Altimetric wavenumber spectra and noise floors

O. Vergara, R. Morrow, I. Pujol and G. Dibarboure

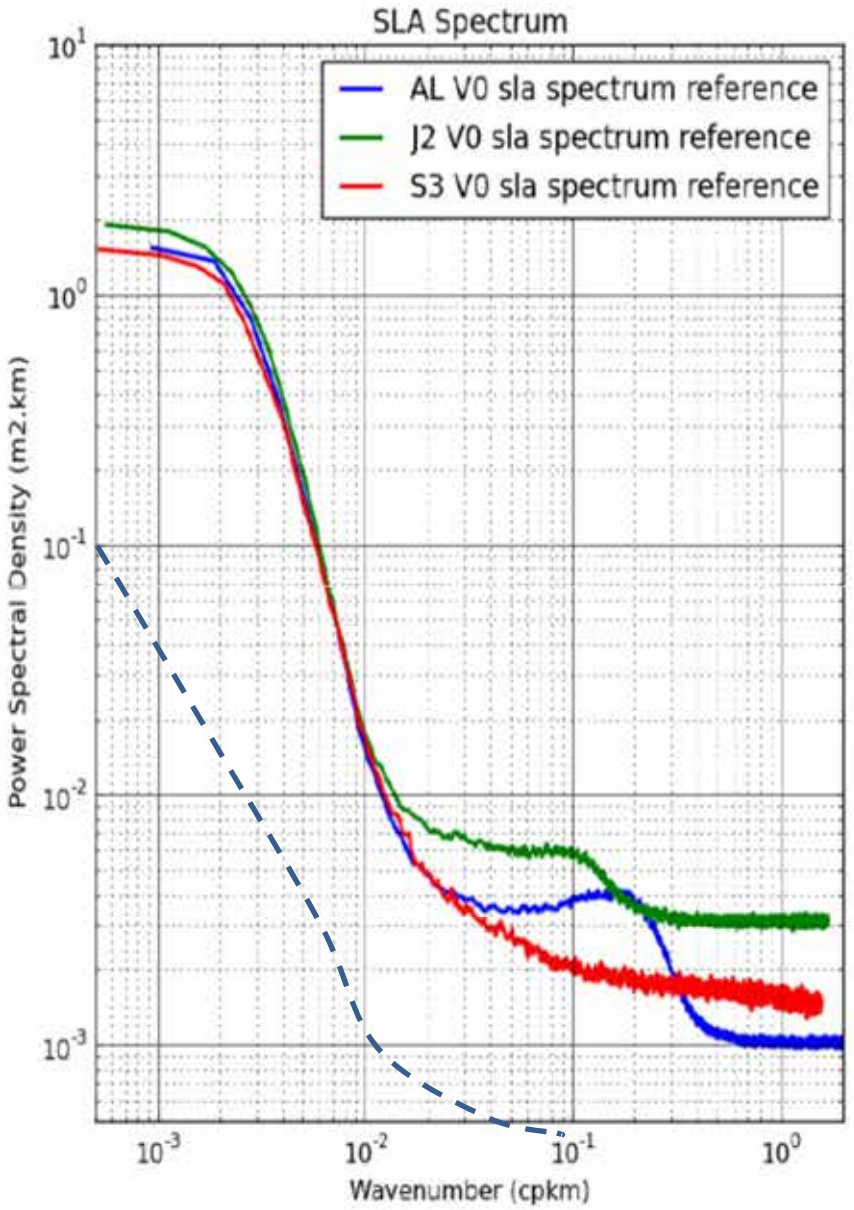
Ocean Surface Topography Science Team Meeting
Miami, October 23-27 2017

First S3A results

- Analyses of SARM Sentinel-3a data (from CNES S3PP products) have been performed to estimate the SAR-mode error budget at small ocean scales

- Main SLA spectrum differences observed between SARM and LRM spectrum are :
  - Detection of a “red” signal
  - Significant reduction of “bump” signal

---- Projection of SWOT noise in 2D … large reduction in instrumental noise ➡ Below current S3-SAR capabilities.



