THE WET TROPOSPHERIC CORRECTION FOR COASTAL ALTIMETRY BASED ON GNSS PATH DELAY MEASUREMENTS

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Abstract

The wet tropospheric correction is one of the major error sources in coastal altimetry. The most accurate method to derive the correction, from Microwave Radiometer (MWR) measurements, becomes unusable due to the large radiometer footprint.

This study addresses the problem of improving the wet tropospheric correction in the coastal regions. Two methods are discussed: the GNSS-based Path Delay (GPD) and the Dynamically Linked Model (DLM).

The DLM is a simple and easy to implement method where the invalid radiometer measurements are replaced by a model based correction, such as ECMWF, dynamically linked to the closest valid radiometer measurement, to avoid discontinuities. This approach is presented as a backup which can be adopted whenever a more sophisticated method is not applicable.

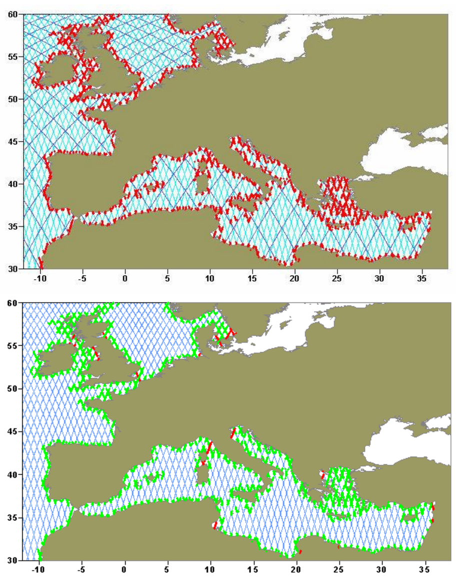
GPD is based on zenith total path delays (ZTD) determined at a network of inland and/or buoys GNSS stations. With additional in situ pressure data each ZTD can be split into a sum of a Zenith Hydrostatic Delay (ZHD or the dry tropospheric correction) and a Zenith Wet Delay (ZWD or the wet tropospheric correction).

The major issues related with the determination of the wet tropospheric correction of altimeter coastal data by using the GPD approach are analysed.

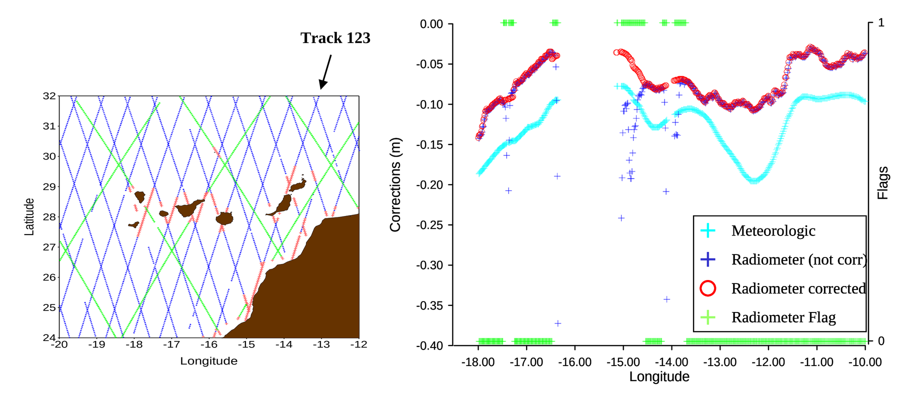
Concerning the GPD approach, a comparative analysis of altimeter tropospheric corrections and the corresponding fields determined by GNSS (ZTD, ZHD and ZWD) is presented. The aim is to understand the spatial and temporal variability of tropospheric corrections present on altimeter data and GPS-derived fields for further development of a merging data methodology.

DLM Approach

- The method uses GDR fields: wet-rad (radiometer wet tropospheric correction) and a meteorological model correction (ECMWF).
- Using a maximum gap length, data are split into segments. For each segment identifies zones with invalid wet-rad correction, i.e. with radiometer flag=1 (red points).
- For points inside invalid zones, the wet-rad field is replaced by the model correction, forced to fit wet-rad on the closest good points, using tilt and bias parameters (green points).
- Algorithm has been applied to various missions.
- Implementation is global.
- Requires as input parameters:
  - GDR Wet-rad correction
  - GDR Model correction
  - GDR Radiometer land flag or Distance-to-land



Example shows the algorithm behaviour for an ERS-2 track (same as ENVISAT) over the Canaries.



