



Estimating baroclinic tides from and for SWOT

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SWOT ST meeting

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Study area, data and motivations

Amazon area:

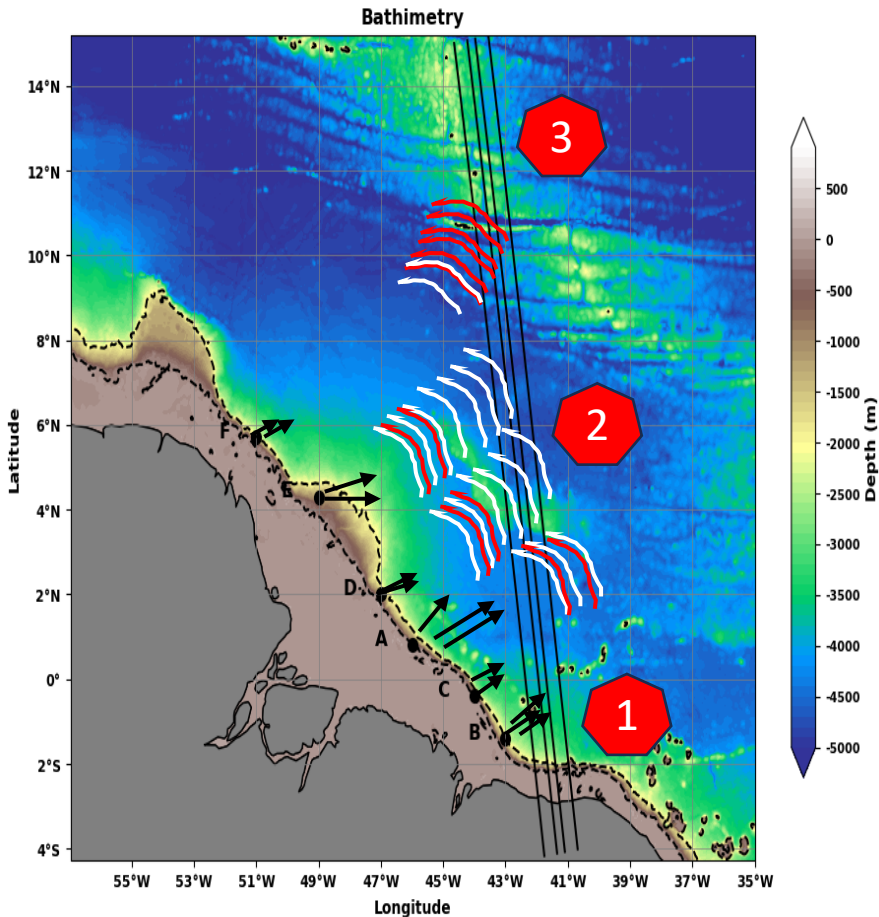
- One of the hot spot of internal tide (IT) generation in the ocean.
- IT generated on six main sites (A to F), (Tchilibou et al.,2022).
- Strong interaction of IT with the background circulation, making them incoherent.
- Strong nonlinear internal solitary waves (ISW) generation and propagation (Macedo et al.,2023).

Track 20 of SWOT's one day orbit crosses 3 dynamic areas:

1. Near IT generation sites on the shelf break.
2. IT interaction with background circulation and ISW propagation.
3. Incoherent IT and ISW propagation. Possible generation on the mid-Atlantic ridge.

Data and motivations:

- 1 day KaRin dataset from mid-March to mid-July (Cycles 459 to 578)
- Focus on interval wave signal.
- Compare KaRin results to existing IT models (Zaron et al., 2019).



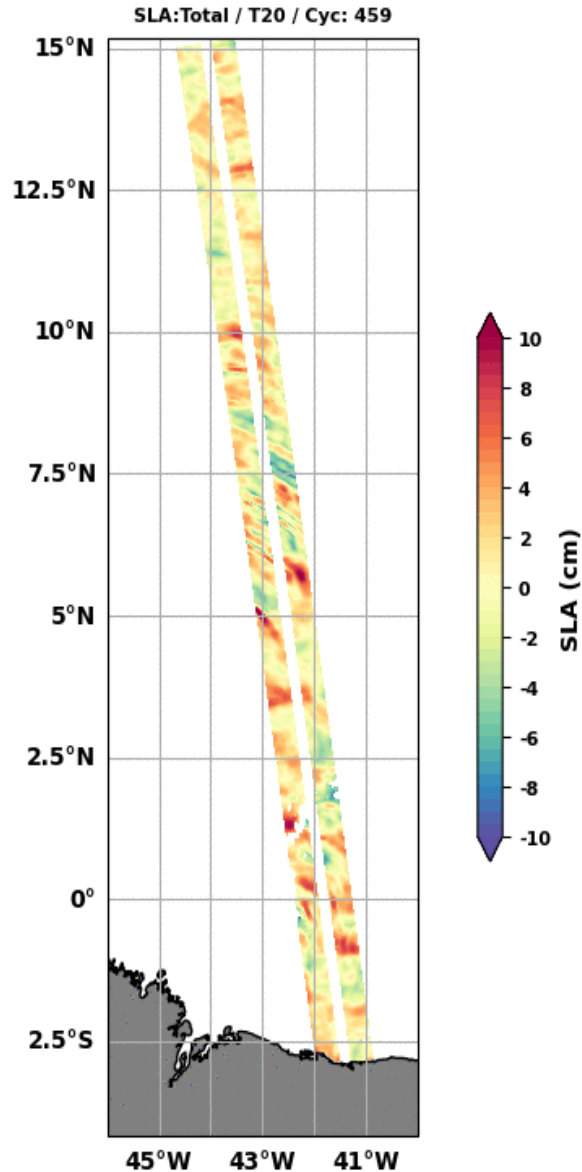
SWOT KaRin: Signal contents

We used L3 KaRin products and the SLA is defined as follows:

$$\text{SLA} = \text{ssha_karin_2_filtered} - \text{duacs_ssha_karin_2_oi} + \text{internal_tide_hret}$$

