Helmholtz-Zentrum Geesthacht
Centre for Materials and Coastal Research

European Climate Prediction system

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The effect of horizontal diffusion parameterization in convection-permitting REMO-NH simulations over Germany

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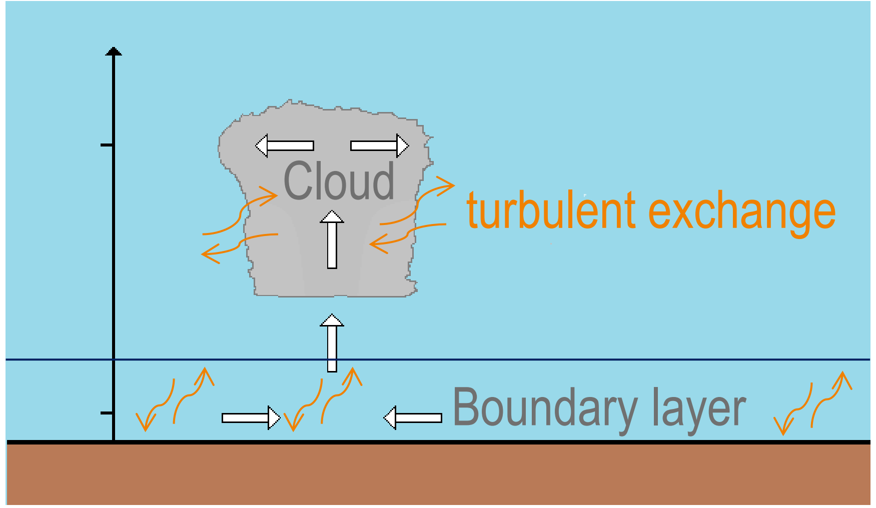
8 May 2020

Role of horizontal diffusion in cloud permitting models

- Many regional models include a microturbulent parameterization in which turbulent exchange is only parameterized in the boundary layer and directed in vertical direction.
- However, turbulent exchange also occurs in and near convective clouds and the turbulent fluxes have significant components in horizontal direction due to the shear of vertical wind. Often, artificial horizontal diffusion mimics this process in models.
- However, for a physically grounded simulation of convective clouds a 3D turbulence scheme must be adopted.



