An alternative to spectral nudging: A test case over the European CORDEX domain

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Context:

Deliverable for the EU-FP6 WATCH

Regional forcing datasets from reanalysis

Generate a regional reanalysis in a "poor way" (without data assimilation):

Poorman's regional reanalysis

Background

- **"Classic" regional climate model (RCM) simulations are normally computed in a continuous way**
  - Started with initial conditions and driven by lateral boundary conditions
- **In certain cases, RCM simulations drift away from the driving field and contravene one of the fundamental downscaling assumptions**
- **To circumvent this problem**
  - Commonly: Large-scale nudging
    - A fraction of the large-scale wind field from the driving field is imposed within the RCM domain
  - Alternative: Frequent restarts
    - Compute short simulations, restarted from the driving field, that are joined together to generate a climatic sample
- **Motivation: Verify that the alternative method generates a "good" regional climate simulation**
- **Methodology: Compare 2 RCM simulations (continuous and restart) with the driving field and the observations**

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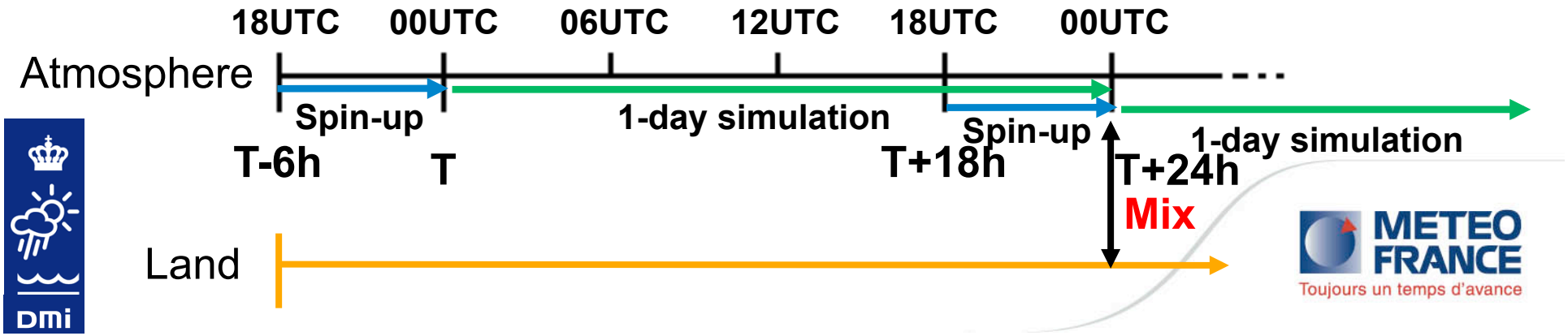
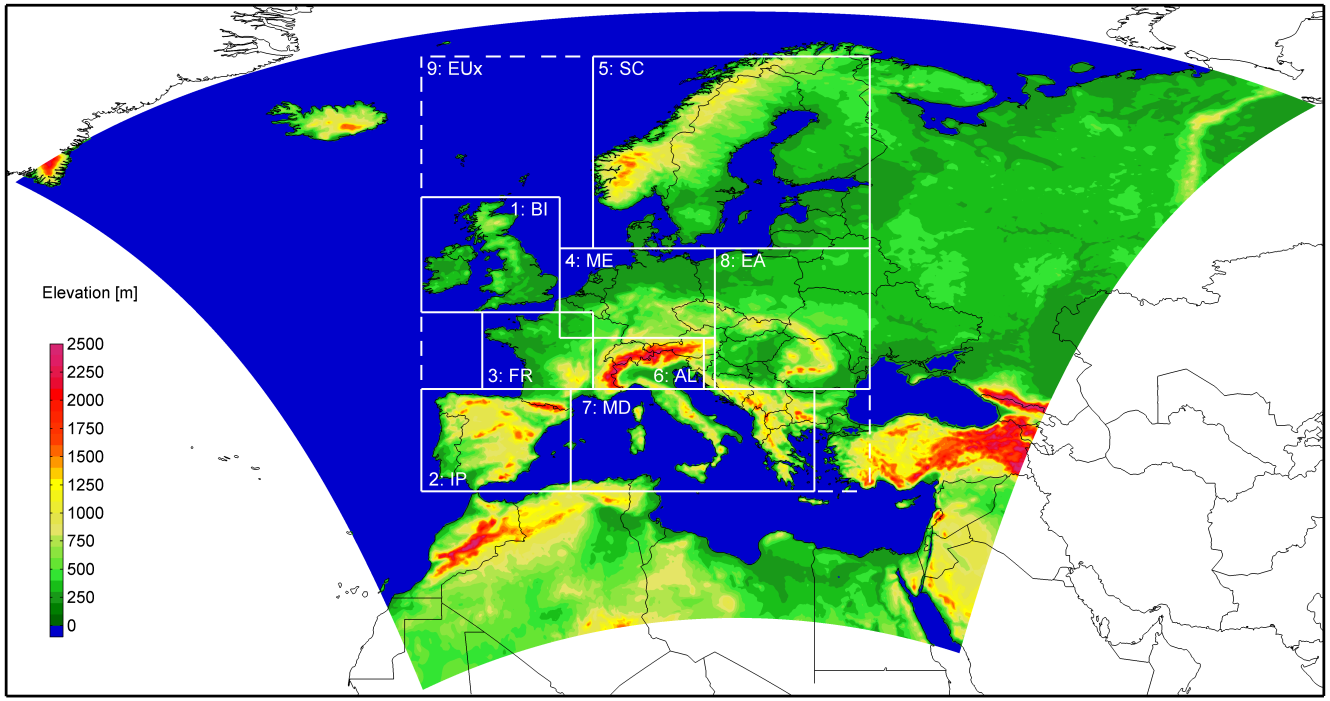
Experimental setup

