IOP-7 Summary of Operations
16 November 2009, 0000 UTC – 18 November 2009 0000 UTC

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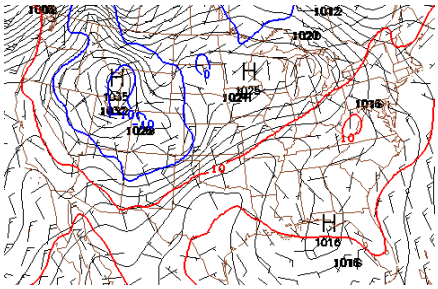
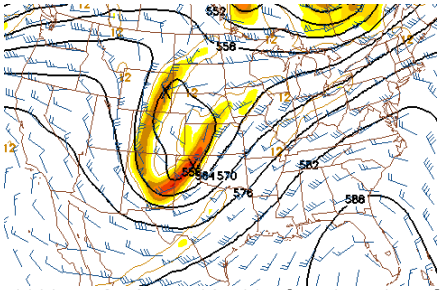
1. Summary of Storm Evolution

IOP-7 focused on a cyclone that developed over the High Plains with a relatively weak surface low pressure signature, but a deep cutoff low aloft. The cutoff low moved very slowly across the plains, with a frontal structure reminiscent of the T-bone frontal structure often observed with marine cyclones. The wrap-around part of the T-bone structure was oriented near east-west across southern Iowa and into Kansas, threading between every WSR-88D PLOW site, and then wrapping southward over western Kansas. Given the orientation and the forecast, the PLOWS forecast team determined that the WSR-88D site most likely to experience precipitation during the active period of the cyclone was Kansas City. We therefore deployed all ground assets to Kansas City. The first platform to arrive on site was the MISS, which was operational by 0000 UTC 16 November. The MIPS was operational by 0600 UTC 16 November. The MAX radar could not be deployed until daylight, since the Kansas City site had not been surveyed, so it came on line at 1500 UTC 16 November. The Missouri Rawinsonde team performed the first launch at 0000 UTC 16 November. Operations continued until 0000 UTC 18 November for all ground platforms. Shortly after this time, all precipitation cleared the Kansas City area. The NCAR C-130 was grounded for the entire IOP due to engine trouble.

Figure 1 shows the weather pattern throughout the period. At 0000 UTC 16 Nov., a deep trough was evident at 500 mb. Although the cyclone precipitation and frontal structure was evident on the radar, no surface low pressure had yet formed. By 1200 UTC 16 Nov., the cutoff low aloft continued to develop over Kansas, while a weak surface low formed over Arkansas. The wrap-around precipitation was disorganized and showed little banded structure during the 12 hour period. By 0000 UTC 17 Nov., the cutoff low had drifted eastward to a position over southwest Missouri at 500 mb, with the weak surface low over the tip of western Kentucky. The precipitation composing the wrap-around orbited the upper level low, primarily rotating around PLOWS operations at KC between 00 16 Nov and 00 17 Nov. (see Figs. 2 and 3). Bands passed over the MISS between 1100-1300 UTC and again after 2000 UTC (Fig. 4), and the MIPS between 1800 and 2200 UTC (Fig. 5). The MIPS profiler was down between 1100-1400 UTC, so bands passing during this period were not observed. Between 0000 UTC 17 Nov 09 and 0000 UTC 18 Nov 09, the cutoff low at 500 mb drifted eastward about 300 km to southeast Missouri. During this time, precipitation in the wraparound region weakened, eventually dissipating. The surface low also weakened and the system became vertically stacked. Operations in Kansas City were terminated at 0000 UTC 18 Nov 09 as the last echoes moved out of the operation area. Fig. 6 shows the MISS 915 Mhz Profiler data during the period 0000 UTC 17 Nov. to 0000 UTC 18 Nov. 09. Stratiform precipitation regions with little banded structure moved over the MISS during this period. The MIPS data for the same period are shown on Fig. 5. Bands appeared more organized, but the vertical velocities suggest they were relatively weak.


0000 UTC 16 Nov 09 Surface P/T/wind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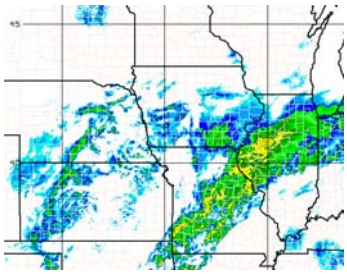
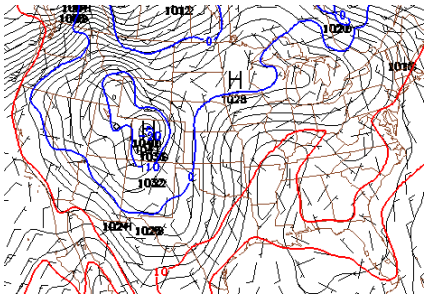
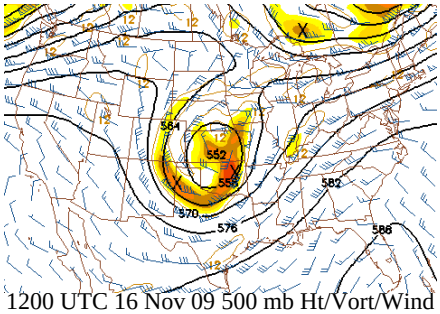
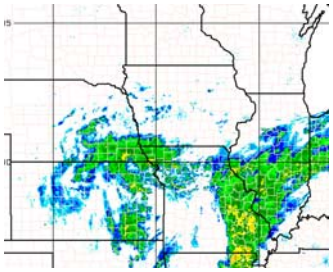
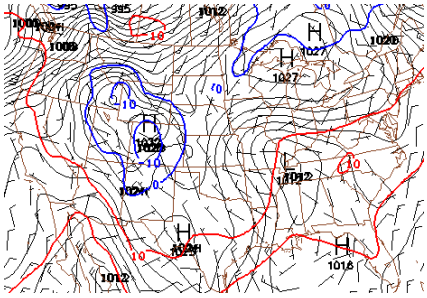
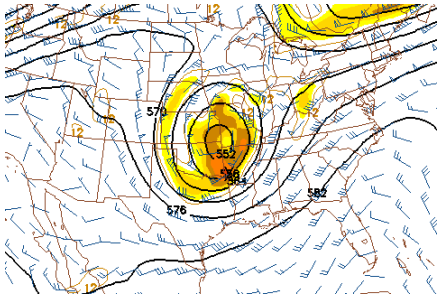

0000 UTC 16 Nov 09 radar

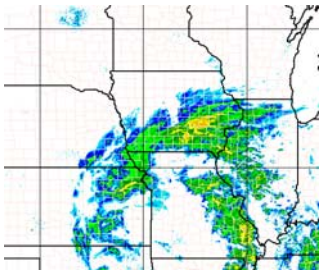

1200 UTC 16 Nov 09 Surface P/T/wind


1200 UTC 16 Nov 09 500 mb Ht/Vort/Wind


1200 UTC 16 Nov 09 radar


0000 UTC 17 Nov 09 Surface P/T/wind


0000 UTC 17 Nov 09 500 mb Ht/Vort/Wind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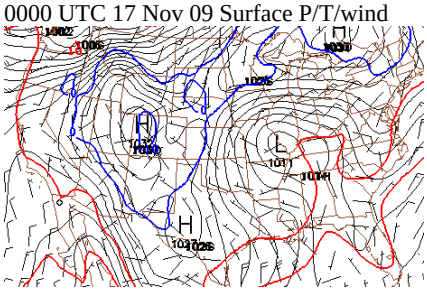
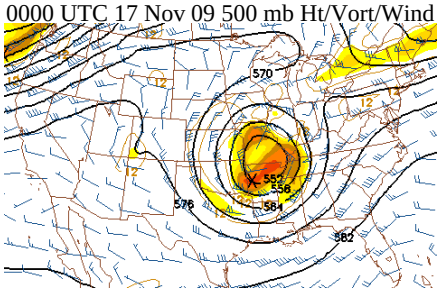
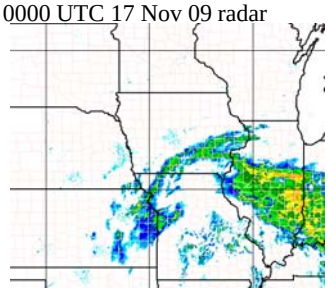
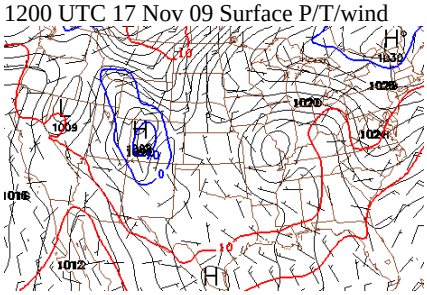
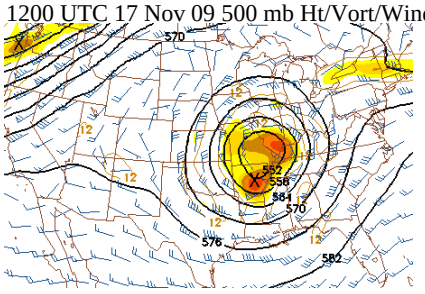

1200 UTC 17 Nov 09 Surface P/T/wind


1200 UTC 17 Nov 09 500 mb Ht/Vort/Wind


1200 UTC 17 Nov 09 radar


0000 UTC 18 Nov 09 Surface P/T/wind


0000 UTC 18 Nov 09 500 mb Ht/Vort/Wind

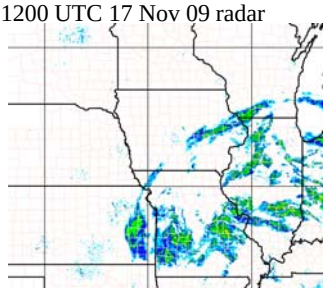

0000 UTC 18 Nov 09 radar

Figure 1: Evolution of the IOP-7 storm at the surface, 500 mb, and radar echoes

2. Locations of instrumentation platforms

MIPS Location:	38°58'30.51"N 93°57'10.71"W
MIPS Profiler Time of Operations	11/16/09 0423 UTC to 11/18/09 - 0017 UTC NDB
MAX Location:	39 04' 13.51"N 94 02' 14.73"W
MAX Radar Time of Operation	11/16/09 1541 UTC to 11/17/09 - 2319 UTC NDB
MISS Location:	39°14' 31.41"N 94°27' 38.68"W
MISS Profiler Time of Operation:	11/14/09 2300 UTC to 11/18/09 0200 UTC
MO Location:	38° 56' 48.50" 93° 57' 20.17" First Three Launches
	38° 58' 30.450" 93° 57' 09.81" Remaining Launches

