A Radiometer Concept to Enable High-Resolution Wet Path Delay Retrievals for the SWOT Mission

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The primary objective of the Surface Water Ocean Topography (SWOT) is to measure for the first time mesoscale phenomena (few-hundred km scale) in the global oceans, as well as the surface height of terrestrial water bodies (such as rivers, lakes, reservoirs, and wetlands) to advance inland hydrology. An important new science objective of SWOT is to transition radar altimetry into the coastal zone, necessitating a novel radiometer to provide high-spatial resolution wet-tropospheric path delay corrections near land.

A study has been performed to assess instrument concepts that will fulfill this objective. This paper presents results from this study that demonstrates that the addition of high-frequency microwave window channels (above 90 GHz) to the baseline low-frequency (around 22 GHz) water vapor correction channels is a viable approach to provide the required wet-tropospheric path delay correction to the radar altimeter measurements in coastal regions. This improvement relies on the inherently finer spatial resolution of microwave radiometer channels at higher frequencies, for a maximum antenna aperture size.

An instrument simulator is developed to assess the performance of the enhanced radiometer in the coastal region. High-resolution three-dimensional Weather Forecasting and Research (WRF) model fields are used with a radiative transfer model to simulate top-of-atmosphere (TOA) brightness temperatures T_Bs. The resolution of the model is 3 km and covers an approximately 300x300 km area off the coast of southern California. The simulated TOA T_Bs are convolved with modeled antenna patterns for the radiometer. Several tracks in the model region from a simulated SWOT orbit are used.

Several retrieval algorithm types using high frequency T_Bs were investigated as a part of the concept study. As the radiometer approaches land, the low-frequency T_Bs are contaminated by the coastline, but the high-frequency T_Bs, which are not contaminated, can be used to continue the path delay measurement up to the coast. Because the nonlinearity of the forward model is much more significant at the high frequencies due to the increased dependence of the T_Bs on cloud liquid water and on the altitude distribution of water vapor, the retrieval coefficients for a high-frequency path delay algorithm must be a function of the atmospheric state. The algorithm that performed the best was one in which the high-frequency retrieval coefficients are dynamically trained using the uncontaminated path delays estimated from the low frequency radiometer channels greater than 50 km from the coast.

It was determined that three additional high frequency radiometer channels centered at 92, 130 and 166 GHz could yield path delay retrievals with an RMS error of less than 1 cm to within 3 km from the coast, which is in the acceptable range of errors for SWOT. Three channels are needed for the retrieval algorithm to work in all weather conditions, to account for variations of cloud liquid water and wind speed in the coastal region. The instrument simulator and the performance of the high-frequency radiometer concept will be discussed. An overview of technology risk reductions activities on-going at JPL to lower the overall implementation risk of this radiometer concept will also be discussed.