**IOP-18 Summary of Operations**
**8 February 2010, 1200 UTC – 10 February 2010 1800 UTC**

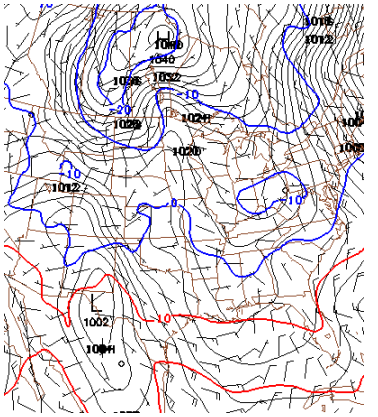
**Authors: Rauber, Knupp, Brown**

## 1. Summary of storm evolution

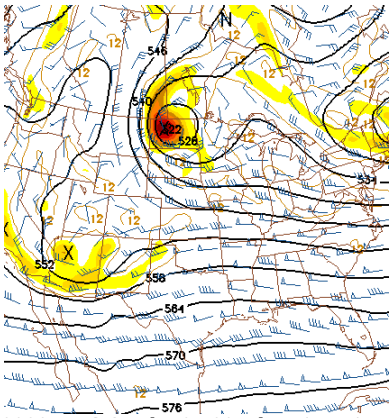
The IOP-18 storm system resulted as two waves, one in the polar jetstream rotating around the polar vortex over Hudson Bay and the other approaching in the subtropical jetstream, merged over the central United States. Precipitation developed independently over the southeast U.S and upper Midwest associated with each wave. The focus of this IOP was the northern precipitation region, which was associated with the more vigorous trough. Because of the timing of precipitation over Peoria and the requirement of daytime flight because of a aircraft crew change, the best option was to try to get in two flights. To avoid grounding of the aircraft because of wing icing, we decided to take off early and fly to Terra Haute to fuel rather than attempt to fuel at Peoria. Between 1200 and 1800 UTC on 8 February, light precipitation fell across Wisconsin within a poorly defined wrap-around region of the wave. The C-130 flew through the storm over Wisconsin at this time. During the flight, radar echoes were not well developed, with precipitation all snow and the clouds shallow, topping at 4 km. Because of uncertainty in the storm track and precipitation distribution, it was decided to deploy the two profilers in different locations, one in Ft. Atkinson, WI and the other in Goshen, IN. The MAX was not deployed because the storms were expected to be shallow and dual Doppler opportunities did not look promising. The main body of precipitation passed over each site as the wave rotated around the polar vortex. By 0000 UTC on 9 February, the southern and northern waves merged, increasing the moisture supply to the circulation of the northern wave and intensifying the precipitation over Indiana. By the time of the second flight on the morning of 9 February, clouds in some regions of the wrap-around area had deepened to 6-7 km, and precipitation across the area became more intense. In all, 4-8 inches of precipitation fell in the vicinity of Ft. Atkinson, and 3-6 inches across northern Indiana. Close to Lake Michigan, these amounts were much higher. Precipitation cleared the area around 0600 UTC on 10 February.

## 2. Locations of instrumentation platforms

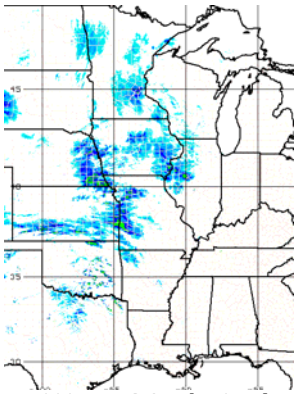
| | |
|---|---|
| MIPS Location: | 41° 34' 16.98" N 85 48' 38.61" W |
| Profiler Time of Operation | 0400 UTC 9 Feb 10 – 1500 UTC 10 Feb 10 |
| MAX Location: | Not used |
| MISS Location: | 42° 56' 39.60" N 88° 51' 47.39" W |
| Profiler Time of Operation | 0000 UTC 9 Feb 10 – 1600 UTC 10 Feb 10 |
| UM Location: | Not used, equipment being repaired |
| RF-10 Flight operations: | 8 Feb 10 14:07 UTC – 9 Feb 10 22:19 UTC |
| RF-11 Flight operations: | 9 Feb 10 14:35 UTC – 9 Feb 10 22:10 UTC |



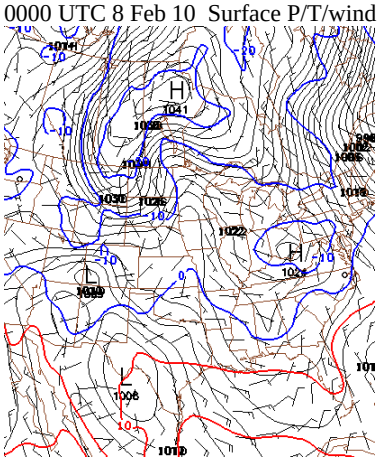
0000 UTC 8 Feb 10 Surface P/T/wind



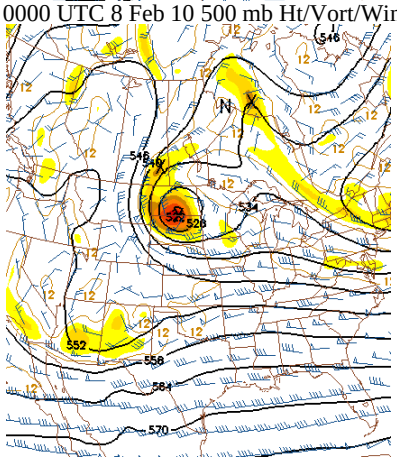
0000 UTC 8 Feb 10 500 mb Ht/Vort/Wind



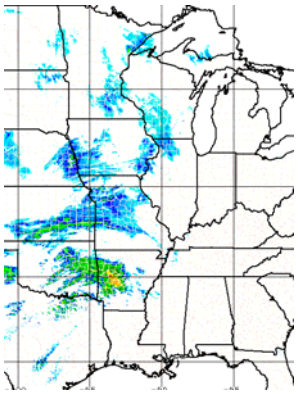
0007 UTC 8 Feb 10 radar



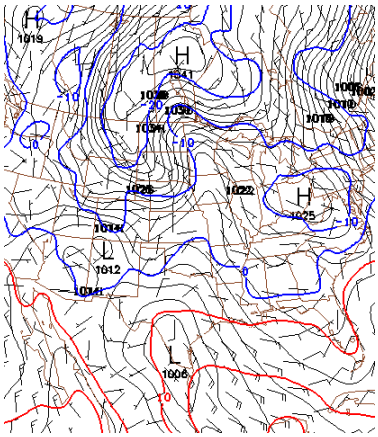
0600 UTC 8 Feb 10 Surface P/T/wind



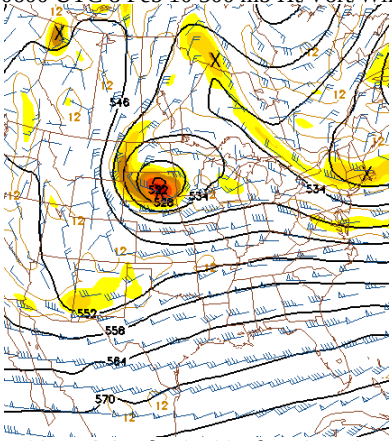
0600 UTC 8 Feb 10 500 mb Ht/Vort/Wind



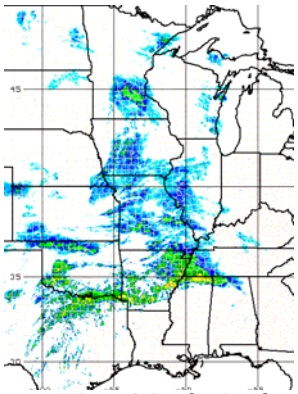
0559 UTC 8 Feb 10 radar



1200 UTC 8 Feb 10 Surface P/T/wind

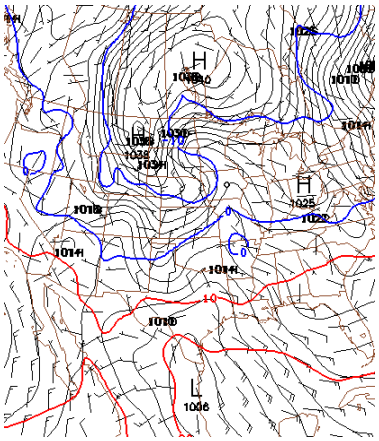


1200 UTC 8 Feb 10 500 mb Ht/Vort/Wind

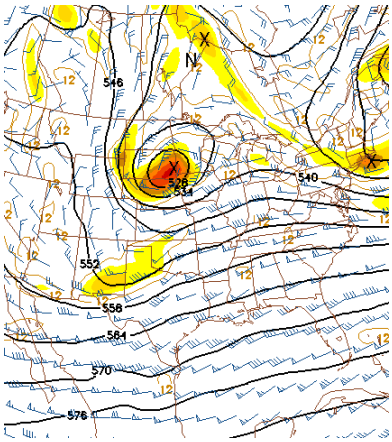


1159 UTC 8 Feb 10 radar

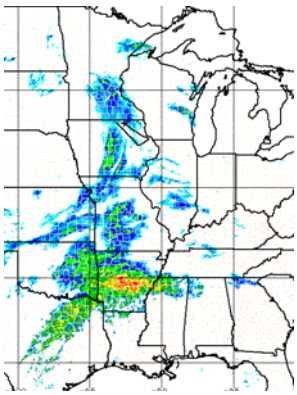
Figure 1: Evolution of the IOP-18 storm at the surface, 500 mb, and radar echoes from 0000 UTC 8 Feb 10 through 1200 UTC 8 Feb 10.



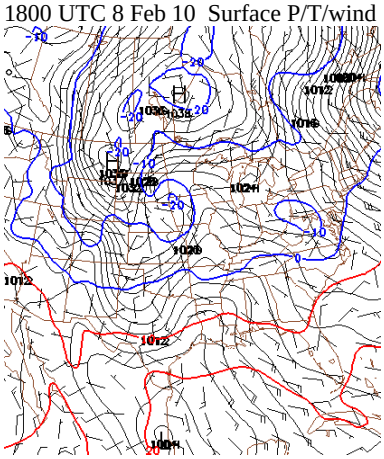
1800 UTC 8 Feb 10 Surface P/T/wind



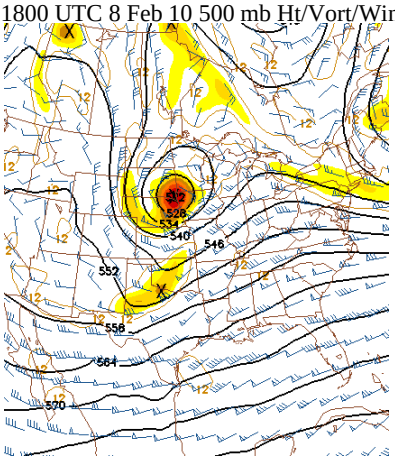
1800 UTC 8 Feb 10 500 mb Ht/Vort/Wind



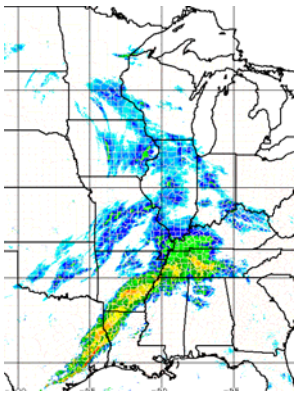
1806 UTC 8 Feb 10 radar



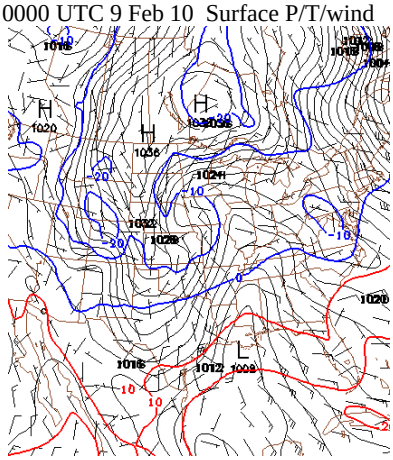
0000 UTC 9 Feb 10 Surface P/T/wind



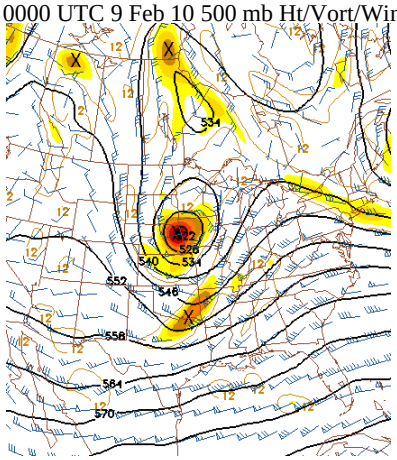
0000 UTC 9 Feb 10 500 mb Ht/Vort/Wind



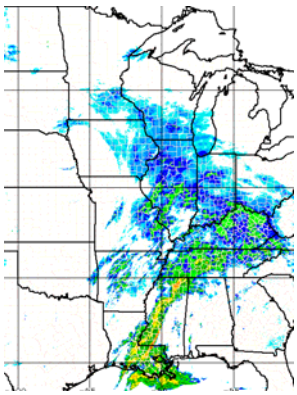
0019 UTC 9 Feb 10 radar



0600 UTC 9 Feb 10 Surface P/T/wind

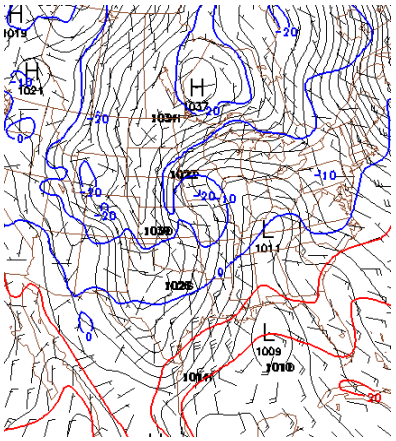


0600 UTC 9 Feb 10 500 mb Ht/Vort/Wind

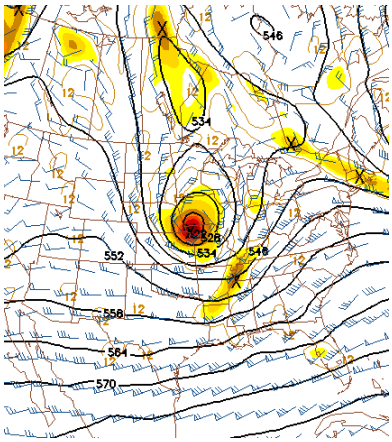


0559 UTC 9 Feb 10 radar

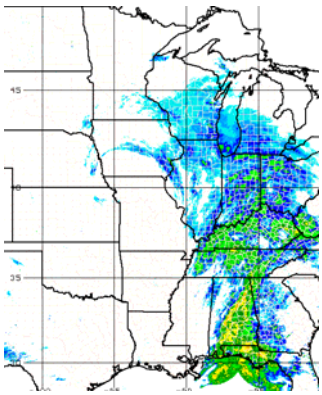
Figure 2: Evolution of the IOP-18 storm at the surface, 500 mb, and radar echoes from 1800 UTC 8 Feb 10 through 0600 UTC 9 Feb 10.



