Markus Neteler

Joint work with
Metz, M.; Rocchini, D.; Marcantonio, M.; Delucchi, L.;
Anfora, G.; Rosà, R.; Rizzoli, A.

Assessing the distribution of disease vectors and fruit crop pests from satellite in GRASS GIS 7

FOSS4G 2014, Portland (OR), USA
8 - 13 Sept 2014

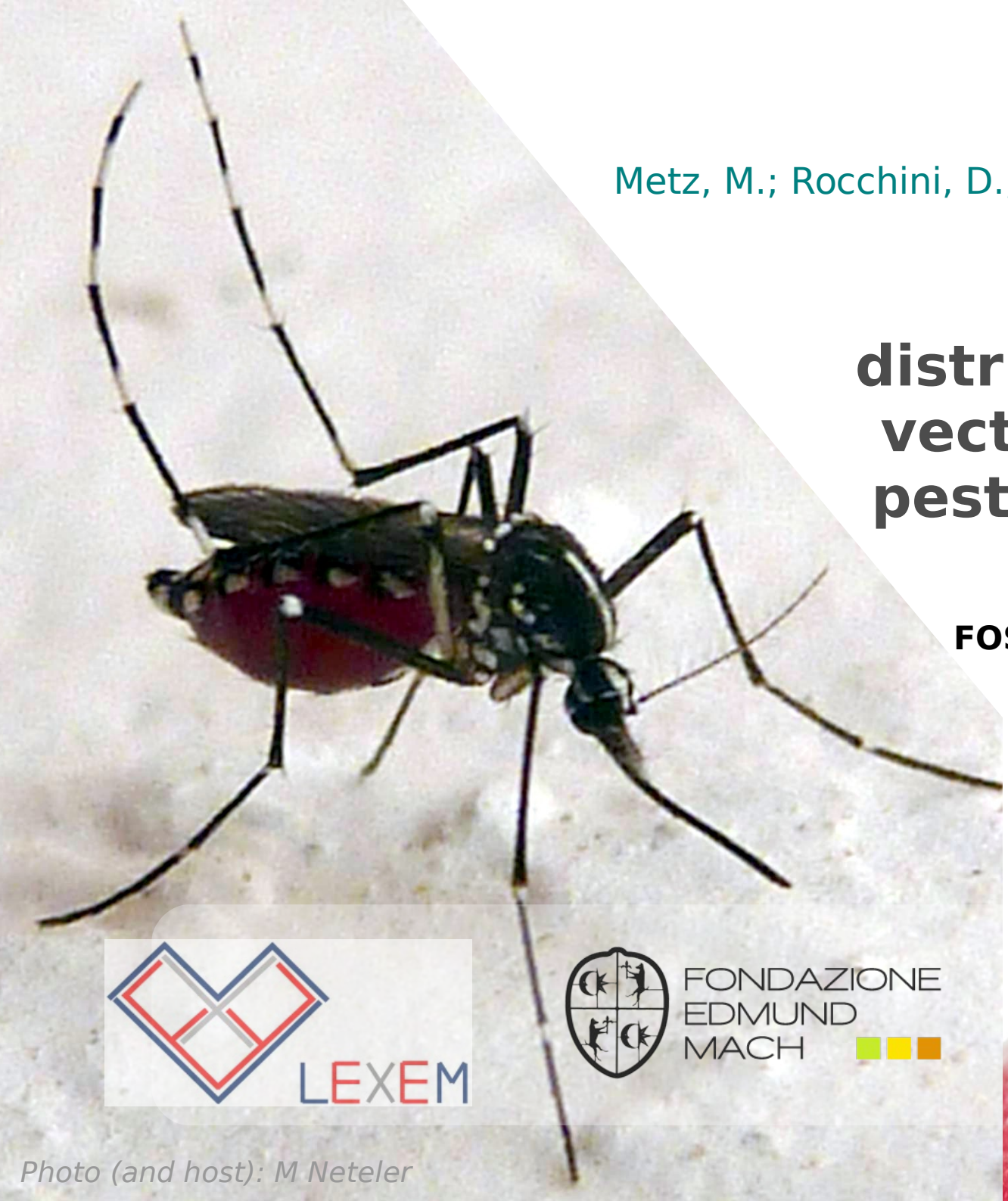


Photo (and host): M Neteler

Fondazione Edmund Mach, Trento, Italy

S. Michele all'Adige

- **Founded 1874** as IASMA - Istituto Agrario San Michele all'Adige (north of Trento, Italy)
- Research Centre + Tech. Transfer Center + highschool, ~ 800 staff
- … of those **350 staff in research** (Environmental research, Agro-Genetic research, Food safety)

PGIS: http://gis.cri.fmach.it

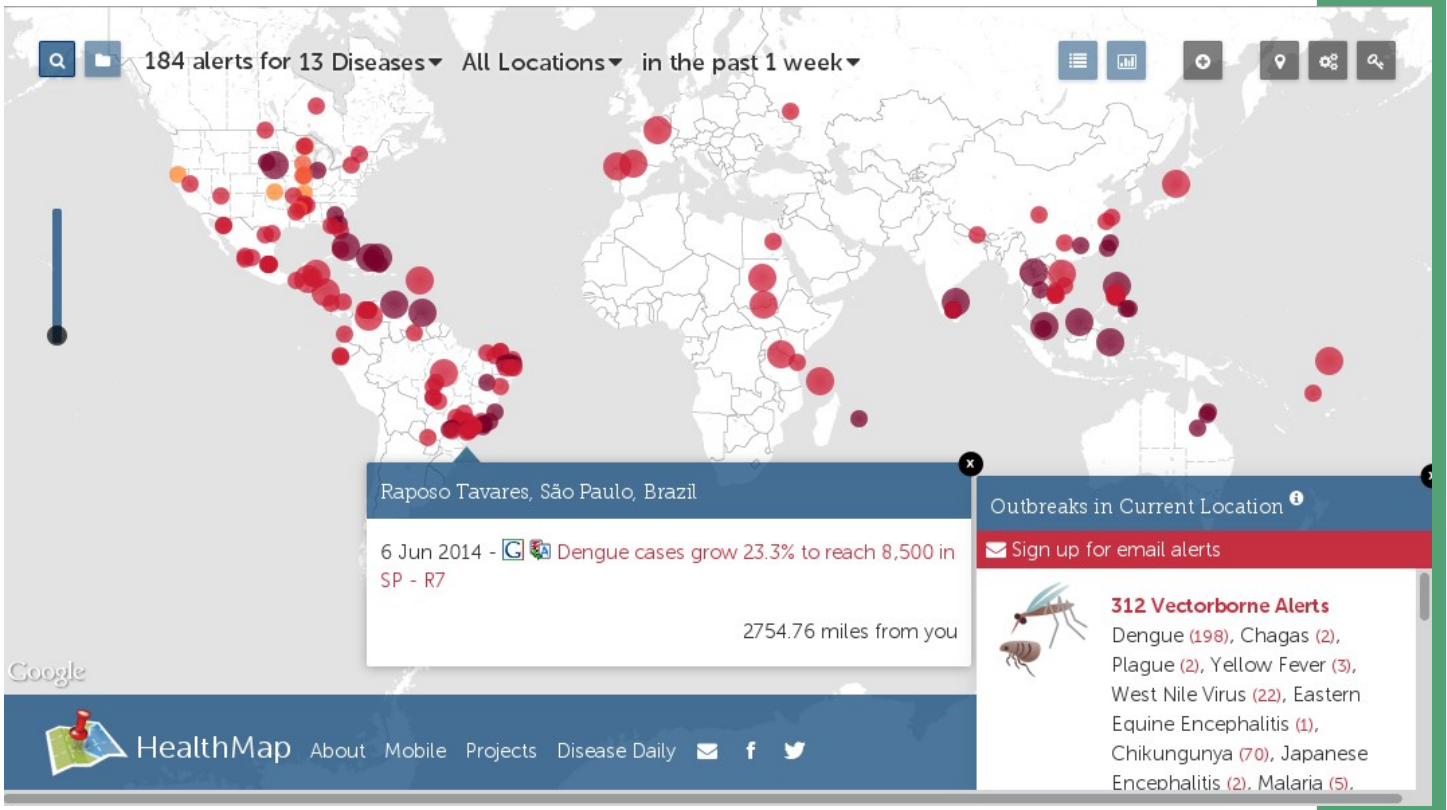
Challenge 1: Emerging infectious diseases

Focus on **zoonotic diseases**

- transmitted from animals to humans, usually by a **vector** (e.g., ticks, mosquitoes)
- reservoir hosts: **wildlife** and **domestic animals**
- zoonoses involve all types of **agents** (bacteria, parasites, viruses and others)

Zoonotic diseases cause **major health problems** in many countries.

