Temporal and Spatial Variability of Integrated Water Vapor Retrievals over Coastal Areas and Inland Water from the High-frequency Airborne Microwave and Millimeter-wave Radiometer (HAMMR)

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In May 2014, NASA and CNES administrators signed a bilateral agreement to transition from feasibility studies to implementation of the Surface Water and Ocean Topography (SWOT) mission, now planned for launch in late 2020. An important science objective of SWOT is to transition satellite altimetry from the open ocean into the coastal zone and over inland water. Past and current precision ocean altimeters, including the Jason series, have nadir-viewing, co-located low-frequency 18-34 GHz microwave radiometers to correct the radar signal for wet-tropospheric path delay. Since surface footprints are substantial at these frequencies, the accuracy of wet path delay retrievals is significantly degraded within approximately 30-40 km of the world's coastlines, and retrievals are not provided over land. To improve this capability, high-frequency millimeter-wave window channels in the 90-180 GHz band may be added to achieve finer spatial resolution for a fixed reflector size. These higher-frequency channels are expected to provide retrievals of wet-tropospheric delay in coastal areas and to enhance the potential for over-land retrievals.

To address these needs, Colorado State University (CSU) and NASA/Caltech Jet Propulsion Laboratory (JPL) have designed, fabricated and demonstrated the HAMMR airborne radiometer instrument with a total of 25 channels, combining low-frequency microwave channels similar to Jason-2/3 at 18.7, 23.8 and 34.0 GHz at both vertical and horizontal polarization with high-frequency, wide-band millimeter-wave window channels at 90, 130 and 168 GHz, as well as temperature and eight water vapor sounding channels near each of 118 GHz and 183 GHz absorption lines, respectively. The new HAMMR instrument (1) provides calibration and validation support for the SWOT, Jason-3 and Jason-CS missions that is complementary to JPL's AirSWOT, (2) assesses wet-tropospheric path delay variability on 1-km and smaller spatial scales, and (3) provides high-frequency millimeter-wave radiometers with direct detection and internal calibration that can be integrated into future space missions, including nanosatellite constellations.

The HAMMR instrument was deployed on a Twin Otter aircraft for the West Coast Flight Campaign (WCFC) between November 4 and 17, 2014. HAMMR successfully collected more than 53.5 hours of data under diverse atmospheric conditions and over nearly the entire U.S. West coast from Camarillo, CA, to the Strait of Juan de Fuca, WA. Both coastal and inland water were overflown at different times of day to measure diurnal variations in wet-path delay under a variety of atmospheric conditions, including clear sky, clouds and fog. The HAMMR WCFC antenna temperatures were radiometrically calibrated and accurately geolocated to retrieve wet-tropospheric path delay with approximately 1-mm height precision and 150-m horizontal resolution. The spatial spectral variability of wet-path delay over coastal areas is currently being analyzed from these retrievals.

Prof. Steven C. Reising is Full Professor of electrical and computer engineering at Colorado State University (CSU) since July 2011, where he served as Associate Professor from August 2004 to June 2011. Shortly before joining the CSU faculty in 2004, he received tenure at the University of Massachusetts Amherst, where he had been Assistant Professor of electrical and computer engineering since 1998. Dr. Reising received the Ph.D. degree in electrical engineering from Stanford University in 1998, where he was supported by a NASA Earth Systems Science Fellowship and advised by Prof. Umran S. Inan. Dr. Reising's research interests span a broad range of remote sensing disciplines, including passive microwave and millimeter-wave remote sensing of the oceans, atmosphere and land; microwave monolithic integrated circuits and radiometer systems; lidar systems for sensing of temperature and winds in the middle and upper atmosphere; and atmospheric electrodynamics.