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# Microwave Radiometer Profilers

Radiometers do NOT provide information that is exactly the same as Radiosondes.

The power of a Radiometer, and its inherent characteristics, are:

- Much greater temporal (time resolution) so that changing atmospheric conditions are effectively detected in real time, as compared to waiting 12 hours between samples when using a radiosonde.
- The atmospheric column that is measured is always directly above the radiometer, compared to a radiosonde which moves laterally with the winds as it ascends.
- Differences in reported profiles between a radiometer and radiosonde in the vertical axis are to be expected, and are simply a representation of the physical difference in the measurement methodology.
- The value of the radiometer in its real-time observation of rapidly changing boundary layer conditions.

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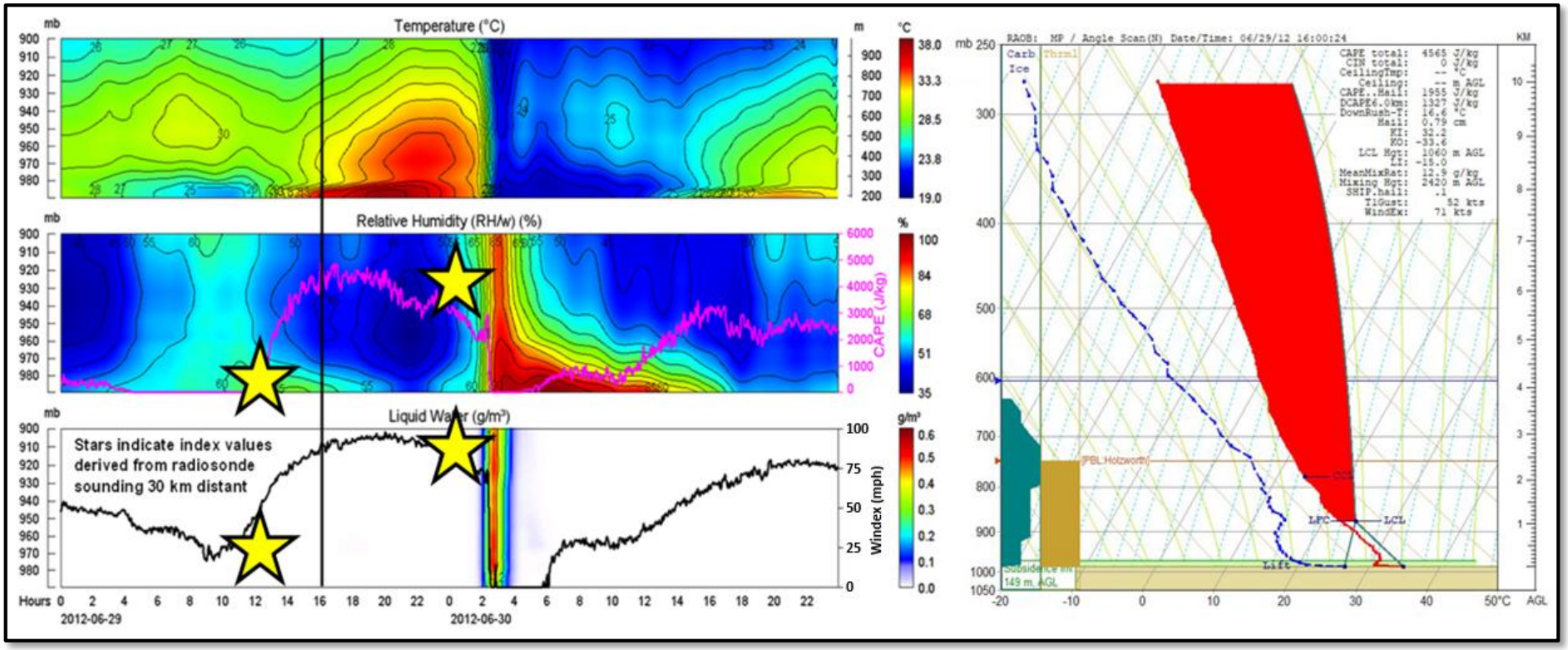
# Severe Weather Nowcasting




Thermodynamics of a convective storm that caused 22 deaths and a 5-day power outage in Washington D.C. MP-3000A data identified extremely unstable conditions (**CAPE = 5,000 J/kg, center panel magenta line**) and high wind risk (**Windex = 100 mph, lower panel black line**) more than six hours in advance.

Local 12-hr radiosondes confirmed these risks one hour before the disaster (stars) – ***too late for effective warnings***.

