Characteristics of snow regimes at North Slope Alaska as derived from the NSA snowfall product

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SSEC

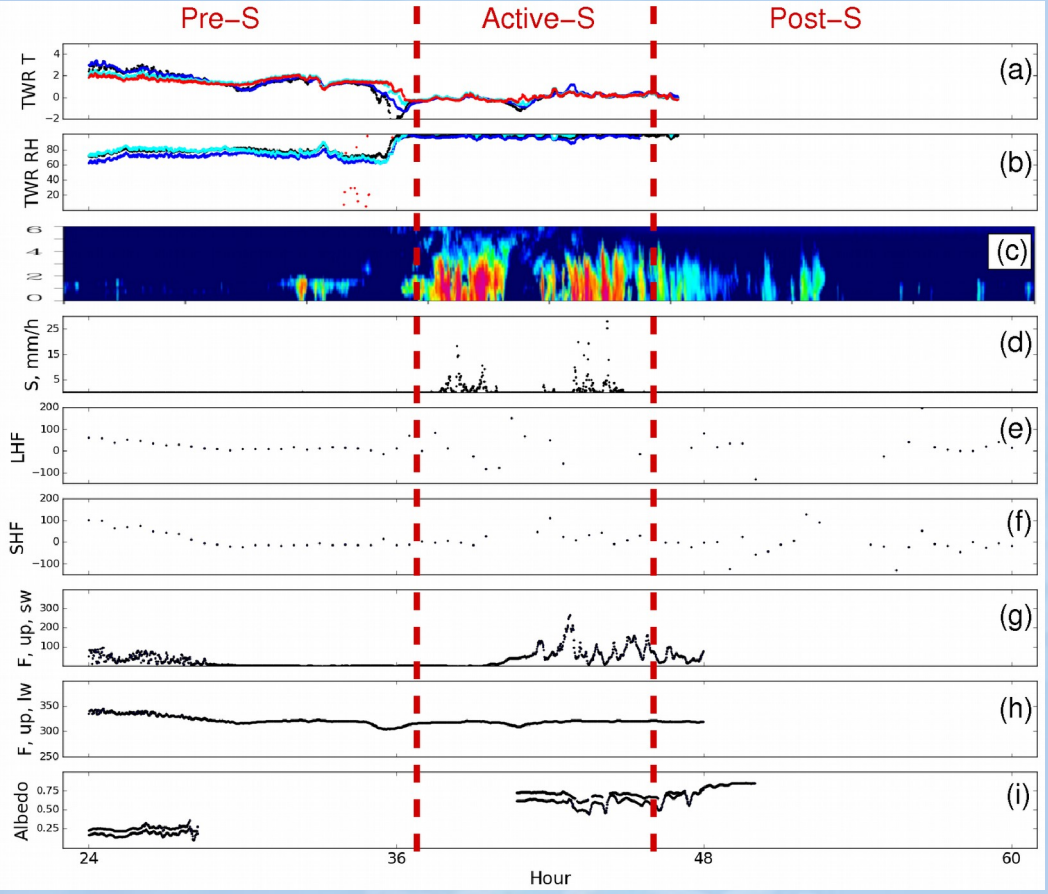
Radar-based snowfall retrieval product for NSA

To provide:

- snowfall intensity, duration, and accumulation;
- a basis for examining the relation between snowfall events and environment;
- and information about the vertical structure of snow properties

