Cover

Reliability in modeling extreme precipitation rain rates supports in progress strategies for the improvement of operational severe weather forecasts and simulations of climate change scenarios

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Outline

- Motivation of this presentation
- Objectives of cutting edge weather and regional climate models
- Results supporting the current strategy
- Conclusions

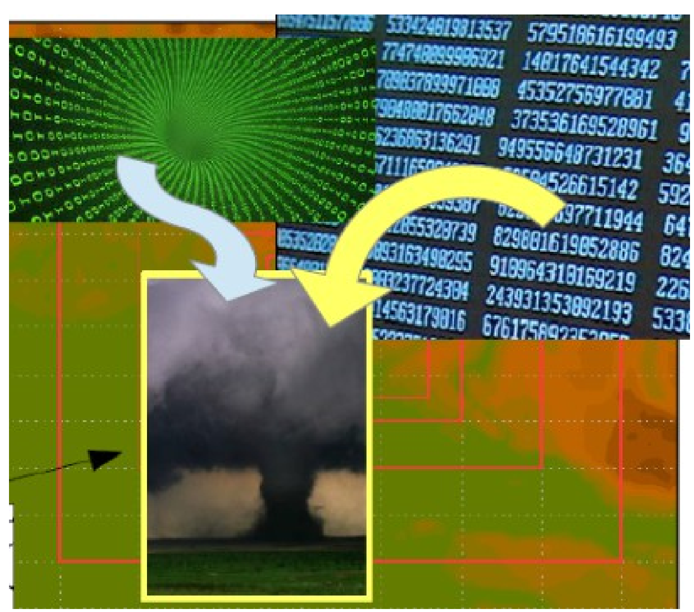
Motivation of this presentation

Mesoscale extreme events are important atmospheric phenomena because they have relevant impacts on:

- environment and ecosystems
- people and human activities

The exposure to **mesoscale extreme events** extends worldwide and it has high frequency

