FDR4ALT

Validation Report Document Inland Waters TDP

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CHRONOLOGY ISSUES

Issue	Date	Object
1.0	17/05/22	Draft version for Phase 2 PM#1
2.0	02/12/22	Intermediate version for Phase 2 PM #1 (80% completed for ENVISAT)
3.0	02/05/23	Final version for Final Review
4.0	23/05/23	Final version for Final Review with RIDs implemented
4.1	03/07/23	Validation report has been separated into distinct reports for each product type

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1 Introduction

This document has been written in the frame of the FDR4ALT project, ESA contract N°4000128220/19/I-BG. It is a deliverable of task 4 of the project and is identified as [D-4-02].

1.1 The FDR4ALT Project

In the framework of the European Long Term Data Preservation Program (LTDP+) which aims at generating innovative Earth system data records named Fundamental Data Records (basically level 1 altimeter and radiometer data) and Thematic Data Records (basically level 2+ geophysical products), ESA/ESRIN has launched a reprocessing activity of ERS-1, ERS-2 and ENVISAT altimeter and radiometer dataset, called the FDR4ALT project (Fundamental Data Records for Altimetry). A large consortium of thematic experts has been formed to perform these activities which are:

1) To define products including the long, harmonized record of uncertainty-quantified observations.

2) To define the most appropriate level 1 and level 2 processing.

3) To reprocess the whole times series according to the predefined processing.

4) To validate the different products and provide them to large communities of users focused on the observation of the atmosphere, ocean topography, ocean waves, coastal, hydrology, sea ice, ice sheet regions.

1.2 Purpose and scope of the validation report

After the FDR/TDP definition step and all benchmarking (Round Robin) between standard solutions addressed by each expert group, comes the production and validation step.

The objective of this document is to provide a validation report for the Inland Waters TDP , following the strategy defined in the Validation Plan Document [D-4-01]. Note that to avoid heavy documents, the validation reports have been divided: there is one validation report for the FDRs (ALT FDR and MWR FDR) and one validation for each of the six TDPs. This document therefore contains only results for the **Inland Waters TDP**.

This document describes in detail the validation that has been performed for the Inland Waters TDP to assess the performances of the FDR4ALT final products. The validation covers the full lifespan of the missions and therefore includes long-term analysis, as well as cyclic analysis or targeted analysis that are relevant for this TDP.

2 Terminology

This section aims at defining clearly the terminology used in the FDR4ALT deliverables.

- **Product** refers a specific type of file, defined and described by a dedicated handbook, and designed for a clear purpose (the FDR4ALT project, the REAPER project, …). It is a “container”. One product refers to one file. The use of plural is designed to refer to a group of files, for instance the Thematic Data Products. “FDR4ALT products” will usually refer to all TDPs and FDRs, i.e., the outputs of the whole project. Note that the word “product” does not imply any notion of start date or end date, whereas “dataset” does.

- **File** can be used to refer to one single product or any other file that is not a product.
- **Parameter or variable** refers to a product's field, i.e., the content of the product. For instance, the sea level anomaly is a parameter of the Ocean & Coastal Thematic Data Products.
  Dataset can be used to refer to any group of data, not necessarily products. However, in the context of this project, it will often be used to refer to a sub-ensemble of products, on a specific period of time or a specific geographic area. For instance, the TDS (test dataset) refers to a dataset of 3 years of test products.

3 Inland Water Thematic Data Products

3.1 Introduction

This section describes the results of the validation of Inland Water data products. The following subsections cover the approach for data validation over different target surfaces, the datasets used for this validation as well as the results obtained.

Validation of the TDP for inland waters includes the comparison to external data (such as in-situ data, models, and other altimeter products) as well as absolute assessment diagnoses.

3.2 Validation datasets

Different external datasets, depending on the hydrological target, are used to assess the quality of the targets included in the inland water products: river, lakes and floodplains.

3.2.1 In situ data

In situ measurements of water level have been collected from multiple sources for the selected study areas related to rivers, lakes and reservoirs for the selected observation period. For the Po River, *in situ* data have been collected from the Po River Basin Authority . The list of the stations used for the analysis are summarized in Table 1 .Table 2 summarizes the *in situ* stations collected for the Amazon River, available from the So-Hybam website https://hybam.obs-mip.fr).Table 3 summarizes the in-situ stations collected for the Godavari River, provided by Indian National authority.

Table 1. Po river. List of in situ stations used for the validation of the Inland Water TDP.

ID station	Name Station	Lon (°)	Lat (°)
1	Piacenza	9.73	45.07
2	Cremona	10.00	45.13
3	Boretto	10.76	45.05
4	Borgoforte	11.29	45.02
5	Pontelagoscuro	11.61	44.89
6	Casalmaggiore	10.42	44.98
7	Ponte Becca	9.23	45.14
8	Spessa	9.35	45.10
9	Sermide	11.43	44.95

ID station	Name Station	Lon (°)	Lat (°)
10	Polesella	11.76	44.96

Table 2.: Amazon River. List of in situ stations used for the validation of the Inland Water TDP.

ID station	Name Station	Lon (°)	Lat (°)
1	Nazareth	-70.04	-4.12
2	Labrea	-64.80	-7.25
3	Serrinha	-64.83	-0.48
4	Manacapuru	-60.61	-3.31
5	Obidos	-55.51	-1.95

Table 3 Godavari River. List of in situ stations used for the validation of the Inland Water TDP.

ID station	Name Station	Lon (°)	Lat (°)	ID station	Name Station	Lon (°)	Lat (°)
1	Ambabal	81.79	19.28	18	Mancherial	79.44	18.84
2	Ashwi	74.60	19.55	19	Manjlegaon	76.25	19.17
3	Betmogra_2	77.54	18.70	20	Murthahandi	82.28	19.05
4	Bhadrachalam	80.88	17.67	21	Nowrangpur		

3.2.2 GIEMS

The Global Inundation Extent from Multi-Satellites (GIEMS) dataset provides the surface water extent over the globe for the 1992-2015 period on a monthly base. It provides surface water extent on cells with an equal area grid (773 km2). All the cells have the same height in latitude (0.25 degrees) and a variable width in longitude [**RD-4**, **RD-6**, **RD** 1**].** This dataset will be used for the analysis of the FDR4ALT products over floodplains and wetland targets.

3.3 Validation procedure and metrics

The validation of the IW TDP was performed by the comparison of generated products.

The quality assessment of the IW TDP product includes the comparison of the dataset to external data (in-situ, model and altimetry-based) as well as tests to determine the global quality of the product.

3.3.1 Absolute assessment

In order to evaluate the continuous and consistent dataset, three criteria were analysed :

- **Completeness**: This analysis aims to determine if the availably of IW data by the estimation of the number of tracks per cycle with data over inland water targets
- **Data availability**: This metrics consist of analysing the valid IW measurements after the editing process is applied. This editing is mainly based on backscatter coefficient values [D-2-01].

- **Data quality:** The objective of this assessment is to identify, through the quality indicator parameter, the overall quality of the IW product on different inland water targets: rivers, lakes, wetlands, floodplains and unclassified targets.

3.3.2 Rivers

The water level quality assessment for rivers is produced by comparing the satellite measurements against those observed at ground stations based on the following performances: correlation coefficient, root mean square error, mean and median error, standard deviation of the error.

3.3.3 Wetland and Floodplains

As described in the validation plan document, statistical analysis of the TDP products have been performed. Over four selected areas the quality of the measurements, based on the waveform classification has been evaluated. Moreover, the generated dataset was also compared to an external dataset: GIEMS and the temporal dynamic compared to the ones described in the literature.

The validation tasks have been performed over 4 areas:

- **Obidos**: a floodplain near the Amazon River with two tracks: 306 and 349 (Figure 3-1). This region has a diversity of surface types.

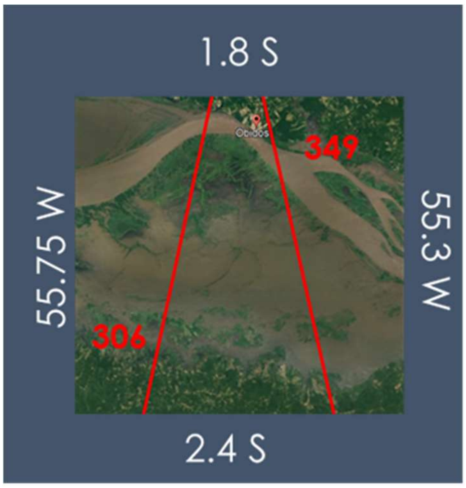


Figure 3-1. Tracks over Obidos Floodplain

- **Parana**: a river floodplain in Northern Argentina, overpassed by tracks 420 and 63 (Figure 3-2). Parana River is the South America's second largest river.

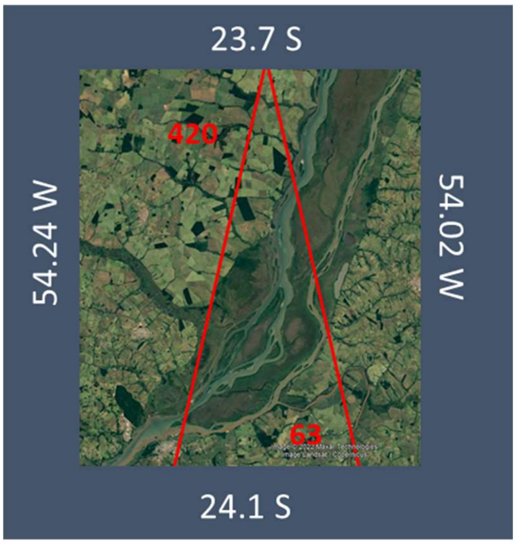


Figure 3-2. Tracks over Parana Floodplain

- **Pantanal**: the largest tropical wetland across three countries: Bolivia, Brazil and Portugal (Figure 3-3). A single track, track 220, overpass this region.

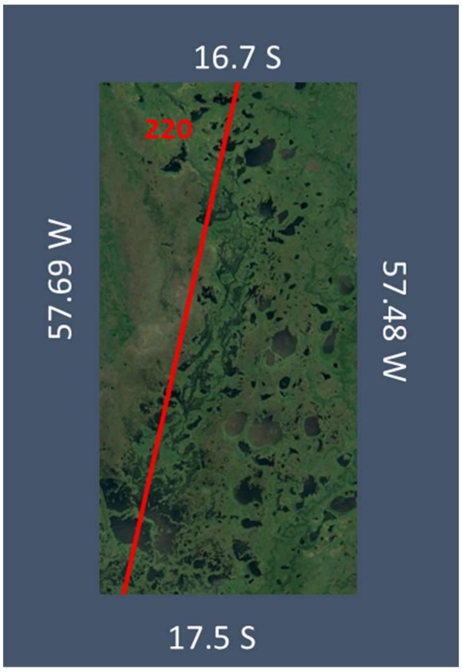


Figure 3-3. Track over Pantanal Wetland

- **Inner Niger Delta**: an area of fluvial wetlands in the semi-arid Sahel area, south of the Sahara Desert. This area, also known as Macina or Masina, is covered by tracks 87 and 474 (Figure 3-4).

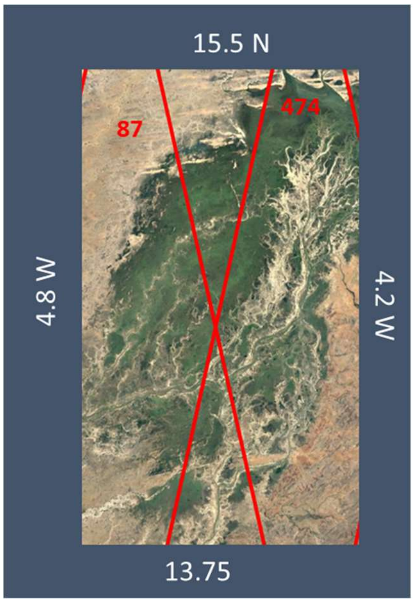


Figure 3-4. Track over Inner Niger Delta

3.4 Validation results

The validation results are presented by satellite platform and by hydrologic target.

3.4.1 ENVISAT

3.4.1.1 Absolute assessment

The first analysis verifies the completeness by estimating the availability of data over the lifetime of the mission. Figure 3-5 shows the evolution of the percentage of missing tracks per cycle. The first/last cycles of each ENVISAT phase (repetitive and geodesic) are not included because, as expected, there are a significant number of missing tracks. For the other cycles, the percentage of tracks without data is less than 25% and for most of them less than 10%.

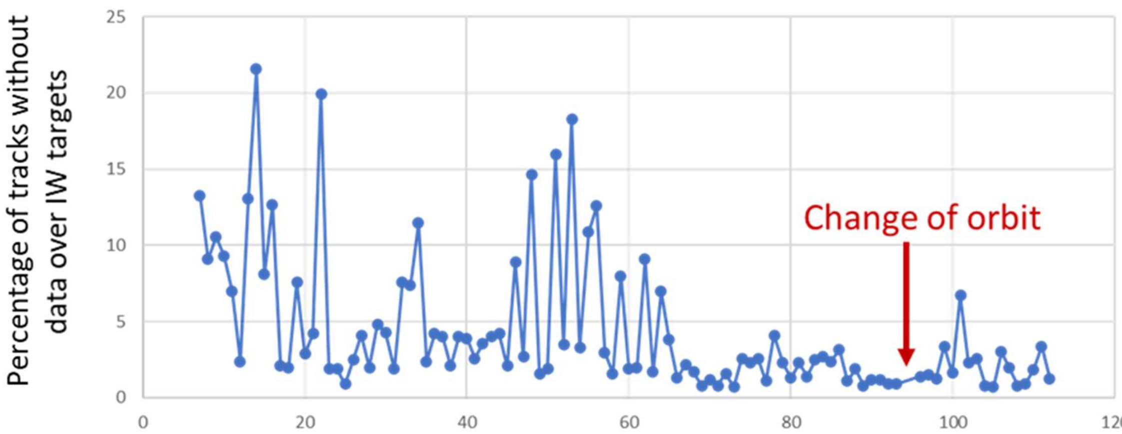


Figure 3-5. Envisat: Percentage of tracks without data over inland water targets

The second analysis monitors the number of invalid data over the cycles. The data are invalid because either the water height could not be estimated, or the value was edited due to a low value of the backscatter coefficient. Figure 3-6 show the evolution of the invalid measurements per cycle. The seasonality of these invalid values can be noticed. Indeed, the measurements are less accurate in winter because of the reflection of snow and ice.

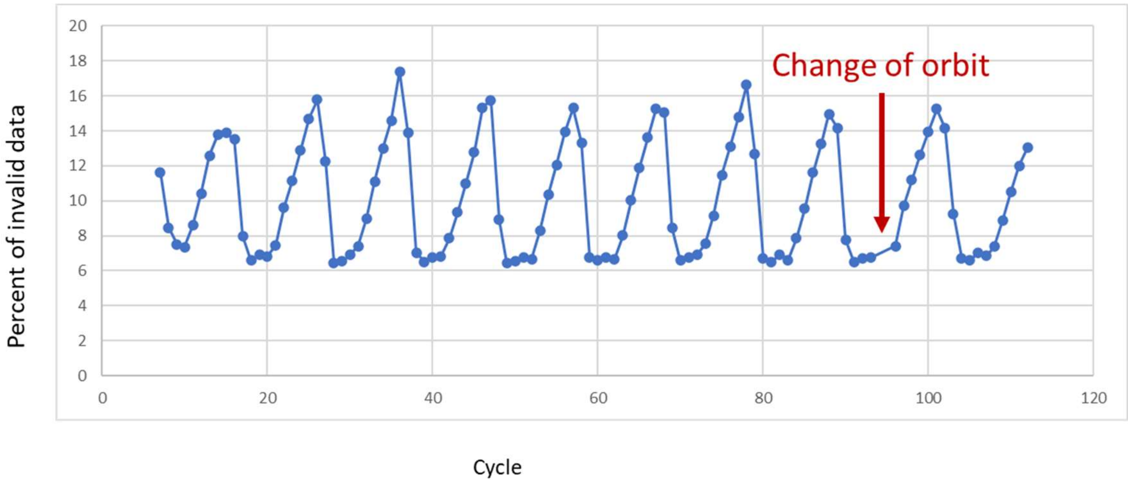
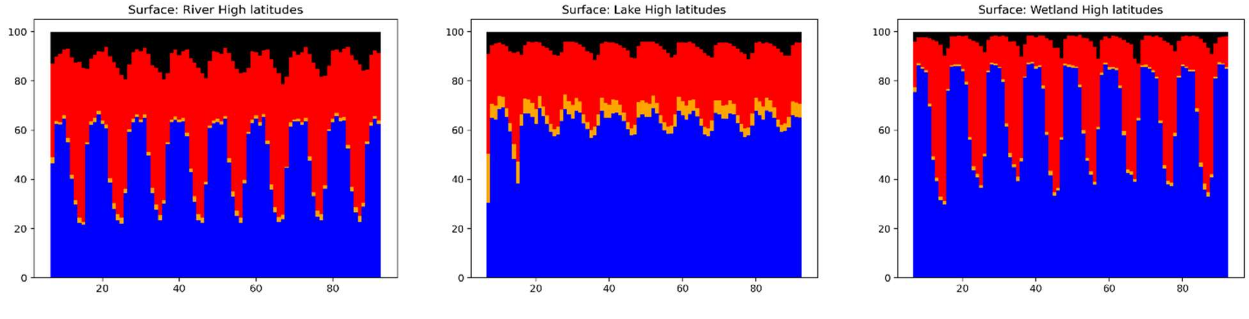
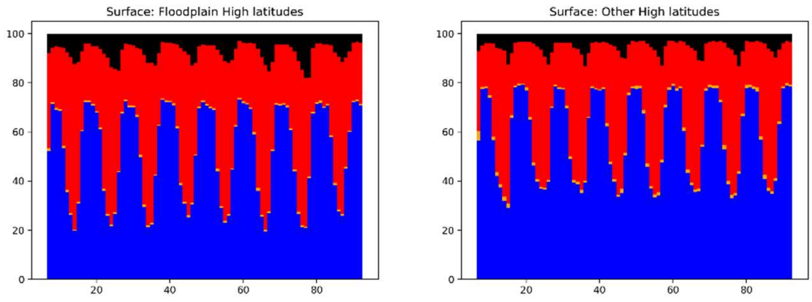


Figure 3-6. ENVISAT: Percentage of invalid measurements per cycle

The third analysis aims to assess the quality of the data per cycle and per inland water target. Figure 3-7 shows the evolution on the quality of the measurements per cycle for the different surface types. As is the case for the invalid measurements, there is a strong influence of the seasonality on data quality. The number of measurements increases considerably during the winter seasons. This is because measurements in high latitudes are impacted by ice and snow in inland water targets. To highlight this impact, Figure 3-7 shows the evolution of the quality flags on the floodplains in high latitudes (above 40 degrees north) with a large variation between winter/summer cycles and low latitudes (under 40 degrees north) with a much smaller variation between cycles. The unknown quality flag corresponds to measurements where the water surface height could not be estimated by ICE1 retracker ('no_data')



(a) (b) (c)



(d) (e)

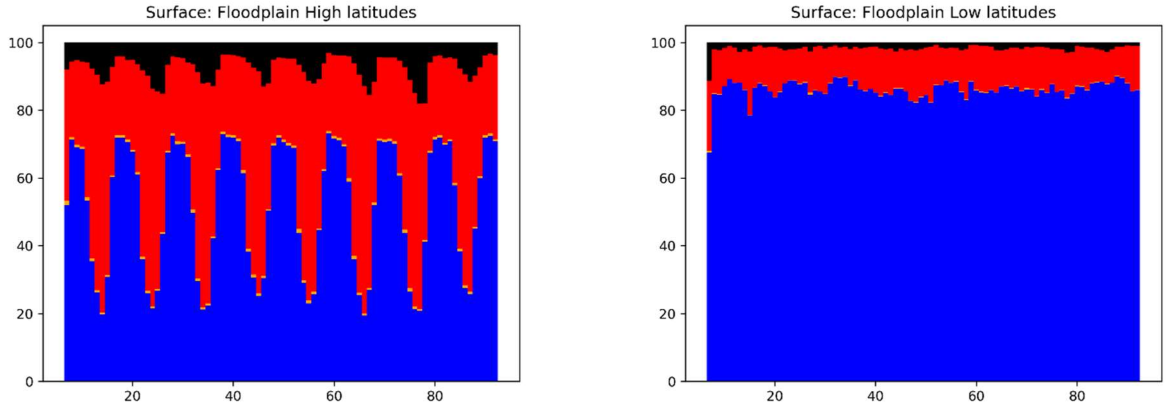
Blue: good quality

Orange: medium quality

Red: bad quality

Black: unknown quality

Figure 3-7. ENVISAT: Evolution of the quality of the measurements per cycle and surface type (a) River (b) Lakes (c) Wetland (d) Floodplain and (e) other types



(a) (b)

Figure 3-8. ENVISAT: Evolution of the quality of the measurement per cycle over floodplains surfaces for (a) high latitudes (northern than 40 degrees North) and (b) low latitudes (southern than 40 degrees north)

3.4.1.2 River

<u>Po river</u>

Herein after, the results related to the validation of the TDP over the Po river are presented. To evaluate the performances of FDR4ALT TDP water level data, a relative comparison between in situ and VS data has been carried out. The performances in terms of RMSE (m) are summarized in Figure 3-9, where the triangles indicate the position of the VS, different triangles colours indicate different ranges for RMSE and the orientation of triangles indicates the *in situ* station (upstream or downstream) with respect to the RMSE is evaluated. Boxplot inside Figure 3-9 summarizes the RMSE values for all the VS and in situ stations.

