Influence of Model Version, Resolution and Driving Data on High Resolution Regional Climate Simulations with CLM

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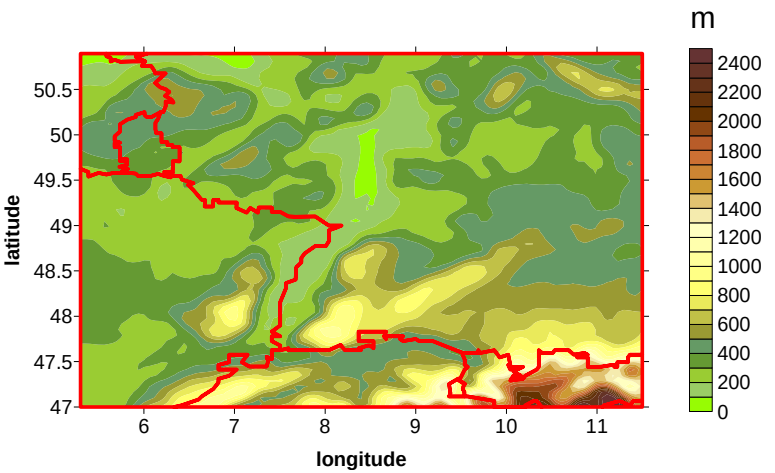
Motivation

- **Performance of high resolution climate simulations on regional scales**
  - Areas of 500 x 500 km
- **Quantification of the influence of resolution and model version on model results**
  - 14km, 7km
  - Version 3.21, Version 3.22 (new cloud microphysical parameterization)
- **Quantification of the influence of lateral and lower boundary conditions on the simulation results**
  - Investigation of the influence of lateral boundary conditions by using different driving data
  - Investigation of the influence of the lower boundary condition by changing the initial soil water content

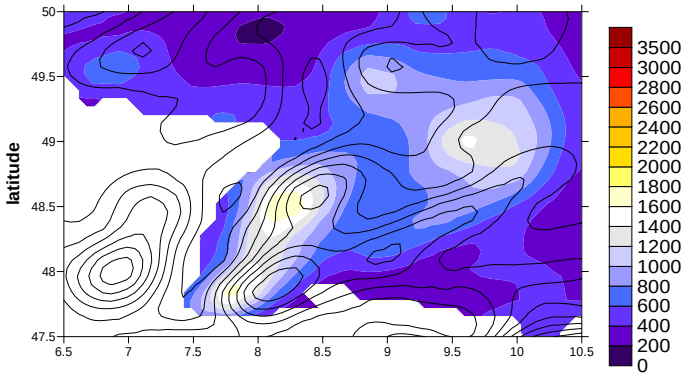
Influence of resolution and model version



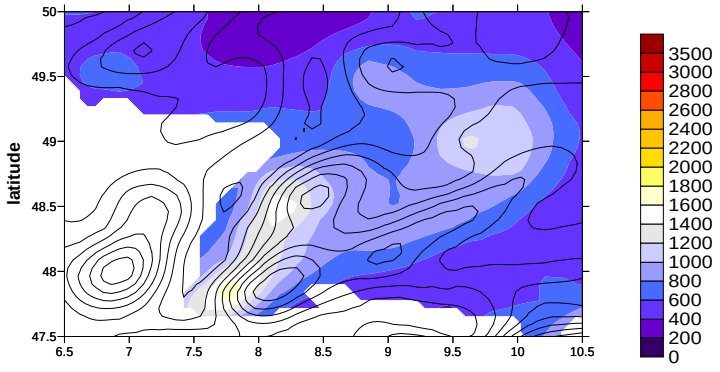
- **Simulations for the year 2001 with GME Analysis Data as driving data every 6 hours**
- **4 simulations with different setups:**
  - 7 km with Version3.21
  - 7 km with Version3.22
  - 14 km with Version3.21
  - 14 km with Version3.22

