Using ASR Observations to Quantify the Seasonal Influence of Stratiform Mixed-phase Clouds on Arctic Sea Ice Growth Rates

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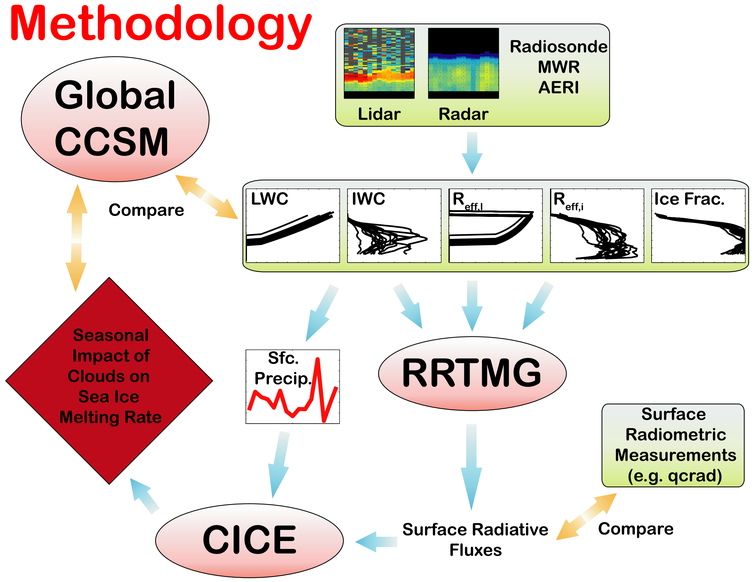
Introduction

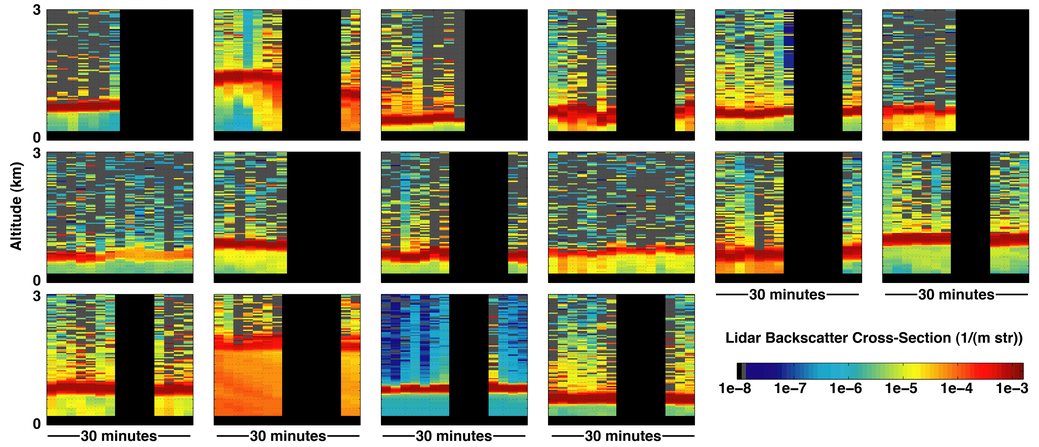
Recent years (e.g. 2007 and 2008) have seen record declines in summer Arctic sea ice extent. While just one of several influences on sea ice melting/growth rates, cloud cover remains one of the most dynamic drivers controlling sea ice growth and decay. Early studies (e.g. Curry et al., 1993) have investigated the impact of clouds on the Arctic surface radiative budget using idealized clouds and early models. Recent observations and advanced modeling tools provide us with a new set of analysis devices to improve quantitative estimates of cloud forcing on sea ice. Here, we outline a plan focused on improving our understanding of these interactions, and how ASR and DOE funded tools will aid in this effort. The proposed methodology, along with preliminary results from a test of this technique using data from the Mixed-Phase Arctic Cloud Experiment are presented. Finally, an overview of future plans is included.