M. Raynal et al., OSTST 2016

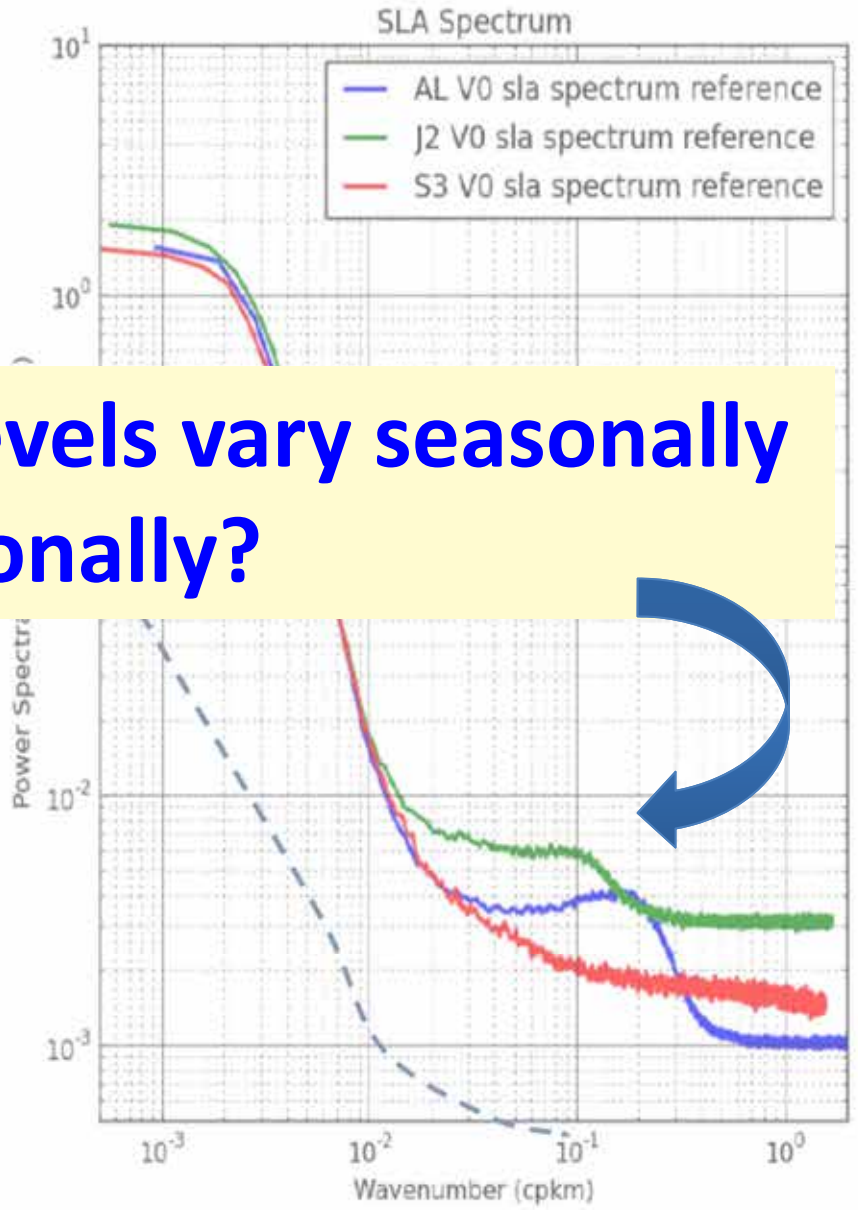
First S3A results

- Analyses of SARM Sentinel-3a data (from CNES S3PP products) have been performed to estimate the SAR-mode error budget at small ocean scales

How do these noise levels vary seasonally and regionally?

- Detection of a "red" signal
- Significant reduction of "bump" signal

---- Projection of SWOT noise in 2D … large reduction in instrumental noise ➡ Below current S3-SAR capabilities.



