Improving altimeter sea level calculation at small ocean scales

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Overview

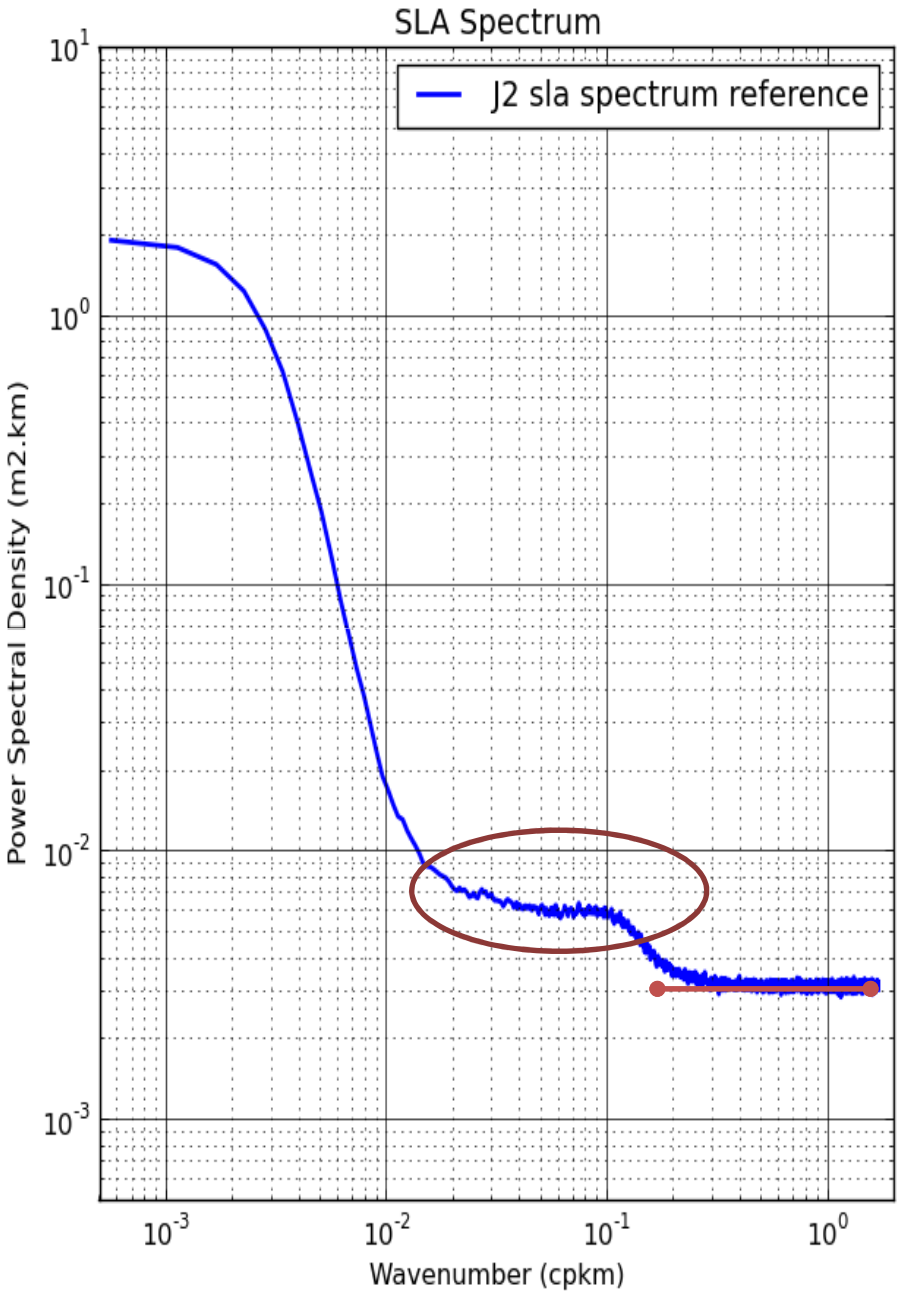
- Small ocean scales are not observed below 80-100 km with current LRM altimeter data (Dibarboure et al., 2014) **mainly** due to surface heterogeneities in the footprint (e.g. rain, sigma bloom, …) and altimeter noise.

- Objective : description of current and improved altimetry data for small sea-level structures in ocean (< 100 km)
  - Error description of current altimetry LRM data (Jason-2 and Altika)
  - SLA improvements with LRM data (Jason-2 and Altika)
  - New expectations with SAR mode missions (e.g. Sentinel-3a)

