P1.48 **ASYNOPTIC HIGH RESOLUTION UPPER-AIR DATA FOR HIGH IMPACT WEATHER EVENTS**

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1. INTRODUCTION

Quality weather support for wildfires and other hazardous material (HAZMAT) incidents often depends on non-routine surface and upper air observations, and model data. These data are invaluable for monitoring current conditions, warning others of impending hazards, and improving forecasts for incident response actions. Unfortunately, the spatial and temporal resolution of upper air observations is coarse. The average distance between rawinsonde stations in the Continental U.S. is 315 km (Fig. 1; OFCM, 1997). Moreover, these observations are routinely taken only two times per day, around 0000 and 1200 UTC.

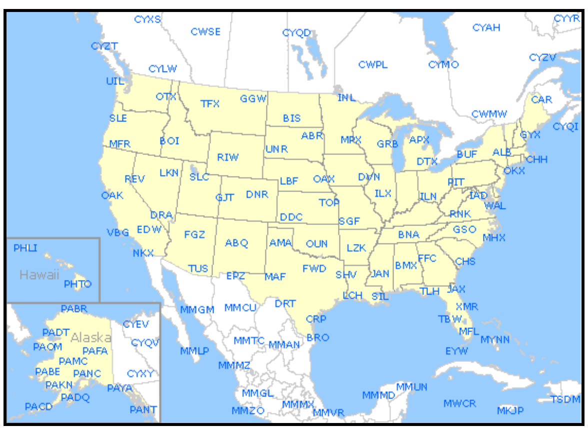

Fig. 1. Continental U.S. rawinsonde sites.

HI-RISE (Hazardous Incident − Rapid In-flight Support Effort) was a collaborative experiment between four organizations: the National Weather Service (NWS), Texas Forest Service, United States Department of Agriculture -- Agricultural Research Station (USDA-ARS), College Station, TX, and Aventech Research Inc., Barrie, ON, Canada.

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NWS participants included meteorologists from Weather Forecast Offices (WFOs) at Austin/San Antonio and Midland/ Odessa, TX, and Southern Region Headquarters in Fort Worth, TX.

The main goal of HI-RISE was a proof-of-concept to provide real-time access to local upper air observations at a prescribed burn simulating a wildfire. Asynoptic upper air data were collected and relayed from a single-engine air tanker aircraft via satellite to Aventech Research, and then via the Internet to on-site Incident Response Meteorologists (IMETs) and to a meteorologist at WFO Austin/San Antonio. A test flight was conducted with a midpoint of 1500 UTC 14 April 2005, followed by two operational flights with midpoints of 1645 UTC and 1930 UTC on 21 April 2005 during prescribed burn operations at Camp Swift, TX.

Witsaman, et al., (2005) describe HI-RISE in detail, including the aircraft, meteorological sensors, data transmission, and application of data to the analysis and forecasting of weather for the burn operations. This paper focuses solely on comparison of the wind, temperature, and dew point temperature (dew point) data of the three flights to the National Oceanic and Atmospheric Administration (NOAA) wind profiler at Ledbetter, TX, and the closest Rapid Update Cycle (RUC) (Benjamin et al., 2004) analysis sounding location (17 km@315° from Giddings-Lee County Airport, TX, (KGYB), or about 18 km east-northeast of Camp Swift (Fig. 2) The data collection and analysis methods are described in the second section. Results and discussion follow in section three, and the conclusion is in section four.

2. DATA COLLECTION AND ANALYSIS

Witsaman, et al. (2005), thoroughly describe the aircraft and meteorological sensors used, as well as the transmission of the data to NWS meteorologists. The data were saved at WFO Austin/San Antonio as ASCII text files, and then imported into a spreadsheet for sorting, selection, and production of graphics.

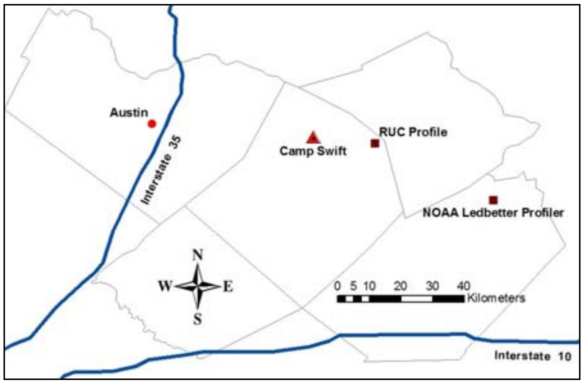

Fig. 2. Locations of HI-RISE sites, with Austin, Texas, and Interstates 10 and 35 for spatial reference.