Atmospheric numerical models are requested to simulate such events



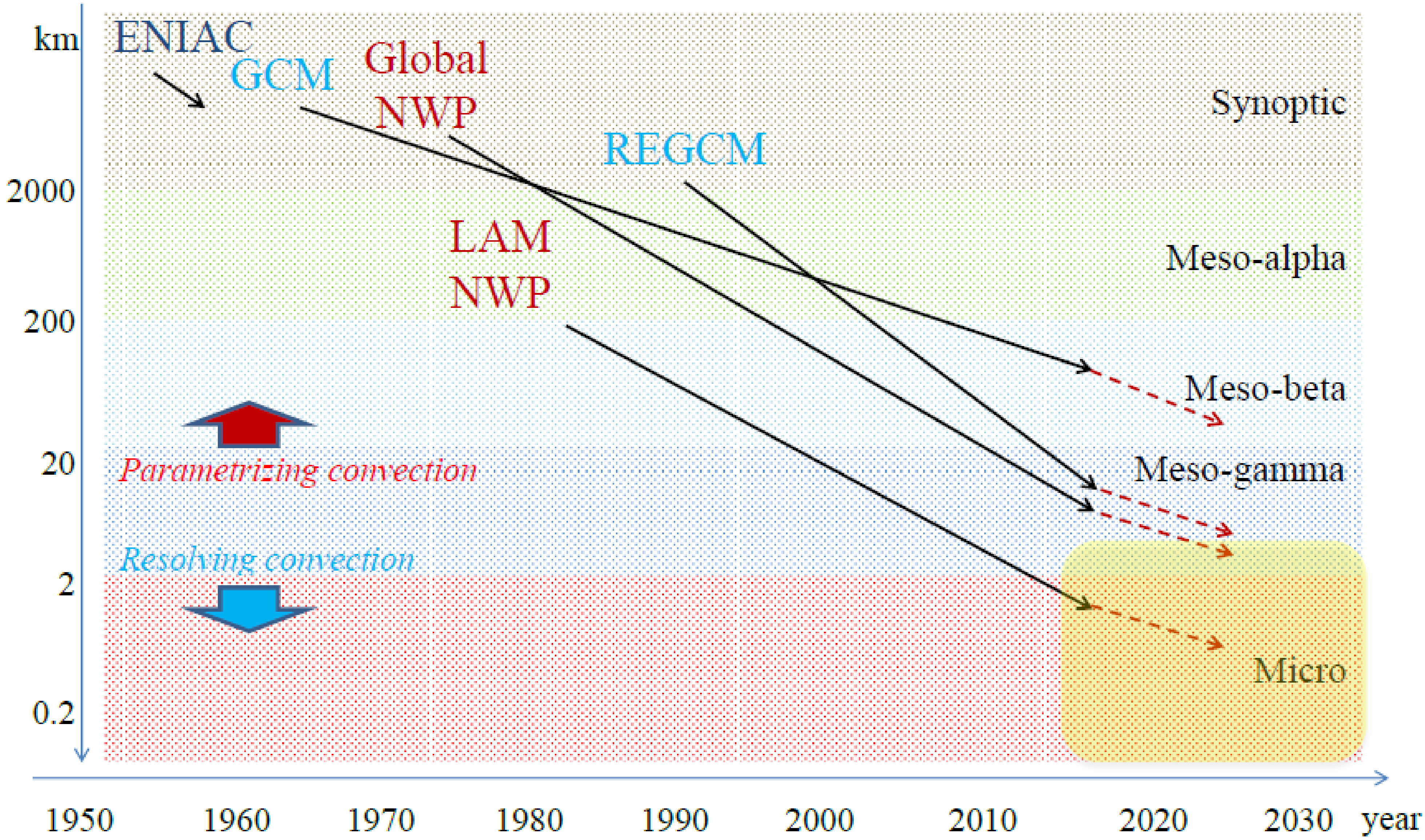
Future Climate Scenarios

Weather Forecast

Weather numerical models: from synoptic scale to mesoscale

Since the ENIAC age (1950s) we increased the numerical model spatial resolution

It is still the atmospheric modelling strategy

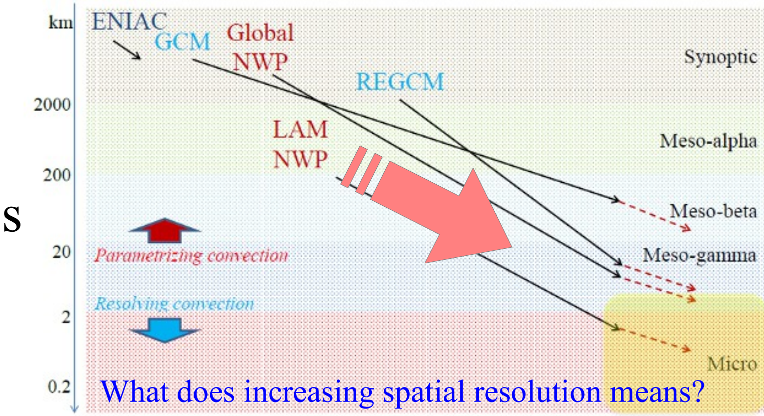


What does to increase spatial resolution means?

Increasing spatial resolution means **to simulate a wider range of atmospheric process**

The model is required:

- to deal with several typical scales
- to manage feedback between neighbour scales
- to reproduce interactions with boundaries



means

The model requires:

- more detailed and reliable initial conditions
- finer boundary conditions
- more computation do be done

Improve model:

- dynamics
- physics
- data assimilation
- boundary processes
- computation

In increasing the spatial resolution (so far) we achieved:

