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Shortwave Spectral and Broadband Measurements During AWARE

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2019 ARM/ASR Joint User Facility and PI Meeting

- Panalytical (Inc.) SW Spectroradiometer at WAIS Divide Ice Camp Dec 2015 – Jan 2016
  - Retrieval of single-phase cloud τ_c and r_e in climatological summer conditions followed by warm surface melt event (Nicolas et al. 2017)
  - Wilson et al., 2018: *JGR*, doi:10.1029/2018JD028347
- MFRSR and SKYRAD at McMurdo Station during 2015-16 summer season
  - Retrieval of mixed-phase cloud τ_c from MFRSR
  - Identification of prevailing meteorological regimes using *k*-means clustering ➔ influence on surface flux
  - Scarci et al., 2019: *GRL*, in review

The ARM West Antarctic Radiation Experiment (AWARE) was jointly supported by DOE ARM/ASR and NSF Office of Polar Programs.

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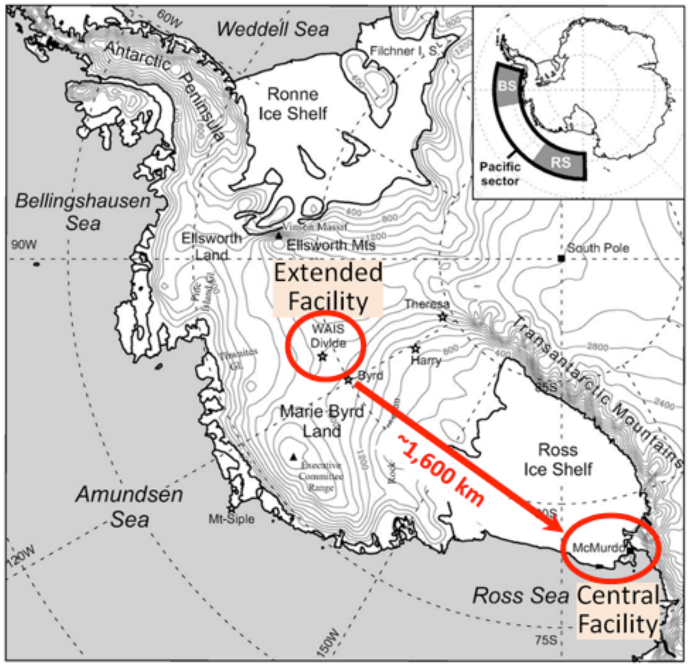
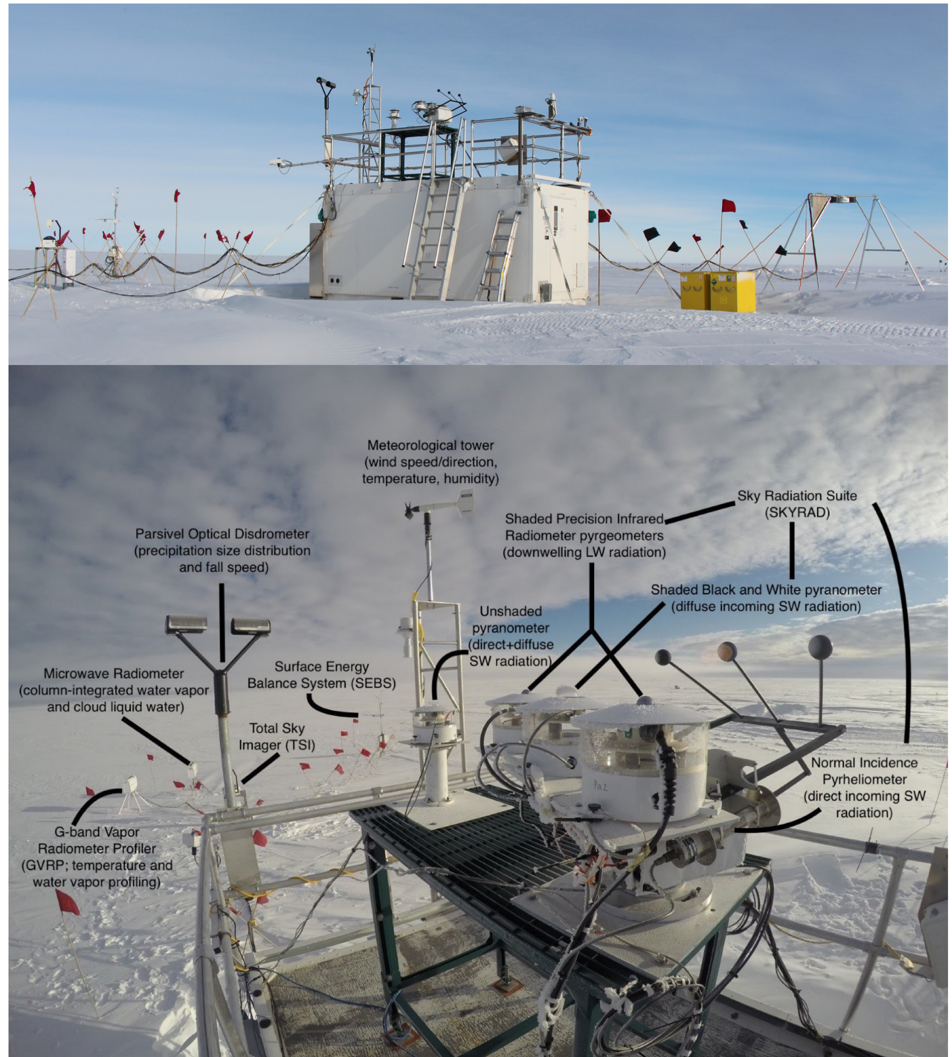
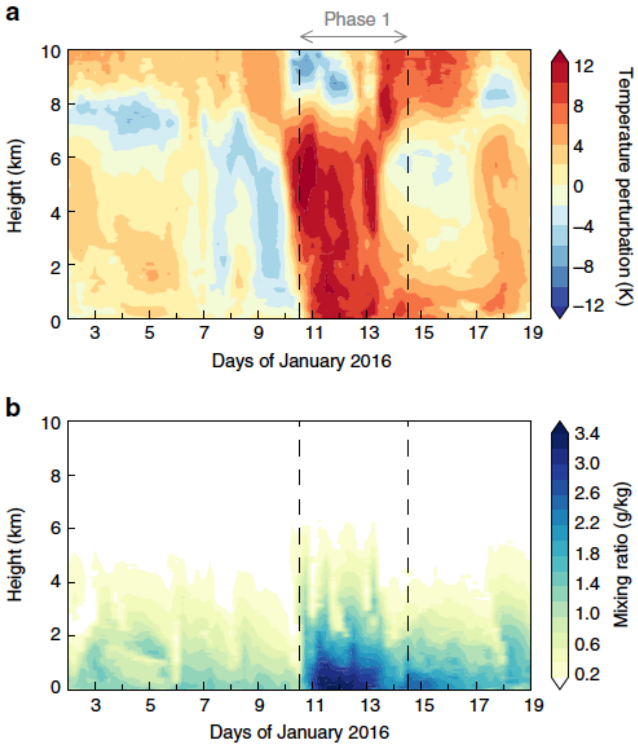
WAIS Divide Ice Camp

