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THE MOBILE INTEGRATED SOUNDING SYSTEM (MISS): DESCRIPTION AND FIRST RESULTS

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1. INTRODUCTION

The Mobile Integrated Sounding System (MISS; Fig 1) is designed to make measurements similar to those made by the Integrated Sounding System (ISS; Parsons et al. 1994), but with the ability to move more quickly between locations. MISS sensors include a 915 MHz boundary layer radar wind profiler, a Radio Acoustic Sounding System (RASS) for temperature profiling, and surface sensors for wind, temperature, relative humidity, and radiation. These same sensors are available with an ISS and their capabilities and limitations are summarized on the ISS web page (http://www.atd.ucar.edu/rtf/facilities/iss/iss.html). MISS, as a modified ISS, is one of the NSF Lower Atmospheric Observing Systems and is available to researchers through the observing facility request process described at http://www.atd.ucar.edu/requests.html.

A series of MISS test deployments took place in eastern Colorado in summer 2003. This paper describes the design goals and components of MISS, presents a result from the test deployments, and describes plans for the first formal deployment in the T-REX experiment to be held in the Owens Valley, California in Spring 2004.

2. MISS DESIGN GOALS AND INSTRUMENTS

MISS consists of a camper on a pick-up truck, and a flat trailer on which the wind profiler antenna is mounted. The camper contains computers and laboratory equipment; some external sensors are stored in the camper while MISS is in transit. The nominal deployment plan will have MISS travel to a site, collect data for a period of several hours to several days, and then move to another site. Deployment for less than several hours is not efficient since the DBS wind profiler would have measured only a few wind profiles. A mobile rawinsonde system (M-GLASS) would be more appropriate for this situation. MISS is also not intended for long-term stationary deployments. Power is supplied by a generator that is not intended for continuous long-term use, and the small camper is not suitable for continuous occupation by an operator. If used at the same site for several days, an external power source (line power or a larger generator) is needed, and a second vehicle is required. For longer deployments at a single site, an ISS would be more appropriate. MISS will not make measurements while in transit between sites.

The MISS trailer will fit inside a standard sea container for transport to overseas projects. Once overseas, an alternative to the camper is needed for computers and laboratory equipment and as a platform to mount sensors.

A design goal of MISS has been that all the equipment can be deployed within 15 minutes of arriving at a suitable site. Current deployment time is about 30-45 minutes, and several future upgrades will be needed to achieve the 15-minute goal. Also, setup time will naturally vary because of site and weather conditions. MISS requires two or three operators for normal operations. For extended continuous operation periods a second shift may be required.

Currently, MISS data are not available remotely in real time. However, a Mobile Internet satellite system is being tested and may allow transfer of data from MISS and allow MISS operators to monitor developing weather and forecasts.

The standard sensor configuration planned for MISS is outlined below. Other sensors can be added if required for a deployment. However, additions may be limited by space, power, safety, or funding considerations. In some circumstances it may be necessary to deploy a second vehicle to accommodate additional instruments.

Basic MISS Measurements:

1. A standard Doppler Beam Swinging (DBS) boundary-layer radar wind profiler (e.g. Carter et al. 1995) mounted on a trailer is deployed. A standard clutter screen is also used. The wind profiler consensus-averaging period is typically 30 minutes. So, given a 15-minute setup period, the first wind profile represents a period from 15 minutes to 45 minutes after arrival at the site, and is generated after approximately 45 minutes. A shorter consensus period can be used but would decrease the precision of the wind measurement. In the future, the NIMA/NWCA algorithms may be used to generate winds from averaging periods as short as 10 minutes. These algorithms use fuzzy logic and global image processing to find moments and vector winds from Doppler spectra.

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Figure 1: The MISS wind profiler, camper, and instrumented tower deployed on 1 Aug. 2003, southeast of Hudson, Colorado. (photograph © H. Bluestein).