M. Raynal et al., OSTST 2016

Power Spectral Density analysis

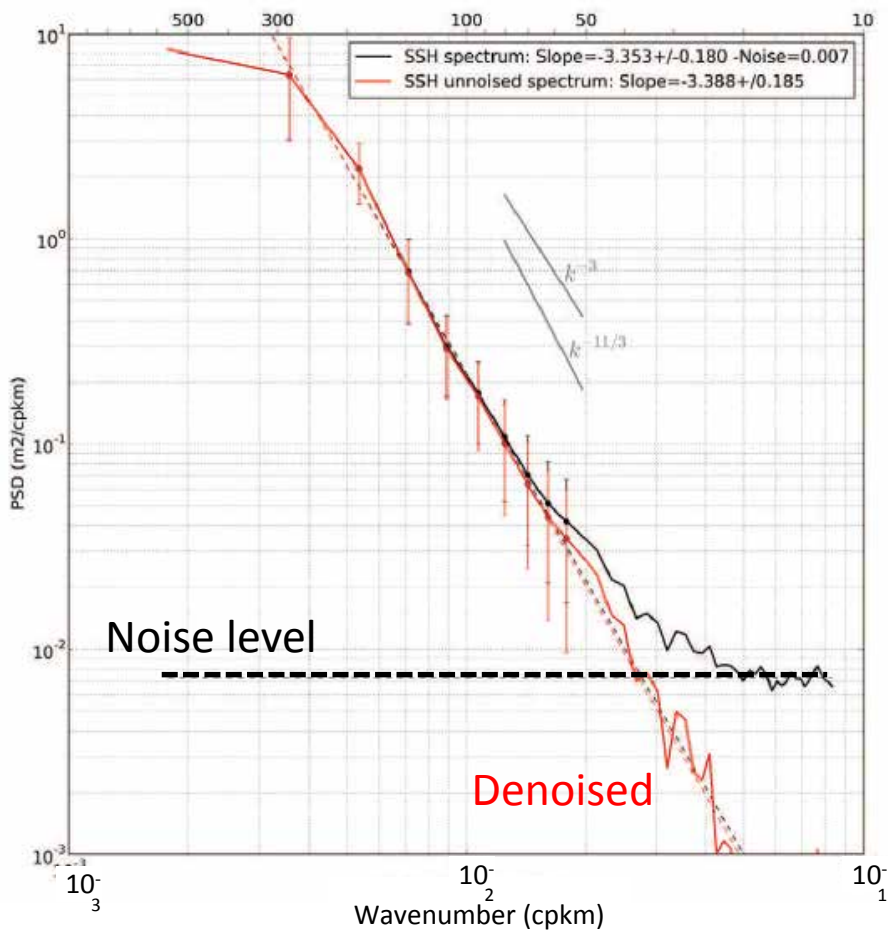
Technique presented by Dufau et al, 2016 & at Lake Constance OSTST 2014

- Spectra computed on along-track measurements:
  1. Tracks sub-sampled at fixed length, inside the region of interest.
  2. Individual spectral estimations for each sample.
  3. Sample averaging yields regional spectrum.
  4. Noise estimation (**sensor dependent**)

Dufau et al 2016 used 5 years of Jason-2 data, but only 6 months of Saral data

=> We can now analyse 3 years of Saral on repetitive orbit.

