Cloud ice water attenuation of shortwave radiation: new and unique spectral measurements from Antarctica

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ASD shortwave spectroradiometer deployed with ISDAC at Barrow, April 2008

Deployed from 10 October 2012 to 04 February 2013 at Arrival Heights, Ross Island Antarctica

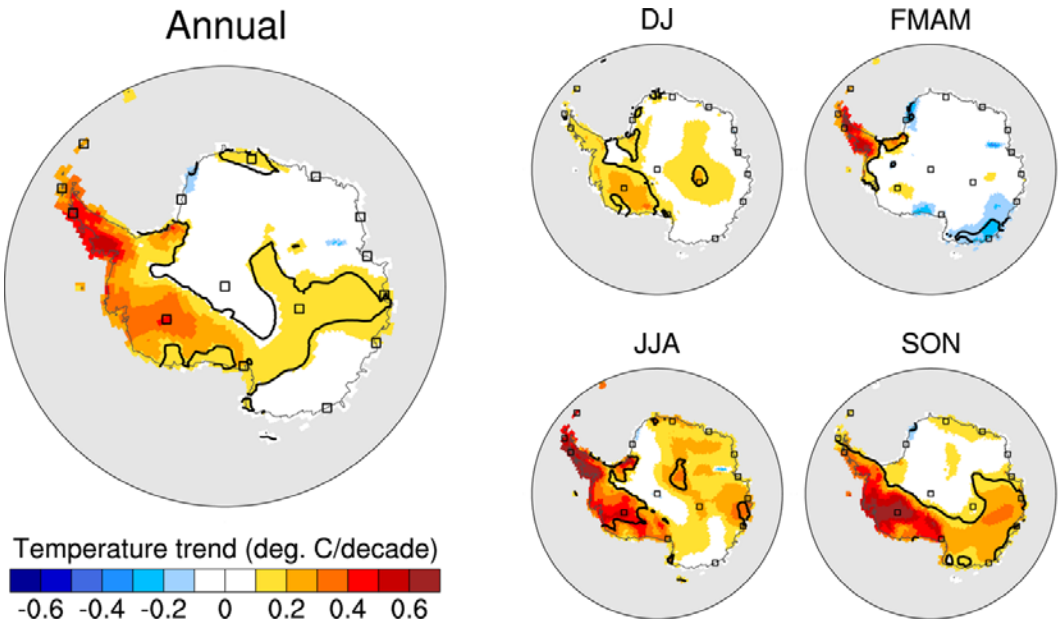
Measures hemispheric (direct + diffuse) spectral irradiance, 350-2200 nm, 3-10 nm resolution, in 1-minute averages nearly continuously. Similar to ARM's SAS-He instrument.

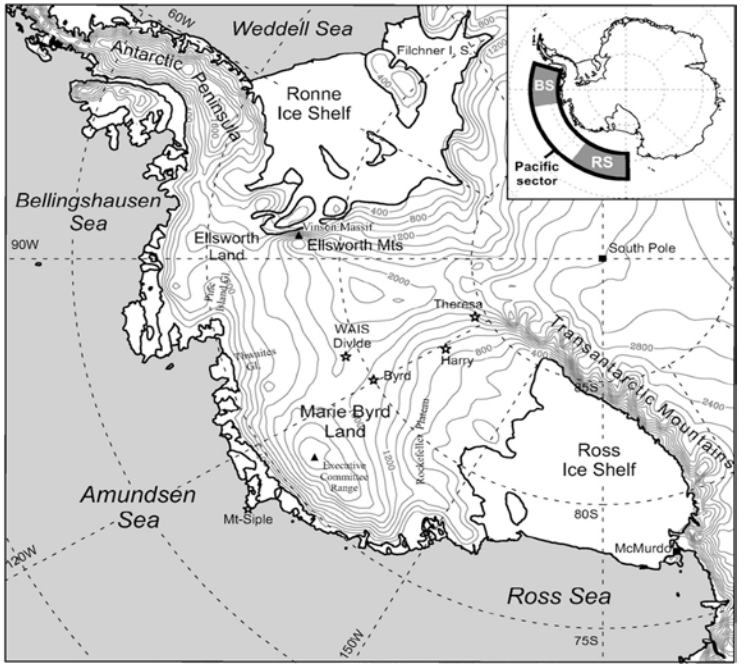
Spectral irradiance data under overcast cloud interpreted in terms of a "supplemental ice absorption A_{si}: Difference in the 1.6 micron window between measured flux and theoretical flux under a liquid water cloud of r_e = 11 μm.