- 2 x 1989-2009 0.11 deg. HIRHAM5 RCM simulations with ERA-I LBC
  - 1. Continuous: Classic continuous
  - 2. Restart: Daily restarted
    - The land fields are continuous, but the atmospheric fields are daily restarted
- ERA-Interim: 1989-2009 0.7 deg. ECMWF reanalysis
- E-Obs: 0.25 deg. gridded 2-m temperature and precipitation over Europe
- ERA-I and E-Obs are interpolated to the RCM domain (over land)
- Analysis: Statistical climate indicators (using daily mean samples)
  - Mean, variability, extremes



Euro-CORDEX domain

- Resolution: 0.11 deg. (~12 km)
- 452 x 432 grid cells with 31 vertical levels
  - 10 grid cells relaxation zone
- Focus on the Scandinavian (SC) region
- Analysis on the free domain (432 x 412)



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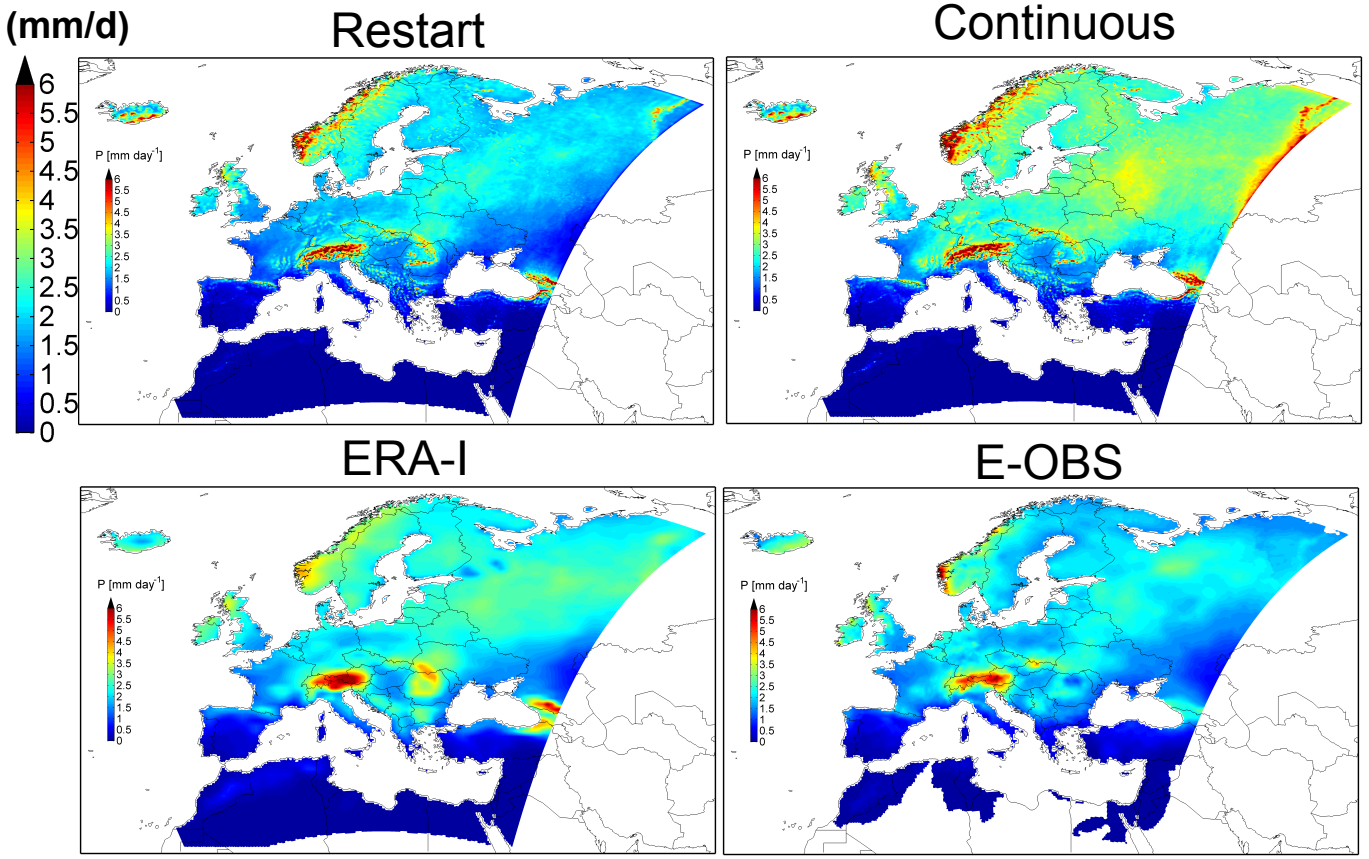
JJA mean precipitation



