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Towards Convection-Resolution Climate Modeling

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Currently comprehensive efforts are underway to refine the horizontal resolution of global and regional climate models to O(1 km), with the intent to represent convective clouds explicitly rather than using semi-empirical parameterizations. This refinement would move the governing equations closer to first principles and is expected to reduce the uncertainties of climate models. High resolution is particularly attractive in order to better represent critical cloud feedback processes (for instance related to tropical maritime clouds and global climate sensitivity, or to extratropical summer convection and the soil-moisture precipitation feedback). Similarly, it is hoped that the representation of extreme events (such as heavy precipitation events, floods, and hurricanes) can be improved.

The presentation will be illustrated using two sets of decade-long simulations at 2 km horizontal resolution, one covering the European continent on a mesh with 1536x1536x60 grid points, the other covering the Alpine region. To accomplish such simulations, use is made of emerging heterogeneous supercomputing architectures. We use a version of the COSMO limited-area weather and climate model that is able to run entirely on GPUs (rather than CPUs). It is shown that kilometer-scale resolution dramatically improves the simulation of precipitation in terms of the diurnal cycle and short-term extremes. Using the high-resolution methodology, we investigate the temperature-dependent scaling of daily and hourly precipitation extremes, and discuss prospects for the representation of climate feedback processes.

It is argued that already today, modern supercomputers would in principle enable global atmospheric convection-resolving climate simulations, provided appropriately refactored codes were available, and provided solutions were found to cope with the potentially huge output volume.