Oliktok Point Site Science: Development of Advanced Observational Perspectives to Aid Model Evaluation

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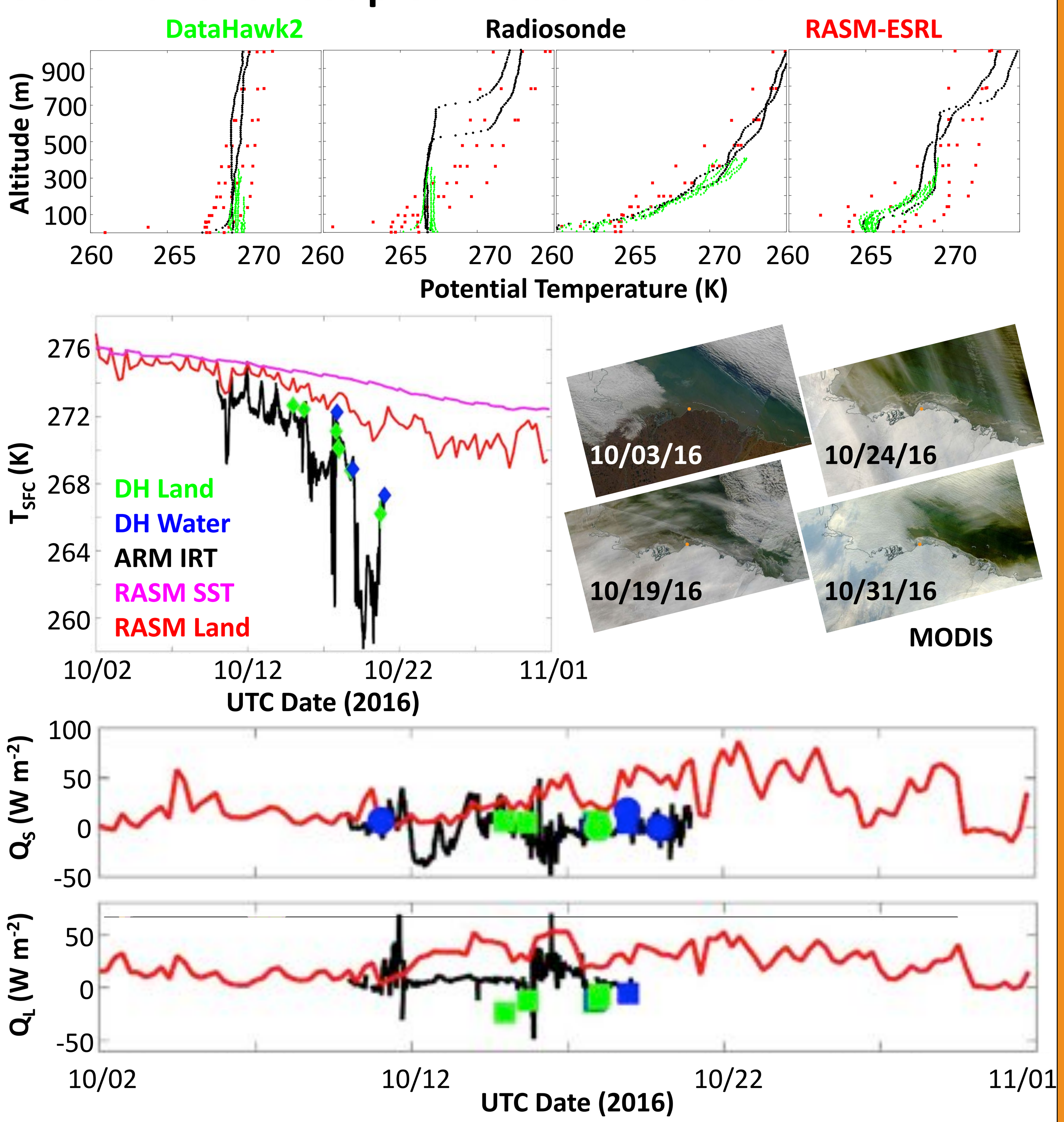
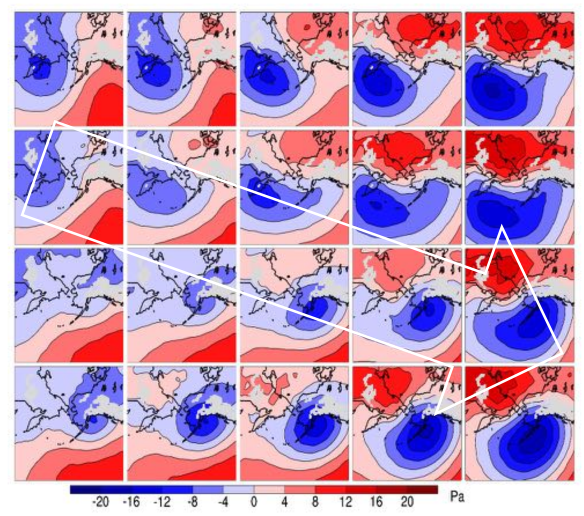
Use of UAS for Coupled Model Evaluation



