



# Wave-current interactions:

a new view of how surface currents influence wave properties using CFOSAT-SWIM data

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2. France Energies Marine

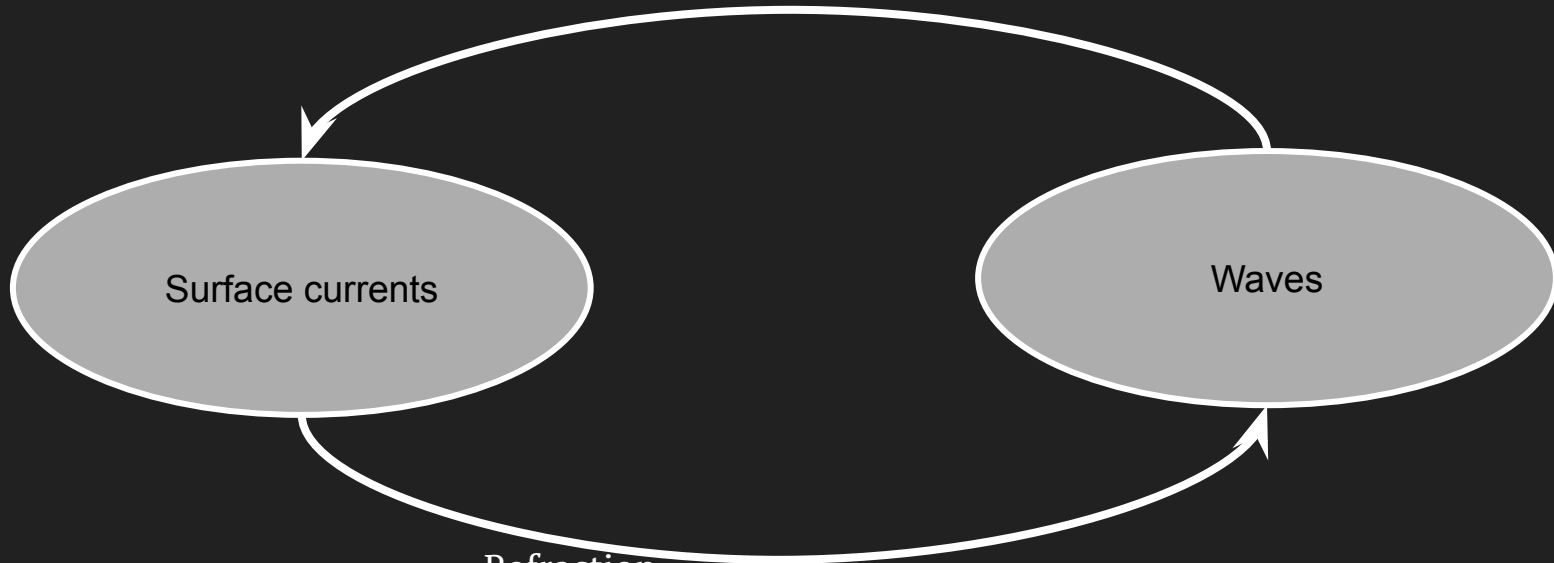
# Outlines

- Introduction
- Presentation of data
- Effects of Agulhas current on the waves spectrum
- Perspectives and conclusion

# Introduction:

Momentum exchanges  
Mixing, Langmuir circulation  
Stokes drift advection

...

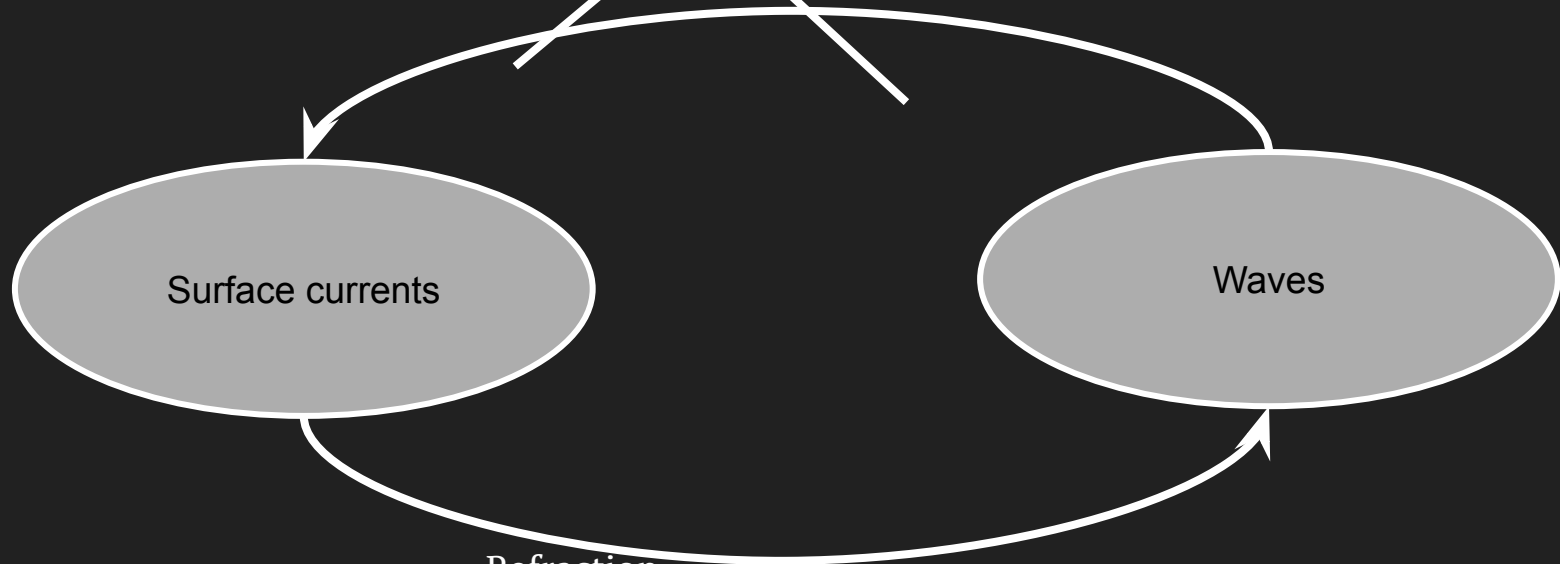


Refraction  
Advection of wave action  
Doppler shift  
Breakings

...

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~~Momentum exchanges  
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Stokes drift advection  
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Refraction  
Advection of wave action  
Doppler shift  
Breakings  
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# Introduction and motivation

- Observation of wave properties variability due to meso- and submesoscale surface current effects (locally and not locally)

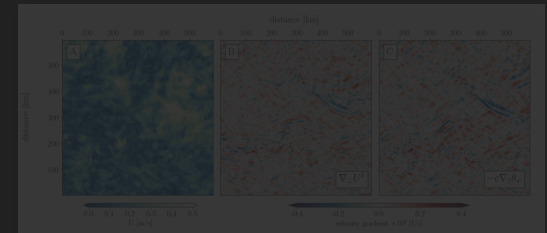
- Refraction (change of wave direction)
- Doppler shift (change in wavenumber)
- (Kudryavtsev et al 2017b, Romero et al. 2017, and others works)