- higher quality weather forecasts
- more detailed climatic scenarios
- increased ability in satisfy stakeholders needs

The quality of models: precipitation as benchmark

A **good atmospheric model** is a model that **produces reliable simulations** for phenomena **at all scales** it is meant for.

Evaluation of the atmospheric model quality has to consider the complexity of phenomena (wind, temperature, pressure, water phases, radiation, etc.)

The quality of models: precipitation as benchmark

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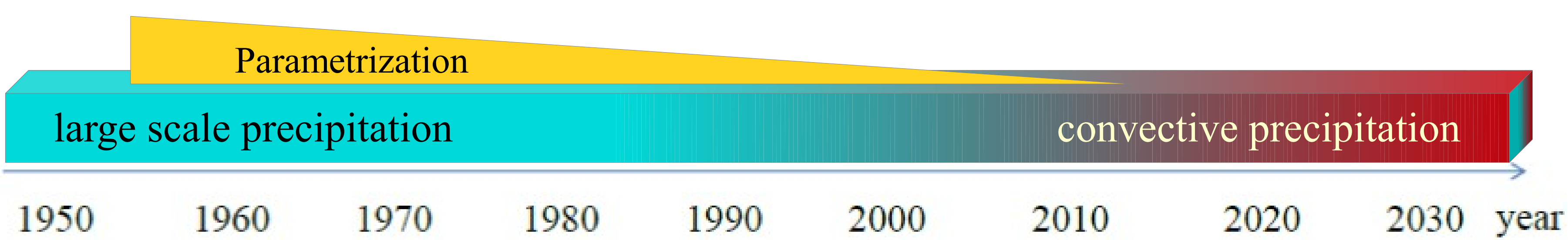
Verification of a field that is the result of the evolution of several other fields is an approach to the quality of atmospheric simulations

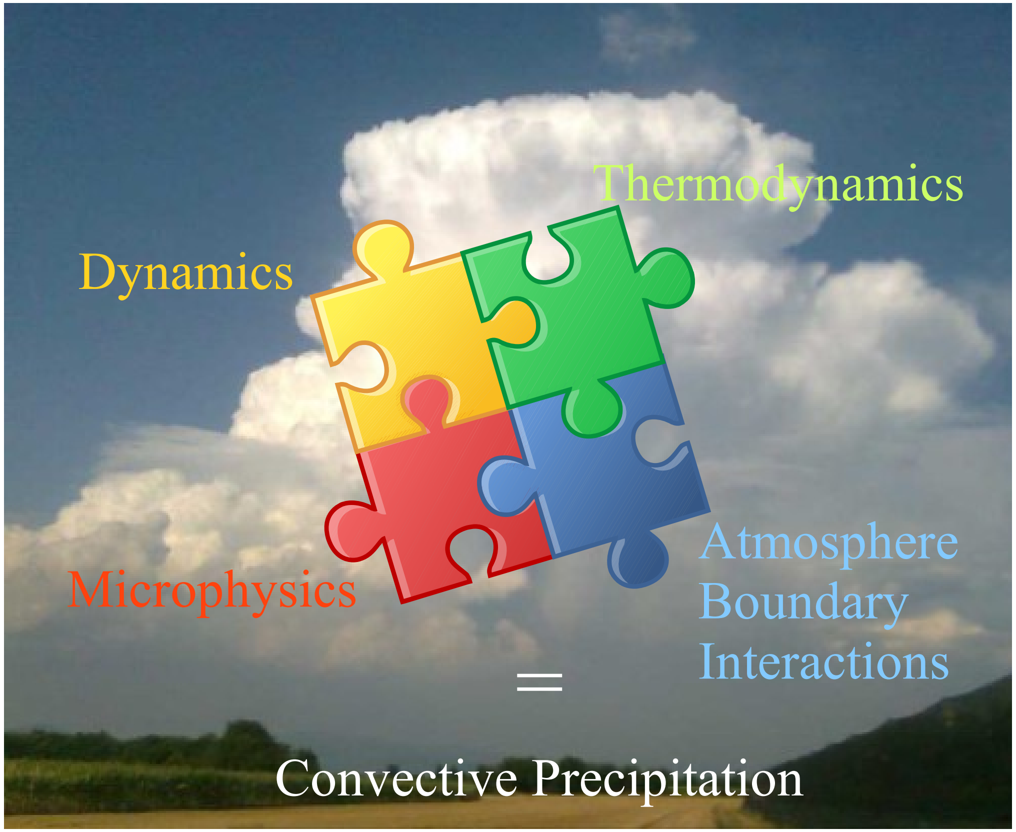
$$R = \boldsymbol{f}(\textit{wind}, \textit{temperature}, \textit{pressure}, \textit{water phases}, \textit{radiation}, \ldots, t)$$