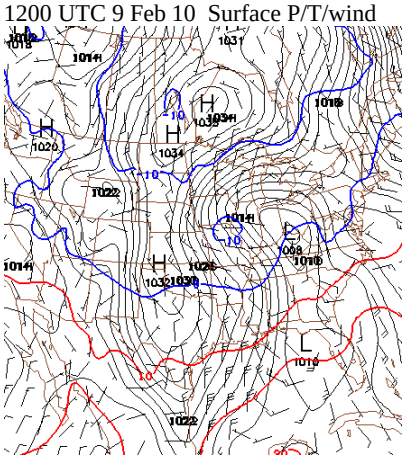
1200 UTC 9 Feb 10 Surface P/T/wind



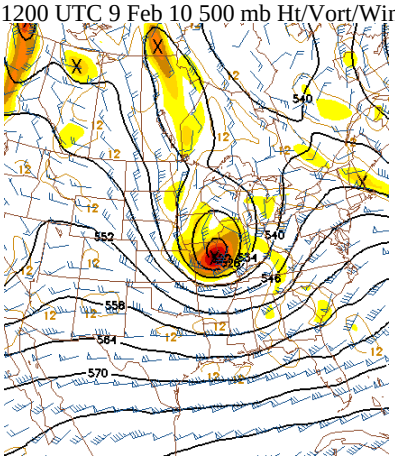
1200 UTC 9 Feb 10 500 mb Ht/Vort/Wind



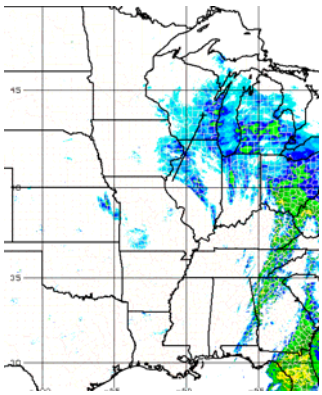
1206 UTC 9 Feb 10 radar



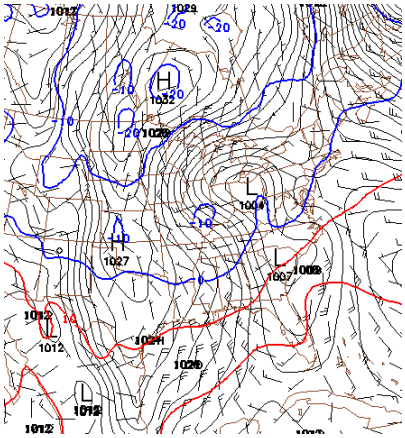
1800 UTC 9 Feb 10 Surface P/T/wind



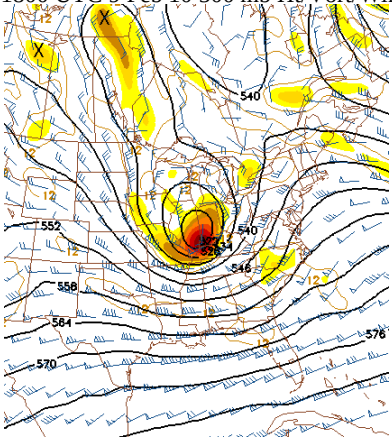
1800 UTC 9 Feb 10 500 mb Ht/Vort/Wind



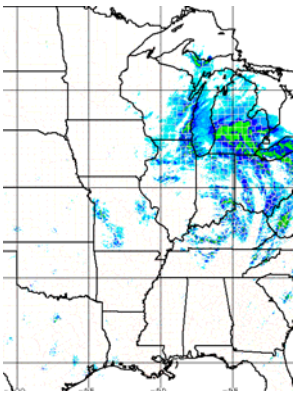
1758 UTC 9 Feb 10 radar



0000 UTC10 Feb 10 Surface P/T/wind

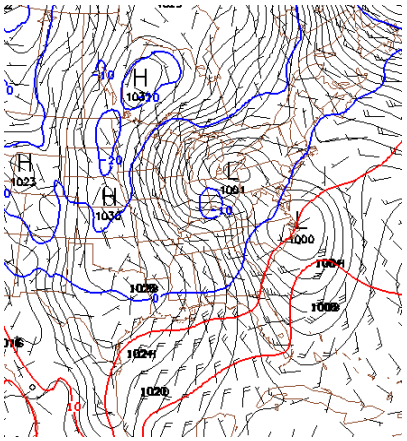


0000 UTC 10 Feb 10 500 mb Ht/Vort/Wind

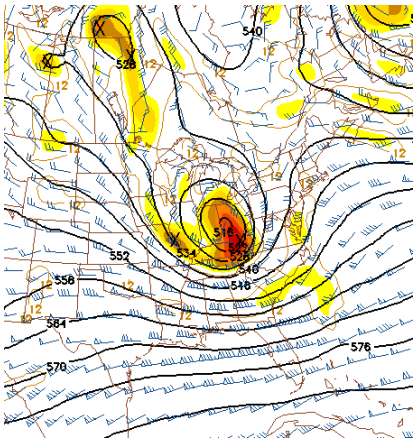


0008 UTC 10 Feb 10 radar

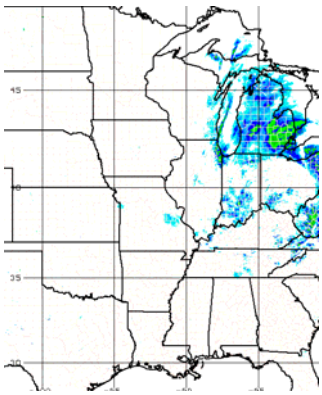
Figure 3: Evolution of the IOP-18 storm at the surface, 500 mb, and radar echoes from 1200 UTC 9 Feb 10 through 0000 UTC 10 Feb 10.



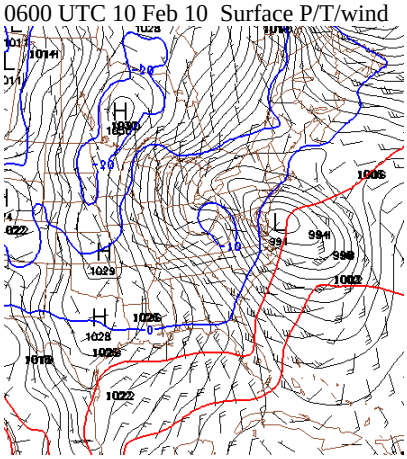
0600 UTC 10 Feb 10 Surface P/T/wind



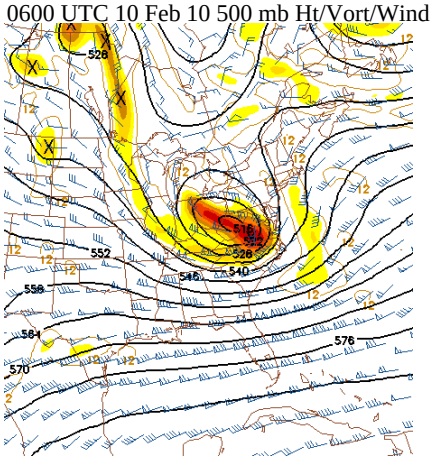
0600 UTC 10 Feb 10 500 mb Ht/Vort/Wind



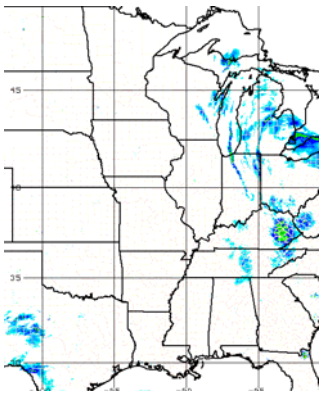
0606 UTC 10 Feb 10 radar



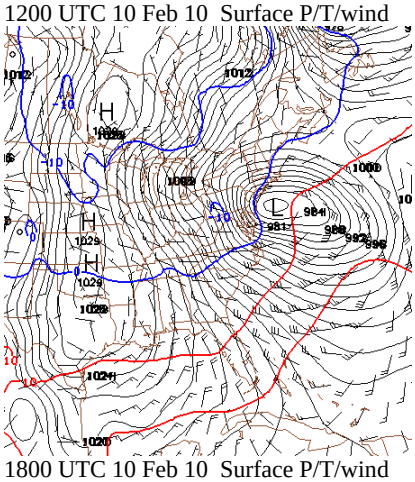
1200 UTC 10 Feb 10 Surface P/T/wind



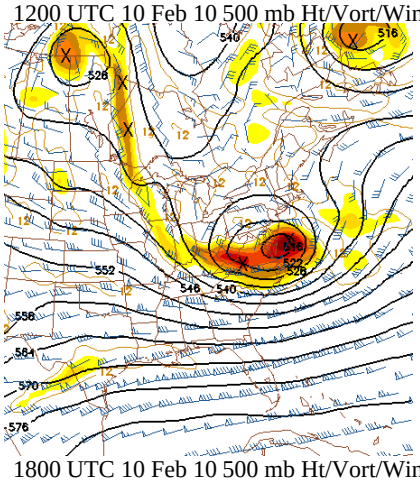
1200 UTC 10 Feb 10 500 mb Ht/Vort/Wind



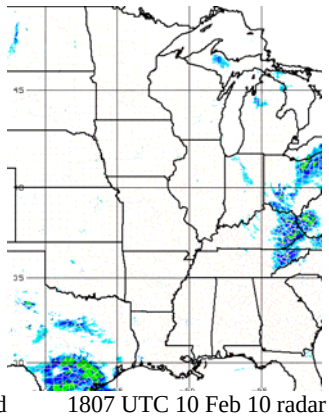
1205 UTC 10 Feb 10 radar



1800 UTC 10 Feb 10 Surface P/T/wind



1800 UTC 10 Feb 10 500 mb Ht/Vort/Wind



1807 UTC 10 Feb 10 radar

Figure 4: Evolution of the IOP-18 storm at the surface, 500 mb, and radar echoes from 0600 UTC 10 Feb 10 through 1800 UTC 10 Feb 10.

## 3. Precipitation over research area

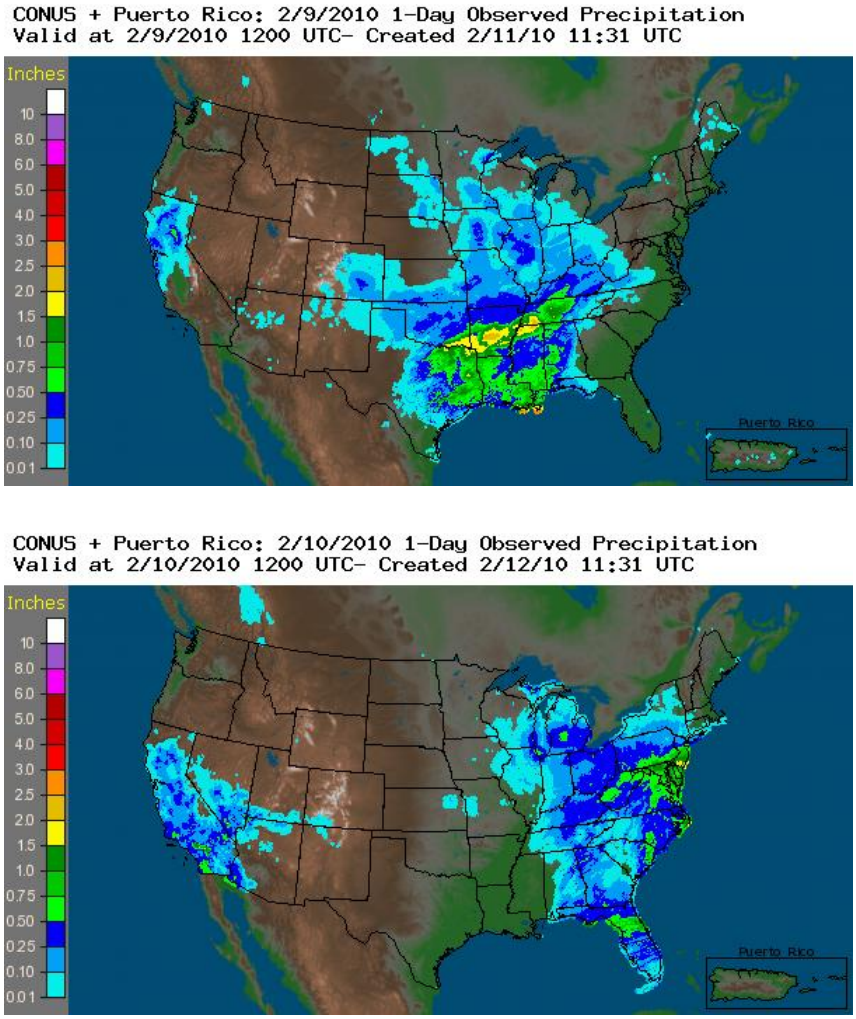



Fig. 5: 24 Hour precipitation ending at 1200 UTC 02/09/10, and 1200 UTC 02/10/10 over the United States

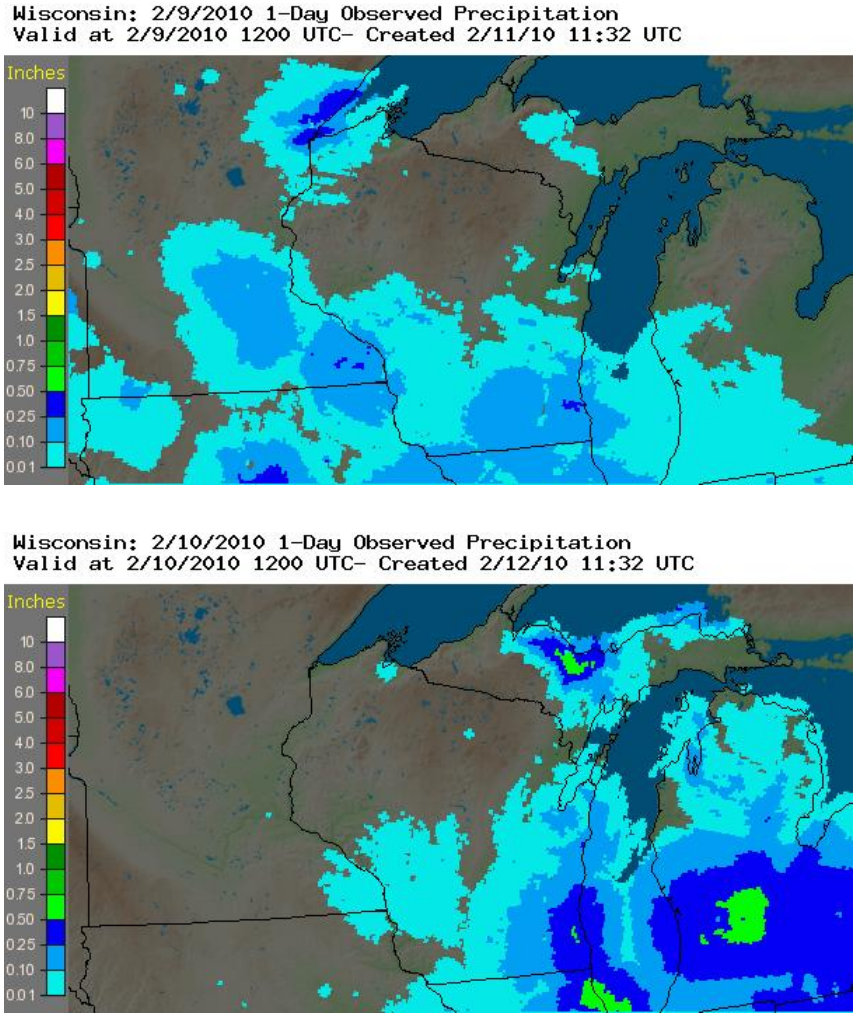



Fig. 6: 24 Hour precipitation ending at 1200 UTC 02/09/10, and 1200 UTC 02/10/10 over Wisconsin.

