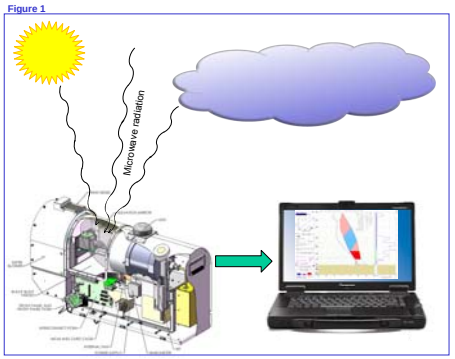
Continuous Upper Air Profiling Near an EF3 Tornado

M. Nelson[1], D. Cimini[4], R. Ware[1,5,6], S. Albers[3], S. Koch[2], T. Laubach[7], Y. Xie[3]

[1]Radiometrics Corporation, Boulder, CO USA, [2]Severe Storms Lab, Norman OK USA
[3]NOAA ESRL, Boulder, CO USA , [4]IMAA-CNR Potenza, Italy, [5]NCAR, Boulder, CO USA ,
[6]CIRES, Boulder, CO USA, [7]TWISTEX

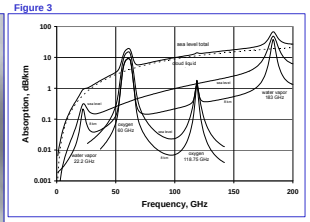
Figure 1



A microwave radiometer is a passive sensor which detects microwave radiation in the atmosphere and converts video voltages from the sky into brightness temperature values using Equation 1. Years of selected radiosonde information is converted into brightness temperature values and used to train neural networks in the radiometer. In this way, radiometric soundings accurately depict thermodynamic structure in real time. High temporal resolution of continuous soundings has great potential for data assimilation to improve high impact local forecasting.

Figure 2

Figure 3



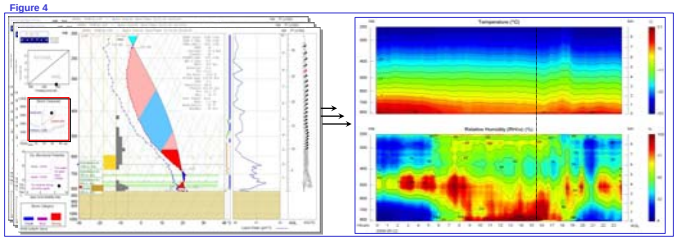
Above: absorption spectrum of a typical mid-latitude atmosphere for two different altitudes and vapor densities.
Left: the radiometer produces the same kind of thermodynamic profile as a radiosonde once each minute.

Equation 1

$$Tsky = \left(\frac{Vsky}{gain_sky}\right)^{\frac{1}{\alpha}} - Trcv_sky$$

Tsky = Brightness temperature
Vsky = Integrated receiver output from sky observation
gain_sky = Gain during sky observation
α = Non-linearity correction exponent
Trcv_sky = Receiver temperature during sky observation

Figure 4



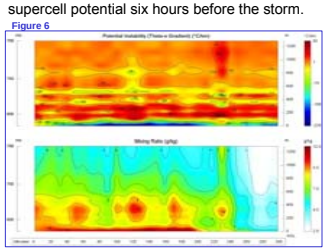
(a) Thermodynamic soundings (www.raob.com) show strong CAPE, lightning potential, clouds and liquid one hour before the storm. Storm character (red box) identified supercell potential six hours before the storm.

(b) Continuous soundings compiled into time-height cross sections show temperature and relative humidity structure before, during and after the tornado with high temporal resolution. Dotted line indicates time of sounding in (a).

Figure 5

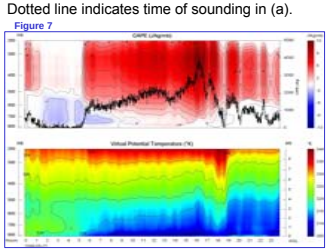
Cloud and liquid data provide fresh insight into storm structure and character. This photo was taken around 1630Z from a point inside the red circle in Figure 9a. This is the cell that destroyed much of Windsor Colorado. The dotted arrow below depicts time in cross section that picture was taken. Note the difference in location (Figure 9a) .