Annual total precipitation amount

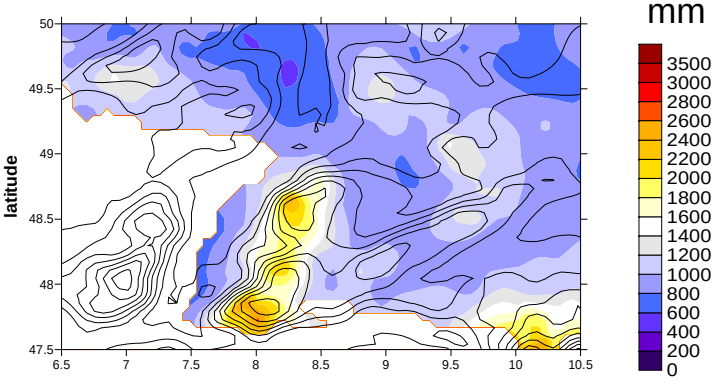
14km V3.21



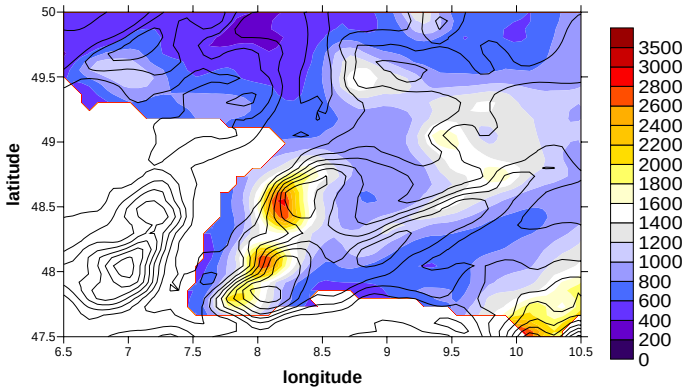
14km V3.22



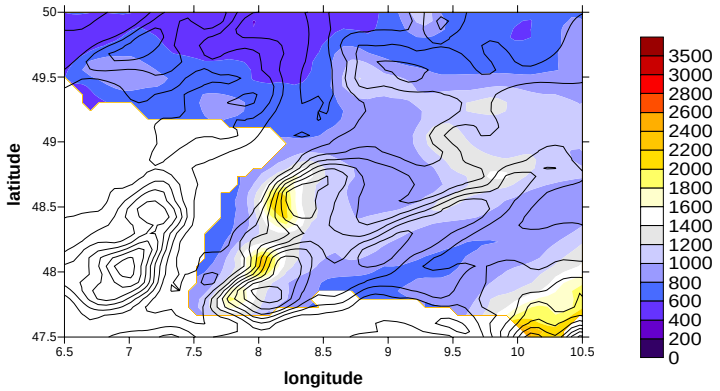
measurements



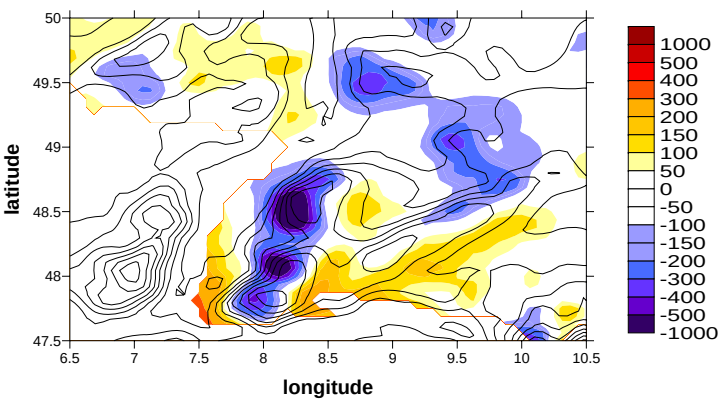
7km V3.21



7km V3.22

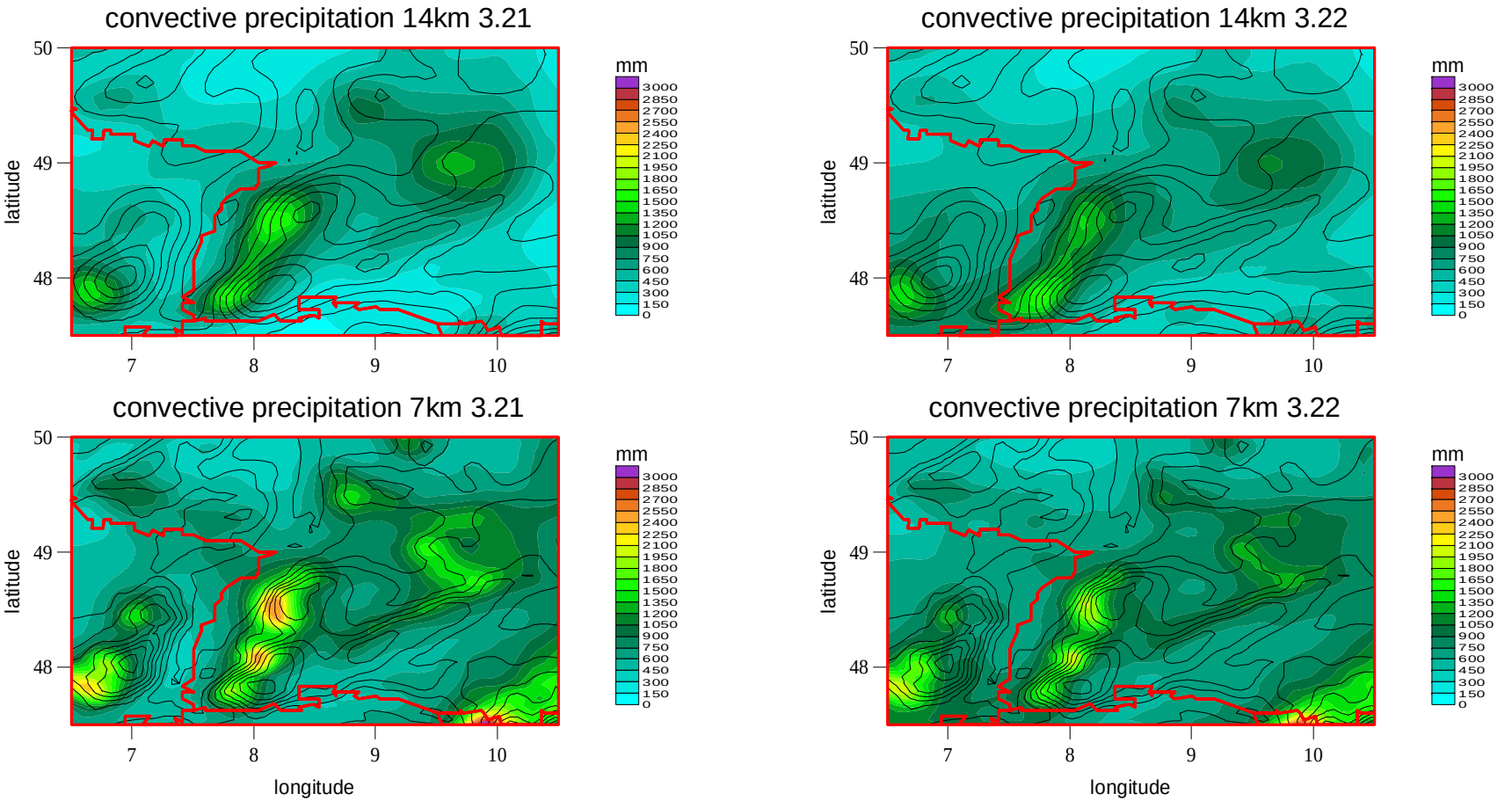


7km V3.22 - V3.21



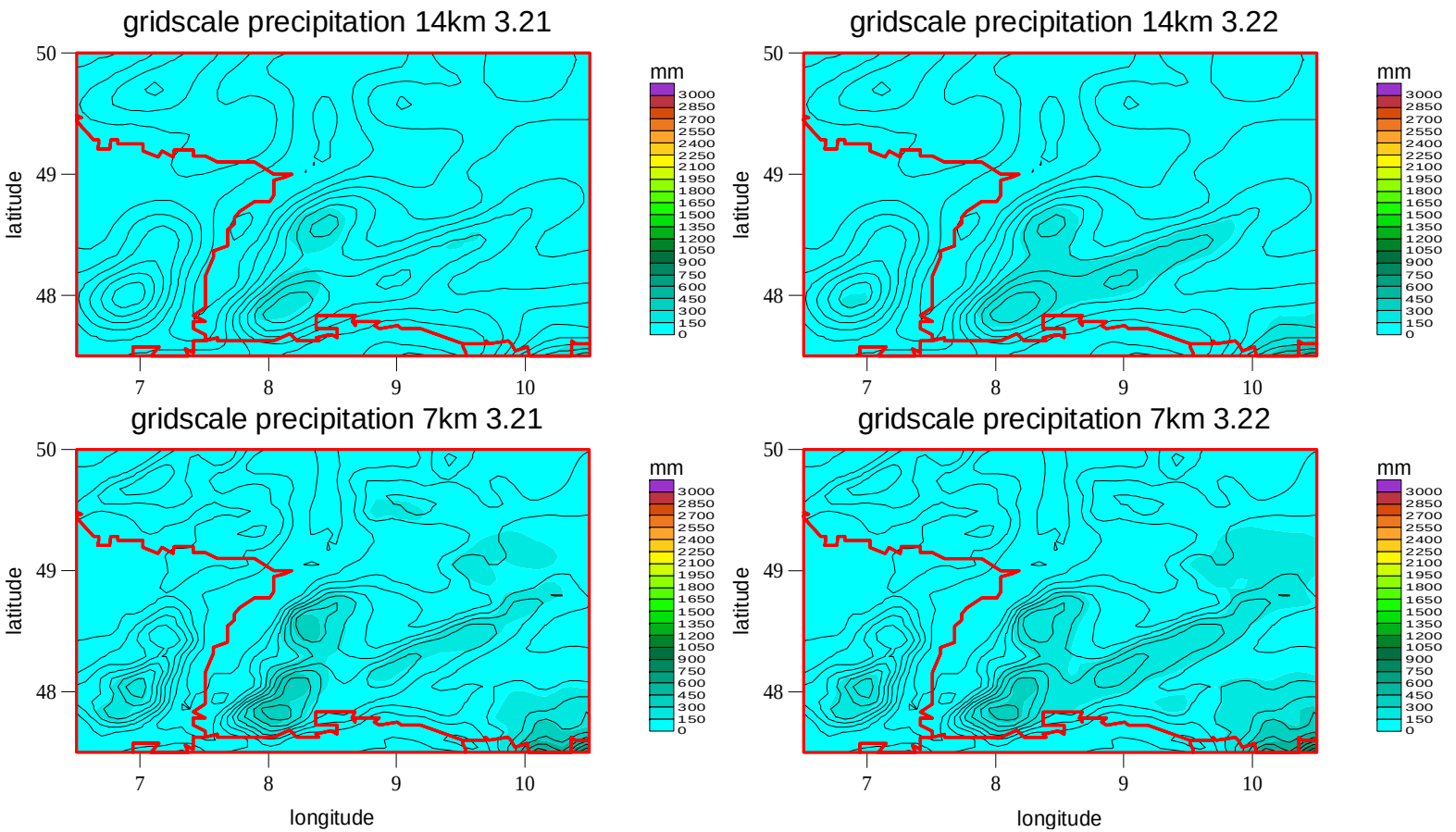
- **Too small precipitation amount with 14 km grid size**
- **LM Version 3.22 with 7km grid size gives best results**

