USE OF A NETWORK OF COMPACT MICROWAVE RADIOMETERS TO RETRIEVE 3-D WATER VAPOR TO ESTIMATE WET TROPOSPHERIC PATH DELAY VARIATIONS IN SPACEBORNE INTERFEROMETRIC SAR IMAGERY

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Spaceborne Interferometric Synthetic Aperture Radar (InSAR) imaging has been used for over a decade to monitor tectonic movements and landslides, as well as to improve digital elevation models. The technique has the potential to measure centimeter-scale changes in surface deformation over a time span of days. One of the major limitations of InSAR is variation in the round-trip propagation delay due to changes in humidity and/or temperature along the signal path. One of the greatest sources of uncertainty in estimates of this tropospheric path delay is the spatial and temporal variability of water vapor density [1]. This variability limits the quality of InSAR products, which could be improved if atmospheric water vapor effects were removed. This problem is addressed by using subsequent SAR interferograms from several satellite overpasses to reduce degradation in the images to a great extent [2]. If instead there is a sudden deformation of the Earth's surface through an earthquake or landslide, the effect of water vapor variation cannot be reduced in this way. Therefore, in these cases of particular interest, the quality of the InSAR imagery is greatly reduced, and additional high-resolution information on the water vapor distribution and its variation with time may be crucial for correction and mitigation of the wet tropospheric path delay.

This work was performed as part of the European Space Agency project Mitigation of Electromagnetic Transmission errors induced by Atmospheric Water Vapor Effects (METAWAVE). The variability of water vapor in the atmosphere and its effect on InSAR data were studied by a large team of remote sensing and atmospheric scientists. To this end, a ground-based network of scanning Compact Microwave Radiometers for Humidity Profiling (CMR-H) was deployed in Rome to observe the 3-D humidity with fine spatial and temporal resolution. The CMR-Hs were developed and fabricated by the Microwave Systems Laboratory at Colorado State University (CSU). Component costs were reduced substantially by the implementation of monolithic microwave integrated circuit technology, yielding a radiometer that is small (24 x 18 x 16 cm), lightweight (6 kg) and low in power consumption (25-50 W, depending on weather conditions) [3]. Three CMR-Hs developed by CSU were deployed in a triangular topology to implement a three-node network of scanning radiometers. Each scan was completed in less than 10 minutes.

Retrieval of 3-D water vapor makes use of radiative transfer theory, algebraic tomographic reconstruction and Bayesian optimal estimation coupled with Kalman filtering [4]. In addition, spatial interpolation (kriging) is used to retrieve the water vapor at unsampled locations. The 3-D water vapor field retrieved from brightness temperatures from a network of scanning microwave radiometers has both vertical and horizontal resolution of about 0.5 km. Additional retrievals of 3-D humidity over Rome from METAWAVE will be presented. Fig. 1 is an example of the retrieved 3-D water vapor density at three heights above ground level.