1 – LRM ERROR DESCRIPTION

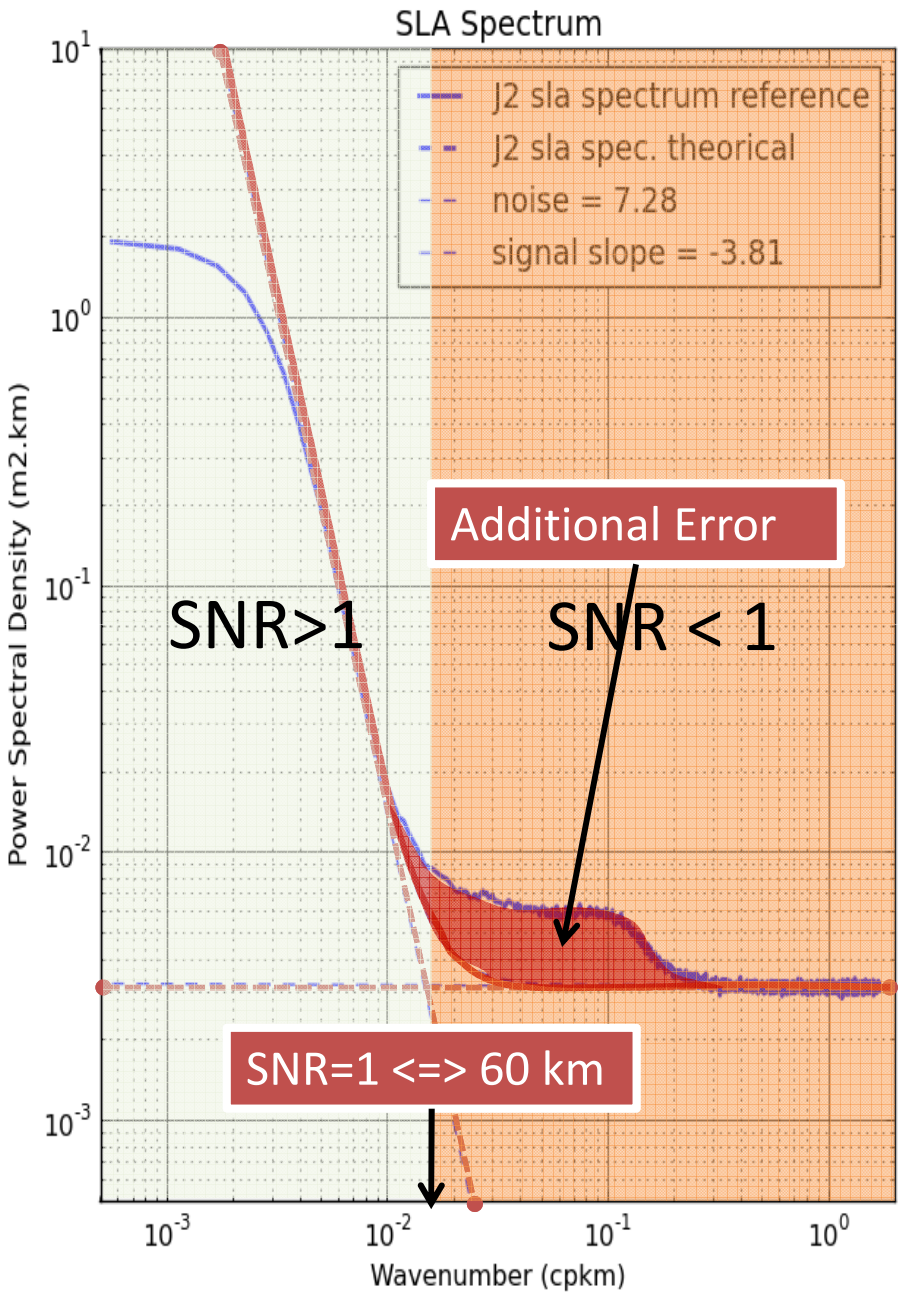
LRM Error descriptio

- Global Jason-2 SLA spectrum :
  - SGDR (MLE-4 retracking) with updated altimeter standards (MSS CNES-CLS 2015,..) and basic editing to remove outliers.
  - HF plateau = Instrumental + processing white noise. Level of energy corresponds to 7.3 cm range level of noise .
  - Large energy rise observed for wavelength under 80 km **mainly** due to surface heterogeneities in the footprint (Dibarboure et al., 2014)



LRM Error descriptio

- Theoretical SLA spectrum is the sum of:
  - 20Hz White noise level (7.3 cm for J2)
  - oceanic slope (as observed by models)
- It allows to quantify:
  - the distance where Signal Noise Ratio (SNR) is higher than 1 : ~60 km for Jason-2
  - The remaining and undesired signal (bump + internal tides + ...)