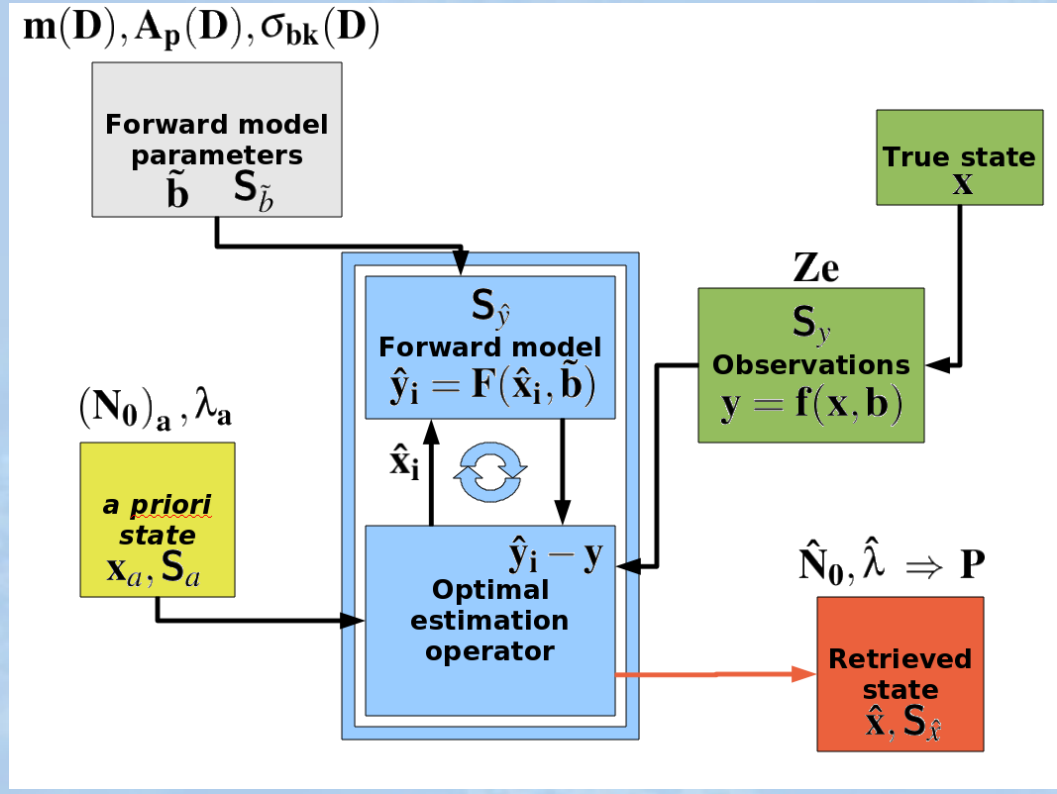
Outline

1. Retrieval and product
2. BRW regimes
3. Evaluations vs SHEBA, MPACE shallow and deep cases:
   - Shallow regime performance is consistent.
   - Deep regime performance has shortcomings – probably traceable to assumed particle model.



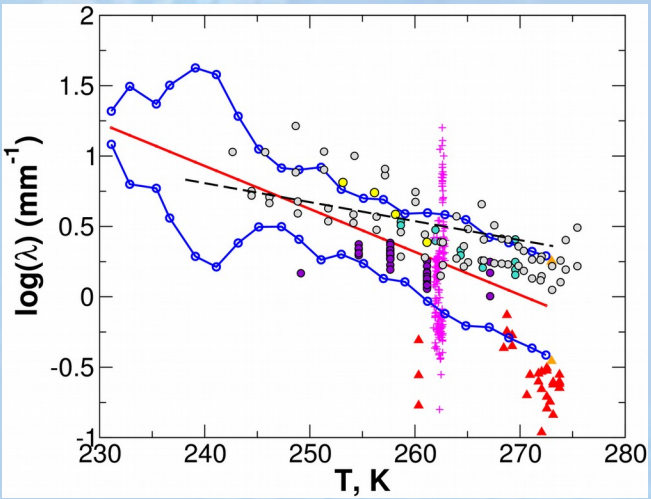
Retrieval

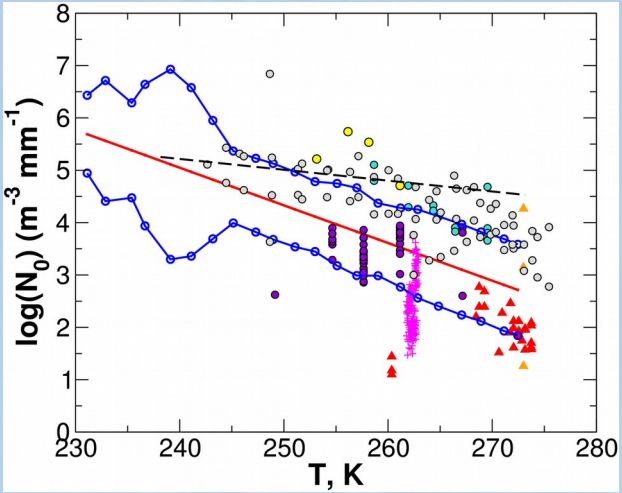
- Bayesian estimation using profiles of KAZR Z_e and temperature with *a priori* information about snowflake properties and particle size distributions (PSDs).
- Water content profiles and surface snowfall rates are derived from intermediate retrieved PSDs
- Uses coincident observations (LWP, T) plus retrieval diagnostics (chi-sq) to assess confidence and flag liquid presence.



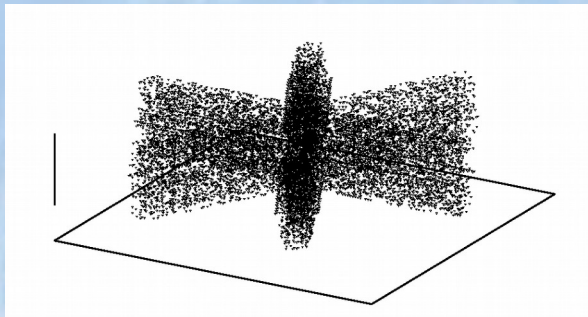
a priori information used by the retrieval

1. “Background” estimates of the state to be retrieved:
   - assumed negative exponential N(D)
   - T-dependent PDF of N(D) parameters





2. Particle model properties derived from PDF of m(D) parameters and simple shape information:
   - provides expected σ_{bk}(D), m(D) and uncertainties