Since the early age of the weather numerical models, rainfall field has been a benchmark



Convective precipitation: a typical mesoscale and microscale process

Convective precipitation is produced by synergy of several atmospheric properties



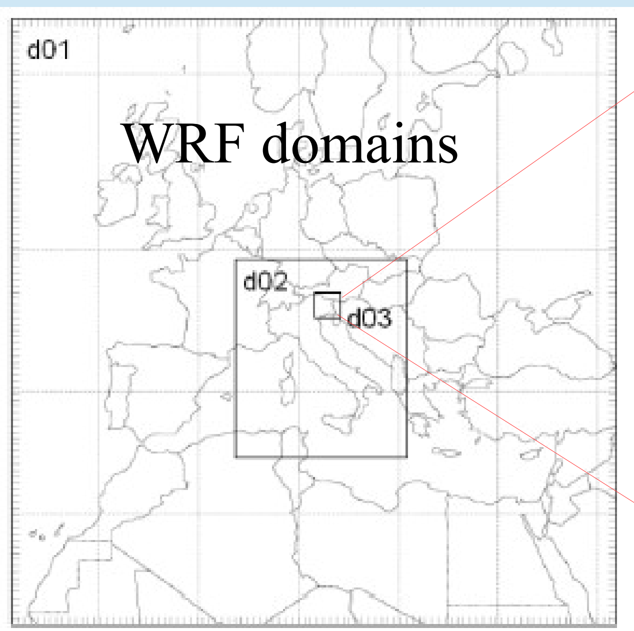
Extreme precipitation rates: up to 100 mm/h (20 mm/5min)

Ability of WRF model to simulate meso-gamma precipitation field

Downscaling ECMWF (IFS) analysis with WRF model

- Mid latitudes subcontinental domain – orography, land, sea lakes (Alpe-Adria region).
- Time coverage 2010-2016 as a test period for a (2000 – last year) project
- Spatial resolution 2 km
- Outputs saved every 1 h
- Nested domains technique – d03 convection fully resolved – Noah LSM – SST update

ECMWF analysis



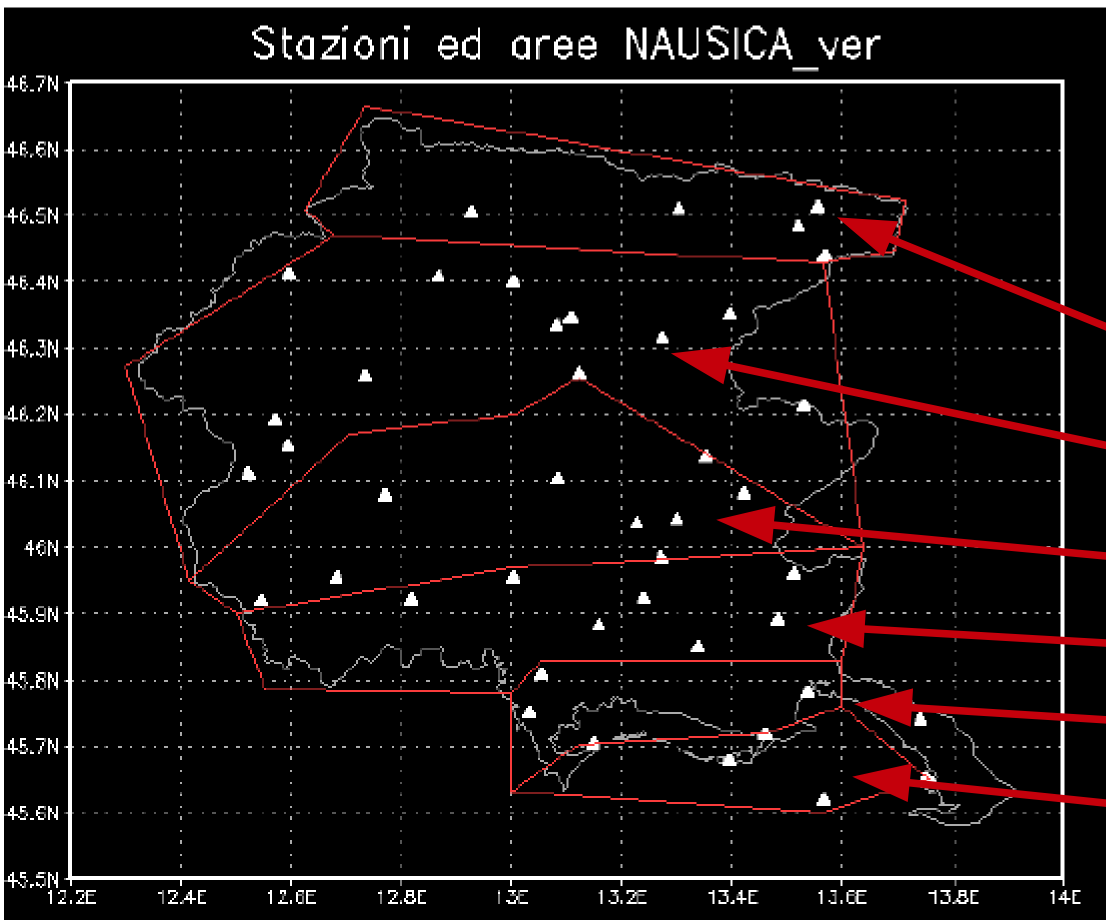
Quality verification area FVG region

Verification approach

Meso-gamma phenomena have an intrinsic spatial and time fluctuations

- Numerical model should be able to reproduce such fluctuations
- Measurements should be able to reveal such fluctuations