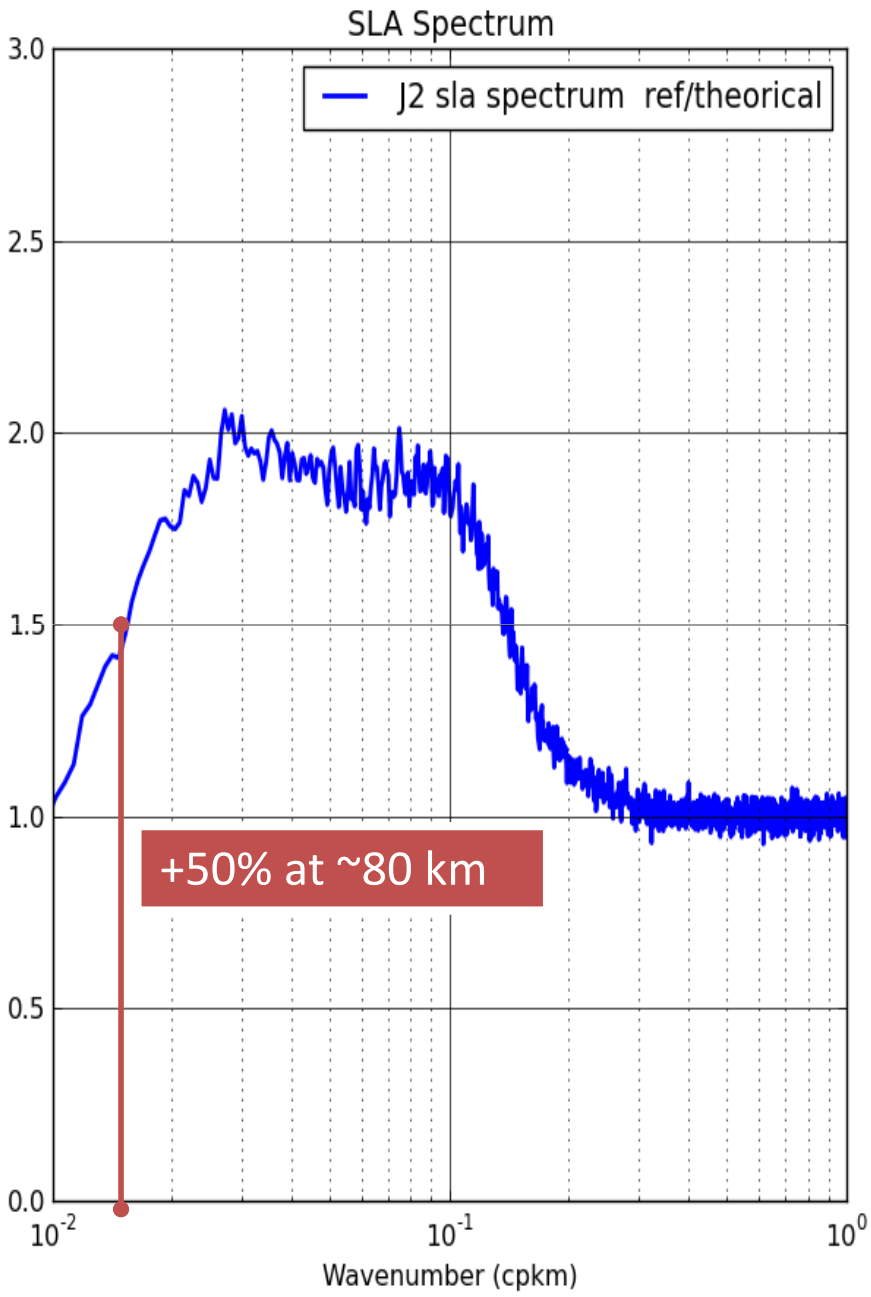


LRM Error descriptio

- The ratio between SLA and theoretical spectra (ocean slope + white noise) highlights the additional error on Jason-2 due to surface inhomogeneities in the footprint :