Arrival Heights

Scientific Motivation

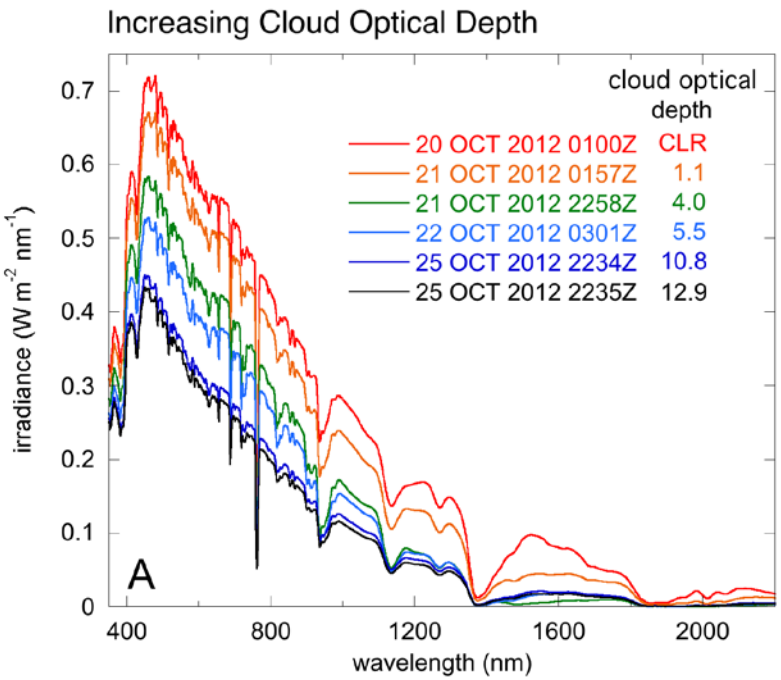
Recent discovery of West Antarctic Ice Sheet warming (Steig et al., 2009) now known to extend as far as McMurdo and parts of East Antarctica (Nicolas & Bromwich, 2013)

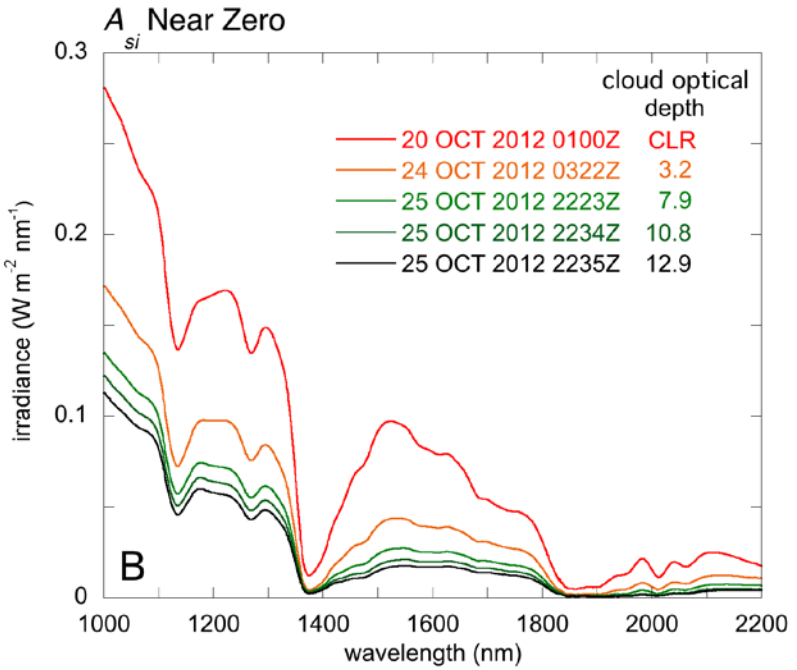




Moisture and cloud cover over the WAIS (Marie Byrd Land) strongly influenced by location of lows in Ross versus Bellingshausen Seas.

Moisture and cloud-bearing air masses advected over WAIS can make their way down onto the Ross Ice Shelf and eventually reach McMurdo.

