Use of a Weather Generator for analysis of projections of future daily temperature and its validation with climate change indices

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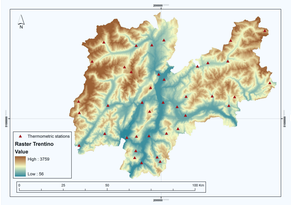
Abstract

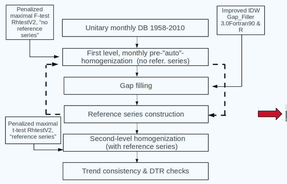
High temporal resolution climate change scenarios are required in the evaluation of the impacts of climate change on agricultural management, energy production, and water management. In this work, a Weather Generator technique was used for downscaling climate change scenarios for temperature. An R package - RMAWGEN - was developed aiming to generate synthetic daily weather conditions by using the theory of vectorial auto-regressive models (see details in RMAWGEN documentation). Here, an application is presented that uses a dataset with daily temperature time series recorded at 41 different sites of the Alpine Trentino region (Italy) for the period 1958-2010. Temperature time series were pre-processed to fill missing values and to remove inhomogeneities. Several climatic indices, selected from the list recommended by the World Meteorological Organization Commission for Climatology (WMO-CCL), were taken into account and their time trends within the time series were analyzed. Each index was applied to both observed data and to synthetic time series produced by the Weather Generator, over the thirty year reference period 1981-2010, in order to validate the model. Climate projections were statistically downscaled for a selection of sites for the two 30-year periods 2021-2050 and 2071-2099 of the European project Ensembles multi-model output (scenario A1B).

Pre-processing data

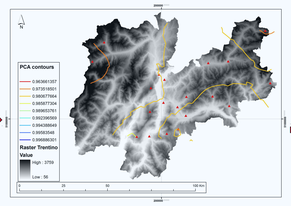
Raw temperature data



Homogenenization and Gap Filling procedure



Patterns of temperature field as the first EOF mode



Stations considered in this study

Station name	ID	Elevation [m]
LEVICO	T0010	502
PIEVE TESINO	T0018	775
SANT'ORSOLA	T0139	930
TRENTO	T0129	312

Time series of raw temperature data, affected by inhomogenities and gaps, coming from 41 weather stations in Trentino

Homogenenization - Gap Filling procedure

Processed data. Only stations that have worked for at least 90% of the period 1958-2010

PCA analysis

map identifying 4 areas of the variability field of temperature data

Data reduction: only **4 stations** considered in this study

RMAWGEN application - Validation

RMAWGEN – Multi-Site Autoregressive Weather Generator

Auto-Regressive Model (VAR(K, p)):

$$x_t = A_1 \cdot x_{t-1} + \ldots + A_p \cdot x_{t-p} + C \cdot d_t + u_t$$

where x_t (endogenous variable) is a **K**-dimensional vector representing the set of weather variables generated at day ***t*** by the model, d_t (composed by exogenous variables) is a set of known **K**-dimensional processes, ***A*** and ***C*** are the coefficients of matrices, u_t is the VAR residual and ***p*** is the autoregression order

More details can be found at **RMAWGEN: a software project for a daily Multi-Site Weather Generator with R**

HS3.3 – Poster session on Open Source Computing in Hydrology /Wed, 25 April, 17:30-19:00 / A138

Validation procedure:

- period: 1981-2010;
- 30 time series generated by RMAWGEN procedure with different values of ***p***;
- climatic indices calculation with generated series;
- comparison of index series distribution (generated vs. observed, 1981-2010) by Kolmogorov-Smirnov and Wilcoxon-Mann-Whitney statistic tests.

Kolmogorov - Smirnov

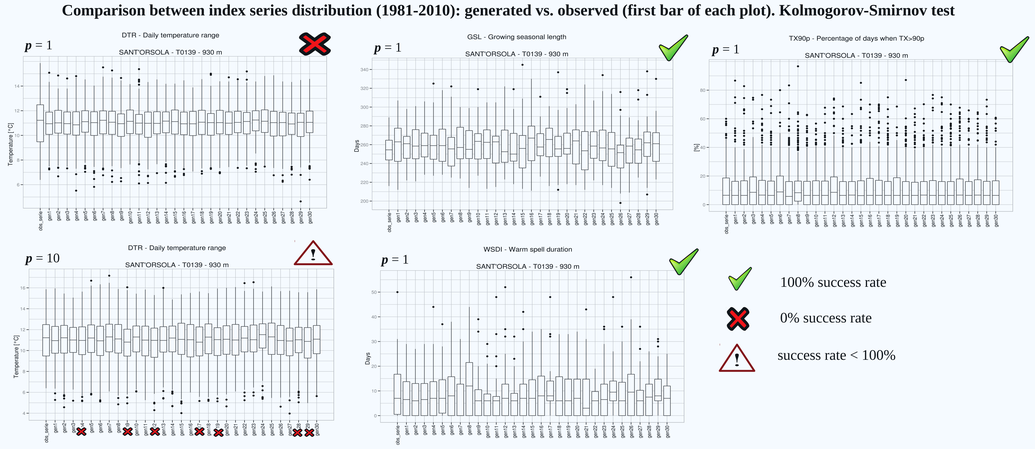
	p = 1		*p* = 3		*p* = 5		*p* = 10	
	T0129	T0139	T0129	T0139	T0129	T0139	T0129	T0139
DTR	0%	0%	10%	47%	40%	80%	77%	93%
GSL	97%	100%	100%	100%	93%	100%	100%	100%
TX90p	93%	100%	90%	100%	97%	100%	93%	100%
WSDI	97%	100%	93%	100%	97%	100%	93%	100%

