

**IOP-8 Summary of Operations**  
**23 November 2009, 0000 UTC – 25 November 2009 1300 UTC**

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**1. Summary of storm evolution**

IOP-8 focused on a cyclone that developed over the Panhandle of Texas at 1800 UTC, 23 Nov 09 and propagated northeast to a position over Kansas City by 0600 UTC, 24 Nov 09 (Fig. 1, left panels). During operations, the center of the cyclone moved east northeast from Kansas City at 0600 UTC to the northeast corner of Missouri at 0000 UTC on 25 Nov 09, and then northeastward to northern Chicago by 1200 UTC, 25 Nov (Fig. 2, left panels). The storm was relatively weak with a central pressure of ~1009 mb during flight operations, deepening to 1004 mb after 0000 UTC, 25 Nov. The storm was associated with a wide trough at 500 mb, that slowly propagated eastward (Fig. 1, middle panels). During the later part of the IOP, a second short wave approached the area from the northwest, but did not arrive until operations were suspended (Fig. 2, middle panels). Precipitation in the frontal region of the storm was non-existent prior to 0600 UTC 24 Nov, and poorly developed with one primary band along the back edge of the storm by 1800 UTC (Figs. 1 and 2, right panels). The primary band dissipated by 2000 UTC and the storm appeared to be dissipating at that time. Redevelopment occurred starting at 2000 UTC, with several bands appearing in the wrap-around region of the storm. These were sampled by the aircraft for the remainder of the flight. Near the center of the cyclonic circulation, essentially over the MIPS/MAX site, a circular region of precipitation formed which morphed into a curved band. The band rotated over the MIPS location for several hours. The circulation slowly drifted east of the MIPS site with precipitation winding down at 0130 UTC on 25 Nov. Precipitation continued at the MISS site in Davenport for several more hours, winding down at about 0900 UTC 25 Nov as the storm moved northeast.

**2. Locations of instrumentation platforms**

MIPS Location:	41°54'49.61"N 93°23'35.25"W
Profiler Time of Operation MIPS:	11/24/09 0255 UTC to 11/25/09 0114 UTC NDB
MAX Location:	42 04' 8.3" N 93 31' 17.3"
Radar Time of Operation MAX:	11/24/09 0441 UTC to 11/25/09 0104 UTC NDB
MISS Location:	41°37' 6.12"N 90°47' 6.14"W
Profiler Time of Operation	22 Nov 09 2200 UTC to 25 Nov 25 09 1300 UTC
MO Location:	42° 00' 28.00" 93° 34' 56.28"
RF-02 Flight operations:	17:01 UTC 24 Nov 09 - 01:20 UTC 25 Nov 09

No Data Breaks

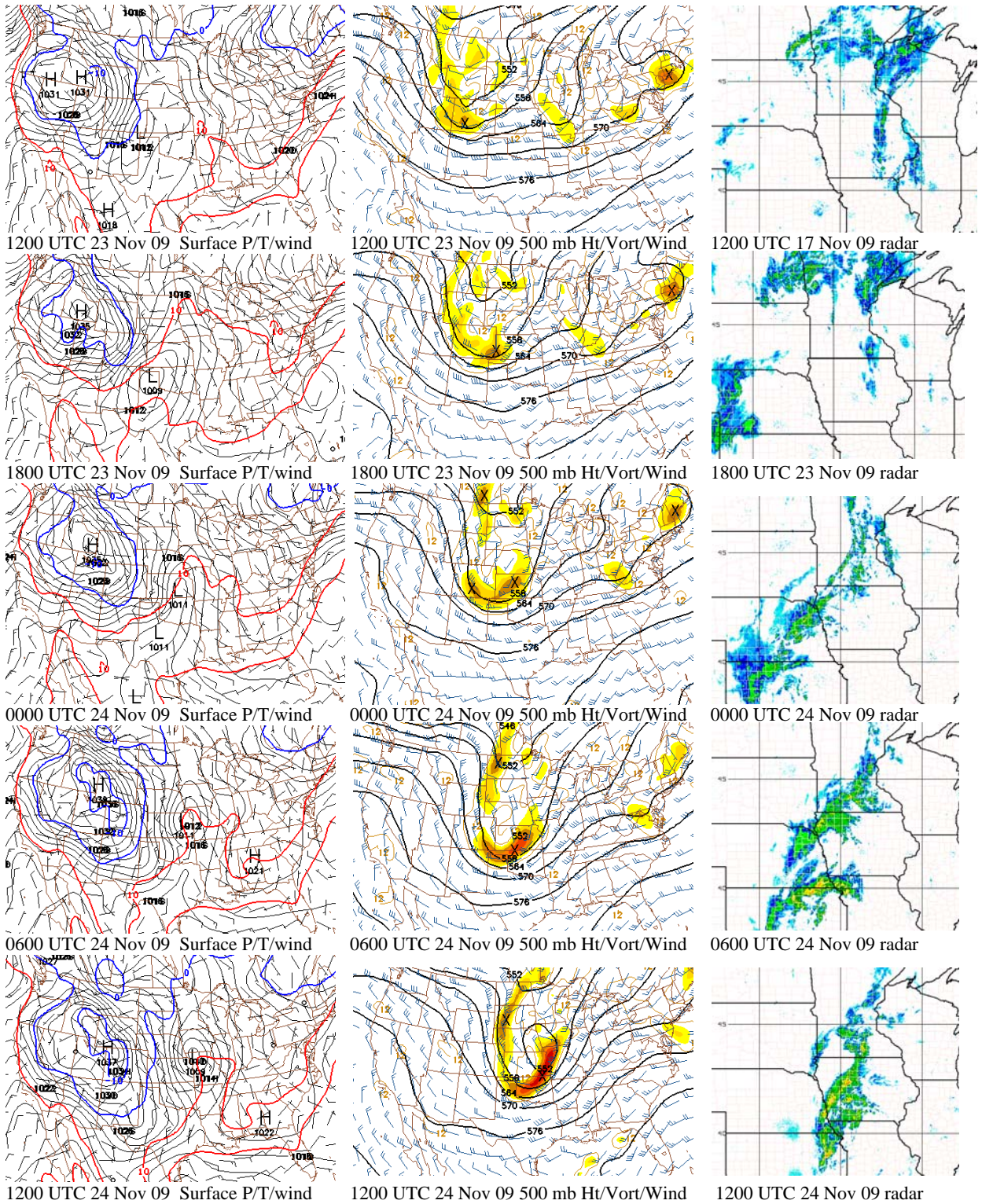


Figure 1: Early evolution of the IOP-8 storm at the surface, 500 mb, and radar echoes from 1200 UTC 23 Nov 09 through 1200 UTC 24 Nov 09.

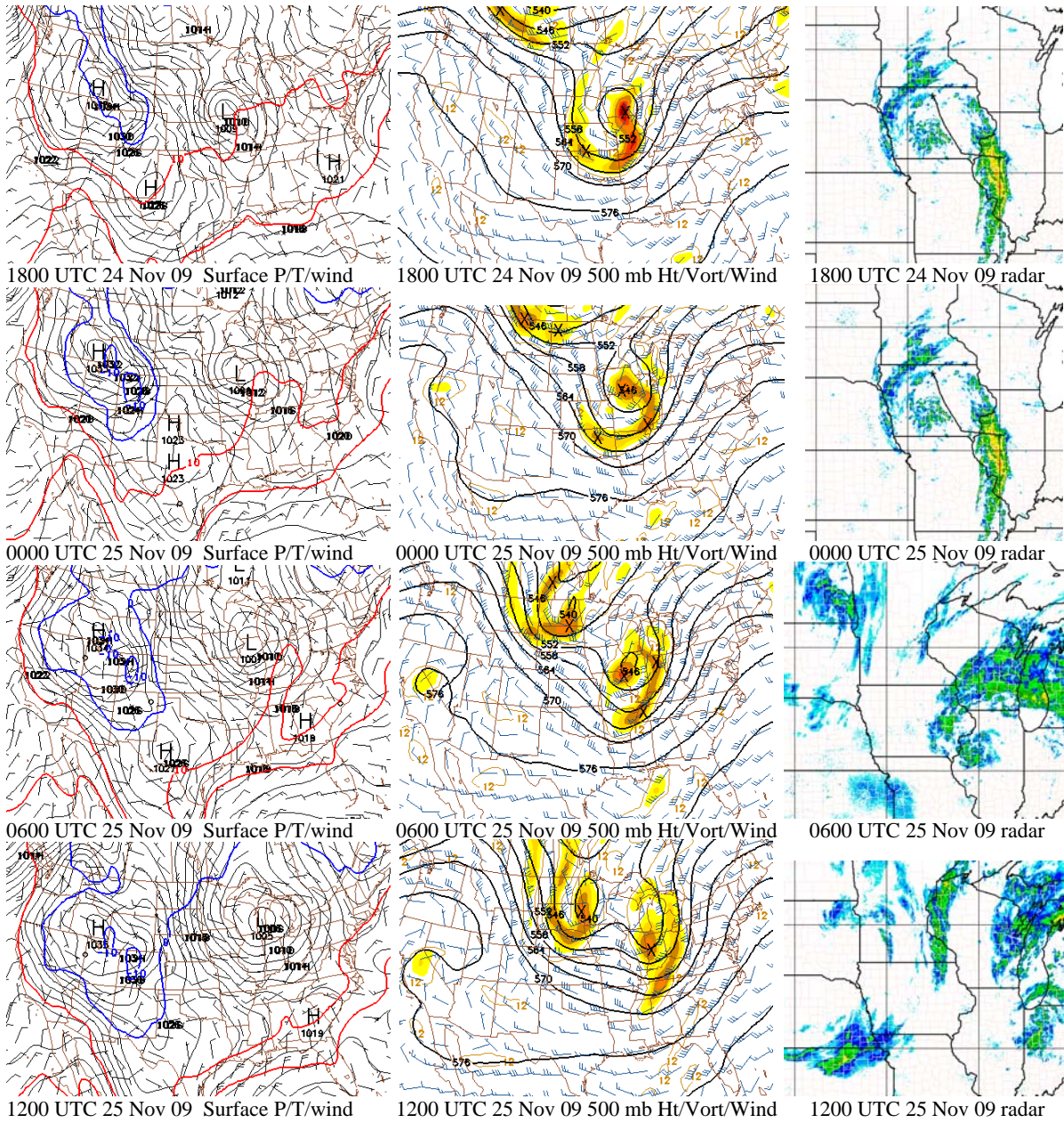


Figure 2: Later evolution of the IOP-8 storm at the surface, 500 mb, and radar echoes from 1800 UTC 24 Nov 09 through 1200 UTC 25 Nov 09.

