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JP1.5 A Radiosonde System for the University of Missouri: An Informal Study of a Decaying Thunderstorm Near Columbia, Missouri

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1. INTRODUCTION

In the modern era, it is not uncommon for meteorology research programs at universities to have access to sophisticated equipment in-house that was available previously to only to research laboratories, or operational facilities. This includes tools like radar (e.g. Doppler on Wheels – Wurman et al., 1997), high end computing hardware and/or software (including in-house modeling capabilities – e.g., Gates et al. 1999), and radiosonde equipment (e.g., Bluestein, 1999). This has facilitated the great progress made in the understanding of various atmospheric phenomena made in that last three decades.

Additionally, given the competitive nature of the job market, it is to the benefit of atmospheric science students to be exposed to such equipment, even (or especially) if their goal is employment in the operational or private sector (e.g., broadcast meteorology). The availability of such equipment gives students valuable experience they can take with them into the marketplace. Thus, sophisticated meteorological instrumentation such as those described above is used as a teaching tool in many classes at institutions that teach meteorology courses. Students tend to get this exposure as part of a class or in an extracurricular setting via research or forecasting opportunities, as many programs do not offer a formal instrumentation course.

During the summer of 2008, funding became available through the College of Agriculture, Food, and Natural Resources at the University of Missouri-Columbia for the Soil, Environmental, and Atmospheric Science Department to purchase a radiosonde system from International Met Systems (iMetS). This effort was spearheaded by the second author (Market), and faculty and students were trained on the use of this equipment during September 2008 by iMetS. The equipment has been used as a teaching tool and has been used in research field projects such as the University of Illinois Champaign-Urbana's Profiling of Winter Storms Experiment (PLOWS). The department has also agreed to provide the data from special launches to regional National Weather Service Forecast Offices. This may provide forecasters with valuable information that may help to fill in a data gap as they anticipate dangerous weather. For example, a sounding was provided to the Saint Louis (STL) WFO during the afternoon of 13 May 2009 just prior to a deadly tornado event that occurred in Kirksville, MO.

In this paper we will describe two special launches into a pre-thunderstorm and thunderstorm environment during the afternoon of 24 September, 2008 as the training phase for use of the radiosonde equipment was coming to an end.

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2. DATA

Included in the radiosonde system were the iMet-3000 403 MHz ground station (Fig. 1) and a differential global positioning system (GPS) with a 403 MHz omnidirectional antenna. The system is portable. The system uses the iMet-1 radiosonde (Fig. 1) and a Windows-based iMetOS meteorological operating system. The data could be archived and the software has several display options for the vertical profiles. One can also display a hodograph (wind speed, wind direction, and height)

A radiosonde can be launched following the preparation of the iMet-1 for launch and the collection of surface data, which is entered into the ground station. The ground station then records and displays the data following a launch. The data are the standard parameters found with any operational launch and these are; temperature (^{o}C), dewpoint depression (^{o}C), height (m), wind speed (kts), and wind direction (degrees). Standard and special level data are stored using the traditional TTAA and TTBB format (see also for more detail Federal Meteorological Handbook No. 3 (FMH-3)). Several derived parameters are displayed on the sounding as well including, but not limited to the Lifted Index (LI), lifting condensation level (LCL), convective available potential energy (CAPE), or convective inhibition (CIN).

3. SYNOPTIC ANALYSIS

An examination of the surface map for 1200 UTC 24 September, 2008 shows that there was a relatively weak cold front extending from a low pressure located north of Hudson Bay and down through the Great Lakes into the Plains states

(Fig. 2). High pressure was located in the northeast US ahead of the cold front and a linear area of convection (Fig. 3) was visible in satellite imagery (not shown) and located over northwest Missouri and northeast Kansas. Over the next 24-h, the surface map did not change greatly as the front would dissipate south of Iowa and progress only about 300 km eastward.

Figure 1. The iMet-3000 403 MHz ground station (top), and the iMet-1 radiosonde (bottom), for more information see http://www.intermetsystems.com.

