Towards a spectral error budget of Nadir Altimetric missions

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SALP
Service Altimetrie & Localisation Precise

OST/ST 2014

October 27-31, 2014
Konstanz, Germany

Overview

- **Altimetry** system provides more and more precise data.
- But, as every remote sensing system, it is affected by **errors**, more or less known and described.
- This presentation is dedicated to **altimetry users** and presents a state of art of the work performed to deliver, jointly to the altimetry products, an estimation of their associated error.
- A series of metrics and diagnoses already enable to constitute an error budget, which can be confronted with the mission goals and specifications.
- But, depending on the applications**, the errors at different spatial and temporal scales are not the same.**
- With the new era of wide swath altimetry, we need to **decline the error budget for various temporal and/or spatial scales.**
- This presentation focuses on the way this new metrics are getting prepared.

Overview

For this study, data used are
along track Jason-2 GDR-D Level-2 products.

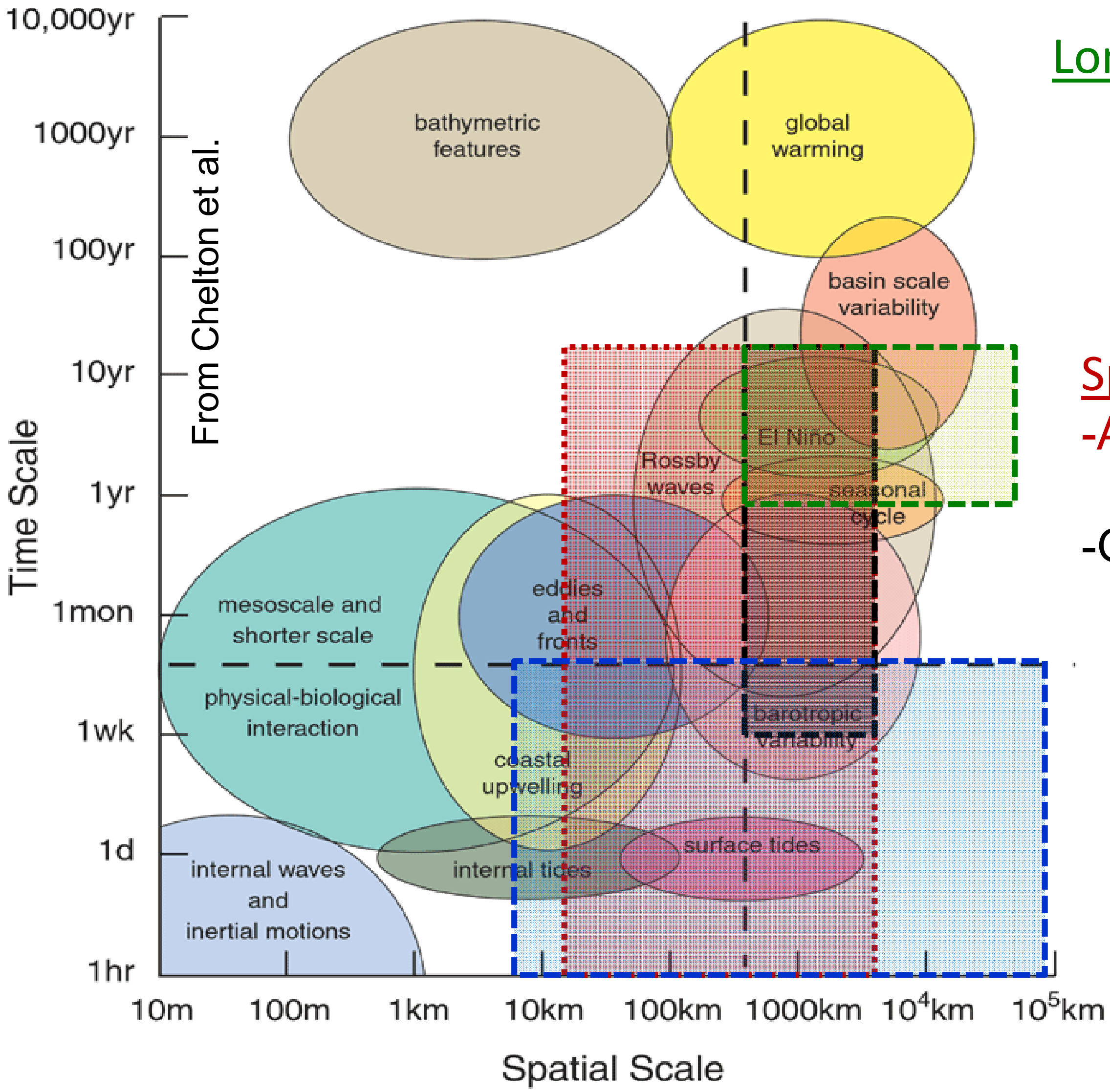
This presentation is splitted into 3 parts:

1. Background and presentation of the problem

2. Example of metrics and analysis of the spectral content

3. Taking into account the spatial/temporal dependency: notion of enveloppes

Background



<u>Long term trend analysis:</u>

1Hz along track data

annual cycle removed

Ex: Ablain et al. Poster

<u>Spectral analysis on:</u>

-Along track 1Hz

Ex: Ubelman et al. OSTST 2013

-Gridded maps (280km)

Ex: Pujol et al. Next talk

<u>Crossover statistics:</u>

along track data

1Hz (7km)

below 10 days

Ex: Philipps et al. OSTST 2012

Background

- The specifications of the mission consists in integrated values over all frequencies available for all the corrections included in the SSH definition:

SSH = Orbit - Range - Iono - Sea State Bias - Dry tropo - Wet tropo

From Philipps at al. OSTST 2012

Parameters and corrections for raw sea surface height	Error budget	Error (<10 days) OGDR	IGDR	GDR	GOAL
	Altimeter range	>1.6 - 1.7 cm			1.5 cm[a,b,c]
	Ionosphere	>1 cm / >0.2 cm			0.5 cm[d,c]
	Sea State Bias	>0.4 cm			1 cm
	Dry troposphere	0.4-0.7 cm	0.3-0.7 cm		0.7 cm
	Wet troposphere	>0.2 cm			1 cm
	Rms Orbit (radial component)	>3.7 cm	>1.7 cm	>1.0 cm	1.5 cm