They are driven by environmental and pathogen **changes** as well as political and cultural changes.



http://healthmap.org/en/

Infections causing also “hidden” problems …

NATURE CLIMATE CHANGE | VOL 3 | MAY 2013 | www.nature.com/natureclimatechange

COMMENTARY:

Blood supply under threat

Jan C. Semenza and Dragoslav Domanović

Europe should take action to prevent contamination of blood products by emerging infectious diseases as the climate warms.

The circulation of safe blood products in Europe is threatened by the recent arrival and dispersal of tropical pathogens commonly associated with warmer temperatures. Contamination of blood products from donors infected with emerging infectious diseases (EIDs) represents a significant threat to the blood supply.

The convergence of infectious disease drivers, such as climate change and globalization, has created conditions favourable to EIDs[1,2]. Europe is now more connected than ever to global EID hotspots and provides conducive epidemiological conditions for disease outbreaks[3]. The spread of insect vectors through

including collection, testing, processing, storage and distribution of blood and blood components. The long-term safety, sustainability and future expansion of the blood supply in Europe is at stake.

The European Centre for Disease Prevention and Control (ECDC) has elicited two expert assessments to prioritize the EID risk for the blood supply that is related to climate change. The first assessment ranked EID threats from climate change[8]; the second prioritizes pressing infectious disease threats to substances of human origin (for example, blood, cells, tissues or organs) in the European Union[9].

Merging these two lists of priorities sheds light on the potential threat level

its range in Europe — particularly in Mediterranean countries — in part due to conducive environmental and climatic conditions[2] (Fig. 2). Over 1,000 cases of dengue fever are imported into Europe each year from endemic areas worldwide. France witnessed the first autochthonous dengue transmission in 2010[11]. Although technically not part of the European continent, at present Madeira is experiencing the first sustained transmission in ‘Europe’ since 1920 with over 2,000 cases as of 9 December 2012; over 70 dengue cases have already been imported to the European mainland[12]. Leishmaniasis is transmitted to humans through the bite of infected female

Challenge 2: Commercial fruits at risk – Drosophila suzukii (Spotted Wing Drosophila)

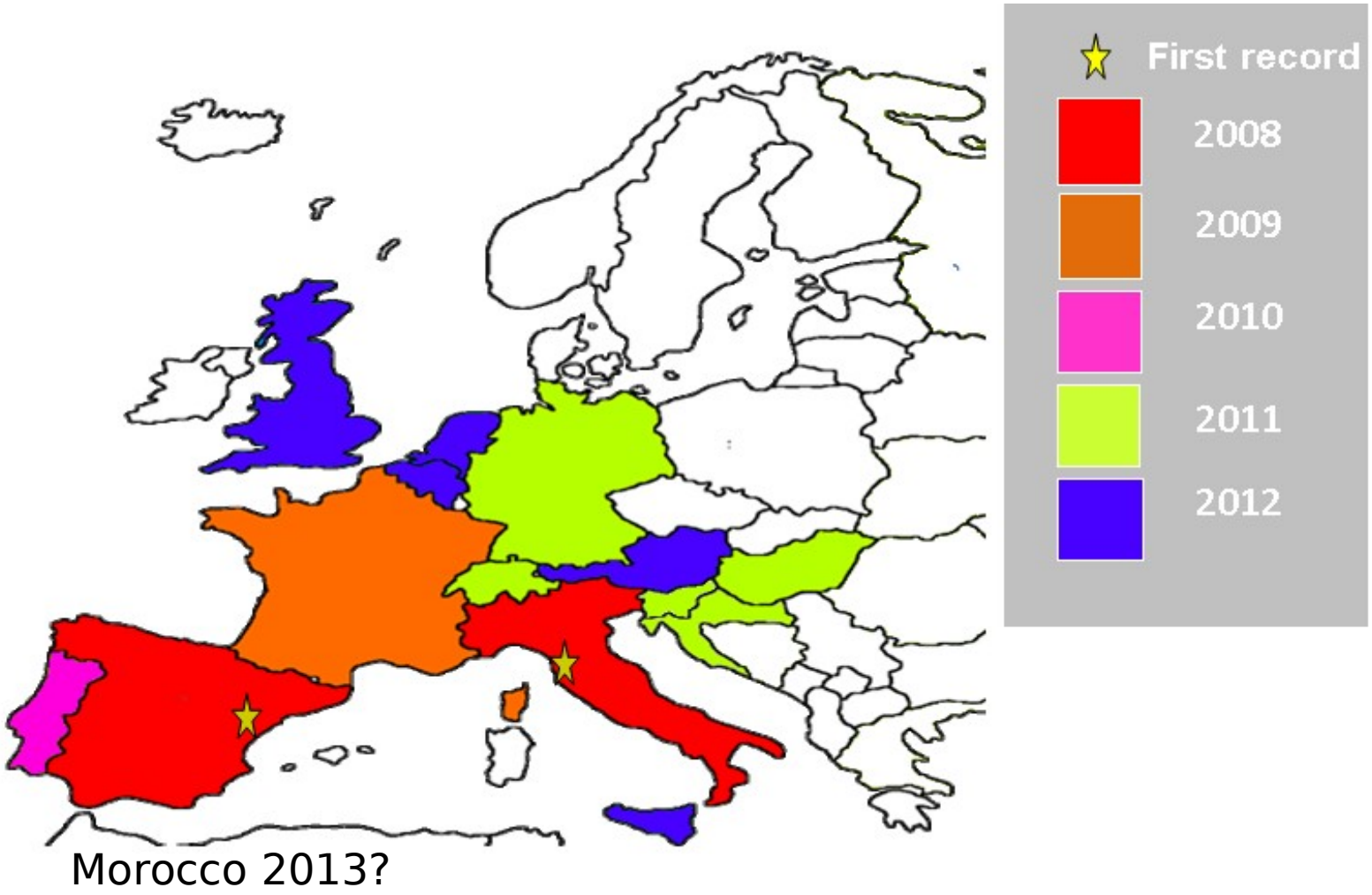
http://www.lexem.eu

Drosophila suzukii

Drosophila suzukii's preference: berries!

Cherry

Spotted Wing Drosophila: Increasing spread in Europe



Morocco 2013?

First fruit damage was reported in 2009 in soft fruits in Trentino (Grassi et al., 2009)

Cini *et al.*, 2012. Bull. Insectol.
Rota Stabelli et al. 2013. Curr Biol.

Big issue also in the United States!

Temperature in space and time driving lifecycle of mosquitoes

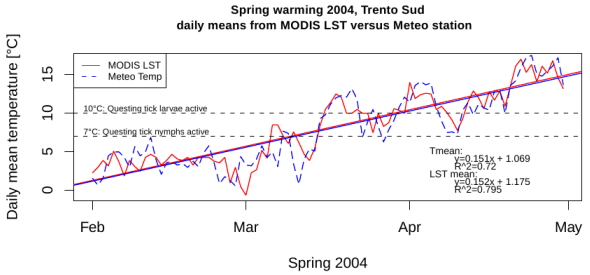
Land Surface Temperature from satellite

Temperature time series

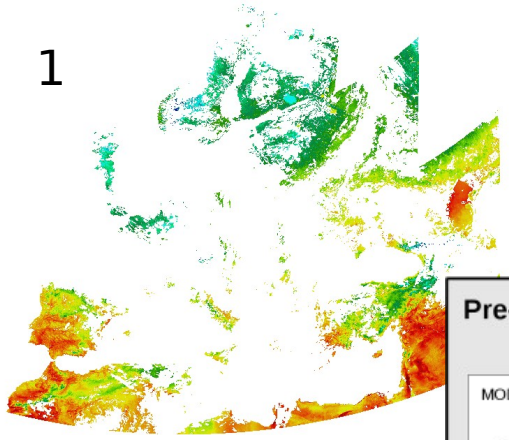
Selected references:

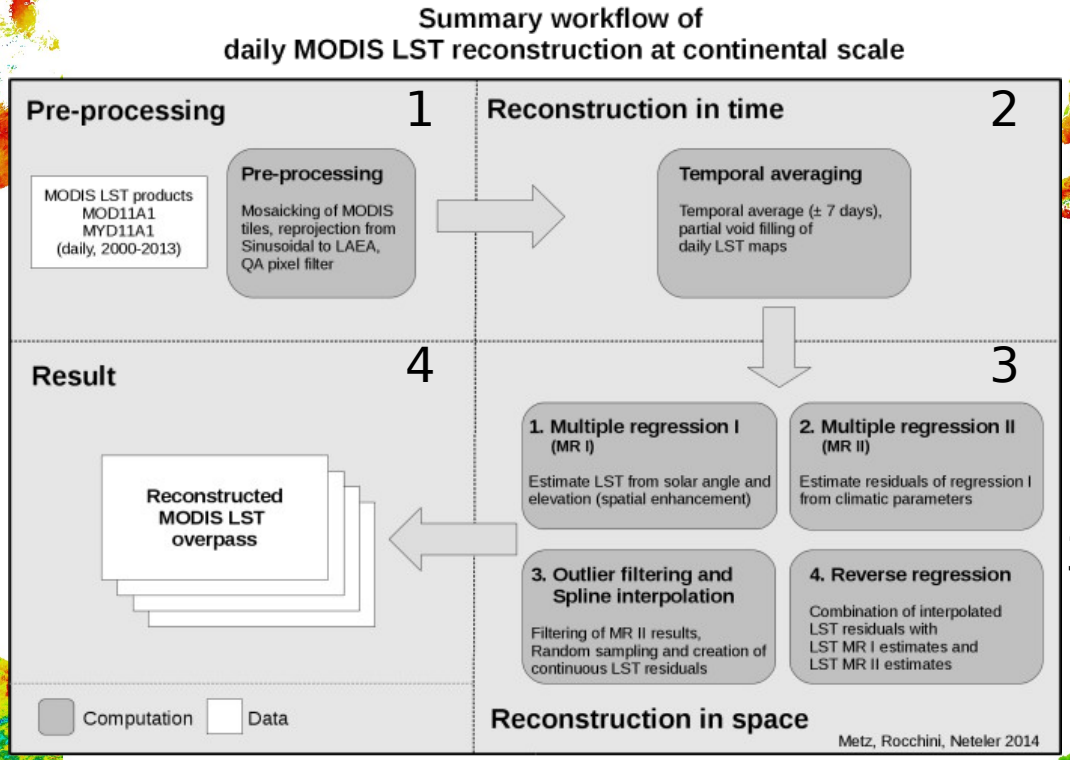
- Kilpatrick et al 2011 (WNV transmission)
- ECDC 2009 (*Aedes albopictus* risk maps)
- Roiz et al 2011(*Aedes albopictus* distribution map)
- Randolph 2004 (tick seasonality)
- Tersago et al 2009 (Hantavirus)
- Rios et al 2000 (Tubercolosis)
- Kalluri et al 2007 (mosquito abundance)
- Epstein et al 2002 (infectious diseases)
- Morand et al 2013 (infectious diseases)
- Peréz-Rodriguez et al 2013 (VB parasites)

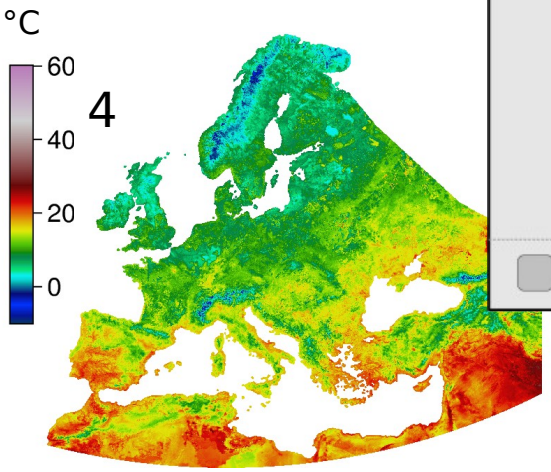
- Average
- Minimum
- Maximum
- Seasonal temperature: Winter, spring, summer, autumn
- Spring warming, Autumnal cooling
- Anomalies, Cool Night Index
- Growing Degree Days (GDD)
- Late frost periods

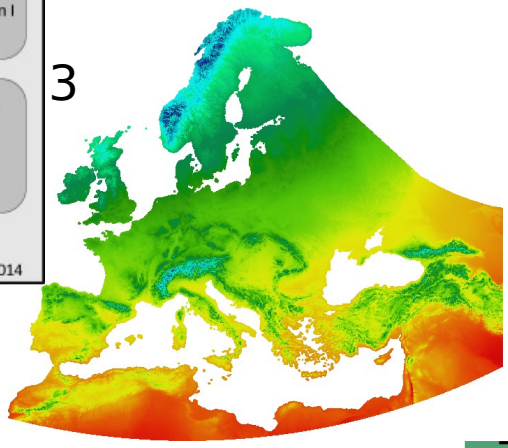


EuroLST: MODIS LST daily time series









EuroLST: http://gis.cri.fmach.it/eurolst/
Metz, Rocchini, Neteler, 2014: Remote Sens 6, DOI: 10.3390/rs6053822

EuroLST: MODIS LST daily time series

Software used for LST reconstruction

~~[MODIS Reprojection Tool (MRT 4.1)]~~

GDAL 1.x

PROJ.4

GRASS GIS 7

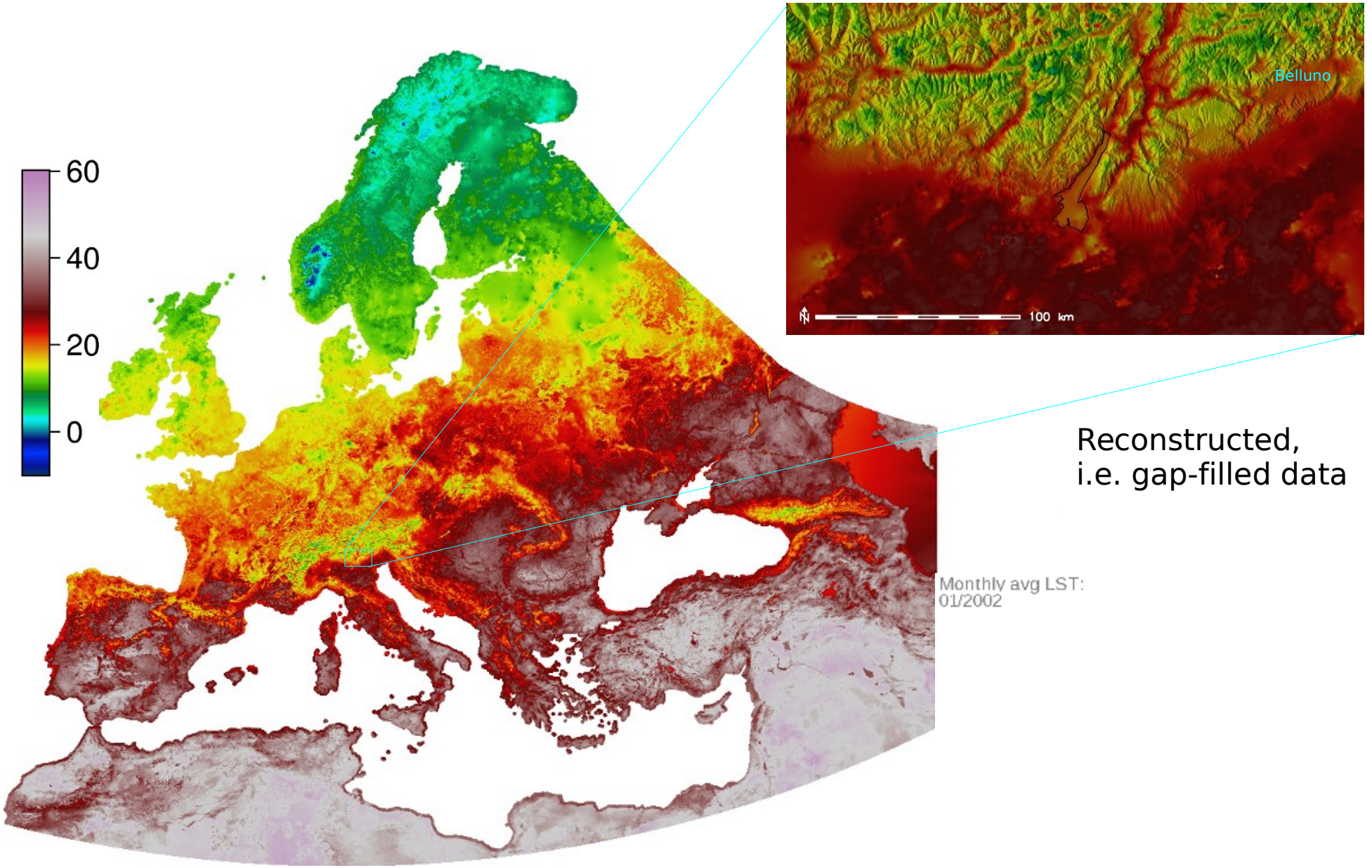
Grid Engine

Scientific Linux 6.x

*[1] Mosaiking of 20 MODIS LST tiles * 17,000 overpasses reduced from 1 week to 1 day*

