Internal waves interactions with eddies and the atmosphere from a high-resolution regional simulation of the California Current System

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SWOT meeting
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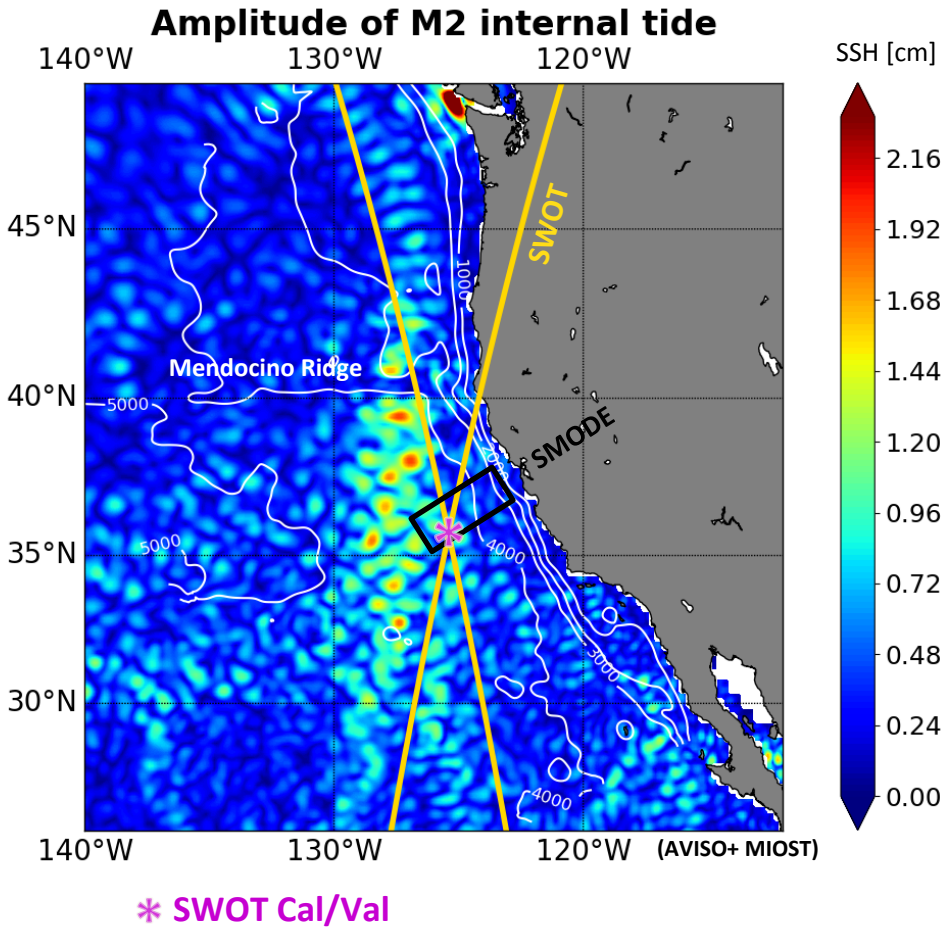
with the support of:

Context

California Current System (CCS)

- Internal Tides generation hotspot at the Mendocino Ridge 1-3 GW (Althaus et al. 2003)
- Internal Tides travelling from remote generation hotspot (Hawaiian Ridge).
- SWOT Cal/Val site