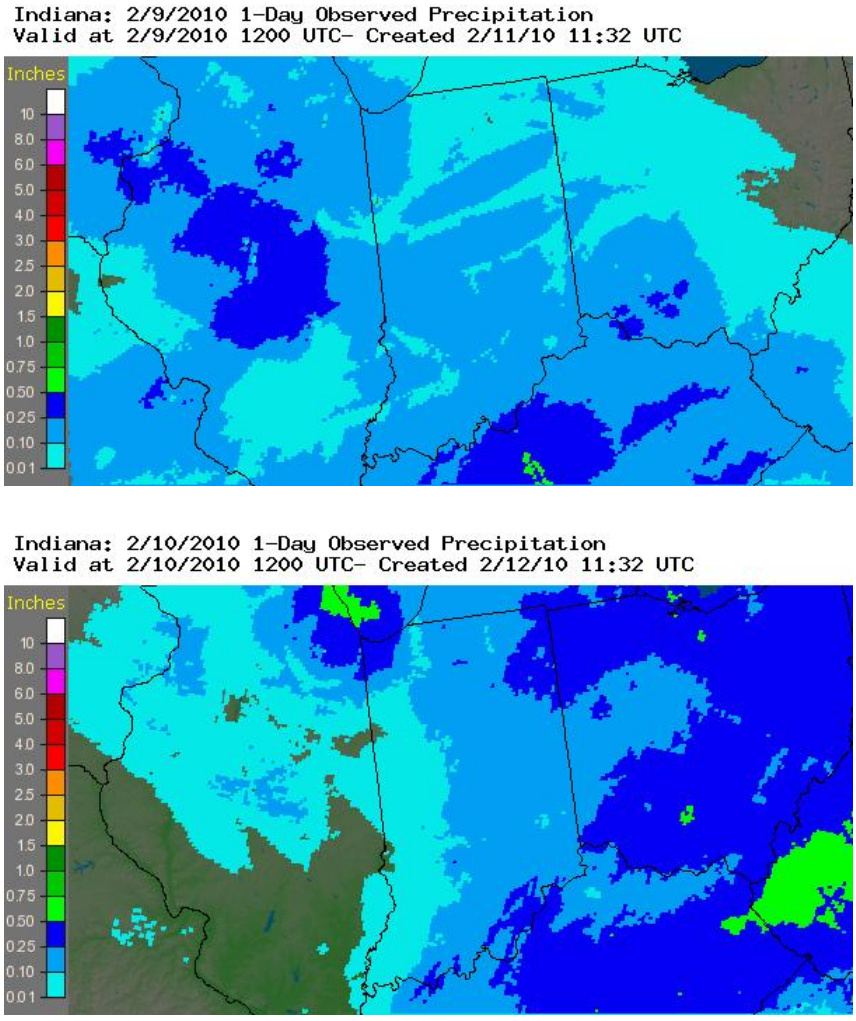


Fig. 7: 24 Hour precipitation ending at 1200 UTC 02/09/10, and 1200 UTC 02/10/10 over Indiana.

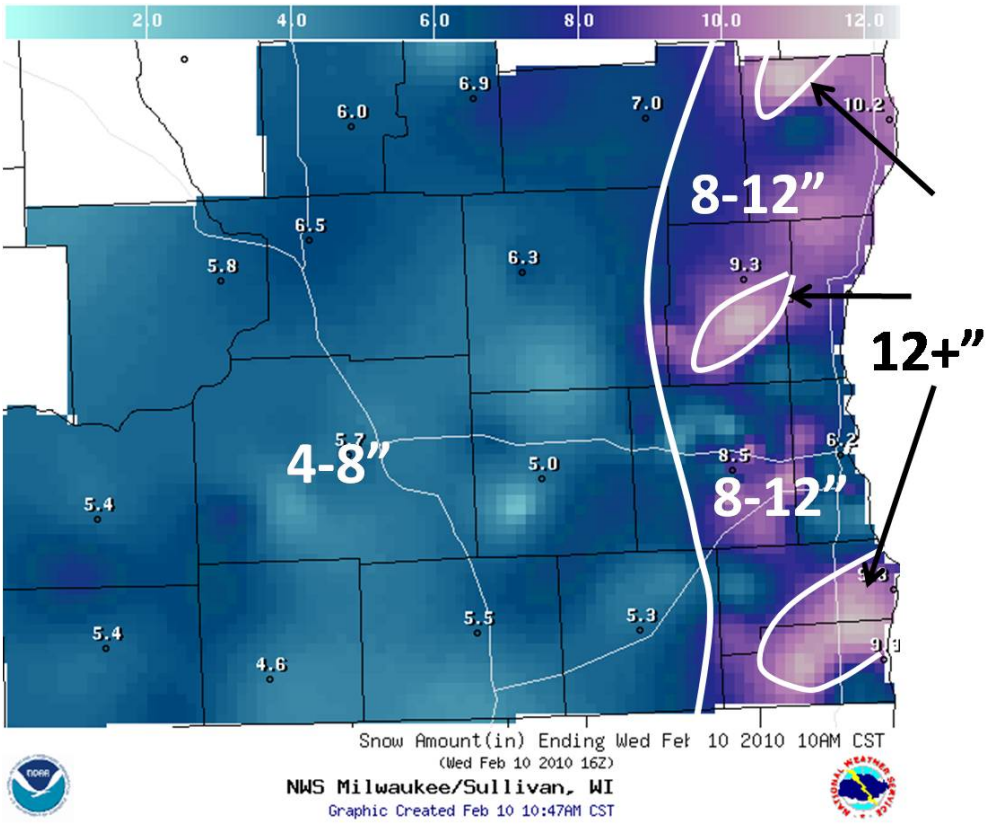



Fig. 8: Storm total snowfall ending at 1600 UTC 02/10/10 over Wisconsin.

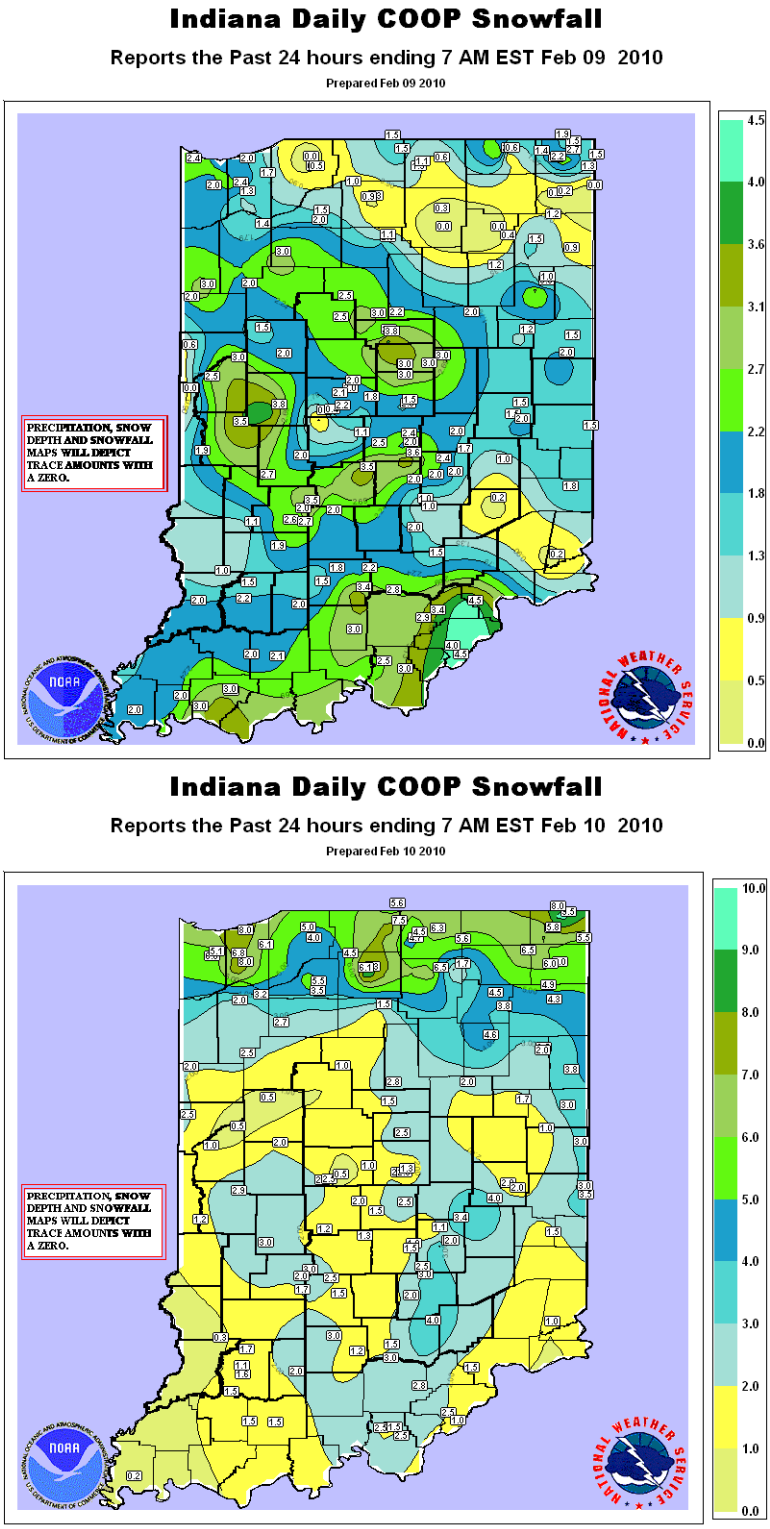



Fig. 9: 24 Hour snowfall ending at 1200 UTC 02/09/10, and 1200 UTC 02/10/10 over Indiana.

## SNOWFALL REPORTS-Wisconsin

PUBLIC INFORMATION STATEMENT
SPOTTER REPORTS
NATIONAL WEATHER SERVICE MILWAUKEE/SULLIVAN  WI
1005 AM CST WED FEB 10 2010

SNOW REPORTS SINCE 7 PM CST TUES FEB 9

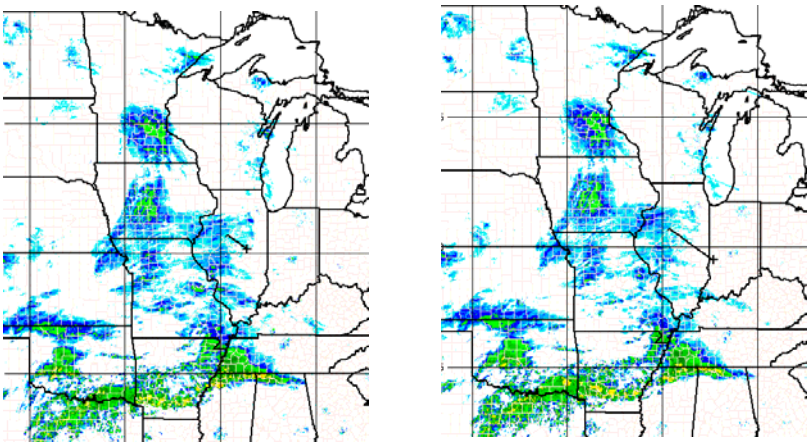
| LOCATION | SNOW FALL (INCHES) | TIME/DATE OF OBSERVATION | LAT | LON |
|---|---|---|---|---|
| WISCONSIN | | | | |
| ...COLUMBIA COUNTY... | | | | |
| 3 SE PORTAGE | 6.3 M | 830 AM 02/10 | 43.52N | 89.42W |
| ...DANE COUNTY... | | | | |
| 1 NW MIDDLETON | 5.1 M | 825 PM 02/09 | 43.11N | 89.52W |
| 2 S MOUNT HOREB | 7.3 M | 745 AM 02/10 | 42.98N | 89.73W |
| ...DODGE COUNTY... | | | | |
| 1 N BEAVER DAM | 6.0 M | 820 PM 02/09 | 43.48N | 88.84W |
| BEAVER DAM | 6.1 M | 1233 AM 02/10 | 43.46N | 88.84W |
| ...FOND DU LAC COUNTY... | | | | |
| FOND DU LAC | 7.0 M | 1059 PM 02/09 | 43.78N | 88.45W |
| 1 NW RIPON | 7.7 M | 649 AM 02/10 | 43.86N | 88.86W |
| ...GREEN COUNTY... | | | | |
| 6 W NEW GLARUS | 6.5 M | 700 PM 02/09 | 42.81N | 89.75W |
| ...IOWA COUNTY... | | | | |
| MINERAL POINT | 7.5 M | 648 AM 02/10 | 42.86N | 90.18W |
| ...JEFFERSON COUNTY... | | | | |
| FORT ATKINSON | 4.2 M | 745 AM 02/10 | 42.93N | 88.84W |
| JEFFERSON | 4.5 M | 700 PM 02/09 | 43.01N | 88.81W |
| 4 WNW LAKE MILLS | 5.8 M | 700 PM 02/09 | 43.10N | 88.98W |
| 3 WNW LAKE MILLS | 6.1 M | 546 AM 02/10 | 43.09N | 88.96W |
| 3 SE SULLIVAN | 6.8 M | 649 AM 02/10 | 42.98N | 88.55W |
| ...KENOSHA COUNTY... | | | | |
| 1 E PLEASANT PRAIRIE | 10.5 E | 700 PM 02/09 | 42.55N | 87.91W |
| BRISTOL | 12.5 M | 825 PM 02/09 | 42.56N | 88.05W |
| 6NW KENOSHA | 13.3 M | 745 AM 02/10 | 42.64N | 87.90W |
| ...LAFAYETTE COUNTY... | | | | |
| SOUTH WAYNE | 6.0 E | 700 PM 02/09 | 42.57N | 89.88W |
| ...MILWAUKEE COUNTY... | | | | |
| 2 NE GLENDALE | 7.0 M | 700 PM 02/09 | 43.16N | 87.91W |
| MILWAUKEE INTERNATIONAL | 8.8 M | 634 AM 02/10 | 42.96N | 87.90W |
| 1 E MILWAUKEE TIMMERMAN | 9.0 M | 938 PM 02/09 | 43.12N | 88.03W |
| 4 SW MILWAUKEE | 9.2 M | 740 PM 02/09 | 42.99N | 87.97W |
| WAUWATOSA | 10.6 M | 701 AM 02/10 | 43.06N | 88.03W |

| | | | | |
|---|---|---|---|---|
| ...OZAUKEE COUNTY... | | | | |
| BELGIUM | 10.5 M | 859 PM | 02/09 | 43.50N 87.85W |
| PORT WASHINGTON | 11.4 M | 745 AM | 02/10 | 43.38N 87.87W |
| ...RACINE COUNTY... | | | | |
| BURLINGTON | 9.0 M | 930 PM | 02/09 | 42.68N 88.28W |
| 3 W RACINE | 11.5 M | 444 AM | 02/10 | 42.73N 87.84W |
| FRANKSVILLE | 11.5 M | 558 AM | 02/10 | 42.76N 87.91W |
| ...ROCK COUNTY... | | | | |
| MILTON | 6.0 M | 745 AM | 02/10 | 42.78N 88.95W |
| ...SHEBOYGAN COUNTY... | | | | |
| SHEBOYGAN | 11.1 M | 720 AM | 02/10 | 43.75N 87.72W |
| RANDOM LAKE | 11.5 M | 831 PM | 02/09 | 43.56N 87.96W |
| ELKHART LAKE | 12.6 M | 648 AM | 02/10 | 43.83N 88.01W |
| ...WALWORTH COUNTY... | | | | |
| 3 S LA GRANGE | 4.5 M | 835 PM | 02/09 | 42.76N 88.60W |
| WHITEWATER | 7.0 M | 745 AM | 02/10 | 42.83N 88.74W |
| ...WASHINGTON COUNTY... | | | | |
| 2 E HOLY HILL | 10.2 M | 505 AM | 02/10 | 43.24N 88.29W |
| HARTFORD | 10.8 M | 545 AM | 02/10 | 43.32N 88.39W |
| JACKSON | 12.5 M | 634 AM | 02/10 | 43.32N 88.16W |
| ...WAUKESHA COUNTY... | | | | |
| 2 SW OCONOMOWOC | 6.8 M | 649 AM | 02/10 | 43.09N 88.53W |
| MUKWONAGO | 8.0 M | 612 AM | 02/10 | 42.87N 88.33W |
| MUSKEGO | 10.5 M | 800 PM | 02/09 | 42.89N 88.12W |
| 3 S WAUKESHA | 11.2 M | 900 PM | 02/09 | 42.97N 88.24W |
| 3 WNW GREENFIELD | 12.2 M | 720 AM | 02/10 | 42.98N 88.06W |
| 4 ESE PEWAUKEE | 11.5 M | 422 AM | 02/10 | 43.06N 88.18W |

## 4. Flight Summary

The decision to schedule flights during this IOP was driven by the fact that frozen precipitation was likely to occur in Peoria for most of the IOP and the aircraft had to get out of the airport prior to precipitation onset. We decided to try to schedule two flights, with the alternate airport as Jeffco Airport in Boulder so that the aircraft could be serviced for the second flight. We also decided to get out of Peoria before precipitation started and fuel for the mission in Terra Haute.

