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GNSS radio occultation (RO) provides extremely high vertical resolution retrievals in the marine boundary layer (MBL) but is unable by itself to distinguish between the contributions of water vapor and the “dry” atmosphere to refractivity. Interesting MBL structure generally incurs super-refraction in RO, which greatly biases retrievals of refractivity in the MBL with grave consequences for the retrieval of other atmospheric variables. We have constructed a retrieval algorithm for specific humidity in the MBL that fuses RO and MW collocated soundings. We simulate RO bending angle profiles and MW radiances as would be measured by the Advanced Technology Microwave Sounder (ATMS) on the Suomi-NPP and the JPSS satellites – including the operational NOAA-20 – and retrieve refractivity and water vapor in the MBL. The procedure is two-step: (1) two-parameter estimation for temperature and water vapor below the super-refraction layer assuming a well-mixed, moist, unsaturated adiabat, and (2) minimizing a regularized cost function of bending angles and ATMS radiances. RO bending angles and retrieve refractivities are simulated and retrieved using forward and inverse Abel transforms. Radiances and Jacobians in microwave radiances are produced by the AER-proprietary Optimal Spectral Sampling (OSS) package.

The results of a simulation-retrieval demonstration are very promising. When fixing atmospheric temperature and water vapor to truth above the RO super-refraction layer, retrievals of water vapor are found to be accurate and unbiased at the level of ~1% with 100-m vertical resolution in the absence of noise in the observations. When the second step is invoked in a general application, the retrieval is very computationally expensive, but when the two-segment approximation for RO impact parameter in the super-refraction layer is implemented (Xie et al. 2008?), the computational expense is reduced by at least an order of magnitude. Objective quality control can be imposed to detect and flag complex super-refraction conditions and even constrain the retrieval toward reality. We will present results for the more general case of a whole-atmosphere simulation-retrieval demonstration that includes the effects of noise in RO and ATMS data.
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