## Coastal wet tropospheric correction: GPD vs RWT

<table>
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<tr>
<th>Study variable</th>
<th>GPD</th>
</tr>
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<tbody>
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<td>Reference variable</td>
<td>RWT</td>
</tr>
<tr>
<td>Missions</td>
<td>Envisat (en)</td>
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<td>Period</td>
<td>[19259, 22209]</td>
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Creation date: 2011/08/30

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**Study overview**

In this study, the wet tropospheric correction computed by the University of Porto, Faculty of science in the scope of the Sea level CCI project (WP2710) has been compared with the radiometric correction to calculate the Envisat sea-level height (SSH).

The impact of using these wet tropospheric corrections on the SSH computation has been analyzed for Envisat mission from September 2002 (cycle 10) to October 2010 (Cycle 93).

The major aim of WP2710 is to provide a wet tropospheric correction for the coastal zone, applicable to all missions, fully compatible with respect to the microwave radiometer (MWR) based correction that shall be adopted in the open ocean, and ensuring its continuity and consistency in the open ocean/coastal transition zone. It has been produced by the university of Porto, Faculty of science (J. Fernandes).

This study has been performed on points where the studied correction is a valid estimate (GPD flag=1) and on non corrupted ocean points where it equals the radiometric correction (GPD flag=0).

For Envisat mission, the reference correction is the radiometric wet tropospheric correction present in GDR products.

All the validation diagnostics displayed in this report have been performed in agreement with the Sea-Level CCI Product Validation Plan (PVP).
**Diagnostic A001 (mission en)**

**Name:** Temporal evolution of differences between both altimetric components

**Input data:** Along-track altimetric components

**Description:** The temporal evolution of global statistics (mean, variance, slope) of differences between 2 different standards of a same altimetric component (sea surface height correction, altimeter parameter, orbit) are calculated from a cyclic way (altimeter repetitivity, daily, weekly, monthly). These statistics are calculated from 1 Hz altimetric measurements after removing spurious sea level measurements.

![Graph showing mean and standard deviation over time](image_url)
Name: Map of differences between both altimetric components over all the period

Input data: Along-track altimetric components

Description: The map of global statistics (mean, standard deviation) of differences between 2 different standards of a same altimetric component (sea surface height correction, altimeter parameter, orbit) are calculated over a given period which is the longer as possible to have obtain reliable statistically results. These statistics are calculated from 1 Hz altimetric measurements after removing spurious sea level measurements.
**Diagnostic A003_a (mission en)**

**Name**: Periodogram derived from temporal evolution of altimetric component differences

**Input data**: Along-track altimetric components

**Description**: The periodogram derived from temporal and global altimetric component differences is calculated from cycle by cycle monitoring of altimetric component differences (derived from diagnostic A001). It is calculated from the mean or the variance differences. The Periodogram can be calculated for all the periods, but it can be focused on a dedicated period.
**Name**: Periodogram derived from temporal evolution of altimetric component differences

**Input data**: Along-track altimetric components

**Description**: The periodogram derived from temporal and global altimetric component differences is calculated from cycle by cycle monitoring of altimetric component differences (derived from diagnostic A001). It is calculated from the mean or the variance differences. The Periodogram can be calculated for all the periods, but it can be focused on a dedicated period.
**Diagnostic A004 (mission en)**

**Name**: Altimetric component differences versus coastal distances

**Input data**: Along-track altimetric components

**Description**: Mean and standard deviation of the differences between 2 different standards of a same altimetric component (sea surface height correction, altimeter parameter, orbit) are computed and plotted in function of coastal distances between 0 and 100 km.

![Graph showing mean and standard deviation of differences vs coastal distance]
Name: Temporal evolution of SSH crossovers

Input data: Sea Surface Height (SSH) crossovers

Description: The temporal evolution of global statistics (mean, standard deviation) of SSH differences are calculated from a cyclic way (altimeter repetivity, daily, weekly, monthly) using successively both altimetric components in the SSH calculation. SSH crossovers are the differences between ascending and descending passes for time differences between both passes lower than 10 days (in order to reduce the effect of the oceanic variability).
**Diagnostic A102 (mission en)**

**Name**: Differences between temporal evolution of SSH crossovers

**Input data**: Sea Surface Height (SSH) crossovers

**Description**: The difference of temporal evolution between the global statistics (mean, standard deviation) of SSH differences are calculated using successively both altimetric components in the SSH calculation. SSH crossovers are the differences between ascending and descending passes for time differences between both passes lower than 10 days (in order to reduce the effect of the oceanic variability).

