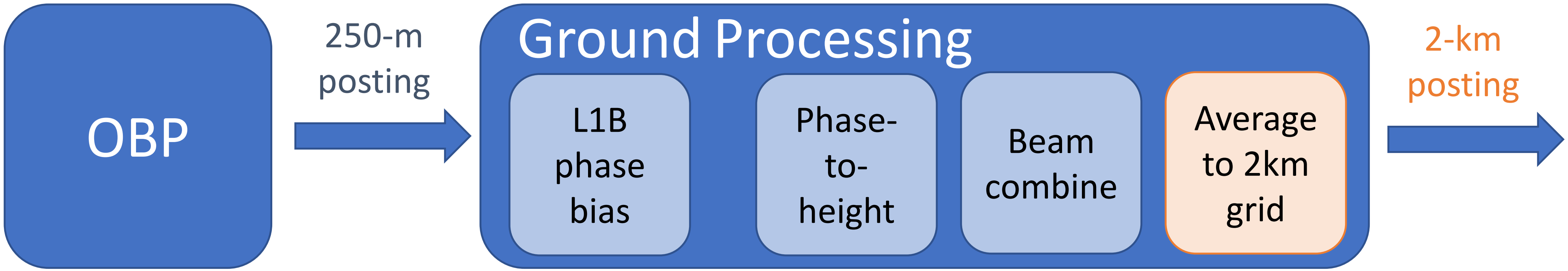
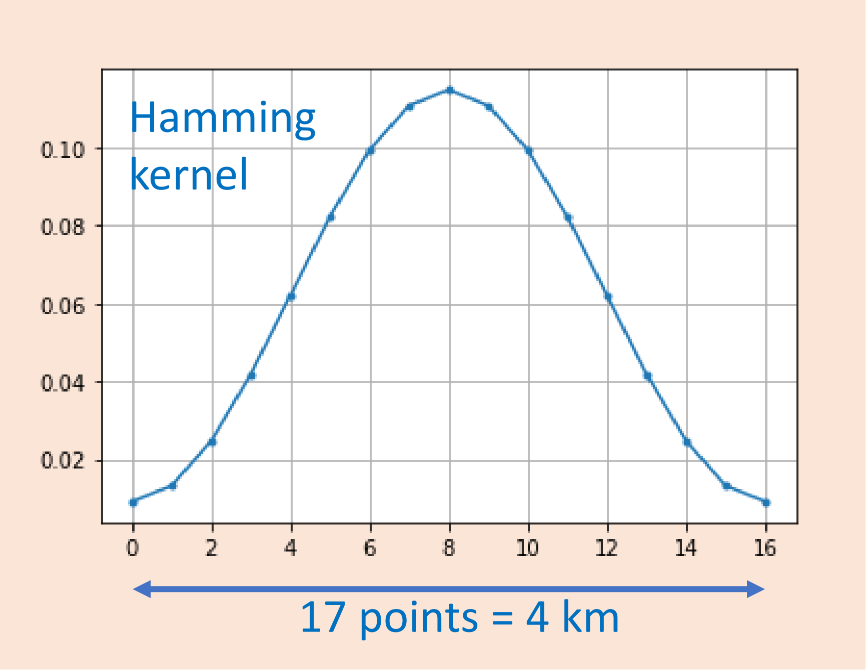
From 250 m to 2 km posting: implications of the L2B averaging step

B. Molero, A. Bohe, P. Dubois

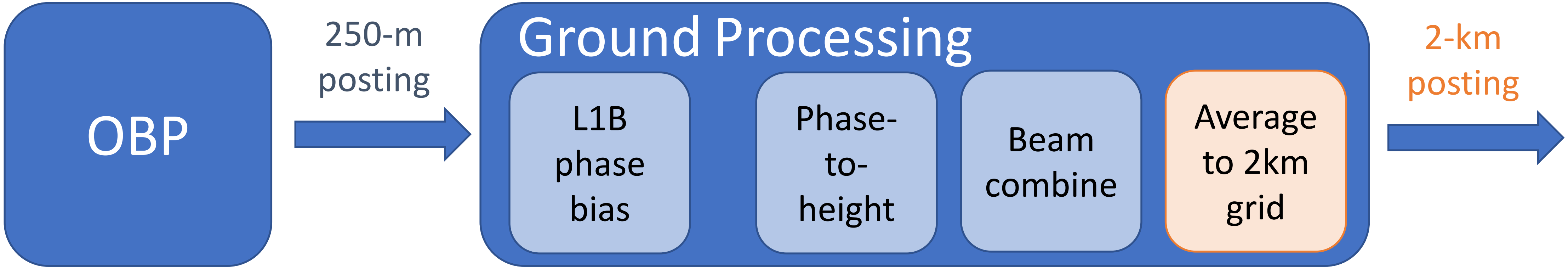
COLLECTE LOCALISATION SATELLITES
CLS
cnes