=>induce a change in significant wave height

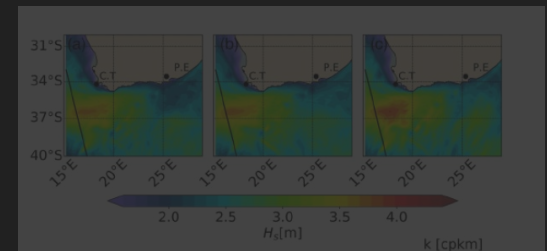
- Retrieve surface currents from wave measurements (Villas Boas et al. 2020)
- Validation of wave models in strong surface current field (Marechal and Ardhuin 2021)



Romero et al. 2017



Villas Boas et al. 2020



Marechal and Ardhuin 2021

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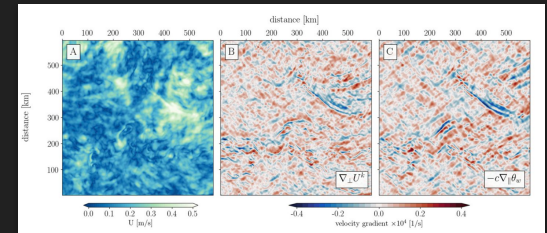
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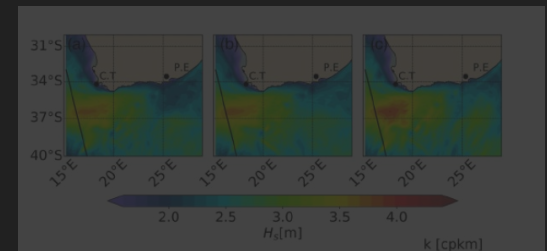
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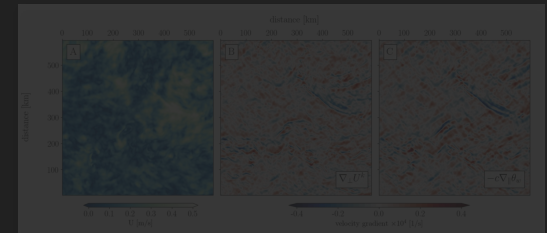
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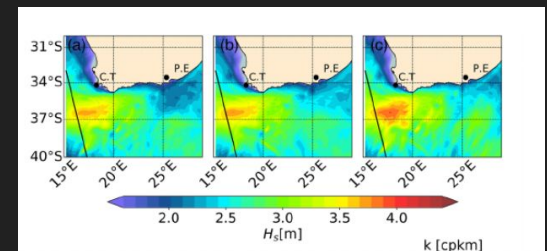
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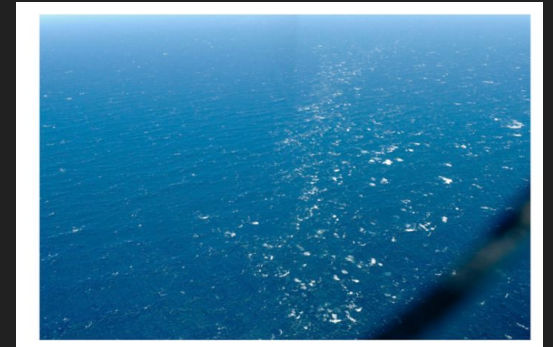
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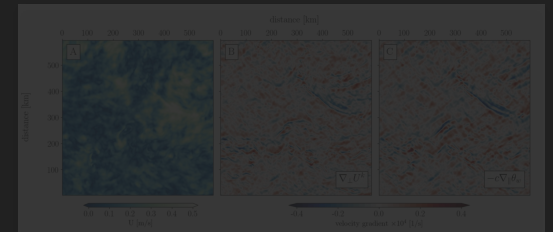
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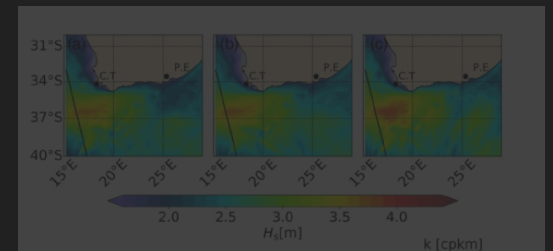
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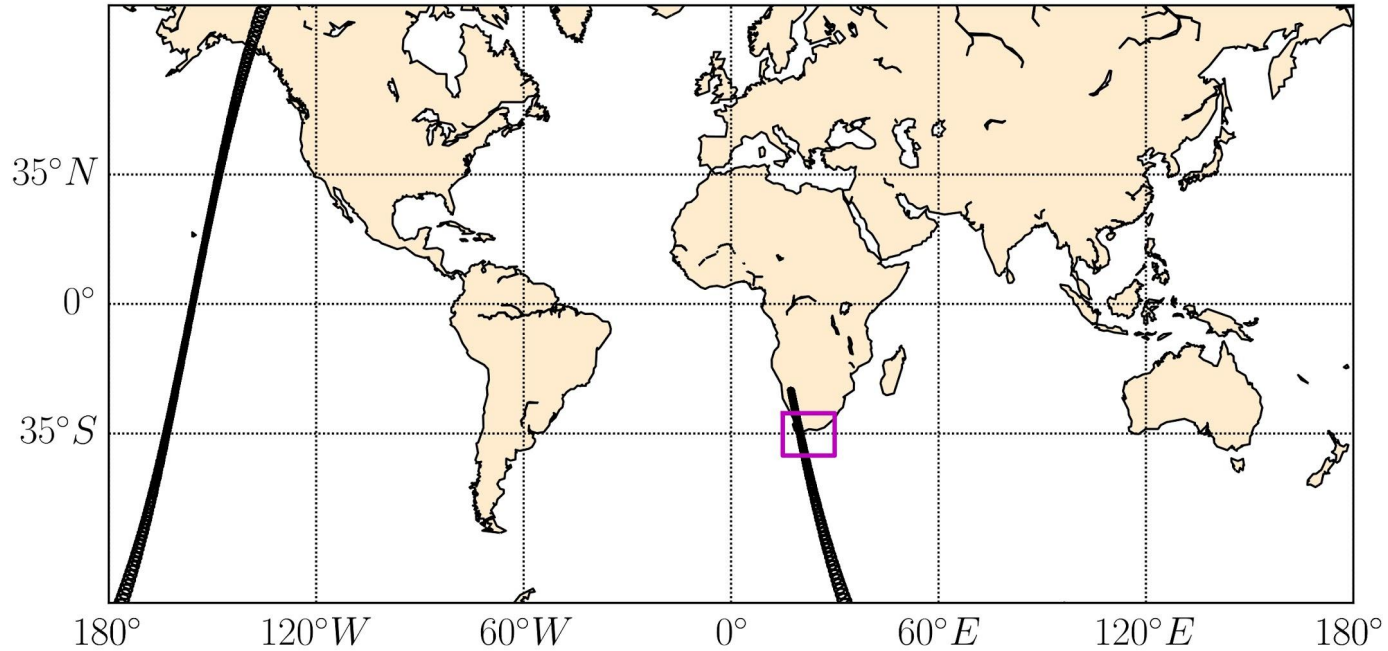
Villas Boas et al. 2020



