Transacqua, Italy
Summer 2010 - 2011

Who are We?

- Outreach initiative of the Fondazione Bruno Kessler

- 38 Students
  - 10 girls, 28 boys
  - 31 Italian, 7 American
- Focus on Science and Technology
  - Especially **Climate Change**

Project 2010

- Develop new algorithms to downscale and upscale global data
- Collection of different links of websites, data and other material concerning the Climate Change
- Cooperation with the agency for the protection of the environment of the UN

Project 2011

- Create a web interface to geographical and environmental data for **regional climate change** studies and decision making

- Assignment from the MUSE Trento

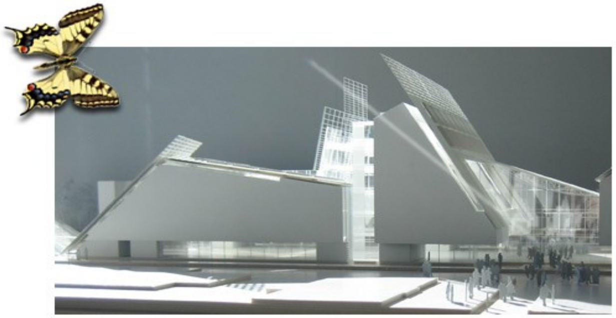
- Create an exhibit that
  - Physically interacts with complex data.
    - Science on a Sphere, WebGIS

  - Raises Climate Change awareness in the Trentino area.


FACT You could probably outrun the Gulf Stream.
It runs from the Gulf of Mexico to Newfoundland.

Vision

- Bring climate change to our “backyard”
- Create a web Interface for politicians and museums
- Create a downscaling algorithms and adapt it to the Alpine area
- Create an interactive way for museum visitors to learn about climate change



Scales

- Regional
  - Alps (Biodiversity)
- Local
  - Trentino (Vineyards)

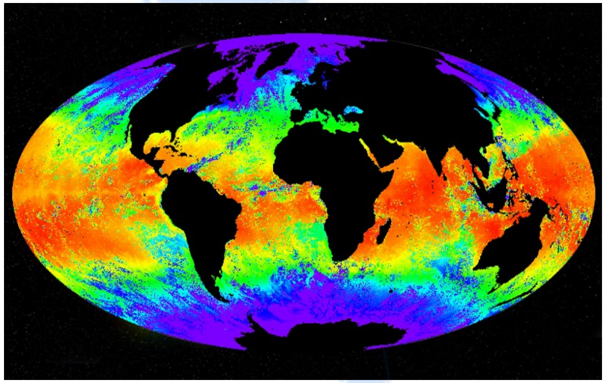
New software

What is our interface useful for?

Regional climate models, which are the most important for politicians when they have to take important decisions (regional/provincial table on climate change), have not been created yet.
Moreover any museum can use the interface to teach visitors about climate change.

Climate Change

The temperature, rainfall and other weather event of a given area over a long term represent the place's climate.



Climate change represents a change in these long-term weather patterns. They can become warmer or colder.

Data Sources

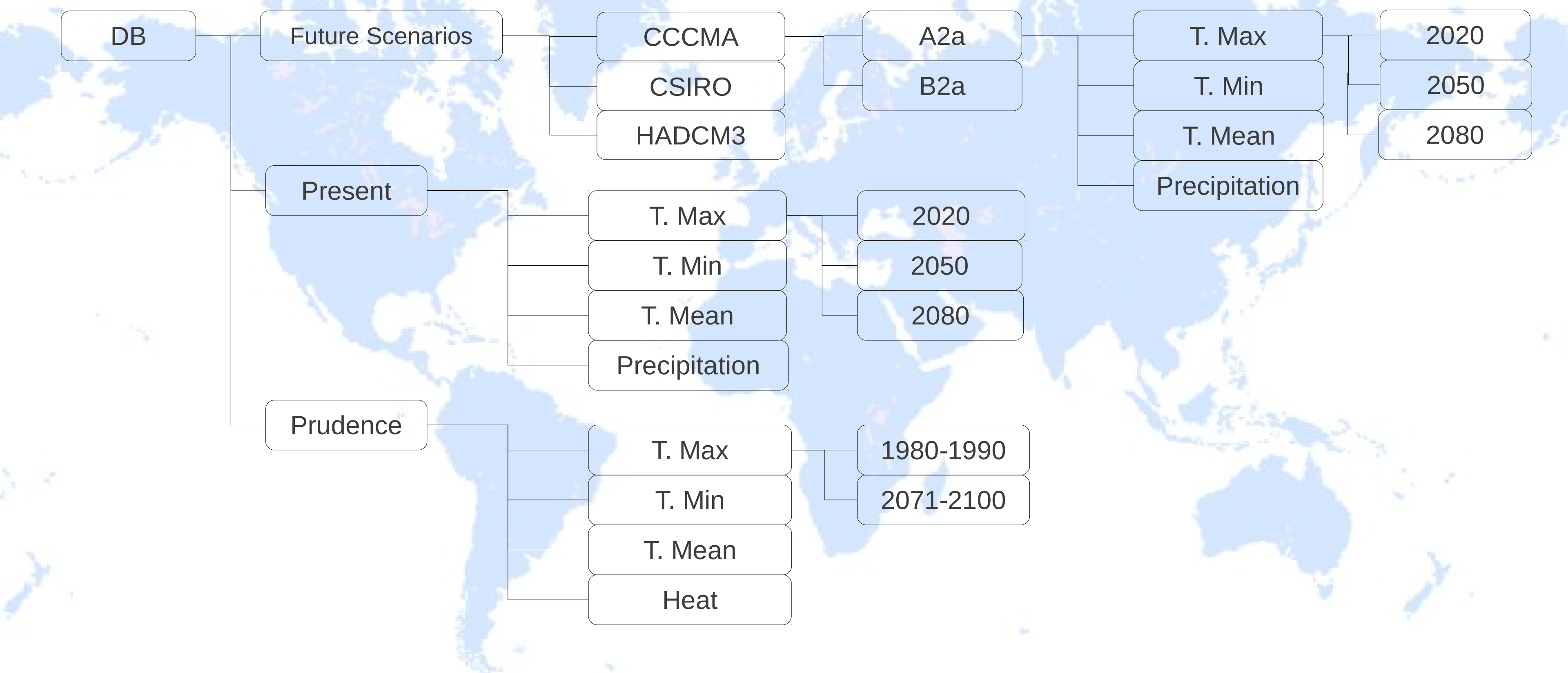
- http://prudence.dmi.dk/
  Daily temperature → Heatindex
- http://www.worldclim.org/
  Monthly precipitations, temperature
- http://www.meteotrentino.it/
- http://geodata.grid.unep.ch/
  300 statistic indicators

Data Processing

The original data came with different resolution:
Prudence (12 km)
Meteo Trentino (200m)
Worldclim (1 km)
UNEP (statistic)

DATA	CONVERSION	RESULT
Prudence	NETCDF → ASCII	45 Mb → 200 Gb (after downscaling)
Worldclim	ADF → TIFF	2 Gb
Meteo Trentino	TXT → ASCII	100 Gb
UNEP	TXT → JSON	56 Mb

Climate Change Database



Heat Index

$$HI = c_1 + c_2T + c_3R + c_4TR + c_5T^2 + c_6R^2 + c_7T^2R + c_8TR^2 + c_9T^2R^2$$

HI = Heat Index (in degrees Fahrenheit)
T = ambient dry-bulb temperature (in degrees Fahrenheit)
R = relative humidity (in percent)

