RECCO

REgional Climate in Complex Orography

Development of ensembles of regional climate change scenarios, with focus on variability, extremes and uncertainties in areas of complex topography

NextData 3 – 4 June 2014 Roma

Unit 1 :
Institute of Atmospheric Sciences and Climate (ISAC),
(CNR coordinating Institute)

Silvia Trini Castelli, Antonio Parodi
Alessia Balanzino, Albert Comellas Prat

Unit 2:
Abdus Salam International Centre for Theoretical Physics (ICTP)

Filippo Giorgi, Laura Mariotti

Unit 3:
Cineca

Giovanni Erbacci, Piero Lanucara

Unit 4:
Institute of Methodologies for Environmental Analysis (IMAA)

Fabio Madonna

The AIM

improving the physical understanding of the changes in climatological regimes over the NextData regions of interest, with the support of their meteorological characterization.

The RATIONALE

The variability and uncertainties of climate and meteorology of the interest areas (Hindu-Kush Karakorum, Alps and Mediterranean region) will be studied with a suite of regional climate models (RCMs) integrated with mesoscale meteorological models.

Each modelling system will be used at different spatial scales, from regional to local, yielding a unique multi-scale modelling framework.

The MODELS

The ICTP RegCM: produces ensembles of regional scenarios using different model configurations, resolutions, driving GCMs and greenhouse gas scenarios, which allow a characterization of different sources of uncertainty.

The WRF model: allow dynamical downscaling at the mesoscale of scenarios provided by the EC-EARTH global model. These will be compared with and integrate the ICTP RegCM ensemble.

The RAMS model: is used to perform high-resolution (cloud-resolving) simulations for specific complex topography areas to investigate relevant physical and dynamical processes.

The results will be evaluated using available observations and released to the NextData databank.

Simulations with RAMS model – UNIT 1 Re-WP3

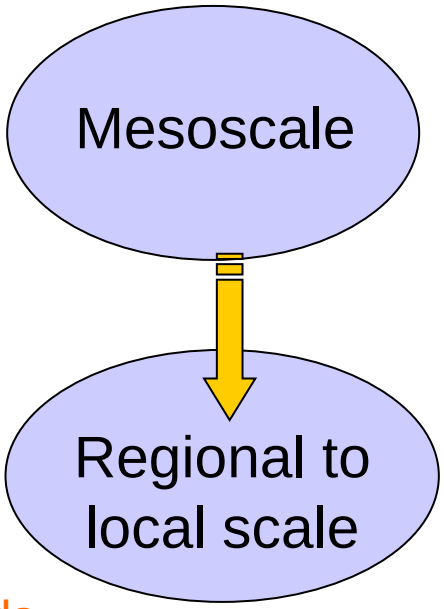
An identification and thorough analysis of critical issues related to the simulation of physical processes in very complex orography settings is attained through high-resolution simulations with the RAMS model over the mountainous areas of Italian Alps and Apennines and of the Hindu-Kush Karakorum.

sensitivity analysis of the model performance versus observed data: simulations in the Italian Alps for guiding lines, the Frejus and Brenner areas

Sensitivity to resolution: 4 km vs 1 km

Frejus: four nested grids
grid 1: 64 km horizontal resolution
grid 2: 16 km horizontal resolution
grid 3: 4 km horizontal resolution
grid 4: 1 km horizontal resolution

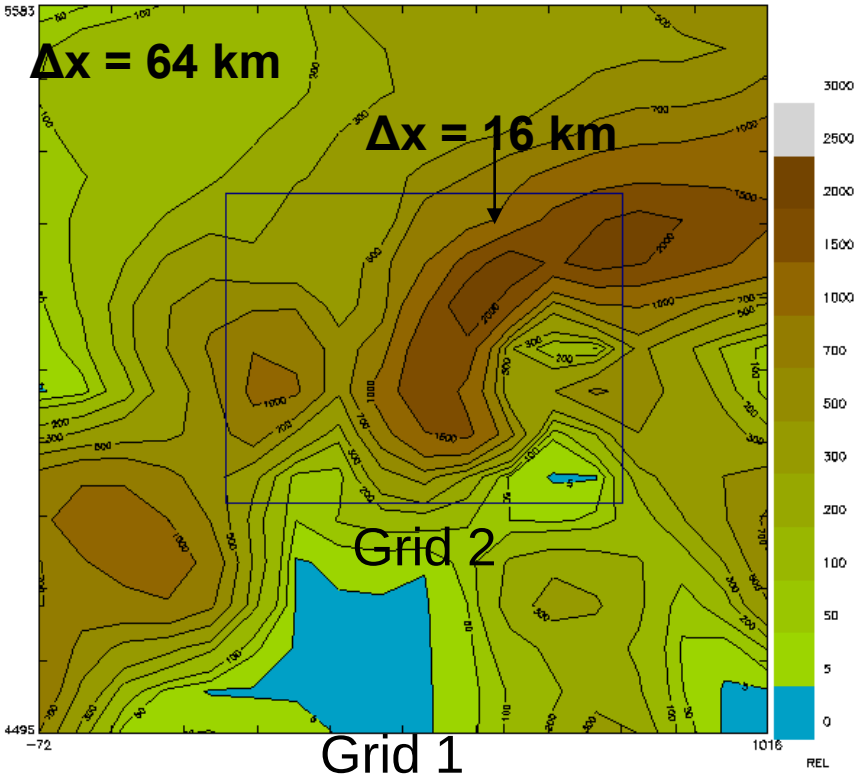
Vertical grid: 27 vertical stretched layers (0 –17500 m),
first layer 50 m depth (first level at 24 m)

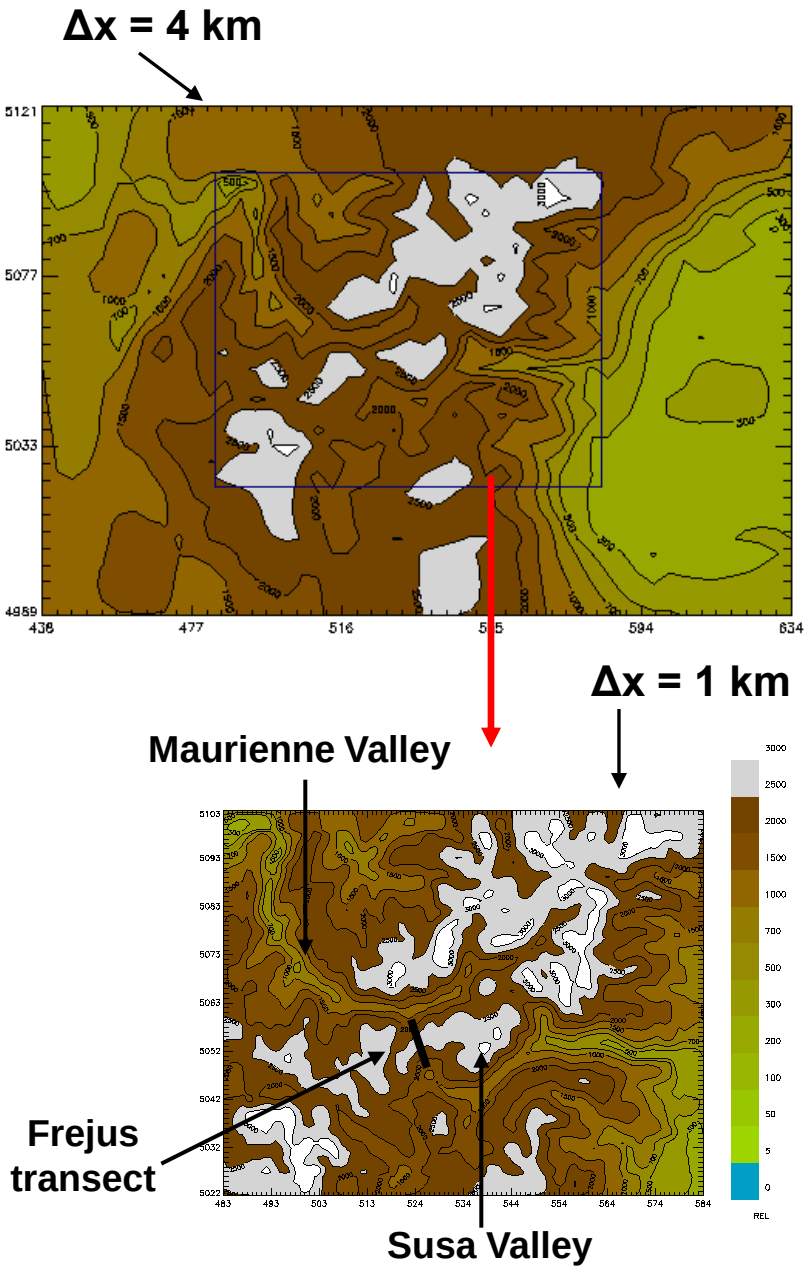


RAMS is initialised with the ECMWF (0.5^{o} lat/lon) analysis fields.

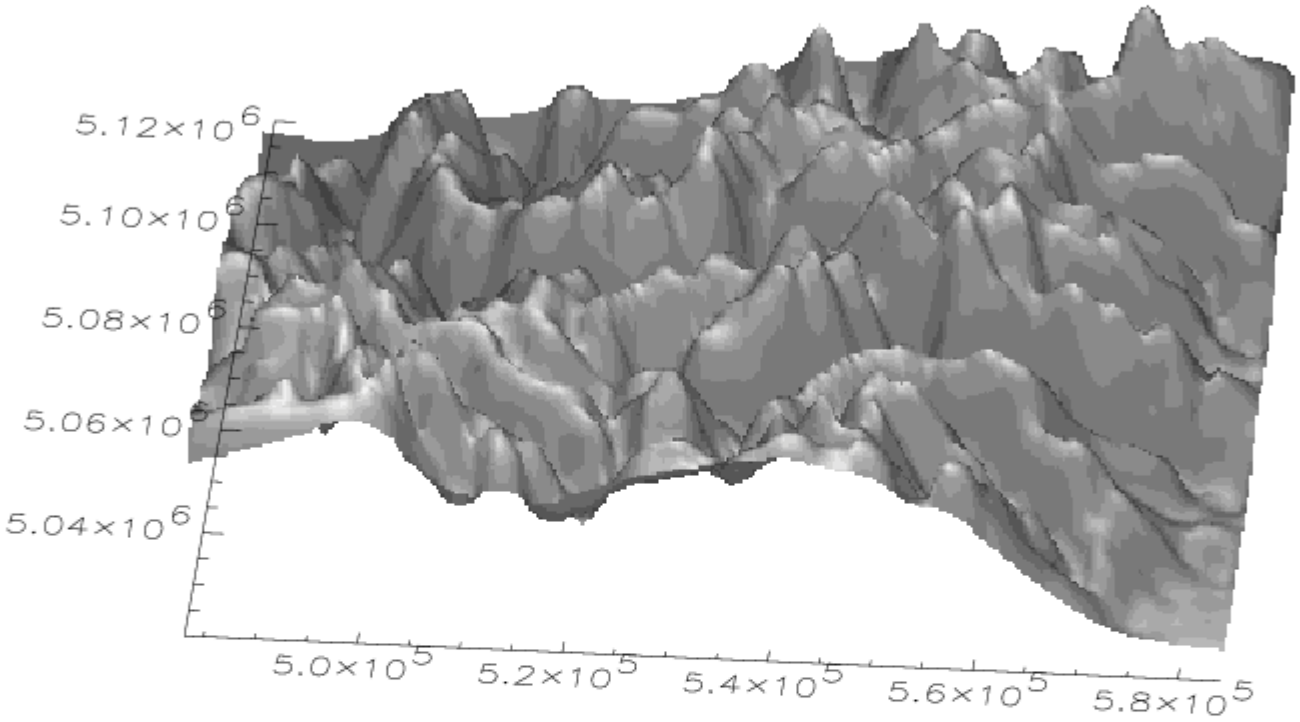
Nudging at the lateral boundaries of the outer grid every 6 hours.