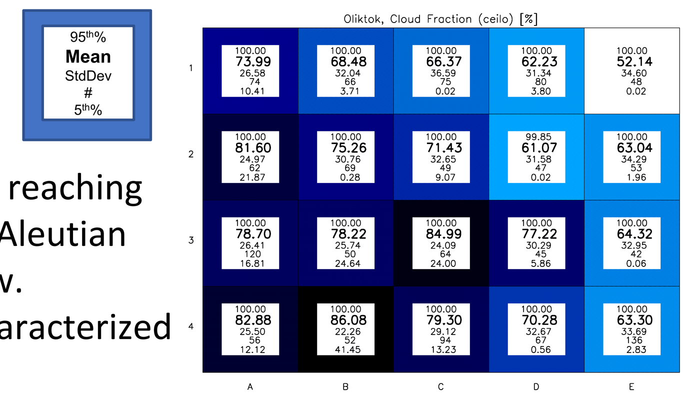
Here we evaluate the performance of the NOAA ESRL version of the Regional Arctic System Model (RASM) in reproducing critical variables for ice formation. This includes lower atmospheric temperature structure, surface temperatures, and turbulent fluxes of heat and moisture at the surface. These comparisons demonstrate the ability of UAS to collect information on vertical structure, spatial variability, and over otherwise difficult-to-sample environments (new sea ice).

Self Organizing Maps to Understand Large-scale Controls on Variability at Oliktok Point