$C_1 = -42.379$

$C_2 = 2.04901523$

$C_3 = 10.14333127$

$C_4 = -0.22475541$

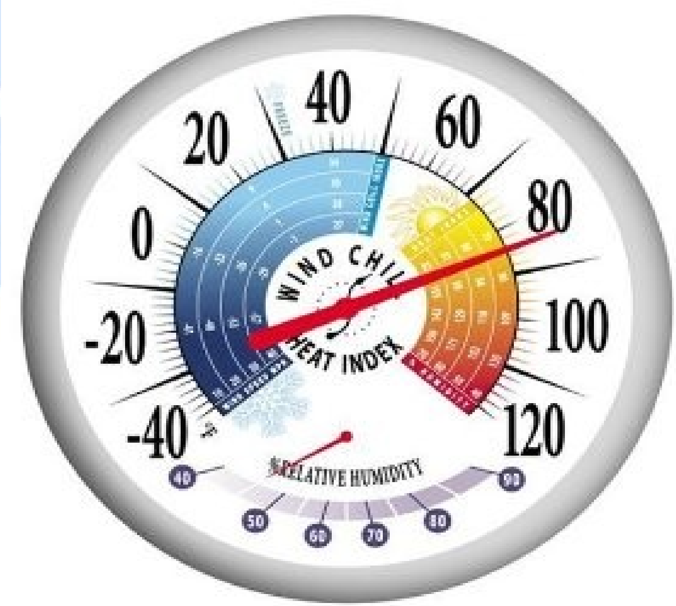
$C_5 = -6.83783 \cdot 10^{-3}$

$C_6 = -5.481717 \cdot 10^{-2}$

$C_7 = 1.22874 \cdot 10^{-3}$

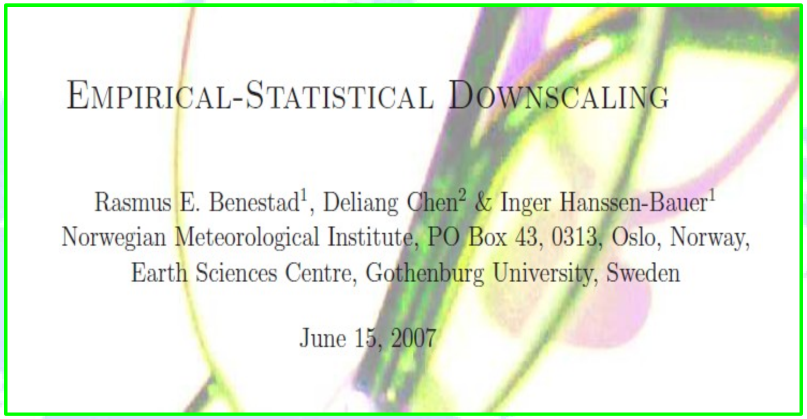
$C_8 = 8.5282 \cdot 10^{-4}$

$C_9 = -1.99 \cdot 10^{-6}$



Downscaling Literature

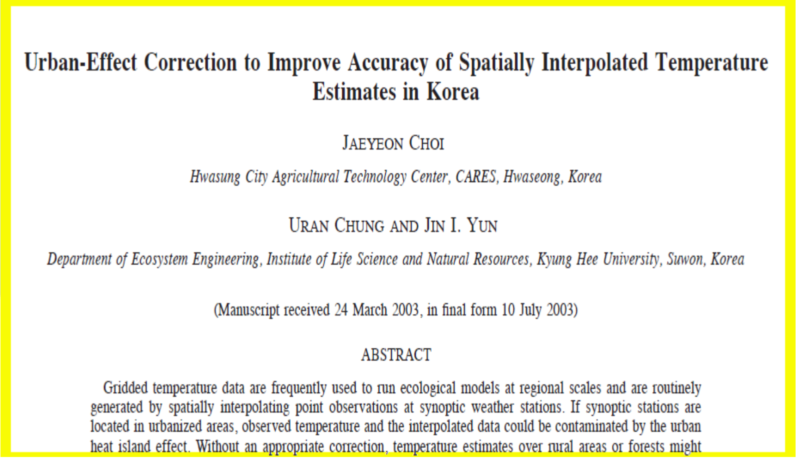
- Choi J, Chung U, Yun JI, 2003: Urban-effect correction to improve accuracy of spatially interpolated temperature estimates in Korea. J Applied Meteorology, 42 (12), 1711-1719
- Cawley GC, Haylock M, Dorling SR, Goodess C, Jones PD, Statistical Downscaling with Artificial Neural Networks, ESANN-2003
- The new R package **clim.pact**
- Girvetz EH, Zganjar C, Raber GT, Maurer EP, Kareiva P, et al. 2009 Applied Climate-Change Analysis: The Climate Wizard Tool. PLoS ONE 4(12) - software http://www.climatewizard.org
- Benestad RE, Hanssen-Bauer I, Chen D Empirical-Statistical Downscaling in Climate Modeling, World Scientific, 2008



EMPIRICAL-STATISTICAL DOWNSCALING

Rasmus E. Benestad[1], Deliang Chen[2] & Inger Hanssen-Bauer[1]
Norwegian Meteorological Institute, PO Box 43, 0313, Oslo, Norway,
Earth Sciences Centre, Gothenburg University, Sweden

June 15, 2007



Urban-Effect Correction to Improve Accuracy of Spatially Interpolated Temperature Estimates in Korea

JAEYEON CHOI

Hwasung City Agricultural Technology Center, CARES, Hwaseong, Korea

URAN CHUNG AND JIN I. YUN

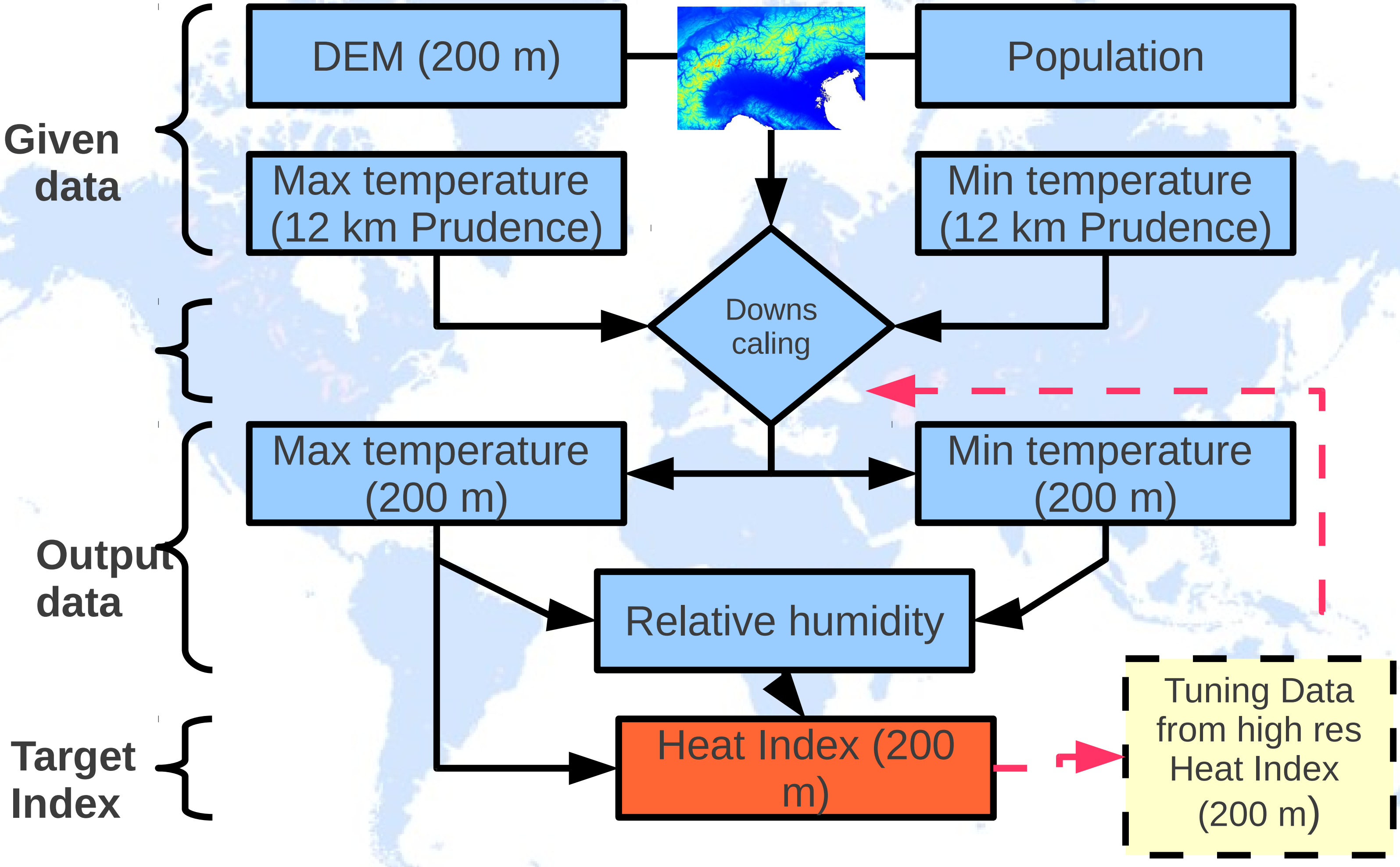
Department of Ecosystem Engineering, Institute of Life Science and Natural Resources, Kyung Hee University, Suwon, Korea

(Manuscript received 24 March 2003, in final form 10 July 2003)

ABSTRACT

Gridded temperature data are frequently used to run ecological models at regional scales and are routinely generated by spatially interpolating point observations at synoptic weather stations. If synoptic stations are located in urbanized areas, observed temperature and the interpolated data could be contaminated by the urban heat island effect. Without an appropriate correction, temperature estimates over rural areas or forests might

Downscaling Framework*



*adapted from Choi et al 2003.