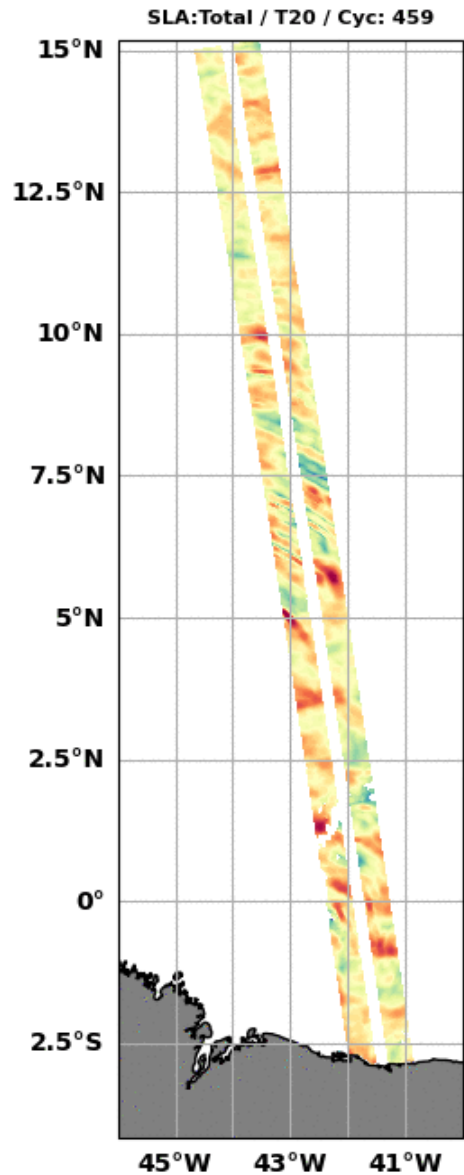
duacs_ssha_karin_2_oi: To removed larges scale (eddies)