2.1 AIMMS-20 Aircraft Observations

The data from the AIMMS-20 meteorological sensor package are of very high resolution (Fig. 2), with measurements every 2-4 hPa from the surface to the aircraft's service ceiling ~600 hPa, or 4100 m above Mean Sea Level (MSL). The sensor package measures Global Positioning System (GPS)-derived MSL altitude, pressure, temperature, dew point, wind direction (relative to true north), wind speed, time, latitude, and longitude.

2.2 RUC Analysis Soundings

RUC analysis soundings were obtained from the NOAA Earth Systems Research Lab soundings website [available online at: http://www-frd.fsl.noaa.gov/mab/soundings/java/] during the HI-RISE experiment. The nearest model grid point was located 18 km east-northeast of Camp Swift. MSL height, pressure, temperature, dew point, wind direction, and wind speed were available at roughly 15 hPa intervals from near the surface to roughly 50 hPa. This well exceeded the service ceiling of the aircraft, and thus only 15-20 data points coincided with aircraft observations.

RUC analysis soundings have been found to compare well to radiosonde observations (Thompson, et al., 2003) for the forecasting of supercell environments. However, the quality of analysis soundings relies on the input observations, first guess from previous cycle, and the analysis methods, which could result in significant error compared to in-situ observations such as a radiosonde or aircraft.

2.3 NOAA Ledbetter Profiler Observations

The Ledbetter profiler was co-located with the test flight at 1500 UTC on 14 April 2005, and 50 km east-southeast of Camp Swift for the operational flights at 1645 UTC and 1930 UTC on 21 April 2005. The Ledbetter profiler data reports MSL height, pressure, wind direction, and wind speed roughly every 25 hPa from the surface to around 100 hPa.

A Radio Acoustic Sounding System was present at the site with the capability of measuring temperature, but there were too few co-located levels with the aircraft data for useful comparison.

Similar to the RUC soundings, profiler soundings have been found to be robust systems with similar error statistics to other upper-air wind measuring systems (NOAA, 1994). However, the profilers are a remote sensing technology and thus subject to poor data quality under certain conditions, mainly where physical assumptions for the retrieval method are violated.

2.4 Additional Data Processing

The data from all three data sources were further processed from into SI units, and converted to standard reporting formats. Selection of co-located pressure levels was facilitated by the 2-4 hPa vertical resolution of the AIMMS-20 aircraft data. Most co-locations between the AIMMS-20 and Ledbetter or the AIMMS-20 and RUC were within 1-2 hPa. In cases were a Ledbetter or RUC level was vertically equidistant between two AIMMS-20 levels, the higher pressure (lower altitude) level was selected (e.g., RUC level at 702 hPa, AIMMS-20 levels at 701 and 703 hPa, 703 hPa would be selected).

The data were plotted on graphs with pressure on the horizontal axis, decreasing to the right. The number of simultaneous data levels for all sources is too small for direct comparison. However, direct comparisons were performed for the AIMMS-20 and the RUC or the Ledbetter profiles. No additional statistical comparison was done due to only three flights, the limited number of comparison levels within those flights, and potential errors due to the distance from the aircraft to the Ledbetter profiler for the flights on 21 April 2005, and from the RUC point 17 km NW of KGYB for all three flights.

3. RESULTS

Overall, temperature and wind speed compare favorably among the AIMMS-20, Ledbetter profiler, and RUC. Wind direction and dew point compare favorably except within, and slightly above the inversion layer. The results for each element are discussed further in the following sections.