Flight operations: None

NDB=No Data Breaks

3. Precipitation over research area

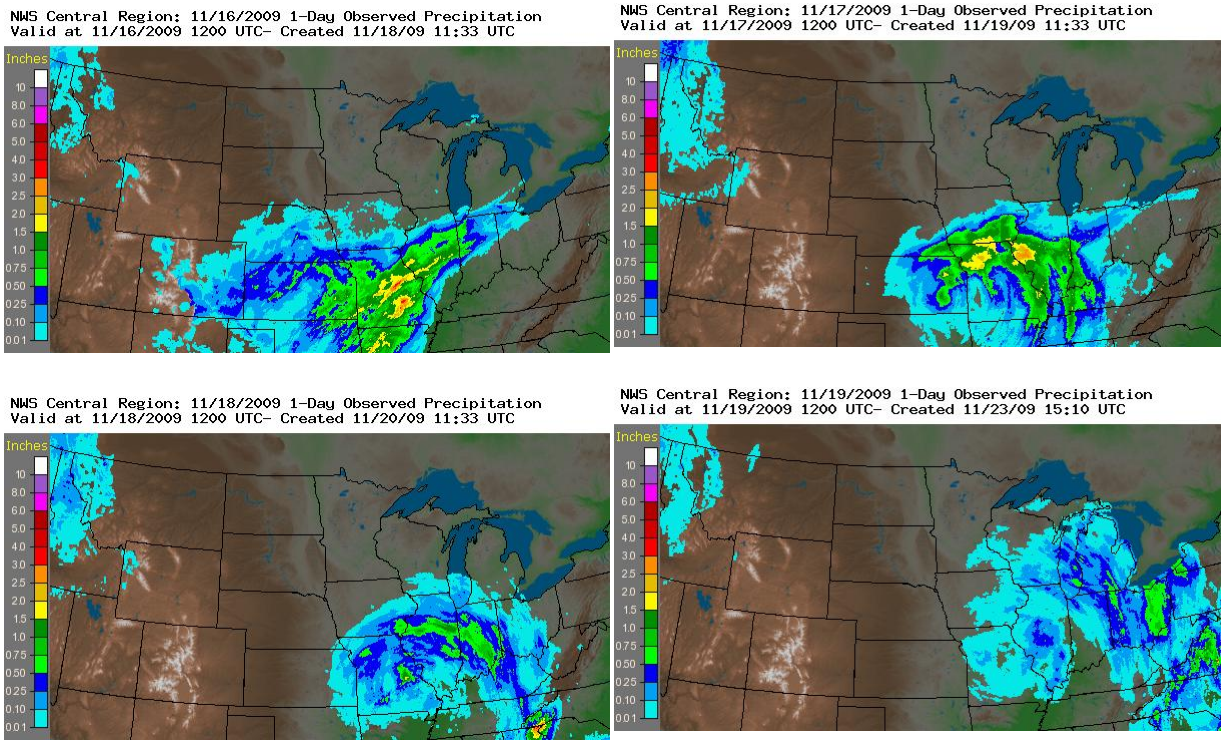


Fig. 2: 24 Hour precipitation ending at 1200 UTC 11/16/09, 11/17/09, 11/18/09 and 11/19/09 over the Midwestern United States

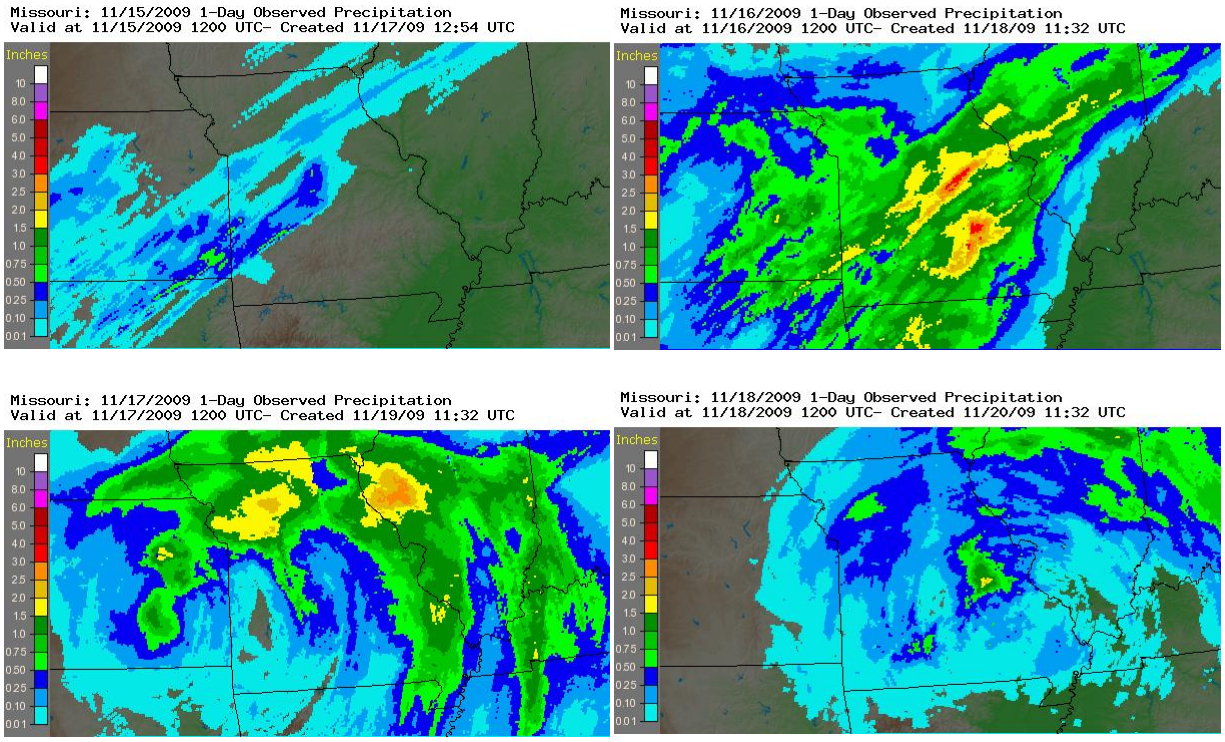


Fig. 3: 24 Hour precipitation ending at 1200 UTC 11/15/09, 11/16/09, 11/17/09 and 11/18/09 over the Missouri-Kansas area.

4. Flight Summary

No flight during IOP-7 due to mechanical problems with Engine that occurred during IOP-6.

5. MIPS operations

MIPS Instruments: 915 MHz Profiler, ceilometer, microwave profiling radiometer (MPR), Parsivel disdrometer, electric field mill and surface met. Missouri set up the snowflake video imager (SVI) and it became operational (after some initial problems) on 17 November after the snow event.

Based on forecast, the Kansas City area was selected as optimum for sampling this cyclone. UAH personnel departed UAH at 0930 CST 15 November and reached the target site near Odessa, MO at 21-22 CST. The primary target had excessive background 915 MHz noise, so the MIPS site was moved 3 km north to a rural church parking lot about 1.5 mi S of Odessa. The 915 signal was clean at this location. The Missouri sounding team co-located at the MIPS site.

Weather at the MIPS: N winds of 4-8 m/s, temperature ranged from 34 to 43F. Snow and mixed rain/snow early on 11/17 (based on 915 data). Drizzle was common. Rain event

during band passages. Total precipitation was relatively light at about 10 mm, much heavier in other regions of the DD domain, including the MISS site.

Several bands and cells were sampled. Convective structures with updraft of 2-3 m/s near the top were observed. Drizzle was common. The main precipitation began as rain and then converted to snow during the early morning hours of 17 November, and then converted back to rain by later morning. The melting level was very near the surface, and this shows up nicely in both the 915 and MAX data over the MIPS site.

Between 1800 and 2100 UTC on 16 Nov 09, a relatively large area of precipitation moved over the MIPS site (Fig. 2-3). This also had embedded banded and convective cell structures that were sampled with the Dual Doppler region. The remains of the wrap-around band progressed over the MIPS site between 0900 and 2300 UTC on 17 Nov 09 (Fig. 5). Between these times, the MIPS was located within the dry slot and only shallow clouds were present.

All systems performed well. The Parsivel dropped out for short periods several times. –The MPR dome collected water and therefore the brightness temperatures have a warm bias. Kevin wiped with a towel numerous times, and this brought the integrated cloud water down to near zero and the Precipitable water jumped by about 20%. This radome needed replacement.

6. MAX operations

The MAX conducted cycles of full volume VAD and RHI scans over the MIPS and MISS sites. The total scan cycle time was about 6 min. The Kansas City WSR-88D remained in VCP-11 model throughout the event.

MAX Scanning Angles: 1.5 2.5 3.8 5.3 6.8 8.2 10.0 13.0 15.0 19.0 65.0
MAX radar parameters 22rpms, 1000prf, .8 pulse width

MAX location was good, with a lot of coverage at 0.7 deg elevation angle.

Problems:

-MAX problem: leaking waveguide produced frequent compressor cycles. These holes will be repaired ASAP.

7. MISS 915 MHz Profiler

Data were obtained throughout the period from 15 Nov 09 2300 UTC through 18 Nov 09 0200 UTC. MISS was running for 51 hours and launched 17 soundings - a record IOP for this system. Data for the IOP and close ups from the most intense periods of precipitation are shown in Figs. 6-11.