GPD Main Issues

Determination of ZWD and/or ZTD at local stations

1. Software used: GAMIT [1].
2. Network configuration: Requires adequate network configuration. Although solutions of interest might be regional the network shall include stations with a good global distribution. For each solution the number of stations shall not exceed ~50.
3. Accuracy: Accuracy of ZTD better than 1 cm (~5-6 mm); accuracy of ZWD: for stations with meteorological data accuracy of ZWD is the same; for stations without meteorological data accuracy of ZHD and therefore of ZWD is degraded depending on model data used.
4. Station coordinates (φ,λ,h), surface pressure and temperature are needed
5. Mapping functions allow evaluation of ZTD from STD:

$$STD(E) = ZHD \times mf_h(E) + ZWD \times mf_w(E)$$

STD – Slant total delay
E – elevation angle
mf – mapping functions for hydrostatic and wet components

- *A priori* ZHD evaluated from meteorological data; STD evaluated from GPS.
- Mapping functions modelled from meteorological or climatological data.
- Several approaches have been developed: Niell [2], GMF, VMF, VMF1 [3].

6. Data has to be corrected for station height, separate corrections must be applied to ZHD and ZWD.

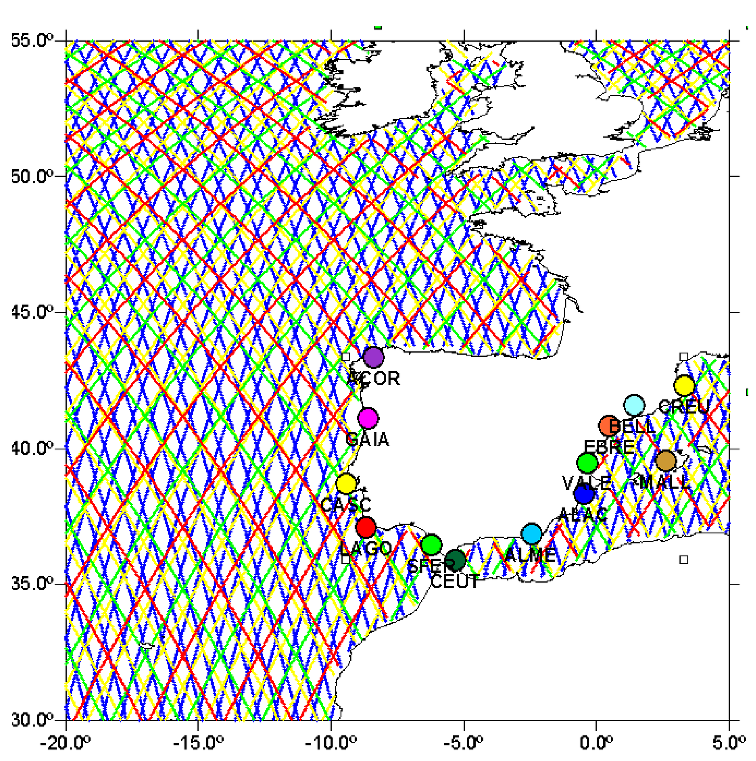
Data sources:
- Zenith Total Delay (ZTD) determined by IGS and EUREF
- ZHD + ZWD determined at local stations (inland and/or buoys), computed at UPorto.
- Microwave Radiometer (MWR) derived correction (wet-rad)
- Global meteorological model (ECMWF) data (where valid)
- Regional meteorological model (ALADIN?) data

Data combination and Interpolation: since various data types have different spatial and temporal resolution, the development of a proper interpolation method is crucial.

