Understanding Aerosol-Cloud Interactions In Ice Saturated Environments Using CALIOP And AHSRL

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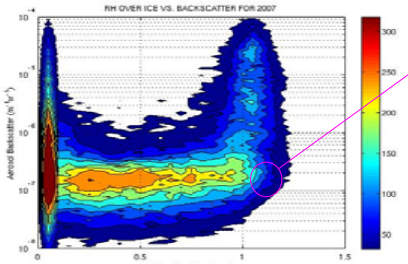
Problem

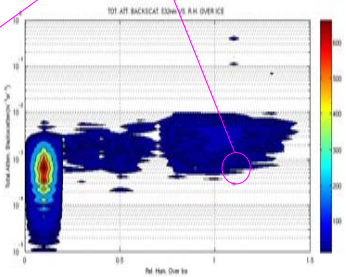
Attempts to model ice clouds using saturation with respect to ice as a sufficient condition produce far too many ice clouds with unrealistic life-times. CALIPSO and AHSRL both show the abundance of environments saturated over ice yet failing to produce clouds in these histograms of relative humidity over ice versus backscatter.

Super-saturation with no clouds

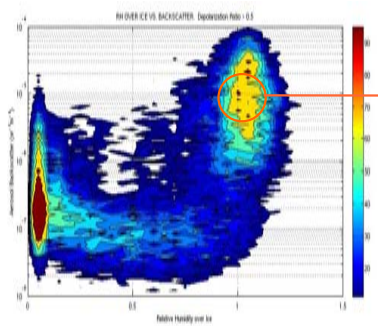
AHSRL And Twice Daily Radiosonde Data



CALIPSO And Reanalysis Profiles

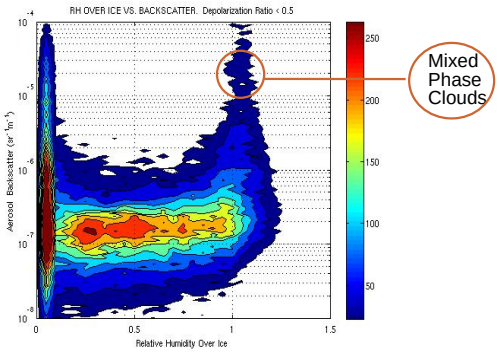


AHSR backscatters with circular depol. ratio > 0.5



Ice Clouds & Ice Precip

AHSRL backscatters with circular depol. ratio < 0.2



Mixed Phase Clouds

Why are ice clouds not nucleating?

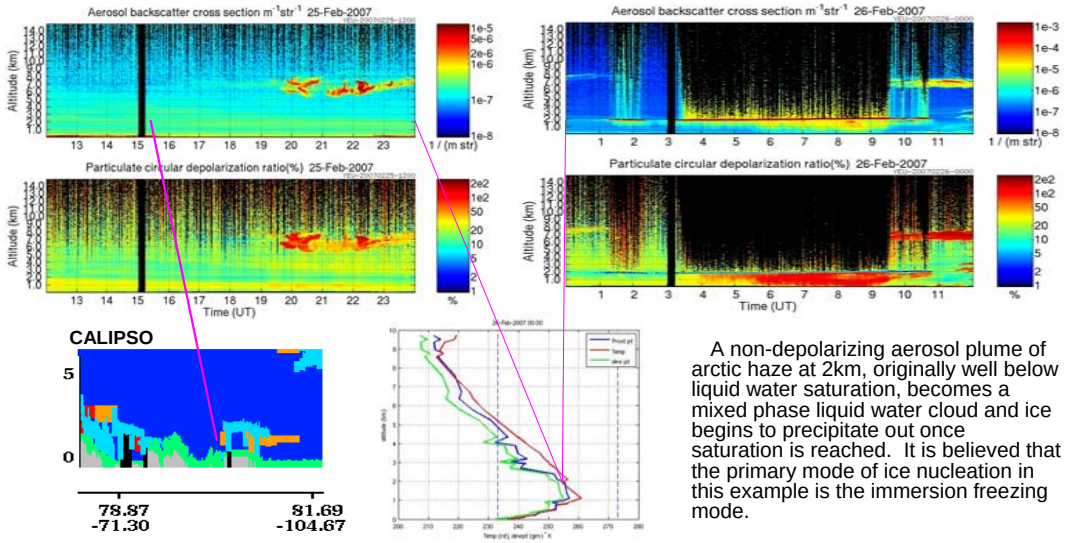
-Dynamics of the environment play a role. The meterological conditions of the arctic region influence the amount of cloud cover and life time.