⇒ At 80 km , 50% additional energy due to error

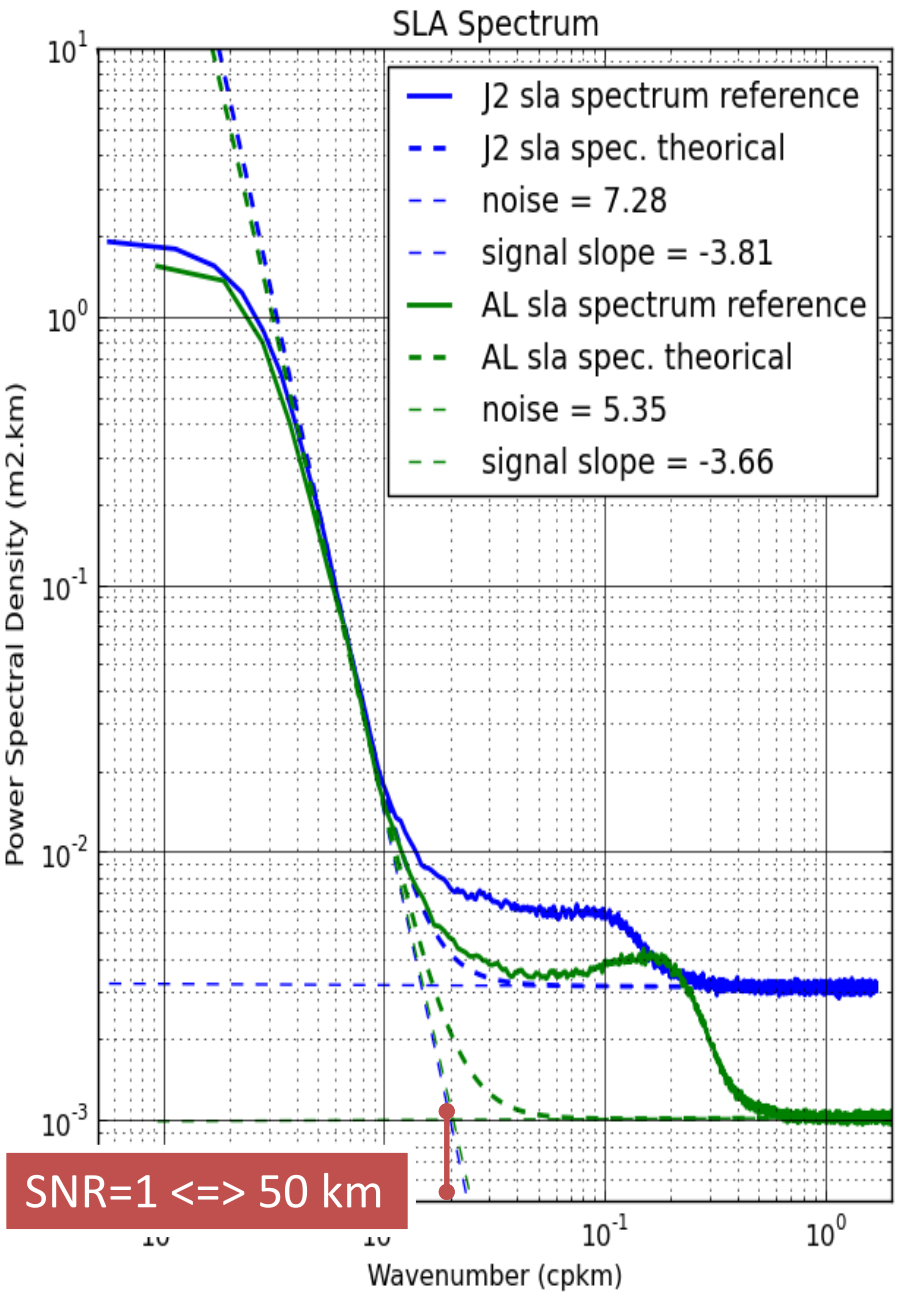
⇒ This additional error added to the white noise prevent the observation of small oceanic scales < 80-100 km for Jason-2



Error description

- Similar results with other Jason missions:
  - same white noise level
  - same signature of surface inhomogeneities in the footprint

- With SARAL/Altika:
  - white noise level is reduced : the distance of SNR>1 is reduced to 50 km (instead of 60 for Jason missions)
  - signature of surface inhomogeneities in the footprint (“Bump”) is also present: stronger than for J2 relatively to the theoretical spectrum



2 – LRM IMPROVEMENT

LRM improvement

- Objectives : improve LRM data for scales lower than 100 km :

- 1) Development of a new editing dedicated to high rate altimeter measurements (20 or 40 Hz) based on the SLA coherence between consecutive measurements

- 2) Application of an empirical method to reduce the correlated noise between altimeter range and SWH developed by Zaron et al., 2016

Principle of Zaron 's method:

1) Computation of coefficient which minimize :

Δ SLA / Δ SWH = α + β SWH

2) Correction of SSH :

