Clouds and radiation processes in regional climate models evaluated using observations over the ice-free Arctic Ocean

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The presence of clouds in the Arctic regulates the surface energy budget (SEB) over the sea-ice surface and the ice-free ocean. Following several previous field campaigns, the cloud-radiation relationship, including cloud vertical structure and phase, has been elucidated; however, modeling of this relationship has matured slowly. In recognition of the recent decline in the Arctic sea-ice extent, representation of the cloud system in numerical models should consider the effects of areas covered by sea ice and ice-free areas. Using an in situ stationary meteorological observation data set obtained over the ice-free Arctic Ocean by the Japanese RV Mirai (September 2014), coordinated evaluation of six regional climate models (RCMs) with nine model runs was performed by focusing on clouds and the SEB. The most remarkable findings were as follows: (1) reduced occurrence of unstable stratification with low-level cloud water consistently in all models in comparison to the observations, (2) significant differences in cloud water representations between single- and double-moment cloud schemes, (3) extensive differences in partitioning of hydrometeors including solid/liquid precipitation, and (4) pronounced lower-tropospheric air temperature biases. These issues are considered the main sources of SEB uncertainty over ice-free areas of the Arctic Ocean. The results from a coupled RCM imply that the SEB is constrained by both the atmosphere and the ocean (and sea ice) with considerable feedback. Coordinated improvement of both stand-alone atmospheric and coupled RCMs would promote a comprehensive understanding of the Arctic air-ice-sea coupled system.

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