-Aerosols and their ability to nucleate ice become extremely important factors in the arctic due to their relative scarcity compared to the mid-latitudes. Arctic Aerosols can originate in far off source regions and their composition and history determine their ability to serve as ice forming nuclei.

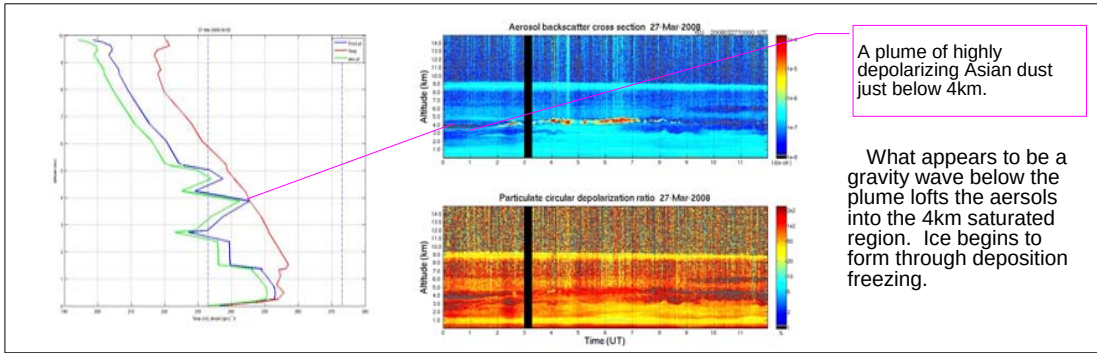
AHSRL and CALIPSO show examples of aerosols influencing ice nucleation.

-Aerosol plumes eventually become sites of ice nucleation as environments become saturated with respect to ice.

-Both depolarizing and non-depolarizing aerosols can be seen initiating cloud formation indicating ice nucleation, although through very different mechanisms



A non-depolarizing aerosol plume of arctic haze at 2km, originally well below liquid water saturation, becomes a mixed phase liquid water cloud and ice begins to precipitate out once saturation is reached. It is believed that the primary mode of ice nucleation in this example is the immersion freezing mode.



A plume of highly depolarizing Asian dust just below 4km.

What appears to be a gravity wave below the plume lofts the aersols into the 4km saturated region. Ice begins to form through deposition freezing.

Further Research:

Investigating the relationship between different source regions and transport histories of aersols and their ice nucleating properties with respect to different modes of nucleation. This will be done by cluster backtracking aersol plumes and confirming this backtracking using CALIPSO. The study will assess their entrance mode into the arctic and relate this to cloud observations with AHSRL while Integrating this information into a dynamical model using the NMS-AMPS (*Non-Hydrostatic Modeling System with Advanced Microphysical Prediction System).*

References:

Ansmann, A., I. Mattis, D. Müller, U. Wandinger, M. Radlach, D. Althausen, and R. Damoah, 2005: Ice formation in Saharan dust over central Europe observed with temperature/humidity/aerosol Raman lidar, J. Geophys. Res., 110, D18S12, doi:10.1029/2004JD005000.

Harrington, JY, T Reisin, WR Cotton, and SM Kreidenweis. 1999. “Cloud resolving simulations of Arctic stratus. Part II: Transition-season clouds.” Journal of Atmospheric Research 51, 45–75.