Marechal and Ardhuin 2021



# Global view of one SWIM pass the 11th June 2019

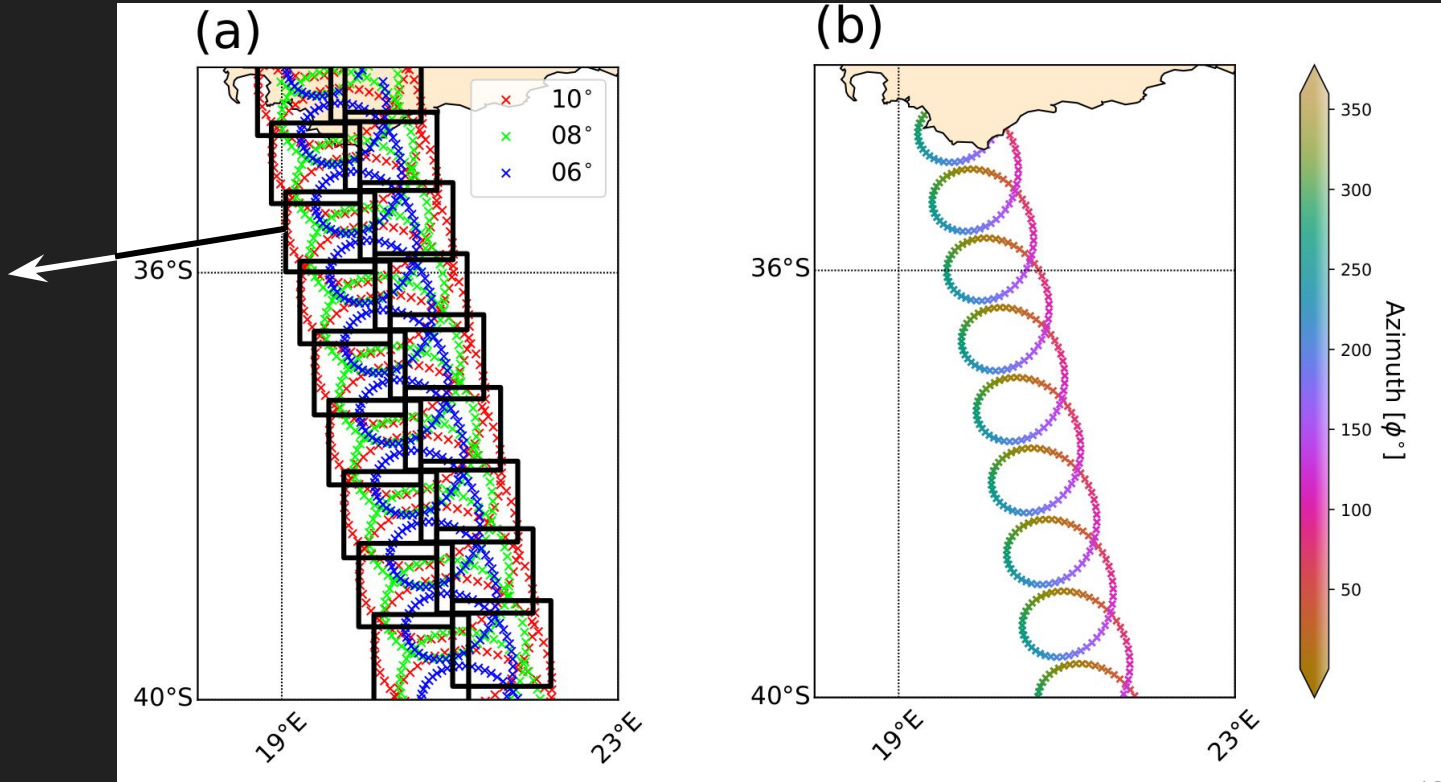


# SWIM DATA: Two SWIM products used (1)

Each cross is a 1D spectrum  $E(k)$ .

One averaged 2D spectrum per box and per incidence (size=90kmx70km)

3 waves parameters ( $H_s$ ,  $\lambda_p$ ,  $\theta_p$ ) per spectrum

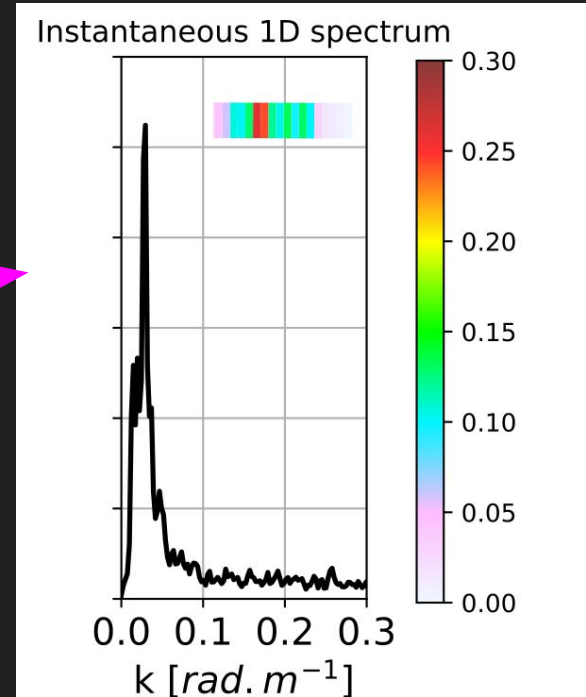
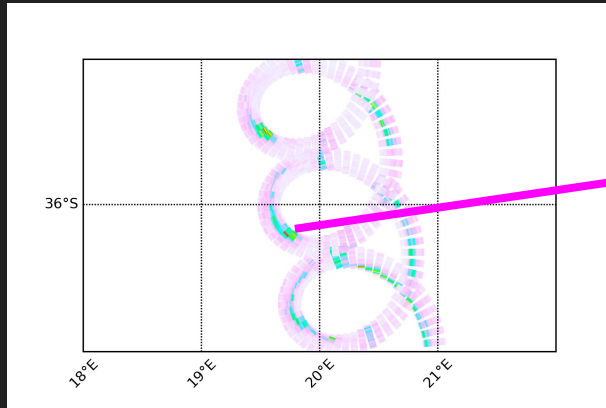


# SWIM DATA: Two SWIM products used (2)

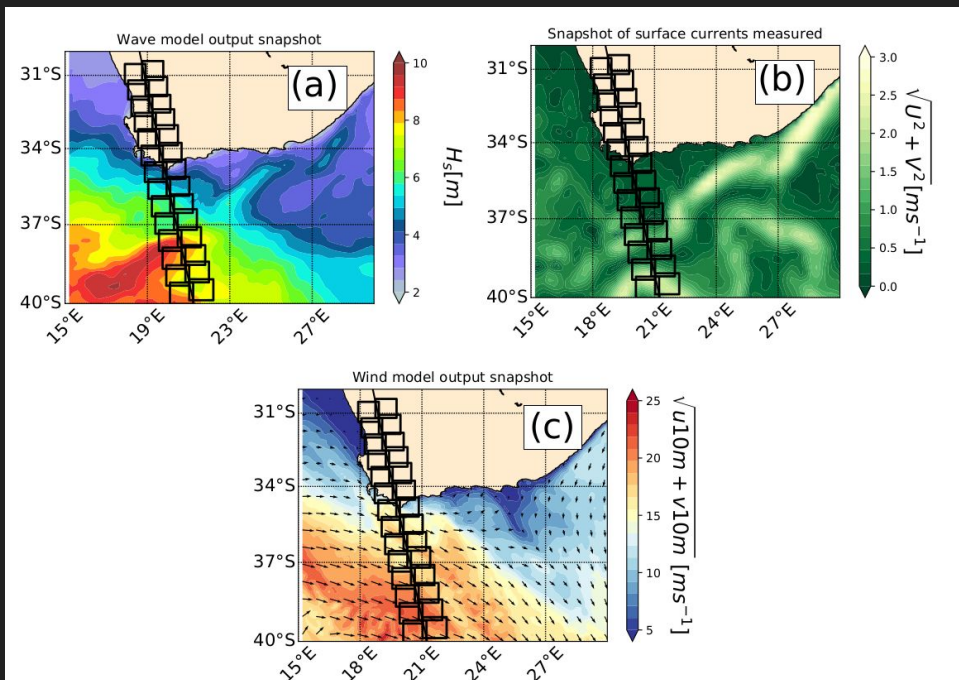
Each ribbon is a 1D spectrum  $E(k)$ .

