INTER-COMPARISON BETWEEN EXISTING WET TROPOSPHERIC CORRECTIONS FOR COASTAL ALTIMETRY

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Abstract

The wet tropospheric correction has been one of the major error sources in coastal altimetry. Recently, various approaches have been proposed for correcting the altimeter measurements in the coastal regions, where the Microwave Radiometer (MWR) measurements become invalid due to land contamination in the radiometer footprint.
In the last years four main approaches have been proposed:
(1) Land Contamination Algorithm (LCA)
(2) Mixed-pixel Algorithm (MPA)
(3) GNSS-derived Path Delay (GPD) approach
(4) Dynamically-Linked Model (DLM) approach

The first method has been implemented to Jason-2 data in the scope of project PISTACH. The second one has been developed by Shannon Brown and applied to Jason-2 data. GPD has been developed and implemented in the scope of the ESA project COASTALT for the generation of Envisat Coastal Geophysical Data Records (CGDR). DLM has first been used by Fernandes et al. (2003) and has also been implemented in COASTALT.
This study presents a summary of each method and a first comparison of the first three approaches for Jason-2. Particular emphasis given to the GPD algorithm by referring to its latest developments and its application to Envisat and ERS-2.

Brief description of present algorithms

Land Contamination Algorithm (PISTACH)

Method:
- Corrects MWR measured TBs from land proportion in the MWR footprint (Desportes et al., 2007)
- Applies existing JMR/TMR/AMR open-ocean PD algorithm to corrected TBs

Data Requirements:
- MWR measured TBs
- Accurate land-sea mask

Accuracy (TMR): 2 – 3 cm in the coastal zone

Local / Global: subject to land TB data availability

Sensors:
- Applied to TMR and AMR (PISTACH)
- Applicable to any MWR

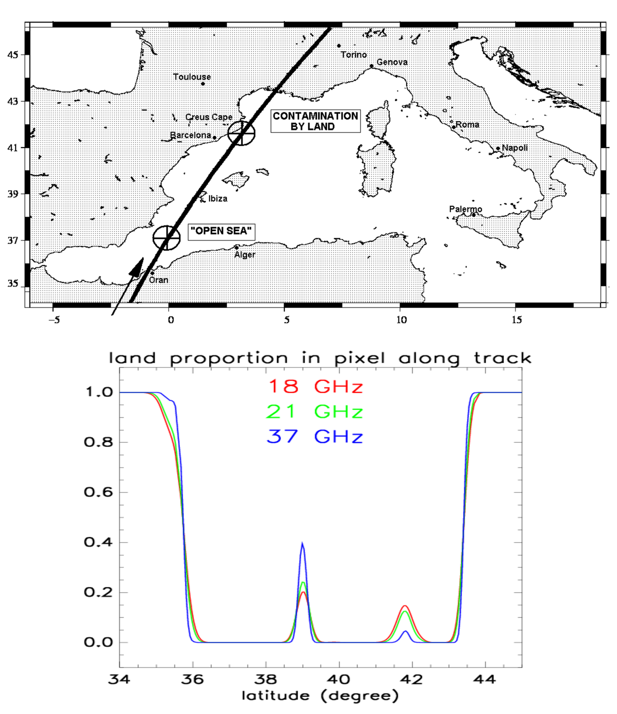

Fig.1 – (Top) TOPEX track number 187, (cycle 202); (Bottom) Land proportion in the footprint along the top figure track (Obligis et al., 2010).

Mixed-pixel Algorithm (MPA)

Method:
- Parameterizes log-linear coefficients as a function of the18.7-GHz land fraction using a database of modelled coastal land TBs (Shannon Brown, 2010).
- Based on existing open ocean algorithm for TMR/JMR/AMR, but extends to ocean and coastal TBs

Data Requirements:
- MWR measured TBs
- Accurate land-sea mask
- Database of modelled coastal land TBs (pre-processing)

Accuracy (AMR):
- 0.8 cm > 15 km from land
- 1.0 cm > 10 km
- 1.2 cm > 5 km
- 1.5 cm up to the coast

Local / Global: Global (open-ocean and coastal)

Sensors:
- Applied to Jason-2 AMR
- Applicable to any radiometer (antenna pattern may impact performance)

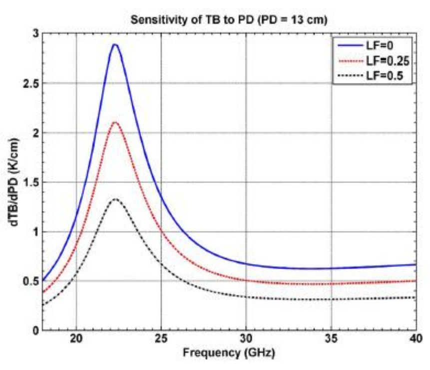

Fig.2 – Sensitivity of TB to PD versus frequency for several land fractions.