2.25 cm²
0.25cm²
1cm²
0.49 cm²
1cm²
2.25 cm²

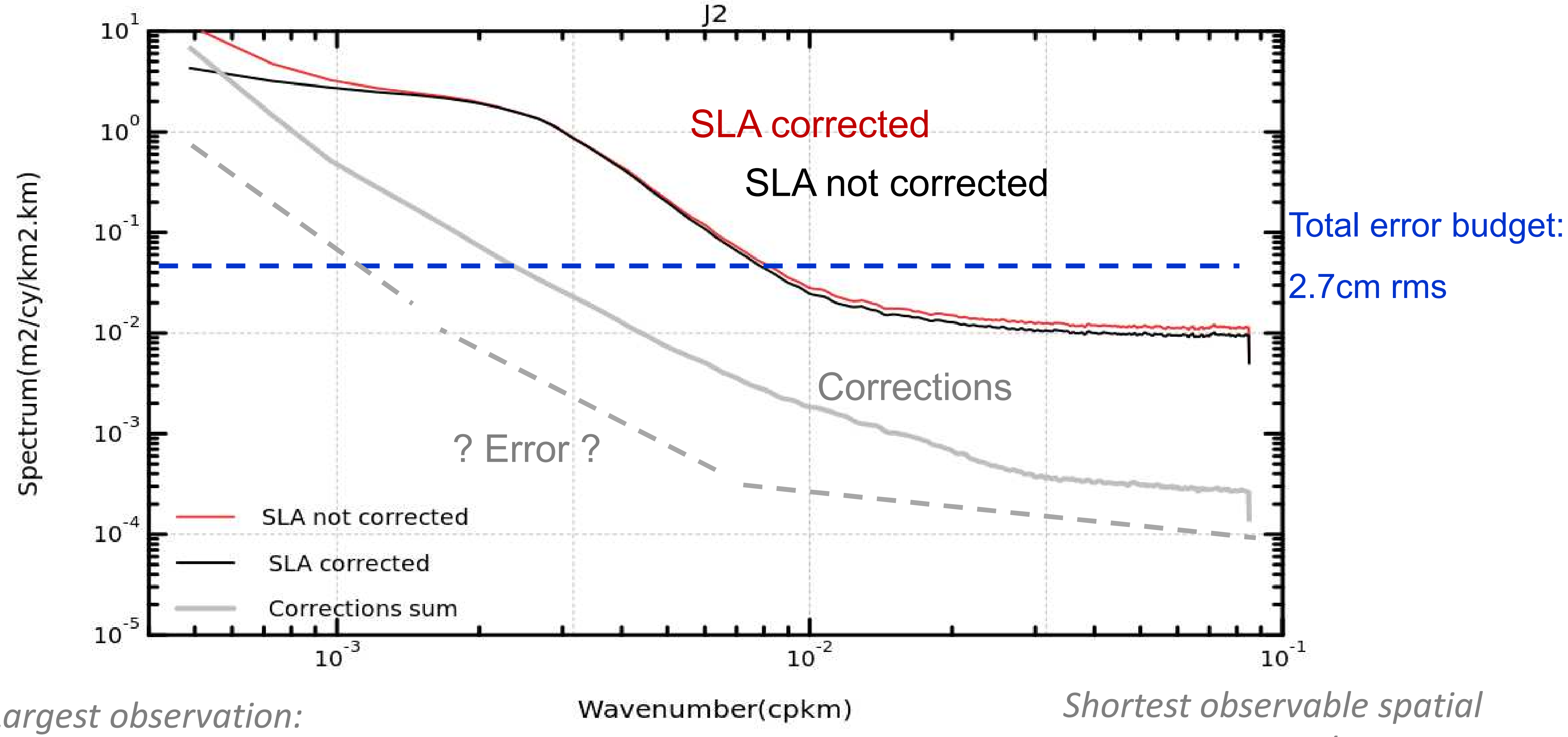
2.7cm ← 7.24cm²

Philipps et al. Proposed an assesment of the specifications, relying on crossover statistics and adresses the **error below 10days.**

All errors are mixed even if we know they don't affect equally the same wavelengths.

Method

- Compared to the Sea Level anomaly power spectrum, our aim is to decline the integrated figures of the specification for each frequency between.



Largest observation:
all the available latitudes 8 000km

Shortest observable spatial sampling: 14km / 1Hz sampling

Method

- In his presentation, Clement Ubelman (OSTST, 2013) initiated a break down of the errors spectral characterisation with a strong assumption of decorrelation of the correction with the corrected signal.

- Following his efforts we propose a complementary approach based on multiple sources of observation of a same geophysical content.

