Comparison of Arctic Clouds Between ECMWF Simulations and ARM Observations at the NSA

Research Highlight

The Arctic is an area that is very sensitive to global climate change, due to strong cloud-radiation feedback coupled with ice-albedo feedback. To better understand the arctic climate, general circulation models (GCMs) have been used to simulate the arctic climate and to project future climate changes. However, there are large differences in simulations of the arctic cloud fraction and properties among GCMs. To improve the model cloud parameterization, this paper evaluated the European Center for Medium-Range Weather Forecasts (ECMWF) model-simulated clouds and boundary-layer properties based on ARM Climate Research Facility observations at the North Slope of Alaska (NSA) site during 1999-2007.

The model overestimated surface latent heat flux in summer partly due to model biases in simulating near-surface humidity. The model errors of humidity and latent heat flux further influence simulation of low-level clouds. Temperature profiles in the boundary layer (BL) are badly represented, especially in the winter season, and the near-surface temperature biases are closely related to the uncertainties of cloud simulations and related surface downward longwave radiations. Furthermore, even though the model captured the general seasonal variations of low-level cloud fraction (LCF) and liquid water path (LWP), it still overestimated the LCF by 20% or more and underestimated the LWP by over 50% in the cold season. For BL mixed-phase clouds, the model-predicted water-ice mass partition was significantly lower than the observations, largely due to the temperature dependence of water-ice mass partition used in the model. The new cloud and BL schemes of the ECMWF model that were implemented after 2003 only resulted in minor improvements in BL cloud simulations in summer.

Although the ECMWF model showed reasonably good skill in simulating Arctic clouds, the model weaknesses discussed above certainly indicate that more efforts are needed to improve model physics parameterization in this region. It is reasonable to expect that sophisticated treatments of BL processes, especially in the cold season, while coupling with larger-scale dynamics could improve the ASC's simulation. Phase partition in ECMWF clearly needs to be improved for better simulations of arctic mixed-phase clouds. Long-term ARM observations over the arctic region offer unique data sets to improve these aspects in models.

Reference(s)

Contributors

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Working Group(s)

Cloud Life Cycle

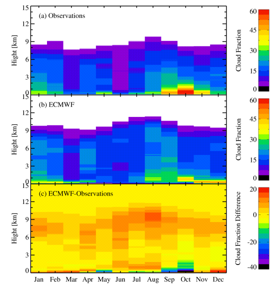

Figure 1: Monthly-averaged vertical distribution of cloud fraction from the observation (a) and the ECMWF model (b), and their differences (c). Both the ECMWF model and observation data are averages from hourly data during 1999 to 2003.

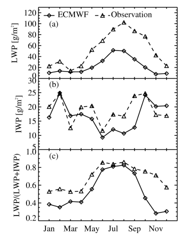

Figure 2: Comparison of monthly mean LWP (a), IWP (b), and LWP/(LWP+IWP) (c) for the low-level clouds between the ECMWF model simulations (solid line) and the observations (dash line) around the NSA site.