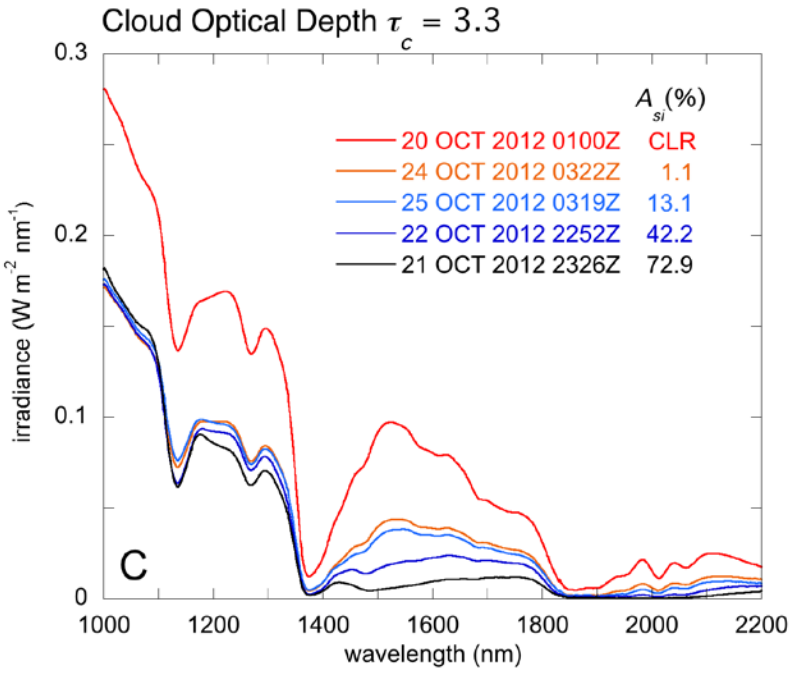




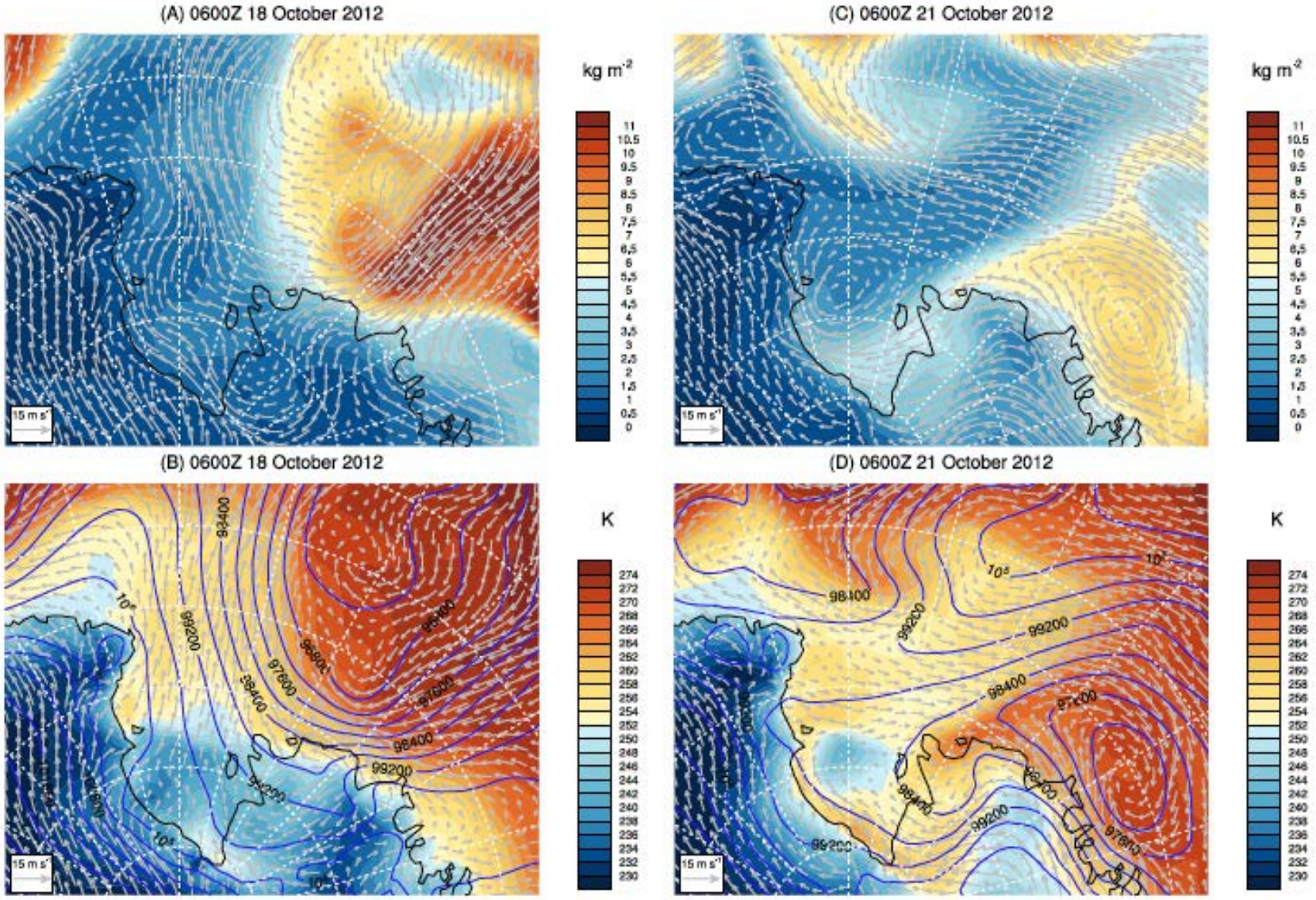
Sample Spectra from October, 2013, Ross Island, SZA=66°.