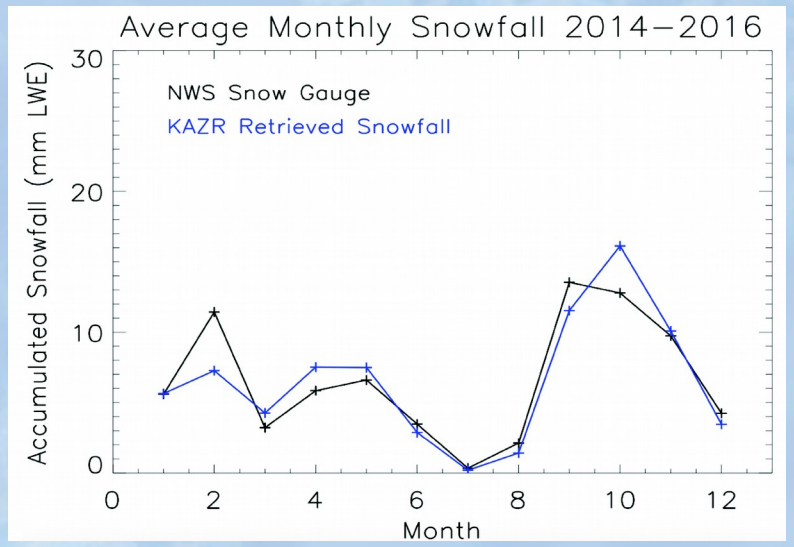


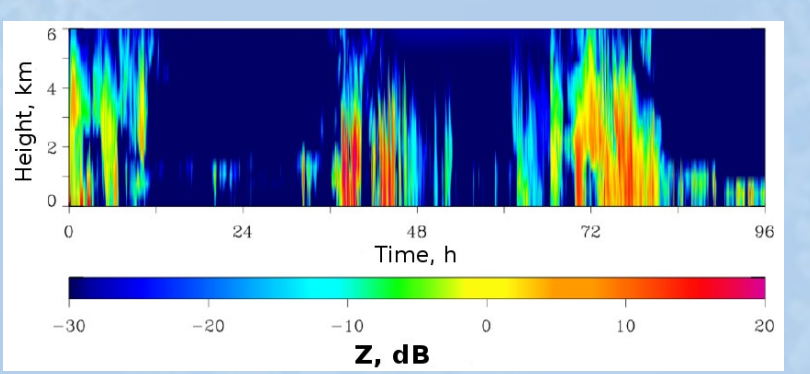
- m(D), σ_{bk}(D) derived from satellite ground validation experiment observations.
- Similar to “radiating assemblages of plates” (Mitchell et al., 1990)

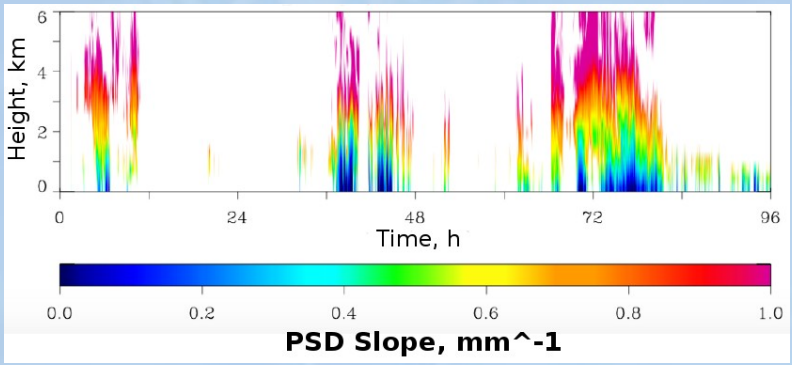
Product

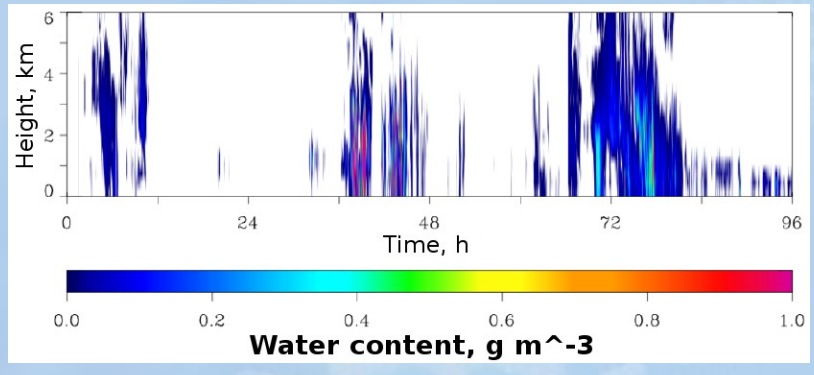
- BRW: Feb 2014 - June 2018
- OLI: (prelim) May - Nov 2016*
- 1 minute x 300m resolution to 9 km
- Vertically resolved intermediate N(D) and water content estimates
- Surface snowfall rate
- Flagging for status, confidence, liquid water presence