The algorithms are described in Morse et al. (2002) and Goodrich et al. (2002), with a validation exercise described in Cohn et al. (2001). The wind profiler clutter screen is stowed during transit and assembled at the site. To save setup time, it is possible to operate the wind profiler without a clutter screen, but in this case the clutter screen must be removed from the wind profiler at NCAR before the start of the project. If the site allows, the wind profiler antenna can be oriented to help reduce ground clutter by directing nulls in the antenna pattern toward clutter sources. The trailer and wind profiler antenna are leveled using four powered jacks on the corners of the profiler trailer. The trailer can be deployed and leveled on a hill with a slope up to about 15 degrees.

2. The Radio Acoustic Sounding System (RASS) uses the DBS wind profiler with acoustic radiators to measure profiles of virtual temperature. MISS will use only two acoustic radiators with reflectors, rather than the four typically used with the ISS. If the site allows, the MISS trailer will be deployed so these are placed on the upwind side, for better altitude coverage. Unlike ISS, MISS acoustic radiators and reflectors will not include an acoustic shroud to reduce the local collateral noise.

3. MISS will use a sounding system borrowed from M-GLASS. If this is the first item deployed after arrival at a site, a rawinsonde can be launched within about 15 minutes. Data is received from the rawinsondes using a monopole antenna. In high winds, use of this antenna may limit the range and altitude to which data are collected when compared with that of the directional antenna that is used for the ISS.

4. Surface sensors will be borrowed from the ISS. Wherever possible, sensors will be placed above the surface at standard World Meteorological Organization (WMO) heights. The surface sensors include temperature (T) and relative humidity (RH) at 2 m, wind speed and direction at 10 m, and solar sensors for direct visible, direct infrared, and net radiation (PSP, PIR, NETRAD). The T, RH, and wind sensors are mounted on a 10 m tower, which will be placed away from the wind profiler in a null in the antenna pattern (approximately off a corner of the antenna). The consequences of fetch and shadowing will be considered when selecting a site.

3. FIRST RESULTS: EASTERN COLORADO

On 1 Aug. 2003 MISS was deployed on a dirt road adjacent to a farm near Hudson, Colorado (about 55 km east of Boulder) as a full field test to observe features associated with convective