Internal_tide_hret: To have total IT signal

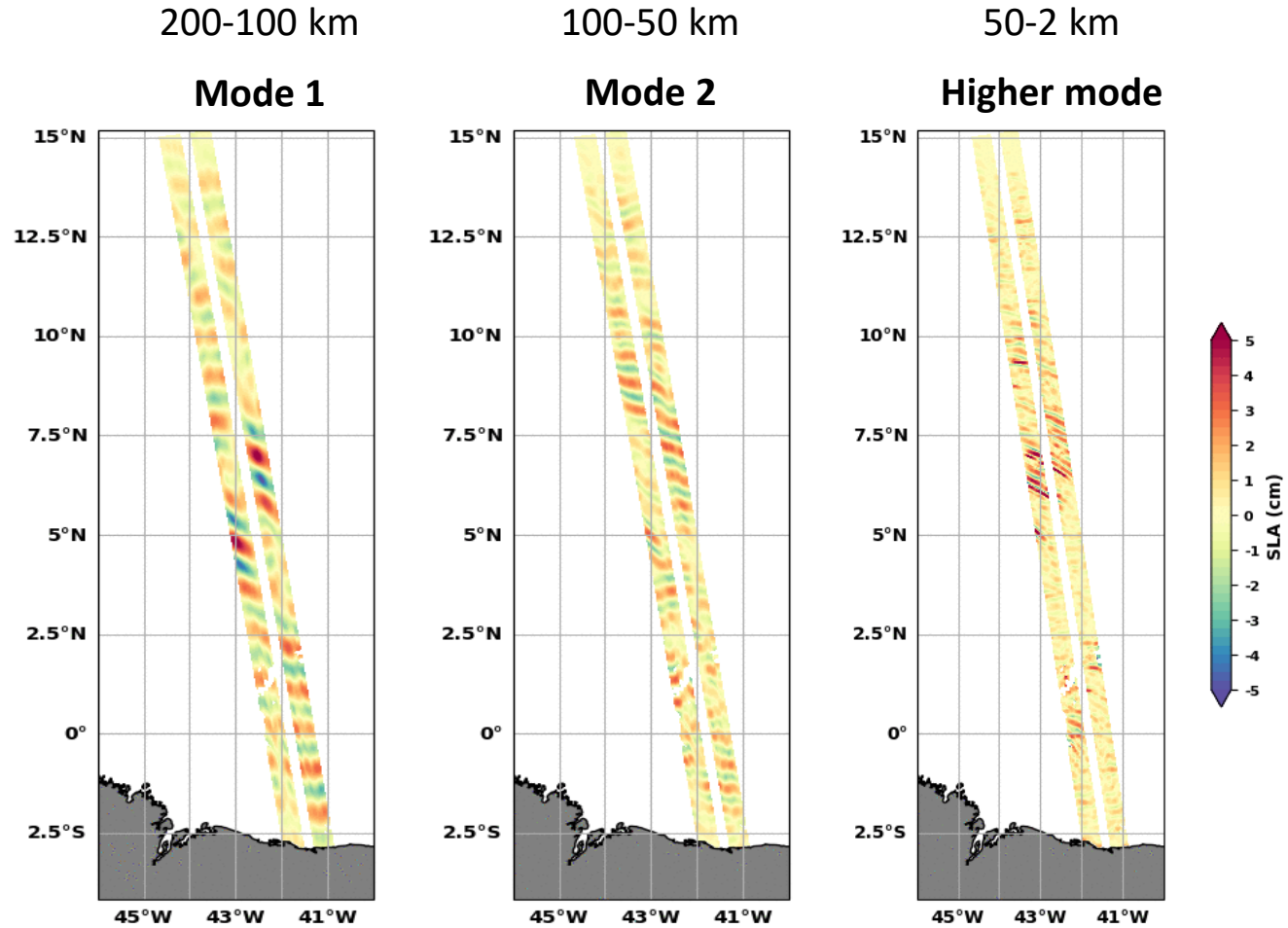


- Evidence of Internal waves structures all along the track.
- A mixture of different wavelengths (larger 200-100 km to smaller 50 - 30km).

SWOT KaRin: Signal contents



Several bandwidth filtering applied on SLA



Strong SLA signature even at small scale (50-2 km)

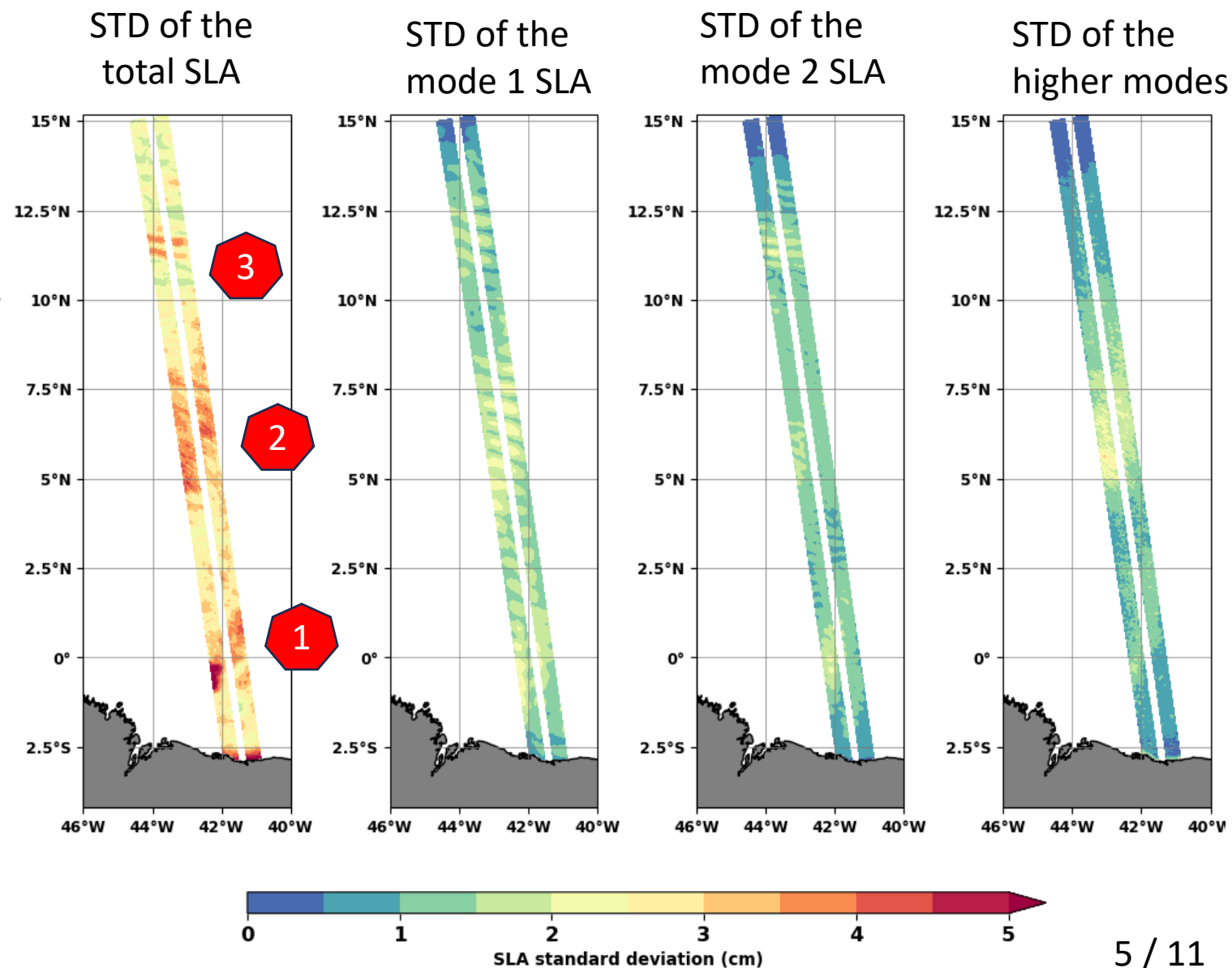
SWOT KaRin SLA: Standard deviation (STD)

STD maximum at the 3 identified areas:

1- Permanent baroclinic flux generated on site A. Variability due to mode 1 and mode 2.

2- Variability due to mode 1 and higher modes (50-2 km). IT and ISW certainly.

3- Variability due to mode 1 and mode 2.