Distance between each semi macrocycle is different for each offnadir beams.

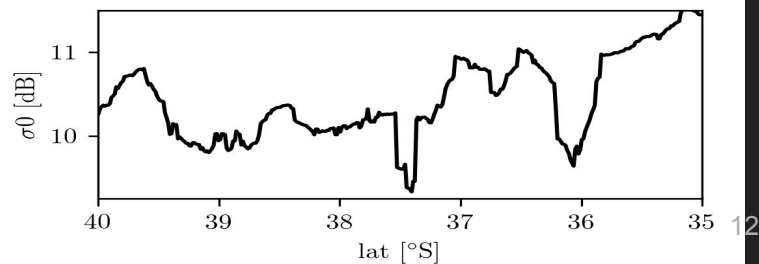
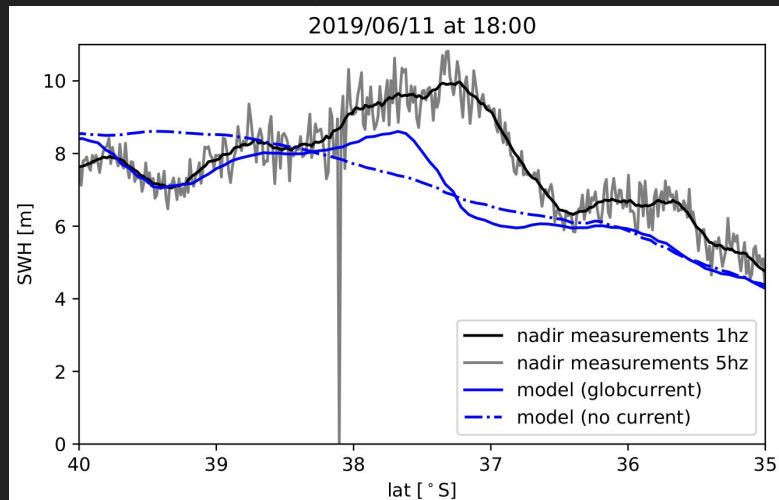
Working on modulation (next step working on wave spectrum).



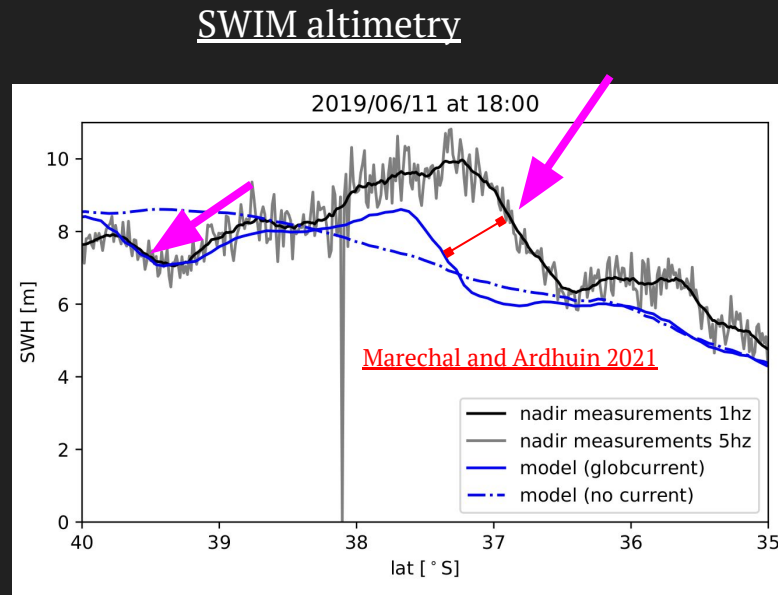
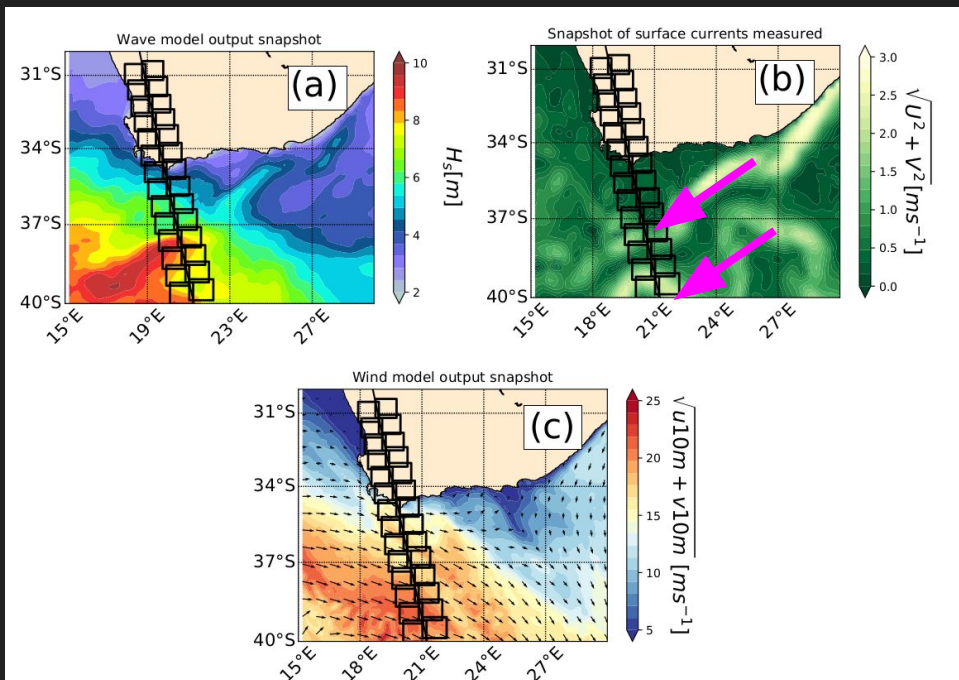
# Effects of Agulhas current on the wind waves spectrum with (1)