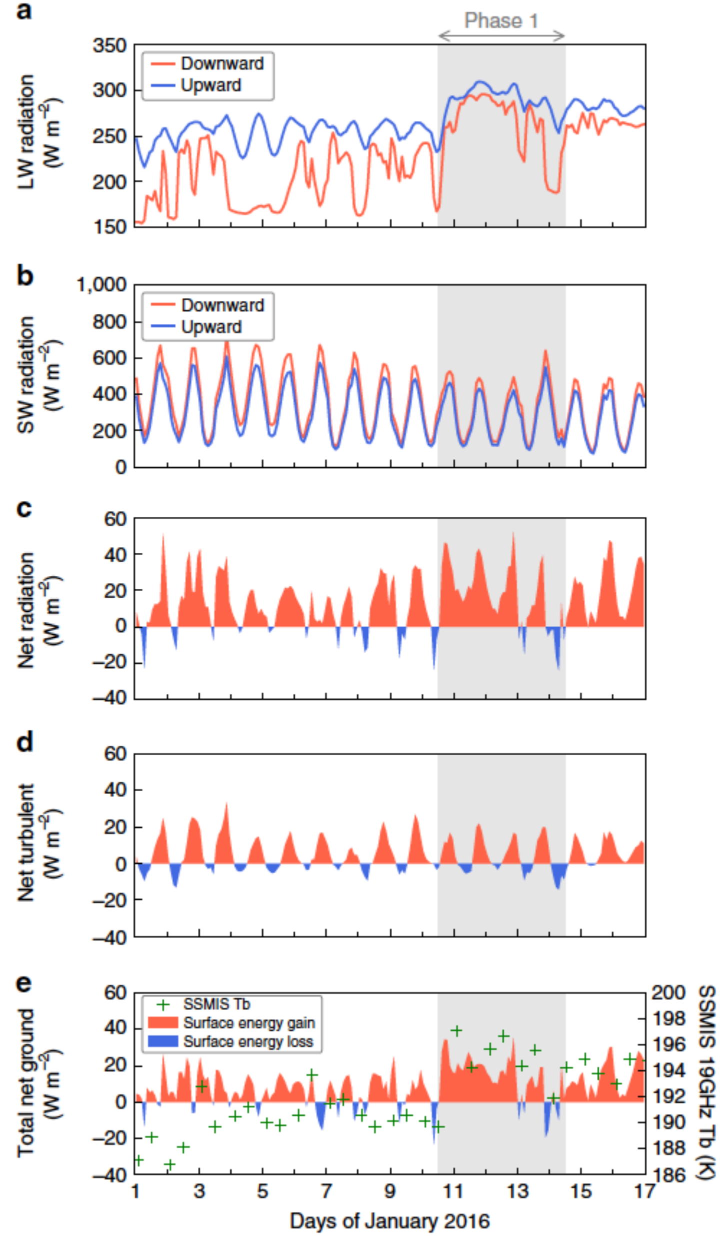




- Small equipment suite optimized for surface energy budget (SEB) measurement
- In location highly relevant for sea level rise
- 4 Dec 2015 – 17 Jan 2016