$$SSH_{Corr} = SSH - (\alpha + \beta SWH_{\lambda})(SWH - SWH_{\lambda})$$

With λ (=100km) the cut-off period of low pass filter

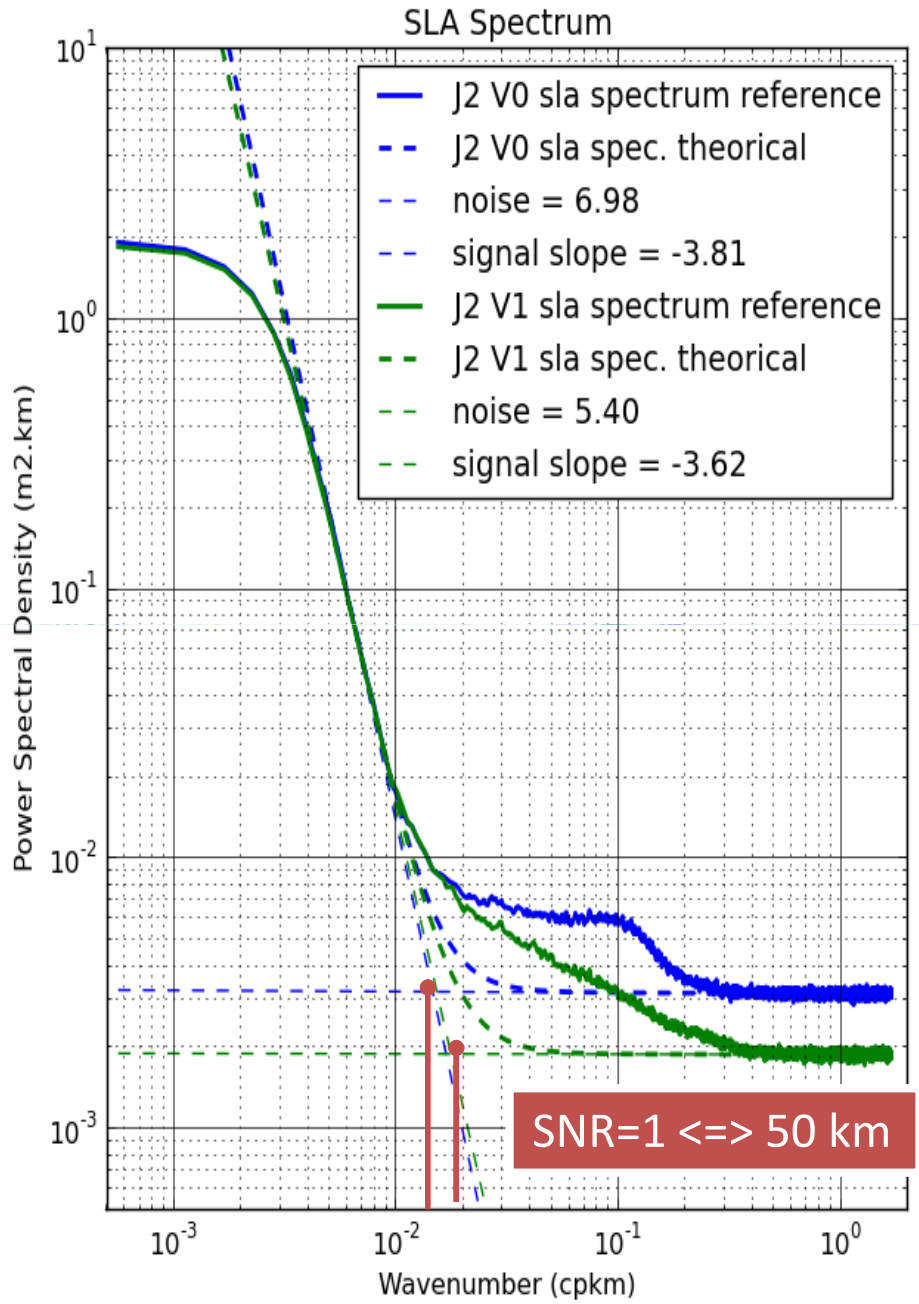
LRM improvement

- SLA Jason-2 spectrum, improved version (noted V1) vs. reference version (V0) :

- White noise level reduction (-40%):

⇒ Distance of SNR=1 reduced by 10 km (~60 to ~50 km)

- Reduction of “Bump” with a slope instead of a plateau for distance < 30 km
- Signal unchanged between 30 and 80 km
- Map of SLA variance differences (0-200km) highlights clearly a variance reduction everywhere, but mainly in wet areas (thanks to new editing)



LRM improvement

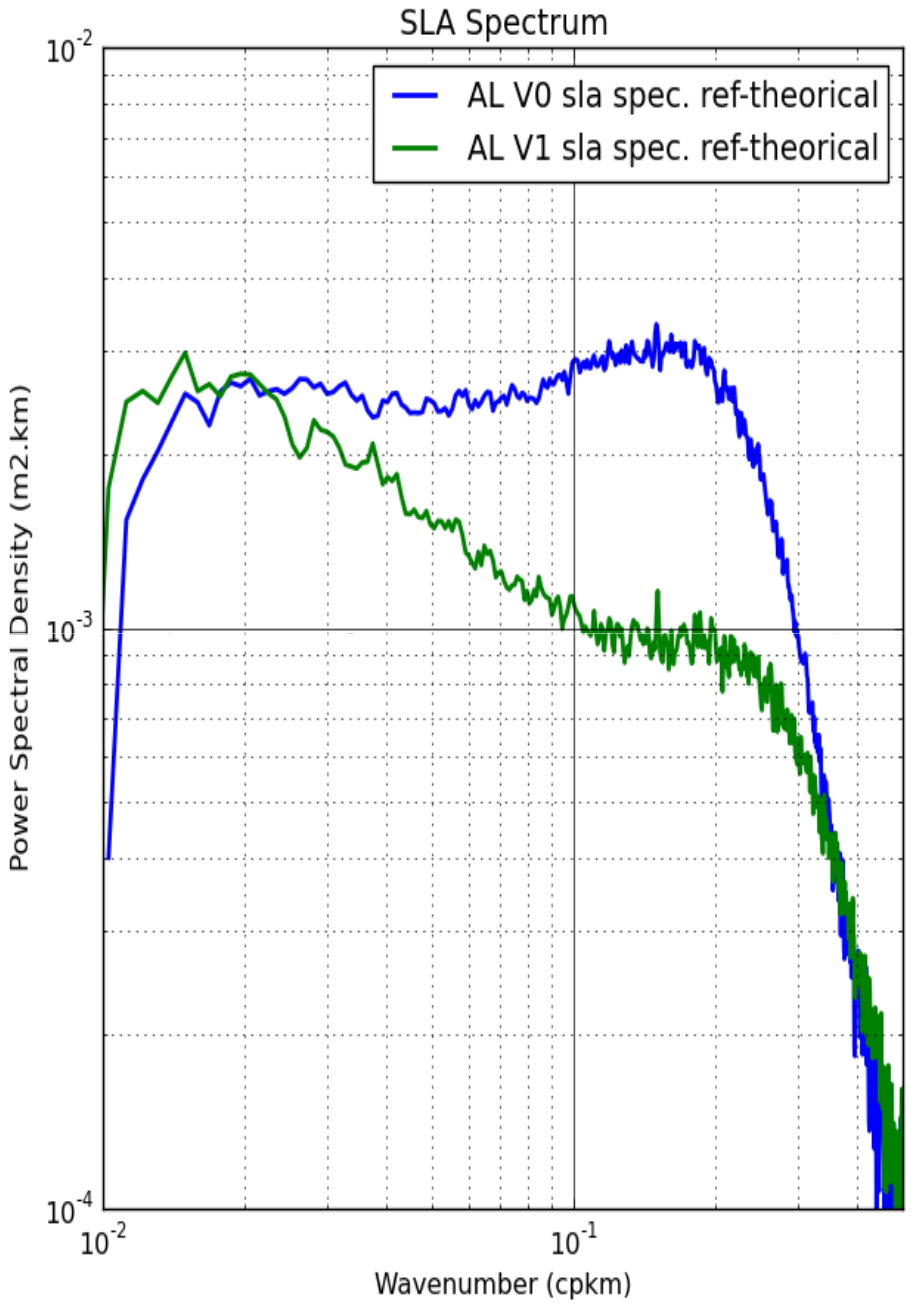
- SLA Altika spectrum V0 vs. V1 :