Frejus area


Δx = 64 km
Δx = 16 km
Grid 2
Grid 1
REL


Δx = 4 km
Δx = 1 km
Maurienne Valley
Frejus transect
Susa Valley
REL

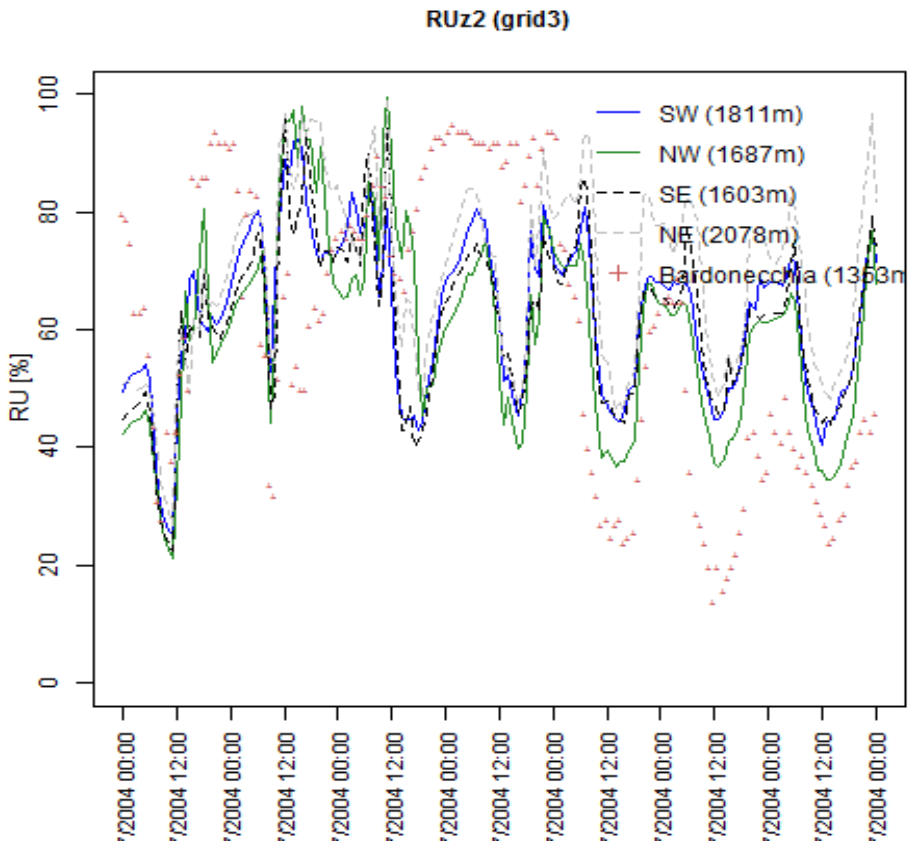
OROGRAPHY ON GRID 4

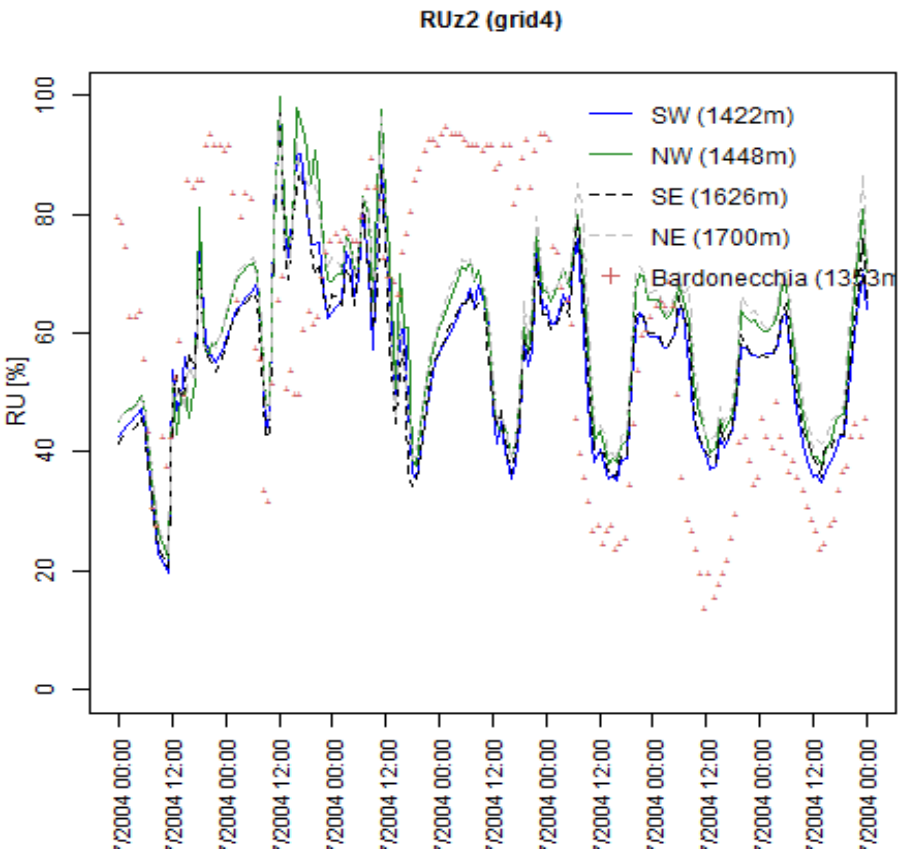


Measuring stations:

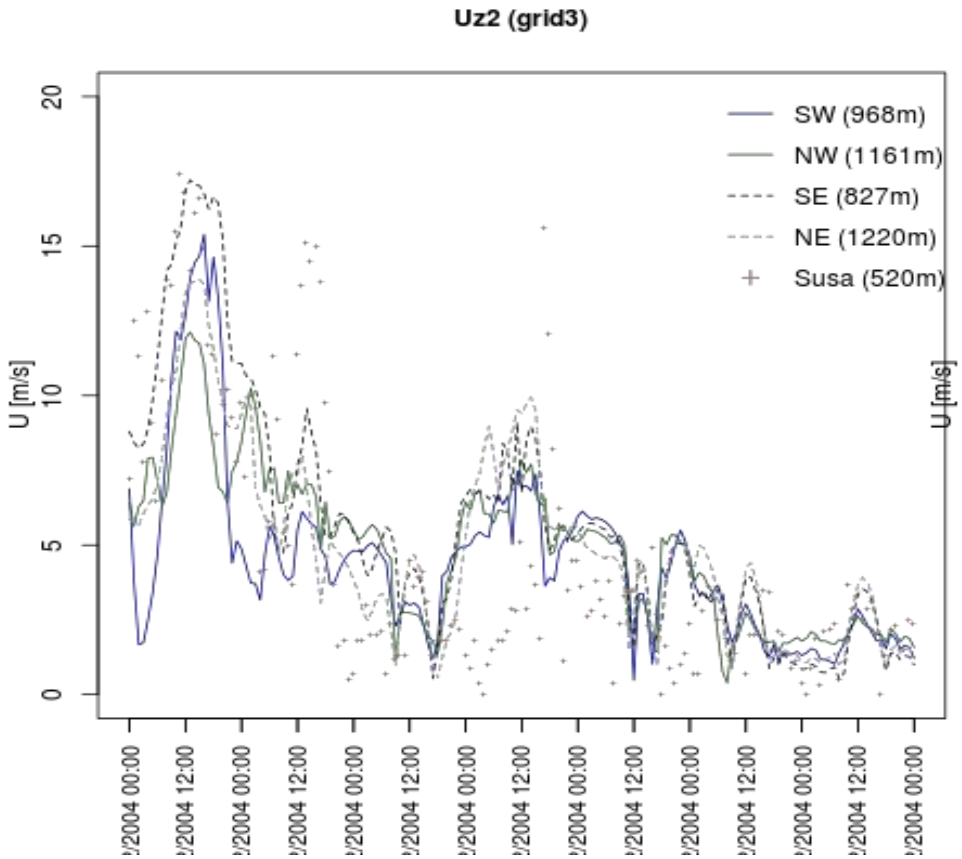
Susa: 7.055° lon, 45.1428° lat, 520 m alt
Bardonecchia: 6.7175° lon, 45.0758° lat, 1353 m alt

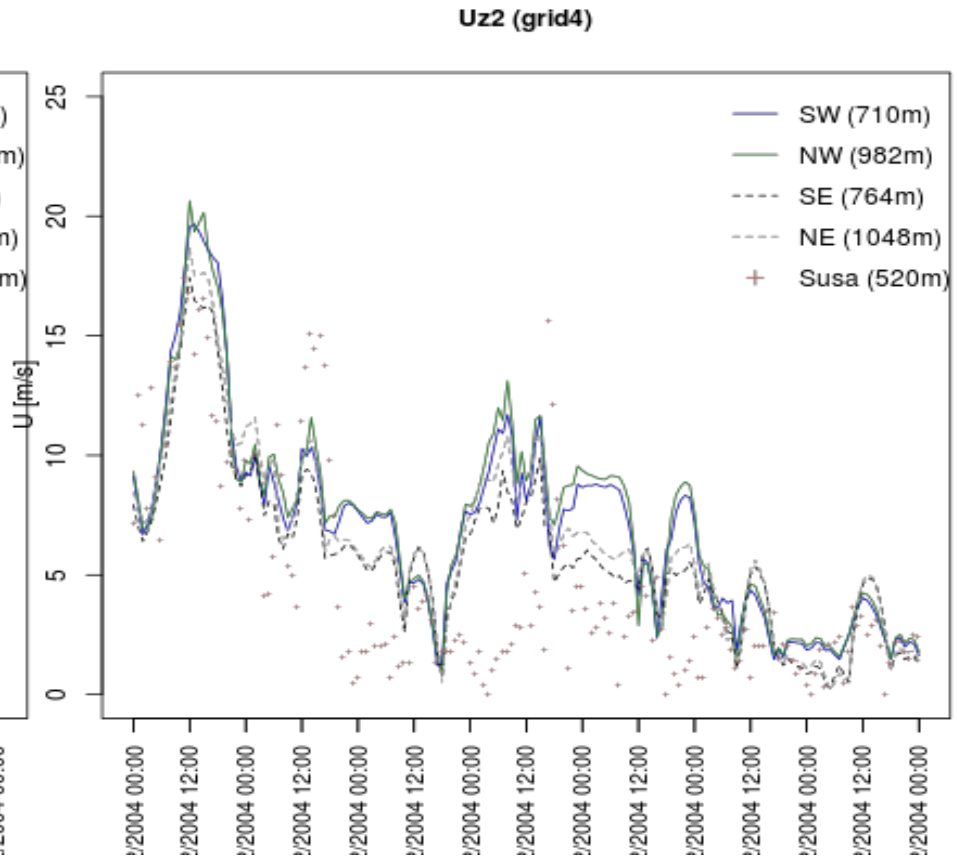
Bardonecchia – July – relative humidity





Susa – February - wind speed



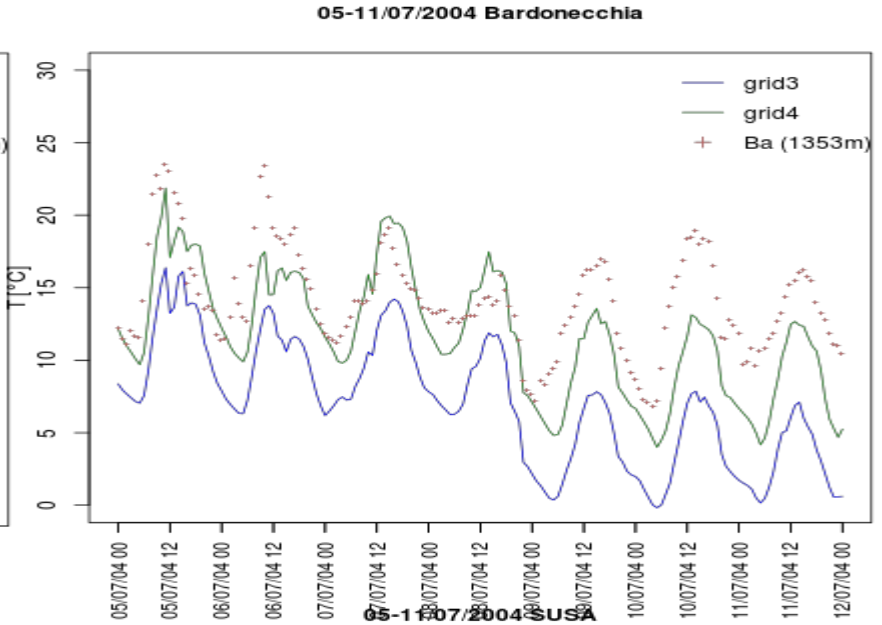


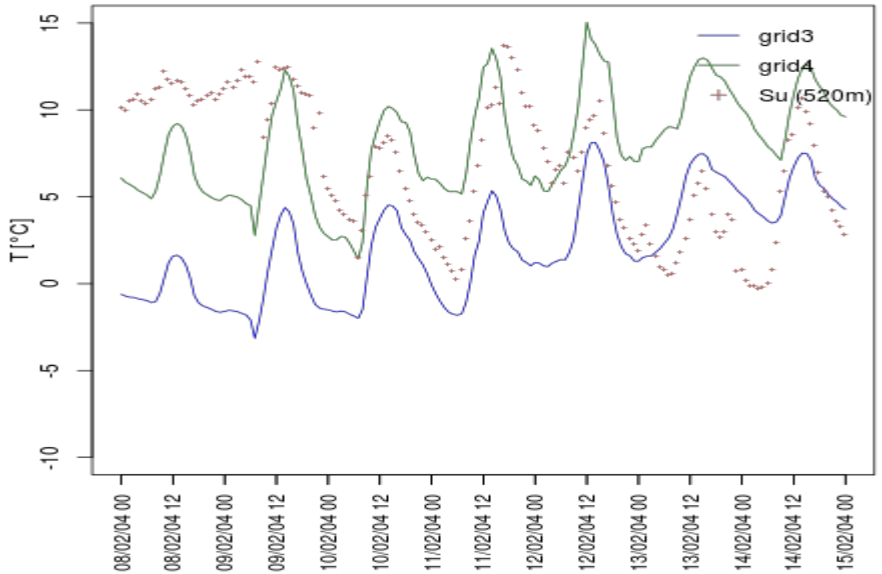
Can we trust interpolation?