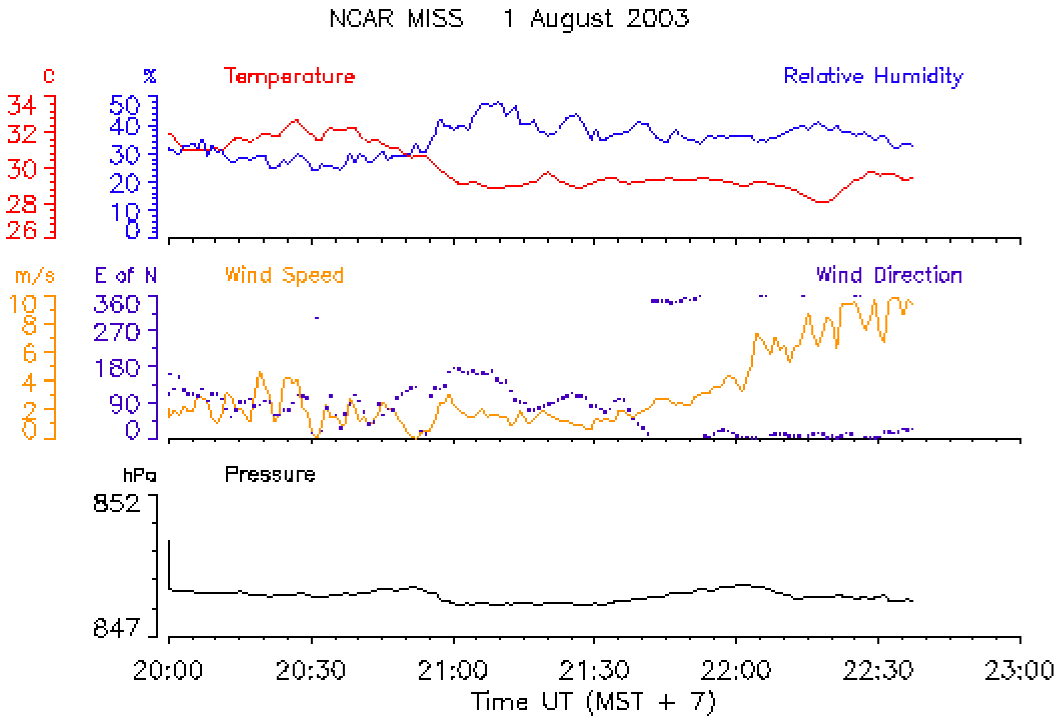

Figure 2: Relative humidity, temperature, wind speed and direction, and pressure as a function of time (UTC; MDT is 6 hr earlier) at the surface at the location of MISS (see Fig. 1).

storms. Vertical wind shear and potential thermodynamic instability (CAPE) were sufficient for supercell development. It was expected that convective storms would develop during the afternoon over the higher terrain of the Cheyenne Ridge along the Wyoming – Colorado border in response to upslope flow and diurnal heating, and then propagate southeastward into northeastern Colorado. The Storm Prediction Center early in the day had issued a forecast for a "slight risk" of severe thunderstorms over the target area; later in the afternoon a severe thunderstorm watch was issued. A severe storm did form 6 miles northwest of Masonville, CO (west-southwest of Ft. Collins, over higher terrain) just before 2100 UTC and headed southeastward towards the location of the MISS. The storm produced 1.25 cm hail and then had weakened to below severe limits by 2130 as it passed over the south side of Ft. Collins. Subsequent severe storms appeared over north central Weld County, to the north of MISS.

Two significant events are depicted in the surface traces of meteorological variables (Fig. 2). At 2045 the temperature fell and humidity rose, while the pressure fell and the wind veered from easterly to southerly. These changes were coincident with a narrow zone of ascending motion of several m s^{-1} (Fig. 3). It was about this time that cirrus clouds from anvils were beginning to block the sun. It is thought that a solenoidal circulation associated with the cirrus edge might have been responsible for this boundary. The changes in meteorological variables seen in Fig. 2 are not consistent with the passage of an outflow boundary.

The second significant event was noted at around 2130, when the wind shifted gradually from easterly to northerly and the pressure rose. The depth of the wind shift was around 2 km (Fig. 3). However, no corresponding changes in surface temperature or relative humidity were noted (Fig. 2). The boundary thus depicted has some characteristics of an outflow boundary; however, the temperature did not fall and the humidity did not rise, as would be expected if an outflow boundary had passed. The passage of this boundary appears to have been associated with the ongoing convective storms to the north and northeast of the MISS (Fig. 4). The second wind shift (at 2130) was probably marked by the passage of the fine line seen in the radar echoes that was connected with the leading edge of the convective cells to the east and southeast. Such a signature is consistent with the passage of an outflow boundary from the convective system that had passed by to the north and northeast.

There are two other features worth noting. The height of the top of the signal from MISS increased with time (Fig. 3), perhaps in response to the diurnal growth of the boundary layer. Also, light rain fell at MISS for a brief time; this event is seen in the reflectivity column and downward vertical velocity at 2220 (Fig. 3) and in the

