Title – Inter-calibrated wet path delays for eight altimetric missions

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Abstract:

The delay induced by the water vapour content of the atmosphere in the altimeter signal or wet tropospheric correction (WTC) is still one of the largest sources of uncertainty for studies such as sea level variation or ocean circulation. One of the aims of the ESA Climate Change Initiative Sea Level (SL-cci) project is to derive the sea level essential climate variable (ECV) and to estimate the long term sea level variation with an uncertainty less than 0.3 mm/yr. In view to meet these requirement, in the phase 2 of the project, wet path delay corrections for all missions used to generate the SL ECV were envisaged.

This paper presents the work developed at University of Porto (UPorto) to generate a new and inter-calibrated set of wet path delays, using the GNSS-derived Path Delay Plus (GPD+) algorithm, for eight altimetric missions: TOPEX/Poseidon (TP), Jason-1 (J1), Jason-2 (J2), ERS-1 (E1), ERS-2 (E2), Envisat (EN), CryoSat-2 (C2) and SARAL/AltiKa (SA).

The GPD+ are improved wet path delays based on: i) WTC from the on-board microwave radiometer (MWR) measurements whenever they exist and are valid; ii) new WTC values estimated by data combination, through objective analysis of all available data sources, whenever the first one is considered invalid; iii) model-derived WTC in the absence of measurements. In the estimation of the new WTC values, the following data sets are used: valid measurements from the on-board MWR, from water vapour products derived from scanning imaging radiometers (SI-MWR) on-board various remote sensing satellites and wet path delays derived from Global Navigation Satellite Systems (GNSS) coastal and island stations. In the estimation process, WTC derived from an atmospheric model such as the European Centre for Medium-range Weather Forecasts (ECMWF) ReAnalysis (ERA) Interim or the operational model are used as first guess.

To ensure the long term stability of the corrections, the large set of radiometers used in the GPD+ estimations require proper inter-calibration. For this purpose, all radiometers have been inter-calibrated, using the set of Special Sensor Microwave Imager (SSM/I) and Special Sensor Microwave Imager/Sounder (SSM/IS) on-board the Defense Meteorological Satellite Program (DMSP) satellite series (F10, F11, F13,F14, F16 and F17) as reference, due to their well known stability and independent calibration. Due to the different orbits and sampling of the various satellites this was performed in three steps: 1) TP, J1 and J2 were adjusted to the FXX set by minimizing the WTC differences at match points; all other SI-MWR were adjusted to TP, J1 and J2 again minimizing the differences at match points; 3) E1, E2, EN and SA were adjusted to TP, J1 and J2 minimizing the differences at crossover points. In each step, a three parameter (offset, scale factor and linear trend) adjustment was performed.

Results show that the calibration parameters are generally small but not negligible, with offsets, scale factors and trends in the range [-12.7, 8.8] mm, [0.85, 1.03] and [-0.25, 0.25] mm/yr, respectively. The new products are shown to reduce sea level anomaly variance with respect to previous non-calibrated versions and to other WTC data sets. The original and calibrated WTC products are also compared with the presently most stable, though not

perfect reference, the ERA Interim model, evidencing the improved alignment and consistency of the new products.