

Use of ARM Products in Reanalysis Applications and IPCC Model Assessment

Contributors

John E. Walsh, University of Illinois

Research Highlight

Recent climate modeling has demonstrated significant sensitivity of the Arctic to climate change; this sensitivity has been verified with observations. According to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC), observed climate change over the last 30 years has been greatest at higher northern latitudes. Average Arctic temperatures have been increasing at almost twice the rate as the rest of the world in the past 100 years. These changes in the Arctic climate potentially influence the rest of the planet through the weakening of the thermohaline circulation, accelerated release of trace gases from thawing permafrost, and the rise of sea level as glaciers and ice caps melt.

Global climate models are one of the most important tools for diagnosis of Arctic climate interactions and projecting Arctic climate change into the future. There is, however, considerable variability in the skill demonstrated by models in their ability to simulate current climate and, presumably, in their projections of change over the next century. Arctic clouds have long been known to be one of the major sources of uncertainty in simulations of Arctic climate. The evolution and formation of Arctic clouds and their associated interactions within the Arctic environment is complex and poorly understood. The interaction of Arctic clouds with incoming and outgoing radiation is very different from that of the lower latitudes. This is due to several factors, such as the high reflectivity of the Arctic surface, lack of solar radiation during the cold season, and extremely cold and dry conditions. Arctic clouds are also more prevalent and persistent than clouds elsewhere#with 90% cloud cover in summer and as much as 80% in winter.

Our study seeks to augment our understanding of Arctic cloud-radiation interactions by utilizing the ARM data set from the ARM Climate Research Facility (ACRF) North Slope of Alaska (NSA). The primary objective of the NSA site is to provide high-resolution measurements of Arctic clouds and radiation. These measurements are designed to elucidate related high-latitude processes and effectively incorporate these processes into global climate models (GCMs). Our recently submitted paper analyzes eight years (1999-2006) of archived products from the NSA site to evaluate the Arctic cloud-radiative interactions for four currently available atmospheric reanalyses. Reanalyses can be considered state-of-the-art proxies for GCMs since many use the same cloud and radiative formulations as GCMs with the added advantage of assimilated primary data such as temperature, pressure, and moisture. Our evaluation of these reanalysis models indicate that they were able to simulate the radiative fluxes if the clouds were simulated correctly. However, the systematic errors of cloud fractions simulated by the reanalyses are substantial. These biases are indicated in Figure 1. They show considerable scatter when compared to those observed at the NSA. The JRA25 and NCEP reanalyses are able to capture the late winter minimums and the late summer maximums of the cloud fraction, but their amplitudes are muted. These amplitude biases are very large, ranging from

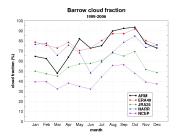


Figure 1. Monthly mean cloud fraction is shown here from ARM-observations (black), ERA40 reanalysis (red), JRA25 reanalysis (green), NARR (blue), and NCEP/NCAR reanalysis (violet).





Use of ARM Products in Reanalysis Applications and IPCC Model Assessment

-10% (winter) to 19% (summer) for the JRA25 and -24% (winter) to -29% (summer) for the NCEP reanalysis. Summer cloud fractions for ERA40 are very well simulated, but the winter minimums are not simulated by the ERA40 as illustrated by a bias of +11% in winter. Winter cloud fraction biases for the NARR are similar to ERA40 (+11%) and the NARR is too clear in summer with a bias of -16% relative to the NSA measurements. These cloud biases have significant impacts on the surface energy budget. In our analysis, simulated cloud fractions are more than 50-100% different than those observed at NSA for an individual summer month and can have absolute errors in the downward surface shortwave radiation exceeding 160 Wm-2. When cloud fractions are undersimulated (oversimulated), the monthly mean net surface longwave flux are negatively (positively) biased by 50 to 80 Wm-2.

Our study has shown that the reanalyses' biases in the radiation variables for the NSA Barrow site are dependent on the biases in the cloud fraction. If the cloud fraction is well-simulated, the radiation is also well simulated. The reanalyses had difficulty in simulating Arctic cloud fraction especially for the summer season when there is 90% cloud cover. Improved parmeterizations and/or numerical simulations are needed to capture the cloud cover distribution in the unique Arctic environment so that a more realistic surface energy budget can be generated. Understanding the Arctic surface energy budget will help GCMs make more accurate climate change scenarios for the Arctic and beyond.

Reference(s)

Walsh, J. E., W. L. Chapman, and D. H. Portis: Arctic clouds and radiative fluxes in large-scale atmospheric reanalysis. Submitted to the Journal of Climate.

Working Group(s)
Cloud Modeling