- The orographically induced precipitation is at the right place in the restart simulation
- The continuous simulation is too wet
- The restart simulation is less wet and is close to the observations
- The restart method takes advantage of the “perfect” atm. conditions every 24h and prevents the drift toward too humid conditions
- The restart simulation prevents problems at the boundaries

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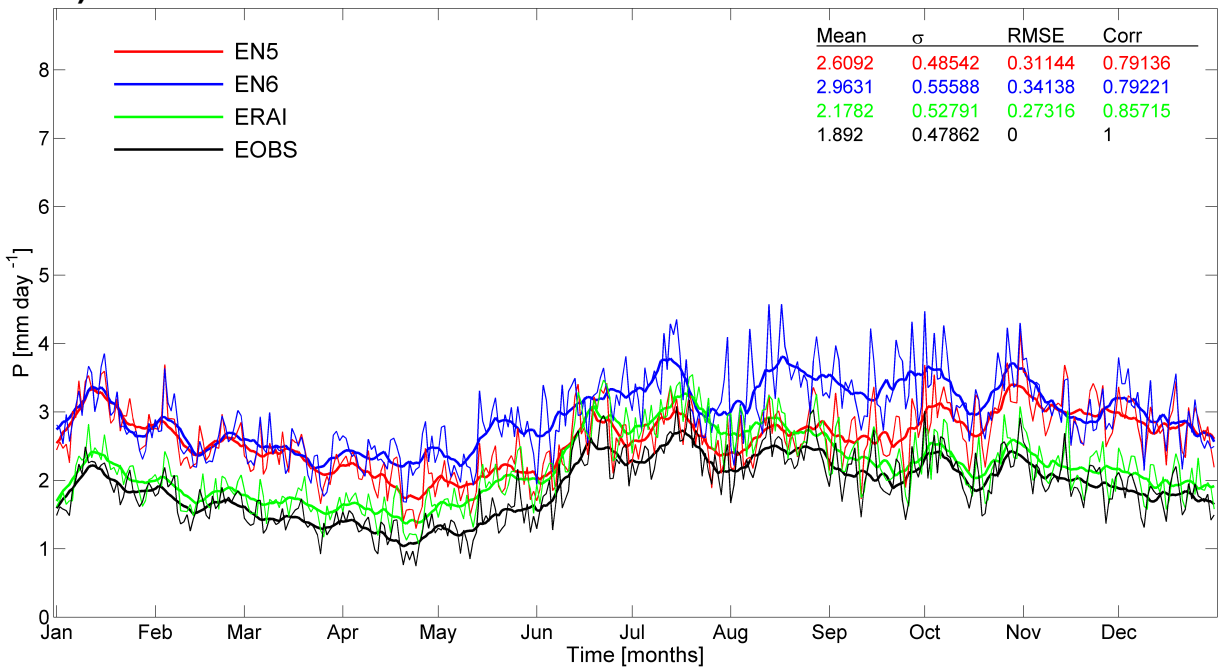
Precipitation mean annual cycle