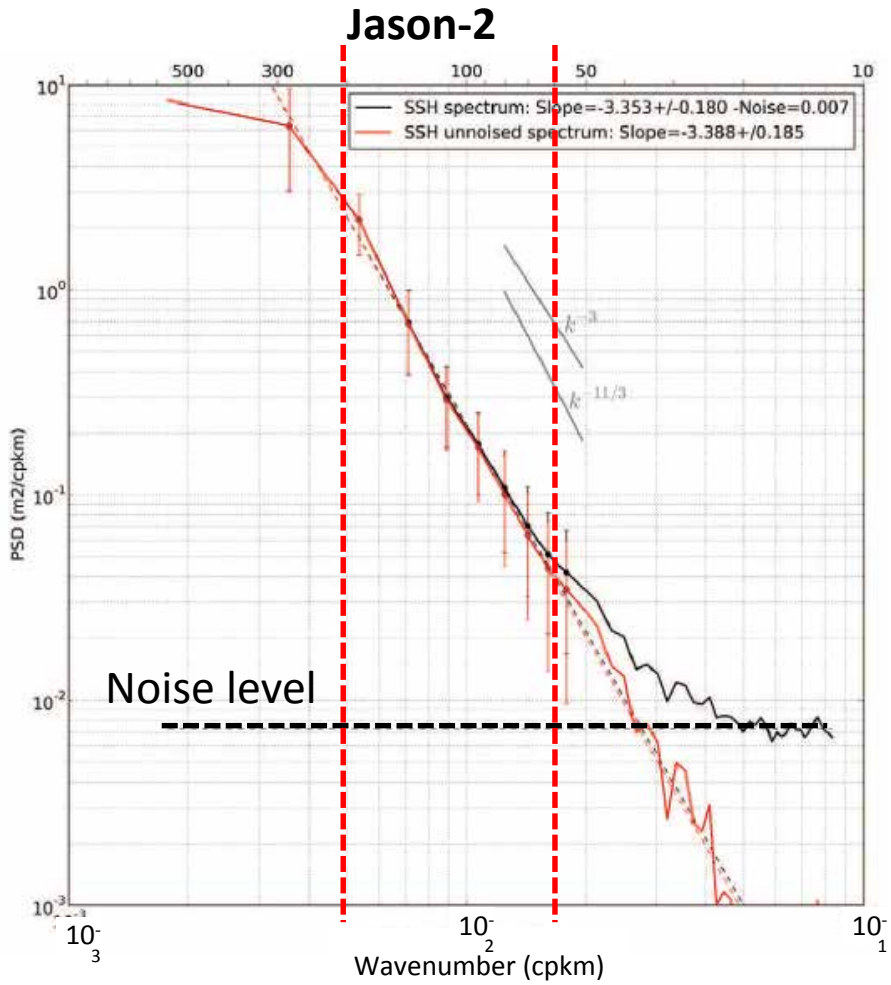
Jason-2



Power Spectral Density analysis

- Spectra computed on along-track measurements:
  1. Tracks sub-sampled at fixed length, inside the region of interest.
  2. Individual spectral estimations for each sample.
  3. Sample averaging yields regional spectrum.

Use of fixed spectral range 70-250 km –>

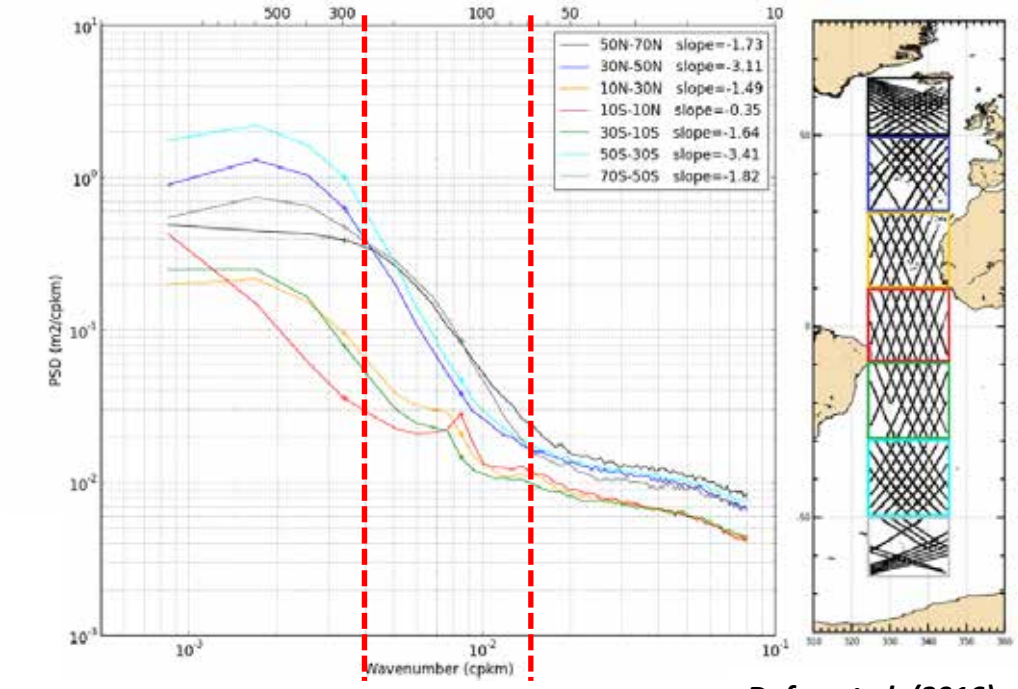


Power Spectral Density analysis

- Spectra computed on along-track measurements:
  1. Tracks sub-sampled at fixed length, inside the region of interest.
  2. Individual spectral estimations for each sample.
  3. Sample averaging yields regional spectrum.

Use of fixed spectral range 70-250 km –>
- well adapted for mid latitudes.
- Flattens spectral estimate at low latitudes.

