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Interaction of Arctic sea ice, air moisture, and clouds

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Air moisture and clouds strongly affect the surface energy balance of sea ice. Radiative fluxes under clear skies are affected by air moisture, and much larger effects are met when clouds are present: in winter the downward longwave radiation at the snow/ice surface is increased by up to 100 Wm-2. Precipitation and evaporation affect the mass balance of snow cover on sea ice and the freshwater budget of the ocean, and evaporation is controlled by the sea ice concentration. The amount of air moisture, clouds, and precipitation in the Arctic strongly depends on the moisture transport from lower latitudes, which is mostly carried by cyclones. Relationships between the sea ice concentration, cloud cover, and air moisture in the Arctic are analysed for the period of 1989-2010 on the basis of the ERA-Interim reanalysis of the ECMWF. The reanalysis shows a significant increasing trend for the annual mean total water vapour (TWV) averaged over the polar cap north of 70∞N, while for the cloud water content (CWC) the increasing trend is not statistically significant. Seasonally, the increasing trends for TWV are significant for summer (July - September) and autumn (October - December), and for CWC in autumn. The TWV correlates with sea ice concentration in every season, and CWC correlates with sea ice concentration in every season except summer. In summer, CWC does not depend on sea ice cover because of thermal decoupling, but the CWC correlates with the Arctic Oscillation index. The ERA-Interim-based results are qualitatively in agreement with satellite observations and in-situ data on the atmospheric transmissivity for shortwave radiation. To find out the causal relationships, the time lags between anomalies in the air moisture, cloud cover, and sea ice concentration are analysed. The inter-annual variations and decadal trends in the meridional moisture transport from lower latitudes are also analysed. Analyses on the interaction of sea ice, air moisture and clouds in the Antarctic are presented for comparison. Although the same physical processes act in the Arctic and Antarctic, the boundary conditions (latitude of the sea ice zone, meridional advection of air moisture, and geographic constrains for sea ice motion) generate large differences in the relationships between the sea ice concentration, air moisture, and clouds.