SSH = Orbit - Range - Iono - Sea State Bias - Dry tropo - Wet tropo

Tri technique
Pure GPS
Pure DORIS

Bifrequency /
GIM model

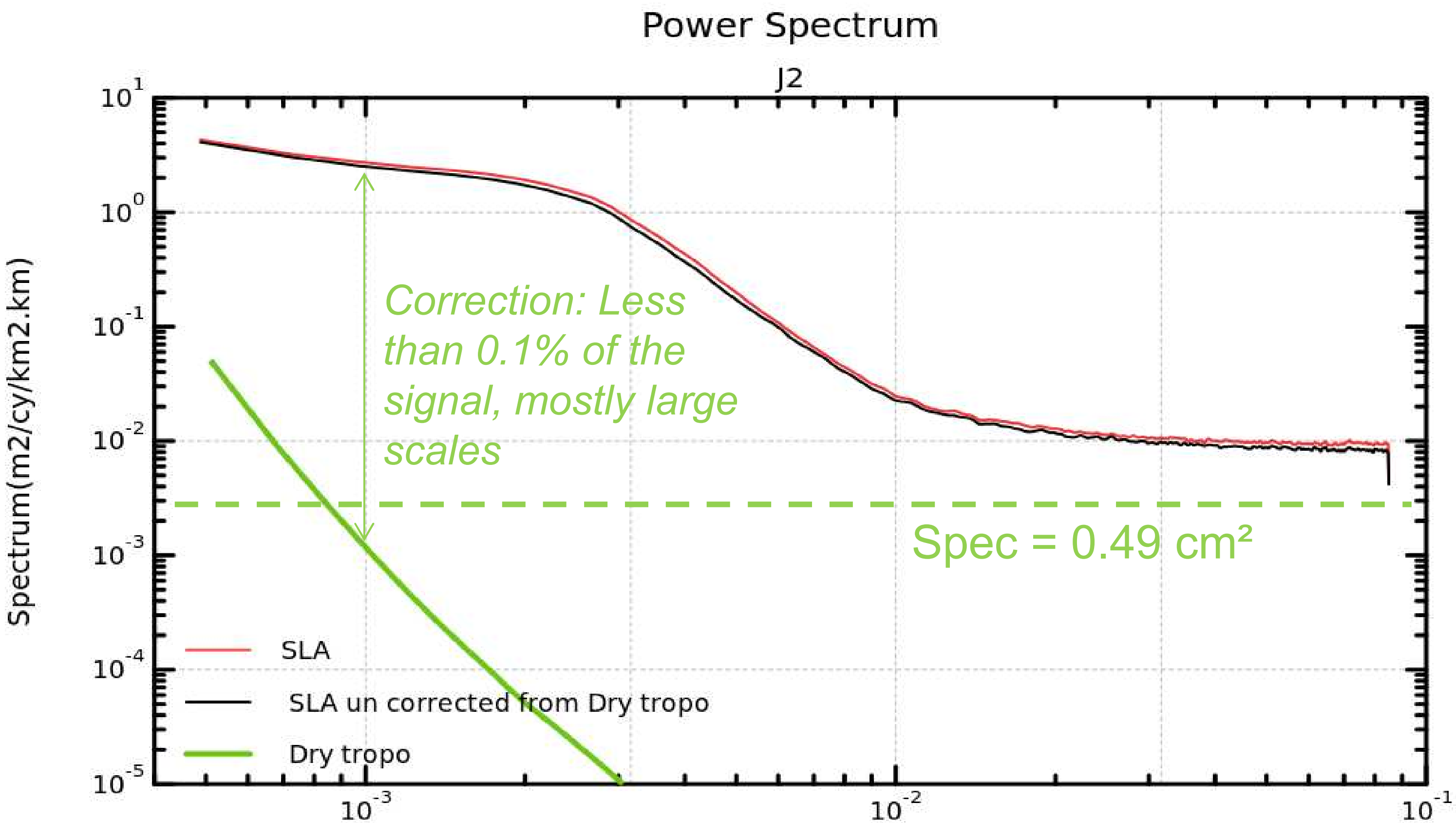
From waveform:
- Non parametric bias
- 1st order approximation
ECMWF ERA model

Single source: ECMWF model

Nadir Radiometer /
ECMWF model /
Wide swath Radiometrer (AMSRE)

Example of metrics and Analysis of the spectral content

Dry troposphere is a large scale effect, the only correction we have is an ECMWF model.

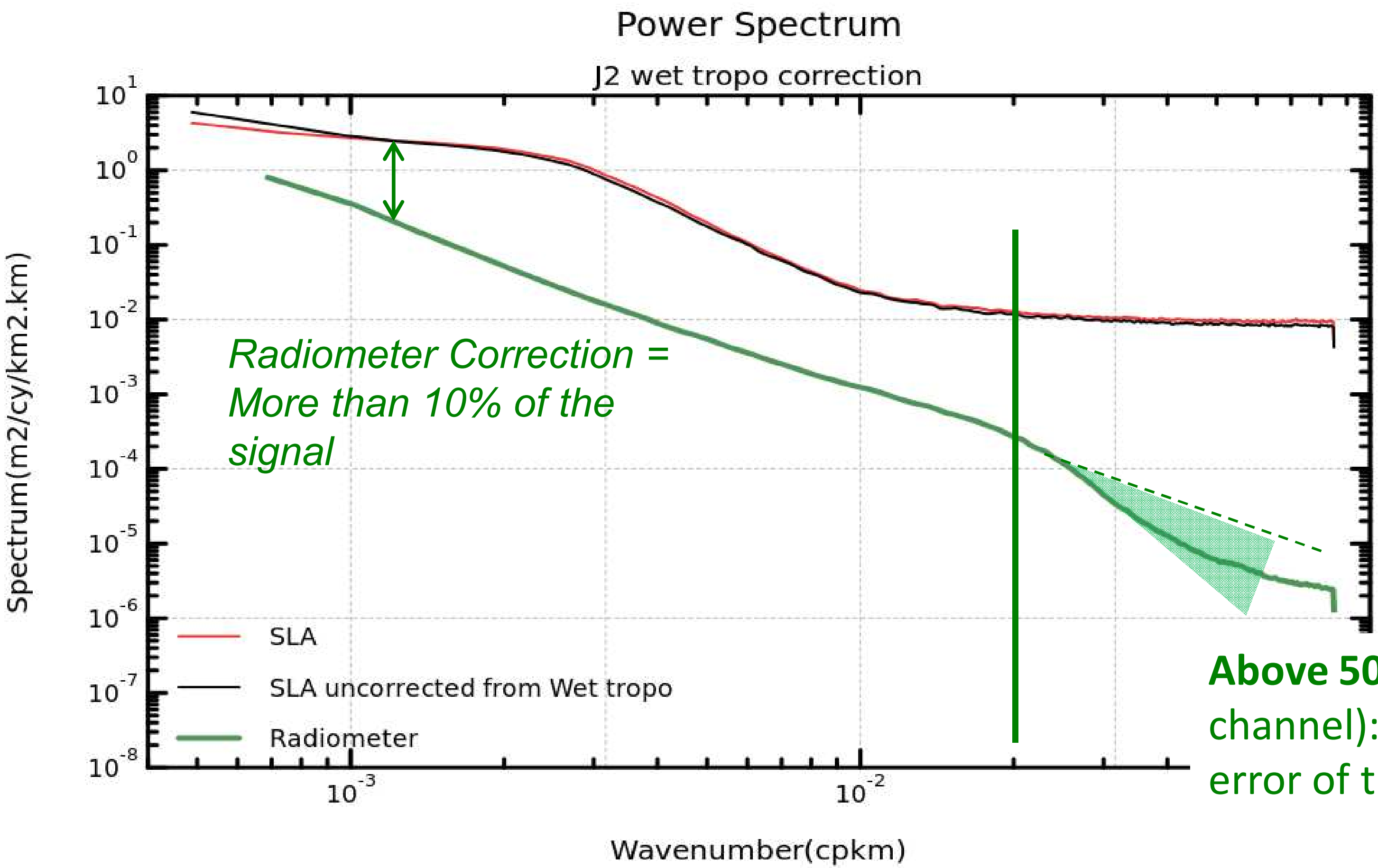


To characterise its error we can assume that it is below the correction itself (otherwise better not correct for it!).