Model REMO-NH and experimental design

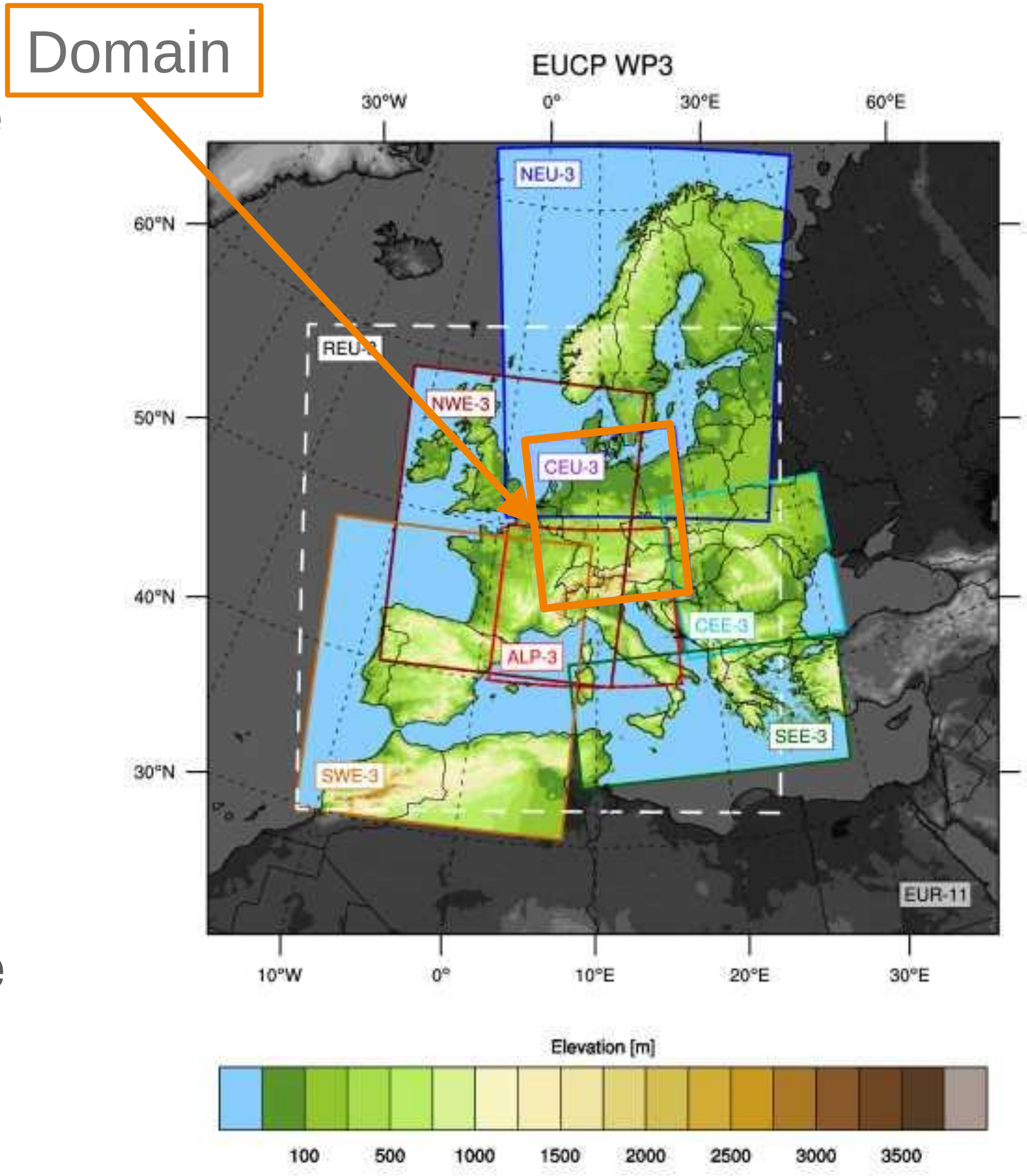
- We investigate the impact of horizontal diffusion with the non-hydrostatic regional climate model **REMO-NH** at convection permitting resolution (~3km).
- We performed **ERA-Interim** driven simulations with double nesting (intermediate resolution 0.11°) for the **Central European domain** and the **year 2006**.
- Three setups have been chosen

  - **DIFF2**: Standard setup used for the **EUCP evaluation run**. Horizontal diffusion is of 2nd order

  - **DIFF4**: As DIFF2 but with 4th order horizontal diffusion

  - **TURB3D**: Implementation of a 3D Smagorinsky- type turbulence scheme without artificial diffusion

