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High resolution climatology
- towards climate change services

Mesoscale impacts of effective horizontal resolution in a convection-permitting model

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Convection-permitting simulations using the COSMO mesoscale model at grid-spacings of O(1km) are conducted to study the impacts of both explicit computational diffusion and horizontal grid-spacing upon the large-scale flow, at which energy is not primarily attenuated by the numerical small-scale filter or truncation, e.g., the scales of the Alps. The modified large-scale flow properties are explored using spectral analysis and by computing physical and dynamical contributions to the bulk Alpine heat budget.

Our simulations reveal reductions of convective precipitation by up to 37 % in the case of strong explicit diffusion. Besides the filter's direct impact on cloud distribution, the Alpine-scale dynamical behavior is substantially modified, since the damped small-scale convective growth suppresses the convective overturning that takes place over the Alpine region. The bulk Alpine net heating is reduced due to less vertical heat transport within the PBL during daytime and the upper tropospheric bulk heating is reduced by up to 30 % in the late evening, mainly due to decreased latent heat release. The simulations indicate that in agreement with linear theory of convective growth, rapid convective amplification is governed by small-scale fluctuations of buoyancy and horizontal momentum components. Explicit diffusion applied to other prognostic variables, especially vertical velocity, exhibits insignificant impact at all scales. Interestingly, the small-scale perturbations originate from near-surface model levels, while explicit filtering above 1 km AGL has hardly any impact on the convective behavior.

The convergence of the simulations with respect to the mesoscale flow behavior is investigated with two sets of experiments that use increasing horizontal resolution. The two sets of simulations use different topographic representations (same spectral representation irrespective of resolution, and full representation truncated to grid-spacing, respectively). The second set of simulations is used also to study the realization of thermally driven mesoscale circulations.