The correction itself can be considered as an uper bound of its own error

Example of metrics and Analysis of the spectral content

Wet tropospheric correction is very critical signal because its signature is very close to the ocean geophysical content.



Above 50km (resolution BT 2nd channel): increasing omission error of the radiometer

Example of metrics and Analysis of the spectral content

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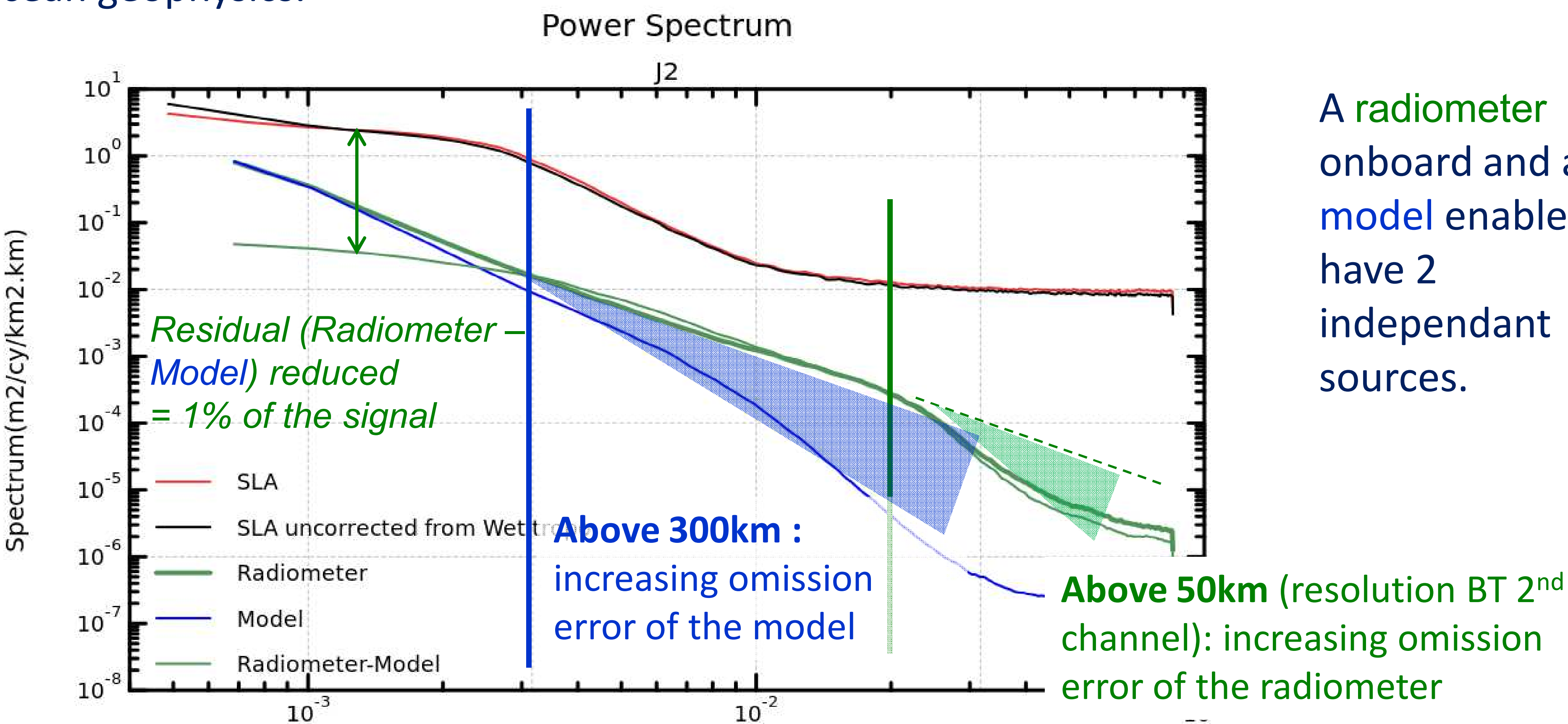
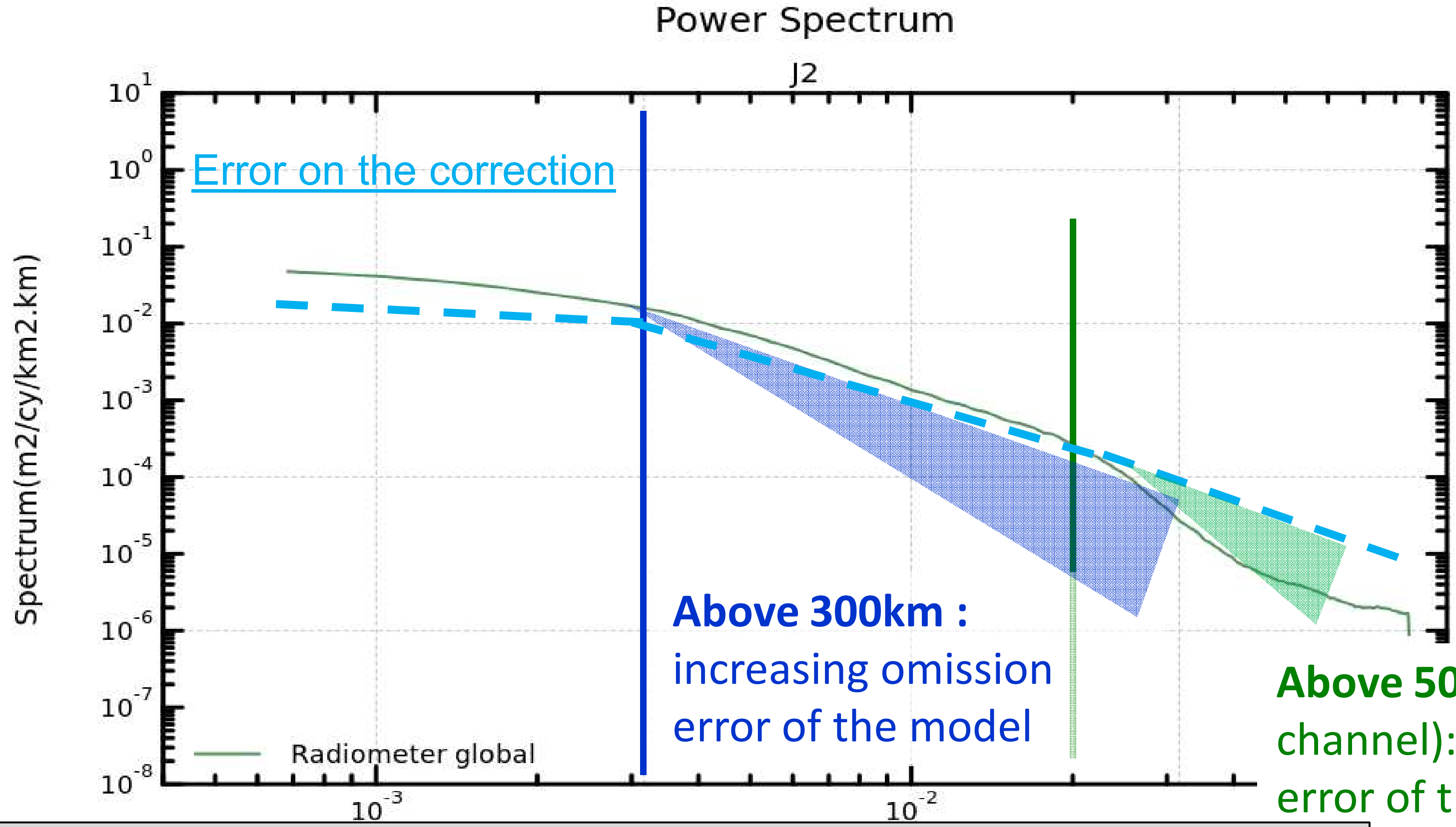


