Comparison of MLE3 and MLE4 retracking performances using Jason-2 GDR-D dataset: impact on Sea Surface Height estimation.

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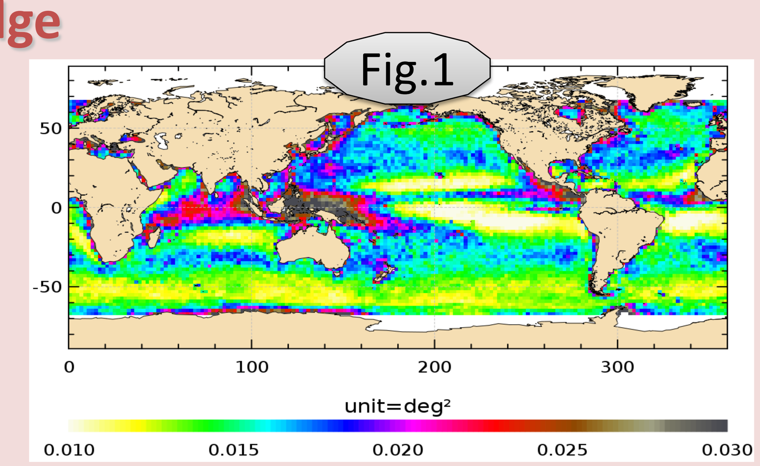
A- Overview :

In 2012, the whole JASON-2 mission data were reprocessed in GDR-D product version. In addition to the parameters computed by the MLE4 retracking algorithm, several parameters computed by the MLE3 retracking are also provided. Both retracking are based on the same least square principle. MLE3 algorithm estimates three parameters (range, significant wave height, and power) whereas MLE4 estimates four parameters (the three previous ones and the slope of the waveform trailing edge). The aim here is to provide a synthesized overview of the relative performances of the two retracking algorithms highlighting their advantages and weaknesses for Jason-2 data. The difference of behavior of the MLE3 and MLE4 parameters are detailed thanks to various Cal/Val statistics over Jason-2 cycles 1 to 145. The impact on parameters and on valid SSH measurements is also presented.
Analysis were done over the same validated data ensemble.

B- The slope of the waveform trailing edge

Fig. 1 represents the absolute value of the square of the off-nadir angle: as globally Jason-2 platform real mispointing is near to zero ➔ the slope of the trailing edge on the map mainly represents the regions where geophysical effects like sigma0 bloom events and rain cells take place.

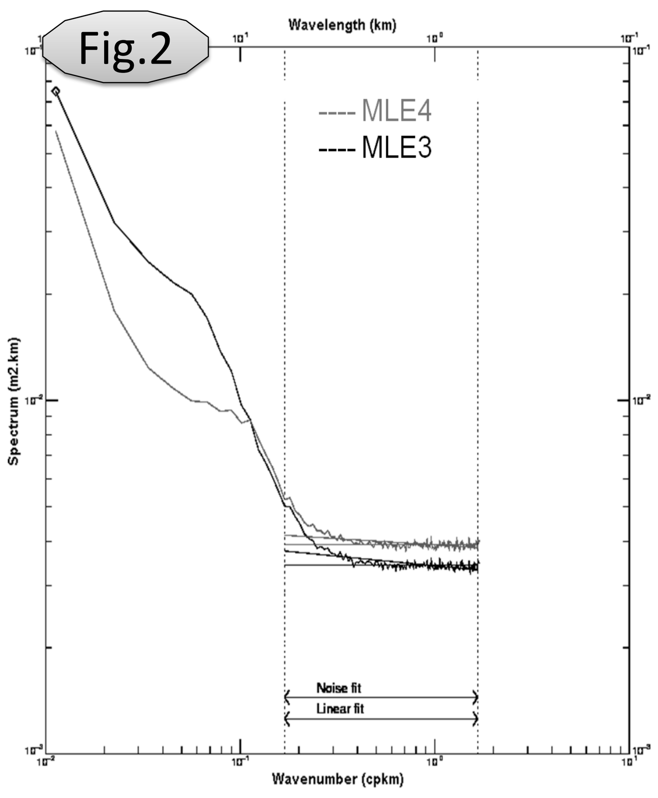
Fig.1



C- SLA Spectrum analysis

Computing the SLA spectra explains the two significant effects of adding the fourth parameter :
- The level of energy of the spectral hump of the MLE4 PSD spectrum is lower than the one observed for the MLE3 by a factor of 2, departing from the linear ocean spectrum approximately at 50km in case of MLE4 instead of the 70km with MLE3.
- The 20Hz white noise level observed on the SLA PSD spectrum is slightly higher in MLE4 because there is one more degree of freedom when adjusting the Brown model.