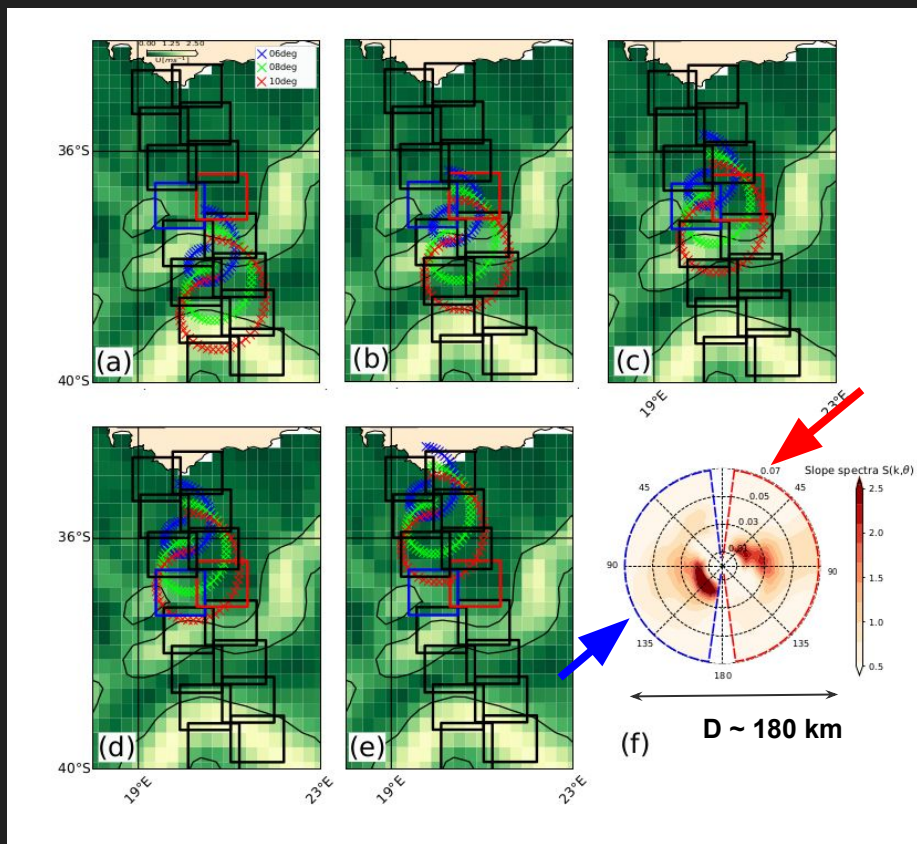
## SWIM altimetry



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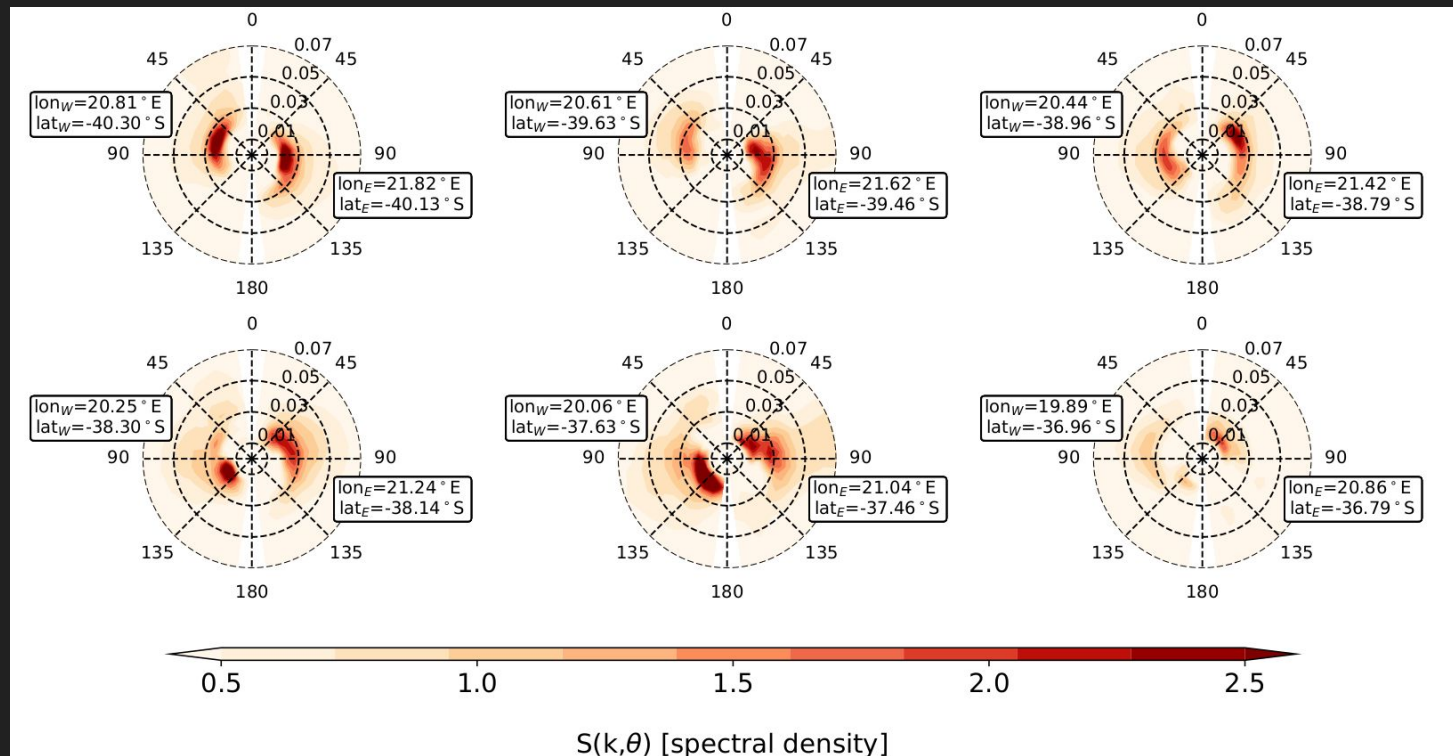


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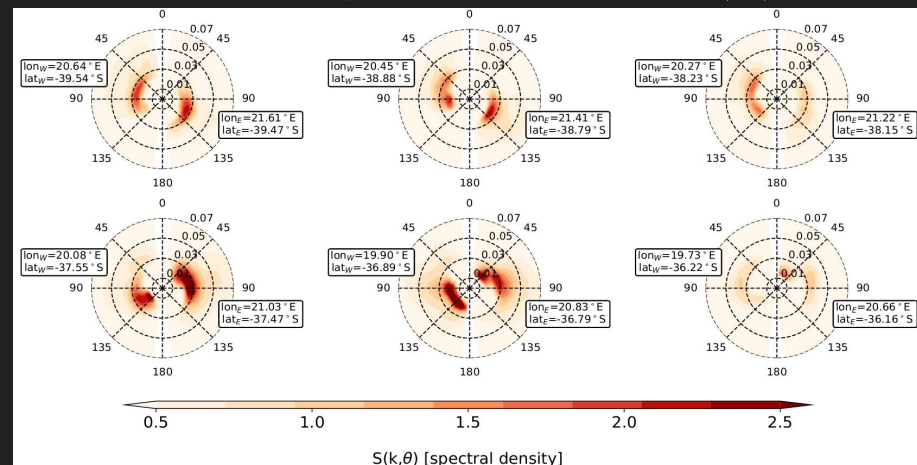
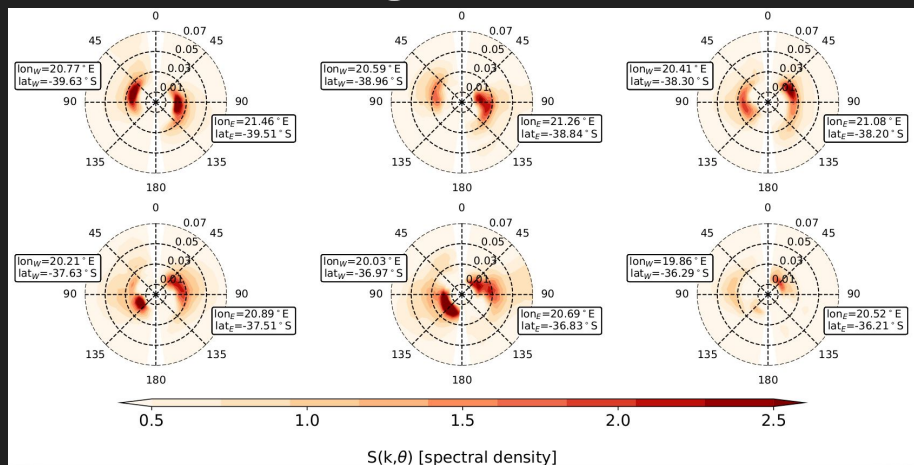