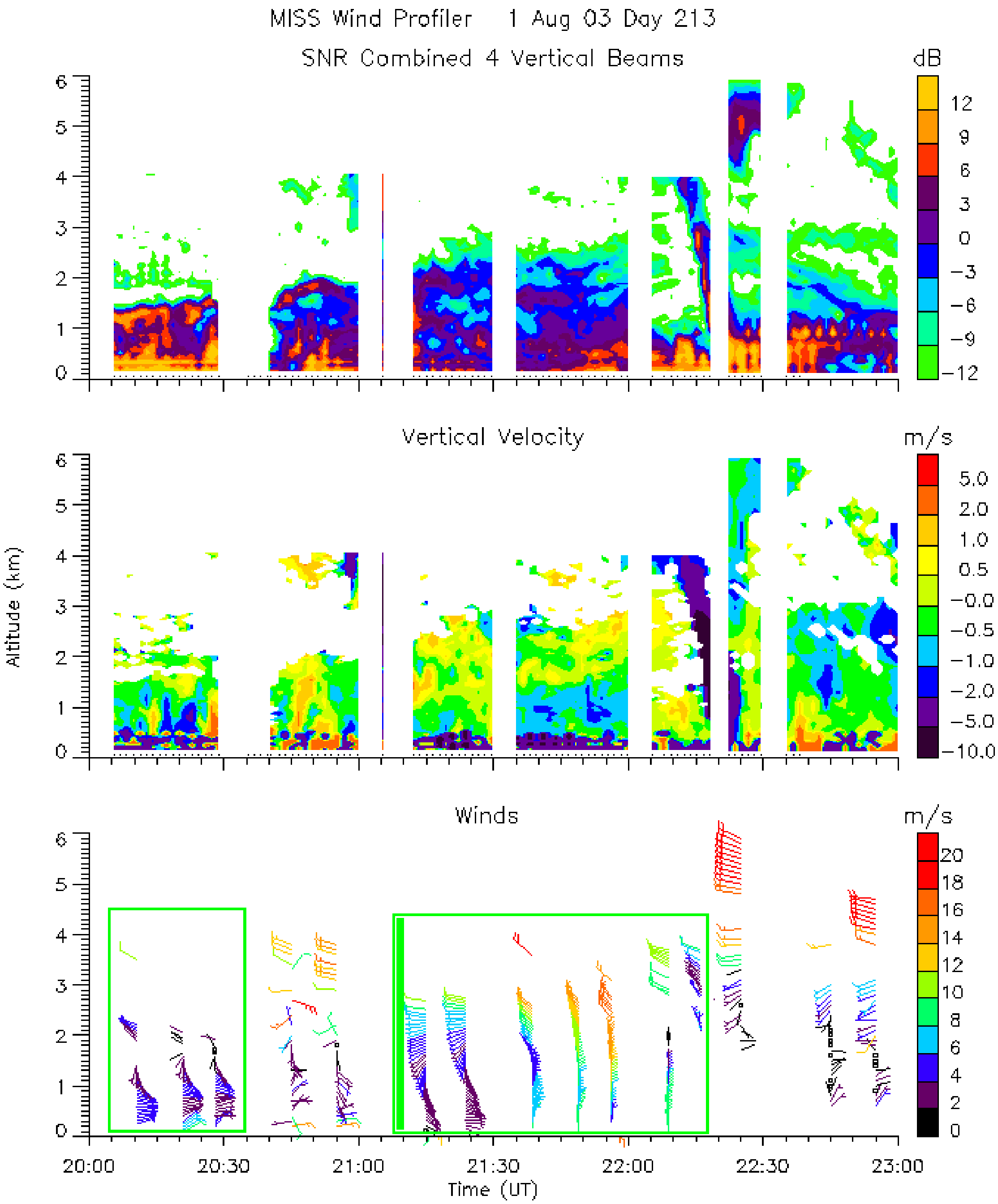

Figure 3: Signal-to-noise ratio (SNR), vertical velocity, and Doppler horizontal winds (standard depiction of wind barbs; whole barb = 10 m s^{-1}; half barb = 5 m s^{-1}) of the MISS Wind Profiler as a function of time. Note the updraft (red) seen in vertical velocity at 2045. Wind barbs within the green boxes were computed with NIMA/NWCA quality control algorithms.

surface cooling measured at the same time (Fig. 2).