A radiometer onboard and a model enables to have 2 independant sources.

Multiple observations enable to refine a lot the error estimation if they are : **independant and consistent**

Example of metrics and Analysis of the spectral content

Wet tropospheric correction is very critical signal because its signature is very close to the ocean geophysics.



A radiometer onboard and a model enables to have 2 independant sources.

Above 50km (resolution BT 2nd channel): increasing omission error of the radiometer

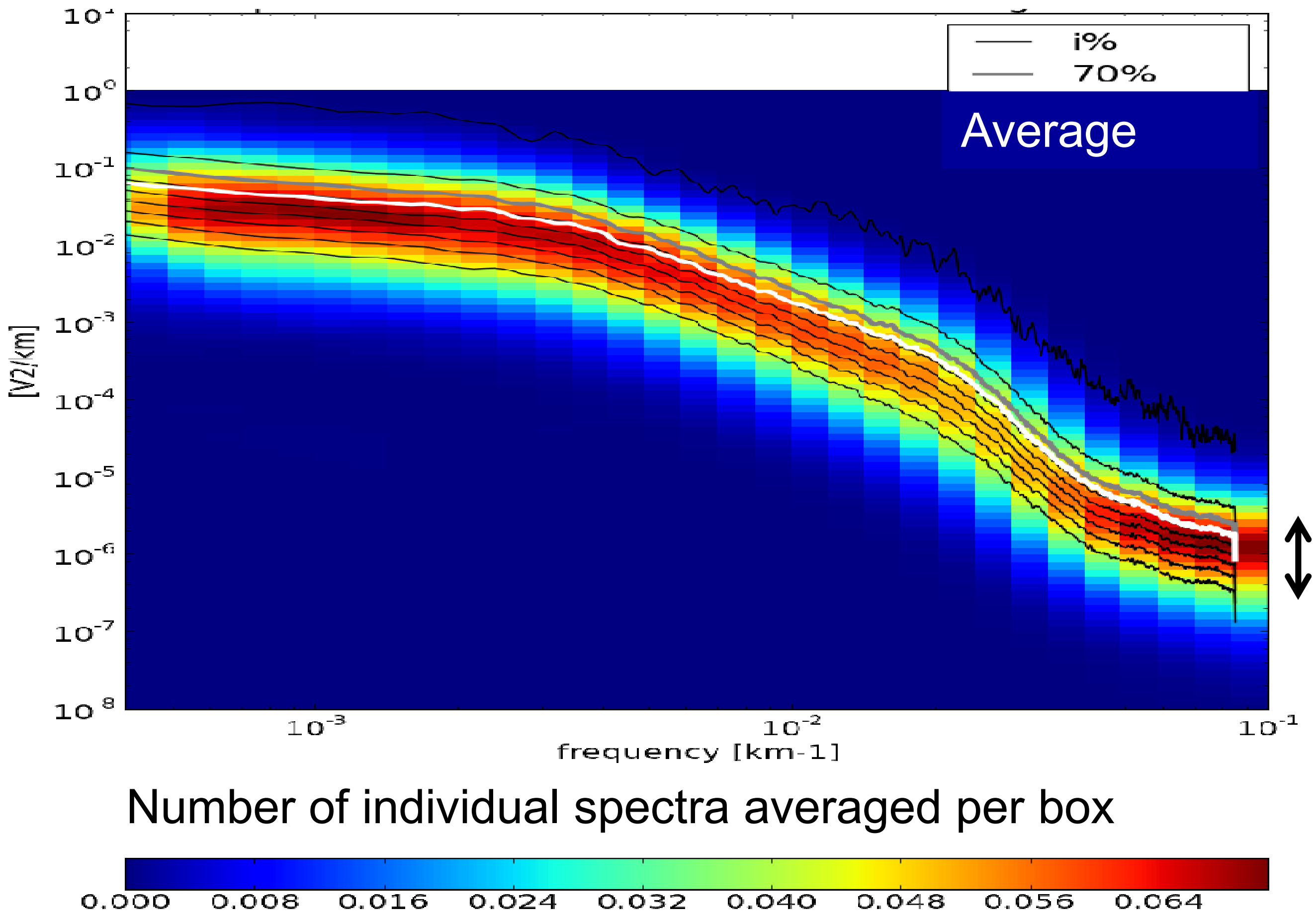
The uper bound of the error given by the signal itself is refined.

➔ Is this uperbound (average spectrum) relevant of all physical events????

Taking into account the spatial/temporal dependency: notion of envelopes

- Distribution of individual spectra around the average (white)

  Global average integrates many geophysical events.