- White noise level reduction (-40%)

⇒ Distance of SNR=1 reduced by 10 km (~50 to ~40 km)

- Reduction of “Bump” with a slope instead of a plateau for wavelength< 50 km:

⇒ Signal unchanged for wavelength higher than 50 km



LRM improvement / Conclusions

⇒ LRM errors for small ocean structures < 100 km can be reduced by improving the post-processing of high rate altimetry data : editing, empirical noise reduction

⇒ Today, LRM errors remain too large for scales 30-80 km **in average**

⇒ However :

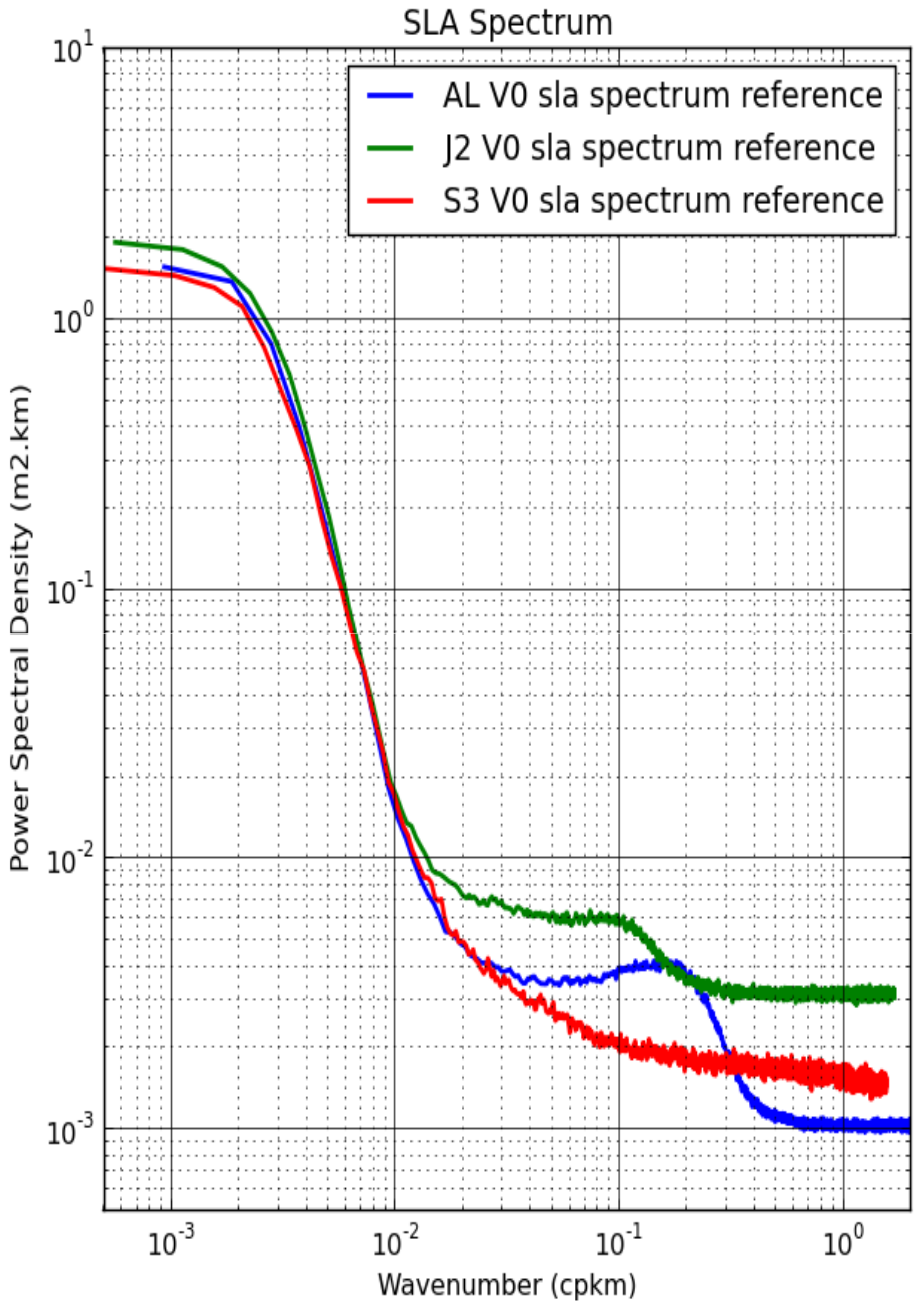
- Locally, the noise reduction and a better editing should allow a better small scale observability
- others improvements are expected applying new “Retracking” algorithm (cf P.Thibaut’s talk) … work on going on PEACHI projects (CNES).