3.1 Wind Speed

Wind speed values between the AIMMS-20 and either the Ledbetter profiler or RUC are generally within 2 ms^{-1} (Fig. 3) with some outlying values up to 5 ms^{-1} (Fig. 4). The aircraft (and AIMMS-20 sensor package) flew directly over the Ledbetter profiler for

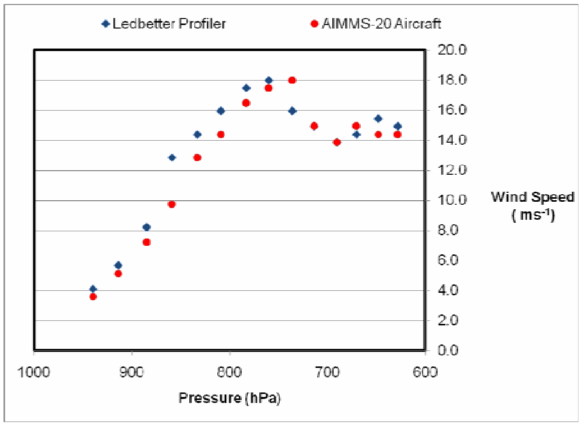

Fig. 3. AIMMS-20 aircraft and Ledbetter profiler wind speed (ms^{-1}) vs. pressure (hPa) over the Ledbetter profiler site around 1500 UTC 14 April 2005.

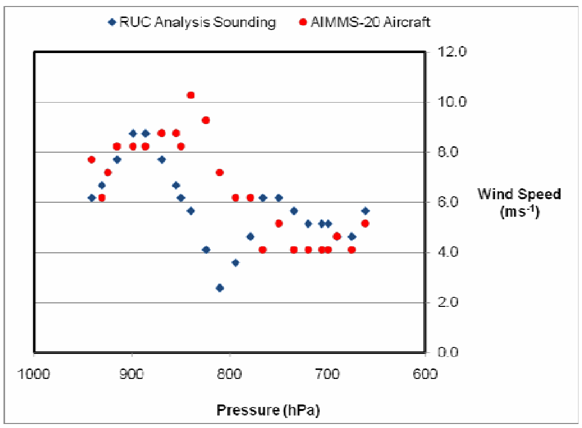

Fig. 4. AIMMS-20 aircraft (over Camp Swift) and RUC analysis sounding (18 km ENE of Camp Swift) wind speed (ms^{-1}) vs. pressure (hPa) around 1930 UTC 21 April 2005.

the period around 1500 UTC on 14 April 2005 (Fig. 3), which is likely responsible for the very close agreement in observations (all but two levels with a difference $\leq$ 3 ms^{-1}, most with a difference $\leq$ 1 ms^{-1}). The differences were on the same order of magnitude between the AIMMS-20 and the RUC for the 1500 UTC profile on 14 April 2005, and between the AIMMS-20 and either the Ledbetter profiler or RUC for the 1645 UTC and 1930 UTC profiles on 21 April 2005 over Camp Swift.

In fact, the differences range from 3 to 5 ms^{-1} (Fig. 4) in the inversion layer between 850 and 800 hPa (Fig. 5 and Table 1). There is a positive bias (i.e., higher values) for the AIMMS-20. Attributing these differences is difficult due to the fact that the RUC sounding is located 18 km east-northeast from Camp Swift, while the Ledbetter profiler is located 50 km east-southeast.

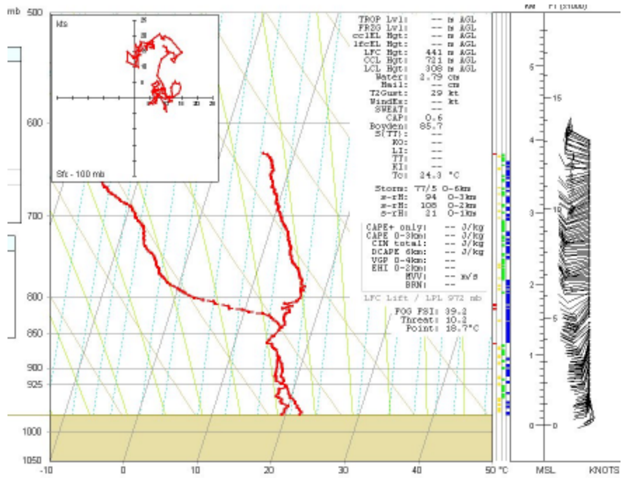

Fig. 5. AIMMS-20 aircraft temperature, dew point temperature, and wind profile over Camp Swift around 1645 UTC 21 April 2005.

Table. 1. AIMMS-20 temperature, dew point temperature, and wind profile over Camp Swift around 1645 UTC 21 April 2005. Note the shaded inversion layer.