Figure 6



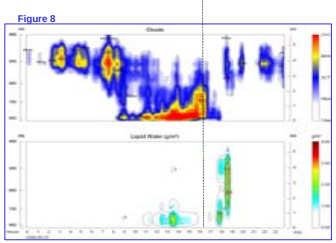
Time begins at 1500Z increasing on 10 minute intervals, the comparison of potential instability and mixing ratio clearly shows the potential for moist air to rise.

Figure 7



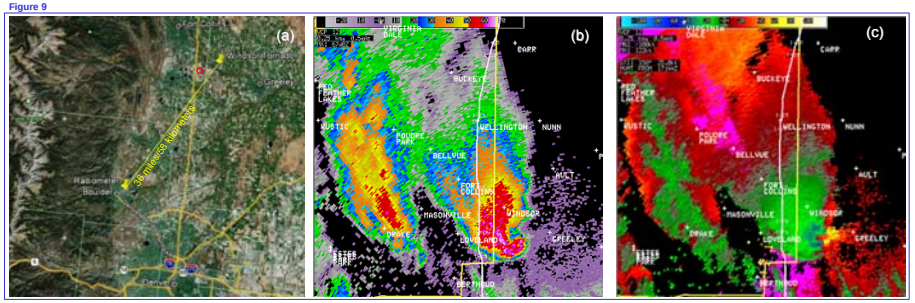
This plot of CAPE shows increasing convective energy just before precipitation onset, visible as a drop in virtual potential temperature.

Figure 8



Clouds parameters are derived in RAOB while Liquid Water is measured directly by the radiometer. Note correlation between liquid water and latent heat release in Figure 4b.

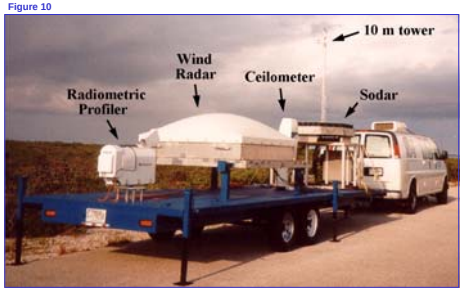
Figure 9



(A) Microwave profiler proximity to Windsor Storm area with approximate location of the photograph from Figure 5 circled in red. (B) Base Reflectivity reaches 70dbz by 17:44Z (C) Doppler Velocity depicts 122 knot winds. ((B) and (C) compliments of NOAA)

The radiometer in Boulder was scanning at 15 degree elevation angles during all stages of the cell that demolished most of the town of Windsor Colorado. Instability indices remained severe throughout the morning of 22 May 08, with a peak CAPE value of more than 4000Jkg^{-1} which occurred about one hour before touchdown shown in Figures 1 and 7. Soundings generated every minute allow for timely analysis of severe weather onset, maturity and dissipation. Figure 3 shows individual soundings compiled in a time-height cross section for easy visualization of atmospheric structure in real time. The high temporal and spatial resolution of continuous atmospheric profiling during severe weather events will help to increase the lead time for severe weather warnings. Network integration of total profiling systems could help forecasters pinpoint initiation time and location.

Figure 10



This Mobile Integrated Profiling System combines thermodynamic information from the radiometer with sodar and Radar wind data, ceilometer and tower surface data. Researchers at the University of Manitoba have placed a total profiling system, consisting of a radiometer and lidar, in the bed of a pick-up truck! The fine temporal and spatial resolution of this data provides a full suite of continuous forecast indices and new insight into severe weather systems with the intention of increasing the lead time for severe weather warnings.

Figure 11

While scenes like those above from Windsor Colorado may be inevitable early warning will help reduce loss of life and property in the path of severe weather. Continuous atmospheric observations can provide early severe weather warning. Increasing the lead time on warnings will decrease loss of life and property, while increased temporal resolution of thermodynamic and liquid profiles opens new avenues in severe storm research.