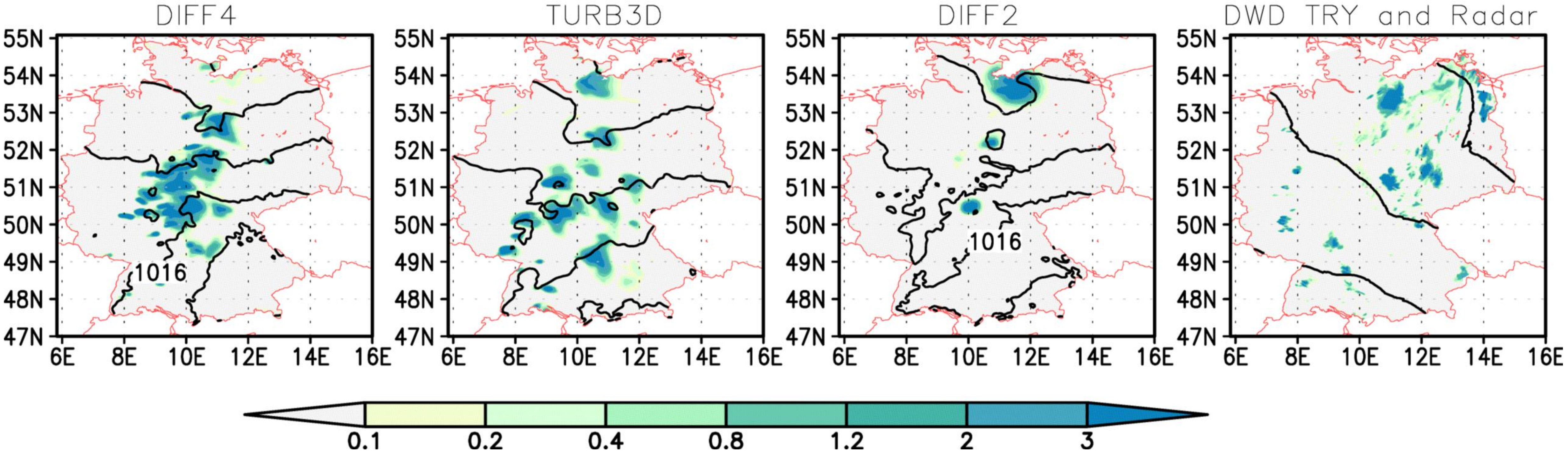
- Results are compared with **DWD TRY** and **DWD Radar** data.



Results

Snapshot (07.07.06, 21UTC) of **precipitation** (shadings, mm/h) and **MSLP** (contours, hPa)

Observations result from DWD TRY (MSLP) and DWD Radar (precipitation)