Comparative analysis between altimeter tropospheric corrections and GNSS derived fields

- Aim: to understand the spatial and temporal variability of tropospheric corrections present on altimeter data and GPS-derived fields for further development of a data-merging methodology
- ALT ZTD = MWR ZWD + ECMWF ZHD
- **Period A: 2002.6 – 2005.5**
  - 3 years of 4 altimeter missions (T/P, Jason1, Envisat, GFO)
  - Regional network of 13 EUREF stations
  - EUREF ZTD solutions (1 h interval, GMF or NMF)
  - UPorto ZWD+ZHD GAMIT solutions (1h interval, VMF1)
- **Period B: 2002 – 2007**
  - 2 altimeter missions (Jason1, Envisat)
  - UPorto ZWD+ZHD GAMIT solutions (1h interval, VMF1)

Altimeter data used are CORSSHs from AVISO [4] and have been stacked. For each point along each altimeter ground tracks GNSS data of the surrounding stations have been interpolated for the altimeter measurement time. Therefore, for each altimeter point on the reference ground tracks, a set of three time series of tropospheric fields have been generated - dry (ZHD), wet (ZWD) and total (ZTD) altimeter tropospheric corrections – and another 3-set of time series for the corresponding fields determined at each GNSS station. For each pair of altimeter and station fields various statistics have been computed: correlation and mean and standard deviation (sigma) of the differences.



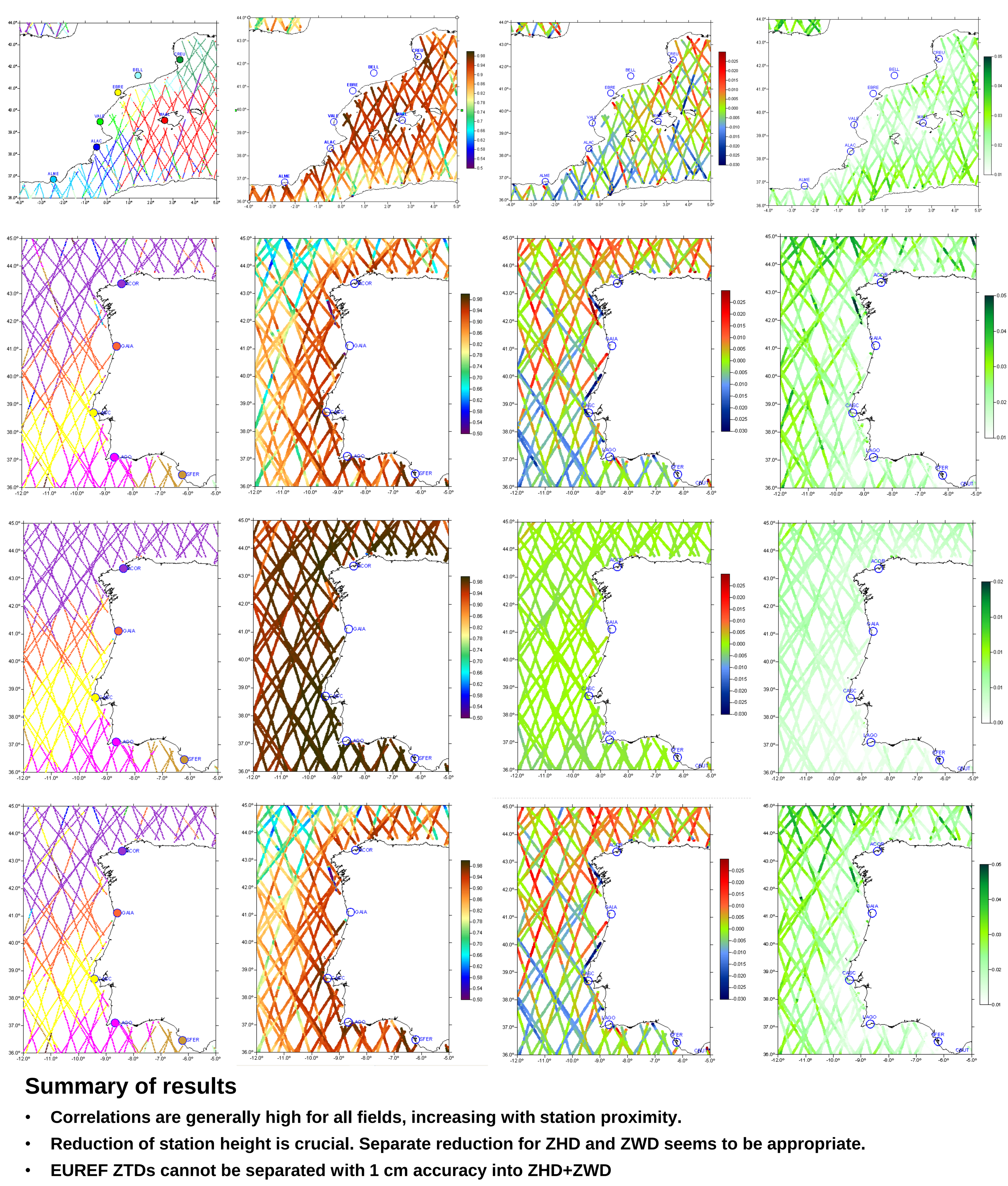
From left to right, maps below show for each point and for period A: station for which the correlation is maximum, maximum correlation, mean and standard deviation of the differences between altimeter field and GNSS derived field from UPorto GAMIT solutions. GNSS fields have been corrected for station height [5].

