Cloud Experiment 2000: Field Report

In early March of 2000, the MISR validation team participated in a joint field experiment with the Atmospheric Radiation Measurement Program (ARM) program.

From the ARM perspective, the primary goal for the experiment was to observe horizontal and vertical structure in single later ice or water clouds. The ARM program is (in large measure) limited to observing the vertical profile of clouds as they advect over a single ground site. That is, the ARM radars and lidars (which will be used extensively in validating MISR cloud retrievals) provide a time-height picture of cloud events whereas satellite data, such as that provided by the MISR instrument, will be providing an essentially instantaneous view of a cloud top properties over a large area surrounding the ARM site.

In order to learn how to extrapolate the ARM time-height data to larger regions, the ARM program deployed several lidars, millimeter radars, and total sky imagers within a mesoscale region around the ARM Central Facility (CF) during a two week period. The ground based measurements where additionally supported by in situ and above cloud radiation measurements.

From the MISR prospective, the objectives of this experiment are to:

(1) Evaluate MISR observed radiances, as well as albedo and cloud top height retrievals using both MISR and AirMISR data with independently gathered ARM data. This evaluation will take the form of both a direct comparison of observed radiances between MISR and AirMISR, as well as simulations based on a combination of ground-based and in situ measured cloud properties.

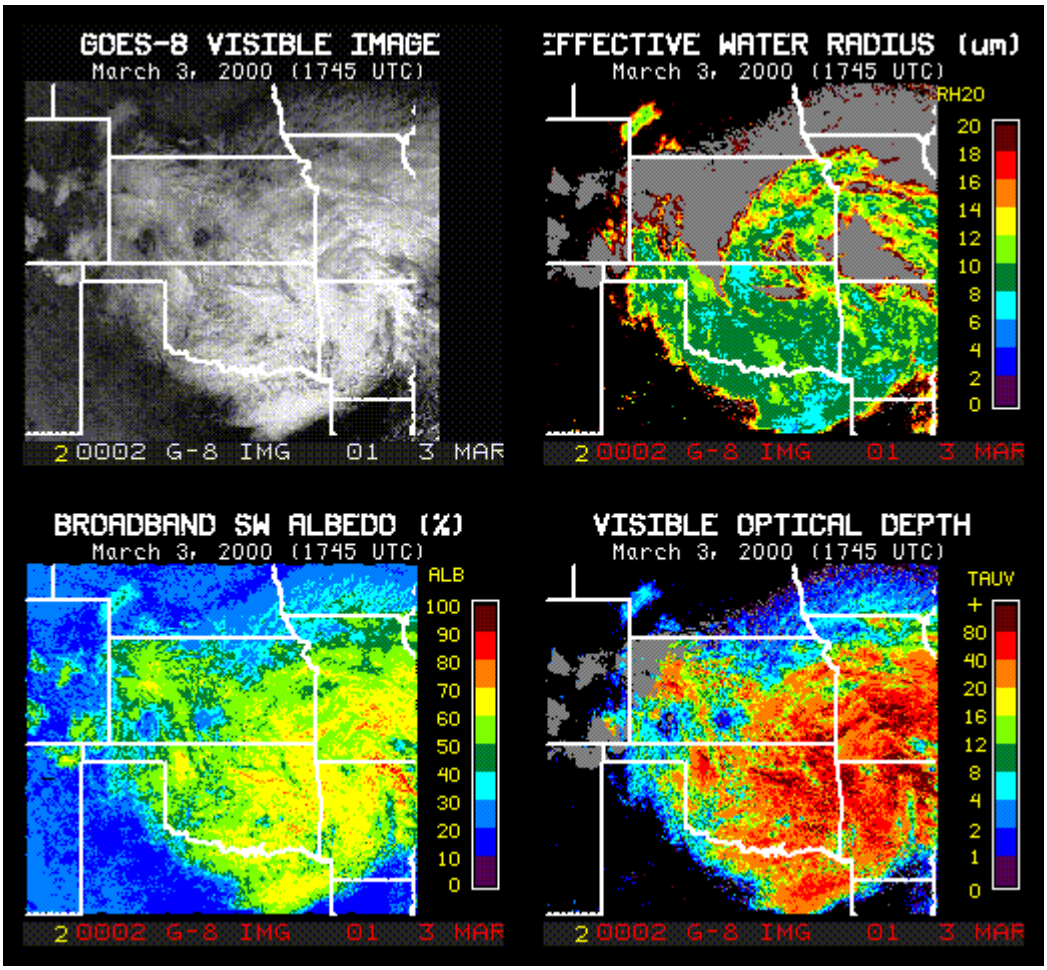
(2) Relate variability in MISR and AirMISR observed cloud fields with variability in the properties observed by several radars.

