Sentinel-3 Delay Doppler Altimeter: a New Insight on High Resolution Ocean Dynamics

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Introduction

The objective of this study is to improve our understanding of the Delay Doppler altimetry (SAR) content at small scales (below 100 km). We aim at progressing regarding:

- Processing level: check if the SAR processing has not some residual error
- Science level: improve our understanding of the small scale content of the ocean as measured by altimetry

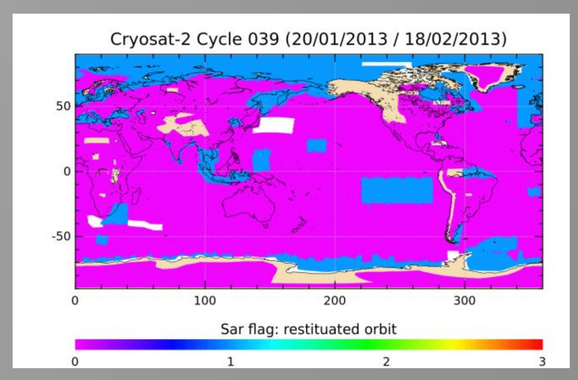
This subject is challenging since:
- we know very little about the ocean processes at small scale dynamics
- we push the limits of altimetry observing capability
- work in between the oceanic processes and the data processing

But this prepares us for better addressing the challenges for Sentinel-3.This work has been performed in the frame of LOTUS project and also supports the activity done in GlobCurrent project regarding the geostrophic currents derived from Delay Doppler altimetry. It follows work done over the Agulhas with Cryosat SAR data (Labroue et al, Edimburgh Symposium 2013) and studies presented by Morrow et al (OSTST 2014).

Cryosat-2 Data Sets

- Use of Cryosat-2 data that embarks a Delay Doppler altimeter
- SAR Level-2 products generated by CNES and CLS teams (Boy et al OSTST 2012)
  - SAR Ocean processing devoted to SAR echoes with Delay Doppler processing inherited from Sentinel-3 Processing Baseline + numerical retracking
  - 2 years time series May 2012 till May 2014.
- Work done with high resolution data sets (20 Hz)
- Focus on the Agulhas region acquired in SAR mode

You can download the CPP level 2 products at : ftp.cy2_sar_l2.oceanobs.com

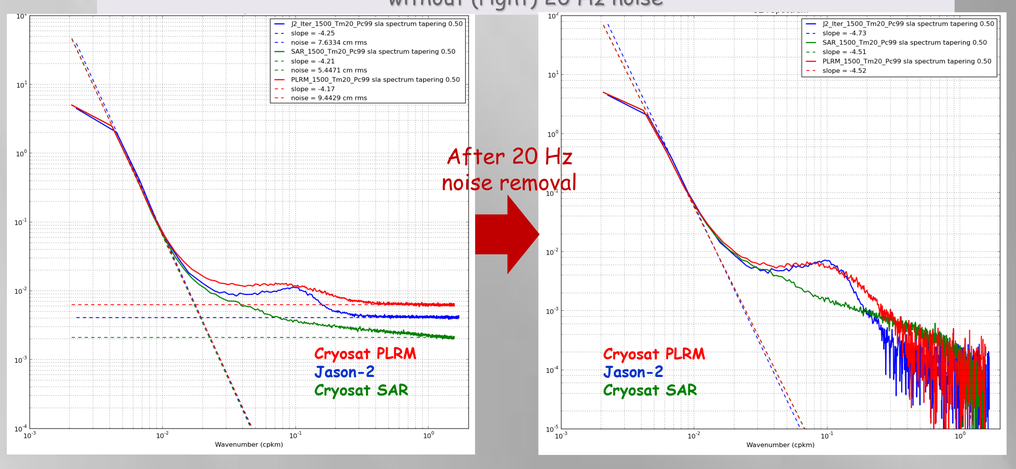


SIRAL acquisitions mode
SAR Mode: blue
LRM Mode : pink

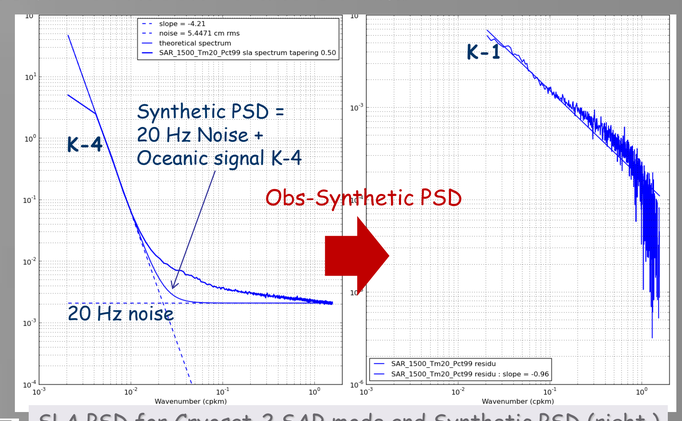
Analysis of Cryosat-2 Delay Doppler Observations – Focus on the Agulhas Current

The 3 data sets (Cryosat SAR, Cryosat-2 PLRM and Jason-2) show the same behaviour at large scales => above 100 km, we observe a slope of K-4.2 in good agreement with the one observed by other authors (Xu and Fu 2012).