### 3. Precipitation over research area

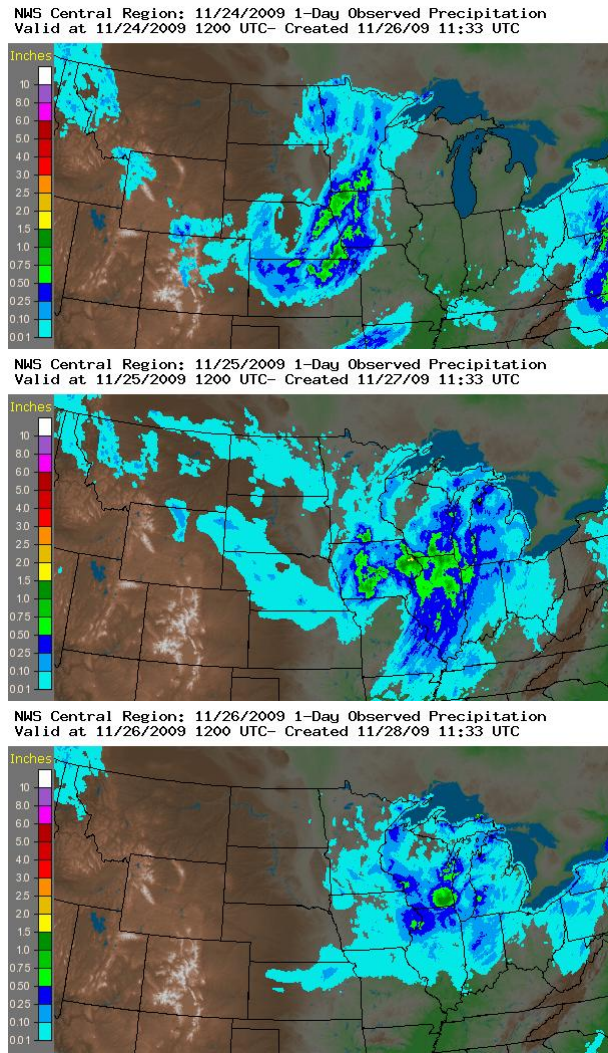
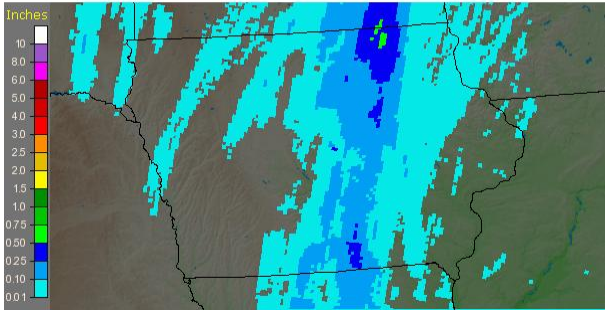
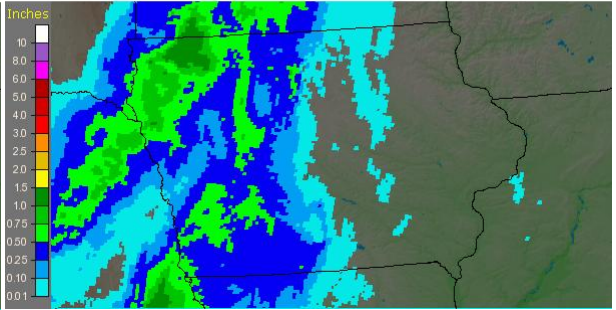


Fig. 2: 24 Hour precipitation ending at 1200 UTC 11/24/09, 11/25/09, 11/26/09 over the Midwestern United States

Iowa: 11/23/2009 1-Day Observed Precipitation  
Valid at 11/23/2009 1200 UTC- Created 11/27/09 20:53 UTC



Iowa: 11/24/2009 1-Day Observed Precipitation  
Valid at 11/24/2009 1200 UTC- Created 11/26/09 11:32 UTC



Iowa: 11/25/2009 1-Day Observed Precipitation  
Valid at 11/25/2009 1200 UTC- Created 11/27/09 11:32 UTC

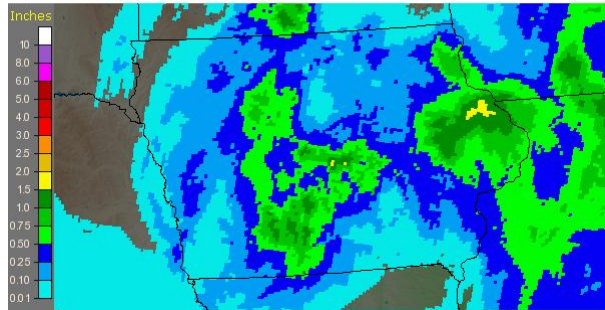
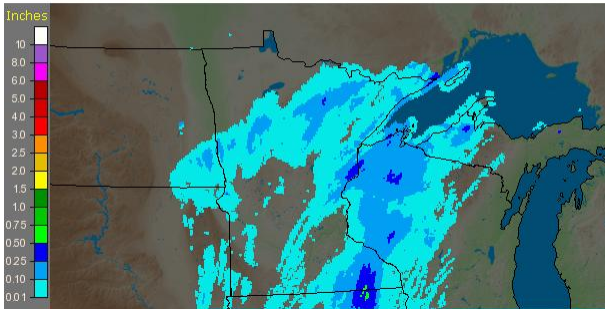
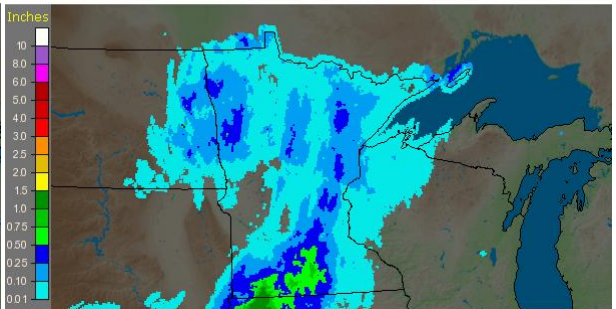


Figure 3a: 24 hour precipitation over Iowa ending at 1200 UTC on 23, 24, and 25 Nov 09

Minnesota: 11/23/2009 1-Day Observed Precipitation  
Valid at 11/23/2009 1200 UTC- Created 11/27/09 20:53 UTC



Minnesota: 11/24/2009 1-Day Observed Precipitation  
Valid at 11/24/2009 1200 UTC- Created 11/26/09 11:32 UTC



Minnesota: 11/25/2009 1-Day Observed Precipitation  
Valid at 11/25/2009 1200 UTC- Created 11/27/09 11:32 UTC

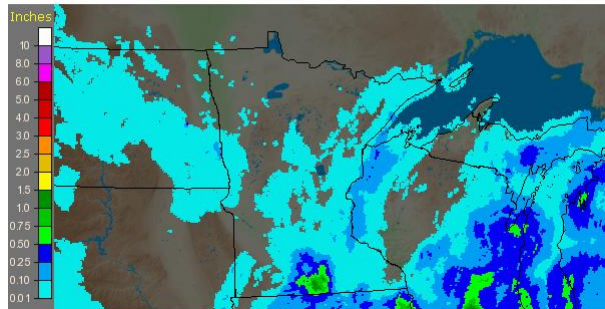


Figure 3b: 24 hour precipitation over Minnesota ending at 1200 UTC on 23, 24, and 25 Nov 09

## 4. Flight Summary

### C-130 Flight RF-02

The NCAR C-130 took off at 17:00 UTC (11:00 local) and made measurements in the wrap-around region to the northwest of a strong line of storms that migrated to the north-east during the course of the mission (Fig. 5). The C-130 initially ascended to approximately 20 kft and flew along dropsonde line F and released 10 dropsondes at the pre-designated points F1 through F10. The C-130 was in and out of cloud during the later part of the flight leg. The F line crossed the leading band on the dry slot and the 2 bands behind it. After completing the dropsonde leg, the C-130 traveled to OTG and then towards and past TNU, descending to 14 kft for this leg. On this leg, the C-130 was about 700 m below cloud top and there was not a lot of structure to the reflectivity, but in general the maximum reflectivity was at the altitude of the C-130 or a couple of thousand feet below. The lidar indicated that there could be some liquid just below cloud top. After point TNU, the C-130 continued past TNU to stay in precipitation, flying approximately along the back of the convective band.

After exiting cloud after TNU, the C-130 turned and started heading towards ILL at 15 kft. Shortly after turning the C-130 hit a 12 m/s updraft with over  $1 \text{ g m}^{-3}$  of liquid water. Very heavy precipitation was noted at the altitude of the aircraft and the pilots zigzagged along the band choosing the best path through. Lightning was also noted in the vicinity of the C-130. Along the line to ILL, it looked like the sampled bands were starting to dissipate, but a decision was made to stay on station longer in case anything redeveloped. Hence, after ILL, the C-130 dropped to 14 kft to sample what was at that time the last remnants of the band of precipitation on the way towards SPW.

Along the line to SPW, it was noted that another band was developing in northern Iowa. Thus, at SPW the C-130 turned and headed north towards OTM at 14 kft, allowing a sampling of two existing bands and the band that was starting to form in Iowa. On this leg, the radar showed tops extending 9 to 10 kft above with not much turbulence or structure in the reflectivity field. Later on in the leg, updrafts up to 3 m/s were noted. After arriving at OTM, the plane turned and headed south towards AEL at 14 kft and then back again to OTM at 16 kft (radar was not functional for about 5 minutes over this band). The tops were about 24 kft on this leg. After AEL, the C-130 turned and headed towards LSE at 19 kft encountering updrafts up to almost 3 m/s. On this leg, the C-130 seemed to be near the level of maximum reflectivity, but the maximum reflectivity was still at higher altitudes for some of the legs. To try and sample the maximum reflectivity of the higher bands, the C-130 ascended to 20 kft for the last southward leg to BRL. Updrafts up to 2.5 m/s were encountered on this leg. After arriving at BRL, the C-130 turned and headed towards Peoria, landing at approximately 0130 UTC.

