Towards a Characterization of Arctic Mixed-Phase Clouds

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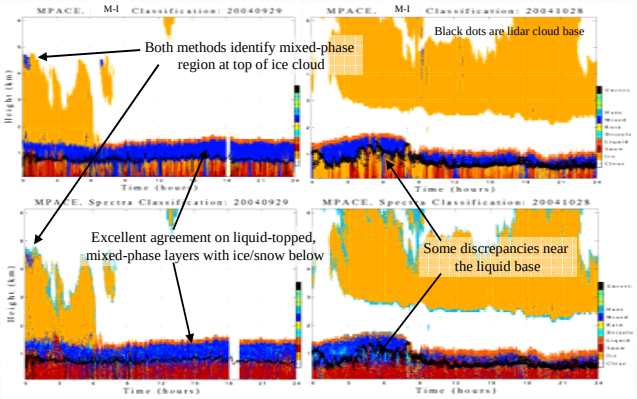
Identifying Mixed-Phase Clouds

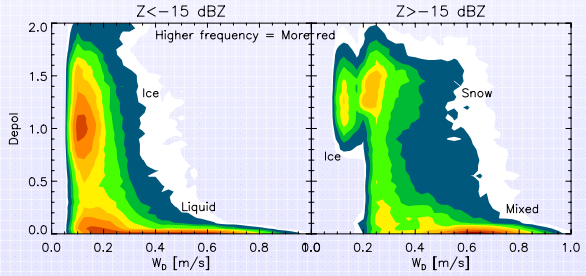
Two new cloud classification methods have been developed and show a promising and exciting level of agreement in a comparison during MPACE:

1) *Multi-instrument Method*: Uses lidar backscatter and depol ratio, MMCR reflectivity, Doppler velocity, and spectrum width, and temperature soundings to classify all cloud pixels observed by lidar or radar
2) *MMCR Doppler Spectra Method*: Uses a trained neural network to identify indicators of cloud type from MMCR Doppler spectra alone. The method utilizes wavelet decompositions and statistics of reflectivity, mean spectrum width, mean velocity, skewness, and kurtosis from the primary spectral peak (see Luke et al. poster).



Can the Doppler spectrum width help with classification?

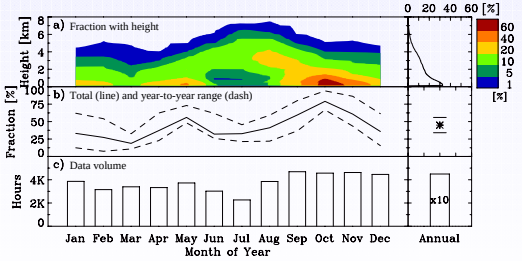
For radar reflectivities > -15 dBZ (which are typical for mixed-phase clouds due to large ice particles), the mixed-phase clouds occupy a distinct, characteristic region with low lidar depolarization ratio (due to the typical high concentration of liquid droplets) and wide MMCR Doppler spectrum width (due to multiple phases present). This information aids the multi-instrument classification discussed above.



Mixed-Phase Cloud Properties

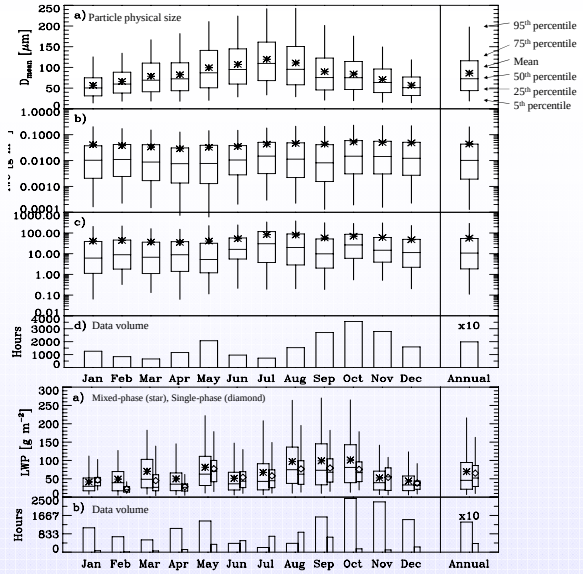
All mixed-phase cloud properties presented in this panel were derived from MMCR and MWR measurements at the NSA site for the time period of March 1998 through December 2004. The statistics in all plots cover this full time period. Microphysical property retrieval methods are summarized by Shupe et al. (2005, ARM Science Team Meeting and JAM, 44, 1544-1562).

Mixed-Phase Cloud Occurrence Fraction



Cloud Occurrence. Mixed-phase clouds occur 45% +/- 10% of the time per year at the NSA site. There is a marked increase in mixed-phase cloudiness in the spring and fall transition seasons, mostly at heights below about 1 km.

Monthly and Annual Microphysics Statistics
Ice properties
Liquid properties



Interesting Microphysics Results

- LWP for mixed-phase clouds is on average similar to the LWP for all-liquid clouds at NSA; this is different from SHEBA where mixed-phase clouds had higher LWPs.
- Ice particles in mixed-phase clouds are 33% larger than in all-ice clouds, while the IWCs are a factor of two larger (not shown).
- Ice particle sizes at NSA are similar to SHEBA, however IWC, IWP, and LWP are significantly larger at NSA than at SHEBA (not shown).

Summary of Typical Arctic Mixed-Phase Cloud Characteristics

- 45% occurrence fraction with maxima in transition seasons.
- Ice particle mean size: 30-150 μm
- Ice Water Content: 0.001-0.04 g/m^3
- Ice Water Path: 10-60 g/m^2
- Liquid Water Path: 20-90 g/m^2
- Ice sizes and LWP are smallest in winter and largest in summer.
- IWC and IWP are smallest in spring and largest in fall.
- LWP, IWP, and ice particle sizes increase in updrafts
- The fraction of ice relative to liquid increases in updrafts

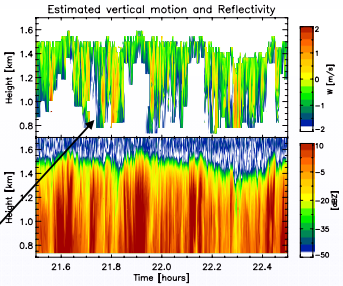
A Case for Vertical Motions

Can Doppler spectra provide information on air motions?

Simple Retrieval Method

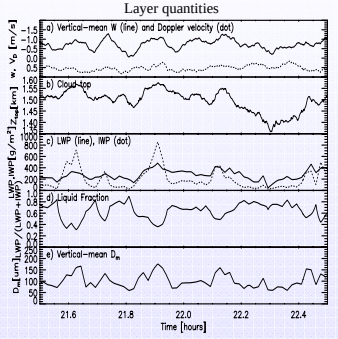
1) Identify time-height pixels that contain liquid water using methods in panel #1 (small liquid droplets are considered as tracers of clear air motions).
2) Determine the most negative (upward) end of the Doppler spectrum above the noise for each pixel.

[Vertical Motion Example]



Case Results

- W results suggest a net large-scale updraft of 0.7 m/s with small scale circulations of magnitude +/- 0.6 m/s.
- All cloud properties and cloud top height are clearly correlated with W; during local updrafts, liquid and ice increase and the cloud top lifts.
- During local updrafts, the fraction of cloud ice relative to liquid increases.



Acknowledgments

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