applications. The availability of these big data, has inspired the research community to test new methodological approaches and tools, leveraging the potential of the latest advances in hardware and computer science, including the application of Machine Learning (ML) techniques to solve a whole range of complex environmental issues.

Although the increasing attention in the last years on the application of ML methods to CCRA, no previous review systematically mapped out trends and gaps within this recent research field, as well as the real-case contribution of these methods to inform assessment processes. To bridge these gaps in extant literature, an in-depth review of the state of art existing studies and applications of ML methods in the field of CCRA was performed, jointly applying scientometrics analysis and systematic review of publications identified across the 2000-2019 timeframe. The integration of both approaches allowed to summarize, in a visual and conceptual way: i) the linkage and working relationships among researchers focusing on this research field; ii) the aspects such as co-citation clusters, keywords and words co-occurrence networks; iii) the contribution of ML to the implementation of the different phases of the CCRA (i.e. hazard, exposure, vulnerability and risk

assessment). Key operational steps and main results from the developed scientometrics and systematic review are here presented and discussed.

ORAL

An innovative tool to mitigate drought impacts through risk financing

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There is evidence in the scientific community that droughts and heat waves will become more frequent and more intense with climate change. Appropriate strategies to mitigate the impacts associated with these extreme events should be implemented, but historically little attention has been given to preparedness, mitigation and early warning for droughts. Among the various mitigation strategies proposed by, such as the development of early-warning systems and the reduction of water demand, insurance plays a key role. Insurance is an appropriate tool for overcoming a situation in which an extreme event exceeds the normal resistance and protection capacity. It allows people to resume normal lives again. Agriculture is the sector that uses and benefit more from drought insurance. The sector is the most affected and more aware of the risk. There are two main options of crop risk transfer solutions: indemnity-based programs, in which the basis for compensation is the actual loss; and weather index-based (or parametric) programs based on variables called indices, that should be highly correlated with agricultural losses. In this second case the policy for drought pays out if a specific value of the index is achieved in a specific period. There is no need to prove the suffered losses, therefore the claim process is fast and requires fewer claims investigation hours, and has an overall lower operational cost to the insurer. The main advantage of indices is that they can hardly be controlled by the insured parties. Index-based insurance has 4 interesting features:

1. It is free of moral hazard (users cannot influence the value of the index)
2. It is free of adverse selection (indemnities are based on observable variables, the indices);
3. It is relatively inexpensive to administer (no on-farm inspections to assess damages);
4. It provides timely financial funds to recover from the disaster.

The aim of this research is to propose a tool to improve drought monitoring and estimate drought-related crop losses by using only remote-sensing data. The tool could be the basis for a parametric insurance product.

The tool is structured in two steps:

1. Implementation of a framework to identify drought events that cause impacts on agriculture: this step includes:

a. The creation of an index that combines, through the use of a bivariate normal distribution function, two of the most renown drought indices, the Standardized Precipitation Index [5], which is based on precipitation only and the Vegetation Health Index [6], which is a measure of the effects of drought on the vegetation and takes into account temperature effects too.

b. The implementation of a framework to identify drought events, by establishing starting and end date of the events on the basis of the percentage of a country's area under drought according to the new index.

2. Estimation of crop yield losses by correlating crop yields with the new index.

Two datasets have been selected to implement the tool. Precipitation were retrieved from the Climate Hazard Group Infrared Precipitation data archive (CHIRP, [7]), which started in 1981 and has global coverage, daily temporal resolution and 0.05° spatial resolution. From CHIRP's precipitation, the SPI was computed and updated at weekly timestep. The VHI was retrieved from the Global Vegetation Health Products of the NOAA (NOAA, 2011). The dataset has global coverage, weekly temporal resolution and 4 km spatial resolution.

The tool has been tested on Haiti, since the country was affected by intense droughts that caused huge loss of crops and deeply affected the population. The country is also very vulnerable to climate change, as reported by data of the Haitian Ministry of Agriculture, Natural Resources, and Rural Development (MARNDR), that noticed that mean observed temperatures rose by more than 1 degree centigrade between 1973 and 2003 [8]. According to projections of future climate, rainfall variability is expected to increase, meaning more extreme droughts in the dry season. Therefore, the implementation of mitigation strategies is crucial to increase the country's resilience. Observed drought events in the period from 1980 to present were retrieved from text-based sources, such as reports of the government, NGOs, FAO and others). Drought events identified by the new index were compared with historical events registered in the country. The Receiver Operating Characteristic (ROC) curve was employed in the validation process. Results showed that the new index was able to identify all major drought events hitting Haiti. Therefore, a correlation analysis between the new index and crop yields was performed, using Pearson correlation coefficient. Data on crop yields for rice, cereals and maize were retrieved from MARNDR for the years from 2009 to 2016; the index was aggregated on the whole country on a yearly basis. Correlation coefficient was high for rice (0.88) and cereals (0.79), while in the case of maize it was 0.66. These results are promising and show that the framework could be implemented in a parametric insurance programme, since the index is highly correlated with yields and drought events are correctly identified. In addition the approach here proposed showed significant advantages: can be easily implemented over the entire globe at country-scale, since both the datasets used have global coverage; can be applied even in areas with sparse gauge coverage, such as Haiti, because the index is based on remote-sensing data and the index can be updated in near-real time, having both the datasets a short latency period. The tool can be an effective mean to improve drought resilience in Haiti, since it could allow farmers to afford drought periods without the need of government or NGO's help and to receive money to plant again the following season.

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ORAL

A portfolio analysis of adaptation strategies in the agricultural sector in Rwanda

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Climate change creates new uncertainties which can compromise the effectiveness of public policies, especially in the case of long-term climate sensitive investments with high sunk costs (e.g. the construction of a dam, planting a perennial crop, the creation of a sewage network, etc.). The scientific literature highlights the "uncertainty cascade": a sequence of interlinked levels of uncertainty, from the one regarding the expected greenhouse gas emission patterns, passing through the uncertainty related to the lack of knowledge about natural processes, until the uncertainty connected to the local impacts of climate change and the effectiveness of the adaptation policies. These uncertainties hamper the possibility to identify the costs of climate change and the benefits of the adaptation measures.