The 500 hPa flow was quite weak over much of Missouri as the jet stream was located far to the north across the Canadian border, with a weak ridge over eastern Canada (Fig. 4). The flow pattern would remain relatively weak over the study area for the next 24-h.

The convection initiated an outflow boundary over northwestern Missouri, which spread into central Missouri as the day progressed (not shown). This outflow boundary was the locus of new convection around 1800 UTC 24 September which would move into mid-Missouri over the next three hours.

4. VERTICAL PROFILES

During the afternoon of 24 September, the decision was made to launch the first radiosonde from the (former) KCBI site area around 1900 UTC. Thunderstorm activity was noted on radar to the northwest, but these were not expected to move into the area during the launch. Fig. 5 shows a Skew-T diagram with the first launch data plotted on it. The Columbia area environment was relatively dry. Most of the thermodynamic indexes were of modest values (e.g. the CAPE was approximately 1300 J kg^{-1}) indicating the possibility of isolated thunderstorms. The Lifted Index (-3.5) was the only value that indicated thunderstorms were probable and possible severe weather. The winds were weak throughout the tropopause and were southerly in the boundary layer, and were northwesterly in the free atmosphere.

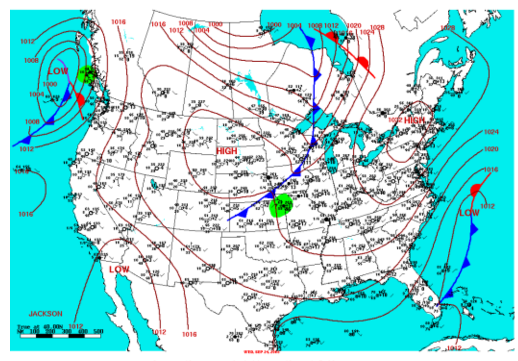

Figure 2. The surface map for 1200 UTC 24 September 2008 taken from the NOAA Daily Weather Map Archive http://www.hpc.ncep.noaa.gov/dailywxmap/.

The first launch was successful going up beyond 100 hPa before the balloon dropped. During the launch, isolated thunderstorms developed to the southeast of the Columbia area. The line of thunderstorms to the northwest began to move into the area and diminish in intensity. The decision was then made to launch another sounding into these storms as they moved into the region. The sounding was launched at approximately 2100 UTC.

According to the Storm Prediction Center severe storm reports archive (http://www.spc.noaa.gov/climo/reports) there were no reports of severe weather on our region. The nearest severe weather report was for high winds in west central Illinois.

Figure 6 shows the Skew-T diagram from the second launch. During the launch, it became apparent that the thunderstorms were decaying fairly rapidly and rain was no longer falling or reaching the surface. The radiosonde disappeared into the clouds just above the 700 hPa level, and the sounding demonstrates that the relative humidity was close to 100% at that level. The sounding remained quite moist up to about 450 hPa or for a layer roughly 3.5 km thick.

The temperature profile did not change dramatically, and many of the thermodynamic indexes shown a reduced potential for thunderstorm activity as the environment moistened and became slightly more stable. The wind profile still showed weak winds, but the cloud environment disrupted the environmental flow below about 300 hPa.

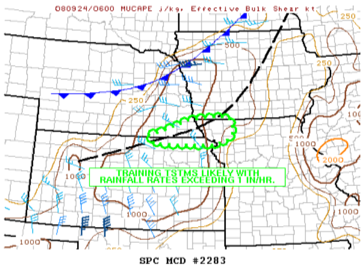

Figure 3. The storm prediction center mesoanalysis showing values for the most unstable CAPE for 0600 UTC 24 September 2008

The second launch continued to produce data even above the 50 hPa level. It was apparent that the launch went through the decaying thunderstorms and captured the moistening and stabilization of the Columbia area environment. It was also evident that the synoptic environment was not favorable for supporting organized convection. Without the presence of the outflow boundary from the previous convective activity, it is likely that the convection in our region would have been more isolated in nature.