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# Air Traffic Control

The National Weather Service uses MP-3000A thermodynamic observations to improve aviation weather advisories for Air Traffic Control.

Continuous thermodynamic information is most effective during dynamic weather conditions that are inadequately characterized by 12-hr radiosondes.

**UNITED STATES DEPARTMENT OF COMMERCE**
**National Oceanic and Atmospheric Administration**
National Weather Service Forecast Office, WS1
Boulder, Colorado 80305
Tuesday, January 23, 2018

Memorandum For: NOAA Grant Evaluation Committee

From: Nezette Rydell, Meteorologist in Charge
National Weather Service Forecast Office, Boulder, CO

National Weather Service Denver Center Weather Service Unit (CWSU) and Weather Forecast Office Boulder, CO (WFO) meteorologists have used continuous thermodynamic sounding information when it has been available via http://weatherview.radiometrics.com to improve aviation advisories and forecasts to the FAA over the last several years. This information has been helpful in forecasting near-term weather for Denver International Airport (DIA) and surrounding areas, particularly in regard to convection, inversions, and with freezing drizzle, snow, and icing.

During convective season, real-time soundings provided by RDX have been instrumental in diagnosing the actual presence or absence of mid- and upper-level instability as compared to model forecasts, directly aiding the forecasting and evolution of showers or thunderstorms at/near DIA and arrival and departure gates.

These soundings were also used in winter seasons; aiding in near real-time to monitor phenomena such as surface inversion strength (to forecast wind speed and direction and low stratus), and for monitoring of depth of low-level moisture and temperature profiles for forecast adjustments with regard to the onset timing of freezing drizzle, rain, and changeover to snow.

We estimate our forecasters used this data, when available, several times a week, and in rapidly evolving weather events, multiple times per day. The temporal resolution for these observations, roughly every 30-40 minutes, provided significant confidence to our staff in updated forecasts and warning operations.

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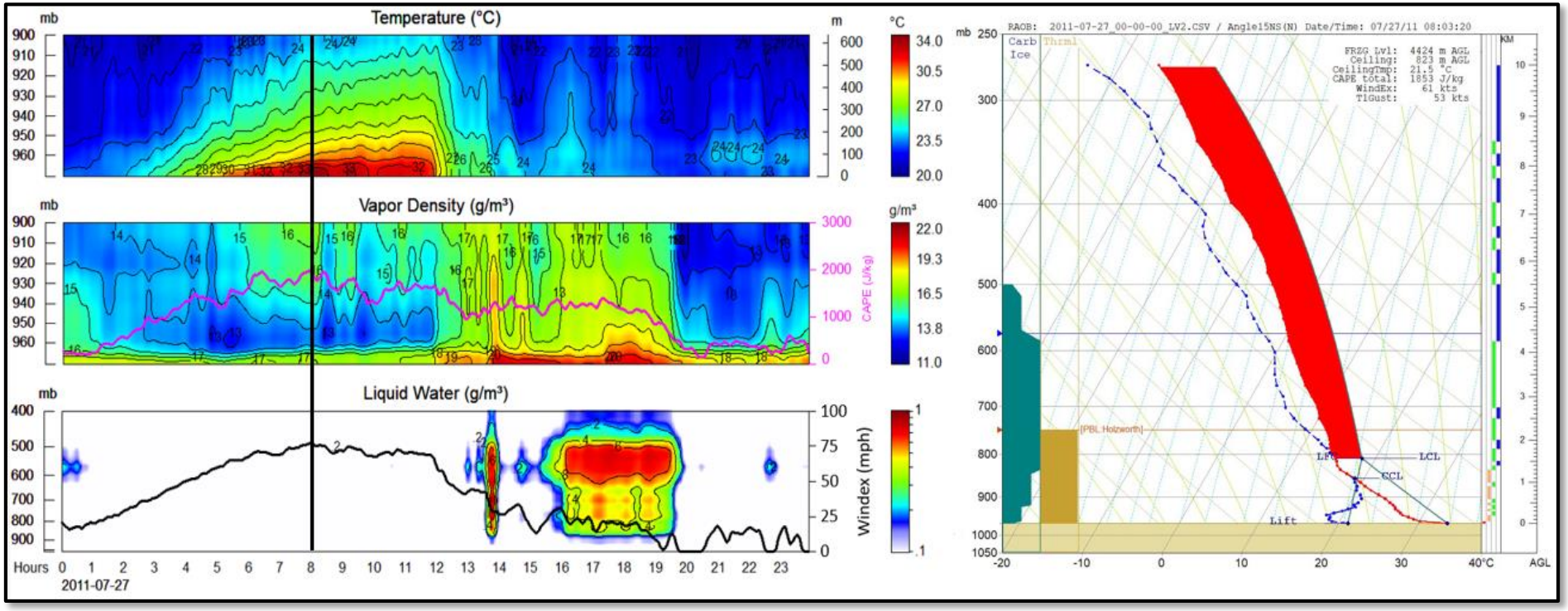
# Air Force Operations




