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Retrieval of Wet-Tropospheric Path Delay over Coastal and Inland Water Regions using Wide-band Millimeter-Wave Radiometry

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Currently, wet-tropospheric path delay measurements over inland water and coastal areas are extremely sparse. They are generally limited to twice-per-day radiosonde launches and a small number of ground-based GPS or radiometer path delay measurements, as well as radar measurements of phase delay to a small number of fixed targets on the ground. Knowledge of the wet-tropospheric path delay is necessary for next-generation high-resolution altimeters, such as the Surface Water and Ocean Topography (SWOT) mission, in formulation and planned for launch in 2020. SWOT has two major science objectives. First, the oceanographic objective is to characterize ocean mesoscale and sub-mesoscale circulation with horizontal resolution of 10 km and order of 1 cm height precision. Second, the hydrological objective is to provide global height measurements of inland surface water bodies with area of greater than 250 square meters and flow rate of rivers with width greater than 100 m. Wet-tropospheric path delay retrieval over coastal and inland-water areas is needed to achieve both of these objectives with sufficient height accuracy. In addition, information on total precipitable water vapor under nearly all weather conditions is needed to improve initialization of numerical weather prediction models.

Currently, 18-34 GHz microwave radiometers provide wet-path delay corrections for the Jason series of nadir-viewing altimeters. However, these retrievals are limited to open ocean, and land incursion is unacceptable within 40 km of coastlines. The addition of millimeter-wave radiometers (70-170 GHz) is needed to address this problem by providing smaller surface footprint dimensions proportional to wavelength.

In this work, we present a prototype algorithm to demonstrate the potential to retrieve wet-tropospheric path delay from brightness temperatures measured by millimeter-wave radiometers using the Brightness Temperature Deflection Ratio (BTDR) method. The BTDR algorithm retrieves wet-path delay without the use of a-priori data by using background contrast in the ground scenes while avoiding the need for specific knowledge of their characteristics. The algorithm uses a deflection ratio, of brightness temperature differences measured by the radiometer viewing two adjacent scenes to resolve the transmissivity of the atmosphere due to water vapor. This transmissivity is mapped to wet-path delay using state-of-the-art atmospheric absorption models.

Brightness temperatures measured by the Special Sensor Microwave Image/Sounder (SSMIS) are used to demonstrate the algorithm's capability. An error analysis technique to assess the self-consistency of the retrieval shows that the error of the retrieved wet path delays is less than 1.5 cm. Retrievals are demonstrated over coastlines and inland water bodies and compared to independently derived total precipitable water products from the GPROF 2010 algorithm using measurements from SSMIS and other space-borne microwave and millimeter-wave radiometers.