KaRIn processing

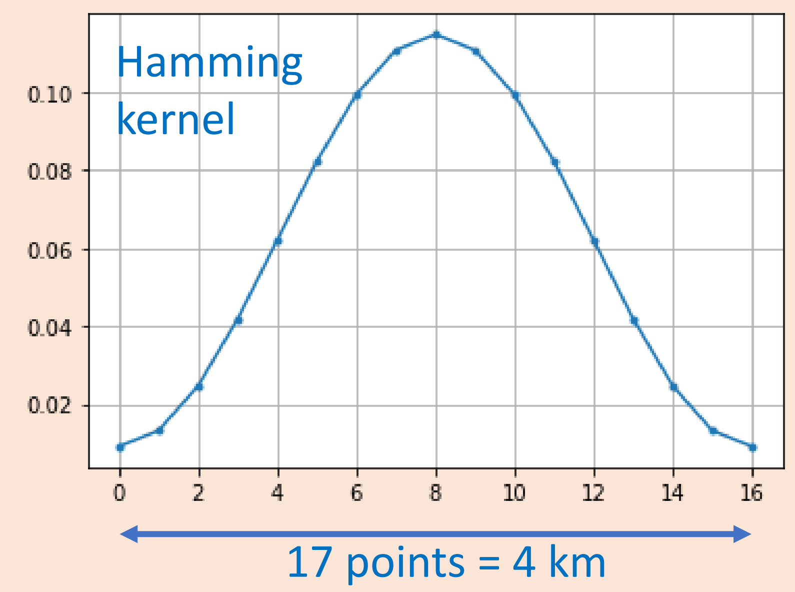




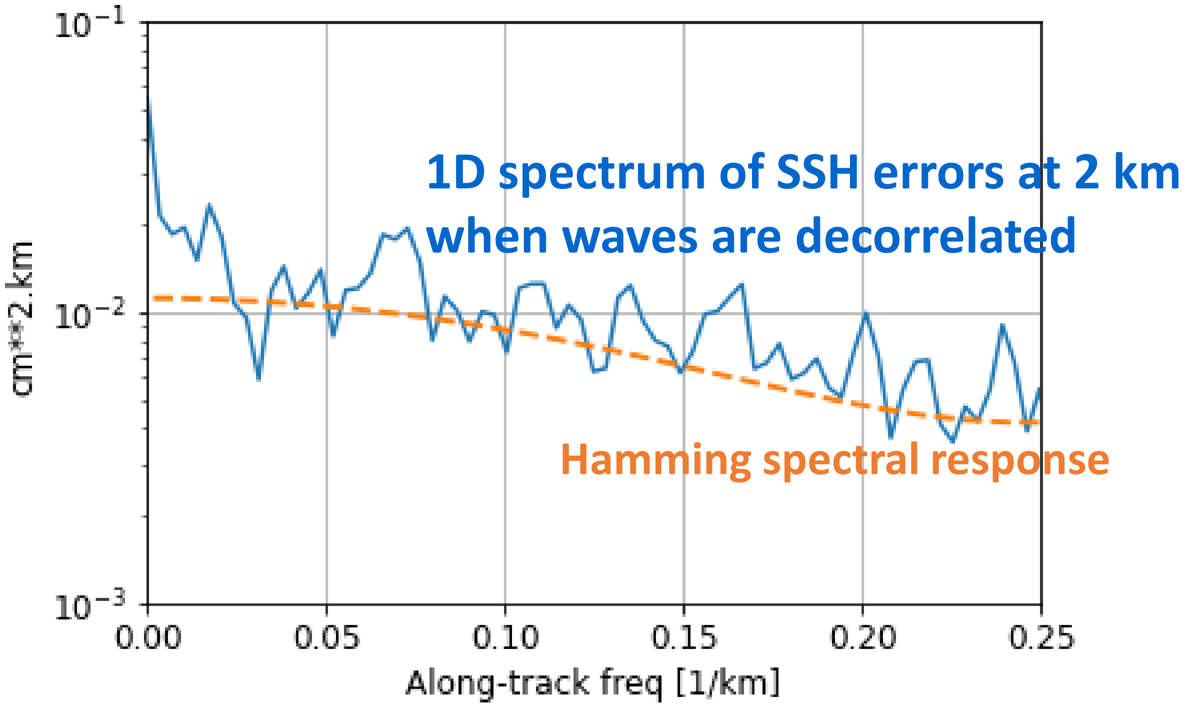
KaRIn processing



- Show that the averaging to the 2 km grid does not add suplementary errors
- Wave signal energy could eventually end close to the band limit of 4 km ($2\lambda_{sampling}$): how is it handled by the 2 km filter?
- What about topography?



Waves

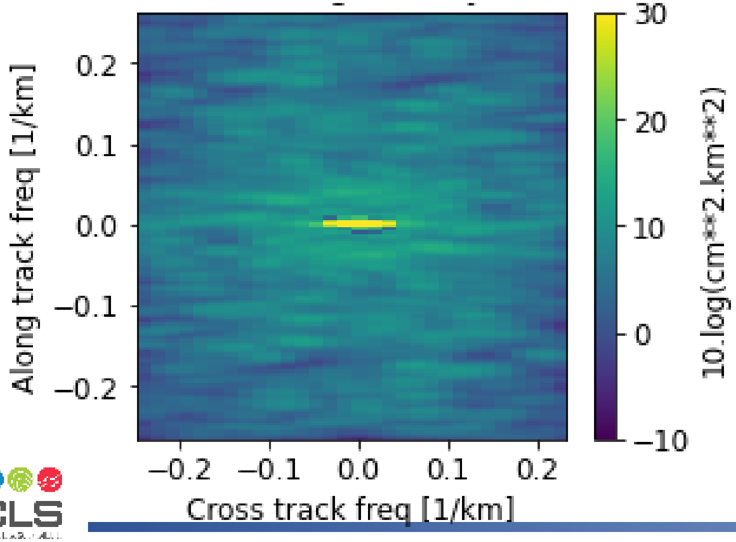


- For waves totally decorrelated in space (white), the SSH errors at 2 km mainly follow the spectral response of the Hamming averaging filter
- This is because, the spectrum of SSH errors out of the OBP basically follow the OBP averaging spectral response
- Under such conditions, the Hamming filter seems a good solution with
  - low aliased power
  - Relatively high spectral resolution (~6 km)
  - Interesting noise variance reduction ratio (75 in 2D)

Waves

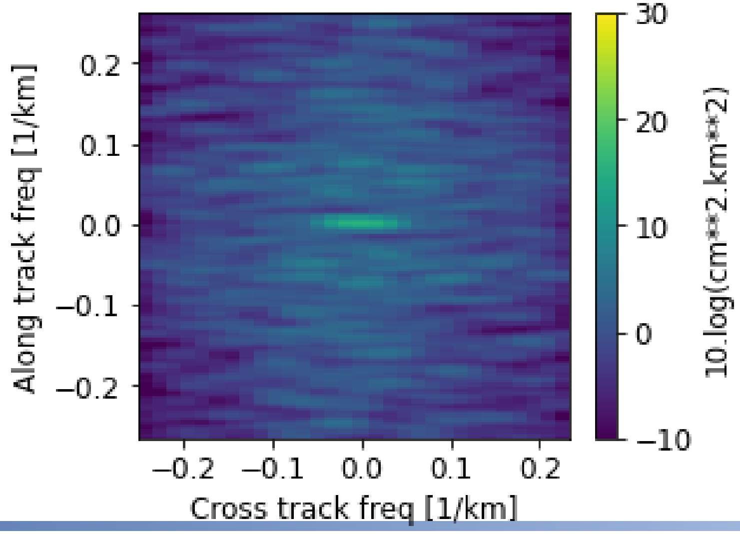
- True waves are however correlated in space
- [Peral et al. 2015] showed that KaRIn changes the shape of the true wave spectrum, aliasing wave energy onto longuer wavelengths
- The OBP distorts the wave spectrum differently depending on the sea state and it is difficult to assess analytically the performance of the 2 km filter for « true » waves
- We run KaRIn simulations for different sea states and compare to uncorrelated waves simulations