Convective precipitation



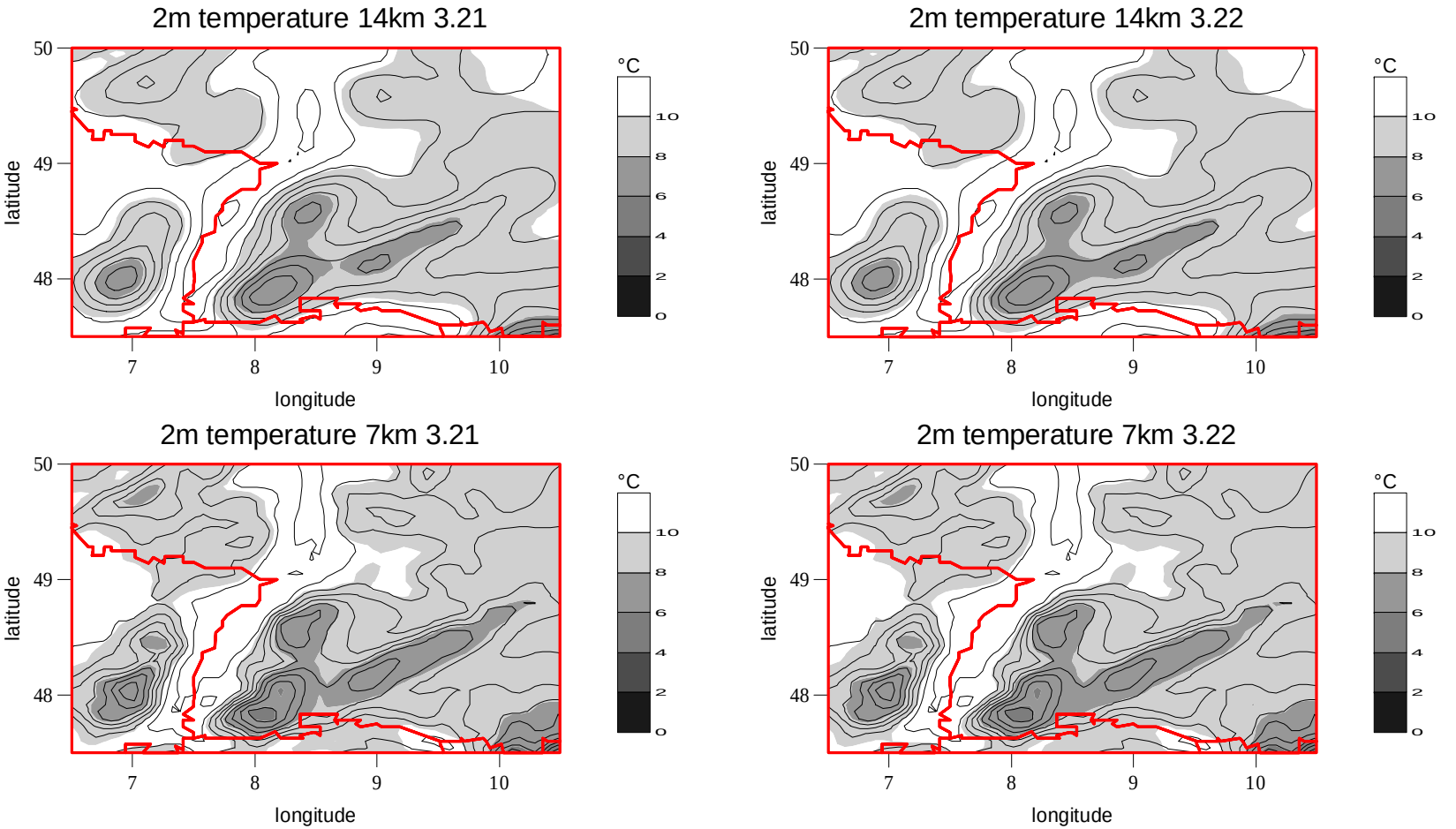
- **Amount of convective precipitation smaller in simulations with 14 km grid size**
- **Less convective precipitation with Version 3.22**

Grid scale precipitation



- **Enhancement of grid scale precipitation in Version 3.22**
- **Larger amount of grid scale precipitation with 7km grid size**

Annual mean of 2m-temperature



- **Simulations with different grid size and model version are very similar**

Influence of resolution and model version

- **Improvement of precipitation forecast using 7 km grid size resolution instead of 14 km**
- **New cloud microphysical parameterisation improves precipitation forecast**
- **Only small differences in temperature simulation between the different model versions**

Quantification of the influence of lateral and lower boundary conditions on the simulation results

