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the future of THE ITALIAN GEOSCIENCES of the future

Generation and use of high-resolution climatic data for hydrological and impact studies

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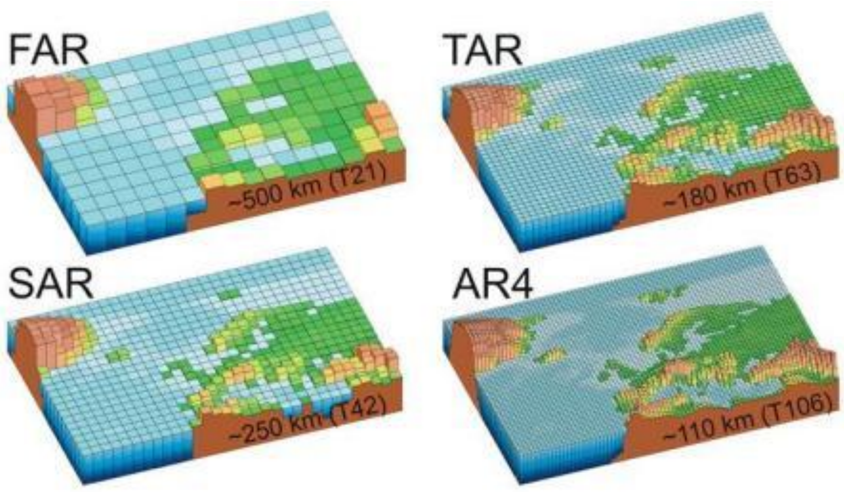
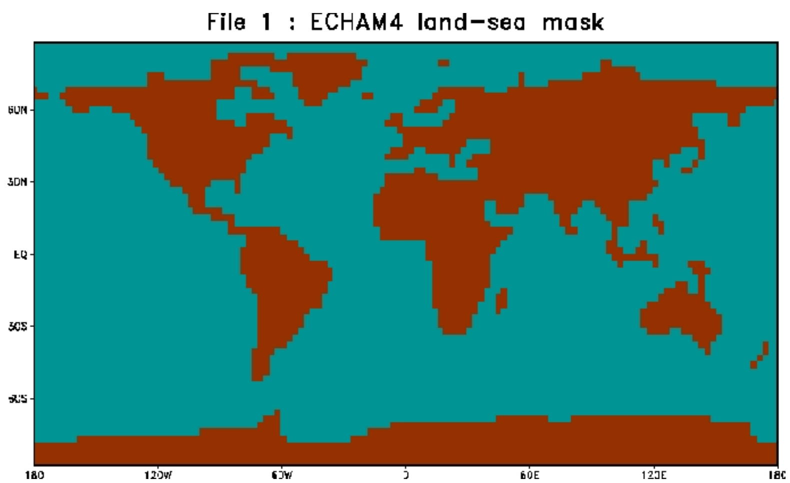
Global Climate models

The most advanced tools currently available for simulating the global climate system (physical processes in the single components and their interactions) and the response of the climate system to anthropogenic and natural forcings.



LAND-SEA MASK



The spatial resolution of GCMs is too coarse to capture the local aspects and it is limited by computational resources.

The sub-grid physical processes have to be parameterized; parameterization is one source of uncertainty in simulations of current/future climate.

Need for finer resolution

Climate model simulations/predictions need to be generated at finer scales than those of GCMs **in order to improve their usability**

Many climate change impacts happen at local scale

The need is for regional climate scenarios/projections but the most complete models are the coupled GCMs

1) One solution is to **run GCMs at a finer resolution** (or enhanced resolution in some regions of interest) → This requires a very powerful computer and is limited by the needed integration times
2) Another is to apply **downscaling methods**

- **Dynamical downscaling**
- **Statistical downscaling**
- **Stochastic (rainfall) downscaling**

Dynamical downscaling

Makes use of a regional climate model (RCM) having higher spatial resolution (typically 10–50 km) than the GCMs over a limited area