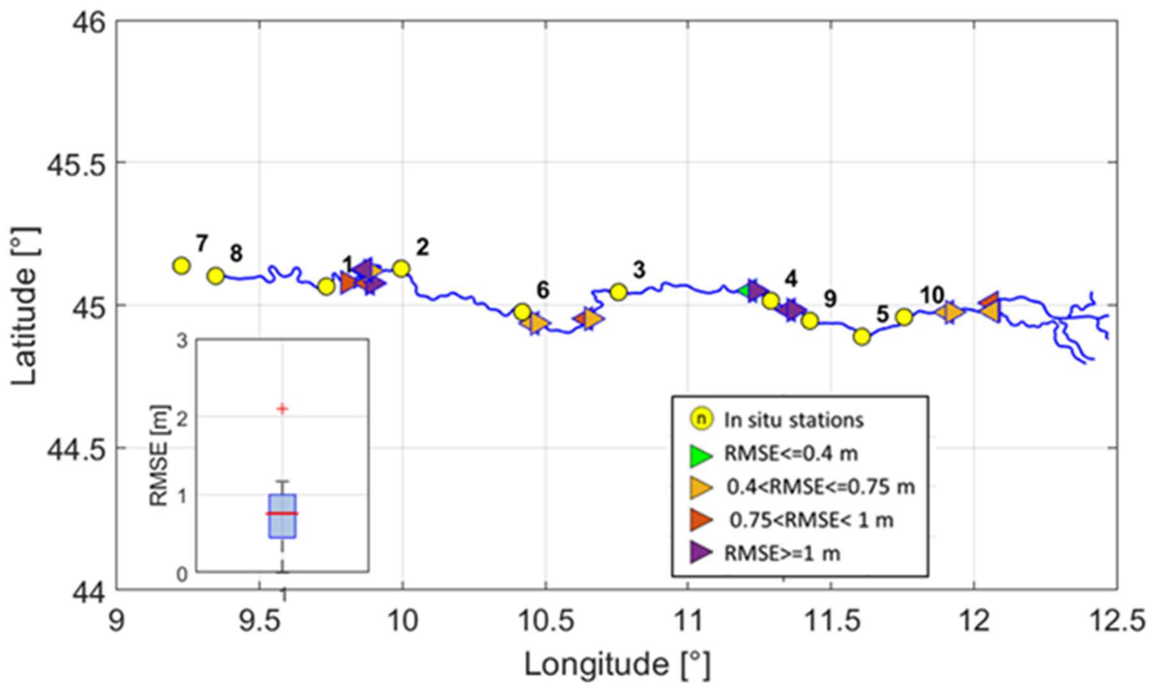


Figure 3-9. RMSE values for the VS located along the Po river. Different triangles colours identify different ranges for the RMSE values, the triangles orientation identifies the gauging station with respect to the RMSE has been computed. The boxplot summaries the RMSE values for all the VS.

Looking at Figure 3-9 it can be noted that the RMSE values for most of the VSs range between 0.4 m and 0.75 m, four VSs show RMSE values higher than 1 m, whereas only one VS is in good agreement with respect to *in situ* data with RMSE lower than 0.4 m. In general, the median and mean RMSE values are equal to 0.76 m and 0.86 m, respectively.

As an example, Figure 3-10 illustrates the comparison between altimetry and observed water levels for two stations along the Po River, Casalmaggiore and Polesella. The water levels provided by the VS over the track 588 quite accurately represent the *in-situ* observations at Casalmaggiore, showing a RMSE value equal to 0.67m. Better performances are obtained at the VS over the track 502 with respect to the *in-situ* data at Polesella. Here the RMSE value is lower than 0.50 m.

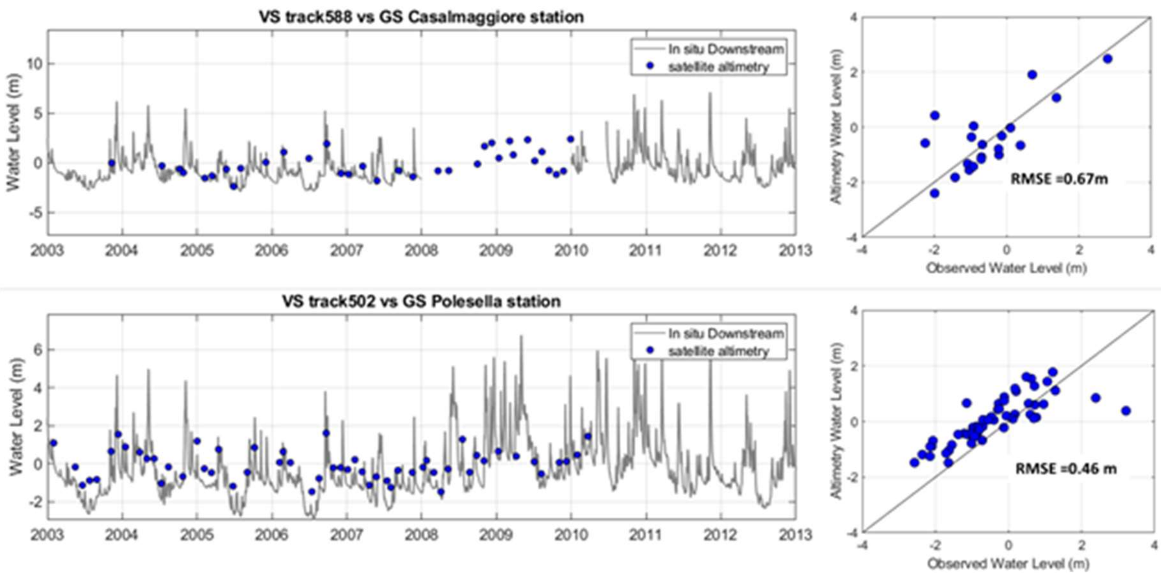


Figure 3-10 Comparison between altimetry and observed water levels for two stations along the Po River, Casalmaggiore and Polesella. The plots on the left show a temporal comparison, the plots on the right show scatterplots.

As an additional comparison, the water level time series obtained from the Dahiti database have been considered. The comparison, illustrated in for three VS along the Po River, shows comparable results between Dahiti and the water level from the FDR4AL TDP product highlighting the goodness of the extraction procedure as well as the quality flag of the data.

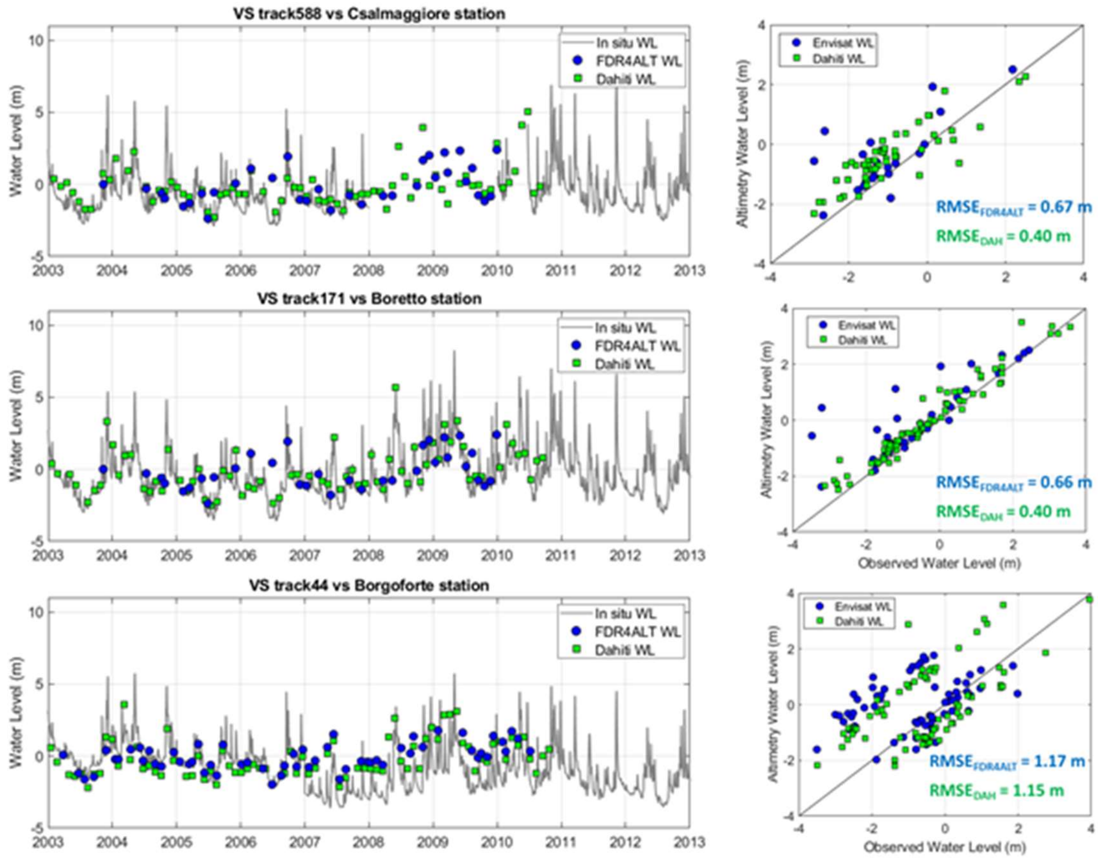


Figure 3-11. Comparison between altimetry and observed water levels for different in situ stations along the Po River. The plot on the left shows a temporal comparison, the plot on the right shows scatterplot.

Amazon river

For the Amazon River, the performances in terms of RMSE (m) are summarized in Figure 3-12 where the same notation used in Figure 3-9 is applied. For the Amazon River, the RMSE values for most of the VSs are higher than 1 m, especially for the VS located upstream the *in-situ* station 4 (Manacapuru, see Table 2). The performances improve for the VS located over around the *in-situ* station 3 (Serrinha, see Table 2) over the Negro river and for the VS located near the *in-situ* station 3 (Obidos station, see Table 2). On overall, the median and mean RMSE values for both upstream and downstream sections are equal to 1.13 m and 1.54 m respectively.

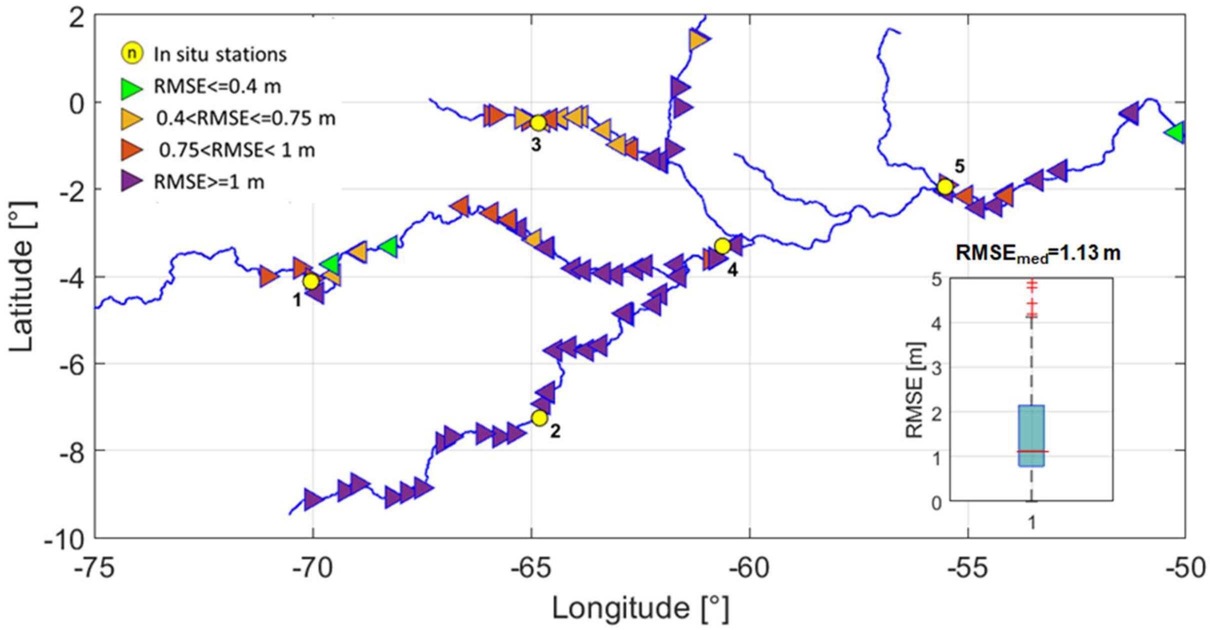


Figure 3-12. RMSE values for the VS located along the Amazon River. Different triangles colours identify different ranges for the RMSE values, the triangles orientation identifies the gauging station with respect to the RMSE has been computed. The boxplot summaries the RMSE values for all the VS.

Figure 3-13 shows the temporal comparison between altimetry and observed water levels for two stations along the Amazon River, Labrea and Serrinha. The water levels provided by the VS over the track 865 follow the *in-situ* observations at Labrea, showing a quite high RMSE value equal to 2.68 m. better performances are obtained at the VS over the track 822 with respect to the *in situ* data at Serrinha. Here the RMSE value is equal to 0.63 m.

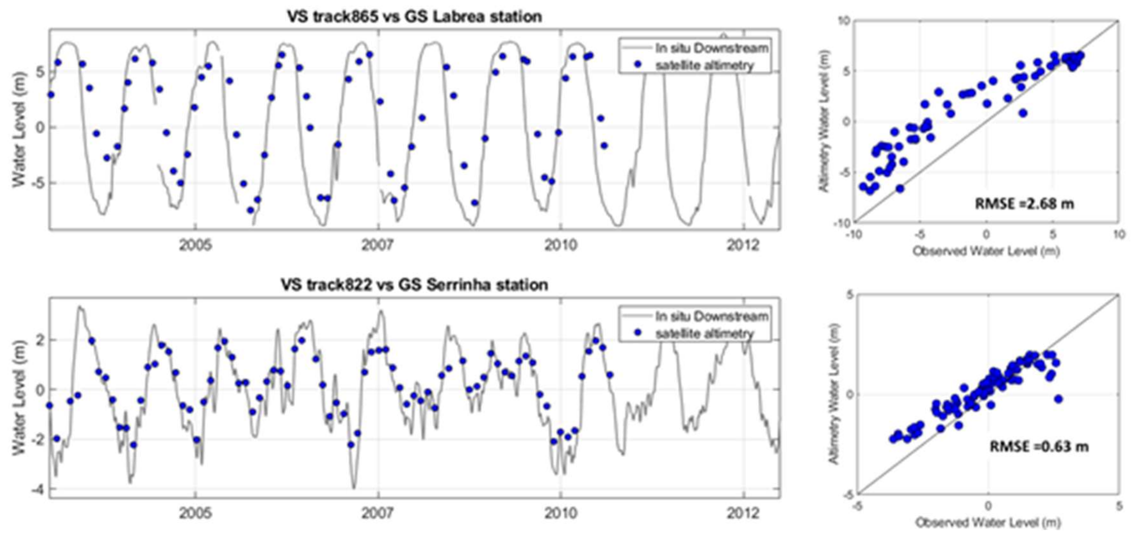


Figure 3-13. Comparison between altimetry and observed water levels for two stations along the Amazon river, Labrea and Serrinha. The plots on the left show a temporal comparison; the plots on the right show scatterplots.

Figure 3-14 shows the relative comparison between the FDR4ALT product and the Dahiti time series. As it can be noted, the two time series are comparable and are affected by the same order of error with respect to the in situ data. In particular, the FDR4ALT time series overperforms in terms of RMSE with respect to the Dahiti time series.

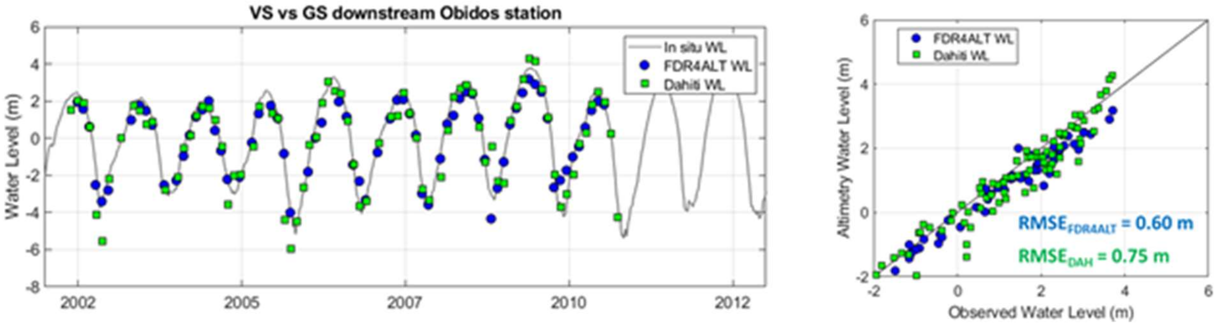


Figure 3-14. Comparison between altimetry and observed water levels at Obidos stations. Altimetry water levels include FDR4ALT and Dahiti time series. The plot on the left shows a temporal comparison, the plot on the right shows scatterplot.

<u>Godavari river</u>

The performances in terms of RMSE (m) are summarized in Figure 3-15 where the same notation used in Figure 3-9 is applied. Along the Godavari River, there are several VS with RMSE values lower than 0.4 m, especially over the west part of the river whereas the performances decrease moving towards the river mouth. On overall, the median and mean RMSE values are equal to 0.54 m and 0.84 m respectively.

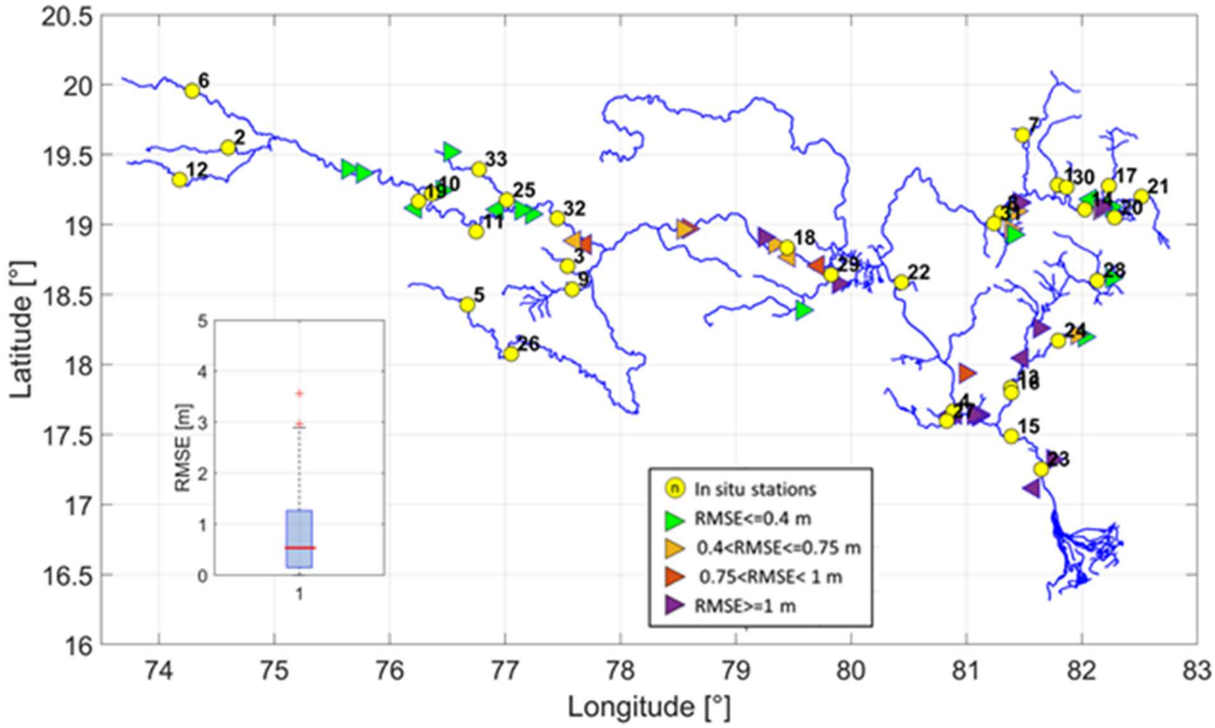


Figure 3-15. RMSE values for the VS located along the Godavari River. Different triangles colours identify different ranges for the RMSE values, the triangles orientation identifies the gauging station with respect to the RMSE has been computed. The boxplot summaries the RMSE values for all the VS.

Figure 3-16 shows the temporal comparison between altimetry and observed water levels for two stations along the Godavari River, Mancherial and Dhalegaon. The water levels provided by the VS over the tracks 2683 and 210 are in very good agreement within *situ* observations. The RMSE value is equal to 0.56 and 0.36 m.