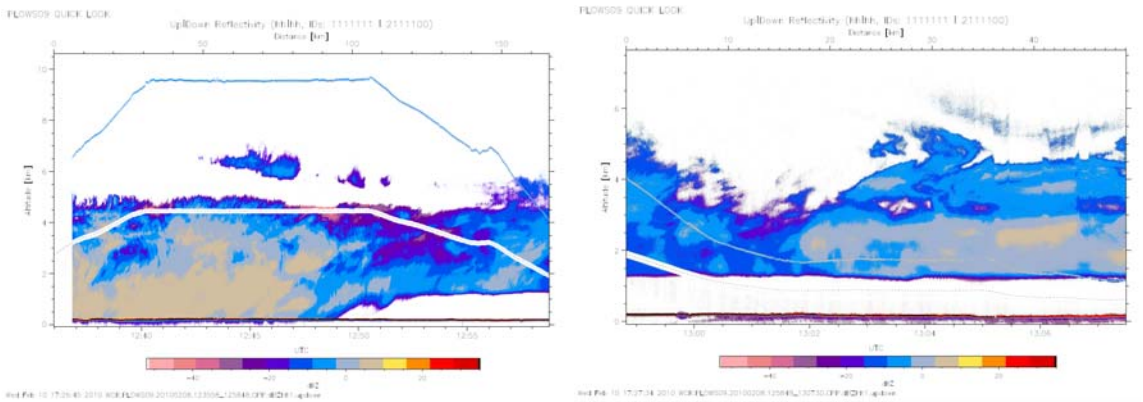
### Ferry flight from Peoria to Terra Haute to fuel



1247 UTC 1318 UTC

Figure 10: C-130 flight track on the ferry from Peoria, IL to Terra Haute, IN overlaid on radar composites from 1247 UTC 8 Feb 10 through 13189 UTC 8 Feb 10. Times shown are the times of the radar composites. The flight track for the period just before the composite is shown.

### WCR Quicklooks- Ferry flight from Peoria to Terra Haute to fuel



1236 UTC to 1259 UTC 1259 UTC to 1309 UTC

Fig. 11: Wyoming Cloud Radar Quicklook of radar reflectivity between 1236 UTC 8 Feb 10 and 1309 UTC 8 Feb 10.

**RF-10 February 8**

The research mission RF-10 focused on the precipitation feature associated with the Alberta Clipper wave approaching from the northwest. The clouds were shallow and the early part of the flight overflew the cloud deck. The focus of the early part of the flight was the precipitation region over Minnesota. The C-130's first pass overflew this area, then the aircraft descended into the cloud top region for the second pass. The dropsonde pass along track E was precisely scheduled with FAA to begin at 1730 UTC, so the aircraft diverted to point E1. Sondes were dropped along dropsonde track E at points E1-E8. Following the dropsonde run, the aircraft again focused on the northern precipitation area making two passes before it had to divert to Boulder. This cloud system was quite shallow, but had interesting structure at cloud top that was well documented.

**C-130 Flight RF-10 Flight track**

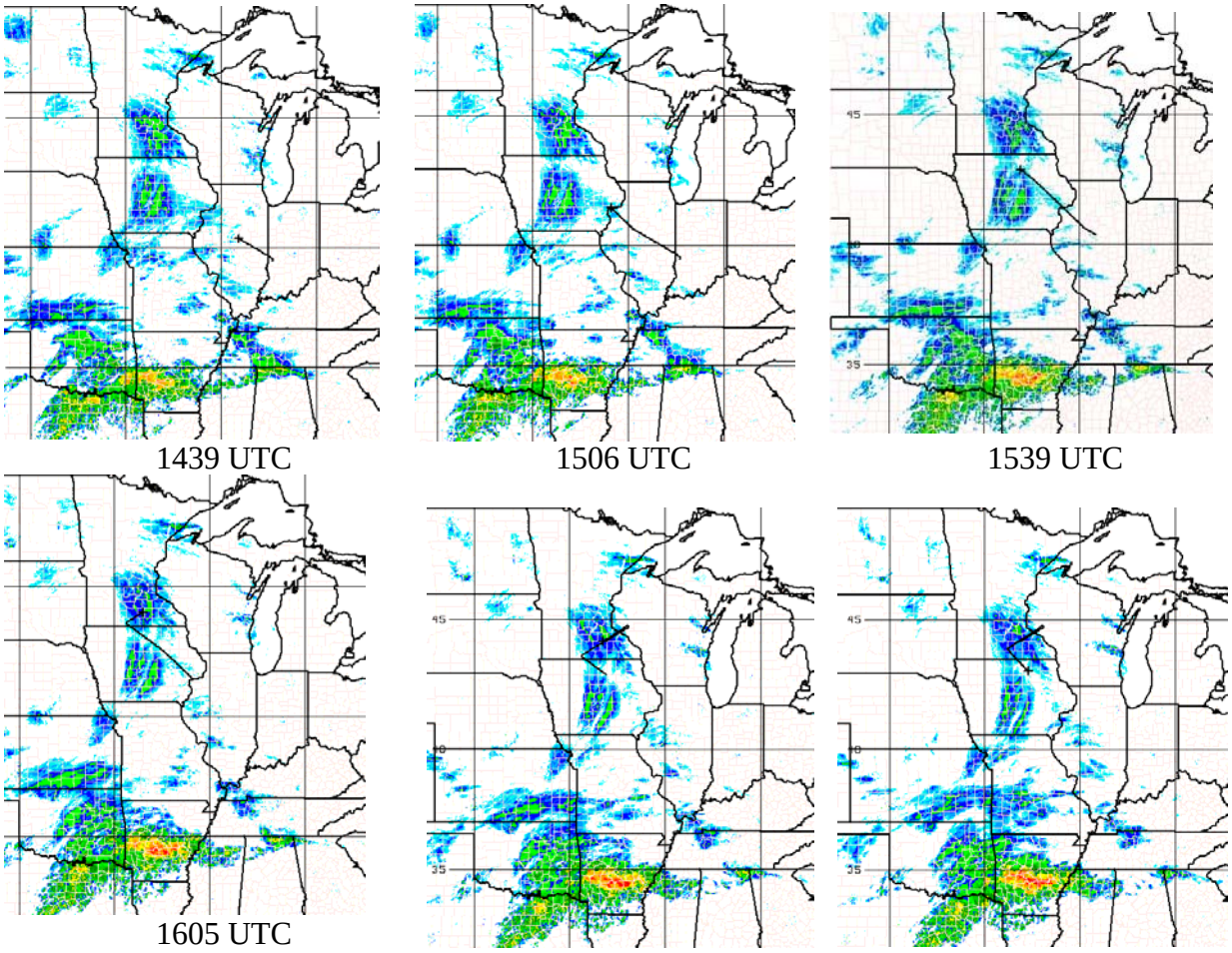



Figure 12: C-130 flight track departing Terra Haute, IN overlaid on radar composites from 1439 UTC 8 Feb 10 through 1859 UTC 8 Feb 10. Times shown are the times of the radar composites. The flight track for the period just before the composite is shown.

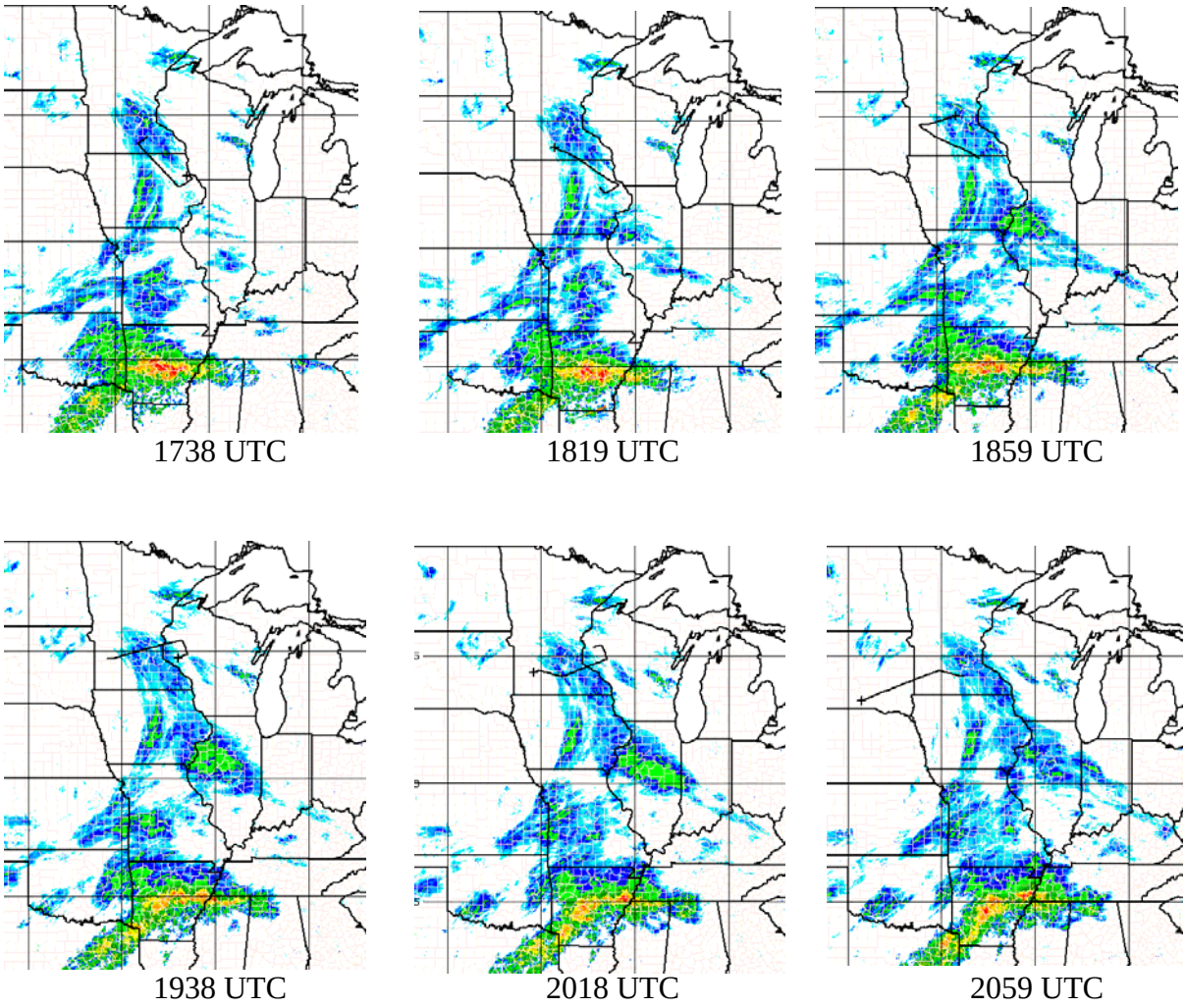
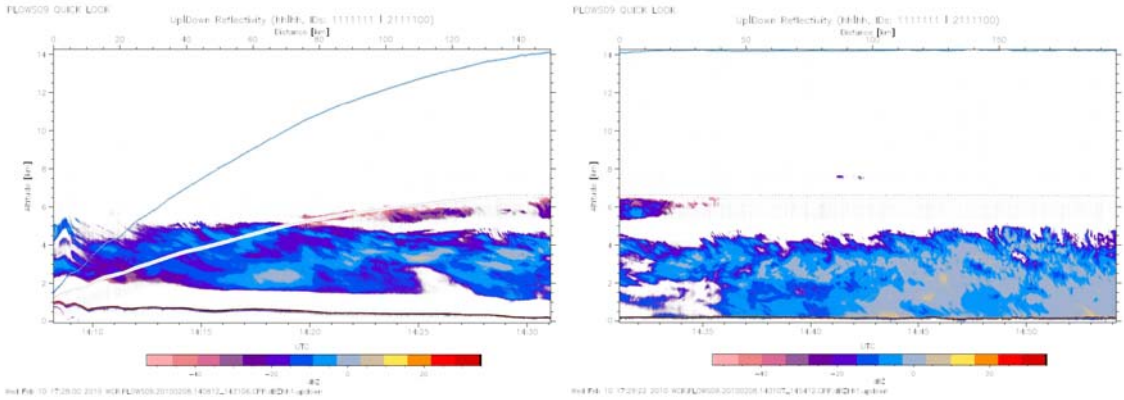



Figure 13: C-130 flight track overlaid on radar composites from 1605 UTC 8 Feb 10 through 2059 UTC 8 Feb 10. After this time the aircraft continued to Boulder, CO. Times shown are the times of the radar composites. The flight track for the period just before the composite is shown.