Quick Looks from the WCR for the flight are shown in Figures 6-8

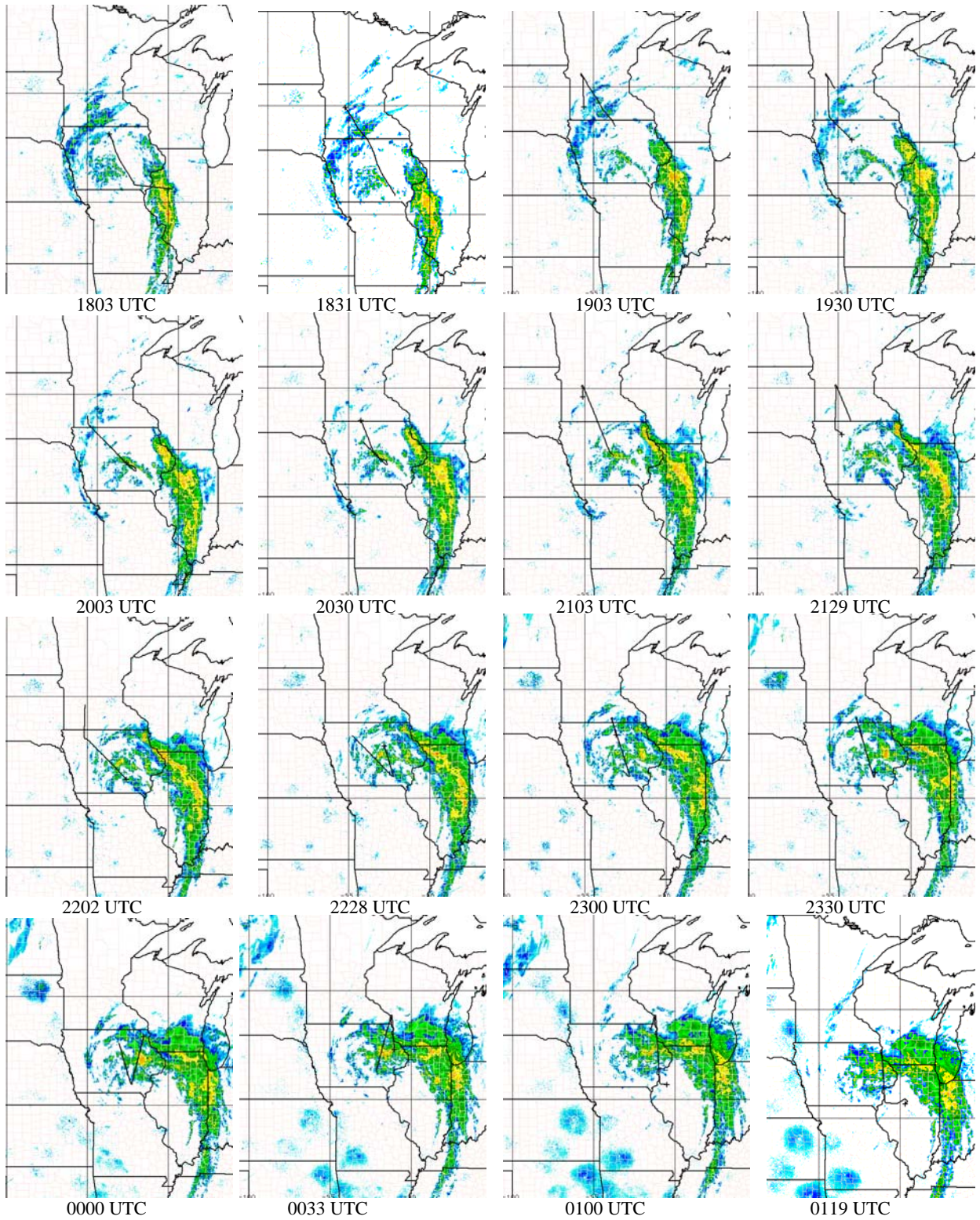
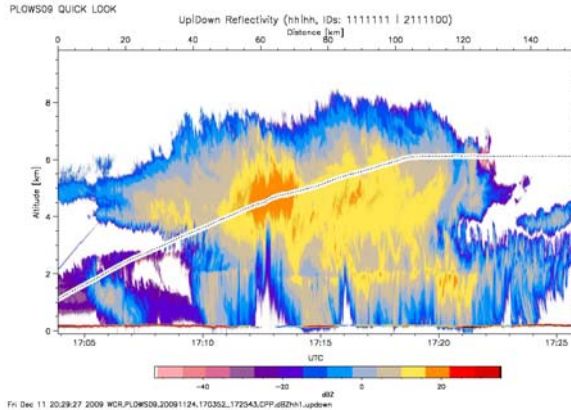
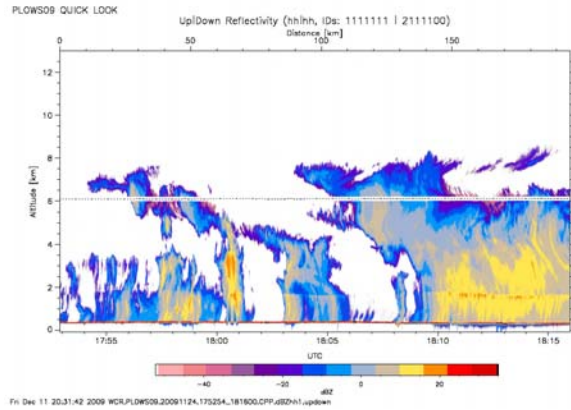


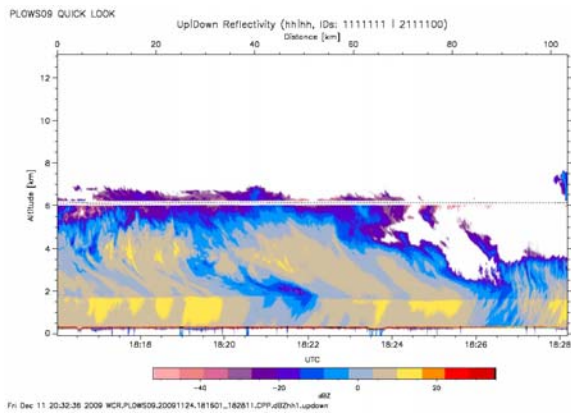
Figure 5: C-130 flight track overlaid on radar composites from 1803 UTC 24 Nov 09 through 0119 UTC 25 Nov 09. Times shown are the times of the radar composites. The flight track for the period just before the composite is shown.



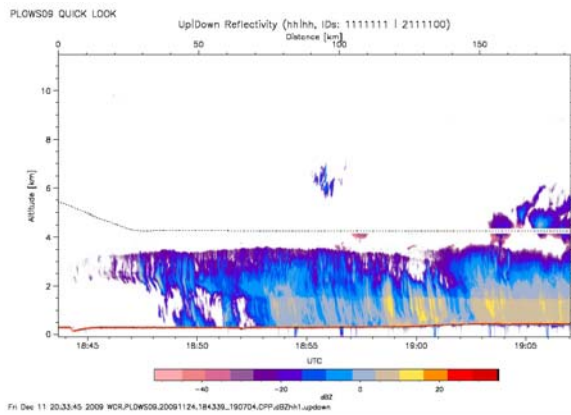
1705 UTC to 1726 UTC



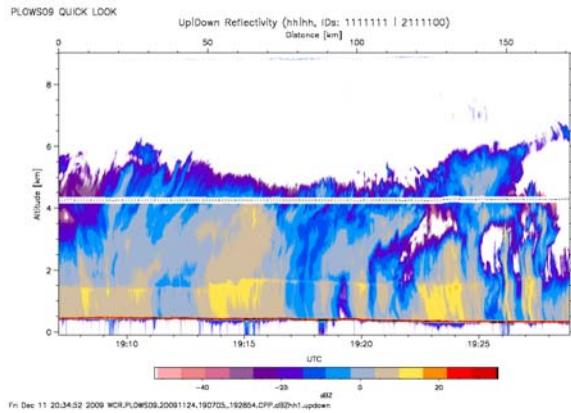
1755 UTC to 1816 UTC



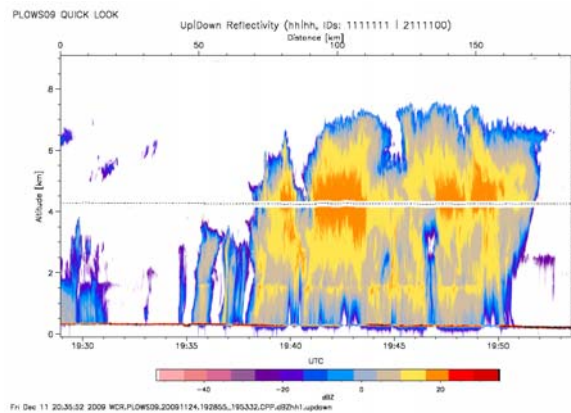
1812 UTC to 1828 UTC



1845 UTC to 1900 UTC



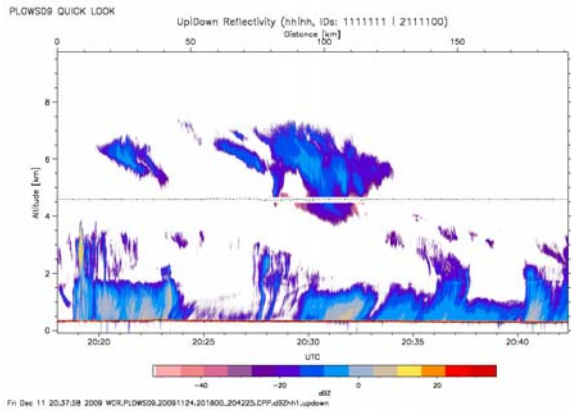
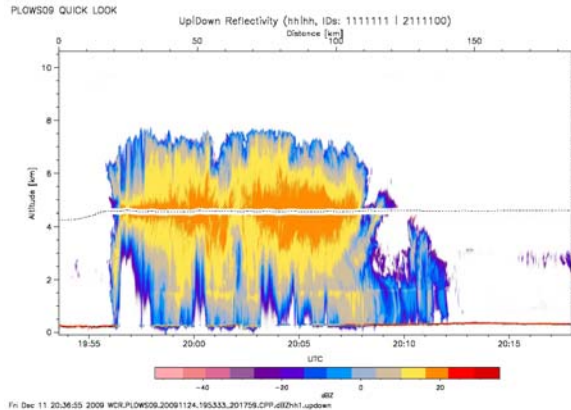
1907 UTC to 1928 UTC



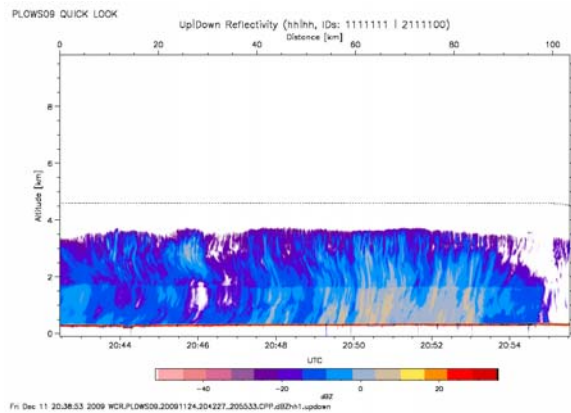
1929 UTC to 1954 UTC

Figure 6: Wyoming Cloud Radar Quick look radar reflectivity images from 1705-1954 UTC during RF-02 on 24 November 09