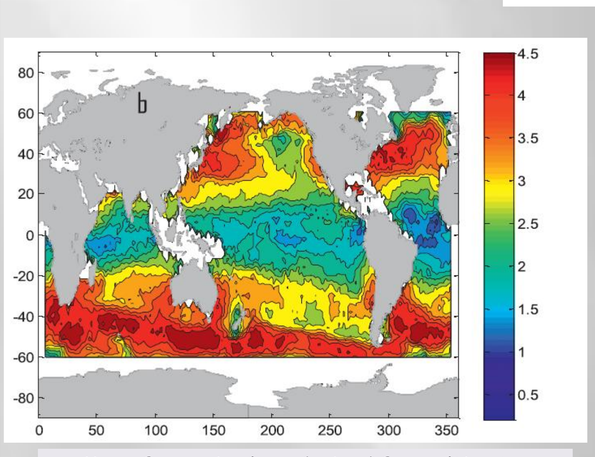
SLA PSD for Cryosat-2 SAR mode, PLRM mode and Jason-2, with (left) and without (right) 20 Hz noise



We build a synthetic PSD with the 20 Hz noise and the oceanic signal at large scales. The difference between the observation and the synthetic PSD reveals a clean PSD with a slope close to K-1 between 10 and 50 km.

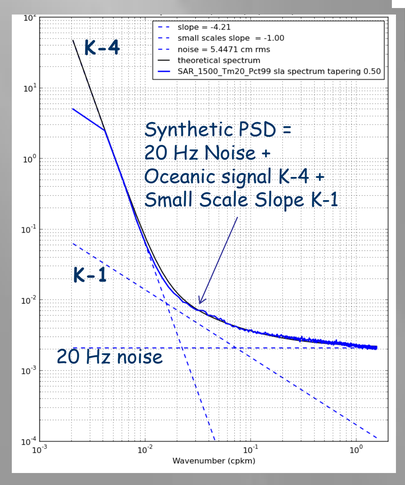


SLA PSD for Cryosat-2 SAR mode and Synthetic PSD (right)
Observation – Synthetic PSD (left)



Map of oceanic slope derived from altimetry
From Xu and Fu 2012

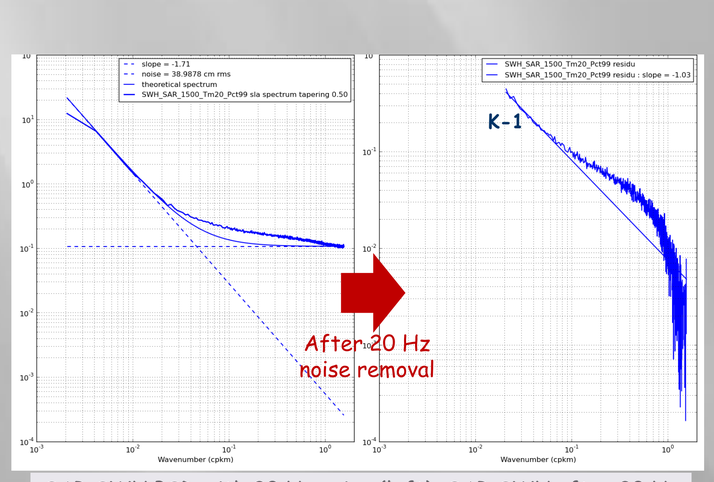
A continuous slope appears on SAR PSD whereas Jason-2 and Cryosat PLRM mode present higher energy between 10-50 km (so called "bump" artefact discussed in Dibarboure et al 2014).
The "bump" signal is due to heterogeneities in the altimeter footprint not modelled by the Brown/Haynes formulation. Error represents only few cms...



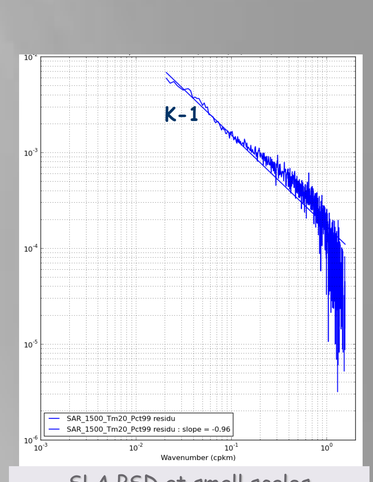
A new synthetic PSD is created by assuming 2 different slopes:
-Large scale slope of K-4.2 for scales > 100 km
-Small scale slope of K-1 for scales 10-50 km
=> Perfect match between the measured and the new synthetic PSD (residual PSD one decade below the observation).

Observed (blue),
New Synthetic PSD (black)
Slopes of K-4.2 and K-1 (dashed)

Small Scale Content of Sea level and SWH



SAR SWH PSD with 20 Hz noise (left), SAR SWH after 20 Hz noise removal and zoom on scales > 50 km (right)



SLA PSD at small scales

The question is raised on the content of the small scale slope observed on the sea level PSD with SAR mode. We tend to discard error in the SAR processing (level 1 and retracking processing) because J2 and SAR agree very well between 30 and 100 km.
We also observe that the slope of SLA perfectly agrees with slope of SWH PSD for scales 10-50 km.

Conclusion

SAR PSD shows a continuous slope of K-1 between 10 and 50 km which is also observed on SAR SWH. We tend to discard error in the SAR processing (level 1 and retracking processing) because J2 and SAR agree very well between 30 and 100 km.

- When assuming two different slopes (K-4 for large scales above 100 km and K-1 for small scale wavelengths), this perfectly models the SAR PSD observed over the Agulhas
- This result is also observed over the North East Atlantic but has to be further confirmed over other regions

The correlation with the sea state of the K-1 slope observed on sea level has to be further characterised and understood thanks to Cryosat time series.

Sentinel-3 will offer a global SAR coverage over all oceans that will provide an efficient mean for observing the different oceanic regimes to further caracterise the small scale slopes in altimetry.

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OSTST Meeting
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