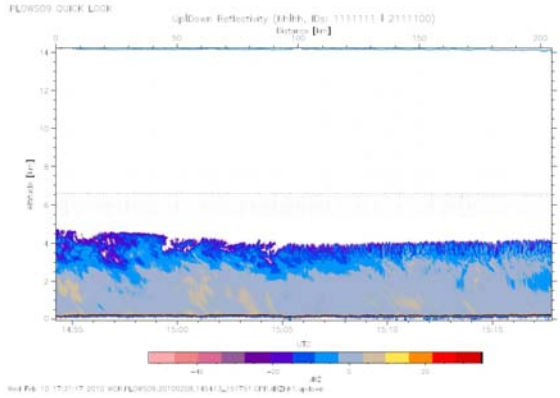
## C-130 Flight RF-10 Wyoming Cloud Radar Quicklooks



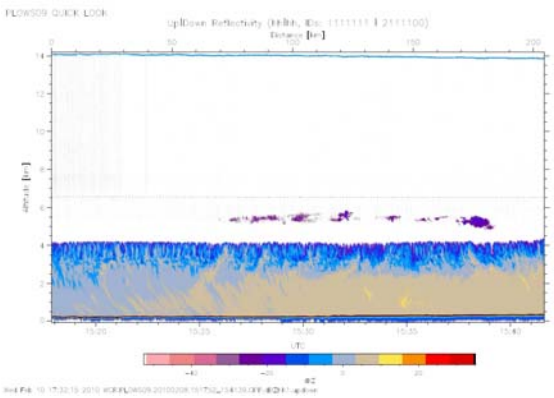
1408 UTC to 1431 UTC



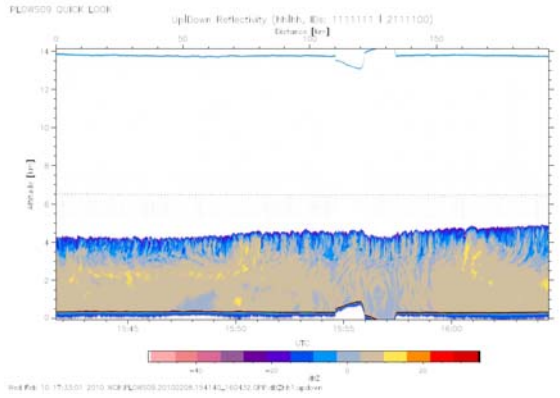
1431 UTC to 1454 UTC



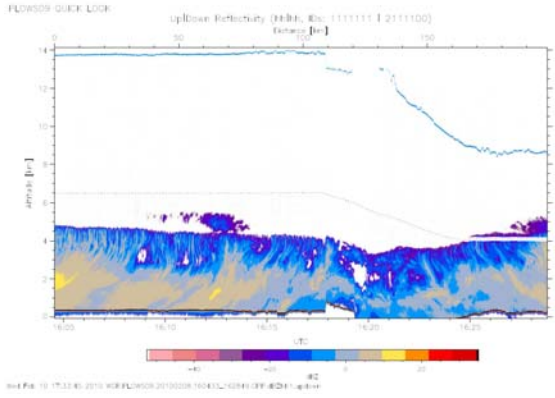
1454 UTC to 1518 UTC



1518 UTC to 1542 UTC

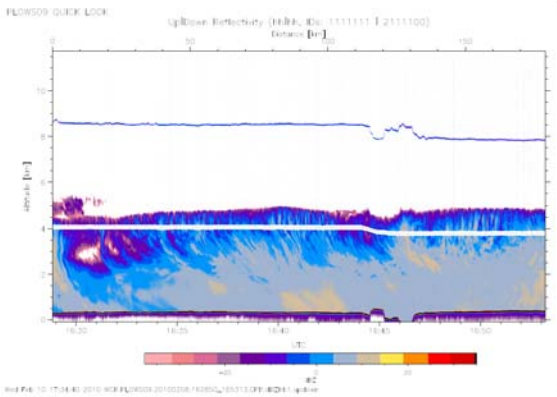


1542 UTC to 1605 UTC

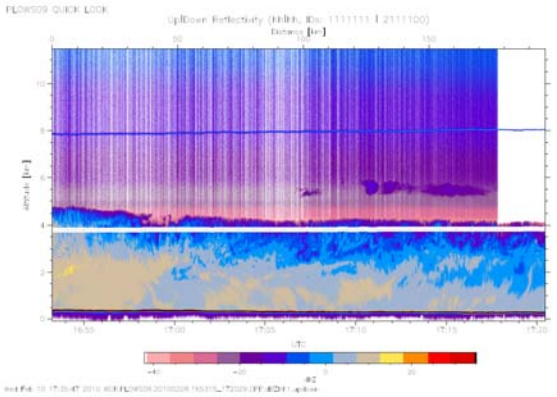


1605 UTC to 1628 UTC

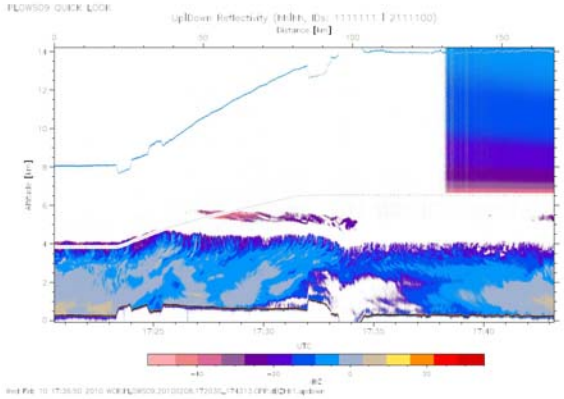
Fig. 14: Wyoming Cloud Radar Quicklook of radar reflectivity between 1408 UTC 8 Feb 10 and 1628 UTC 8 Feb 10.



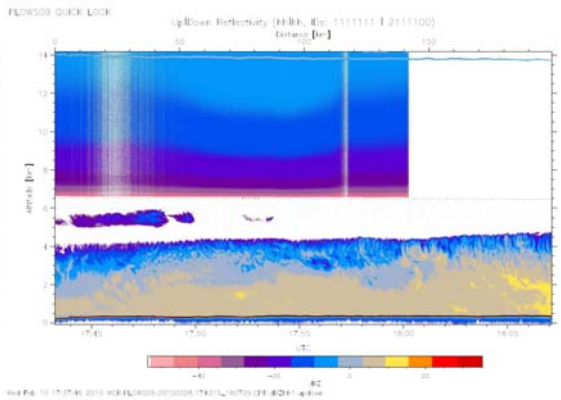
1628 UTC to 1653 UTC



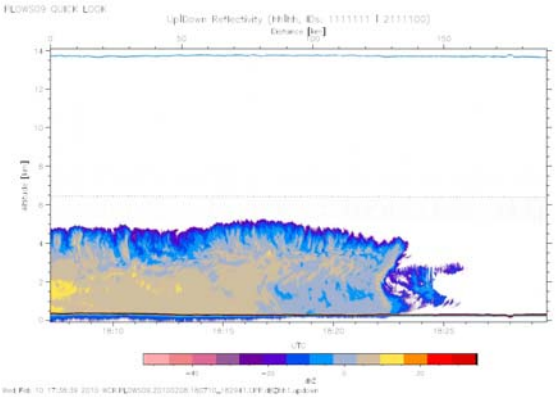
1653 UTC to 1720 UTC



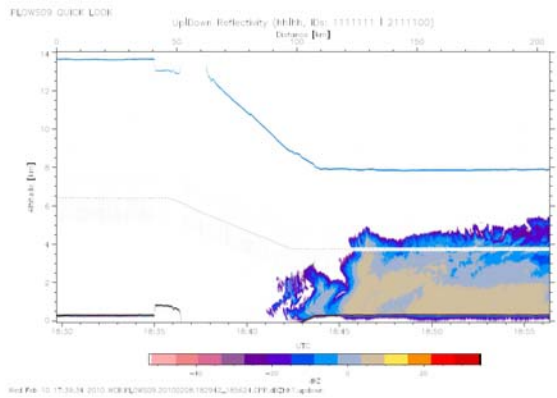
1720 UTC to 1743 UTC



1743 UTC to 1807 UTC

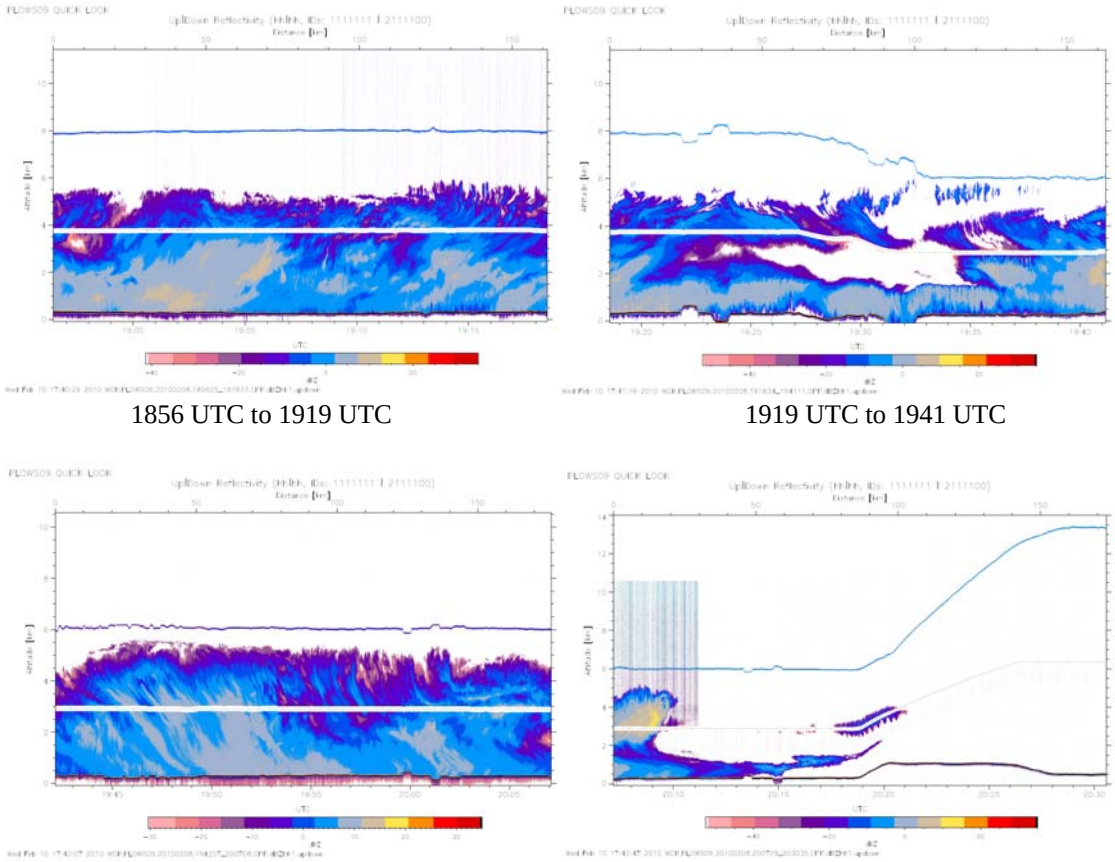


1806 UTC to 1829 UTC



1829 UTC to 1856 UTC

Fig. 15: Wyoming Cloud Radar Quicklook of radar reflectivity between 1628 UTC 8 Feb 10 and 1856 UTC 8 Feb 10.



1856 UTC to 1919 UTC

1919 UTC to 1941 UTC

1941 UTC to 2007 UTC

2007 UTC to 2030 UTC

Fig. 16: Wyoming Cloud Radar Quicklook of radar reflectivity between 1856 UTC 8 Feb 10 and 2030 UTC 8 Feb 10.

## RF-11 Summary

RF-11 began with a ferry from Boulder to Illinois. The flight focused on the Alberta Clipper storm exiting the Midwest. Note that there was a short data loss from the Lincoln radar on the radar composites at 1700 UTC making it appear that a band disappears and reappears as the aircraft crosses the first band. The early legs focused on clouds oriented in bands north of the storm's dry slot. The clouds sloped upward toward the north, reaching 6 km. Because the clouds were cold, the aircraft was able to sample a wider variety of altitudes, making this flight optimal for microphysical studies. After legs over Illinois/Wisconsin, the aircraft was diverted over southern Indiana for legs over the ground based equipment. Two legs were flown over the MIPS site in Goshen and then the aircraft returned to Peoria.

## C-130 Flight RF-11 Flight track

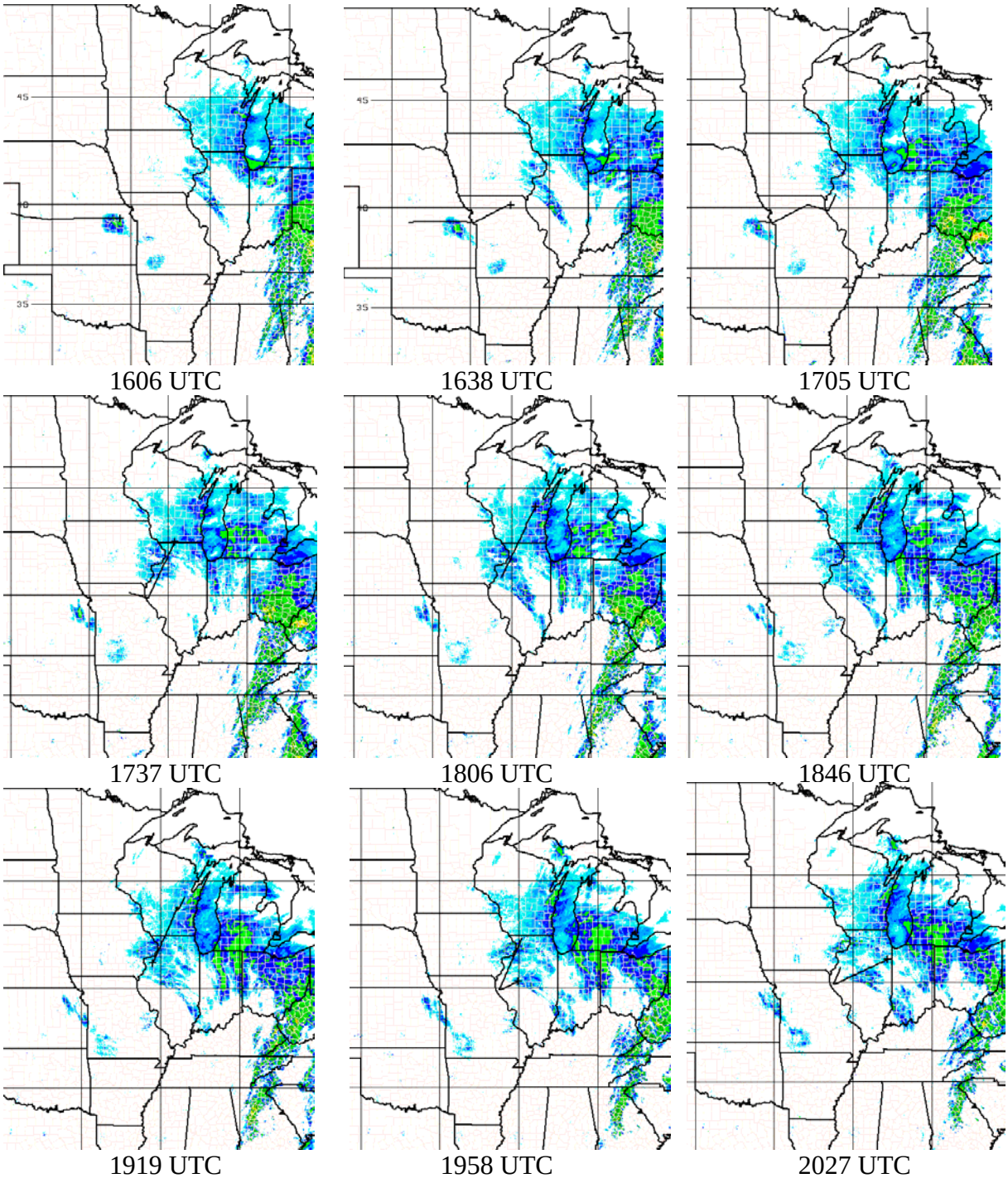



Figure 17: C-130 flight track departing Terra Haute, IN overlaid on radar composites from 1606 UTC 8 Feb 10 through 2027 UTC 9 Feb 10. Times shown are the times of the radar composites. The flight track for the period just before the composite is shown.

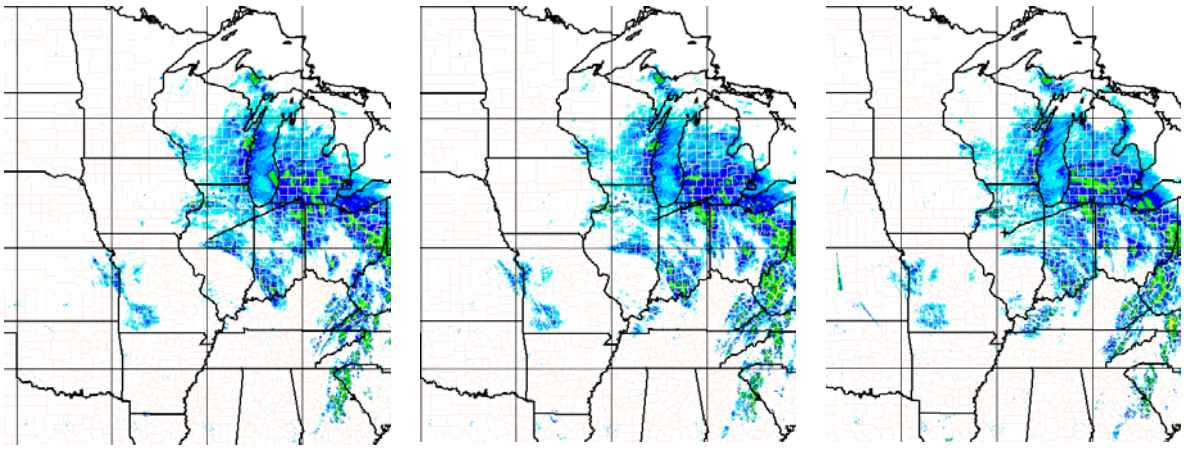



Figure 18: C-130 flight track departing Terra Haute, IN overlaid on radar composites from 2059 UTC 9 Feb 10 through 2207 UTC 9 Feb 10. Times shown are the times of the radar composites. The flight track for the period just before the composite is shown.