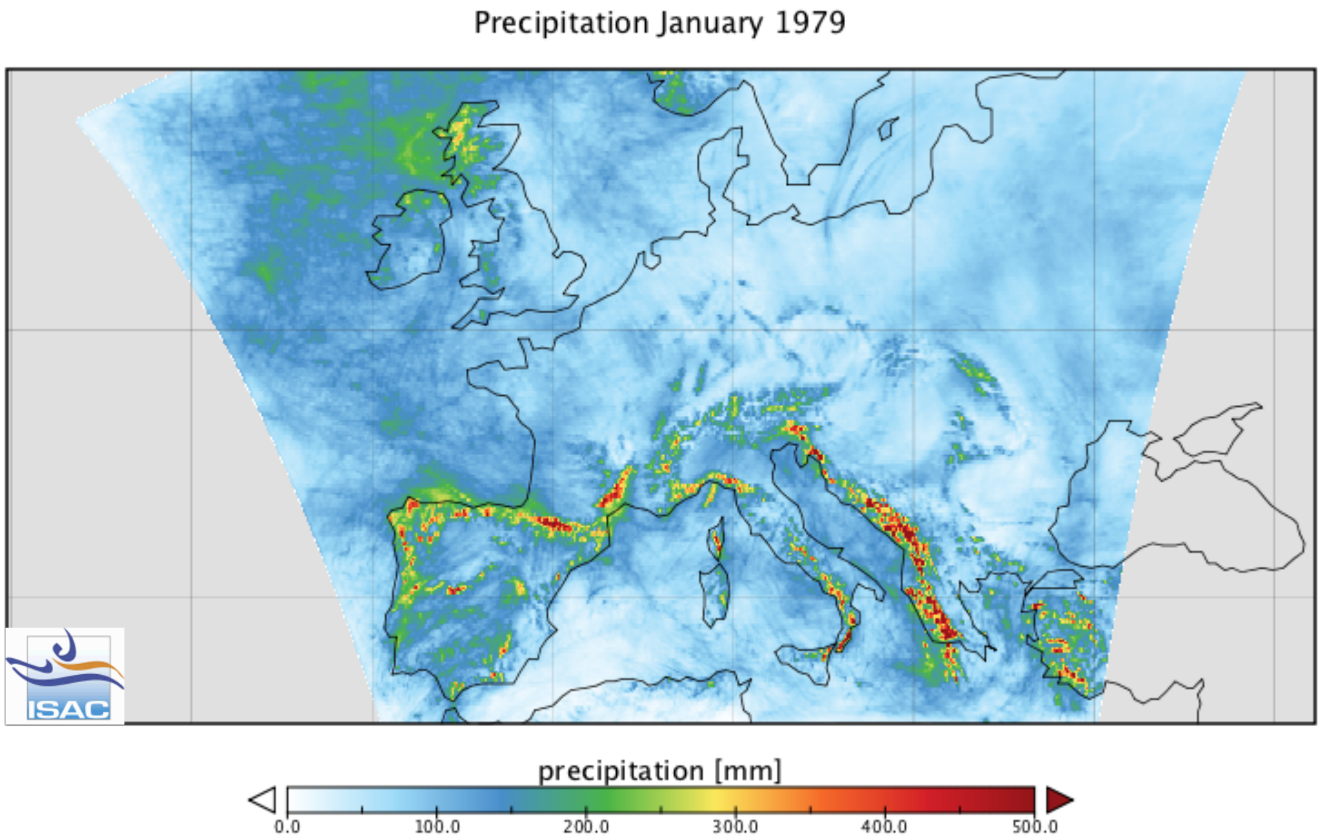
The RCM is

- Is fed with large-scale forcing from the driving GCM at the boundaries of the domain
- Is conceptually similar to a GCM; both focus on the dynamical and physical processes that governs the climate and the numerical approaches for solving the equations are similar
- Uses different parameterisations because of the different resolution
- At very high resolutions, non-hydrostatic equations of motion become necessary

Simulations with WRF, a non-hydrostatic RCM

WRF - Weather Research & Forecasting Model
http://www.wrf-model.org/index.php

Climate simulations (30 years) with WRF at high spatial resolution (0.11° and 0.04°) nested into reanalyses (to be nested also into the EC-Earth GCM)



Total precipitation

from WRF climate simulations at 3.5-4 km

January 1979

Simulations @ Leibniz-Rechenzentrum (LRZ)/ SuperMUC, Munich

Some issues in dynamical downscaling

- **Boundary conditions**

(Interpolation; sponge zone; artefacts and spurious effects at the boundary)