2D spectrum of errors for correlated waves

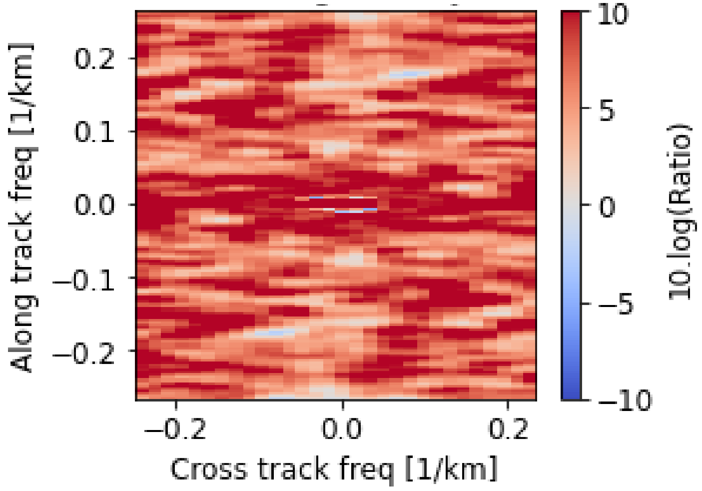


vs

2D spectrum of errors for de-correlated waves



Ratio

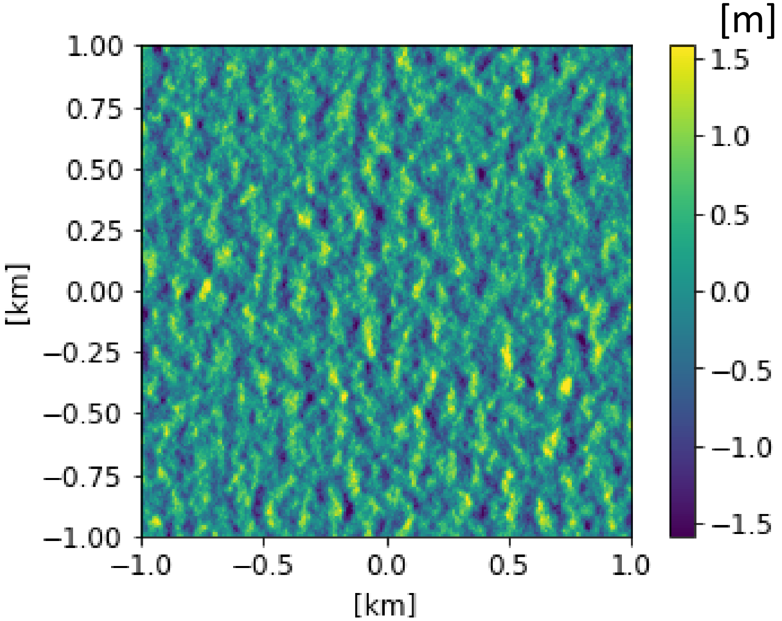


Waves

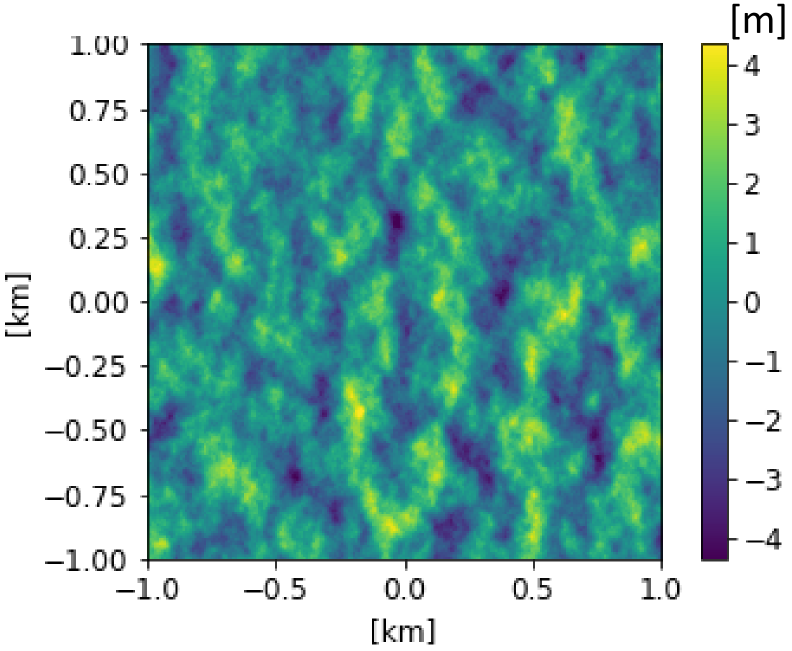
- Apart from simulating waves, we need also to simulate backscatter, whose modulation along the wave profile adds extra bias and variance to SSH errors
- However, for the case of KaRIn, we don't know accurately the amplitude and the phase of this backscatter modulation
- We set amplitude to reproduce 3% of the SWH value (as nadir altimeters) and no phase shift
- Because this is probably an overestimate, simulations with this backscatter modulation define a worst case scenario while simulations with no backscatter modulation define a best case scenario.
- The reality will lay somewhere in between these two cases

Wave fields

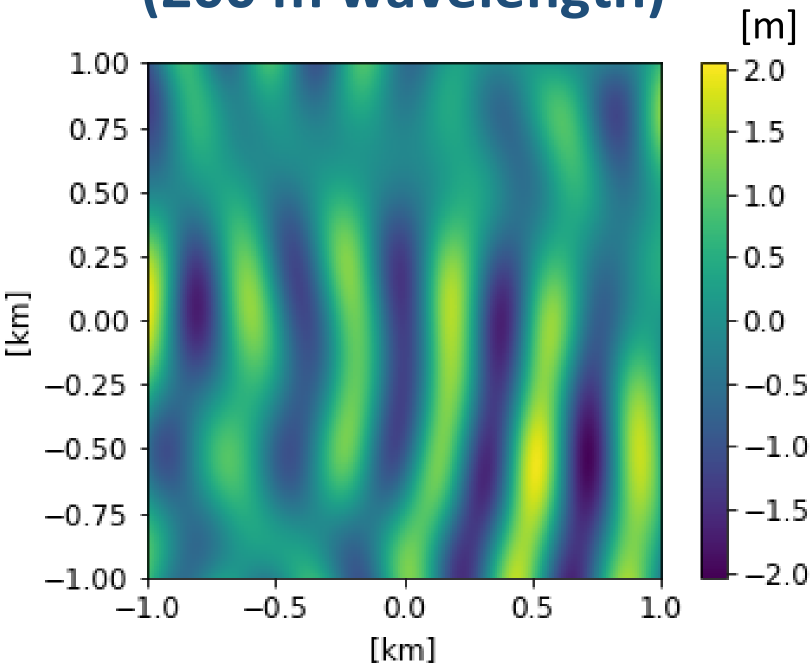
2 m wind field



6 m wind field



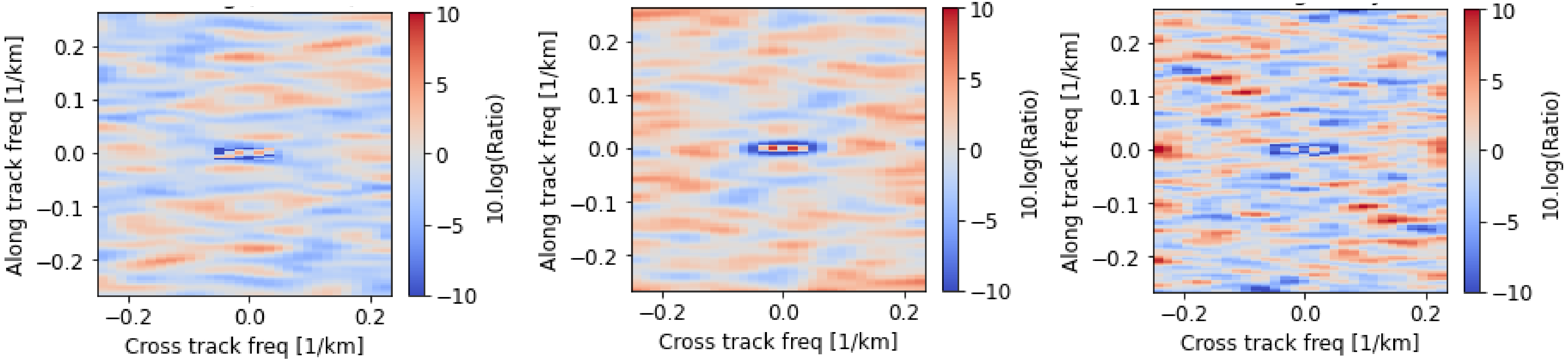
3 m swell field (200 m wavelength)



(Other directions and wavefields also tested, only 3 showed here)

Results no backscatter modulation

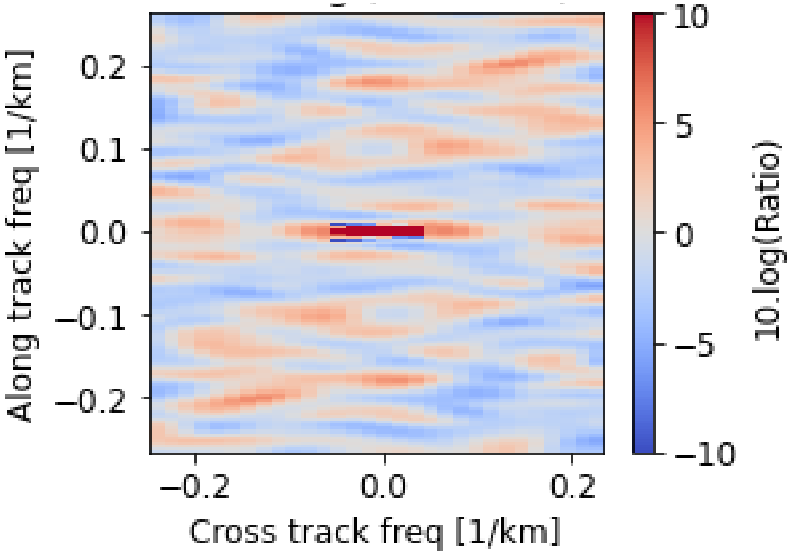
2 m wind field | **6 m wind field** | **3 m swell field (200 m wavelength)**