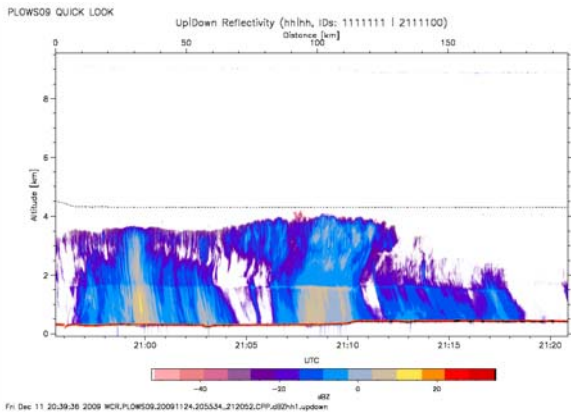




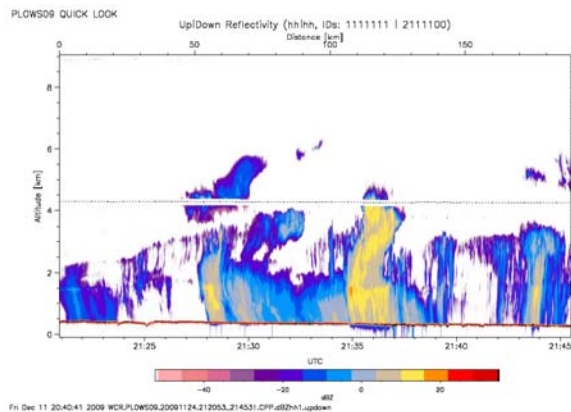
1954 UTC to 2018 UTC



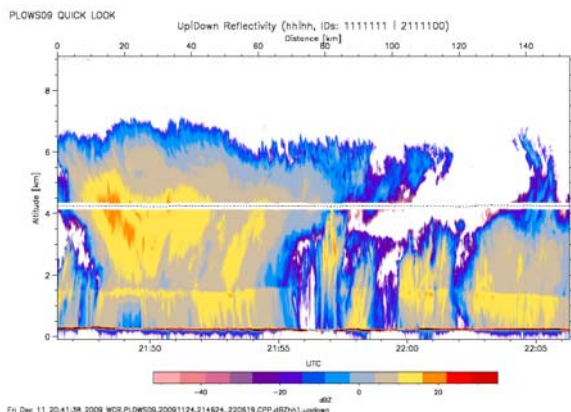
2018 UTC to 2043 UTC



2041 UTC to 2057 UTC



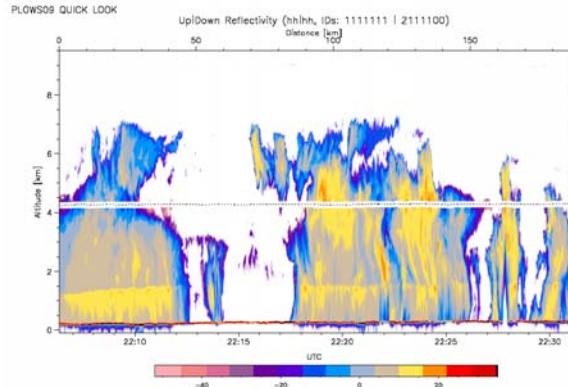
2057 UTC to 2120 UTC



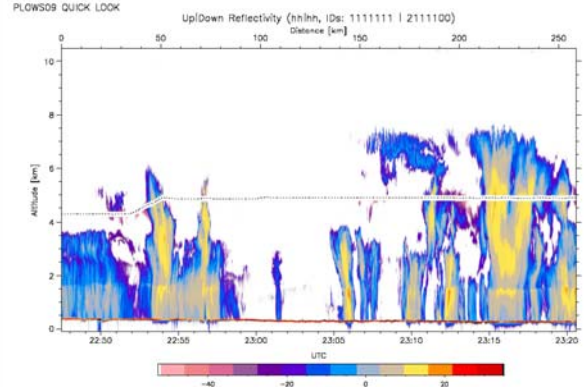
2120 UTC to 2146 UTC

2146 UTC to 2207 UTC

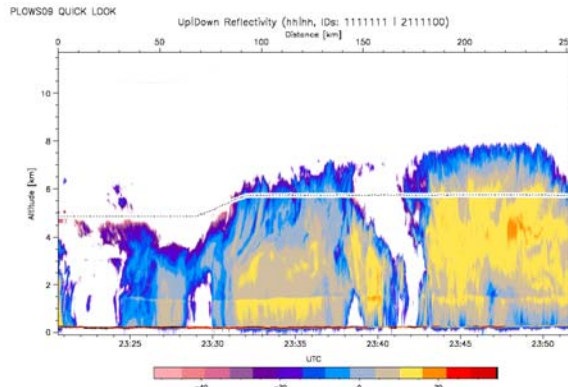
Figure 7: Wyoming Cloud Radar Quick look radar reflectivity images from 1954-2207 UTC during RF-02 on 24 November 09



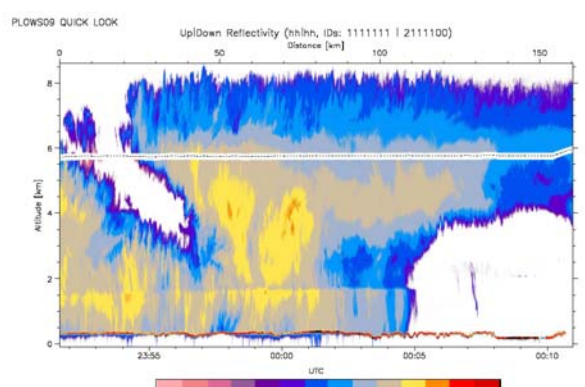
2207 UTC to 2231 UTC



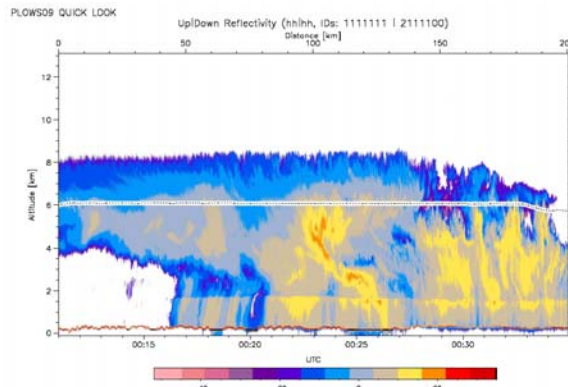
2247 UTC to 2320 UTC



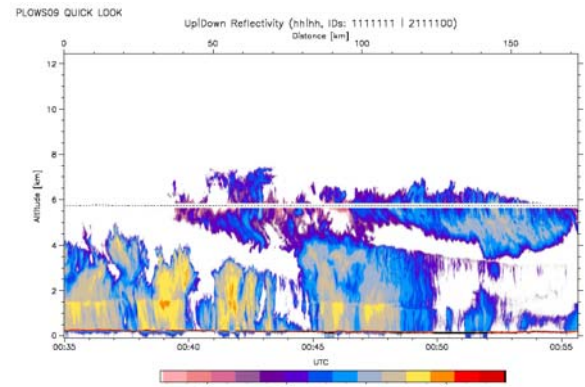
2320 UTC to 2352 UTC



2352 UTC to 0011 UTC



0011 UTC to 0035 UTC



0035 UTC to 0056 UTC

Figure 8: Wyoming Cloud Radar Quick look radar reflectivity images from 2207-0056 UTC during RF-02 on 24-25 November 09

## 5. MIPS operations

The MIPS operated continuously at a site (along a gravel road) east of Ames, IA. The heading of the MIPS van/trailer was 280 deg from magnetic north. During the event, a single band passed near 1400 UTC. This band produced a lightning strike within about 100 m of the MIPS trailer (Fig. 9). Several lightning strikes occurred over the next 10 min.

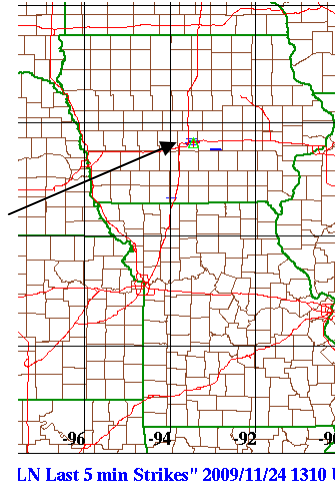


Figure 9: Lightning strike by MIPS at 1310 UTC

The dry slot moved over the MIPS between 1430 -1800 UTC. At 1800 UTC, liquid water was indicated by the radiometer, along with weak updraft near echo top at 4 km AGL. After about 1830 UTC, as the core of the cyclone approached the site, a tightly curved band, almost circular in shape, developed over the site. The circular band rotated over the site for several hours producing the band observed on the 915 MHz Profiler between 1800 and 2200 UTC. Rainfall rates approaching 20 mm/hr were measured from reflectivity cores in excess of 50 dBZ. A total of rainfall of about 50 mm occurred at the MIPS site, and much of this was from the slow-moving convective band. Large drops of 4-6 mm diameter were measured by the Parsivel at 2145 UTC. Figure 10 shows the SNR, W, and Spectral Width from the MIPS for the IOP.

## 6. MAX operations

The MAX conducted cycles of full volume VAD and RHI scans over the MIPS site (the MIPS was located at 148.4 deg, 20 km from the MAX). MISS was in Walcott near Davenport so no RHIs were done over MISS for this IOP. The total scan cycle time was about 6 min. The Des Moines WSR-88D remained in VCP-11 mode throughout the event. PPI scans through the circular region are shown on Fig. 11 for the period between 2143 and 2202 UTC. During the latter part of the event (around 2100 -2200 UTC), strong winds up to 16 m/s were measured at the MAX site, while relatively weak winds (~6 m/s) persisted at the MIPS site. Blockage at the MAX site was minimal.

MAX Scanning Angles: 0.5 1.0 1.5 2.5 3.8 5.3 6.8 8.2 10 13 15 19 65

MAX radar parameters 24rpms, 1000prf, .8 pulse width

## **7. MISS 915 MHz Profiler**

Data were obtained throughout the period from 22 Nov 09 2200 UTC to 25 Nov 25 09 1300 UTC. Because of the uncertainty in the cyclone position, and timing restrictions due to the upcoming Thanksgiving holiday break, it was decided to position the MISS in Wolcott near Davenport so we could document the entire storm evolution. Data for the IOP are shown in Figs. 12-17. During the IOP several convective bands passed over the MISS.

