

# Note on in-situ information cards

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January 21, 2015

The present document intends to give the reader useful information about how to understand the in-situ information cards available on the AVISO website <sup>1</sup>. We provide here a short introduction on the information displayed by the different tables and plots as well as useful references for readers who might be interested in digging deeper into the methodologies.

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<sup>1</sup> available at <http://www.aviso.altimetry.fr/en/data/calval/in-situ-calibration-and-validation/in-situ-global-statistics.html>

## Introduction

We will present the different information boxes that appear on the in-situ information cards. In the current version of the processing, two information cards are generated for each tide gauge station in the database. The standard version presents the key metrics while the expert version is enriched with specific tests and results and provide more information on the agreement between altimetry and in-situ records.

This document is illustrated with plots and figures taken from actual in-situ information cards <sup>2</sup>. The presenting order used here follows the content of the expert mode information cards.

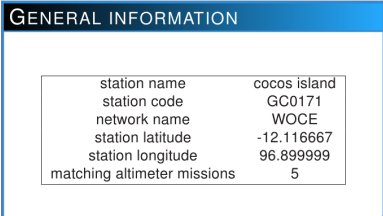
<sup>2</sup> I've used the Cocos Island station for this pupose

## General information

This box is present in both standard and expert versions of the information card and provides general information about the station:

- the station's name and code,
- its network,
- its position, as provided by the data delivery service,
- and the number of matching altimetry missions.

This last figure is the first quality indicator for the in-situ record, the higher this number the better the agreement between in-situ and altimetry. We currently proceed to comparisons to 6 altimeter missions: ERS-2, TOPEX/Poseidon, Jason-1, Envisat, Jason-2 and SARAL/AltiKa. A complete description of the methodology used to compare satellite altimetry to tide gauge records can be found in the 2013 annual report of this activity <sup>3</sup>, the important point here is that a positive match is set if the two time series fall within correlation and RMSd thresholds.



GENERAL INFORMATION	
station name	cocos island
station code	GC0171
network name	WOCE
station latitude	-12.116667
station longitude	96.899999
matching altimeter missions	5

Figure 1: General information box for station Cocos Island

<sup>3</sup> also available through AVISO website at [http://www.aviso.altimetry.fr/fileadmin/documents/calval/validation\\_report/annual\\_report\\_insitu\\_TG\\_2013.pdf](http://www.aviso.altimetry.fr/fileadmin/documents/calval/validation_report/annual_report_insitu_TG_2013.pdf)

## Statistics

This box is present in both the standard and expert versions of the information card but some extra statistics are added in the expert version. Each satellite altimetry mission is associated with a color

STATISTICS					
statistics	Envisat	AltiKa	TOPEX/Poseidon	Jason-1	Jason-2
distance (km)	158.05	81.27	94.75	94.75	94.75
correlation	0.94	0.97	0.93	0.92	0.94
Taylor distance	0.35	0.28	0.38	0.40	0.36
altimeter std (cm)	9.94	10.47	12.36	11.43	13.00
tide gauge std (cm)	10.27	9.96	12.19	11.85	12.93
rms of the differences (cm)	3.55	2.54	4.67	4.65	4.61
sea level drift (mm.yr <sup>-1</sup> )	-4.22	-33.05	-1.38	-2.96	-3.99
drift uncertainty (mm.yr <sup>-1</sup> )	4.62	32.52	3.22	2.90	7.58

with is consistently used throughout the whole information card. For each matching satellite altimetry mission, different metrics are estimated:

- the distance between the tide gauge station and the point (grid cell) where the satellite altimetry time series was extracted,
- the correlation between in-situ and altimeter time series,
- the Taylor distance between the two time series<sup>4</sup>,
- the standard deviation of altimetry SSH,
- the standard deviation of in-situ SSH<sup>5</sup>,
- the RMS of the SSH differences between altimetry and in-situ time series,
- the SSH drift or the trend of the SSH differences,
- the uncertainty associated with this trend, estimated using a Monte-Carlo method using and AR(1) process to model the residuals.