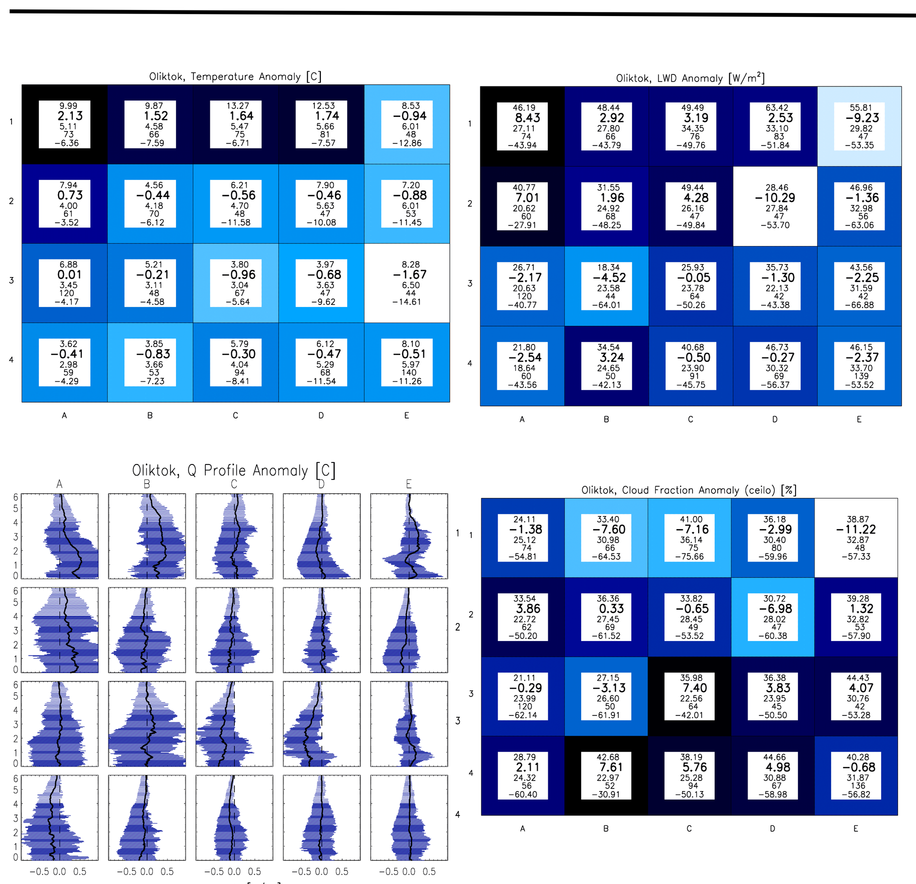


Self Organizing Maps

- Groups similar data into nodes
- Input: daily sea-level pressure anomaly maps from NCEP-NCAR reanalysis (1948 – 2017)
- ← Output: 5x4 grid of generalized patterns with a day list for each node.



- Transition from summer-dominated (low reaching into Arctic) to winter-dominated (strong Aleutian low) nodes along direction of white arrow.
- Daily-mean observations from OLI are characterized for SOM nodes. E.g. cloud fraction →



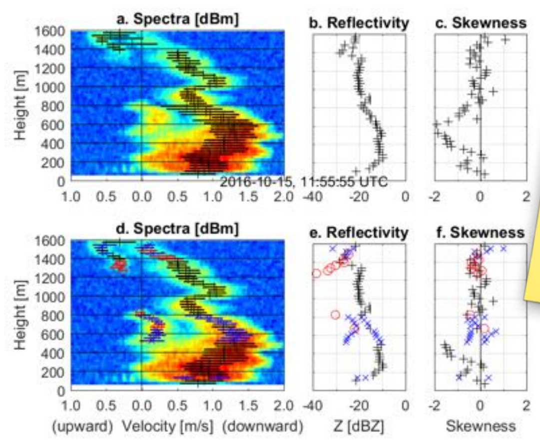
Temperature Variability

- Warm anomalies at OLI w/ low over Kamchatka Peninsula, Russia
- Driven by (1) enhanced LWD from warm moist air; (2) enhanced SWD from decreased clouds.
- OLI surface temperature anomalies are strongly correlated with LWD anomalies (0.74), moderately correlated with PWV (0.41), but weakly correlated with cloud occurrence (0.27) or LWP (0.18).

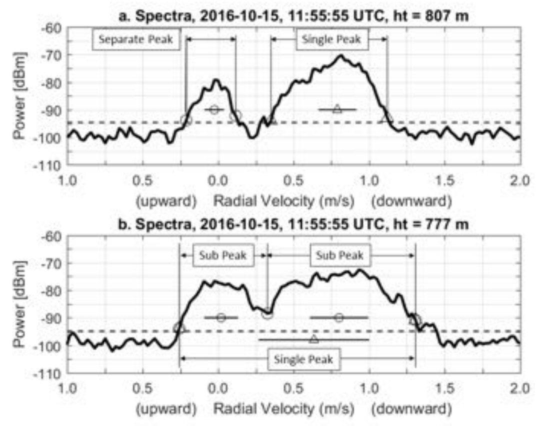
Clutter Mitigation, Multiple Peaks, and High-Order Spectral Moments for Oliktok Point KAZR Spectra

Identifying Multiple Peaks

By analyzing radar velocity spectra, different hydrometeor habits can be identified by their velocity signatures. For example, this velocity spectra profile shows both cloud particles and ice particles occurring in the same height region between 500 to 800 m.