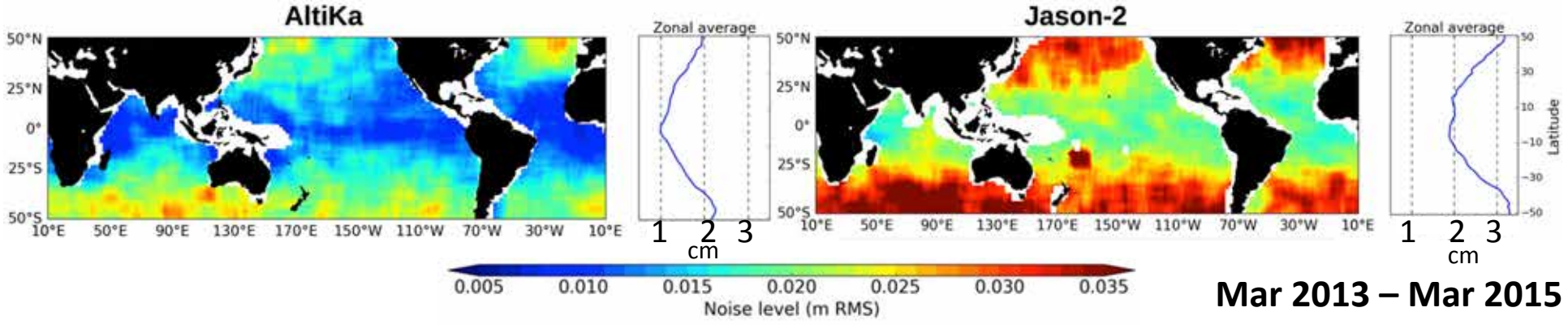
Mean SSH spectra for Jason-2 (5.5 years of data)



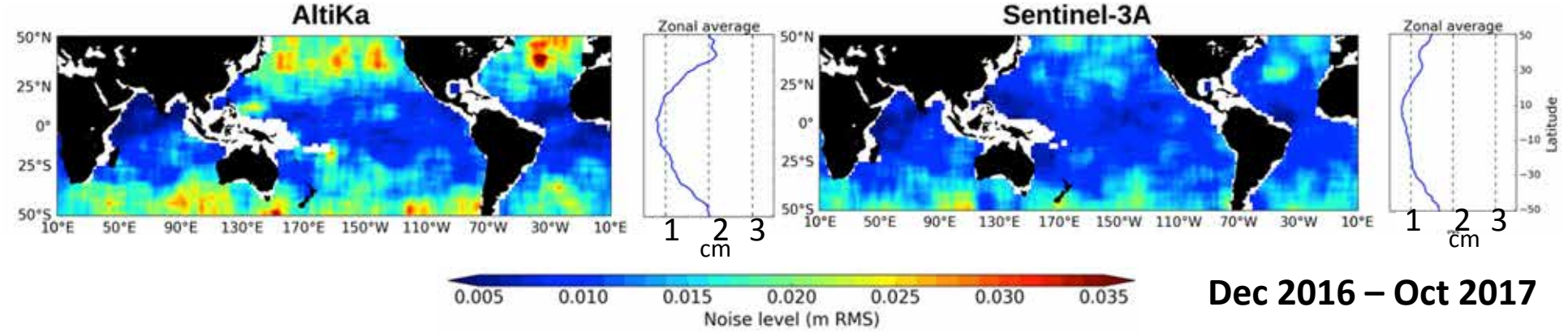
Dufau et al. (2016)

See Poster SC3-09 : Vergara et al., using variable spectral range based on local dynamics in Science Session III : sub-mesoscale to mesoscale oceanography.