Mode1= 200-100 km
Mode2= 100-50 km
Higher mode = 50-2 km

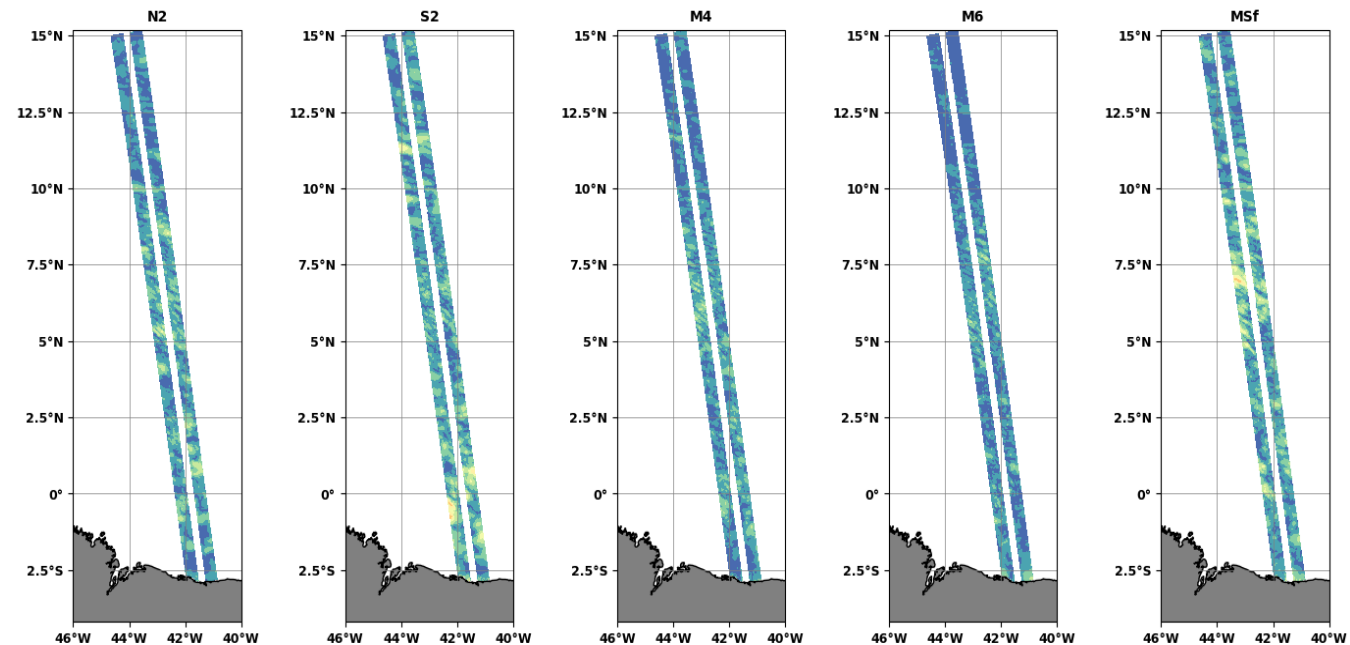
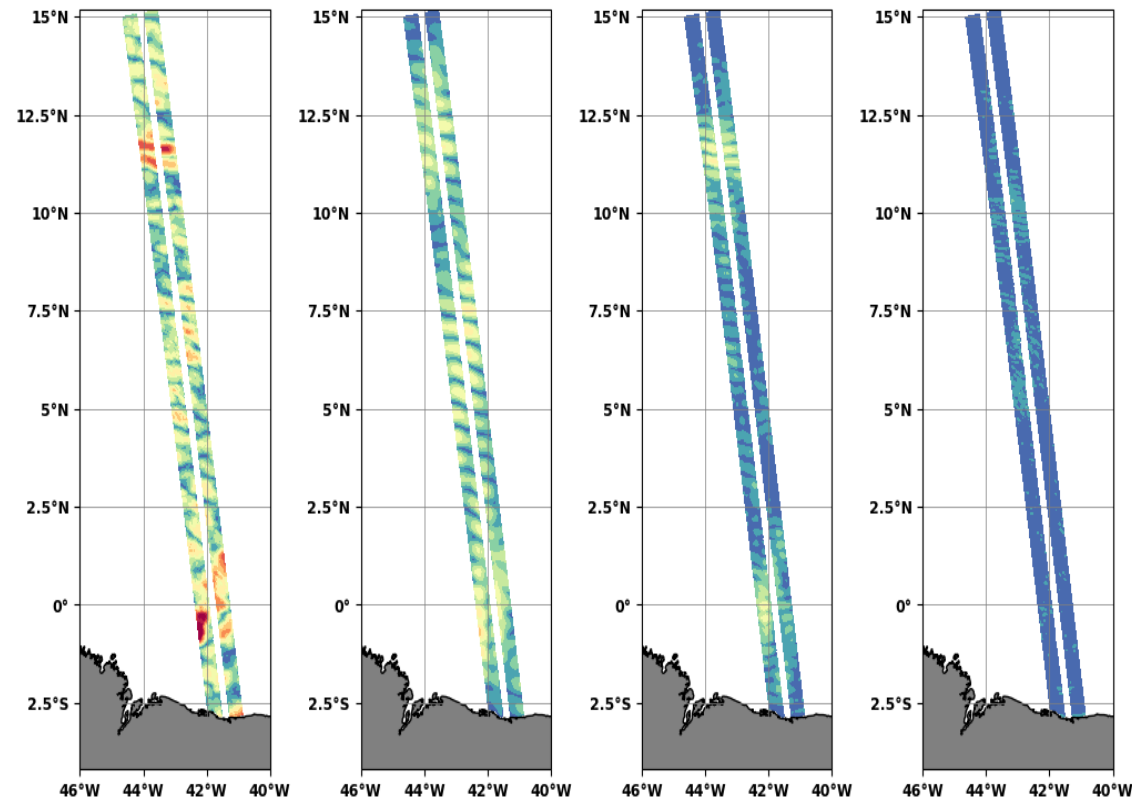
SWOT KaRin SLA: Coherence at some tidal frequencies

Harmonic analysis of the total and filtered SLA over the entire 1day observation period.

