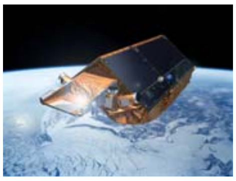

GLOBAL Data quality assessment of the Cryosat-2 altimetric system over ocean

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1 Overview

The primary payload of Cryosat-2, launched on April 2010, is a radar altimeter operating in Ku band (13.575 GHz) capable of operating in a number of modes, optimised for measurements over different surfaces (LRM mode on oceans and central ice sheets, SAR mode over sea-ice).

Even if Cryosat-2 mission has been primarily designed for cryosphere observation, all data acquired over ocean are, in theory, valuable for the observation of oceanic circulation and mesoscale variations. **This study is dedicated to the assessment of Cryosat data and performance over ocean surface thanks to calibration and validation analysis** (Labroue et al 2011 under revision).

2 Dataset used

A Cryosat-2 Processing Prototype (C2P) has been developed on CNES side to lay the ground for various SAR processing studies.

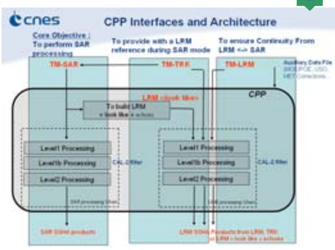
The processing chains start from Level-0 telemetry files and perform the following steps to generate Sea Level Anomalies (SLA) values for each altimeter measurements (20Hz) (fig. 1):

- Level-1: Decommutation, time-tagging and localization of measurements
- Level-1b: Calculation of instrumental corrections and geophysical/meteorological corrections
- Level-2: MLE4 waveforms Retracking and calculation of SLA

C2P validation

A validation of C2P has been done processing Jason-2 telemetry data, and comparing to classical ground segment outputs. SWH and SLA present centimetre-level differences (all explained by known differences of the retracking processing) with respect to Jason-2 SIGDR. This shows that C2P is fully validated and can therefore be used to process Cryosat data.

Fig1



3 Data coverage

The C2P products generated for Cryosat-2 span 70 days from October 2010, 1st till January 2011, 10th. Here, results are only shown for December 2010, over 30 days (Cryosat-2 sub cycle). Results from other sub-cycles of this three month period are consistent with observations from December.

The maps (fig. 2) show the data available over ocean in LRM mode for December 2010 separating ascending and descending passes. The large missing zones are due to data acquired in SAR mode over ocean. Besides these expected zones, two bands located at 20°North and 20°South also show missing measurements due to instrument calibration.

Fig2

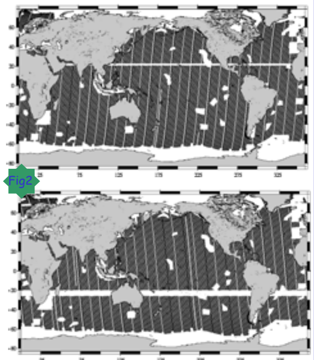
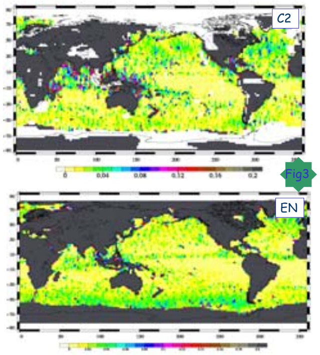


Fig3



Editing

A new kind of editing procedure based on statistical criteria has been developed. After a crude selection of the data thanks to the MQE parameter, the outliers over ocean surface are removed by a 3 sigma criteria when comparing raw and filtered 20 Hz SLA measurements.

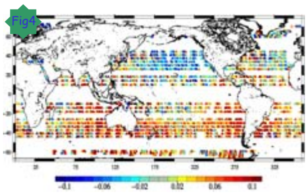
Comparison to Envisat (fig. 3) show similar patterns in the map of edited measurements. More data are edited in regions of strong sea states, which is explained by the larger signal to noise ratio, since the altimeter noise is a function of SWH. Indeed, the editing procedure at 20 Hz removes more data in regions where data noise is larger.

4 Performance based on Cryosat alone

Crossover metrics

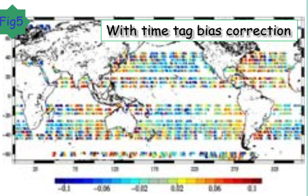
The analysis of the SSH differences at crossovers between Cryosat ascending and descending tracks (fig. 4) shows an hemispheric signal which varies between -6 and +6 cm. This can be related to a -1.0ms time tag bias in the data (due to the presence of noise pulses in the LRM altimeter pattern not considered by the C2P time-tagging process) .