- Limitations in the nesting approach

- Multiple nesting
- One-way or two-way nesting

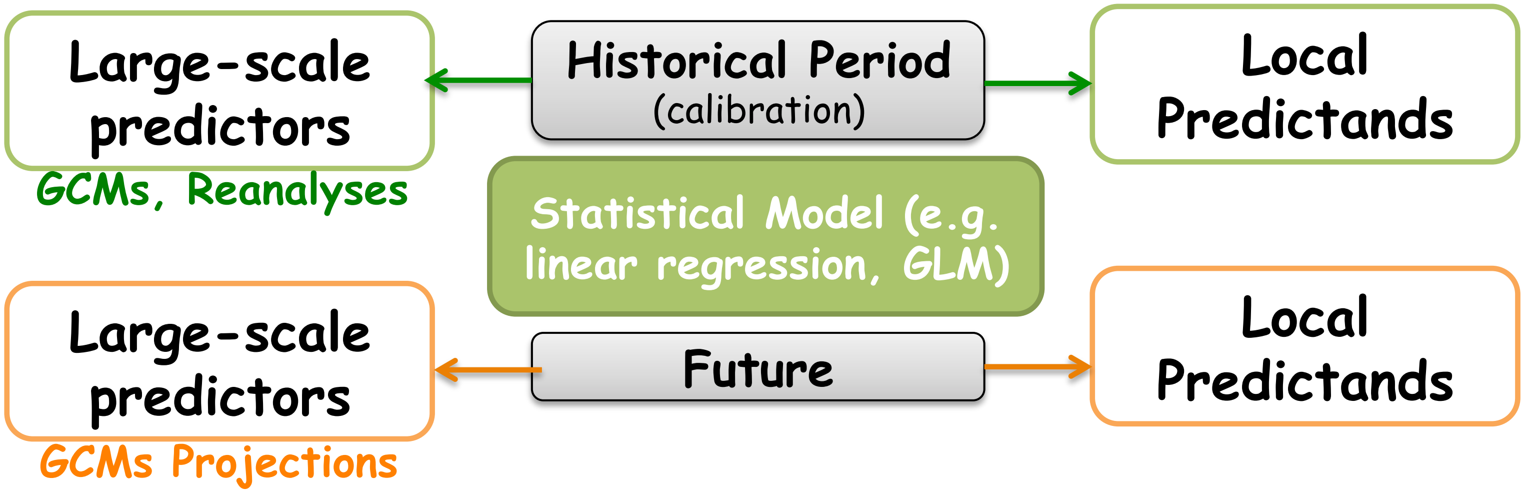
- **Time consuming and huge storage requirements**