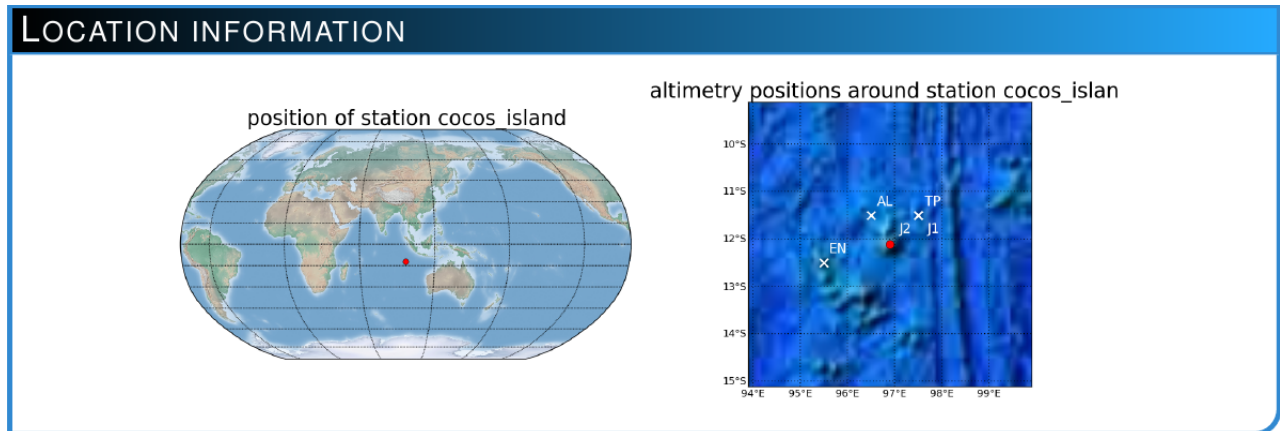
## Location Information

The location box is present on the standard and expert versions of the information cards and provides information about the position of the tide gauge station and the position where satellite altimetry time series were extracted. Two plots are shown, the first one is a global map displaying the position of the tide gauge station. The

Figure 2: Statistics box for station Cocos Island

<sup>4</sup> this metric is presented in section dedicated to Taylor diagrams

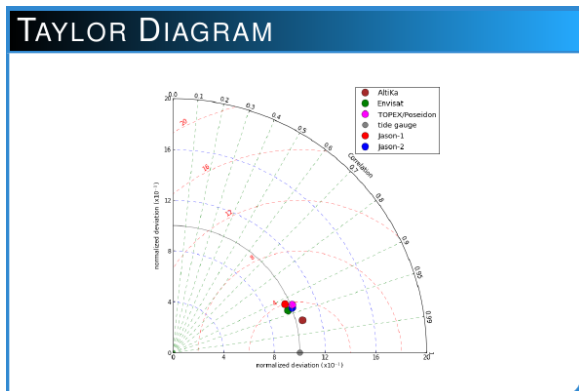
<sup>5</sup> this is not a constant because the estimation is performed over each altimeter's period and therefore vary



second one is a zoom centered on the tide gauge station (red dot) where the white crosses indicate the positions from which satellite altimetry time series (in the process, satellite altimetry along-track data are averaged onto 1 degree grids) were extracted. All these information are plotted over the ETOPO bathymetry<sup>6</sup>.

### Taylor diagram

Taylor diagrams allow for an easy graphical representation of how close two time series are. This diagram is only available on the expert version of the information cards<sup>7</sup>.



How to read such a diagram ? The horizontal axis displays the standard deviation of the reference time series (in this case the in-situ SSH time series). In order to display multiple points on one diagram, all standard deviation are normalized, hence the reference is the unique grey dot corresponding to  $\sigma = 1$ . The vertical axis refers to the standard deviation of the observation (here altimeter SSH time