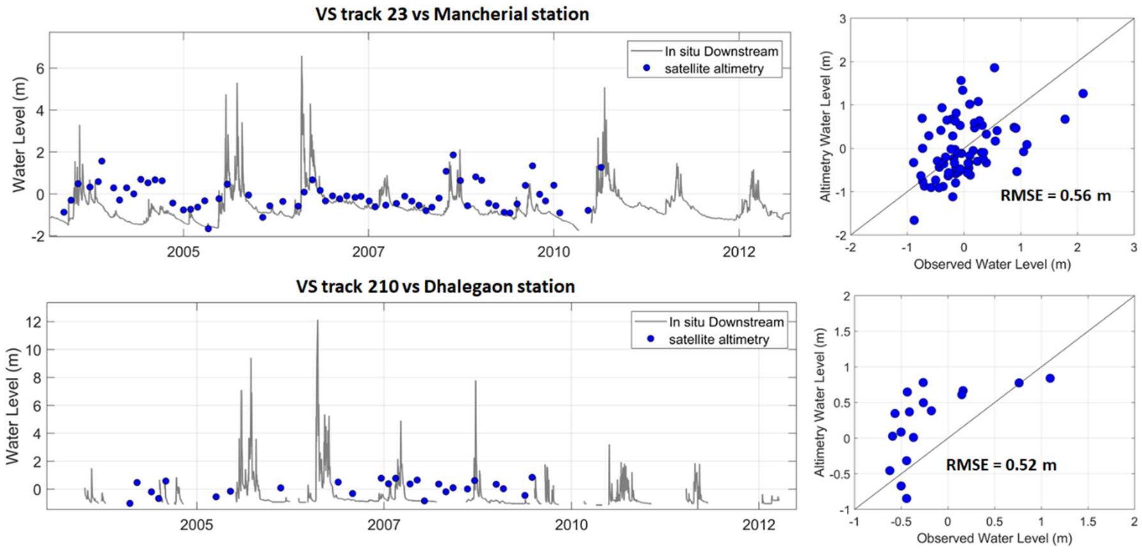


Figure 3-16: Comparison between altimetry and observed water levels for two stations along the Godavari river, Mancherial and Dhalegaon. The plots on the left show a temporal comparison, the plots on the right show scatterplots.

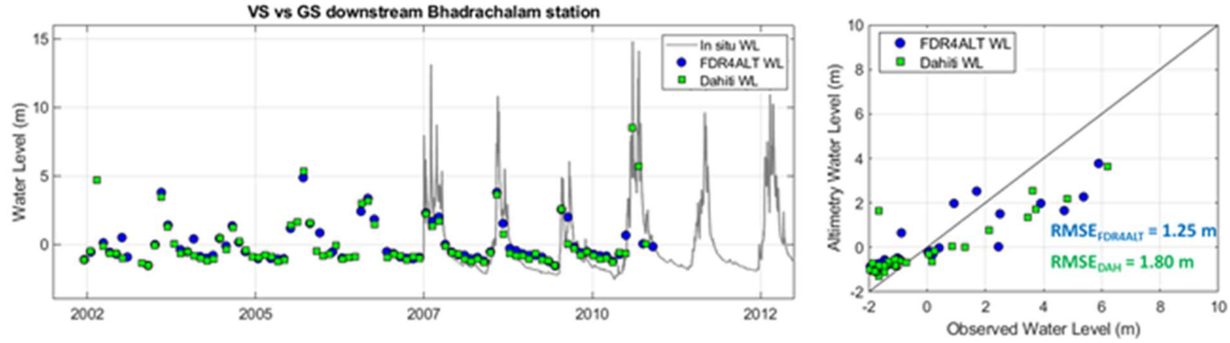


Figure 3-17: Comparison between altimetry and observed water levels at Bhadrachalam station. Altimetry water levels include FDR4ALT and Dahiti time series. The plot on the left shows a temporal comparison, the plot on the right shows scatterplot.

3.4.1.3 Floodplains and wetlands

In following sections, the evaluation over each selected floodplain and wetland is illustrated by analysing:

- The evolution of the timeseries of water surface height and the flooding area from GIEMS.
- The evolution of the quality flag
- The normalised monthly variation of the water level per year

3.4.1.3.1 Obidos

Figure 3-18 shows the comparison of the time series of track 349 over the Obidos floodplain in the IW TDP and the GIEMS data. Since the GIEMS data are provided on a monthly basis, the IW TDP data was averaged at the same temporal resolution. The time series show a marked level of seasonality and the correlation between the two time series is also very high (0.94). Figure 3-19 shows the evolution of the quality flag per cycle for track 306. More than 60% of the measurements per cycle are good level of quality.

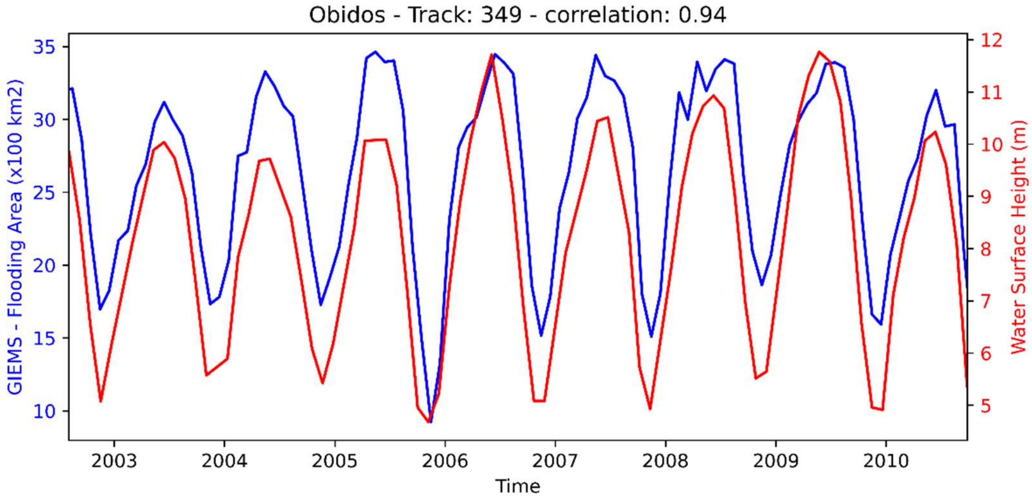


Figure 3-18. ENVISAT. Obidos: Comparison of timeseries from IW TDP and GIEMS

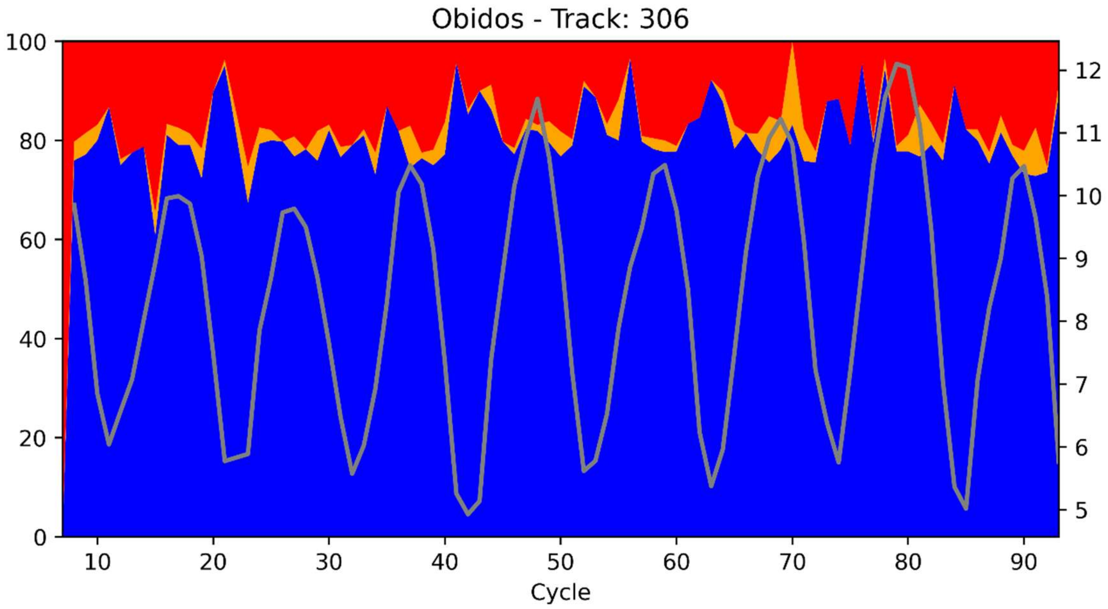


Figure 3-19. ENVISAT. Obidos: quality flag per cycle for track 306. Blue: good quality, Orange: medium quality, Red: bad quality and Black: unknow quality

Figure 3-20 shows the normalised water level variation between 2002 and 2010. Yellow indicates high water level values and blue low water level values. White boxes indicate that no data is available in the IW TDP. ENVISAT variation is in agreement with what is described in [RD **8**].

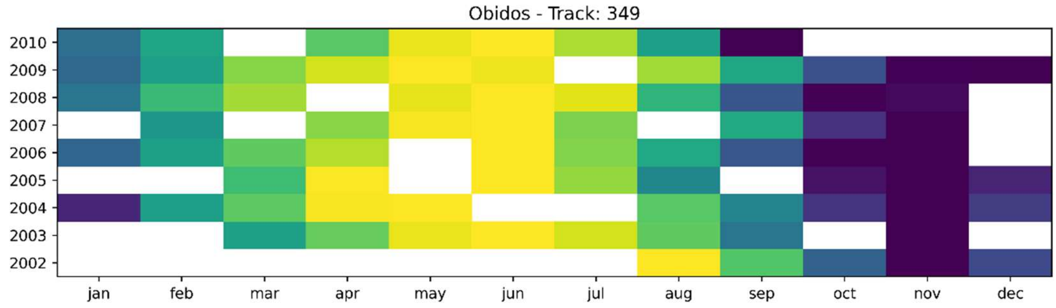


Figure 3-20. ENVISAT. Obidos: Normalised water level change per year

3.4.1.3.2 Parana

Figure 3-21 shows the comparison of the time series of track 63 over the Parana floodplain in the IW TDP and the GIEMS data. The correlation is lower than in the previous area (0.25 compared to 0.94). As indicated in previous sections, the landscape is very complex resulting in a higher number of bad quality measurements (Figure 3-22)

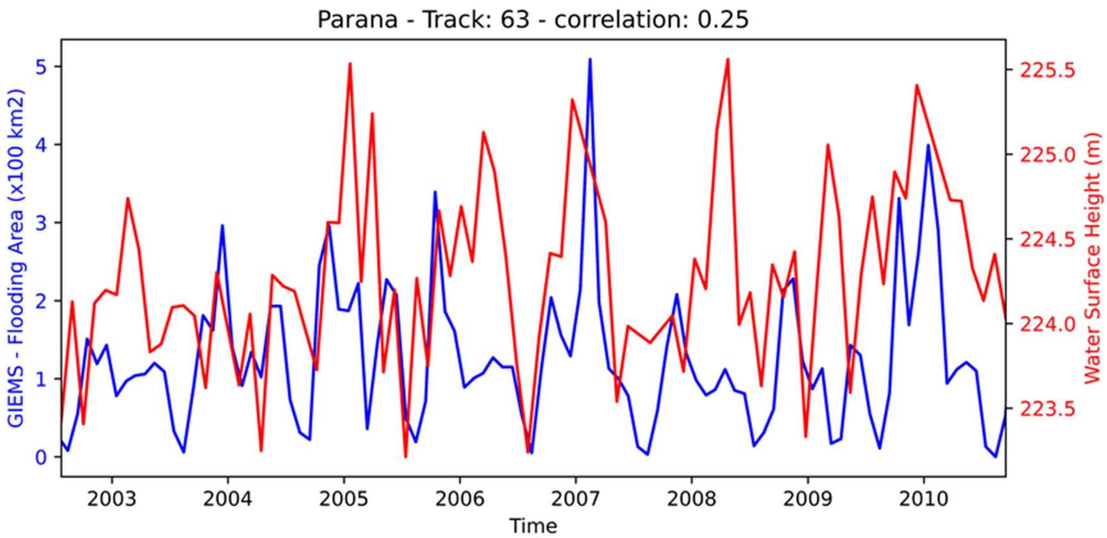


Figure 3-21. ENVISAT.Parana: Comparison of timeseries from IW TDP and GIEMS

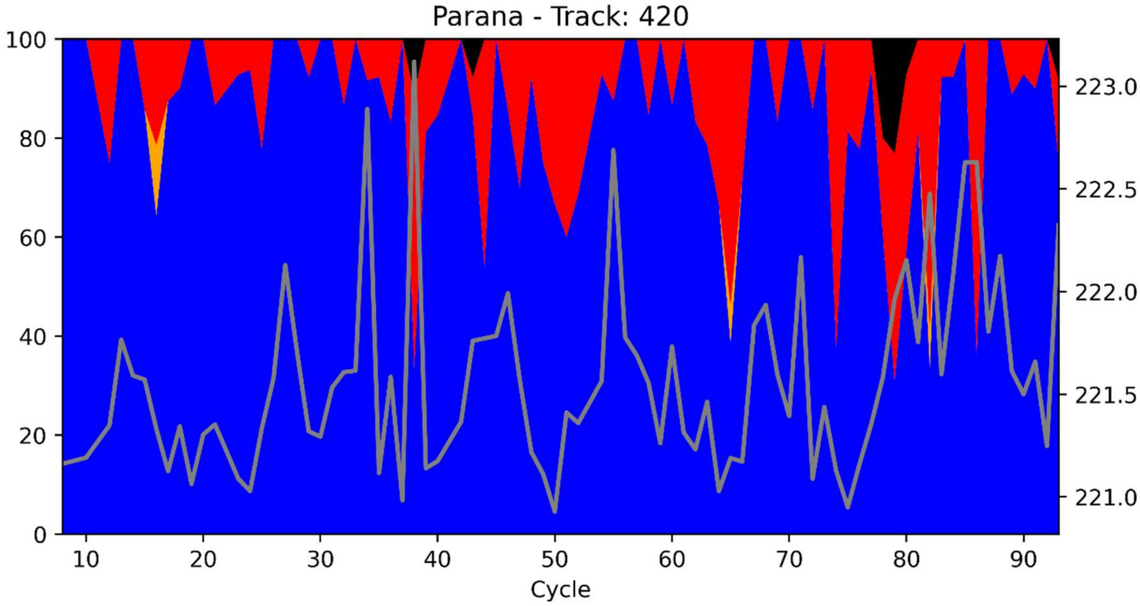


Figure 3-22. ENVISAT. Parana: quality flag per cycle for track 420. Blue: good quality, Orange: medium quality, Red: bad quality and Black: unknow quality

Even if the comparison to GIEMS is less successful, the variation per year shown in Figure 3-23 is in concordance with [RD 2]. In the Parana, the high-water period usually occurs from November/January to May/June

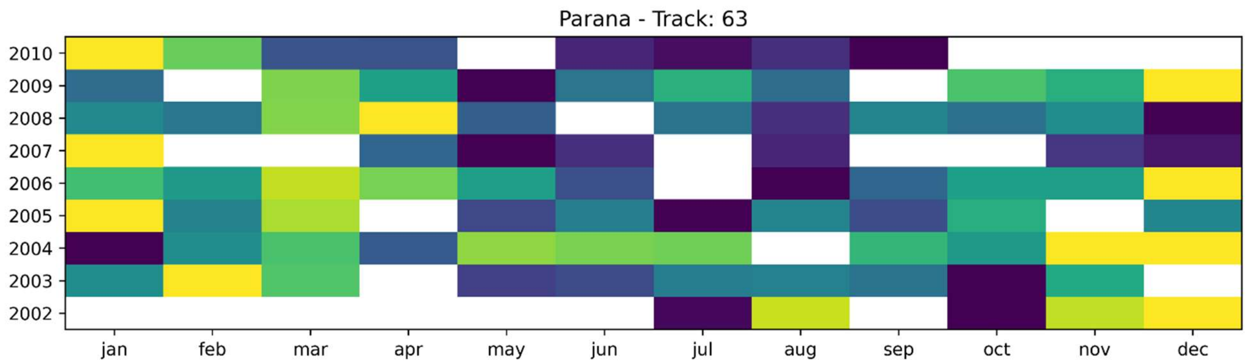


Figure 3-23. ENVISAT. Parana: Normalised water level change per year

3.4.1.3.3 Pantanal

Over Pantanal wetland, the results are not as good as expected. While GIEMS timeseries with flooding area show high seasonality, IW TDP timeseries of water level is very noisy (Figure 3-24) even if the quality of the data based on the waveform classification is good for most of the measurements (Figure 3-25). The most important differences are found when the flooding area is lower. One hypothesis is that backscatter signal is being reflected from surfaces other than water (land contamination). Another characteristic of this large area is its low slope, so that small changes in water level can correspond to large changes on flooding area. Figure 3-26 shows the normalised water level change. In this wetland area located in the Mato Grosso, the well-defined dry season lasts from June to August in the northern part of Mato Grosso, while it lasts from April to October in the southern [RD **7**, RD-3].

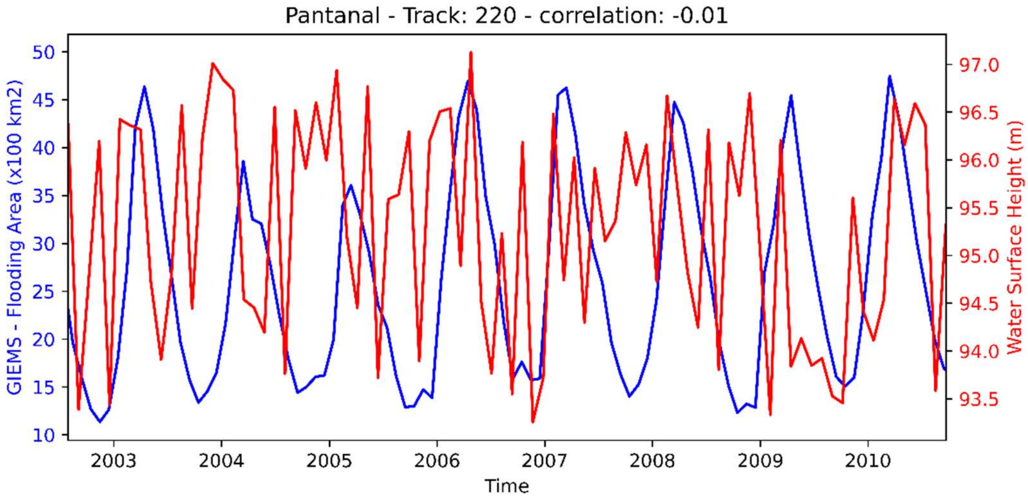


Figure 3-24. ENVISAT. Pantanal: Comparison of timeseries from IW TDP and GIEMS

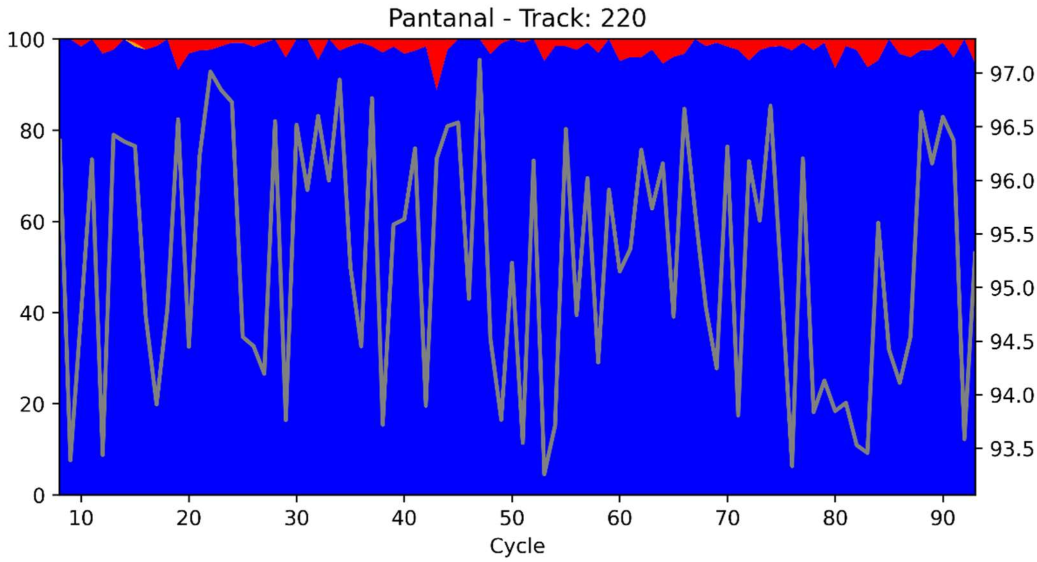


Figure 3-25. ENVISAT. Pantanal: quality flag per cycle for track 220. Blue: good quality, Orange: medium quality, Red: bad quality and Black: unknow quality

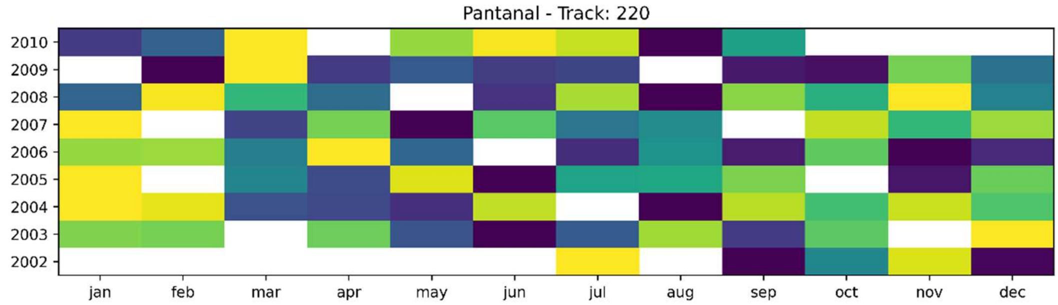


Figure 3-26. ENVISAT. Pantanal: Normalised water level change per year

3.4.1.3.4 Inner Niger Delta

Over the Inner Niger Delta, there is a very good correlation between timeseries from GIEMS and ENVISAT. Figure 3-27 shows the comparison for track 87 with a Pearson Coefficient of 0.89. Bigger differences occur when the water level is low. This is because in those cases the altimetry measurements contain lower quality waveforms as shown in Figure 3-28. Indeed, some humidity zones could affect the backscattered signal. Several patches can also appear generating multi peak waveforms. Moreover, GIEMS resolution (773 km2 cells) may not be sufficient to detected small flooded areas.