M2 amplitude

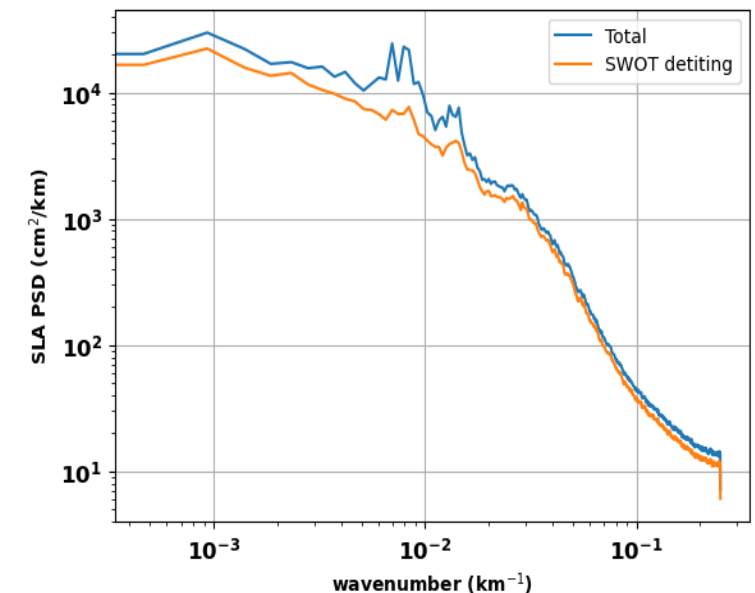
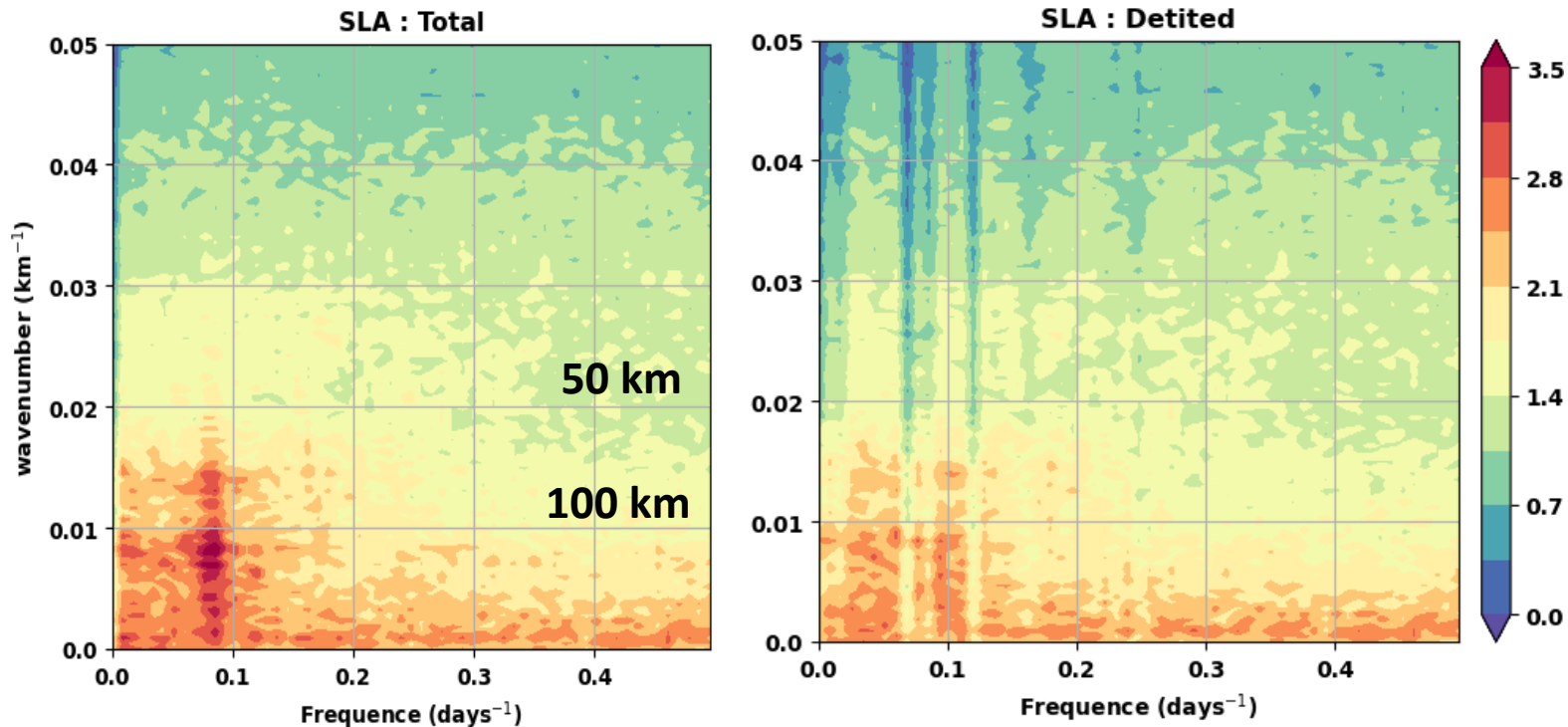
- M2 amplitude up to 5 cm
- Between 1-3 cm for mode 1, over the entire altimeter track.
- Local mode 2 maximum in the south and north path of the track.
- Higher modes signal also visible at M2 freq.
- Non-negligible SLA amplitude for N2, S2, M4, M6 and MSf with likely some leakage due to other oceanic variability.