Cloud optical depth τ_c retreived from 1022-1033 nm irradiance

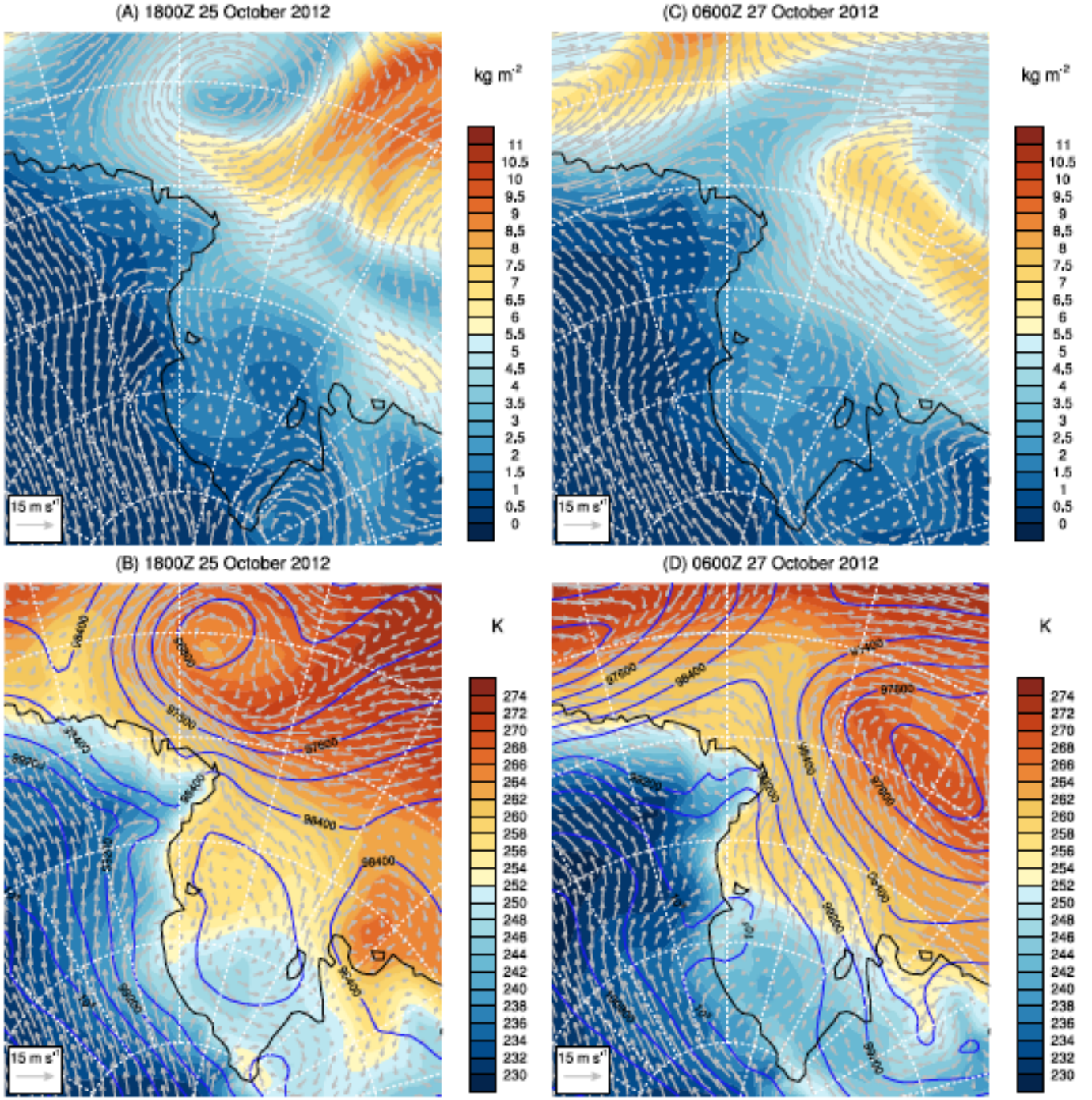
A. Influence of increasing τ_c.
B. Examples with $A_{si} \approx 0$, increasing τ_c.
C. Fixed optically thin τ_c, increasing A_{si}.