Description of MISR overpass events

During the experiment, TERRA / MISR overflew the ARM site on three occasions during the two weeks of the experiment. On two of these days, March 3rd and 12th, the ER-2 also managed to make a coordinated measurements. A summary of each of these cases follows.

March 3, 2000

Given the limited number of possible observations, we appear to have been fortunate to capture an almost ideal case. The ARM central facility was located in the post-frontal cold zone of a surface low (centered east and north). See below geostationary satellite (GOES-8) visible imagery and retrieved cloud parameters (produced by Pat Minnis).



All morning, a mid and upper level cloud layer persisted over a low (relatively drizzle free) stratus layer, as the large scale low lifted slowly northeastward. About the time of the overpass the upper clouds parted and allowed a clear look at the stratus layer by the platforms aloft. Soon after the end of the aircraft operations the cirrus returned. (See below, a figure of the radar reflectivity and aerial photograph).

Three aircraft were on station at the time of the overflight and for several hours thereafter. The ER-2, as mentioned previously, flew near its usual 65 kft in a “rose” pattern similar to the one used during the FIRE.ACE experiment. The following table list times of the data acquisition and other useful information. A citation was making in situ measurements of the cloud, and a Twin Otter was sampling radiometric fluxes and operating a millimeter airborne cloud radar at 24 kft.

On the surface, the cloud field was sampled by 4 cloud radars, lidars and microwave radiometers distributed east and northeast of the central facility. Mark Hemlinger and I also made measurements at the ARM Central Facility with PARABOLA III and an ASD.

A following table list some of the instruments of interest.

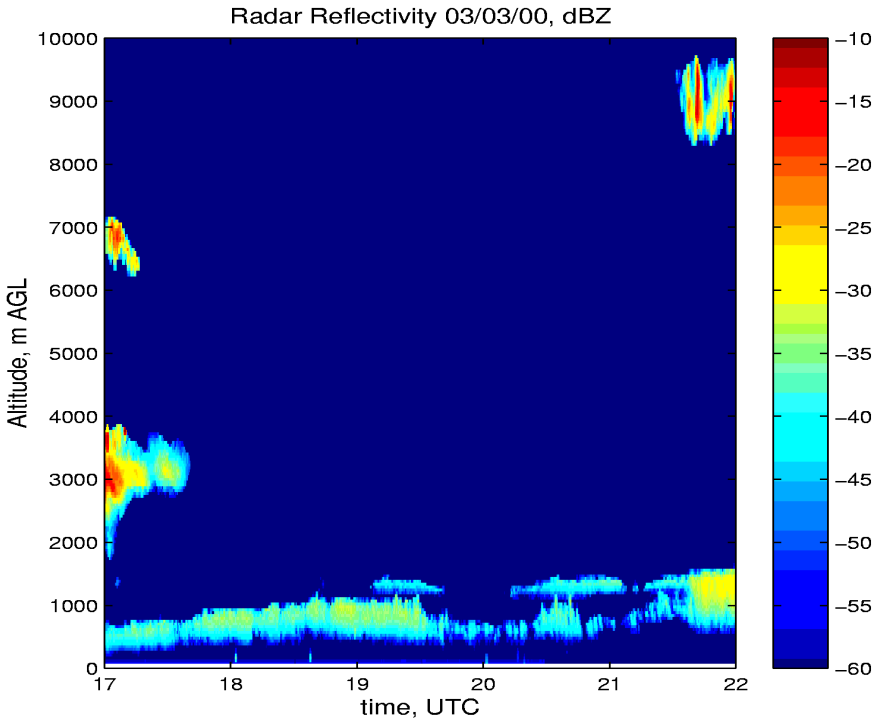

Radar Reflectivity 03/03/00, dBZ
Altitude, m AGL
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
17
18
19
20
21
22
time, UTC
−10
−15
−20
−25
−30
−35
−40
−45
−50
−55
−60

Table - March 3 Flight Summary:

	Target/Heading	**Supporting Measurements**	**Time**
Run 1	Clear Sky	None - – for geo rectification	16:07
Run 2	ARM site ~ 192^{o} Only one cloud layer observable in any of the MISR images. More variability in cloud structure than for artic case.	(mucho - see followng table)	17:39
Run 3	ARM site ~ 270^{o} Possible mid-level or high cloud visible in D and edge of C images. Texture “looks” different From Run 2.	(mucho - see followng table)	18:03
Run 4	ARM site ~ 330^{o} Definite mid-level or Upper level cloud in or on edge of all images. Texture noted above may be view angle driven	(mucho - see followng table)	18:25
Run 5	Clear Sky	None – for georectification	19:49

Table – primary measurements of interest

Instrument	Description/Paramater of Interest
TERRA*	
MISR	36 Radiance Measurements (4 wavelengths x 9 angles)
MODIS	Radiance Measurements (50 wavelengths) and associated retrievals
CERES	Broad Band Radiance and Flux estimates
ASTER	Hi-Resolution (15m) imagery
ER-2	
AirMISR	same as MISR
MAS	same as MODIS
CLS*	Cloud Lidar System / cloud top height
Citation	
FSSP	Cloud particle size distribution (2-47 microns)
CPI*	Particle type / Cloud particle size distribution (20 - 2500 microns)
PMS 1DC/2DC	Cloud particle size distribution (20 – 1500 microns)
CVI*	Liquid water content
King Probe*	Liquid water content
Twin Otter	
Radiometers	RAMS & MRI / up and downwelling hemispheric broadband
Spectral flux	SSFR / up and downwelling spectral hemispheric
Cloud Radar	Cloud boundaries and microphysical retrievals
Surface	
Cloud Radars(4)	Cloud boundaries, Doppler spectra, and microphysical retrievals
MWR	Microwave Radiometer / cloud liquid water
PARABOLA III*	Radiance at MISR wavelengths over the complete sphere (5^0 FOV).
ASD	Surface spectral albedo, downwelling spectral counts (several surfaces).
Sky imagers	cloud fraction and sky imagery
Radiometers	Broadband & spectral hemispheric plus narrowband narrow field of view
Rawinsondes	balloon-based measurements of pressure, temperature, RH, and winds
Wind profilers	Radar-based estimates of wind speed and direction
Other Satellites	
AVHRR	Overpasses at 1
LandSat	high resolution (3/3 Only)

***Have not seen this data as of 4/00 but believe it exists and will be of good quality.**

A first look at the data suggests that most of the instruments appear to have performed well. (See MODIS and AirMISR data below). One potential difficulty is that one of the ER-2 navigation data streams was found to be faulty. Navigation data was acquired by AirMISR, and this data should be distributed back to other ER-2 investigators. It is unclear how this will impact their processing.

In terms of analysis, two complications will be (1) the proximity of mid and high level clouds and (2) there was a second, very thin liquid water later during some portions of the experiment (again see the radar imagery above).

