Reducing altimetry small-scales errors to access (sub)mesoscale dynamic

Dream or reality ?

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Abstract

The purpose of along-track spatial filtering applied to Sea Level Anomalies currently distributed through AVISO and MYOCEAN is two-fold: (1) removing the non-oceanic small-scale signals (error, noise) and (2) keeping ocean dynamics that can be monitored by the satellite constellation. If it is suited for computing afterwards maps of SLA over the global ocean, it is clearly too radical for applications focused on (sub)mesoscale dynamics. We revisit the along-track filtering applied to SLA by using spectral analysis to determine the mesoscale capability of J2. This paper focuses on the small-scale errors contained in SLA and on the spectral slope estimation. A new specification of filtering cut-off length to reduce these errors and access (sub)mesoscale dynamics is detailed as well as an estimation of the remaining error to be prescribed in data assimilation systems that will use this new data.

The mesoscale capability of 1hz Jason-2 altimetry data

Dufau et al. , 2014 a, In Prep

The determination of the mesoscale capability depends on the small-scales errors.

SSH wavenumber spectral characteristics of Jason-2 GDR-D data are used to extract a geographical description of this mesoscale capability. SSH is corrected from all altimeter corrections and from the Mean Sea surface CNES-CLS-2011.

Wavenumber spectra are calculated following Le Traon et al. 1990 or Stammer 1997 over a 1-year period (2011) over 10°x10° boxes. Figure 1 shows one SLA wavenumber spectrum obtained in one of these areas.

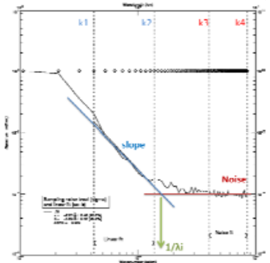

Figure 1 : SLA wavenumber spectrum

In the mesoscale band, between two wavenumbers k1 and k2, the spectral slope are estimated by a least squares regression.

At high wavenumbers, between k3=20km and k4=12km, the noise level is estimated as the mean value of energy in this band.

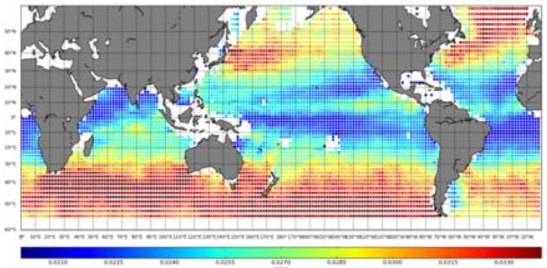

Figure 2: Noise Level in 1hz Jason-2 SLA estimated from mean wavenumber spectra over 2011 in 10°x10° boxes (cm rms)

The 1hz noise level, namely "spectral hump" at small-scales

The 1hz noise level distribution (Figure 2) follows the instrumental white-noise linked to the Surface Wave Height but also connections with the backscatter coefficient .

The full understanding of this hump of spectral energy (Dibarboure et al. in rev) still remain to be achieved and overcome with new retracking, new editing strategy or new technology.

The theoritical slope linked to SQG or QG dynamics

Le Traon et al. (2008) and Xu and Fu (2011, 2012) computed spectral slopes in two mesoscale band definitions. These 2 bands are tested (Figure 3 a and b) and for each of them, the impact of 1hz noise level on the slope estimation is evaluated (Figure 3c and 3d) and removed.

The 1hz noise level is less affecting 100km scales than 70km and the 300-100km mesoscale band is better fitted to estimate the mesoscale capability of the jason-2 altimeter mission.

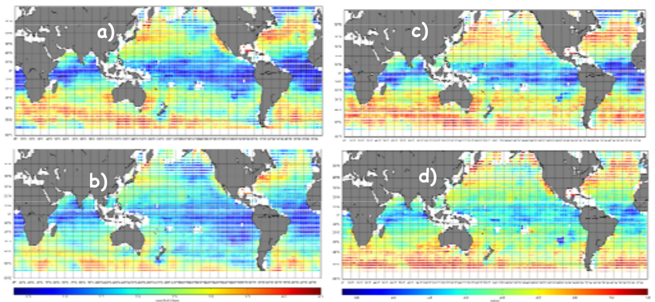

Figure 3: Spectral slope (with opposite sign) estimated in different mesoscale bands using J2 SLA. Mean Spectra computed over 10°x10° boxes. a,c) between 100 and 300km, b,d) between 70 and 250km. c) and d) being estimated after theoretical noise removal.

Mesoscale capability of the Jason-2 mission

Its mean value over the World Ocean is around 55km (Figure 4) but lower in the equatorial band (20°S-20°N) and in the Western Boundaries Currents.

The small-scales capability prescribed by this method at low latitudes is questionnable, due to an estimation of low spectral slopes in these areas.

These low slopes computation with altimeter SSH is not yet well understood. Some modelling studies over the North Pacific Ocean (Richman et al. 2012, Sasaki and Klein, 2012) give some clues but still need to be further investigated.