- RCM adds its own biases to the output data

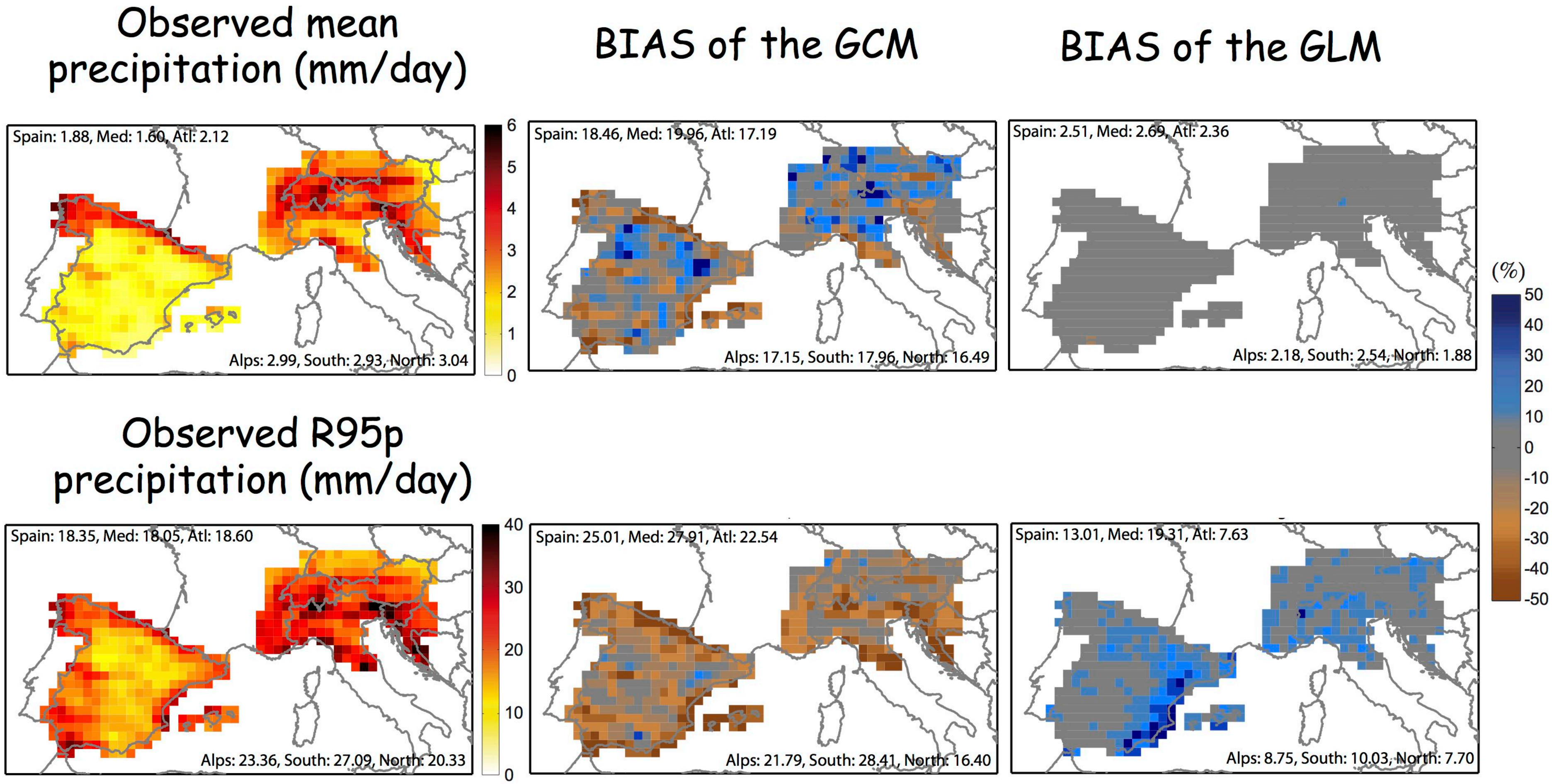
Statistical downscaling

Find statistical relationships between large-scale climate features and fine-scale climate for a given region:

1. Find large-scale predictors
2. Determine their statistical relation with a predictand
3. Use the projected values of the predictors to estimate the future values and variability of the predictand (assuming statistical stationarity)



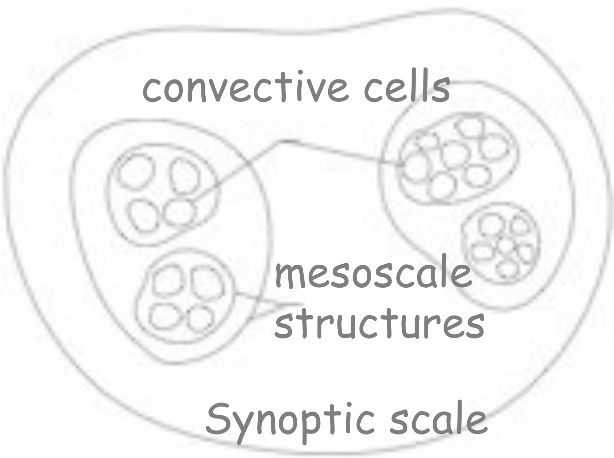
Statistical downscaling - GLM



Observed: SPAIN02 & APGD_v1.2 (Alpine precipitation grid dataset)
Models: GCM (ERA-Interim); statistical model (GLM, Turco et al. in preparation)

Stochastic downscaling

Highly intermittent fields such as rainfall can be difficult to handle with dynamical or statistical downscaling (no simple interpolation is possible).