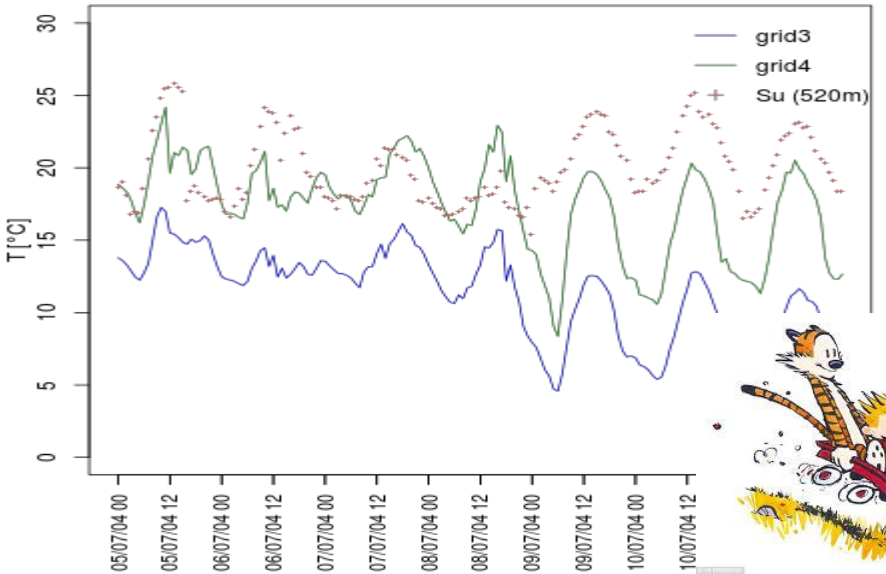
GRID 4

SUSA : 7.05566 lon, 45.1798 lat, 1800 m alt!!!

BARDO: 6.78825 lon, 45.0757 lat, 1321 m alt !!





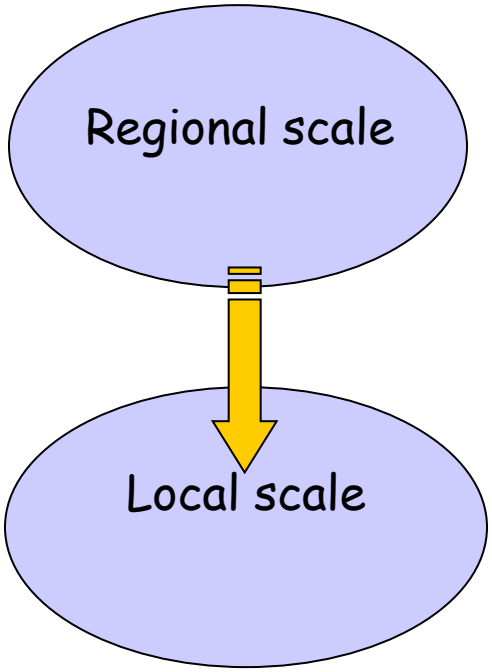


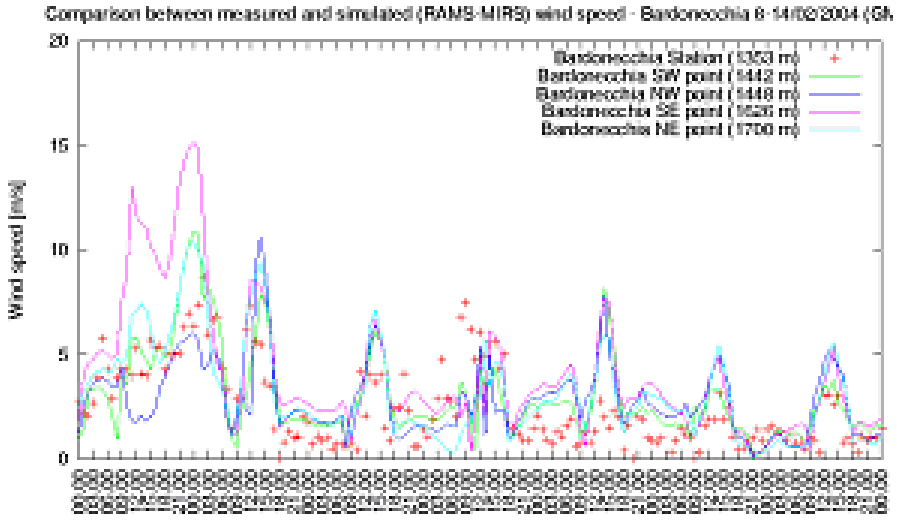
How to proceed? Downscaling with a mass consistent model: MINERVE

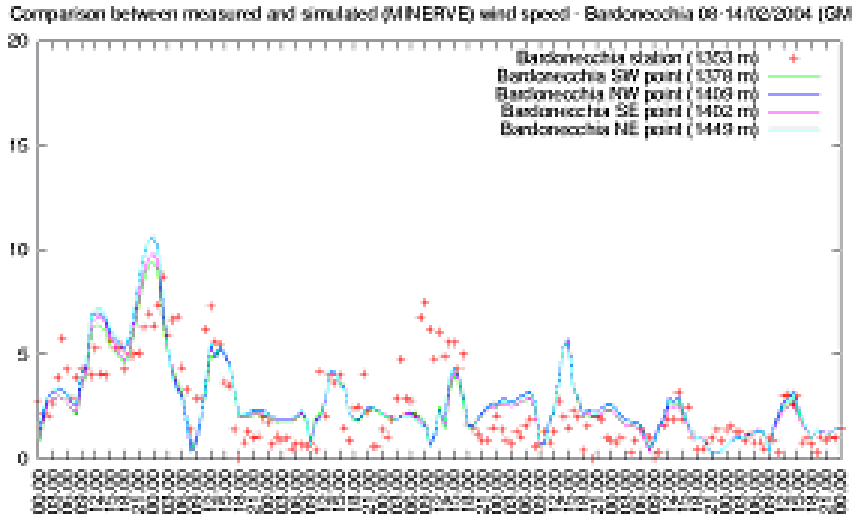
Simulation of the meteo fields using the diagnostic code MINERVE up to 100 m resolution, subdomains

Susa valley 20 x 15 km, 100 m resolution
Vertical grid: 27 vertical stretched layers (0 –8000 m), *first level at 20 m*

MINERVE gets as input the hourly RAMS 3D gridded dynamical and thermal fields



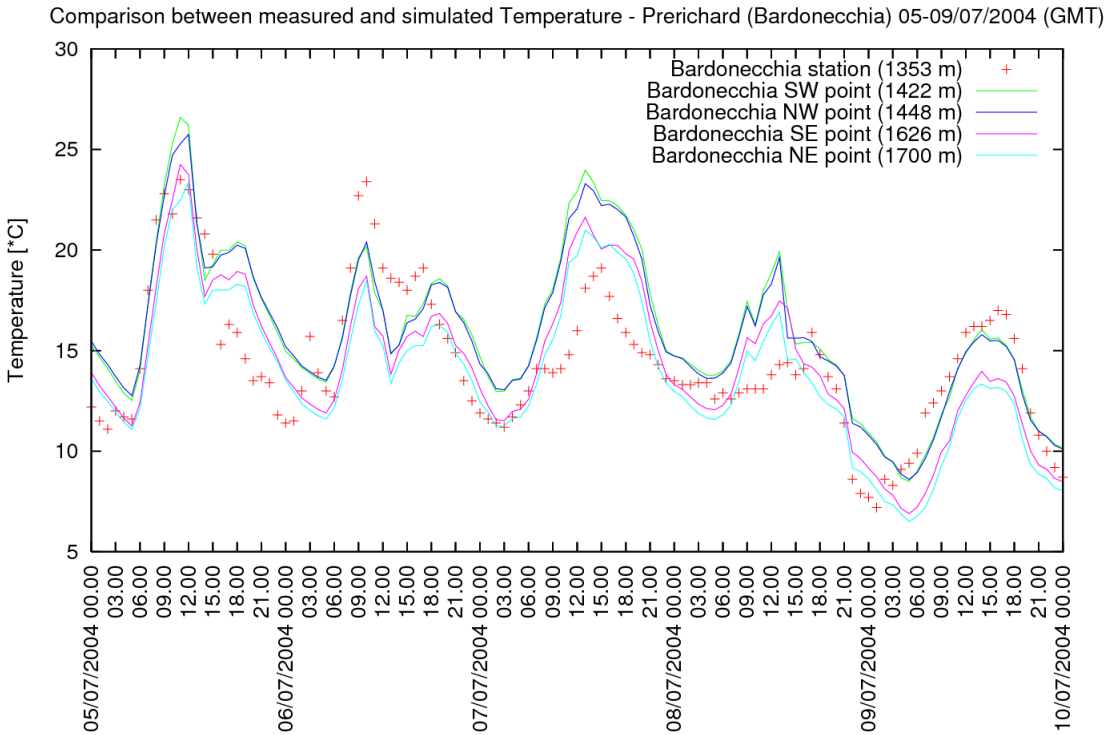




Sensitivity to initialization: soil humidity

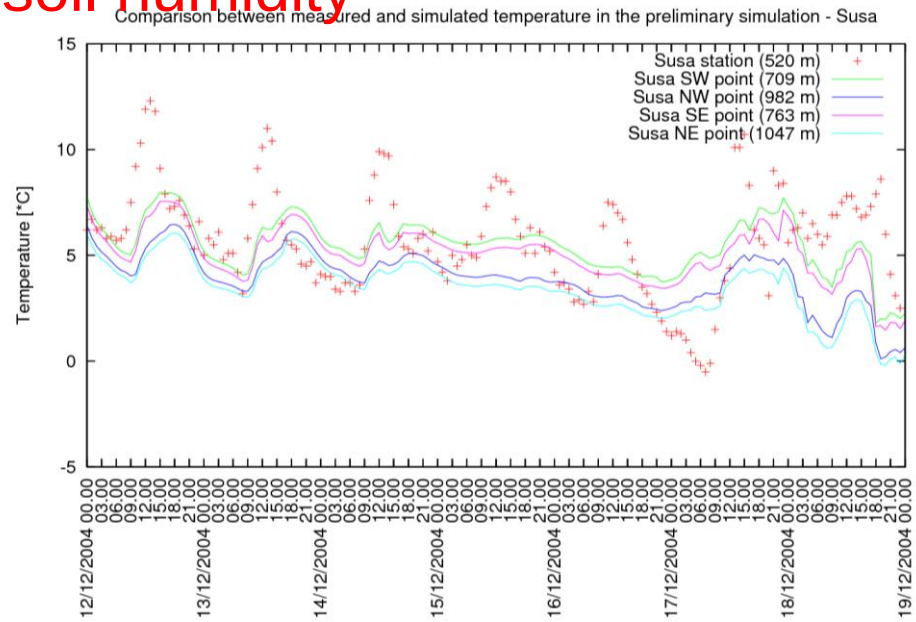
The initial profile of temperature and humidity in the soil represents the triggering-start of the soil model, part of the 'engine' of the surface layer and boundary layer physical processes.