Error levels in altimetric signal



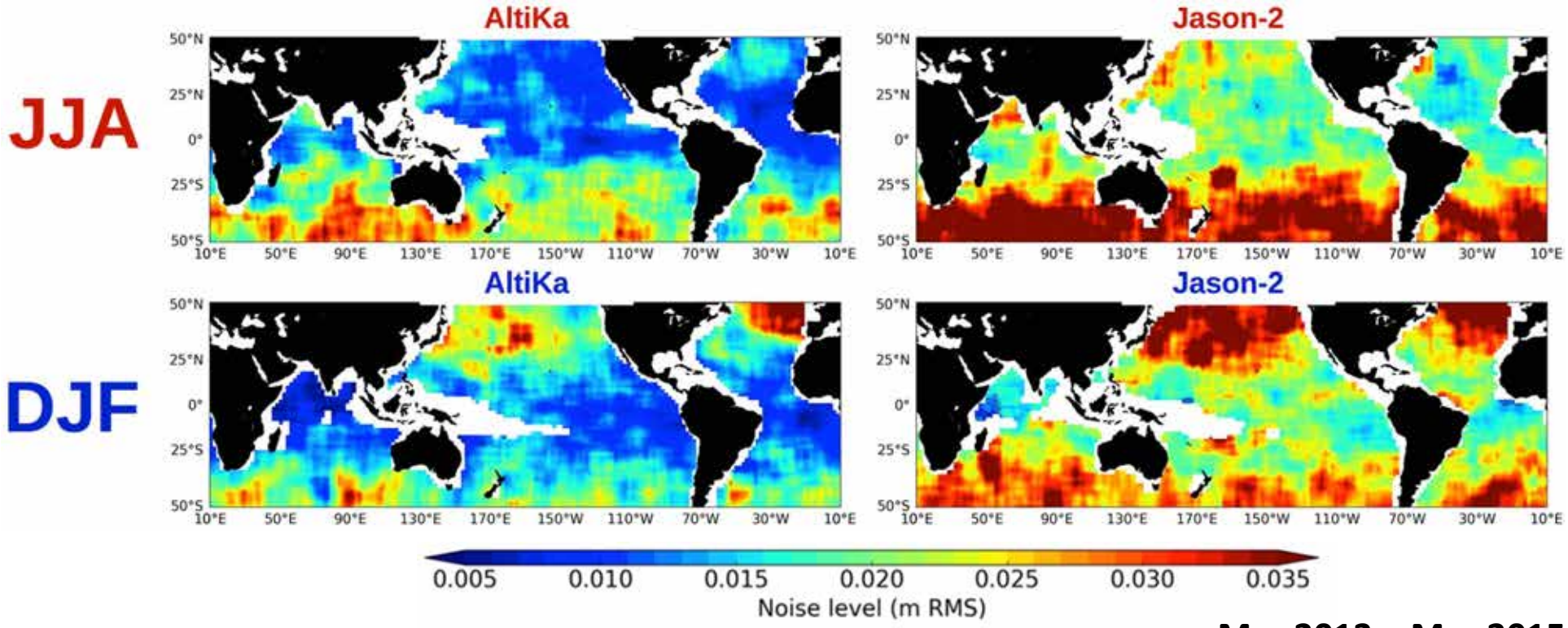
Mar 2013 – Mar 2015



Dec 2016 – Oct 2017

- Error levels are the lowest in the inter-tropical band, and increase with latitude.
- Error levels drastically reduce in recent missions (by ~1.5cm from **J2** to **S3A**).

Seasonal variability in error levels



Mar 2013 – Mar 2015

- Error levels are lower during summer than during winter, which impacts the fine-scale resolution capabilities.

- Large contribution to J2 and Saral errors from the local sea-state and rain, sigma-0 blooms.

MSS errors signature on SLA PSD: methodology

Pujol et al., in prep.

We consider :

H = SLA signal including the MSS errors (**e**) and the SLA signal free from MSS errors (**h**)

A and B = two different cycles

3 main assumptions:

1) There is no covariance between the SLA signal and the MSS errors.

2) The SLA signal is completely uncorrelated between the two cycles considered.

3) The MSS error is the same, independent of the considered cycle .

1) We use a mission/period independent from MSS computation: S3PP/CNES Sentinel-3A (20Hz); PEACHI SARAL/AltiKa (40Hz)