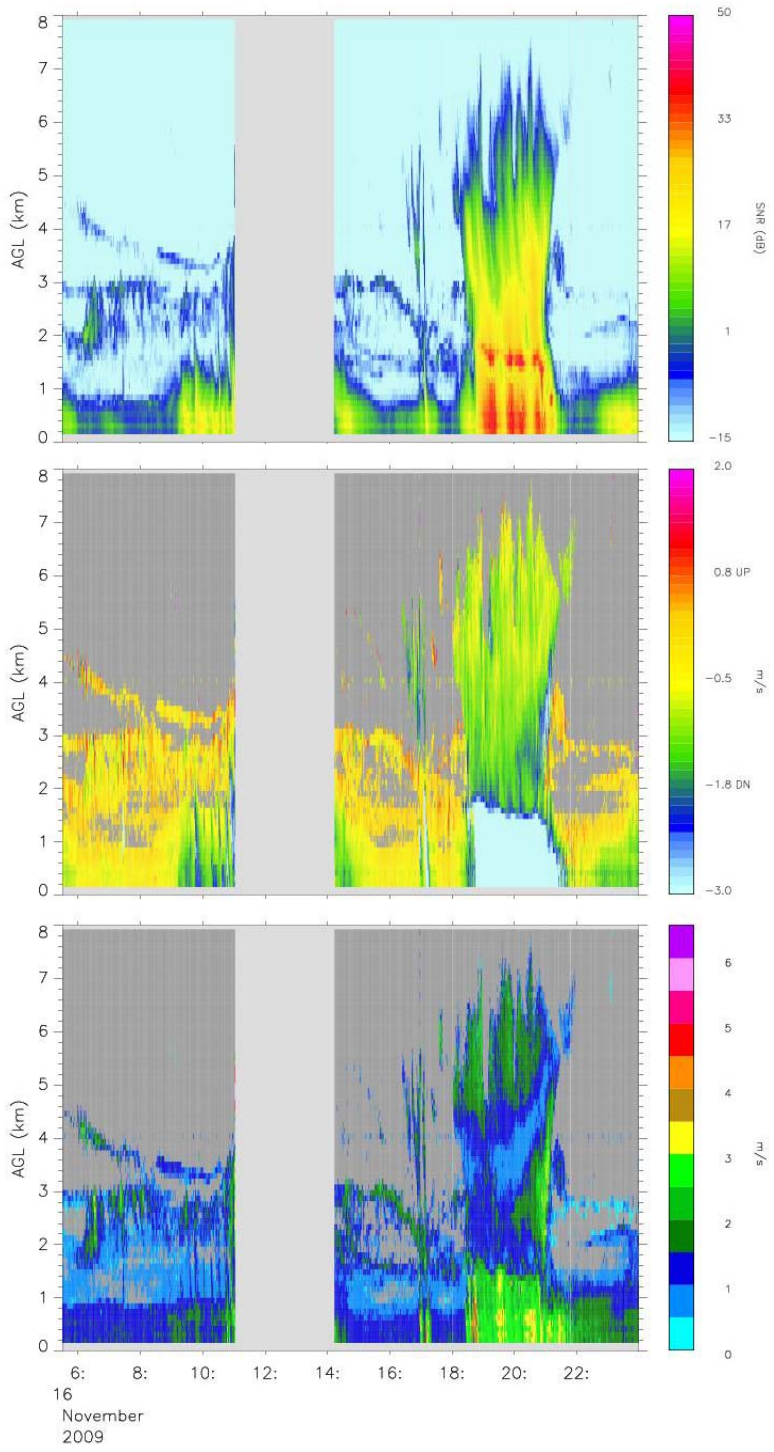


Figure 4: MIPS 915 MhZ Profiler SNR (top), Radial Velocity (center) and Spectral Width (bottom) for the period 0545 UTC 16 Nov 09-0000 UTC 17 Nov 09

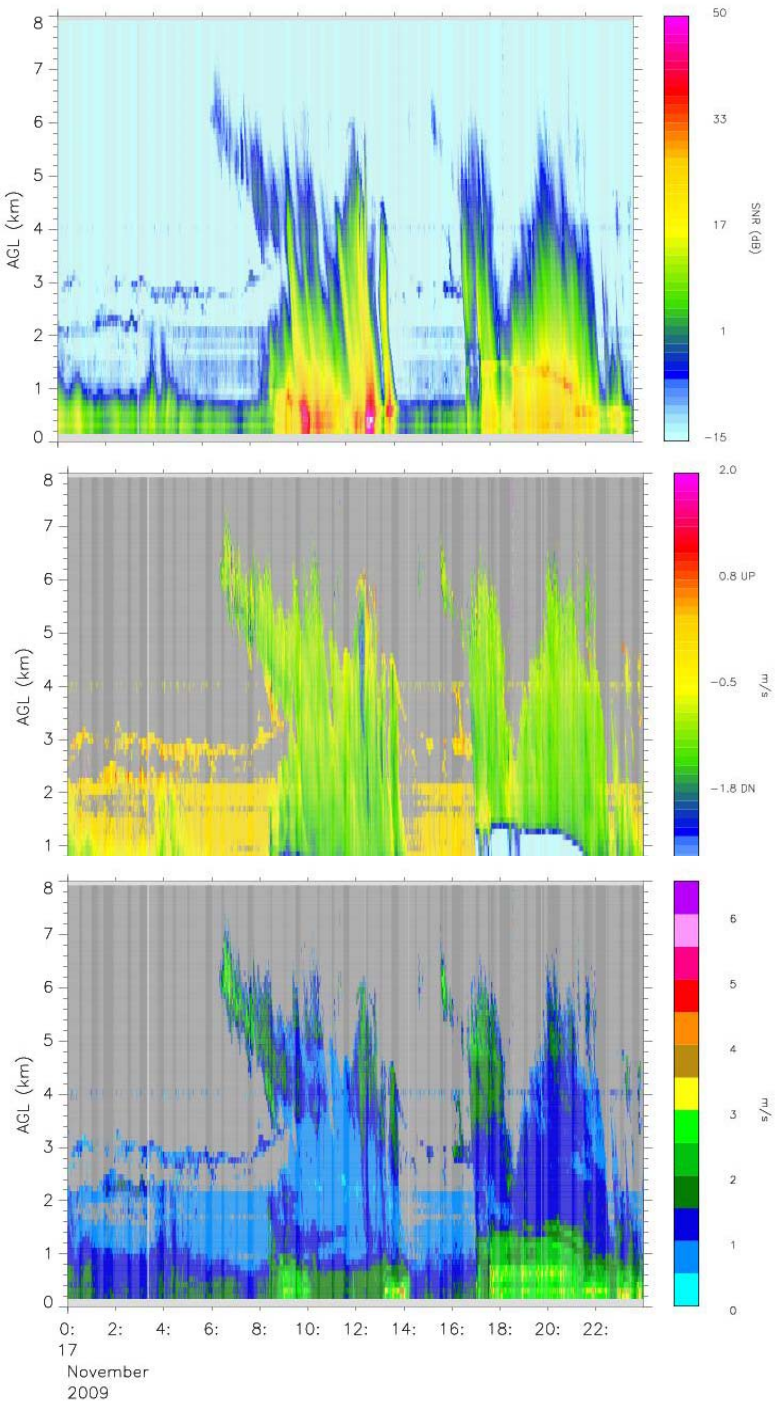


Figure 5: MIPS 915 MhZ Profiler SNR (top), Radial Velocity (center) and Spectral Width (bottom) for the period 0545 UTC 17 Nov 09-0000 UTC 18 Nov 09

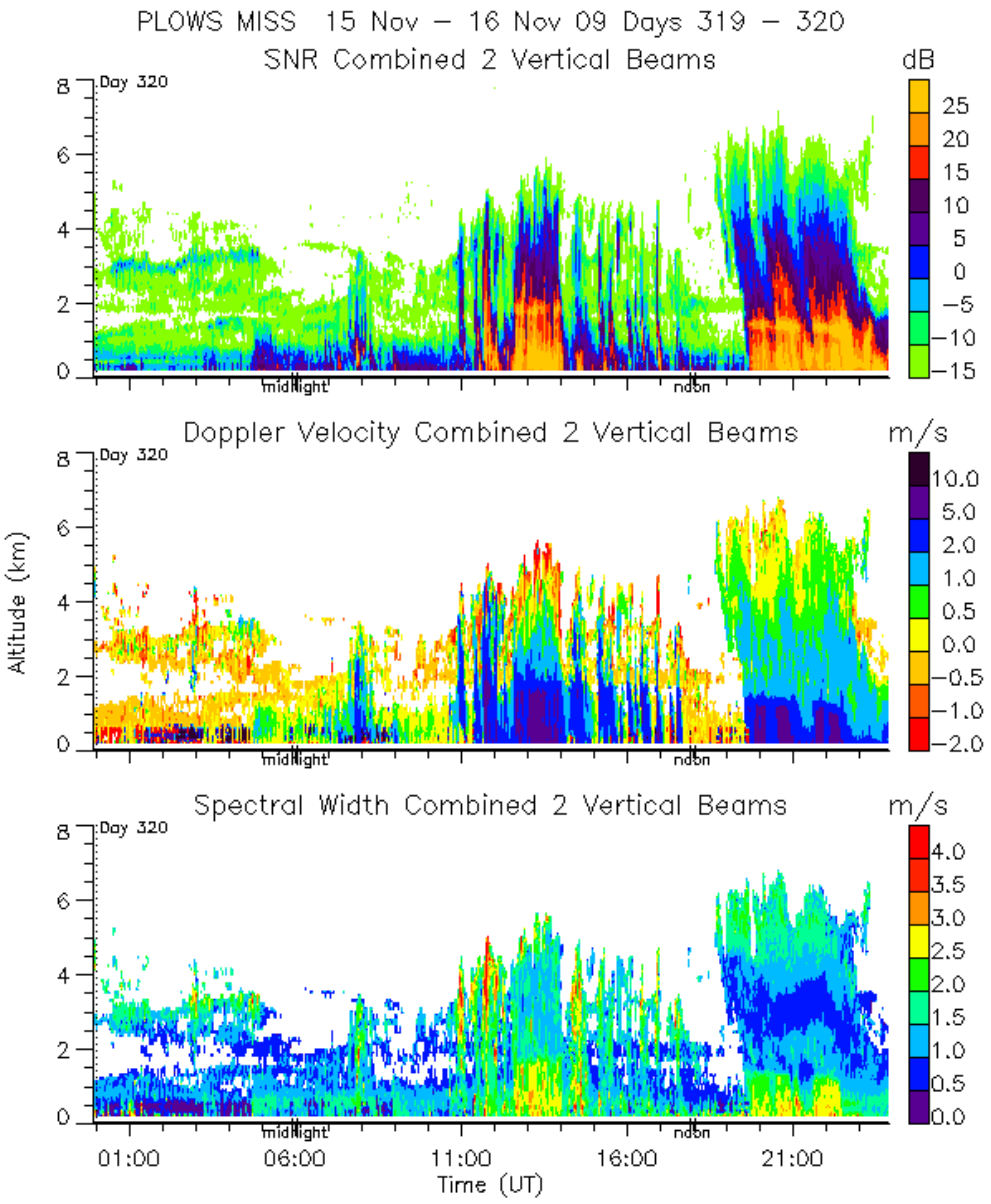


Figure 6: MISS 915 MhZ Profiler SNR (top), Radial Velocity (center) and Spectral Width (bottom) for the period 0000 UTC 16 Nov 09-0000 UTC 17 Nov 09