Verification is based on sets of time series belonging to the same area

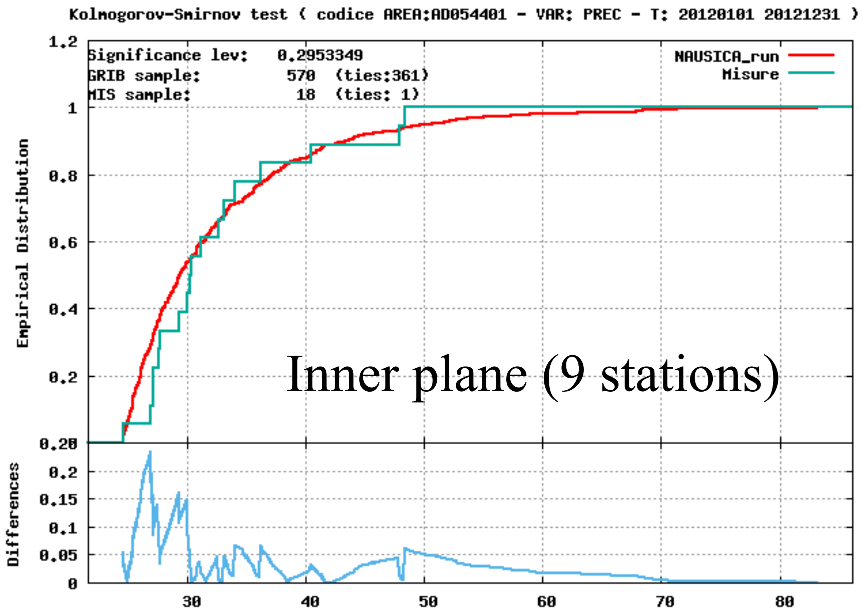


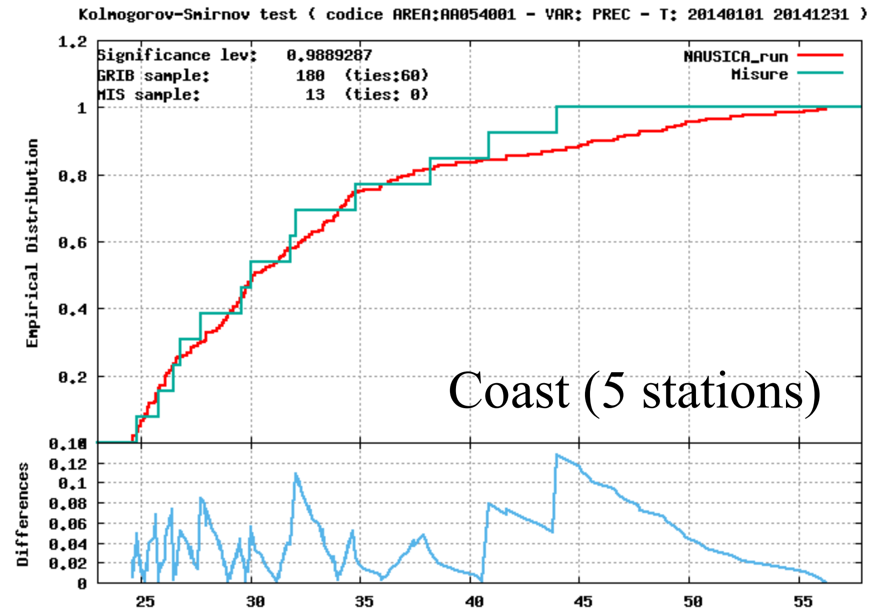
Areas are defied to be homogeneous for the phenomenon fluctuations by means of mesonetwork measurements △

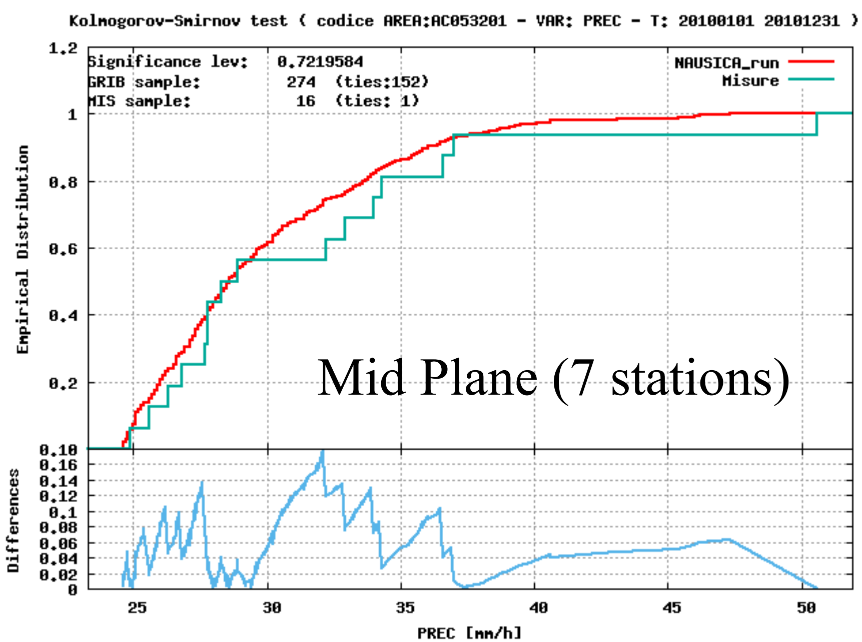
- Inner Alpine (5 stations)
- Mountains (13 stations)
- Inner plane (9 stations)
- Mid Plane (7 stations)
- Lower Plane (3 stations)
- Coast (5 stations)