(mm/d)



Scandinavian region

restart **continuous** **ERA-I** **E-OBS**

- In summer, the restart simulation is closer to the observations than the continuous simulation
- In winter, the restart and the continuous simulations are too wet

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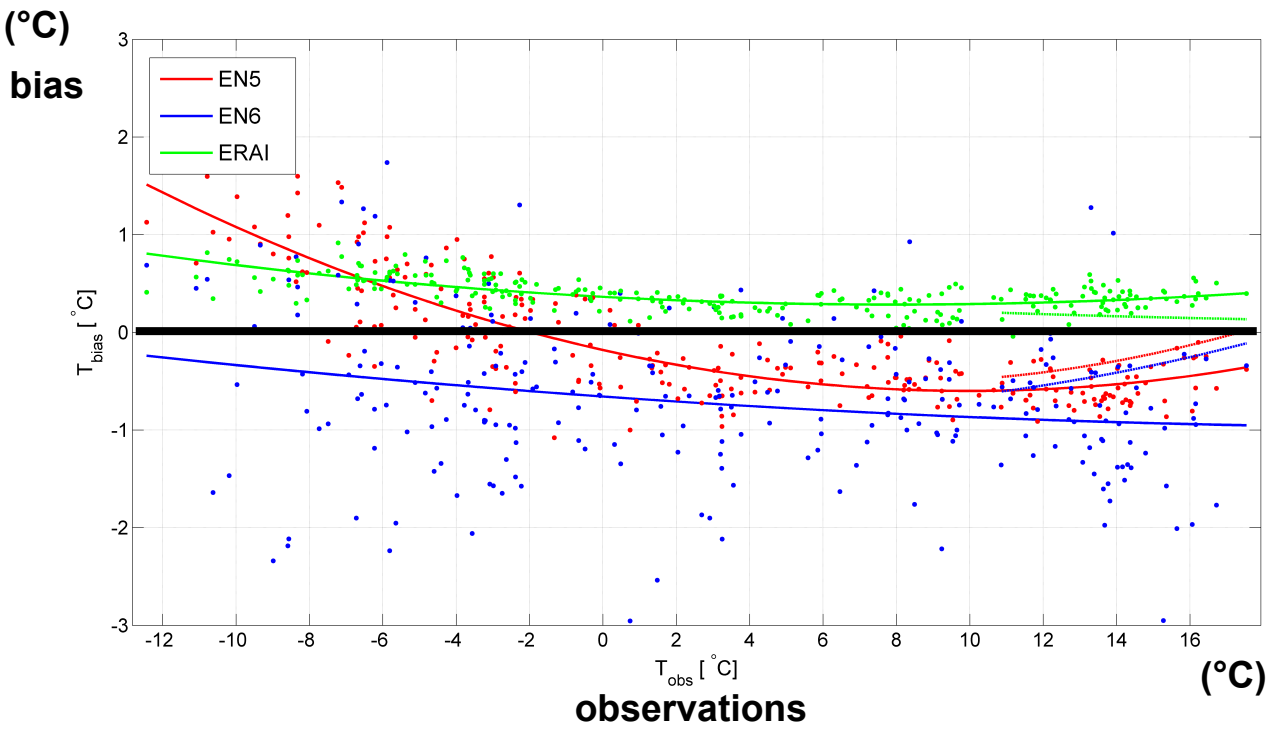
Monthly temperature biases vs the observations (need for bias correction ?)