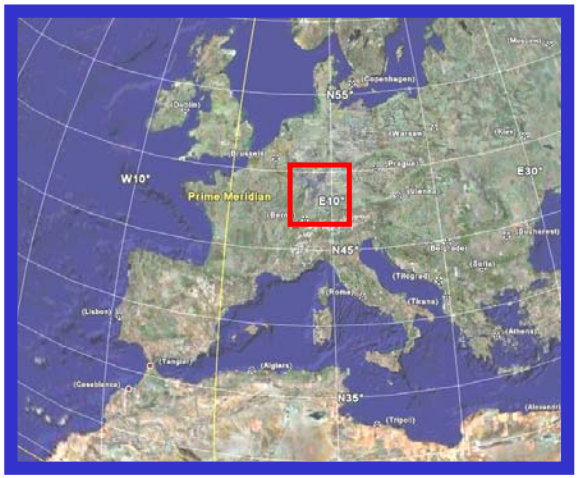
- Normally driving data have coarser resolution than GME Analysis => nesting necessary to get reasonable results for small model area
- Simulation of big model domain with 0.44° grid size resolution
- Uncertainty how strong the influence of boundary data can bee => Simulations with:

  – **Variation of driving data:**

    - ERA40 Reanalysis data
    - NCEP Reanalysis data

  – **Variation of soil initialisation:**

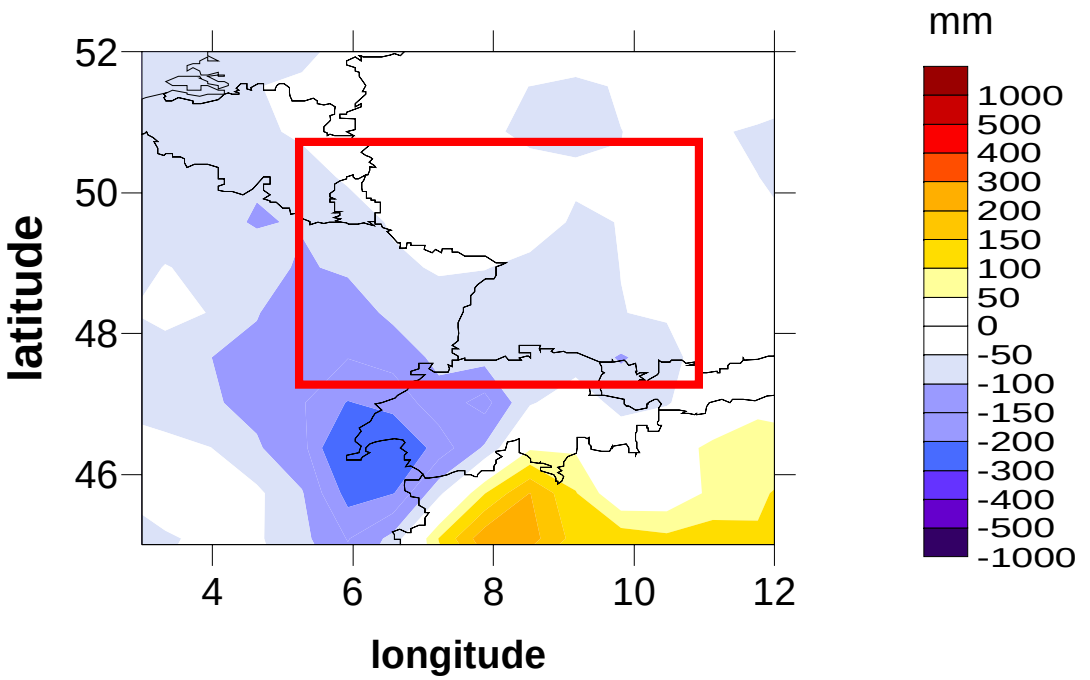
    - Taken over from driving data (ERA40, NCEP)
    - Climatological values provided by ETH Zürich



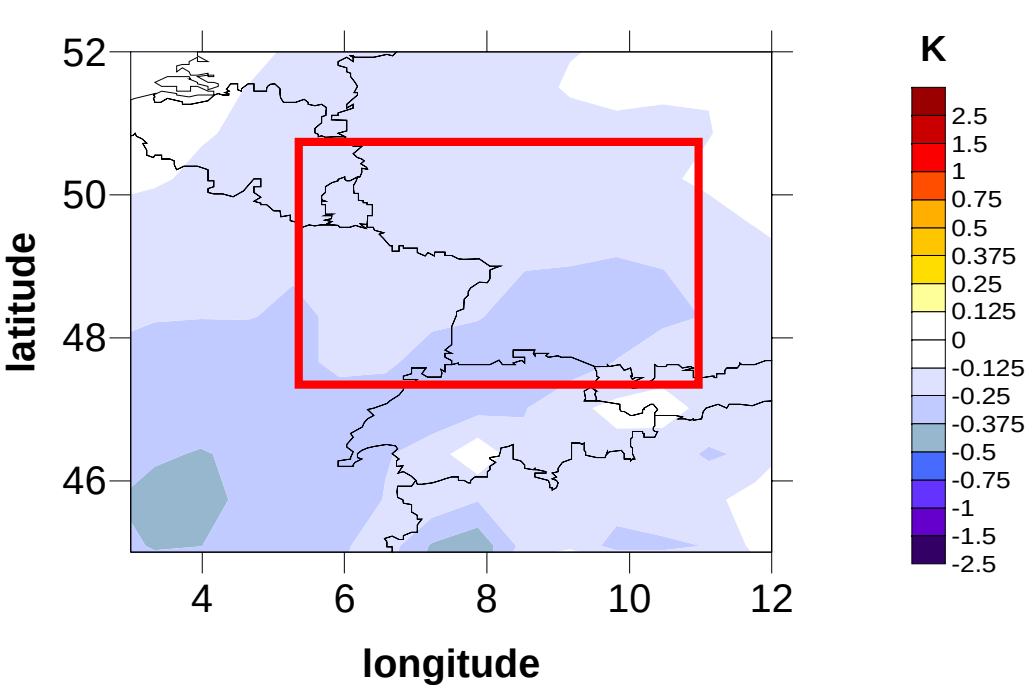
Variation of driving data

Difference of the annual mean/sum between simulation driven by ERA40 and NCEP averaged over the period 1990 - 1999