EuroLST: MODIS LST daily time series

Example: Land surface temperature for Sep 26 2012, 1:30 pm

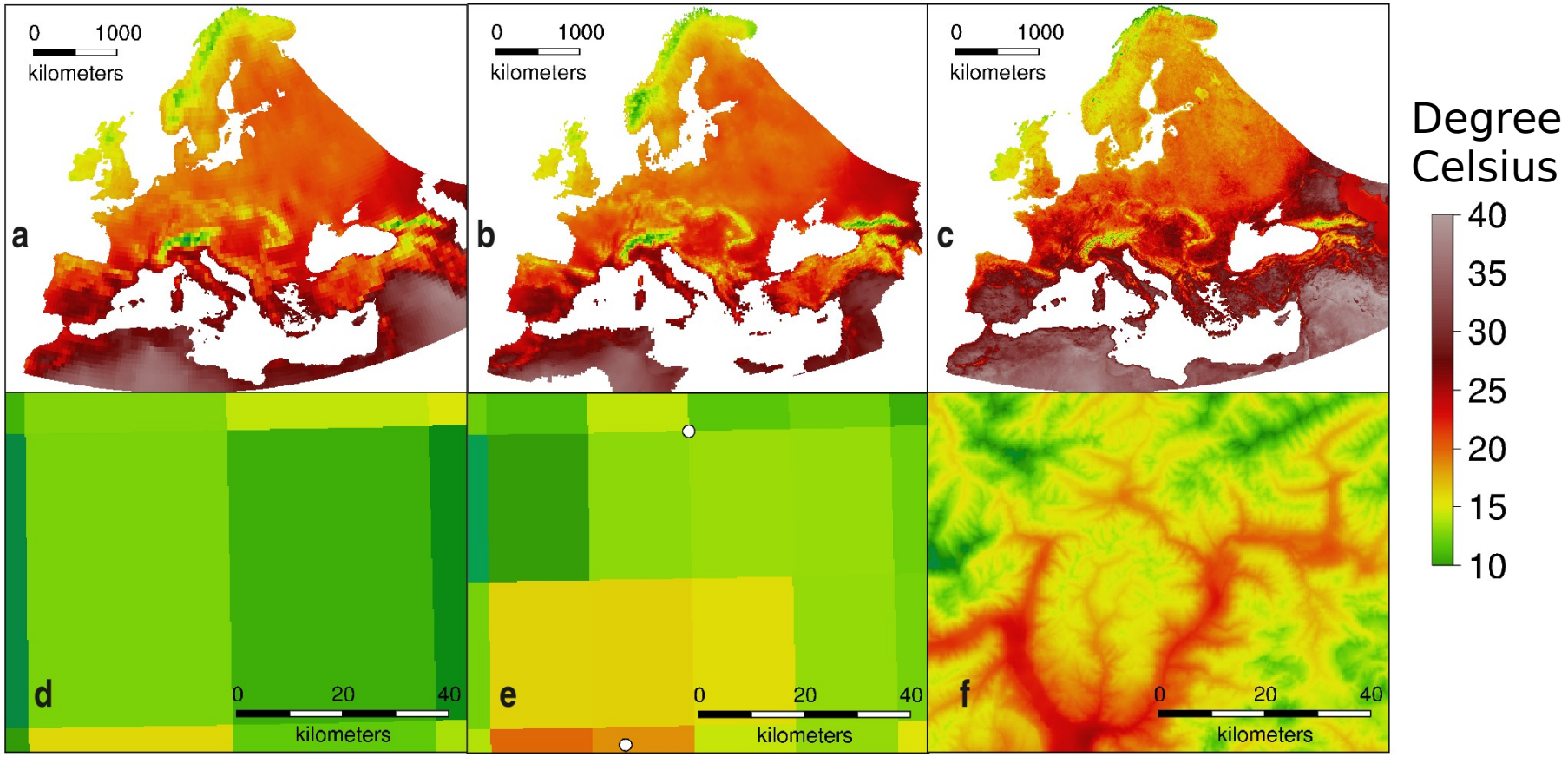


Reconstructed,
i.e. gap-filled data

Metz, Rocchini, Neteler, 2014: Rem Sens
EuroLST: http://gis.cri.fmach.it/eurolst/

New EuroLST dataset: Comparison to other datasets

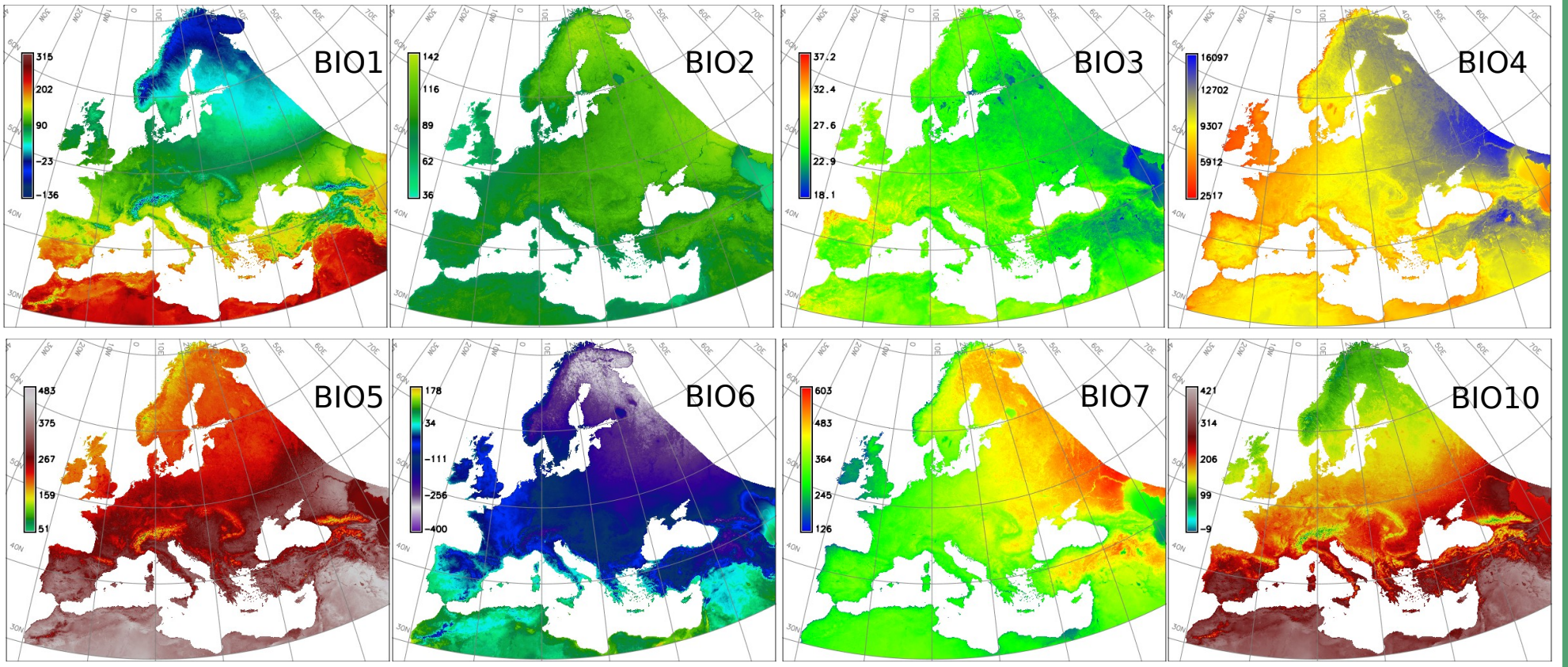
(and advantages of using remote sensing time series)

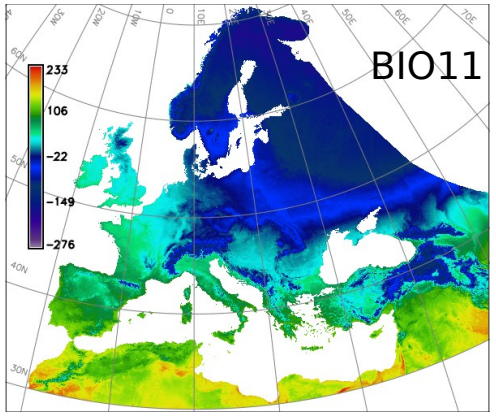


CRU TS 3.1 | ECA&D 5.0 | MODIS v005 (reconstructed)

