CHARACTERIZATION OF THE MEASUREMENT UNCERTAINTY AND STABILITY OF A MINIATURIZED WATER VAPOR RADIOMETER BASED ON MMIC TECHNOLOGY

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A Miniaturized Water Vapor Radiometer (MWVR) based on Monolithic Microwave and Millimeter-wave Integrated Circuit (MMIC) technology has been developed, fabricated and tested at the University of Massachusetts Amherst and Colorado State University. The MWVR is designed to profile the water vapor in the troposphere using four frequencies in the vicinity of the 22.235 GHz water vapor resonance.

MMIC technology has provided the capability to reduce the volume, weight and cost of instrumentation for remote sensing applications. As a consequence, MMIC-based radiometers are excellent candidates for deployment on small, light Unmanned Aerial Vehicles (UAVs) or to realize networks of significant numbers of remote sensing instruments. In addition to reductions in mass, volume and cost, MMIC technology tends to decrease the power consumption of microwave radiometers, both by increasing component power efficiency and by reducing power requirements of heating/cooling systems to maintain internal temperature stability.

The MWVR is a Dicke radiometer in which gain calibration is achieved both by external calibration, i.e. tipping curves and viewing an ambient microwave absorber load, and by internal calibration, i.e. a two-point calibration internal to the radiometer. MMIC-based radiometers can be implemented in small volumes and with low power consumption compared to waveguide-based or connectorized component radiometers. Therefore, maintaining stable internal temperature tends to be easier for these low-power, low-volume radiometers.

Radiometric sensitivity (NEΔT) is commonly used to characterize the measurement precision of a microwave radiometer. However, the uncertainty of brightness temperature measurements depends not only on radiometric sensitivity but also on other factors, such as accuracy and stability of internal/external calibration reference sources, algorithms to combine internal and external calibration, and the stationarity of gain variations between successive calibrations. The stability and measurement uncertainty of the MWVR are evaluated under field measurement conditions using tipping curves and ambient microwave absorber calibrations performed over long time durations and observed on each of MWVR´s four frequency channels.

Finally, the feasibility of ground-based network operation is considered, using low-mass, low-volume radiometers to retrieve 3D estimates of the water vapor in a given atmospheric volume using tomographic inversion techniques. A network consisting of MWVRs performing coordinated scanning of the troposphere would have spatial resolution determined both by vertical profiling and by antenna beamwidth considerations.