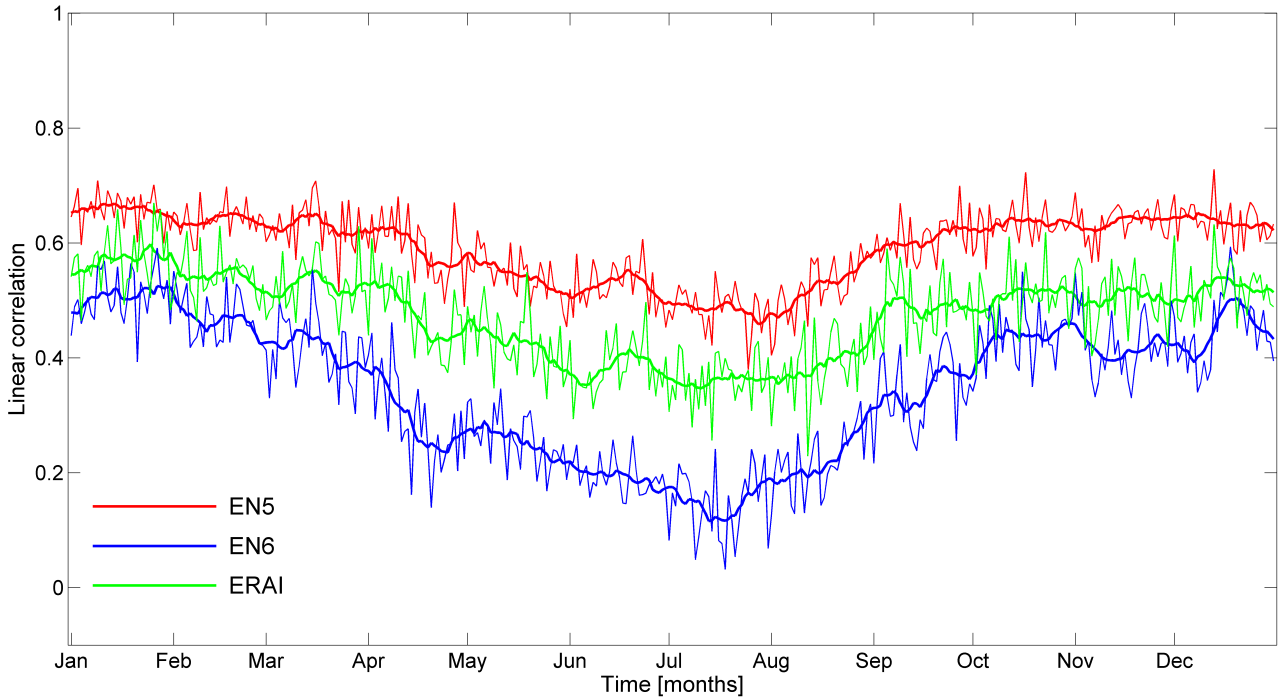


- The restart simulation is closer to the observations than the continuous simulation except for the cold months
- Little bias correction is needed

Scandinavian region

restart **continuous** **ERA-I**

Mean annual cycle of the precipitation spatial correlation with E-OBS



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restart **continuous** **ERA-I**

- The spatial correlation of the restart simulation is higher than that of the continuous simulation
- The sequence of events of the restart simulation matches better the observations
- Stronger control of the driving field with the restart simulation
- Reduction of the RCM's internal variability with the restart simulation