Downscaling Formula

$$T = \frac{\sum \frac{T_i}{d_i^2}}{\sum \frac{1}{d_i^2}} + \left(z - \frac{\sum \frac{z_i}{d_i^2}}{\sum \frac{1}{d_i^2}} \right) \Gamma + \log \left(P - \frac{\sum \frac{P_i}{d_i^2}}{\sum \frac{1}{d_i^2}} \right) \Pi$$

Elevation proxy term

Population proxy term

- T output high res temp
- T_i input low res temp
- i neighbor index
- d_i distance to neighbor
- z_i elevation (low-res)
- P input population
- P_i input popul low res
- Γ elevation par
- Π population par

Adaptation of formula to Alps ecosystem

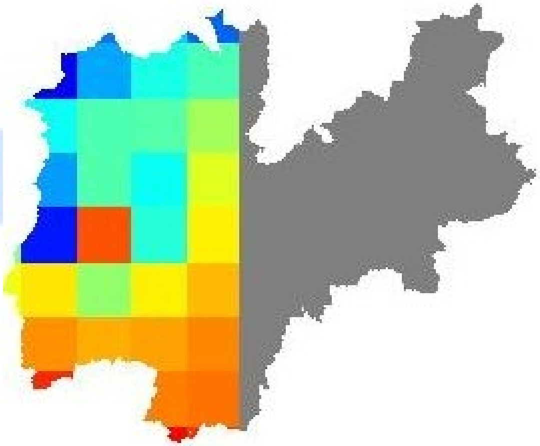
$$T = \frac{\sum \frac{T_i}{d_i^2}}{\sum \frac{1}{d_i^2}} + \left(z - \frac{\sum \frac{z_i}{d_i^2}}{\sum \frac{1}{d_i^2}} \right) \Gamma + \log \left(P + \frac{\sum \frac{P_i}{d_i^2}}{\sum \frac{1}{d_i^2}} \right) \Pi$$

+ correction term (real population used)

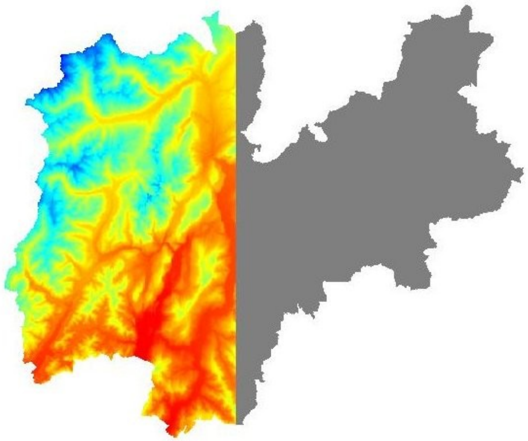
Π empirically estimated from Trentino high res data

Calibration Model

Prudence DATA



$$\Gamma=\left(T-\frac{\sum\frac{T_i}{d_i^2}}{\sum\frac{1}{d_i^2}}-\log\left(P-\frac{\sum\frac{P_i}{d_i^2}}{\sum\frac{1}{d_i^2}}\right)\Pi\right)\left(1/\left(z-\frac{\sum\frac{Z_i}{d_i^2}}{\sum\frac{1}{d_i^2}}\right)\right)$$

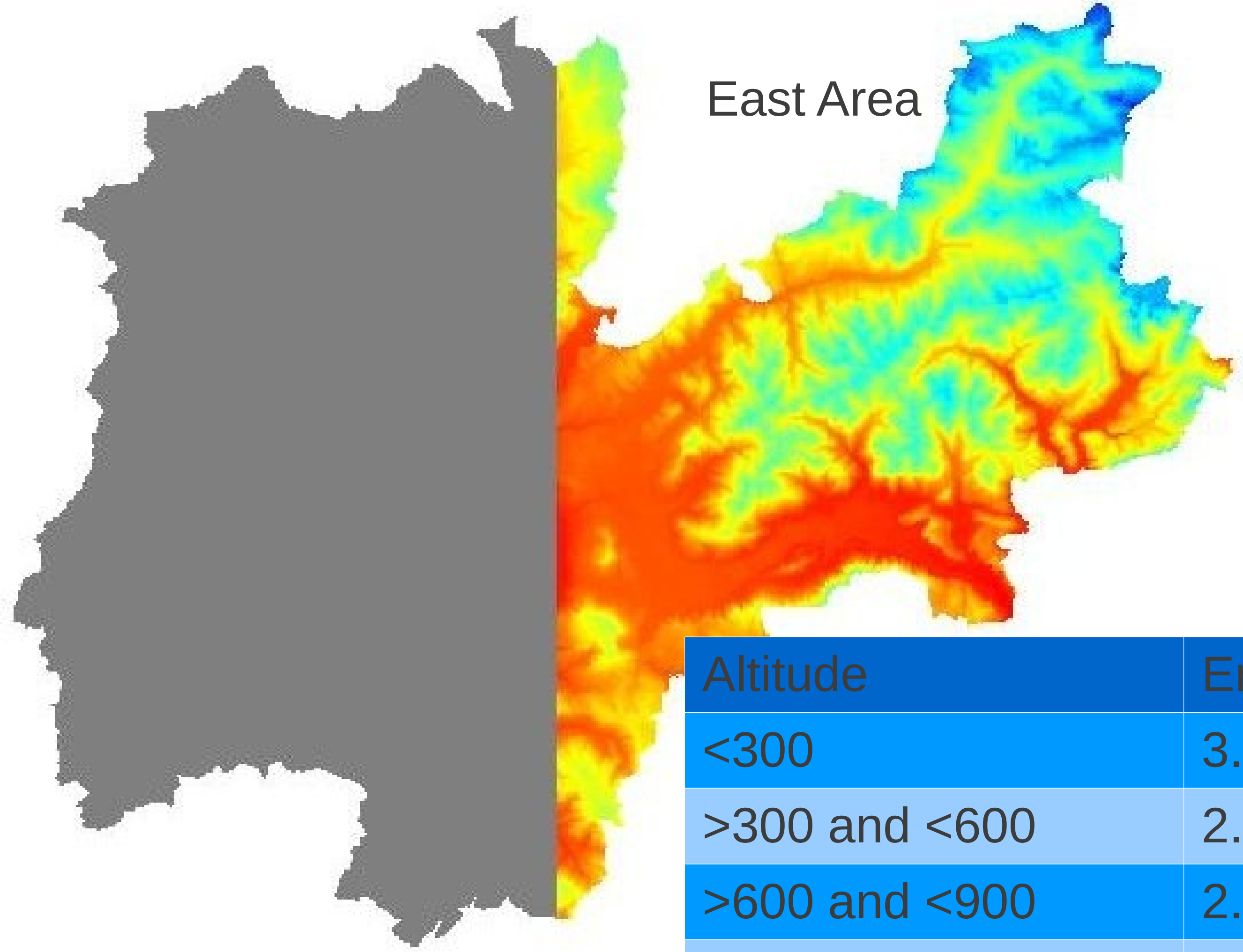


cell_number	gamma	altit_200	population
1	-0.011816	2118	0.98
2	-0.011013	2204	0.98
3	-0.012454	2050	1.01
4	-0.013083	2022	0.96

ENVIROCHANGE

Global change and sustainable management of agriculture in highly developed mountain environment