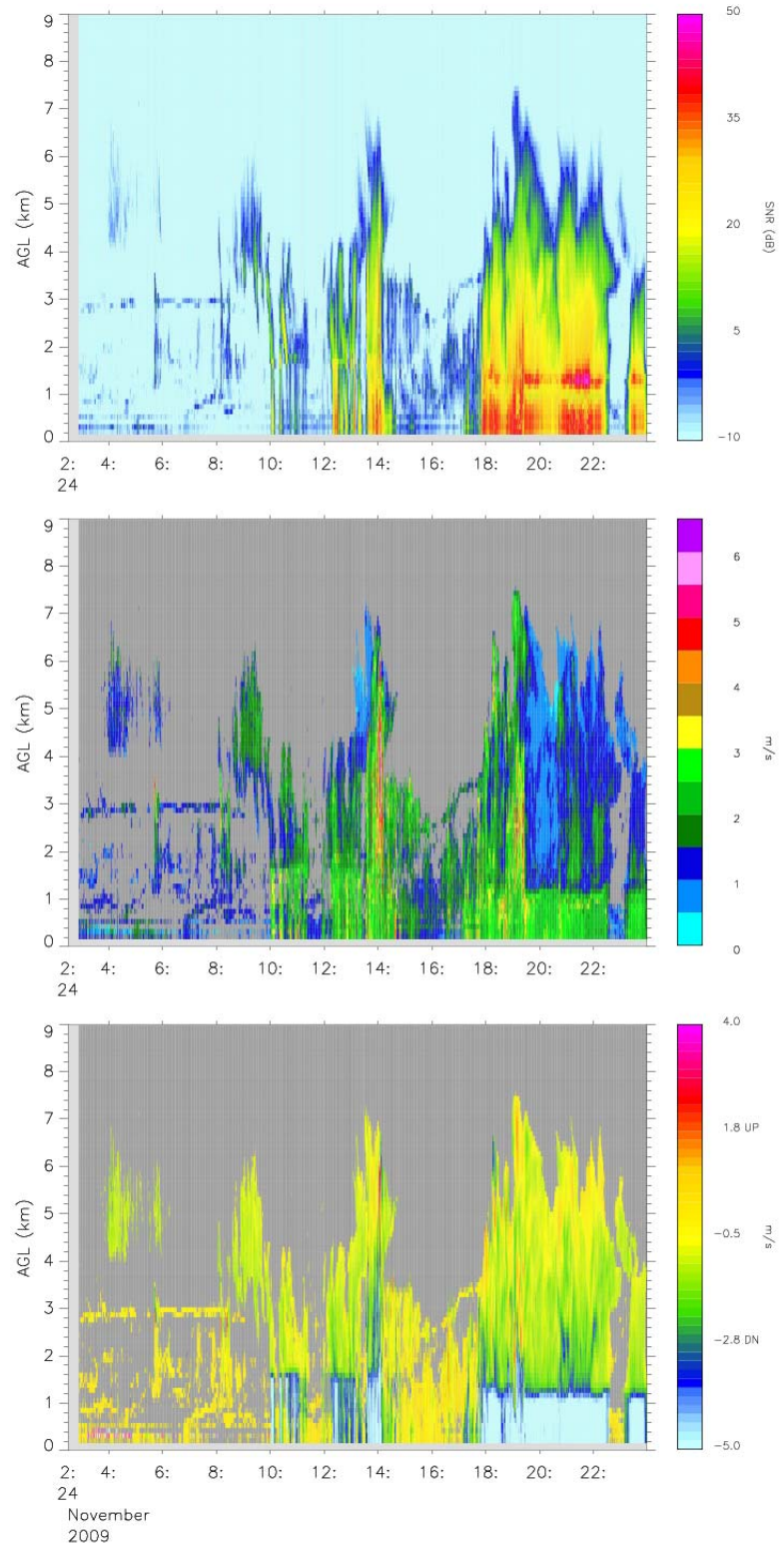
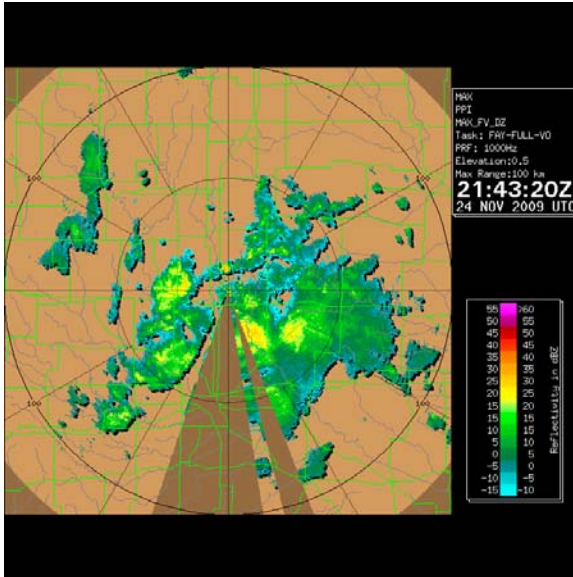
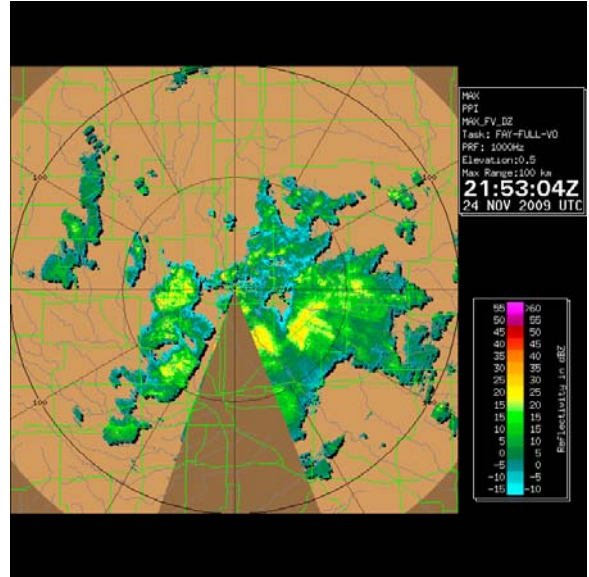


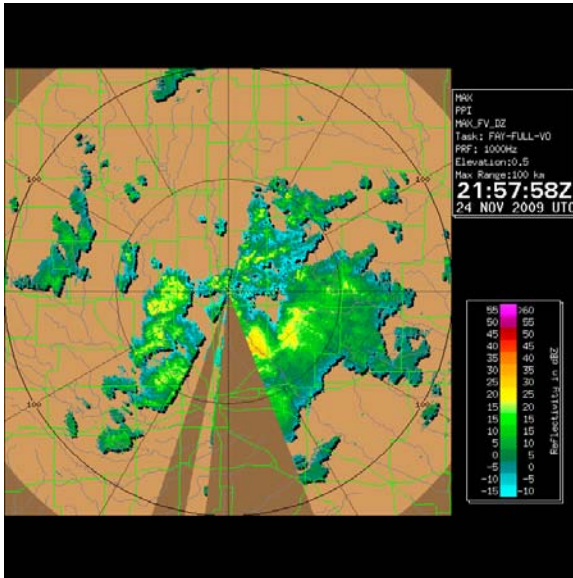
Figure 10: MIPS 915 Mhz Profiler SNR (top), Radial Velocity (center) and Spectral Width (bottom) for the period 0255 UTC 24 Nov 09-0000 UTC 25 Nov 09. The profiler was shut down at 0114 UTC 25 Nov 09



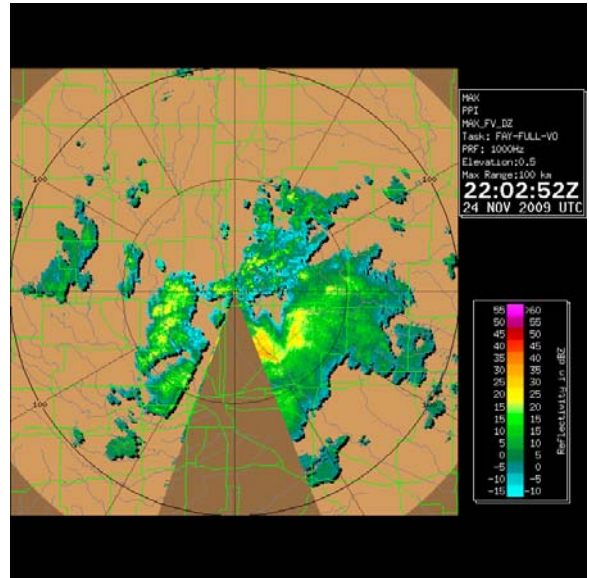
MAX radar PPI at 214320 UTC 24 Nov 09



MAX radar PPI at 215304 UTC 24 Nov 09



MAX radar PPI at 215758 UTC 24 Nov 09



MAX radar PPI at 220252 UTC 24 Nov 09

Figure 11: MAX images during passage of band of precipitation near cyclone core around 2200 UTC 24 Nov 09

PLOWS MISS 23 Nov – 24 Nov 09 Days 327 – 328  
SNR Combined 2 Vertical Beams

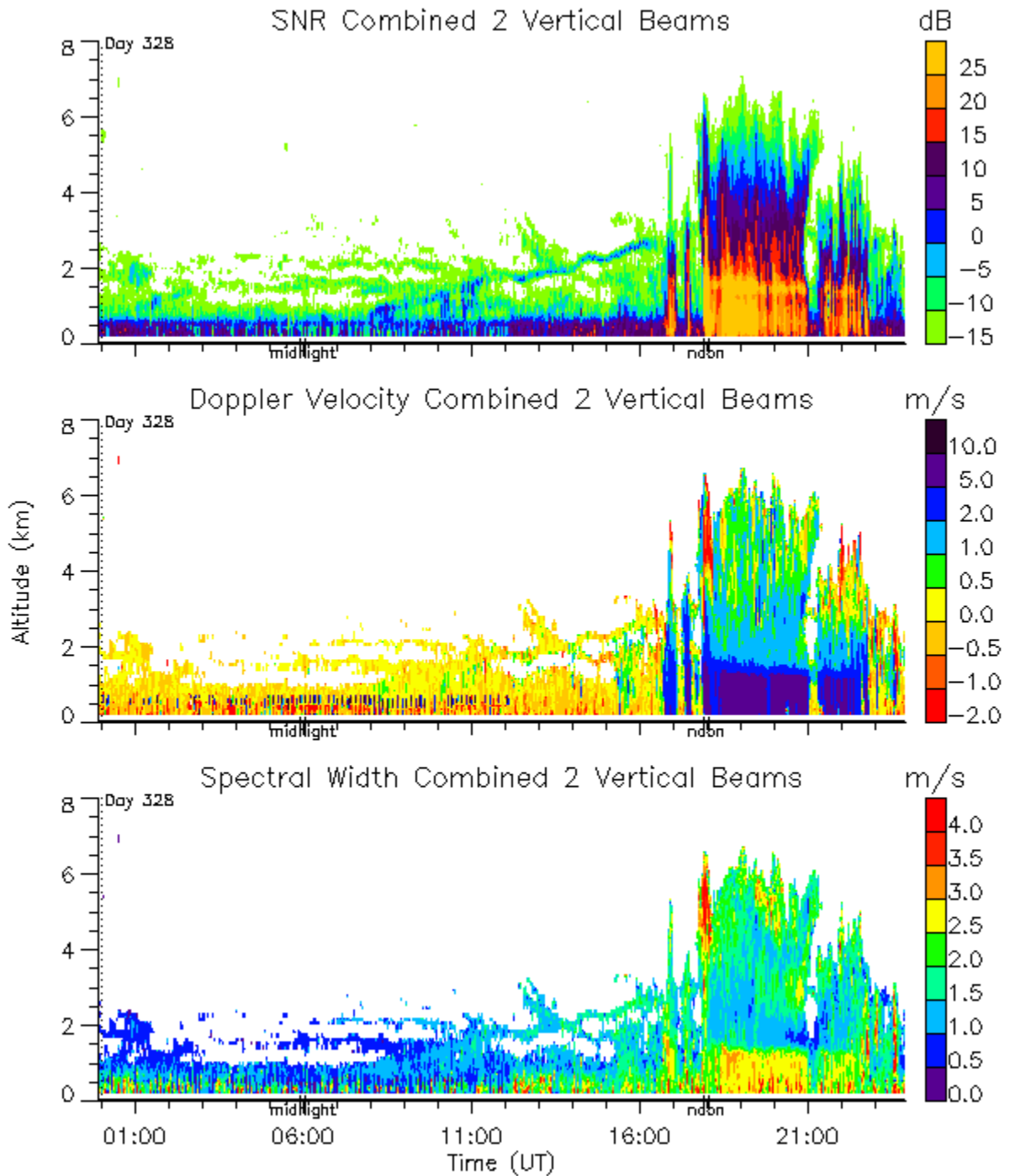


Figure 12: MISS 915 MhZ Profiler SNR (top), Radial Velocity (center) and Spectral Width (bottom) for the period 0000 UTC 23 Nov 09-0000 UTC 24 Nov 09