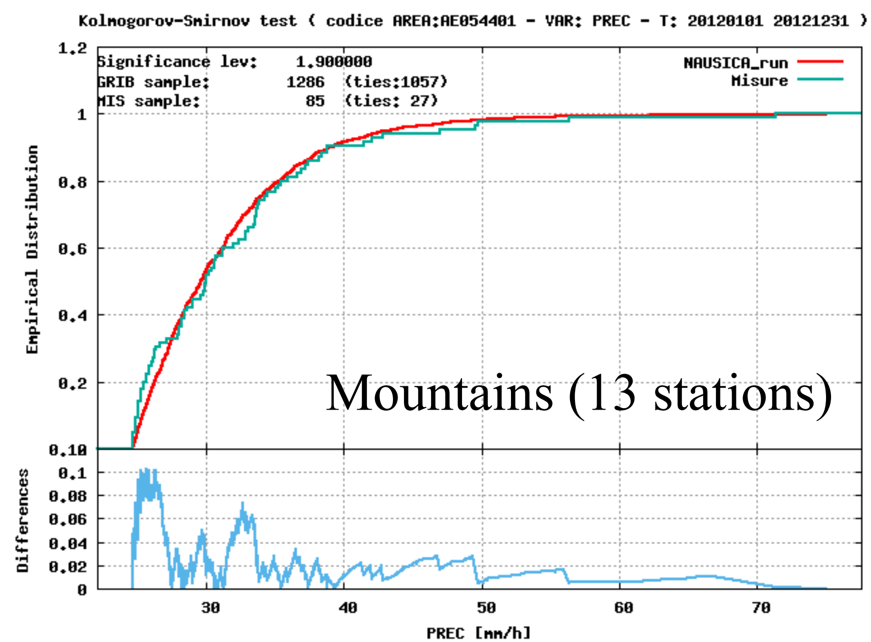
Quality of extreme rain rates: > 25 mm/h - the best performances

Empirical distributions for one year of events – each graph reports one validation area









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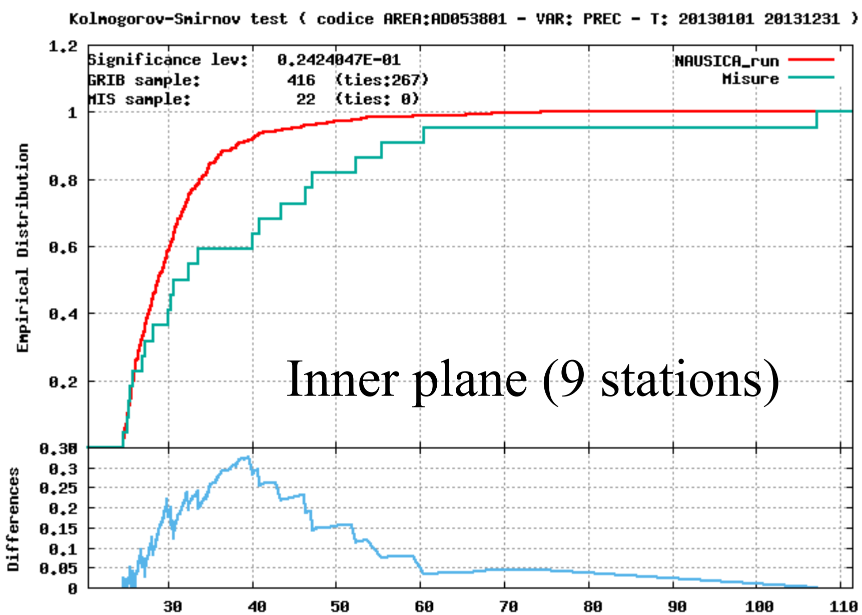
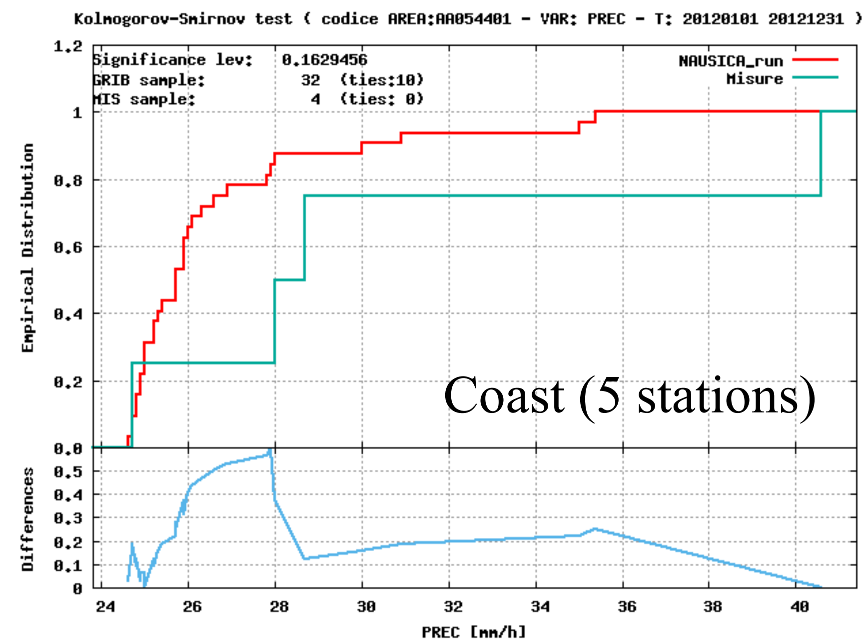
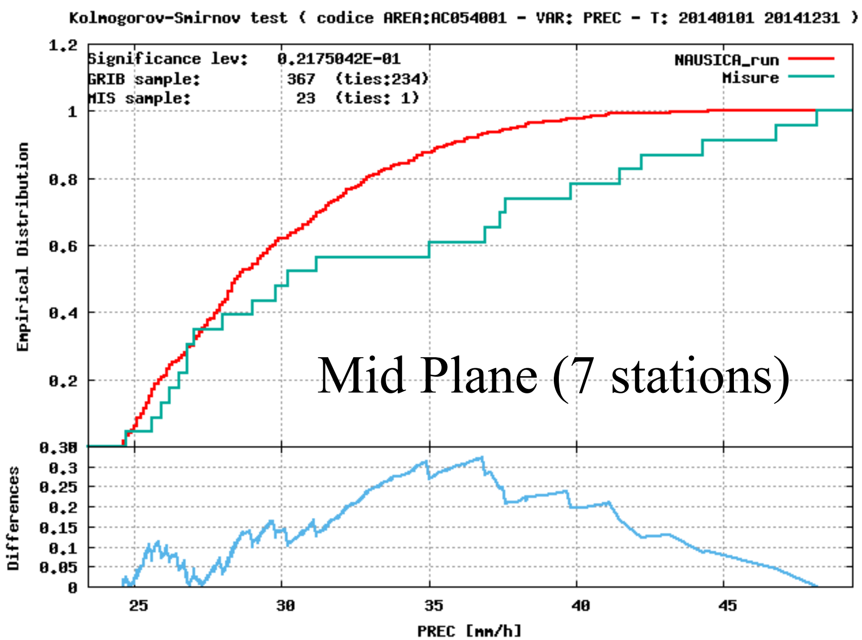
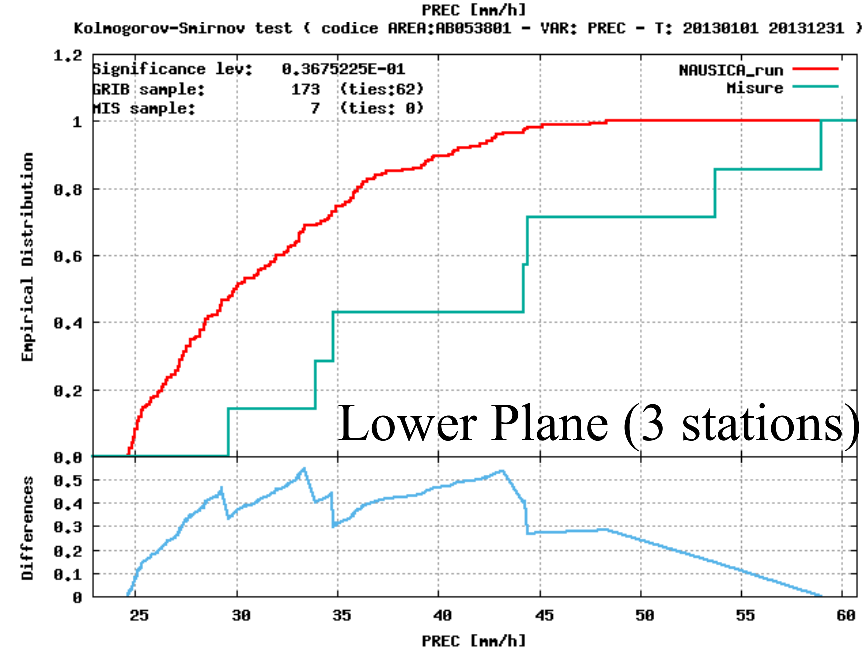