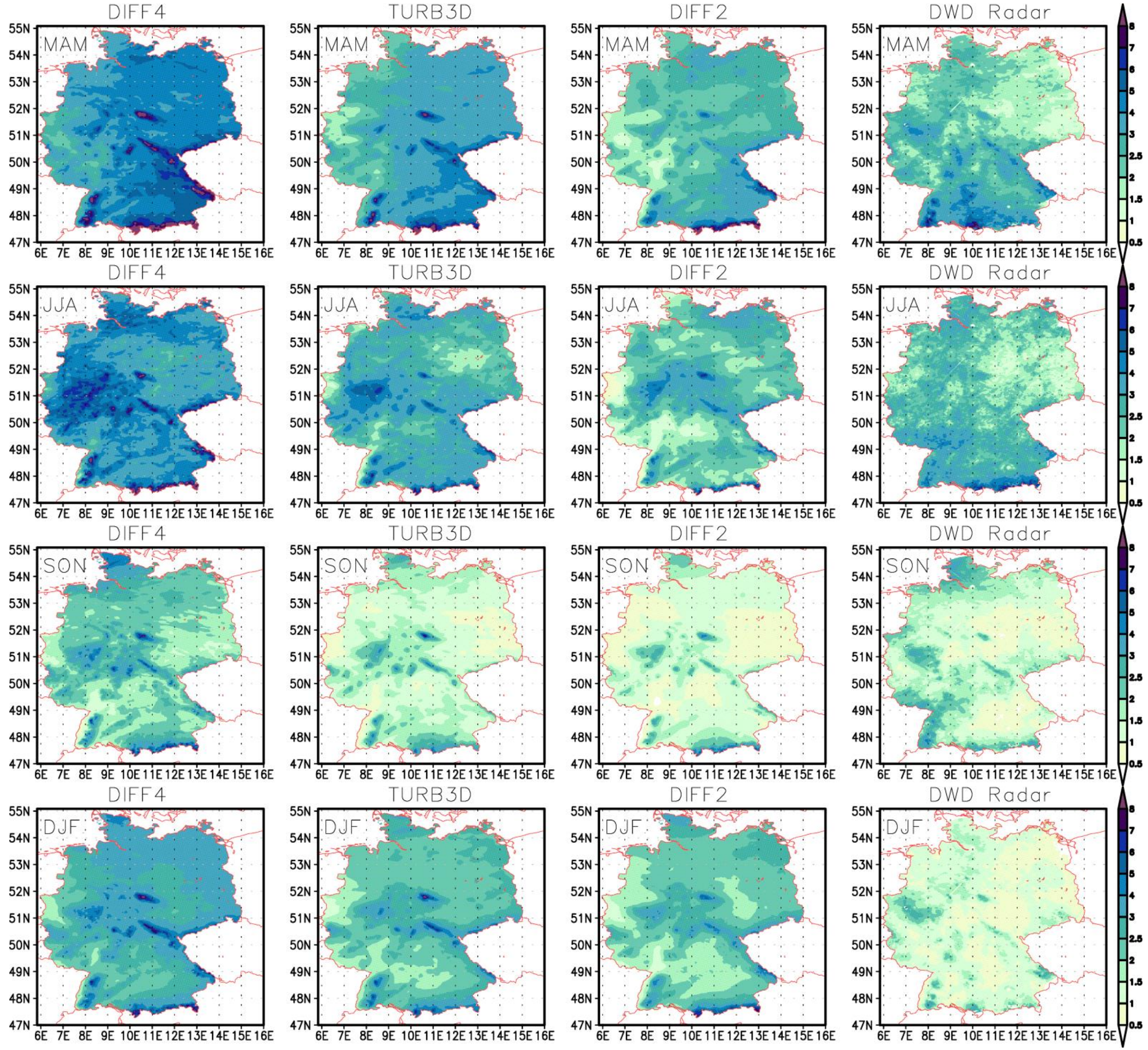


- Model fields do not coincide with observations because REMO-NH produces its own regional weather.
- DIFF2 has very smooth precipitation anomalies compared to radar. DIFF4 and TURB3D show more details.

Seasonal mean precipitation

Comparison with DWD Radar data:

- Spatial pattern and annual cycle show some agreement but differences are also evident.
- DIFF4 overestimates precipitation significantly.
- The best agreement is given by TURB3D but the precipitation is still too high in the winter season.



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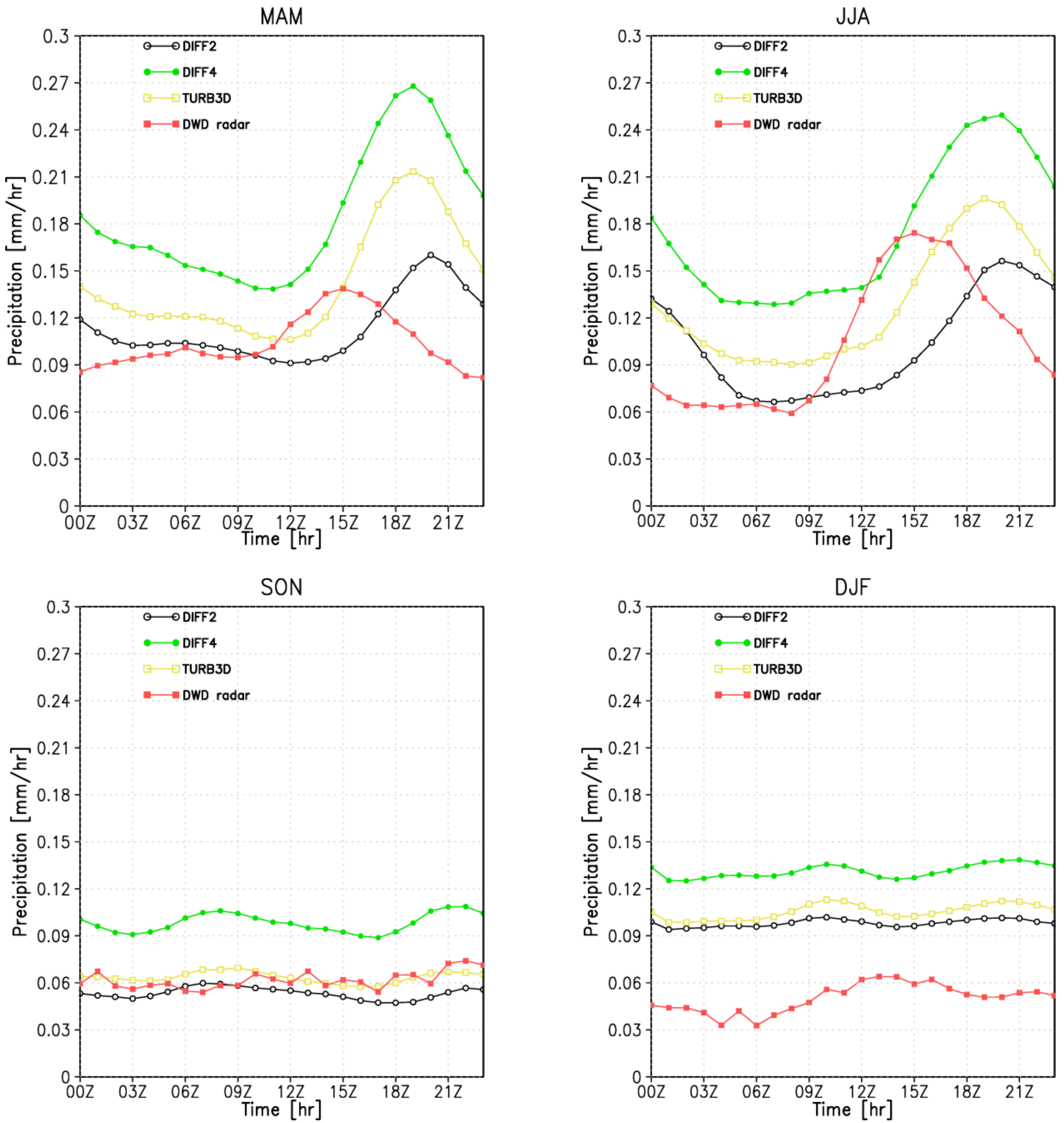
Diurnal cycle of precipitation