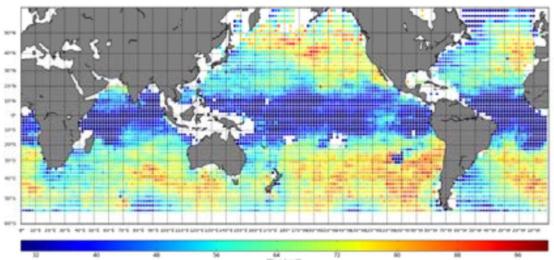

Figure 4: Mesoscale Capability of J2 mission (km) computed from Figure 2 and Figure 3a

A new along-track spatial filtering on high level SLA

Dufau et al. , 2014 b, In Prep

The global MyOcean/AVISO along-track SLA are **filtered differently with** latitude (210km near Equator, until 55km at high lat.) linked to the ability of Topex/Poseidon mission **to capture mesoscale** structures, (Le Traon and Dibarboure 1999).

To provide higher resolution along-track SLA to MyOcean and DUACS users, the future generation of high-level SLA (March 2014)* will be filtered taking into account the mesoscale capability computed for the Jason-2 1hz SLA (figure 4) but first with a **unique cut-off length of 65km.**

At low latitudes, it will change drastically the content of SLA profiles as cut-off lengths will be reduced from more than 100km in this region (Figure 5).

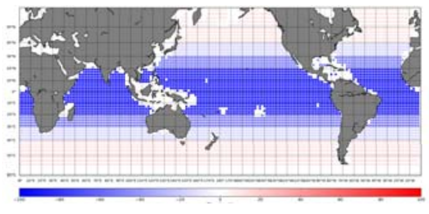

Figure 5: Change in cut-off lengths (km) in spatial filtering with future SLA product (future values – current values)

Future products will provide **higher resolution SLA profiles below 30°** in latitude (Figures 6a and 6b) and **a noise reduction at latitude higher than 40°** (Figure 6c).

Additional meso-scale dynamics will be added at low latitudes (Figure 7b), future products will follow original energy until a length scale of 80km approx. In the Gulf Stream area (Figure 7a), less impacted by this filtering change, future products will nevertheless give access to smaller scales.

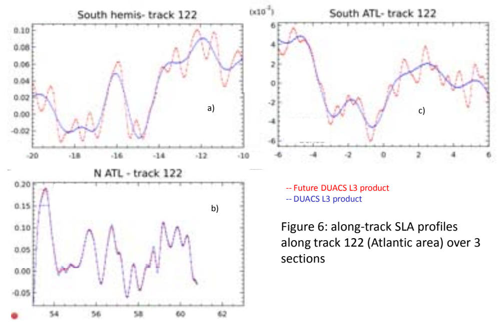

Figure 6: along-track SLA profiles along track 122 (Atlantic area) over 3 sections

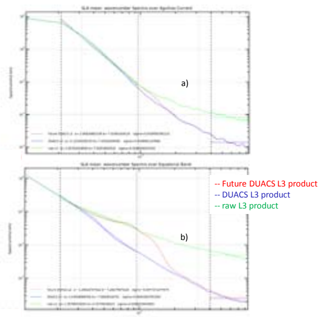

Figure 7 : Mean wavenumber Spectra

Future products will be available in March 2014 both in RT (MyOcean V4 release) and DT (DUACS reanalysis). More details on these products, see « SSALTO/DUACS: the Reprocessing of the 20 Years of Data is On Going » (Pujol et al.) and « Ssalto/DUACS : The Jason1 / Altika unexpected handover » Faugere et al.

Residual Error in altimeter high-level SLA (for modelers)

Dufau et al. , 2014 b, In Prep

Instead of a **constant value,** data assimilation systems should **a map** of SLA observation errors. **For users of non-filtered SLA : a** map of the 1hz estimated white noise (Figure 2). **For users of future DUACS SLA** : a map of the remaining error level after filtering is estimated (Figure 8).

In addition to these maps, a dependency to the coastal distance (+ 1 cm rms from 60 to 10 km) have to be added.

Ideally, these error maps should be estimated separately for each altimeter and for different periods of the year to follow error change with time.

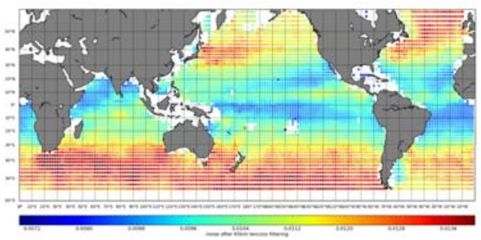

Figure 8: Map of remaining altimeter SLA noise after a 65km spatial filtering (cms rms)

Future Work : from Jason-2 to SWOT altimetry

With Altika and Cryosat-2 SAR mode measurements, both instrumental noise and spectral hump are reduced (ref). These two recent altimeter mission are then really promising for accessing sub-meso and small scales of ocean dynamics and would require reduced along-track filtering compared to present Jason-2 results. Extending this analysis to these new missions is foreseen to prepare the SWOT mission. Meanwhile, follow-on studies on retracking techniques are also needed to reduce noise and spectral hump and thus improve altimetry resolution. New post-processing techniques [data selection strategy and smarter along-track filtering] will also be envisaged in MyOcean/DUACS systems.

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