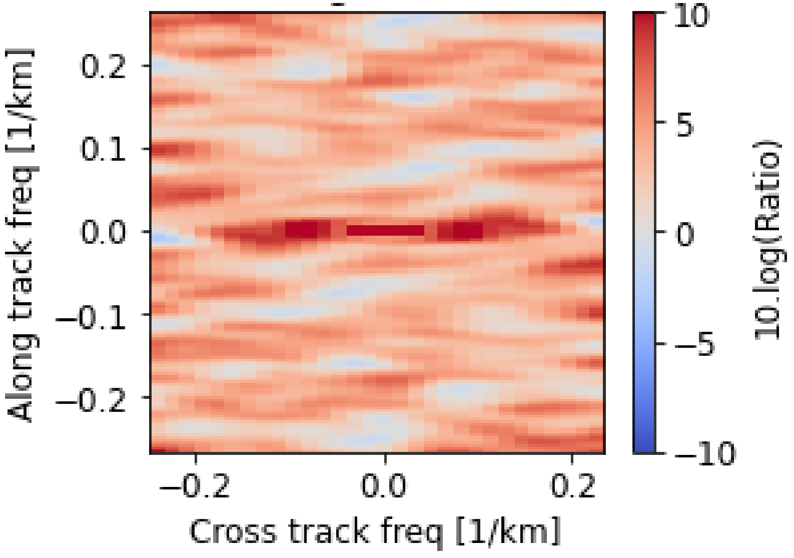
- No important extra energy wrt the uncorrelated wave case
- At low frequency, some difference mostly due to PSD estimation uncertainty
- The Hamming filter does not add additionally errors

Results: « worst » backscatter modulation

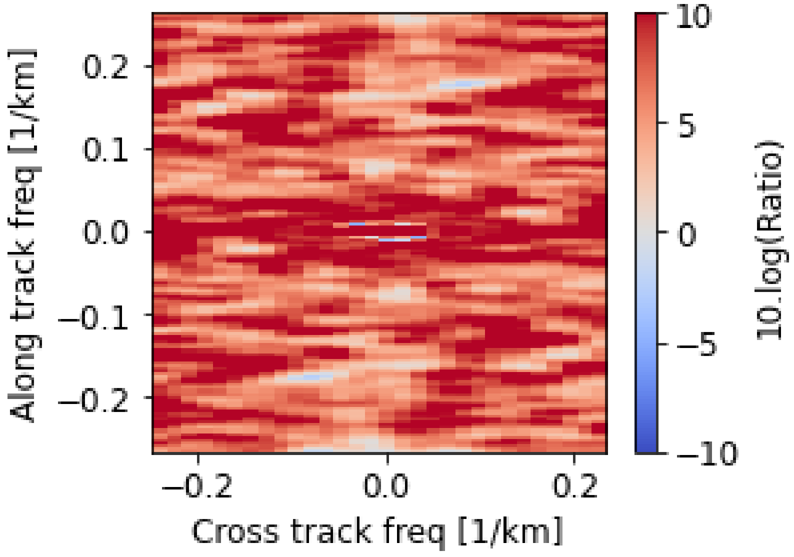
2 m wind field



6 m wind field



3 m swell field (200 m wavelength)



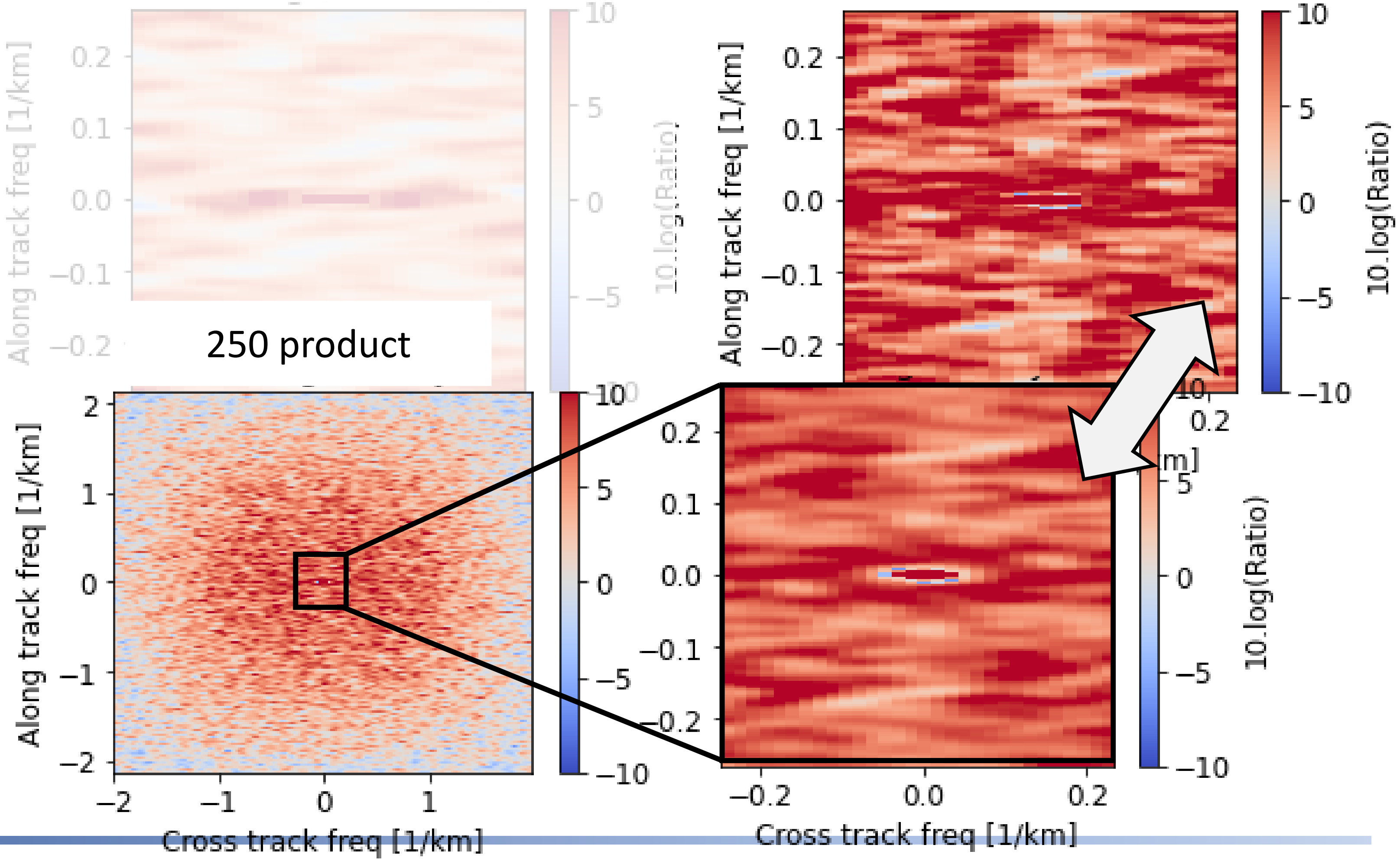
- More important extra energy when waves are bigger than 2m SWH wind waves
  - Is t due to the 2 km filter?