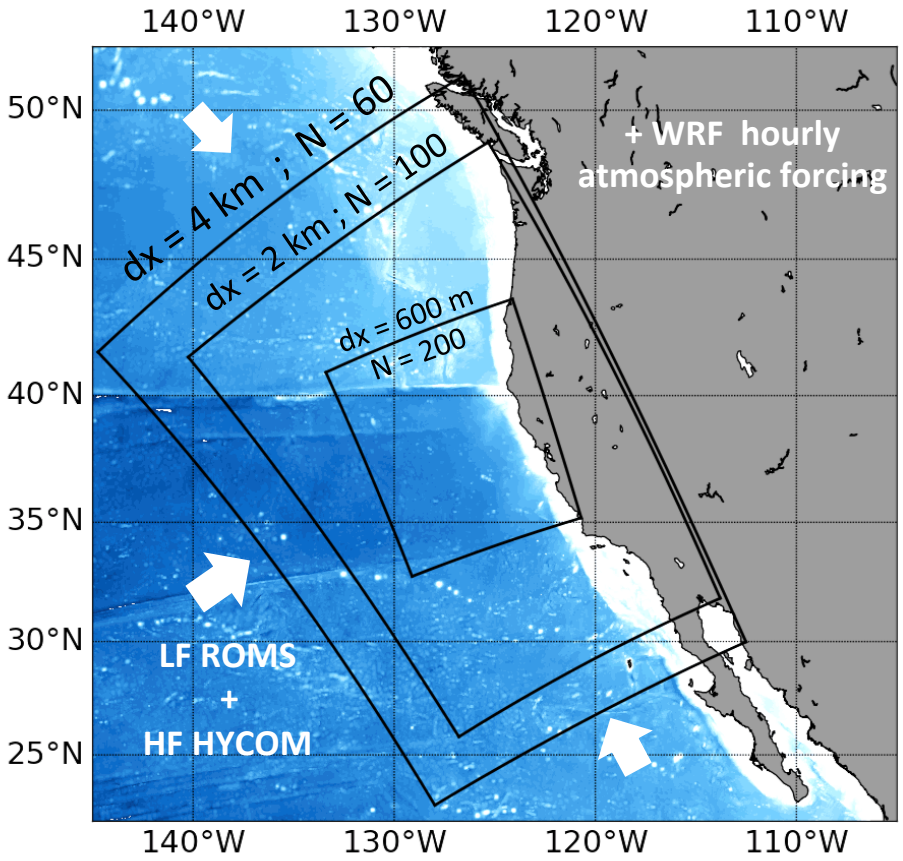
Internal tides energetics of particular importance for SWOT because of their aliasing in low frequency SSH.

Context

HR Simulations of CCS

- 1 year simulation at 4km and 2km with hourly outputs.
- Open Boundary Conditions: 2d Flather, 3d specified
- Low frequency > 1 day ROMS
- High frequency < 1 day HYCOM
- Tuning of sponge layers to minimize the reflection of internal waves at the OBC

(Siyanbola et al. 2022, in prep.)



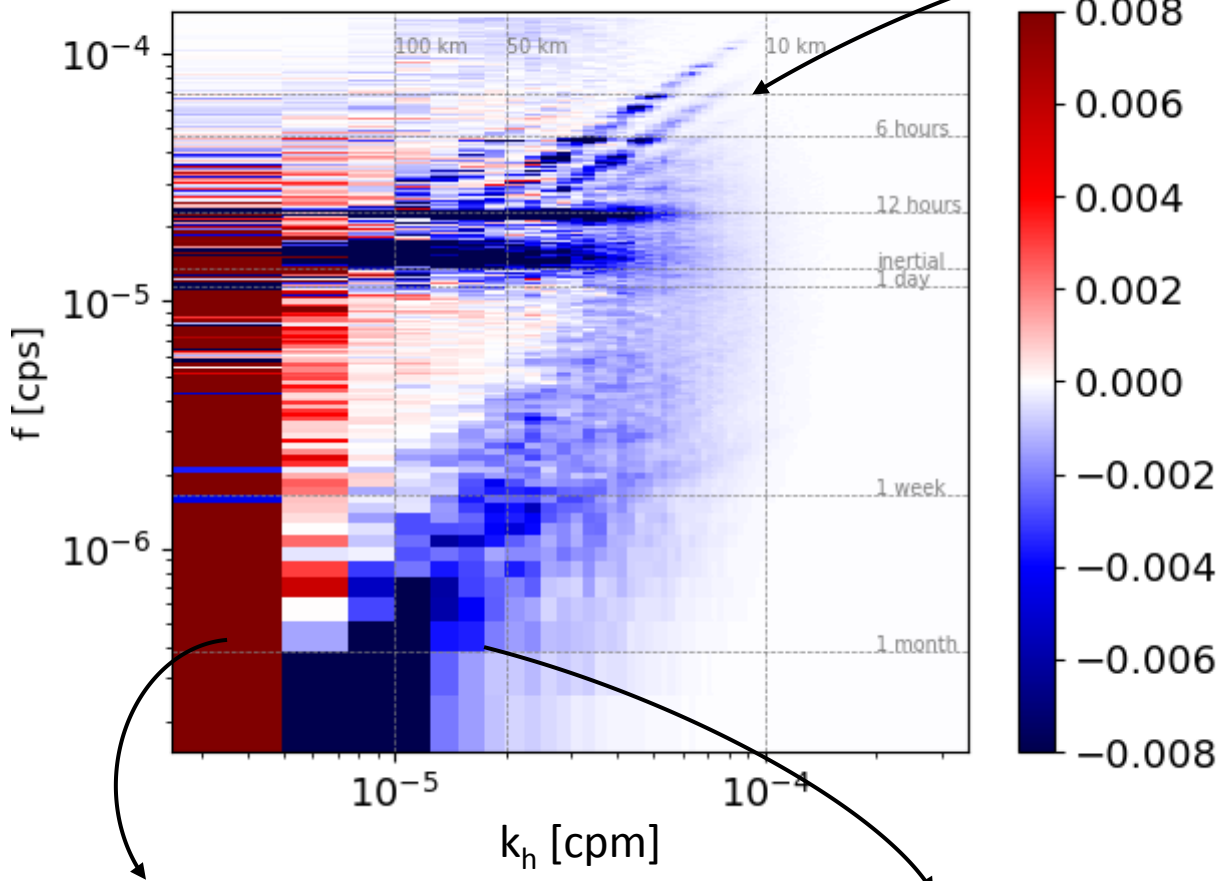
Process studies affecting the energetics of internal waves: eddy-internal waves interactions, **wind-internal waves interactions**.

