Jason-2 global error budget for time scales lower than 10 days

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Overview :

The objective of this study is to describe the Jason-2 error budget derived from altimeter level 2 products (OGDR, IGDR, GDR), for each component used in the sea-level calculation.

Although, errors on altimetry measurements exist on several temporal and spatial scales, we have only focused our analyses **on errors lower than 10 days and at global scale**. Altimetry errors at climate scales have already been described by [Ablain et al, 2012].

The second objective is also to compare this error budget with Jason-2 mission requirements and to scientific goals.

Methods

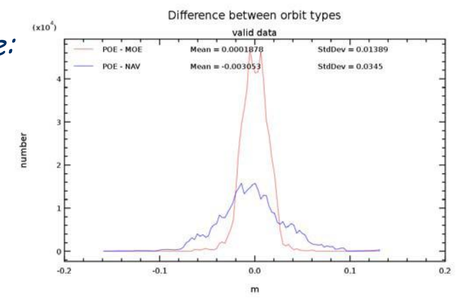
In order to asses the errors, several approaches are used:

- taking advantage of the formation flight phase of Jason-2 with Jason-1 (cycles 1 - 20)
- spectral analysis
- analysis of the rms of 20 Hz data
- comparison with other corrections
- consulting the available literature.

Orbit

The errors of the different orbit types for timescales less than 10 days are approximately 1 cm for GDR, 1.7 cm for IGDR and 3.7 cm for OGDR.

Example:

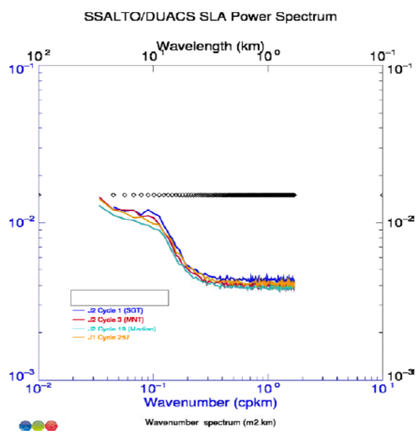


Comparison between different orbit types provides an estimation of the errors, e.g.:
- *Cerri et al. 2010 : error of 1 cm for POE*
- *the global mean standard deviation (STD) between CNES POE GdrC and MOE is 1.4 cm, and between POE and nav is 3.5 cm, leading to an error of 1.7 cm for MOE and 3.7 cm for navigator orbit*

Altimeter range

The error is mainly composed of a random noise of about 1.6 cm to 1.7 cm for significant wave height of 2 m. The total error at 10-day time scale is higher but not yet evaluated

Example:



The spectrum shows a plateau of 0.004 m². This means a noise of 7.6 cm for 20 Hz. Assuming uncorrelated data yields a noise of 1.7 cm on 1 Hz data.

Global Jason-2 error budget for time-scales < 10 days

The global error budget of Jason-2 has been synthesized from the parameters and corrections. Sometimes errors are defined only with a lower bound because the exact error or the upper bound has not been estimated yet.

Jason-2 specifications and scientific goals have also been added. However figures are not easily comparable, since for instance specifications describe sometimes only the "white noise" contribution, but not all the error content < 10 days.