Total SLA Mode1 SLA Mode2 SLA Higher Modes



SWOT KaRin SLA: Spectrum of the total and detided SLA

SLA Detided = SLA – prediction of each wave over the observation period

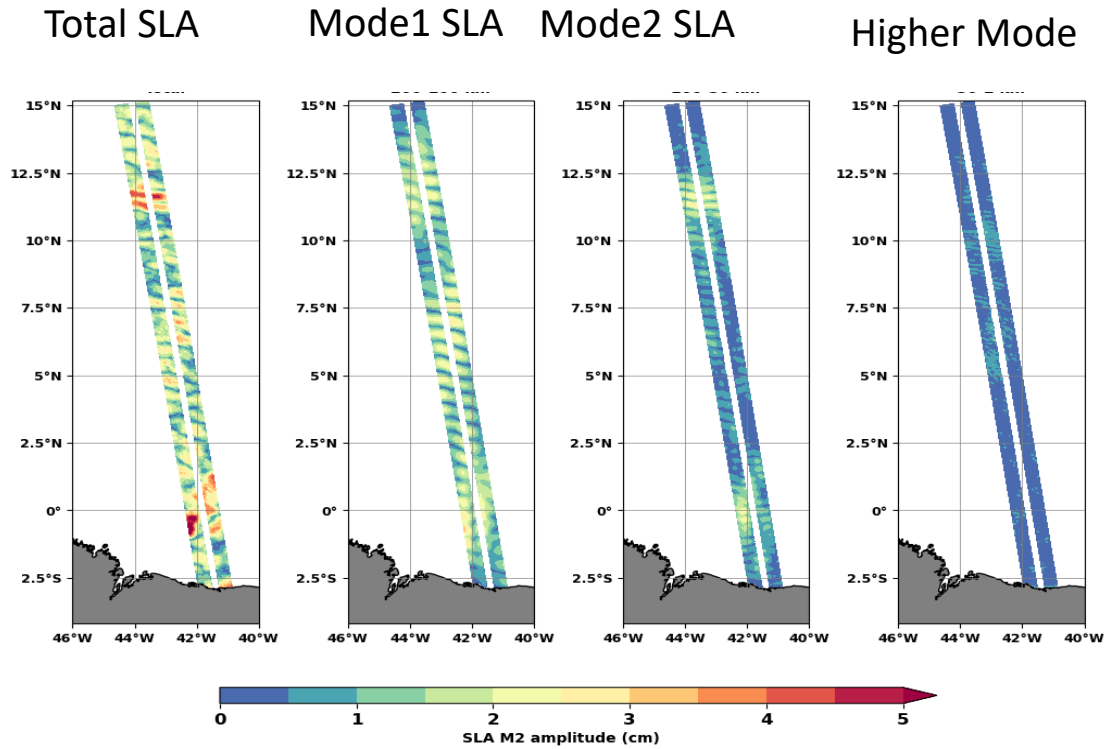


- 1- At M2: mode 1 and mode 2 maximum, some peaks at scale under 50 km.
- 2- Visible effects of the detiding around M2, N2, M4 and M6 frequencies.
- 3- Mode 2 and smaller scales are less or not impacted by the detiding.
- 4- Some large scales were also removed indicating some leakage of oceanic variability in the estimations

