# Comparison between Research Aircraft and Balloon-borne Radiosonde Observations

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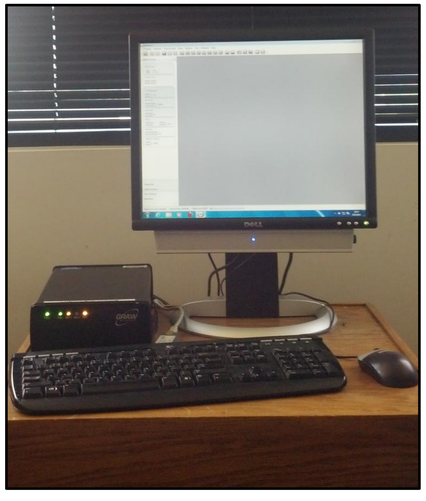
## Abstract

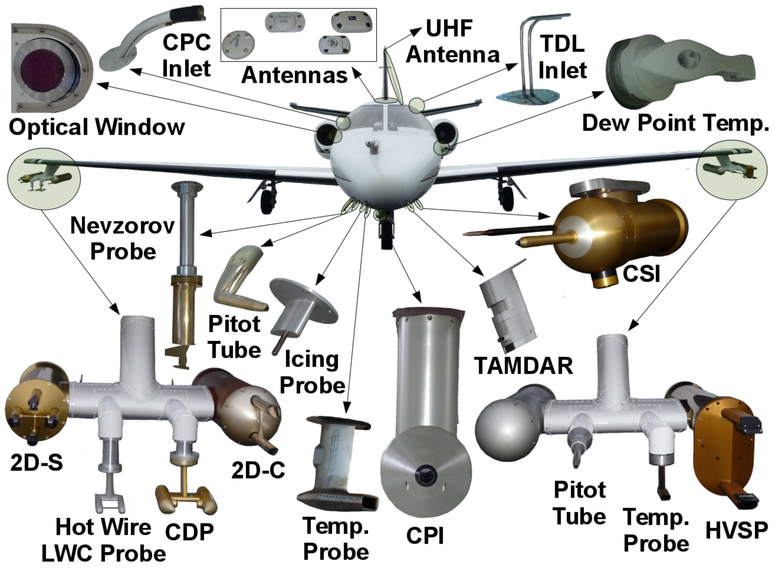
Inter-comparison of atmospheric measurements from different platforms allows any systematic differences that exist to be discovered; hence, increasing our confidence in the observations. Several research aircraft flights have obtained measurements concurrent in time and location with profiles obtained from balloons carrying radiosondes. On 19 August 2013, the University of North Dakota's Citation Research Aircraft flight corresponded with a Department of Atmospheric Science's balloon launch in Grand Forks that carried a GRAW Radiosonde. On 23 March 2009, a King Air 200 Research Aircraft flight corresponded with a radiosonde launch in Riyadh, Saudi Arabia. The 24 and 25 July 2003 Citation Research Aircraft flights corresponded with a National Weather Service launch in Bismarck, North Dakota. These flights enable comparisons between aircraft and balloon measurements of temperature, pressure, relative humidity and winds. While research aircraft sampling is conducted with fundamentally different sensors and at a horizontal speed of 100 m $s^{-1}$, measurements should agree within instrument uncertainty. While comparisons between aircraft and balloon profiles generally agree, some differences were observed and point to a systematic problem, such as, heaters affecting aircraft temperature measurements.


University of North Dakota, Atmospheric Sciences Students (Marc Provencher and Brandon Bigelbach) laugh a weather balloon on July 31, 2013. Photo by John Stennes, Forum News Service.

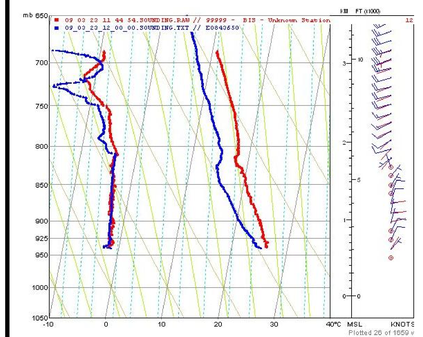


The GRAW radiosonde balloon receiving stations (above) is located on the top of Clifford Hall on the University of North Dakota campus in Grand Forks, North Dakota. The station records data from the package in real time through out the ascent of the balloon.