Summer time,
Bardonecchia,
July 2004
ECMWF profile



Sensitivity to initialization: soil humidity

December 1st try



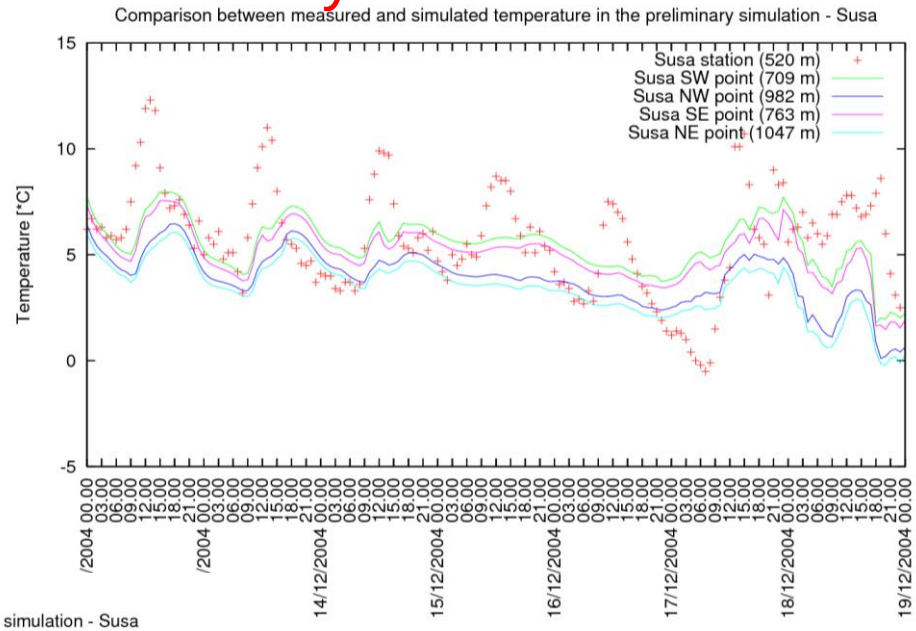
….but in Winter time….

1st try: initial soil profiles of temperature and humidity the values extracted by the ECMWF analyses,

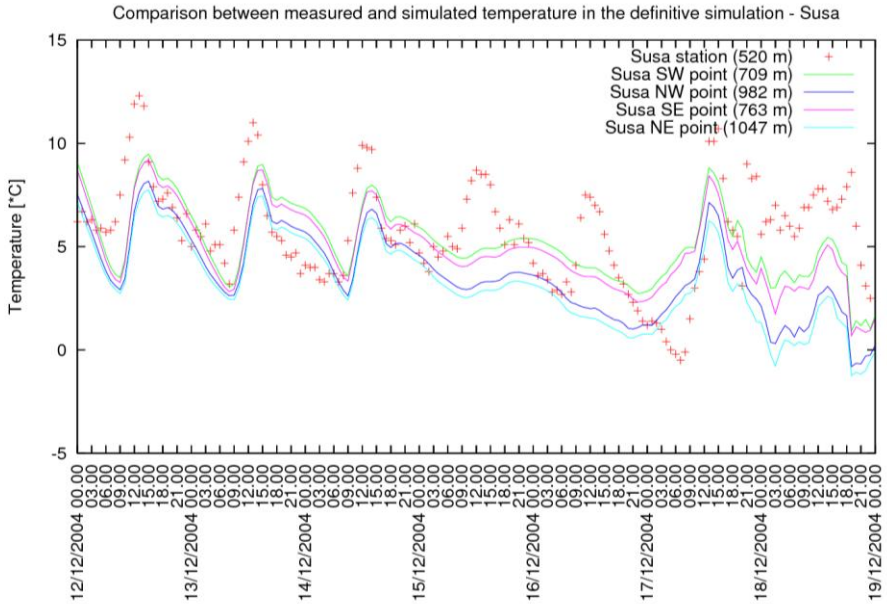
2nd try: using a constant profile of humidity with lower values than the ECMWF ones (ex. RH = 25 %)

Sensitivity to initialization: soil humidity

December 1st try

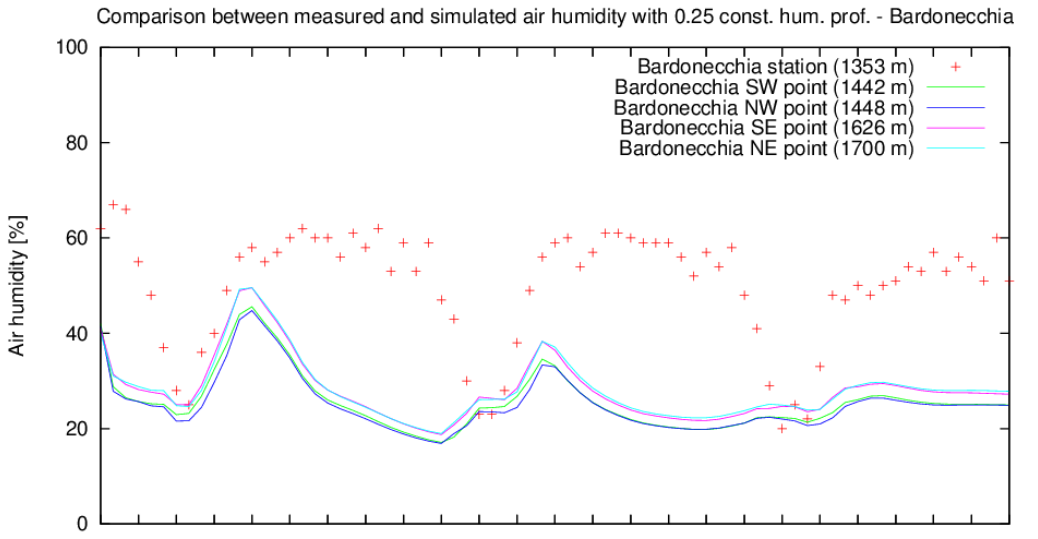


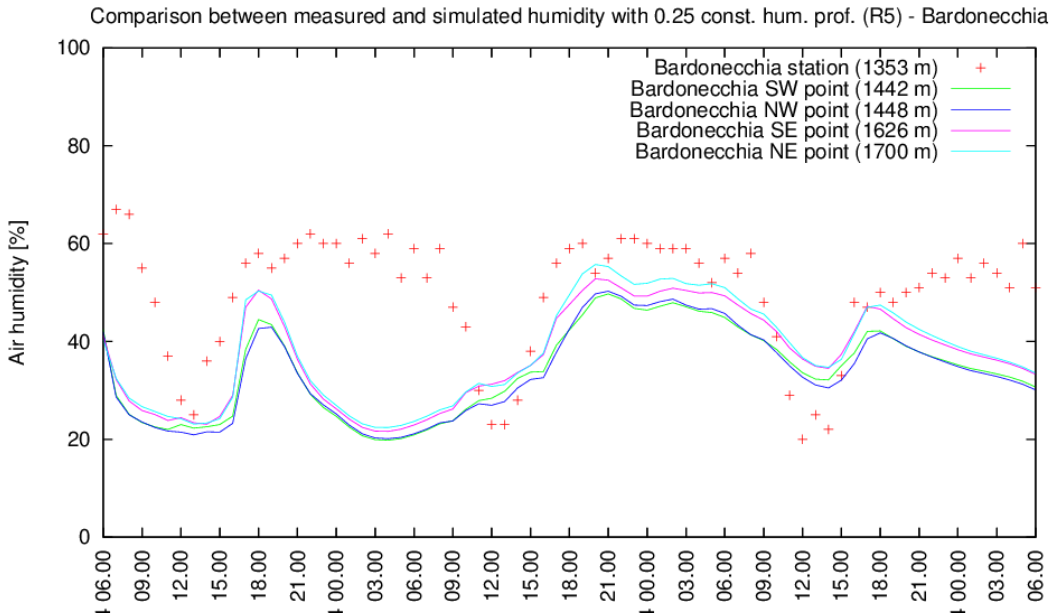
….but in Winter time….



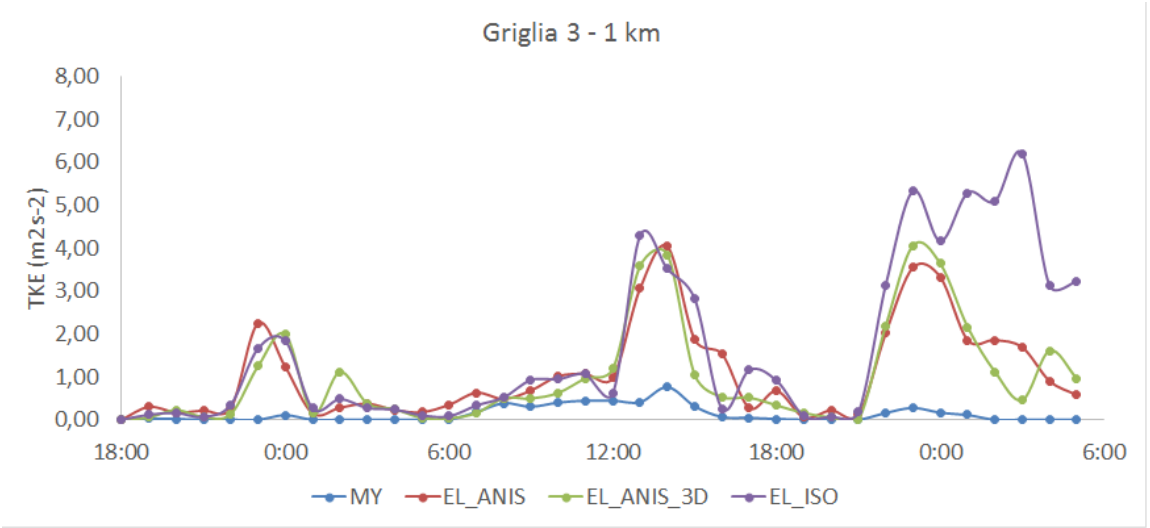
December 2nd try

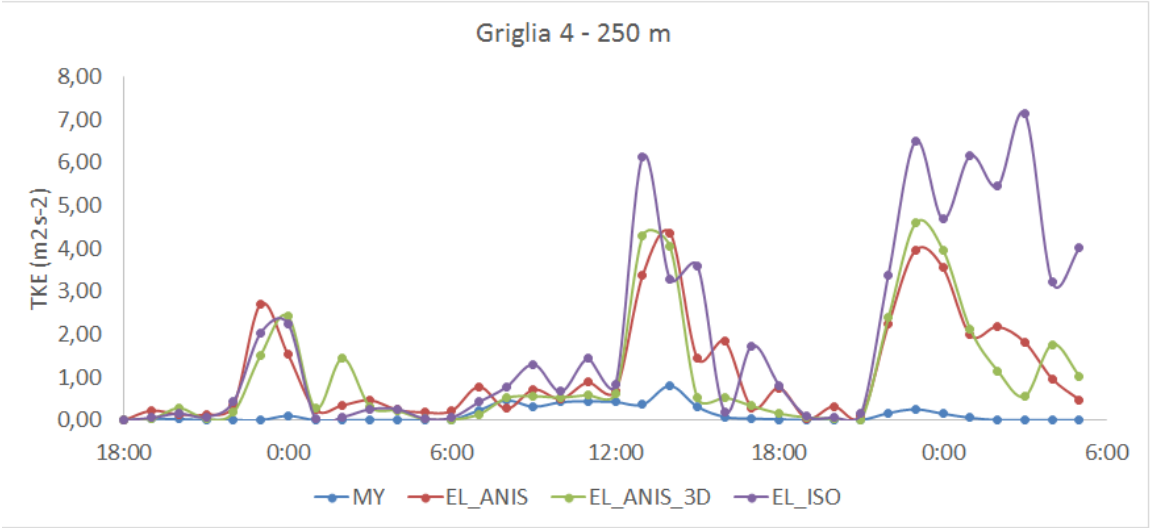
Sensitivity to different version of the model





Sensitivity to different boundary-layer and turbulence parameterizations: the TKE





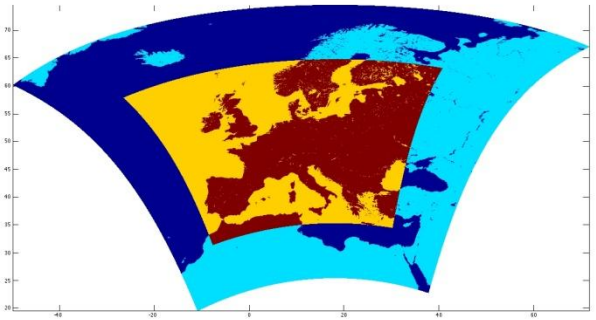
Simulations with WRF model: Unit 1 Re-WP2

Analysis of changes in variability and extreme events, such as flood, drought, and heat waves, focusing on events that are the most important in determining impacts on a wide variety of sectors in environmental and health protection

completion of mesoscale dynamical downscaling of emission scenarios produced with the EC-Earth global model.