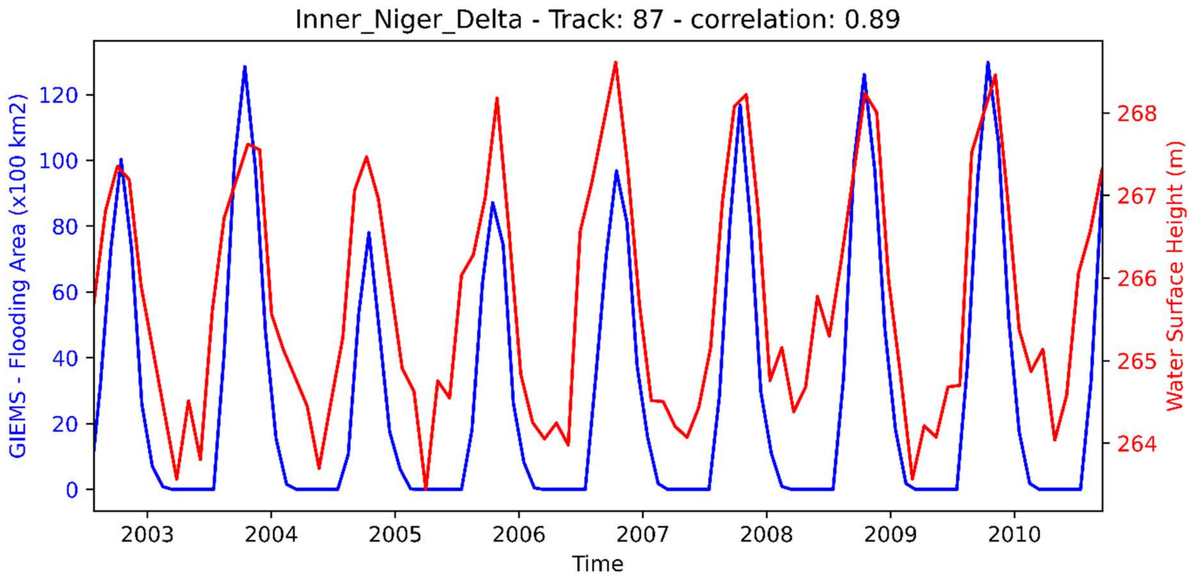


Figure 3-27. ENVISAT. Inner Niger Delta: Comparison of timeseries from IW TDP and GIEMS

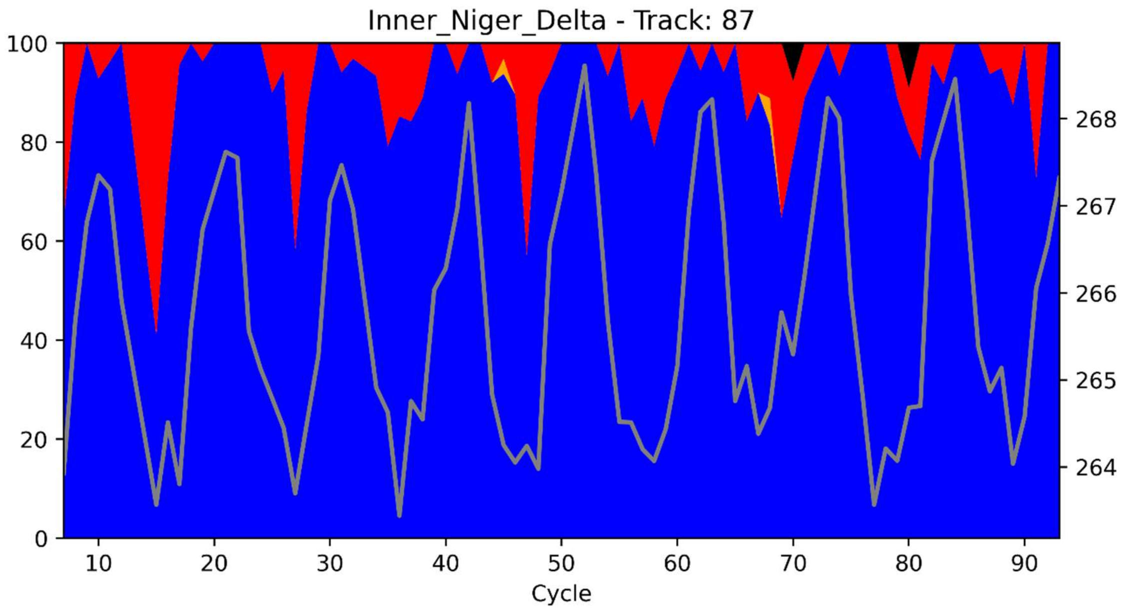


Figure 3-28. ENVISAT. Inner Niger Delta: quality flag per cycle for track 87. Blue: good quality, Orange: medium quality, Red: bad quality and Black: unknow quality

Rain falls on the Niger's headwaters from May to September creating a flood surge that reaches the inland delta in October as it also shown in the Figure 3-29 containing the normalised water level change per year.

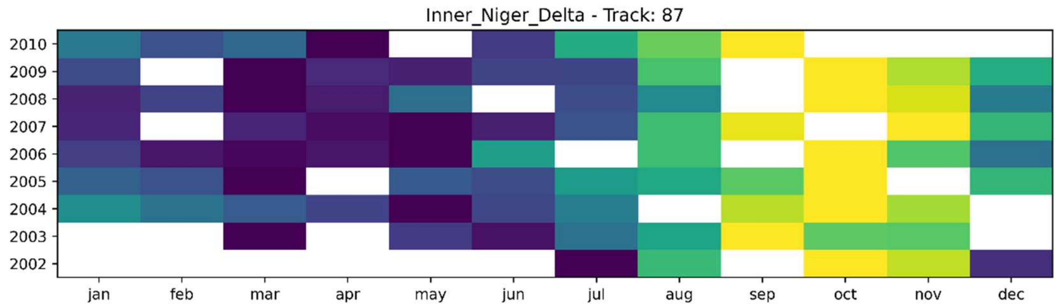


Figure 3-29. ENVISAT. Inner Niger Delta: Normalised water level change per year

3.4.2 ERS-2

3.4.2.1 Absolute assessment

The number of tracks without data over the lifetime of the mission provides information about the availability of data. Figure 3-30 shows the evolution of the percentage of missing tracks per cycle. For most of the cycles, the percentage of tracks without data il lower than 20%. Nevertheless, for three cycles, this value increase to more than 40% with a maximum of 59 % in cycle 60.

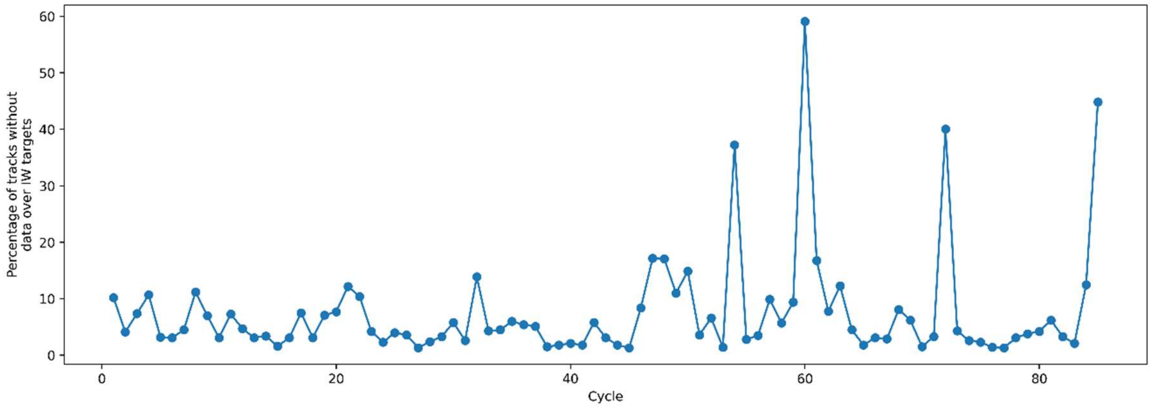


Figure 3-30.ERS-2: Percentage of tracks without data over inland water targets

However, the number of cycles with data is not a sufficient criterion. The number of measurements per cycle (Figure 3-31) and the percentage of invalid data among the measurements (Figure 3-32), give additional information about the amount of data that can be really useful for the estimation of the water level over inland targets. The data are invalid either because the water level could not be estimated or because they were eliminated during the editing process due to a low backscatter coefficient value. As expected, during the winter season, with the reflection from ice and snow, there are fewer measurements and more invalid values.

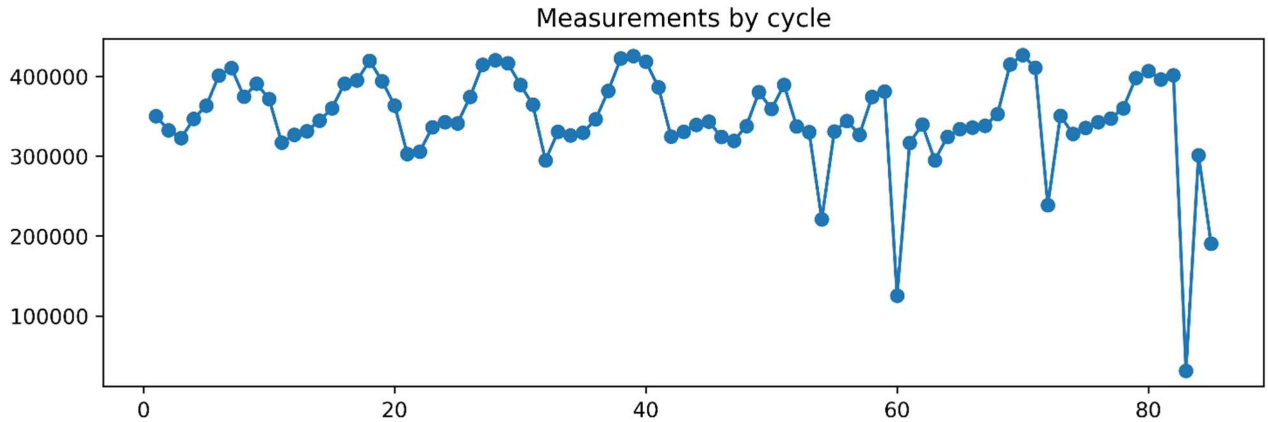


Figure 3-31. ERS-2: Number of measurements by cycle

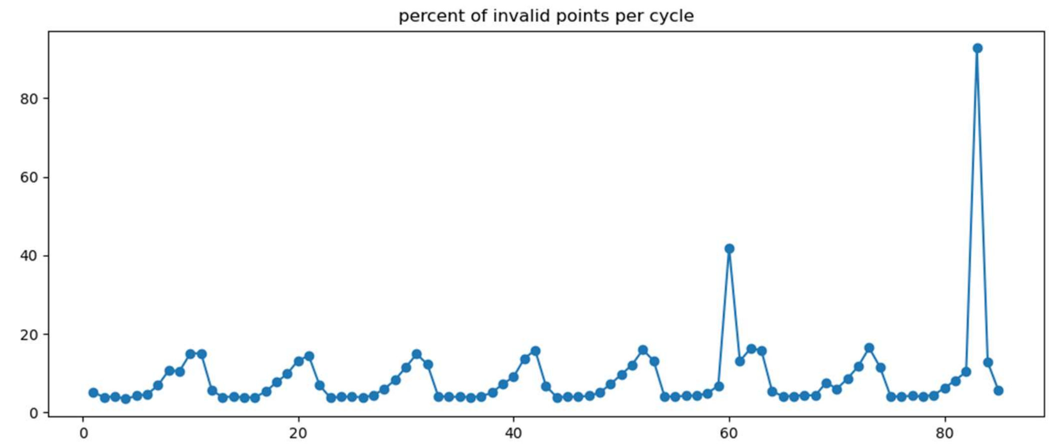
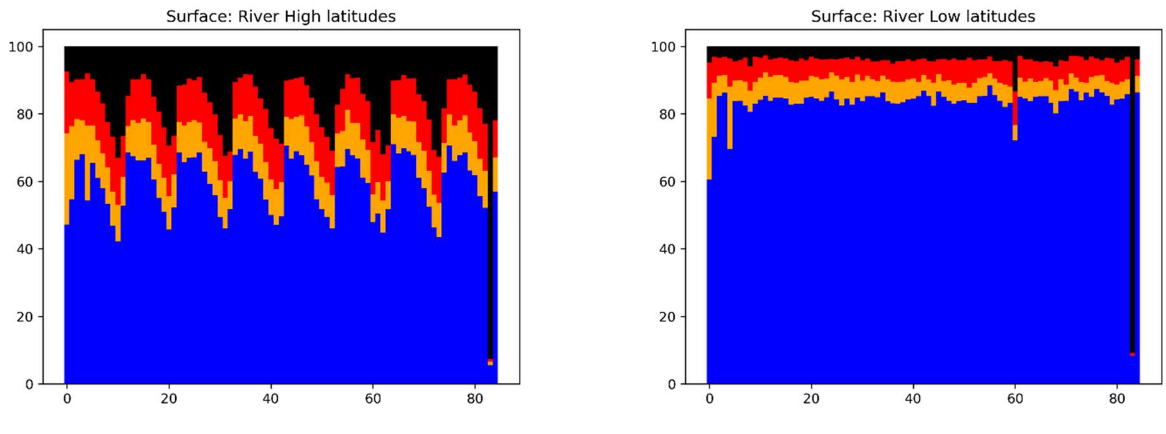


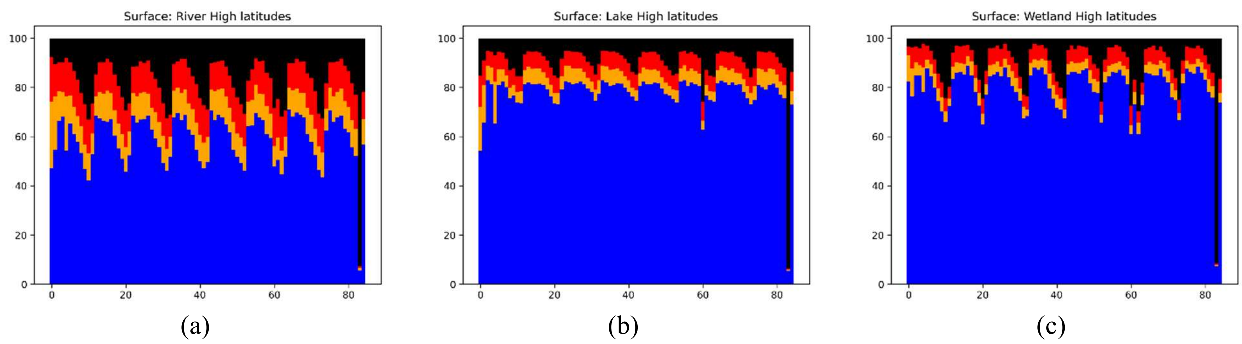
Figure 3-32. ERS-2: Percent of invalid measurements per cycle

Other interesting diagnosis concerns the evaluation of the quality of the data as a function of the inland water surface type: lakes and reservoir, rivers, wetland, floodplains, and remainders. The evolution of the quality measurements per surface type for high latitudes which are impacted by winter season while the ratio per quality flag is almost constant for targets in low latitudes (under 40 degrees north). Figure 3-33 shows for rivers the difference of the evolution of the quality flag over rivers in high/low latitudes and Figure 3-34 the evolution over the different inland water targets in high latitudes.

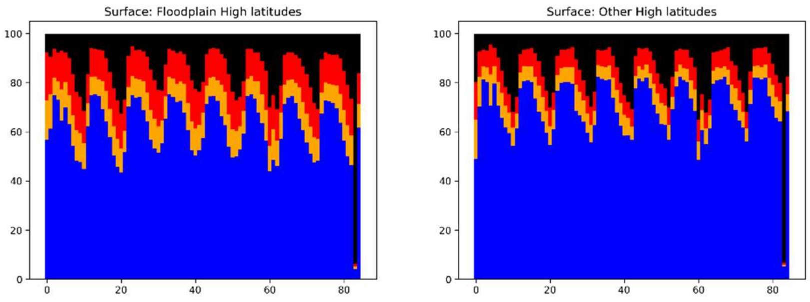


(a) (b)

Figure 3-33. ERS-2: Evolution of the quality of the measurement per cycle over rivers for (a) high latitudes (northern than 40 degrees North) and (b) low latitudes (southern than 40 degrees north)



(a) (b) (c)



(d) (e)

Blue: good quality

Orange: medium quality

Red: bad quality

Black: unknown quality

Figure 3-34. ERS-2: Evolution of the quality of the measurements per cycle and surface type at high latitudes (a) River (b) Lakes (c) Wetland (d) Floodplain and (e) other types

3.4.2.2 River

Po river

Herein after the results related to the validation of the TDP product over the Po river are presented. For sake of the comparison the same figures illustrated for the ENVISAT TDP are here repeated for the ERS-2 TDP. The performances in terms of RMSE (m) are summarized in Figure xx1, where the triangles indicate the position of the VS, different triangles colours indicate different ranges for RMSE and the orientation of triangles indicates the *in situ* station (upstream or downstream) with respect to the RMSE is evaluated. Boxplot inside Figure 3-35 summarizes the RMSE values for all the VS and in situ stations.

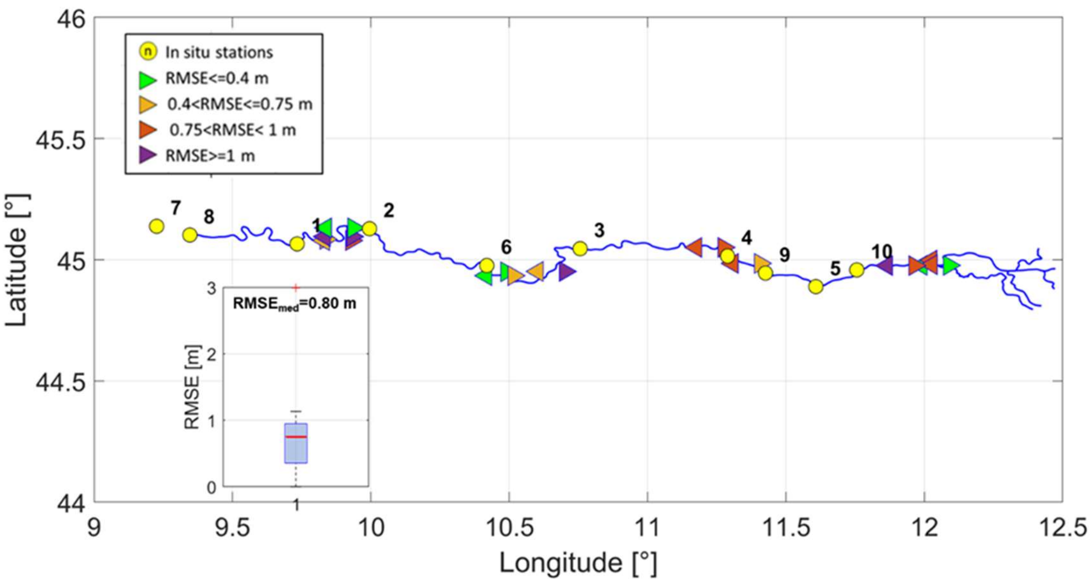


Figure 3-35 : RMSE values for the VS located along the Po river. Different triangles colours identify different ranges for the RMSE values, the triangles orientation identifies the gauging station with respect to the RMSE has been computed. The boxplot summaries the RMSE values for all the VS.

Looking at Figure 3-35 it can be noted that the RMSE values for most of the VSs range between 0.4 m and 0.75 m, four VSs show RMSE values higher than 1 m, whereas six VSs is in good agreement with respect to *in situ* data with RMSE lower than 0.4 m. In general, the median RMSE value is equal to 0.80 m.

As an example, Figure 3-36 illustrates the comparison between altimetry and observed water levels for two stations along the Po River, Casalmaggiore and Polesella. The water levels provided by the VS over the track 588 does not represent the *in-situ* observations at Casalmaggiore, having only few observations over the station. Better performances are obtained at the VS over the track 502 with respect to the *in-situ* data at Polesella. Here the RMSE value is equal to 1.12 m.