	Error budget	Specifications			Error (<10 days)			GOAL
		OGDR	IGDR	GDR	OGDR	IGDR	GDR	
Parameters and corrections for raw sea surface height	Altimeter range	>1.7 cm[a,b,c]			>1.6 - 1.7 cm			1.5 cm[a,b,c]
	Ionosphere	1 cm[d,c]	0.5 cm[d,c]		>1 cm[h] / >0.2 cm[i]			0.5 cm[d,c]
	Sea State Bias	3.5 cm	2 cm		>0.4 cm			1 cm
	Dry troposphere	1 cm	0.7 cm		0.4-0.7 cm	0.3-0.7 cm		0.7 cm
	Wet troposphere	1.2 cm			>0.2 cm			1 cm
	Rms Orbit (radial component)	10 cm[e]	2.5 cm	1.5 cm	>3.7 cm	>1.7 cm	>1.0 cm	1.5 cm
Altimeter parameters	Significant wave height	10% or 50 cm[f]	10% or 50 cm[f]		13 cm			5% or 25 cm[f]
	Wind speed	1.6 m/s	1.5 m/s		1 m/s			1.5 m/s
	Sigma0 (absolute)	0.7 dB			0.11 dB			0.5 dB
Raw sea surface height		11 cm[c]	3.9 cm[A]	3.4 cm[A]	> 4.2 cm[A]/-	> 2.6 cm[A] - 2.8 cm[B]	>2.1 cm[A] - 2.4 cm[B]	2.5 cm[A]
Final sea surface height		?	?	?	< 5.0 cm[c]	< 4.1 cm[C]	< 4.0 cm[C]	

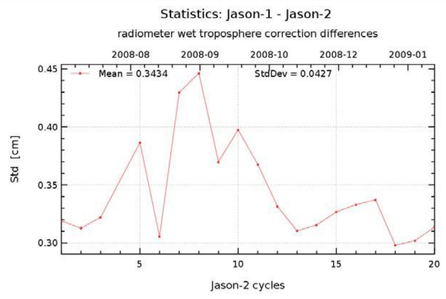
a Ku-band after ground retracking
b Averaged over 1 sec
c Assuming 320 MHz C-bandwidth
d filtered over 100 km
e real time doris onboard ephemeris
f whichever is greater
h non filtered value
i filtered over 300 km

A Computed with $\sqrt{\sum \sigma_i}$, Assuming that errors in the table are uncorrelated (which is not the case).
B from formation flight phase (jason-1/ Jason-2)
C from cross-over computations of jason-2 data

Wet troposphere correction (AMR)

The error of radiometer wet troposphere is at least 0.2 cm. Long-term monitoring shows that Jason-2 radiometer is subject to jumps and drifts within a 10-day window (especially for IGDR).

Example:

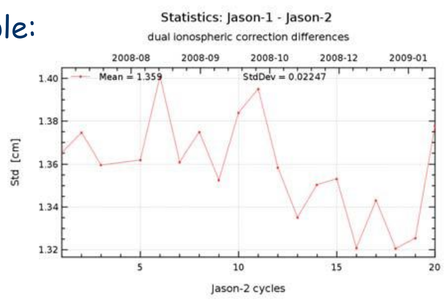


The mean STD differences between AMR (Jason-2) and JMR (Jason-1) during the Jason-2 formation flight phase is 0.34, therefore there is a minimal error of 0.2 cm for each radiometer.

Altimeter Ionosphere Correction

The error is at least 1 cm for un-filtered ionosphere correction and 0.2 cm for ionosphere correction filtered over 300 km. These figures are minimum values as the same errors might exist on both JA1 and JA2.

Example:



The mean STD differences between JA1 and JA2 un-filtered ionosphere correction during the Jason-2 formation flight phase is 1.36 cm -> 1.36 cm / sqrt(2) = 1 cm error

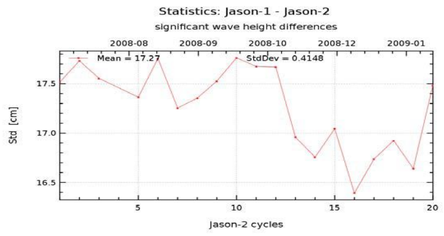
Dry troposphere correction

The error of the dry troposphere is between 0.3 cm (comparison between models) and 0.7 cm (theoretical considerations, Salstein et al, 2008) for IGDR and GDR products. For OGDR products the error ranges between 0.4 cm (comparison between analyzed and predicted fields) and 0.7 cm.

SWH and Sea State Bias

The error of SWH is ~13 cm. The white noise is about 11.2 cm.