![Graph showing SSH crossovers](image-url)
Name: Map of SSH crossovers

Input data: Sea Surface Height (SSH) crossovers

Description: The differences between maps of SSH crossovers differences (mean, variance) are calculated using successively both altimetric components in the SSH calculation. SSH crossovers are the differences between ascending and descending passes for time differences between both passes lower than 10 days (in order to reduce the effect of the oceanic variability).
Name : Differences between maps of SSH crossovers

Input data : Sea Surface Height (SSH) crossovers

Description : The differences between maps of SSH crossovers (derived from diagnostic A103) are calculated from the SSH crossover differences (mean, standard deviation) using successively both altimetric components in the SSH calculation. SSH crossovers are the differences between ascending and descending passes for time differences between both passes lower than 10 days (in order to reduce the effect of the oceanic variability).

VAR(SSH with GPD) – VAR(SSH with RWT)
Mission en, cycles 9 to 93

SSH crossovers : difference of variances ( cm^2 )
Name: Temporal evolution of Sea Level Anomaly (SLA)

Input data: Along track SLA

Description: The temporal evolution of SLA statistics (mean, standard deviation) are calculated from a cyclic way (altimeter repetivity, daily, weekly, monthly) using successively both altimetric components in the SLA calculation. These statistics are calculated from 1 Hz altimetric measurements after removing spurious sea level measurements. They are calculated globally, but also separating ascending and descending passes (except for SLA Grids), or separating North and South hemispheres.

![Graph: Temporal evolution of Global Mean Sea Level (Global MSL) showing SLA with GPD and SLA with RWT with linear fits indicating slopes and correlation coefficients.]
Name: Temporal evolution of Sea Level Anomaly (SLA)

Input data: Along track SLA

Description: The temporal evolution of SLA statistics (mean, standard deviation) are calculated from a cyclic way (altimeter repetivity, daily, weekly, monthly) using successively both altimetric components in the SLA calculation. These statistics are calculated from 1 Hz altimetric measurements after removing spurious sea level measurements. They are calculated globally, but also separating ascending and descending passes (except for SLA Grids), or separating North and South hemispheres.
**Name**: Temporal evolution of Sea Level Anomaly (SLA)

**Input data**: Along track SLA

**Description**: The temporal evolution of SLA statistics (mean, standard deviation) are calculated from a cyclic way (altimeter repetivity, daily, weekly, monthly) using successively both altimetric components in the SLA calculation. These statistics are calculated from 1 Hz altimetric measurements after removing spurious sea level measurements. They are calculated globally, but also separating ascending and descending passes (except for SLA Grids), or separating North and South hemispheres.
Name: Temporal evolution of Sea Level Anomaly (SLA)

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Description: The temporal evolution of SLA statistics (mean, standard deviation) are calculated from a cyclic way (altimeter repetivity, daily, weekly, monthly) using successively both altimetric components in the SLA calculation. These statistics are calculated from 1 Hz altimetric measurements after removing spurious sea level measurements. They are calculated globally, but also separating ascending and descending passes (except for SLA Grids), or separating North and South hemispheres.
Name: Temporal evolution of Sea Level Anomaly (SLA)

Input data: Along track SLA

Description: The temporal evolution of SLA statistics (mean, standard deviation) are calculated from a cyclic way (altimeter repetivity, daily, weekly, monthly) using successively both altimetric components in the SLA calculation. These statistics are calculated from 1 Hz altimetric measurements after removing spurious sea level measurements. They are calculated globally, but also separating ascending and descending passes (except for SLA Grids), or separating North and South hemispheres.
Name: Differences between temporal evolution of Sea Level Anomaly (SLA)

Input data: Along track SLA

Description: The differences between temporal evolution of SLA are calculated from statistics derived from diagnostic A201 (mean, variance) using 2 different components in the SLA calculation. They are calculated globally, but also separating ascending and descending passes (except for SLA Grids) or separating North and South hemispheres.
Name: Differences between temporal evolution of Sea Level Anomaly (SLA)