Testing Model

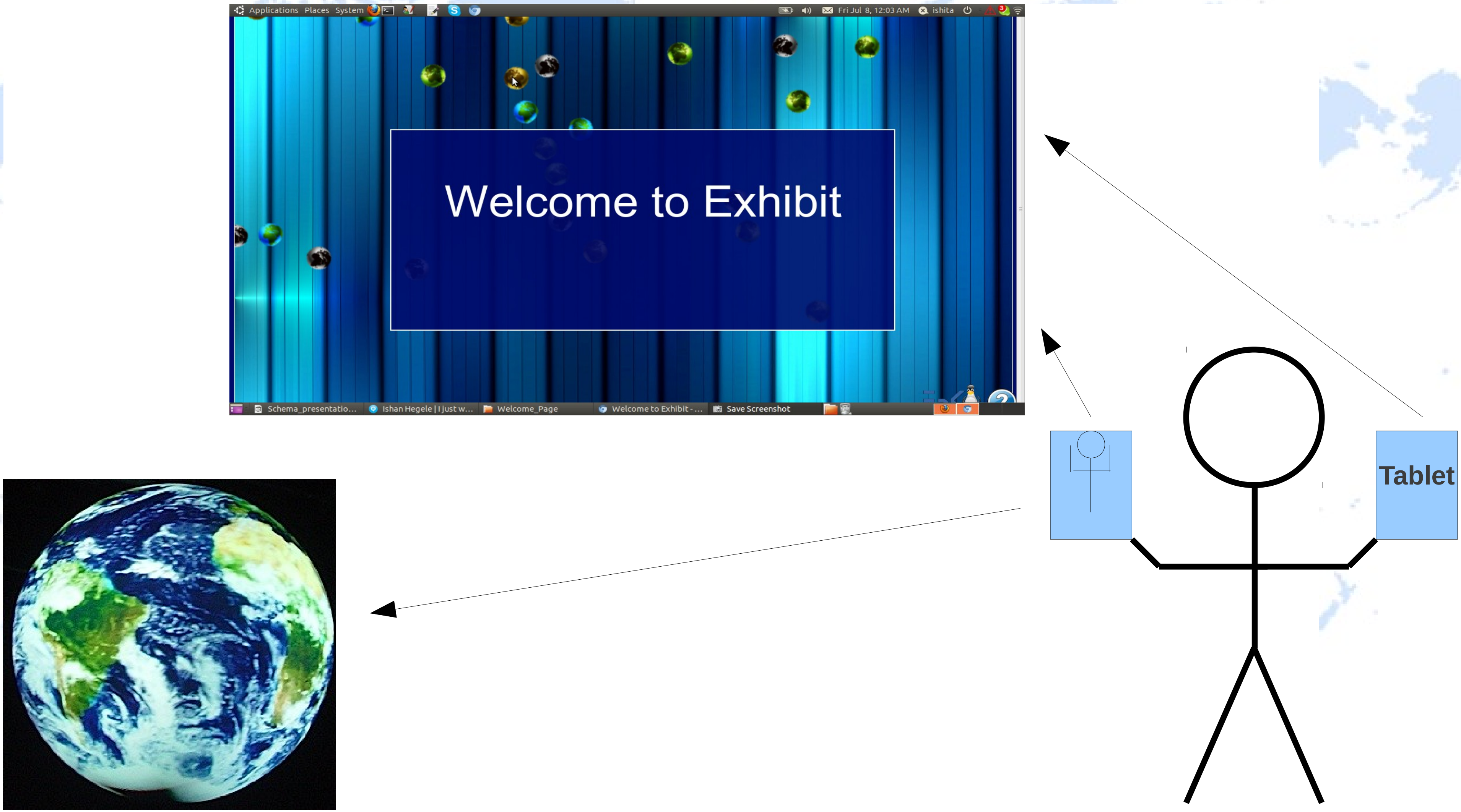


Downscaled temp
from Prudence DB

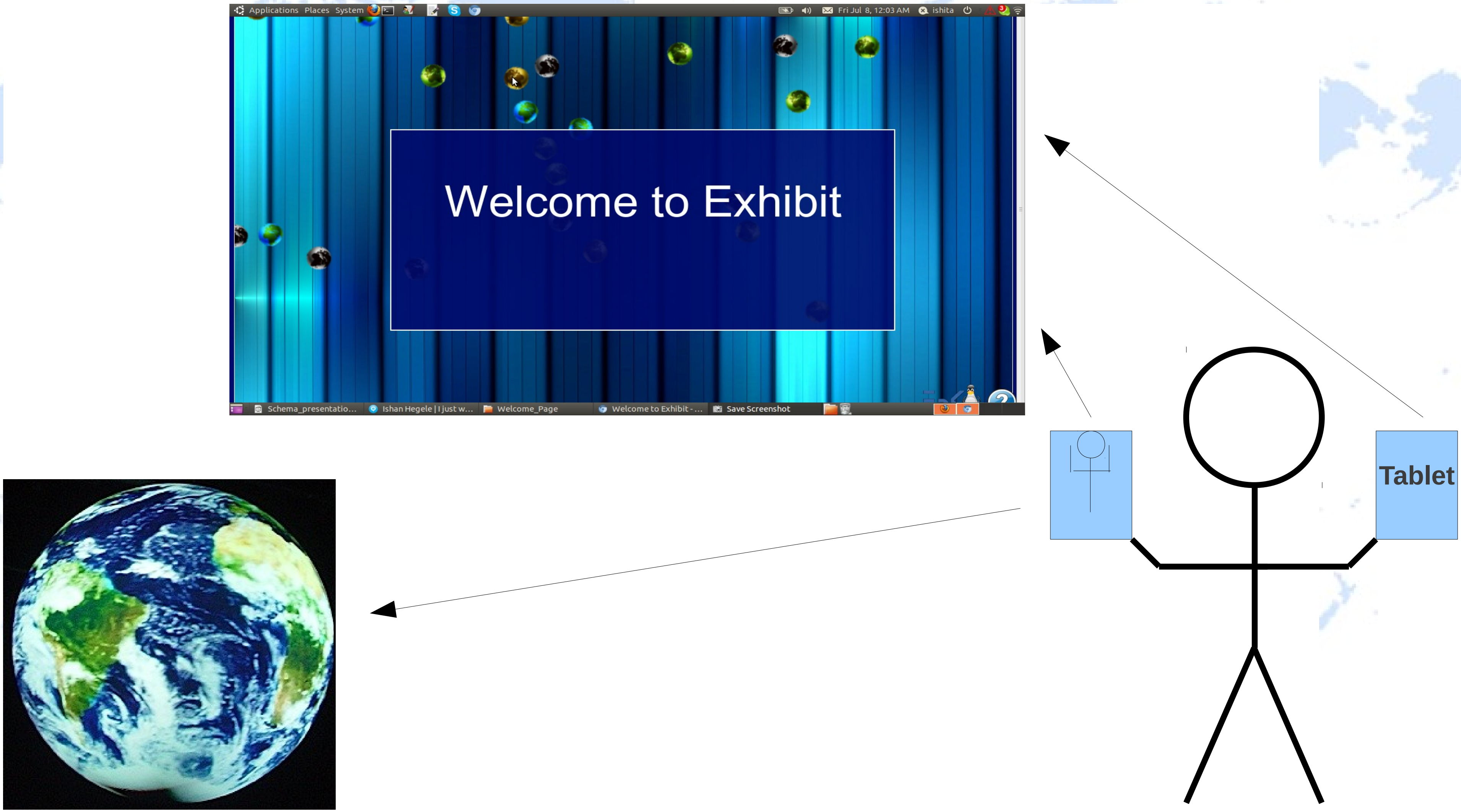
12 km -> 200m

Altitude	Error
<300	3.19628
>300 and <600	2.66044
>600 and <900	2.23999
>900	4.28777

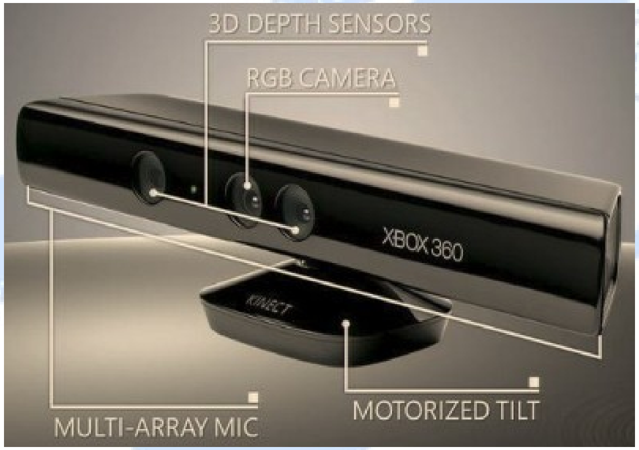
What about interactivity ?



What about interactivity ?



The Kinect



PrimeSense

What is a Kinect For?

Applications

- Calibration
- Recognize Gestures
- Sphere and Interface interaction

Demo

Tablet Interface

Chapters

- Chapter 1: Models
- Chapter 2: Vineyards- Trentino
- Chapter 3: Phenology- Trentino
- Chapter 4: Biodiversity- Alps

Predictive models?

A model is a statistical and simplified representation of reality.

A model is to consider predictive if its goal is to foresee, even approximately, the trend of a phenomenon.

During WebValley 2011 we developed environmental predictive models based on geographic (maps) and climatic data.

What is a model useful for ?

- To foresee the climate change.
- To anticipate the effect of climate change on a world scale and, for example in agriculture.
- Study trends in economics.
- Being able to predict shortage of resources (water, petrol, etc.).
- Study the spread of a disease.

More in general they are useful to predict future problems with the goal of finding a solution or to eliminate the triggering causes.

How models are created.

A model is usually obtained from the analysis of past and current data and then applied to future scenarios.

In WebValley we used for the most part climatic data (temperature and precipitation).

A model is created with specific statistical analysis programs. Those programs try to find a pattern in the data that can describe the phenomenon.

Validation of a model.

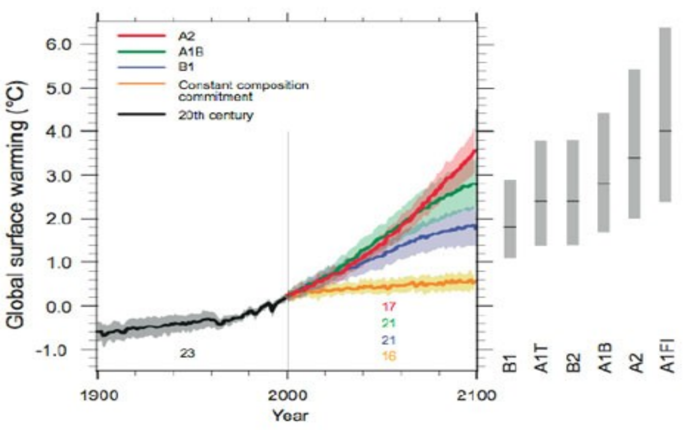
Before it can be used for predictions a model needs to be validated.

Some of the available data are used to test the model, the rest of them are compared with the output of the model to understand how good the prediction is.

If the model is considered valid it can be used, otherwise the creation process for that model starts again.

