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Large eddy simulation of a cold air outbreak during ARTIST98: stationary versus non-stationary model domain

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We simulated a cold air outbreak (CAO) as examined within the ARTIST98 campaign. The stationary model domain was large enough to capture the evolution of the large scale organized convection ($400 \times 64 \times 5\,\mathrm{km}^3$), while the small scale unorganized turbulence was explicitly resolved (grid sizes: 25 m vertically, 50 m horizontally) resulting in 1.3×10^9 grid points. To save computing time so far most LES studies of cold air outbreaks used cyclic lateral boundary conditions. Since the model domain is there moving in mean wind direction the model domain can be much smaller in contrast to simulations with stationary model domain. As mentioned in *Gryschka and Raasch* (Geophys. Res. Let., 32, 2005) cyclic boundary conditions prevent thermal wind effects as well as the increase of the wavelength of cloud streets between the two lateral boundaries in flow direction. Since the temperature field in CAOs is strongly inhomogeneous in flow direction, we expect thermal wind effects and as a result modified vertical wind shear especially at the entrainment zone. Therefore we carried out a corresponding non-stationary simulation.

During the simulation convective rolls are formed, with the same characteristics as observed in nature during CAOs, such as significant increasing aspect ratios with increasing distance from the ice edge. Along with the organized convection cloud streets appear in the simulated cloud field, which looks very similar to high resolved satellite pictures of cloud streets. In contrast to simulations with coarser resolution where the cloud streets looks laminar, their appearance is clearly turbulent in this study. The cloud streets are formed by a sequence of small singular cloud cells. Furthermore we investigate the transition from rolls to cells.