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A HPC based hydro-meteorological model chain to assess impacts of climate change on extreme events – advances and challenges

Florian Willkofer (1), Martin Leduc (2), Jens Weismüller (3), Raul Wood (1), Fabian von Trentini (1), Josef Schmid (1), and Ralf Ludwig (1)

(1) Ludwig-Maximilians-Universität, Faculty of Geosciences, Department of Geography, Munich, Germany (florian.willkofer@lmu.de), (2) Ouranos, Montréal, Quebéc (P), Canada, (3) Leibniz Supercomputing Centre (LRZ), Garching, Germany

The ClimEx project (Climate change and hydrological extreme events – risks and perspectives for water management in Bavaria and Québec) studies the effects of climate change on hydro-meteorological extreme events and their implications for water management in Bavaria and Québec.
Extreme flood events occur on various spatio-temporal scales, ranging from hours to days and hillslopes to large river basins. Process-based analysis and integrated management of such events are computationally very demanding. In recent years, the scientific community has started to take advantage of High Performance Computing (HPC) to satisfy the ever increasing demand for process-based modeling and analyses of extreme events and provide support for their integrated management by river basin management. Meanwhile, the application of High Performance Computing (HPC) shows significant advantages for data processing along a hydro-meteorological model chain.
The project employs HPC capacity of LRZ's SuperMUC to dynamically downscale 50 members of the Global Circulation Model CanESM2 over an European and Eastern North American domain using the Canadian Regional Climate Model (RCM) CRCM5 (single-model large-ensemble – SMLE). Over Europe, this unique SMLE is conjointly analyzed with the latest information provided through the CORDEX-initiative, to better assess the influence of natural climate variability and climatic change in the dynamics of extreme events. The 50 members of the SMLE are utilized to enhance extreme value statistics (extreme return periods) by exploiting the available fiftyfold model years, e.g. 1500 model years representing the reference period from 1981 to 2010. The SMLE output is applied to drive the process based, fully distributed, and deterministic hydrological model WaSiM in high temporal (3h) and spatial (500m) resolution, covering 98 Bavarian river basins for approximately 100.000km^2.WaSiM also runs on the LRZ's SuperMUC using the Message Passing Interface (MPI) parallelization to meet the high computational demand. WaSiM and the SMLE are further used to derive the hydro-meteorological patterns leading to severe flood events. A tool for virtual perfect prediction shall provide a combination of optimal lead time and management strategy to mitigate certain flood events following these patterns. Therefore, the LRZ's Linux Cluster as well as the SuperMUC is used to cope with the large demand on computation time and storage.
The study presents recent advances and advantages (e.g. enhanced computation speed, storage and backup) as well as remaining challenges (e.g. handling of vast amount of data, parallelization) of HPC along the modelling chain.