Vineyards

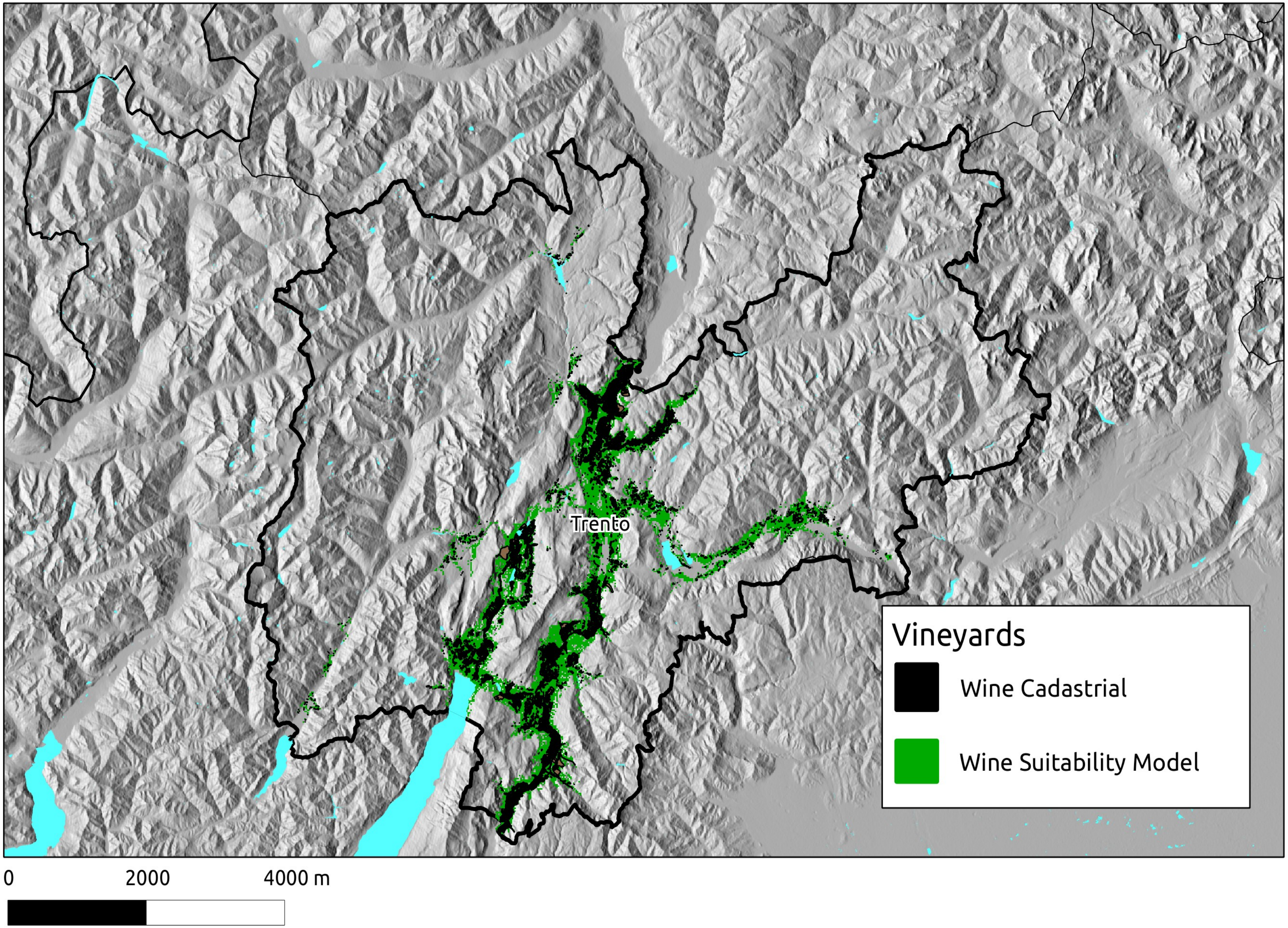
- Produce maps of areas with & without vineyards
- Include precipitation and temperature data
    - Regional Data from WorldClim and Local from Meteotrentino
- Two IPCC scenarios simulated at **1km resolution** and European extent:
    - A1a, B2a /One IPCC scenario simulated at **200m resolution**
    - Trento region extent: A1b



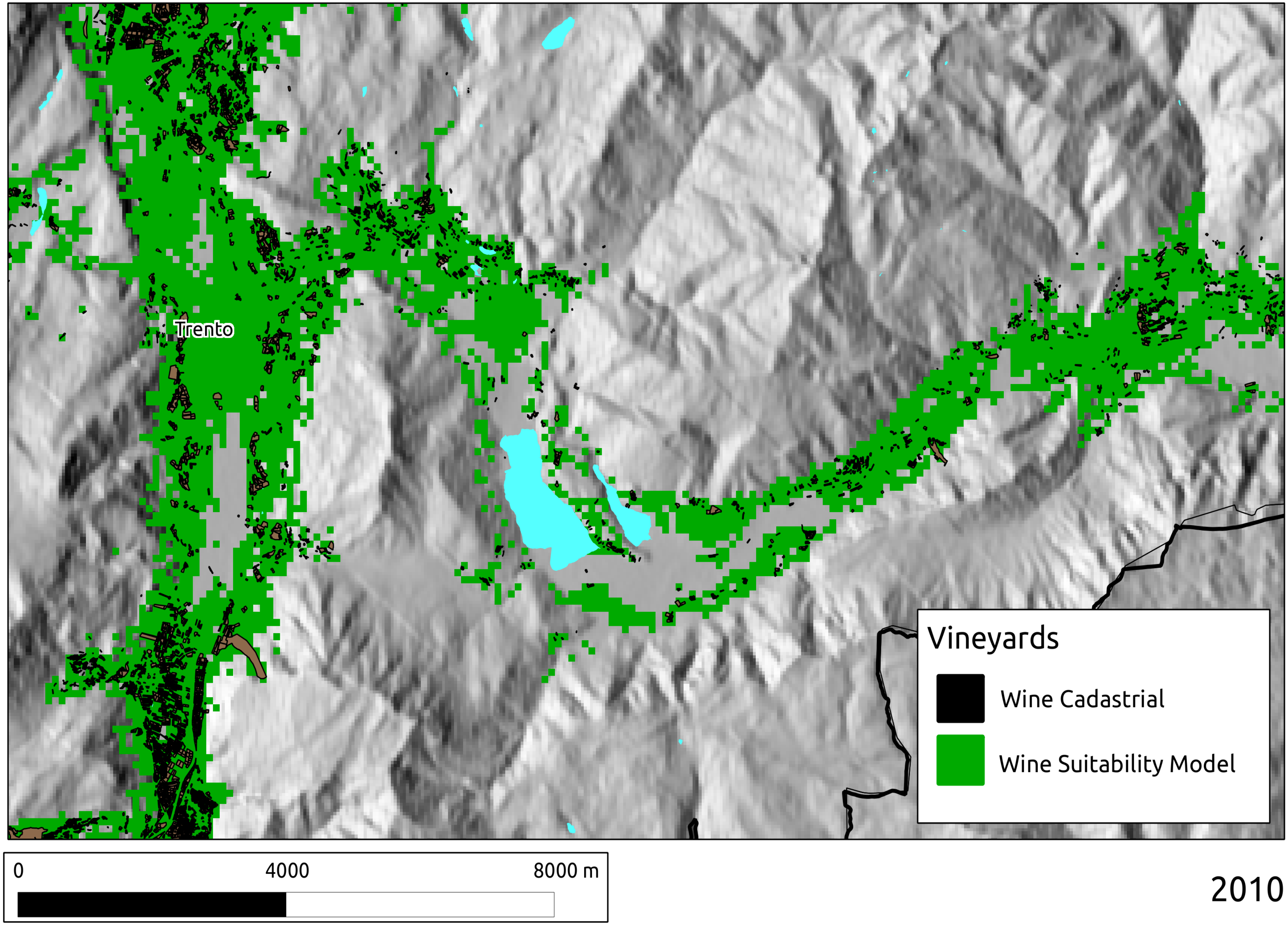
Vineyards

- Distribution models of different scenarios (current, 2020, 2050, 2080)
- 140 models tested
- 48 variables
  - 20 temperatures points are more significant than precipitation
- Parameters for simulation decided after testing

Vineyard Suitability Model (2010)



Vineyards Suitability Model (Focus on Caldonazzo and Levico Lakes)



2010

Vineyard Phenology

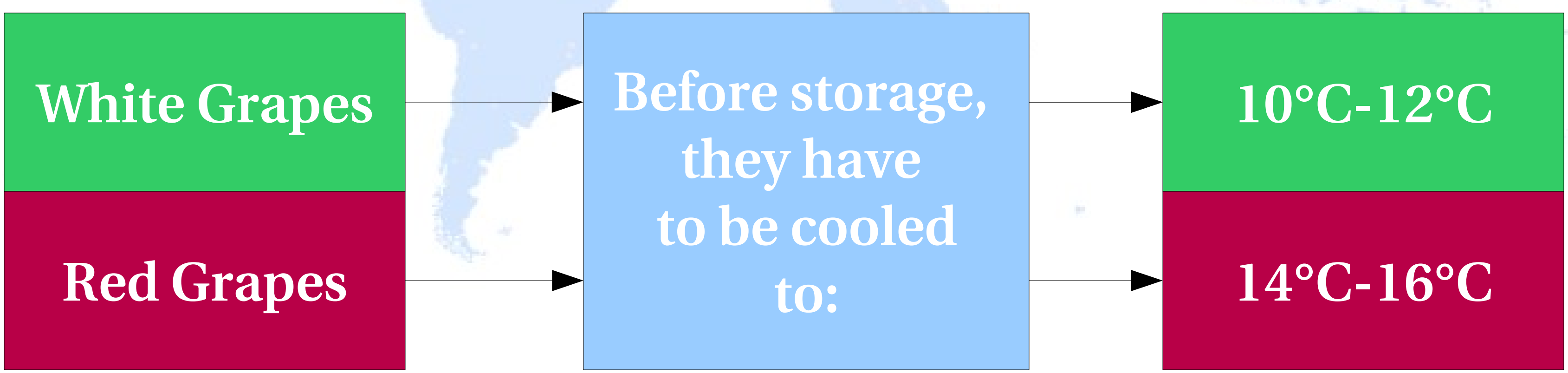
- Critical Hot Temperatures
  - 30°C- Minimal photosynthetic activity
  - 40°C – Photosynthetic activity stops