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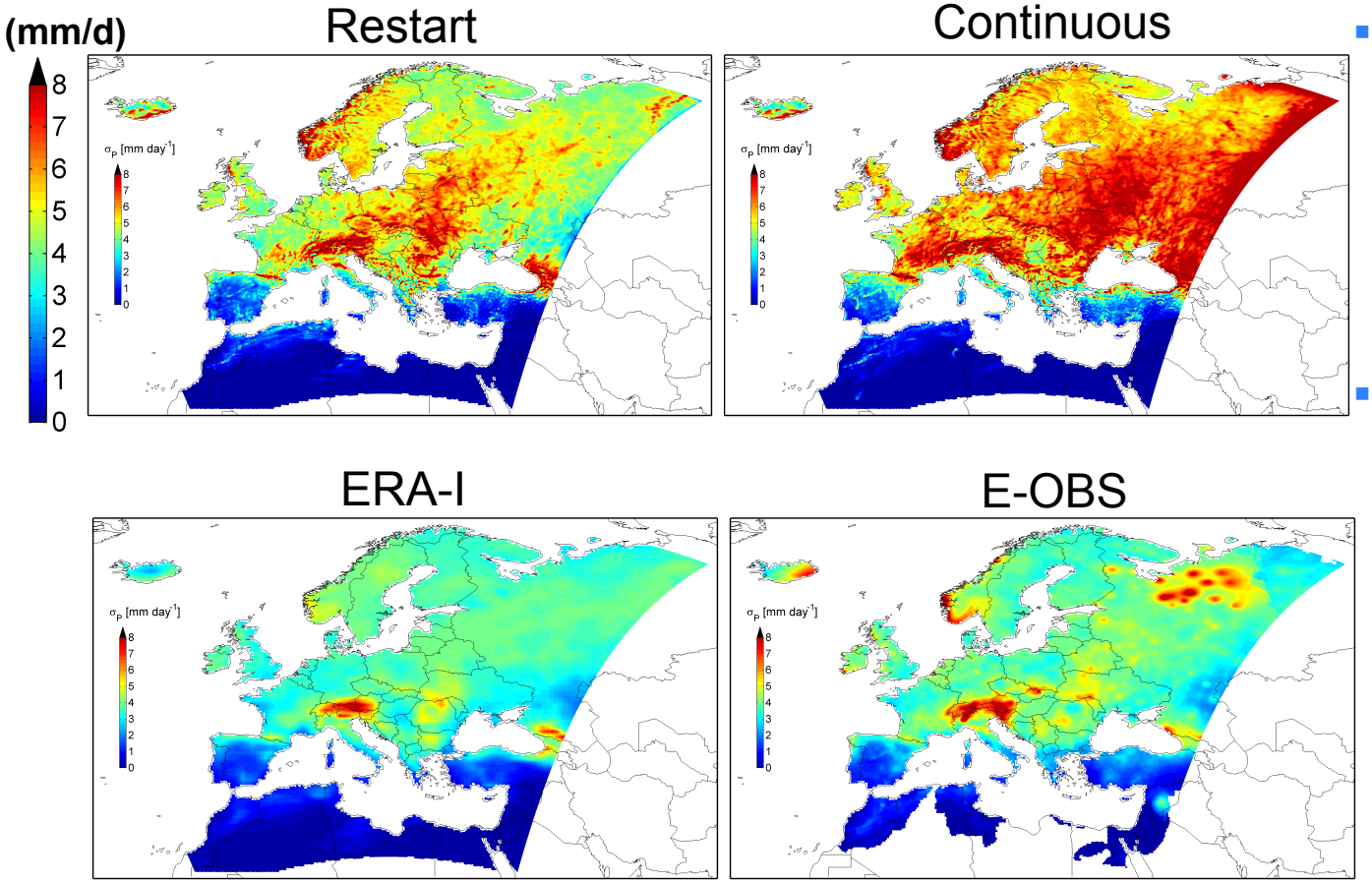
JJA standard deviation precipitation (day-to-day variability)



- Despite being restarted every day, the day-to-day variability of the restart simulation is comparable to that of the continuous simulation
- This indicates that the 6-hour spin-up is long enough to generate
  - a good equilibrium state
  - good fine-scale details (added value)
  - strong precipitation events

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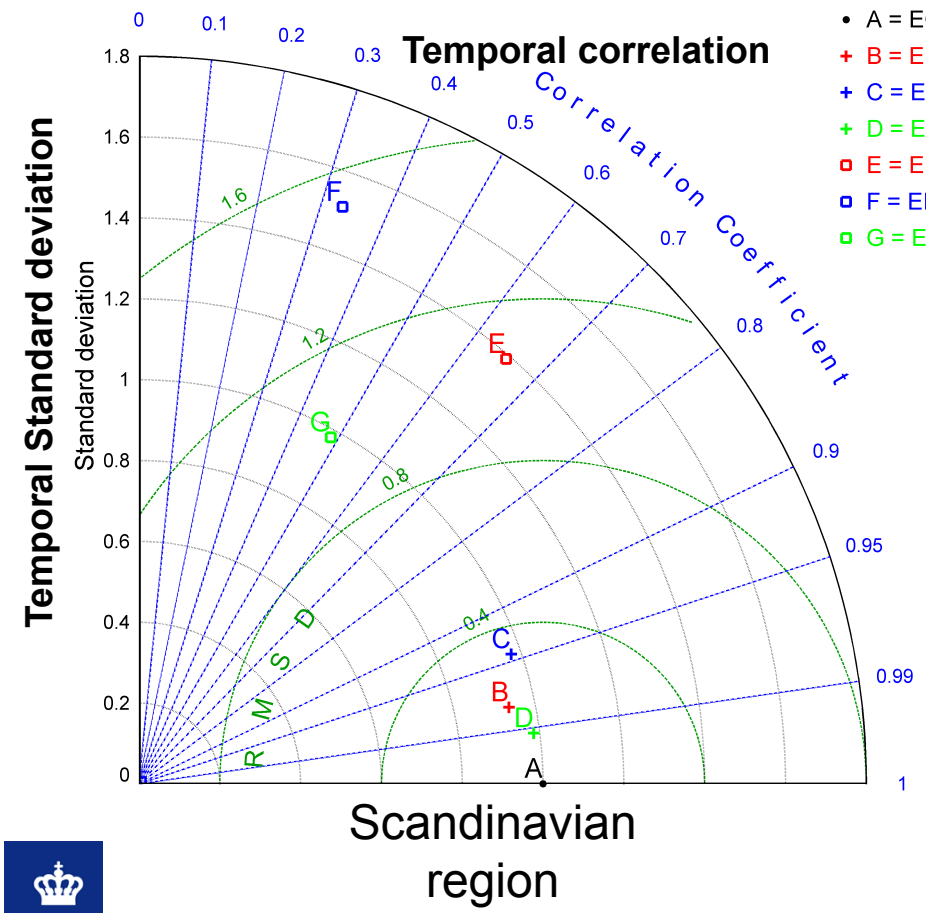
Taylor diagram