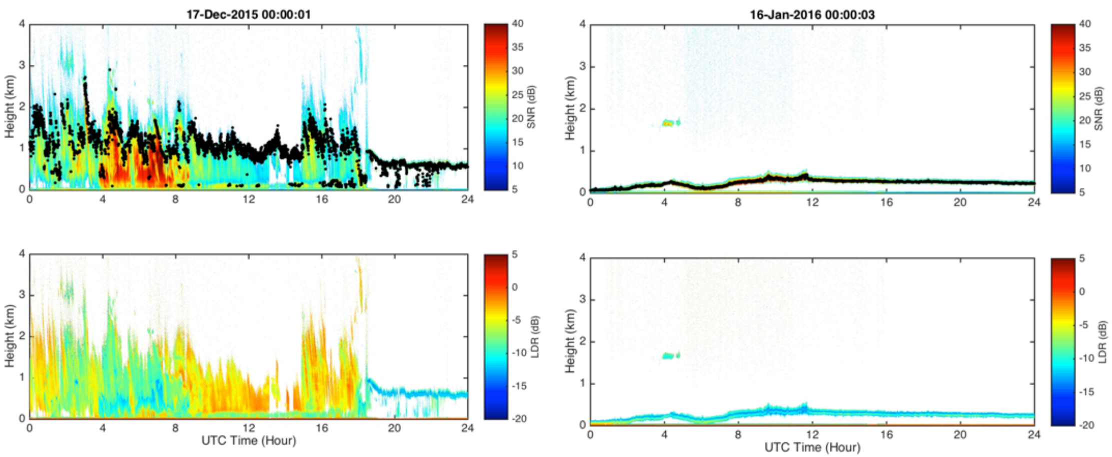
2016 Surface Melt Event



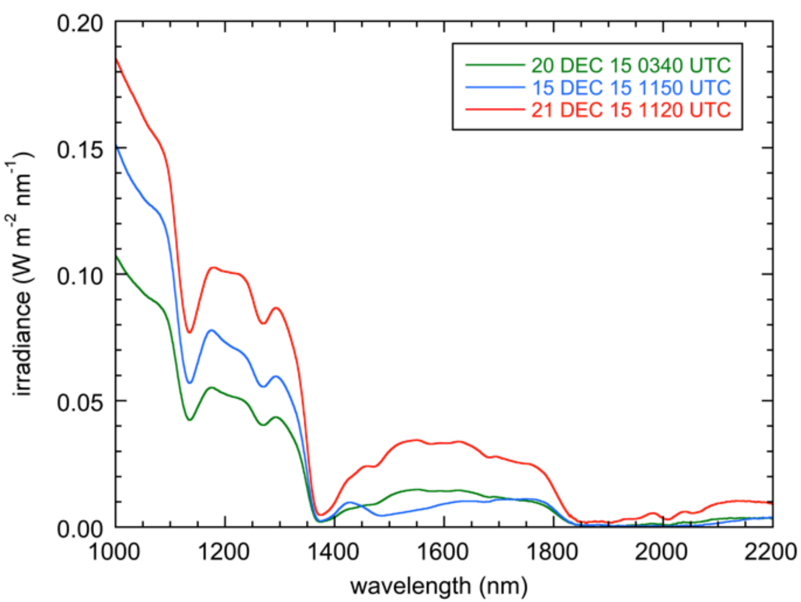


- AWARE sampled major surface melt event Jan 10-18 2016
- Atmospheric "river" brought huge impulse in temperature and moisture
- Measured SEB diagnoses cloud LW & SW role

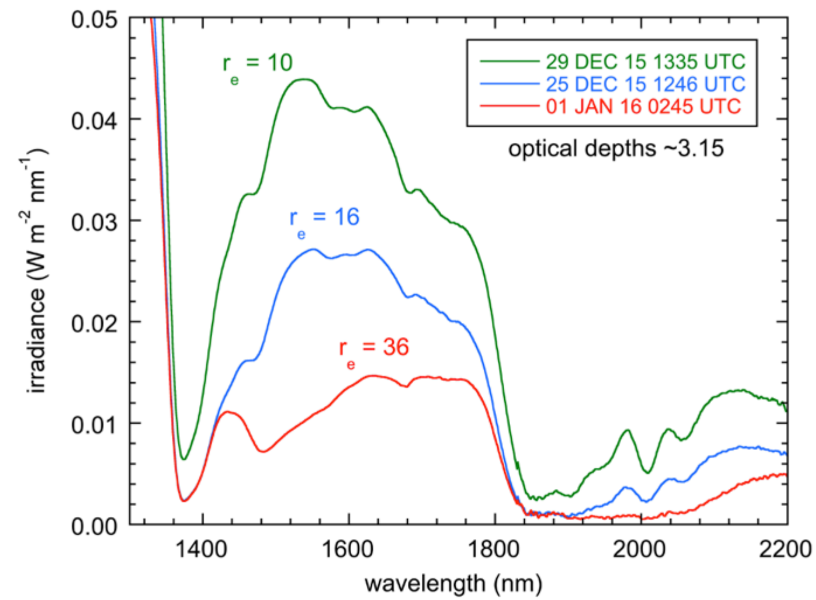
SW Spectral and MPL Data



- Left: Micropulse Lidar (MPL) data identify cloud phase via depolarization ratio
- Below: Information content in SW spectra, particularly in 1.6-µm window