- Critical Cold Temperatures
  - Early Frost can kill emerging buds, their shoots, and any developing fruit)

Vineyard Growing Season

The Danger of Climate Change

- Mid- August
  - The temperature at which the grapes are harvested:
    - Morning: 24°C-34°C
    - Evening: 35°C
- Mid- September
  - The temperature at which the grapes are harvested:
    - Morning: 16°C-18°C
    - Evening: 25°C-28°C



Extreme Events

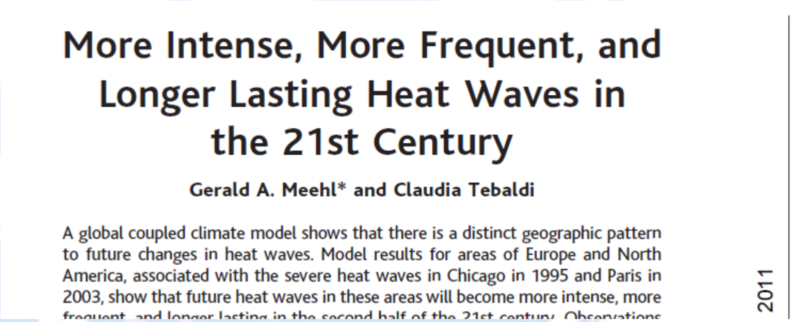
- Environmentally high-impact weather situation
- Two classes :

1) Heat Wave - can dry the harvest from August to September

2) **Frost** - can kill newborn buds from April to May

Heat Waves

HOURLY DATA, 36 STATIONS,
20 YEARS, 30 GENERATIONS,
1.9 Gb

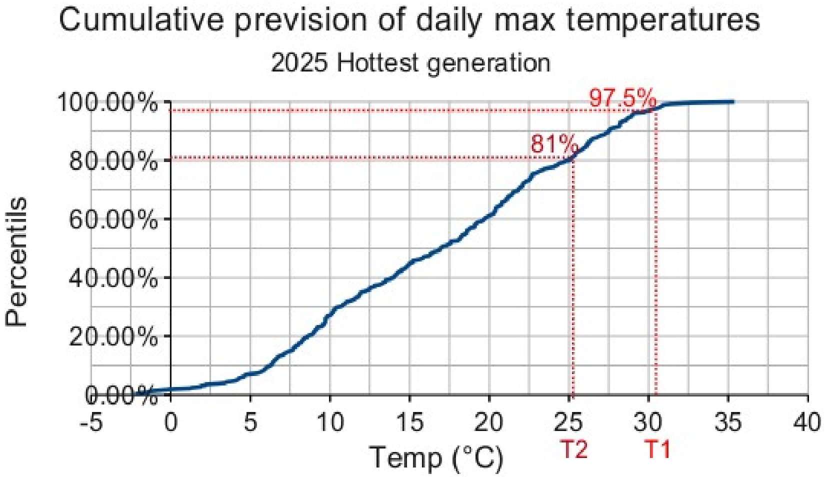


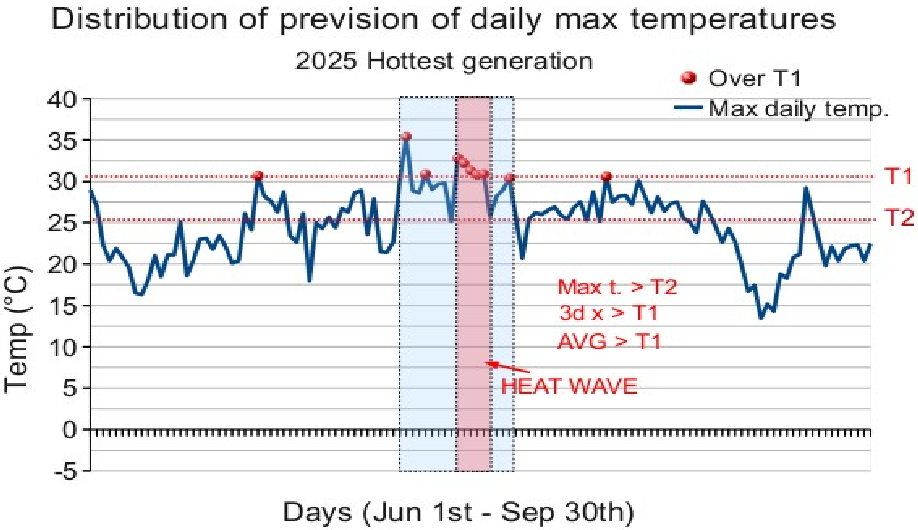
More Intense, More Frequent, and Longer Lasting Heat Waves in the 21st Century

Gerald A. Meehl* and Claudia Tebaldi

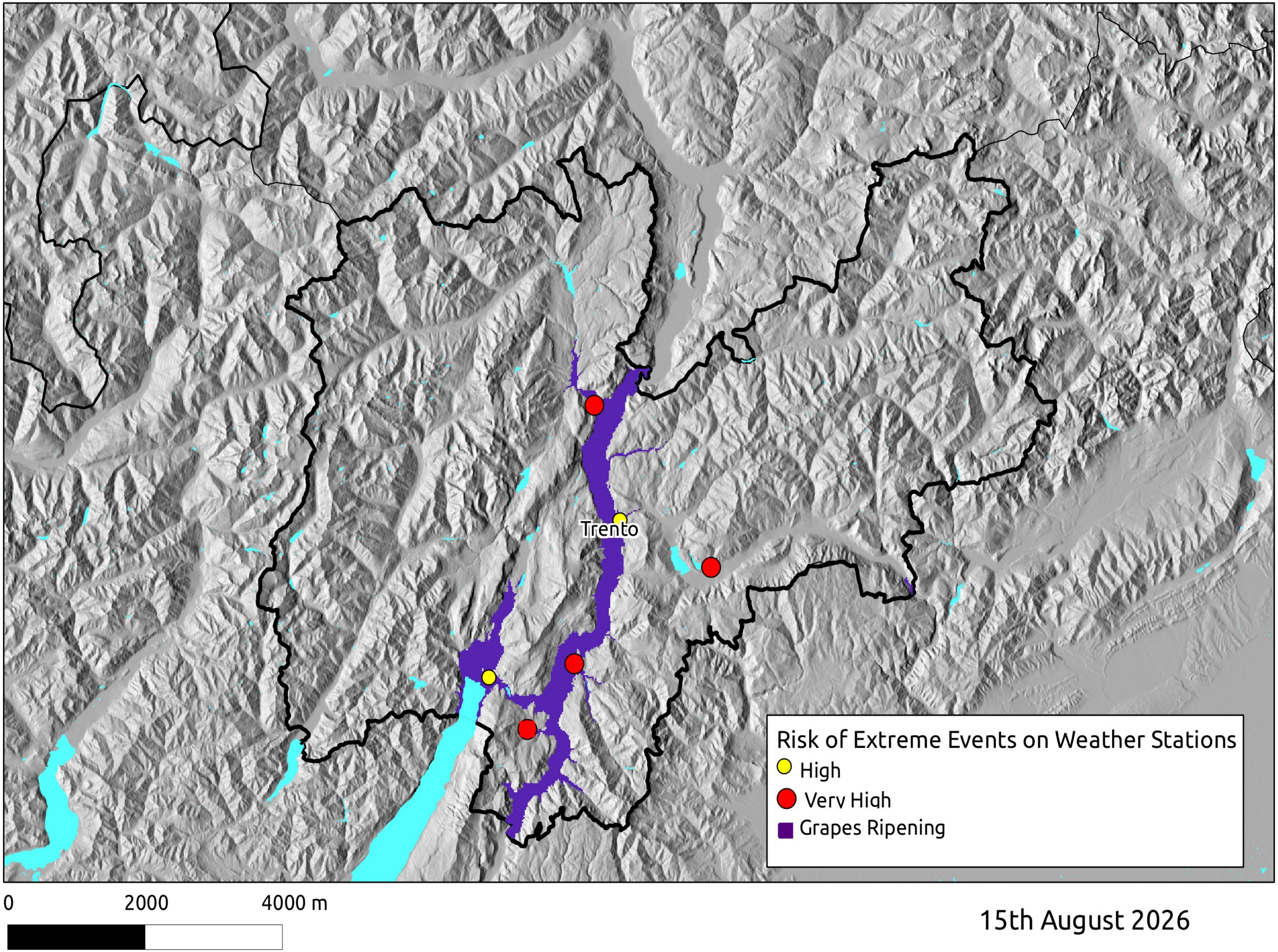
A global coupled climate model shows that there is a distinct geographic pattern to future changes in heat waves. Model results for areas of Europe and North America, associated with the severe heat waves in Chicago in 1995 and Paris in 2003, show that future heat waves in these areas will become more intense, more

Science vol. 305, 13 August 2004, Gerald A. Meehl, et al.