Fig.2



MLE4 retracking has a different and much more moderate response to waveform corruption on SSH thanks to the use of the fourth parameter.

During a sigma naught bloom event, the MLE3 does not fit well the waveforms and trailing edge artifacts are not captured. In these cases, the MLE4 model is more coherent with the measured waveforms.

➔ In consequence, MLE3 and MLE4 exhibit major differences when the measured waveform is significantly distorted (for example by a bloom event or a rain cell).

D- MLE-3/MLE-4 comparison of altimeter parameters/corrections

The choice of retracking method impacts range, sea state bias and dual-frequency ionospheric correction, which are directly involved in Sea Surface Height computation.
Sea state bias with MLE3 solution differs of about 3.2cm from SSB with MLE4 solution, but this bias is due to the computation method and does not represent a real geophysical bias. There is a difference of about 6mm in average between MLE3 and MLE4 ionospheric correction. Comparisons for other parameters such as sigma0, SWH, altimeter wind speed can be found in [*ref1*]

Fig.3

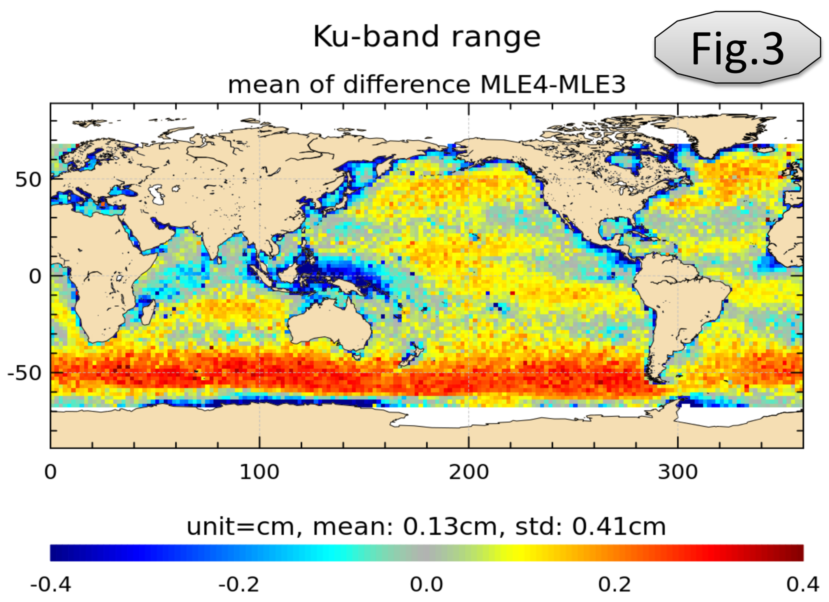


Fig.4

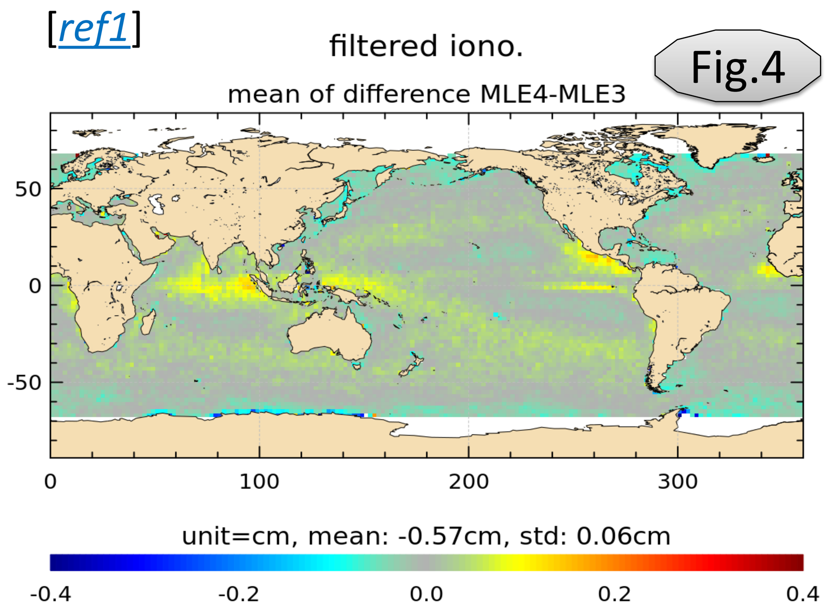
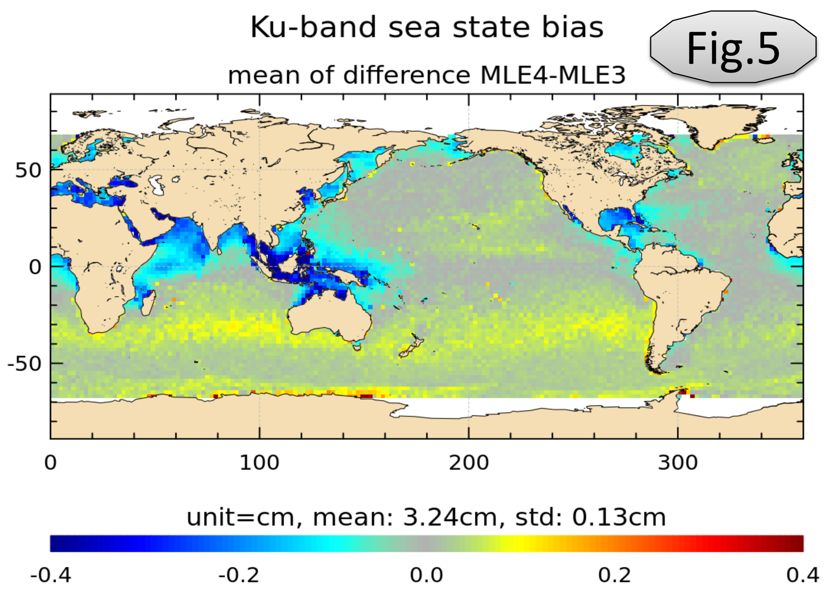


Fig.5



Ionospheric correction: Geographical differences are at an amplitude less than 1mm [not significant]. *Sea state bias*: spatial differences can reach 0.4cm. *Range:* **local differences between MLE3 and MLE4 estimations can differ of more than 0.6cm** between Indonesia and areas whose latitude is between -30° and -50°. **This will impact the regional estimations of sea surface height.**

E- Sea Surface Height differences at crossover points

SSH differences at crossover points are computed for time differences less than 10 days between ascending and descending tracks (*this period allows to minimize the contribution of the oceanic mesoscale variability*). Computing the differences of the variances of the SSH differences at crossover points (using on the one hand MLE3 data and on the other hand MLE4 data) allows to measure the improvement in the computation of the SSH depending on retracking solution.