Fig4



SSH Crossover differences (m)

Fig5



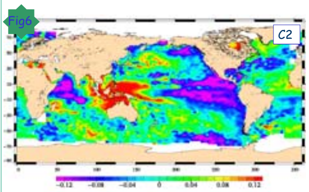
After correction of this bias, the map is more consistent (fig. 5). Remaining geographical patterns of 3 cm magnitude may be due to residual orbit error. The crossover standard deviation is decreased to 6.5 cm. After a standard selection of crossover data (on latitudes, oceanic variability and bathymetry), it falls to 6 cm compared to 5.5 cm and 6 cm obtained for Jason-2 and Envisat respectively. **Cryosat-2 mission presents the same accuracy than ENVISAT altimeter and is not far from Jason-2 mission.**

Along track analysis

Maps of sea Level Anomaly (SLA) relative to a mean sea surface (fig. 6) shows that Cryosat-2 well captures all the main features of the oceanic variability, compared to ENVISAT on the same period (fig. 7).

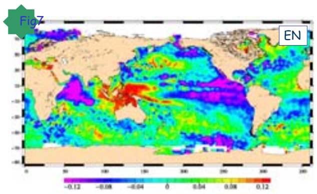
A constant bias of -3.74 m is observed on the range measurement which is close to the value of -3.80 m found after the verification phase. The residual 6 cm can be partly explained by the lack of accuracy of the SLA, especially regarding the SSB, the GIM ionospheric correction and the ECMWF wet tropospheric model.

Fig6



SLA (m) with respect to the MSS

Fig7



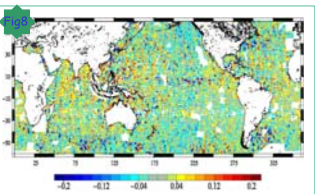
5 Comparison with external data

Comparison with ENVISAT and Jason-2 data

The SSH differences at Cryosat-2/ENVISAT crossovers (fig. 8) shows a general good agreement between both missions, except some East/West geographic patterns of 4 to 5 cm due to orbit error present on both ENVISAT and Cryosat-2.

The performance for Cryosat-2/ENVISAT and Cryosat-2/Jason-2 with 5.8 cm and 5.7 cm respectively is very close to the reference level (ENVISAT / Jason-2: 5.7 cm).

Fig8



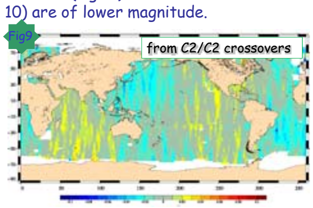
SSH EN/C2 Crossover differences (m)

Cryosat-2 system (altimeter + orbit) is at the same level of accuracy than the two other missions, provided that the same "degraded" corrections are used (the GIM ionospheric correction and the ECMWF wet tropospheric model).

Orbit error reduction

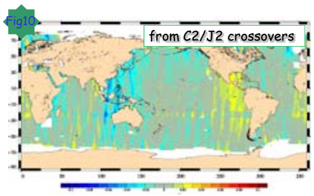
The results presented here are obtained with a MOE orbit solution which is not as accurate as Precise Orbit Ephemeris. Therefore, the orbit error reduction is an important issue for data quality assessment. The orbit error presents large East/West biases when deduced from single mission (fig. 9) crossovers whereas the patterns obtained with respect to Jason-2 mission (fig. 10) are of lower magnitude.

Fig9



Along track orbit error (m)

Fig10

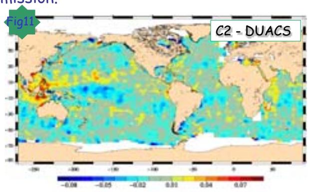


It shows the importance of cross calibration between several altimeters instead of mono-mission one, which helps to better estimate the orbit error signals on a given mission.

Comparison with DUACS SLA

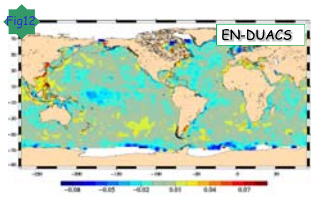
Difference between Cryosat-2 SLA and DUACS SLA (Jason-1 + Jason-2) (fig. 11) shows an excellent agreement between them with differences below 4 cm. Same level of accuracy is obtained with ENVISAT(fig. 12) which shows again that Cryosat-2 is very close to ENVISAT mission.

Fig11



Mean of SLA differences (m)

Fig12



Conclusion

The analysis performed with the C2P products shows that Cryosat-2 has very good performances over ocean. Crossover standard deviation is close to 6.5 cm over the analysed period (3 months) which is close to the Jason-2 and ENVISAT performance. All these results confirm that Cryosat's altimeter can provide data almost as valuable as other flying altimetric missions, and that it has the potential to contribute to oceanography (e.g. multi-mission climate record, mesoscale monitoring in near real time) or to geodesy (e.g. mean sea surface, bathymetry).

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