total precipitation



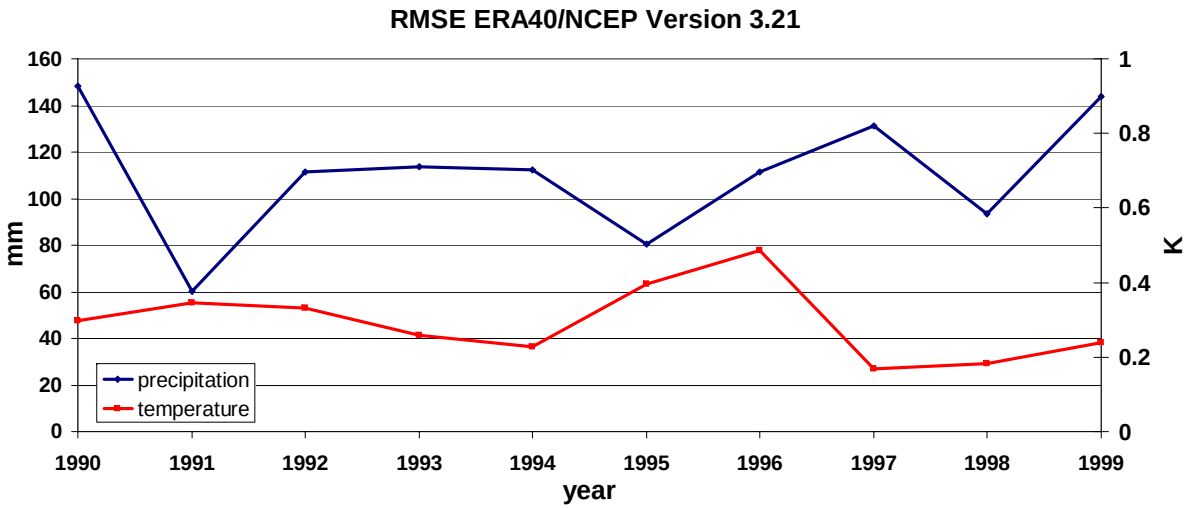
2m - temperature



- **Differences in the small model domain up to 0.4 K and 150 mm**
- **Simulation driven by ERA40 is colder and produces less rain**

Variation of driving data

Assessment of the influence of driving data for the small model domain by calculating the root mean square error for the simulation with ERA40 and NCEP as driving data



- Differences between ERA40 and NCEP simulation persist over the whole decade

  => nesting the small model domain in the different driving data will give different simulation results

  => simulations soon will be done with model version 3.22 to see if there is an amplification of differences due to downscaling

Variation of soil initialisation

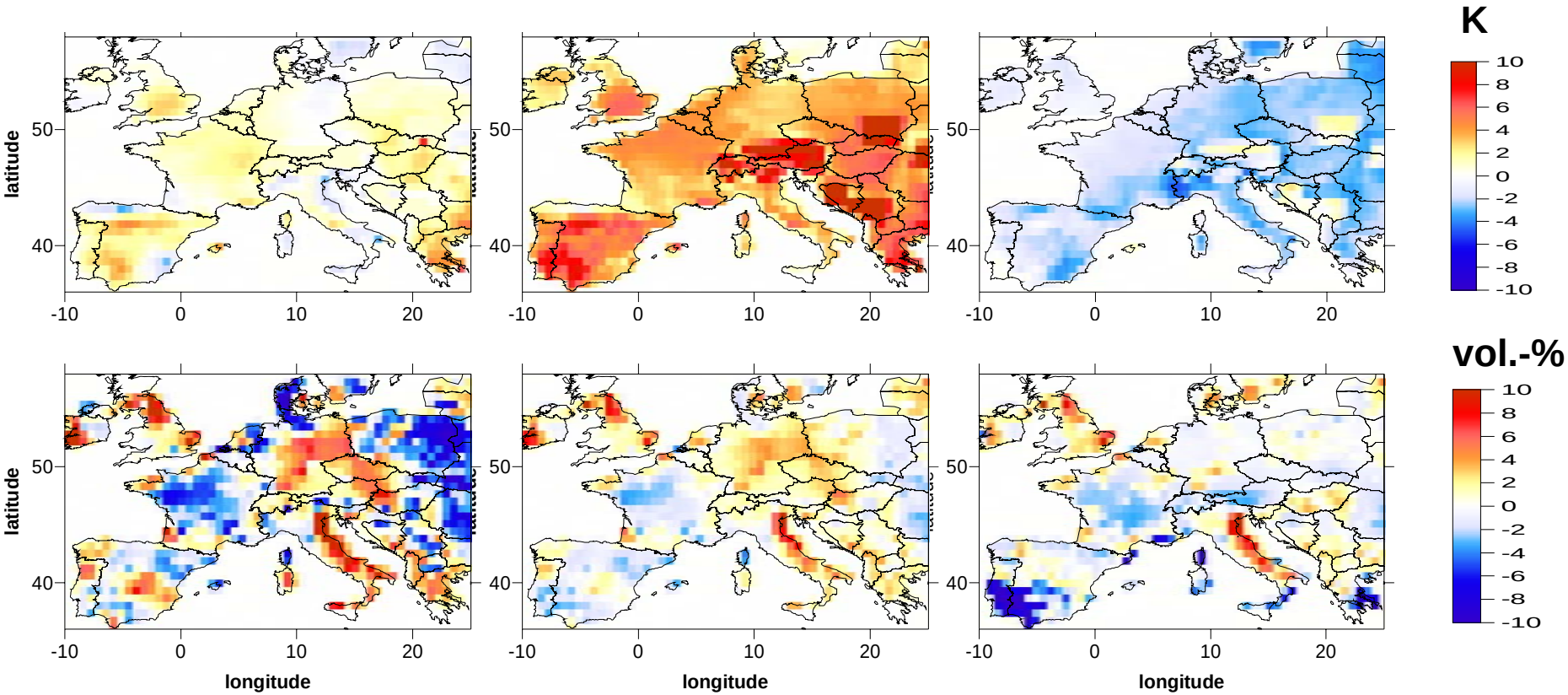
- **Known that ERA40 data does not provide best soil initialisation**
- **Possible to initialize with climatological mean soil data obtained by running the CLM for 40 years ?**
  - Climatological mean was provided by Daniel Lüthi, ETH Zürich
- **2 Simulations:**
  - Continuous simulation from summer 1988 to 2001 with ERA40 as driving data and initialization data for the soil (ERA40)
  - Continuous simulation from summer 1988 to 2001 with ERA40 as driving data and climatological mean from 40 year run as initialization data for the soil (ERA40KLIM)

Differences at the initial day (ERA40 – ERA40KLIM)

