Design and Performance of an Ambient Calibration Target for an Airborne Microwave and Millimeter-Wave Radiometer

Thaddeus P. Johnson(1)*, Xavier Bosch-Lluis(1), Steven C. Reising(1), Weldon A. Johnson(1), Victoria D. Hadel(1), Pekka Kangaslahti(2), Shannon T. Brown(2), and Alan B. Tanner(2)
(1) Microwave Systems Laboratory, Colorado State University, Fort Collins, CO 80523
(2) Jet Propulsion Laboratory, California Institute of Technology, Pasadena, CA 91109

Current satellite ocean altimeters include nadir-viewing, co-located 18-34 GHz microwave radiometers to measure wet-tropospheric path delay. Due to the large antenna footprint sizes at these frequencies, the accuracy of wet path retrievals is substantially degraded within 40 km of coastlines, and retrievals are not provided over land. A viable approach to improve their capability is to add wide-band millimeter-wave window channels in the 90-180 GHz band, thereby achieving finer spatial resolution for a fixed antenna size. In this context, the upcoming Surface Water and Ocean Topography (SWOT) mission is in formulation and planned for launch in late 2020 to improve satellite altimetry to meet the science needs of both oceanography and hydrology and to transition satellite altimetry from the open ocean into the coastal zone and over inland water. To address wet-path delay in these regions, the addition of 90-180 GHz millimeter-wave window-channel radiometers to current Jason-class 18-34 GHz radiometers, is expected to improve retrievals of wet-tropospheric delay in coastal areas and to enhance the potential for over-land retrievals.

To this end, an internally-calibrated, wide-band, cross-track scanning airborne microwave and millimeter-wave radiometer is being developed in collaboration between Colorado State University (CSU) and Caltech/NASA’s Jet Propulsion Laboratory (JPL). This airborne radiometer includes microwave channels at 18.7, 23.8, and 34.0 GHz at both H and V polarizations; millimeter-wave window channels at 90, 130, 168 GHz; and temperature and water vapor sounding channels adjacent to the 118 and 183 GHz absorption lines, respectively. Since this instrument is a space flight prototype, substantial effort has been devoted to minimizing the mass, size and power consumption of the radiometer’s front-end.

A black-body calibration target is used for the end-to-end calibration of each radiometer channel and to validate internal calibration for the millimeter-wave window and microwave channels. Often commercially-available pyramidal absorbers are used, but due to the large frequency range (18-183 GHz) and limited size requirements of the instrument, no pyramidal absorbers were sufficient to meet the needs of this instrument. This led to the development of an ambient calibration target with a different physical structure, allowing it to be physically smaller and to work across a larger frequency range. The target was developed to maximize the number of reflections that an incident wave undergoes before reflecting out of the target. Upon each reflection, the electromagnetic wave undergoes attenuation, and after a number of bounces it is sufficiently absorbed. The target was constructed using aluminum sheet metal and Eccosorb HR microwave absorber from Emerson & Cuming and is about 4 cm in height. An added benefit of this target is its low heat capacity, so it quickly changes temperature to match that of its environment. This reduces temperature gradients across the target and minimizes uncertainties associated with its use as a calibration target.