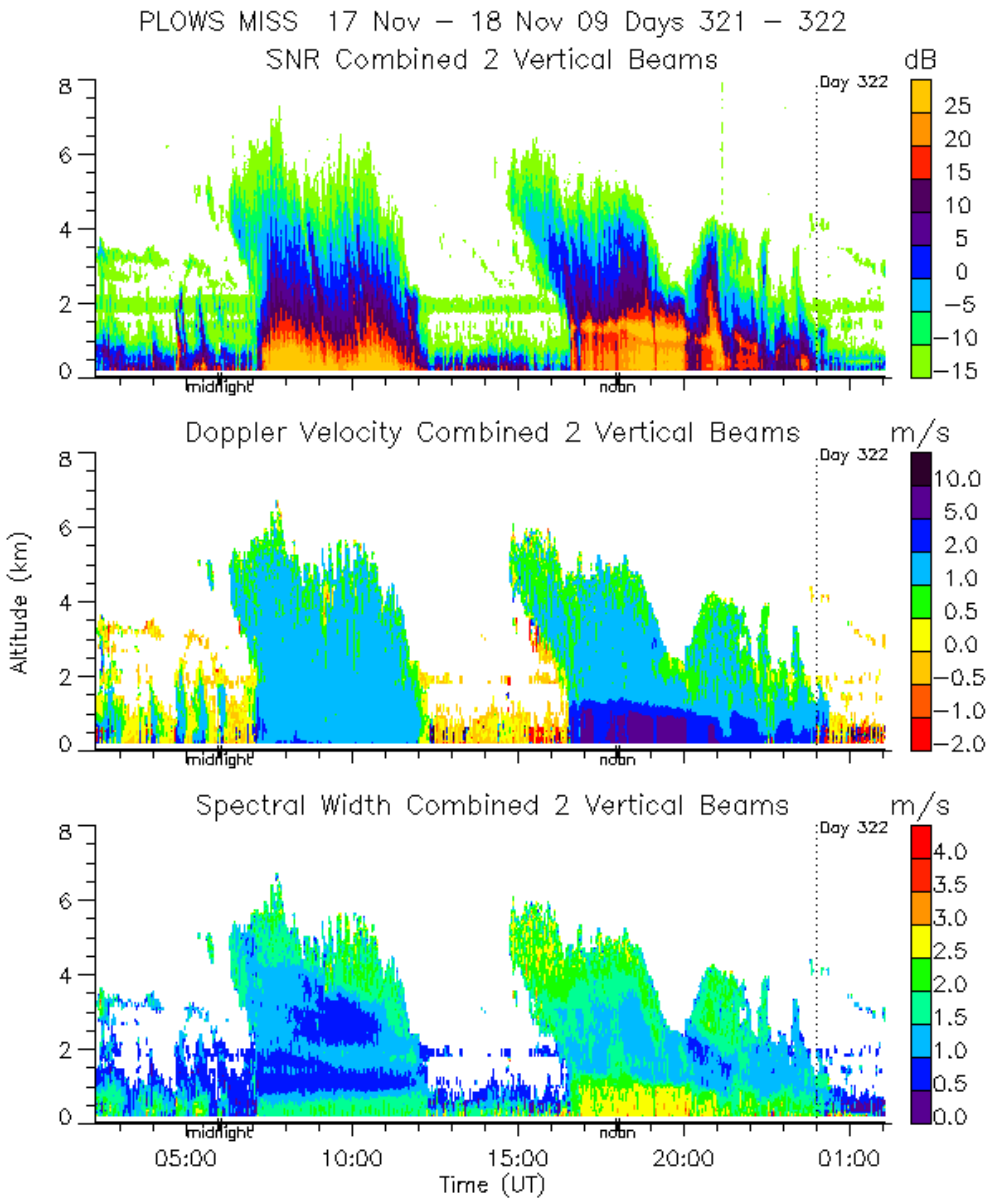


Figure 7: MISS 915 MhZ Profiler SNR (top), Radial Velocity (center) and Spectral Width (bottom) for the period 0000 UTC 17 Nov 09-0000 UTC 18 Nov 09

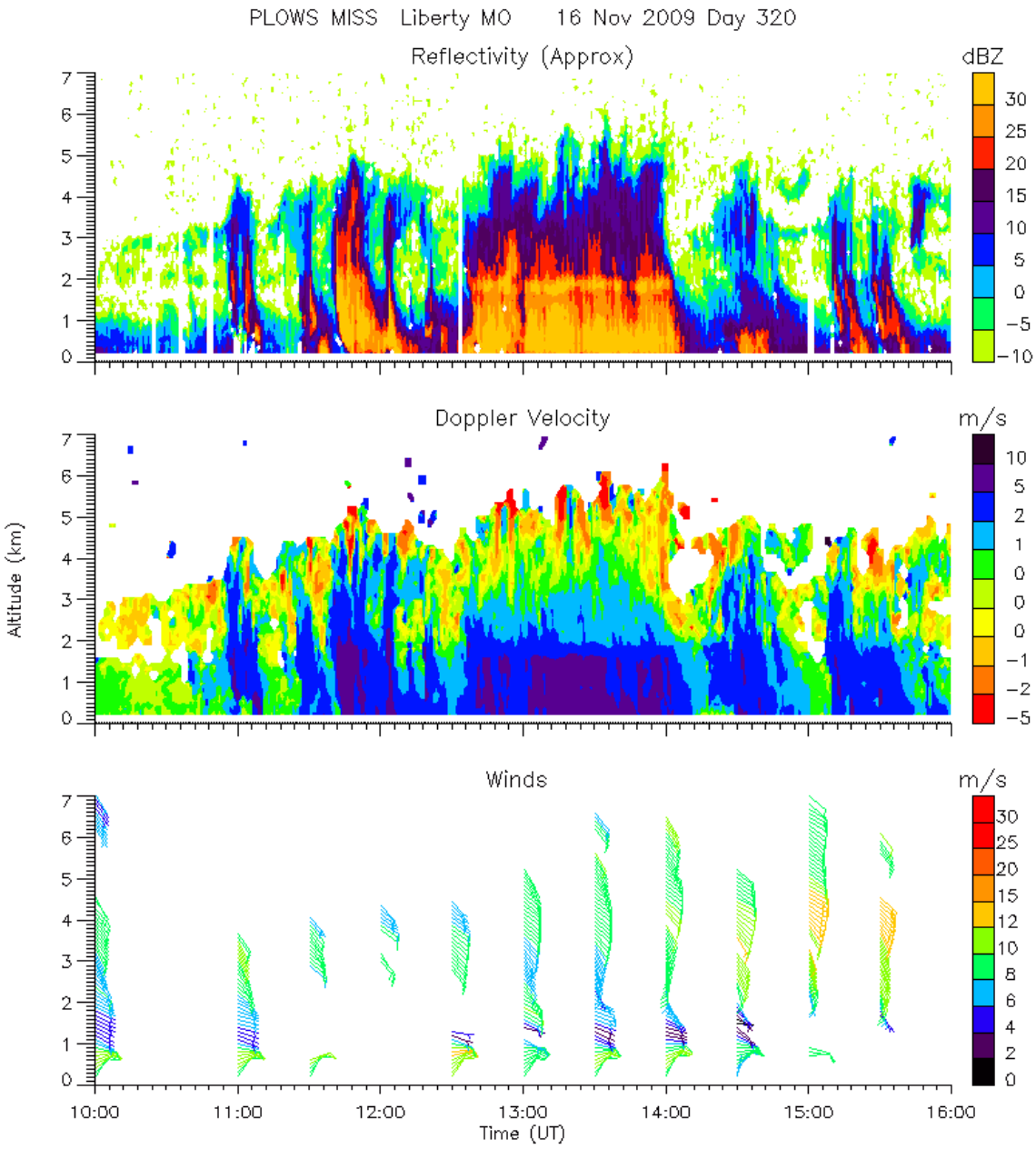


Figure 8: MISS 915 MHz Profiler SNR (top), Radial Velocity (center) and Winds (bottom) for the period 1000 UTC 16 Nov 09-1600 UTC 16 Nov 09