*using C. Williams' denoised OLI KAZR product



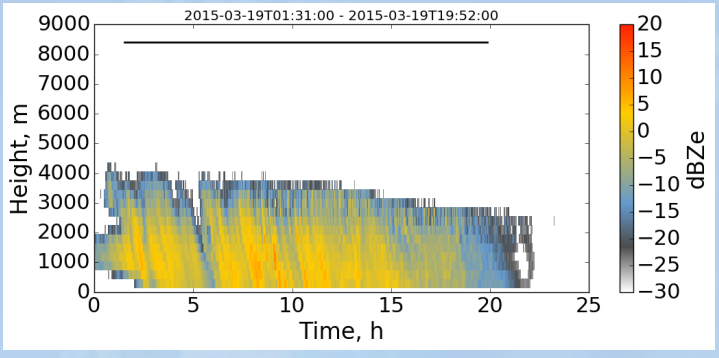


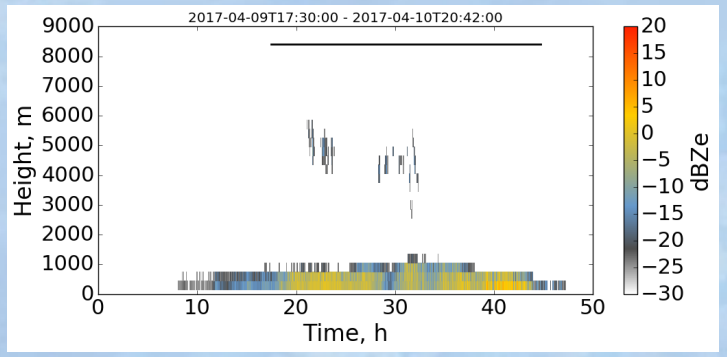


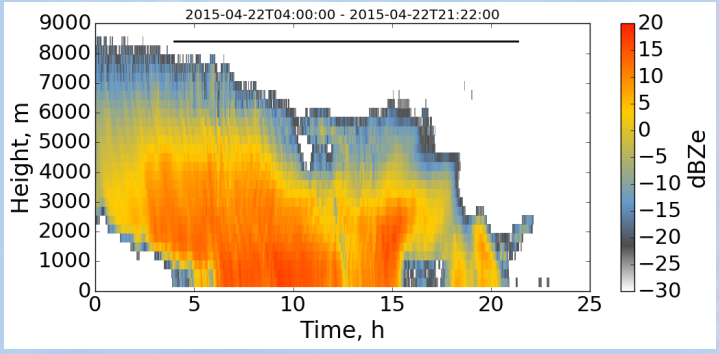


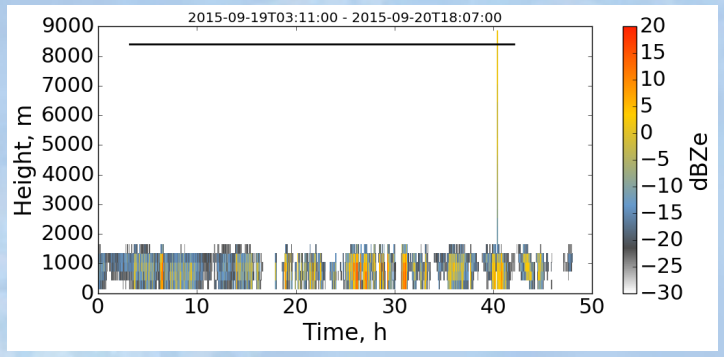
Diagnosing and classifying snowfall events

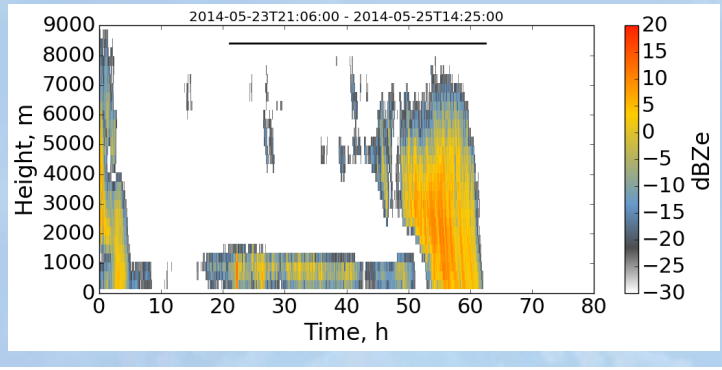
- Onset and end of events determined from surface by smoothing, thresholding, contiguity of snowfall rate time series
- Classify by precipitation echo top heights:
  - Within-event clustering of precipitation echo top heights
- 452 events: shallow (168), midlevel (51), deep (25), mixed or not yet classified (208)