Therefore, in this complex uncertain framework, designing good adaptation policies is a challenging task. This is why, although there is a proliferation of adaptation strategies and plans, the concrete implementation of adaptation measures remains uneven.

In the attempt to assist the decision makers in the identification of good adaptation policies, a series of decision support tools and approaches has been considered in the last years. These instruments differ from the conventional ones (e.g. cost-benefit analysis or multi criteria assessment) because they are able to include climate change uncertainty in the analysis, finding political strategies that are robust to possible future scenarios and climate change impacts. The most interesting tools are: Real Option Analysis, Robust Decision Making and Portfolio Analysis.

Portfolio Analysis (PA) is an instrument originating from finance and it has been widely used in the management of natural resources. However, whilst PA is recognised as having the potential for bringing about a more holistic economic analysis of adaptation, it remains rarely used in the climate change framework. PA aggregates different adaptation measures in different portfolios instead of considering a single intervention and it attempts to identify the best portfolios according to their trade-offs among economic efficiency (the Expected Net Present Value) and its risk (Variance of the economic performance of the different scenarios). These recommended portfolios are then collected into an efficient frontier. The decision makers can choose the best solution on this frontier, following their own attitude to risk.

By means of a case study, this paper assesses key strengths and limitations of PA in helping decision makers to identify economically robust adaptation interventions in the face of climate

change uncertainty. Our analysis is focused on tea production in Rwanda, a sector that have significant economic and cultural importance for this country. Stakeholder demand is led by the recognition of the fact that this crop is climate sensitive and tea plants have lifetimes of 40-50 years, thus becoming a highly risky investment in a climate change framework. Returns on investments in new plants now are therefore likely to be subject to greater climate-induced uncertainty than in the past.

In this case study, we test portfolios of different altitude bands and therefore temperatures - for the expansion of the tea plants, considering a spectrum of climate scenarios ranging from a 'no climate change' future to the 'RCP8.5'. Data on the costs and revenues associated with production in plantations at different altitude levels is provided by tea producers in the regions where plantation expansions are possible. Our results show that whilst a single adaptation measure (in this case planting at a single altitude) can have very high economic performance but also has high variance, portfolios of various diverse interventions (planted across a range of altitudes) can identify more robust investment solutions with better trade-offs among economic revenues and risk. The diversification of adaptation investments in multifaceted portfolios is therefore shown to help decision makers in better manage the threats of a wide range of climate scenarios and related impacts. Key lessons learnt from the Rwanda study include:

i) positive opportunities do emerge in the use of new decision support tools;

ii) the inclusion of climate change scenarios in the analysis leads to different results instead of tailoring

the investment just focusing on the past climate trends;

iii) the best portfolios of measures are the ones that mixes investments which are non-perfectly correlated, thus having good economic performances in different alternative climate scenarios.

However, there are also some weaknesses in the use of portfolio analysis in this context:

i) the analysis requires a considerable amount of biological and economic data, good computational skills and it is time consuming;

ii) portfolio analysis is fundamentally based on a cost-benefit approach and it thus helps the evaluation of the economic performances of the investment; this is why the outcome of the analysis should be integrated with other considerations, especially about the stakeholders' values and preferences and the natural and social externalities of the investment;

iii)an adaptation strategy should consider a plurality of interventions, through the integration of measures in different sectors of the public administration; therefore, in this case study, the portfolio analysis of the tea investment should be integrated in a more comprehensive plan for the adaptation policies in the agriculture sector for that specific location. In spite of these limitations, this case study emerges as a straightforward example of the use of a decision support tool in the identification of concrete adaptation interventions. Portfolio analysis here helps in identifying new robust solutions, confirming the insights from the literature. Given the significant outcomes of this study, this methodology could be tested in other locations, in the attempt to confirm the results and to disseminate the use of this tool.

ORAL

Water Pricing under Climate Risks and SDGs

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Since "Clean water and sanitation" became one of the 17 important projects in the Sustainable Development Goals (SDGs) in 2015, it has been the key issue for a sustainable and resilient society in the 2018 United Nations Sustainable Development High-Level Political Forum (High Level Political Forum on Sustainable Development, HLPF). Due to the persistence of unfairness, depletion of natural resources, continued deterioration of environmental quality, and accelerated acceleration of climate change, the management of water resources and ecosystems on which social and economic development depends is extremely challenging.

"The future we want" as Stockholm International Water Institute (SIWI) mentioned, freshwater connects economies, ecosystems and social systems across local, national, regional and global scales, and hydrological resources and risks determine the feasibility of achieving environmental, social and economic goals at these scales. Performance and actual cost of water service need to be improved in order to the SDGs targets, such that financing remains a major deficiency. A significant increase in levels of investment of infrastructure and intelligent equipment are required to manage the future risks.

Economic instruments used for climate change adaptation should contribute to achieving the objectives of efficiency, equity and adaptive efficiency. And pricing of water services should be viewed in terms of three key aspects: cost recovery, efficiency and scarcity (OECD, 2013). In the case of Taiwan, the tariffs of water have not been adjusted for 25 years, not only the historic cost but also the future costs under climate risks did not be covered which including infrastructure cost and scarcity pricing. In many cities around the world, affordability constraints always became the core issue of water pricing that limited efficiency and scarcity improving. But in Taiwan, affordability is not such a serious problem because in average the water bill shares family's expenditure 0.3% which is very low.

In order to discuss the achievability of clean water and sanitation SDGs goals, this research compared the efficiency, equity and affordability under various pricing and climate risks scenarios with a Water Computable General Equilibrium model (WCGE). And so far, we found that an increasing block tariff with larger max/min relative block rate helps the efficiency and equity without injuring affordability, and such kind of tariff adjustment will reduce government subsidies to water company such that the budgets could be used to develop multi-water resources (like water recycle or desalination) to avoid the extremely impact of climate change and induce new industries to contribute the economic and human life.

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ORAL

What the effect of International Agreements on the diffusion of climate insurance?