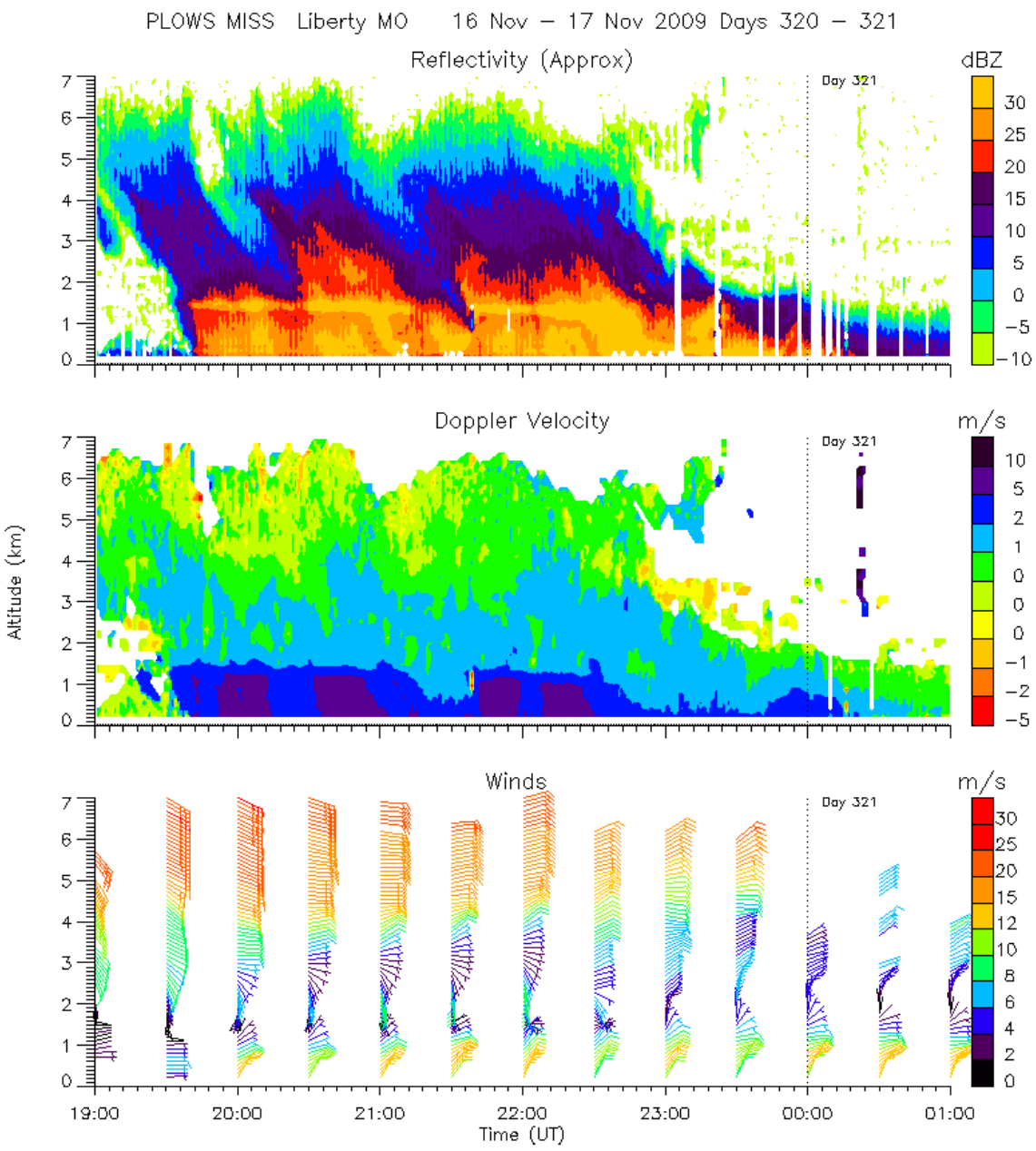


Figure 9: MISS 915 MHz Profiler SNR (top), Radial Velocity (center) and Winds (bottom) for the period 1900 UTC 16 Nov 09-0100 UTC 17 Nov 09

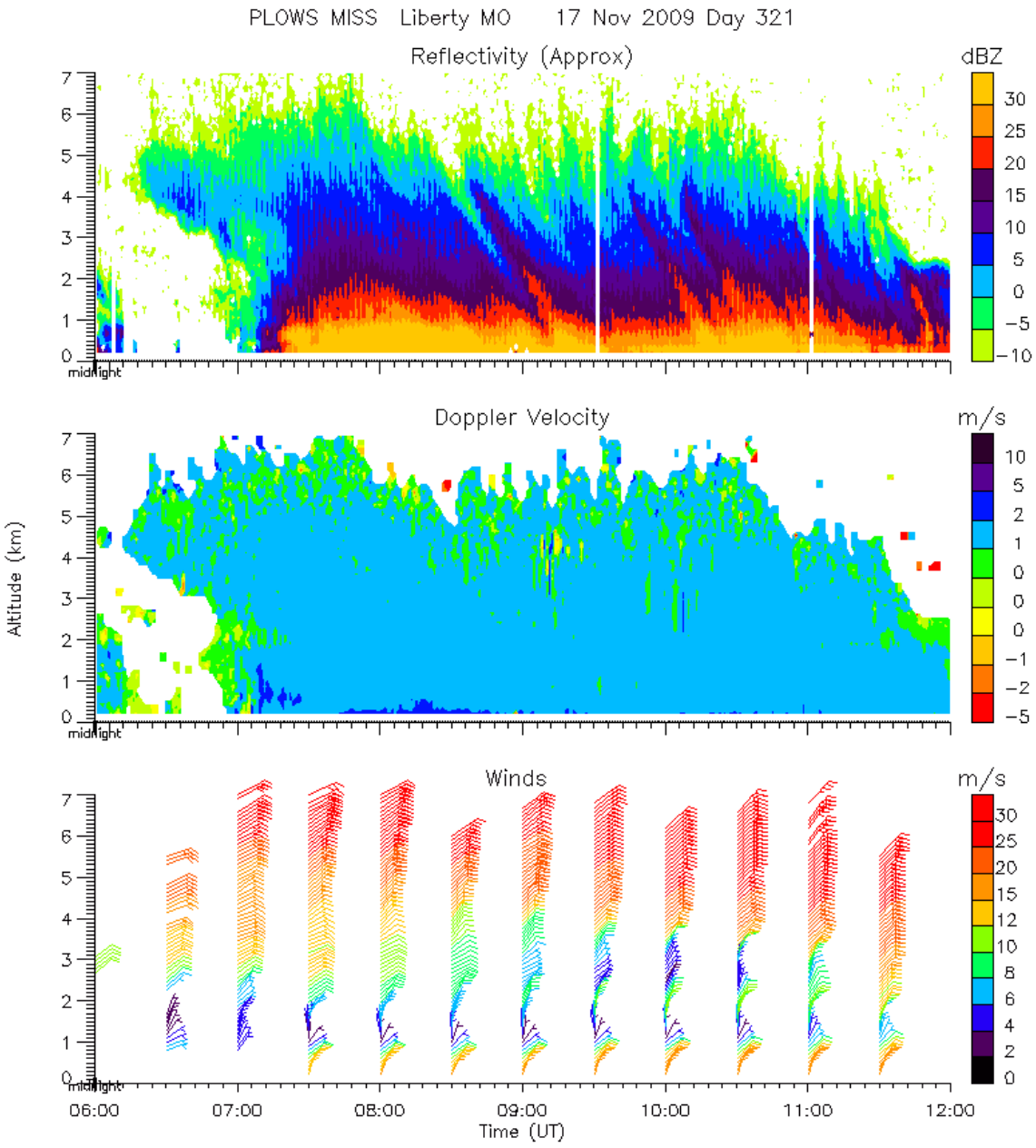


Figure 10: MISS 915 MHz Profiler SNR (top), Radial Velocity (center) and Winds (bottom) for the period 0600 UTC 17 Nov 09-1200 UTC 17 Nov 09

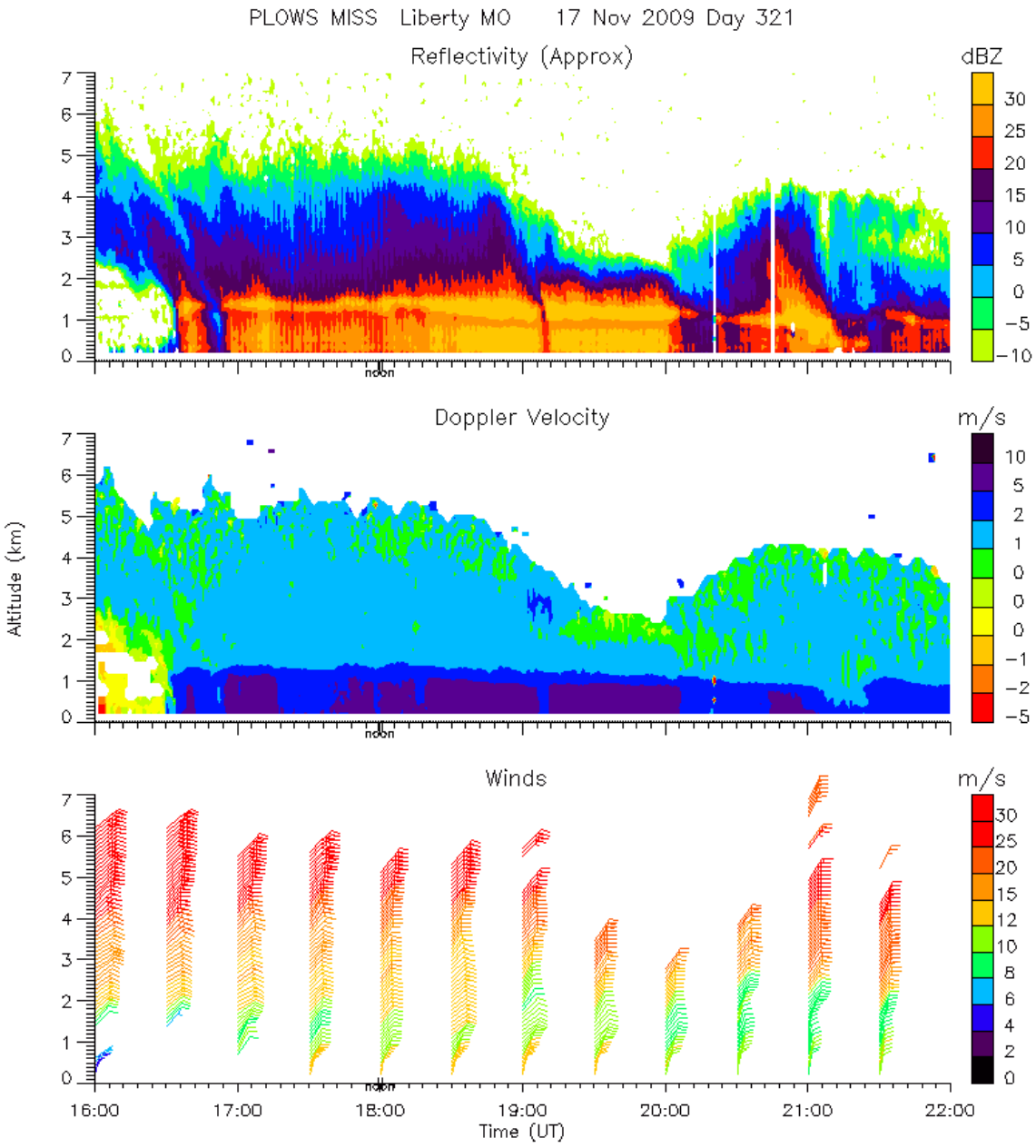


Figure 11: MISS 915 MHz Profiler SNR (top), Radial Velocity (center) and Winds (bottom) for the period 1600 UTC 17 Nov 09-2200 UTC 17 Nov 09