Input data: Along track SLA

Description: The differences between temporal evolution of SLA are calculated from statistics derived from diagnostic A201 (mean, variance) using 2 different components in the SLA calculation. They are calculated globally, but also separating ascending and descending passes (except for SLA Grids) or separating North and South hemispheres.
Diagnostic A203.a (mission en)

Name: Map of Sea Level Anomaly (SLA) over all the period

Input data: Along track SLA

Description: The map of global statistics (mean, standard deviation) of SLA are calculated using successively both altimetric components in the SLA calculation over a large period. These statistics are calculated from 1 Hz altimetric measurements after removing spurious sea level measurements.
Diagnostic A203_b (mission en)

**Name:** Map of Sea Level Anomaly (SLA) over all the period

**Input data:** Along track SLA

**Description:** The map of global statistics (mean, standard deviation) of SLA are calculated using successively both altimetric components in the SLA calculation over a large period. These statistics are calculated from 1 Hz altimetric measurements after removing spurious sea level measurements.
**Diagnostic A203_c (mission en)**

**Name:** Map of Sea Level Anomaly (SLA) over all the period

**Input data:** Along track SLA

**Description:** The map of global statistics (mean, standard deviation) of SLA are calculated using successively both altimetric components in the SLA calculation over a large period. These statistics are calculated from 1 Hz altimetric measurements after removing spurious sea level measurements.
Diagnostic A204.a (mission en)

Name: Differences between maps of SLA

Input data: Along track SLA

Description: The difference of SLA maps (mean, standard deviation, slope) is calculated from maps derived from diagnostic A203 using successively both altimetric components in the SLA calculation over a given period. This can be done globally, or separating in ascending and descending passes (except for SLA Grids).

SLA with GPD trends – SLA with RWT trends
Mission en, cycles 9 to 93

Trends (mm/yr)
**Name:** Differences between maps of SLA

**Input data:** Along track SLA

**Description:** The difference of SLA maps (mean, standard deviation, slope) is calculated from maps derived from diagnostic A203 using successively both altimetric components in the SLA calculation over a given period. This can be done globally, or separating in ascending and descending passes (except for SLA Grids).

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**Diagnostic type:** Global internal analyses
Diagnostic A205.a (mission en)

Name: Differences between maps of SLA (2)

Input data: Along track SLA

Description: The difference of SLA maps (mean, standard deviation, slope) is calculated from maps derived from diagnostic A203 using successively both altimetric components in the SLA calculation over a given period. This can be done globally, or separating in ascending and descending passes (except for SLA Grids).
Diagnostic A205_b (mission en)

Name: Differences between maps of SLA (2)

Input data: Along track SLA

Description: The difference of SLA maps (mean, standard deviation, slope) is calculated from maps derived from diagnostic A203 using successively both altimetric components in the SLA calculation over a given period. This can be done globally, or separating in ascending and descending passes (except for SLA Grids).
Diagnostic A206.a (mission en)

**Name**: Periodogram derived from temporal evolution of Sea Level Anomaly (SLA)

**Input data**: Along track SLA

**Description**: The periodogram derived from temporal evolution of SLA (global, northern or southern hemisphere) can be done over all periods or focusing on particular periods, such as annual, semi annual or 60 day signal. Therefore mean of SLA differences are computed (every day or cycle), and time data series are plotted as a periodogram.

![Periodogram of SLA](image1)

Periodogram of SLA (reference period = 1 year)
Mission en, cycles 9 to 93

![Periodogram of SLA](image2)

Periodogram of SLA (period = [0, 1 year])
Mission en, cycles 9 to 93
**Diagnostic A206_b (mission en)**

**Name**: Periodogram derived from temporal evolution of Sea Level Anomaly (SLA)

**Input data**: Along track SLA

**Description**: The periodogram derived from temporal evolution of SLA (global, northern or southern hemisphere) can be done over all periods or focusing on particular periods, such as annual, semi annual or 60 day signal. Therefore mean of SLA differences are computed (every day or cycle), and time data series are plotted as a periodogram.
**Name**: Periodogram derived from temporal evolution of Sea Level Anomaly (SLA)

**Input data**: Along track SLA

**Description**: The periodogram derived from temporal evolution of SLA (global, northern or southern hemisphere) can be done over all periods or focusing on particular periods, such as annual, semi annual or 60 day signal. Therefore mean of SLA differences are computed (every day or cycle), and time data series are plotted as a periodogram.
Name: Sea Level Anomaly (SLA) versus coastal distance

Input data: Along track SLA

Description: Mean and standard deviation of SLA - computed by using successively both altimetric components - are plotted in function of coastal distances between 0 and 100 km.
### Diagnostic A208 (mission en)

**Name:** Sea Level Anomaly (SLA) differences versus coastal distance

**Input data:** Along track SLA

**Description:** The differences of SLA variances - computed by using successively both altimetric components - are plotted in function of coastal distances between 0 and 100 km.

