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Project Progress
Most recent report of results to date:
Year-3 of the project was spent developing an observed cloud climatology for Barrow, AK and relating the observed cloud fractions to the surface circulation patterns and locally observed winds. Armed with this information, we identified errors and sources of errors of cloud fraction simulations by numerical models in the Arctic. Specifically, we compared the cloud simulations output by the North American Regional Reanalysis (NARR) to corresponding observed cloud fractions obtained by the Department of Energy's Atmospheric Radiation Measurement (ARM) program for four mid-season months: (January, April, July, and October). Reanalyses are obtained from numerical weather prediction models that are not run in real-time. Instead, a reanalysis model ingests a wide variety of historical observations for the purpose of producing a gridded dataset of many model-derived quantities that are as temporally homogeneous as possible. Therefore, reanalysis output can be used as a proxy for observations, although some biases and other errors are inevitable because of model parameterizations and observational gaps.

In the observational analysis we documented the seasonality of cloudiness at the north slope including cloud base height and dependence on synoptic regime. We followed this with an evaluation of the associations of wind-speed and direction and cloud amounts in both the observational record and the reanalysis model.

The Barrow cloud fraction data show that clear conditions are most often associated with anomalous high pressure to the north of Barrow, especially in spring and early summer. Overcast skies are most commonly associated with anomalous low pressure to the south. The observational analysis shows that low, boundary layer clouds are the most common type of cloud observed North Slope ARM observing site. However, these near-surface clouds are a major source of errors in the NARR simulations. When compared to observations, the NARR over-simulates the fraction of low clouds during the winter months, and under-simulates the fraction of low clouds during the summer months.

The NARR wind speeds at the North Slope are correlated to the observed ARM wind speeds at Barrow. The following correlations were obtained using the 3-hourly data: Jan (0.84); Apr (0.83); Jul (0.69); Oct (0.79). A negative bias (undersimulation) exists in the reanalysis wind speeds for January through July, but is typically 3ms-1 or less in magnitude. Overall, the magnitude of the wind vector is undersimulated approximately 74% of the time in the cold season months and 85% of the time July, but only about half of the time in October. Wind direction biases in the model are generally small (10-20 degrees), but they are generally in the leftward-turning direction in all months.

We also synthesized NARR atmospheric output into a composite analysis of the synoptic conditions that are present when the reanalysis model fails in its simulations of Arctic cloud fractions, and similarly, those conditions present when the model simulates accurate cloud fractions.

Cold season errors were highest when high pressure was located north of Barrow favoring anomalous winds and longer fetches from the northeast. In addition, larger cloud fraction biases were found on days with relatively calm winds (2-5 m/s). The most pronounced oversimulation biases associated with poorly simulated clouds occur during conditions with very low cloud-base heights (< 50 m). In contrast, the model appears more adept at capturing cloudless conditions in the spring than the winter with oversimulations occurring just 5% of the time in spring compared to 20% in the winter months.

During the warm season, low level clouds are present in 32% of the time with onshore flow and less than half this frequent in offshore wind conditions. Composite sea level pressure fields indicate that clear sky conditions typically result when high pressure is centered at or near Barrow, AK. Overcast days are associated with generally lower sea level pressures near the North Slope and onshore flow from the NW in most months.

Warm season errors were highest when high pressure was persistent to the north of Barrow, AK. This synoptic situation results in onshore flow for the North Slope with persistent winds from the east and northeast. In these situations, the predominant climatological synoptic situation, the NARR model under-simulates summer clouds on the North Slope.

In general, the NARR often fails to capture clouds in the lowest 200 meters of the atmosphere. We conclude that the cloud model parameterization fails to cature boundary layer clouds like Arctic stratus and fog, which are observed in 65% of the undersimulations. These NARR undersimulations occur most often during onshore flow environments, such as when high pressure is located north of Barrow and the prevailing winds are from the northeast. In these cases, the airflow is along a fetch of scattered sea ice and open ocean (ice concentrations between 0 and 100%). NARR treats sea ice as a binary function. Grid cells are either considered a slap of ice cover, or totally open ocean. We note that implementing provisions for partial sea ice concentrations in the reanalysis model may help in more accurately depicting surface moisture fluxes and associated model-derived low cloud amounts.
Most recent products delivered:
Clark, Joseph V., J. E. Walsh, 2010: Observed and Reanalysis Cloud Fraction, Journal of Geophysical Research Atmosphere, revised.

M. S. Thesis (2009) for Joseph V. Clark, University of Illinois.
Most recent notes concerning the project:
None
Other Project Information Sources:

Project URL:
http://igloo.atmos.uiuc.edu/ARM/