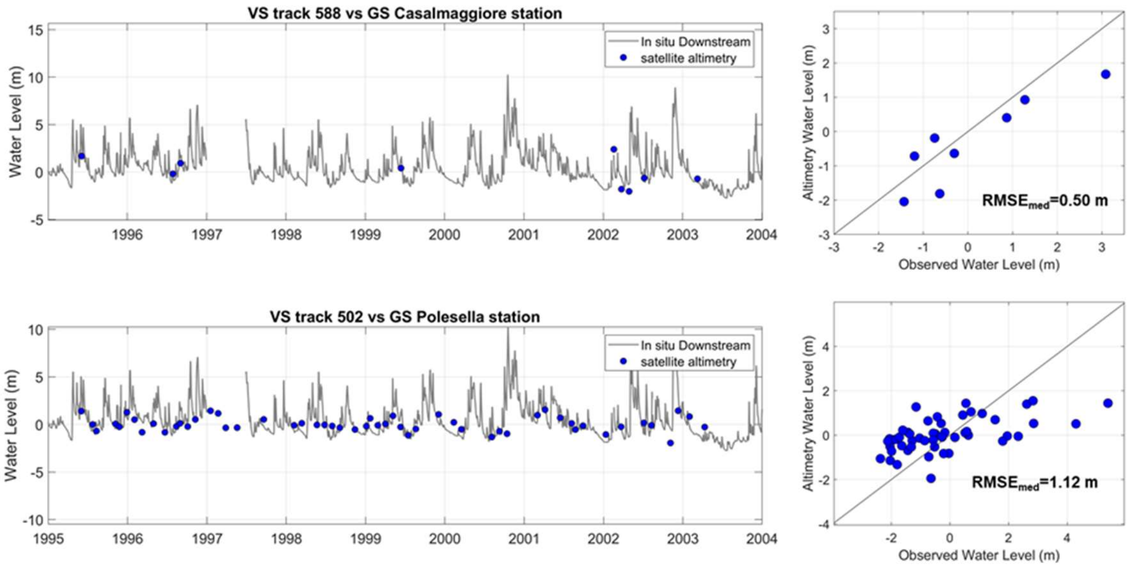


Figure 3-36 : Comparison between altimetry and observed water levels for two stations along the Po River, Casalmaggiore and Polesella. The plots on the left show a temporal comparison, the plots on the right show scatterplots.

The ERS-2 TDP data cannot be compared with external datasets as neither DAHITI nor River&Lake take ERS-2 data into account to elaborate long water level data.

Amazon river

For the Amazon River, the performances in terms of RMSE (m) are summarized in Figure 3-37, where the same notation used in Figure 3-35 is applied. For the Amazon River, the RMSE values for most of the VS are higher than 1 m, especially for the VS located upstream the *in-situ* station 4 (Manacapuru, see Table 11). The performances improve for the VS located over around the *in-situ* station 3 (Serrinha, see Table 11) over the Negro river and for the VS located near the *in-situ* station 5 (Obidos station, see Table 11). On overall, the median RMSE value for both upstream and downstream sections is equal to 1.68 m.

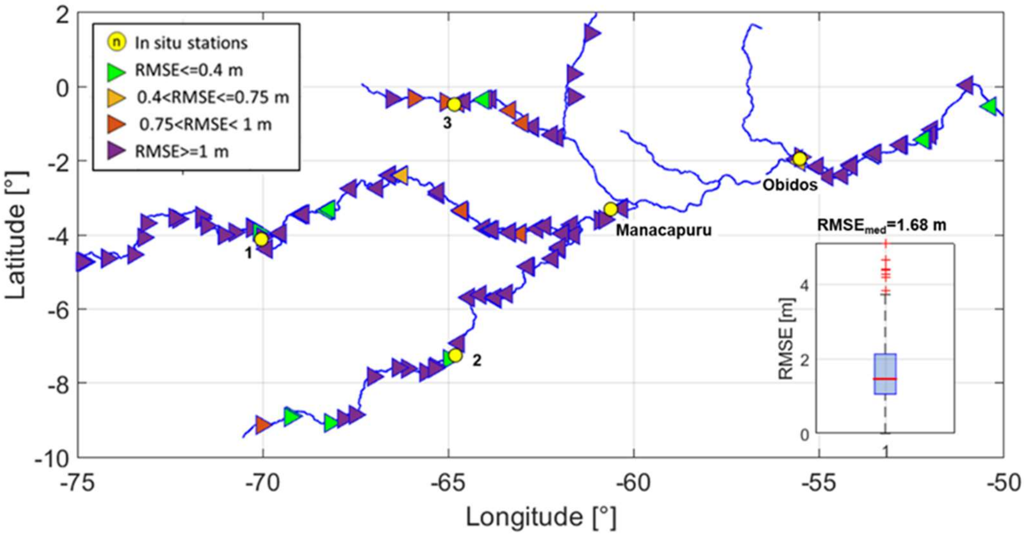


Figure 3-37 : RMSE values for the VS located along the Amazon River. Different triangles colours identify different ranges for the RMSE values, the triangles orientation identifies the gauging station with respect to the RMSE has been computed. The boxplot summaries the RMSE values for all the VS

Figure 3-38 shows the temporal comparison between altimetry and observed water levels for three stations along the Amazon River, Labrea, Serrinha and Obidos. The water levels provided by the VS over the track 865 are sparse and does not follow the *in-situ* observations at Labrea, showing a quite high RMSE value equal to 2.90 m. Better performances are obtained at the VS over the track 822 with respect to the *in situ* data at Serrinha. Here the RMSE value is equal to 0.80 m. Similar behaviour can be observed between the VS over the track 349 and the *in situ* data at Obidos station. Here the RMSE value is equal to 1.13 m.

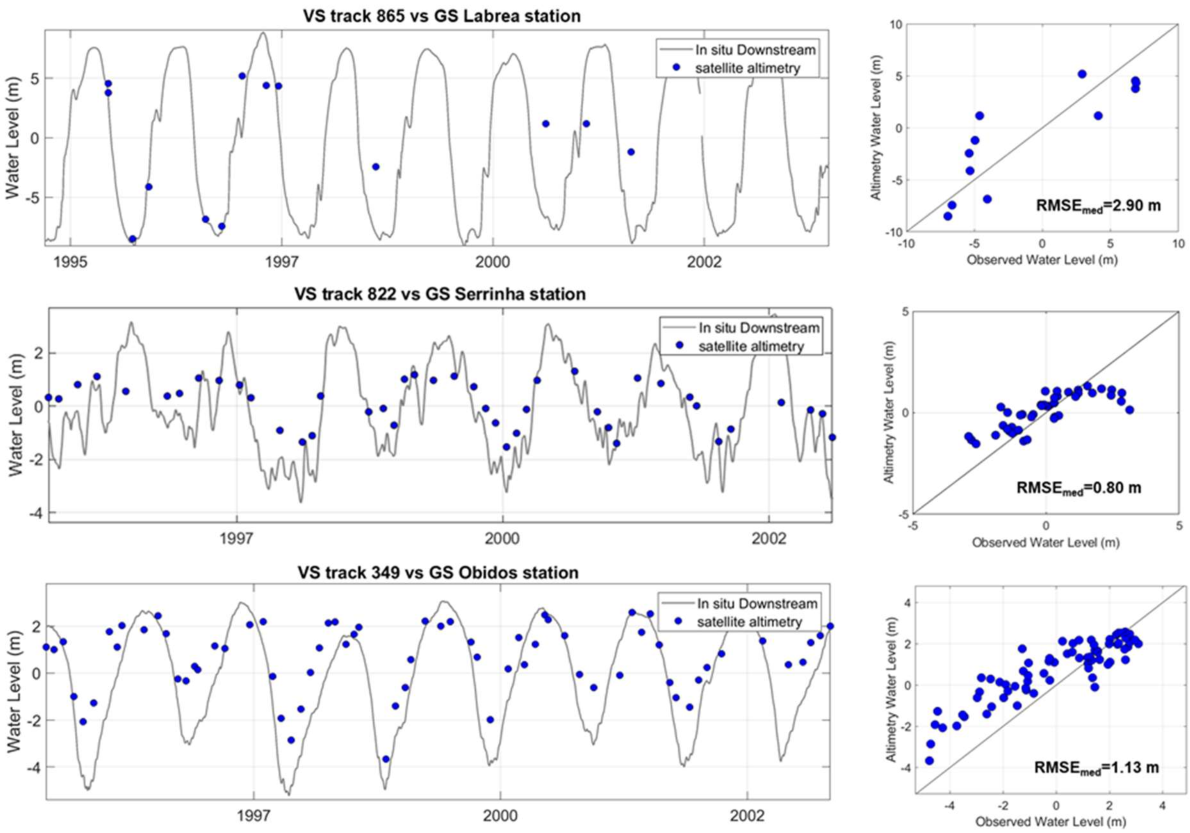


Figure 3-38 : Comparison between altimetry and observed water levels for three stations along the Amazon river, Labrea, Serrinha and Obidos. The plots on the left show a temporal comparison; the plots on the right show scatterplots.

The ERS-2 TDP data cannot be compared with external datasets as neither DAHITI nor River&Lake take ERS-2 data into account to elaborate long water level data.

Godavari river

The performances in terms of RMSE (m) are summarized in Figure 3-39, where the same notation used in Figure 3-35 is applied. Along the Godavari River, there are several VS with RMSE values lower than 0.4 m, especially over the west part of the river whereas the performances decreases moving towards the river mouth. On overall, the median RMSE value is equal to 0.85 m.

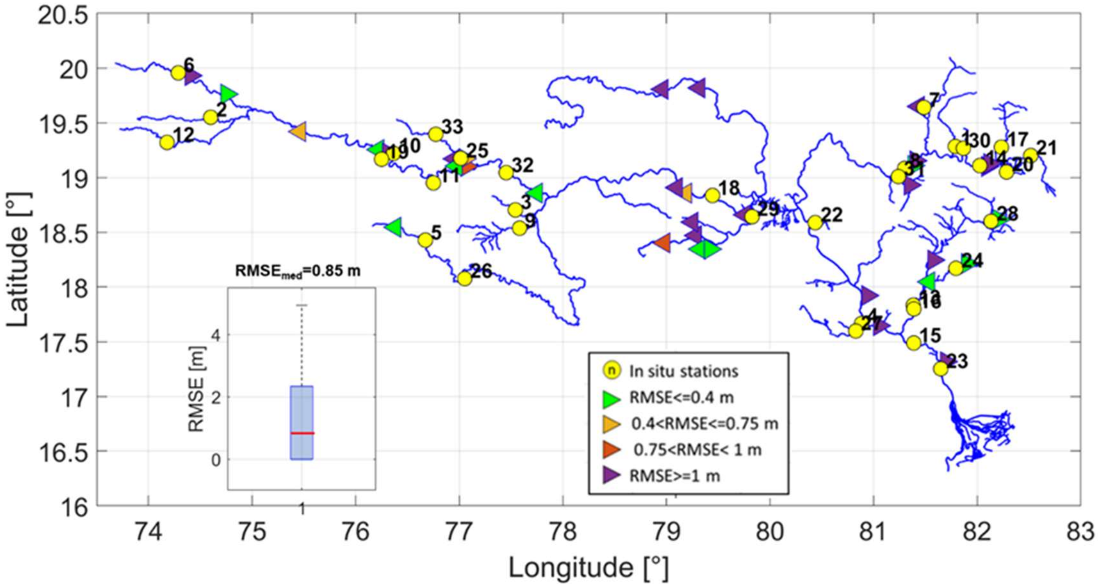


Figure 3-39 : RMSE values for the VS located along the Godavari River. Different triangles colours identify different ranges for the RMSE values, the triangles orientation identifies the gauging station with respect to the RMSE has been computed. The boxplot summaries the RMSE values for all the VS.

Figure 3-40 shows the temporal comparison between altimetry and observed water levels for one station along the Godavari River, Mancherial. The water levels provided by the VS over the tracks 26 follow quite well in situ observations. The RMSE value is equal to 0.83 m.

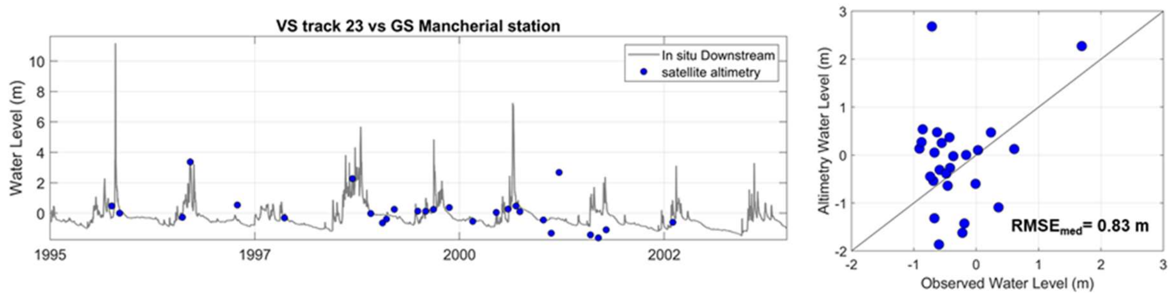


Figure 3-40 : Comparison between altimetry and observed water levels for one station along the Godavari river, Mancherial. The plot on the left shows a temporal comparison, the plot on the right shows scatterplot.

The ERS-2 TDP data cannot be compared with external datasets as neither DAHITI nor River&Lake take ERS-2 data into account to elaborate long water level data.

3.4.2.3 Floodplains and wetlands

3.4.2.3.1 Obidos

Figure 3-41 shows the comparison over Obidos floodplain of the time series of track 349 estimated with ERS-2 measurements and the timeseries estimated using GIEMS data. Since the GIEMS data are provided on a monthly basis, the IW TDP data was averaged at the same temporal resolution. The time series exhibits a marked level of seasonality and the correlation between the two time series is also very high (0.91). Figure 3-42 shows the evolution of the quality flag per cycle for track 306. More than 60% of the measurements per cycle are good level of quality.

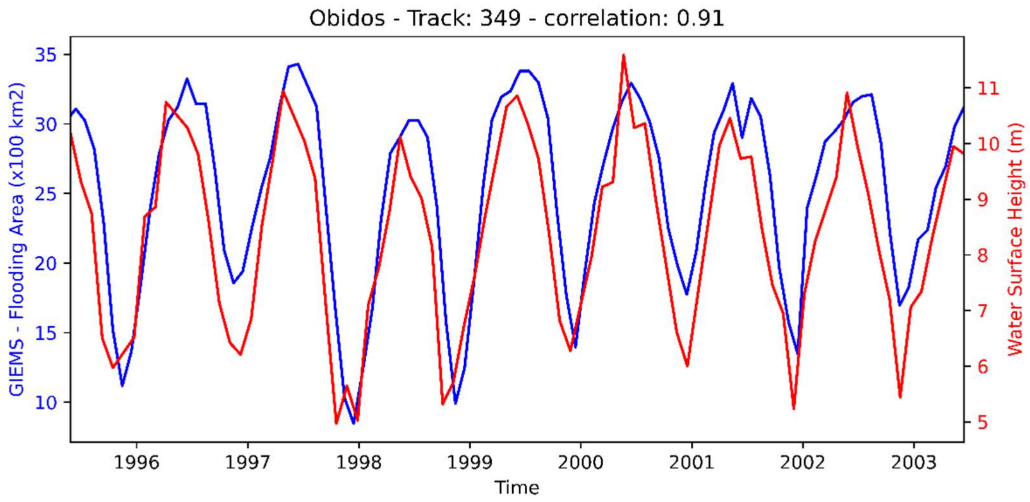


Figure 3-41. ERS-2. Obidos: Comparison of timeseries from IW TDP and GIEMS

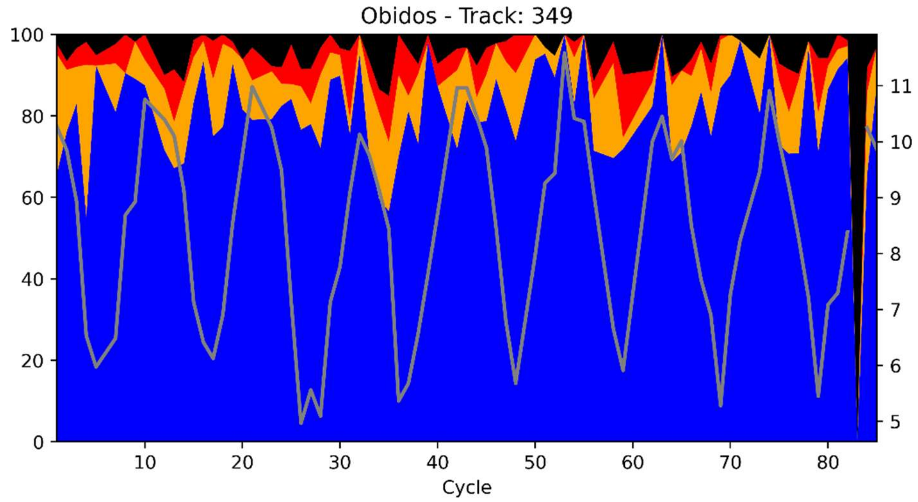


Figure 3-42. ERS-2. Obidos: quality flag per cycle for track 306. Blue: good quality, Orange: medium quality, Red: bad quality and Black: unknow quality

The evolution of the normalised water level variation over the year for the period 1995-2003 is shown in Figure 3-43 . Yellow indicates high water level values and blue low water level values. White boxes indicate that not data is available in the IW TDP.

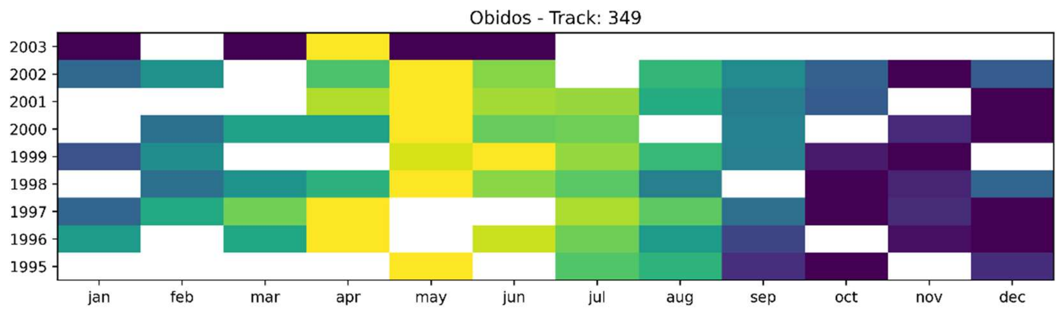


Figure 3-43. ERS-2. Obidos: Normalised water level change per year

3.4.2.3.2 Parana

Figure shows the comparison of the time series of track 63 over the Parana floodplain in the IW TDP and the GIEMS data. The Pearson coefficient is low (0.16) indicating a poor correspondence. Indeed, the landscape of Parana floodplain is very complex (Figure 3-45) with some parts of the region containing muddy sediment, small channels and past channels resulting in a high number of bad quality measurements for some cycles (Figure 3-46).

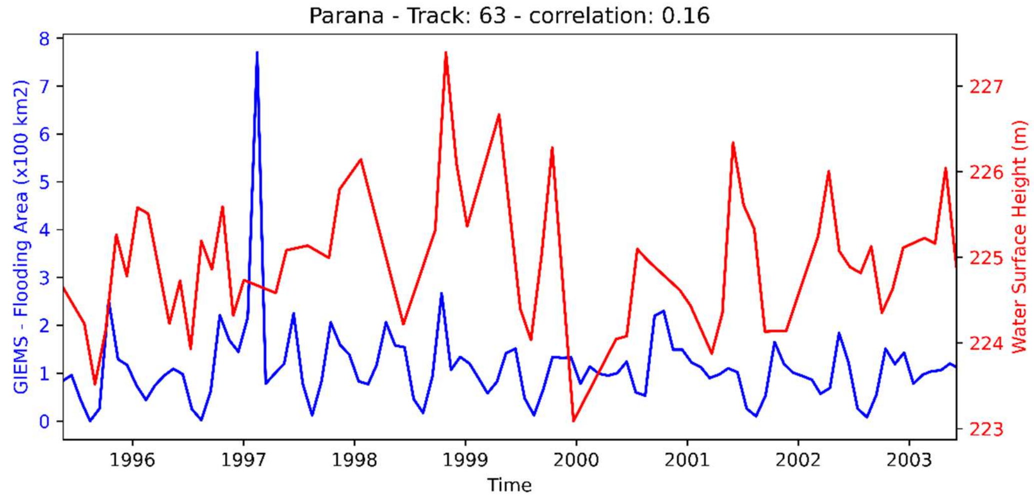


Figure 3-44. ERS-2. Parana: Comparison of timeseries from IW TDP and GIEMS

Figure 3-45. Zoom on Parana landscape. Credit Earth Observatory – NASA

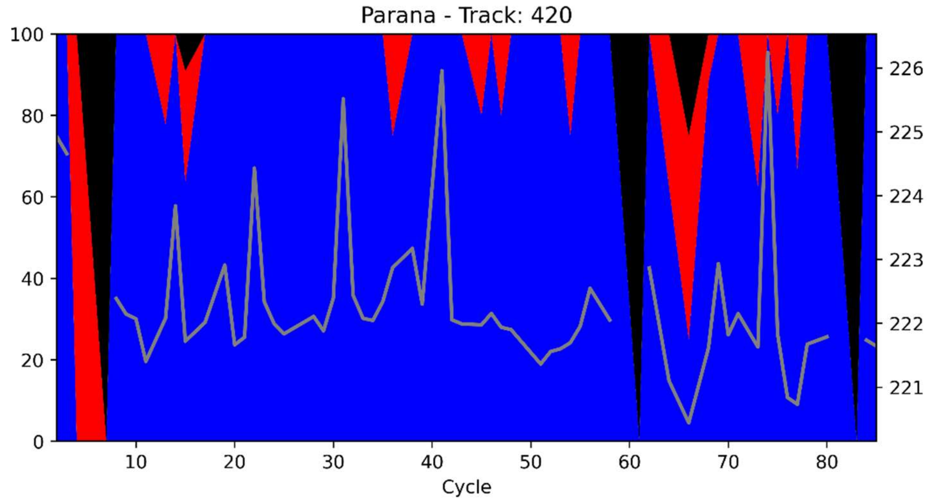


Figure 3-46. ERS-2. Parana: quality flag per cycle for track 420. Blue: good quality, Orange: medium quality, Red: bad quality and Black: unknow quality

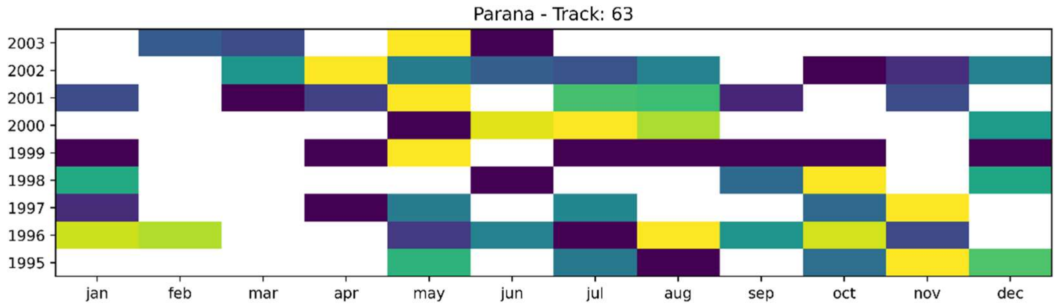


Figure 3-47. ERS-2. Parana: Normalised water level change per year

3.4.2.3.3 Pantanal

Over Pantanal wetland, similar to ENVISAT, the ERS-2 results are not as good as expected and the IW TDP timeseries of water level is very noisy (Figure 3-48) even if the quality of the data based on the waveform classification is good for most of 90% of the measurements (Figure 3-49). The most important differences are found when the flooding area is lower. Figure 3-50 shows the normalised water level change. In this wetland area located in the Mato Grosso, the well-defined dry season lasts from June to August in the northern part of Mato Grosso, while it lasts from April to October in the southern [RD **7**, RD-3].