0.005 m **0.16 m** **2.86m**

Soil temperature

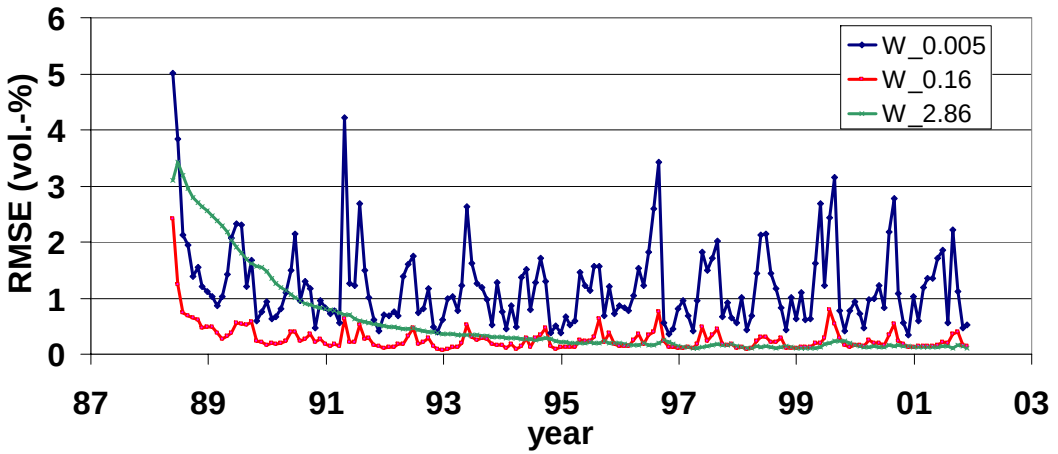
Soil moisture



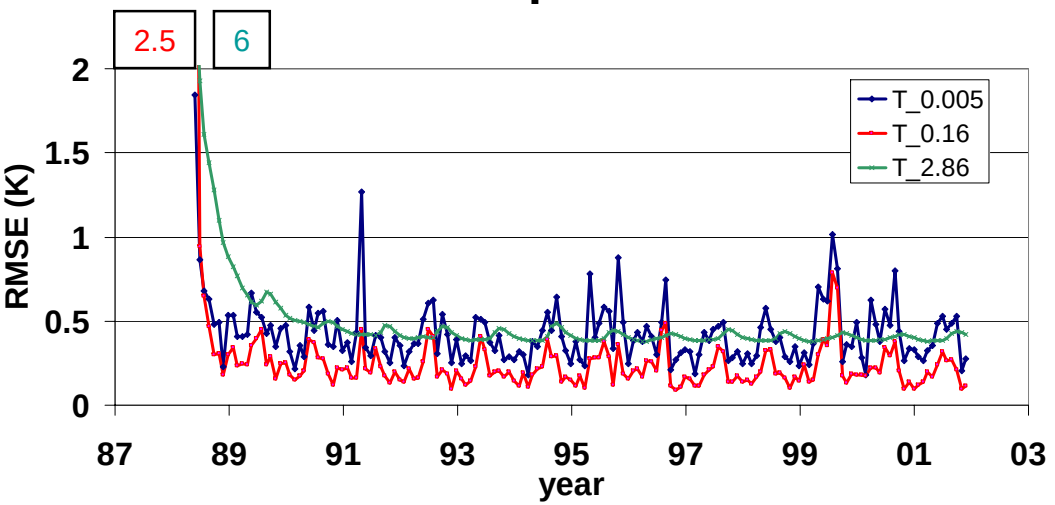
- **Strong differences between soil temperatures (up to 10K) and soil water content (up to 10 vol.-%)**

RMSE (ERA - ERAKLIM) from 1988 - 2001

Soil water content

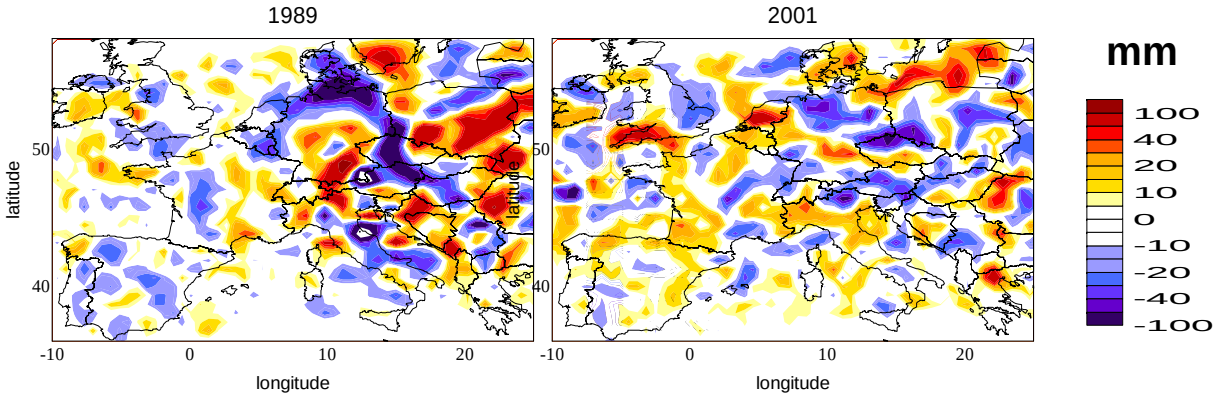


Soil temperature

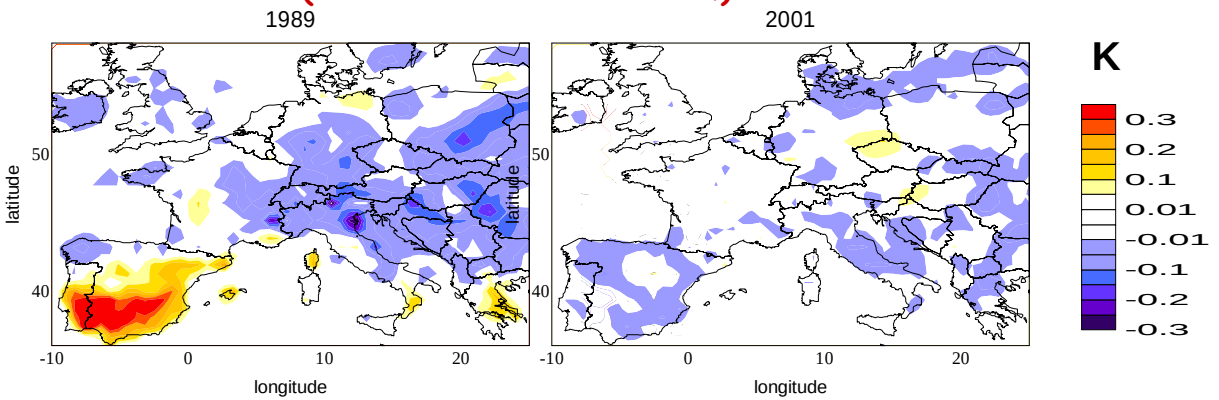


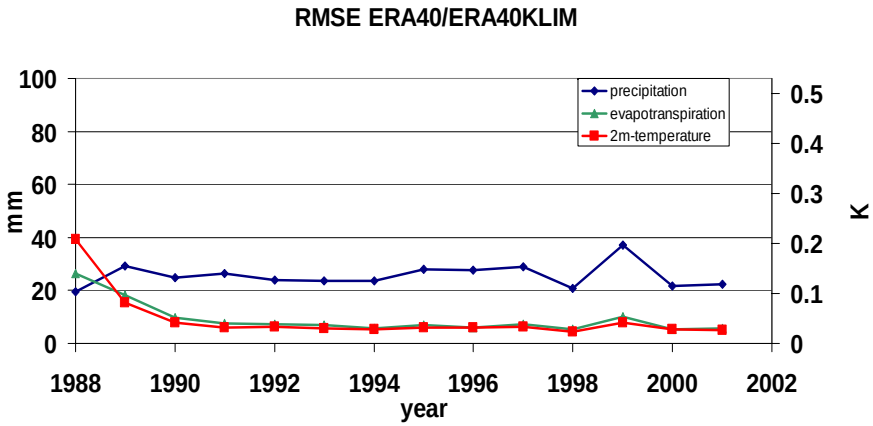
- Strong differences in soil temperature and water content decrease during the first three years
- Annual cycle in difference visible over the whole decade
- RMSE does **not** vanish => simulations do not fit together