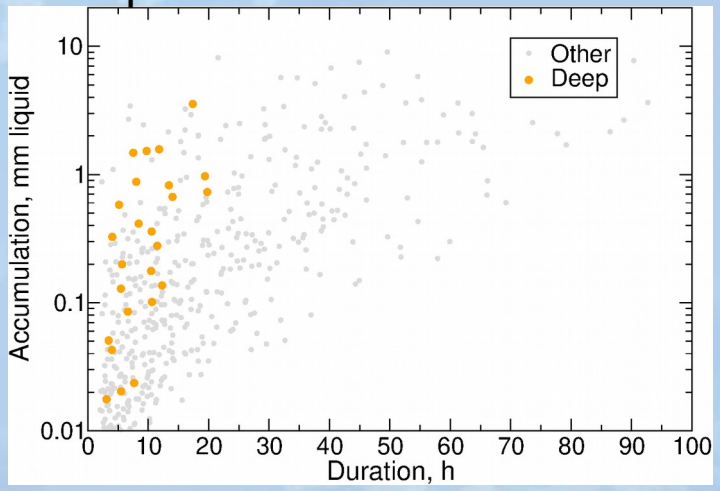




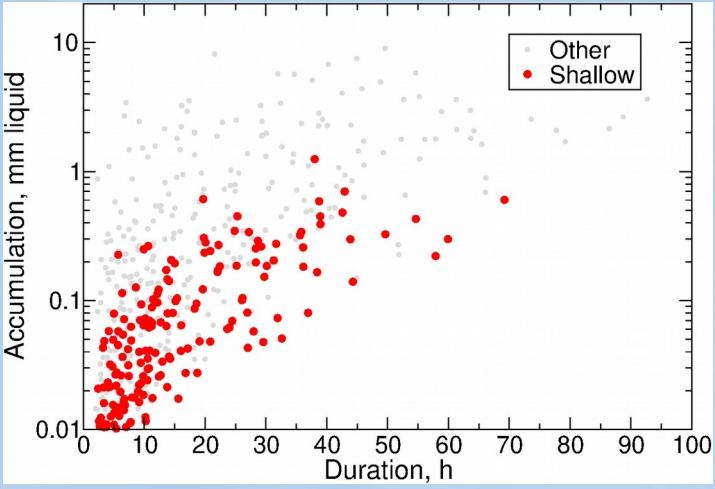
Regime duration and accumulation

- Deep events characterized by relatively short durations and potentially high accumulations
- Shallow events require longer duration to achieve larger accumulations

