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Surface Energy Fluxes During Arctic Freeze-Up

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This presentation will use atmospheric and ocean mixed-layer observations from three cruises during the past two years to examine the magnitude and variability of the air-ocean energy fluxes, the sources of the variability, the impact of the fluxes on the ocean mixed-layer thermal structure, and how these surface energy fluxes impact the initial ice formation. The measurements were made during the ACSE, Mirai, and Sea State field programs, the first two obtaining measurements near the ice edge in the Laptev and Chukchi Seas in September 2014 and the last along the advancing ice edge in the Beaufort/Chukchi Sea in October 2015. These time periods include the onset of continuous ocean heat loss, the initial episodic ice formation, and the core period for southward advance of the ice. Frequent atmospheric soundings and continuous remote-sensor measurements provide the vertical kinematic and thermodynamic structure in the lower troposphere. Broadband radiometers, turbulent flux sensors, surface temperature sensors, surface characterization instruments, and basic meteorological instrumentation provide continuous measurements of all surface energy flux terms (shortwave/longwave radiation, sensible/latent turbulent heat fluxes), allowing the quantification of the total energy exchange between the ocean and the atmosphere. Furthermore, each cruise provided continuous measurements of the upper-ocean temperature and salinity and frequent CTD measurements of the ocean temperature and salinity profiles, providing estimates of upper-ocean energy evolution. Various methods for characterizing the ocean surface (open ocean, ice cover, ice thickness, wave state, etc.) allow linking energy changes with changes in ocean surface conditions.

Analyses of the September and October conditions show persistent ocean heat loss after Sep. 15 because of the reduction of downwelling shortwave radiation and strong impacts of off-ice airflow on turbulent heat fluxes and downwelling longwave radiation. Atmospheric cooling in the lowest 300-500 m over adjacent ice and subsequent cold-air advection was crucial to rapid ocean heat loss. Freeze-up and formation of pancake ice was associated with thermal changes primarily in the upper few meters of the ocean, though sub-surface ocean heat was at times brought to the surface to retard ice growth, likely through the effects of waves. Observations from all three cruises demonstrate the importance of both the atmospheric and oceanic boundary layers, and the air-ocean-ice interactions at their interfaces for the autumnal evolution of the sea ice.