Comparison with DWD Radar data:

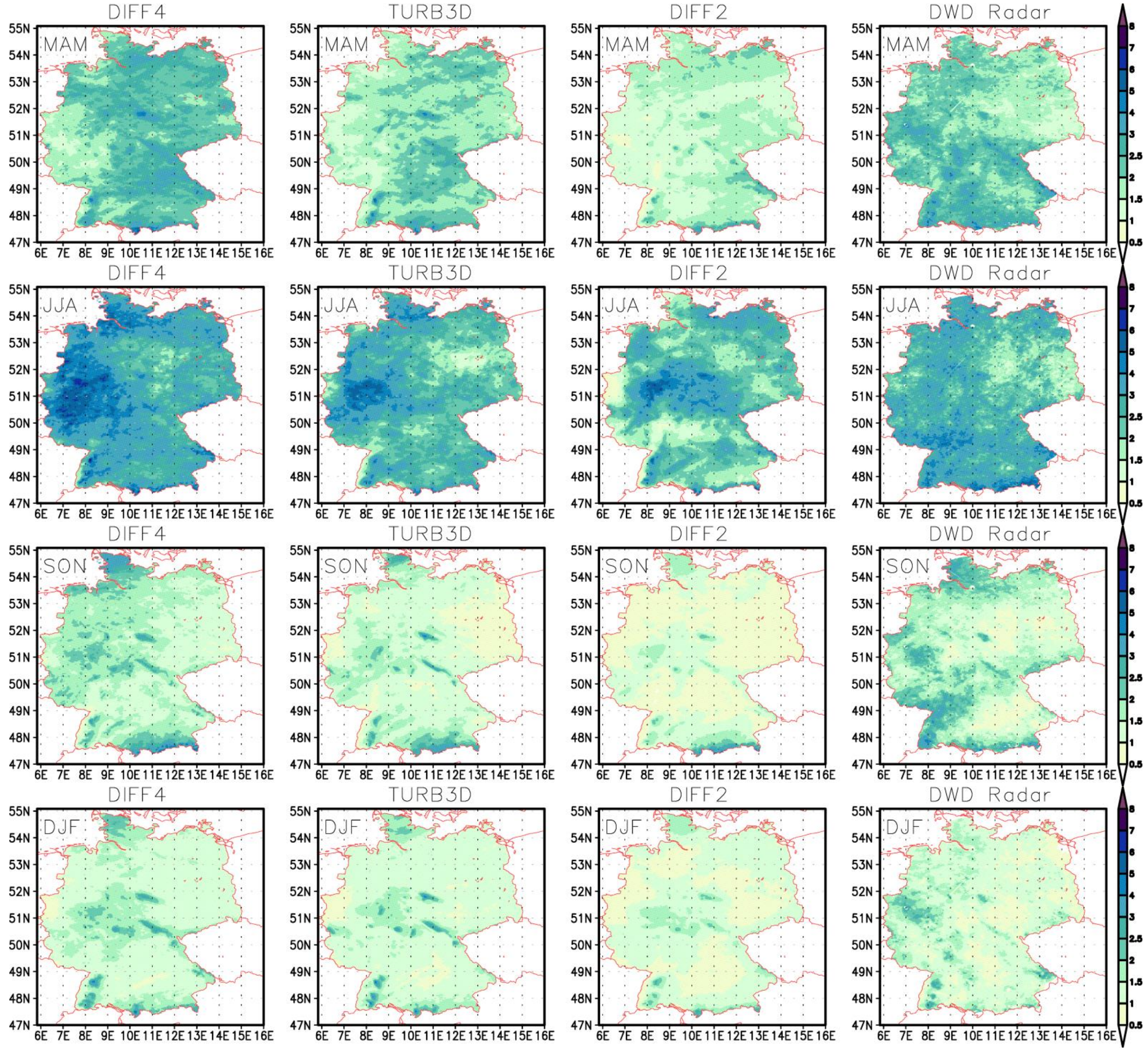
- In spring and summer the maximum of precipitation is delayed by several hours compared to DWD Radar.
- TURB3D yields intermediate results and has the best agreement with observations.
- In winter the already mentioned overestimation of precipitation is evident.



