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Convection-permitting WRF and TerrSysMP simulations for a European model domain – Implementation and initial results

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High-resolution regional atmospheric or fully coupled model runs at resolutions below 5 km can explicitly resolve e.g. convective processes and small-scale surface heterogeneities like land-use patterns, topography or coastlines. This has multiple effects on local wind systems, surface fluxes, flux partitioning, boundary layer evolution and land-atmosphere coupling as a whole, influencing convection and clouds and precipitation intensity and thereby also the hydrological cycle. Continent-wide model domains in this context offer the potential to investigate processes and their variances across multiple spatial scales and watersheds. Such model runs are however technically and computationally demanding. Here we primarily show the feasibility of such model runs for continental model domains and give an indication of a possible added value of these simulations.

The experiment design consists of two simulations with the Weather Research and Forecasting model (WRF) and the Terrestrial Systems Modelling Platform (TerrSysMP) that are run on a common grid for a 3 km European model domain (more than 2.3 Mio. grid elements) for two months January and July 2010. The model domain is inscribed into the official Coordinated Regional Downscaling Experiment (CORDEX) EUR-11 model grid (about 12 km).

The WRF model is used with the Noah LSM and a climate mode setup similar to runs performed for EURO-CORDEX. Its forcing is derived from these 3-hourly 50-level validation runs on the EUR-11 grid. The relatively new TerrSysMP has been developed in the Transregional Collaborative Research Centre 32. It is a fully coupled integrated model system where the NWP model COSMO, the LSM CLM and the variably saturated subsurface flow model ParFlow are externally coupled with the OASIS3 coupler. It allows for a complete simulation of the hydrologic cycle from the bedrock across the land surface into the atmosphere. TerrSysMP is driven by a high-resolution regional re-analysis based on the COSMO NWP model at about 6.2 km resolution, also nested into the EUR-11 domain from research groups of the Hans Ertel Centre for Weather Research (HErZ) branch on Climate Monitoring and Diagnostics of the German Weather Service (DWD).

We show initial results of January and July simulations with a focus on precipitation events and boundary layer processes. A comparison is done to radar rainfall estimates and flux measurements and in case of WRF also to coarser resolution simulations.

The models run on the massively parallel 28-rack 5.9 PFLOP IBM Blue Gene/Q system JUQUEEN of the Jülich Supercomputing Centre (JSC). A substantial effort in terms of application porting, tuning and optimisation is needed to efficiently operate geoscience codes on such highly scalable low-memory architectures. Only with large model domains and/or high spatial resolutions a good scaling behaviour seems achievable. TerrSysMP can meanwhile efficiently be run using the OASIS3-MCT coupler with over 32k processes.