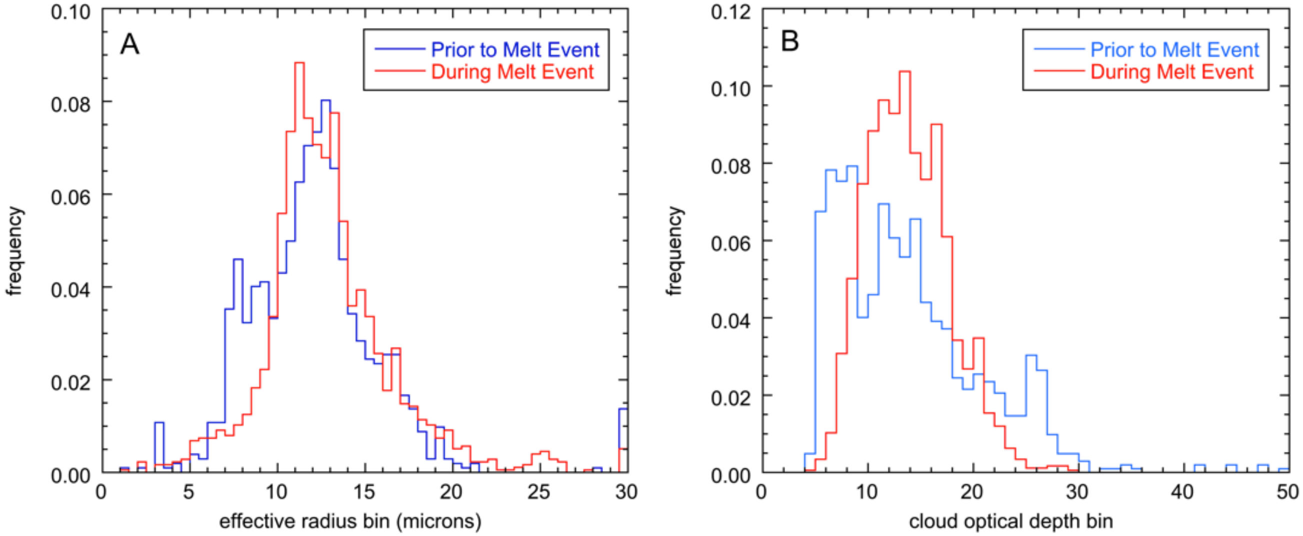


Clear Sky – Liquid Water Cloud – Ice Cloud



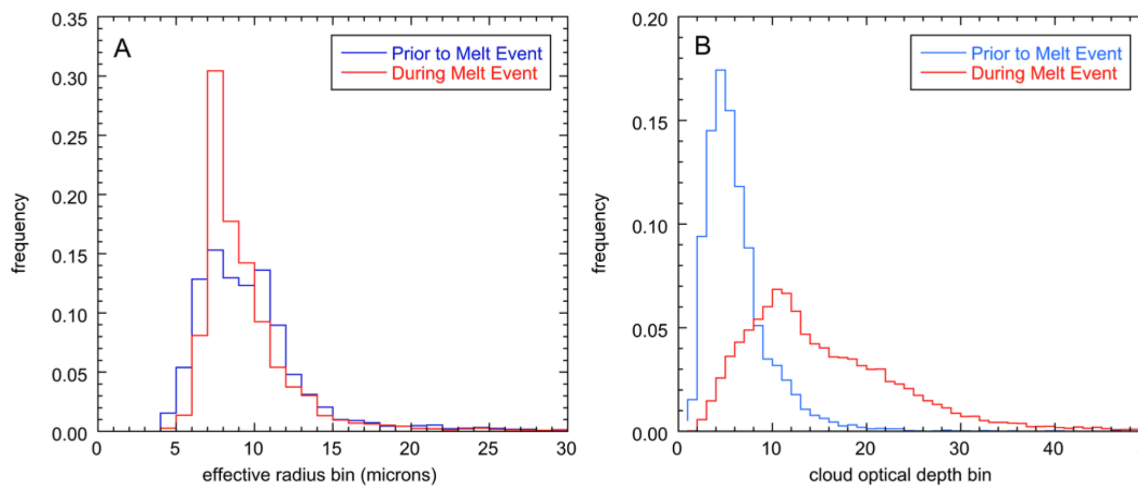
Ice clouds of similar τ_c, different r_e

Cloud Property Retrievals



DISORT-based lookup table, least-squares minimization technique adapted from McBride et al. (2011)

Results suggest a bimodal r_e distribution before melt event



Right: Concurrent MODIS retrievals are qualitatively consistent with AWARE results