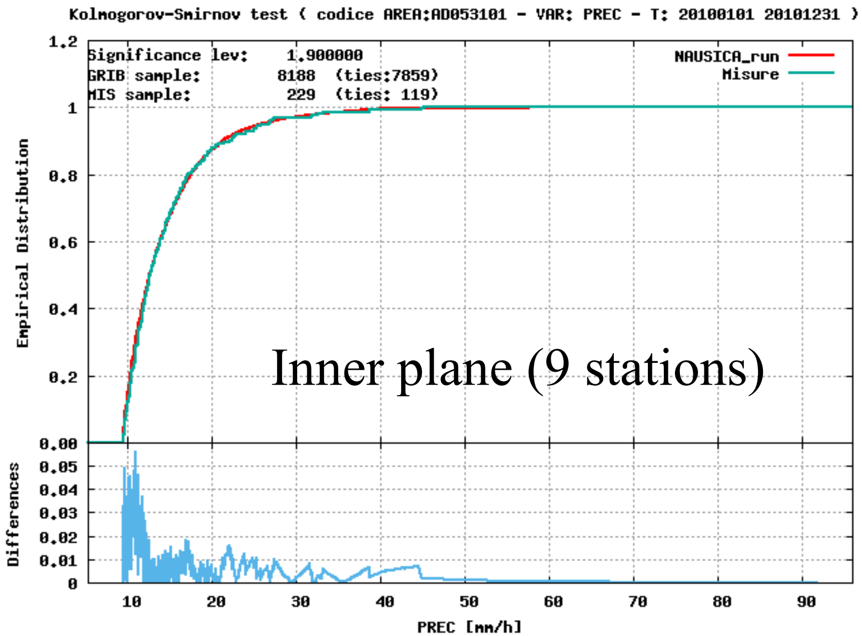


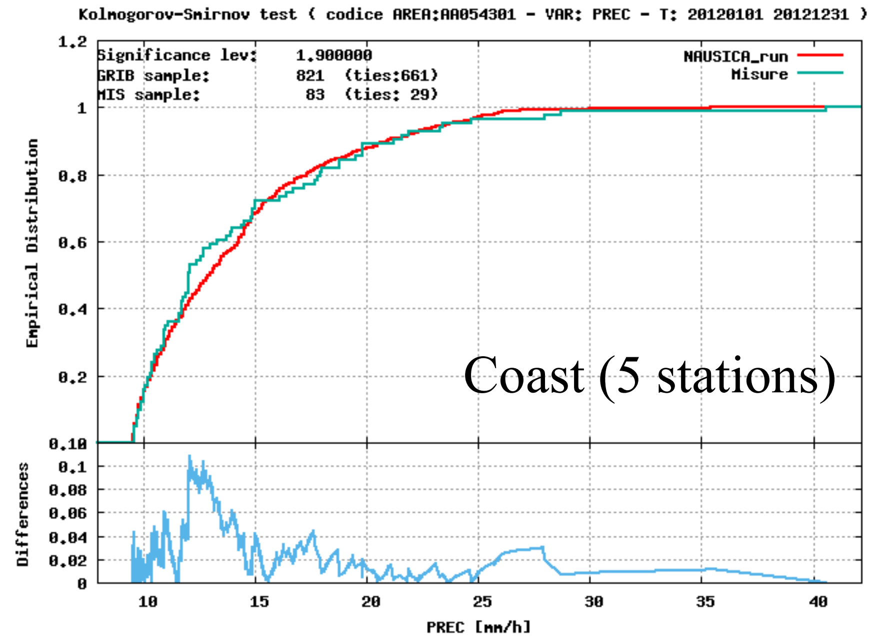


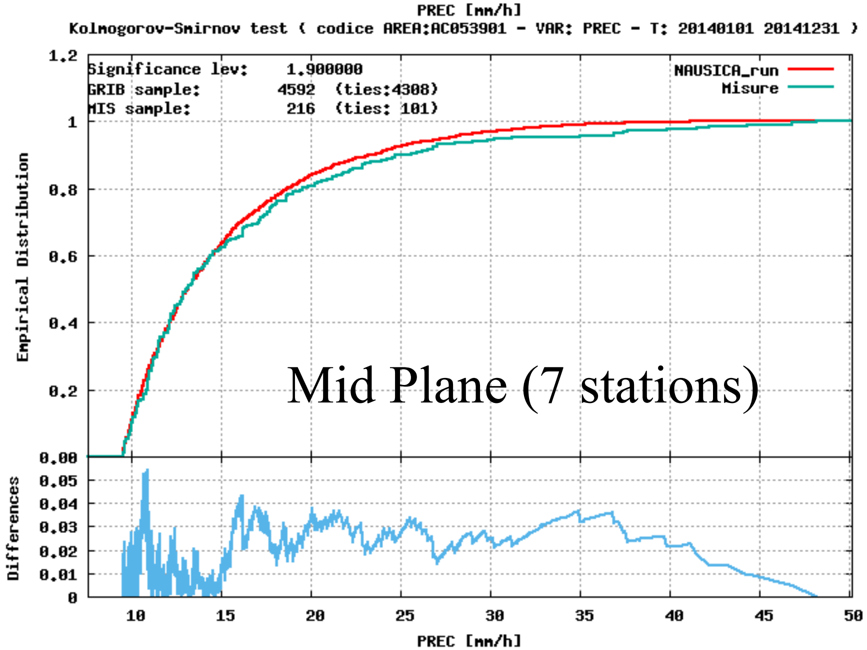


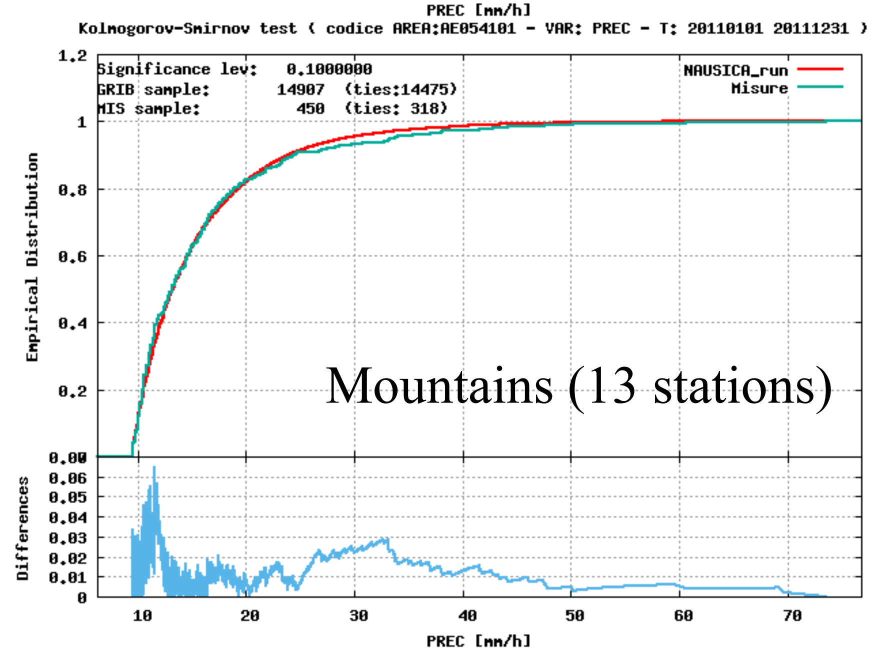
Quality of extreme rain rates: > 10 mm/h - the best performances

Empirical distributions for one year of events – each graph reports one validation area









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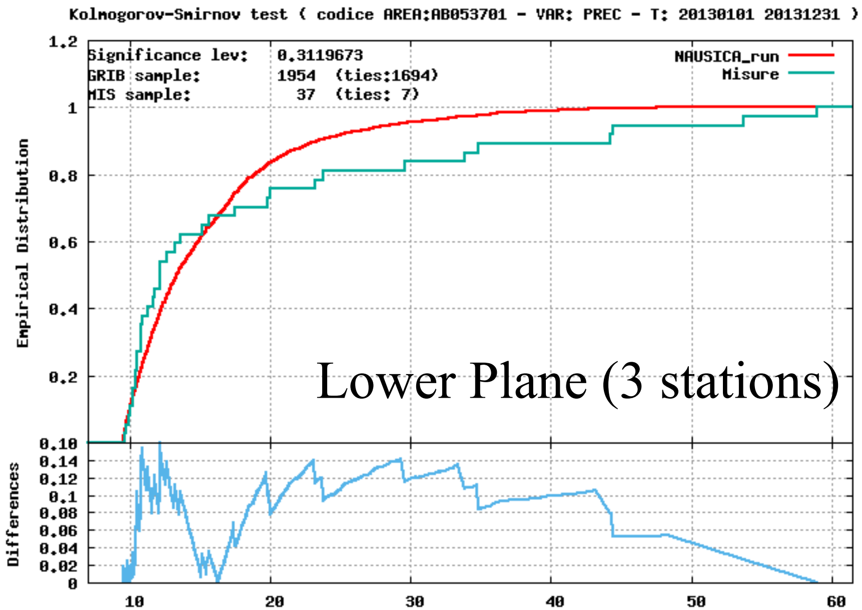