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International Environmental Agreements often include specific reference to different risk management strategies as means to share and transfer natural disasters economic consequences. Particularly, insurance appears as a risk reduction strategy to minimize countries vulnerability in a world in which the dimension and the frequency of natural disasters are increasing due to climate change. For this reason, this paper analyses the contents of some Global Initiatives about climate change and their provisions with a specific focus on insurance.

Going into details, the number of natural disasters has increased in the last few decades together with the economic costs associated with extreme weather events. Between 1980 and 2016, 90% of disaster events were weather-related and 80% of economic losses were related to weather extremes (Munich Re, 2019).

In the meanwhile, there is a growing consensus that insurance, as a risk transfer mechanism, has a relevant role to play, particularly in offsetting the economic impacts associated with extreme events. It is also clear that such instruments encourage adaptation programs and policies that would serve to minimize future loss and damage and, hence, contribute to sustainable development (Porrini, Schwarze, 2014).

The insurance industry is increasingly aware of the emerging challenges associated with disasters and climate change. Insurance is traditionally operated by the private sector. However, government institutions have an important role to play, providing support to develop the market for innovative extreme-weather insurance and adapt the regulatory and institutional frameworks so that climate insurance products can be promoted.

In this field, government institutions provide support to develop insurance markets and adapt the regulatory and institutional frameworks so that climate insurance products can be promoted (Cashman et al. 2018). The International Agreements have the purpose of coordinating state policies, finding out the relative and necessary resources, and thus distributing cooperative gains for their members (Böhmelt and Butkuté 2018). In particular, as far as insurance systems are concerned,

agreements involve different risk management and reduction strategies, including insurance as an instrument to share and transfer disasters risk.

For this reason, our aim is to deeply analyze the relevance of the International Agreements in promoting insurance as a risk reduction strategy in order to minimize vulnerability (Capstick et al. 2015; Hein et al. 2019) in a world in which natural disasters are increasing (Hoeppe 2015; Swiss Re 2018).

In this direction, we test two research hypothesis formulated in order to evaluate the effect of the International Agreements (particularly Kyoto Protocol in 1997 and Hyogo Framework in 2005) as a means to encourage countries to adopt insurance, to cover the damages deriving from natural disasters. They are defined as follows:

- H1: Is Kyoto Protocol relevant to the diffusion of insurance?
- H2: Is Hyogo Framework relevant to the diffusion of insurance?

To verify the accuracy of the two hypothesis H1 and H2, we focus on five countries characterized by different cultural and geographic features: China, France, Germany, Great Britain, and the United States of America.

For our purpose, three temporal periods are considered in relation to two International Agreements. In details, we are going to take into account the following periods:

1. 1980 – 1997;
2. 1998 – 2005;
3. 2005 – 2018.

The first period deals with a scenario that is antecedent the Kyoto Protocol to test the diffusion of insurance before this agreement. The second one is centered on a period that goes from Kyoto Protocol to Hyogo Framework, and, in the end, the third period is mainly based on a scenario post-Hyogo.

In order to avoid problems of scarce homogeneity of data, we have decided to focus our research on a specific kind of natural disaster: the floods.

Our choice takes into account that, as a consequence of climate change, the frequency of natural disasters such as floods has been increasing (Van Aalst 2006; Ju et al. 2019; Dankers et al. 2013). Such increasing trend may have a serious impact on society, with high damages in terms of human lives and economic losses. In addition, this impact can increase due to the steady growth in population and economic activities in flood-prone areas (Winsemius et al. 2015). As a result, floods are considered responsible for a greater number of damaging events than any other type of natural hazard (Kron 2005).

Therefore, great efforts are needed to well understand all risks involved so that effective countermeasures can be adopted. Insurance can be seen as an ex-ante mechanism based on the identification, assessment and understanding of a risk in order to minimize the potential harm of natural disasters, by implementing strategies and actions to control and reduce risks (Valente et al. 2019). For this reason, our focus is on the spread of this type of contracts among countries, so that we can evaluate if insurance is used as a way to manage floods risks.

The first step in this analysis was the data collection from Munich Re's Nat Cat SERVICE, a data set that provides information on catastrophic events worldwide. This database integrates different types of data, such as the number of events, overall and insured losses, all elements required for our study.

As said before, our focus is on relevant floods occurred in five different countries, across three time periods. Through this selection, changes in the insurance diffusion can be evaluated by comparing values collected before and after Kyoto (1998) and Hyogo (2005) agreements.

In particular, we have developed our analysis differentiating two main losses: overall losses and insured losses. In this way, we use data that are homogeneous not only for the events we are considering but also for the effective significance of values.

As a final result, we can affirm that the International Agreements considered have a high importance for the well-functioning of the insurance markets since four countries out of five have registered positive variation in the diffusion of climate insurance and that three of them have positive double-digit differentials. In our research, the only "bad" example in that field is represented by China with a negative variation.

We can conclude that, as far as insurance systems are concerned, the International Environmental Agreements can be an effective means in promoting risk management and reduction strategies, such as insurance, in relation to the global purpose to share and transfer natural disasters economic consequences.

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ORAL

Risk assessment for coastal ecosystem services under changing climate and land use scenarios: Results from the SAVEMEDCOAST and TRITON projects

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Climate change is causing serious threats on natural and human systems worldwide. In particular, climate-related impacts will be especially relevant in coastal areas, where a dense interaction between terrestrial and marine systems occur. Located at the land-sea interface, coastal areas are dynamic environments in which natural and anthropogenic forcing interact at diverse temporal and spatial scales (e.g. waves, tides, storms, tectonic and physical processes, sediment transport, land use changes and touristic activities), modifying their geomorphological, physical and biological characteristics. Against this complex interplay, coastal managers and policy makers are increasingly calling for new integrated approaches and tools supporting the multi-scenario analysis of environmental risks arising from natural and anthropic stressors.

In order to support integrated coastal zone management (ICZM) and the preservation of ecosystems services in coastal areas, two different risk-based methodologies were developed allowing to identify, map and prioritize natural and human targets at higher risk from climate-related and human-induced hazards.