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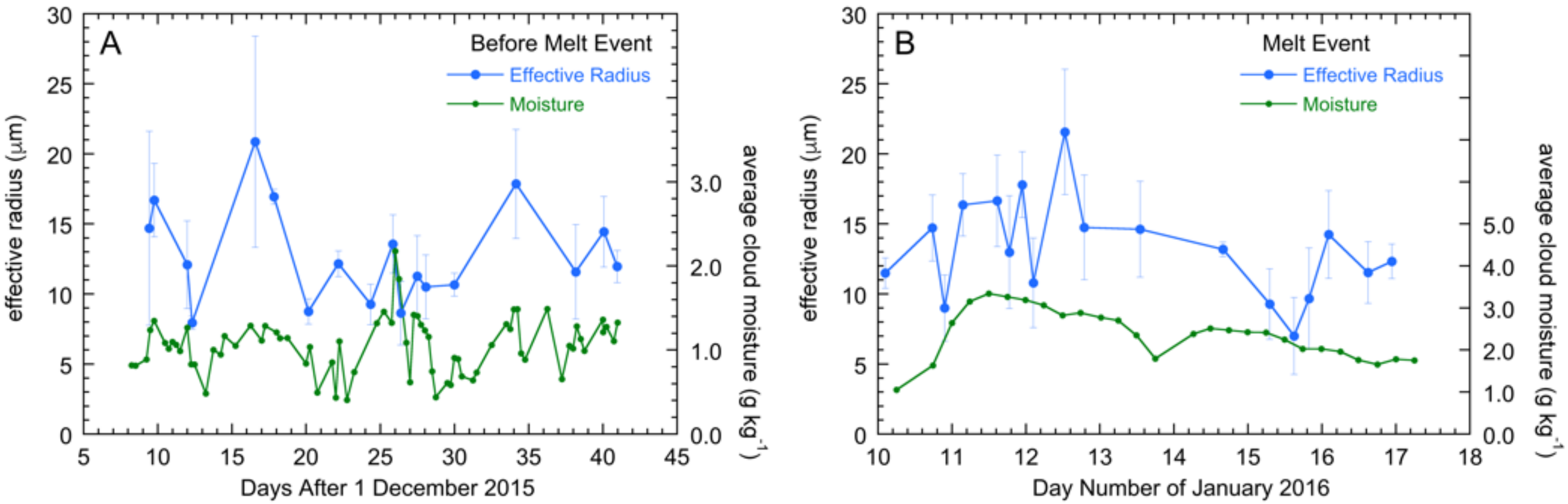
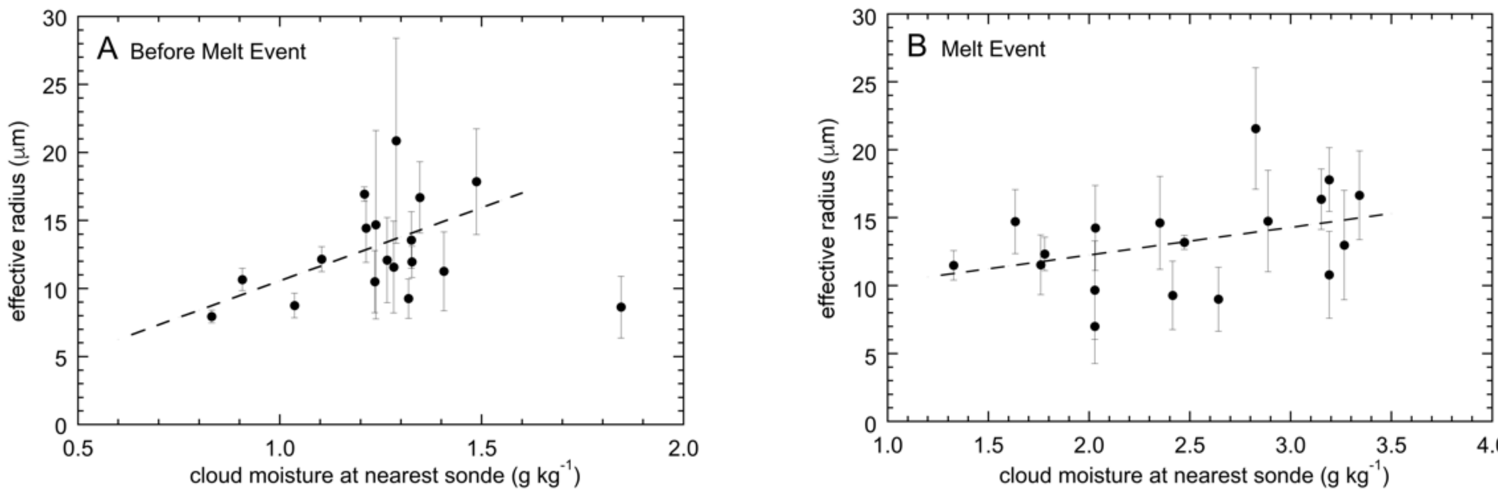
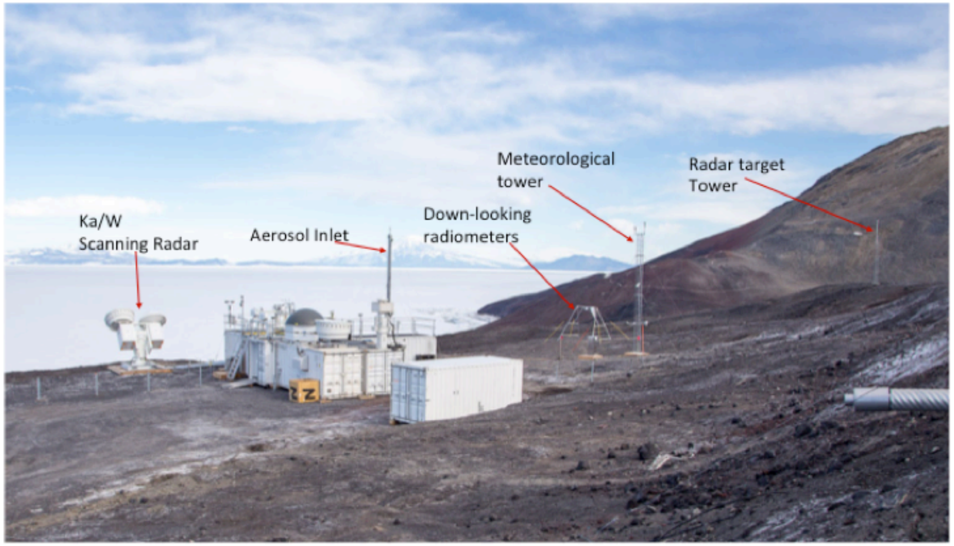
Interpretation