Dynamically-Linked Model (DLM)

Method: Replaces the MWR measurements by NWM values, dynamically linked to nearest valid MW+R measurement(s) (Fernandes, 2003).

Data Requirements:
- GDR-MWR and -NWM wet tropo fields
- Reliable radiometer flags
- Distance-to-land grid (optional)

Accuracy : 1-2 cm in the coastal zone

Local / Global Implementation Global
- At present there are various implementations: COASTALT, PISTACH, AVISO (?)

Sensors: Applicable to any mission

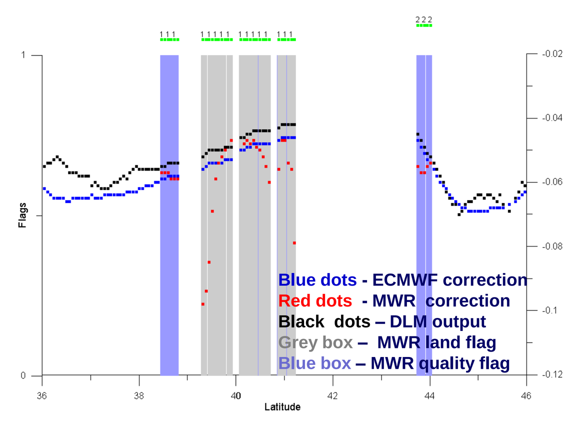

Fig.3 – Envisat pass 160, cycle 54.

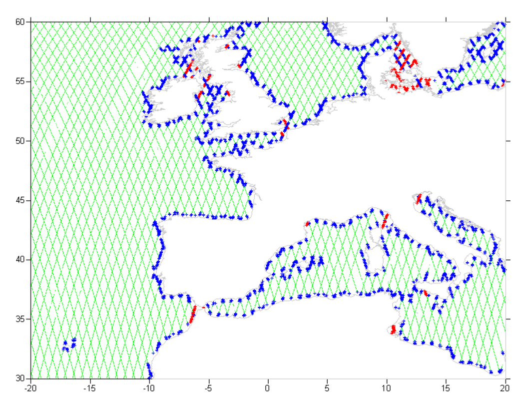

Fig.4 – Envisat pass 160, cycle 54. Corrected (blue), Uncorrected (red)

GNSS-Derived Path Delay (GPD)

Method: Data combination (objective analysis) of GNSS-derived + NWM +valid MWR tropospheric fields (Fernandes et al., 2010)

Data Requirements:
- Valid MWR-derived measurements + flags
- NWM surface and sea level pressure, TCWV and surface temperature (2T) grids
- GNSS-derived Zenith total delays (ZTD) at coastal stations (separated into zenith Hydrostatic Delays (ZHD) and Zenith Wet Delays (ZWD), reduced to sea-level)

Accuracy :
- Within 1-2 cm formal error in the coastal zone dependent on spatial and temporal distribution of data types

Local / Global Implementation : Global

Sensors:
- Applicable to any mission
- Better for recent mission (more GNSS data available)

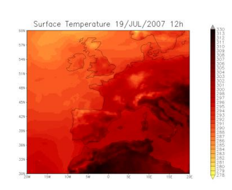

Fig.5 – Surface Temperature (2T).

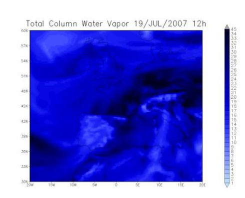

Fig.6 – TCWV.

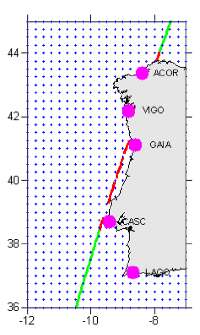

Fig.7 – Envisat pass 160.