06deg  
08deg  
10deg

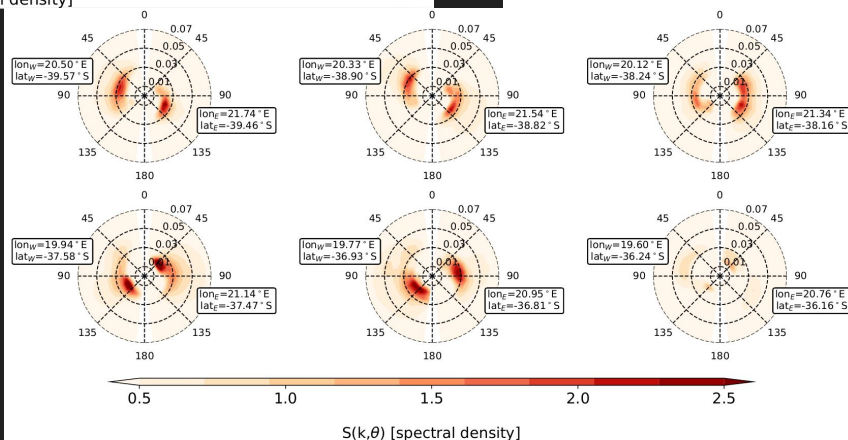
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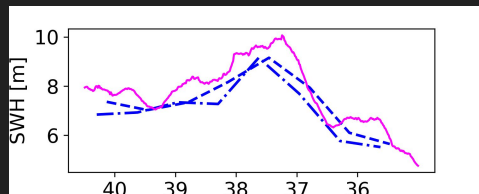
08 deg

10 deg

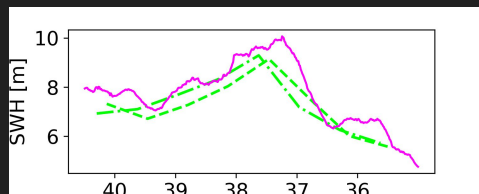


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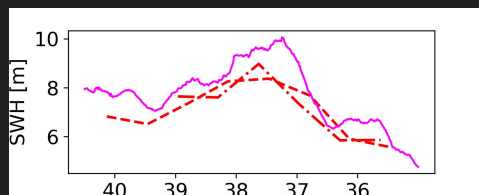
06°



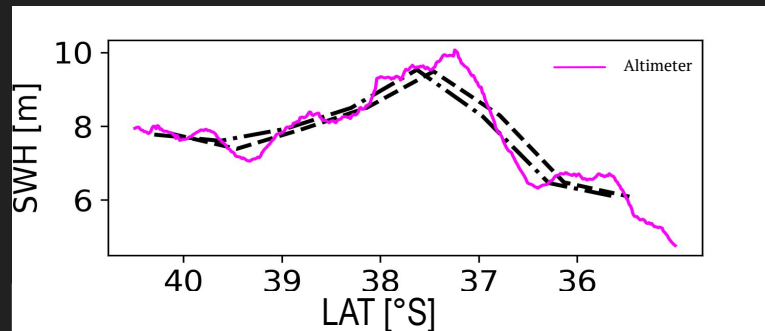
08°



10°

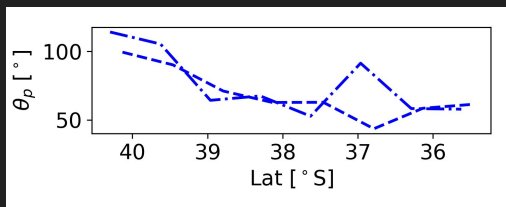


— · — West boxes  
— · — East boxes



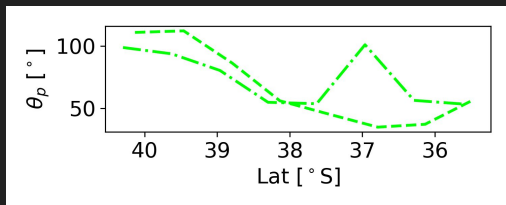
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06°

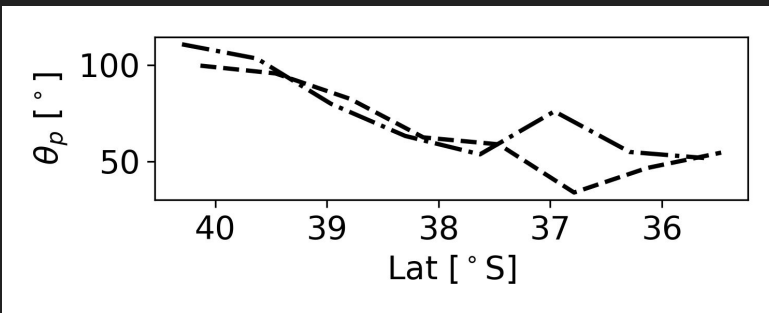
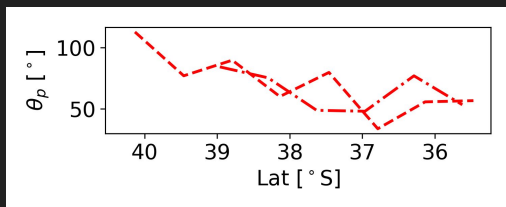


--- West boxes  
-.- East boxes

08°

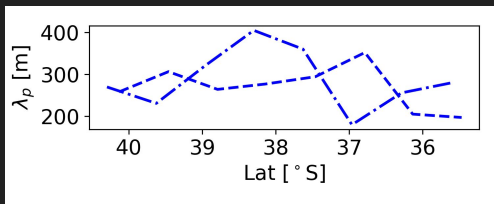


10°

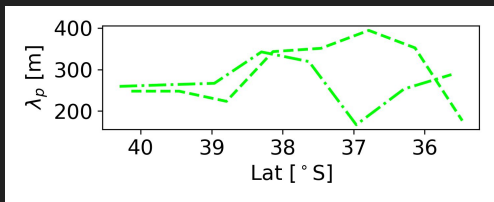


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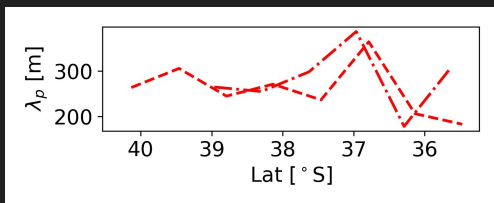
06°



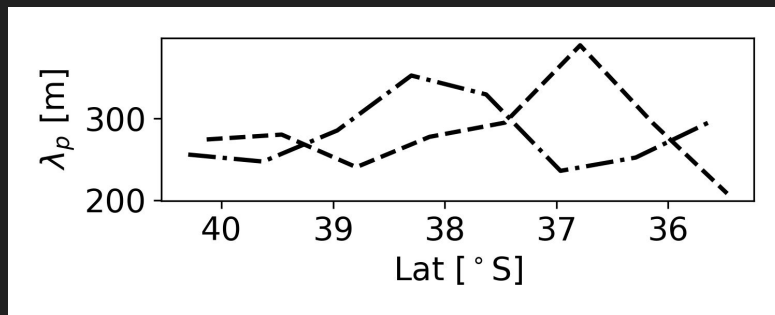
08°



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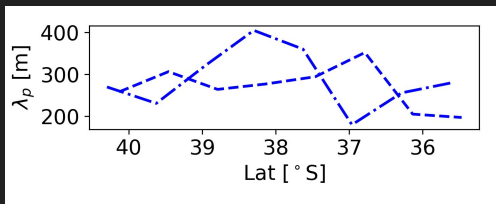
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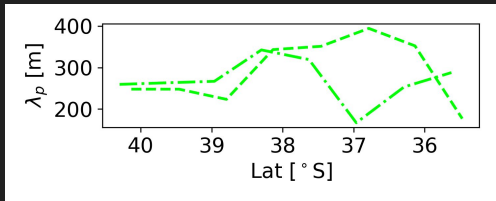
Estimation of  $U$  from doppler shift  
( $\omega = \sigma + \mathbf{k} \cdot \mathbf{U}$ , assuming crests are conserved),  
is not straightforward here!