Figure 3: Location box for station Cocos Island

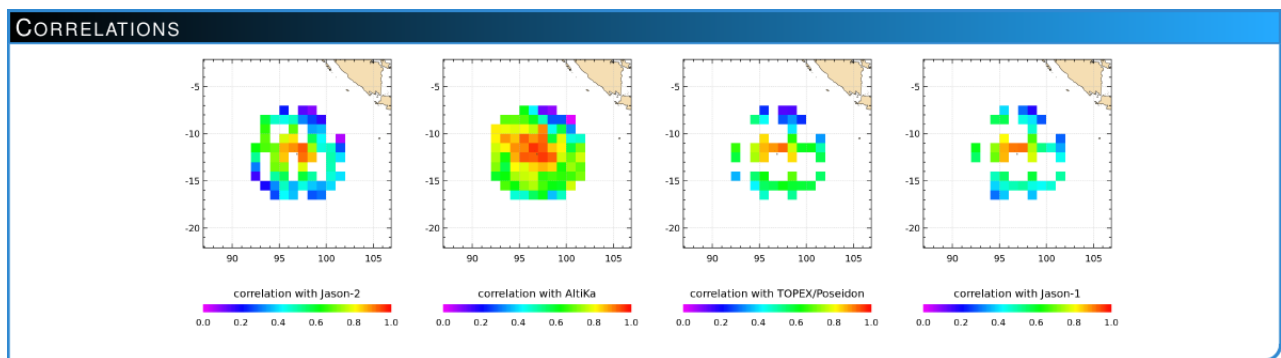
<sup>6</sup> Amante, C. and B.W. Eakins, 2009. ETOPO1 1 Arc-Minute Global Relief Model: Procedures, Data Sources and Analysis. NOAA Technical Memorandum NESDIS NGDC-24. National Geophysical Data Center, NOAA. doi:10.7289/V5C8276M

<sup>7</sup> I'll only give here a few clues on how to understand the present diagram, for an excellent introduction to Taylor diagrams, please refer to [http://www-pcmdi.llnl.gov/about/staff/Taylor/CV/Taylor\\_diagram\\_primer.pdf](http://www-pcmdi.llnl.gov/about/staff/Taylor/CV/Taylor_diagram_primer.pdf)

Figure 4: Location box for station Cocos Island

series for the different missions considered) and is supplemented by the blue lines while the quarter of a circle axis displays the correlation between the observed and reference time series (supplemented by green lines). The red lines show contours of RMSd between time series. As a result the Taylor Diagram displays how close the reference (in-situ) and observed (each altimetry missions, represented by a colored dot) time series are in terms of correlation and ratio of standard deviations. It also provides a unique measure, the Taylor distance, for this level of agreement which is simply the distance of the observation point to the reference in the Taylor diagram space.

### *Correlations*



This part of the information card shows the correlations obtained when comparing in-situ to altimetry SSH time series. The comparison process involves the estimation of a correlation map for each altimeter mission, which is shown here. These maps show us the spatial distribution of correlations between the tide gauge SSH and the different altimetry missions. At some stations, a very peaky pattern is observed with the correlation decreasing very quickly with the distance, at other stations high correlations are more widely distributed. Sometimes a relation with the bathymetry can be observed.

Figure 5: Correlations box for station Cocos Island

### *Sea level time series*

This section of the information cards displays two time series graphs. These plots are available on both the standard and expert version of the information cards. The left one represents the SSH time series for the tide gauge (black line) and altimetry missions (colored lines). The right one is the time series of altimetry minus tide gauge SSH differences. For both graphs, all time series are centered before

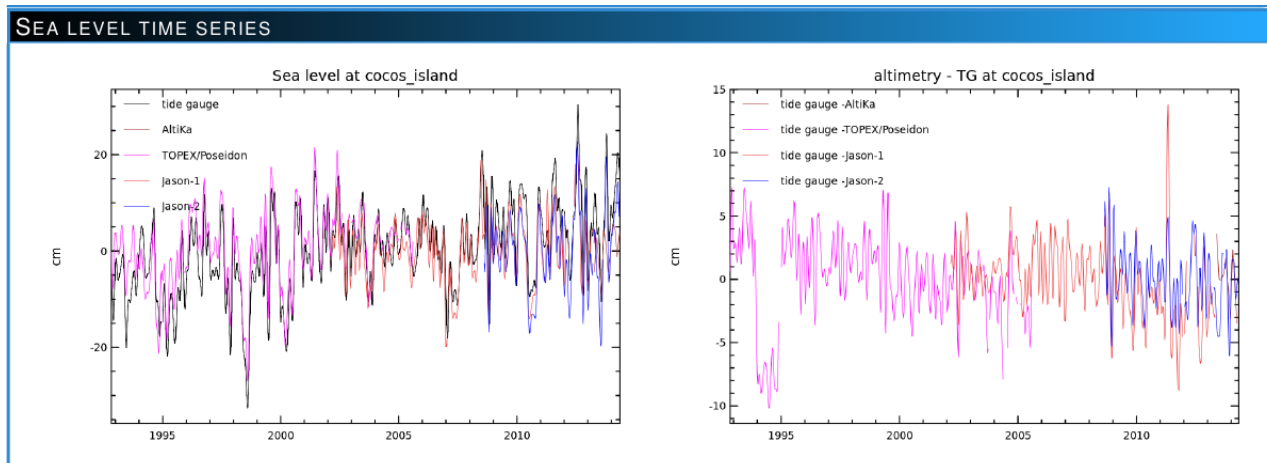
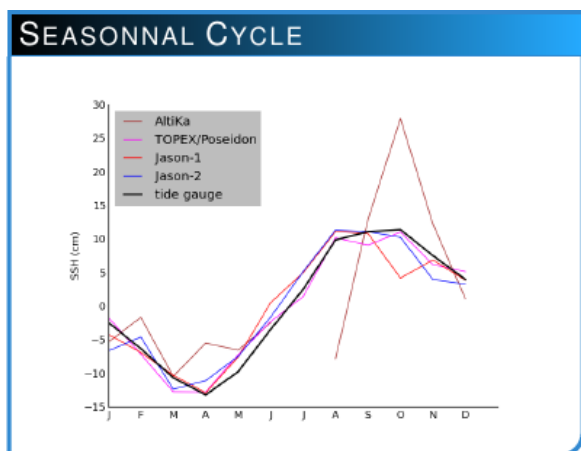