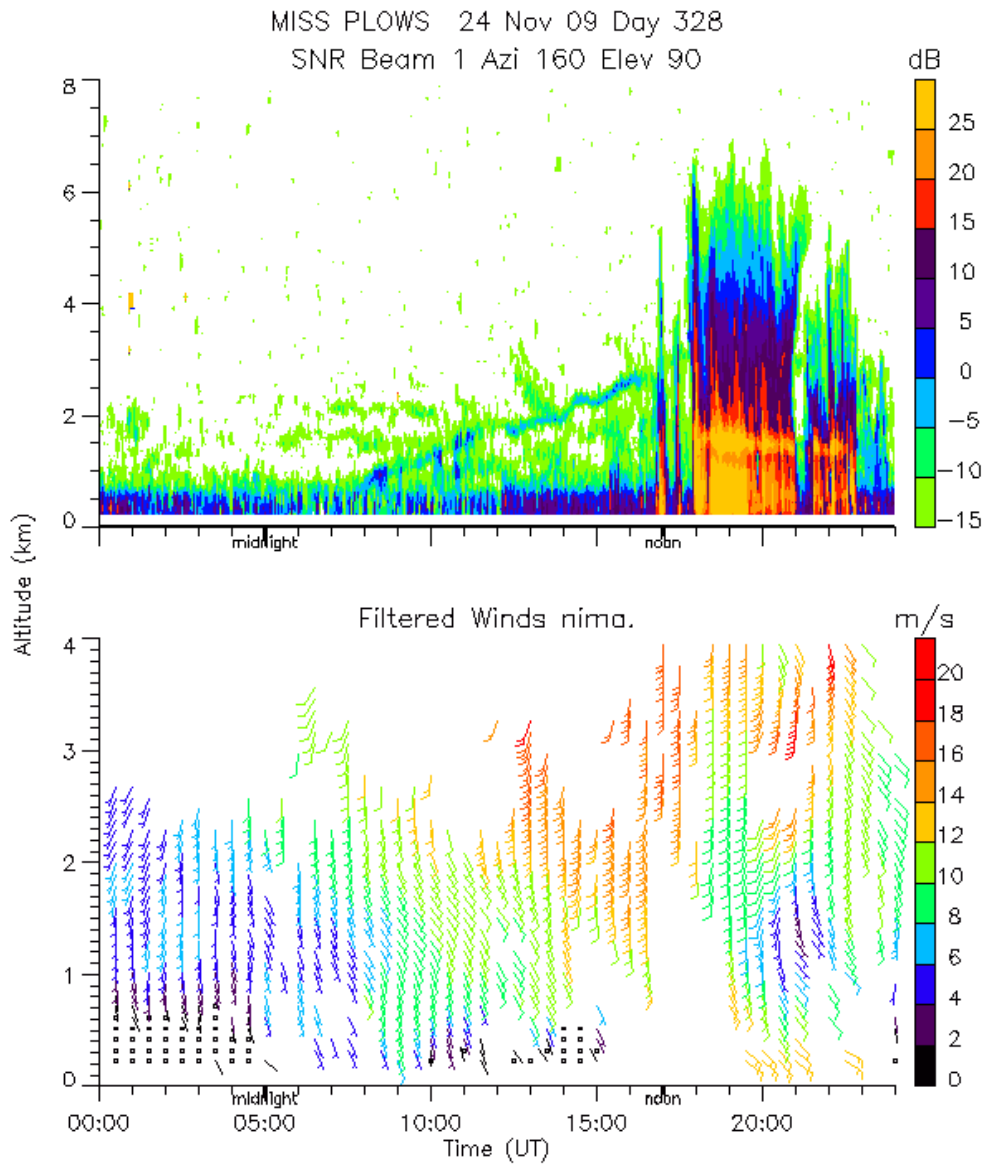


Figure 13: MISS 915 MhZ Profiler SNR (top), and winds for the period 0000 UTC 23 Nov 09-0000 UTC 24 Nov 09



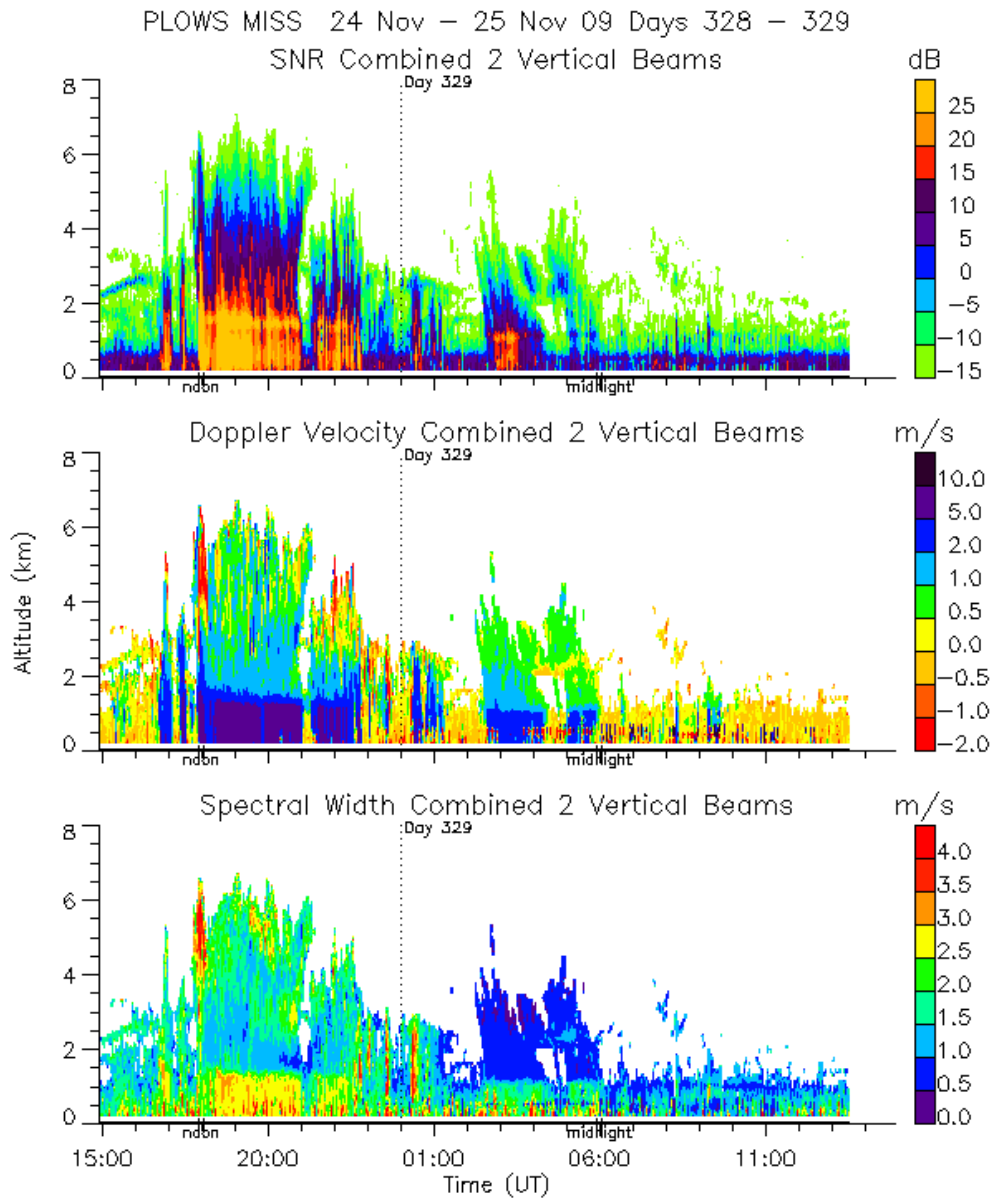


Figure 14: MISS 915 MhZ Profiler SNR (top), Radial Velocity (center) and Spectral Width (bottom) for the period 1500 UTC 24 Nov 09-1500 UTC 25 Nov 09

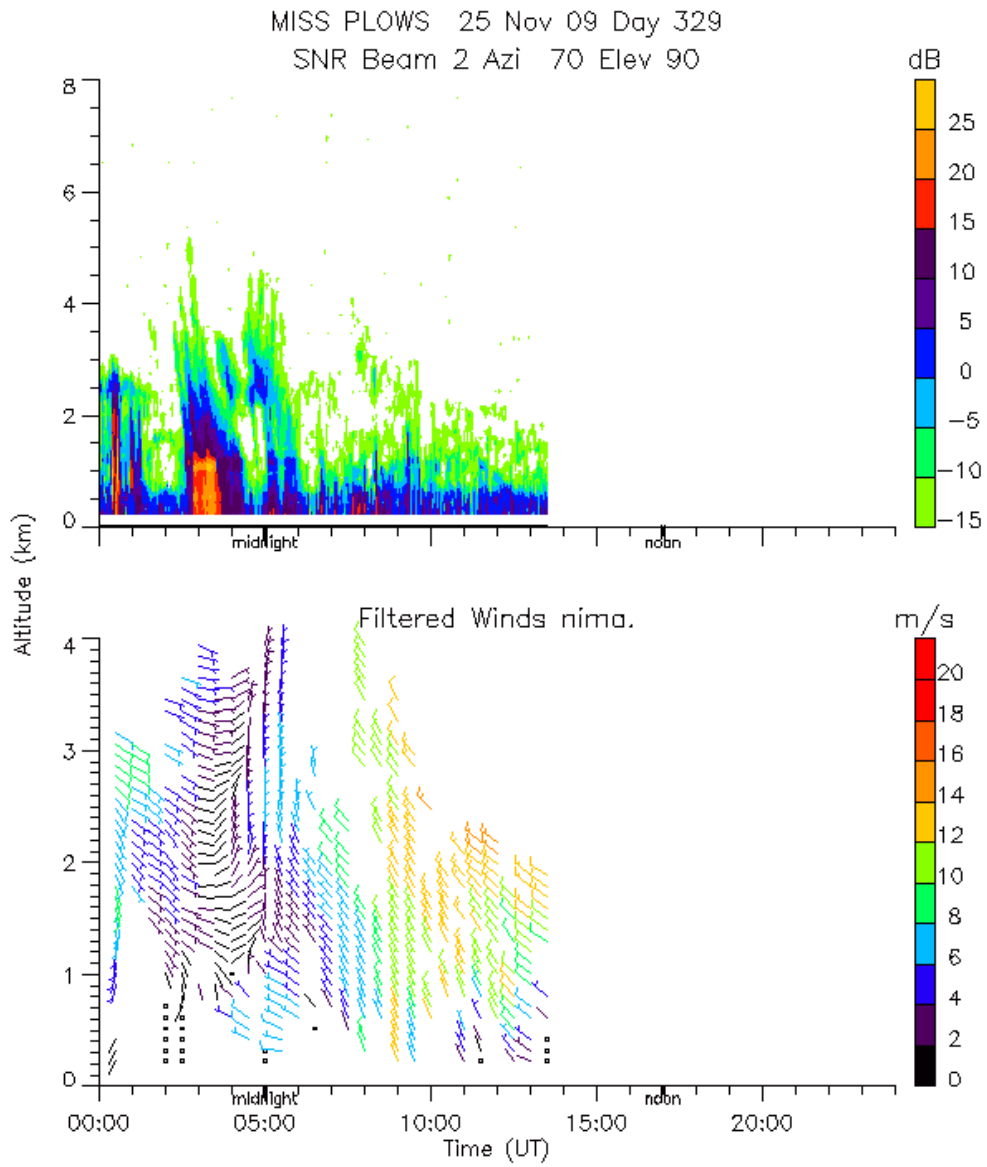


Figure 15: MISS 915 MhZ Profiler SNR (top), and winds for the period 0000 UTC 25 Nov 09-1300 UTC 25 Nov 09