# Effects of Agulhas current on the wind waves spectrum with (1)

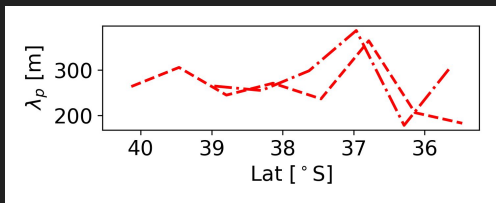
06°



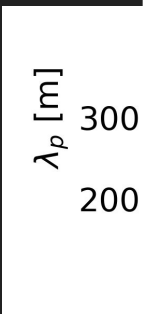
08°



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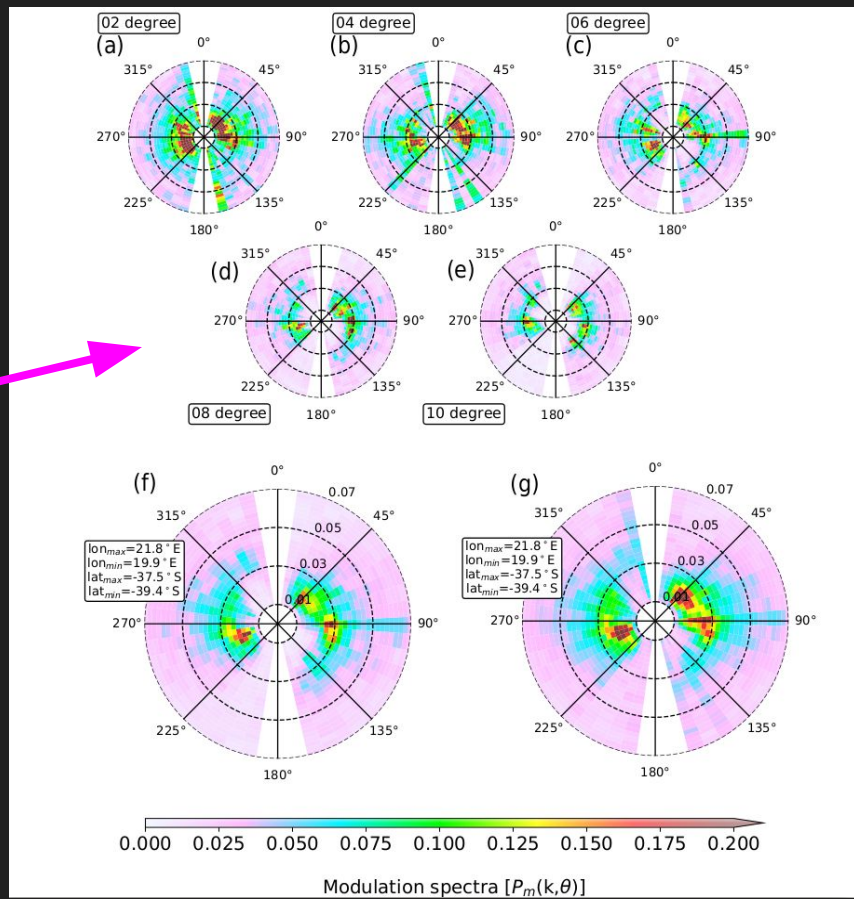
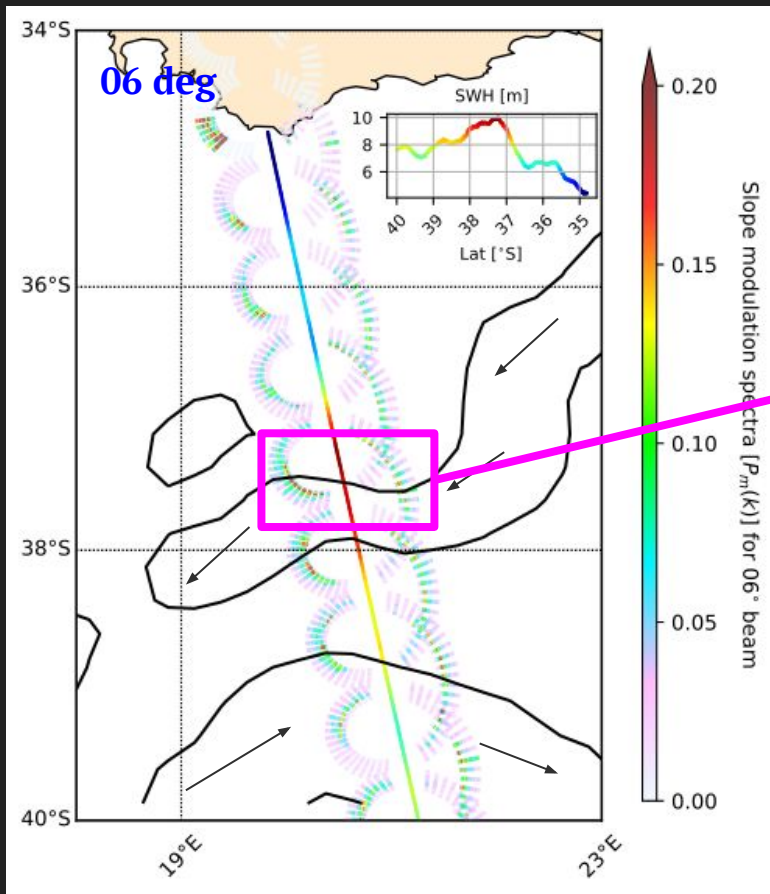
--- West  
 --- East



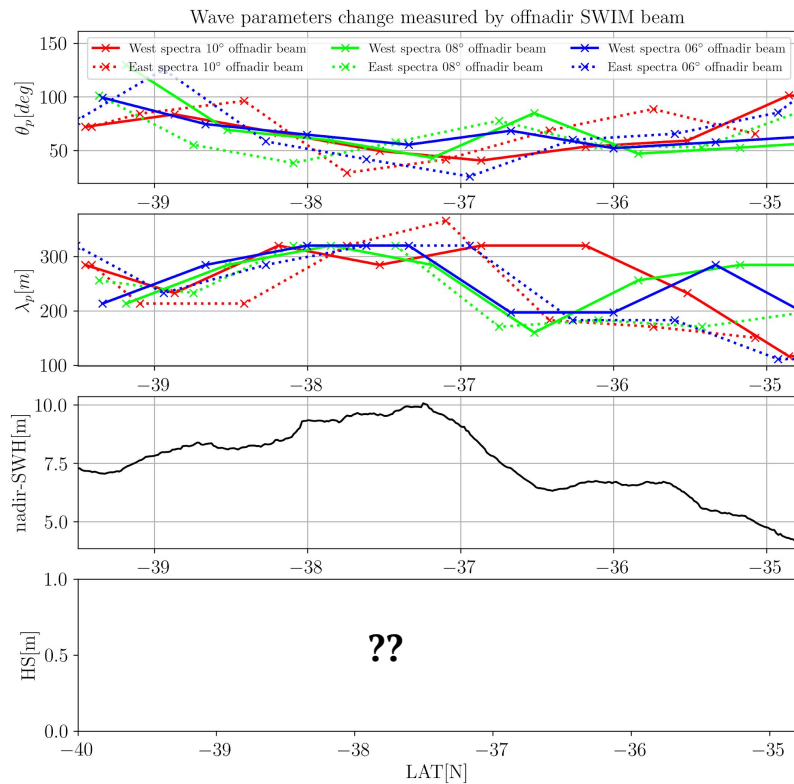
Estimate  
 ( $\omega = \sigma + k$ )  
 is not st