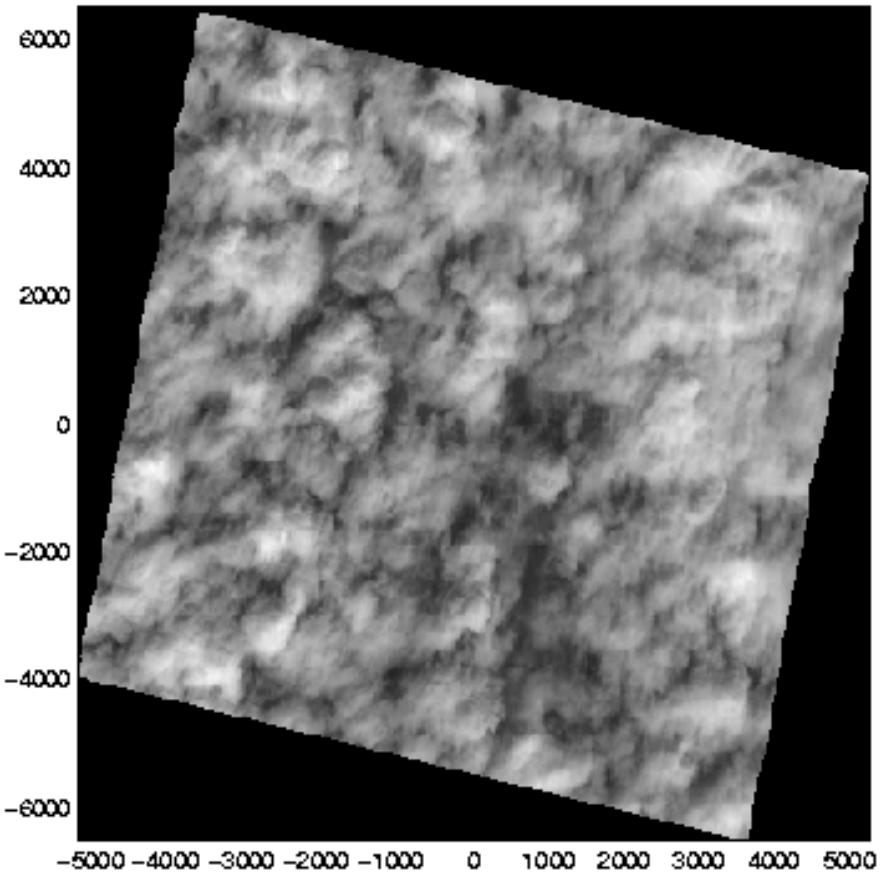


Figure – AirMISR Nadir IR image near ARM Site 3/3/00 at approximately 17:38 UTC.