High-resolution dynamical downscaling of global scenarios over Europe

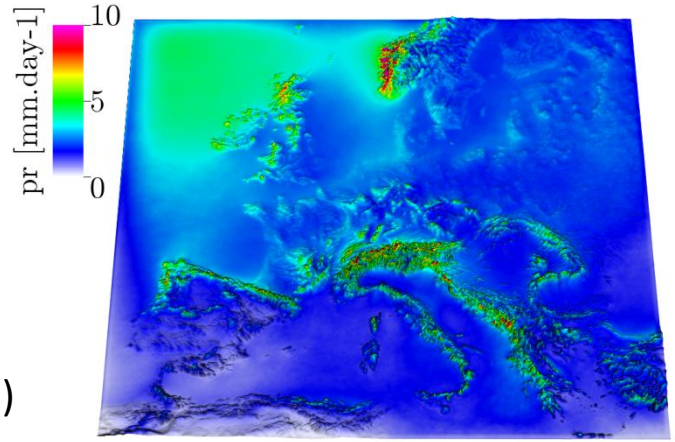
- Climate simulations with the WRF non-hydrostatic regional model for the European domain.
- Resolutions 0.11° and 0.04°.
- 30-yr present (1979-2008), large scale driver ERA-Interim at 0.04° resolution, done.
- Simulations with large scale driver EC-Earth, present-day and future RCP4.5 and RCP8.5 scenarios, at 0.11°, in progress, to be finished by the end of the year.



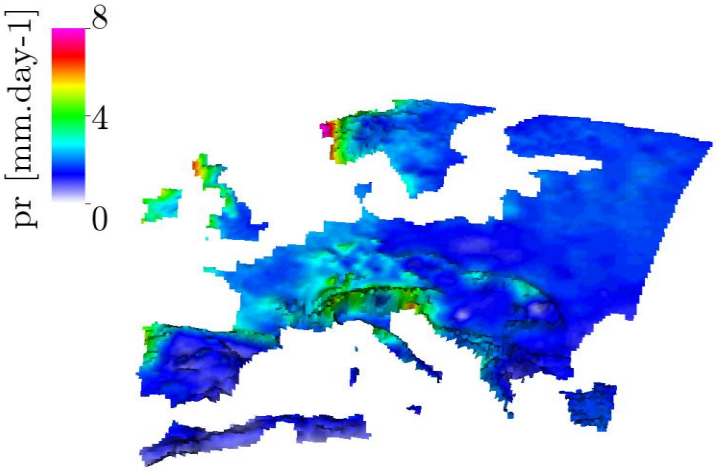
Simulations @ LRZ/SuperMUC, Munich

Downscaling dinamico con WRF

Fig.2: climatologie. Confronto tra la climatologia di WRF (2a) e di E-OBS (2b) per il periodo 1979-1999



(2a)



(2b)

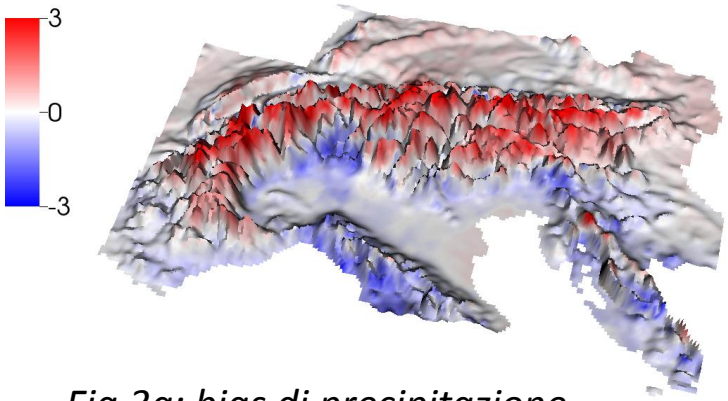


Fig.3a: bias di precipitazione. Differenza tra le climatologie di WRF e EURO4M sul periodo 1979-1999: circa 30% di bias.

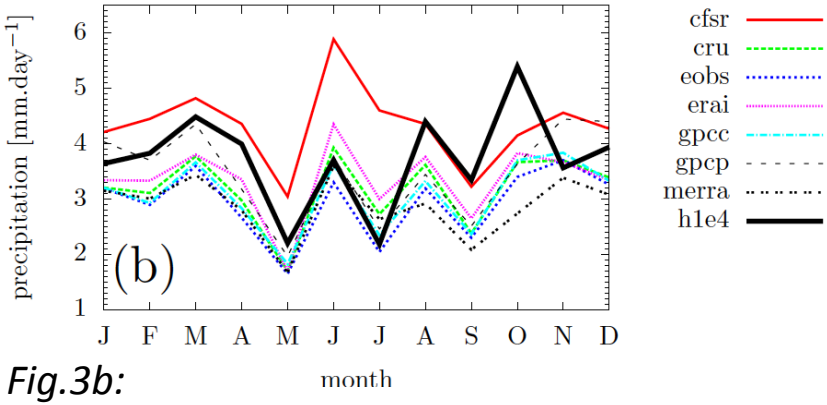


Fig.3b: Confronto della media areale di WRF sul GAR con diversi dataset osservativi.

Downscaling dinamico con WRF

Comunicazioni:

International Conference on Regional Climate – CORDEX 2013, Bruxelles, 4-7 Novembre 2013.

European Geosciences Union General Assembly 2014, Vienna, Austria 27 Aprile – 02 Maggio 2014.

Articoli: Pieri, Hardenberg, Parodi, Provenzale: Do precipitation rates from non-hydrostatic simulations agree with data? A view from the WRF model over Europe. Submitted to Journal of Hydrometeorology.

Prospettive: bias correction con EURO4M sul GAR per applicazioni future all'idrologia

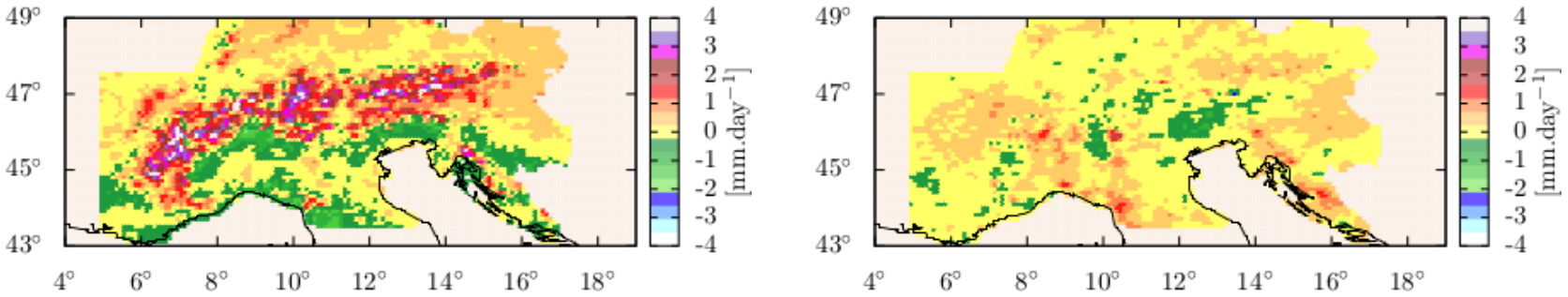


Fig.4: climatologia di precipitazione per il periodo 1999-2003 senza (sinistra) e con (destra) bias correction. La correzione consiste nel normalizzare per la climatologia del periodo 1979-1998.

Simulations with ICTP RegCM, Unit 2, Re-WP1

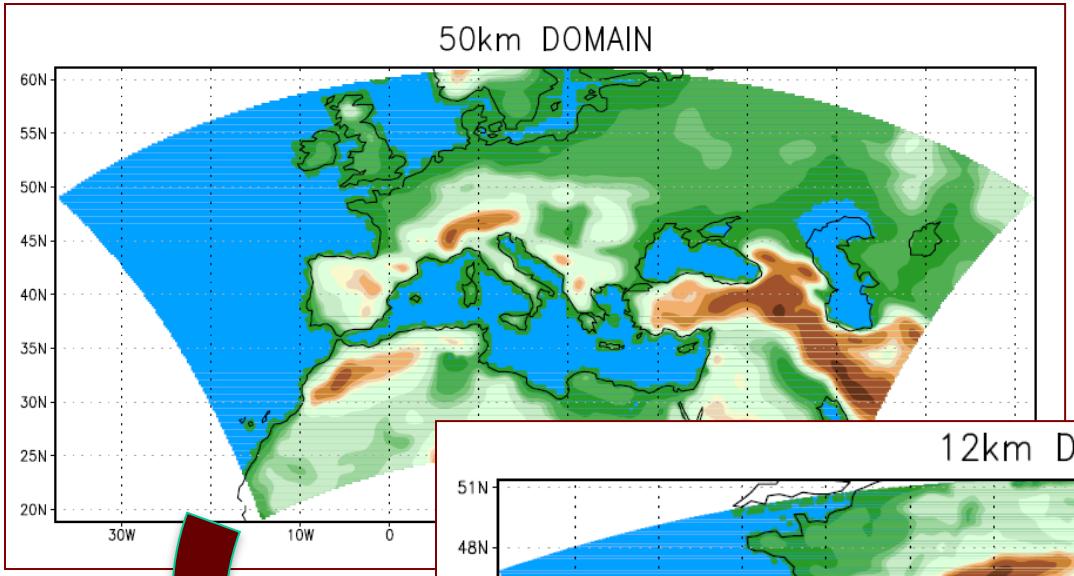
Uncertainty analysis of climate scenarios with emphasis on changes in climate variability, hydroclimatic regimes and extremes, and on the characterization of primary sources of uncertainty in the scenarios, for impact assessment studies.

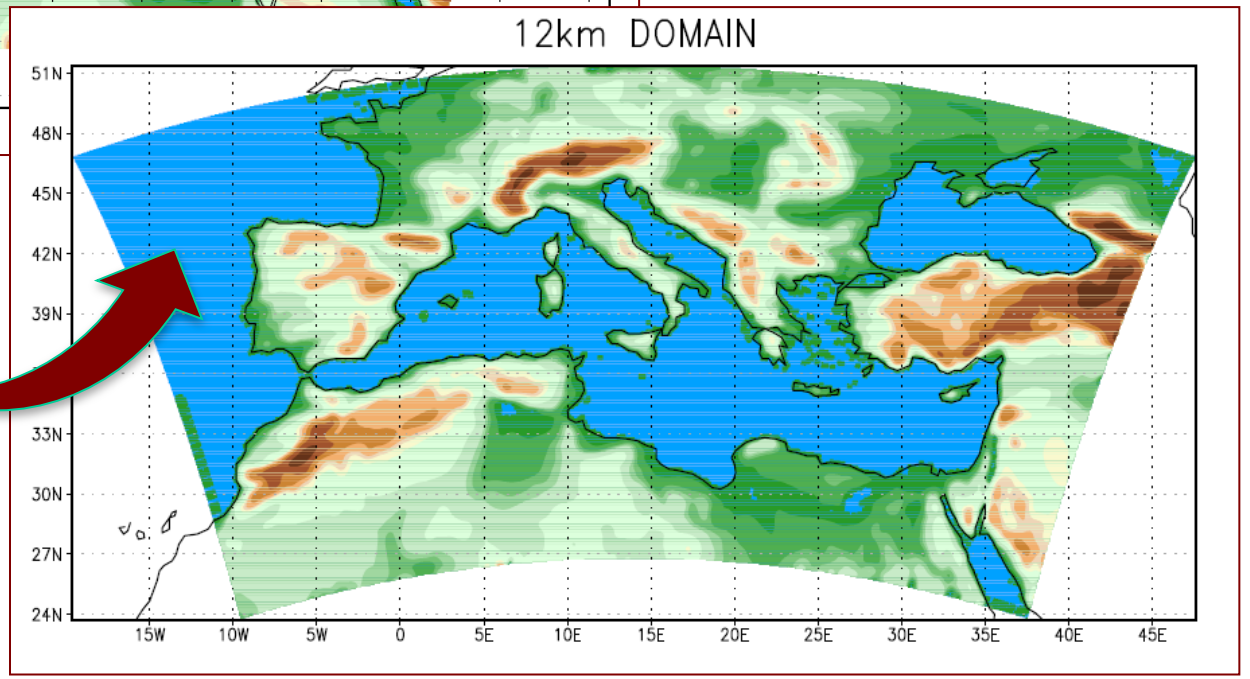
the completion of an ensemble of simulations with the ICTP RegCM.