- Organized in **hierarchical structures (scaling property of rainfall)**

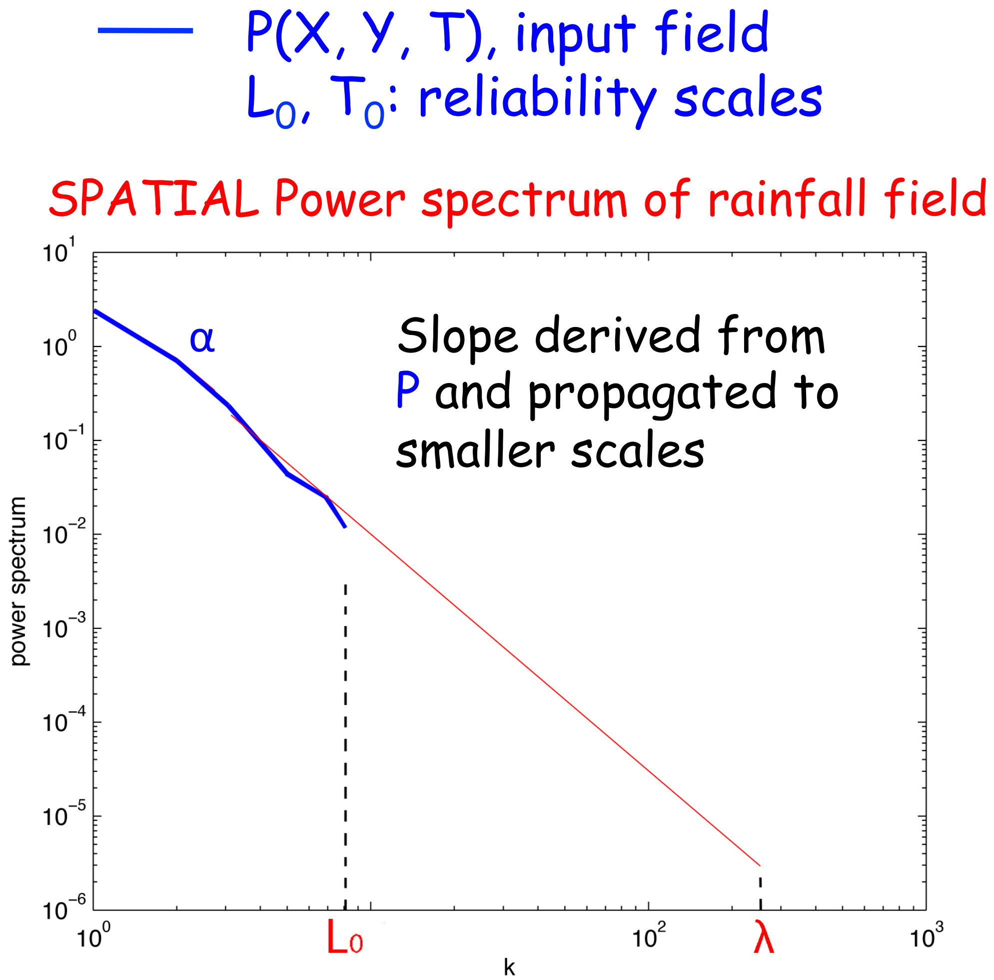
- **Highly intermittent in space and time** (alternating between dry and rainy periods).

An alternate approach is **stochastic downscaling**

Stochastic downscaling

RainFARM (Rainfall Filtered Auto Regressive Model)

RainFARM uses simple statistical properties of large-scale rainfall fields, such as the **shape of the power spectrum**, and generates small-scale rainfall fields **propagating this information to smaller (unreliable/unresolved) scales, provided that the input field shows a (approximate) scaling behaviour**



Stochastic downscaling
RainFARM (Rainfall Filtered Auto Regressive Model)

- Efficient method for generating ensembles of small scale precipitation fields, with the correct statistical properties, from long-term climate simulations.

- The small-scale statistical properties of rainfall are determined only by the behaviour of the model at large scale (no calibration).

- This method can be easily applied to climate scenarios for impact studies, provided that the models produce precipitation fields with the correct large-scale behaviour, without requiring extrapolation of current conditions to future situations