## C-130 Flight RF-11 Wyoming Cloud Radar Quicklooks

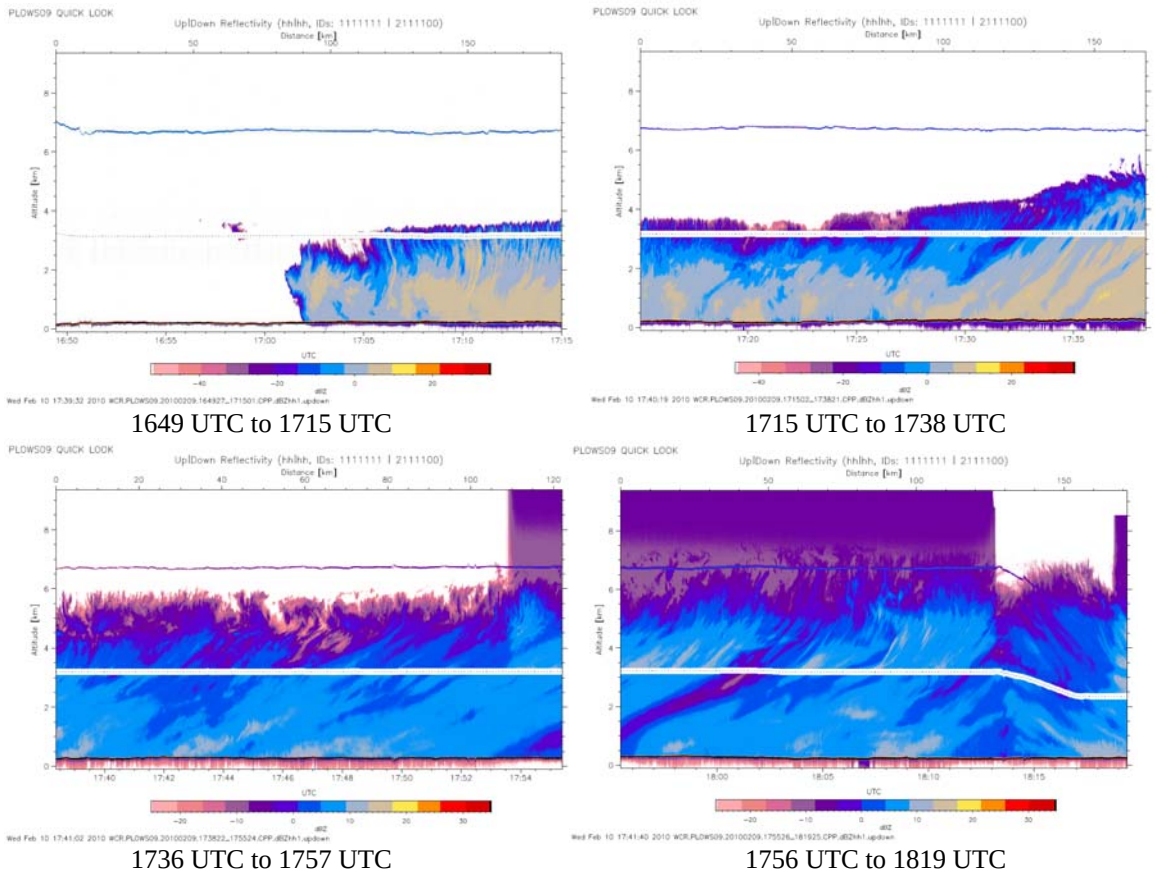
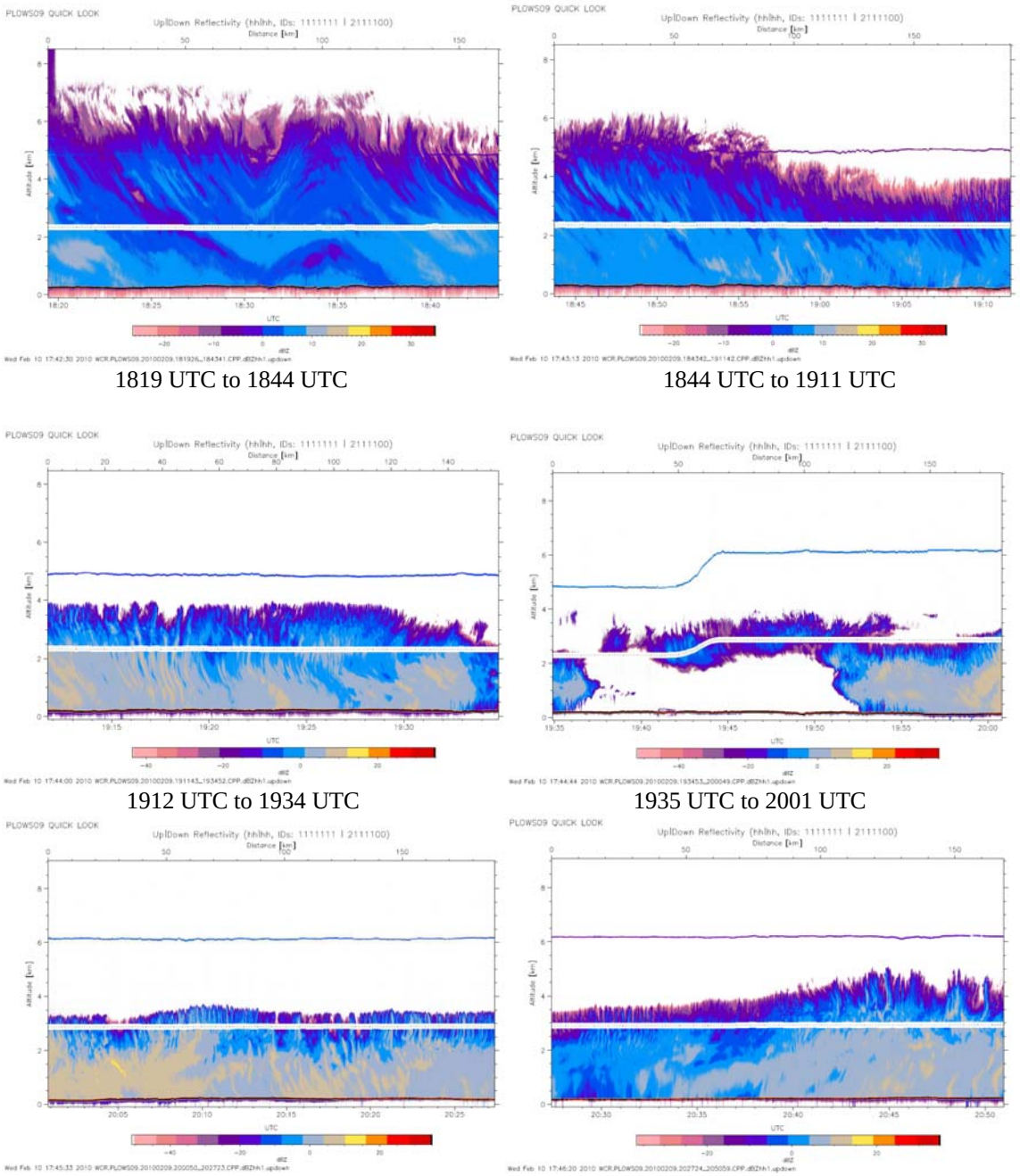



Fig. 19: Wyoming Cloud Radar Quicklook of radar reflectivity between 1649 UTC 9 Feb 10 and 1819 UTC 9 Feb 10.




1819 UTC to 1844 UTC

1844 UTC to 1911 UTC

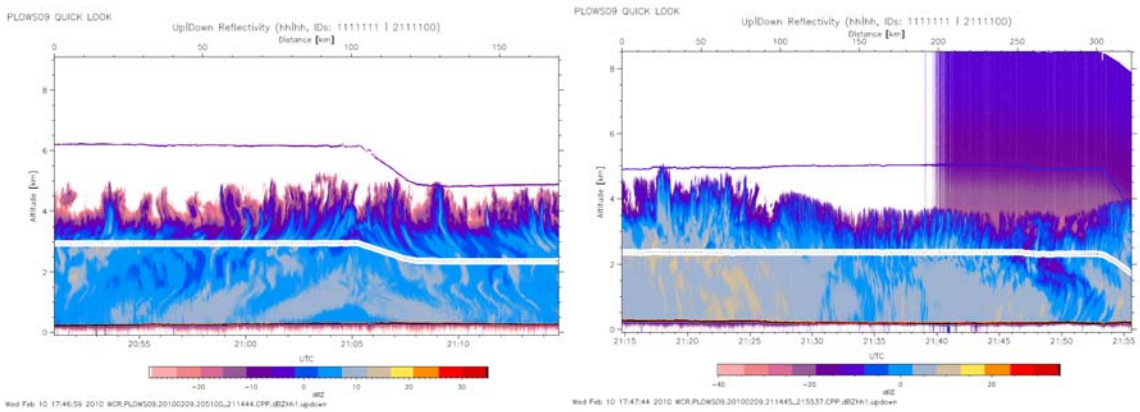
1912 UTC to 1934 UTC

1935 UTC to 2001 UTC

2001 UTC to 2027 UTC

2027 UTC to 2051 UTC

Fig. 20: Wyoming Cloud Radar Quicklook of radar reflectivity between 1819 UTC 9 Feb 10 and 2051 UTC 9 Feb 10.




2051 UTC to 2114 UTC

2115 UC to 2155 UTC

Fig. 21: Wyoming Cloud Radar Quicklook of radar reflectivity between 2051 UTC 9 Feb 10 and 2155 UTC 9 Feb 10.

## 5. MIPS operations:

The MIPS operated at the Holiday Inn Express in Goshen, IN. Both the profiler and the XPR operated without problems. The snowflake imager did not work until about 1400 UTC when we were able to correct the problems with advice from the owner at NASA. Figures from the MIPS 915 MHz profiler are shown on the following pages.

## 6. MAX operations:

The MAX was not used during this IOP.

## 7. MISS 915 MHz Profiler

The MISS operated at the Holiday Inn Express hotel at Ft. Atkinson, WI. No problems occurred during operations. Figures from the MISS 915 MHz profiler are shown on the following pages.

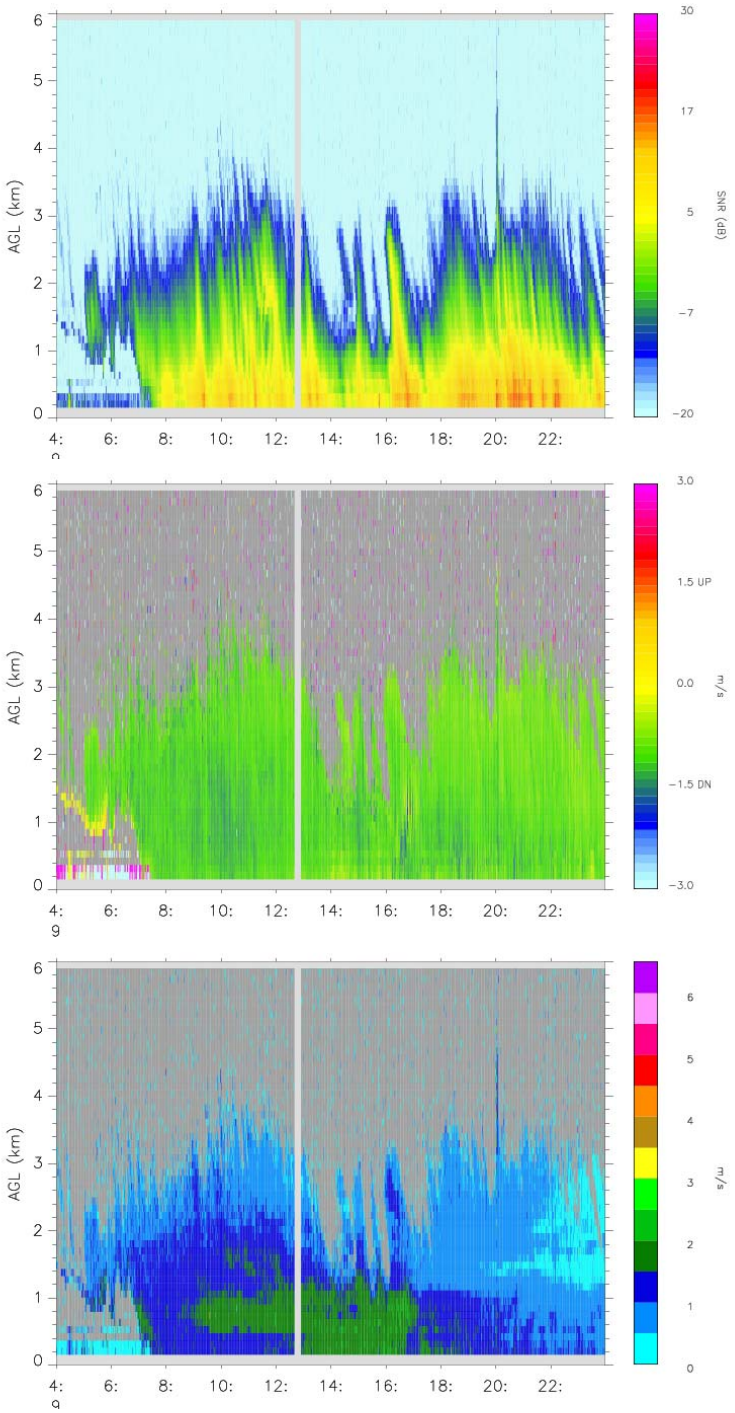


Figure 22: MIPS 915 MHz Profiler SNR, vertical velocity and spectral width for the period of operation 0400 UTC 9 Feb 10 through 0000 UTC 10 Feb 10