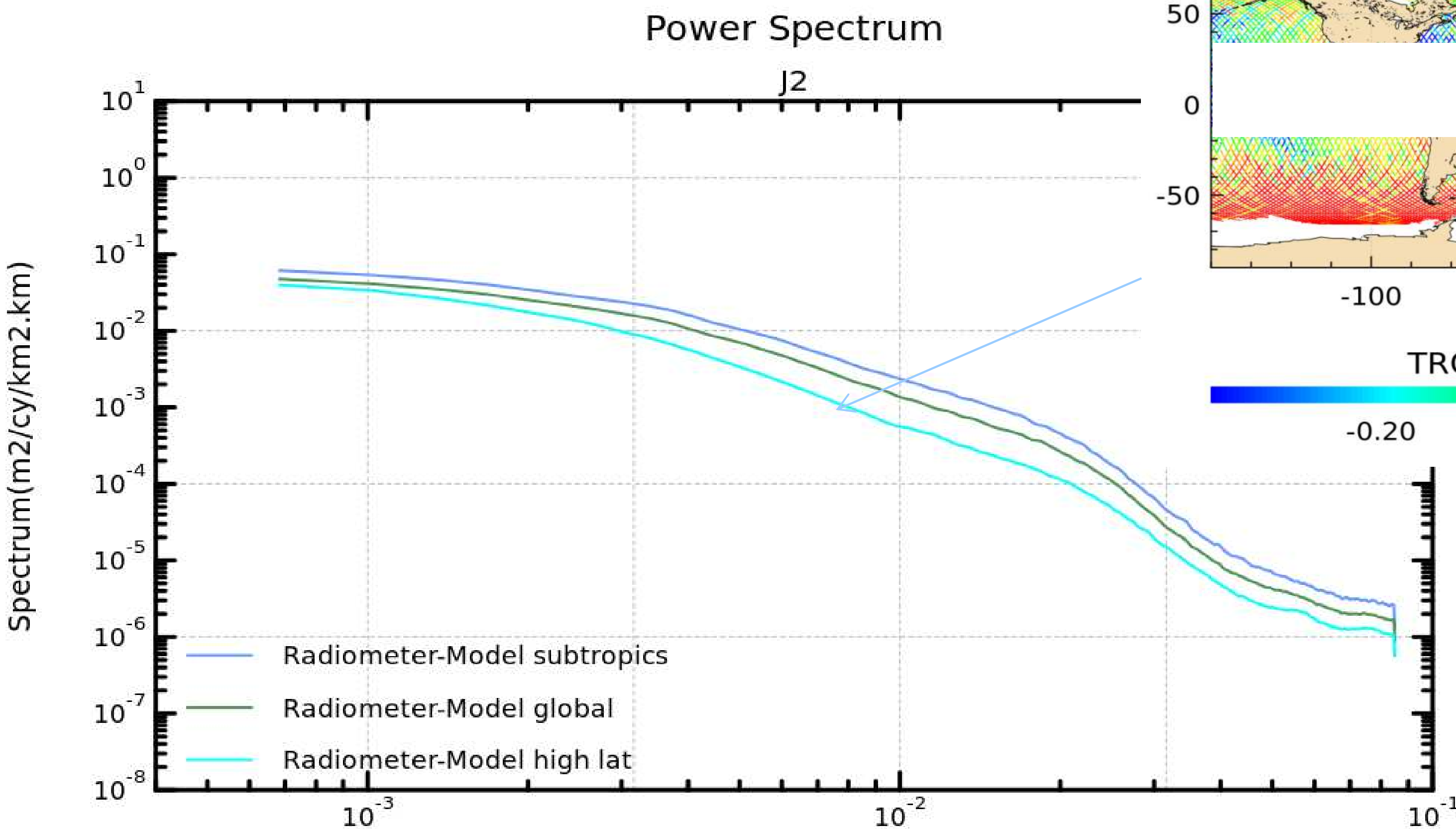


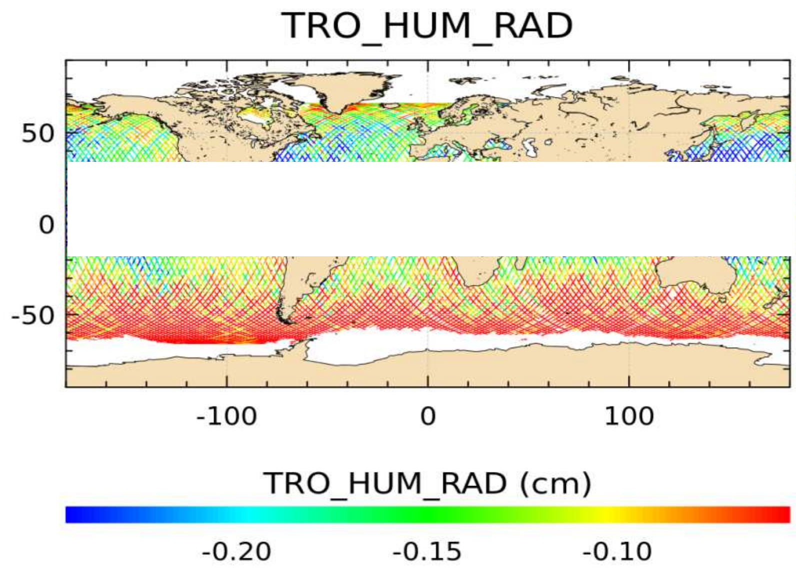
One single gaussian population around the average.

Few very energetic samples shift the average / mediane.

The energy of signal varies over more than one decade, depending on the geographic zone.

Taking into account the spatial/temporal dependency: notion of envelopes





The envelope around the average enables to take into account the temporal/spatial variability of the signal observed.

Depending on the application, the upper/lower bound can be taken into account.

Conclusion

We showed that:

- The spectral analysis of the SLA corrections gives information on their distribution of energy relatively to the spatial scales

- The error of each correction is supposed to be below the correction itself. And it is an uper bound of what we look for.