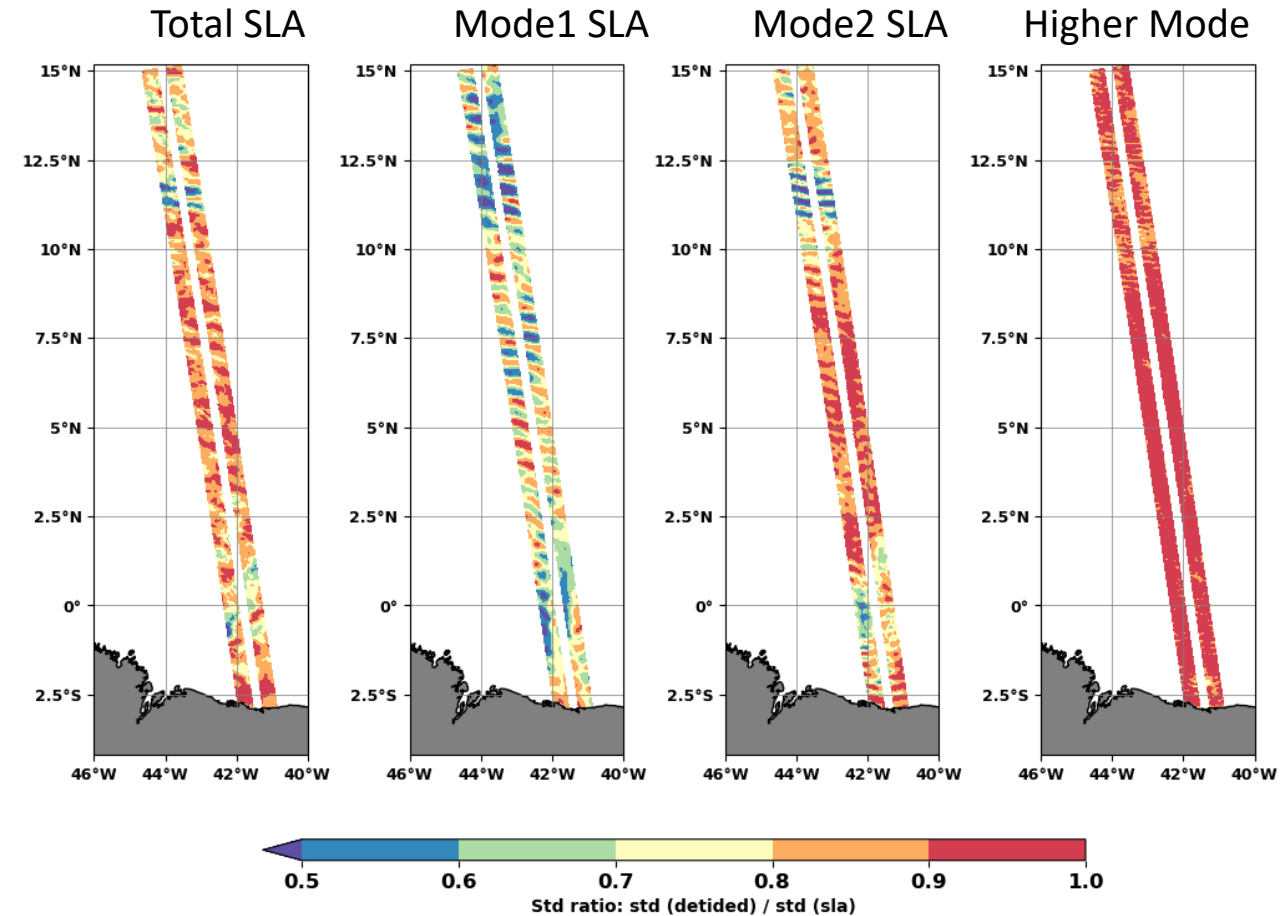
SWOT KaRin SLA: Detiding of the filtered SLA.

Standard deviation ratio = $\text{STD detided SLA} / \text{STD SLA}$

M2 amplitude



Standard deviation ratio

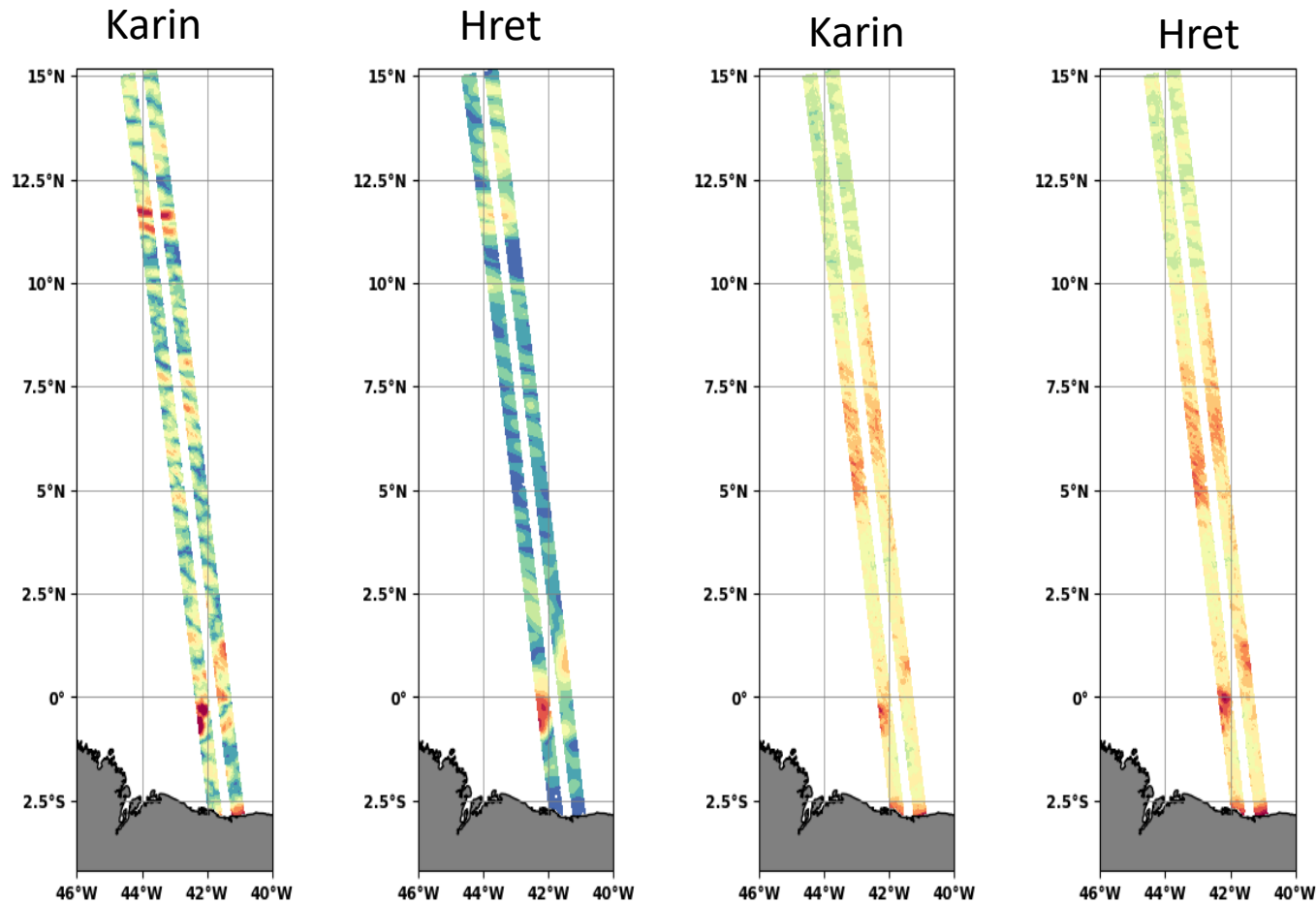


- Standard deviation ratio greater than 0.5 except where M2 is maximum.
- Mode2 and smaller scales are less detided.