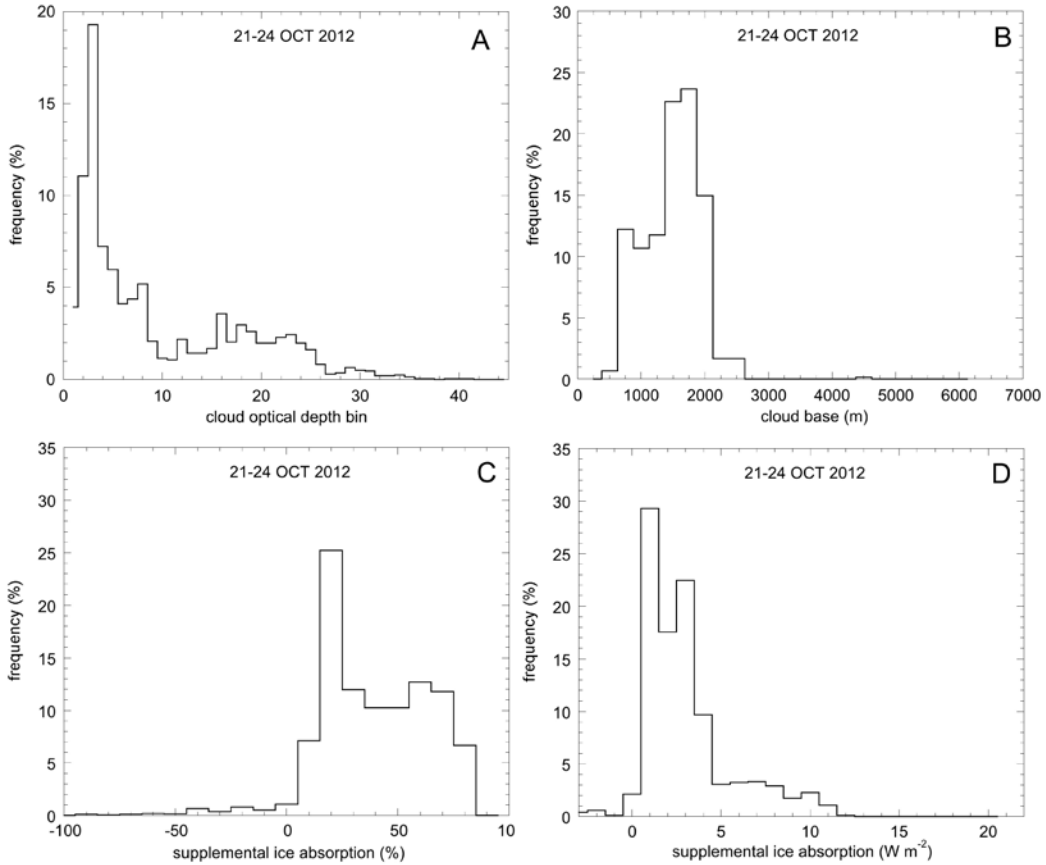


21-24 October 2012 Case: Moisture descending the WAIS and transiting RIS to reach McMurdo in a southerly flow.

