Airborne G-Band (183 GHz) Water Vapor Radiometer

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Instrument:

Funded by a Phase II DOE SBIR contract, ProSensing Inc. developed a turnkey G-band (183 GHz, 1.5 mm) water Vapor Radiometer (GVR) for measuring low concentrations of atmospheric water vapor and liquid water. Using four double sideband receiver channels, the instrument simultaneously measures sky brightness temperature at 183.31 ±1, ±3, ±7 and ±14 GHz. A prototype ground-based unit has been continuously operating since April 2005 at the Great White NSA ARM site near Barrow, Alaska.

A more compact, airborne version of the GVR was also developed, shown in Figure 1, packaged and wired to operate from a standard PMS probe canister. A few new design features of this Airborne GVR include solenoid actuated hot and warm calibration loads, a surface matched TPX radome window, 1 ms precision data time stamp with external fine and coarse time synchronization and an RS-422 data bus.

The Airborne GVR was installed on the NRC Canada Convair-580 aircraft in September 2006 to participate in the CloudSat validation experiment (funded by Canadian Space Agency, Environment Canada and NRC) through March 2007, as shown in Figures 2 and 3.

Figure 1. Airborne GVR, packaged and wired to operate from a standard PMS probe canister. A sampling rate of about 10 Hz is interrupted with a 0.25 sec calibration gap once every three seconds. Instrument weight is 22 lb; 38 lb total as shown installed in a PMS 2-D probe canister.

System Parameters:

- Receiver frequency: 183.31 ±1, ±3, ±7 and ±14 GHz.
- Receiver bandwidth: 0.5 (1), 1.0 (3), 1.4 (7), 2.0(14) GHz .
- T_{REC}: 1750 K (1), 1610 K (3), 1600 K (7) and 2170 K (14).
- Delta-T: 0.2K @ 200 ms integration (5 Hz data rate).
- Measurement Stability (Allan STD): 0.05 K @ 1000 seconds .
- Measurement Rate: 17 Hz with 0.25 sec calibration gaps once every 3 seconds.
- Antenna: 4" Aperture, 90 deg Parabolic Metal Mirror, 2° BW.
- Radome : Surface matched TPX window.
- Weight: 22 lb; 38 lb as shown installed in a PMS 2_D probe canister.
- Power: 28 W AC, 126 W max. (~50 W ave.) 28 VDC.

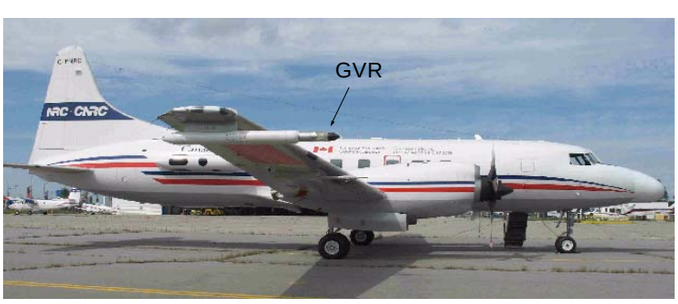

Figure 2. In September 2006 the Airborne GVR was installed in the NRC Canada Convair-580 Aircraft to participate in the CloudSat validation flights.

Figure 3. On the NRC Convair-580 Aircraft, GVR was installed in one of the outside PMS probe pods, so the Zenith pointed antenna beam would clear the wing.

Example Data:

On October 26, 2006 the NRC Canada Convair aircraft descended into a liquid cloud for a 50 minute level flight leg, then ascended out of the cloud layer. The recoded Zenith brightness temperature from the four receiver channels are shown in Figure 4 and the corresponding retrieved Precipitable Water Vapor (PWV) and Liquid water Path (LWP) are shown in Figure 5.

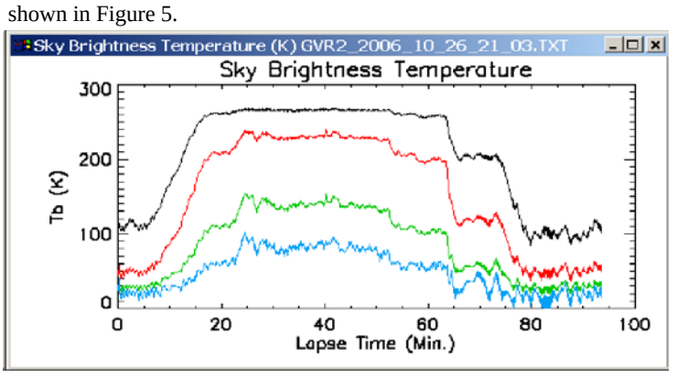

Figure 4. Data collected with the Airborne GVR during a CloudSat validation flight near Ottawa, Canada on October 26, 2006. Zenith brightness temperature data is shown from the four double sideband receiver channels: Black=183.31 +-1 GHz, Red=+-3 GHz, Green=+-7 GHz and Blue=+-14 GHz.

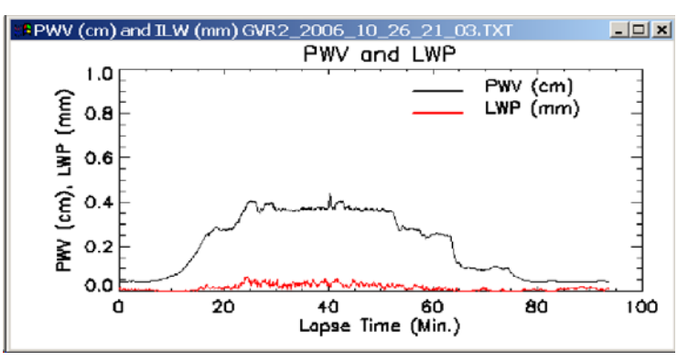

Figure 5. Precipitable Water Vapor (PWV) and Liquid Water Path (LWP) estimated using a neural network algorithm from the measured brightness temperature data of Figure 4 and flight level air temperature. The neural network was trained with a combined multi-year radiosonde data-set from Albany, New York and Barrow, Alaska. The sounding data was processed to a data set of brightness temperatures at the four radiometer frequencies, air temperature at the instrument and corresponding PWV and LWP. This simulated data set was used to train and test the neural network.

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