The coupled Terrestrial Systems Modelling Platform (TSMP):

Evaluation of daily forecasts over a small convection-permitting model domain in Central Europe

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1. Introduction. TSMP

The Terrestrial System Modelling Platform (TSMP, https://www.terrsysmp.org) is an integrated regional Earth system model that simulates processes from the groundwater across the land surface to the top of the atmosphere on multiple spatio-temporal scales. TSMP consists of the COSMO atmospheric model, CLM surface scheme, and hydrologic model ParFlow, all coupled together through OASIS3-MCT (Fig. 1).

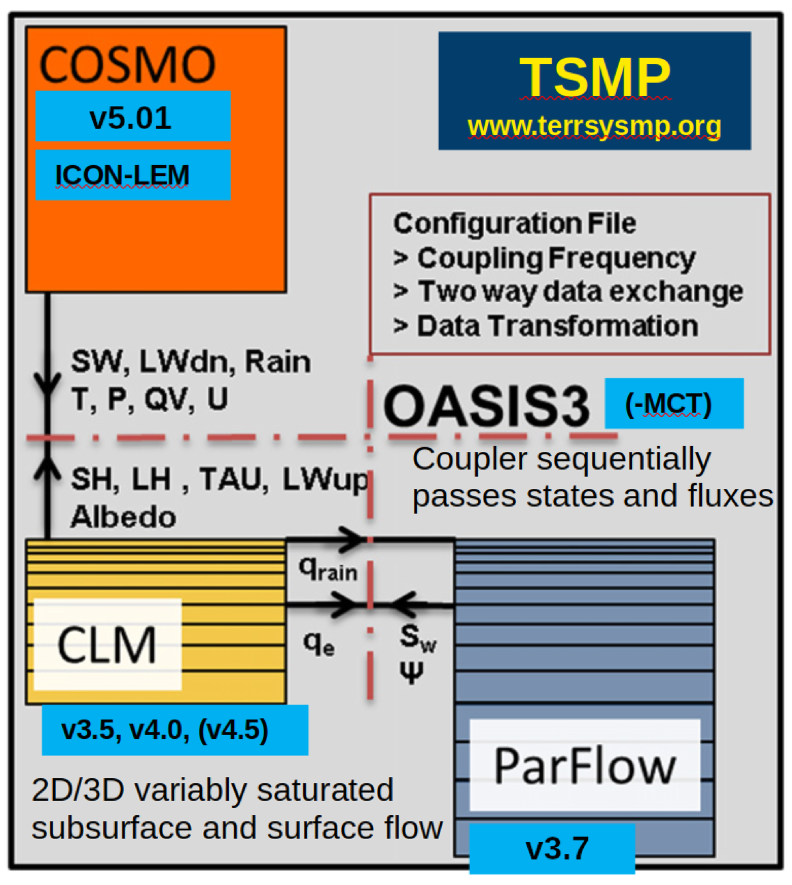

Figure 1: TSMP components

TSMP is used in various studies from climate change simulations to near-real time forecasting and monitoring. Here we present the results of the evaluation of the TSMP in a **monitoring** setup (**TSMP-M**). TSMP-M provides daily forecasts with a lead time of *10 days* of the atmospheric, land, and subsurface states and fluxes for a heterogeneous mid mountain-ranges area in Western Germany. The model domain covers an area of 150 km x 150 km at 1 km (atmosphere) and 0.5 km (land surface and subsurface) resolution.

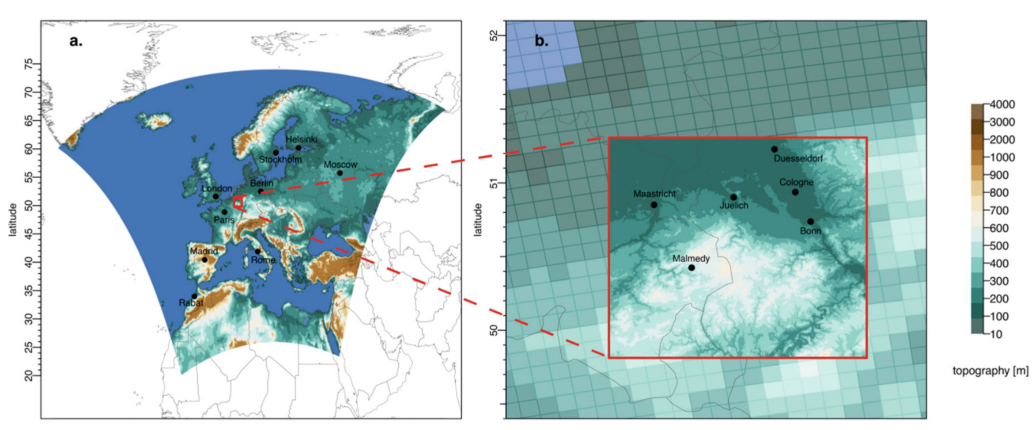

Figure 2: TSMP-M domains: EU-cordex (left) and NRW (right)

Computational requirements. TSMP-M is working on the JURECA-DC supercomputer at JSC: ≈4 h for EU-cordex and NRW domains, ≈77 Gb of data (NRW). This work is aimed on evaluation of TSMP-M performance in NRW domain working in a "Monitoring" mode, i.e. only the first day of each forecast participates in the validation process.