3) FIRST RESULTS WITH SENTINEL-3A

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

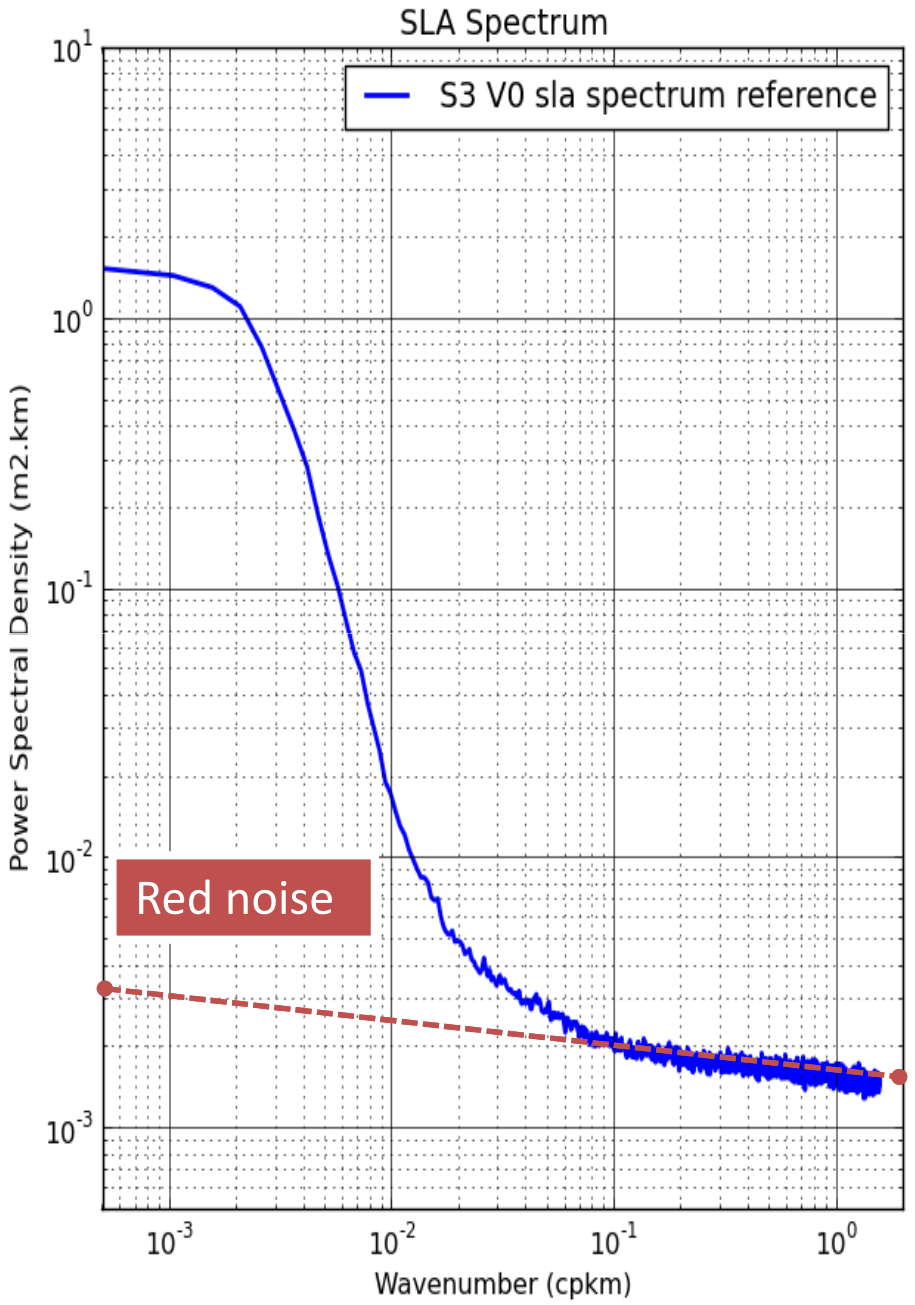


First S3A results

- “Red noise” is composed of :