Correlating r_e with sonde moisture: Smallest r_e are in driest environment (pre-melt)

AMF2 on Ross Island



AMF2 deployed at the CosRay site

- ~1 km from McMurdo Station
- Best compromise for hemispheric radiometry
- Dec 2015 through Dec 2016

- Lots of great instruments, but no SW spectroradiometer until Feb 2016
- First summer – we use MFRSR and SKYRAD to examine cloud properties and their influence on SW surface radiation

Meteorological Regimes

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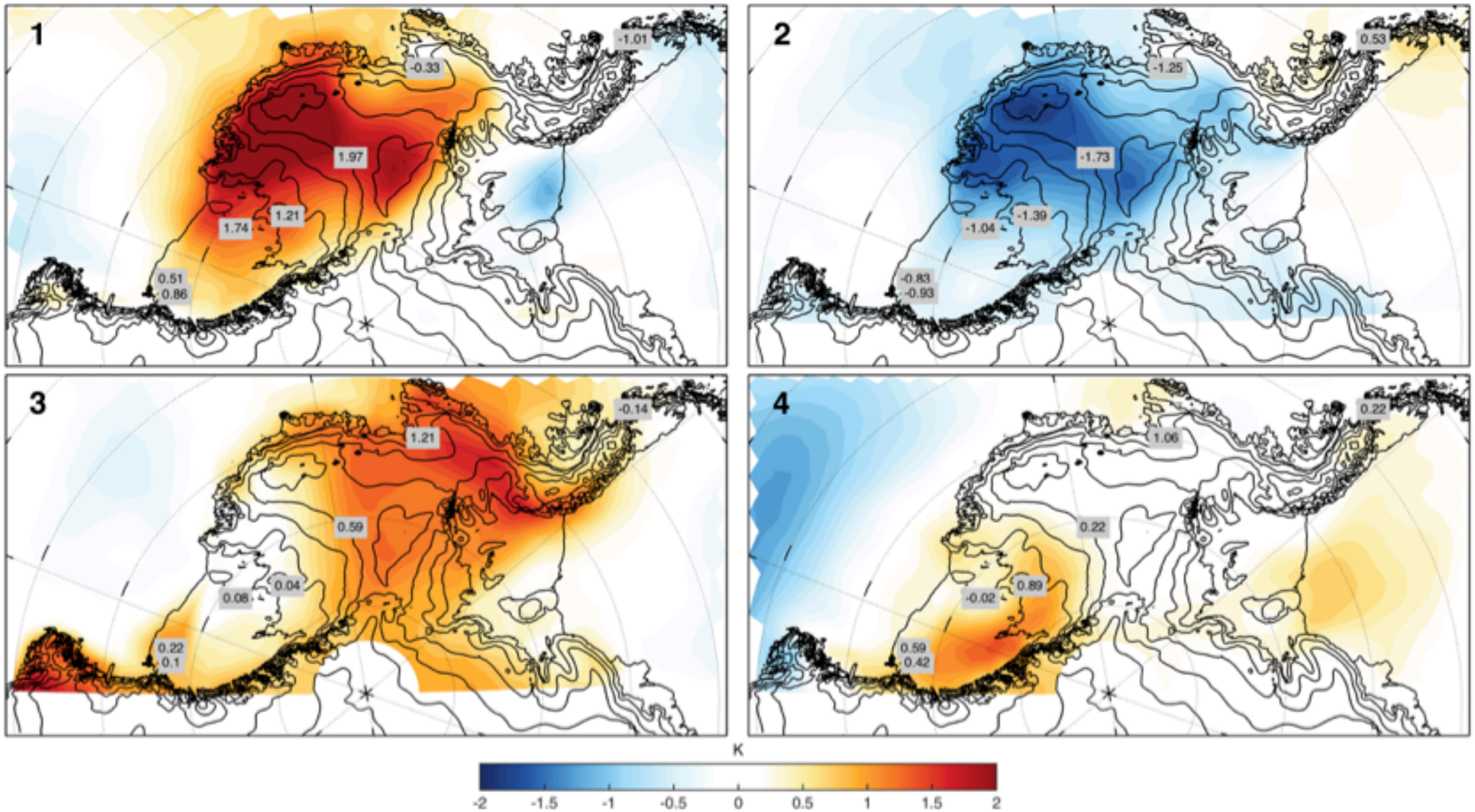