Methodology

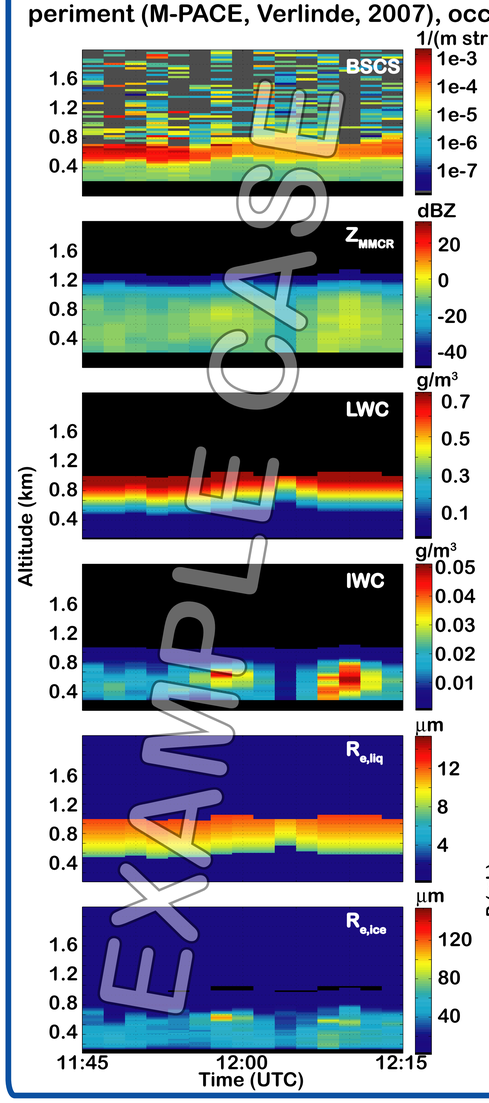


- Utilize cloud macro- and microphysical retrieval algorithms from Shupe et al. (2008) to derive cloud properties. These include the use of lidar (HSRL, MPL), radar (MMCR), MWR, AERI, and radiosondes. All are available at the ASR NSA site.
- Drive a column version of AER's Rapid Radiative Transfer Model (RRTMG, used in CAM4) to derive a distribution of surface radiative fluxes.
- Compare derived surface fluxes with those measured at NSA, using the qcrad datastream.
- Use the validated surface fluxes, along with retrieved surface precipitation rate to drive a column version of the Los Alamos sea ice model (CICE). CICE can provide us with a distribution of sea ice growth and melting rates estimates based on observed cloud properties.
- Compare these melting and growth rates on a seasonal basis with those simulated in CCSM.

Test Case: M-PACE



Mixed-phase cloud cases from the North Slope of Alaska Mixed-Phase Arctic Clouds Experiment (M-PACE, Verlinde, 2007), occuring within 15 minutes of a radiosonde launch.

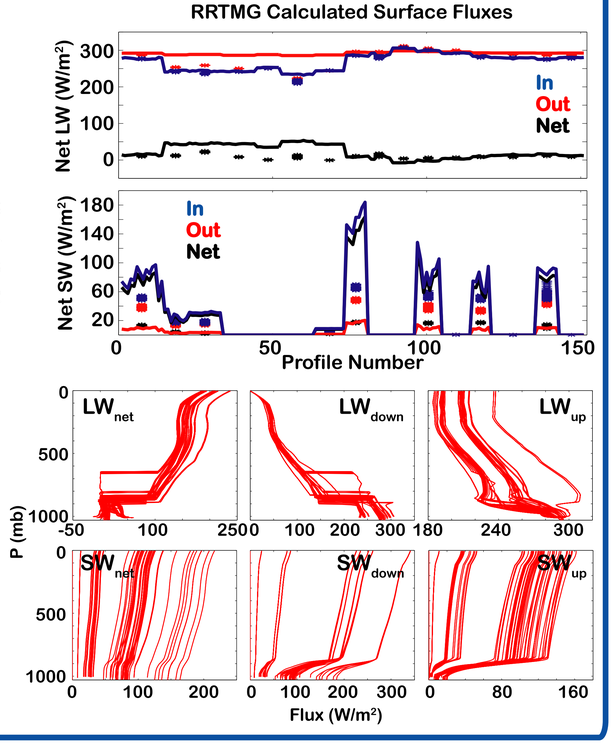


Retrievals Used (guide: Shupe et al., 2008)

- Cloud Base: Lidar
- Cloud Top: Radar
- LWC: Scaled-Adiabatic (Lidar, Radar, MWR/AERI Radiosonde)
- IWC: Radar Z-IWC relationship (Radar)
- $R_{e,l}$: Scaled adiabatic based on constant N and assumed cloud base droplet size
- $R_{e,i}$: Radar lidar to liquid cloud base, and $Z^{(1/6)}$ weighted above liquid cloud base.
- Surface Precip: IWC flux at lowest level
- Ice Fraction: IWC/LWC ratio

EARLY RADIATIVE TRANSFER ESTIMATES

RRTMG Calculated Surface Fluxes



Future Work

- Compare clear sky flux to surface measurements to see whether differences are due to clouds or surface features.
- Include better representation of surface in the test case.
- Use best-estimate radiative fluxes and precipitation information to drive CICE.
- Expand analysis to multiple years of measurements, and derive seasonal distributions of the impact of mixed-phase clouds on sea ice melting rates.
- Include measurements from other measurements sites (SHEBA, Uttal et al., XXXX; Eureka, de Boer et al., 2009; etc.)
- Compare results to those from CAM (e.g. Xie et al., 2008) and CCSM.
- Complete similar analyses for other Arctic cloud types (cirrus, diamond dust, liquid clouds, Arctic haze, etc.)
- Complete sensitivity studies based on measured profiles, comparing influences at different latitudes and over different sea ice states.

References

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