Metz, M.; Rocchini, D.; Neteler, M. 2014: *Surface temperatures at the continental scale: Tracking changes with remote sensing at unprecedented detail*. Remote Sensing. 2014, 6(5): 3822-3840 (DOI | HTML | PDF)

BIOCLIM from reconstructed MODIS LST at 250m pixel resolution





BIO1: Annual mean temperature (°C*10)
BIO2: Mean diurnal range (Mean monthly (max - min tem))
BIO3: Isothermality ((bio2/bio7)*100)
BIO4: Temperature seasonality (standard deviation * 100)
BIO5: Maximum temperature of the warmest month (°C*10)
BIO6: Minimum temperature of the coldest month (°C*10)
BIO7: Temperature annual range (bio5 - bio6) (°C*10)
BIO10: Mean temperature of the warmest quarter (°C*10)
BIO11: Mean temperature of the coldest quarter (°C*10)

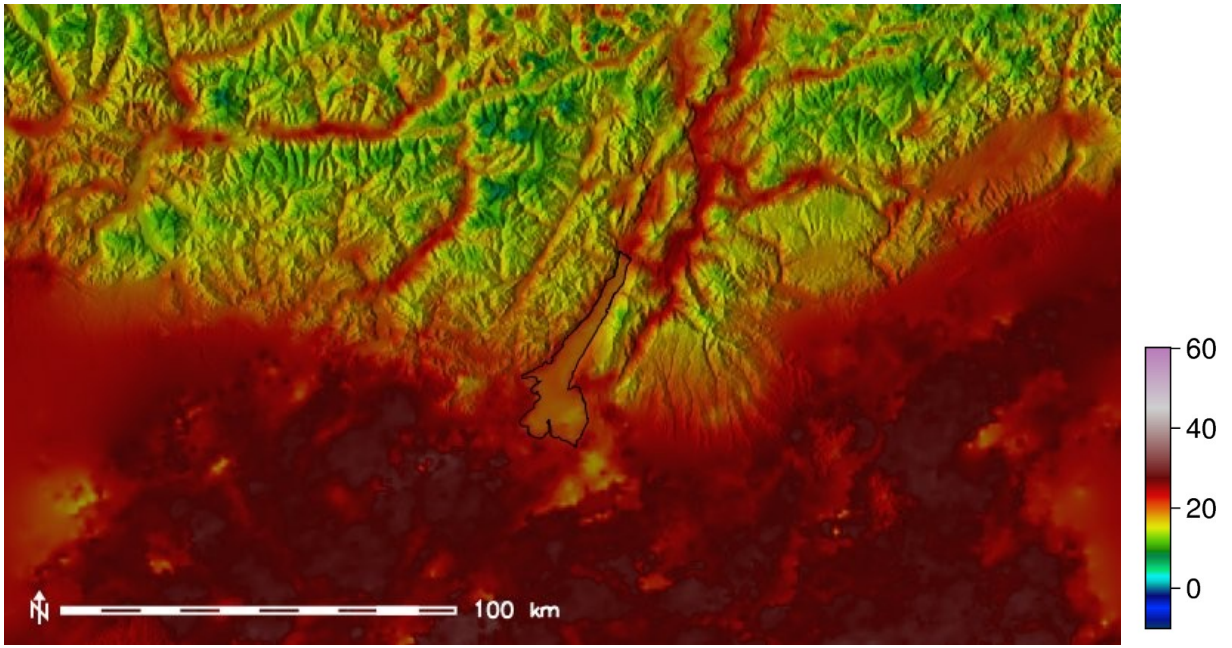
Metz, M.; Rocchini, D.; Neteler, M. 2014: *Surface temperatures at the continental scale: Tracking changes with remote sensing at unprecedented detail*. Remote Sensing. 2014, 6(5): 3822-3840 (DOI | HTML | PDF)

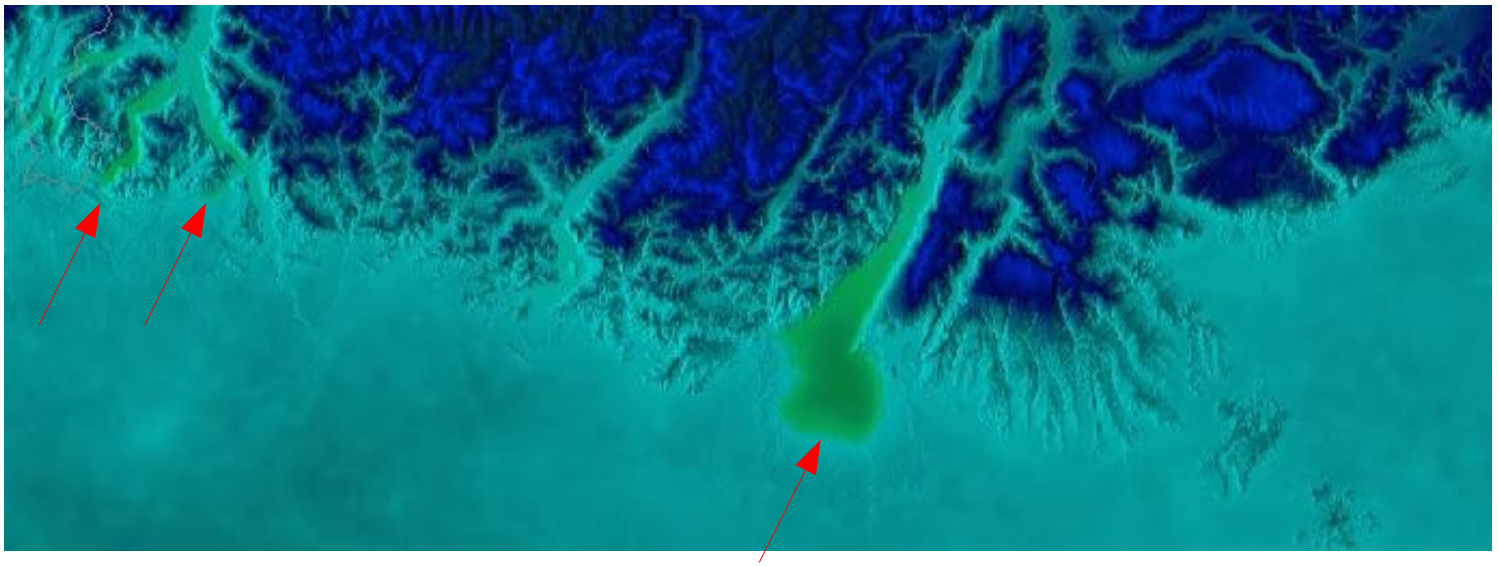
Selected data download:
http://gis.cri.fmach.it/eurolst/

MODIS Land Surface Temperature

Examples:

"Hot" year 2003 and effects





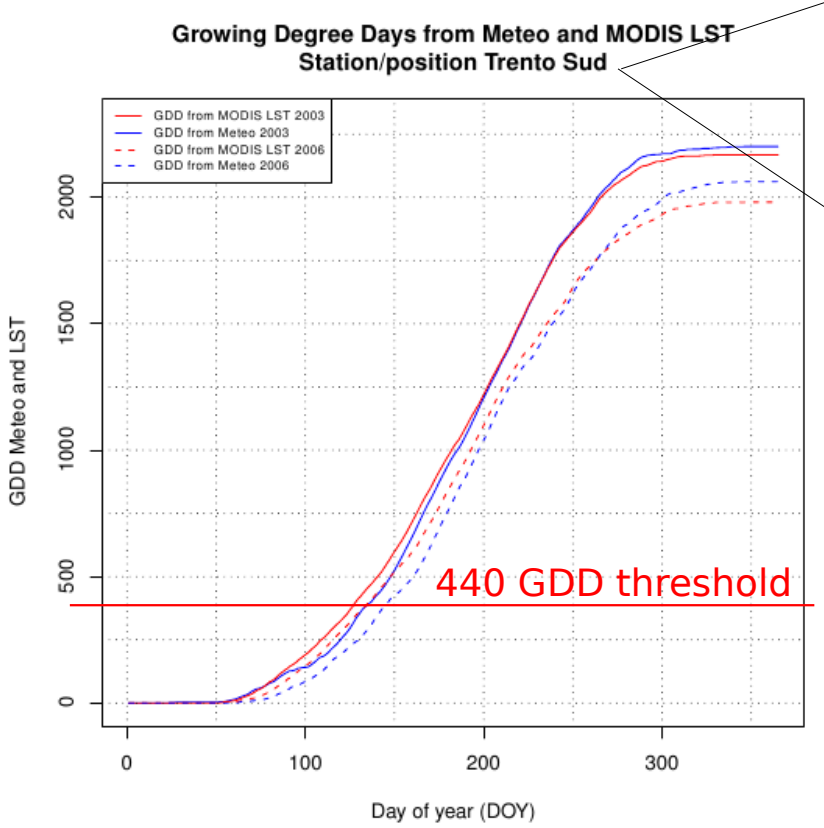
January 2004: Lake Garda still "warm" after hot 2003 summer
--> local heating effect = insect overwintering facilitated