![Graph showing the difference of SLA variances versus coastal distance](image)

VAR(SLA with GPD) - VAR(SLA with RWT)
Mission en, cycles 9 to 93

Mean = -0.3894
Name: Differences between maps of SLA (3)

Input data: Along track SLA

Description: The differences between maps of SLA are calculated from the SLA differences (mean, standard deviation) using successively both altimetric components in the SLA calculation.

VAR(SLA with GPD) – VAR(SLA with RWT)
Mission en, cycles 9 to 93

Difference of variances (cm^2)
**Diagnostic C001 (mission en)**

**Name**: Temporal evolution of SSH differences between tide gauges and altimetry measurements

**Input data**: Tide gauges SSH measurements

**Description**: The temporal evolution of global statistics (mean, variance, slope) of SSH differences between tide gauges and altimeter measurements are calculated from a cyclic way (altimeter repetivity) using successively both altimetric components in SSH calculation. The altimetric and tide gauges data are colocated with criteria of maximum of correlation, and tide gauges used are derived from global networks (GLOSS/CLIVAR, REFMAR).

![SLA differences: altimetry measurements - tide gauges](image)

Mission en, cycles 9 to 93

- SLA with GPD - T. G.  
  Slope = -0.925 mm/yr  
- SLA with RWT - T. G.  
  Slope = -0.778 mm/yr
## Diagnostic C002 (mission en)

**Name:** Differences of temporal evolution of SSH differences between tide gauges and altimetry measurements

**Input data:** Tide gauges SSH measurements

**Description:** The difference between temporal evolution of global statistics of differences between tide gauge and altimeter data differences are calculated from a cyclic way (altimeter repetivity, daily, weekly, monthly) using successively both altimetric components in altimetric SSH calculation. The altimetric and tide gauges data are collocated with criteria of maximum of correlation, and tide gauges used are derived from global networks as GLOSS/CLIVAR.

### Difference of variances:

\[
\text{VAR(SLA with GPD - T. G.) \cdot VAR(SLA with RWT - T. G.)}
\]

**Mission en, cycles 9 to 93**

![Graph showing the difference of variances over the years 2004 to 2010](chart.png)

- **Mean** = -0.1556
- **StdDev** = 0.9389

<table>
<thead>
<tr>
<th>Year</th>
<th>Difference of variances (cm$^2$)</th>
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</thead>
<tbody>
<tr>
<td>2004</td>
<td></td>
</tr>
<tr>
<td>2006</td>
<td></td>
</tr>
<tr>
<td>2008</td>
<td></td>
</tr>
<tr>
<td>2010</td>
<td></td>
</tr>
</tbody>
</table>
**Diagnostic C003 (mission en)**

**Name**: Periodogram derived from temporal evolution of SSH differences between tide gauges and altimetry

**Input data**: Tide gauges SSH measurements

**Description**: The periodogram derived from temporal evolution of altimetric and tide gauges SSH differences is calculated using successively both altimetric components in the altimetric SSH. The periodogram is calculated from the mean or variance statistics and it can be displayed for all the whole time period or a dedicated one.

![Periodogram of SLA differences - altimetric measurements - tide gauges (ref. period = 1 year)](image1)

![Periodogram of SLA differences - altimetric measurements - tide gauges (period = [0, 1 year])](image2)
Diagnostic C004 (mission en)

Name: Histograms of differences between tide gauges and altimeter SSH differences

Input data: Tide gauges SSH measurements

Description: The difference of histograms between altimeter and tide gauge SSH differences is computed from the elementary statistics (mean, variance) at each tide gauge using successively both altimetric components in the altimetry SSH.

Histogram of the difference of variances: \( \text{VAR(SLA with GPD - T.G.)} - \text{VAR(SLA with RWT - T.G.)} \)
Mission en, cycles 9 to 93

- Nbr = 146
- Mean = 0.006024
- StdDev = 0.02047