Results: « worst » backscatter modulation

2 m wind field

6 m wind field

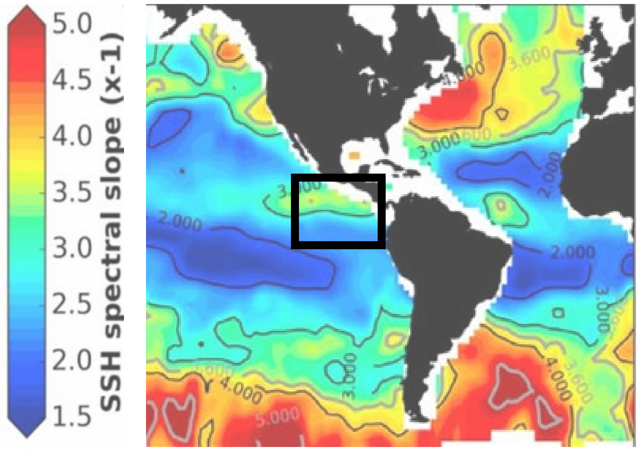
3 m swell field
(200 m wavelength)



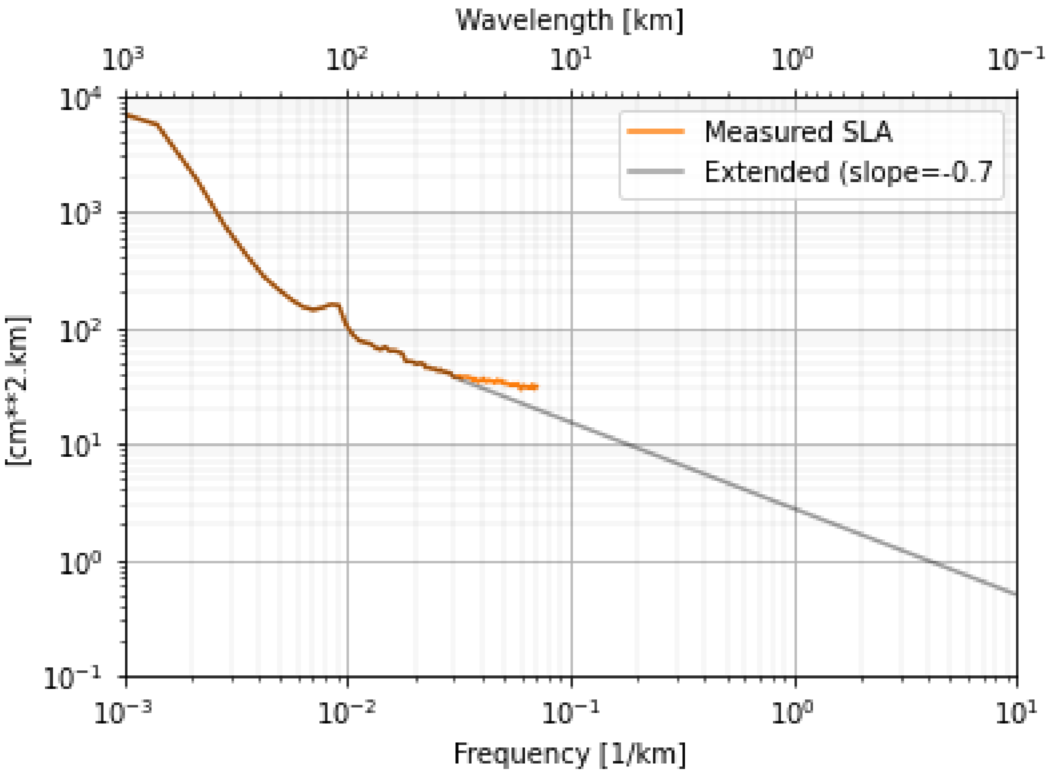
- Extra noise already present in the OBP output, before the 2 km filter
- The Hamming filter does not sum additionally errors

SLA

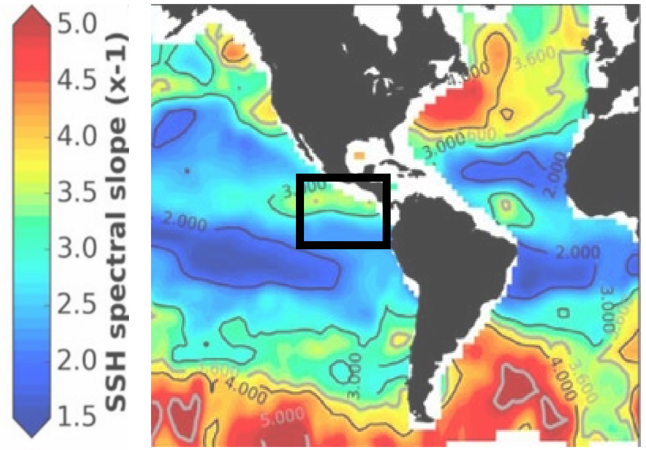
Approach



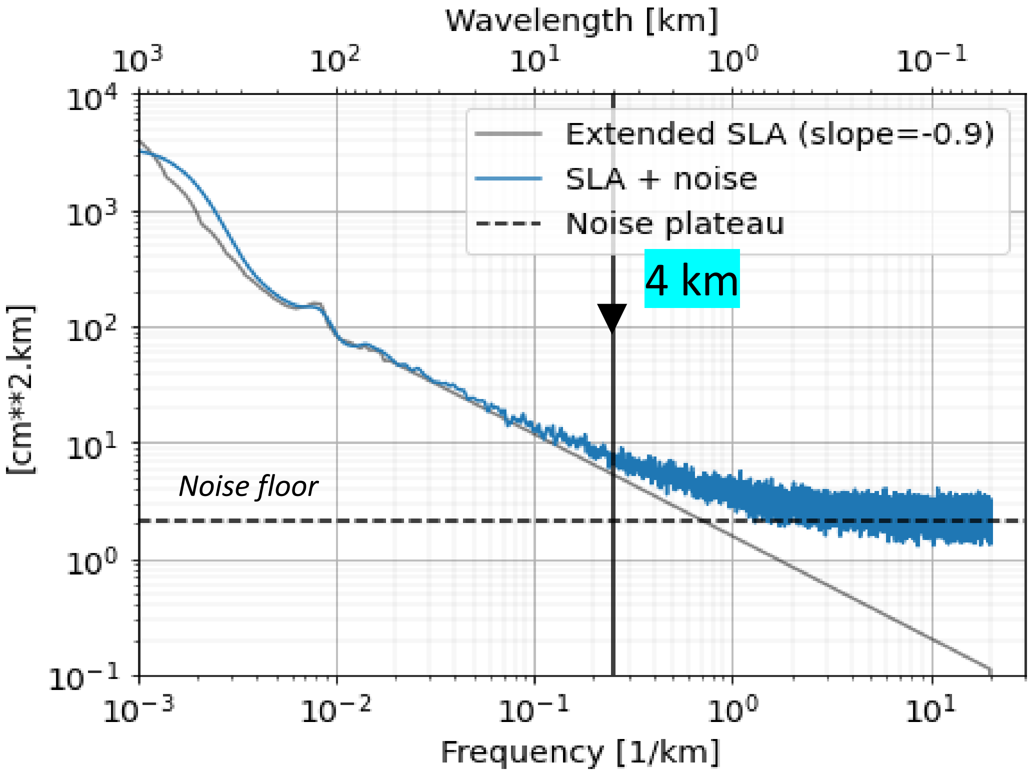
(O. Vergara et al.)