Fig.6

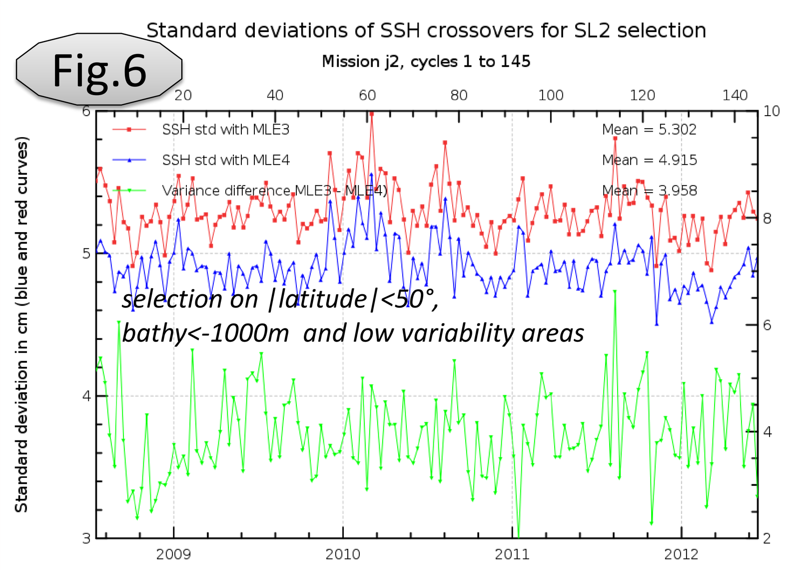


Fig.7

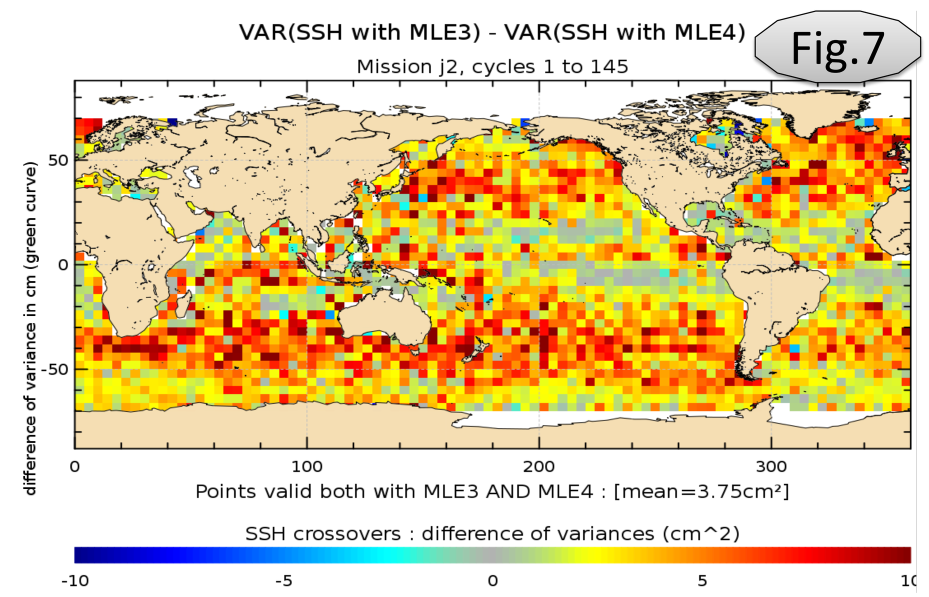


Fig6: The standard deviation at SSH crossovers is largely higher using MLE3 data than using MLE4 data, which means **an important improvement of the performances at time scales less than 10 days in case of MLE4 retracking against MLE3 retracking.**

Fig7: The average difference of variance between MLE3 and MLE4 SSH crossovers is 3.75cm², which represents a **great improvement**. The global SSH variance difference is positive **everywhere** (yellow and red points on the map), meaning a reduction of variance from MLE3 to MLE4.

Concerning SSH performances at crossover points: **the MLE4 algorithm performs better than the MLE3 algorithm everywhere** (in agreement with SLA spectrum).

F- Along-track performances of Sea Level Anomaly (SLA = SSH – MSS)

The difference between SLA computed with MLE4 data or MLE3 data is 2.8cm in average. It is mainly due to the differences in sea state bias (-3.2cm from MLE4 to MLE3) and ionospheric correction (+0.6cm from MLE4 to MLE3).
Fig8: shows the regional distribution of the SLA bias: lower near coasts (*figure centered around the mean difference of 2.8cm*). This map allows to evaluate the origin of the regional differences of SLA: there are mainly due to range differences, particularly concerning areas between 30°S and 60°S and around Indonesia. Sea state bias differences contribution to the differences is also important around Indonesia and near coasts (See part**D**).