- 2m temperature
  - The restart simulation is better correlated with the observations than the continuous simulation
  - The variability ratio of the restart simulation is close to 1
- Precipitation
  - The restart simulation is better correlated with the observations than the continuous simulation
  - The variability of the RCM simulations is higher than that of the observations

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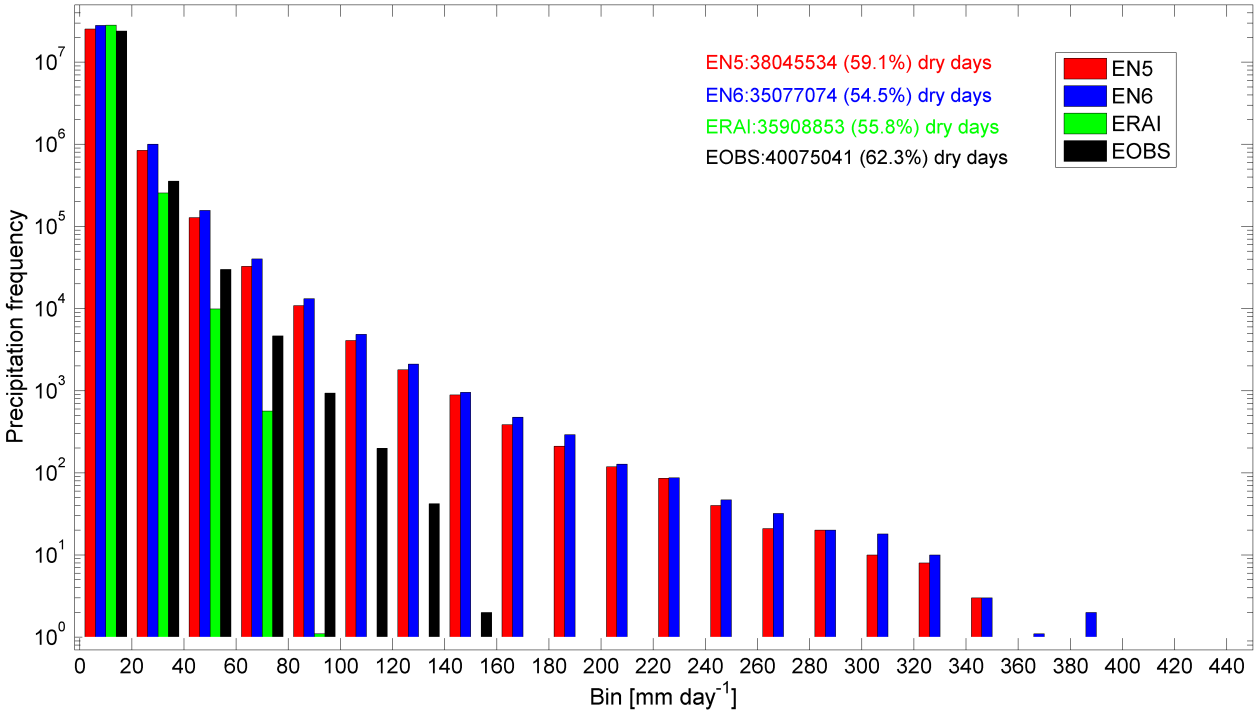
Precipitation distribution