Example:



The mean STD differences between JA1 and JA2 SWH during the Jason-2 formation flight phase is 17.3 cm, assuming that both missions contribute equally to the error, yields 12.2 cm
- *White noise (from spectrum): ~11.2 cm*
- *Abdallah et al 2010 find an error of 13 cm*

The error of sea state bias is at least 0.4 cm (estimated from comparisons between JA2 and JA1)

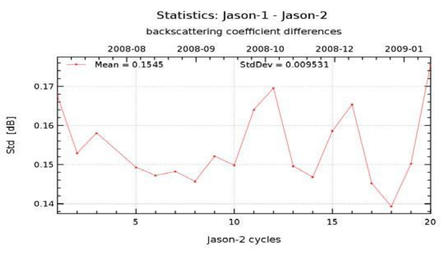
Sigma0 & Altimeter Wind Speed

The error of the backscattering coefficient is 0.11 dB. The white noise has a value of 0.08 dB.

The error of the altimeter wind speed is about 1 m/s (from Abdalla et al. 2011).

Example:

The mean STD differences between JA1 and JA2 sigma0 during the Jason-2 formation flight phase is 0.15 dB -> 0.11 dB

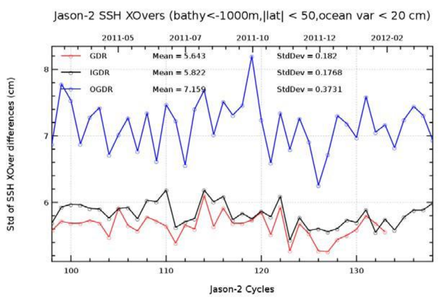


Final Sea Surface Height

The errors of the final sea surface height are less than 5.1 cm for OGDR, 4.1 cm for IGDR and 4.0 cm for GDR.

Example:

The mono-mission cross-overs reveal a std of 5.6 cm for Gdr, 5.8 cm for Igdr, and 7.2 cm for OGDR. As errors are on ascending as well as on descending tracks, figures have to be devided by sqrt(2)



Summary & Conclusions

In this study, a rigorous and formal approach has been developed to provide the error budget of Jason-2 altimeter level 2 products for time scales lower than 10 days and over the global ocean:

⇒"White noise" (when useful) and all error content < 10 days have been estimated separately
⇒ Errors has been estimated with the systematic definition of a lower bound

This study could be improved in future refining the estimation of error with an upper bound and focusing on regional scales.

Currently, the time and spatial scales of the altimeter mission specifications (as Jason-2) are not described separating clearly the different time and spatial scales, nor give specifications distinguishing the types of applications (mesoscale, climate, …)

Ideally, future altimeter mission should contain error specifications more detailed and separated for the different temporal and spatial scales, respecting a formal approach such as in this study.

References:
•Cerri, L., J.P. Berthias, W.I. Bertiger, B.J. Haines, F.G. Lemoine, F. Mercier, J.C. Ries, P. Willis, N.P. Zelensky, and M. Ziebart. 2010. Precision Orbit Determination Standards for the Jason Series of Altimeter Missions. Marine Geodesy. Vol. 33 (S1):379-418.
•Abdalla,S., P. Janssen, and J.-R. Bidlot. 2010. Jason-2 OGDR Wind and Wave Products: Monitoring, Validation and Assimilation. Marine Geodesy. Vol. 33 (S1):239-255.
•Abdalla,S., P. Janssen, and J.-R. Bidlot. 2011. Altimeter Near Real Time Wind and Wave Products: Random Error Estimation. Marine Geodesy. Vol. 34:393-406.
•Lambin, J. and C. Tourain. 2007. OSTM/ Jason-2 System Performances Budget. TP3-J0-NT-909-CNES.
•Salstein, D., R. Ponte, K. Cady-Pereira. 2008. Uncertainties in atmospheric surface pressure fields from global analyses. J. Geophys. Res., 113, D14107, doi:10.1029/2007JD009531.
•Ablain, M., G. Larnicol , Y Faugere, A. Cazenave, B. Meyssignac , N. Picot, J. Benveniste . 2012. Error Characterization of Altimetry Measurements at Climate Scales. OSTST Venice 2012.

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