2) We chose A and B far enough from each other

3) We use a repetitive mission

$$0.5\ V(H_A - H_B) - 0.5\ V(H_A + H_B) = 2\ V(e)$$

Mean spectral content of the h signal

Mean spectral content of the h+e signal

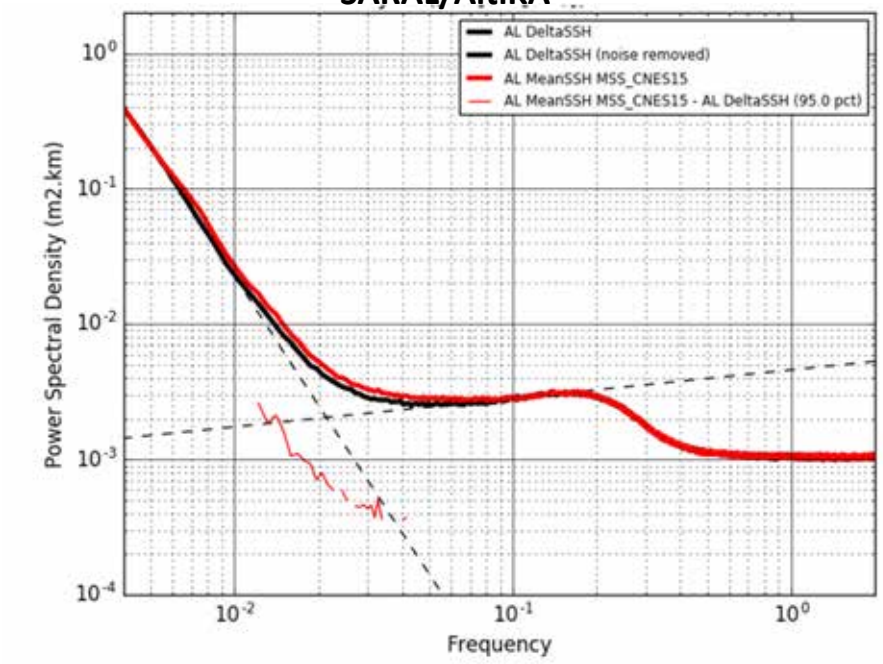
MSS errors signature on SLA PSD

MSS CNES_CLS15 used

- PSD of the SLA free from MSS errors
- PSD of the SLA including twice the MSS errors
- PSD of twice the MSS errors

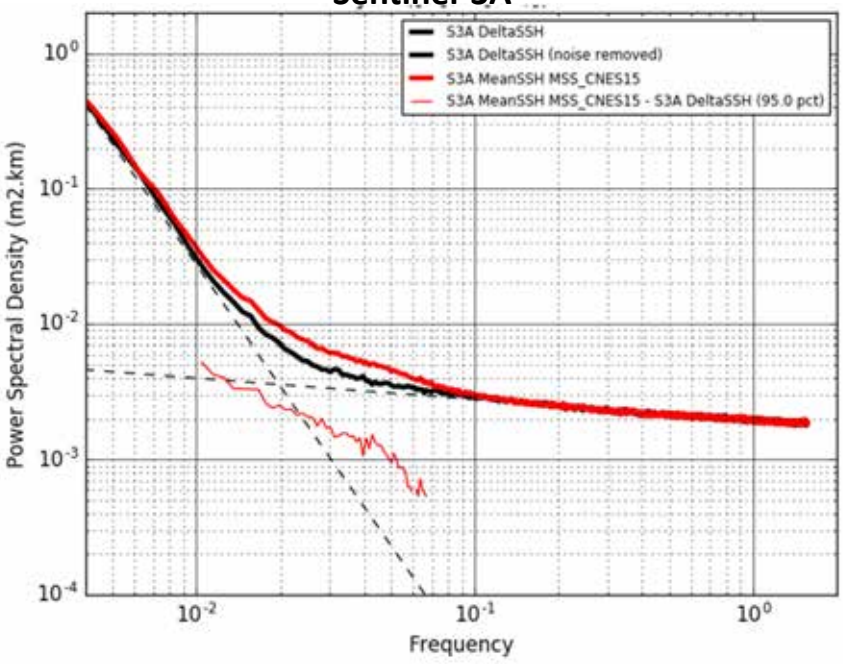
Pujol et al., in prep.

SARAL/AltiKA



➢Mean MSS errors over [100, 30km] = 0.35 cm (**12.1%** of the SLA variance)