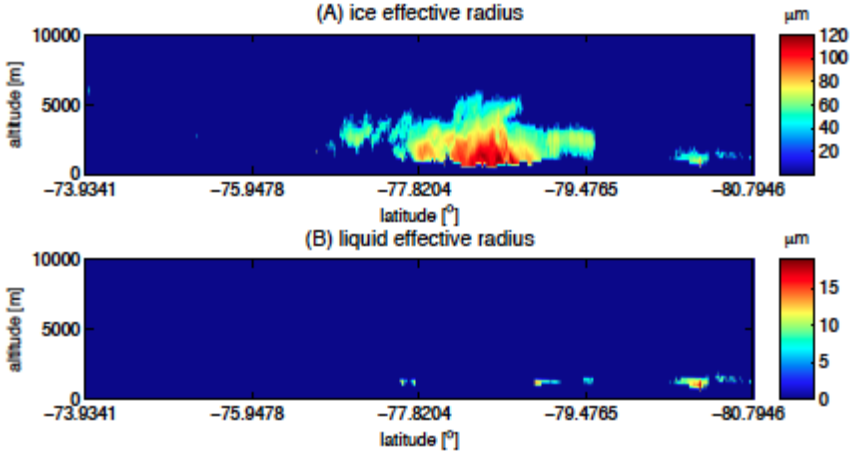


25-26 October 2012
Case: Shift to northerly onshore flow of moist marine air

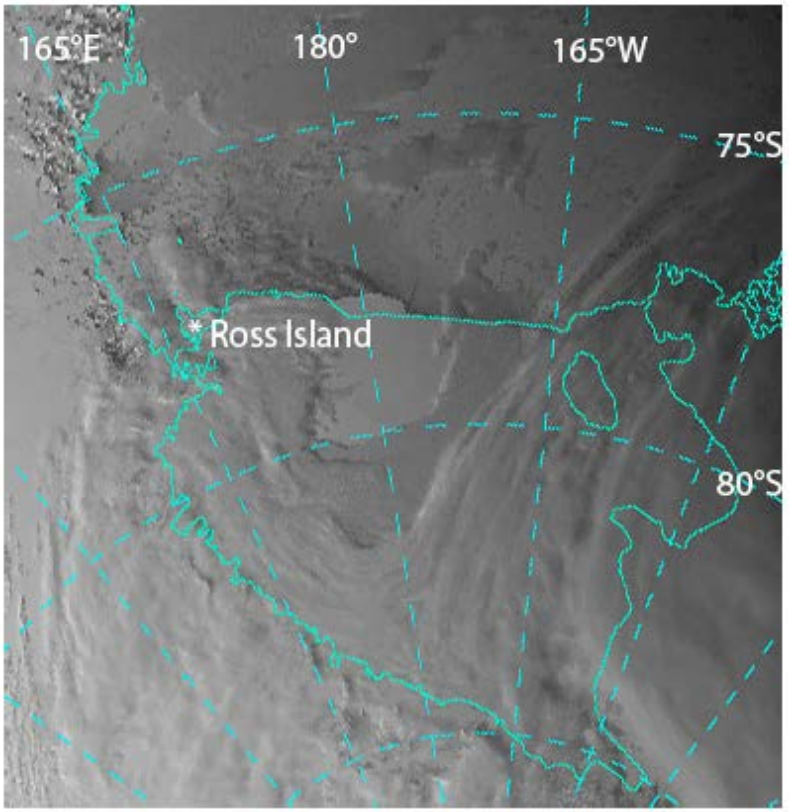


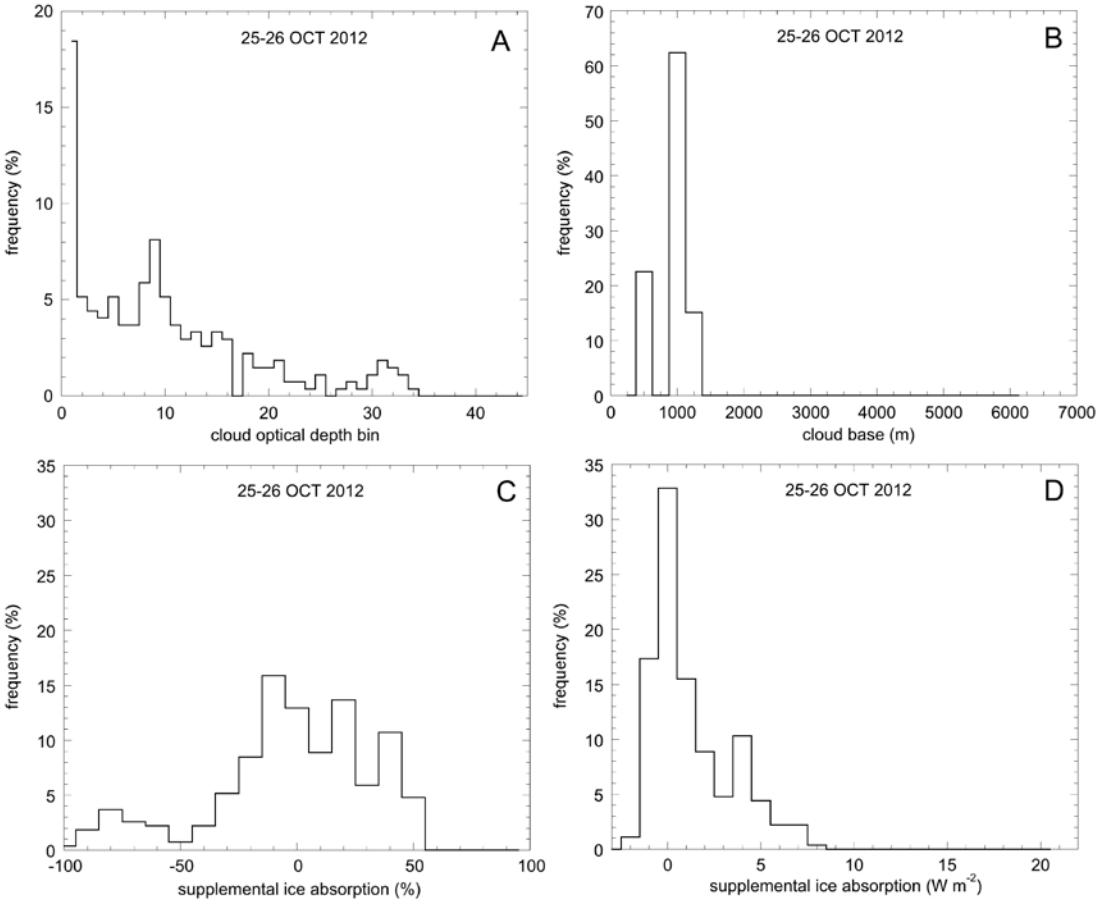


ASD spectroradiometer and FMQ-19 ceilometer retrievals, 21-24 OCT 2012

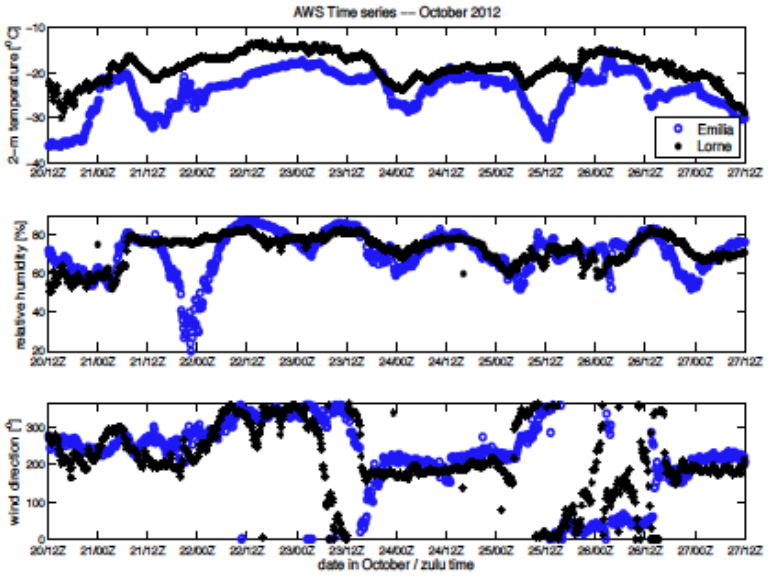


CloudSat CPR 0528 Z, MODIS 0700 Z 21 OCT 2012

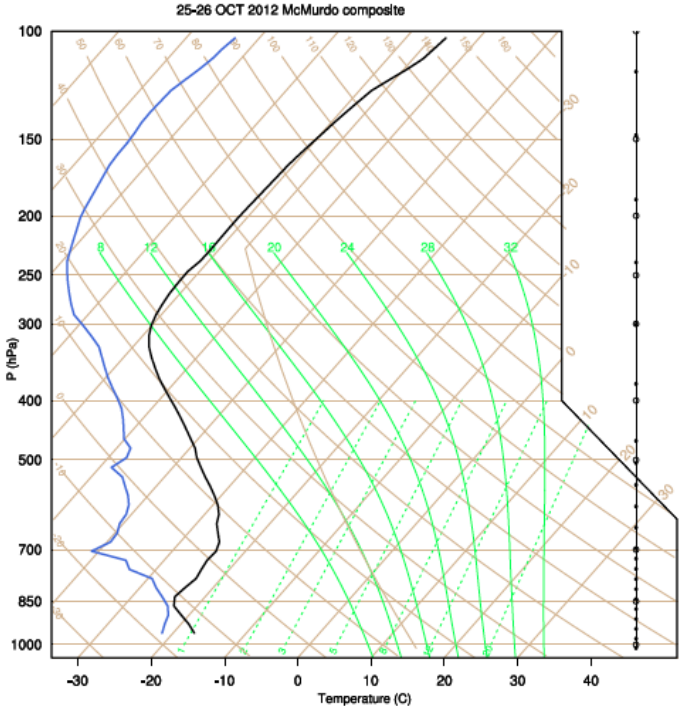




ASD spectroradiometer and FMQ-19 ceilometer retrievals, 25-26 OCT 2012



AWS data near Arrival Heights



Sonde composite 25-26 OCT 2012

CloudSat CPR and ASD spectroradiometer retrieval match-ups in 5 case studies

Table 1. Available CloudSat (CS) retrievals directly over McMurdo Station during the case studies considered in this study, for October 2012 and January 2013. Also shown are