The first approach, developed in the frame of the SAVEMEDCOAST project for the coast of Italy, is a composite risk index designed to evaluate the potential risk of loss or degradation of ecosystem services due to coastal inundation. It supports the integration of heterogeneous information on i) hazard-prone areas potentially inundated by sea level rise and extreme water levels under a baseline and future RCP4.5 and RCP8.5 scenarios; (ii) exposure, including a classification of ecosystem services supplied by coastal areas (provisioning, regulation and maintenance, cultural); (iii) vulnerability, represented by indicators of physical and environmental susceptibility to flooding. The second approach, applied within the TRITON project in the coast of the Apulia region, combines Geographic Information System (GIS) and Bayesian Network (BN), exploiting functionalities offered by both methods to evaluate and spatially represent the probability (and related uncertainty) of coastal erosion risks against multiple 'what-if' scenarios, representing different coastal management measures (e.g. building of coastal artificial protection structures) and climate conditions (e.g. sea level rise, increase in extreme events).

Both methodologies provide a wide array of spatially resolved risk scenarios and indicators, representing valuable information to support robust decision-making and to provide the means for dynamic adaptive policy pathways in the context ICZM implementation and disaster risk reduction. The main operational steps of both methodologies and the applicability of results for risk management and adaptation planning are here presented and discussed.

POSTER

Assessing geomorphological threats from a changing alpine cryosphere: Little ice age glacial deposits and permafrost areas in the hazard maps of Trentino

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The alpine cryosphere is strongly affected by the current atmospheric warming and glacier shrinkage and permafrost thawing are two of the main climate-related effects. Since the end of the Little Ice Age (LIA, about 1850), the glaciers of the European Alps lost more than 50% of their surface and, during their retreat, they left large amounts of unconsolidated debris in the valleys and on the slopes (i.e. moraines and thick layers of deposits). At the same time, the warming and the resulting degradation of perennially frozen ground (permafrost) can seriously affect slope stability, and permafrost-related landforms such as rock glaciers can change their kinematic behaviour, showing an acceleration and in many cases a complete destabilization.

Concerning the glacial morphodynamics, the major geomorphological hazards are represented by debris and mud flow phenomena from unconsolidated till, mass wasting phenomena activated by the sustained melting of debris-covered ice (ice-cored moraines), and potential floods triggered by the sudden release of water from lakes or small water bodies dammed by unconsolidated till.

The climatically-driven degradation of permafrost in rock walls is probably one of the main triggers of recent, present and future rock falls and rock avalanches at high altitudes. Rock falls can involve human infrastructures and generate risks for mountaineering activity in the Alps, where many alpinists and hikers are present throughout the year. In most cases, rock glaciers do not represent serious hazards. However, their recent acceleration can lead to rock falls from their steep front and increase the occurrence of debris flows, which can affect alpine trails and cause damages to sensible infrastructures like cableways or buildings.

The province of Trento is a mountainous region located in the Eastern Italian Alps, where both glacial and periglacial processes are still active at high elevation. In this region, the spatial distribution of LIA and post-LIA glacial deposits was recently mapped, along with the reconstruction of the LIA glacier extent. The distribution of permafrost and rock glaciers in Trentino have been also investigated and mapped in detail, thanks to research activities carried out in the last decade. In addition, the dinamics of several permafrost creeping landforms is subject to long-term monitoring since 2001.

Recently, the administration of the province of Trento defined the criteria for building a new synthesis hazard map of its territory, and included the modern and LIA glaciers and their deposits as

potentially hazardous areas, as well as the areas affected by permafrost and covered by rock glaciers. For this reason, a regional-scale, detailed mapping of these features was required by the law.

In this work, we identified at the regional scale the areas of potential geomorphological hazard related to LIA and post LIA glacial deposits and to the distribution of permafrost and rock glaciers. Some relevant examples of potential hazards from glacial deposits and rock glacier dynamics are presented. The data collected in this work could be combined with other available spatial databases (e.g. ski resorts and alpine trails inventories) in order to investigate the interaction with human infrastructures. As a result, a better assessment and management of the areas under geomorphological risk could be achieved at the regional scale.

POSTER

Building community resilience against climate change: The "Atrapaniebla Comuneros" project in Peña Blanca, Chile

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Desertification, exacerbated by climate change, represents one of the greatest environmental challenges of our times (UNU-INWEH, 2007). In Chile it is estimated that the desert will advance from 0.4 to 1 km per year, having as main causes climatic changes that accentuate the aridity of the territory, as well as inadequate and persistent human activities, overgrazing and erosion. Facing this scenario people living in drylands must adapt. Adaptive capacity is defined by the IPCC (Intergovernmental Panel on Climate Change) as the ability of a system to adjust to climate change - including climate variability and extremes - to moderate potential damages, to take advantage of opportunities, or to cope with the consequences. Especially in areas where rainfall is becoming more and more scarce the adaptive capacity is important from a water harvesting point of view.

This work aims to analyse a project of water collection in a semi-arid area of Chile, where the worsening of climate has tangible consequences in particular for small rural communities strictly dependent on natural resources. Rural communities in Chile are very vulnerable to water scarcity due not only to decreasing rainfall but also to national water management (Codigo de Agua 1981): as water in Chile is considered a private good it is often in the hands of mining or agricultural companies that by law can use water without restrictions, thus leaving populations dry. The project analysed in this work is a Fog Harvesting project called "Atrapaniebla Comuneros" located in the agricultural community of Peña Blanca, Coquimbo region (central-northern Chile). Given this geographical and social context, fog harvesting is a very valuable water resource. The collection of fog takes place passively, i.e. without the need for energy or machinery, allowing the spread of this technology even in hostile and isolated places. In fact, a perforated mesh is placed perpendicularly to the main wind direction to capture the water trapped in the fog when the air passes through it. Since there are no

significant technical concerns, what is crucial is to understand where this technology is effective. Advection fog is the ideal fog type to catch. Factors such as high pressure, wind circulation, sea currents and topography must be considered to identify which areas are subject to this fog type. Central northern coast of Chile, thanks to its geographical conformation, meets all the conditions for advection fog formation and its harvesting. A specific study on the performance of fog water collected with different fog-meshes is reported thanks to the collaboration with the Chilean foundation “Un Alto en el Desierto”. The study consists in the creation of a database on the water collected by four Standard Fog Collectors (SFCs), to investigate fog potential of the place, the efficiency of different mesh materials, and the correlation between fog collection and other weather phenomena. The potential and limits of this technology have been evaluated to draw up proposals for the development of the project. Three proposals to cope with climate change are presented, striving to make the most of this unconventional water resource. The proposals respond directly to the needs expressed by the community of Pena Blanca on the future use of the Atrapaniebla Comuneros project: the "comuneros" (inhabitants) expressed a commitment to greater involvement in the project with the possibility of creating jobs related to it. A multi-level network of bodies for each proposal has been identified to provide a framework for cooperation and support to ensure their effective implementation.

