Fine-Scale Retrieval of Tropospheric Water Vapor using a Network of Compact Microwave Radiometers

Sharmila Padmanabhan[1], J. Vivekanandan[2], Steven C. Reising[1] and Flavio Iturbide-Sanchez[1]

1. Department of Electrical and Computer Engineering, Colorado State University, Fort Collins, CO 80523.
2. National Center for Atmospheric Research, Boulder, CO 80301.

Quantitative precipitation forecasting is currently limited by the paucity of observations on sufficiently fine temporal and spatial scales. In particular, convective storms have been observed to develop in regions of strong and rapidly evolving moisture gradients that vary spatially on sub-meso γ scales (2-5 km). Therefore, measurements of water vapor aloft with high time resolution and sufficient spatial resolution have the potential to improve forecast skill for the initiation of convective storms. Such measurements may be used for assimilation into and validation of numerical weather prediction (NWP) models.

Currently, water vapor density profiles are obtained *in-situ* using probes on radiosondes and remotely using lidars, GPS ground and satellite networks and a relatively small number of radiometers on-board satellites. *In-situ* radiosonde measurements have excellent vertical resolution but are severely limited in temporal and spatial coverage. In addition, each balloon takes 45-60 minutes to rise from ground level to the tropopause, affecting the representativeness of even a single profile. Tomographic inversion applied to ground-based measurements of GPS wet delay is expected to yield data at 30-minute intervals with 0.5-1 km vertical resolution but only 50 km horizontal resolution. COSMIC satellites in low earth orbit (LEO) provide measurements on 30-minute intervals with 0.1-0.5 km vertical resolution but only 200 km horizontal resolution. Radiometers in orbit provide either reasonable profiles with mesoscale horizontal resolution with long repeat times (twice daily at the equator) using microwave from LEO or 2 km vertical and 50 km horizontal resolution nearly continuously using infrared from GEO.

New measurements from a ground-based network of coordinated, scanning microwave radiometers are expected to provide 0.5-1 km resolution both vertically and horizontally with 15-minute temporal sampling. To increase the temporal and spatial sampling of water vapor in the troposphere, the Compact Microwave Radiometer for Humidity profiling (CMR-H) was developed at the Microwave Systems Laboratory at Colorado State University. The use of MMIC technology and unique packaging yields a light-weight, inexpensive and low-power consumption instrument that is highly suitable for deployment in a network of remote sensors. In such a network, multiple radiometers provide different perspectives on the same volume. The network design is based on an optimal hexagonal topology, in which each sensor "node" scans its "domain" using 10 elevation and 10 azimuthal angles in less than 15 minutes. In pre-storm conditions, this is shorter than the time scales of humidity variations that occur on the spatial scales that these measurements can sense. Therefore, algebraic reconstruction tomography can be used to retrieve the 3-D water vapor field from these multiple looks of the same volume using radiative transfer theory, optimal estimation and Kalman filtering.

Results of measurements during REFRACTT (**R**efractivity **E**xperiment **F**or H_2O **R**esearch **A**nd **C**ollaborative Operational **T**echnology **T**ransfer) and of an Observation System Simulation Experiment (OSSE) using the Weather Research Forecasting (WRF) model at a grid scale of 500 m will be described.