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Aircraft remote sensing of the surface roughness of sea ice

Mai, S., Hartmann, J., Wamser, C., Augstein, E., Kottmeier, C.

Alfred Wegener Institute for Polar and Marine Research, Bremerhaven, Germany

Ocean and sea ice models require a specification of the drag coefficients, which relate the turbulent fluxes of heat and momentum to atmospheric wind and temperature. The drag coefficients of sea ice depend on the structure of the surface and on atmospheric conditions. Observational programs with aircraft and boundary layer modeling work have been performed to obtain new parameterizations of the drag coefficients for wide ranges of sea ice conditions and atmospheric stabilities.

The geometric surface roughness and the size distribution of sea ice floes have been investigated by airborne laser altimetry and camera surveys in the marginal ice zone of the Greenland sea. Downward looking scanning cameras in the visible and thermal infrared and a laser altimeter have been used. The 50 flight legs at a height of 30 m covered an area of about 90 km^2. The total length of the flight track has been 1500 km. The measurements have been analysed to derive the heights of freeboards and pressure ridges as well as the floe sizes and ridge spacings. Freeboard heights range from 0.2 m close to the ice edge up to 0.6m deep in the pack-ice, where multiyear ice floes prevail. The mean ridge height of 0.8 m is independent of the location in the marginal ice zone. Frequency distributions of ice ridge heights and separations are in good agreement with previous results from the Arctic and Antarctic. Statistics of the sea-ice surface geometry have been used to evaluate the aerodynamic roughness of the pack-ice which is a combination of form and skin drag.

Direct measurements of the turbulent fluxes of momentum, sensible and latent heat have been simultaneously performed and allow a direct determination of the aerodynamic roughness. Both experimental and model results clearly reveal a dependency of the drag coefficient on the geometric surface roughness of sea-ice. The stability corrected drag coefficient at a height of 10 m increases from $1.1 \cdot 10^{-3}$ to $2.4 \cdot 10^{-3}$ as the product $h \cdot r$ of freeboard height h and mean floe radius r increases from 0 to 0.03. The drag coefficient decreases to $1.5 \cdot 10^{-3}$ for 100 per cent ice concentration, where the ridge-statistics instead of the freeboard-statistics become relevant.