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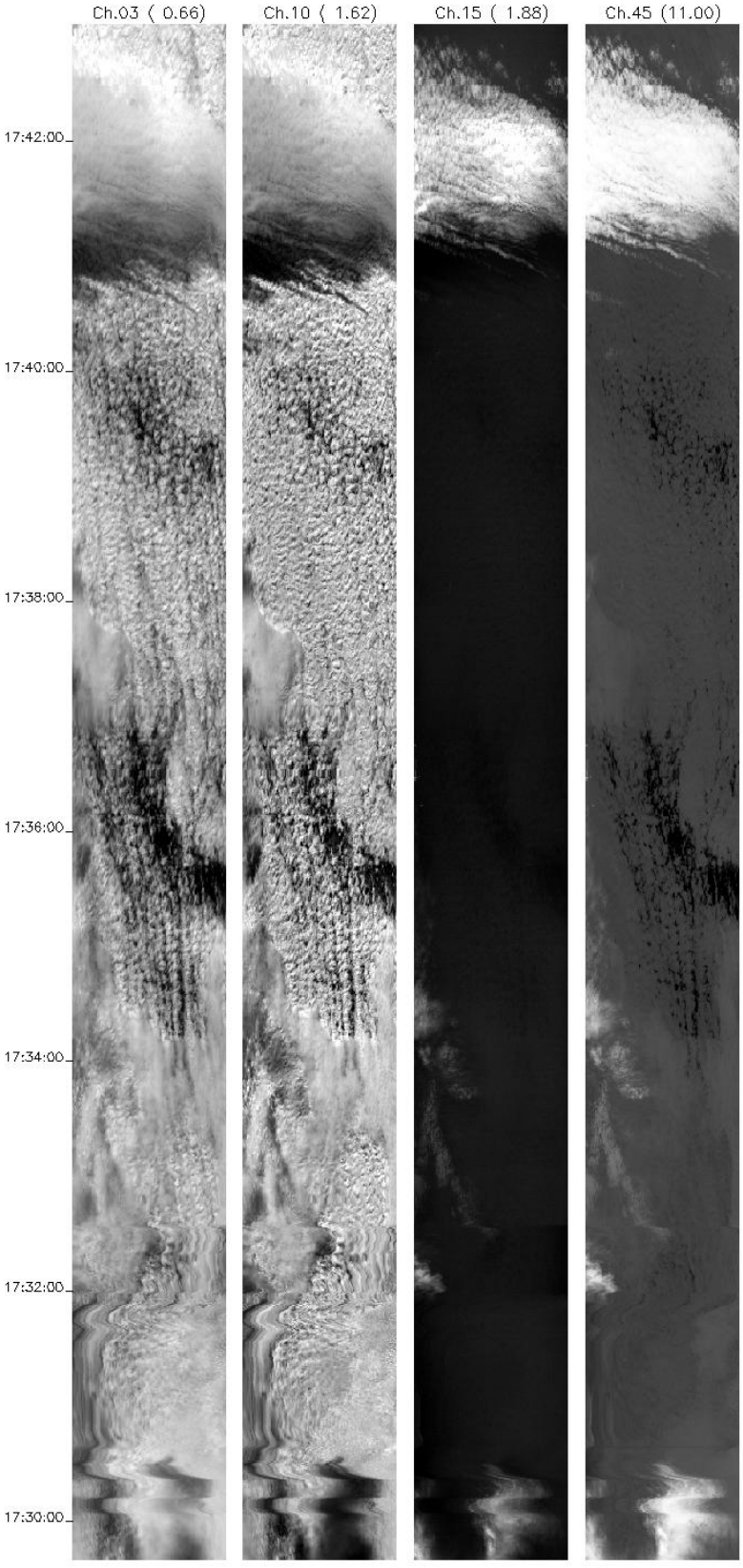
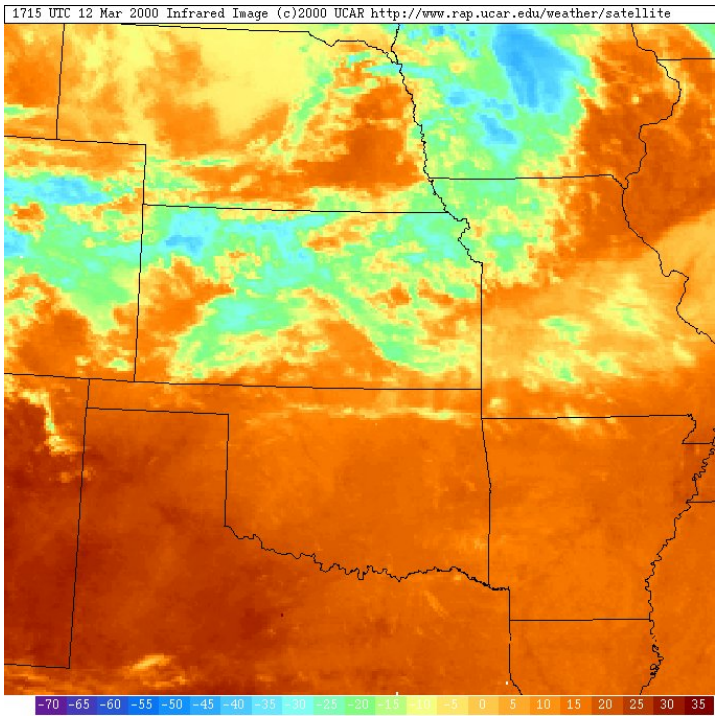
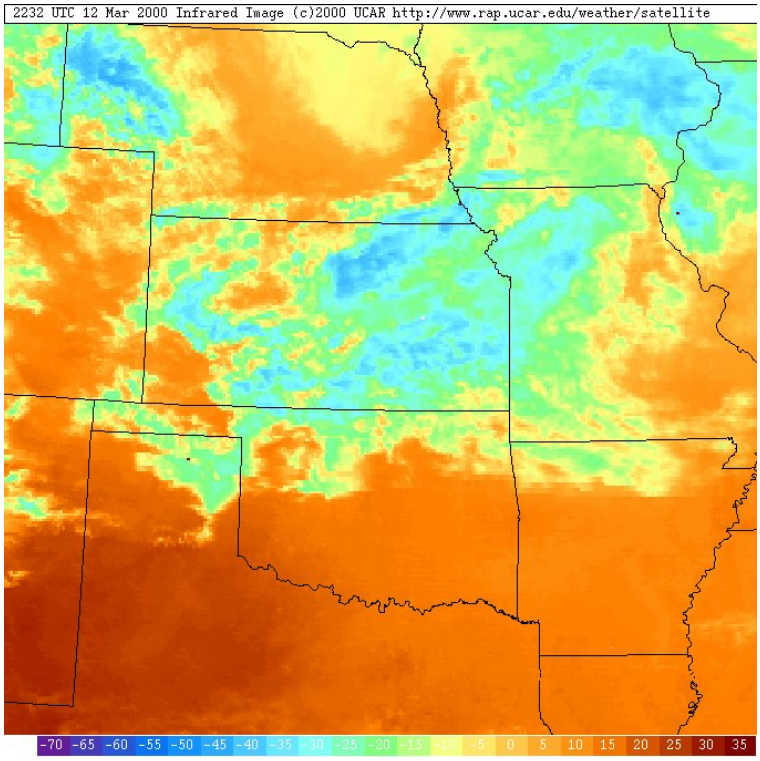