Ultimately, the work seeks to demonstrate how fog harvesting - an adaptive technique that already occurs in nature allowing plants to grow in hostile environments - has the same strengthening effect for communities: fog water proves to be a valuable contribution to drylands and to boost rural areas.

POSTER

Mapping wildfire risk in Lebanon: Challenging a stepwise approach for effective purposes

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Forests in Lebanon are a unique feature of the Eastern Mediterranean; they comprise a variety of broadleaf and conifer trees covering the mountains in patches. Increasingly, Lebanese forests are exposed to degradation as a result of recurrent fires, improper management, outdated laws, poor policy enforcement, and climate change. During the past two decades, fires have been especially damaging Lebanese forest landscapes in Lebanon.

In this context, wildfire risk assessment is an essential component of wildfire management by supporting fire prevention measures and risk mitigations. At the same time, appropriate fire vulnerability assessments are needed to be investigated and assessed under climate change

conditions. This helps in assessing fire impacts and prioritizing adaptation options and development plans.

According to the Intergovernmental Panel on Climate Change (IPCC) fifth assessment report (AR5) risk concept, risk is the interaction of vulnerability (e.g., propensity or predisposition to be adversely affected), exposure (e.g., presence of people, livelihoods, species or ecosystems, environmental functions, services, resources, infrastructure, socio-economic and cultural assets in places and settings that could be adversely affected), and hazard (e.g., climate-related physical events, their trends and their physical impacts).

In this study, the main objective was to develop a forest fire risk assessment and mapping model under actual and future climatic conditions (i.e., in the context of the IPCC AR5 framework) and in function of hazard, vulnerability and exposure. The study area comprised the Beirut river watershed characterized by a dense vegetation cover and increased fire hazard.

The methodology of work involved a stepwise approach (i.e., impact chain) to evaluate the following main components: exposure, sensitivity, hazard and adaptive capacity in the context of the IPCC AR5.

Multi-sources spatial data on natural, human, infrastructure, economic and financial factors were collected and integrated to create composite indices, representing each of the evaluated component and expressed in multiple dimensions. In addition, 87 municipalities and 15 civil defense centers (i.e., fire-fighting stations) were also surveyed to acquire data concerning the adaptive capacity components. Aggregating and weighing the different components through the impact chain resulted in the final risk assessment for the whole Lebanon (provinces level) and for the study area.

Overall, this work highlighted the potential of the proposed approach to visualize the main vulnerable areas to fire risk and possible gaps in adaptation to fire risk. This is expected to help in identifying and selecting future measures that could support the development of fire risk management plans and strategies taking into account variations in climatic conditions.

Adaptation planning and sustainability in Hungary

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Climate change is one of the most important challenges of our time, and our knowledge regarding its consequences is improving rapidly. In addition to international treaties and accords, an increasing number of actors from science, research and technology are calling attention to potential solutions. The expected impacts of climate change are difficult to forecast with certainty, creating challenges for the analysis of the capacity and willingness to adapt in different social and economic systems. There are two three-pronged sets of objectives in climate change and sustainability. On the one hand, the dimensions of the economy, society and the environment must be harmonized, and on the other hand, there are the possible measures (adaptation, mitigation, climate consciousness). Adaptation

and sustainability are closely interconnected and reinforce each other. The possible effects of climate change can be felt on our own skin today and will not be change in the future, i.e. the expected impacts will reach everyone from the most vulnerable social groups, sectors and communities to the most resilient ones. Impacts, especially with regard to the increase in the frequency and intensity of extreme weather events, can be mostly interpreted on the local level, thus it is strongly advisable for local decision makers to prepare for these phenomena.

The impacts of climate change hinder and complicate the transition toward sustainability in the preparation for expected impacts (human resources), prevention (increasing the site of green areas, action plans, stockpiling pharmaceuticals, etc.), management and recovery (after the impact has occurred, financial, technical, institutional, etc. conditions). Climate change can also have a fundamental influence on the local quality of life, income, health etc., which make up the basis for a liveable settlements. The core of an adaptation strategy includes making sure that risks can be managed, their consequences minimized, providing a clear framework of responsibilities and providing the necessary financial and technical conditions.

Among several different pathways, climate planning at the local level can be a key to foster also the practical implementation of sustainability. Recent research is focusing on adaptation planning on local level evaluating the recent status of adaptation strategies, tools and practices in Hungary. The mapping of adaptation practices in Hungary is as yet incomplete, making further analysis and classification problematic. National level initiatives are the most documented. On the national level, adaptation analyses available in literature are mostly made for specific sectors, such as tourism, transport and energy management, especially in buildings. Hungarian case studies with a regional approach can also be found. Studies also exist on settlement level programs, calling attention to their shortcomings and potential for improvement. The common theme in available analyses is a tendency towards monitoring, in other words, the planning and evaluation of adaptation based on indicators. Available data on settlement level practices is scarce. The number of municipalities active in this field can be somewhat roughly approximated through data on membership in organizations dealing with climate change. In general, it can be stated adaptation initiatives in Hungary are mostly initiated by the government or local municipalities. These institutions command the necessary financial background and expertise, and can organize activities locally, enabling long-term, proactive planning. However, experiences show that the necessary knowledge and financial tools are only available to larger municipalities and cities. In smaller communities, dealing with climate change is possible if external financial frameworks and tenders are available, or if the commitment of local professional is sufficient to sustain an active community that is prepared to act without external financial support. The opportunities for local action on the part of municipalities may be further limited by the availability of human resources and know-how, making improved access to information crucial. This may be achieved by trainings, sharing information, or providing access to databases such as the National Adaptation Geo-information System (NAGiS).