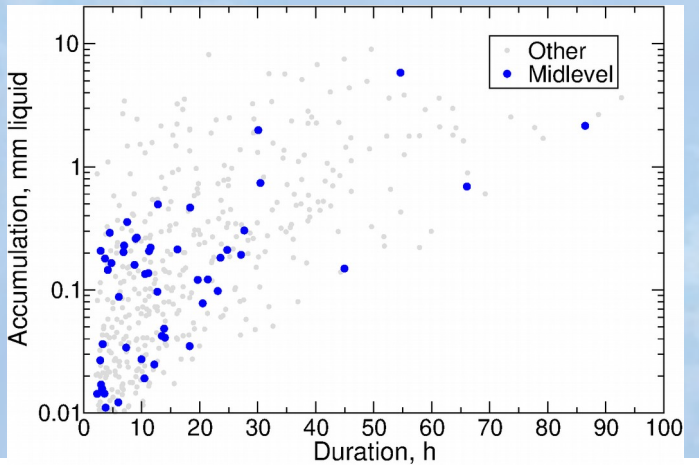
Deep



Shallow

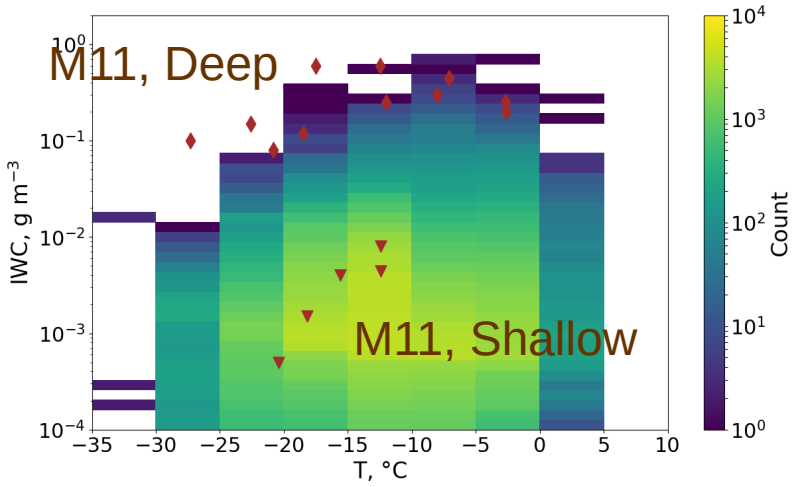


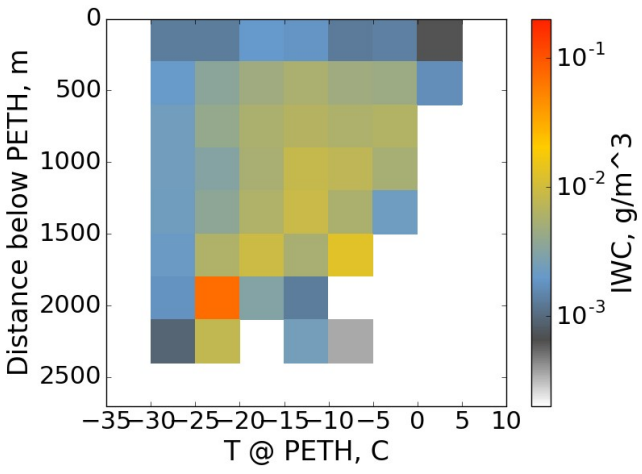
Midlevel

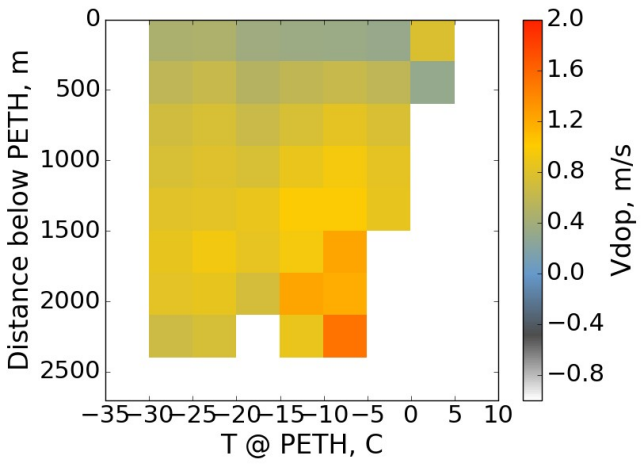


Shallow event characteristics

- Retrieved IWCs are consistent with M11 shallow events
- Suggests surface snowfall rates would also be reasonable





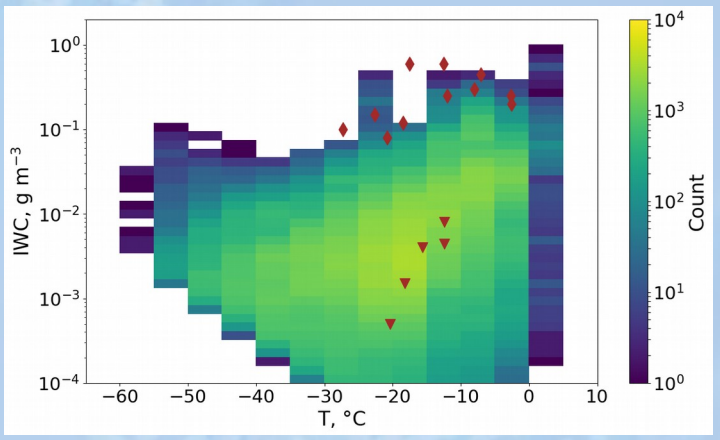


M11: Morrison et al., 2011, QJRMS

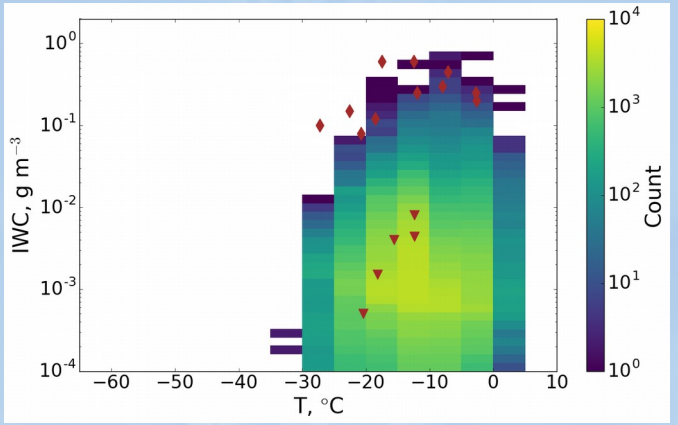
Deep event characteristics

- Retrieved IWC's are larger compared to shallow, but don't increase enough to match M11 deep cases.