SWOT KaRin SLA: Comparison to HRET (Zaron et al., 2019)

M2 amplitude on period 1

M2 Detided STD on period 1



Dataset divided in two periods :

- Period 1: C459 to C550 (89 days), to build an M2 model from SWOT KaRin observations.
- Period 2: C551 to C578 (28 days), independent data for M2 model validation.

Period 1 results

M2 amplitude: Karin and HRET show the same spatial distribution, but higher and noisier amplitudes for Karin.

M2 detided: STD detided HRET > STD detided with Karin

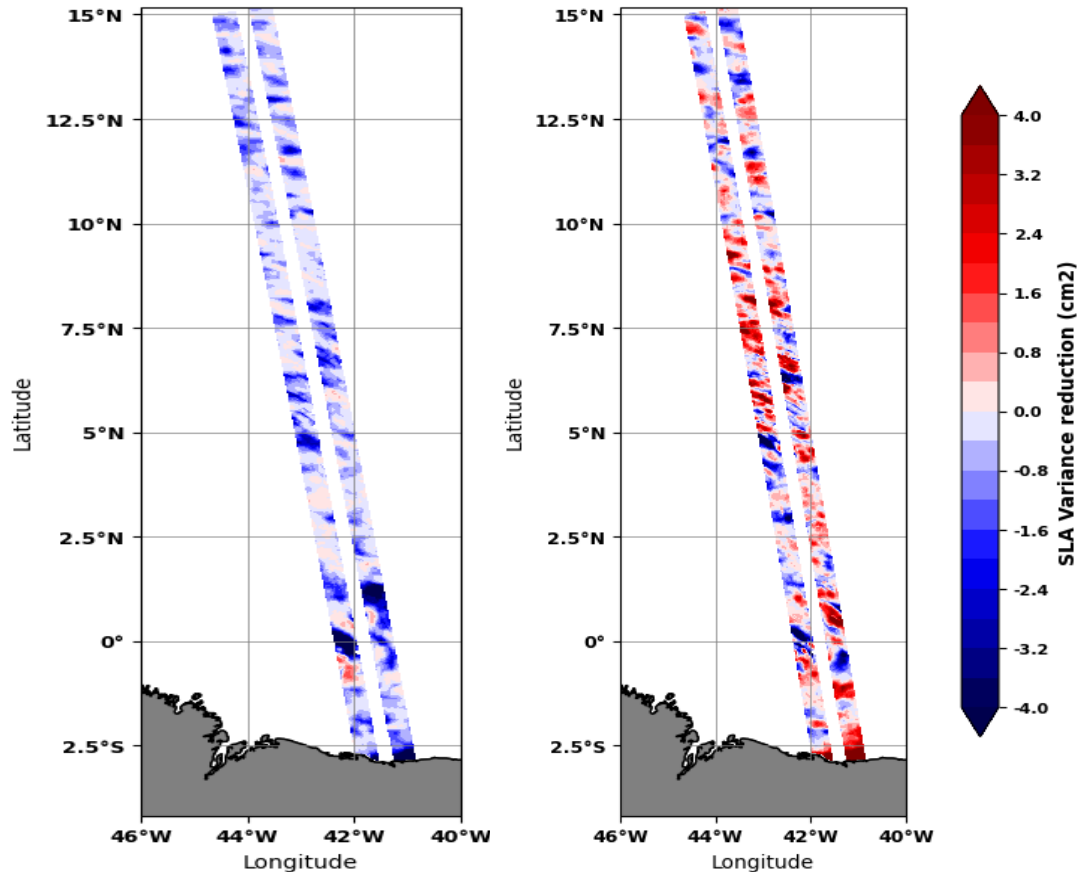
SWOT KaRin SLA : Comparison to Hret (Zaron et al., 2019)

Variance reduction = $\text{Var}(\text{SLA-Karin}) - \text{Var}(\text{SLA} - \text{HRET})$

Variance reduction of the M2 detided SLA

Period 1

Period 2



1- Period 1: **SWOT reduces the variance more than HRET.**

2- Period 2: M2 prediction based on amplitude and phase of period 1 M2 model. **HRET reduces the variance more than our SWOT model.** Certainly because of the non stationarity of the waves (IT and ISW).

Conclusions

- We observe strong internal tides (waves) surface signatures in KaRin data for different wavelengths and frequencies
- Harmonical analysis and detiding can be efficient locally
- Very small scales are not corrected with the detiding
- We are strongly constrained by the short temporal series available + tidal aliasing/separability.
- Less efficiency of the detiding on the independant validation likely due non-stationarity of the waves.
- Analysis of the altimeter tracks crossing New Caledonia, the Solomon Sea, and Indonesia is ongoing.