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Diffusion impact on atmospheric moisture transport

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To ensure numerical stability, many global and regional climate models employ numerical diffusion to dampen short wavelength modes. Terrain following sigma diffusion is known to cause unphysical effects near the surface in orographically structured regions. They can be reduced by applying z-diffusion on geopotential height levels. We investigate the effect of the diffusion scheme on atmospheric moisture transport and precipitation formation at different resolutions in the European region. With respect to a better understanding of diffusion in current and future grid-space global models, current day regional models may serve as the appropriate tool for studies of the impact of diffusion schemes: Results can easily be constrained to a small test region and checked against reliable observations, which often are unavailable on a global scale. Special attention is drawn to the Alps - a region of strong topographic gradients and good observational coverage. Our study is further motivated by the appearance of the "summer drying problem" in South Eastern Europe. This too warm and too dry simulation of climate is common to many regional climate models and also to some global climate models, and remains a permanent unsolved problem in the community. We perform a systematic comparison of the two diffusion-schemes with respect to the hydrological cycle. In particular, we investigate how local meteorological quantities - such as the atmospheric moisture in the region east of the Alps - depend on the spatial model resolution. Higher model resolution would lead to a more accurate representation of the topography and entail larger gradients in the Alps. This could lead to consecutively stronger transport of moisture along the slopes in the case of sigma-diffusion with subsequent orographic precipitation, whereas the effect could be qualitatively different in the case of z-diffusion.

For our study, we analyse a sequence of simulations of the regional climate model REMO employing the different diffusion methods over Europe. For these simulations, REMO was forced at the lateral boundaries with ERA40 reanalysis data for a five year period. For our higher resolution simulations we employ the double nesting technique.