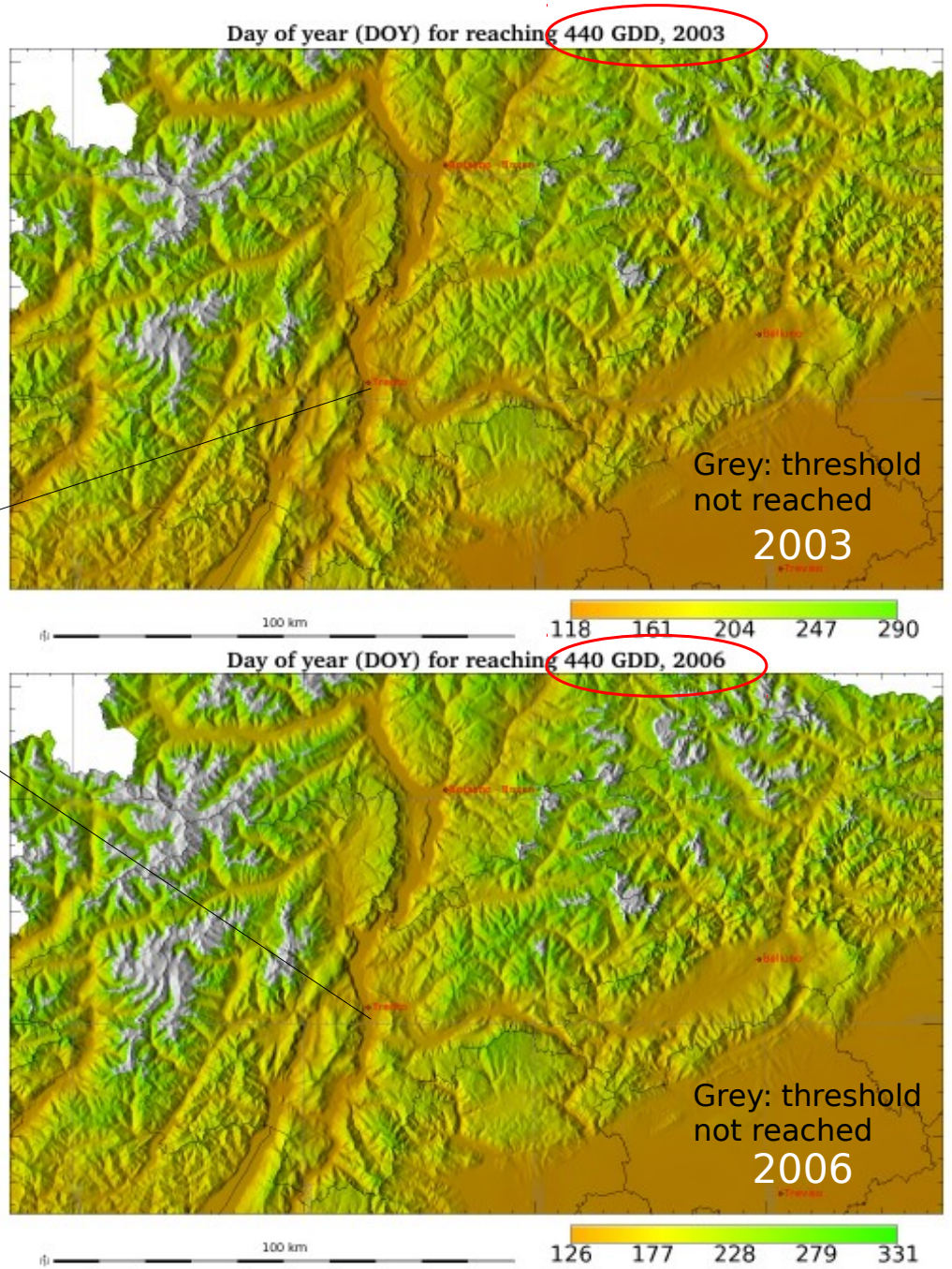
Metz, Rocchini, Neteler 2014.

Growing Degree Days from gap-filled MODIS LST

Number of Day-Of-Year (**DOY**) to reach **440** accumulated growing degree days (GDD) in the years 2003 and 2006:

- proxy for life-stage survival analysis of insect
- satellite-derived GDD are delivered as map, each pixel is "measured"