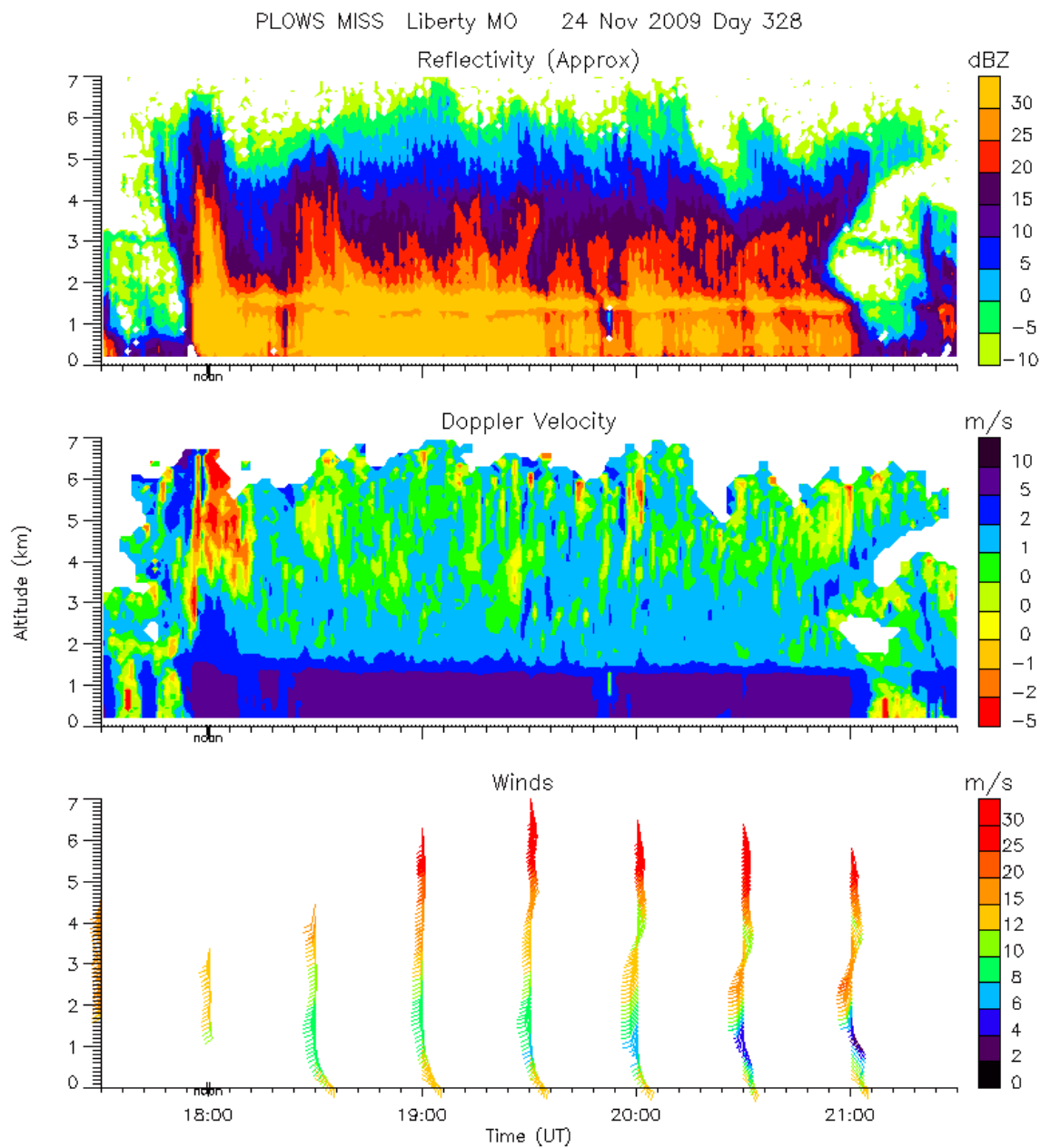


Figure 16: Closeup of MISS 915 MhZ Profiler SNR (top), and winds for the period 17300 UTC-21300 UTC 24 Nov 09

PLOWS MISS Liberty M0 24 Nov - 25 Nov 2009 Days 328 - 329

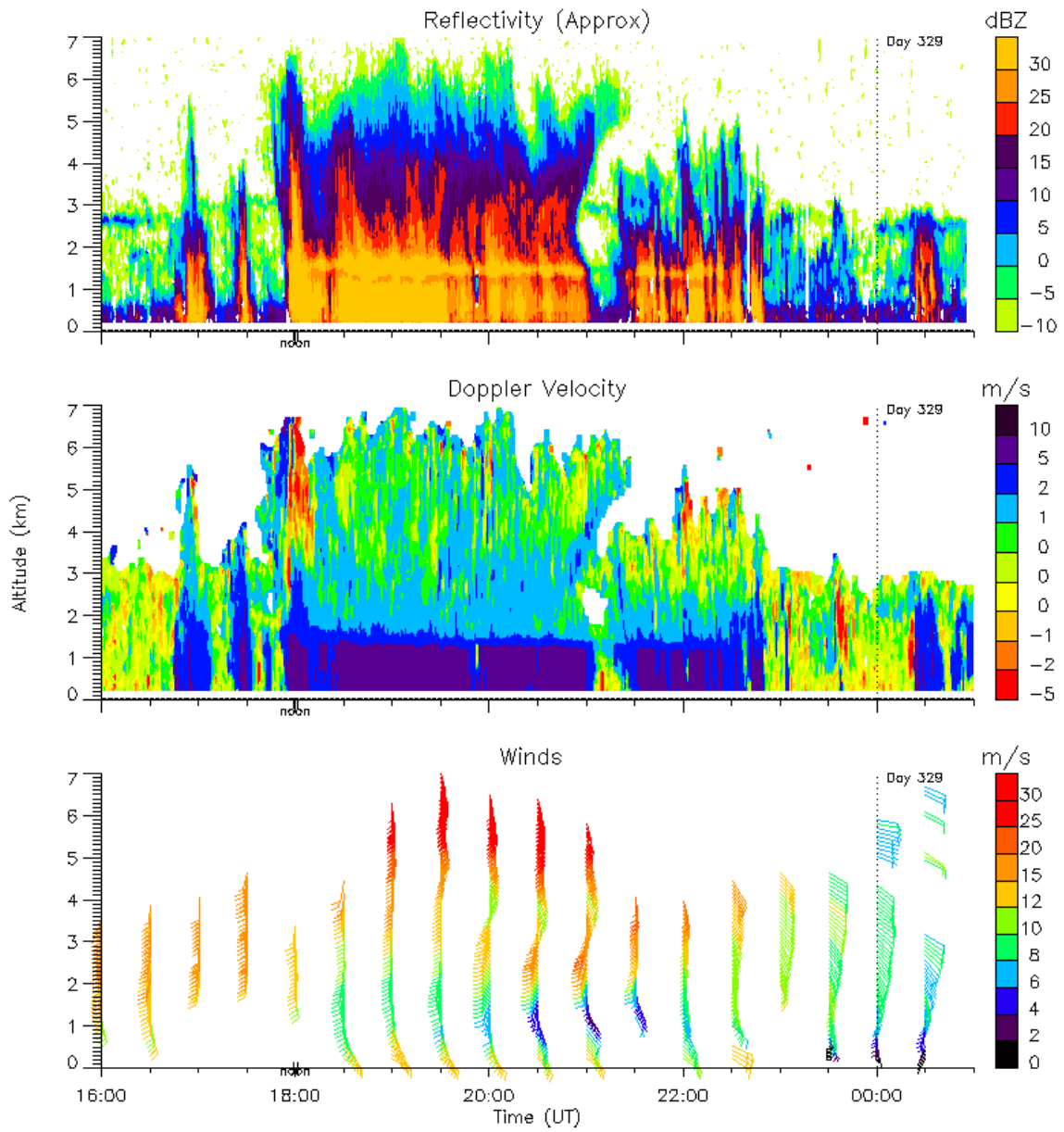


Figure 17: Closeup of MISS 915 MhZ Profiler SNR (top), and winds for the period 1600 UTC 24 Nov 09-0100 UTC 25 Nov 09

## 8. Rawinsondes

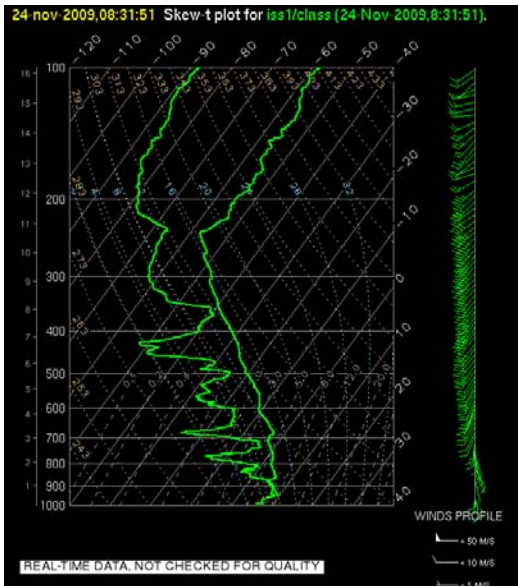
Rawinsondes were launched at the MISS site on a three hourly schedule. The following soundings were launched

DATE	Launch	Nominal Date and time		Status
2009 11 24	0831 UTC	2009 11 24	0900 UTC	Good
2009 11 24	1130 UTC	2009 11 24	1200 UTC	Good
2009 11 24	1426 UTC	2009 11 24	1500 UTC	Good
2009 11 24	1735 UTC	2009 11 24	1800 UTC	Good
2009 11 24	2027 UTC	2009 11 24	2100 UTC	Good
2009 11 24	2330 UTC	2009 11 25	0000 UTC	Good
2009 11 25	0230 UTC	2009 11 25	0300 UTC	Good
2009 11 25	0530 UTC	2009 11 25	0600 UTC	Good

