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- towards climate change services

Meteorological factors controlling year-to-year variations in the spring onset of snow melt over the Arctic sea ice

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The spring onset of snow melt on the Arctic sea ice shows large inter-annual variability. Surface melt triggers positive feedback mechanisms between the albedo, snow properties and thickness, as well as sea ice thickness. Hence, it is important to quantify the factors contributing to inter-annual variability of the melt onset (MO) in various parts of the Arctic Ocean. Meteorological factors controlling surface heat budget and surface melting/freezing are the shortwave and longwave radiative fluxes and the turbulent fluxes of sensible and latent heat. These fluxes depend on the weather conditions, including the radiative impact of clouds, heat advection and wind speed.
We make use of SSM/I-based MO time series (Markus, Miller and Stroeve) and the ECMWF ERA Interim reanalysis on the meteorological conditions and surface fluxes, both data sets spanning the period 1989-2008 and covering recent years with a rapid sea ice decline. The advantage is that SSM/I-based MO time series are independent of the ERA-Interim data. Our objective is to investigate if there exists a physically consistent and statistically significant relationship between MO timing and corresponding meteorological conditions.
Results based on the regression analysis between the MO timing and seasonal anomalies of surface longwave radiative fluxes reveal strong relationships. Synoptic scale (3-14 days) anomalies in downward longwave radiation are essential in the Western Arctic. Regarding the longer history (20-60 days) the distinct contribution from the downward longwave radiative fluxes is captured within the whole study region. Positive anomalies in the downward longwave radiation dominate over the simultaneous negative anomalies in the downward shortwave radiation. The anomalies in downward radiative fluxes are consistent with the total column water vapor, sea level pressure and 10-m wind direction. Sensible and latent heat fluxes affect surface melt timing in the Beaufort Sea and in the Atlantic sector of the Arctic Basin. Stronger winds strengthen the relationship between the turbulent fluxes and the MO timing.
The turbulent surface fluxes in spring are relatively weak, of the order of 1-10W/m2, compared to the downward shortwave and longwave radiative fluxes, which are of the order of 100-150W/m2. As soon as data uncertainties are comparable to the anomaly in turbulent fluxes, statistical relationships found between MO timing and preceding anomaly in turbulent fluxes do not necessarily prove their reasonal-causal relationship.
This joint study of SSM/I-based MO record and the ERA-Interim meteorological fields region-wide with a focus on the seasonal transition demonstrates their consistency in time and space. Such result could be regarded as an important indicator that both data sets have the appropriate performance of the surface state in the Arctic Ocean. Nevertheless, an important additional effort is needed for to resolve better the cloud radiative and boundary layer turbulent processes over the sea ice.