Mapping ARM Radar Observations to Microphysical Processes in Mixed-phase Single-layer Clouds

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Introduction and objectives

Arctic low-level clouds remain a challenge for global circulation models.

Especially important is the representation of cloud phase owing to the strong role of liquid condensate in the radiation budget of the Arctic.

Controls on cloud phase and liquid content include microphysical processes of droplet and ice crystal growth, autoconversion, accretion, depositional growth, aggregation and riming.

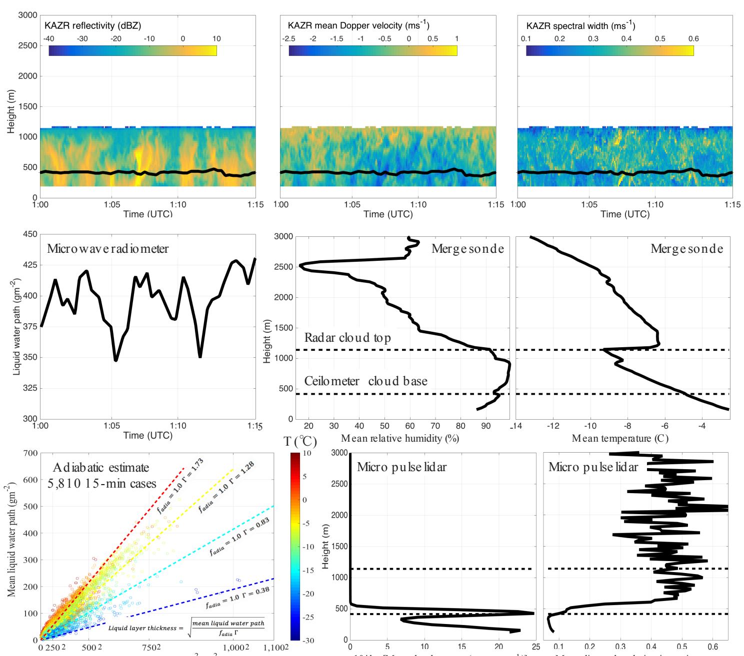
Establishing the frequency of active microphysical processes provides a meaningful target for model evaluation and improvement.

The first task to achieve this goal is to determine which observational platforms can be used to identify microphysical processes in clouds.

Observations available for investigation

Our objective is to conduct a long-term analysis which will provide robust occurrence frequencies. To begin with, we isolate simple cloud systems: single layer, stratiform, mixed-phase clouds with liquid extending to cloud top. 1,452 hours were identified at the NSA between 2011-11 & 2014-02.

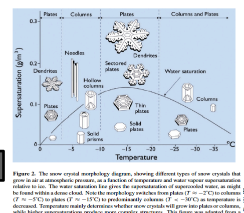
This study exploits a combination of radar, ceilometer, microwave radiometer, micro-pulse lidar, and soundings (mergesonde dataset).


KAZR reflectivity (dBZ)
KAZR mean Doppler velocity (ms^{-1})
KAZR spectral width (ms^{-1})
Height (m)
Time (UTC)
Microwave radiometer
Liquid water path (gm^{-2})
Mergesonde
Radar cloud top
Ceilometer cloud base
Mean relative humidity (%)
Mean temperature (C)
Adiabatic estimate
5,810 15-min cases
Mean liquid water path (gm^{-2})
Liquid layer thickness^2 (m^2)
T (℃)
Micro pulse lidar
10*log[Mean backscatter (counts us^{-1})]
Mean linear depolarization ratio

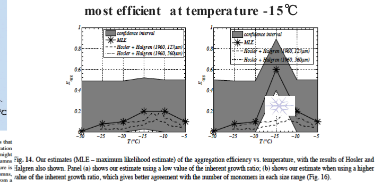
Microphysical processes and their relationship to temperature and liquid water - Past studies

Laboratory, wind tunnel and high resolution modeling studies suggest that microphysical processes evolve differently under different temperature and moisture regimes.

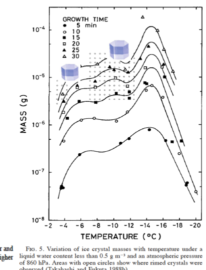
Depositional growth was shown to have a temperature dependency



Aggregation is hypothesized to be most efficient at temperature -15℃



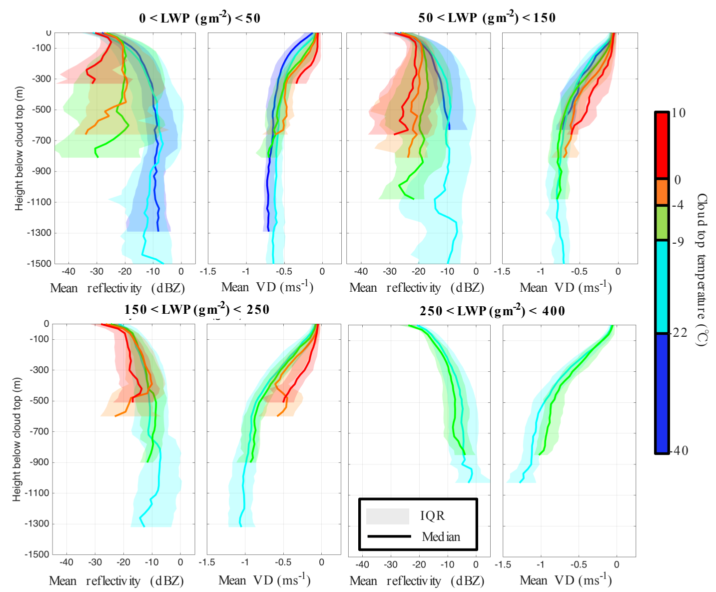
Evidence supporting that isotropic crystals [-4℃ and -9℃] grow more efficiently by riming



Microphysical processes and their relationship to temperature and liquid water - Current study in Arctic clouds with liquid reaching cloud top

Distinct radar reflectivity profile shapes, radar mean Doppler velocity profile shapes are found when the dataset is parsed by cloud top temperature and liquid water path.

The objective of ongoing work is to link these radar signatures to underlying microphysical processes.



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