Heat Waves Risk Vs. Ripening Phenological Phase



15th August 2026

Biodiversity

- Global Biodiversity Information Facility (GBIF)
  - Informatics on occurrence of various species in the world
- GBIF data is only on European scale (useful for biodiversity on the sphere)
  - Not enough information for Italy

Biodiversity

- Select endangered and endemic species in the Alps
  - Data from MUSE of Trento & Professor Mauro Gobbi
- Chose an endemic species to build up a distribution model for the entire Alps region:
  - Parnassius apollo (lepidoptera order)
  - Numerous samples in database

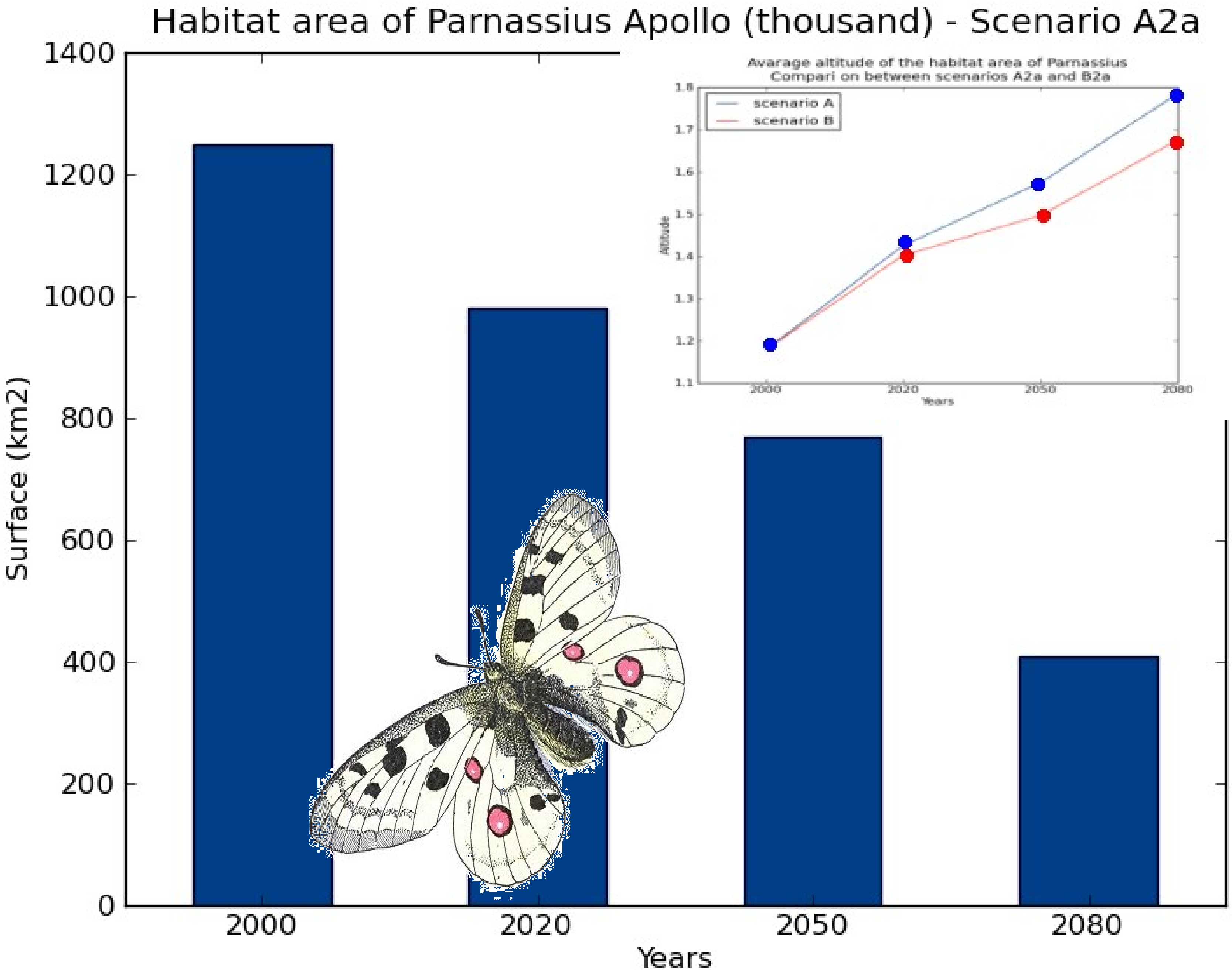
Creating Models

Use GRASS GIS to randomly select points of presence and absence

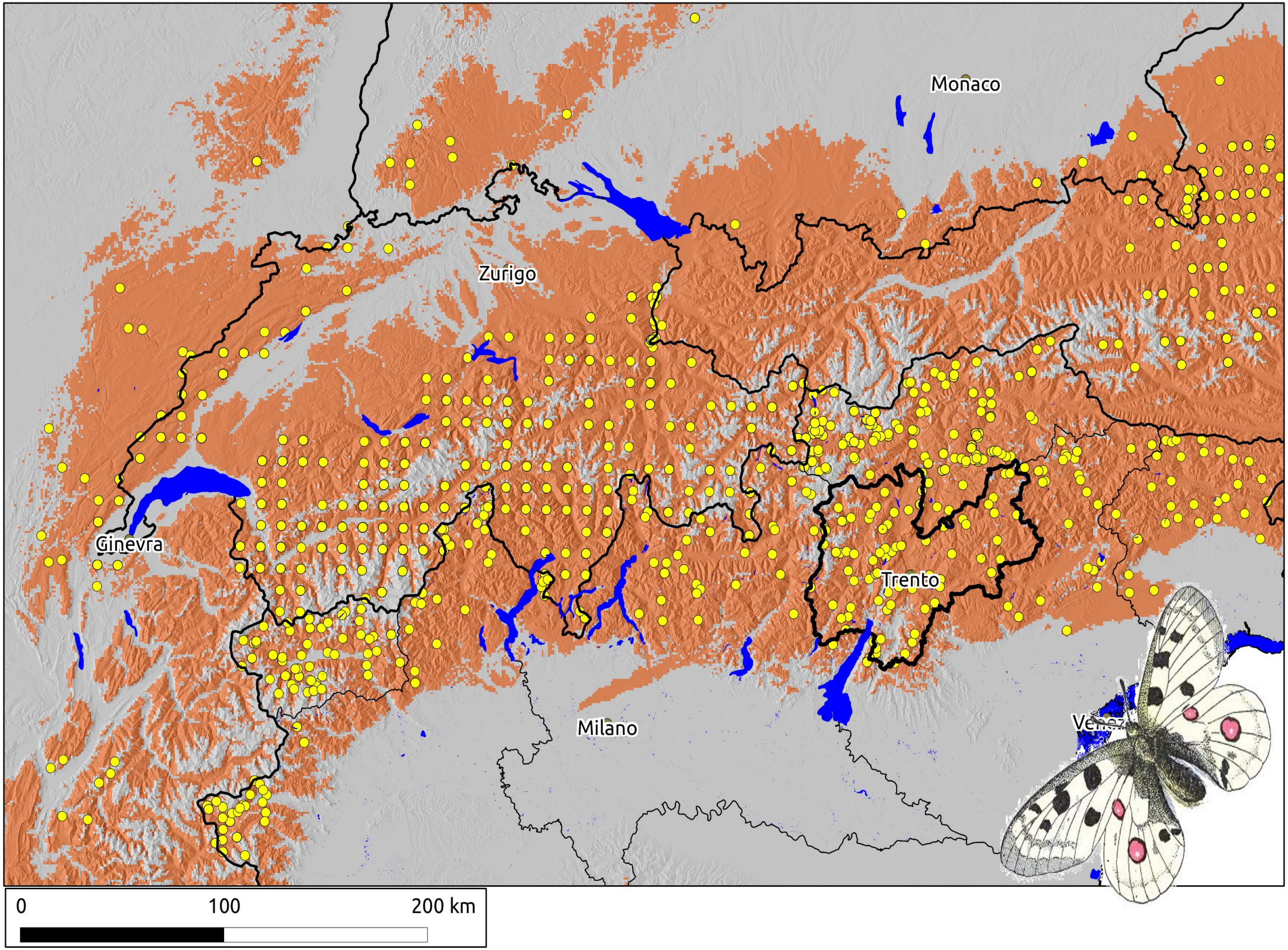
Build model to analyse different variables that influence the distribution of *Parnassius*.

With R we produced and tested the model which will be apply to A2a B2a scenarios and so obtain possible future projection of the distribution of the spieces (today, 2020, 2050, 2080).

