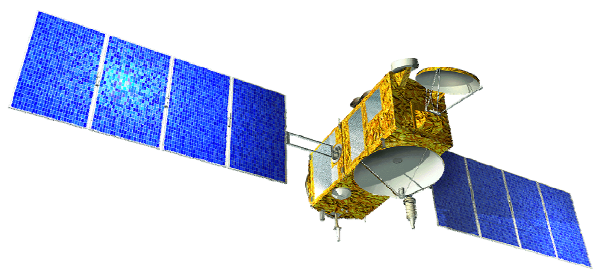
SSALTO/DUACS: INNOVATIVE METHOD TO REDUCE THE ORBIT ERROR SIMULATNEOUSLY ON SEVERAL SATELLITES



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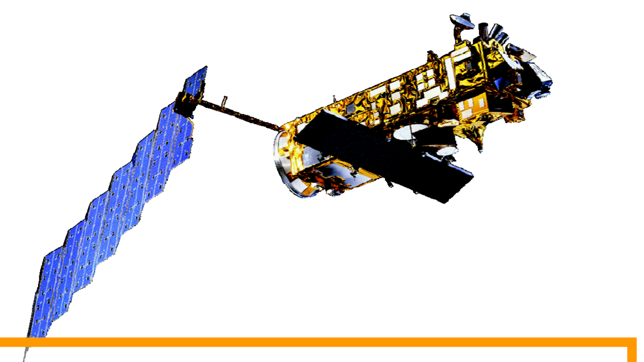


Overview

One year of ENVISAT and Jason-1 Near Real Time (NRT) data is used to attempt an innovative method of orbit error reduction allowing to calculate an orbit error on the two satellites simultaneously. It is inspired of the cubic splines minimization method described in le Traon and Ogor, 1998 and is based on the minimization of multi- and mono- mission crossovers. The MSLAs are introduced to avoid the singularity of the solutions.

Indeed, in the SSALTO/DUACS system, the orbit error reduction method of cubic splines usually used is implemented, using TOPEX/Poseidon, Jason-1/2 missions as a reference. It is operationally applied to ERS-1/2, ENVISAT and GFO satellites. This method is used for Delayed Time (DT) as well as for Near Real Time (NRT) products and allows us to combine and homogenize the individual time series before the calculation of the Maps of Sea Level Anomalies (MSLAs).

The limitation of this method is to fix one of the satellites (currently TOPEX/Poseidon, Jason-1 or 2) as a reference which is supposed to have better performances than the other satellites. Nowadays, ENVISAT and Jason-1/2 have similar performances in terms of POE and MOE. Then, it is not relevant to use Jason-1/2 as a reference anymore. The evolution of the SSALTO/DUACS system seems to be evident to avoid taking a mission as a reference and to allow the continuity of the production of MSLAs in case of temporary unavailability of one of the missions.

The results over one year of ENVISAT and Jason-1 NRT data are significant especially for the MOE in terms of reduction of geographically correlated errors for both satellites at crossovers. Statistics of SLAs before and after the adjustment also verify the consistency of the method.

Methodology

For ENVISAT and Jason-1, we want to find two functions, respectively SE and SJ, which simultaneously minimize the crossover differences of EN/EN, J1/J1 and EN/J1 crossovers. Thus, the function to minimize is the following:

$$\mathrm{F(C)} = \sum_{i=1}^{M} w_i^2 \left[SE(t_{i1}) - SE(t_{i2}) - Xee_i\right]^2 \quad \text{Minimization of EN/EN crossovers}$$

$$+ \sum_{j=1}^{P} w_j^2 \left[SJ(t'_{j1}) - SE(t_{j2}) - Xje_j\right]^2 \quad \text{Minimization of J1/EN crossovers}$$

$$+ \sum_{k=1}^{Q} w_k^2 \left[SJ(t'_{k1}) - SJ(t'_{k2}) - Xjj_k\right]^2 \quad \text{Minimization of J1/J1 crossovers}$$

$$+ \sum_{l=1}^{R} w_l^2 \left[SE(t_{l1}) - Comb(MSLA)_l\right]^2 + \sum_{p=1}^{T} w_p^2 \left[SJ(t'_{p1}) - Comb(MSLA)_p\right]^2$$

Minimization including MSLA

An innovative solution in this method is to include a minimization of the Maps of Sea Level Anomaly (MSLA) to solve the singularity given by the minimization of crossover differences only. Thus, two terms are included in the function: the minimization of SE and SJ to comb(MSLA) where comb is a function of the MSLA.

