Breakout Session Report
ARM/ASR User and PI Meeting
March 16-20, 2015

Session Title: Arctic Aerosol-Cloud-Climate Interactions
Session Date: Thursday, March 19, 2015
Session Time: 1:30–2:30 pm
Summary Authors: David Mitchell, Greg McFarquhar, and Daniel Knopf

Description

This session will investigate ways to examine the impacts of aerosols on cirrus and low-level stratiform clouds in the Arctic. Discussions will cover a potential winter field campaign, including the types of measurements needed, the role of ARM sites, and the contributions of tethered balloon and unmanned aircraft.

Motivation

The original motivation for having this breakout session was to share a recent satellite remote sensing technique and finding that indicated cirrus clouds that were evidently formed through homogeneous ice nucleation were primarily occurring during winter in the Polar Regions. In the case of the Arctic, these clouds occur primarily between western Greenland and Norway, but they also occur over Siberia. Since these clouds were believed to be unique regarding their microphysical and radiative properties, one motive was to conduct in situ measurements over Greenland to more accurately characterize the microphysics of these clouds (i.e. not relying solely on satellite measurements). A recent CAM5 experiment that assumed cirrus formed through homogeneous ice nucleation (hom) only at high latitudes showed that high latitude (> 60 deg.) surface temperatures were 2 to 6 °C warmer under winter "hom cirrus" conditions than under winter "het cirrus" conditions (i.e. when heterogeneous ice nucleation dominates). This is because at low or non-existent sun angles, the cloud radiative forcing due to sunlight is either absent or nearly absent, leaving only the longwave radiative forcing (i.e. the shortwave and longwave forcing do not partially cancel).

Another motivation for this breakout session was to identify pressing scientific questions (i.e. knowledge gaps) regarding low-lying Arctic stratus/stratocumulus clouds, or any other Arctic cloud/snowfall critical issue. One presentation identified the importance of Arctic light snowfall (< 1 mm/h) or ALS as a critical and yet unmeasured component of the Arctic water and radiation budget. While it is estimated that ASL may contribute ~ 50% of Arctic snowfall, it escapes conventional snow gage measurements due to the small crystal sizes (< 500 microns). Arctic snow cover in general affects many things such as the radiation balance, the formation of low pressure troughs and thus the general circulation (see Cohen et al., Nature Geoscience 2014).

Other studies presented showed that (1) the liquid fraction in Arctic stratiform mixed phase clouds was governed by the cloud top temperature and the ice particle number concentration, and (2) the impact of CCN on cloud droplet size distributions (SDs) is not straightforward due to cloud processing of CCN, subsequent evaporation and re-introduction of "enhanced CCN" into the cloud. More research was recommended for understanding the impact of cloud processing on droplet SDs.

Main Discussion

NSA and/or Oliktok Point sites: The group agrees that measuring Arctic aerosol from the ground is a good idea, including ice nuclei or IN. There was considerable discussion on whether to measure aerosol

from the ground or from the air using a tethered balloon. Discussion emphasized that continuous ground-based observations of IN and CCN, and their relationship to cloud properties would be a good focus. Although we might not have the perfect strategy for doing this right now, we should start by characterizing aerosol properties and their ability to interact with cloud, even though the actual properties in the cloud will not be measured at first; future efforts can build upon this and address whether current instrument techniques are even appropriate for making these type of measurements (e.g., CCN measurement techniques are more developed than IN measurement techniques). The Arctic is a potentially good location for such an experiment because of high biological marine activity that can be important for IN numbers, but not many measurements have been made there. An IN closure experiment can be done at the ground before worrying about what is going into the cloud (based on content of aerosols). However, the low numbers of IN may also make this closure experiment difficult (e.g., might be below the noise threshold of the CFDC instrument), and may hence identify limitations of current instruments. Need for additional composition information was also discussed. Trish Quinn has been collecting filters for years, but does not have the funding to analyze them (e.g., there is a backlog since 2010 and maybe even later). Making funding available to analyze these filters should also be a priority.

The group recommended using many instruments to measure aerosols and ice particles, including the PALMS instrument if cirrus clouds were measured. The PALMS instrument measures the chemical composition of the aerosol outside of a cloud and the residue of an evaporated small ice crystal (i.e. the chemical composition of an IN) within the cloud. These measurements have been used to determine whether ice nucleation occurred homo- or heterogeneously (Cziczo et al. 2013, Science). That is, if the aerosol composition is similar to the IN composition, hom is inferred; otherwise het is inferred. Gijs de Boer emphasized that many aerosol attributes need to be measured (more than just IN). An IN-aerosol closure study was also proposed by Daniel Knopf following a similar discussion in the breakout session "Ice Nucleation and Aerosol Mixing State" (Riemer, Fridlind, Knopf) and the group seemed to support this idea.

David Mitchell asked the group if there were logistical constraints for sampling cirrus clouds over Greenland during Arctic winter. Matt Shupe stated that aircraft access to Greenland is not a problem, with a large airport in Iceland and a more local USAF base airport on Greenland. The NASA ER-2 has flown over Greenland and can reach the lower stratosphere, and thus can sample cirrus at all levels. It was not clear whether sampling cirrus clouds during the Arctic night (i.e. winter) would be feasible, but Matt did not appear to feel this was a show-stopper. When David Mitchell asked the group whether there was interest in a field campaign to characterize the microphysical properties of hom cirrus over Greenland, there was silence, apparently an indication that interest was not there.

Key Findings

Key scientific findings are described under "Motivation" and are related to the presentations.

Decisions

The group appeared to adopt the philosophy that it is better to perfect ground measurements before using a tethersonde to make aerosol particle measurements at the NSA or Oliktok Point.

While there was no formal decision to NOT pursue a field campaign for sampling cirrus over Greenland, it could be argued that such a decision was implicit based on the silence encountered when the group was asked whether there was interest in such a field campaign.

Future Plans/ Action Items

Since significant interest was not expressed for an Arctic field campaign, there are no future plans or action items.