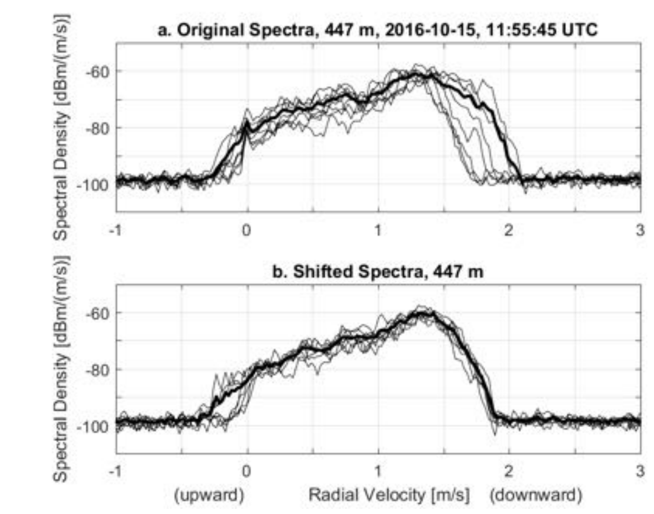
Data Available:
Oliktok Point KAZR Multiple-Peak and High-Order Spectral Moments are on the DOE ARM Archive: www.archive.arm.gov, under "Evaluation Data" and "/Williams".



To study cloud dynamics and microphysics, we need to identify multiple peaks in the spectra corresponding to cloud and ice particles. Identifying multiple peaks is the process of identifying boundaries, or integration limits, which will be used in the spectrum moment equations (Luke and Kollias, 2013). Three types of peaks are identified in the spectra: **single peak**, **sub-peaks**, or **separate peaks**. Every spectrum will have a single peak. However, not every spectrum with a single peak will have sub-peaks or separate peaks.

Shift-then-Average Spectra

Velocity spectrum skewness is a noisy estimator due to velocity bin-to-bin spectrum power fluctuations. Shifting spectrum to a common reference during an averaging interval reduces spectrum broadening due to vertical air motion variability (Giangrande et al. 2001). As an example of the shifting processing, these panels show eight (8) spectra collected over 15 second interval before and after shifting to the mean velocity. The thick line is the corresponding mean spectrum.