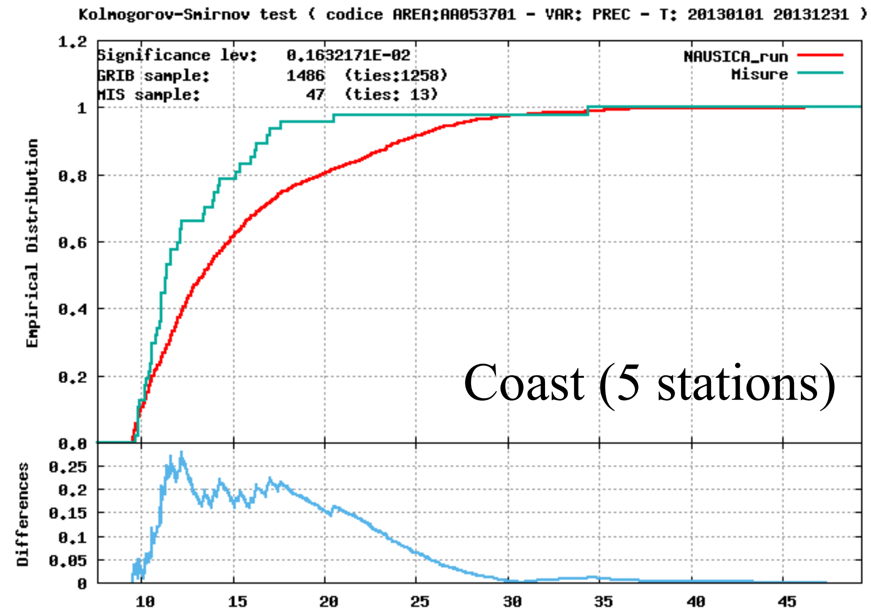

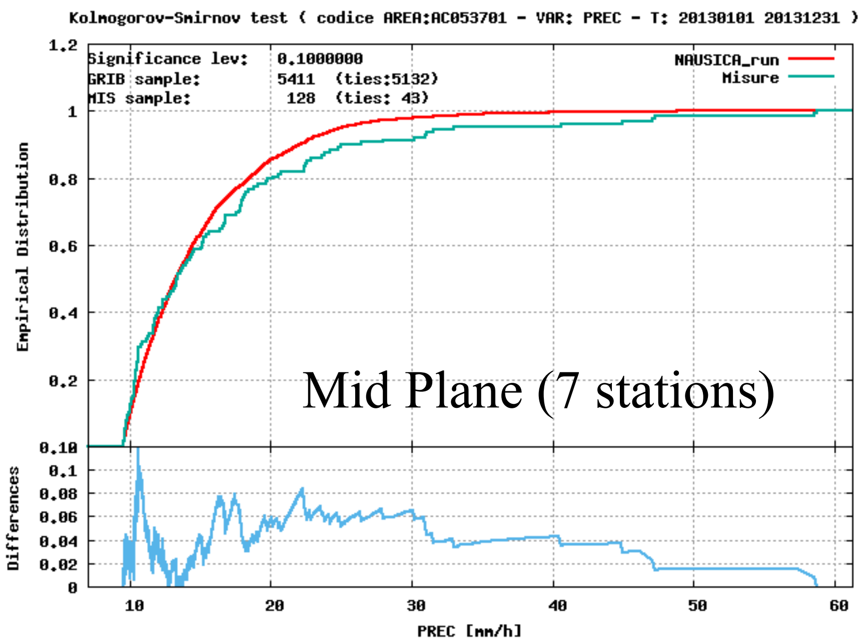

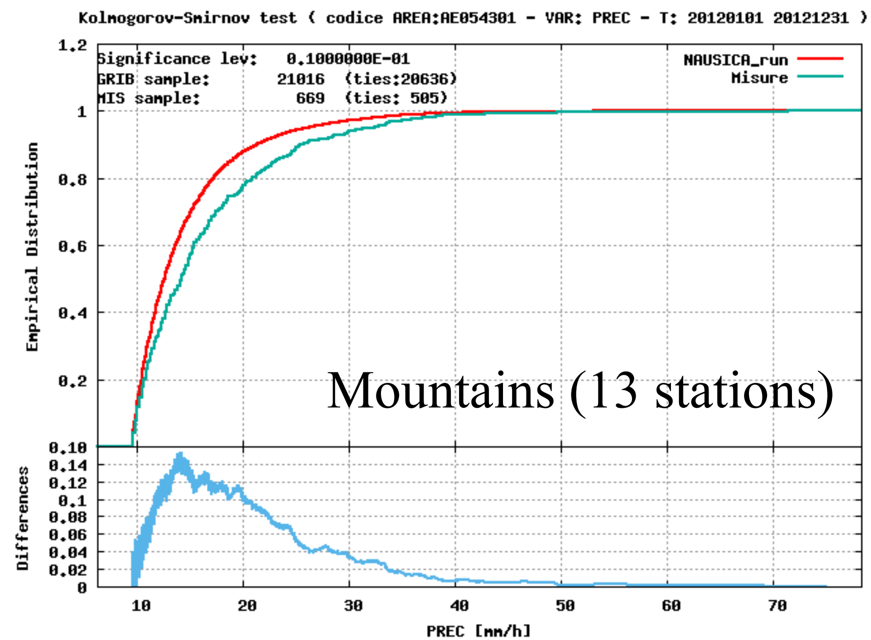

Conclusions

Downscaling GCMs simulations with LAMs demonstrates that nowadays cutting-edge atmospheric models have physical, dynamical, feedback and boundary interaction processes representation suitable to reproduce **meso-gamma/micro-alpha** phenomena (here precipitation only was shown)

Increasing models spatial resolution is a good strategy to produce better and useful atmospheric simulations.

- for both LAMs and GCMs
- at least down to micro-alpha atmospheric scale (phenomena)
- likely this strategy is going to characterize the next 20 years of research and applications

This strategy is going to **impact at least two areas** of model application

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Weather Forecast