GPS Altitude (m)	P (mb)	T (°C)	Td (°C)	Wind Direction (deg)	Wind Speed (m s^{-1})	Time (UTC)	Lat. (°N)	Long. (°W)
1347	865	15.1	15.1	211	11.3	1644	30.279	-97.378
1357	863	14.6	14.6	226	10.8	1644	30.282	-97.377
1368	863	14.4	14.4	225	9.8	1644	30.285	-97.376
1403	859	14.6	14.6	228	8.7	1644	30.287	-97.374
1454	854	14.8	14.8	223	8.7	1644	30.29	-97.372
1461	853	15.1	15.1	225	9.3	1645	30.292	-97.37
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2058	795	16.9	1.2	269	5.7	1646	30.308	-97.32
2079	793	16.8	0.8	268	5.7	1646	30.307	-97.318
2102	791	17.1	0.4	269	6.2	1646	30.307	-97.315
2129	789	16.6	0	264	7.2	1647	30.307	-97.312
2156	786	17.1	-0.6	258	7.7	1647	30.308	-97.309

The differences in wind speed simply could be due to differences in distance alone. However, as shown in Fig. 3, the 1500 UTC 14 April profiles between Ledbetter and the AIMMS-20 were nearly identical. This suggests the AIMMS-20 is closer to the correct values over Camp Swift, which is also supported by theory that in-situ observations at the site will be more accurate that remotely sensed observations for a point away from the site. Overall, the AIMMS-20 compares very favorably to the Ledbetter and RUC profiles, giving IMETs a number of options for wind speed, although the in-situ, on-the-spot observations of the AIMMS-20 would be preferred.

3.2 Wind Direction

Wind direction differences between the AIMMS-20 and either the Ledbetter or RUC profiles were generally within 25° for all three profile periods, with the exception being between 750 and 650 hPa (or just above the inversion layer (Fig. 6). Differences in this layer were mostly between 25° and 50°. Note the Ledbetter and RUC values are in fairly close agreement. This again suggests that the in-situ, AIMMS-20 observations at the site may be more accurate that the remotely-sensed Ledbetter or RUC soundings, both of which are at a distance from Camp Swift. While wind direction errors < 30° may be inconsequential for many meteorological applications and forecasts, wind direction is critical for wildfire and HAZMAT plume monitoring and prediction.

3.2 Temperature and Dew Point

Similar to wind speed, temperature values between the AIMMS-20 and RUC profiles compare well, with most differences between 1° and 3° (Fig. 7). Both profiles show the inversion present for both the 1645 UTC and 1930 UTC profiles (between about 825 mb and 775 mb in Fig, 7). This inversion layer was critical to the IMET forecasts that day, as the primary threat to burn operations was possible afternoon convection. The AIMMS-20 data delivered in real-time allowed the IMETs to forecast that the inversion would continue through the afternoon, thereby capping vertical motion of surface-based parcels, and inhibiting convection.

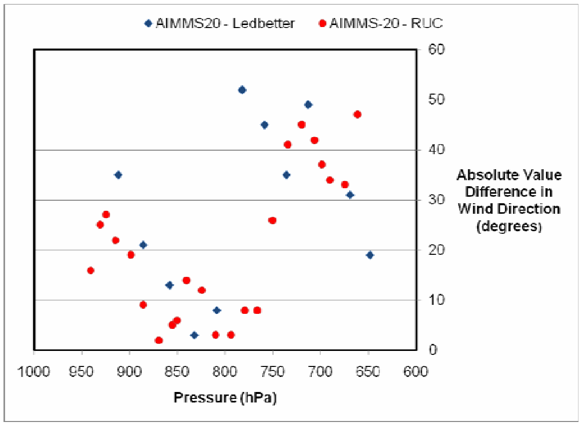

Fig. 6. Absolute value of degree difference in wind direction between the AIMMS-20 aircraft (over Camp Swift) and RUC analysis sounding (18 km ENE of Camp Swift), and AIMMS-20 and Ledbetter profiler (50 km ESE Camp Swift) vs. pressure (hPa) around 1930 UTC 21 April 2005.

