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Arctic mixed-phase summer clouds: Lessons from ASCOS

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As part of the 2007-2009 International Polar Year, the 2008 Arctic Summer Cloud and Ocean Study (ASCOS) experiment gathered detailed observations of the autumn central Arctic troposphere, boundary layer and surface energy budget, with an emphasis on how mixed-phase clouds impact the system. This presentation provides an overview of results from ASCOS examining the interactions between thermodynamics, boundary layer structure and dynamic motions generated within mixed-phase clouds.

Over the Arctic Ocean, mixed-phase clouds in the lower troposphere occur frequently. These clouds exert the largest, most critical component on the surface energy budget via interactions with radiative fluxes. The surface cloud-radiative effect has the potential to control the sign and magnitude of the surface energy residual (positive – melting, or negative - freezing) and the boundary layer stability.

Despite a common near-neutrally stratified boundary layer up to below $\sim$ 500 m, mixed-phase clouds were most frequently found to be decoupled from the surface. Cloud-generated vertical motions produced via radiative divergence near cloud top produce mixing across the cloud layer and into the sub-cloud layer. The extent at which these motions couple with the surface mixed-layer correlates positively with liquid water path, cloud base height and cloud thickness; all of these factors affect the strength of vertical motions produced by the cloud layer.

Persistence of the cloud is attributed to moisture inversions co-located with temperature inversions, often characterizing the upper third of the cloud layers. In-cloud vertical velocity characteristics derived from cloud radar shows a unique vertical structure that corresponds with the thermodynamic structure within the cloud. Despite cloud penetration within the stable, yet moist, temperature inversion, we show that peak cloud-generated vertical velocity overturning time scales are surprisingly similar and coherent across three levels within cloud; additionally velocity overturning time scales are similar regardless of coupling between the cloud-surface system. These findings help to better understand the resilience of Arctic mixed-phase clouds.