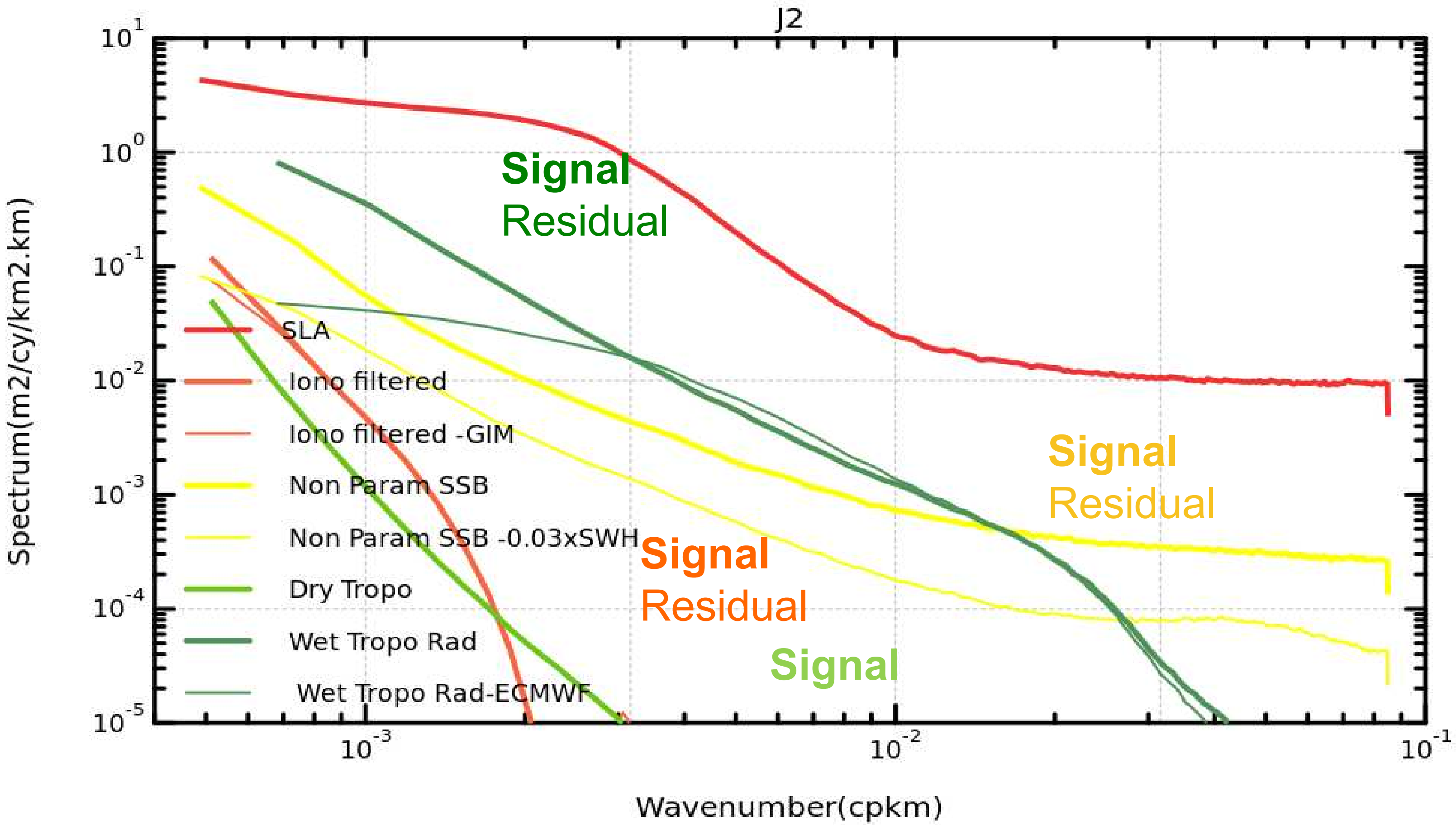
- Multiple sources of a similar geophysics can be compared:
  - If they are fully independant, the error of the difference gives a more accurate upper bound
  - If they are not fully independant, the error of the difference is only an estimation, (may be underestimated) of the total error

- Considering the envelope around the average sprectrum enables to better take into account all the temporal/spatial situations

Conclusion

- The work presented was derived for all correction.

SSH = Orbit - Range - Iono - Sea State Bias - Dry tropo - Wet tropo



Perspectives

- This work is on going…
- The method is complementary to other error estimation techniques and should be carried on jointly with them. For this:
  - Multiple observation system of a same correction must be carried on
  - The method can also be applied to other missions during tandem/not tandem phases

Discussions with the data users would be usefull:
What would they need?

Thank you for your attention

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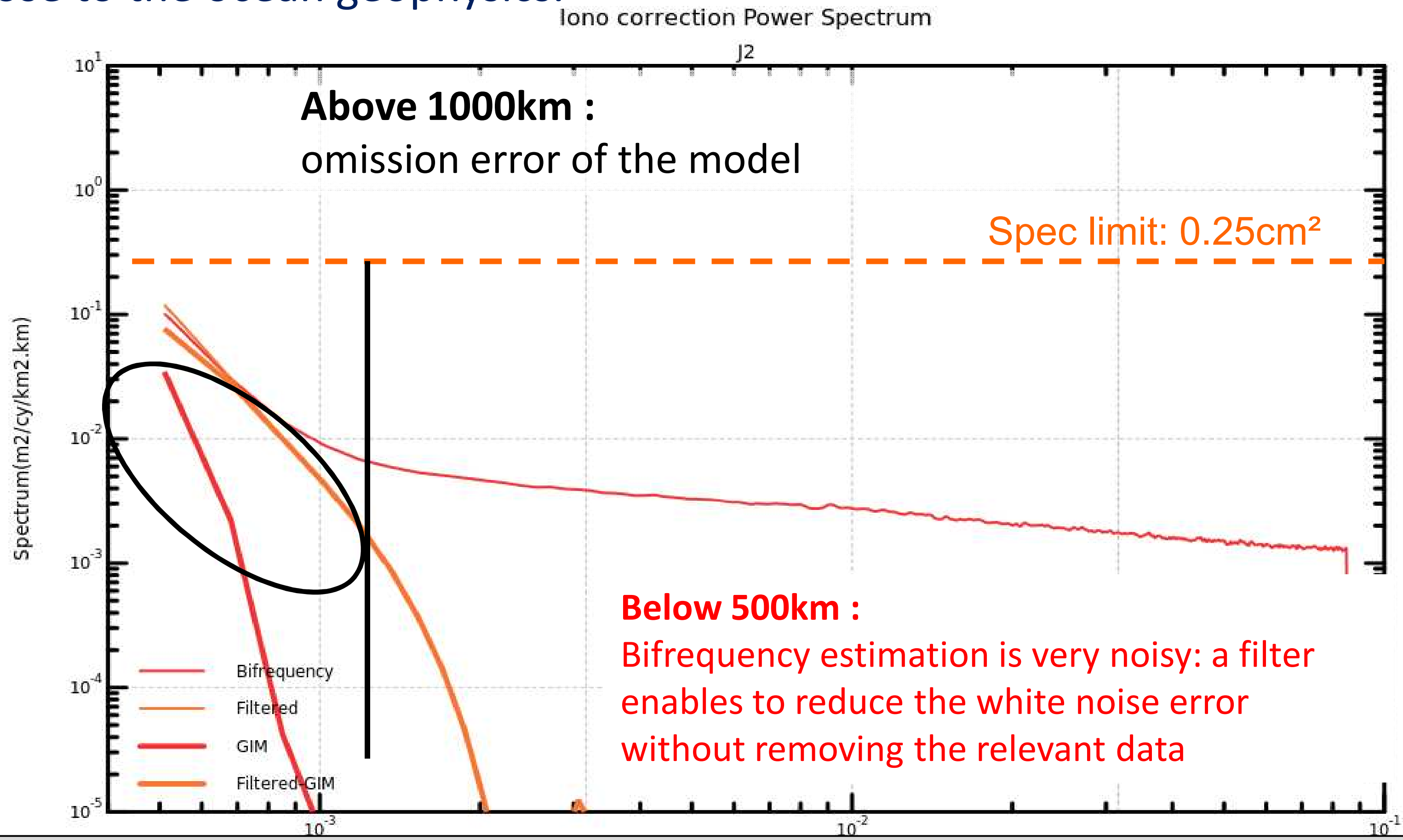
Example of metrics and Analysis of the spectral content