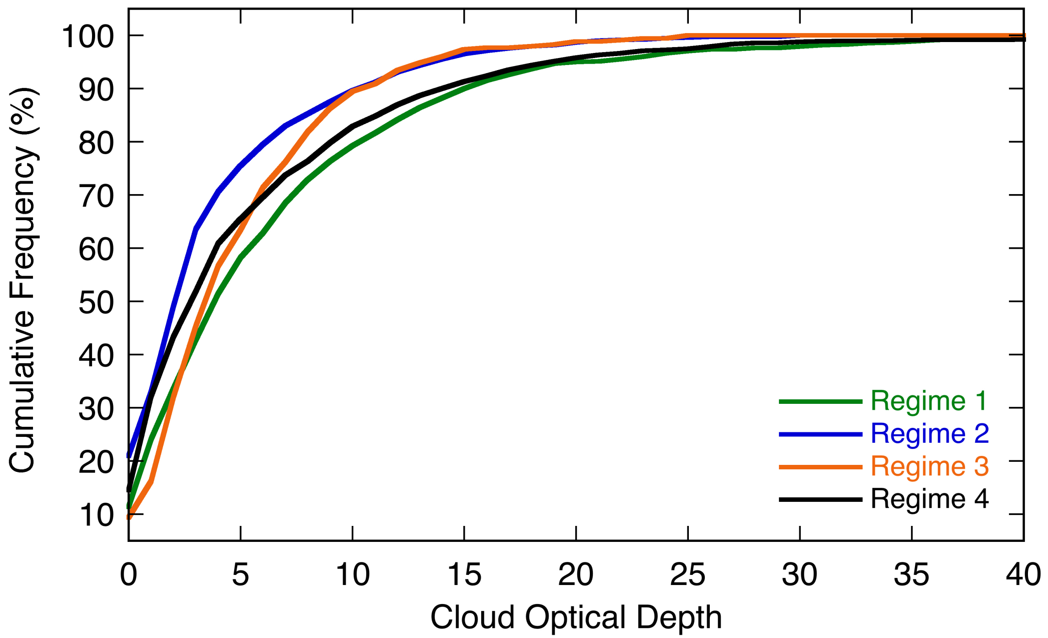
Cluster 2:
Cold - Outflow

Cluster 4:
Orographic impact on cloud

Using *k*-means clustering we identify four prevailing meteorological regimes

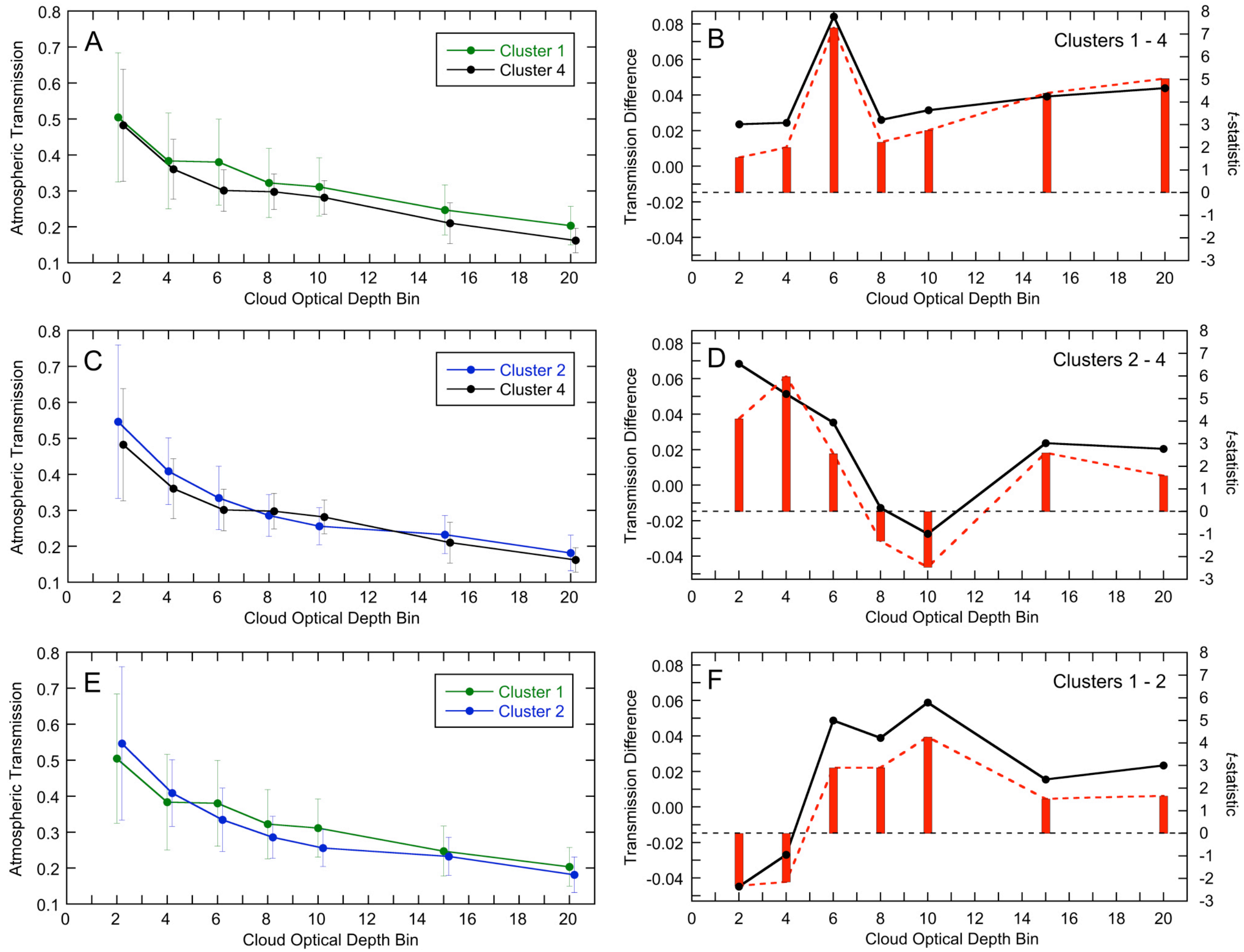
1. Blocking high over Amundsen Sea, northeasterly onshore flow
2. Low over Bellingshausen Sea causes outflow of continental polar air
3. Anticyclonic flow over Ross Sea advects marine air toward Ross Island
4. Large-scale cyclonic flow brings air from over Transantarctic mountains