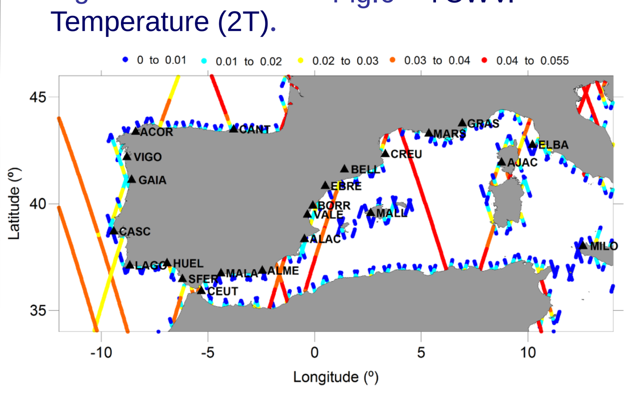

Fig.8 – Formal error (in meters) for Envisat cycle 58.

Comparisons for Jason2

The following methods are compared for Jason2, cycle 3
- Land Proportion Algorithm – PISTACH
- Mixed-pixel Algorithm – MPA
- GNSS-derived Path Delay - GPD

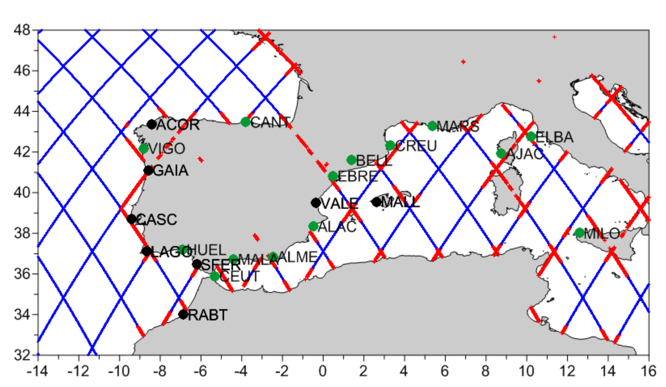

Fig.9 - Region used on the GPD computations.
- Black – GNSS stations (UPorto solutions);
- Green – GNSS stations (IGS/EUREF solutions);
- Blue/red – Jason2 measurements (cycle 3) with valid/invalid AMR correction

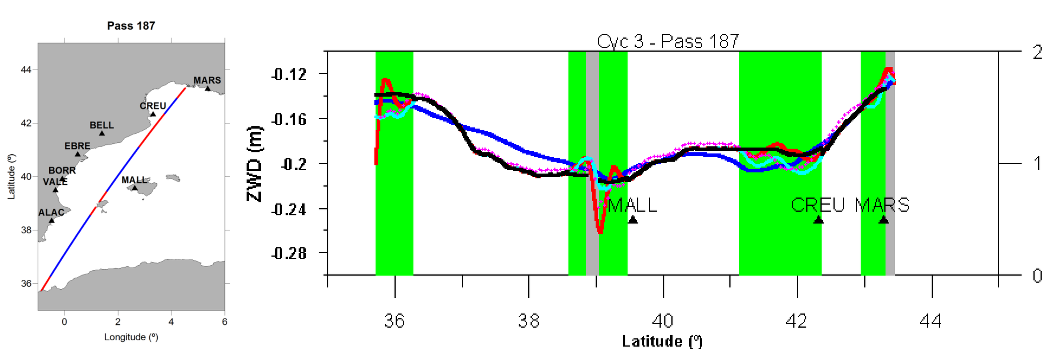

Fig.10 – Comparisons for Jason2 pass187.