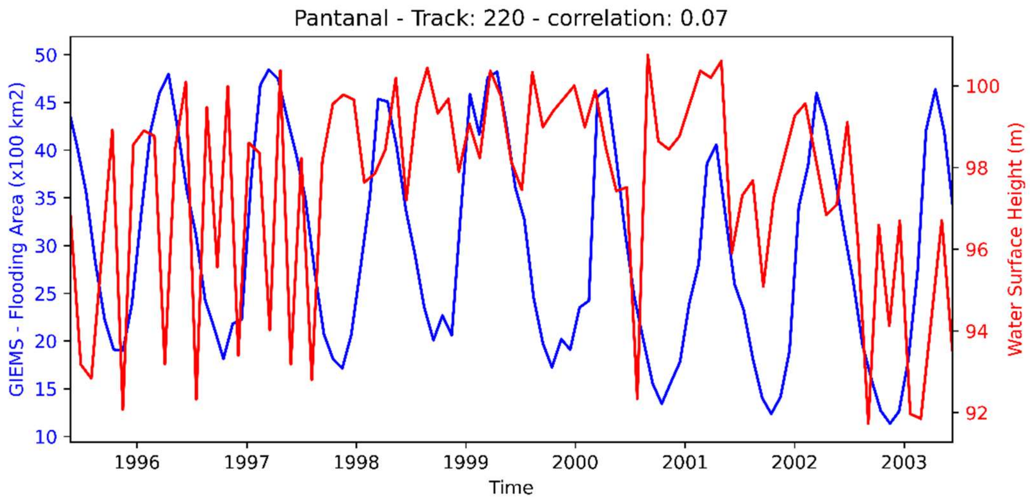


Figure 3-48. ERS-2. Pantanal: Comparison of timeseries from IW TDP and GIEMS

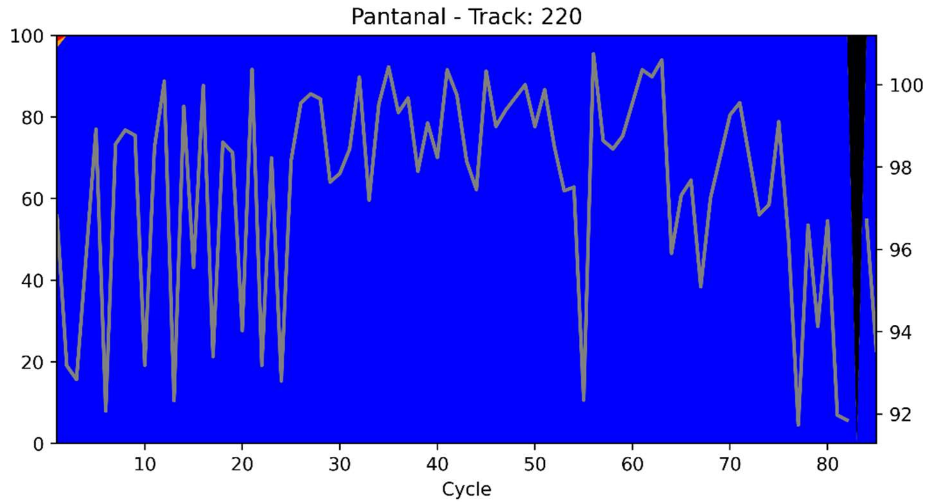


Figure 3-49. ERS-2. Pantanal: quality flag per cycle for track 220. Blue: good quality, Orange: medium quality, Red: bad quality and Black: unknow quality

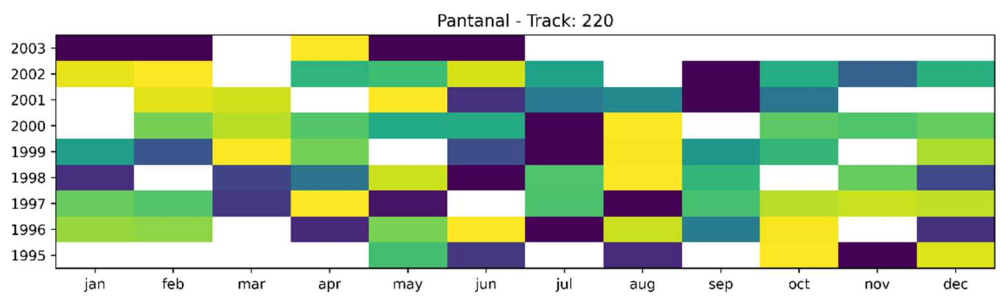


Figure 3-50. ERS-2. Pantanal: Normalised water level change per year

3.4.2.3.4 Inner Niger Delta

Time series based on ERS-2 , track 87 measurements, exhibits a poor correlation compared to time series based on GIEMS datasets (Figure 3-51) even if most of the measurements correspond to an inland water as indicted by the good quality flag(Figure)

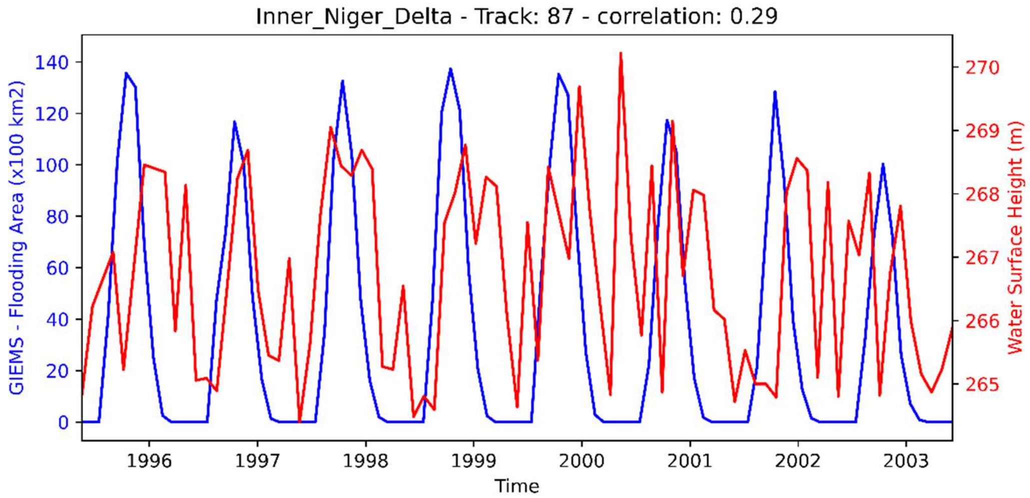


Figure 3-51. ERS-2. Inner Niger Delta: Comparison of timeseries from IW TDP and GIEMS

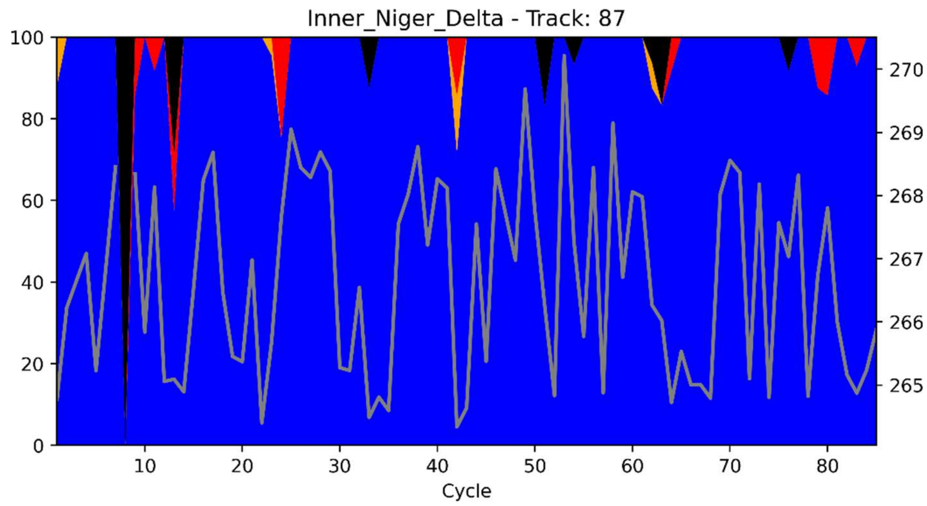


Figure 3-52. ERS-2. Inner Niger Delta: quality flag per cycle for track 220. Blue: good quality, Orange: medium quality, Red: bad quality and Black: unknow quality

3.4.3 ERS-1

3.4.3.1 Absolute assessment

ERS-1 is a complex mission with multiple phases and different repetition cycles: 3 days (86 tracks), 35 days (1002 tracks) and 168 days, as described in the Product User Guide ([D-5-03]). This document shows the evaluation during the phases with 1002 tracks: cycles 83-100 and 145-156. Figure 3-53 shows the percentage of tracks without data while Figure 3-54 shows the percentage of invalid measurements per cycle. The percentage of missing tracks is always less than 20%. The number of cycles is not high enough to detect the seasonal variation clearly visible in ERS1 or ENVISAT, but an increase in the number of invalid values is observed at the end of the mission.

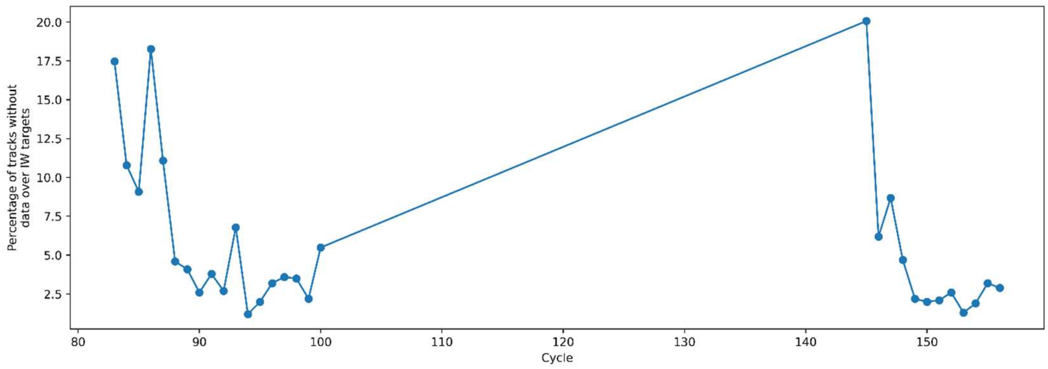


Figure 3-53 ERS-1: Percentage of tracks without data over inland water targets

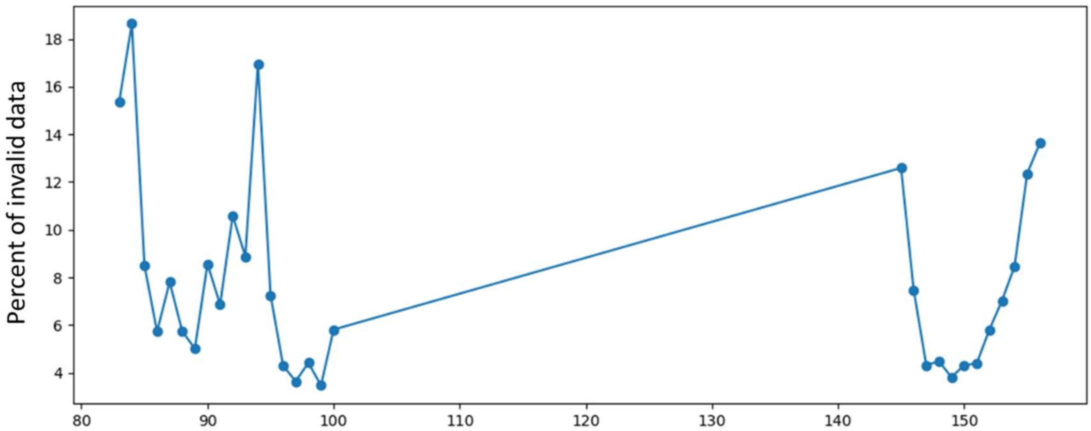


Figure 3-54. ERS-1: Percent of invalid measurements per cycle

As for ENVISAT and ERS-2 missions, the quality of the data is impacted by the seasons in high latitudes. Figure 3-55 shows the evolution over the different inland water targets in high latitudes for cycles with 1002 tracks.

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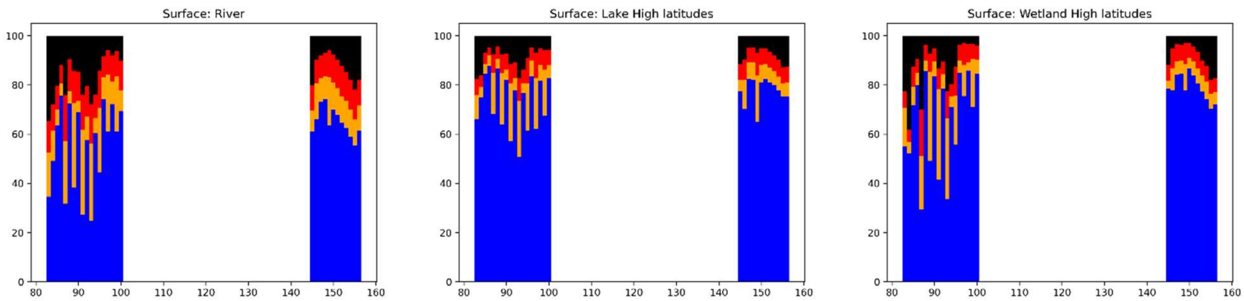
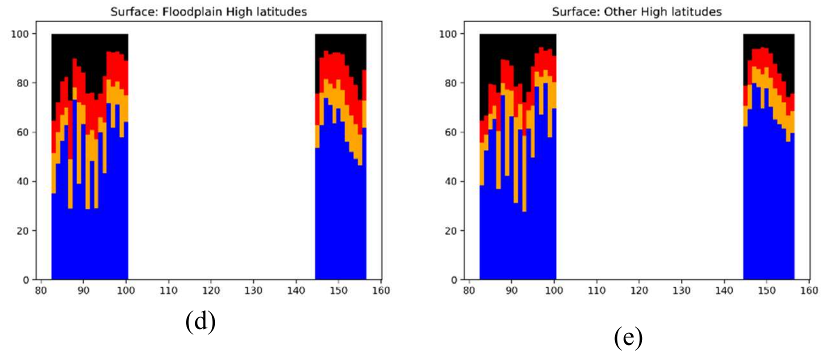


(a) (b) (c)



Blue: good quality

Orange: medium quality

Red: bad quality

Black: unknown quality

Figure 3-55. ERS-1: Evolution of the quality of the measurements per cycle and surface type at high latitudes (a) River (b) Lakes (c) Wetland (d) Floodplain and (e) other types

3.4.3.2 River

Po river

Herein after the results related to the validation of the TDP product over the Po river are presented. For sake of the comparison the same figures illustrated for the ENVISAT and ERS2 TDP are here repeated for the ERS-1 TDP. The performances in terms of RMSE (m) are summarized in Figure 3-56, where the triangles indicate the position of the VS, different triangles colours indicate different ranges for RMSE and the orientation of triangles indicates the *in situ* station (upstream or downstream) with respect to the RMSE is evaluated. Boxplot inside Figure 3-56 summarizes the RMSE values for all the VS and *in situ* stations.

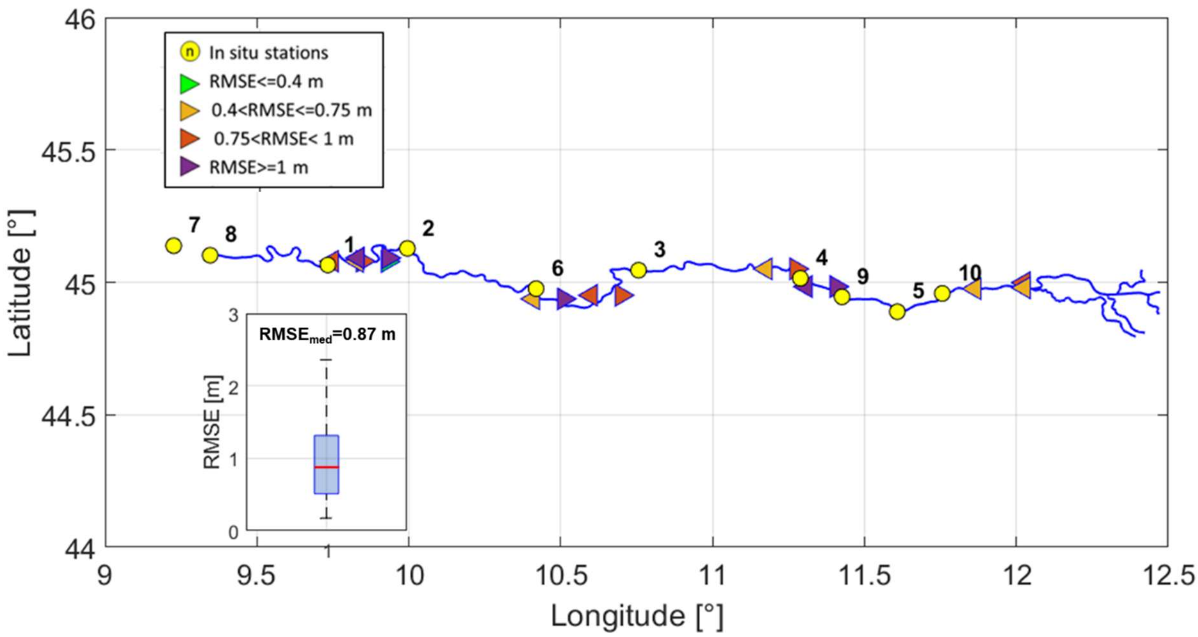


Figure 3-56 : RMSE values for the VS located along the Po river. Different triangles colours identify different ranges for the RMSE values, the triangles orientation identifies the gauging station with respect to the RMSE has been computed. The boxplot summaries the RMSE values for all the VS.

Looking at Figure 3-56 it can be noted that the RMSE values for most of the VSs range between 0.4 m and 0.75 m, whereas for most the VSs the RMSE is greater than 0.75 m. In general, the median RMSE value is equal to 0.87 m. It has to be noted that, with respect to the ENVISAT TPD validation, for the ERS-1 validation, some tracks consider a lower number of *in situ* data as for some stations observations before the year 1995 are not available.

As an example, Figure 3-57 illustrates the comparison between altimetry and observed water levels for two stations along the Po River, Casalmaggiore and Polesella. The VS over the track 588 provides few observations in the period 1993-1994 and 1995 which follow the data recorded at Casalmaggiore station with a RMSE equal to 1.47 m. Similar considerations can be drawn for the track 502 with respect to the *in-situ* data at Polesella. Here the RMSE value is equal to 0.48 m.

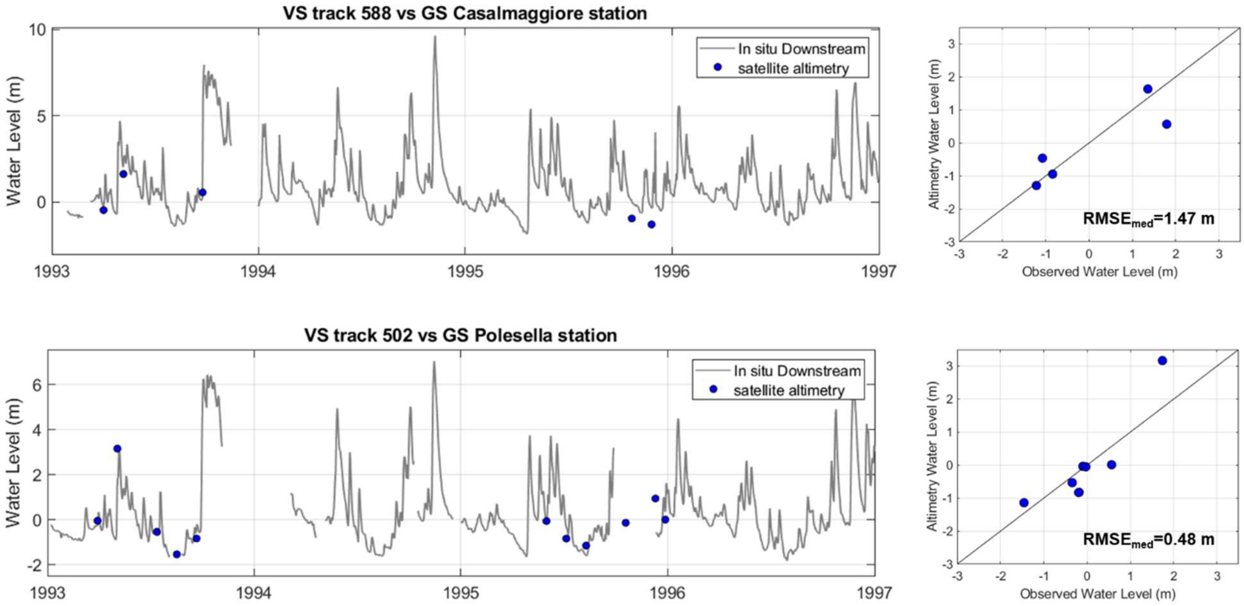


Figure 3-57 : Comparison between altimetry and observed water levels for two stations along the Po River, Casalmaggiore and Polesella. The plots on the left show a temporal comparison, the plots on the right show scatterplots.