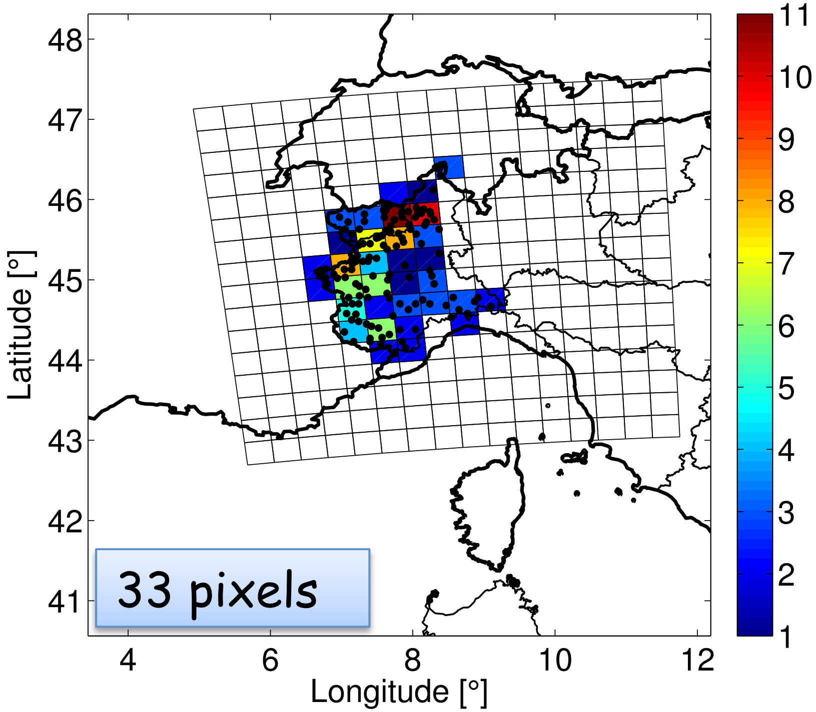
Stochastic downscaling

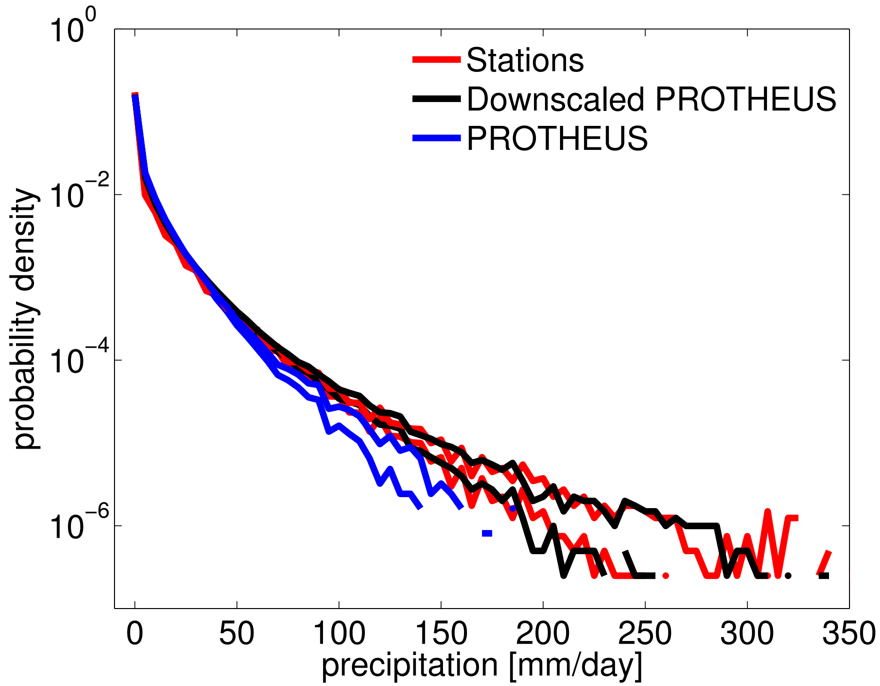
RainFARM (Rainfall Filtered Auto Regressive Model)

- 122 rain gauges
- 1958-2001
- Daily resolution
- Altitude max: 2526 m
- Altitude min: 127 m

