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The effect of leads in the sea-ice on the Antarctic boundary layer: a high-resolution study using a parallelized LES model with turbulent inflow

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The energy exchange between ocean and atmosphere in the Arctic and Antarctic marginal sea-ice zone is strongly influenced by the extent of sea-ice cover. While ice sheets have an isolating effect, areas with open water or thin new ice generate strong convection and turbulence due to the large temperature difference between air and water, especially in winter. This implies large vertical heat fluxes which significantly modify the structure of the polar atmospheric boundary layer. Open water areas in the sea-ice zone are called leads and polynyas respectively. In contrast to the lake-like polynyas, leads resemble channels in the sea-ice and have a width of several meters up to several kilometers. As they are observed during the whole year in the entire sea-ice zone, leads have a significant effect on the polar climate which is still insufficiently considered in weather and climate models.

To gain a better understanding of the still not well understood effects of leads on the boundary layer turbulence and to clarify their importance for the energy budget and structure of the ABL, high-resolution large-eddy simulations are performed with the parallelized LES model PALM. The results will later be used to (further) develop parameterizations of the lead effect which can be used in non-eddy resolving models with different grid sizes.

Presented are the results of a sensitivity study in which the resolution was gradually decreased from 50 to 500 grid points per lead width. It is shown that with a resolution of 200 or more grid points per lead width it is now possible to resolve turbulence not only behind but also directly above most parts of the lead where the convective boundary layer is very shallow. Furthermore, a turbulent inflow was realized, ensuring that the flow is already turbulent when approaching the upstream edge of the lead. Thus, convection starts at a much closer distance downstream of the upstream edge compared to simulations with laminar inflow. This allows for a more realistic estimation of the lead effect.