Retrieval of Atmospheric Humidity with Fine Spatial Resolution using 3D Tomographic Inversion of Passive Microwave Measurements from a Ground-based Network of Scanning Radiometers

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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 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 using *in-situ* sensors on radiosondes and remote sensors including lidars, GPS ground-based networks, GPS radio occultation from satellites and a relatively small number of space-borne microwave radiometers. *In-situ* radiosonde measurements have excellent vertical resolution but are severely limited in temporal and spatial coverage. In addition, each radiosonde takes 45-60 minutes to rise from ground level to the tropopause and is typically advected by upper-level winds up to tens of km horizontal displacement from its launch site. Tomographic inversion applied to ground-based measurements of GPS wet delay is expected to yield data with 0.5-1 km vertical resolution at 30-minute intervals. COSMIC and CHAMP satellites in low earth orbit (LEO) provide measurements with 0.1-0.5 km vertical resolution at 30-minute intervals but only 200-600 km horizontal resolution, depending on the magnitude of the path-integrated refractivity. Microwave radiometers in low-earth orbit provide reasonable vertical resolution (2 km) and mesoscale horizontal resolution (20 km) with long repeat times.

However, the prediction of both the location of convective initiation and the amount of precipitation require knowledge of water vapor variations on sub-meso γ scales (<2-5 km) with update times on the order of a tens of minutes. Such measurements have not been available due to the relatively high cost of both commercially-available microwave radiometers for network deployment and rapid radiosonde launches with close horizontal spacing. To make such measurements possible, the Compact Microwave Radiometer for Humidity profiling (CMR-H) was developed and fabricated by the Microwave Systems Laboratory at Colorado State University. Using monolithic microwave integrated circuit technology and unique packaging yields a radiometer that is small (24 x 18 x 16 cm), light weight (6 kg), relatively inexpensive and low in power consumption (25-50 W, depending on weather conditions). Recently, both observation system simulation experiments and field measurements at the DOE Atmospheric Radiation Measurement (ARM) Southern Great Plains site in Oklahoma have demonstrated the potential for a network of coordinated scanning microwave radiometers to provide 0.5-1 km resolution both vertically and horizontally with sampling times of 15 minutes or less. In both cases, algebraic reconstruction tomography is used to retrieve the 3-D water vapor field from simultaneous brightness temperatures using radiative transfer theory, optimal estimation and Kalman filtering. Results of both the OSSE and field measurements will be shown and discussed.