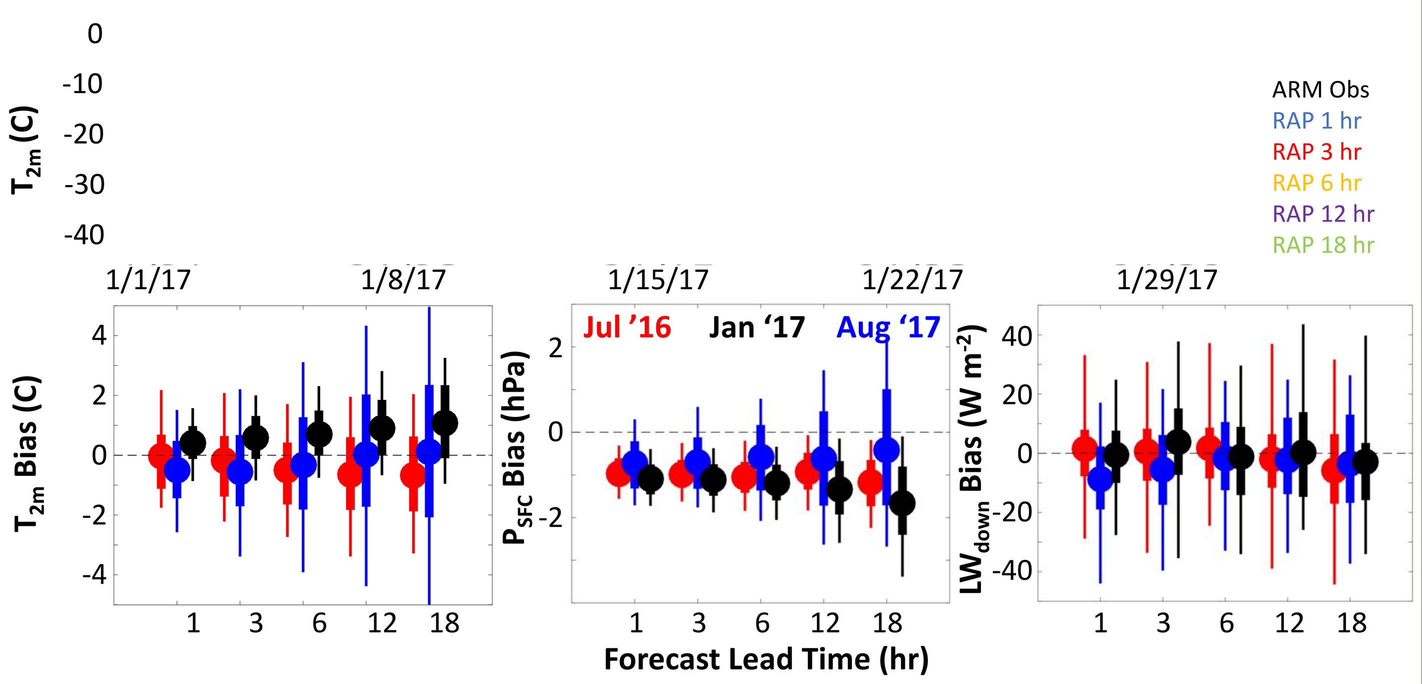
Manuscript describing the data set:
Williams, C., M. Maahn, J. Hardin, and G. de Boer, 2018: Clutter Mitigation, Multiple Peaks, and High-Order Spectral Moments in 35-GHz Vertically Pointing Radar Velocity Spectra. Atmos. Meas. Tech., submitted.

References
Giangrande, S. E., Babb, D. M., and Verlinde, J.: Processing millimeter wave profiler radar spectra. J. Atmos. Oceanic Technol., 2001.
Luke, E. P. and Kollias, P.: Separating cloud and drizzle radar moments during precipitation onset using Doppler spectra, J. Atmos. Ocean. Tech., 2013.