This examination is focusing on those settlements which are members of the Climate Friendly Settlement Association in Hungary. The Climate Friendly Settlement Association was formed in 2009 on the initiative of some enthusiastic, proactive mayor and expert to be able to deal with the possible effects of climate change. The Association aims to create an alliance where members see the key to a sustainable and climate-friendly world in creating a more harmonious relationship between man

and nature. The main purpose of this paper is to make step forward in the assessment of the development of local climate planning in Hungary, to identify and discuss the main shortcomings of the examined plans. Adaptation to climate change is a collaborative undertaking, requiring cooperation on different levels of society, politics and governance. At present, the adaptation strategy is usually part of the climate strategy, and its objective is to increase resilience to expected impacts, by shifting the emphasis from prevention and control to learning to live with an ever-changing, and sometimes dangerous environment.

Climate services and their potential to support adaptation and risk management

ORAL

Evaluation of meteorological information and services: A case study of Taiwan's agricultural sector

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In the conventional meteorological service supply decision-making process, since these services are public goods, the specific needs of each department and the economic and social benefits of these services are usually not considered. Such a process is not in line with the public service system's pursuit of policy efficiency and underestimates the economic and social benefits that meteorological information services can bring to society. In addition, the lack of such reference information can easily lead to bias in the investment in innovative services or technologies in meteorological information. Therefore, the economic value assessment of meteorological information and related services has become an important task for decision-making in recent years. The meteorological information services have a public goods nature in Taiwan and have lacked a complete economic analysis (especially cost-benefit analysis). This has led to an inability to explore whether current meteorological information services can bring better benefits to society and weaken the incentives of innovation of meteorological services in different fields. Therefore, when constructing a decision support system based on economic and social benefit needs, it is necessary to consider the changes in the value derived from meteorological information and related services in different fields. Based

on the background mentioned above, this paper takes Taiwan's agricultural sector as the research target and uses the contingent valuation method (CVM) to evaluate the willingness to pay for the current meteorological information services of "Core Farmers" in Taiwan. Based on the WTP results, the total economic value of application of current meteorological information services in Taiwan can be estimated further. According to the preliminary empirical results, the median value of annual WTP of Core Farmers in Taiwan is about 123.7 $US and the total economic value of meteorological information services of agriculture sector in Taiwan is estimated as $11.8 to $19.3 million annually.

ORAL

Turning climate data into value for productive activities in the users perspective

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ENEA

Climate variability and it impacts has recently received an increasing amount of interest within and well beyond the international climate science community, reaching policy makers, local administrations and stakeholders.

Increasing the quality, reliability and detail of climate information for societal use has become a major challenge in regions whose economic growth and social development crucially depend on adaptation to climate variability and change.

In the last years several initiatives at European (FP7, H2020, JPI, COPERNICUS) and International level (WMO-Global Framework Climate Services GFCS…) are supporting the development of climate services, with the ambition of turning the huge amount of climate data actually available into tailored, accessible and usable information to be included in the end-users decisional process

Climate services must focus on very different productive sectors and on their different requirements, in terms of targeted climate information, forecast time horizon and acceptable level of uncertainty. It is not enough to produce only meteorological information in the services, but it is especially needed to quantify vulnerabilities to climate variability within the sectors and come up with appropriate adaptation solutions.

To this regard, climate services do not only create user-relevant climate information, but also stimulate the need to quantify vulnerabilities and come up with appropriate adaptation solutions that can be applied in practice.

The terminology adopted is pivotal to the successful co-development of climate services. However, rather than sticking to the technical concepts used by scientists, it is imperative that such terminology is discussed and co-developed between users and scientists to allow a shared understanding of the key concepts relevant to users' decision-making.

Here we present recent activities research developed by Climate & Impact Modeling Lab in ENEA in the framework H2020 projects MED-GOLD, S2S4E, SECLI-FIRM devoted to fill this gap in the development of prototype climate services particularly for agriculture and energy sector.

ORAL

Statistical tools for Mediterranean seasonal forecast

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Seasonal forecasts are essential tools to offer early-warning decision support, that can help to reduce the socio-economics related risk associated with anomalous events. Advances in statistical prediction are often linked with the enhance of understanding that usually leads to improve dynamical forecast. Thereby, both approaches are frequently combined in order to increase the robustness of the forecast.

MEDSCOPE project (MEDiterranean Services Chain based On climate PrEdictions) aims to improve the predictability of climate predictions from seasonal to decadal timescales over the Mediterranean area. One of the main lines of re- search of MEDSCOPE is to improve the extraction of relevant information from climate prediction systems and assess their robustness and uncertainty through a toolbox "CSTools". In this Toolbox, we are developing methodologies to extract usable information from predictions, producing tools for prediction verification, calibration, downscaling, ensemble member combination and selection that will be publicly released in a R-package and a Gitlab webpage.

Here we present the CMCC contribution to CSTools using two case studies of seasonal forecast: Spain and Italy. We focus on dynamical based method for Bias Correction, Statistical Downscaling and Orographic Downscaling, and tools for visualization and forecast verification. The dynamical forecast of precipitation is provided by the new Copernicus C3S Seasonal Prediction System.

ORAL

Isolating the role of end-user behavior in the assessment of seasonal forecast value

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Recent increase in model resolutions, improvement in initialization procedures, and more accurate representation of large-scale hydro-meteorological processes contributed in greatly advancing the accuracy of weather and climate services. State-of-the-art meteorological and hydrological forecast products are becoming more and more skillful over the seasonal and longer timescales and thus potentially more valuable for informing multi-sector strategic decisions. Irrigated agriculture is one of these sectors and climate services can improve crop choices and irrigation scheduling decisions, which strongly depend on the expected hydro-meteorological conditions. In this context, forecast modelling accuracy is important but the associated value is filtered by the way decision makers use the provided information.