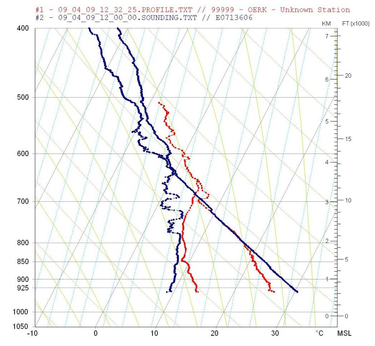
## UND Citation Research Aircraft



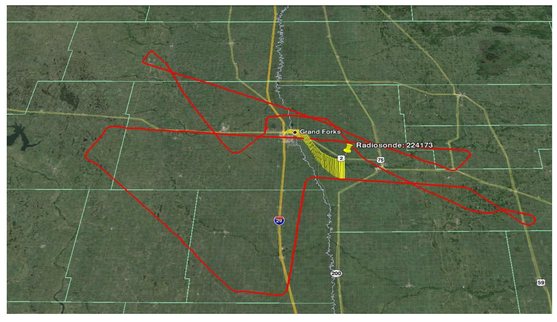

**UHF Antenna:** Ultra high frequency (UHF) antenna for long range communications.
**TDL Inlet:** Gas inlet for the Tunable Diode Laser Hygrometer (TDL) instrument.
**Dew Point Temp.:** Chilled mirror sensor for measurement of dew point temperature.
**CSI:** Measures total hydrometer water content.
**TAMDAR:** The Tropospheric Airborne Meteorological Data Reporting (TAMDAR) probe measures and down-links various meteorological parameters.
**HVPS:** The High Volume Precipitation Spectrometer version (HVPS) measures precipitation size particles in 128 channels from 150 µm to 1.9 cm.
**Temp. Probe:** The Temperature (Temp.) Probe measures the ambient air temperature.
**Pitot Tube:** Measures the aircraft's air speed using pressure transducers.
**CPI:** Cloud Particle Images (CPI) determines habits using 2.3 µm resolution images.
**2D-C:** 2-dimensional cloud (2D-C) probe measures sizes from 30-3000 µm diameter.
**CDP:** The Cloud Droplet Probe (CDP) measures droplets number concentration from 3-50 µm diameter in 30 channels at 8 Hz, with particle-by-particle information.
**Hot Wire LWC Probe:** The King Hot Wire Liquid Water Content (LWC) Probe measures cloud liquid water content.
**2D-S:** 2-dimensional stereo (2D-S) probe images hydrometeor using 128, 10 µm sized, diodes.
**Icing Probe:** The Icing Probe detects supercooled liquid water that forms ice on the aircraft.
**Nevzorov Probe:** The Nevzorov Probe uses hot wires to measures total cloud liquid and ice water content.
**Optical Window:** The normal windows have been replaced with specially designed optical glass windows for sampling with LIDAR based instruments.
**CPC Inlet:** Condensation Particle Counter (CPC) measures are obtained via a 1.0 inch diameter heated inlet.
**Antennas:** Several GPS and Iridium antennas provide time and position information, along with two-way satellite based communication.



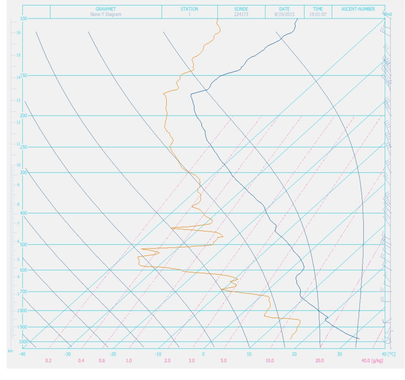
Comparison between radiosonde (blue) and measurements made with the Aircraft-Integrated Meteorological Measurement System (AIMMS) system on a King Air 200 research aircraft (red). Measurements were made in Riyadh, Saudia Arabia on 23 March 2009.

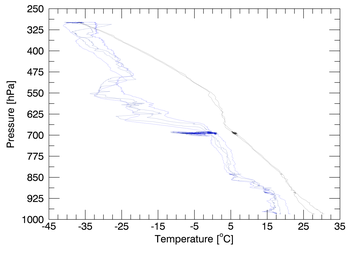


Comparison between radiosonde (blue) and measurements made with the a Rosemount Total Temperature Probe and EG&G Dew Point Temperature Probe on a King Air 200 research aircraft (red). Measurements were made in Riyadh, Saudia Arabia on 9 April 2009.




Flight path of the Citation Research Aircraft (red) and the radiosonde balloon (yellow) on August 19, 2013. Balloon launch time was 18:22 UTC and the Aircraft flight time was between 15:59 and 18:05 UTC.






Soundings obtained by balloon (left) and aircraft (top) on August 19, 2013. Aircraft dew point temperature was measured using a chilled mirror sensor (light blue) and TDL (dark blue).