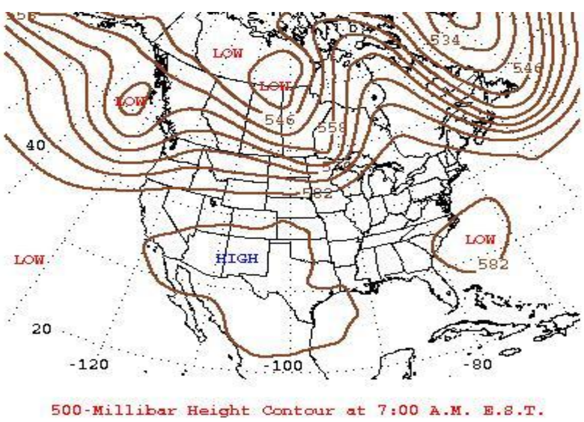

Figure 4. The 500 hPa height (m) map from 1200 UTC 24 September 2008. The source is the same as that in Fig. 2.

Finally, none of these storms resulted in severe weather reports at SPC. The Community Collaborative Rain Hail and Snow network (CoCoRaHs – http://www.cocorahs.org) reports from that day indicated rainfall amounts from 0.02 to 0.43 inches within the Columbia area. There was one report of 0.51 inches of precipitation to the north as well as an isolated report of 1.39 inches to the east of Boone County.

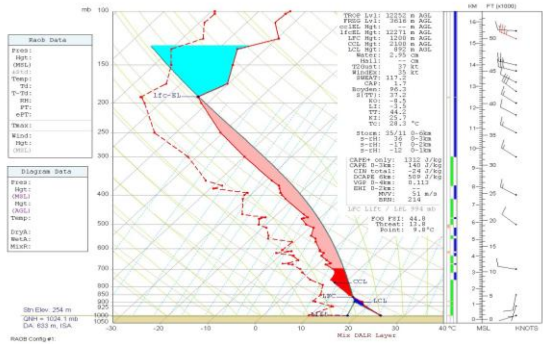

Figure 5. The Skew-T diagram and severe weather indexes from the first launch at 1900 UTC 24 September 2008.

5. SUMMARY AND CONCLUSIONS

During the summer of 2008, the University of Missouri provided funding for the acquisition of a radiosonde system for the Department of Soil, Environmental, and Atmospheric Sciences. The system was purchased from International Met Systems, and the faculty and students were trained to use the system during 22-24 September, 2009. The first launches took place during the afternoon of 24 September 2009 into an area of approaching and decaying thunderstorms.

A synoptic and mesoanalysis of the weather situation for that day revealed that the environmental flow was relatively weak and not supportive of organized convective activity. The convection that did occur was probably focused by an outflow boundary generated by convection to the north and west from early in the day that was perhaps associated with the weak cold front located in northwest Missouri and northeast Kansas. Without this outflow boundary, it is likely the convection would have been more isolated in nature.

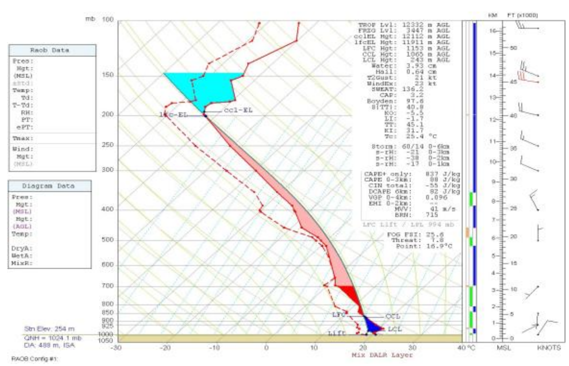

Figure 6. As in Fig. 5 except for launch two at 2100 UTC 24 September 2009.

The radiosonde system has been of use as a teaching tool for University of Missouri students, as well as a tool that was deployed during field missions for the University of Illinois Champaign-Urbana’s PLOWS experiment. In particular, the second author has used this equipment in a laboratory class and continues to train interested students on the use of the system. The radiosonde system has also been launched for aiding the National Weather Service in anticipation of the dangerous weather conditions of, for example 13 May 2009, which resulted in deadly tornadoes in the Kirksville, MO area. Thus, it is anticipated that this instrumentation will contribute to the meteorological profession and the university's teaching, research, and outreach mission for many years to come.

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