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Exploring the impact of the vertical grid spacing for the climate simulated in a global storm-resolving model

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In recent years, great efforts have been made to reduce the horizontal grid spacing of atmospheric models to a few kilometers to build so-called Global Storm-Resolving Models (GSRMs). However, the vertical grid spacings used in these models are generally of the same order of magnitude as those used in classical climate models with horizontal grid spacings of a few hundred kilometers. From previous sensitivity experiments with a variety of model types, from direct numerical simulations to these classical climate models, it is known that especially the simulation of clouds can strongly depend on the vertical model resolution. To test the importance of the vertical grid spacing in GSRMs we have performed simulations with the ICON atmospheric model at 5 km horizontal grid spacing and with between 55 and 540 vertical layers, corresponding to maximum tropospheric vertical grid spacings between 800 and 50 m.

Here we present results of these simulations. They results show that for most of the variables considered, halving the vertical grid spacing by half has a less pronounced impact than halving the horizontal grid spacing, but the effect is not negligible. For example, for each halving of the vertical grid spacing, coupled with necessary reductions in the time step length, cloud liquid water increases globally by approximately 7%, while it decreases by roughly 16% when halving the horizontal grid spacing. Both the grid spacing and the time step contribute to these effects. Comparison of selected climate variables with observations shows that model biases are only in some cases reduced by higher vertical resolution, because of the dominance of model biases with other origins.