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Arctic Autumn Air-Ice-Ocean Interactions Resulting from Recent Sea-ice Decline

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The recent decline in Arctic sea-ice extent has produced large areas of open water in September that were previously ice covered. Autumn air-ice-ocean interactions in these regions are now characterized by ice-edge or marginal ice zone (MIZ) processes rather than by primarily air-ice refreezing processes. This study will utilize field program measurements to illustrate this change in processes, provide examples of new processes, and to quantify changes in energy fluxes resulting from some of the key processes. Observations from SHEBA (1998) and near the North Pole during ASCOS (2008) are used to illustrate freeze-up over existing sea ice ("old Arctic" processes) while observations from ACSE (2014), Mirai (2014), and Sea State (2015), supplemented with mesoscale model output, are used to illustrate "new Arctic" processes. In the "old Arctic", energy budgets show that freeze-up over remaining end-of-season sea ice occurred in late August, primarily because of the high albedo of the ice enhanced by snowfall events. In the "new Arctic" with extensive open water, summertime upper-ocean heating, formation of atmospheric ice-edge fronts, atmospheric thermal circulations, formation of thin new ice, ocean waves, and upper-ocean mixing all play a role in the autumn freeze-up process. These new processes also significantly impact the temporal extent and magnitude of the ocean heat loss to the atmosphere during this critical season from September to November, and possibly beyond. The magnitude of this heat loss plays an important role in various hypotheses regarding the impact of Arctic sea-ice loss on mid-latitude atmospheric circulations. While these hypotheses will not be discussed, the observations directly provide estimates of heat loss magnitudes in the "old Arctic" and the "new Arctic", thereby quantifying changes in heat loss, which can then be used to assess the accuracy of the various models and reanalyses.