Approach

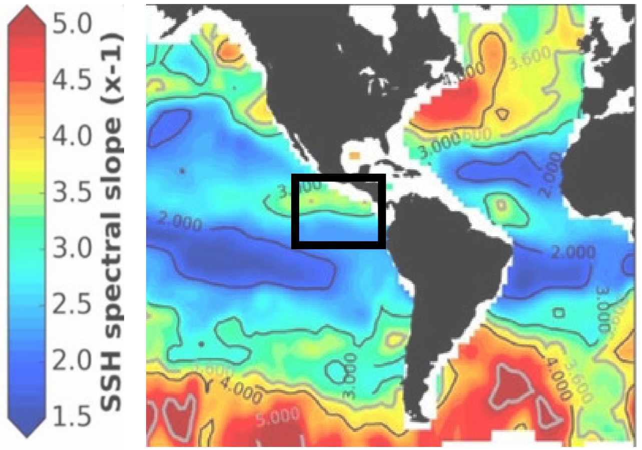


(O. Vergara et al.)

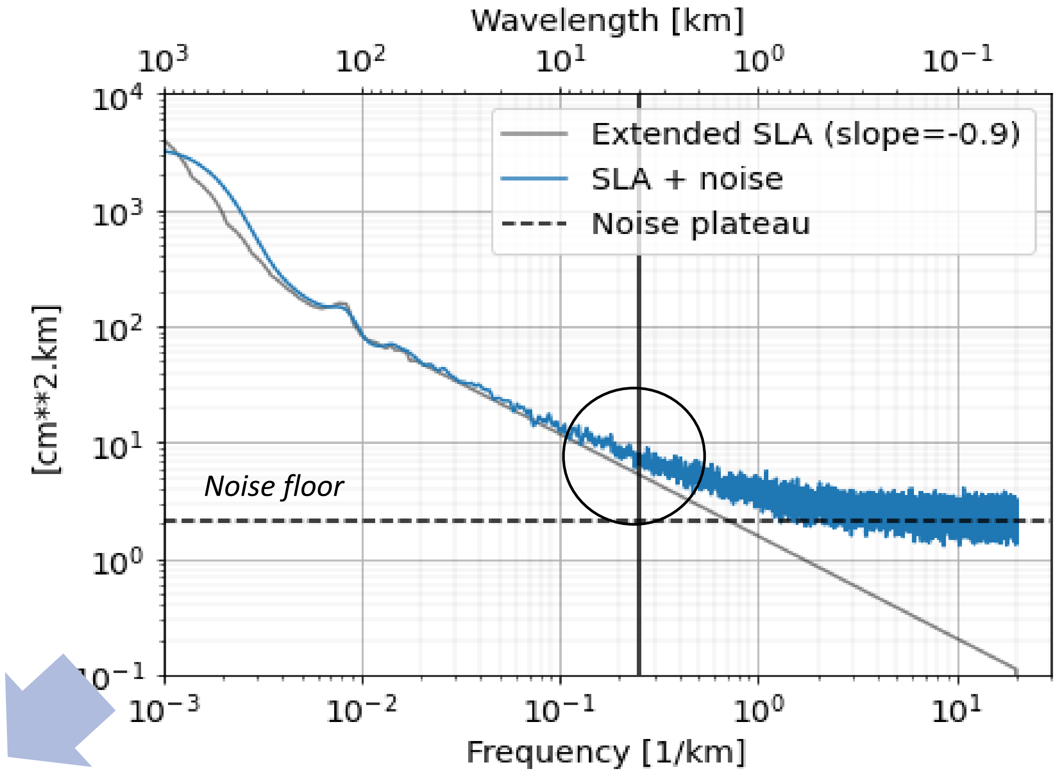


- Add arbitrary noise floor so that it starts close to the 2km product pass band (low noise compared to signal)
- Noise level will be modulated by an amount of elements (waves, atmosphere, SNR, etc.)

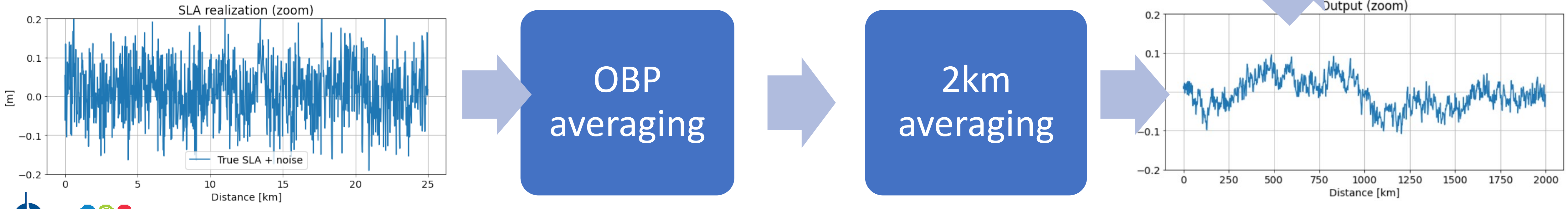
Approach



(O. Vergara et al.)