Fig.8

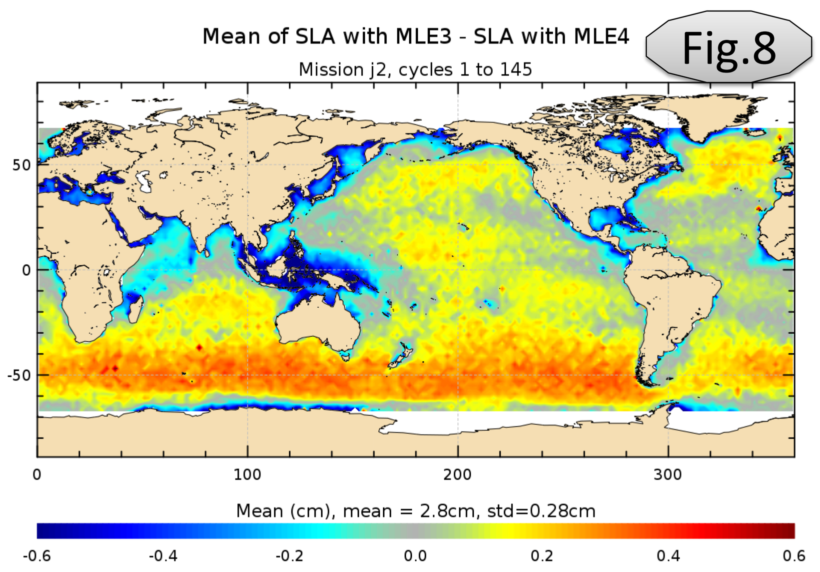


Fig.9

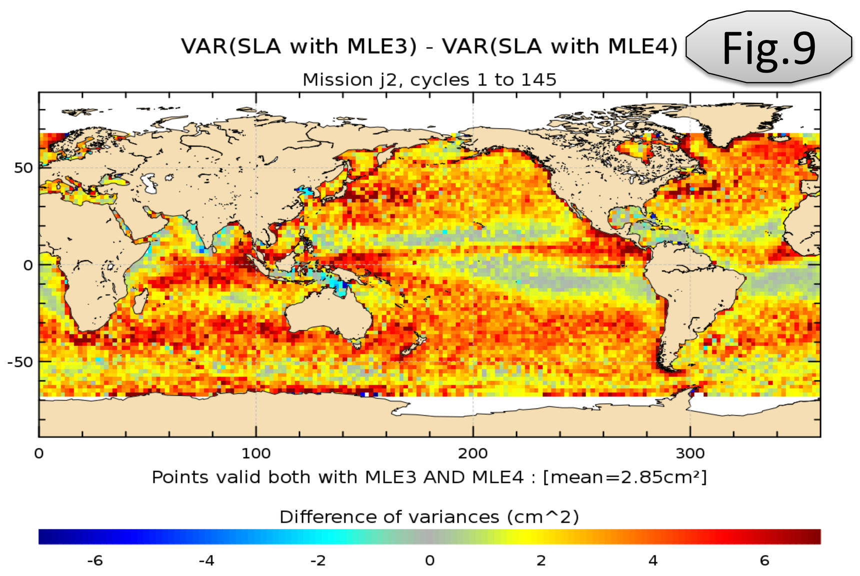


Fig9: The total SLA variance reduction is 2.85 cm² [this result is consistent with the one in partE]. In addition, the monitoring of the global SLA standard deviation (not shown here but available in [*ref1*]) is for each cycle higher using MLE3 data than using MLE4 data.
The gain in along-track SLA variance differences (in red on Fig 9) is strongly correlated with the absolute value of the square of the off-nadir angle value (see part B) and so with the regions where geophysical effects like sigma0 bloom events and rain cells take place.

In conclusion MLE4 performs better than MLE3 for Jason-2 with reduction of the variance of SLA in these regions where the waveforms differ from the theoretical Brown's model.

G- Long-term monitoring

The choice of dataset does not impact significantly the Global Mean Sea Level trend over the 145 cycles (difference on trend is lower than 0.1mm/yr).

H- Summary & Conclusions

The variance of SSH crossovers and along-track SLA shows higher values for MLE3 than for MLE4. Our results highlight an important improvement of the performances at time scales <10 days when considering a MLE4 rather than a MLE3 algorithm.

This study confirms that using a MLE4 retracking is recommended in the case of Jason-2 measurements.

It mainly allows an improvement of the high physical content of SLA for along track distances between 10 and 70 km.

References
[*ref1*] : S. Philipps, H. Roinard and M. Ablain, 2012: Jason-2 reprocessing impact on ocean data (cycles 001 to 145). Comparison of Jason-2 Gdr-D with Gdr-T, as well as with Jason-1 Gdr-C and Envisat GDR v2.1. SALP-RP-MA-EA-22140-CLS.
{http://www.aviso.oceanobs.com/fileadmin/documents/calval/validation_report/J2/Jason2ReprocessingReport.pdf}
[*ref2*] : P.Thibaut, J.C.Poisson, E.Bronner, N.Picot: ``Relative Performance of the MLE3 and MLE4 Retracking Algorithms on Jason-2 Altimeter Waveforms'' (Marine Geodesy, 33(S1):317-335, 2010.)
[*ref3*] : G.Dibarboure, F.Boy, J.D.Desjonqueres, S.Labroue, Y.Lasnes, N.Picot, J.C.Poisson, P.Thibaut. ``Investigating short wavelength correlated errors on low-resolution mode altimetry''. Submitted to the Journal of Atmospheric and Oceanic Technology [in review].

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