99th percentile of precipitation

Comparison with DWD Radar data:

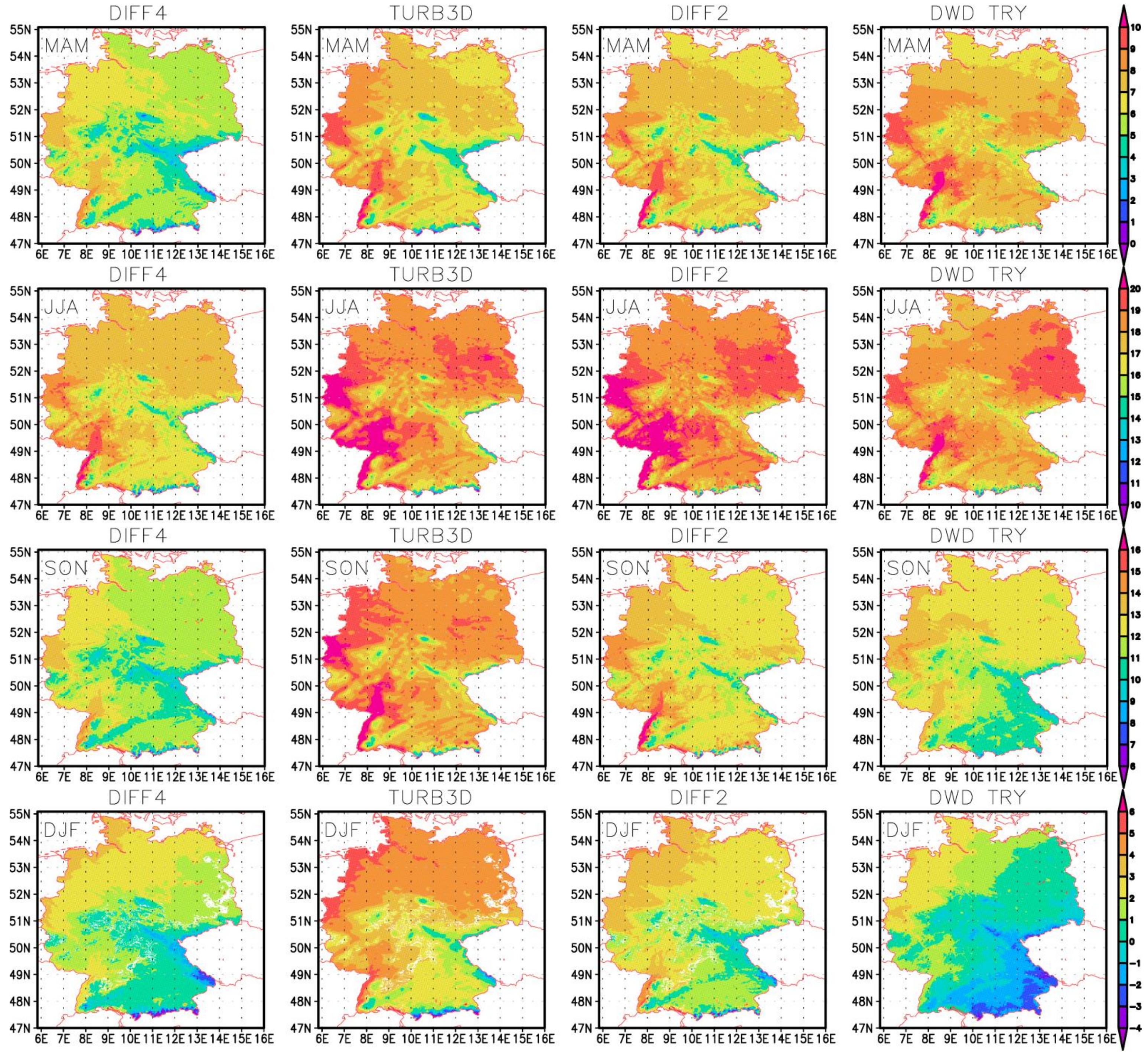
- Spatial pattern and annual cycle shows some agreement but differences are also evident.
- DIFF2 underestimates extreme precipitation.
- The best agreement is given by TURB3D.



Seasonal mean 2m temperature

Comparison with DWD TRY data:

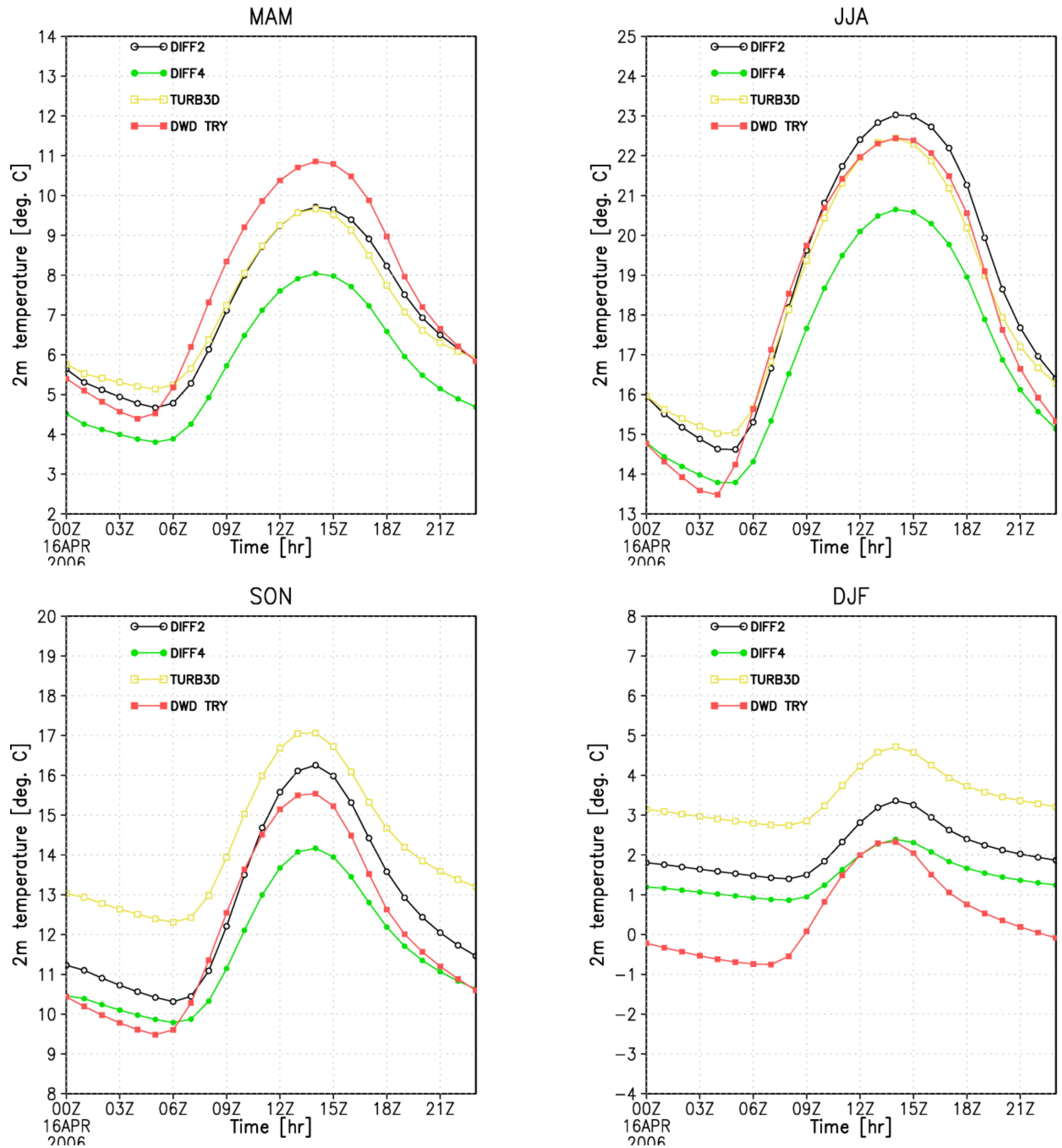
- Spatial pattern and annual cycle shows some agreement but differences are also evident.
- In spring and summer DIFF4 has a cold bias.
- TURB3D has a warm bias in autumn and winter.
- DIFF2 has the best agreement with observations.



Diurnal cycle of 2m temperature

Comparison with DWD TRY data:

- The timing in the diurnal cycle of the simulations is in agreement with observations.
- The previously mentioned warm and cold biases are also evident in this figure, i.e. DIFF4 has a cold bias in spring and summer and TURB3D a warm bias in autumn and winter.
- A good fit results for TURB3D in summer.



Summary

- Convection permitting 1 year simulations have been done with REMO-NH for different horizontal diffusion parameterization schemes.
- The kind of horizontal diffusion has a significant impact on precipitation and 2m temperature fields.
- DIFF2 yields large and smooth convection cells and, therefore, it underestimates extreme precipitation.
- On the other hand, DIFF4 overestimates mean precipitation.
- The maximum of the model diurnal cycle occurs too late in comparison with observations.
- TURB3D appears to be the best parameterization for precipitation although there is a wet bias in winter.
- On the other hand, TURB3D exhibits a warm bias in the 2m temperature field in autumn and winter.
- For 2m temperature, DIFF2 represents the best parameterization.

Conclusion

- The three used schemes depend on the magnitude of the exchange coefficient (in TURB3D there are much more physical parameters). Therefore, by varying this parameter one can achieve different results.
- Hence, it cannot be stated here that one of the schemes is superior or inferior regarding realistic convection permitting climate simulations.
- However, TURB3D is the scheme that is based on physical considerations while simple horizontal diffusion was introduced as a necessity to produce stable simulations with little numerical artefacts.
- Results were produced for only one year. Therefore, part of the disagreement between model and observations may disappear in longer term simulations which are more appropriate to climate time scales. This issue will be investigated in the future.

The presented research is supported by the European Union within the Horizon2020 project European Climate Prediction (EUCP), Project Number 776613.