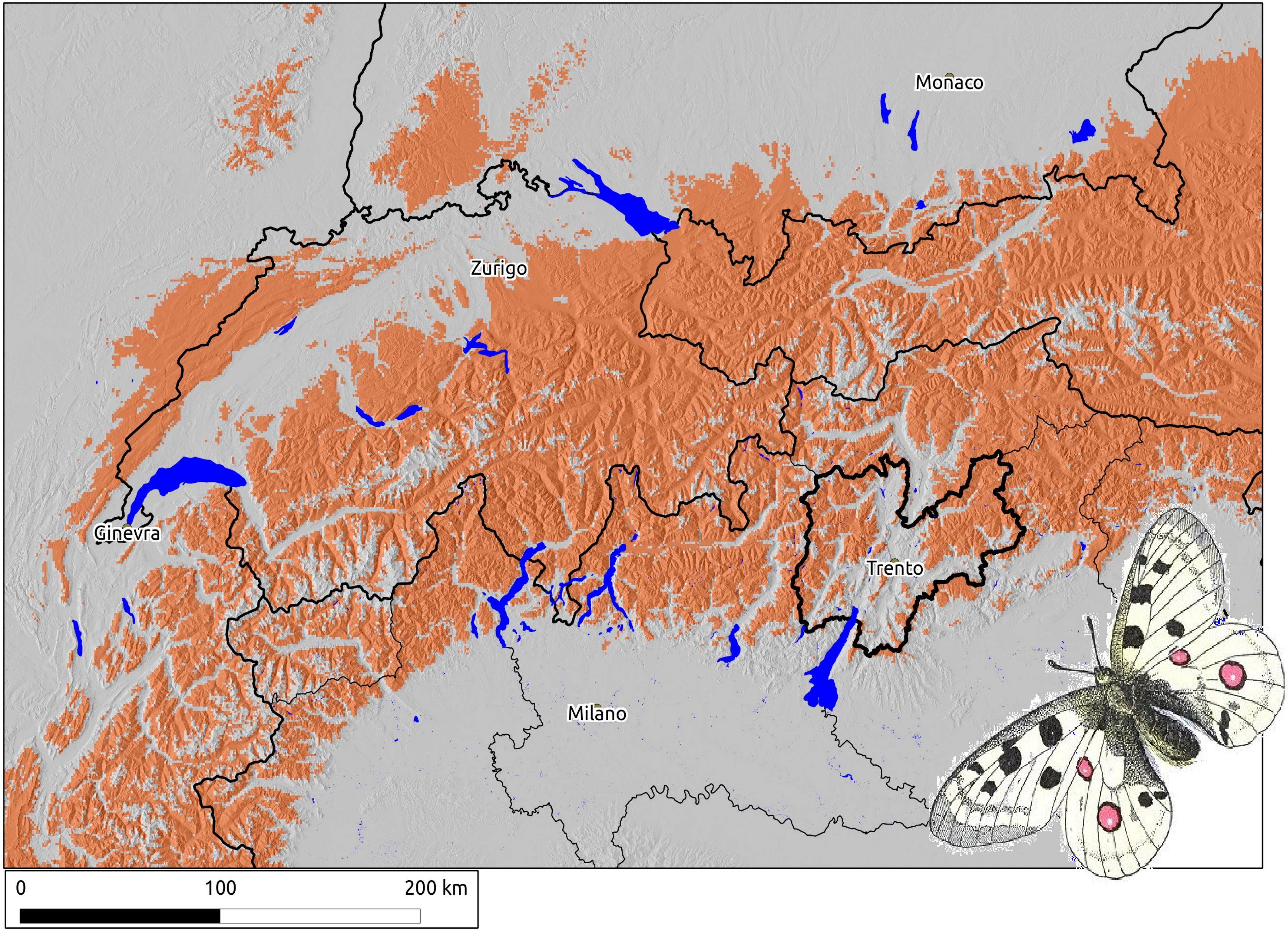
Finally we produced graphs about the changes in the areas of presence.


Habitat area of Parnassius Apollo (thousand) - Scenario A2a
Surface (km2)
0
200
400
600
800
1000
1200
1400
Years
2000
2020
2050
2080
Avarage altitude of the habitat area of Parnassius
Compari on between scenarios A2a and B2a
scenario A
scenario B
Altitude
1.1
1.2
1.3
1.4
1.5
1.6
1.7
1.8
Years
2000
2020
2050
2080

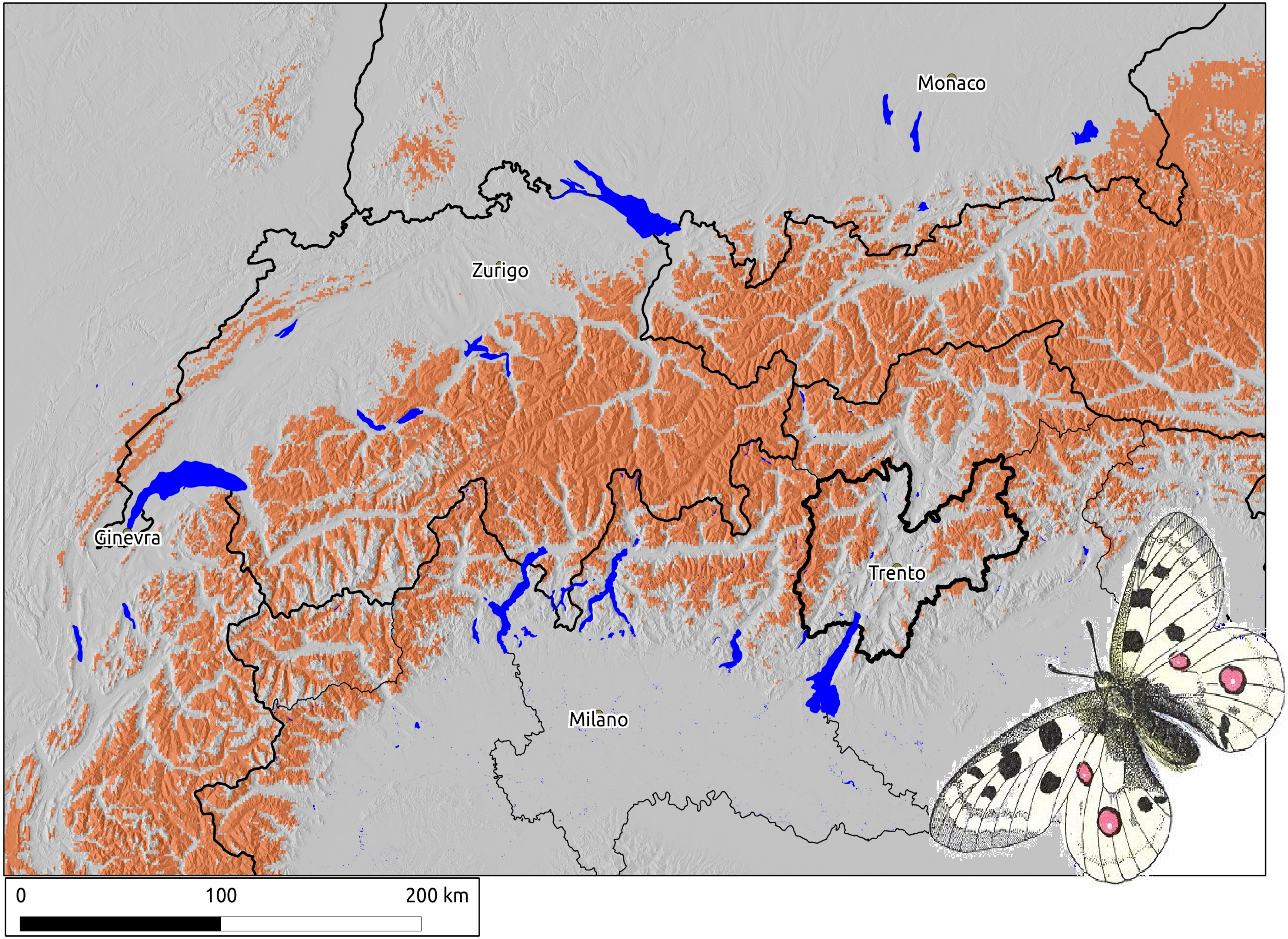
Parnassius Apollo Distribution (2000)



Parnassius Apollo Predictive Model on A2A Scenario (2020)



Parnassius Apollo Predictive Model on A2A Scenario (2080)



Conclusion

- Localize climate change data
  - 3 scales: Global, Regional (Alps), Local (Trentino)
- Interactive MUSE experience
  - Personal experience
    - Use Kinect or Mobile Device
- Raise Awareness
  - Bringing climate change to our backyard

Acknowledgements

- MeteoTrentino, Osservatorio clima trentino (Roberto Barbiero)
- Museo Tridentino di Scienze Naturali (Lanzinger, Gobbi)
- NOAA
- Fondazione Mach - Envirochange Project
- Cavit, Andrea Faustini
- JRC Ispra, Giuseppe Amatulli
- University of Genova (Verri, Barla)
- APPA (Katia Monauni)
- Rudi Bogni
- Regione Veneto (Paolo Santinello)
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- University of Padua, Massimo Faccoli
- Giulio Maria Busulini, Washington
- Progetto Nazionale Lauree Scientifiche (PNLS), Gabriele Anzellotti

Support

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- Eurac Research
- Unep
- Computer Learning SRL
- Trentino Network

Thank you!