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- The RCM simulations generate distributions that have more strong events than in the driving field and the observations
- The restart simulation closely reproduces the distribution of the continuous simulation
- The 6-hour spin-up seems sufficient to generate added value
  - Variability and extremes
  - More strong events and more dry days than in the driving field (ERA-I)

restart **continuous** **ERA-I** **E-OBS**

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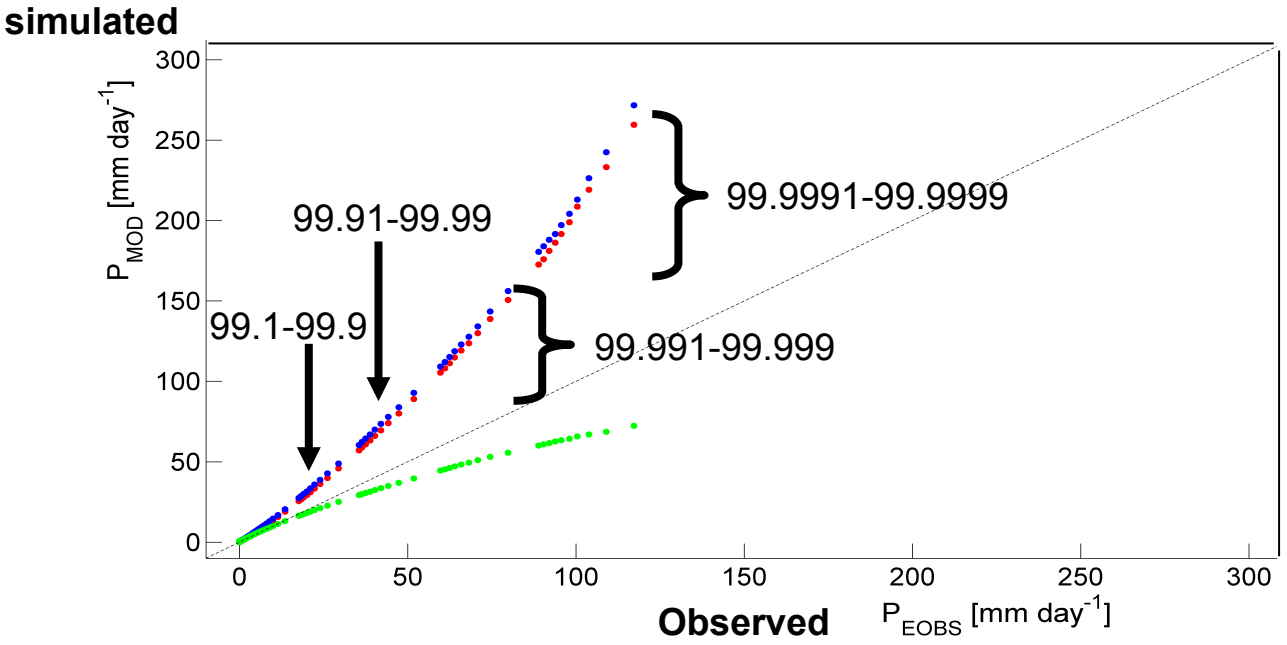
Quantile-quantile plot (precipitation)



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restart **continuous** **ERA-I**

- The RCM simulations generate stronger extremes than the driving field (ERA-I)
- The restart simulation is generating precipitation extremes that are close to that of the continuous simulation
- Some extremes are probably missing in the observations
  - Resolution and interpolation
  - Distribution of the stations
  - Method to obtain a gridded product

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Conclusions

Does the restart method generate a good regional climate simulation?
Answer: yes !

- The restart method (benefits)
  - takes daily advantage of the observations assimilated in the reanalysis within the domain
  - prevents the drift
  - generates small-scales with increase variability and extremes vs driving field
  - increases the control of the driving field
    - higher spatial correlation with the observations
    - prevention of the problems at the boundaries

- The restart method (drawbacks)
  - is more expensive in computer power
    - extra computation for spin-up
    - extra data transfer (input/output)
  - doesn't close the budgets
  - creates discontinuous time series

- Optimization of the method
  - 3 parameters
    - spin-up period
    - starting time
    - length of simulations

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