Spatial Resolution and Accuracy of Retrievals of 2D and 3D Water Vapor Fields from Ground-based Microwave Radiometer Networks

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Atmospheric water vapor is known to affect many processes, including cloud formation and precipitation. Water vapor can be measured using both *in situ* instruments, including radiosondes, and remote sensing instruments, including Raman lidar. Radiosondes provide measurements of atmospheric water vapor and temperature that are some of the most widely used in numerical weather prediction models. They have high vertical resolution but poor temporal and horizontal sampling since they are launched every 12 hours and radiosondes are launched regularly in the U.S. from sites at an average separation of approximately 100 km. Therefore, there is a paucity of information on the horizontal, vertical and temporal variability of water vapor and temperature. Sensitivity studies indicate that severe storm forecasting is limited by a lack of accurate observations of water vapor aloft in the lower troposphere. Therefore, the availability of fine-resolution and accurate 2D and 3D water vapor field measurements would substantially improve numerical weather prediction model initialization. Microwave radiometers have the capability to measure atmospheric water vapor and temperature at sufficiently high spatial and temporal resolution to aid in advance forecasting of the onset, timing and location of severe weather.

This study focuses on the spatial resolution and accuracy of the retrieval of 2D and 3D water vapor fields from brightness temperatures measured by a network of ground-based microwave radiometers. Both vertical and horizontal spatial resolution is affected by the topology and scanning patterns of microwave radiometer network nodes as well as the grid spacing of the 2D and 3D retrievals. The spatial resolution of microwave radiometers is also affected by the weighting functions at each frequency of operation. In this work, first, the locations and scanning patterns of the network nodes are analyzed to determine the number of independent measurements performed by the radiometers. Second, the choice of frequency channels between 20 and 60 GHz is analyzed to maximize the number of independent measurements to retrieve water vapor and temperature profiles. Finally, the grid spacing of the retrieval is adjusted to improve spatial resolution, which is also traded off with retrieval accuracy. This study will determine the parameters of networks of microwave radiometers and retrieval algorithms for the measurement of water vapor and temperature in the lower troposphere with the best possible spatial resolution and accuracy.