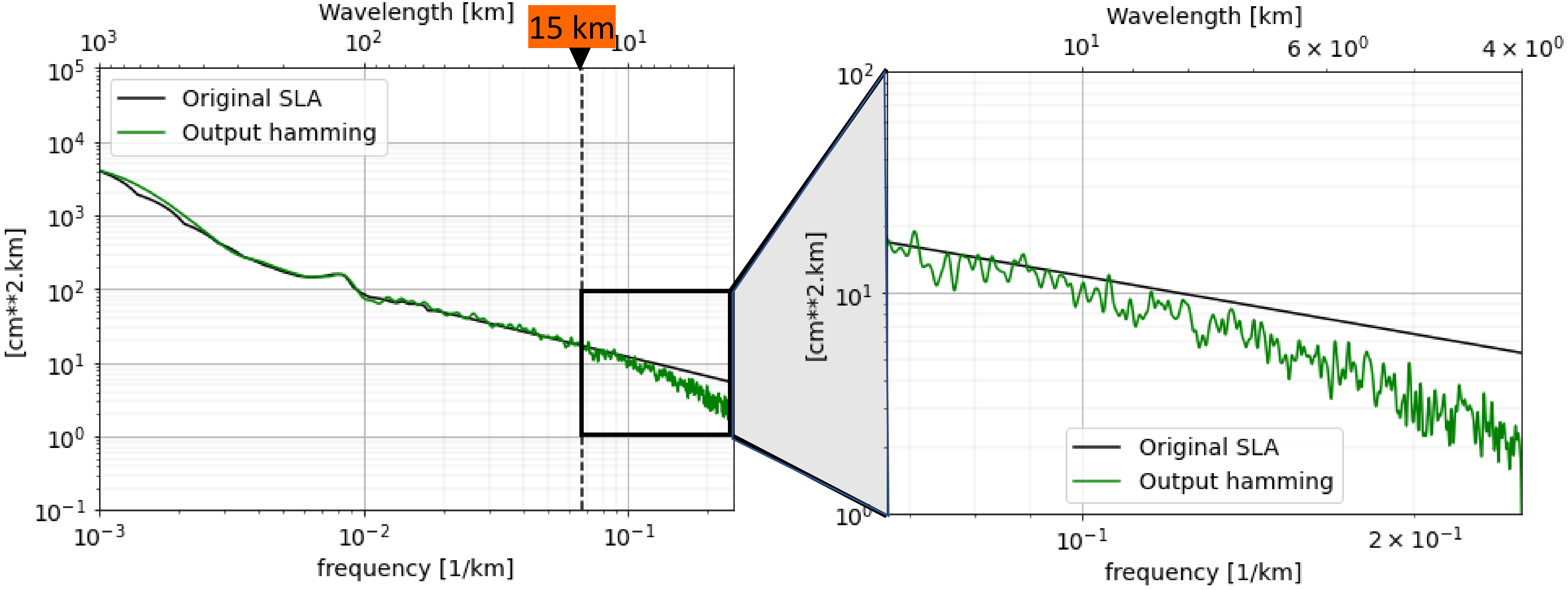


Check output spectrum and compare to true SLA



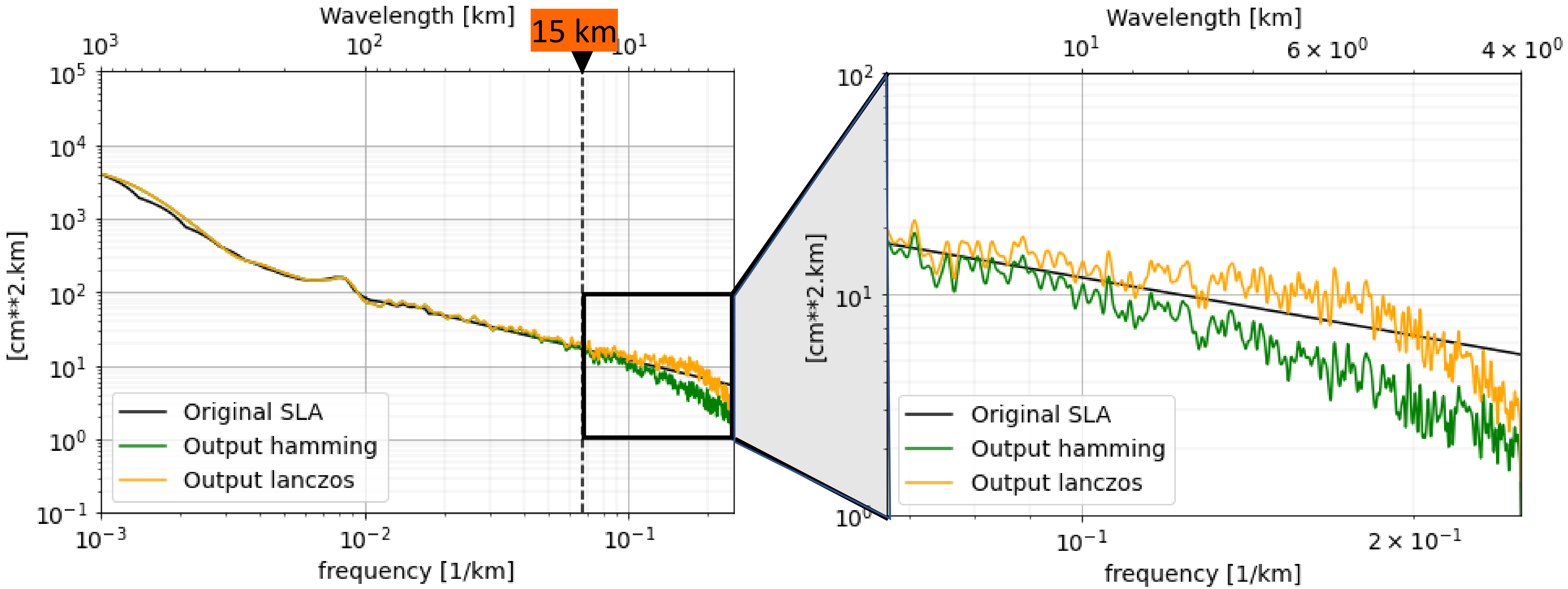
Results

- No impact at wavelengths > 15 km
- Signal energy underestimated at wavelengths < 15 km



Results

- Other filters might provide improvements at wavelengths < 15 km
- At the expense of some drawbacks (filter length)

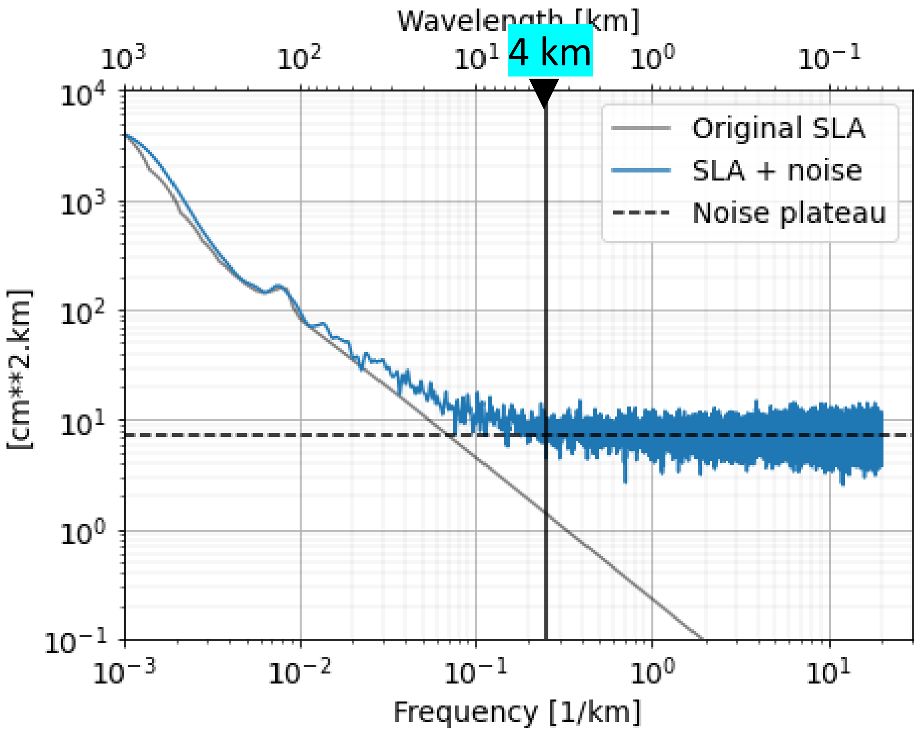


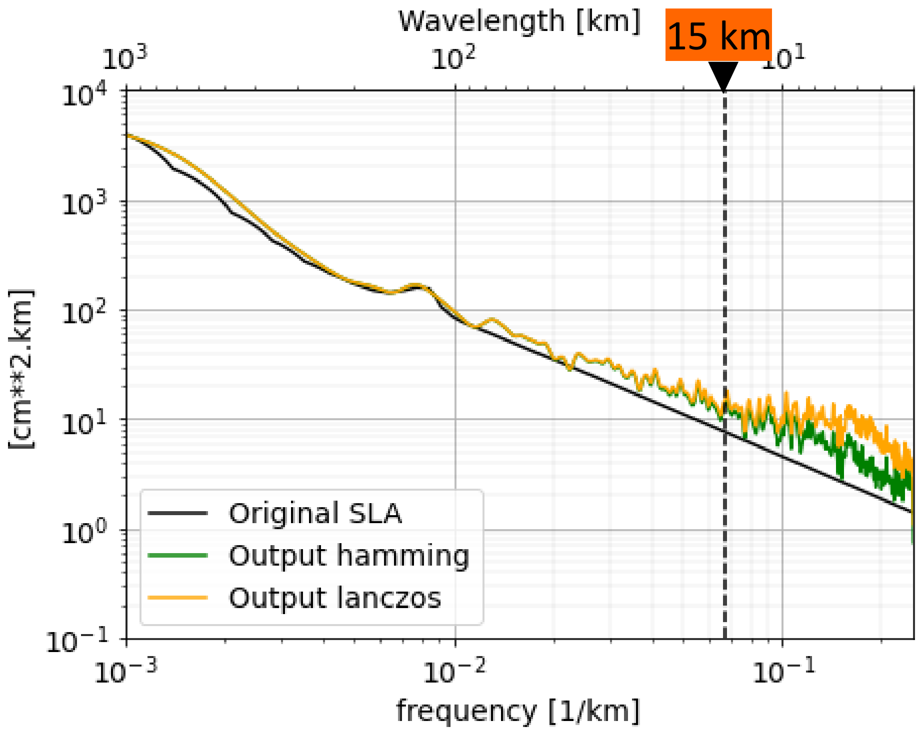
Conclusions

- When waves are present, the 2 km filter does not add important supplementary errors or aliasing
- Wave errors within the pass band come from the OBP
- Regarding topography, the 2 km filter does not add errors at wavelengths > 15 km
- At short wavelengths (< 15 km), the SLA energy is underestimated
- Those ST members interested in these short wavelengths: 250 m products will be available and we can work together on your specific cases