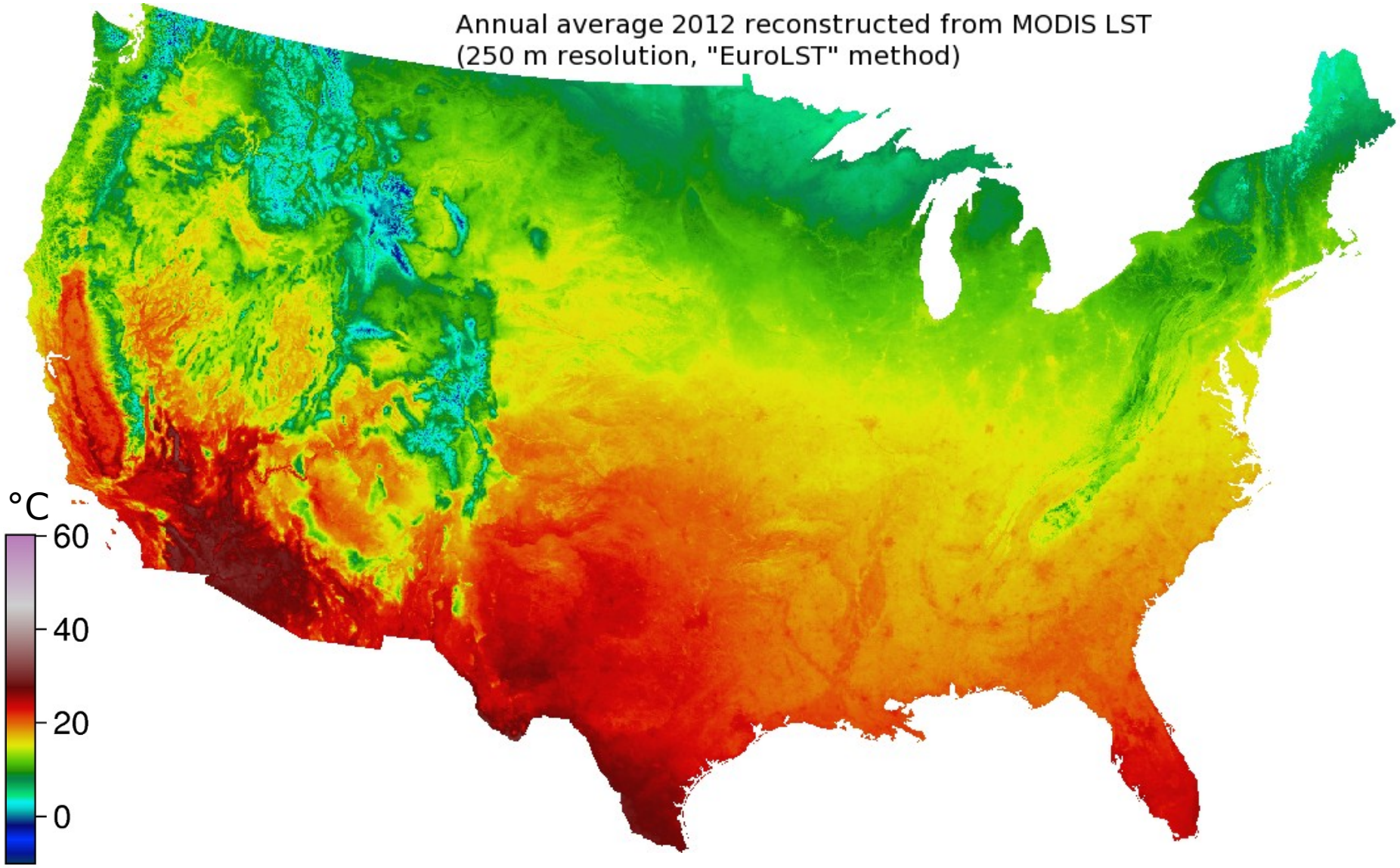




Data: EuroLST

New! CONUSLST - MODIS LST daily time series

Example: Annual Average 2012

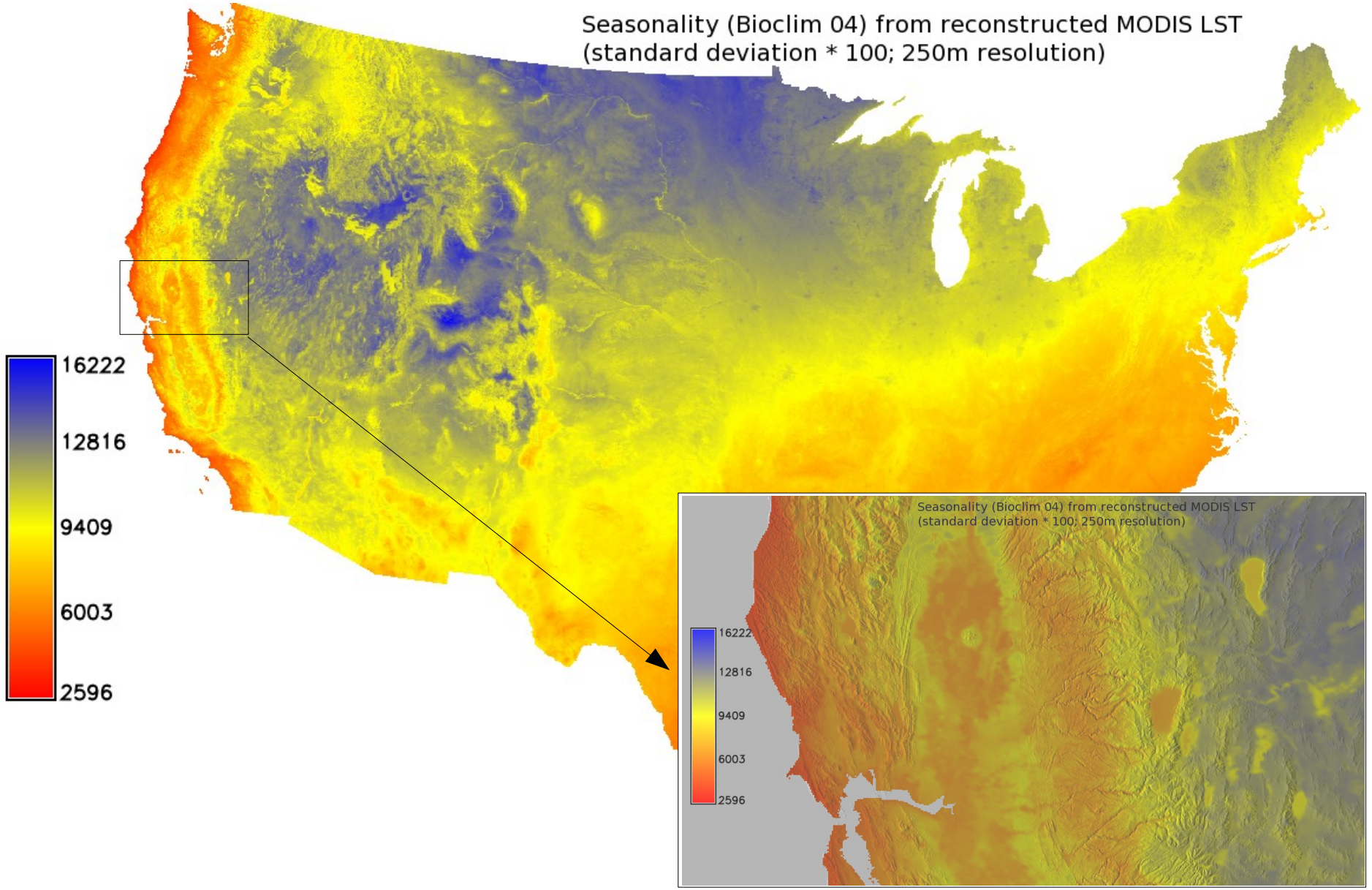


Metz, Rocchini, Neteler, 2014: Rem Sens, 6(5): 3822-3840
EuroLST: http://gis.cri.fmach.it/eurolst/

(new 09/2014, yet unvalidated)

CONUSLST: New MODIS LST daily time series

Example: BIOCLIM04 (2003-2013): the higher the more variability



Metz, Rocchini, Neteler, 2014: Rem Sens, 6(5): 3822-3840
EuroLST: http://gis.cri.fmach.it/eurolst/

MODIS Land Surface Temperature

LST reconstruction

... on a cluster computer

FEM-GIS Cluster

- In total 300 nodes with 610 Gb RAM
- 132 TB raw disk space, XFS, GlusterFS
- Circa 2 Tflops/s
- Scientific Linux operating system, blades headless
- Queue system for job management (Grid Engine), used for GRASS GIS 7 jobs

MODIS Land Surface Temperature

LST reconstruction

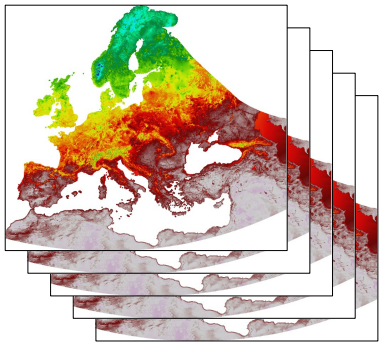
Massive spatial data processing with GRASS GIS 7:

- Our **MODIS EuroLST** [1] sensor time series reconstruction required:
  - 6 **input** grids (LST map, altitude, solar angle, two principal components, ocean mask) with about 400 million raster cells in each map (in total: **2.4 * 10^9 pixel per job**),
  - 1 **output** LST map (temporary files not considered)

  ... this done for 17,000 maps:

  --> EuroLST: about **4 trillion (4.76e+13) pixels** processed for “just” Europe without preprocessing.

  Computational time: 1 month



[1] http://gis.cri.fmach.it/eurolst/

“Big data” challenges on a cluster

GRASS GIS – LST data processing “evolution”:

- 2008: **internal 10Gb network** connection way to **slow**...

✔ *Solution:* TCP jumbo frames enabled (MTU > 8000) to speed up the internal NFS transfer

- 2009: hitting an **ext3 filesystem limitation** (not more than 32k subdirectories but more files in cell_misc/ – each raster maps consists of multiple files)

✔ *Solution:* adopting **XFS filesystem** [err, reformat everything]

- 2012: Free inodes on **XFS exceeded**

✔ *Solution:* Update XFS version [err, reformat everything again]

- 2013: **I/O saturation** in NFS connection between chassis and blades

✔ *Solution:* reduction to one job per blade (queue management), 21 blades * 2.5 billion input pixels + 415 million output pixels

- **GlusterFS saturation**

✔ *Solution:* New 48 port switch, 8-channel trunking (= 8 Gb/s)

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journal homepage: www.elsevier.com/locate/envsoft

TGRASS: A temporal GIS for field based environmental modeling

Sören Gebbert [a,*], Edzer Pebesma [b]

[a] Thünen Institute of Climate-Smart Agriculture, Bundesallee 50, D-38116 Braunschweig, Germany
[b] Institute for Geoinformatics, University of Muenster, Weseler Strasse 253, 48151 Muenster, Germany

Temporal data processing in GRASS GIS

The temporal GIS framework in GRASS introduces three new datatypes that are designed to handle time series data:

- *Space time raster datasets* (strds) are designed to manage raster map time series. Modules that process strds have the naming prefix *t.rast*.
- *Space time 3D raster datasets* (str3ds) are designed to manage 3D raster map time series. Modules that process str3ds have the naming prefix *t.rast3d*.
- *Space time vector datasets* (stvds) are designed to manage vector map time series. Modules that process stvds have the naming prefix *t.vect*.