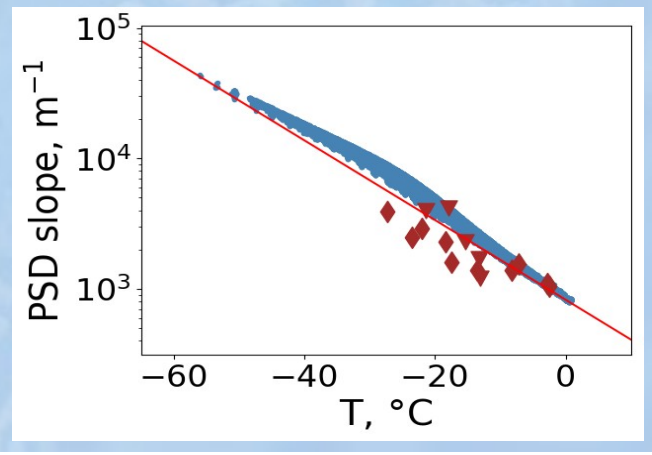
Deep

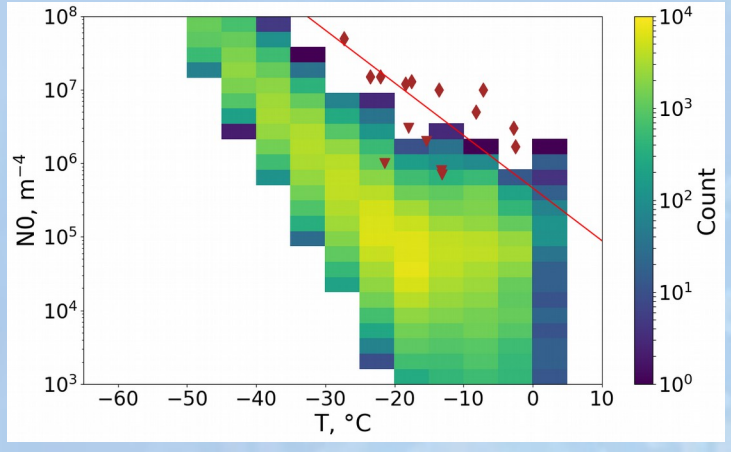


Shallow



- N0 departs significantly from M11 and from *a priori*

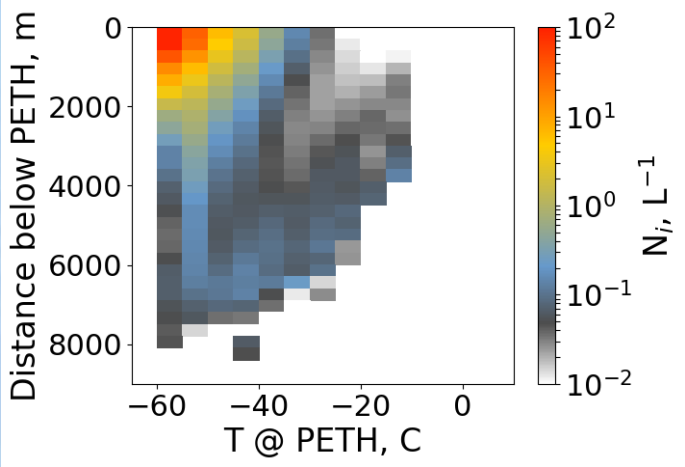




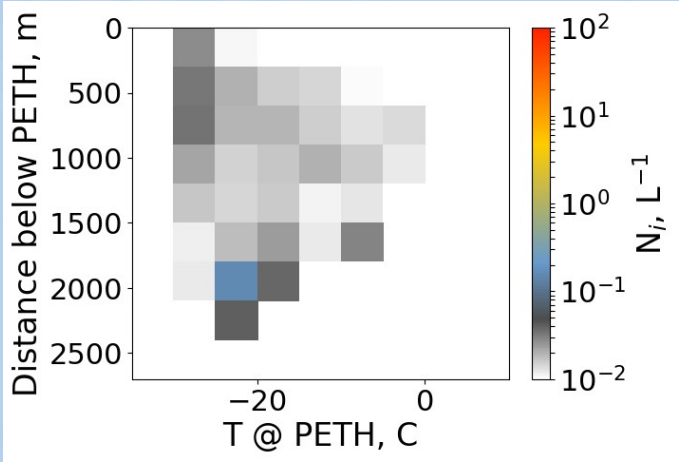
Particle concentration profiles

- Change in magnitudes from warmer regions of Deep to Shallow Is roughly consistent with M11 (~50-fold)
- Coldest, deepest Deep and Midlevel have strongly enhanced concentrations at echo top.