8. Rawinsondes

Rawinsondes were launched at the MISS site on a three hourly schedule. The following soundings were launched

DATE	Launch	Nominal Date and time		Status
2009 11 15	**2344 UTC**	**2009 11 16**	**0000 UTC**	**Good**
2009 11 16	**0245 UTC**	**2009 11 16**	**0300 UTC**	**Good**
2009 11 16	**0534 UTC**	**2009 11 16**	**0600 UTC**	**Good**
2009 11 16	**0837 UTC**	**2009 11 16**	**0900 UTC**	**Good**
2009 11 16	**1138 UTC**	**2009 11 16**	**1200 UTC**	**Good**
2009 11 16	**1440 UTC**	**2009 11 16**	**1500 UTC**	**Good**
2009 11 16	**1735 UTC**	**2009 11 16**	**1800 UTC**	**Good**
2009 11 16	**2026 UTC**	**2009 11 16**	**2100 UTC**	**Good**
2009 11 16	**2334 UTC**	**2009 11 17**	**0000 UTC**	**Good**
2009 11 17	**0243 UTC**	**2009 11 17**	**0300 UTC**	**Good**
2009 11 17	**0533 UTC**	**2009 11 17**	**0600 UTC**	**Good**
2009 11 17	**0828 UTC**	**2009 11 17**	**0900 UTC**	**Good**
2009 11 17	**1132 UTC**	**2009 11 17**	**1200 UTC**	**Good**
2009 11 17	**1429 UTC**	**2009 11 17**	**1500 UTC**	**Good**
2009 11 17	**1728 UTC**	**2009 11 17**	**1800 UTC**	**Good**
2009 11 17	**2028 UTC**	**2009 11 17**	**2100 UTC**	**Good**
2009 11 17	**2334 UTC**	**2009 11 18**	**0000 UTC**	**Good**

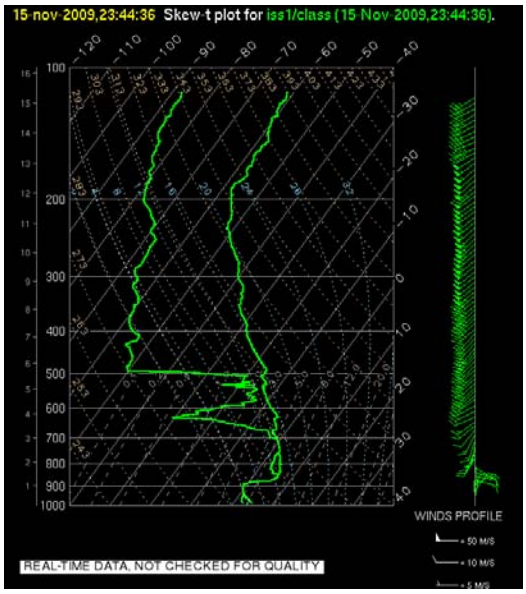
Rawinsondes were launched by the University of Missouri on a three hourly schedule at two sites, the first three launches at the first site, and the remainder collocated with MIPS. The following soundings were obtained

DATE	Launch	Nominal Date and time		Status
2009 11 15	**2357 UTC**	**2009 11 16**	**0000 UTC**	**Good**
2009 11 16	**0232 UTC**	**2009 11 16**	**0300 UTC**	**Good**
2009 11 16	**0524 UTC**	**2009 11 16**	**0600 UTC**	**Good**
2009 11 16	**0831 UTC**	**2009 11 16**	**0900 UTC**	**Good**
2009 11 16	**1131 UTC**	**2009 11 16**	**1200 UTC**	**Good**
2009 11 16	**1432 UTC**	**2009 11 16**	**1500 UTC**	**Burst @ 880 mb**
2009 11 16	**1457 UTC**	**2009 11 16**	**1500 UTC**	**Good**
2009 11 16	**1729 UTC**	**2009 11 16**	**1800 UTC**	**Caught-powerlines**
2009 11 16	**1756 UTC**	**2009 11 16**	**1800 UTC**	**Burst @ 890 mb**
2009 11 16	**2028 UTC**	**2009 11 16**	**2100 UTC**	**Lost sig. @ release**
2009 11 16	**2057 UTC**	**2009 11 16**	**2100 UTC**	**Caught-powerlines**
2009 11 16	**2337 UTC**	**2009 11 17**	**0000 UTC**	**Good**
2009 11 17	**0220 UTC**	**2009 11 17**	**0300 UTC**	**Good**
2009 11 17	**0525 UTC**	**2009 11 17**	**0600 UTC**	**Good**
2009 11 17	**0822 UTC**	**2009 11 17**	**0900 UTC**	**Good**
2009 11 17	**1128 UTC**	**2009 11 17**	**1200 UTC**	**Good**
2009 11 17	**1435 UTC**	**2009 11 17**	**1500 UTC**	**Good**
2009 11 17	**1748 UTC**	**2009 11 17**	**1800 UTC**	**Good**
2009 11 17	**2032 UTC**	**2009 11 17**	**2100 UTC**	**Good**
2009 11 17	**2330 UTC**	**2009 11 18**	**0000 UTC**	**Good**

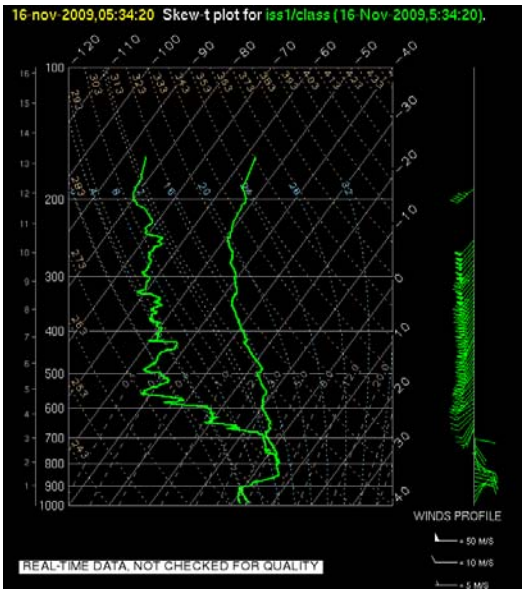
Problems with the Missouri rawinsondes early in the IOP were the result of using 200 gram balloons. These were discontinued after it was determined that they provided insufficient lift to carry the sondes through the melting level, particularly in moderate rain. Discussions

are ongoing between Pat Market (Missouri) and Lou Verstraete (NCAR) as well as Shaun Skibinski (technician with InterMet, radiosonde system manufacturer) regarding this issue. To help with this problem, students assisting with the Missouri radiosonde system have been reminded to use the appropriate counterweight to inflate the balloons and not simply inflate "by feel." We will also take much greater care to deploy away from powerlines, and when doing so becomes necessary, launch with as much distance away from them as possible.