- ✓CORDEX RegCM4 hyper-Matrix (CREMA) experiment
  - Basic experiments (50 km, CORDEX domains) being analysed
  - Higher resolution experiments (25 km, 12 km) being tested over the South Asia and Africa domains

- ✓High resolution (12 km) scenario simulation (1970-2100)
  - Completed until 2085 and continuing

Mediterranean experiment RegCM HadGEM-CMIP5-driven simulation with the future scenario “RCP8.5”:





Experiment design

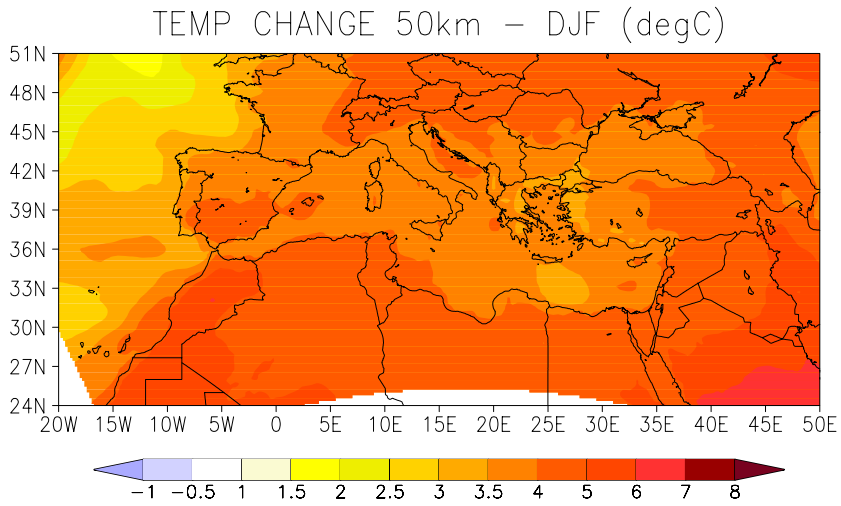
Mediterranean CORDEX domain from 1970 up to 2099 with RegCM4.4

Horizontal Resolution: 12 km

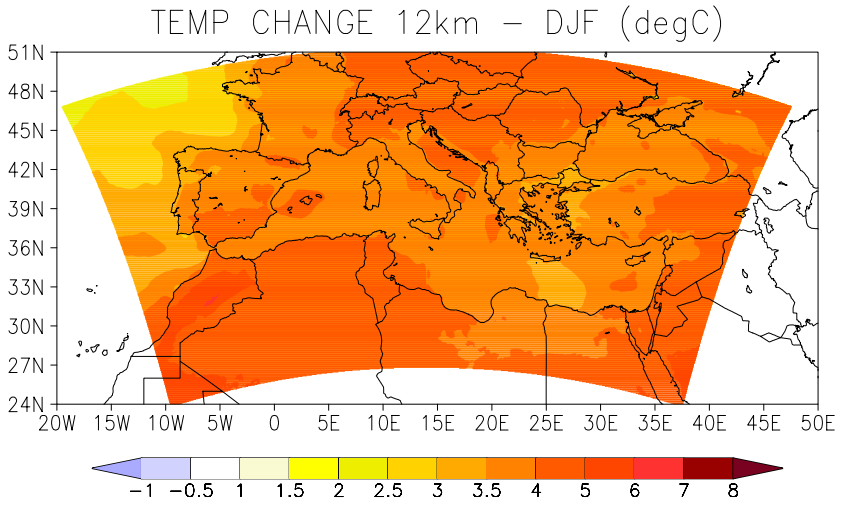
Boundary conditions: RegCM4.4 driven by HadGEM CMIP5, scenario RCP8.5, at 50km

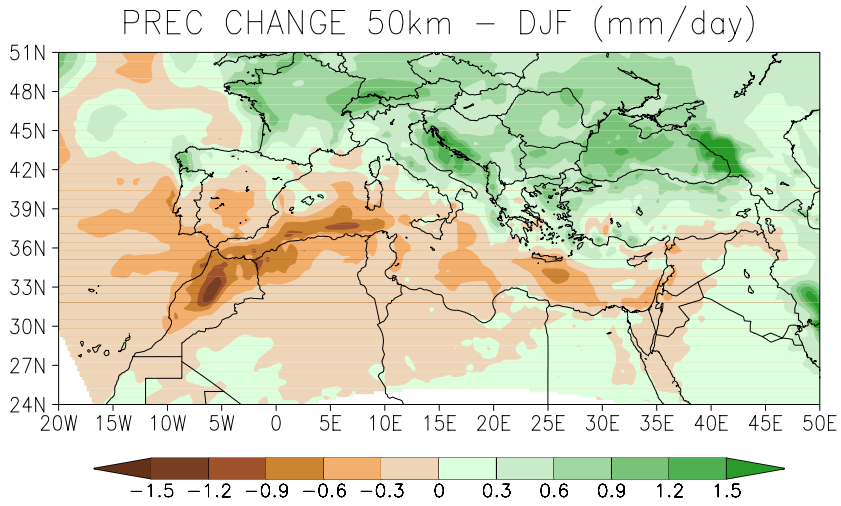
Temperature and precipitation change: 2080-2099 compared to 1975-2004

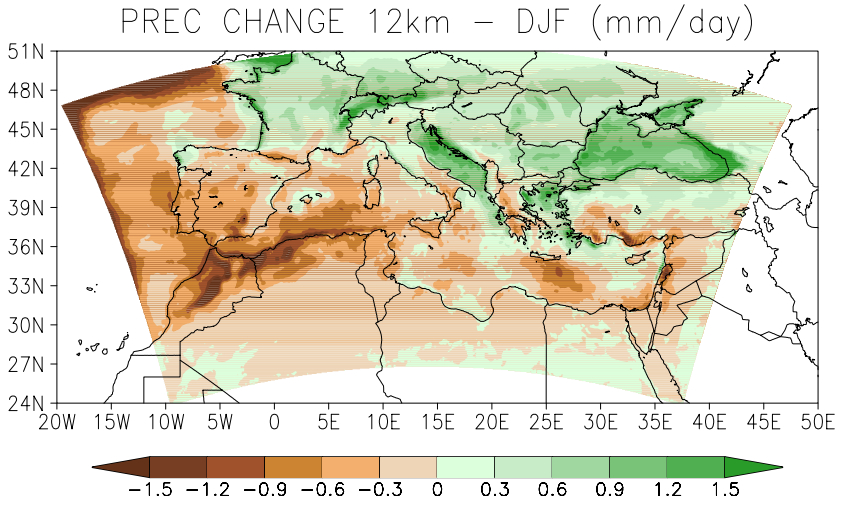
50 km



12 km

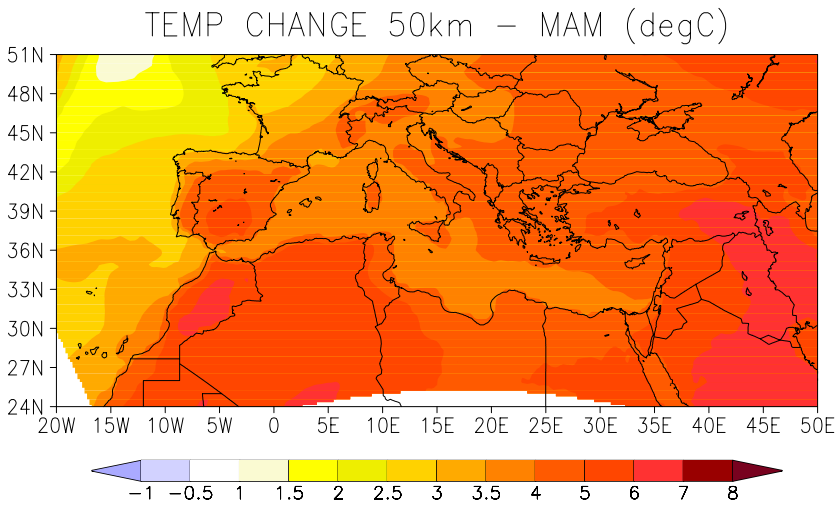




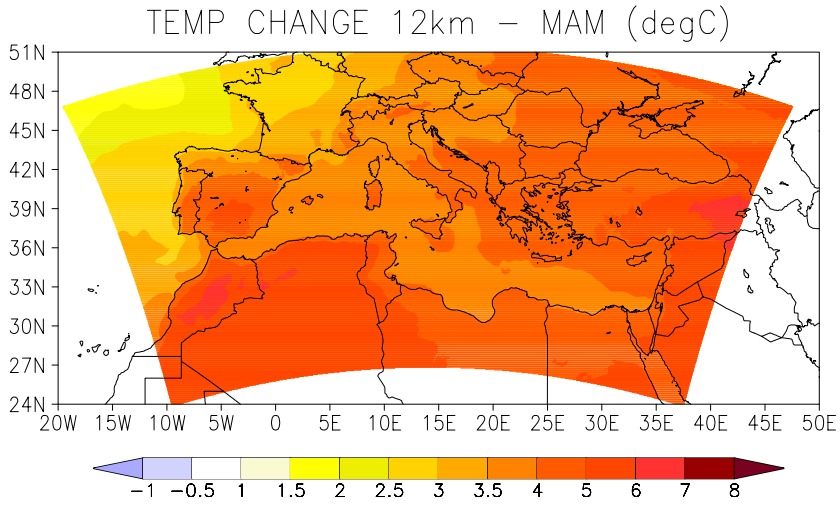


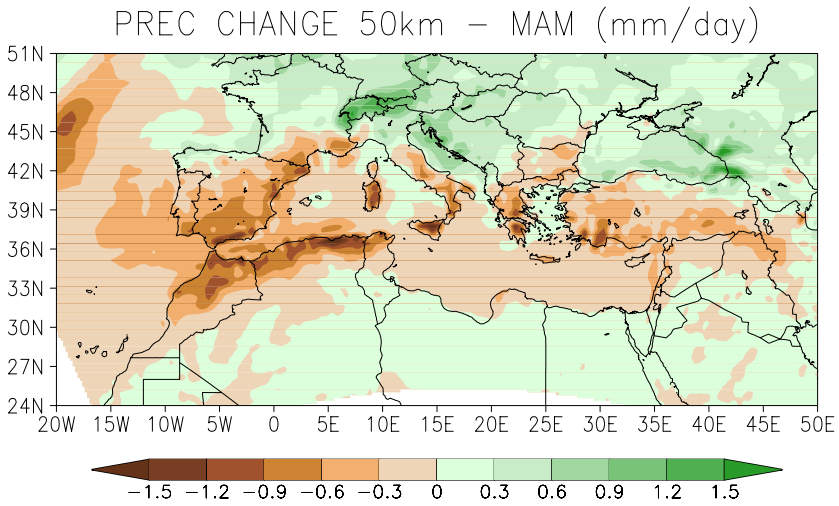
Temperature and precipitation change: 2080-2099 compared to 1975-2004