Figure 6: Time series box for station Cocos Island

plotting them.

### Seasonal cycle



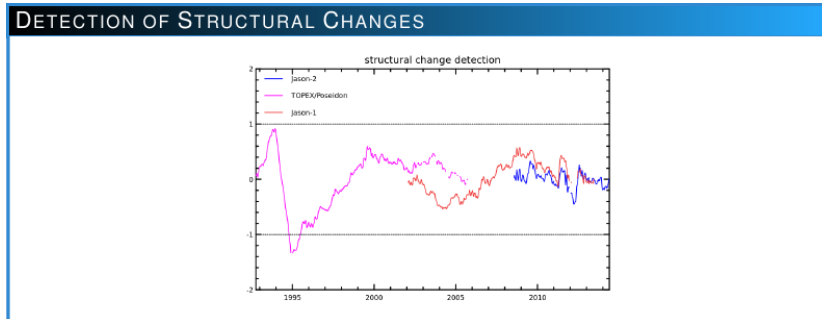
The seasonal cycle section presents an estimation of the seasonal cycle for the in-situ SSH and for the different altimeter missions selected. The purpose is to give the reader an indication about how the seasonal cycles of altimetry and tide gauges match or differ. The seasonal cycle is estimated by computing monthly climatologies from all available data, and is therefore not constrained by any model<sup>8</sup>.

Figure 7: Seasonal cycle box for station Cocos Island

<sup>8</sup> like a  $\cos(\omega t) + \sin(\omega t)$  model for example

### Structural change detection

This section of the information cards is only available in the expert version. The aim of test performed here is to detect any structural change in the time series of altimetry minus in-situ SSH differences, like jumps, drifts changes or sudden variance changes. The test proposed here is based on the work of Zeileis et al., 2003<sup>9</sup>. We only provide here the general idea behind the test, the interested reader may read the original paper. The test is based on estimating a simple



linear model  $\hat{y} = \alpha \times t + \beta$  linking the SSH differences to time, of course this does not describe the full variability of SSH differences and we study the residuals  $r = y - \hat{y}$  to this model. The assumption behind the test is that a structural change in the time series will translate as a modification of the distribution of the residuals. A metric for the distribution of residuals is built over the full period and compared to the same metric estimated over segments of the initial time series. On the plot displayed on figure 8, the two black dotted horizontal lines show the 95% uncertainty level. If, for a given mission, the metric goes beyond these lines (either above or below), there is a statistically significant structural change in the SSH differences time series at the 95% confidence level. If this gives no clue about which change is occurring (it could be a jump or a drift change for example), it does provide a dating of this change and one can refer to the SSH differences plot (see section on time series) around the same time to try to detect the change. On this example, the jump at the beginning of the TOPEX/Poseidon time series is clearly visible.

<sup>9</sup> Achim Zeileis, Christian Kleiber, Walter Krämer, Kurt Hornik, Testing and dating of structural changes in practice, Computational Statistics & Data Analysis, Volume 44, Issues 1–2, 28 October 2003, Pages 109–123, ISSN 0167-9473. available at <http://www.sciencedirect.com/science/article/pii/S0167947303000306>

Figure 8: Structural change detection box for station Cocos Island