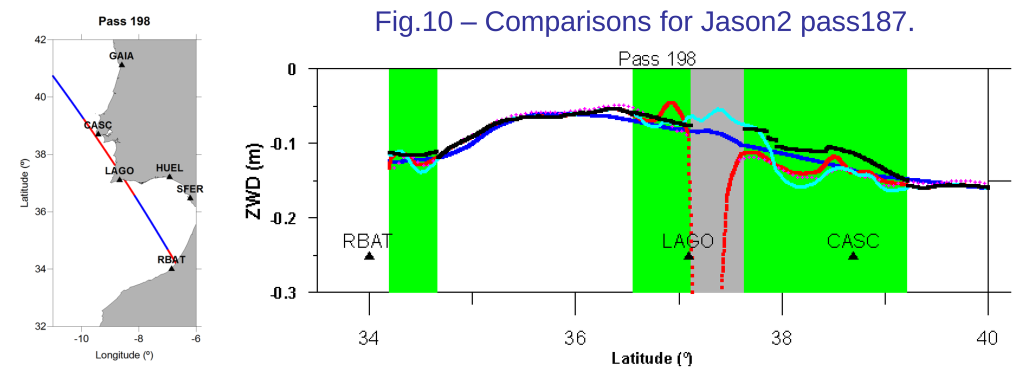

Fig.11 – Comparisons for Jason2 pass198.

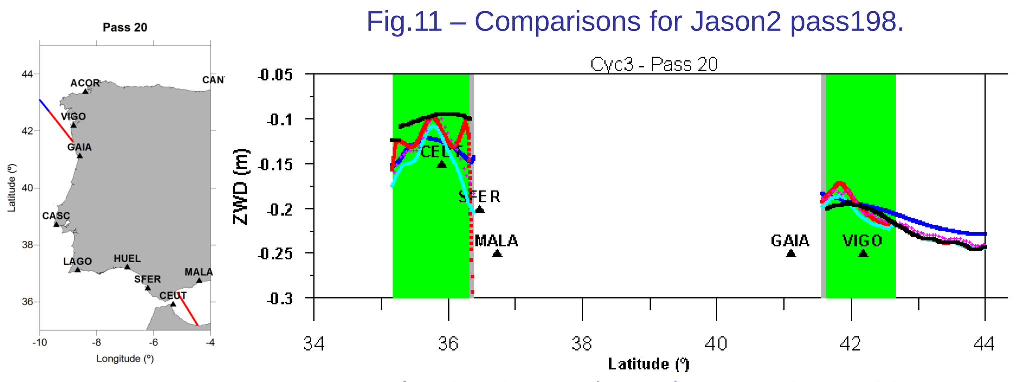

Fig.12 – Comparisons for Jason2 pass20.

ECMWF (Blue), MWR original (Red), GPD (Black), PISTACH (Magenta), MPA (Cyan)

GPD on Envisat and ERS2

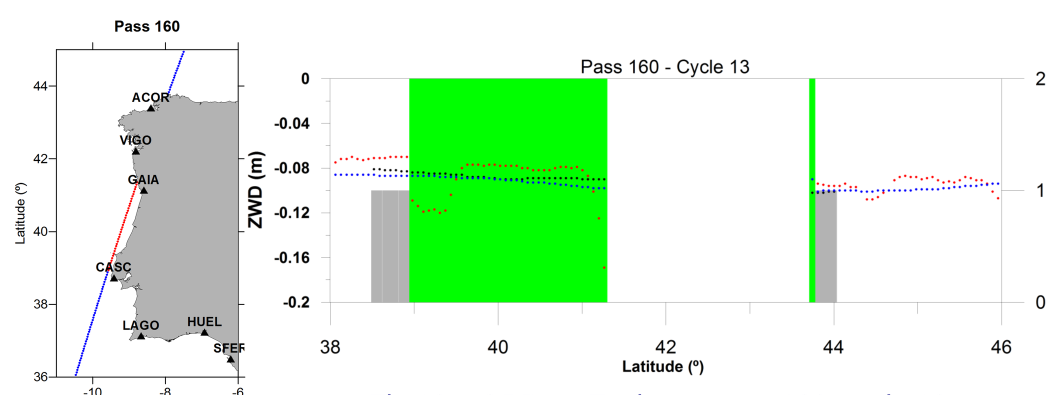

Fig.13 – GPD on Envisat – pass 160, cycle 13.