ZTD

ZTD

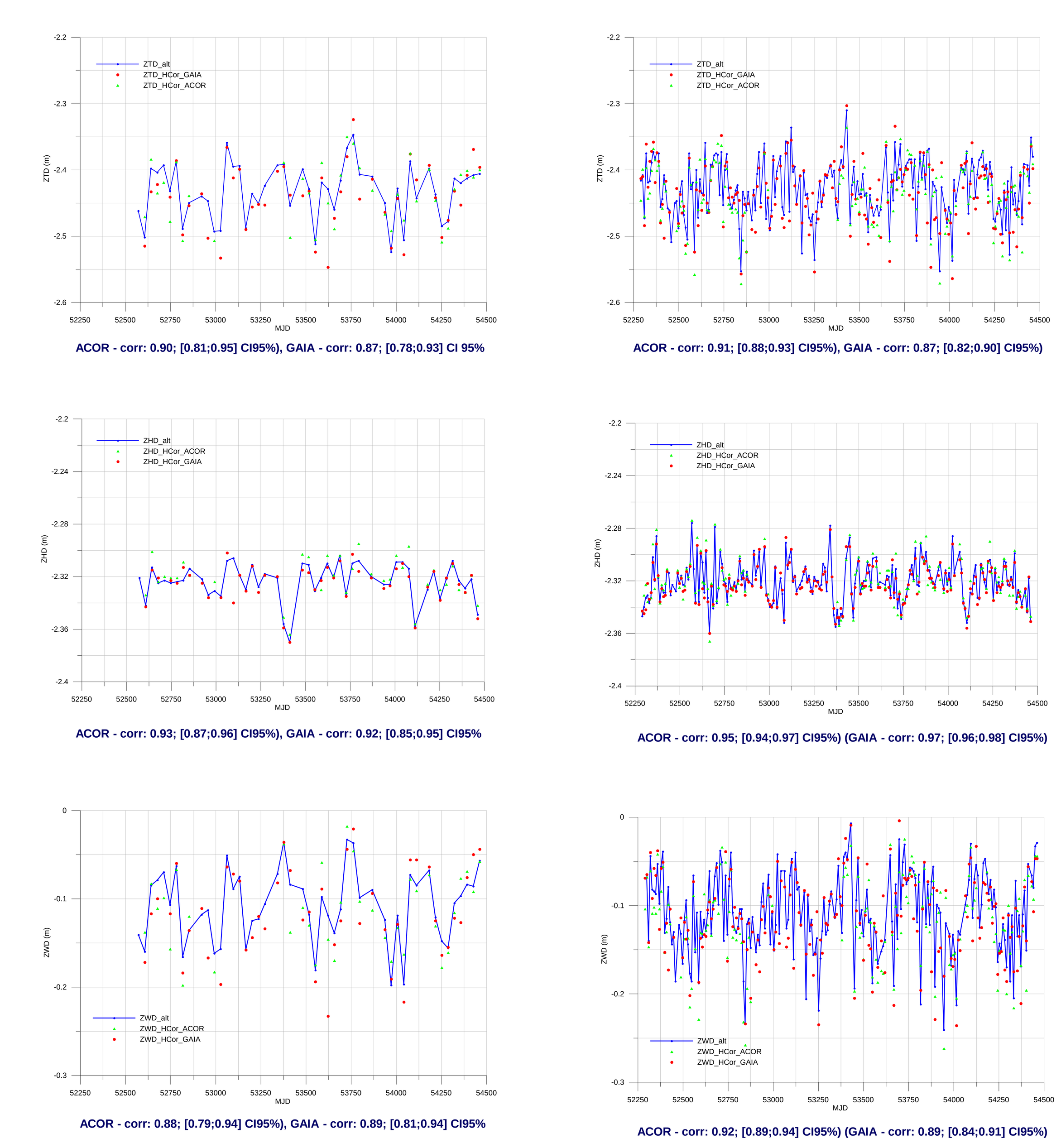
ZHD

ZWD

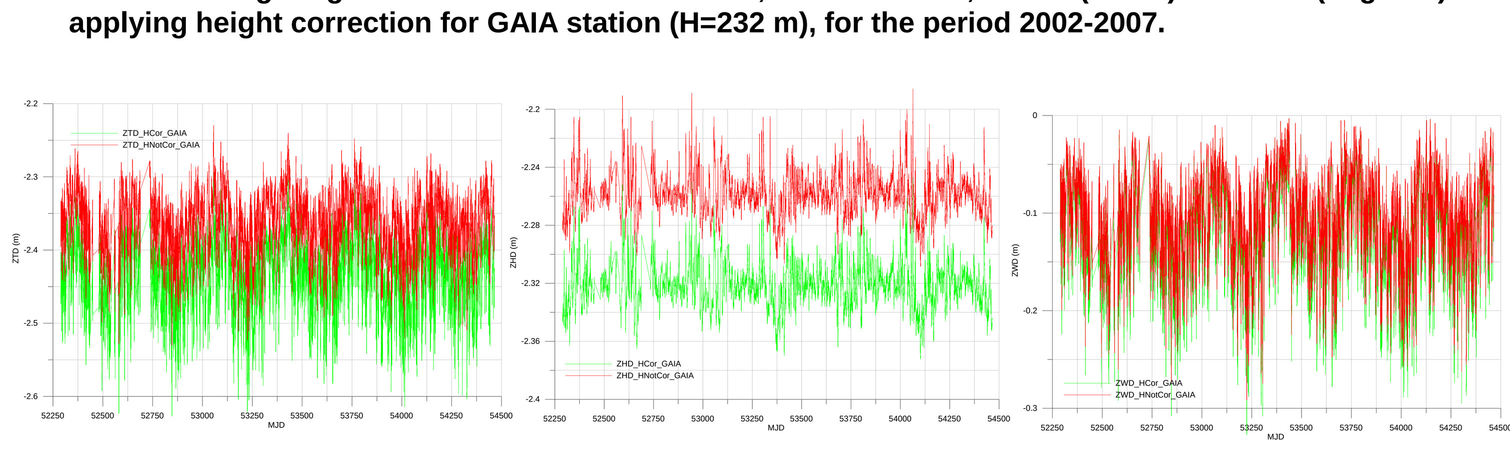


From top to bottom figures show time series of UPorto ZTD, ZHD and ZWD for GAIA (red) and ACOR (green) vs. the corresponding ALT field (blue line) for an ENVISAT (left column) and a Jason1 (right column) close points. Period of analysis is 2002-2007. All GNSS fields have been corrected for station height [5].

ENVISAT point φ = 42.04º, λ = -9.26º | **JASON1 point φ = 42.13º, λ = -9.23º**



From left to right figures show UPorto GAMIT ZTD, ZHD and ZWD, before (in red) and after (in green) applying height correction for GAIA station (H=232 m), for the period 2002-2007.



Summary of results

- **Correlations are generally high for all fields, increasing with station proximity.**
- **Reduction of station height is crucial. Separate reduction for ZHD and ZWD seems to be appropriate.**
- **EUREF ZTDs cannot be separated with 1 cm accuracy into ZHD+ZWD**
- **UPorto derived ZHD + ZWD allow proper reduction of station height and separation between dry and wet components**
- **Addition of model (ECMWF/local) data seems to be important to get spatial information**

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[5] Kouba, J. (2008) - Implementation and testing of the gridded Vienna Mapping Function 1 (VMF1), Journal of Geodesy , 82, 193–205

ACKNOWLEDGMENT
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