Error Structures in Altimetry Data from the Wet Tropospheric Correction

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The use of satellite altimeter data has grown significantly over the past two decades. In particular, it has proved valuable for assimilation into ocean models and is critical for monitoring and understanding the impacts of global sea level rise. Both of these applications rely on an understanding of the error structures in the altimeter data. Of the various corrections that must be applied to the altimeter range, the wet tropospheric correction provided by the microwave radiometer on board is a significant contributor to the overall systematic error in the SSH measurement. Experience with Topex/Poseidon and Jason-1 has shown that it can be the largest source of error in the global mean sea level (GMSL) time series, requiring careful long term calibration of the wet path delay (WPD) product.

Previous work has been done to try to understand the error structures in altimetry data for the purposes of data assimilation and GMSL analyses (Tsaoussi and Koblinsky, 1994; Fukumori et al., 1999; Ablain et al., 2008). In these studies, the wet troposheric correction has proved to be a significant error source for residual geographically and temporally correlated errors. This study was performed with the objective to develop a complete understanding of the WPD error structure, including the spatial and temporal correlation of the errors, as well as errors correlated with the geophysical state of the atmosphere and surface. There are three main sources of errors in the radiometer WPD measurements. The first is encountered in the calibration of the raw radiometer voltage measurements to an antenna temperature. The second is incurred in the removal of antenna pattern sidelobe contributions and the third is due to limitations of the geophysical retrieval algorithm.

We have estimated the significant individual error contributions associated with each of the processing steps based on analytical expressions for each error term which are then propagated through to the path delay measurement. We have performed this analysis for the radiometers on the Topex/Poseidon, Jason-1 and Jason-2 missions. The resulting error structures are specific to each instrument, but several features are common. There are residual systematic errors that are correlated with instrument temperature that exhibit a periodicity associated with an orbit (~90 minutes) and with a satellite yaw-steering cycle (~60 days).

Uncertainties in the antenna pattern correction create errors that are correlated geographically and with time of year. These errors have spatial scales of greater than 100 km and time scales ranging from the individual measurement to years. Additional antenna pattern effects include the contamination of land in the main beam causing larger errors near land. Recent work has been done to improve the radiometer retrieval near land. Currently, each radiometer employs a binary land flag, only indicating whether the measurement is good or bad. We have generated a realistic error bar for measurements approaching land using these new algorithms allowing individual users to determine whether or not the error is acceptable for their particular application.

The major systematic errors in the retrieval algorithm are due to non-linearities in the retrieval algorithm manifesting themselves as errors correlated with the geophysical state of the scene (Obligis et al., 2009). Such errors include, but are not limited to, deficiencies in accounting for surface roughness variations due to wind, variability in the scale height of the water vapor, non-linearity in the water vapor absorption and accounting for the contribution of clouds. These errors occur on variable scales related to the geophysical parameter that is associated with the error. The structure of these errors is computed using simulations with NWP outputs.

Finally, an important error structure to understand is the long term calibration stability of the radiometer WPD measurement. Significant calibration drifts/jumps have been observed in altimeter data requiring periodic post-launch corrections. The time scale of these the systematic errors due to component changes on-orbit can not be predicted or known *a priori* and requires careful monitoring post launch. We use a combination of stable on-Earth brightness references and comparisons of the WPD product to those from other sensors and models to estimate the long term stability. We compare the WPD product to the ECMWF and NCEP models and other microwave radiometers including SSMI/I, AMSR-E, TMI and WindSat. This combination of inter-comparisions allows the residual long term stability to be assessed with high fidelity.

We will show the results of this complete error analysis through residual SSH error spectrum and two dimensional error maps for increasing time scales, beginning with an individual measurement through monthly, annual, and decadal time scales. These data show the correlation scales of the error and are particularly useful for studies involving data assimilation of the SSH data.

References

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