In this work, we contribute a novel framework to evaluate the value of weather and climate services by extending traditional forecast quality assessment methods with estimates of the potential economic benefit of the forecasts to the end-user. We also explore the sensitivity of the potential economic benefit on both the model set up and decision maker behavioral factors. The approach is demonstrated on the Lake Como system (Italy), a regulated lake primarily operated for flood protection and irrigation supply. The analysis is run over the time period 1996 to 2008, including a fairly balanced number of normal, wet, and dry agricultural seasons. Our framework relies on an integrated modeling chain composed of three building blocks: (1) bias-adjusted ECMWF System 4 seasonal meteorological forecasts are used as input to the continentally-calibrated E-HYPE hydrological model; (2) predicted lake inflows are then used for conditioning the daily lake operations; (3) the resulting lake releases finally feed an agricultural model to estimate the net profit of the farmers in the downstream irrigation district.

Results suggest that, on average, informing the Lake Como operations based on E-HYPE hydrological forecasts allows gaining about 1% of the farmers' profit with respect to a baseline solution not informed by any forecast. This gain rises up to about 15% during intense drought episodes. Moreover, our analysis suggests that this value can be largely attributed to the hydrological model and its initial conditions, while the role of meteorological forcing emerges only during dry seasons. Lastly, our results show a high sensitivity to behavioral factors capturing decision maker's perception of risk and uncertainty, with the estimated forecast value being potentially undermined if end-users are not able to properly extract the most valuable information from the forecast ensemble.

ORAL

Clim'Ability Diag, web tool for a self-diagnostic of the sensitivity of a company to climate change

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Clim'Ability Diag is a climate service developed in the context of an INTERREG project named Clim'Ability, which ended in June 2019. The aim of this project was to help companies of the upper Rhine region to adapt to climate change.

Around 150 companies have been interviewed during the project, working in different sectors, with a qualitative survey to evaluate their sensitivities/vulnerabilities to climate events and climate change. Case studies were realized, on the forest and wood sector, logistics, energy, and middle-height mountain tourism. A toolbox for companies was produced, with different tools and resources.

Based on the analysis of the interviews, Clim'Ability Diag is a simple web tool to get a diagnostic of the sensitivity of your company to climate change. Developed by Météo France, it is available in French, English and German. Clim'Ability Diag uses the NACE classification of companies and propose to enter an evaluation of the impacts of some climate hazards on your activity. 25 meteorological and climatological hazards or events are proposed, for 9 functions of the company, like production process, human resources or sales.

Once this impact grid is entered for the current situation, a diagnostic is given for the evolution in future climate. Different possibilities of elaborating this diagnostic are available : global or partial, either in a table or in a graphic form, and can be edited in a pdf file. Elements of information about the evolution of climate hazards in the context of climate change are also proposed, using those achieved by the project in its climate projections analysis.

Clim'Ability Diag was tested with around 50 companies, and improved with their comments.

It takes around 20 minutes to be done, at the shortest, but more when used for a discussion with several people. They generally were interested by the tool, that gives them a very synthetic vision of the evolution of their sensitivity to climate, and allows them, when made with several stakeholders, to discuss and deepen the problems and the needs met by the company in the climate change context.

Web access : http://www.diag-clim-ability.eu/

ORAL

Valuing climate services: Evidences from the CLARA project

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Since the launch of the Global Framework for Climate Services (GFCS) in September 2009, there has been a growing interest in promoting the use of climate services in support of climate risk management in agriculture, disaster risk reduction, health, water management, energy and a variety of other vulnerable sectors. GFCS mission "to strengthen the production, availability, delivery and application of science-based climate prediction and services" is far from been completed. Despite recognizing that climate services constitute an important component of the climate adaptation agenda, there has been little progress in providing evidence on the value added of tailored climate information in the hands of users. Nonetheless, monitoring and evaluation of the value of specific services remains a significant challenge.

Generally, climate services are defined as decision-making support tools, based on a process of transforming climate information into relevant advisory services that assist decision-making by individuals and organizations of a society. Therefore, a climate service provides tailored, salient and usable advisories for policy-makers and vulnerable communities, based on available climate information. Assessing the value of climate services responds to persistent requests from donors and investors that are engaged in the co-delivery process. Engagement of the private sector requires demonstrating profitability of investments and their potential positive impact. Nevertheless, assessing the value of climate services is crucial for the public sector to charge them.

This presentation shows outcomes from the CLARA project. Here, we present the maximum value of a selection of climate services (based on seasonal forecasts as well as climate projections) in different application domains (i.e. agriculture, water management and renewable energy) for different users (i.e. public and private). Setting up a specific case study for each service, we want to assess quantitatively their maximum potential value for specific final users as a way to foster adoption of these climate services into operational decisions. Since CLARA- enabled services are innovative and at the developmental stage, the exercise is retrospective and assesses only the maximum value they can reach in a specific context in a reference time period. We acknowledge that this analysis does not consider the skill of the climate service as a fundamental supply- side characteristic, but this information could be retrieved only ex post when the service will be tested in the future. However, demonstrating the maximum value is relevant at the beginning of the co-production process as an indicator of potential gains and remuneration for initial investments as well as a target to reach in the development of the service itself.

POSTER

Evaluation of rainfall seasonal forecast: An operational case study

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The information stored in seasonal forecasts mostly come from the slowly evolving components of the climate system, in particular the ocean, whose surface and deep temperature anomalies are able to impact on precipitation in the following months. In particular, the state of the equatorial Pacific conveys local and remote long-range predictability, due to the strong air-sea coupling that carries information in several regions of the globe. As a consequence, the regions teleconnected to equatorial Pacific (ENSO region) through air-sea interactions have larger predictability. In general, ocean and tropical regions are more predictable, thus the models' predictive skill is higher in this part of the globe. However, mid-latitudes continental regions may benefit of another source of predictability not only bases on ENSO teleconnection but also on the Siberian snow cover state, and the PDO. Due to that it is crucial to assess the predictive skills of the models in different regions of the world.