March 12, 2000

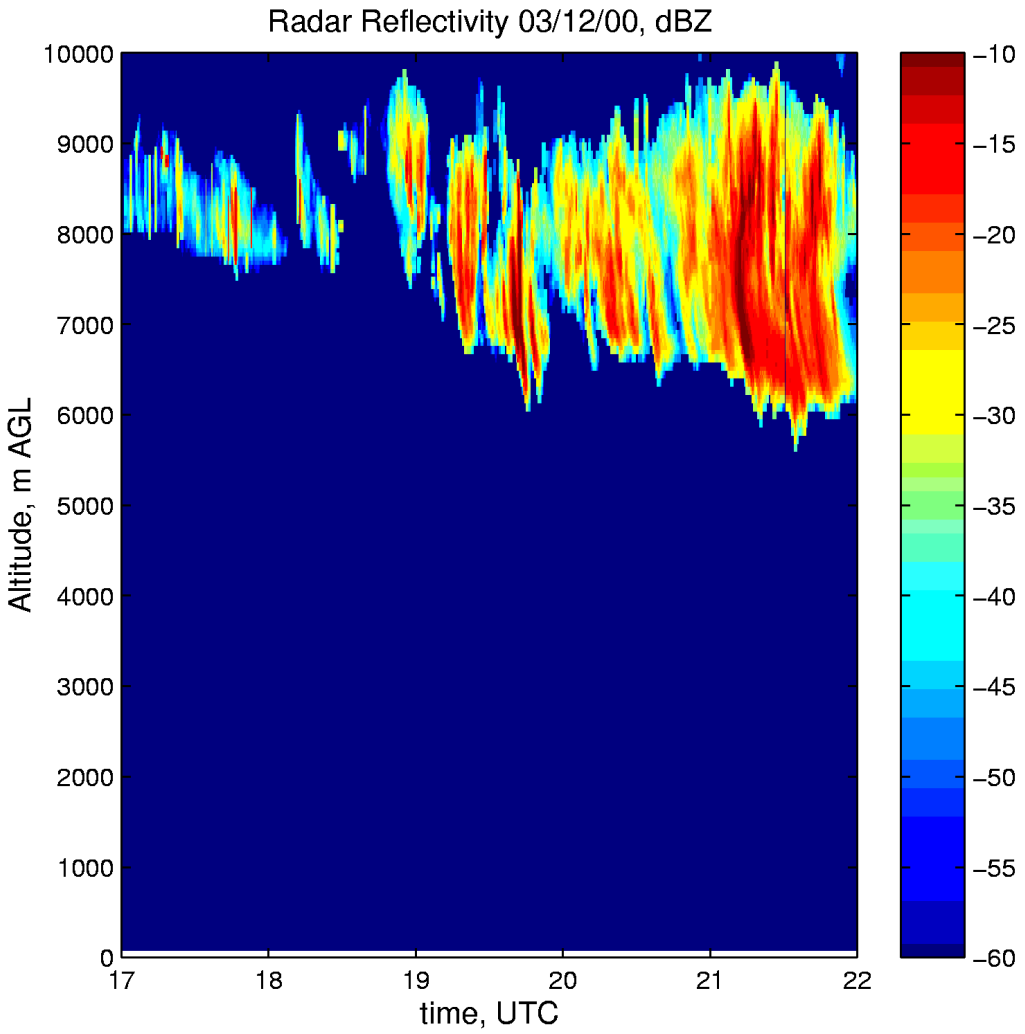
North central Oklahoma was a winter wonderland Saturday morning after 6 inches of snow fell Friday night. The snow melted away by Sunday and there was an attempted to coordinate the ER2 with the last good Terra over pass. The Citation got into some scattered-broken mid-level (and very likely mixed phased) clouds near the overpass time. Cloud was visibly tenuous from the ground.



The layer thickened and transitioned into altostratus as clouds moved south from Kansas.



The radars observed much of what looks like ice crystal precipitation but the actual concentration of ice crystals was very small. Reports from the citation were for water contents less than a few milligrams per cubic meter and a strong gradient of water content was observed from north to south.



Overall, the 12th does not present a particularily good case for further study using AirMISR. It should, however prove interesting to compare MISR retrieved cloud top height with that observed by cloud lidar system. The visibly patchy clouds observed near the ARM site should also prove an interesting test case for the cloud masks.