2. Observation data

To evaluate the TSMP-M setup, data from the *Eifel/ Lower Rhine valley observatory* was used (Fig. 3).

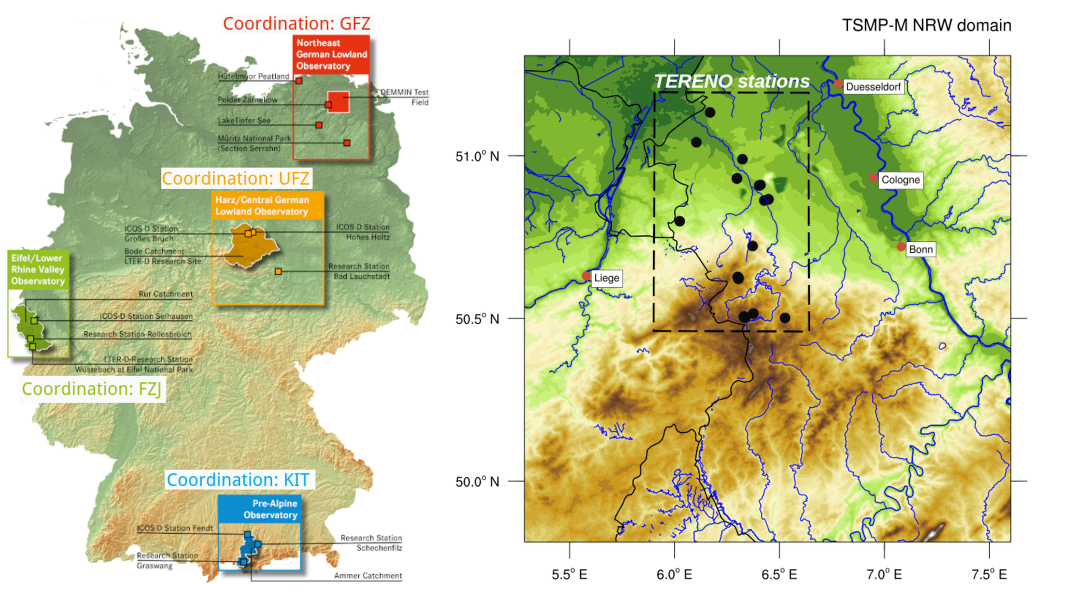

Figure 3: TERENO network (left); Chosen stations of the Eifel/Lower Rhine valley observatory on the NRW domain

Overall, 51 observational sites in the NRW domain area were used, data of which was preprocessed including careful gap-filling and remapping on 1-hour time scale. To match an observation value with some model grid box, a 9 grid points weighed average approach was used:

- a grid box with the best lat_i/lon_i pair regarding the station location (lat_0,lon_0) was determined;
- weights for 9 grid boxes around the chosen one was calculated using the following equation:

$$weight_i = \frac{1}{\sqrt{(lat_i - lat_0)^2 + (lon_i - lon_0)^2}} \quad (1)$$

After normalizing weights to one, model variable's value was calculated as:

$$Var = \sum_{i=1}^{9} weight_i \cdot Var_i$$

3. Results: air temperature, sensible heat flux, and specific humidity

2m Air temperature. Overall, TSMP-M 2 metres air temperature values are in a good agreement with the observations with correlation coefficient of 0.96 and root mean square error of $1.66°$C. Higher values ($> 25°$C), however, are slightly underestimated by the model (Fig. 4).

Air sensible heat flux. Sensible heat flux values show moderately higher biases but an average correlation coefficient of all stations in the comparison is 0.8. Linear regression lines built for each station, however, data comparison for Rollesbroich, Wuesterbach, and Merzenhausen stations demonstrate slopes of $1.39 - 1.59$, while Selhausen (SE_EC_001) station's data fits 1:1 line almost perfectly (1.01 slope). Mean bias for SE_EC_001 is $1.33 W/m^2$ and RMSE is $43.5 W/m^2$.

Specific humidity. The values of specific humidity calculated from observed absolute humidity. Model data correlates well (corr. coef. 0.93) with observations showing only a very small underestimation in high values.