⇒ white noise (instrumental + processing)

⇒ additional unknown signal that we assume to be an error in the Sea Level signal

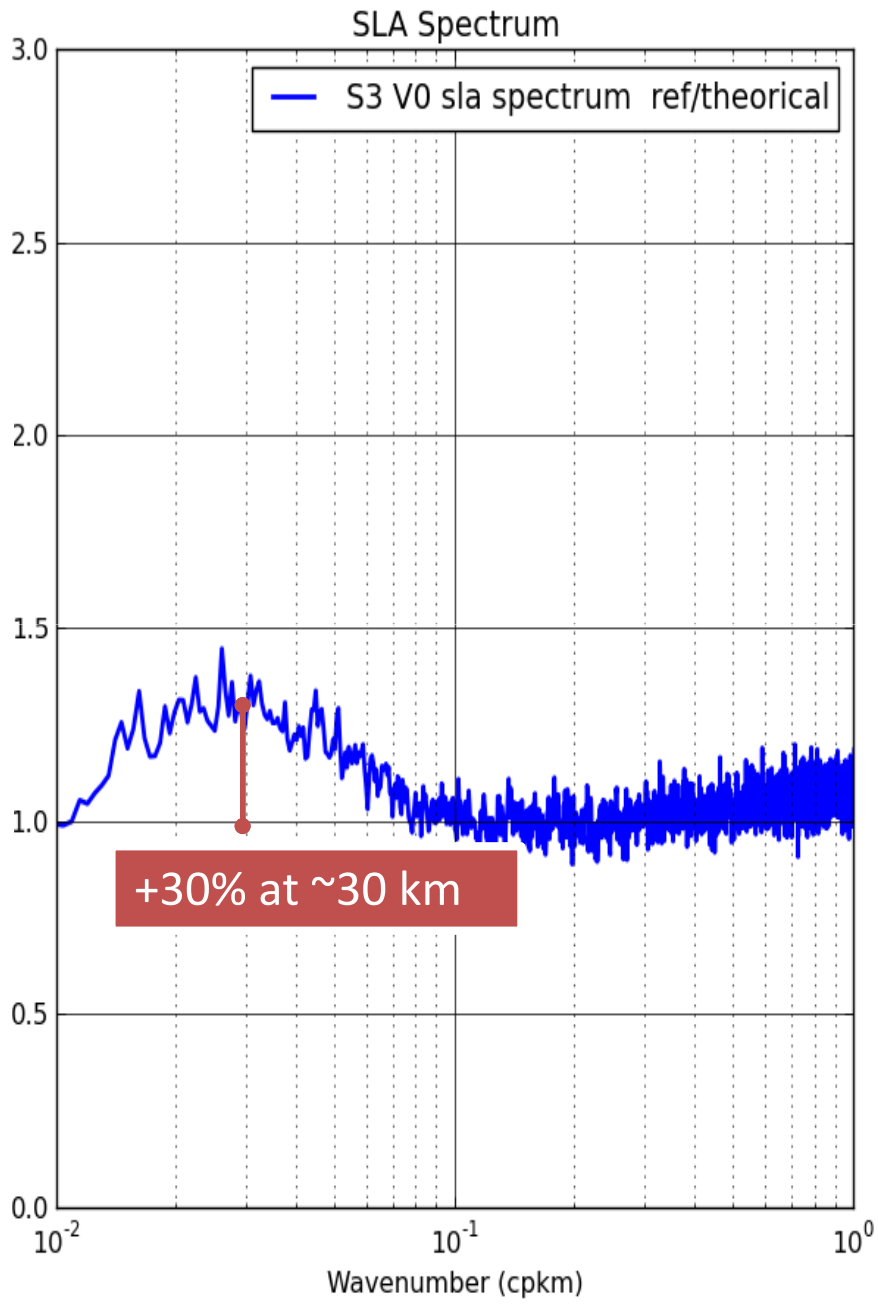


First S3A results

- The ratio of SLA and theoretical spectra highlights the small level of error for scales between 10 and 100 km after removing the red noise.

- Recent studies (cf SAR meeting) have shown that most of these errors was due to the MSS errors :

⇒ MSS not yet optimize at these scales on the new S3-a ground track



First S3A results / Conclusions

⇒ S3-A performances at small oceanic scales are very promising thanks to the SAR mode

⇒ Some errors are still observed **on average** preventing the observation of small oceanic scales:

- MSS errors will be removed after accumulating few years of data.
- “Red noise” error is under investigation (Swell effects ??)

⇒ Compared to LRM altimetry errors, both SARM errors are quite well understood.

⇒ When these errors will be removed, S3-A SAR data should allow the observation of small oceanic scales until 30-40 km on average at global scale, less in specific areas.

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