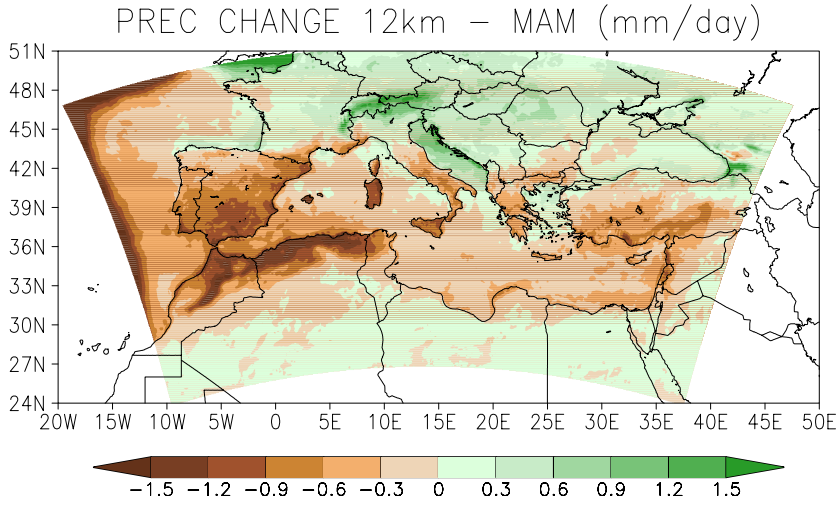
50 km



12 km

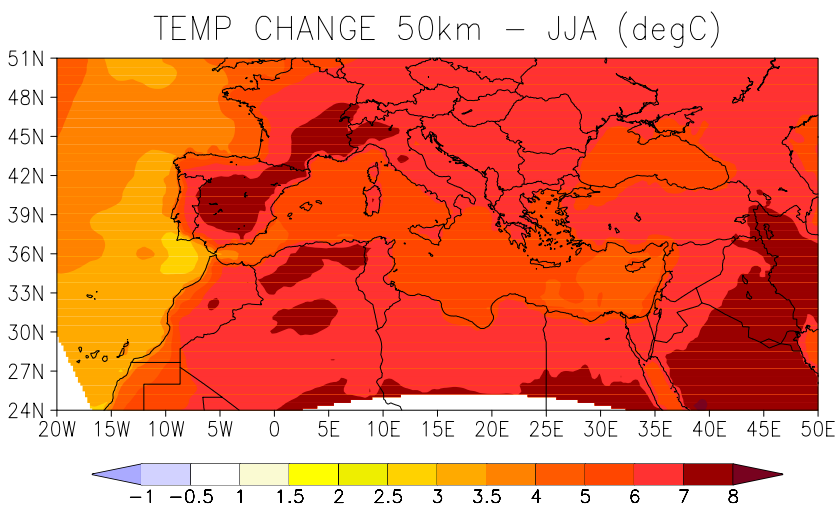




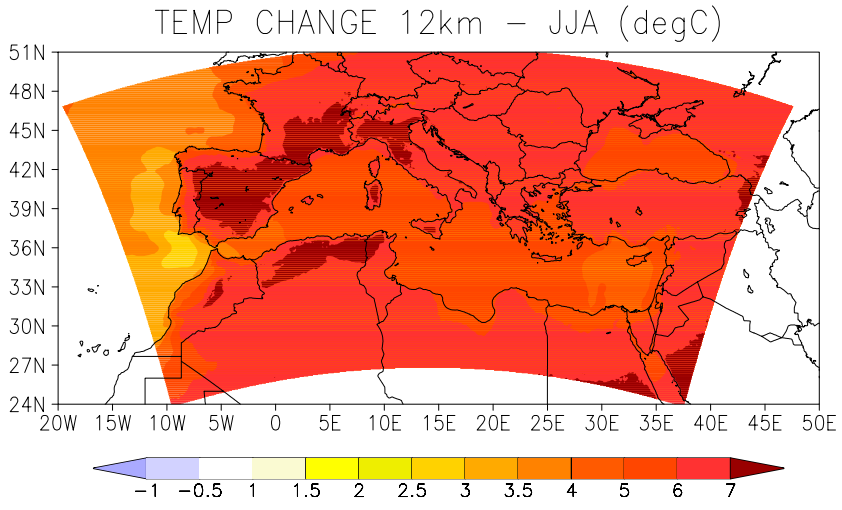


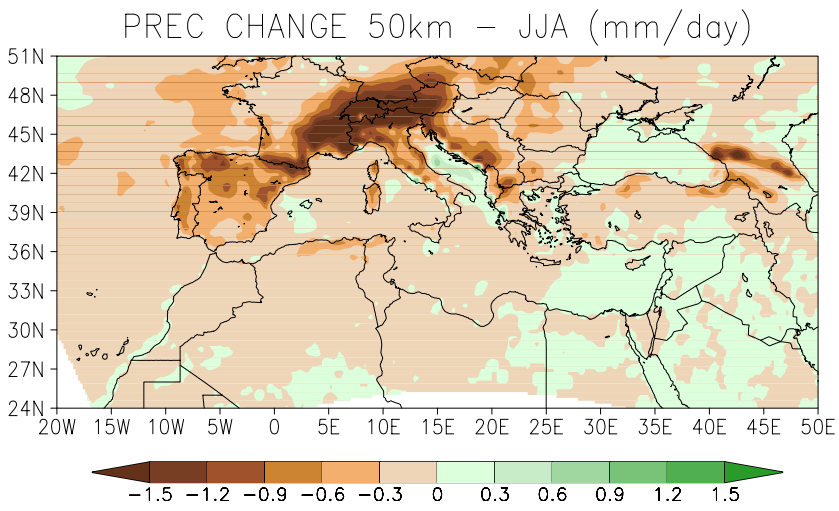
Temperature and precipitation change: 2080-2099 compared to 1975-2004

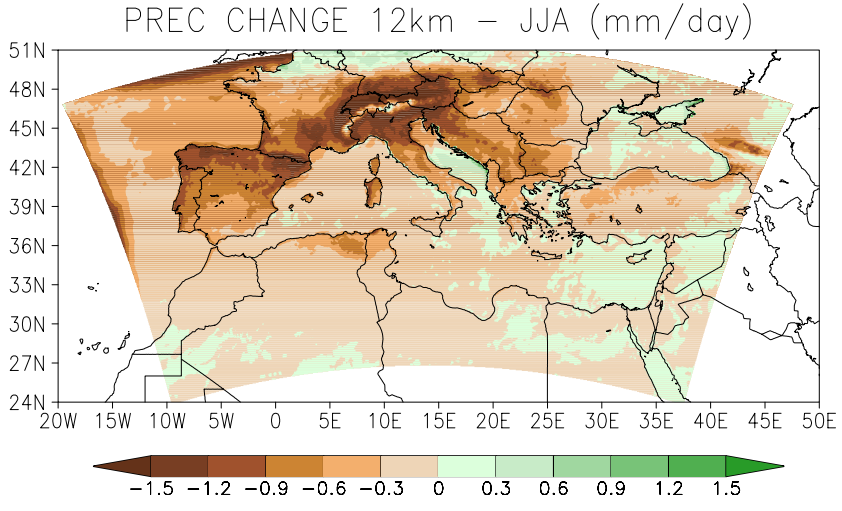
50 km



12 km

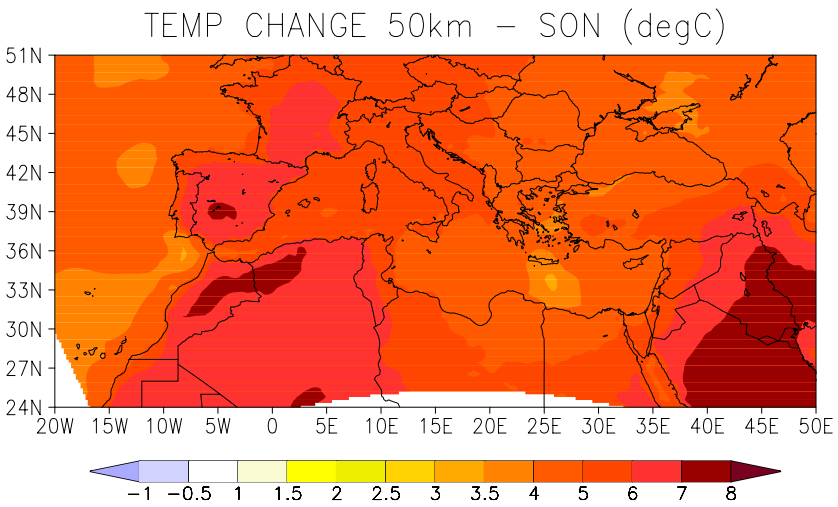




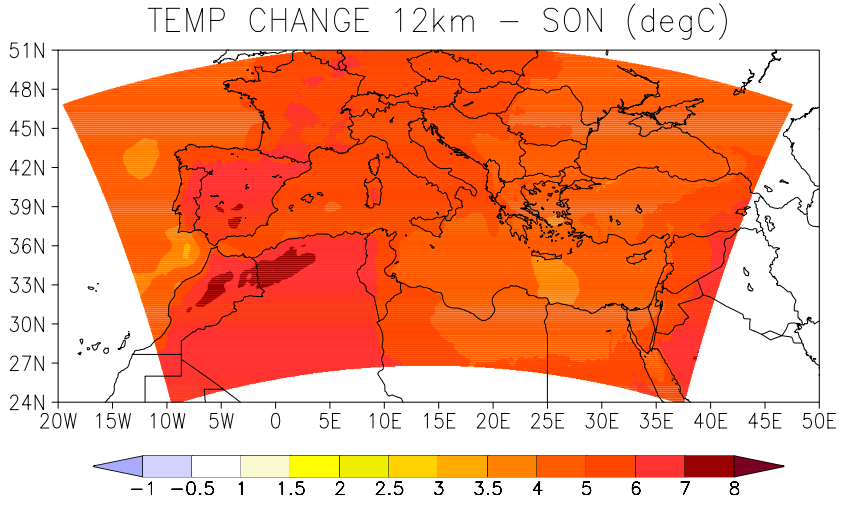


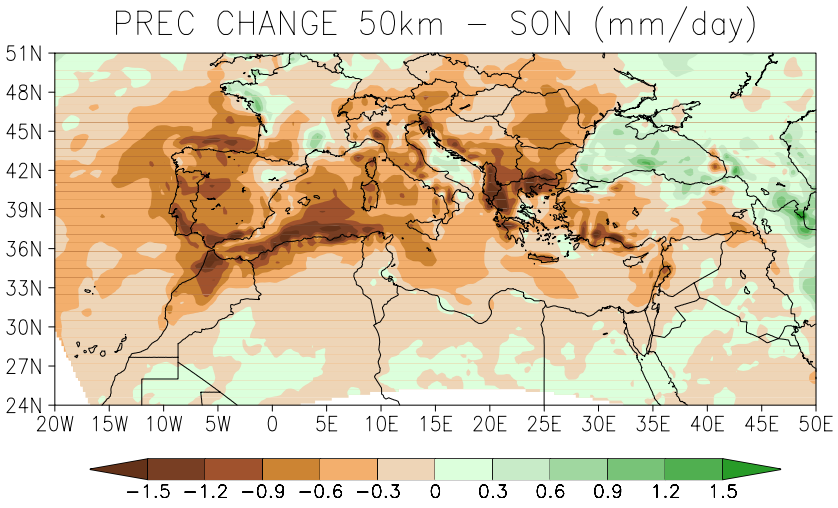
Temperature and precipitation change: 2080-2099 compared to 1975-2004