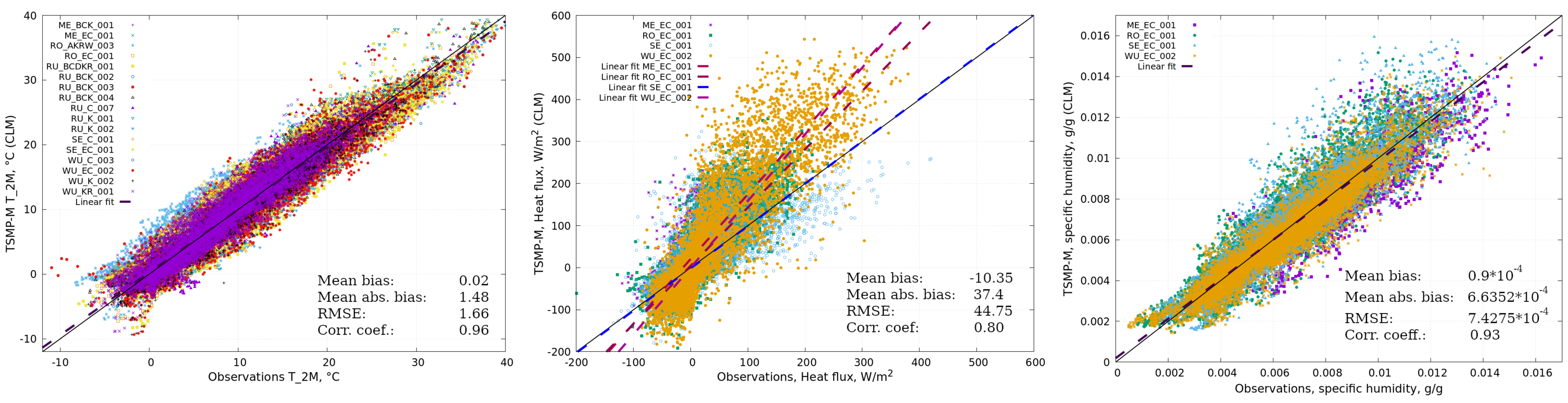

Figure 4: Scatter plots T_2M (left), Sensible heat flux (center), and specific humidity (right).

4. Results: precipitation

Precipitation in the TSMP-M belongs to the COSMO model and exists in a coarser spatial resolution of $1 \times 1\ km$. To compare model precipitation with the observations, we did not used the 9 grid points weighed average value, but picked the best fit value of the 9 grid cell area around the point where the station is found. Despite the coarser spatial resolution, it is difficult to match modelled values with observations on a hourly scale, so for a direct comparison daily sums were calculated (scatter plot in Fig. 5). Correlation coefficient varies from 0.32 to 0.67 with an average value of 0.54. Frequency distribution of hourly precipitation rate indicates that the model tends to overestimate the precipitation. Notably that high precipitation rates($> 15\ mm/h$) are captured well by the model. One of the possible reasons of such moderate correlation could be the fact that observation stations are located in a relatively small territory inside the model domain, thus, if the precipitation footprint is shifted in time or space, it could be missed in the target grid cells. This result can be improved by including more spatially distributed observation stations into the analysis.

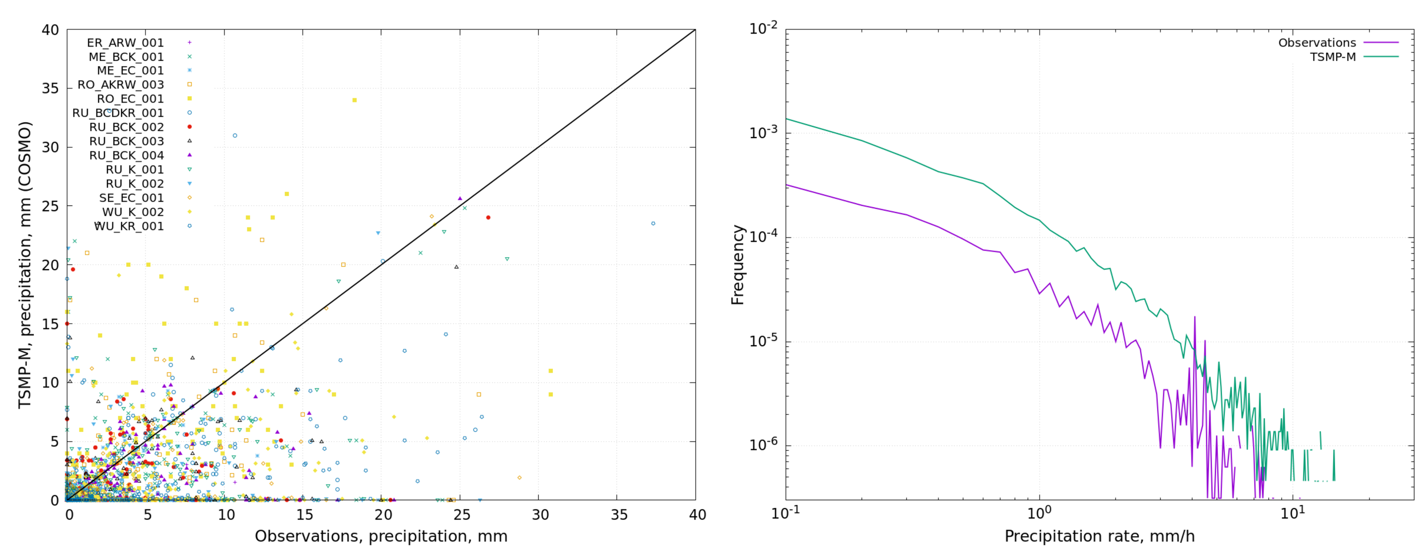

Figure 5: Daily accumulated precipitation scatter plot (left); frequency distribution of hourly precipitation rate (right)

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