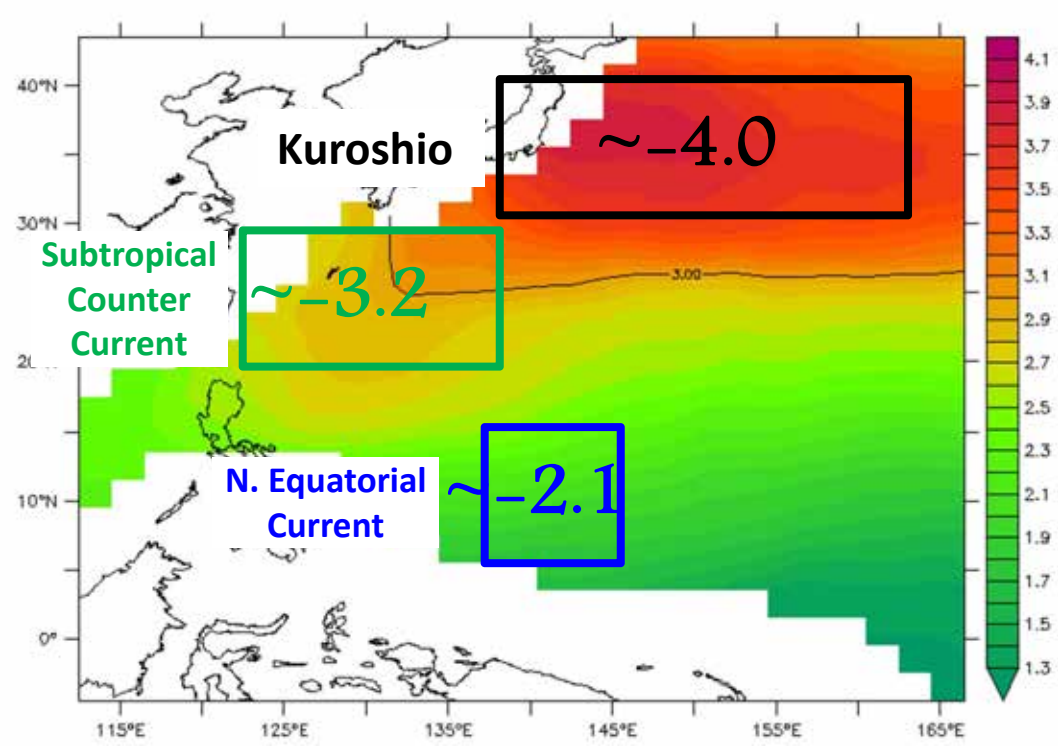
Sentinel-3A



➢Mean MSS errors over [100, 30km] = 0.55 cm (**30.3%** of the SLA variance) = **2.5 x errors observed along AL tracks**

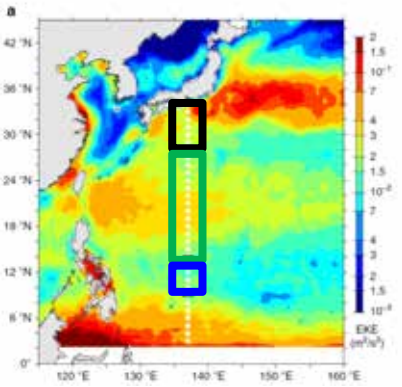
SARAL (**1Hz**) slope estimates distribution

Average SSH spectral slope for Saral (2013-2015)

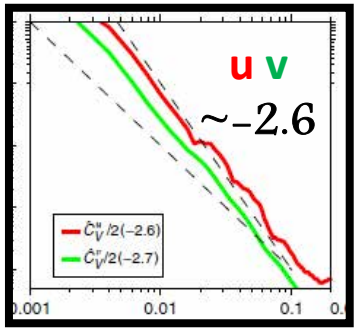


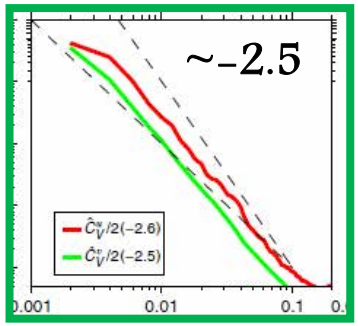
SSH slope = k^{-2} x KE spectral slope :

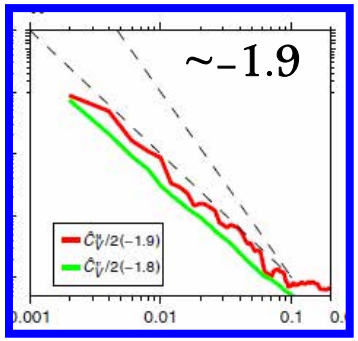
Surface EKE (2004-2015)



Qiu et al. (2017)







- Good agreement with *in situ* observations in extra-tropical region.
- Differences increase at lower latitudes.

<u>Slope differences could be due to:</u>

- Internal waves in the low latitudes.
- Noise bias: (1) instrumental (2) MSS errors.

Conclusions

- SARAL and S3-SAR missions have lower noise in 15-100 km wavelength band, and measure similar global SSH PSD down to 30-40 km.

⇒Good candidates to observe 1D SSH in preparation for SWOT

- MSS errors in S3-SAR (new orbit, with CLS-MSS-2015) may be similar to SWOT MSS errors in early period of mission.
- Wavenumber spectral slope from LR product varies seasonally, as well as noise levels.
- **Ongoing work** (Poster SC3-09)**:**
  - Look at S3-SAR spectral slopes.
  - Compute max spectral slopes over range which varies with latitude range / Rossby radius.