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Polynya dynamics and associated atmospheric forcing at the Ronne Ice Shelf

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The Ronne Ice Shelf is known as one of the most active regions of polynya developments around the Antarctic continent. Low temperatures are prevailing throughout the whole year, particularly in winter. It is generally recognized that polynya formations are primarily forced by offshore winds and secondarily by ocean currents. Many authors have addressed this issue previously at the Ross Ice Shelf and Adélie Coast and connected polynya dynamics to strong katabatic surge events. Such investigations of atmospheric dynamics and simultaneous polynya occurrence are still severely underrepresented for the southwestern part of the Weddell Sea and especially for the Ronne Ice Shelf. Due to the very flat terrain gradients of the ice shelf katabatic winds are of minor importance in that area. Other atmospheric processes must therefore play a crucial role for polynya developments at the Ronne Ice Shelf.

High-resolution simulations have been carried out for the Weddell Sea region using the non-hydrostatic NWP model COSMO from the German Meteorological Service (DWD). For the austral autumn and winter (March to August) 2008 daily forecast simulations were conducted with the consideration of daily sea-ice coverage deduced from the passive microwave system AMSR-E. These simulations are used to analyze the synoptic and mesoscale atmospheric dynamics of the Weddell Sea region and find linkages to polynya occurrence at the Ronne Ice Shelf. For that reason, the relation between the surface wind speed, the synoptic pressure gradient in the free atmosphere and polynya area is investigated.

Seven significant polynya events are identified for the simulation period, three in the autumn and four in the winter season. It can be shown that in almost all cases synoptic cyclones are the primary polynya forcing systems. In most cases the timely interaction of several passing cyclones in the northern and central Weddell Sea leads to maintenance of a strong synoptic pressure gradient above the Ronne Ice Shelf. This strong synoptic forcing results in a moderate to strong offshore surface wind. It turned out that these synoptic depressions lead to strong barrier winds above the northwestern Ronne Ice Shelf and along the eastern flank of the Antarctic Peninsula. The fact, that these barrier winds often appear prior or during the initial break up of sea ice at the shelf ice edge, suggest that this mesoscale wind phenomenon plays a crucial role for polynya development. Furthermore, even mesoscale cyclogenesis above the Ronne Ice Shelf and the following northeastward passage of such a system can break up sea-ice cover under large-scale stationary weather conditions.