Backup

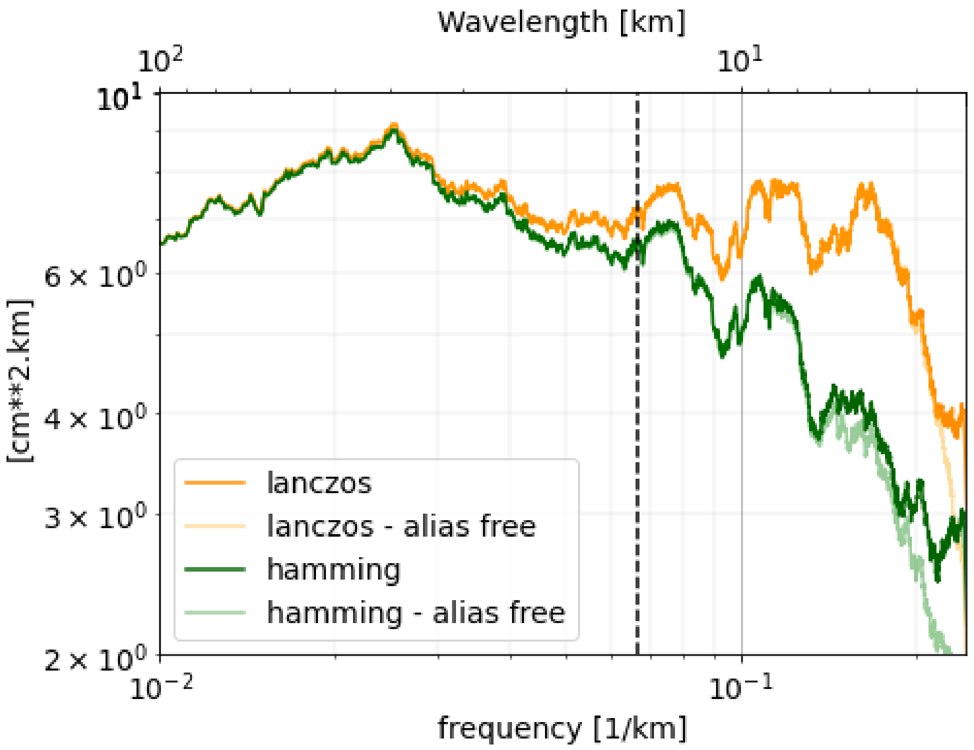
Increase the noise floor





- At wavelengths < 15 km, we have error power because this is already present within the output pass band
- That could be removed using more restrictive filters
- Which part of the errors is due to alias?

Error power



- We compare the errors obtained before with the errors obtained with an input signal where high frequencies have been removed
- Aliased energy (SLA + noise) is restricted to very high frequencies (4 to 6 km)

- For wavelengths << 15 km, the requirements are at 10 times less power than the SLA

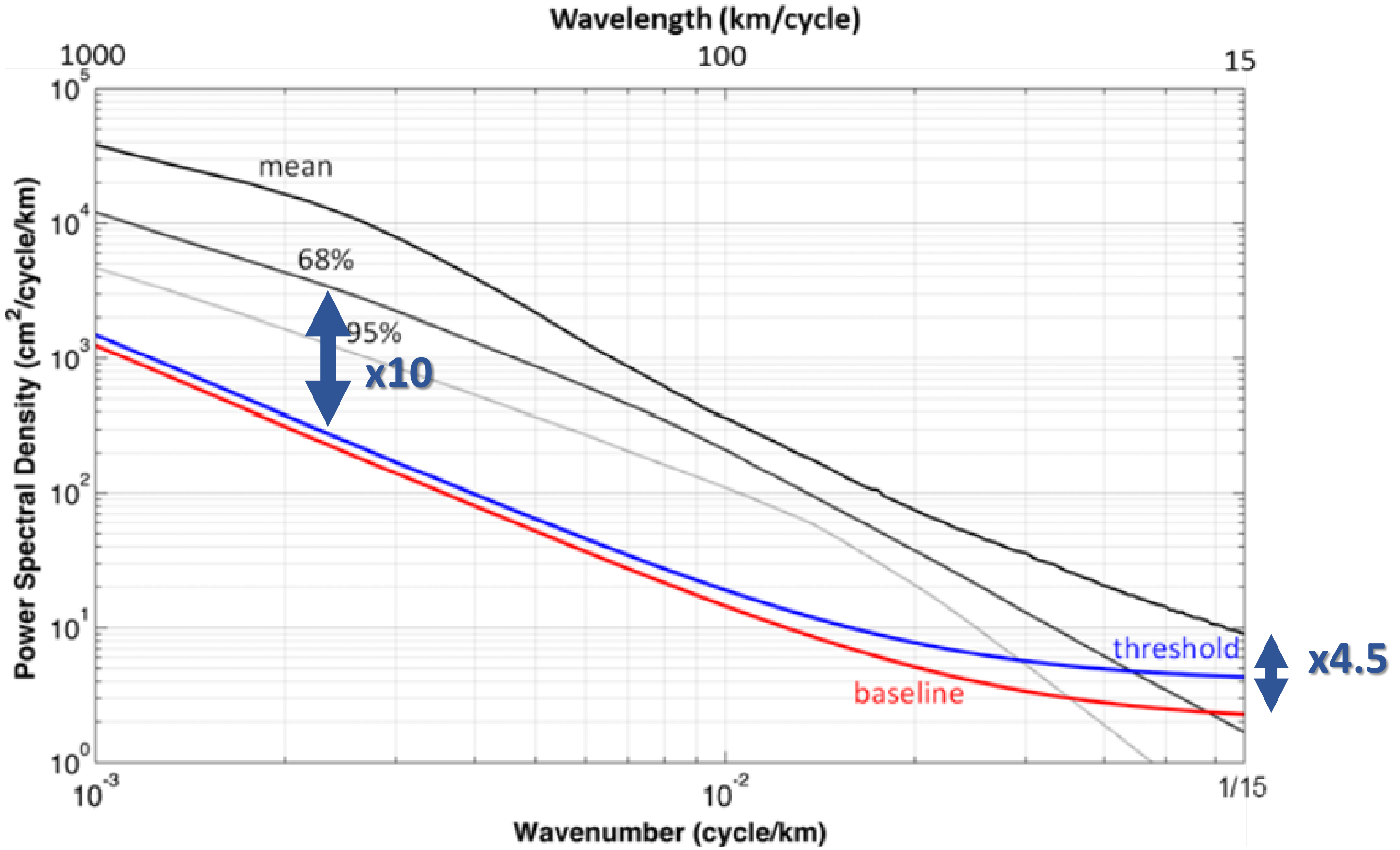


Figure 6. SSH error spectrum requirement (red curve) as a function of wavenumber, given by $E_{SSH}(f) = 2 + 1.25e\text{-}3f^{-2}$. Also shown is the global mean SSH spectrum estimated from the Jason-1 and Jason-2 observations (thick black line), the lower boundary of 68% and 95% of the spectral values (upper gray dotted line and lower gray dotted lines, respectively). The intersections of the two dotted lines with the error spectrum at ~ 15 km (68%) and 30 km (95%) determine the resolving capabilities of the SWOT measurement. The threshold requirement is also shown (blue), which follows the expression $E_{SSH}^{threshold}(f) = 4 + 1.5e\text{-}3\,f^{-2}$.