Similar to the ERS-2, the ERS-1 TDP data cannot be compared with external datasets as neither DAHITI nor River&Lake take ERS-1 data into account to elaborate long water level data.

Amazon river

For the Amazon River, the performances in terms of RMSE (m) are summarized in Figure 3-46, where the same notation used in Figure 4-138 is applied. For the Amazon River, the RMSE values for almost all the VS are higher than 1 m. We have to note that, due to the observation period of ERS-1 period, only few *in situ* observations data are available and the results in terms of RMSE are linked to this aspect. On overall, the median RMSE value for both upstream and downstream sections is equal to 1.40 m.

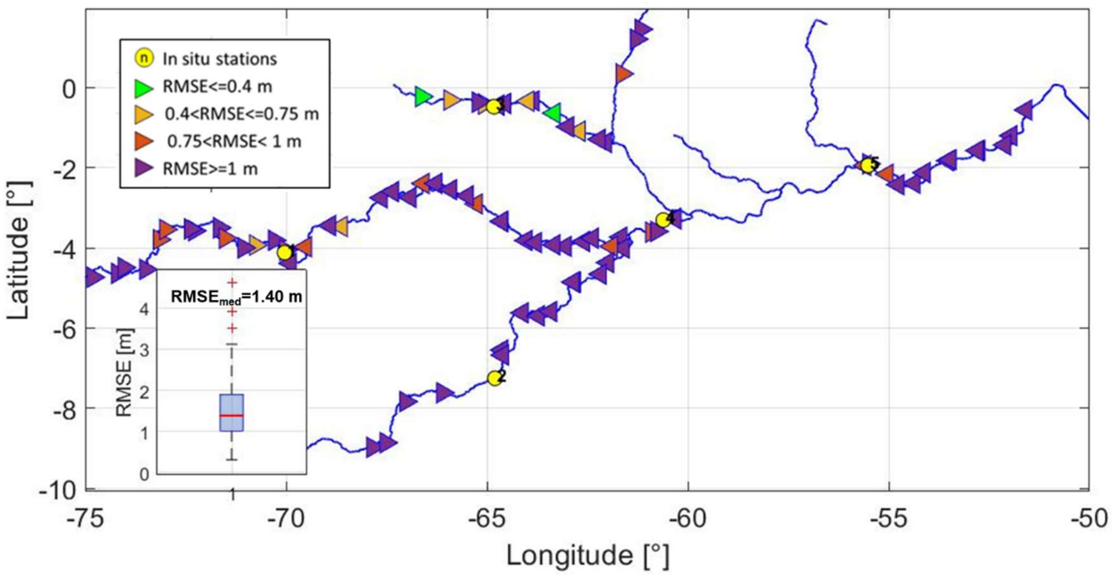


Figure 3-58 : RMSE values for the VS located along the Amazon River. Different triangles colours identify different ranges for the RMSE values, the triangles orientation identifies the gauging station with respect to the RMSE has been computed. The boxplot summaries the RMSE values for all the VS

Figure 3-59 shows the temporal comparison between altimetry and observed water levels for three stations along the Amazon River, Labrea, Serrinha and Obidos. The water levels provided by the VS over the track 865 are sparse and does not follow the *in-situ* observations at Labrea, showing a quite high RMSE value equal to 5.60 m. Better performances are obtained at the VS over the track 822 with respect to the *in situ* data at Serrinha. Here the RMSE value is equal to 0.52 m. Similar behaviour can be observed between the VS over the track 349 and the *in situ* data at Obidos station. Here the RMSE value is equal to 0.90 m.

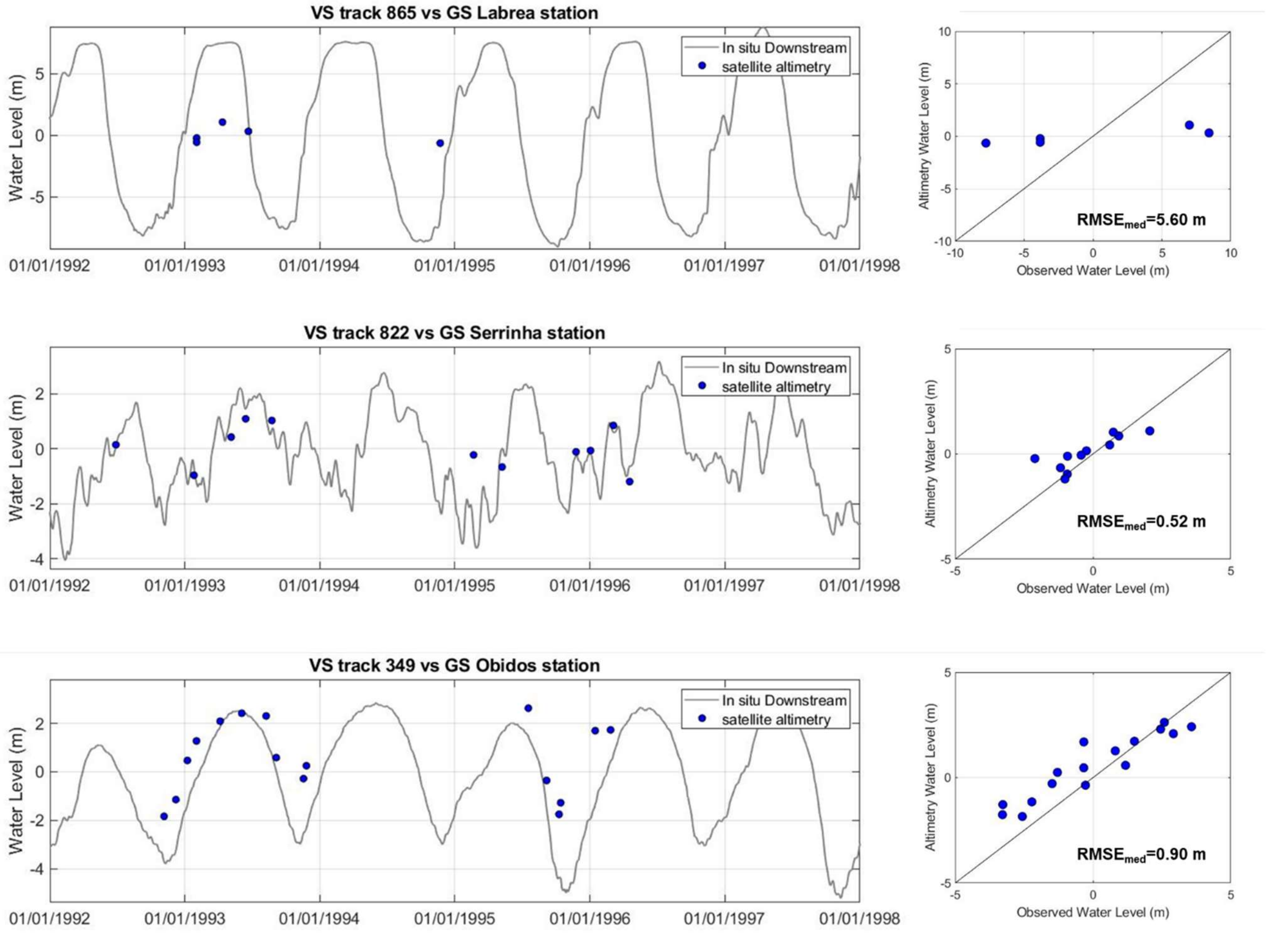


Figure 3-59 : Comparison between altimetry and observed water levels for three stations along the Amazon river, Labrea, Serrinha and Obidos. The plots on the left show a temporal comparison; the plots on the right show scatterplots.

The ERS-1 TDP data cannot be compared with external datasets as neither DAHITI nor River&Lake take ERS-1 data into account to elaborate long water level data.

Godavari river

The performances in terms of RMSE (m) are summarized in Figure 3-48, where the same notation used in Figure 3-35 is applied. Along the Godavari River, only few VS can be compared against *in situ* data due both to the lack of water level observation in the ERS-1 period and to the lack of good altimetry data (data with quality flag lower than 2). The analyzed VS show RMSE values greater than 0.4 m. On overall, the median RMSE value is equal to 2.35 m.

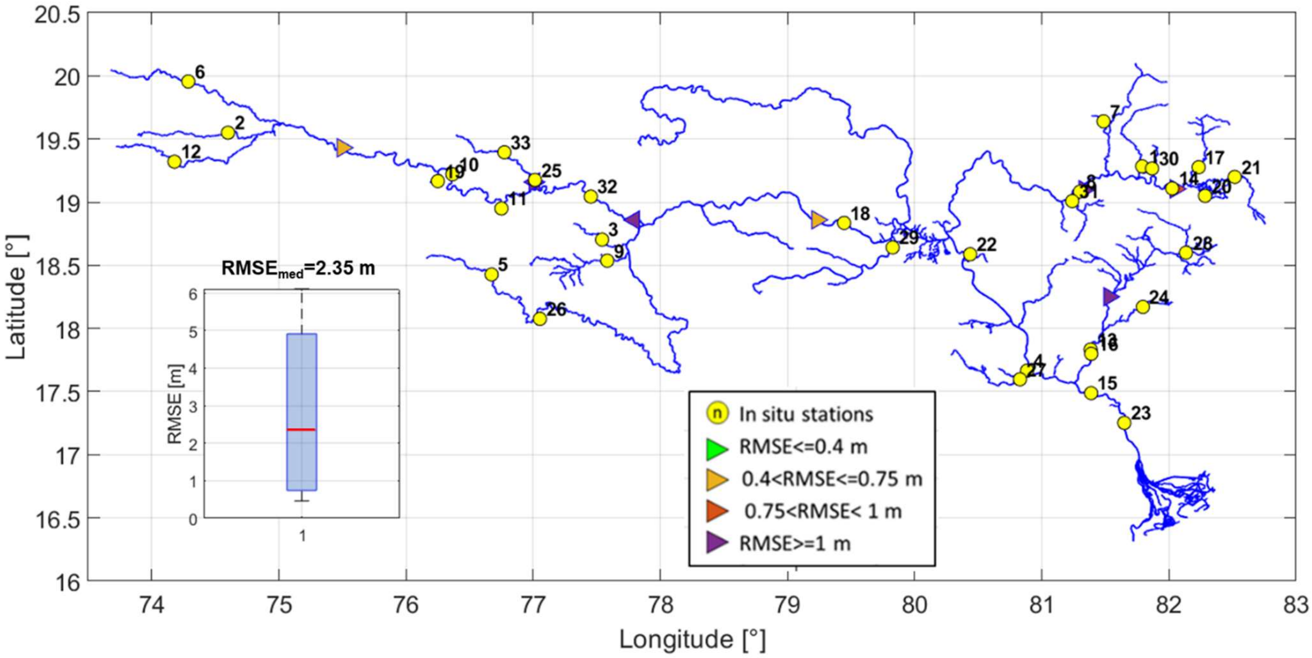


Figure 3-60 : RMSE values for the VS located along the Godavari River. Different triangles colours identify different ranges for the RMSE values, the triangles orientation identifies the gauging station with respect to the RMSE has been computed. The boxplot summaries the RMSE values for all the VS.

Figure 3-61 shows the temporal comparison between altimetry and observed water levels for one station along the Godavari River, Mancherial. The water levels provided by the VS over the tracks 23 follow quite well *in situ* observations. The RMSE value is equal to 0.62 m.

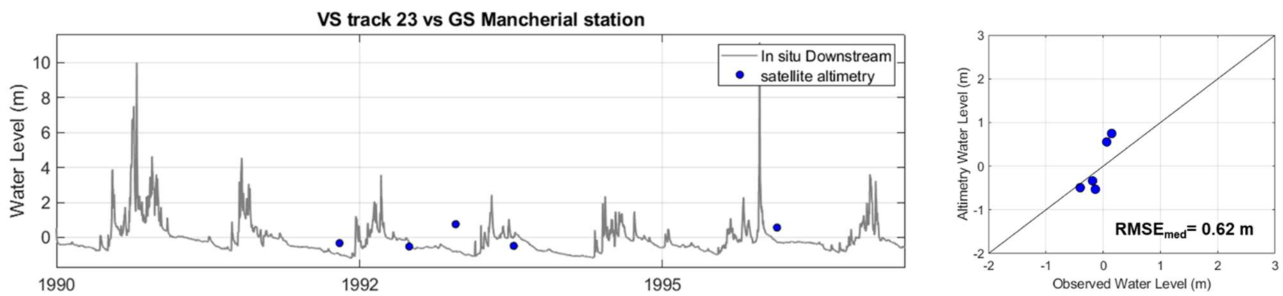


Figure 3-61 : Comparison between altimetry and observed water levels for one station along the Godavari river, Mancherial. The plot on the left shows a temporal comparison, the plot on the right shows scatterplot.

The ERS-1 TDP data cannot be compared with external datasets as neither DAHITI nor River&Lake take ERS-1 data into account to elaborate long water level data.

3.4.3.3 Floodplains and wetlands

Comparison with ERS-1 data is not always obvious, due to the multiple phases of the mission with a variable number of tracks per cycle as described in the Roadmap &Product Summary Document (CLS-ENV-NT-19-0561)

The external dataset for the comparison of measurements over floodplains and wetlands is GIEMS. The comparison is evaluated during the ERS-1 phases with 1002 tracks per cycle: years 1992-1993 (cycle 83 – cycle 100) and 1995-1996 (cycle 145-156).

3.4.3.3.1 Obidos

Figure 3-62 shows the comparison over Obidos floodplain of the time series, on a monthly basis, of track 349 estimated with ERS-1 measurements and the timeseries estimated using GIEMS data. The time series shows a high degree of seasonality and the correlation between the two time series is also very high (0.90). Figure 3-63 shows the evolution of the quality flag per cycle for track 349. It is necessary to keep in mind that the duration of the ERS-1 mission cycles depends on the mission phases.

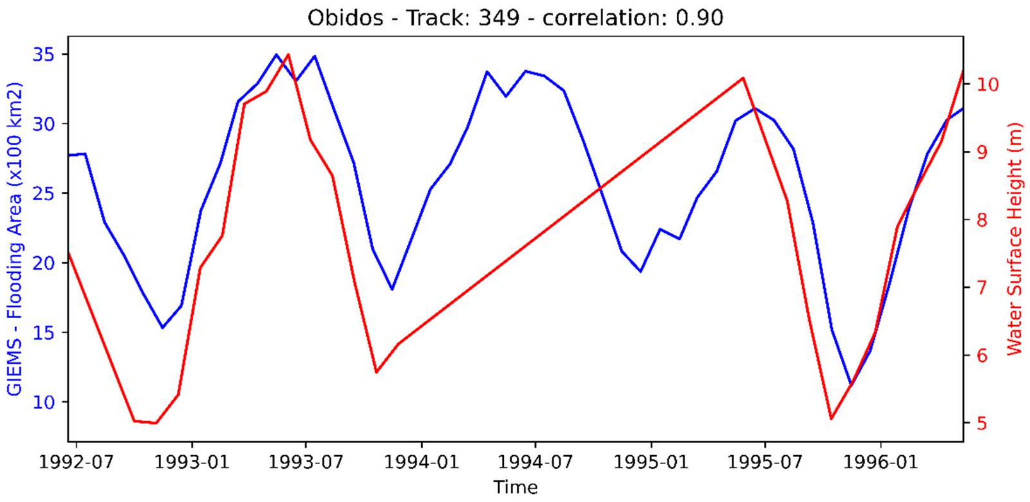


Figure 3-62 ERS-1. Obidos: Comparison of timeseries from IW TDP and GIEMS

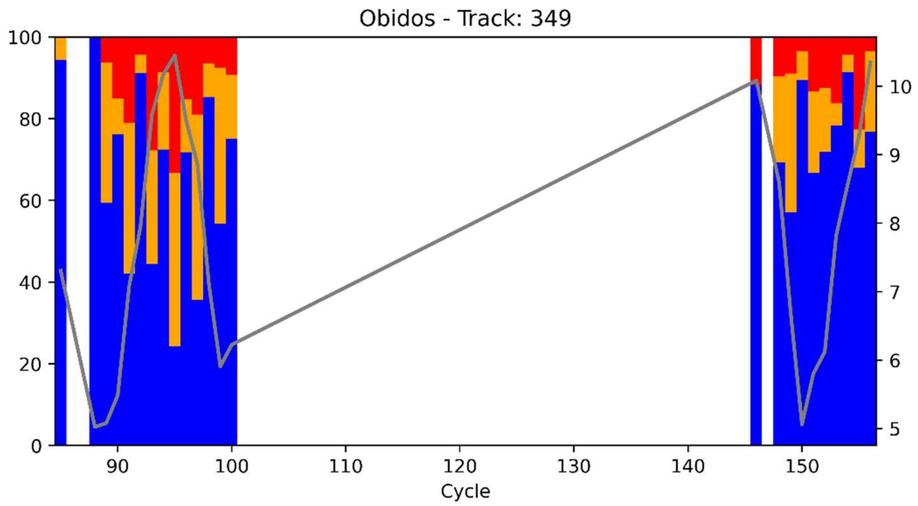


Figure 3-63. ERS-1. Obidos: quality flag per cycle for track 349. Blue: good quality, Orange: medium quality, Red: bad quality and Black: unknow quality

The evolution of the normalised water level variation over the year for the period 1995-2003 is shown in Figure 3-64. Yellow indicates high water level values and blue low water level values. White boxes indicate that not data is available in the IW TDP. This variation

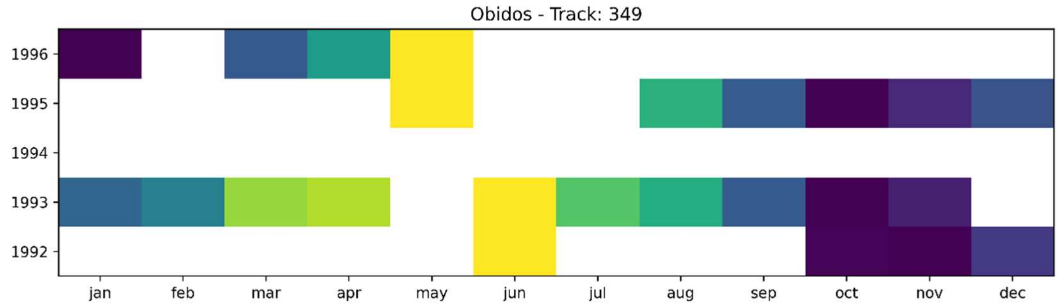


Figure 3-64. ERS-1. Obidos: Normalised water level change per year

3.4.3.3.2 Parana

There are few ERS-1 measurements over Parana floodplain as show in the analysis figures: comparison with time series for GIEMS(Figure 3-65), evolution of the quality flag(Figure 3-66) and normalised water level change per year (Figure 3-67)