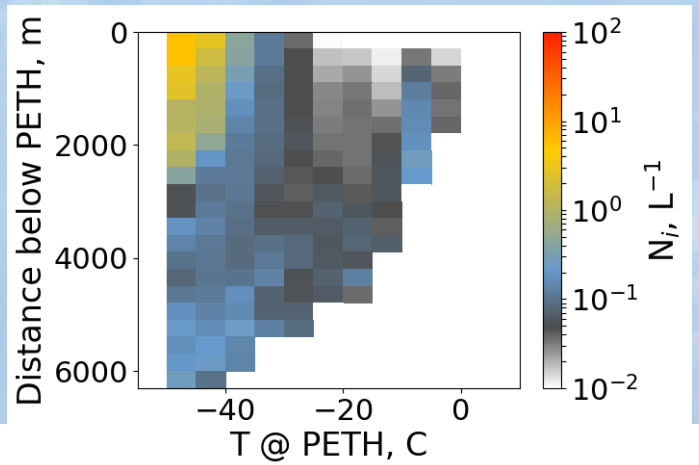
Deep



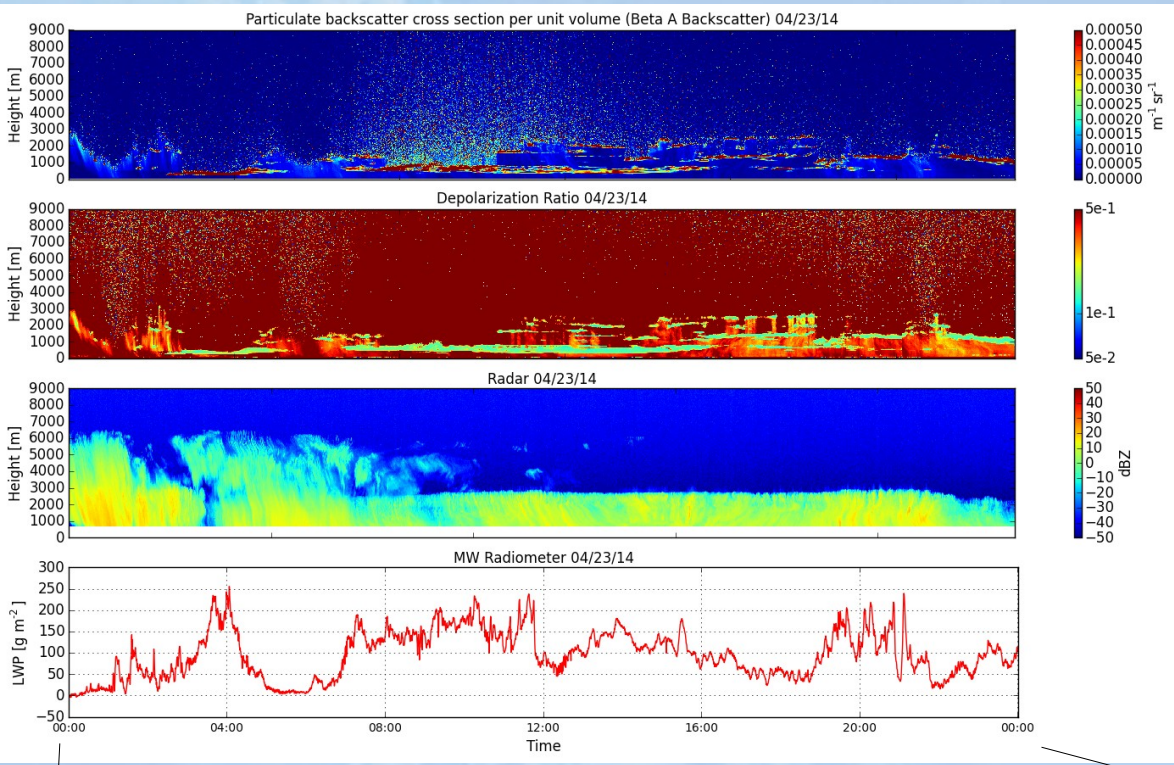
Shallow



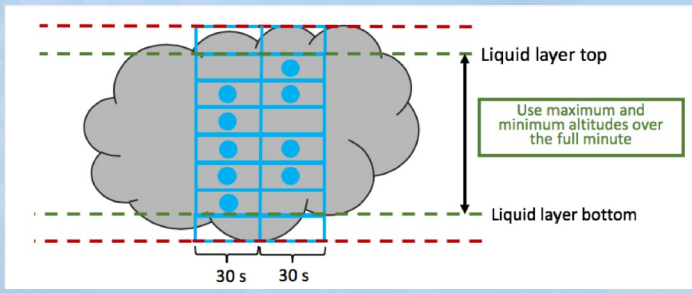
Midlevel



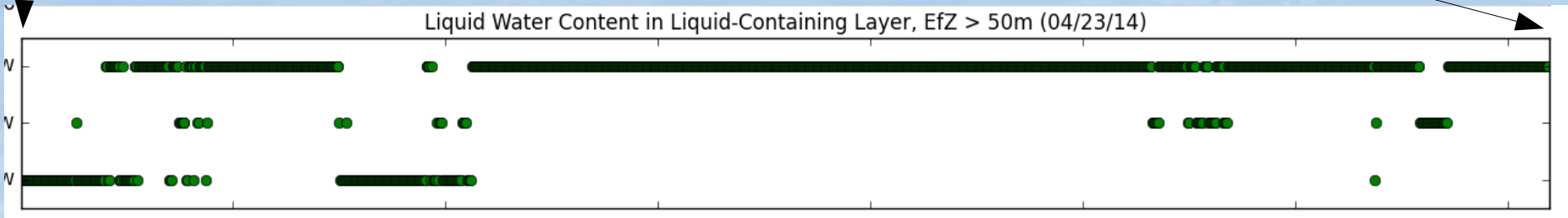
Characterizing liquid water for riming



- Uses thresholds on depolarization and backscatter within the precipitation profile.
- Quantifies frequency of lidar detections within the liquid-containing layer.



Flag: “Likely”/”Possible”/”Unlikely”



Summary

For shallow regimes, water content is ~consistent with M11, suggesting surface snowfall rates would be as well.

For deep regimes, underestimation of N0 is significant, leading to underestimation of water content and likely underestimation of snowfall rate. This is probably symptomatic of a bias in assumed particle properties.

The retrieval of size distribution parameters consistent with the particle model assumptions provides a route to assess, diagnose, and improve retrieval performance.

MMCR observations (pre-KAZR) can be used to extend the snowfall record to earlier time periods.