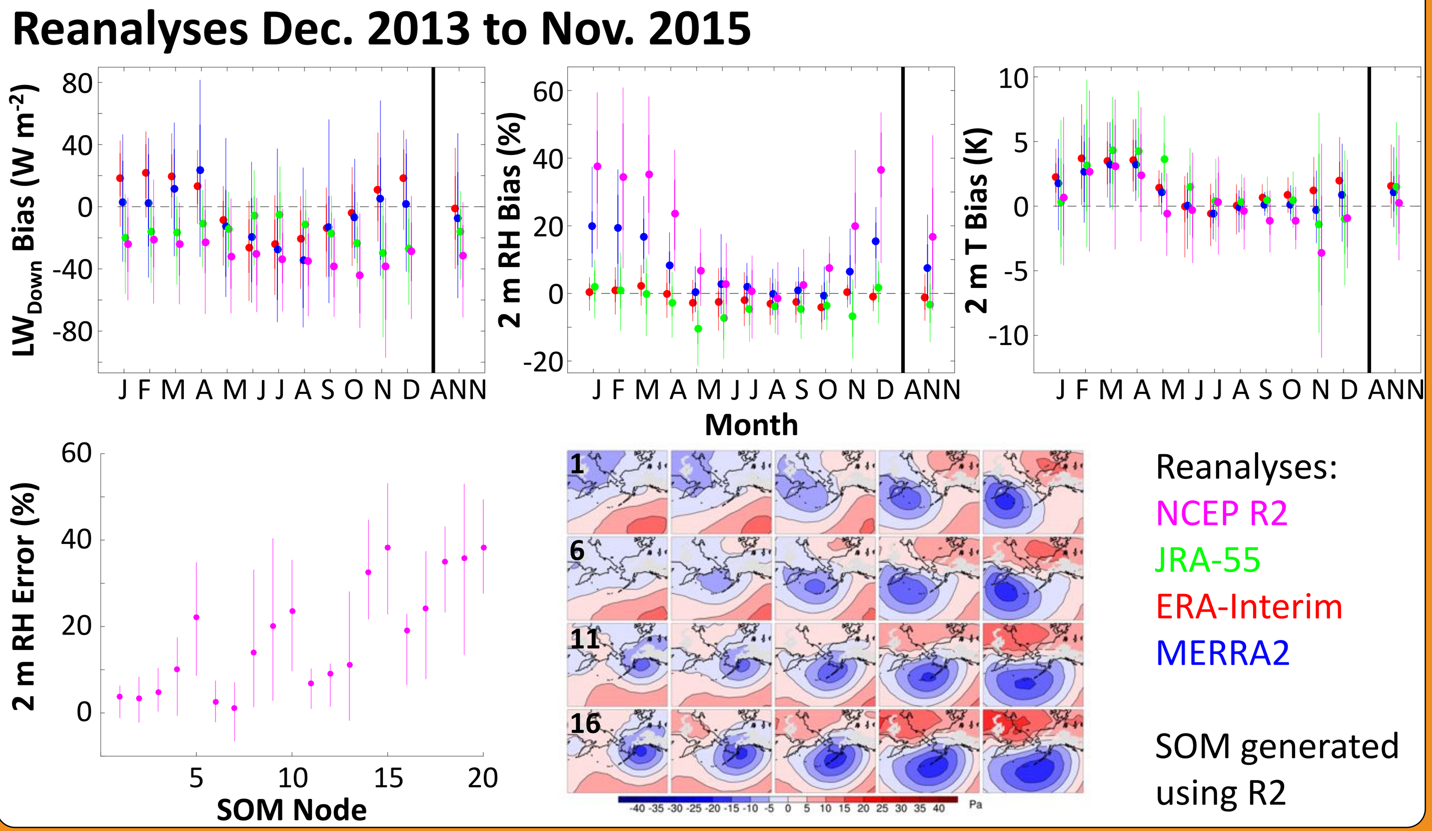
Oliktok Data for Long-Term Model Evaluation

In addition to event-based model evaluation (e.g. sea ice formation period), the long measurement record at Oliktok Point and the fact that these have not been assimilated through the GTS makes this a great dataset for general model evaluation work.

Operational Forecast Models (RAP, HRRR)