Wilcoxon – Mann – Whitney

	p = 1		*p* = 3		*p* = 5		*p* = 10	
	T0129	T0139	T0129	T0139	T0129	T0139	T0129	T0139
DTR	93%	100%	97%	100%	97%	100%	93%	97%
GSL	93%	100%	90%	93%	90%	100%	93%	97%
TX90p	90%	100%	87%	100%	97%	100%	97%	100%
WSDI	97%	100%	93%	83%	87%	87%	90%	83%

success rate to statistical tests of generate indices series for different value of ***p*** **(autocorrelation order)**

Comparison between index series distribution (1981-2010): generated vs. observed (first bar of each plot). Kolmogorov-Smirnov test



100% success rate

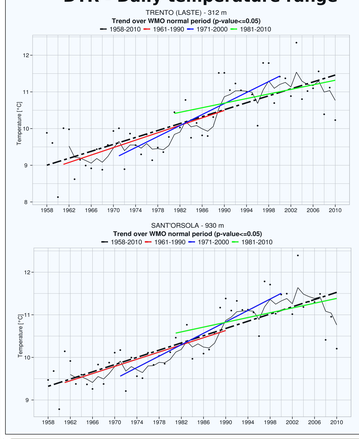
0% success rate

success rate < 100%

Climatic change index

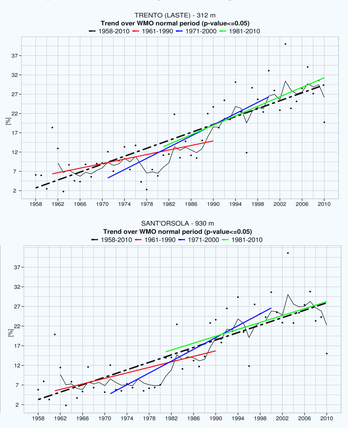
In this study the **climdex.pcic package** was used to obtain the climatic extremes indices following methodologies of Zhang et al. (2005) and Haylock et al. (2006). This packages provides PCIC's implementation of RClimdex 1.0 software developed by Zhang and Yang (2004) at the Canadian Meteorological Service. It provides 27 indices in total (including temperature and precipitation indices). However, only 4 indices based on air temperature data were chosen for discussion here:

DTR - Daily temperature range

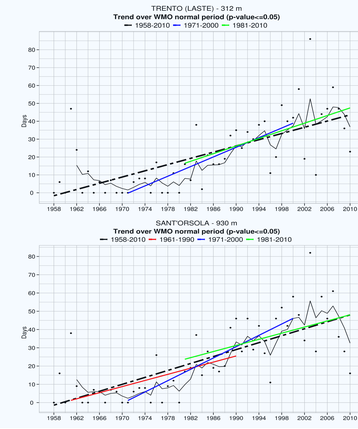


GSL - Growing season length

TX90p - Percentage of days when TX > 90p

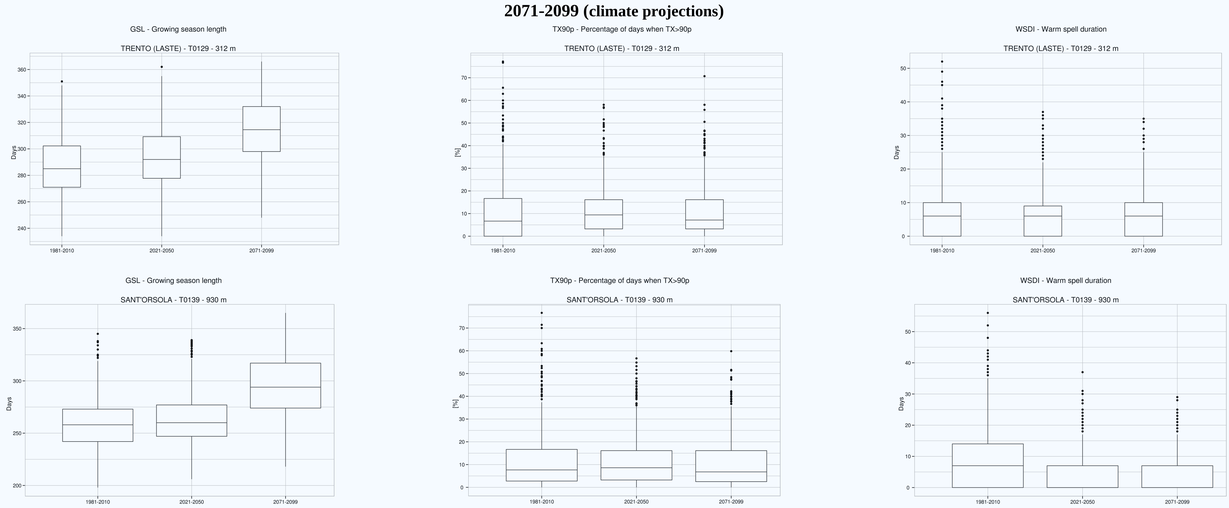


WSDI - Warm spell duration



Results

Climate index distribution of series generated with RMAWGEN: 30-year periods 1981-2010 (climatology from instrumental series), 2021-2050 and 2071-2099 (climate projections)



Conclusion and Future developments

- Good results for GSL, TX90p and WSDI indices with autoregression order ***p*** = 1;
- Good results for DTR index with autoregression order ***p*** = 10 for K-S test;
- RMAWGEN is a good tool for the assessment of climatic change for future projections by use of these climatic change indices .

- No full success rate for DTR with K-S test;
- Further improvement of RMAWGEN procedure.

References

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