Here, we describe the analysis and verification performed with a dynamical Multi-Model Ensemble for an operational case study with energy purposes. Results are displayed for the macro-areas covered by the basins of interest of the company in Argentina, Chile, Brazil, Colombia, Peru, Italy and Spain. To assess the forecast performance, we need to verify whether the predicted event has actually occurred, then four possible combinations between the forecast and verification can be identified for each of the events. Different skill scores are also calculated.

POSTER

Innovation in agriculture risk management

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Climate changes in the last 30 years have led to profound changes in the management of the farm with a consequent increase in production problems related to frost risk, particularly in sensitive areas such as Trentino. This is why it is essential to know the risk that the farmer is running. Risk strongly

connected with the productive area. To limit this problem Co.Di.Pr.A. - Condifesa di Trento has presented an PEI (C & A) as leader that seeks to mitigate climate change through the implementation of good risk management, testing in the field of passive defense methodologies and proposing innovative systems of passive defense, like IST. Furthermore, through the PEI ITA2.0, the Condifesa is building a platform for the efficient management of the entire insurance flow, to reduce the bureaucratic burden on the farmer and to make the agricultural system more efficient.

Co.Di.Pr.A. associates over 95% of Trentino farmers and, thanks to the network of contacts, manages to sensitize the agricultural world through targeted communication actions.

POSTER

High-resolution gridded datasets of near-surface variables for climate applications

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Reanalysis datasets are gridded climate datasets obtained through numerical models in combination with observed data. Those datasets represent the recent climate and they are available with grid spacings of a few tenths of kilometers on a global scale.

Traditionally, in-situ observations of near-surface temperature and precipitation are used to create observational gridded datasets with grid spacing of few kilometers on a regional level. This is the case at the Norwegian meteorological institute (MET Norway), where observational gridded datasets of daily-aggregated temperature and precipitation have been produced routinely over Scandinavia covering the time period 1957-2019.

This contribution focuses on the ongoing work aiming at comparing climate indices derived from reanalyses against those derived from observational gridded datasets over the complex terrain of the Scandinavian peninsula. The newest global reanalysis dataset ERA5 produced by the European Centre for Medium-Range Weather Forecasts (ECMWF) is considered. Two sets of indices that follow the definitions recommended by the CCl/CLIVAR/JCOMM Expert Team on Climate Change Detection and Indices (ETCCDI) are currently under production for: ERA5 and MET Norway's observational datasets. Since we are considering two independent data sources, the comparison of their climate indices is of particular interest. The outcome of our investigation will be used for e.g. climate change assessments.

POSTER

Cost or loss? Assessing skill and potential value of cold-spell subseasonal forecasts

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Producing probabilistic subseasonal forecasts of extreme events up to six weeks in advance is crucial for many economic sectors, such as energy, transport and agriculture. In agribusiness, this time-scale is particularly critical because it allows for mitigation strategies to be adopted for counteracting weather hazards and take advantage of opportunities. For example, spring frosts are detrimental for many nut trees, resulting in dramatic losses at harvest time. To explore subseasonal forecast quality in boreal spring, identified as a sensitive time of the year by agribusiness end-users, we build a multi model ensemble using four forecast systems involved in the Subseasonal-to-Seasonal (S2S) Prediction Project. Near-surface temperature are used in a multi-model approach to analyze cold spell predictions in southern coastal Black Sea, an area that is a global leader in the production of hazelnuts. When analyzed at global scale, the multi-system ensemble forecasts for near-surface temperature is better than climatology for several regions, even 5-6 weeks in advance; however, in coastal Black Sea skill is low after the second forecast week. Nevertheless, when cold spell are predicted instead of temperatures, skill improves for the region, and the forecasts prove to contain potentially useful information to stakeholders willing to put mitigation plans into effect. Using a cost-loss model for the first time in this context, we show the added value of having such a subseasonal forecast system instead of a business-as-usual strategy, not only for predictions released one to two weeks ahead of the cold spell event, but also at longer lead times.

POSTER

Evaluation of Climate Services and Risks Management: the Case of Agriculture

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Climate change has been intensifying the extreme weather which makes the demand of weather information with high resolution and frequency become more and more imperative. Various adaptation options are researched, verified or promoted in agriculture sector, such as strengthening

plants adapted ability through improving varieties, adjusting crop, farm and value-chain management, or changing the operated production systems. No matter which kind of adaptation will be adopted, they all need a specific and customized weather forecast. The better weather information is supplied the more precisely adaptation decision will be made and less damage will happen. That is where the value of climate services come from.

Generating weather information, nevertheless, involves a vast infrastructure of space and terrestrial-based weather observations, numerical weather models, and scientific development that require significant investment and coordination, and are necessarily unprofitable for the government to provide. On the other hand, the private weather industry is also compelling need for making progress in weather forecasts. For example, an expansion of commercially available data from private industries could improve both highly localized weather monitoring and the initialization of global weather models. In Taiwan, however, the incentive is too insufficient to attract people into investing in private weather industry because the value of climate services had never been measured specifically.

Hence, this paper is trying to evaluate climate services and illustrate how it could assist the risk manager. The main contribution is hopefully boosting the development in related industries and enhancing the weather forecasts accuracy by figuring out the real value in climate services, and rise up the welfare to farmers by improving the weather forecasts.

In most researches, willing to pay is the most popular approach to measure the non-market value, relative to such a micro-foundation and direct effect counted method, we applied a macro-foundation process. First, a Tobit model is established to estimate damage function to measure the direct value of weather information, and then a computable general equilibrium model is adopted to access the indirect value induced by damage industries.

We applied these approaches to the case of agriculture (split to 6 kinds of aggregated plants to fit input-output table categories) in Taiwan, we found that the agriculture lost 427 million US dollar every year in average because of weather events, the lost accounted 2% of agricultural product value and induced 0.57% GDP loss caused by declining production value of downstream industries (such as food and beverage industries) and decreasing household expenditure under higher consumption price. If the weather events get worse and worse in the future under climate change, the loss of agriculture product value and GDP will expand to 5.9% and 1.97%.

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