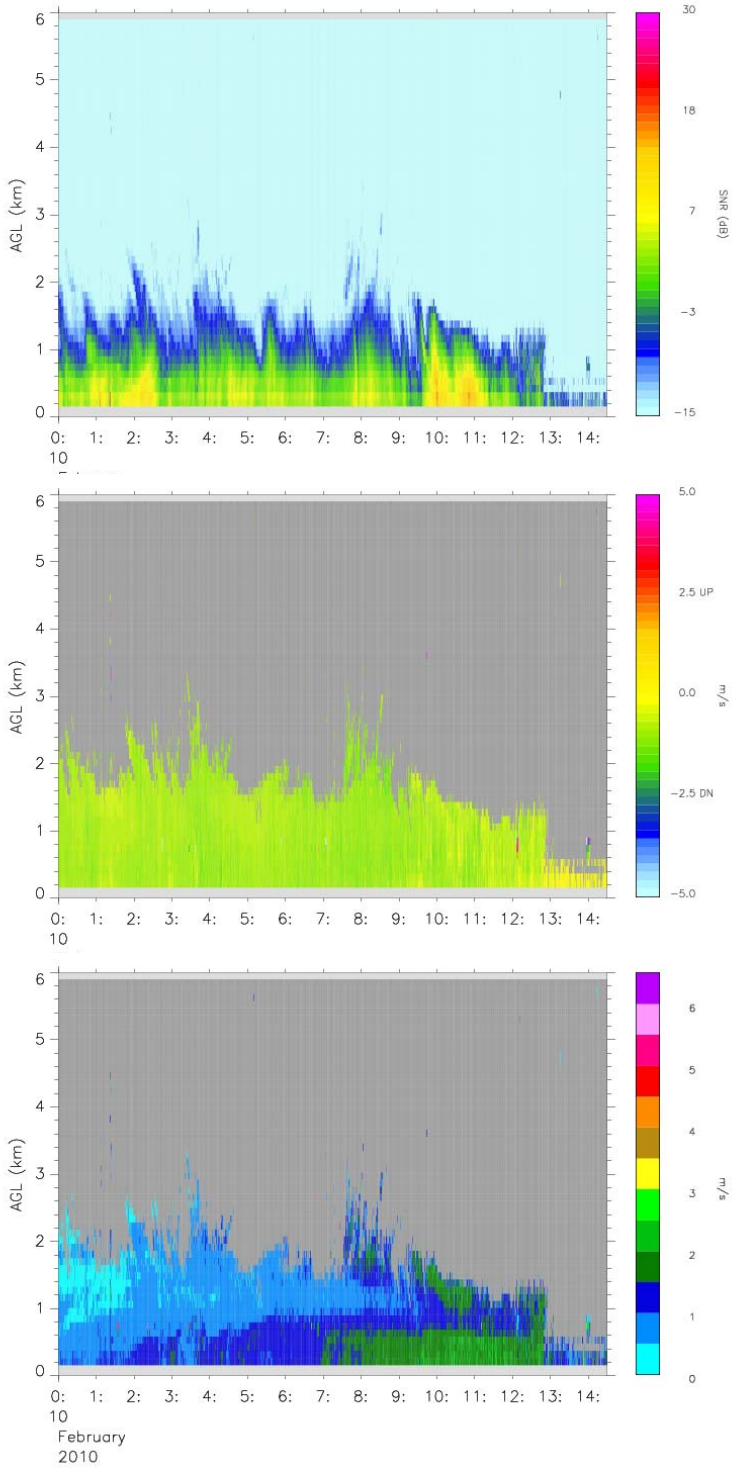



Figure 23: MIPS 915 MHz Profiler SNR, vertical velocity and spectral width for the period of operation 0000 UTC 10 Feb 10 through 1500 UTC 10 Feb 10

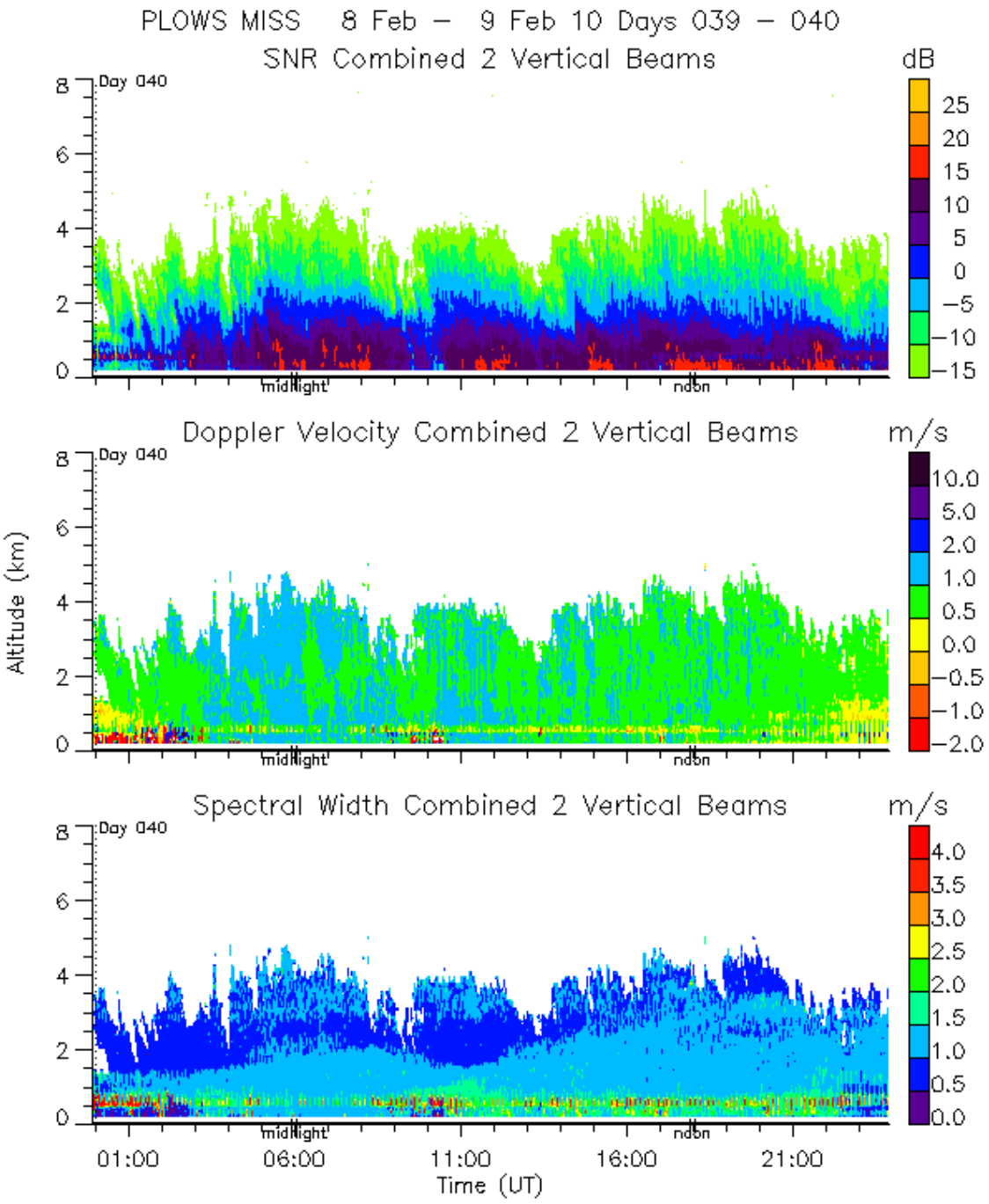



Figure 24: MISS 915 MHz Profiler Winds
for the period of operation 0000 UTC 9 Feb 10 through 0000 UTC 10 Feb 10

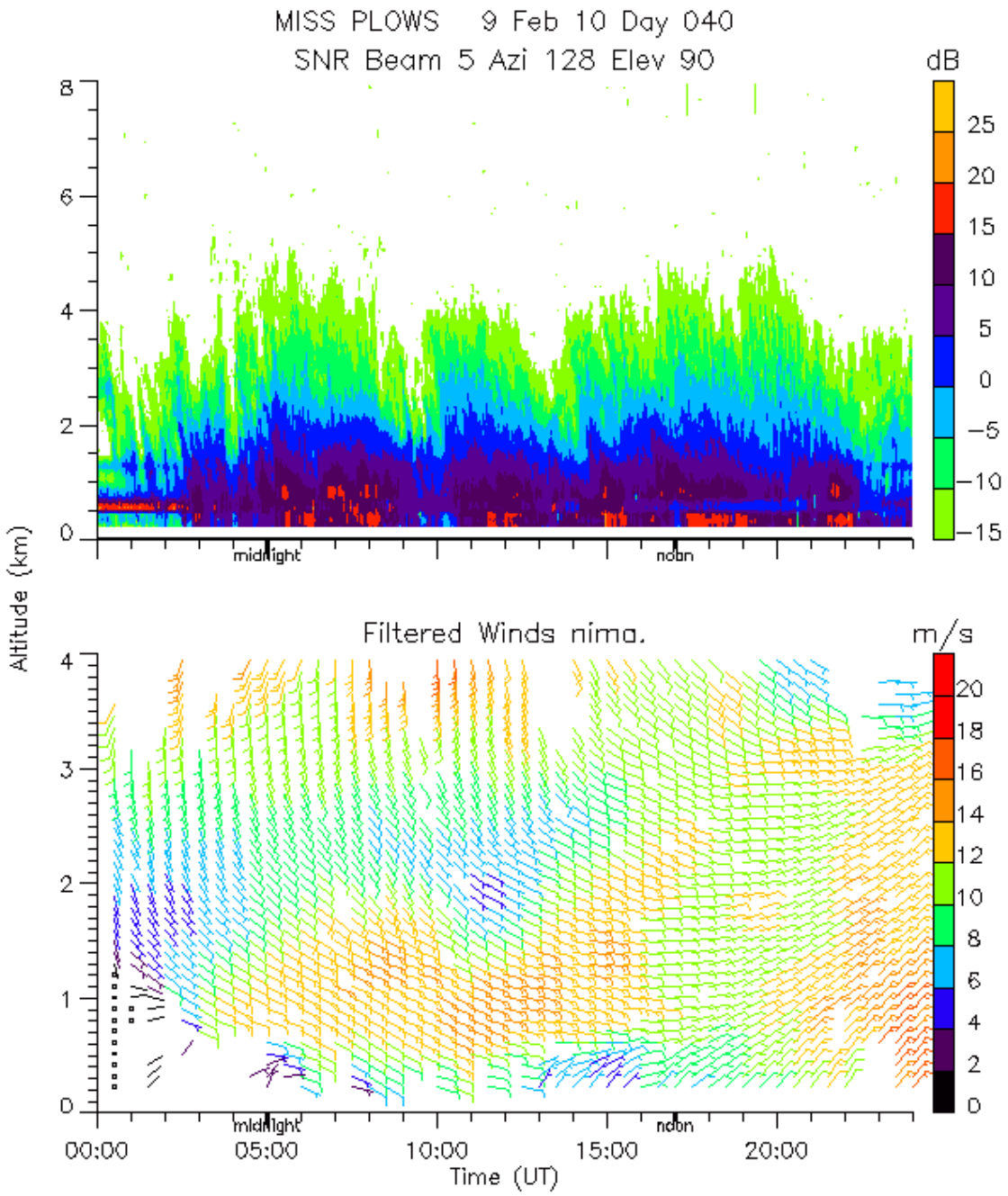



Figure 25: MISS 915 MHz Profiler Winds
for the period of operation 0000 UTC 9 Feb 10 through 0000 UTC 10 Feb 10

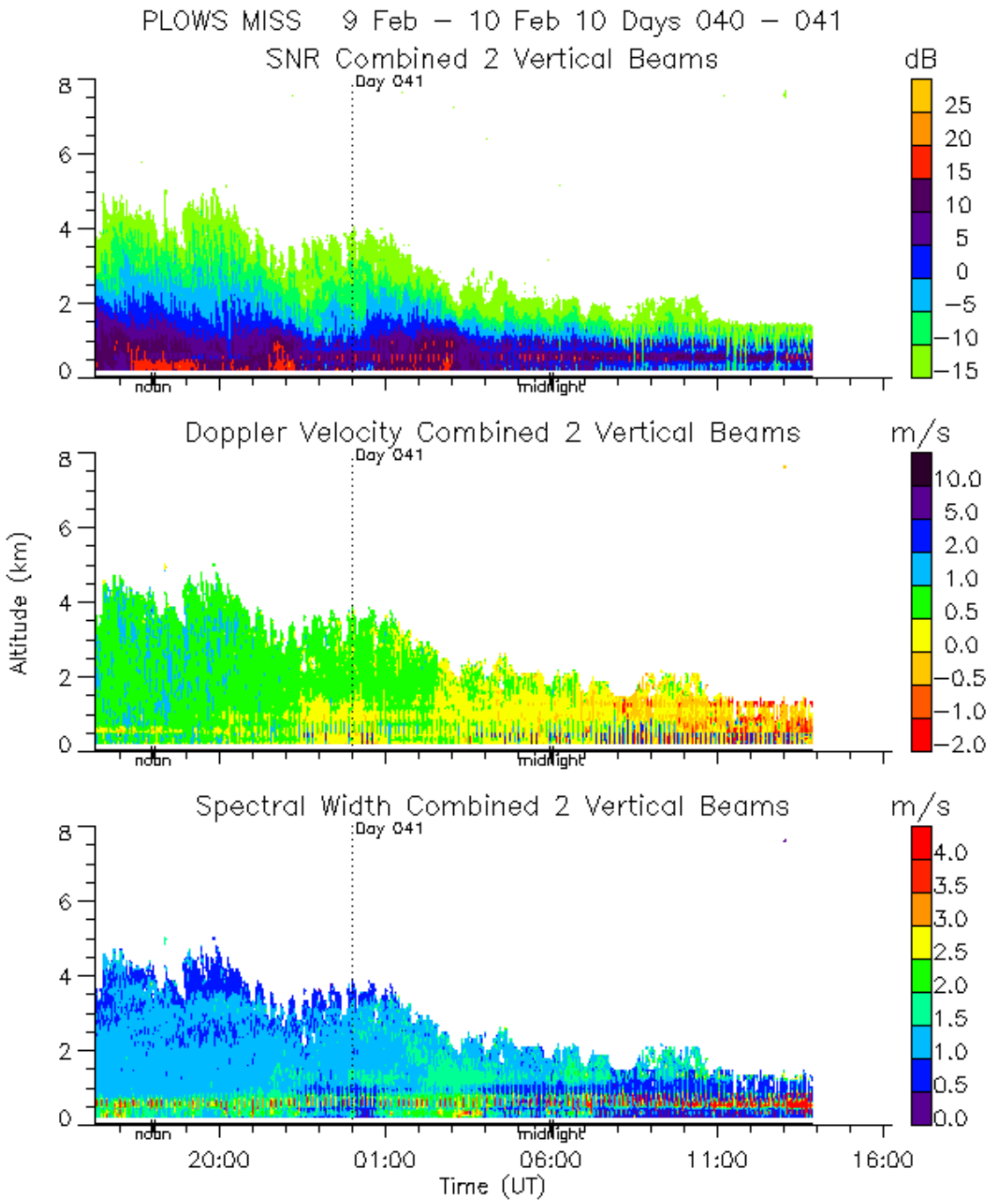



Figure 26: MISS 915 MHz Profiler SNR (top), Radial Velocity (center) and Spectral Width (bottom) for period from 1600 9 Feb 10 to 1400 UTC 10 Feb 10