Reanalyses Dec. 2013 to Nov. 2015

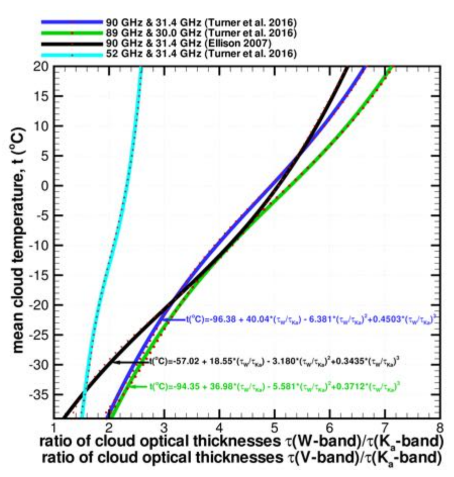


Reanalyses:
NCEP R2
JRA-55
ERA-Interim
MERRA2

SOM generated using R2

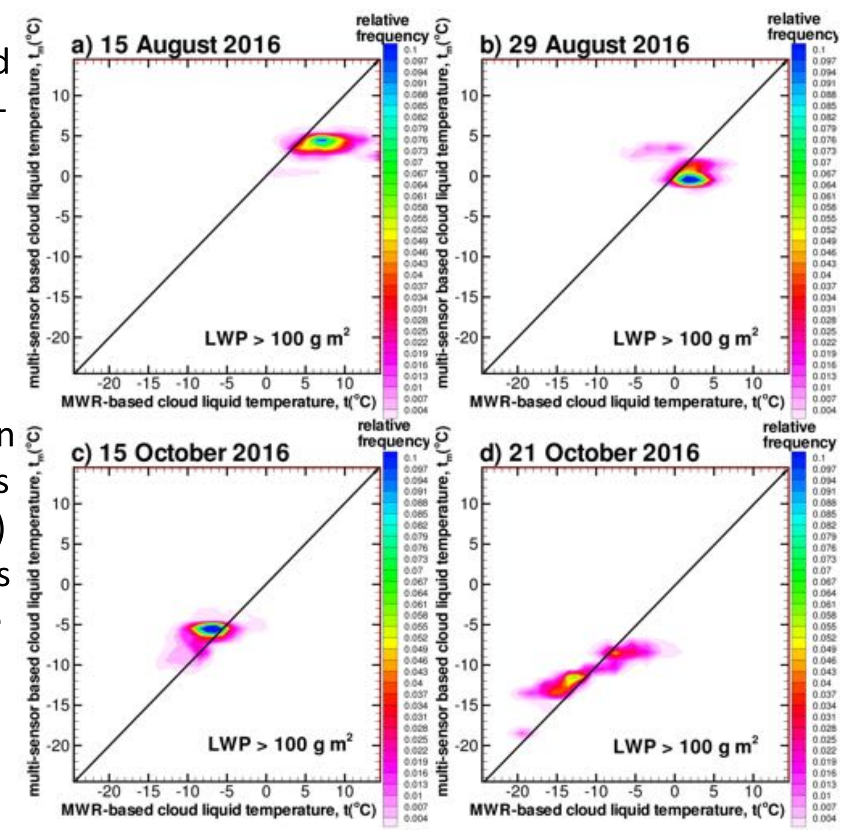
Retrieving cloud liquid temperature from three-channel microwave radiometer measurements

Besides the standard retrievals of integrated water vapor (IWV) and liquid water path (LWP) using ARM three-channel (~ 24, 30 and 90 GHz) microwave radiometer brightness temperature measurements, estimates of the mean cloud liquid temperature can also be obtained. This does not require any additional remote sensor or radiosonde data.



The novel method suggested here uses the strong temperature dependence of the cloud liquid optical thickness ratio at W-band (~ 90 GHz) and K_a-band (~30 GHz) frequencies. Modeling results shown on the left are for different dielectric constant models (i.e., Turner at al. 2016; Ellison 2007). The gaseous contributions to the total optical thicknesses are accounted for using IWV radiometer retrievals and near surface air temperature and pressure data.

Comparisons of mean cloud liquid temperatures derived from three-channel microwave radiometer at the AMF3 with those obtained from ceilometer cloud base and interpolated radiosonde data are shown on the right.