- One 2D spectrum for each box for all incidences.
- Noise in the measurements is reduced due to the averaging of several spectra in the boxes.
- BUT**
- Boxes location is assimilated to a point (LON,LAT), waves variability at scales smaller than 70km is lost.
- What about using the fact that swim beams do not look at the same location for their different incidences without averaging?

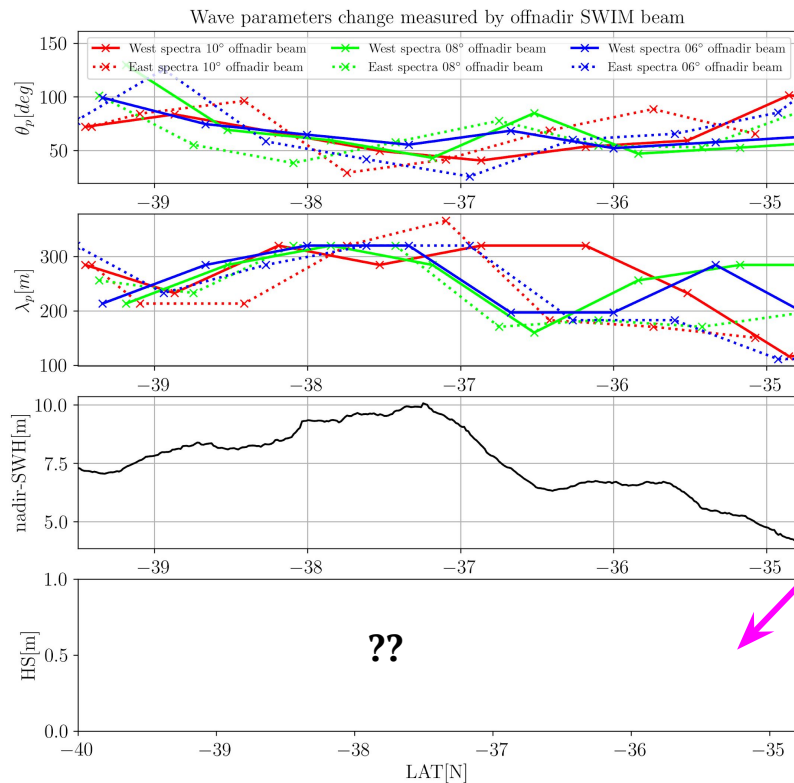
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## Wave height using off-nadir beams:

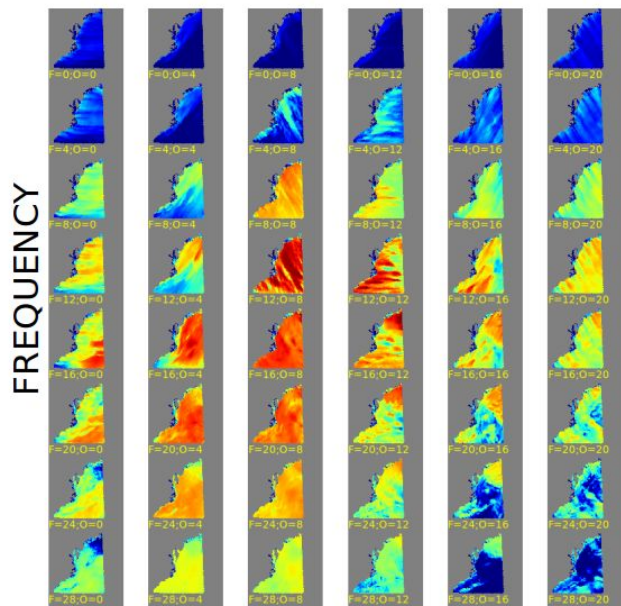
- **Observation** of small-scale open ocean currents effects on wave height
- Dealing with a large amount of **light memory data** ( $\neq$  SAR or optical data).
- **Coming works:**
- Quantify parameters that induce changes in fluctuation spectra (azimuths, wind speed, incident angles, ...)
- Need to switch from fluctuation spectrum to wave spectrum (preliminary works in progress...)

## Conclusion:

- Quick changes in significant wave height are well captured by the altimeter onboard SWIM.
- Averaged waves parameters in 70km x 90km boxes do not capture small scales currents effects on waves.
- Promising results to observe how small surfaces scales affect the properties of waves using a combination of local 1D spectrum.
  - Need to better understand the SWIM speckle noise and parameters needed to define a MTF between fluctuations and waves spectrum.
- ... need to measure waves and currents both simultaneously and at high resolution (SWOT, SKIM, STREAM)

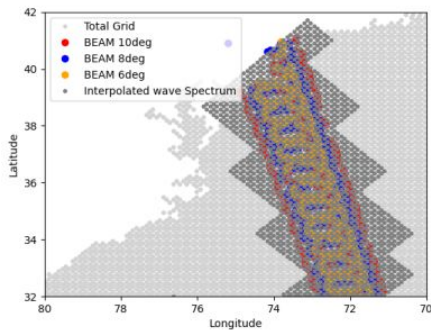


## INPUT WW3 SIMULATION



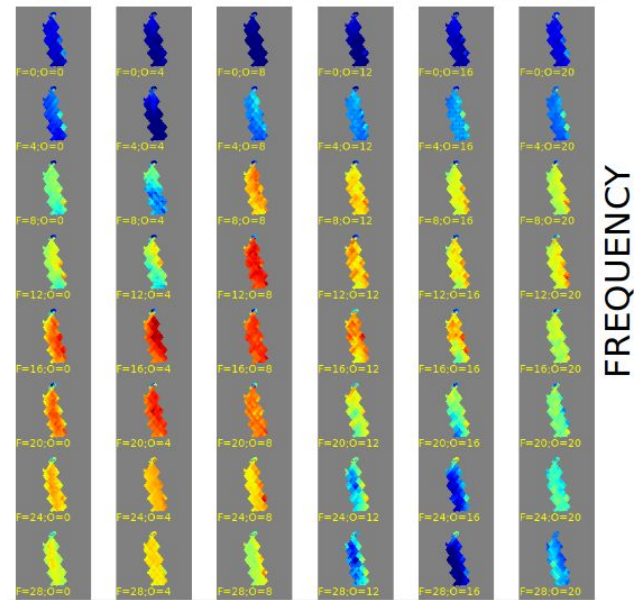
Orientation

## ONE CFOSAT SCAN



Preliminary test on  
Gulf Stream  
simulation

## SROLL OUTPUT WW3 SIMULATION



Orientation

Thank you!



*CFOSAT CalVal mission 2021  
Scientific team.*