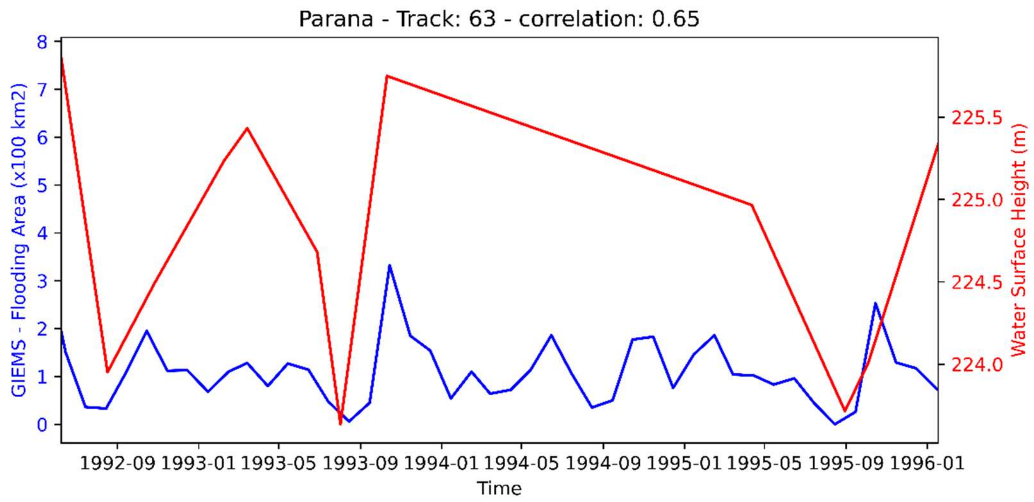


Figure 3-65. ERS-1. Parana: Comparison of timeseries from IW TDP and GIEMS

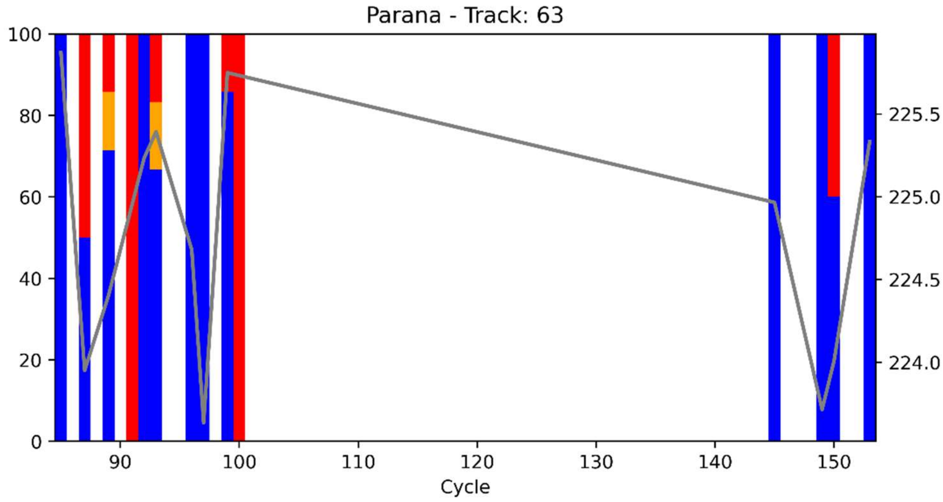


Figure 3-66. ERS-1. Parana: quality flag per cycle for track 63. Blue: good quality, Orange: medium quality, Red: bad quality and Black: unknow quality

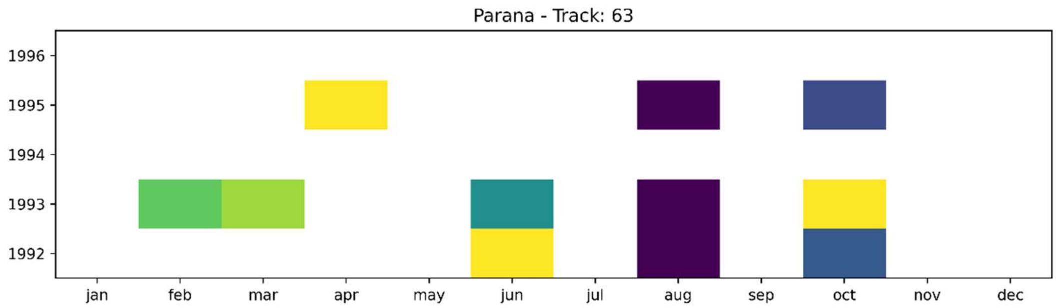


Figure 3-67. ERS-1. Parana: Normalised water level change per year

3.4.3.3.3 Pantanal

As for the Parana, the time series on the Pantanal wetland are very sparse, as shown in the figures of the comparison with GIEMS (Figure 3-68) and the evolution of the quality flag (Figure 3-69). Nevertheless, in the figure of normalised water levels (Figure 3-70), low water levels are observed towards the middle of the years, while low values are observed at the beginning or end, in accordance with what is described in the literature [**RD** 2]: the period of high water generally occurs from November/January to May/June.

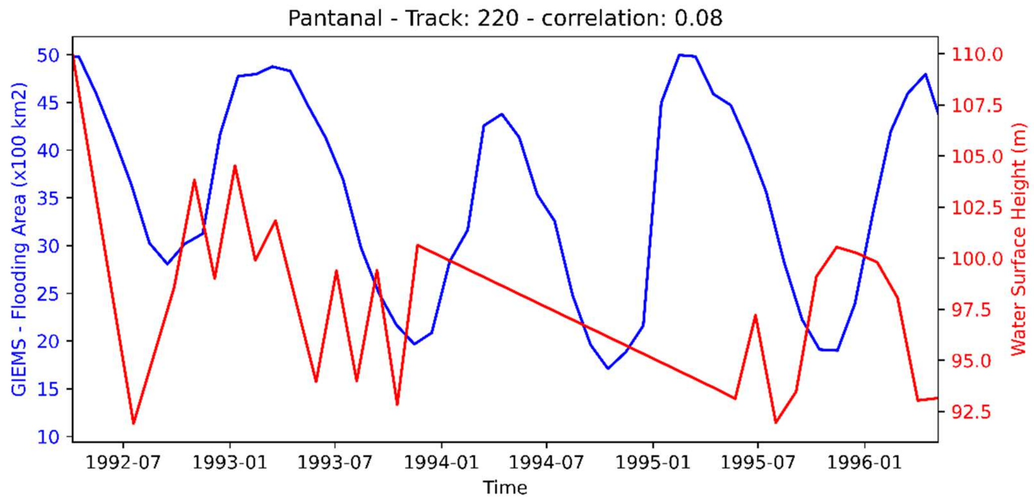


Figure 3-68 ERS-1. Pantanal: Comparison of timeseries from IW TDP and GIEMS

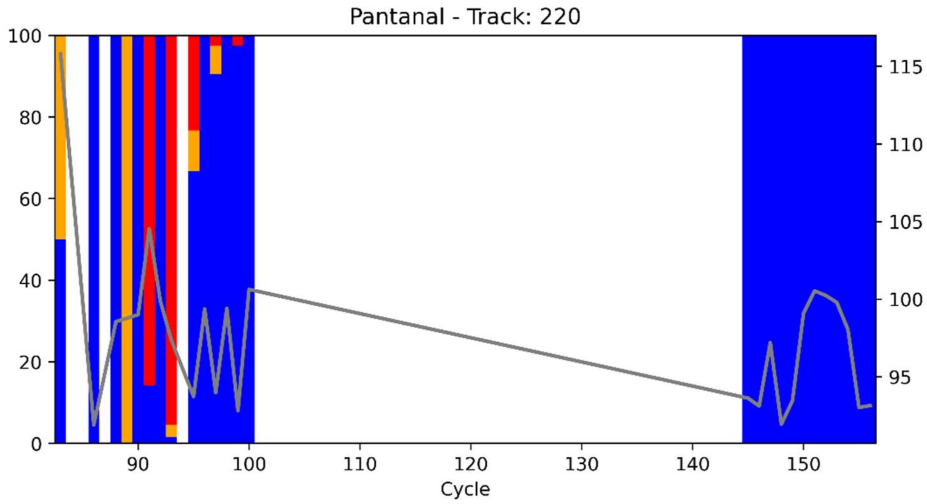


Figure 3-69 ERS-1. Pantanal: quality flag per cycle for track 220. Blue: good quality, Orange: medium quality, Red: bad quality and Black: unknow quality

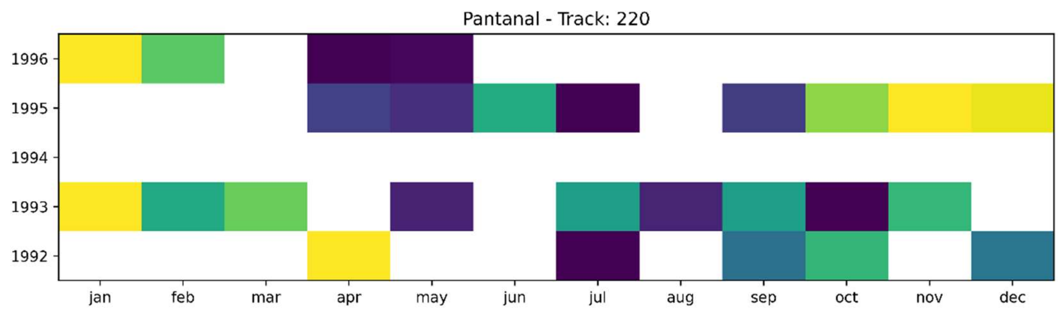


Figure 3-70 ERS-1. Pantanal: Normalised water level change per yea

3.4.3.3.4 Inner Niger Delta

For the Inner Niger Delta, there is also a limited amount of data available, as shown in the various figures (Figure 3-71, Figure 3-72 and Figure 3-73) for an assessment of the ERS-1 data on this target.

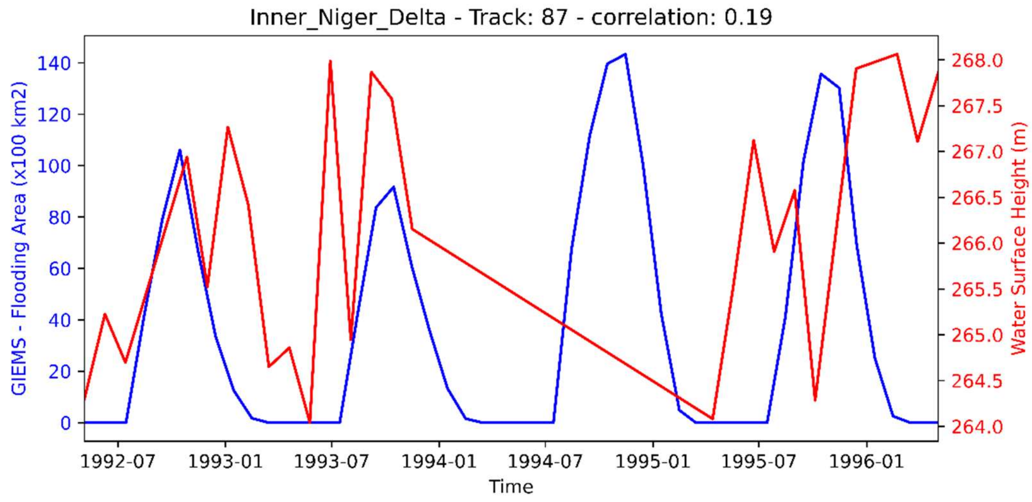


Figure 3-71. ERS-1. Inner Niger Delta: Comparison of timeseries from IW TDP and GIEMS

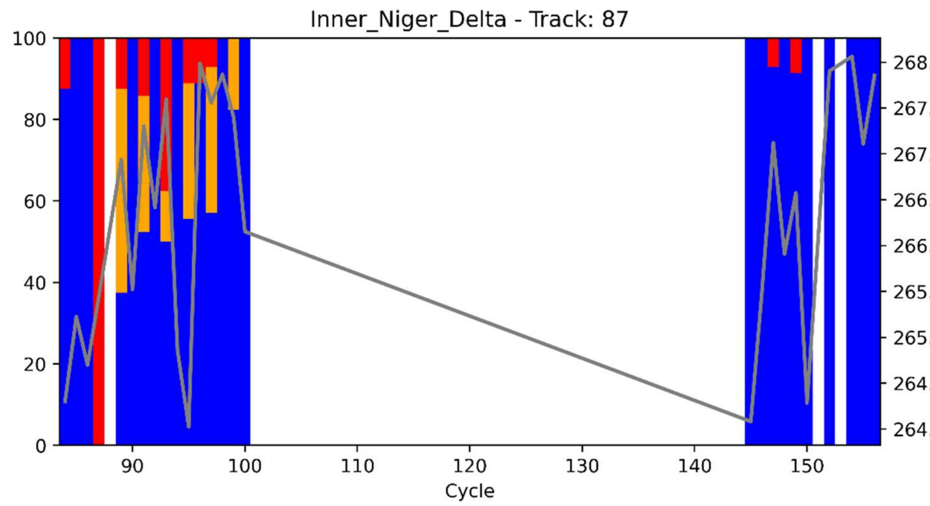


Figure 3-72. ERS-1. Inner Niger Delta: quality flag per cycle for track 87. Blue: good quality, Orange: medium quality, Red: bad quality and Black: unknow quality

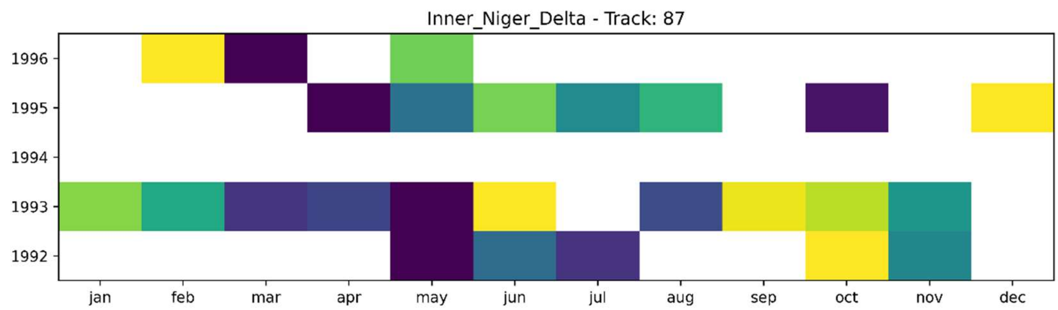


Figure 3-73. ERS-1. Inner Niger Delta: al: Normalised water level change per year

3.5 Conclusion and remarks

The FDR4ALT Inland Water TDP contains valuable information for final users that did not exist in previous datasets including quality flags, uncertainty and external data such as the type of the surface and the water occurrence. This data is useful to estimate more accurate water height values over multiple inland targets.

3.6 Reference documents

RD 1	Prigent, C., Jimenez, C., and P. Bousquet (2019). Satellite-derived global surface water extent and dynamics over the last 25 years (GIEMS-2), JGR, doi.org/10.1029/2019JD030711, 2019.
RD 2	Agostinho et Al. Biodiversity in the High Parana River Floodplain. Biodiversity in wetlands: assessment, junction and conservation, volume 1 edited by B. Gopal, W:J. Junk and J.A. Davis, pp. 89-118 ~ 2000 Backhuys Publishers, Leiden, The Netherlands.
RD-3	Dubreauil V. et al. ESTIMATION DES PRECIPITATIONS PAR TELEDETECTION AU MATO GROSSO (BRESIL). Annales de l'Association Internationale de Climatologie, vol 1, 2004
RD-4	Papa, F., C. Prigent, C. Jimenez, F. Aires, and W. B. Rossow, Interannual variability of surface water extent at global scale, 1993-2004, J. Geophys. Res., 115, D12111, doi :10.1029/2009JD012674, 2010.
RD-5	Prigent, C., Papa, F., Aires, F., Rossow, W. B. & Matthews, E. (2007). Global inundation dynamics inferred from multiple satellite observations, 1993-2000. Journal of Geophysical Research, 112(D12107), 1-1
RD-6	Prigent, C., E. Matthews, F. Aires, and W. B. Rossow, Remote sensing of global wetland dynamics with multiple satellite data sets, Geo. Res. Lett., 28 , 4631-4634, 2001.
RD 7	Cornero C. et al. ANALYSIS OF WATER MASS VARIATION IN WETLANDS USING DATA FROM GRACE SATELLITE MISSION: THE PANTANAL CASE. Revista Braliseira de Geofisica. (2017) 35(4): 307-321
RD 8	R. Zocatelli, P. Moreira-Turcq, M. Bernardes, B. Turcq, R.C. Cordeiro, S. Gogo, J.R. Disnar, M. Boussafir, Sedimentary evidence of soil organic matter input to the Curuai Amazonian floodplain. Organic Geochemistry,Volume 63, 2013, ISSN 0146-6380, https://doi.org/10.1016/j.orggeochem.2013.08.004.

Appendix A - FDR4ALT deliverables

The table below lists all FDR4ALT deliverables with their respective ID number and confidentiality level.

Document	ID	Confidentiality Level
Products Requirements & Format Specifications Document	[D-1-01] [D-2-02]	Public
Roadmap & Product Summary Document	[D-1-02]	Project Internal
Data Requirements Document	[D-1-03]	Project Internal
System Maturity Matrix	[D-1-04]	Project Internal
Examples of products	[D-1-05]	Project Internal
Review Procedure Document	[D-1-06]	Project Internal
Review Data Package	[D-1-07]	Project Internal
Phase 1 Review Report Document	[D-1-08]	Project Internal
Detailed Processing Model Document	[D-2-01]	Public
Round Robin Assessment Report Document	[D-2-03]	Public
Data Production Status Report	[D-3-01]	Project Internal
Final Output Dataset	[D-3-01]	Public
Product Validation Plan	[D-4-01]	Project Internal
Product Validation Report : FDR	[D-4-02a]	Public
Product Validation Report : Sea-Ice TDP	[D-4-02b]	Public
Product Validation Report: Land-Ice TDP	[D-4-02c]	Public
Product Validation Report : Ocean Waves TDP	[D-4-02d]	Public
Product Validation Report : Ocean & Coastal TDP	[D-4-02e]	Public
Product Validation Report: Inland Waters TDP	[D-4-02f]	Public
Product Validation Report: Atmosphere TDP	[D-4-02g]	Public
Uncertainty Characterization Definition Document	[D-5-01]	Project Internal
Uncertainty Characterization Report	[D-5-02]	Public
Product User Guide	[D-5-03]	Public
Completeness Report ALT	[D-7-01]	Public
Completeness Report MWR	[D-7-02]	Public

Table 4 : List of FDR4ALT deliverables

Appendix B - Acronyms

AATSR	Advanced Along-Track Scanning Radiometer
AEM	Airborne electromagnetic
AIR	AIRWAVES2
AVISO	Archivage, Validation et Interprétation des données des Satellites Océanographiques
AMSR-E	Advanced Microwave Scanning Radiometer - Earth Observing System sensor
AMSU-A	Advanced Microwave Sounding Unit-A
ALT	Altimetry
ASSIST	Arctic Shipborne Sea Ice Standardization Too
ATM	Airborne Topographic Mapper
BDHI	Base de datos Hidrologica integrada
BGEP	Beaufort Gyre Exploration Project
CAL	Calibration
CCI	Climate Change Initiative
CFOSAT	Chinese-French Oceanic SATellite
CDS	Copernicus Data Service
CLS	Collecte Localisation Satellite
CMEMS	Copernicus Marine Environment Monitoring Service
CMSAF	Climate Monitoring Satellite Application Facility
CNES	Centre National des Etudes Spatiales
CRREL	Cold Regions Research and Engineering Laboratory
DAHITI	Database for Hydrological Time Series of Inland Waters
DGA	Direccion General de Aguas
ENVISAT	ENVIronment SATellite
EMD	Empirical mode decomposition
EO	Earth Observation
EPS	European Polar System
ERA	ECMWF Re-Analysis
ERS	European Remote-Sensing Satellite
ESA	European Space Agency
ESTEC	European Space Research and Technology Centre
FCDR	Fundamental Climate Data Record
FDR	Fundamental Data Records
FIDUCEO	Fidelity and uncertainty in climate data records from Earth Observations
FMR	Full Mission Reprocessing
FYI	First Year Ice
GEWEX	Global Energy and Water Exchanges
GFO	Geosat Follow-On
GIEMS	Global Inundation Extent from Multi-Satellites
GMSL	Global Mean Sea Level
GNSS	Global Navigation Satellite System
GPM	Global Precipitation Measurement
GRDC	Global Runoff Data Centre
G-REALM	Global Reservoir And Lake Monitor
G-VAP	GEWEX Water Vapour Assessment
HYBAM	HYdro-géochimie du Bassin AMazonien
ICARE	

IGM	Instituto Geografico Militar
IGN	Instituto Geografico Nacional
IMB	Ice Mass Balance
INA	Instituto Nacional de Agua
ISRO	Indian Space Research Organisation
IRPI	Istituto di Ricerca per la Protezione Idrogeologia
IWMI	International Water Management Institute
LEGOS	Laboratoire d'Etudes en Géophysique et Océanographie Spatiales
LIDAR	Ligth Detection And Ranging
LTAN	Local time of the ascending node
LWP	Liquid Water Path
MAC	Multisensor Advanced Climatology
MEAS-SIM	Measure-Simulation
MQE	Mean Quadratic Error
MSSH	Mean Sea Surface Height
MWR	Microwave Radiometer
NASA	National Aeronautics and Space Administration
NE	North East
NN	Neural Network
NPI	Norwegian Polar institute
NWP	Numerical Weather Prediction
NOAA	National Oceanic and Atmospheric Administration
OIB	Operation Ice Bridge
OLC	Open Loop Calibration
OSTST	Oceanography Surface Topography Science Team
POSTEL	Pôle d'Observation des Surfaces continentales par TELEdétection
PTR	Point Target Response
RD	Reference Document
REAPER	Reprocessing of Altimeter Products for ERS
RM	Review Meeting
RSS	Remote Sensing System
SALP	Service d'Altimétrie et de Localisation Précise
SARAL	Satellite with Argos and Altika
SLA	Sea Level Anomaly
SCICEX	Submarine Arctic Science Program
SGDR	Sensor Geophysical Data Record
SHOA	Servicio Hidrografico y Oceanografico de la Armada
SSB	Sea State Bias
SSH	Sea Surface Height
SSM/I	Special sensor microwave/imager
SST	Sea Surface Temperature
SWH	Significant Wave Height
SWIM	Surface Waves Investigation and Monitoring instrument
TAC	Thematic Assembly Center
TB	Température de Brillance (Brightness Temperature)
TDP	Thematic Data Products
TDS	Test Data Set
TFMRA	Threshold First-Maximum Retracker Algorithm
TMR	Topex Microwave Radiometer
TP	Topex/Poseidon

TCWV	Total column water vapour
VCC	Vicarious calibration
VS	Virtual Station
ULS	Upward Looking Sonar
USA	United States of America
USDA	United States Department of Agriculture
WHALES	Wave Height Adaptive Leading Edge Subwaveform
WTC	Wet Tropospheric Correction