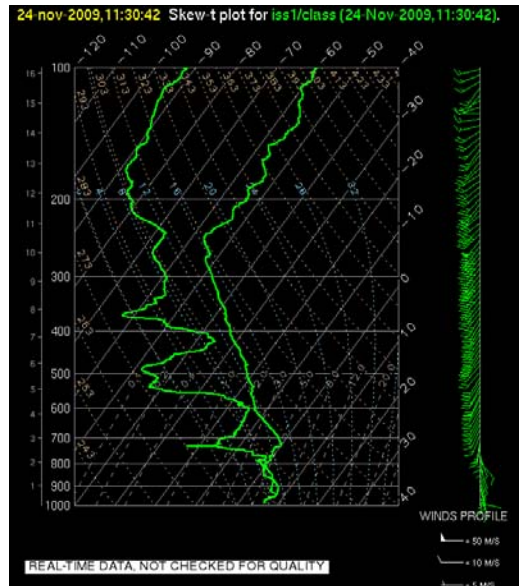
Rawinsondes were launched at the Comfort Inn Hotel in eastern Ames, Iowa by the University of Missouri on a three hourly schedule. The following soundings were obtained

DATE	Launch	Nominal Date and time		Status
2009 11 23	2338 UTC	2009 11 24	0000 UTC	Good
2009 11 24	0231 UTC	2009 11 24	0300 UTC	Good
2009 11 24	0531 UTC	2009 11 24	0600 UTC	Good
2009 11 24	0833 UTC	2009 11 24	0900 UTC	Good
2009 11 24	1121 UTC	2009 11 24	1200 UTC	Good
2009 11 24	1432 UTC	2009 11 24	1500 UTC	Good
2009 11 24	1749 UTC	2009 11 24	1800 UTC	Good
2009 11 24	2030 UTC	2009 11 24	2100 UTC	Lost at ~810 mb
2009 11 24	2059 UTC	2009 11 24	2100 UTC	Good
2009 11 24	2319 UTC	2009 11 25	0000 UTC	Good
2009 11 25	0229 UTC	2009 11 25	0300 UTC	Good

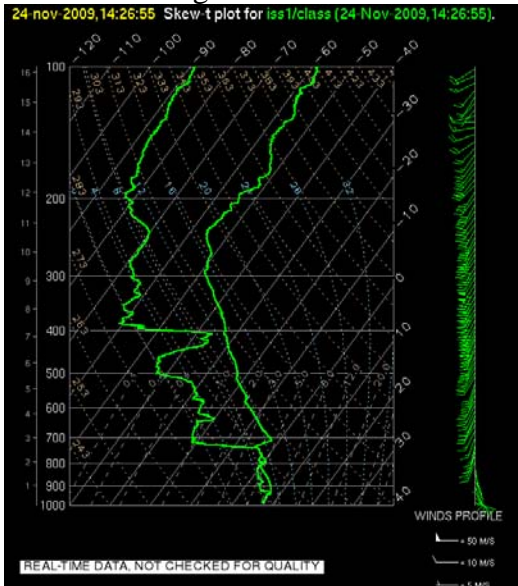
Quick Looks at the soundings appear in Figures 18-20.



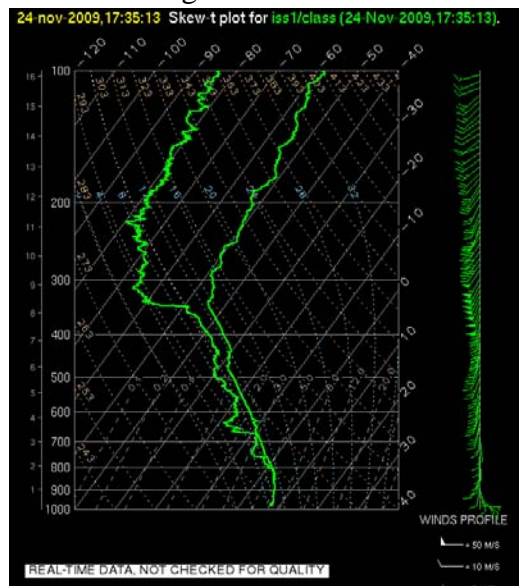
MISS Sounding 0900 UTC 24 Nov 09



MISS Sounding 1200 UTC 24 Nov 09

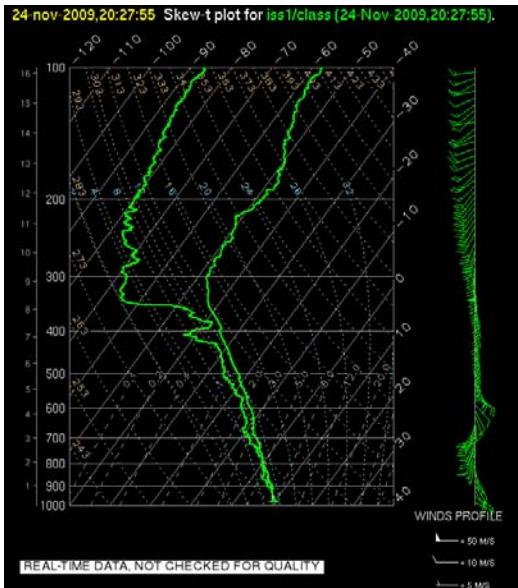


MISS Sounding 1500 UTC 24 Nov 09

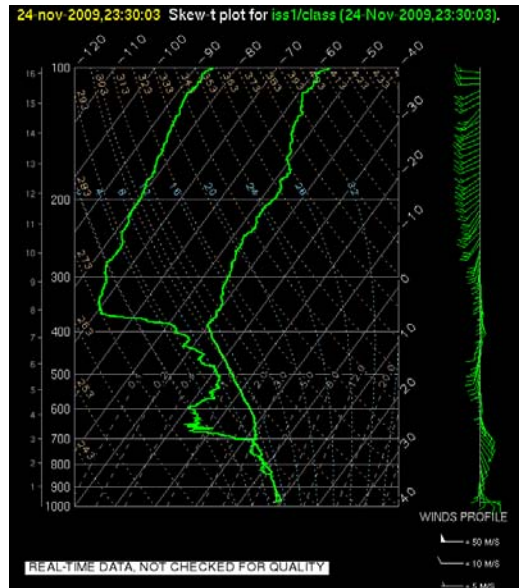


MISS Sounding 1800 UTC 24 Nov 09

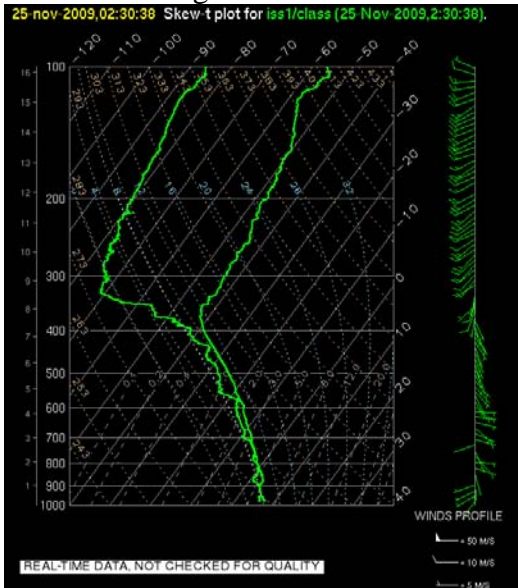
Fig. 18: MISS soundings for early period of storm



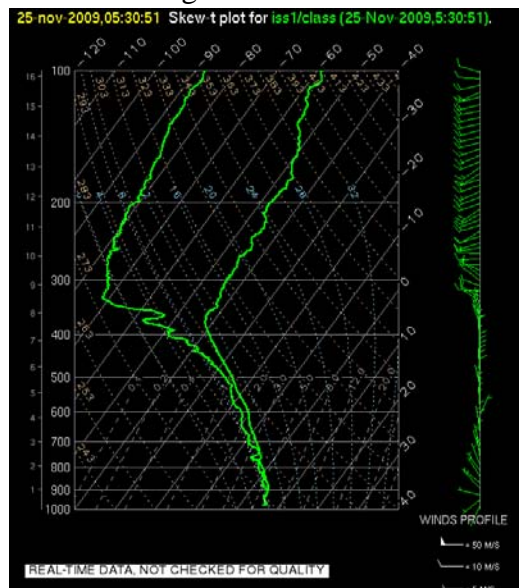
MISS Sounding 2100 UTC 24 Nov 09



MISS Sounding 0000 UTC 25 Nov 09



MISS Sounding 0300 UTC 24 Nov 09

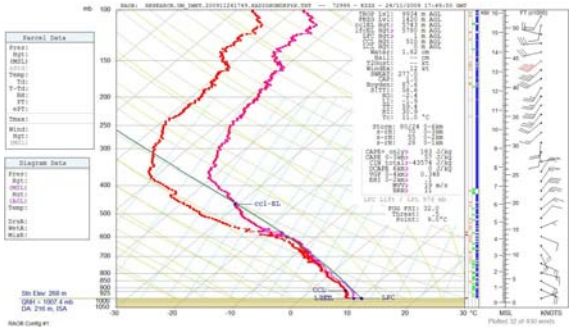


MISS Sounding 0600 UTC 25 Nov 09

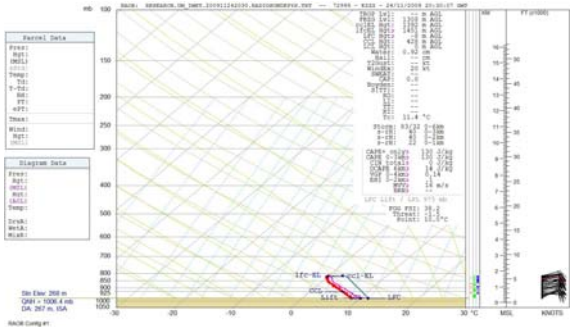
Fig. 19: MISS soundings for early period of storm



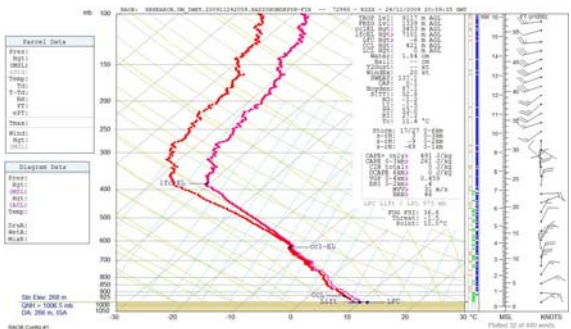




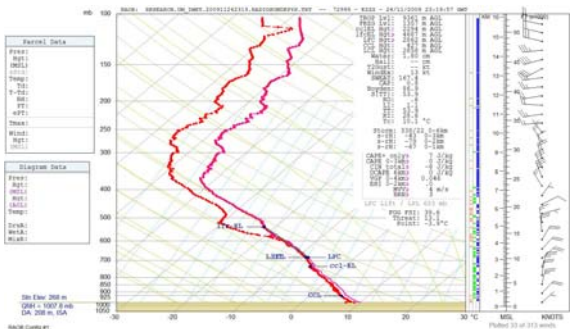
UM sounding 1800 UTC 24 Nov 2009



UM sounding 2100 UTC 24 Nov 2009 – **failed**



UM sounding 2100 UTC 24 Nov 2009 - **good** UM sounding 0000 UTC 25 Nov 2009



UM sounding 0300 UTC 25 Nov 2009