Temporal data management in general

List of general management modules:

- t.connect
- t.create
- t.remove
- t.register
- t.unregister
- t.info
- t.list
- t.rast3d.list
- t.vect.list
- t.vect.db.select
- t.sample

Export/import conversion

- t.rast.export
- t.rast.import
- t.rast.out.vtk
- t.rast.to.rast3
- r3.out.netcdf
- t.vect.export

Statistics and gap filling

- t.rast.gapfill
- t.rast.univar

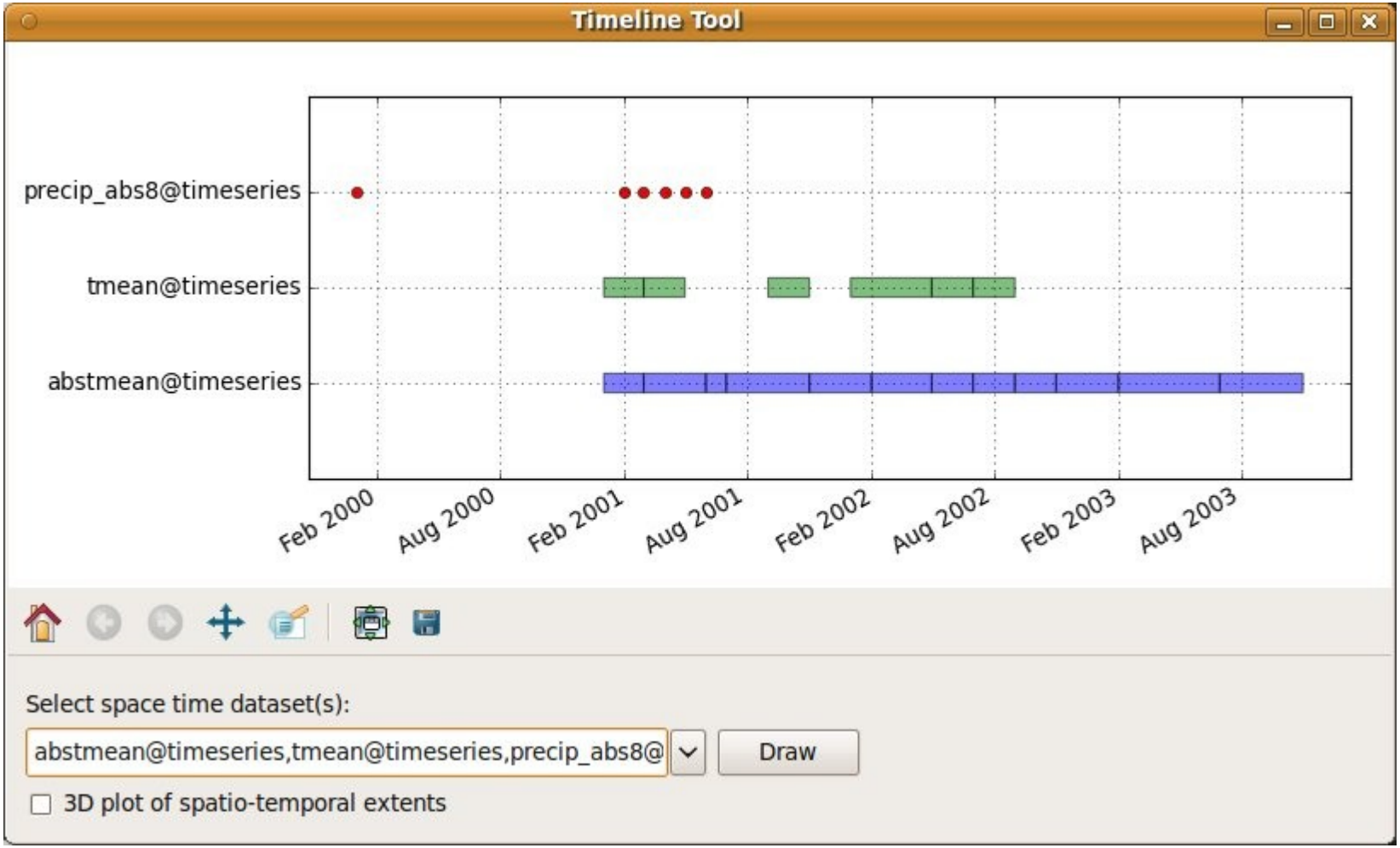
Querying and map calculation

- t.rast.list
- t.rast.extract
- t.rast.gapfill
- t.rast.mapcalc
- t.rast3d.extract
- t.rast3d.mapcalc
- t.rast3d.univar
- t.vect.extract
- t.vect.import
- t.vect.observe.strds
- t.vect.univar
- t.vect.what.strds

Aggregation

- t.rast.aggregate.ds
- t.rast.aggregate
- t.rast.series

New Space-Time functionality in GRASS 7



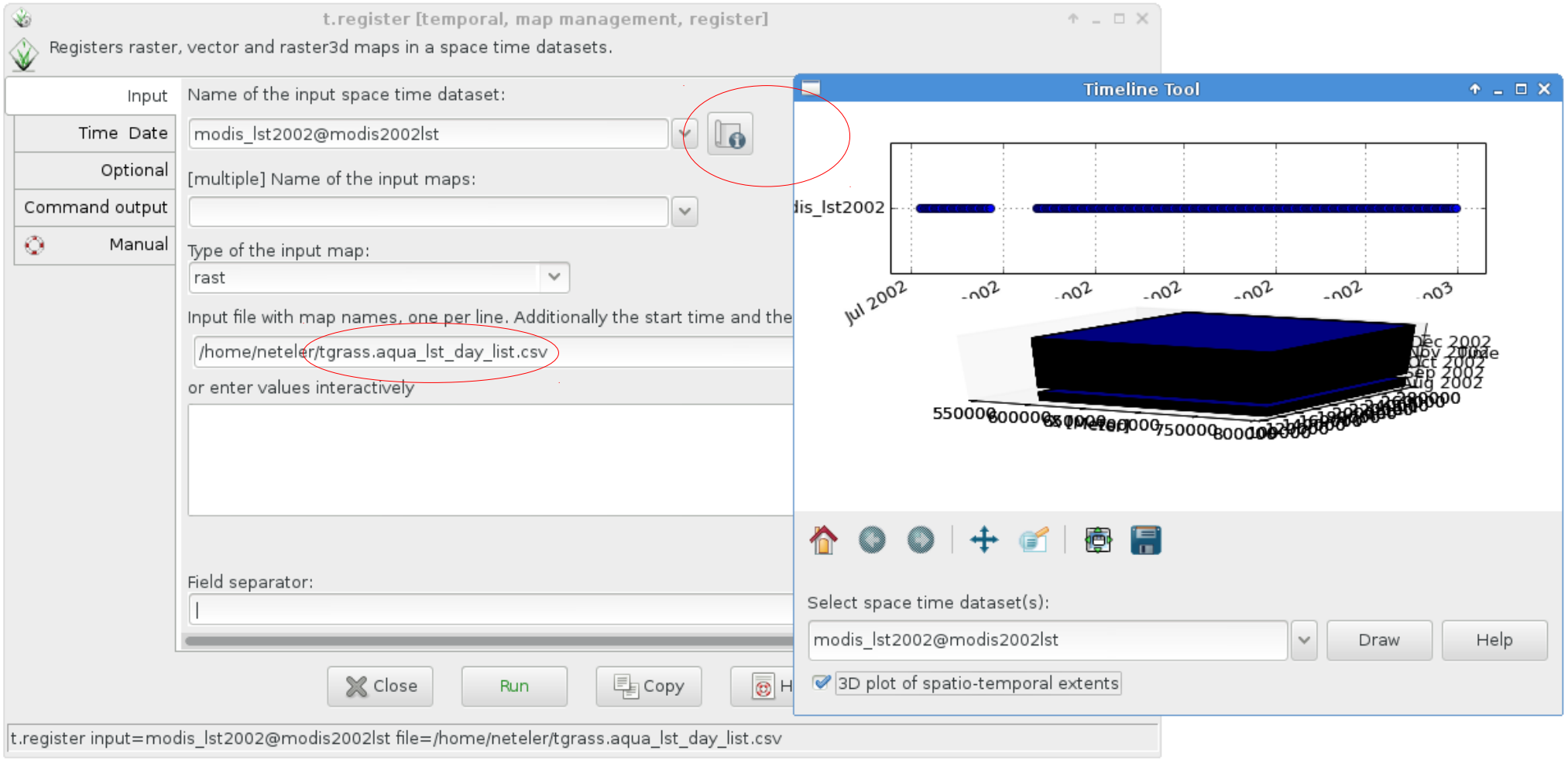
Screenshot: S Gebbert/A. Petrasova

t.register: Registers raster, vector and raster3d maps in a space time dataset

New Space-Time functionality in GRASS 7

FONDAZIONE EDMUND MACH

Example: daily MODIS Land Surface Temperature time series



t.register: Registers raster, vector and raster3d maps in a space time dataset

Conclusions

- **Emerging diseases** and **emerging agro pests** need to be considered among the “emerging themes” to be covered by integrated research strategies because of their dramatic impact on well being and economy
- **Current and potential distribution of disease vectors** (like *Ae. albopictus*) can and should be modelled at high resolution, relevant to many health projects. Likewise Spotted Wing Drosophila
- **New reconstructed high temporal resolution datasets** allow for real spatial modelling
- **... bring it all together in *FOSS4G*!**

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EDENext
Biology and control of vector-borne infections in Europe

LEXEM