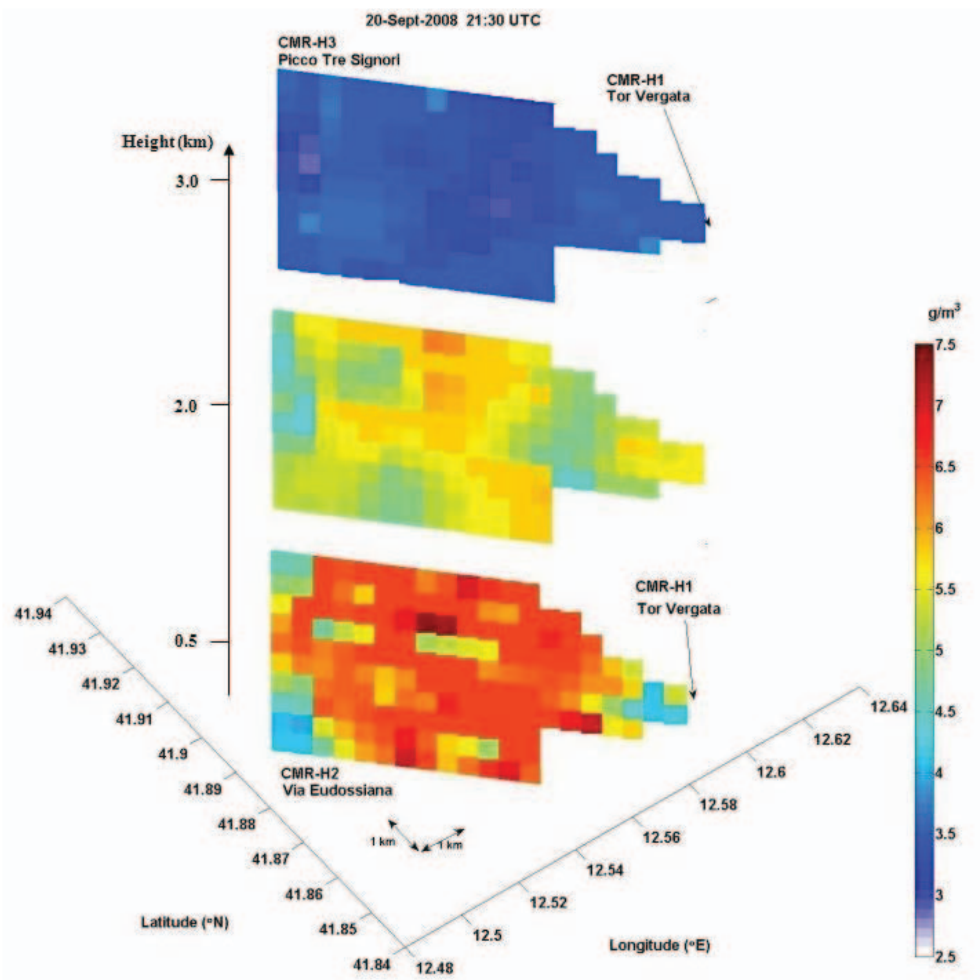

Figure 1. Retrieved water vapor density (g/m^3) at various heights above ground level (km)

Fig 2. shows a comparison between Integrated Water Vapor (IWV) retrieved from compact microwave radiometer (CMR-H) network measurements with a resolution of 0.5 km with that retrieved from the Medium Resolution Imaging Spectrometer (MERIS) with a resolution of 0.3 km. The CMR-H network measurements were scaled to 0.3 km to match the resolution of MERIS. There seems to be less spatial variability in the IWV from the CMR-H network than that in the IWV from MERIS data. There is good agreement in the mean value of the IWV from the CMR-H network and from MERIS. Additional comparisons between the Integrated Water Vapor (IWV) retrieved from CMR-H network measurements with MM5 Mesoscale Model output with 1-km resolution and data from MERIS and the Moderate Resolution Imaging Spectroradiometer (MODIS) will be presented and discussed.

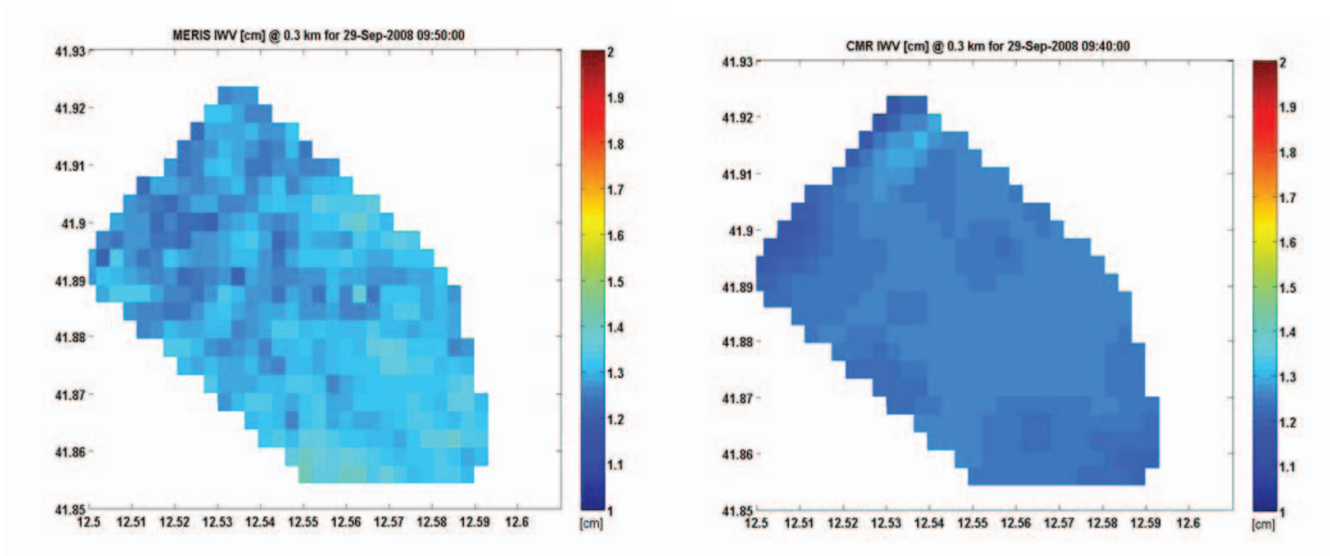

Figure 2. Comparison of high-resolution IWV data from MERIS and CMR-H. The CMR-H network data, originally at 0.5 km resolution, have been scaled to the MERIS resolution of 0.3 km.

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