the cloud optical depth τ_c retrievals from the ASD spectro-radiometer data. Time is in UTC. Effective radius averaged over the cloud vertical extent, $\langle r_e \rangle$ is given in microns. Cloud ice water path (IWP) and liquid water path (LWP) are given in g m^{-2}.

Date	CS Time	ASD Time	CS τ_c	ASD τ_c	CS ice $\langle r_e \rangle$	CS liq $\langle r_e \rangle$	CS IWP	CS LWP
21 OCT	0528	0528	2.70	5.15	60.1±22.1	0	115.6	0
23 OCT	0516	0516	1.78	1.64	57.4±16.9	7.4±4.1	36.5	3.9
13 JAN	0504	0504	4.84	3.19	65.2±17.9	0	205.1	0
15 JAN	0454	0454	4.33	1.87	51.6±16.1	6.6±3.8	27.8	14.4
15 JAN	0454	0505[a]		3.46				
18 JAN	0526	0530[b]	0.24	0.40	41.2±15.7	0	6.0	0

[a] At exactly 0454 UTC the weather observation from Williams Field specifies clear sky, with overcast not occurring until 0505. This may represent a spatial mismatch between weather observations and ASD instrument location.

[b] The nonzero ASD cloud optical depth retrieval nearest in time occurs at 0530 UTC. These very small optical depths are within the spectral irradiance measurement and retrieval modeling uncertainties.

- Ross Island, Antarctica manifests optically thin clouds, mostly glaciated, with varying properties related to traceable meteorological histories.
- A useful mixed-phase contrast from the Arctic, should be a valuable additional test of microphysical parameterizations.

- Reference: Scott, R. C., and D. Lubin, 2013: Mixed-phase cloud radiative properties over Ross Island, Antarctica: variability associated with contrasting synoptic-scale atmospheric circulation regimes. *Journal of Geophysical Research*, in review.