Ionospheric correction 's signature is weak in Ku (very week ni Ka) but the signature is very close to the ocean geophysics.



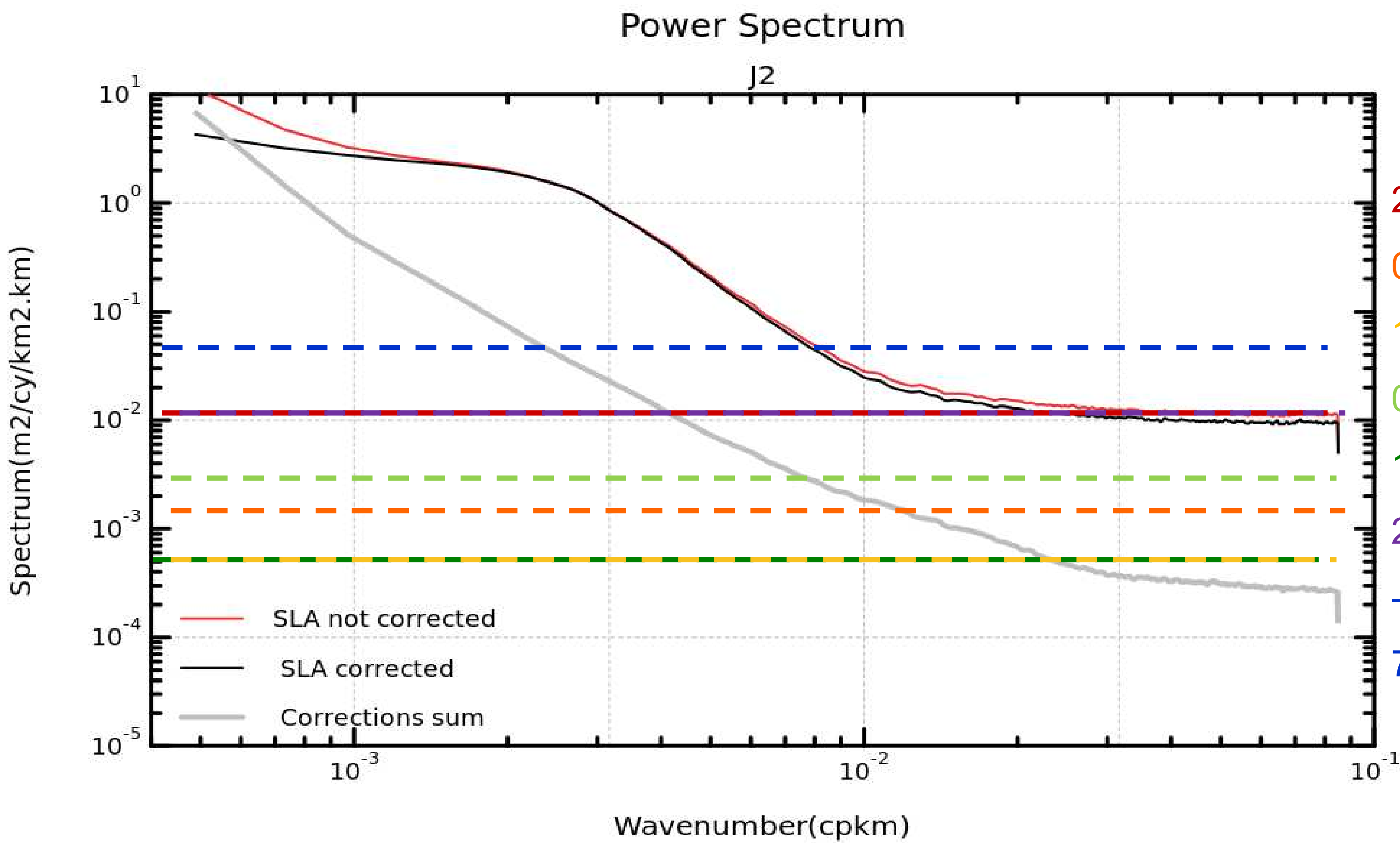
A bifrequency altimeter onboard and a model enables to have 2 independant sources.

The model is very smooth and does not enable to reduce the error at these scales

Method

- To do so, a break down on all the corrections is performed:

  SSH = Orbit - Range - Iono - Sea State Bias - Dry tropo - Wet tropo



2.25 cm² → 1.3. 10-2
0.25cm² → 1.5. 10-3
1cm² → 5.9. 10-3
0.49 cm² → 2.9 10-3
1cm² → 5.9. 10-3
2.25 cm² → 1.3.10-2

7.24cm² → 4.3. 10-2