Difference of annual precipitation (ERA40 – ERA40KLIM)



Difference of annual mean 2m-temperature (ERA40 – ERA40KLIM)





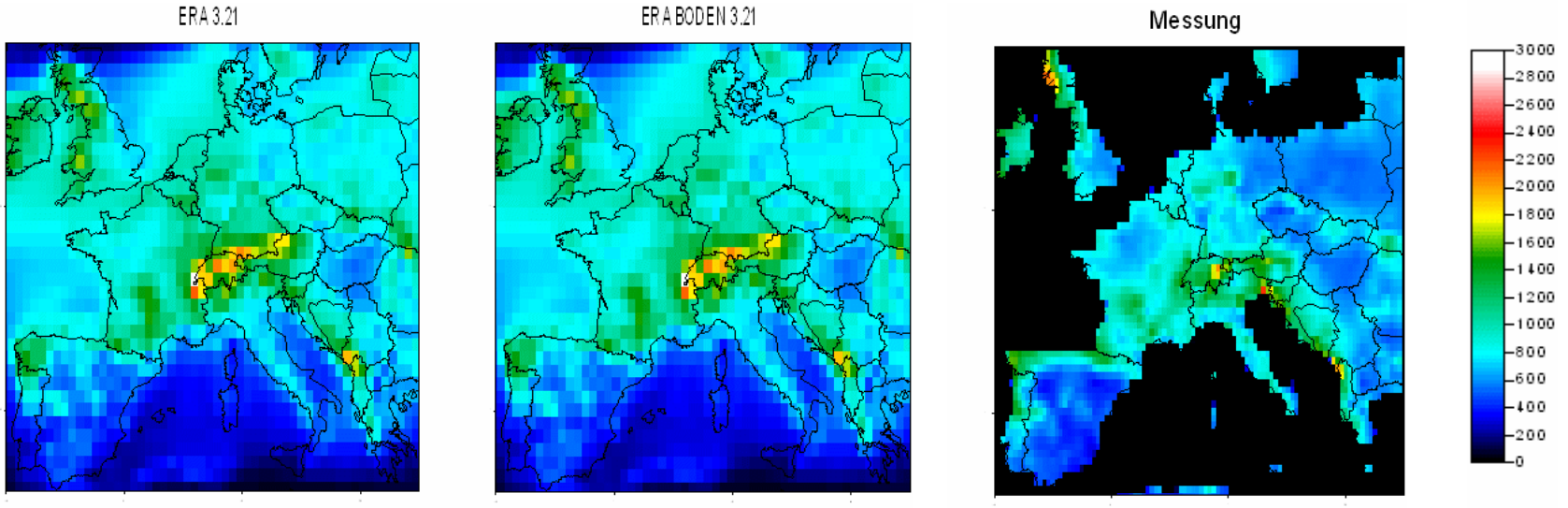
- Differences in annual precipitation and mean 2m-temperature are higher during the first years and do **not** vanish during the decade

  => Temperature differences between both simulations to small to decide if one initialisation gives better results than the other

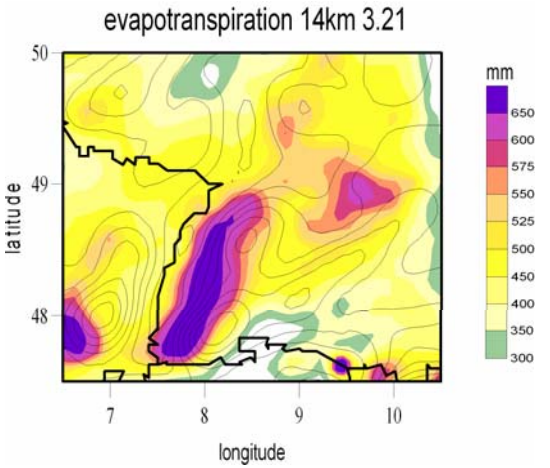
Conclusions

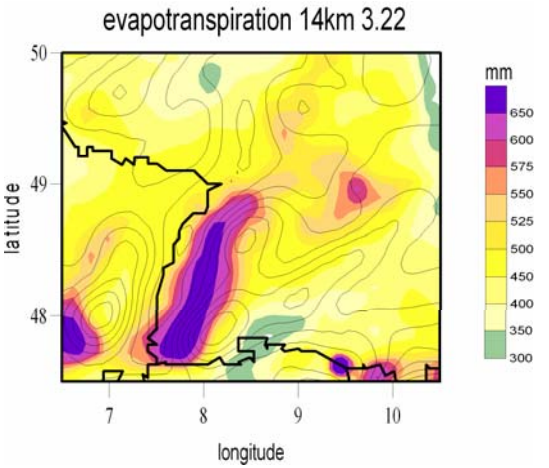
- 7km grid size gives better precipitation results than 14 km grid size in orographically structured region
- Precipitation amount is more realistic with new cloud microphysical parameterisation
- Strong influence of driving data on simulation results
- Soil initialization has a strong effect on precipitation simulation which persists over the decade

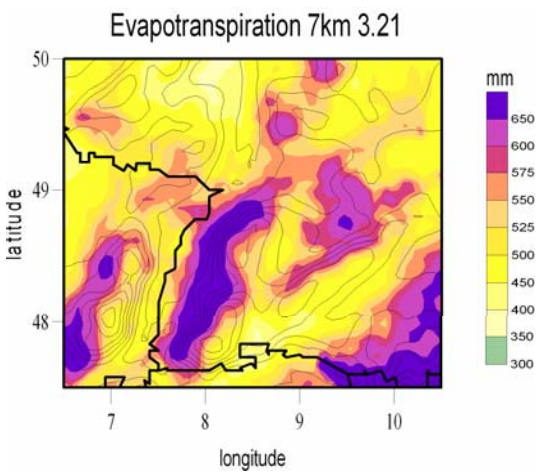
- **Ensemble with different physical parameterisations and initial states should be generated for climate decades to quantify the uncertainty in model results**
  - One part of my PhD thesis in near future
  - Ideas for meaningful simulations are welcome

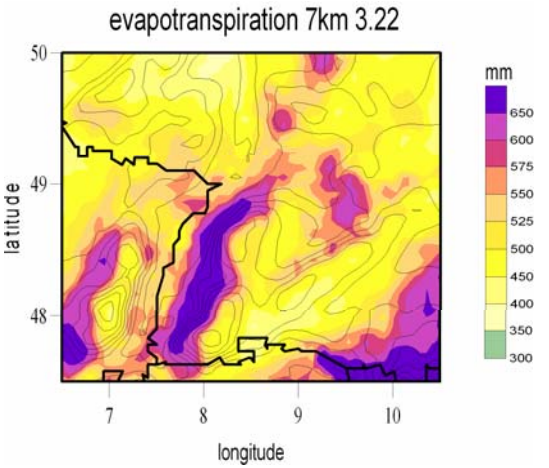

ERA 3.21
ERA BODEN 3.21
Messung
3000
2800
2600
2400
2200
2000
1800
1600
1400
1200
1000
800
600
400
200
0