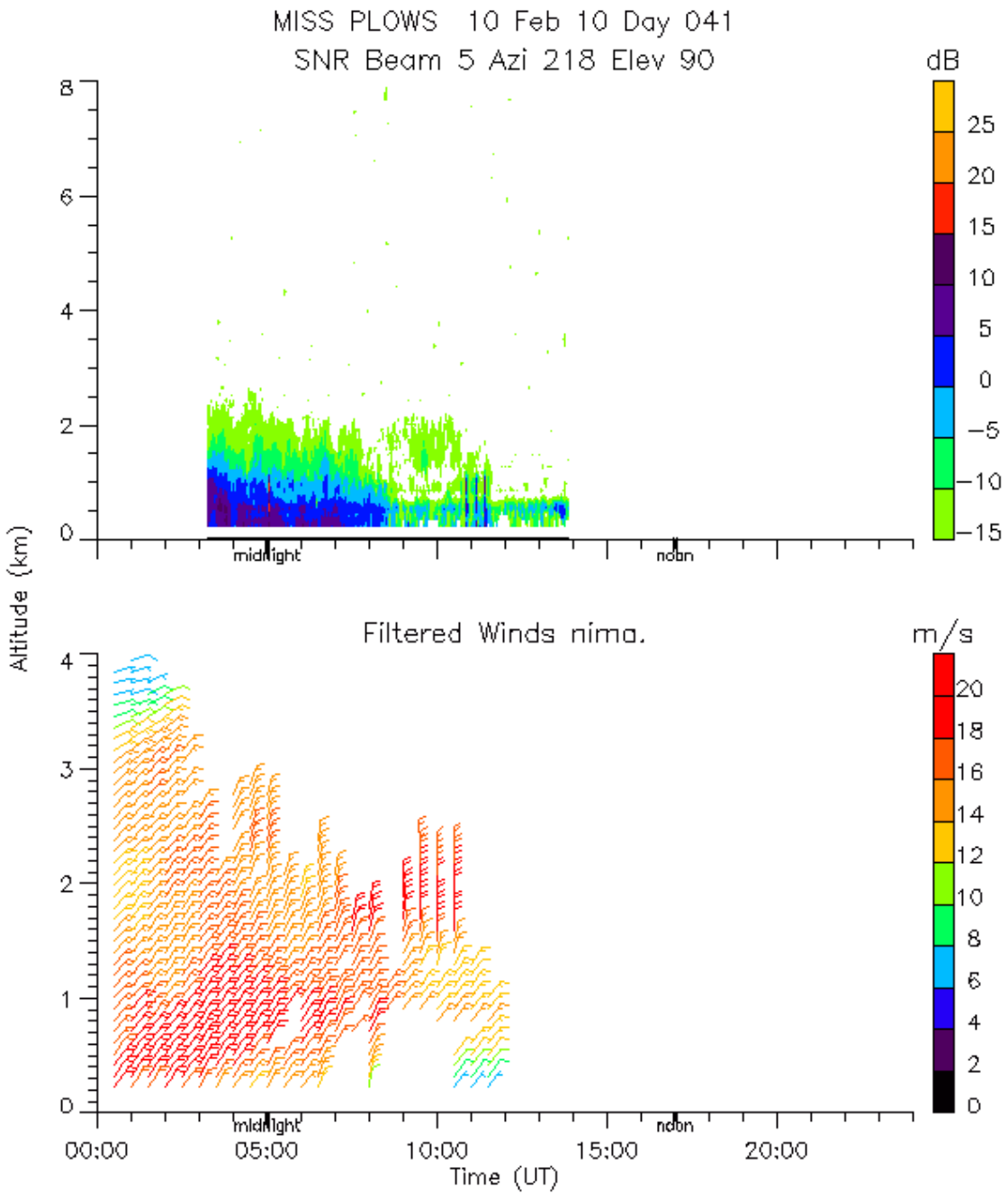


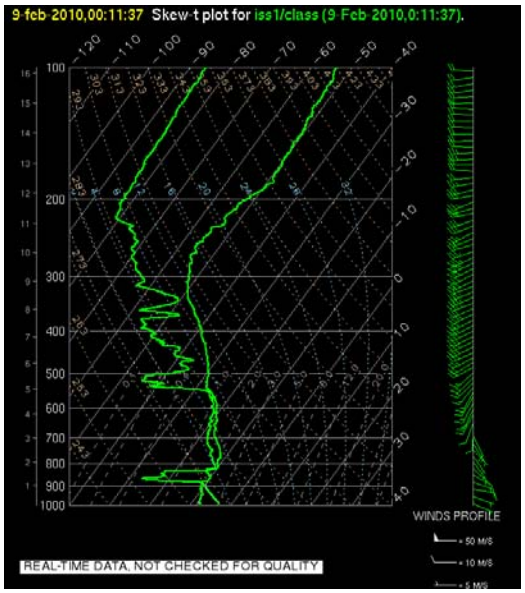

Figure 27: MISS 915 MHz Profiler Winds
for the period of operation 0000 UTC 10 Feb 10 through 1200 UTC 10 Feb 10

## 8. Rawinsondes

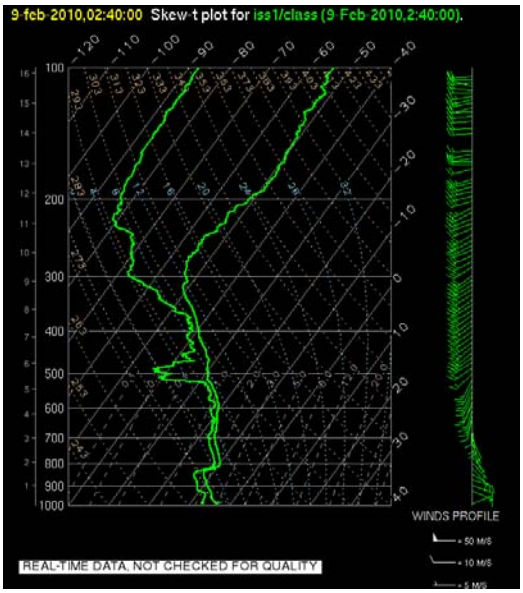
Rawinsondes were launched at the MISS site in Ft. Atkinson, WI on a 3 hourly schedule. The following soundings were launched

| DATE | Launch | Nominal Date and time | | Status |
|---|---|---|---|---|
| **2010 02 09** | **0011 UTC** | **2010 02 09** | **0000 UTC** | **Good** |
| **2010 02 09** | **0240 UTC** | **2010 02 09** | **0300 UTC** | **Good** |
| **2010 02 09** | **0534 UTC** | **2010 02 09** | **0600 UTC** | **Good** |
| **2010 02 09** | **0837 UTC** | **2010 02 09** | **0900 UTC** | **Good** |
| **2010 02 09** | **1131 UTC** | **2010 02 09** | **1200 UTC** | **Good** |
| **2010 02 09** | **1429 UTC** | **2010 02 09** | **1500 UTC** | **Good** |
| **2010 02 09** | **1736 UTC** | **2010 02 09** | **1800 UTC** | **Good** |
| **2010 02 09** | **2034 UTC** | **2010 02 09** | **2100 UTC** | **Good** |
| **2010 02 09** | **2337 UTC** | **2010 02 10** | **0000 UTC** | **Good** |
| **2010 02 10** | **0235 UTC** | **2010 02 10** | **0300 UTC** | **Good** |
| **2010 02 10** | **0528 UTC** | **2010 02 10** | **0600 UTC** | **Good** |

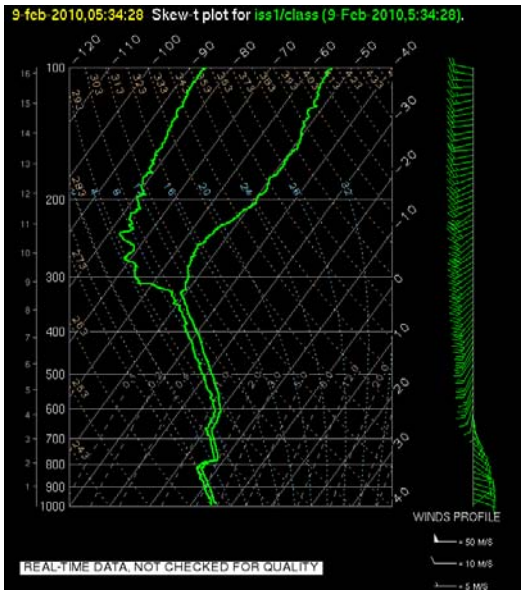
Rawinsondes were launched not launched by Missouri during this IOP. Their equipment was being repaired after an earlier equipment failure.



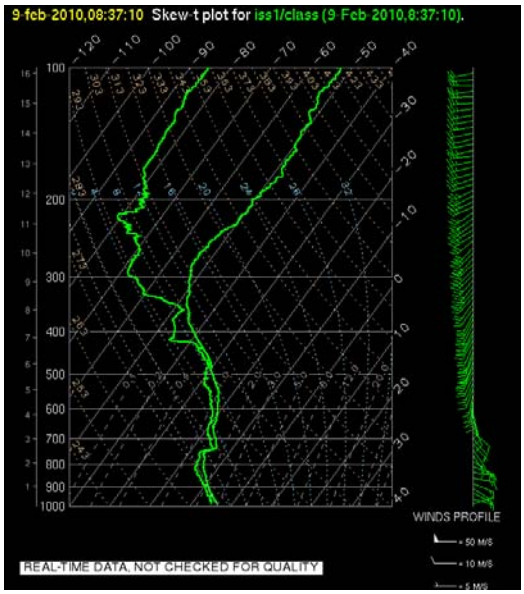

MISS Sounding 0000 UTC 9 Feb 10



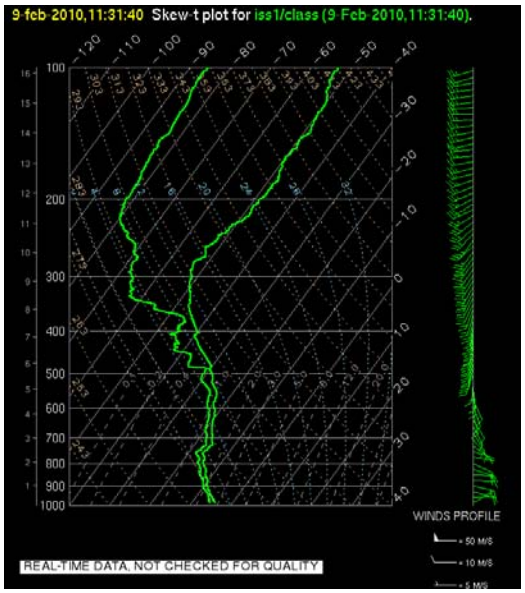

MISS Sounding 0300 UTC 9 Feb 10



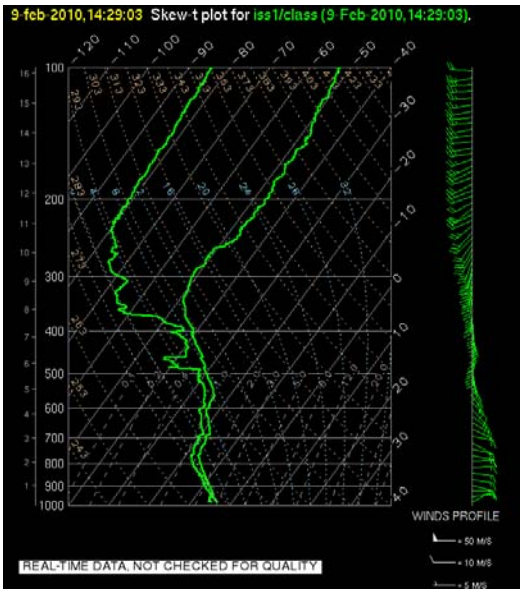

MISS Sounding 0600 UTC 9 Feb 10



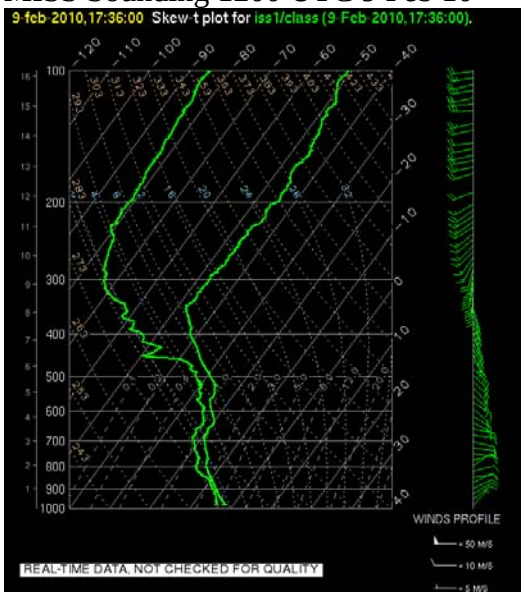

MISS Sounding 0900 UTC 9 Feb 10



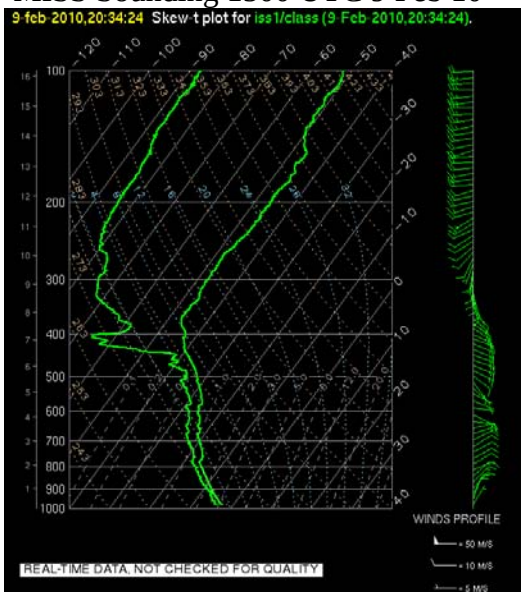

MISS Sounding 1200 UTC 9 Feb 10



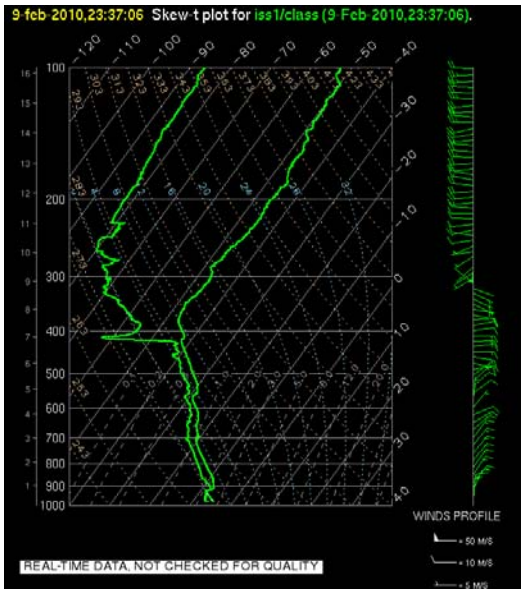

MISS Sounding 1500 UTC 9 Feb 10



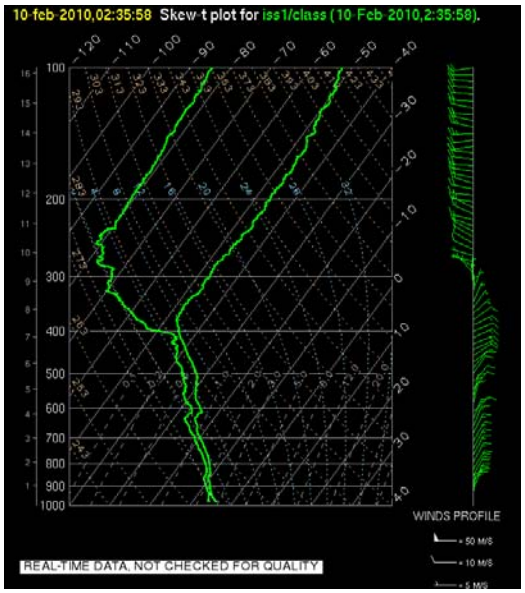

MISS Sounding 1800 UTC 9 Feb 10



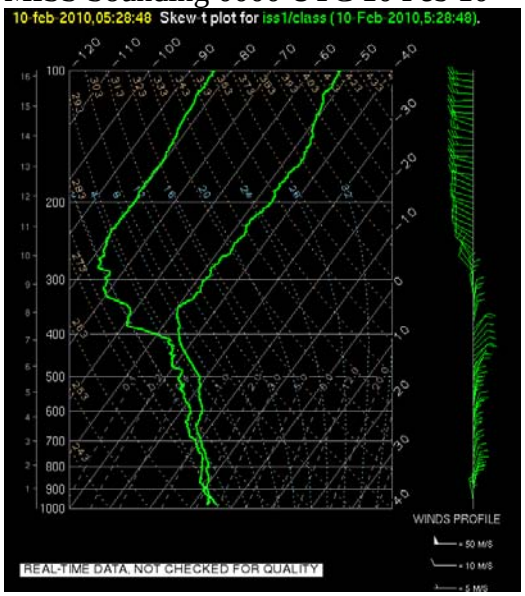

MISS Sounding 2100 UTC 9 Feb 10




MISS Sounding 0000 UTC 10 Feb 10




MISS Sounding 0300 UTC 10 Feb 10




MISS Sounding 0600 UTC 10 Feb 10