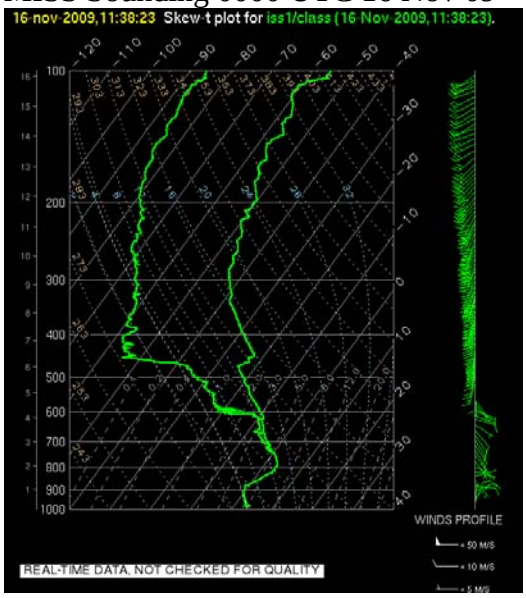
Example Rawinsondes from MISS



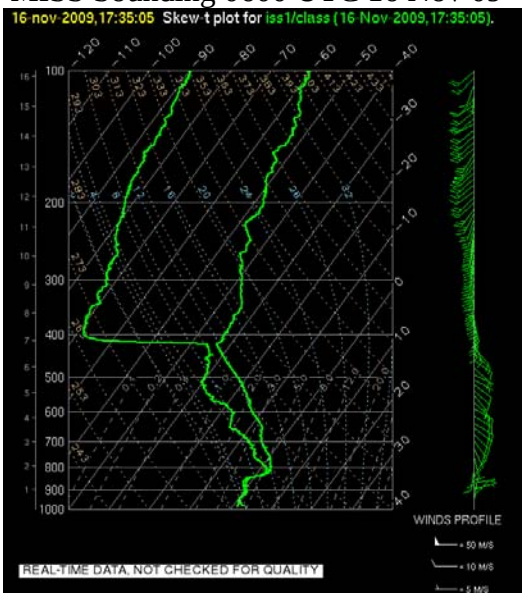
MISS Sounding 0000 UTC 16 Nov 09



MISS Sounding 0600 UTC 16 Nov 09

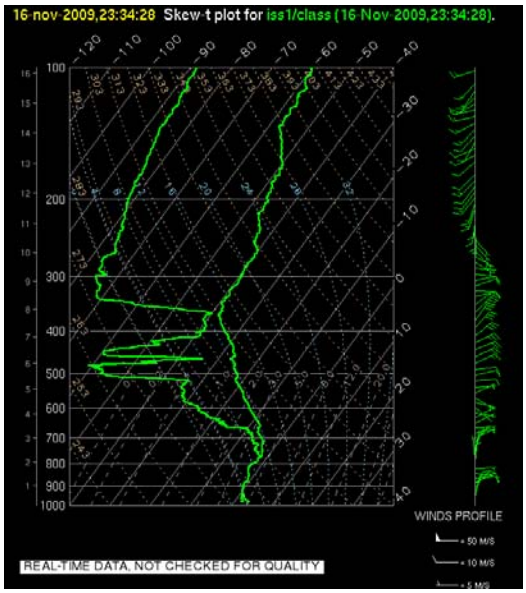


MISS Sounding 1200 UTC 16 Nov 09

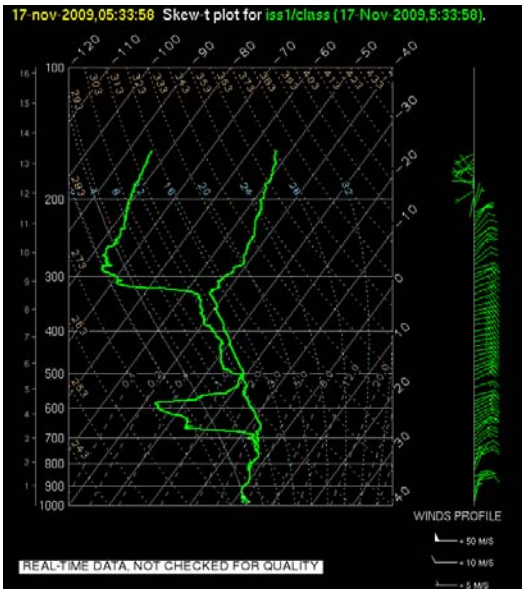


MISS Sounding 1800 UTC 16 Nov 09

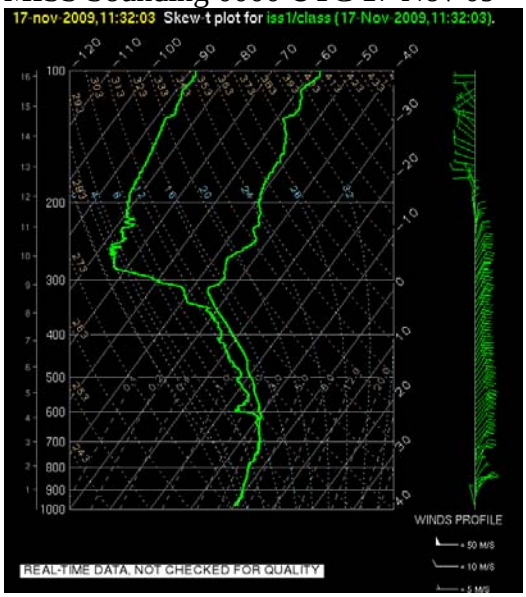
Figure 12: Example MISS soundings 16 Nov 09



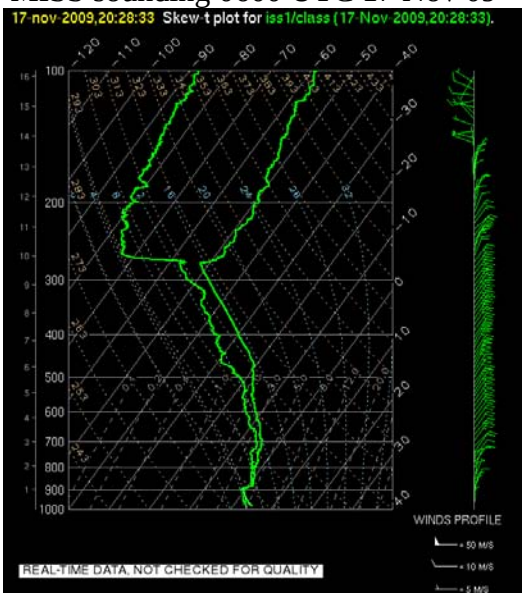
MISS Sounding 0000 UTC 17 Nov 09



MISS sounding 0600 UTC 17 Nov 09



MISS Sounding 1200 UTC 17 Nov 09



MISS Sounding 1800 UTC 18 Nov 09

Figure 13: Example MISS soundings 17 Nov 09

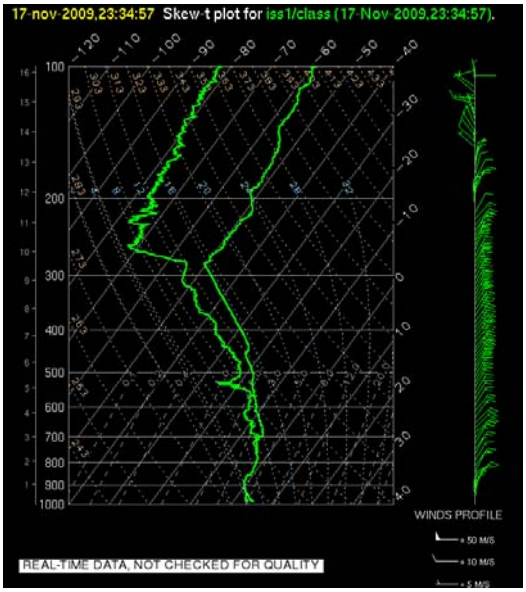
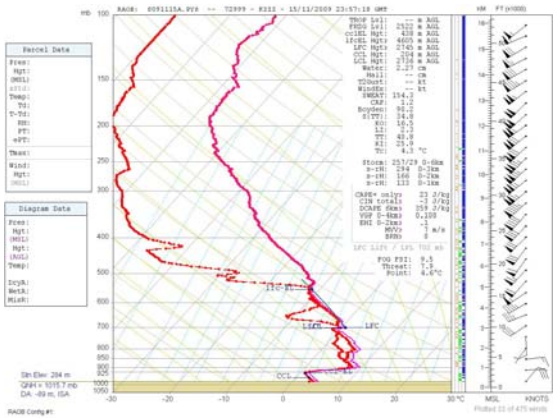
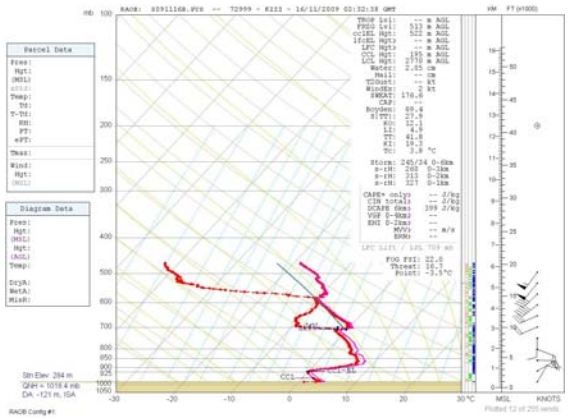