MP-3000A observations at Gadanki, India, identifying high wind risk 6 hours in advance (black line, lower left panel).

Nowcasting severe convective activity over southeast India using ground-based microwave radiometer observations, M. Rajeevan et al, Journal of Geophysical Research, 2013.

High wind risk information can be used to improve flight operations safety and efficiency.

# Calibration and Maintenance

- Proper calibration and maintenance are essential for optimum MP-3000A operations.
- Radiometrics provides calibration and maintenance documentation, training and support to satisfy customer operational requirements.

# Neural Networks

- Atmospheric temperature, humidity and liquid profiles, and integrated water vapor and liquid, are retrieved from MP-3000A observations using neural networks.
- All season, high resolution, location specific radiosonde data is required for optimum neural network training.
- Radiosonde data from similar climatology can be substituted if local radiosonde data are unavailable.
- Neural network performance will only be as good as the radiosonde data used to train them.

# Analysis and Display Software

- Continuous local atmospheric thermodynamic surveillance can optimize airport operation safety and efficiency.
- Real time MP-3000A data display and analysis capability is introduced in the following videos:
  - RAOB Unleashed
  - Radiometrics Data Decoder
  - Real Time Data Display
  - Time-Height Diagrams
- Additional RAOB software information is available from Radiometrics and via www.raob.com

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# Atmospheric Measurement Accuracy

- **Observation error**[1] assigned to radiosonde data during weather model assimilation, is dominated by representativeness error[2] (the error characterizing a volume by a point measurement). This error is relatively insignificant for radiometer (volumetric) measurements. Collocated, simultaneous (within ~1-hr) radiosonde and radiometer soundings converge approximately to radiosonde observation accuracy[3].
- **Latency error** dramatically increases during the 12-hr interval between radiosonde soundings, particularly in dynamic weather conditions. In contrast, real time radiometer data have no latency error.

[1] Radiosonde Observation Error, RDX TechNote, 2018.

[2] Representativeness errors for radiosonde observations, M. Kitchen, QJRMS, 1989.

[3] Remote Sensing of the Thermodynamic State of the Atmospheric Boundary Layer by Ground-Based Microwave Radiometry, J. Güldner and D. Spänkuch, JAOT, 2001.

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# Measurement Accuracy

| Point Measurement Accuracy | | |
|---|---|---|
| | Radiosonde | MP-3000A |
| Temperature | 0.5 ˚C | na |
| Humidity | 5 % | na |

- Along uncontrolled flight path Vaisala RS92 radiosonde.
- Not applicable (na) for MP-3000A volumetric remote sensing.

| Volumetric Measurement Accuracy | | |
|---|---|---|
| | Radiosonde | MP-3000A* |
| Temperature | ≤ 1.4 ˚C | ~ 2 ˚C |
| Humidity | ≤ 2 $gm^{-3}$ | ~ 2 $gm^{-3}$ |

- Observation error is introduced when a model cell volume is represented by a radiosonde point measurement.
- Model cell volume well represented by volumetric measurement (MP-3000A).

*These accuracies require optimum calibration, maintenance and neural networks

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# Latency

| Latency Dependent Accuracy | | | |
|---|---|---|---|
| | | Radiosonde | MP-3000A |
| Temperature | 0 - 1 hr | ≤ 1.4 ˚C | ~ 2 ˚C |
| | 2 – 12 hr | RS >> 2 ˚C | ~ 2 ˚C |
| Humidity | 0 - 1 hr | ≤ 2 $gm^{-3}$ | ~ 2 $gm^{-3}$ |
| | 2 – 12 hr | RS >> 2 $gm^{-3}$ | ~ 2 $gm^{-3}$ |

- MP-3000A thermodynamic profile accuracies are roughly equal to radiosonde observation error for one hour after radiosonde data become available.
- Latency (stale data) degrades radiosonde accuracy, but not (real time data) MP-3000A accuracy.