The cubic spline method is used to determine SE and SJ. It consists in placing an arbitrary number of knots along ENVISAT and Jason-1 passes. Thus, N and M time intervals are created. On each of those intervals, we look for the coefficients of a 3 degree polynom. This means to find 4N+4 coefficients for SE and 4M+4 for SJ. We constraint the continuity of the function and of the first and second derivatives at each knot, thus reducing the number of coefficients to N+3 and M+3 respectively for SE and SJ.

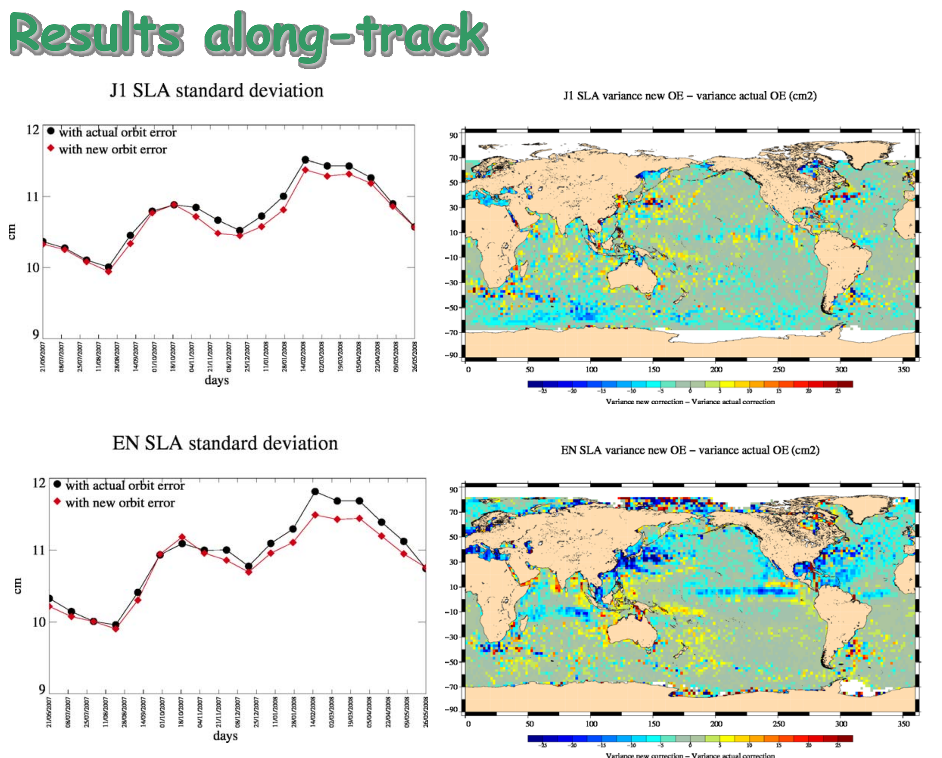
The spline functions on each interval are the B splines of degree 3 as described in Hayes, 1974.

The minimization of F, leads to a traditional least-square system to solve. The system is of the form $^{t}AA\ X = {}^{t}A\ B$ and is solved using the Cholesky decomposition.

