A non-hydrostatic three-dimensional meso-scale numerical model and a two-class sea ice model have been used for idealized numerical simulations with the goal to get insight into the development of coastal polynyas driven by the katabatic wind and associated forcing and feedback processes. The simulations are performed for idealized orography structures and the realistic orography of East Greenland. Sensitivity studies with respect to synoptic forcing, sea ice coverage and polynya width are carried out using the uncoupled version of the model. The thermal forcing associated with reduced sea ice coverage and the synoptic forcing by the superimposed geostrophic wind are more important for the intensity of the katabatic LLJ than the orography structure. For a moderate cold summertime situation, the air-sea interaction is also moderate, but for a typical wintertime situation a strong feedback between the katabatic windsystem and turbulent fluxes over the coastal sea ice is present. A coastal polynya acts also in the sense of intensifying the katabatic wind, but develops a secondary circulation opposed to the katabatic wind, which prohibits the katabatic wind to extend over the sea ice.

Studies with the coupled atmospheric/sea ice model for the Angmassalik region of Greenland show that synoptically forced katabatic winds can result in a fast formation of a coastal polynya within 24 h. Sea ice advection is the main process during the first 12 h, but the production of frazil ice and the subsequent conversion to consolidated ice becomes important at later stages. Simulations for a scenario of an eastward moving cyclone being typical for piteraq events in the Angmassalik area reproduce the main features known from observational and realistic modeling studies, such as the development of the lee trough, its interaction with the katabatic wind and a development of a low-level mesoscale cyclone in the bay-like area southwest of Angmassalik. The simulations of the present studies were performed for the Greenland area, but because of their idealized setup the results are also applicable for the conditions of the Antarctic.