Arctic Atmospheric Rivers: Triggers for Linking Atmospheric Synoptic Transport, Cloud Phase, Surface Energy Fluxes, and Sea-ice Growth

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Observations from the Surface Heat Budget of the Arctic Ocean (SHEBA) project in the Beaufort Sea are used to describe a sequence of events linking midwinter long-range advection of atmospheric heat and moisture into the Arctic Basin, formation of supercooled liquid water clouds, enhancement of net surface energy fluxes through increased downwelling longwave radiation, and reduction in near-surface conductive heat flux loss due to a warming of the surface, thereby leading to a reduction in sea-ice bottom growth. The first part of this sequence of events, i.e., the midwinter long-range advection of heat and moisture, is an Atmospheric River (AR) at times traversing the North Pole from the European side of the Arctic before impacting sea ice just north of Alaska. While the moisture content of these Arctic ARs is much less than their midlatitude and subtropical counterparts, their impacts on the surface are nevertheless dramatic, though not for producing precipitation but rather for modulating the surface radiative environment.

The presentation will summarize studies examining long-range heat and moisture transport to the Arctic (e.g., Doyle et al. 2011; Woods et al. 2013). It will then describe analyses of two events presented by Persson et al. (2016) during Jan 1-12, 1998, one entering the Arctic through Fram Strait and the other from northeast Siberia; winter statistics extend the results. Both deep, precipitating frontal clouds and post-frontal stratocumulus clouds impact the surface radiation and energy budget. Cloud liquid water, occurring preferentially in stratocumulus clouds extending into the base of the inversion, provides the strongest impact on surface radiation and hence modulates the surface forcing, as found previously. The observations suggest a minimum water vapor threshold, likely case dependent, for producing liquid water clouds. Through responses to the radiative forcing and surface warming, this cloud liquid water also modulates the turbulent and conductive heat fluxes, and produces a thermal wave penetrating into the sea ice. About 20% of the observed variations of bottom ice growth can be directly linked to variations in surface conductive heat flux, with retarded ice growth occurring several days after these moisture plumes reduce the surface conductive heat flux. This sequence of events modulate pack-ice wintertime environmental conditions and total ice growth, and has implications for the annual sea-ice evolution. If time permits, key aspects of efforts for modeling these January 1998 events will be described.

References:

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