Fig l4: MISS Sounding 0000 UTC 18 Nov 09

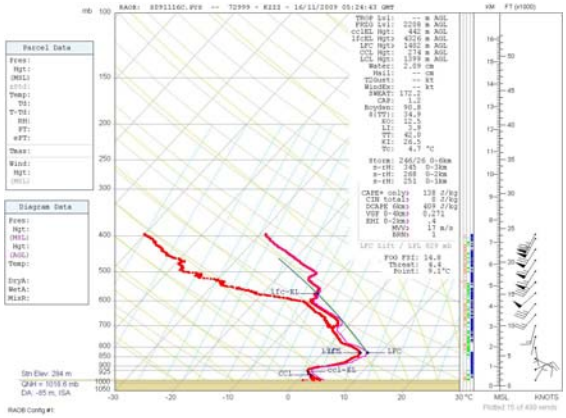
Example Rawinsondes from Missouri



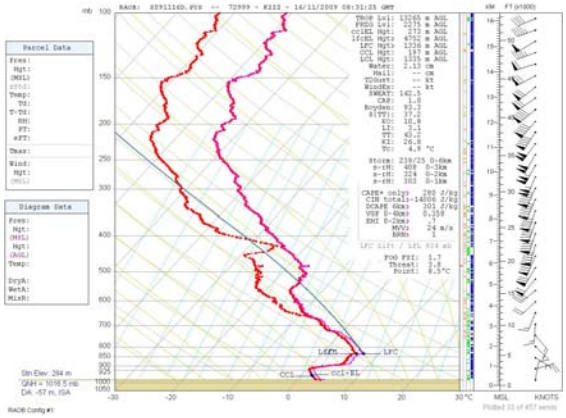
UM sounding 0000 UTC 16 Nov 2009



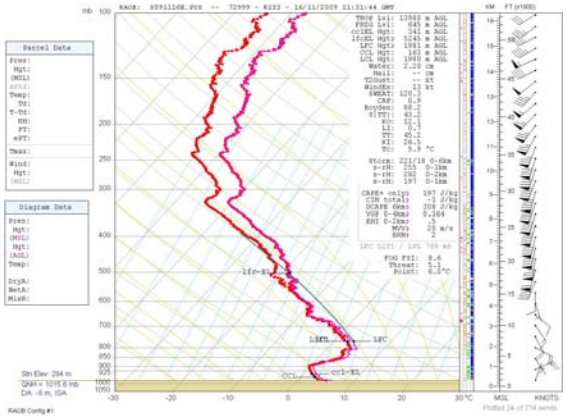
UM sounding 0300 UTC 16 Nov 2009



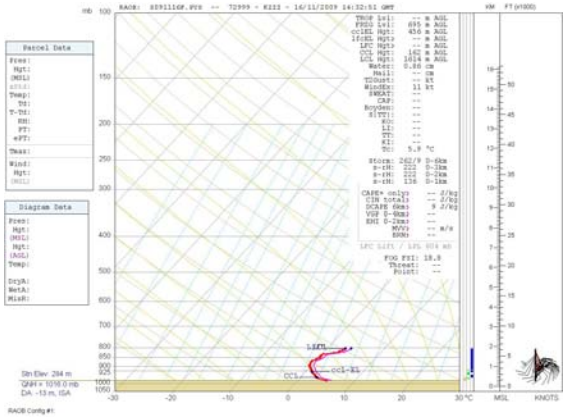
UM sounding 0600 UTC 16 Nov 2009



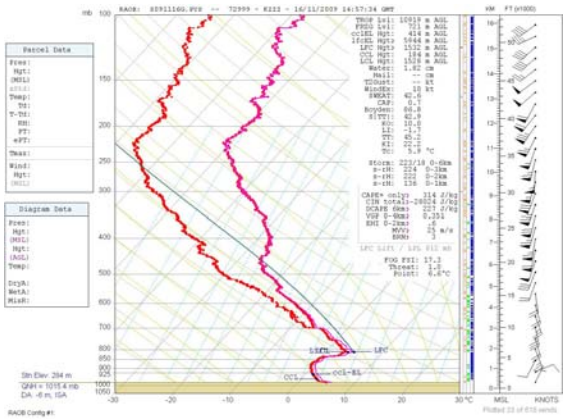
UM sounding 0900 UTC 16 Nov 2009



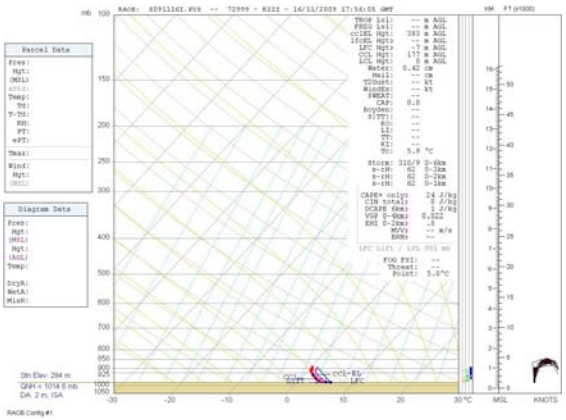
UM sounding 1200 UTC 16 Nov 2009



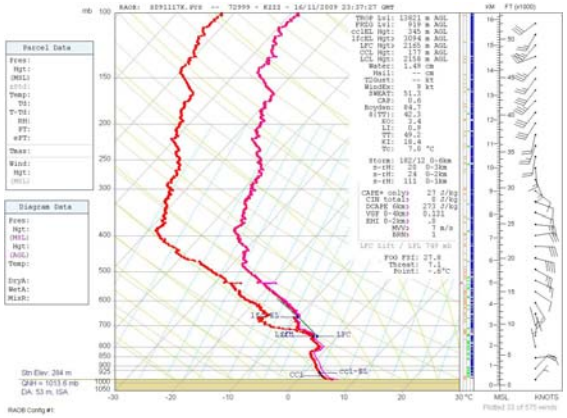
UM sounding 1500 UTC 16 Nov 2009



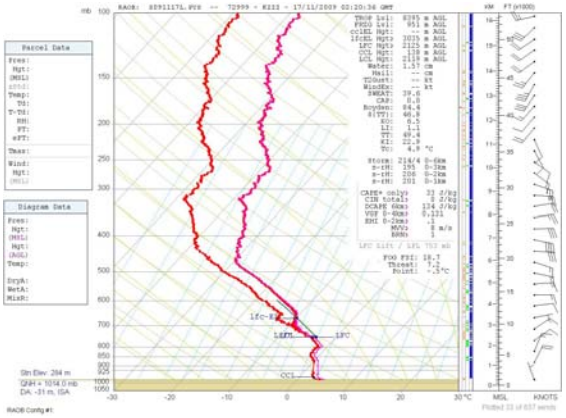
UM sounding 1500 UTC 16 Nov 2009 (**retry**)



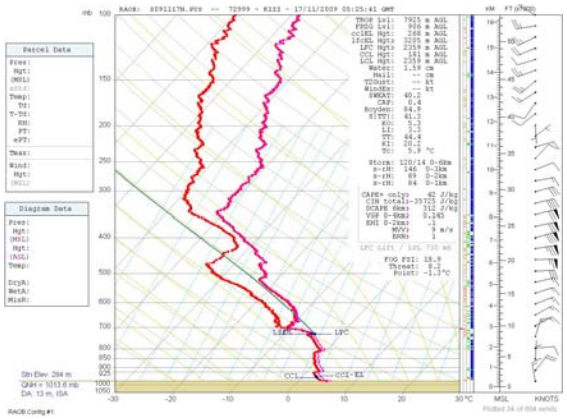
UM sounding 1800 UTC 16 Nov 2009



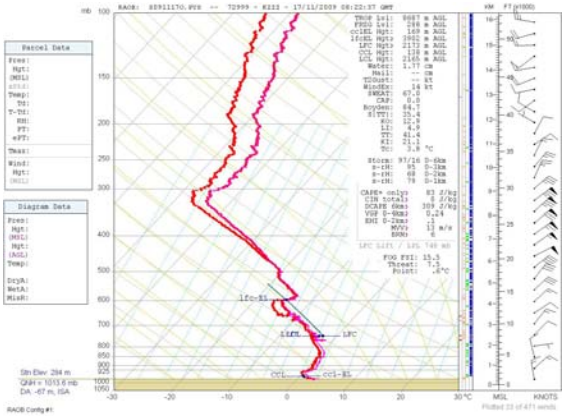
UM sounding 0000 UTC 17 Nov 2009



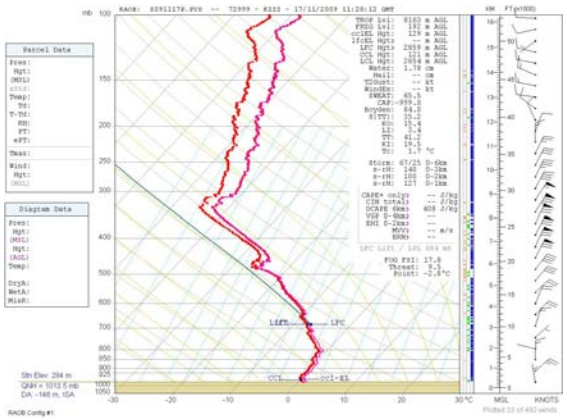
UM sounding 0300 UTC 17 Nov 2009



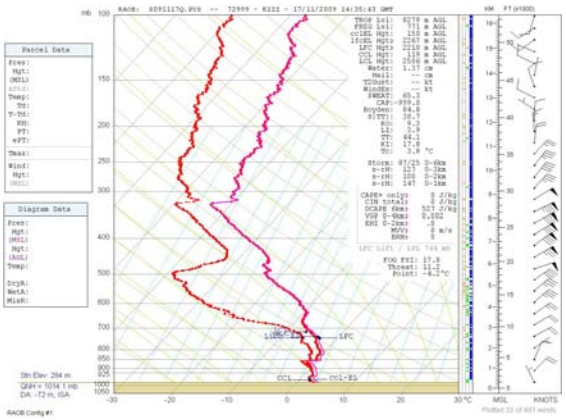
UM sounding 0600 UTC 17 Nov 2009



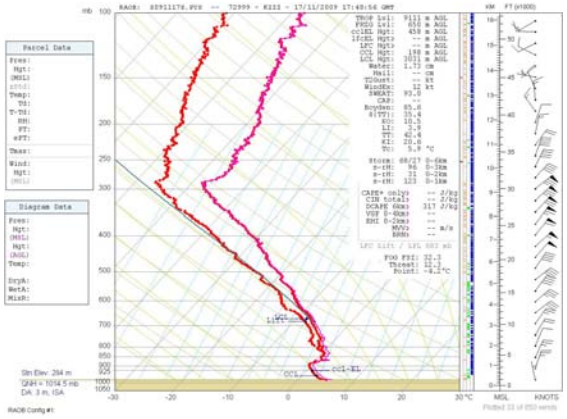
UM sounding 0900 UTC 17 Nov 2009



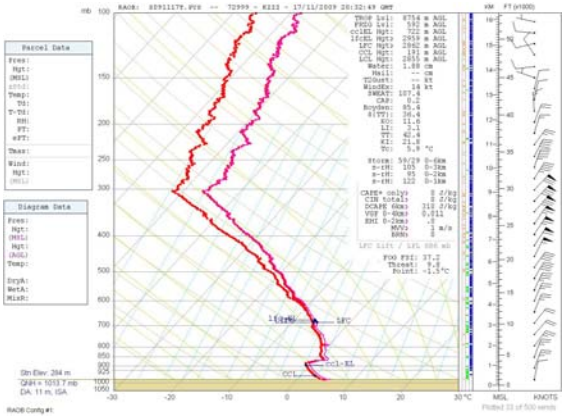
UM sounding 1200 UTC 17 Nov 2009



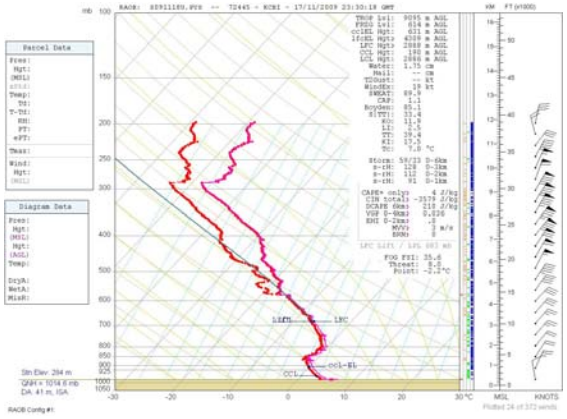
UM sounding 1500 UTC 17 Nov 2009



UM sounding 1800 UTC 17 Nov 2009



UM sounding 2100 UTC 17 Nov 2009



UM sounding 0000 UTC 18 Nov 2009