Data

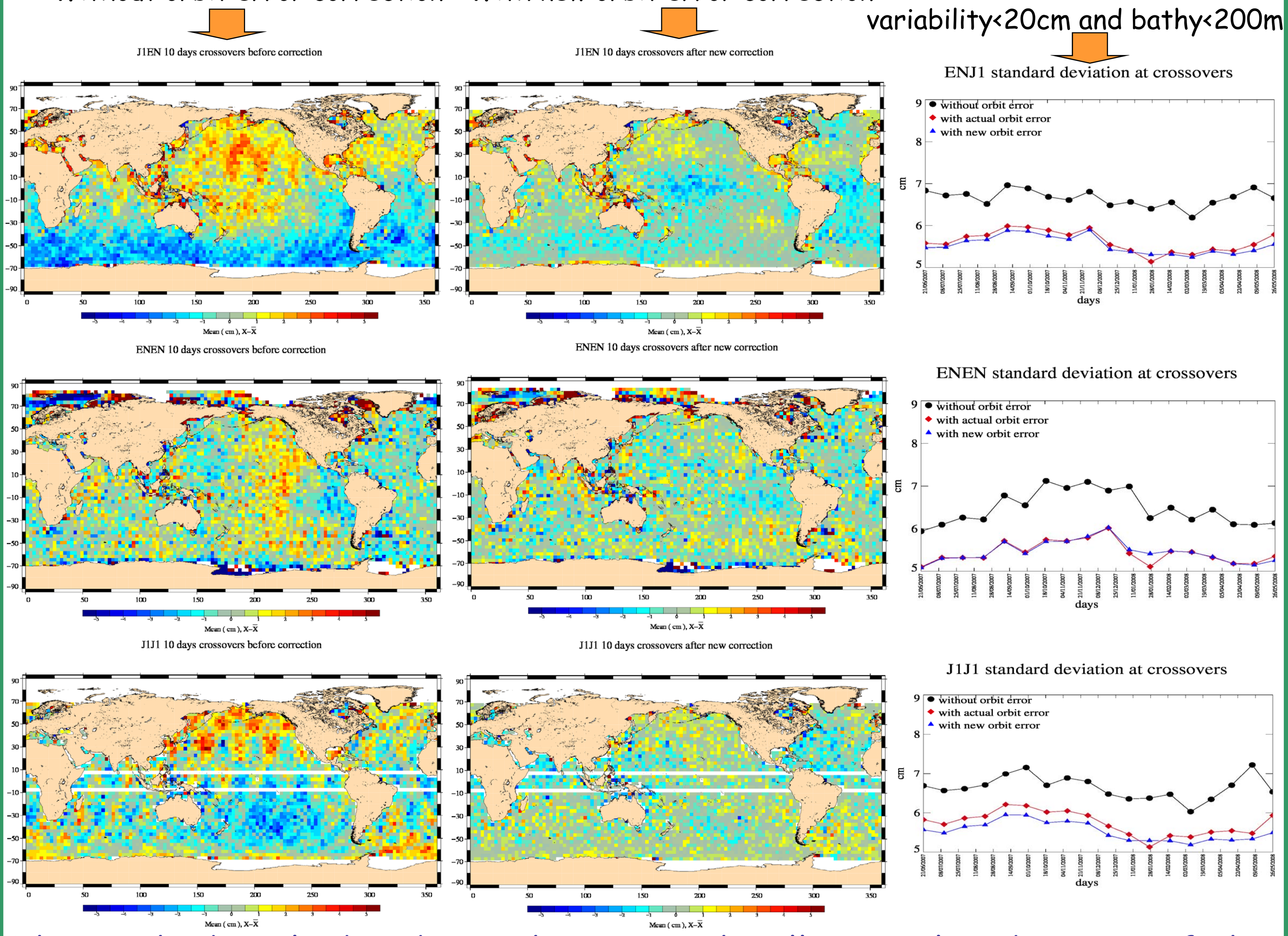
1 year of NRT data have been processed with ENVISAT and Jason-1 satellites from june 2007 to june 2008. The results thus show analysis of the MOE for both satellites. The MSLAs used are the merged NRT SSALTO/Duacs products already distributed by AVISO.

Results along-track



The statistics of the along-track SLA show the good consistency of the corrections for both satellites. The maps of variance differences show geographical patterns (the variance is reduced in Mediterranean Sea for both satellites and especially in Northern hemisphere for ENVISAT)

Results at crossovers



The method applied reduces the geographically correlated errors of the MOEs for both satellites which is clearly shown on the maps of the 10 days mean crossover differences.

Statistically, the standard deviation at crossovers is smaller with the new correction compared to the actual correction (used operationally in SSALTO/Duacs) especially at J1J1 and ENJ1 crossovers.

	J1EN	ENEN	J1J1
Gain at crossovers with the new correction (cm)	3.63	3.53	3.68
Gain at crossovers with the actual correction (cm)	3.45	3.47	3.30

Conclusion

It was a challenge to compute orbit error corrections simultaneously for several satellites. This study shows the successful possibility to do it with an adaptation of the existing method of the cubic spline interpolation. An innovative solution compared to the existing method is to use the MSLAs in the minimization in order to constrain the splines.

The first results are promising: they show a gain of the new method compared to the actual one for the crossover performances as well as for along track performances. Moreover, the improvement is at the same time geographical and statistical.

Perspectives

This method shall be included in the SSALTO/Duacs system by the end of this year. The feasibility of the integration in the system has been done otherwise.

The operational needs impose to use incremental calculation of MSLAs. Indeed in the results shown here use the MSLAs already computed over the period. In an operational mode, the method uses the information of the past SLA to compute the correction of the current SLA. Thus, a propagation of an error could lead to a divergence in the solutions.

Moreover, working without any reference mission can be a problem for the quality of the Mean Sea Level in Duacs products because it will depend of all the missions used.

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References

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