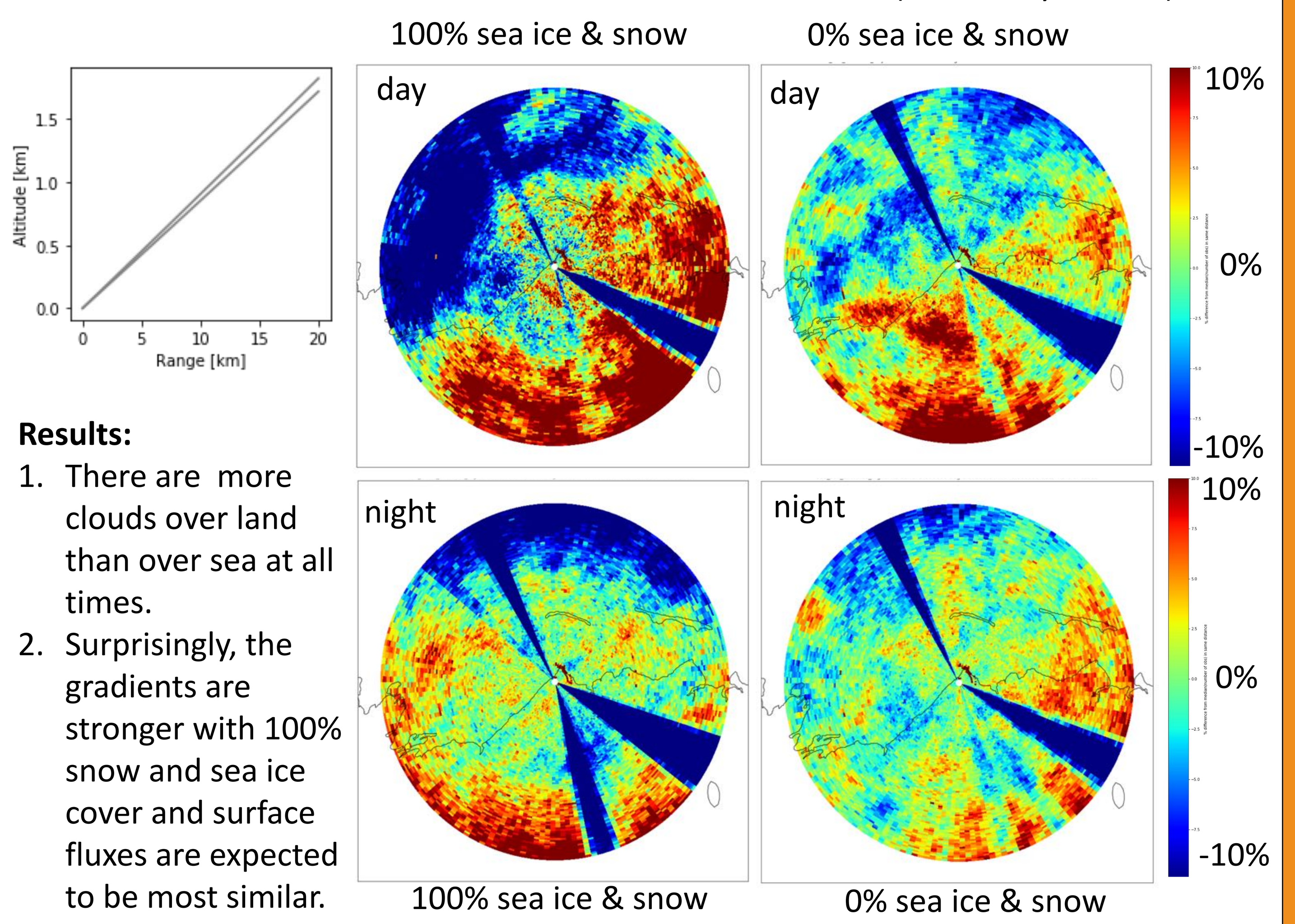


The agreement is generally within ~3°C for widely varying conditions ranging from all warm stratus (a) to supercooled liquid cloud layers embedded into precipitating ice hydrometeors (d).

Matrosov, S.Y., and D.D. Turner, 2018: Retrieving mean temperature of atmospheric liquid water layers using microwave radiometer measurements. *J. Atmos. Oceanic Technol.*, **35**, in press, doi: 10.1175/JTECH-D-17-0179.1

Spatial Dependence of Cloud Properties at Oliktok Point in Northern Alaska

At Oliktok Point, the scanning 35 GHz KaSACR radar is located directly at the shore.
Key Question: How do surface properties (water, ice, bare soil, snow) impact cloud properties?
Data: All KaSACR 5° PPI scans from March 2016 to September 2017.
Method: Look at relative differences in number of occurrence (reflectivity > 6 dBz).



Results:

1. There are more clouds over land than over sea at all times.
2. Surprisingly, the gradients are stronger with 100% snow and sea ice cover and surface fluxes are expected to be most similar.
3. In the polar night, the gradient is strongest at distances larger 15 km, i.e. in the free troposphere at altitudes larger than 1.2 km.

Acknowledgments

ASR Atmospheric System Research

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