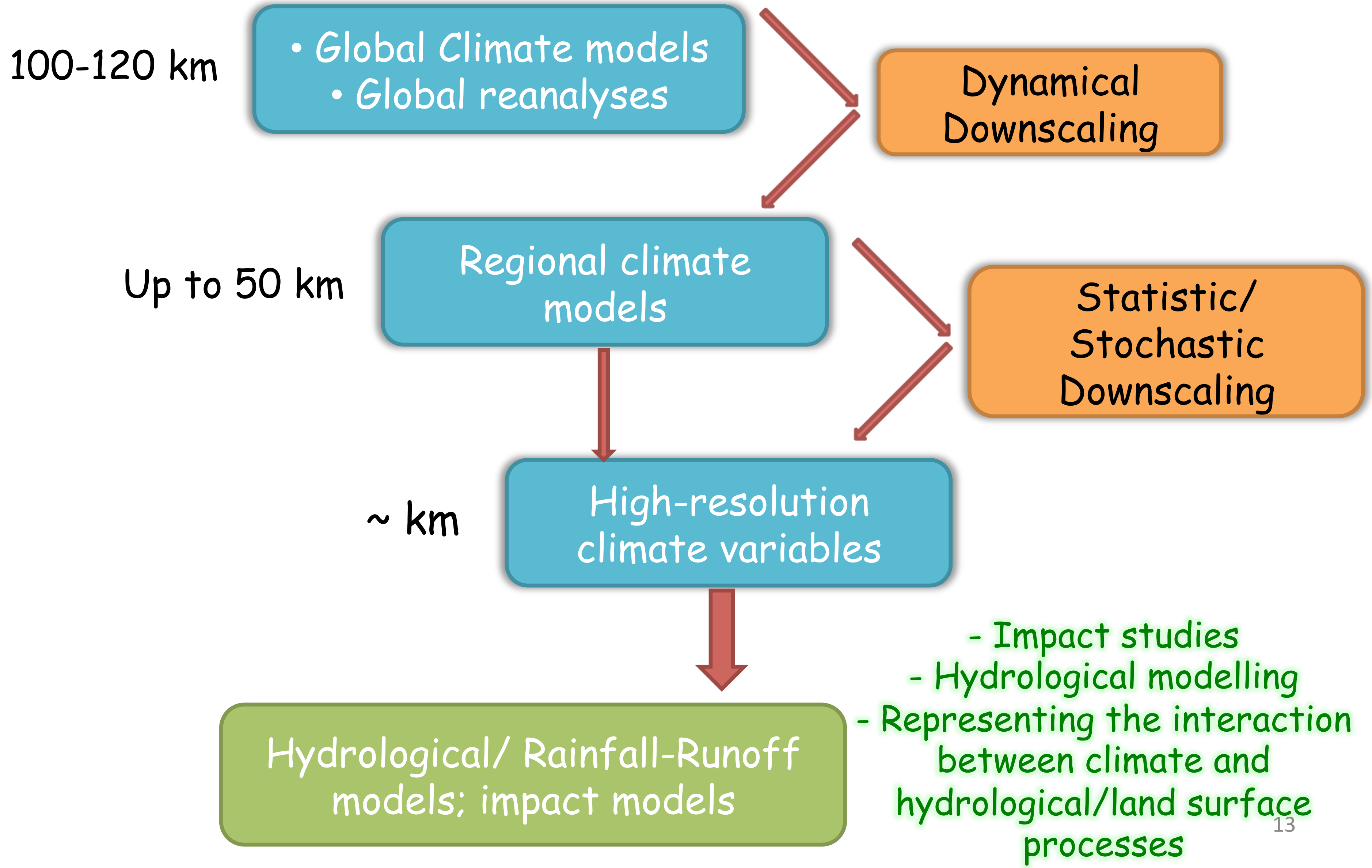
D'Onofrio et al., *J. Hydrometeor, 15, 830–843, 2014*

PROTHEUS: Δx≈30km





Modeling chain: bridging the gap



Some initiatives & projects

NextData

A national system for the retrieval, storage, access and diffusion of environmental and climate data from mountain and marine areas

http://www.nextdataproject.it/

Group on Earth Observations → seeks to strengthen ecosystem monitoring through the Global Earth Observation System of Systems.

http://www.earthobservations.org/

GEO/GEOSS Task: ecosystems

Ministero dell'Istruzione, dell'Università e della Ricerca

Progetto PRIN

MIUR Bando 2010-2011

Innovative methods for water resources management under hydro-climatic uncertainty scenarios

ECRA

European Climate Research Alliance

http://www.ecra-climate.eu/

Collaborative programme: Changes in the hydrological cycle

Some initiatives & projects

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Grand challenge

Develop a set of **downscaled climatic projections for the Italian territory**, using an ensemble of methods which include dynamical and statistical downscaling techniques and stochastic rainfall downscaling.

Validated downscaled scenarios will be made available, together with the appropriate technical documentation, on the NextData portals.

The high-resolution, downscaled climatic information will become an open-access national database of forcing conditions for impact studies (water resources, risk assessment, ecosystems, air quality)

Thank you for your attention

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