In contrast to temperature, and more similar to wind direction, dew point was within 1 to 2°C except in and just above the inversion layer (roughly between 825 and 725 mb in Fig. 7. In this layer, differences as large as 5.6°C were present. The AIMMS-20 showed a positive (higher dew point) bias compared to the RUC. One possible explanation for the difference would be how the RUC analysis system handles inversions. Obviously, sharp horizontal (front) or vertical (inversion) gradients are a substantial challenge for model analysis systems.

Overall, temperature and dew point compare favorably between the AIMMS-20 and the RUC. But, if convection is a threat to the wildfire or HAZMAT area, continuously updated, real-time, in-situ observations will likely provide a more accurate analysis and forecast.

4. CONCLUSION

The HI-RISE experiment provided a unique opportunity to carry out a limited field test of the AIMMS-20 meteorological package, including comparison to nearby Ledbetter profiler and RUC analysis soundings. Any of these sources seem to provide valuable data to the analysis and forecast process for wildfire and HAZMAT incidents. NOAA profilers are mainly located on the Great Plains, and thus out of the primary wildfire areas of the U.S.. RUC analysis soundings are available across all of North America, and with increasing horizontal, vertical, and temporal resolution, hold the potential for highly accurate temperature, wind, and dew point profiles near wildfire or HAZMAT sites. However, the AIMSS-20 can be mounted on tanker aircraft, offering nearly continuous, real-time profiles to the IMET at the Incident Command Post. This would provide a new level of tactical support for response and planning operations. Moreover, a number of tanker aircraft working a fire could also provide profile cross sections or profiles localized to different sections of large wildfires.

5. ACKNOWLEDGEMENTS

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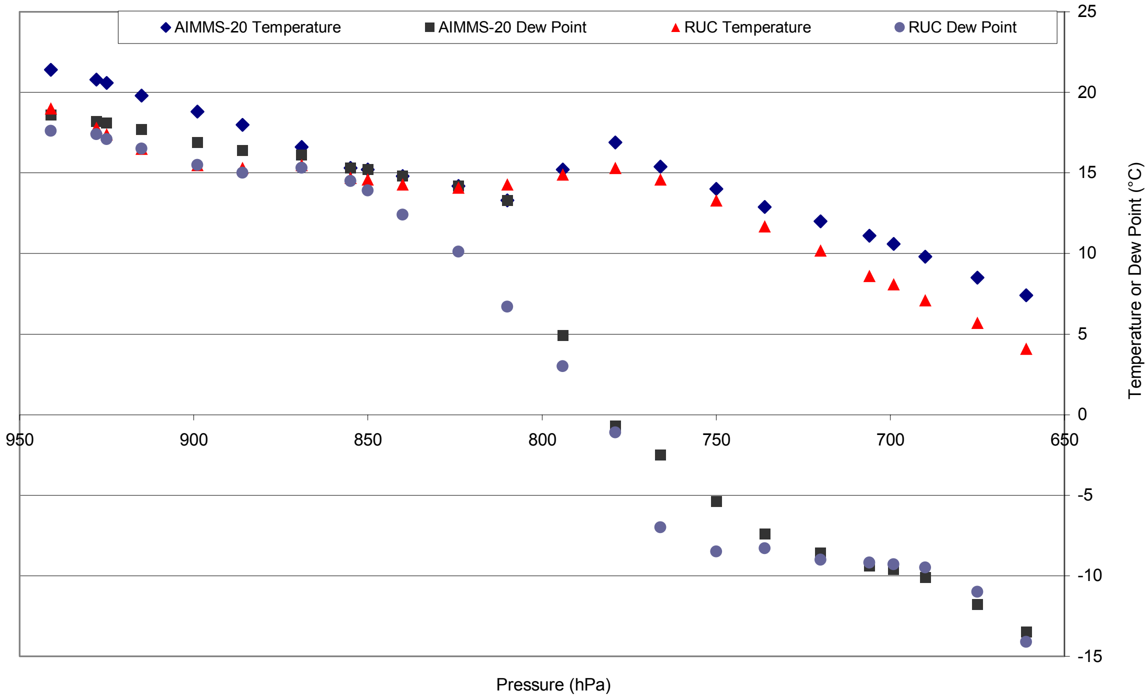

Fig. 7. Temperature and dew point temperature vs. height for the AIMMS-20 aircraft (over Camp Swift) and RUC analysis sounding (18 km ENE of Camp Swift) around 1930 UTC 21 April 2005.