MFRSR Cloud Optical Depth



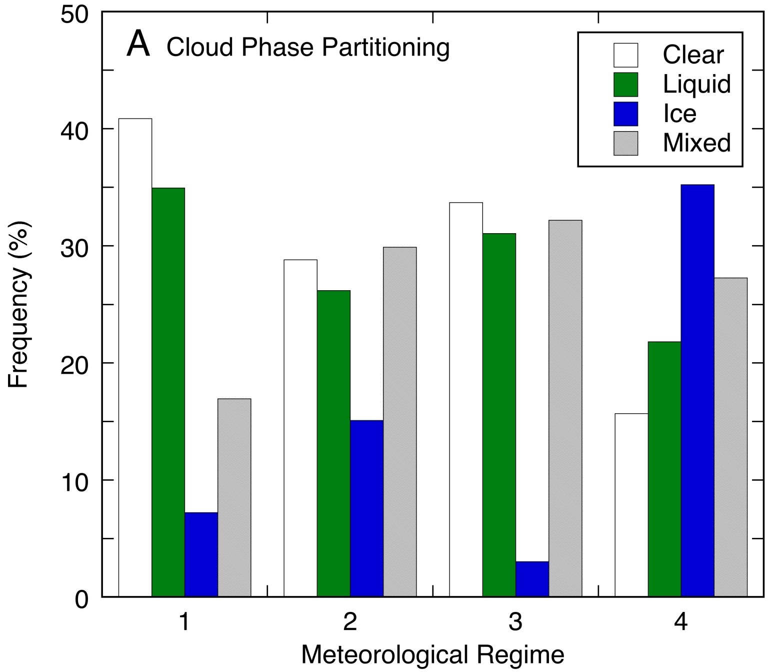
- We use MFRSR 870-nm channel to retrieve cloud optical depth
- Averaged over 10 minutes to eliminate autocorrelation (Bretherton et al. 1999)
- TSI total cloud cover >95% for overcast skies
- Radiative transfer – surface irradiance is simple monotonic function of τ_c
- Smaller range of τ_c for regime 2 (cold) and regime 3 (warm, infrequent)
- Larger and similar ranges of τ_c for regime 1 (warm onshore) and regime 2 (orographic)

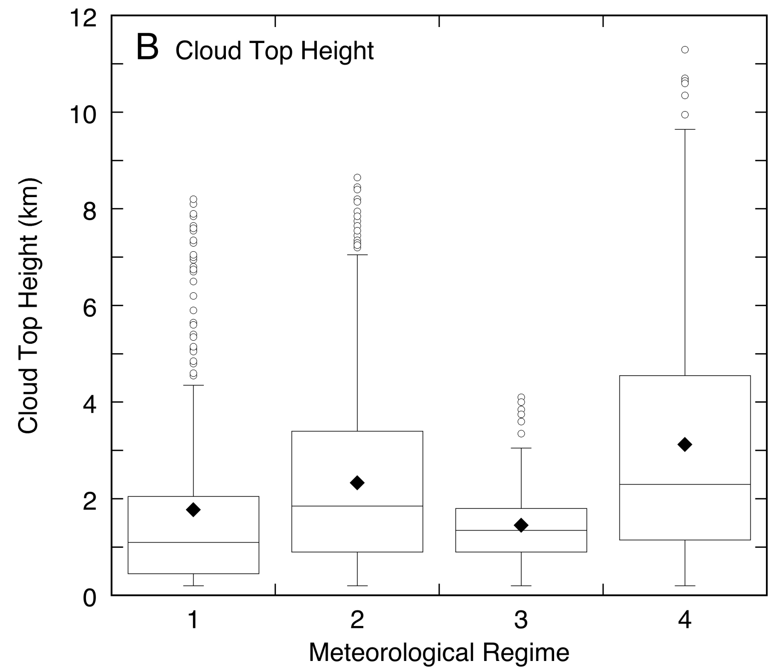
SKYRAD Interpretation



- We find statistically significant differences between clusters, in constant τ_c bins
- Average SKYRAD flux difference between regimes 1 and 4 is 6.6 W m^{-2}

MODIS Cloud Properties





MODIS cloud data product shows greater cloud liquid water in warm, onshore flow regimes and greater ice content in orographic regime.

MODIS also shows greater cloud geometrical extent for the cold regime (2) and particularly the orographic regime (4).

THANKS! ***QUESTIONS?***