4. THE T-REX EXPERIMENT

The first MISS deployment as an NSF Observing Facility will come in March-April 2004 as part of the Terrain Induced Rotors Experiment (T-REX) described in Grubisic and Kuettner (2003). Two ISS systems, MISS and MAPR (Cohn et al. 2001) will observe the wave and rotor motions associated with high winds in Owens Valley, California. MAPR will operate from a fixed site, but the mobility of MISS will be used to adjust the

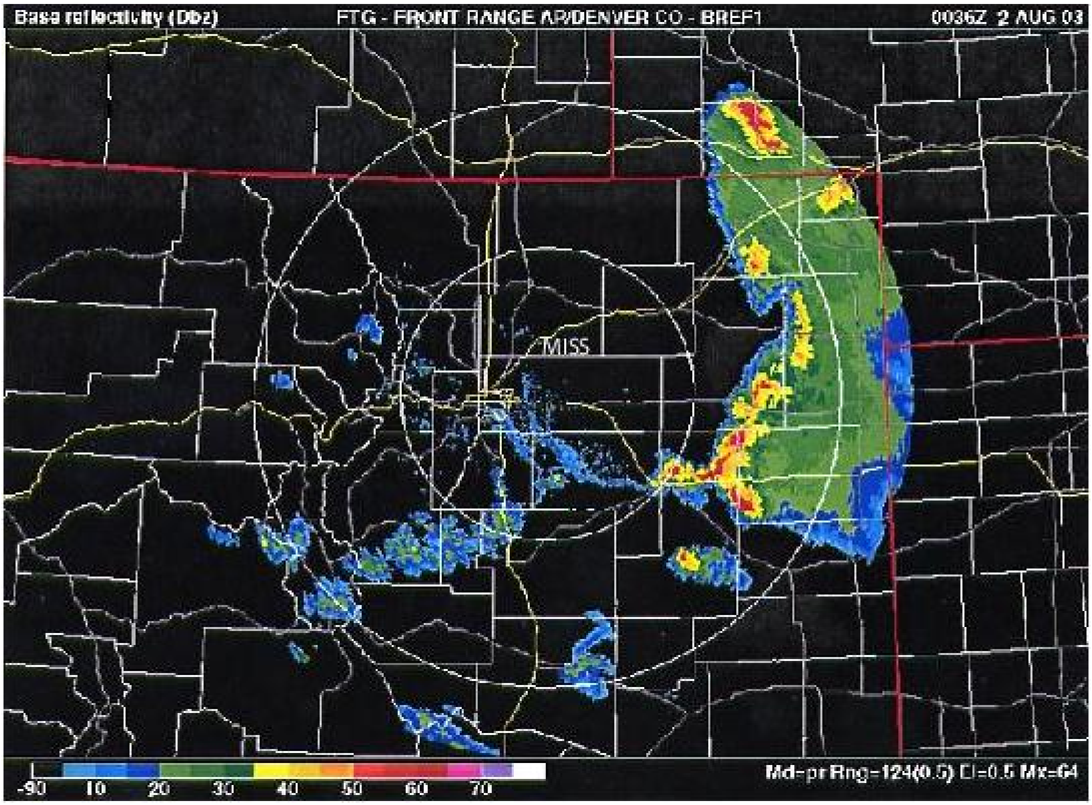

Figure 4: Radar reflectivity seen by the Denver, Colorado WSR-88D at 0036 UTC, 2 Aug. 2003, 1.5 h after data collection had ceased. The location of MISS is indicated.

wind profiler and rawinsonde measurements to be under the rotor. The experiment is an excellent example of the usefulness of MISS.

5. SUMMARY

It has been shown how MISS can be useful in documenting the vertical structure of surface boundaries and other features associated with convective systems. It is rare that high-resolution measurements of the properties of boundary-layer features associated with convective systems are made. These boundary-layer features are very important in determining whether or not subsequent convective cells are triggered. MISS could be an important addition to any field experiment involving convective systems and their initiation, and to experiments involving any clear-air boundary-layer phenomena. To increase the probability of success in setting up MISS in the best location, it is important that the deployment time be reduced significantly. This will be addressed in future upgrades.

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