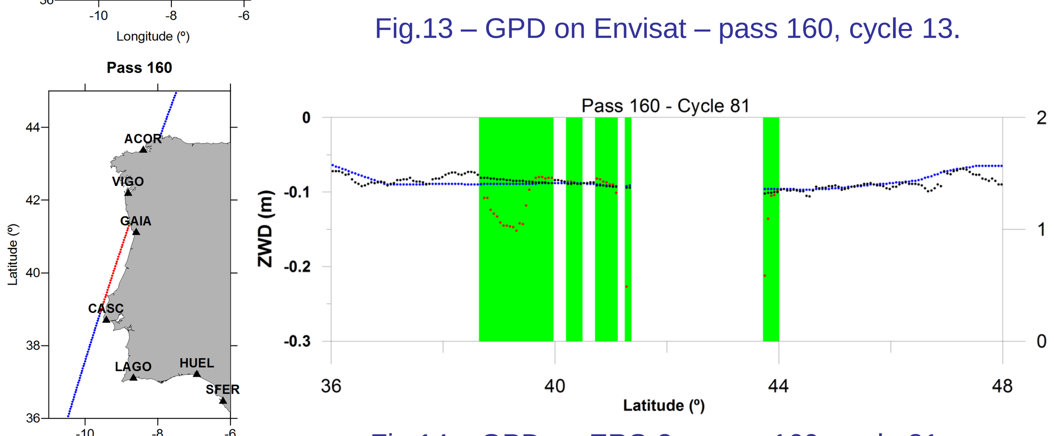

Fig.14 – GPD on ERS-2 – pass 160, cycle 81.

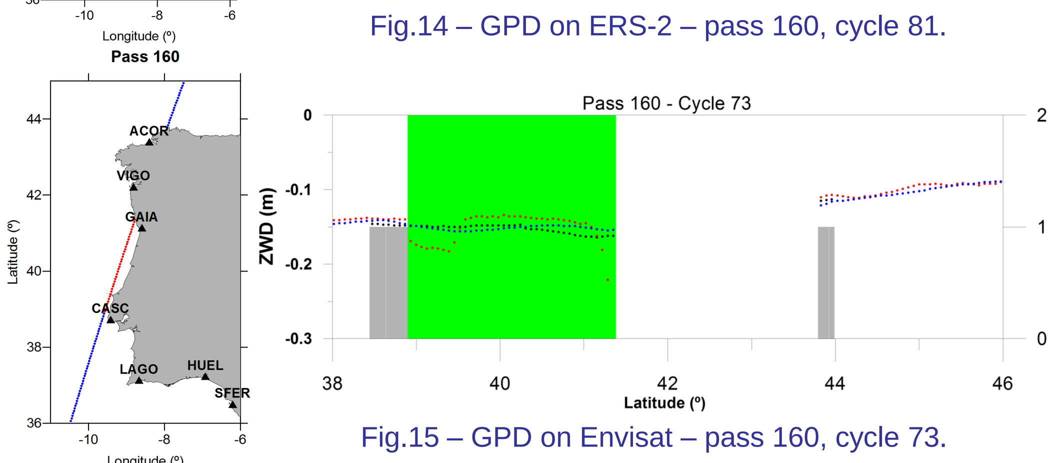

Fig.15 – GPD on Envisat – pass 160, cycle 73.

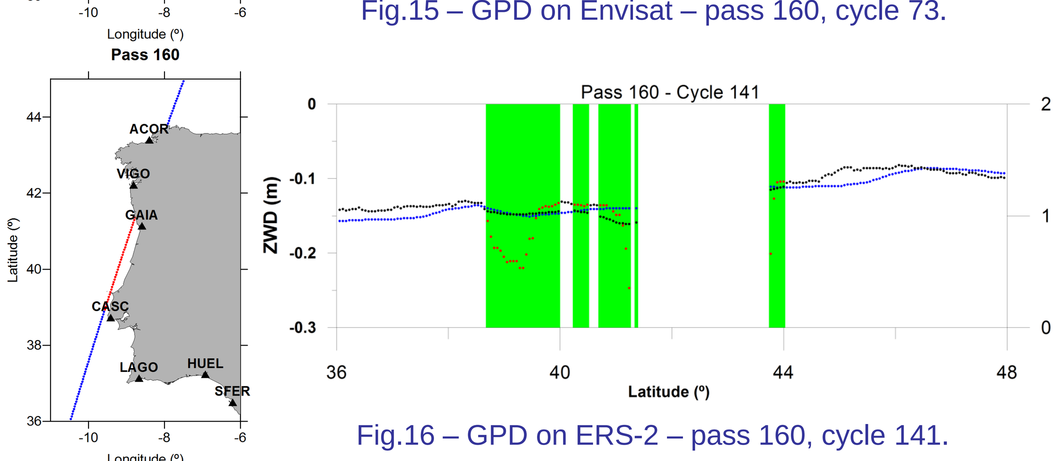

Fig.16 – GPD on ERS-2 – pass 160, cycle 141.