Influence of resolution and model version on the simulations









Comparison of annual area mean of precipitation

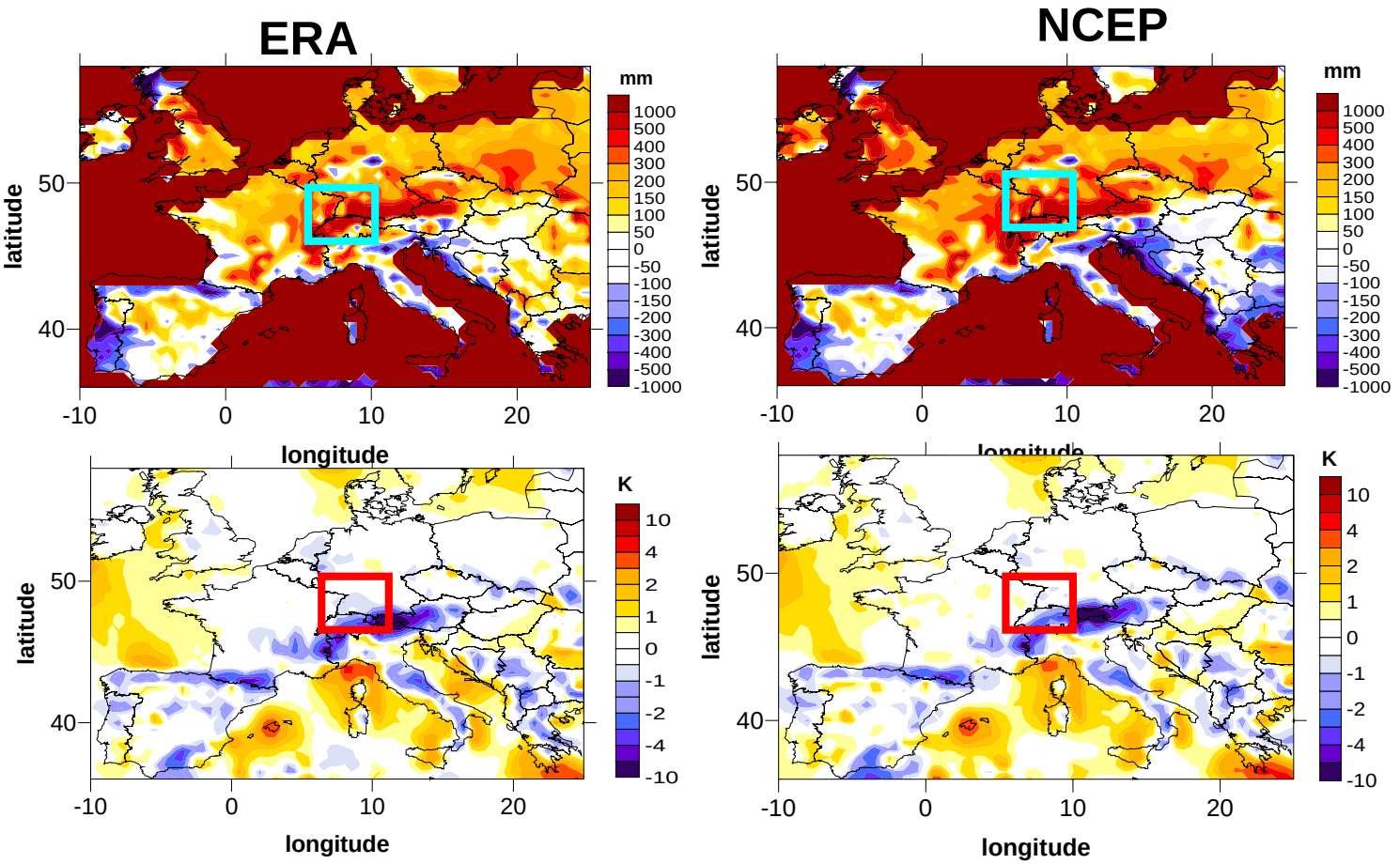
Model version	V3.21_7km	V3.22_7km		V3.21_14km	V3.22_14km
Total precipitation	69.8	72.1		43.2	52.9
Convective precipitation	62.4	61.1		38.8	44.4
Grid scale precipitation	7.3	11.0		4.4	8.5

- **Enhancement of area mean in convective and grid scale precipitation from 14 to 7 km**
- **Enhancement of area mean from version 3.21 to version 3.22**

Difference model - measurements

Total precipitation

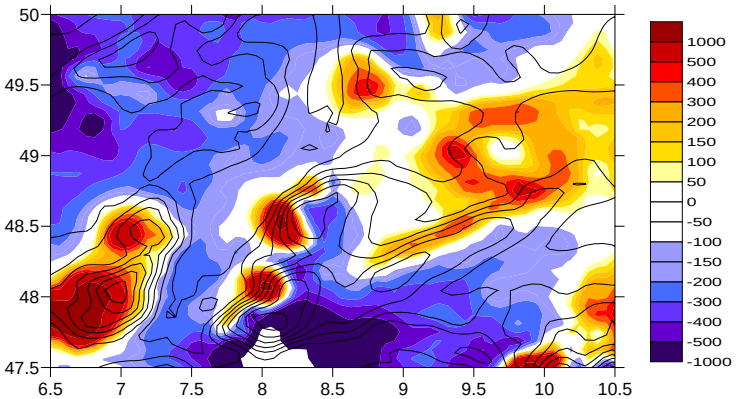
2m Temperature



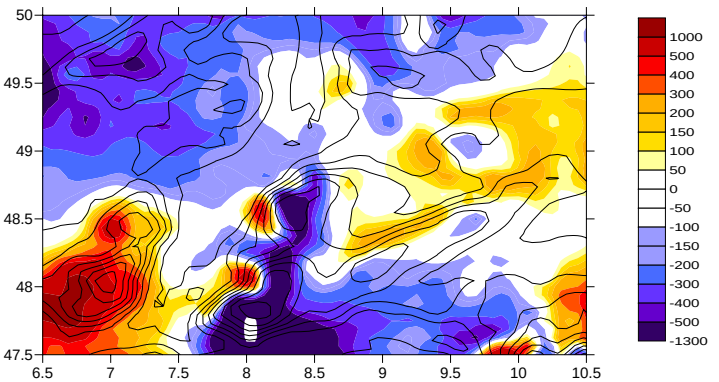
Precipitation strongly overestimated by the simulations in Central Europe

Good agreement of temperature with measurements in both simulations in Central Europe

3.21 - measurements



3.22 - measurements



7km V3.22 - V3.21