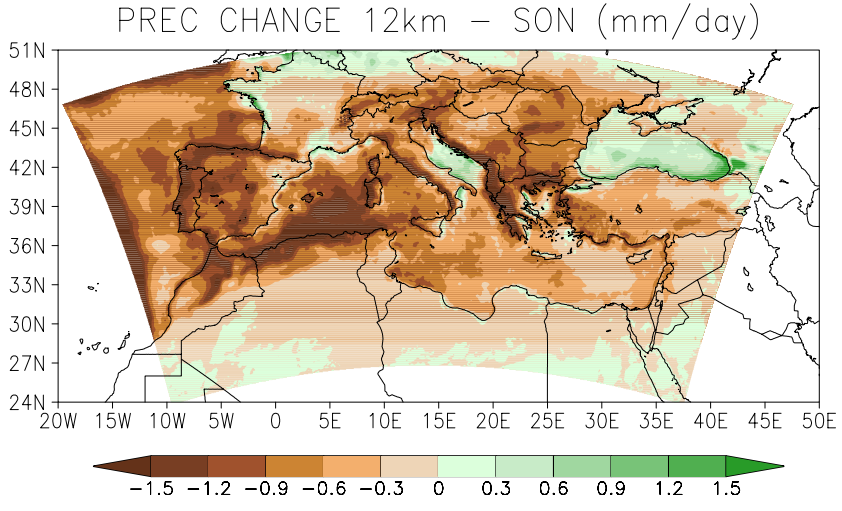
50 km



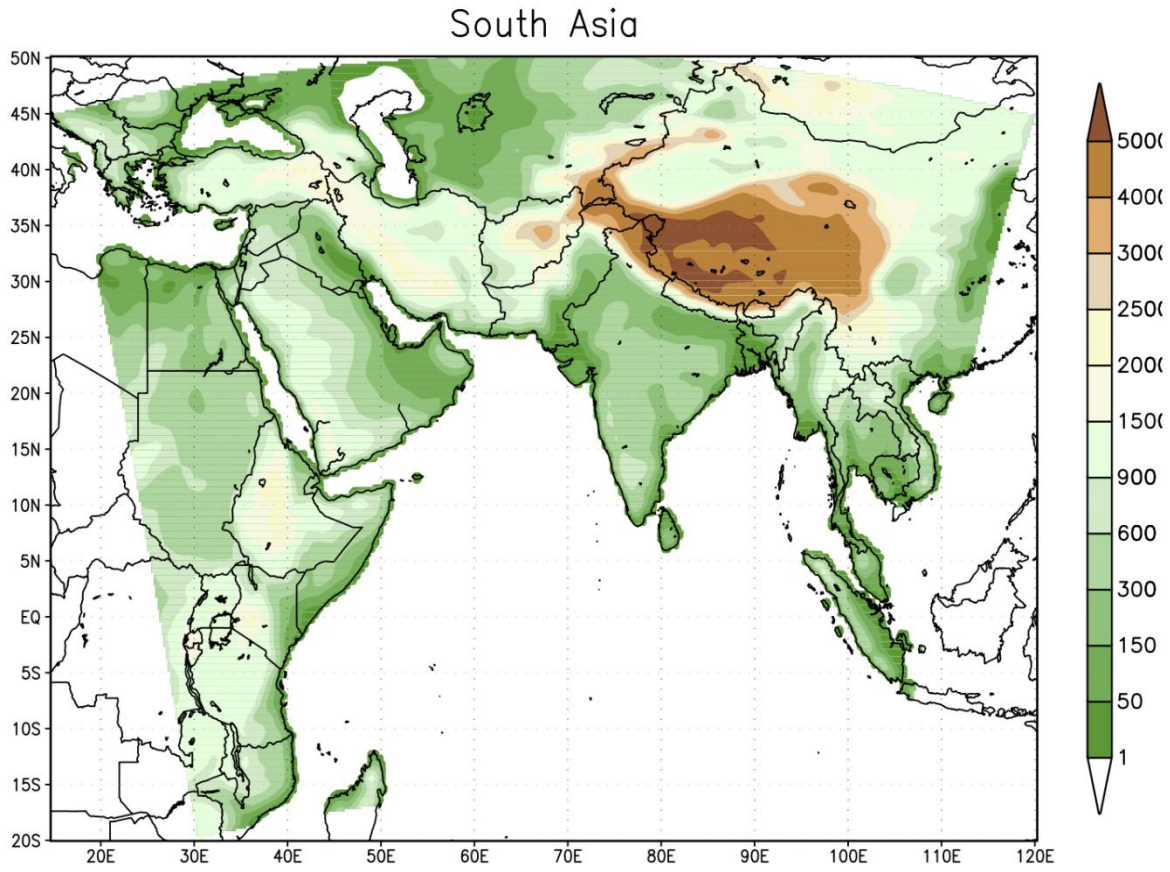
12 km







A new regional climate simulation using RegCM4.4 over the CORDEX South Asia domain



Experiment design

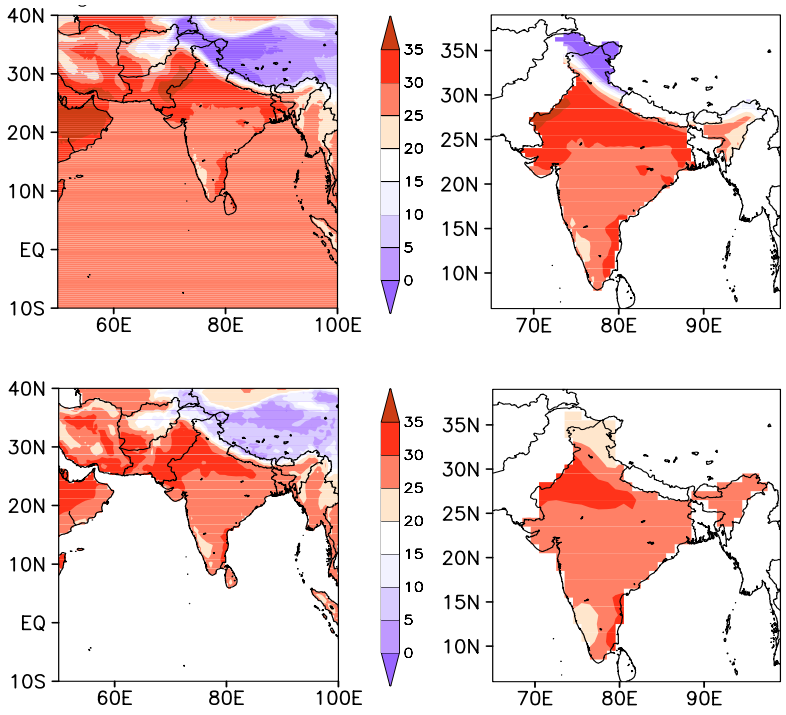
South Asia CORDEX experiment from 1980 up to 2006 with RegCM4.4 (still on going)

Horizontal Resolution: 25 km

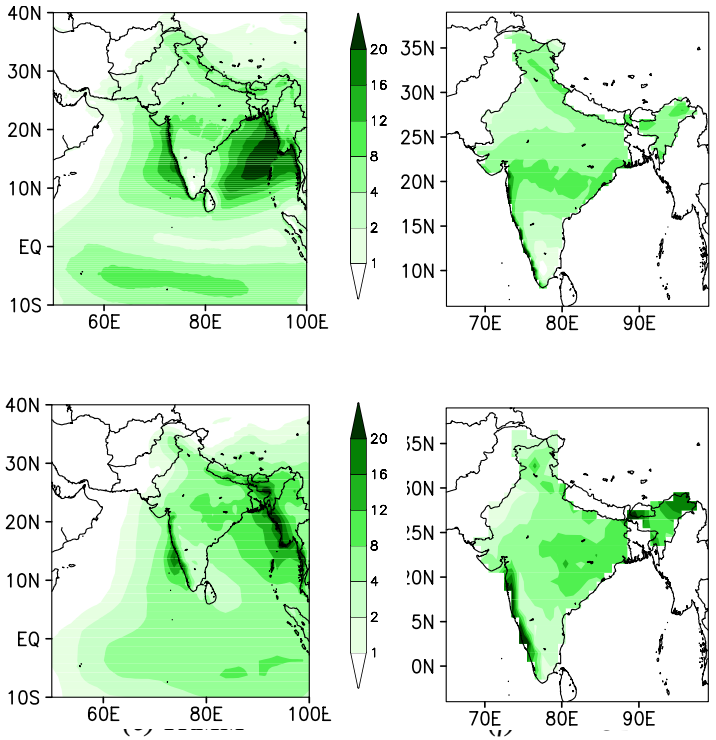
Boundary conditions: ERA-Interim Reanalysis

Temperature and Precipitation climatology

(a) RegCM4.4 *(c) RegCM4.4 Indian land*



(a) RegCM4.4 *(d) RegCM4.4 Indian land*



Temperature over the Indian land area is well represented. The monsoon precipitation over the Indian continent is reasonably well represented; a slight underestimation is observed over the Ganges river basin. JJAS temperature has a slight cold bias over the mountain and the coastline compared with the observations.

Mean Annual Cycle over Homogeneous Climate Subregions

*Indian homogeneous monsoon regions (based on source available at **www.tropmet.res.in**)*
*Northwest (**NW**)*
*Central Northeast (**CNE**)*
*Northeast (**NE**)*
*West Central (**WC**)*
*Peninsular (**PS**)*

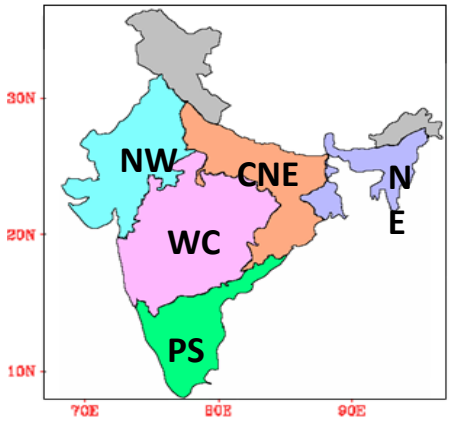
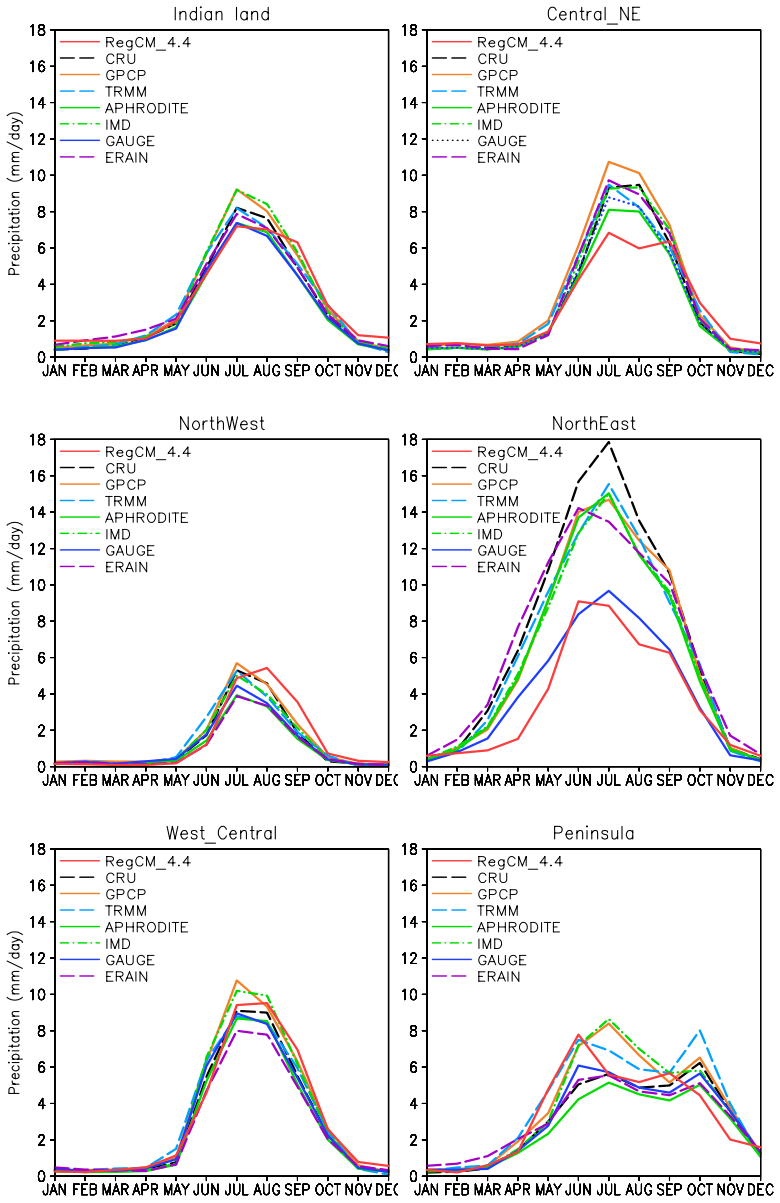


Table 1: Summary of available observational data and their temporal coverage

Data	RegCM4	CRU	IMD	APHRODITE	GPCP	TRMM	ERAIN	GAUGE
Period	1980 2006	1980 2006	1980 2006	1980 2006	1980 2006	1998 2006	1980 2006	1980 2005

The precipitation annual cycle of RegCM4.4 is well reproduced everywhere compared with the observations. The only underestimation observed is in the Northeast region where the Ganges basin river is.



Finalizing the WPs

Re-WP1 RegCM modelling activities

Re-WP2 WRF modelling activities

Re-WP3 RAMS modelling activities

Re-WP4 Evaluation and joint analysis of simulation results

Over common study regions and time-slices an intercomparison will be carried out between the RegCM and WRF dynamical downscaling results for a range of variables and statistics. The WRF results will be compared with the RAMS simulations in the common subareas through graphical and statistical analyses. All simulations will be compared to observed data where available. Results obtained for the Apennines will also be compared with remote sensing observations. The purpose of the intercomparison will be to identify the added value of increased resolution, particularly in terms of representation of dynamical processes in complex topography regions, and to explore methods to account for such processes in climate projections (e.g. regression techniques).