ECMWF (Blue), MWR original (Red), GPD (Black)

Recent Developments on GPD

Key issues about the GPD under investigation:
- Be able to separate the GNSS-derived ZTD into the dry (ZHD) and wet (ZWD) components without losing accuracy
- Use appropriate a priori signal variance, correlation functions and correlation scales in the Objective Analysis
- Achieve a global implementation, although with a non-uniform accuracy

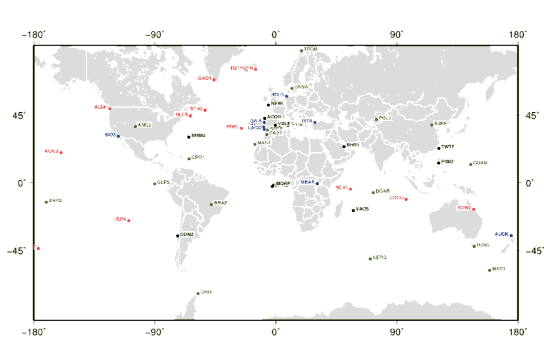

Fig.17 – Global network of 52 GNSS stations chosen to encompass all possible levels of variability for the dry and wet tropospheric corrections.

ZTD assessment by comparison with IGS/EUREF solutions:
- Comparison between UPorto and IGS/EUREF ZTD solutions was made for the 52 stations and the period 2002 – 2009;
- IGS recent solutions are uniform since 2000 (use PPP);
- EUREF solutions have suffered a great improvement in November 5, 2006;
- From 5 November 2006 until the end of 2009, the differences between the UPorto and the IGS/EURED-derived ZTDs have a mean value of 0.0 mm and a standard deviation of 4.4 mm.

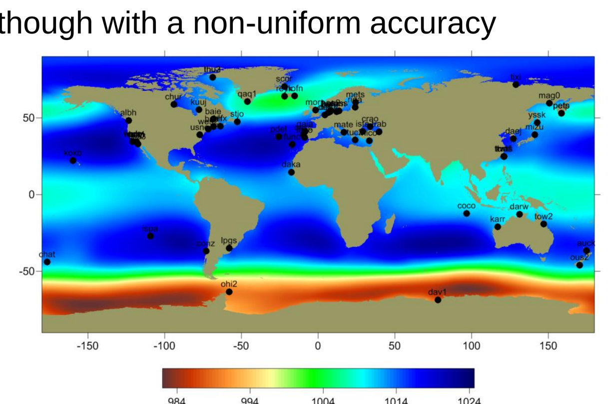

Fig.18 – Mean value of sea level pressure (SLP, in hPa) and location of stations with *in situ* pressure data

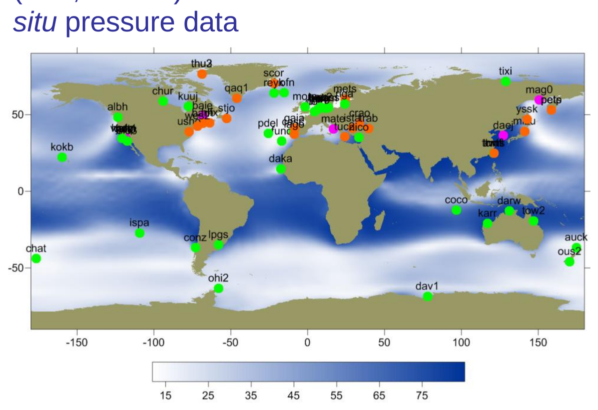

Fig.19 – same as on Fig. 20???? for the normalised wavelet variance (%) of the seasonal cycle of SLP (from Barbosa et al., 2009).

ZHD assessment
- In situ pressure data, which should be the best source for computing ZHD may not be suitable: outliers, calibration problems, large periods with invalid data;
- VMF1 ZHD global grids, freely available online, can be a valid source for ZHD computation, but only over regions where the SLP has a negligible or very low seasonal signal;
- ECMWF-derived ZHDs agree with the corresponding values from in situ data within 1-2 mm accuracy (1 σ) for most of the stations with reliable measurements;
- Recent GPD computations use ECMWF to separate the dry and wet components at the GNSS stations.

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