Question

How does the wind affects the energetics of internal tides ?

1. Spectral wind power

Co-spectrum of winds and surface currents from dx=2km CCS simulation



« Internal Waves killing effect » ?

Energy from the wind to the ocean

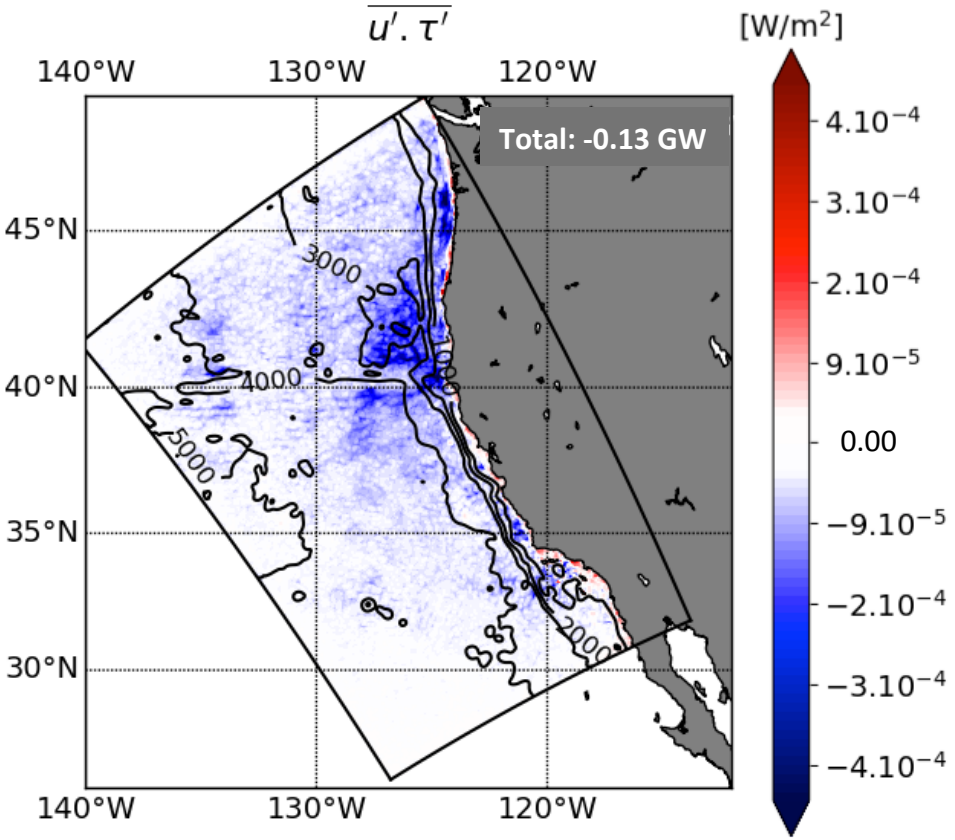
Energy from the ocean to the wind

energy input at large scales

Eddy killing effect
(e.g. Renault et al. 2016)

2. Quantification of the energy sink

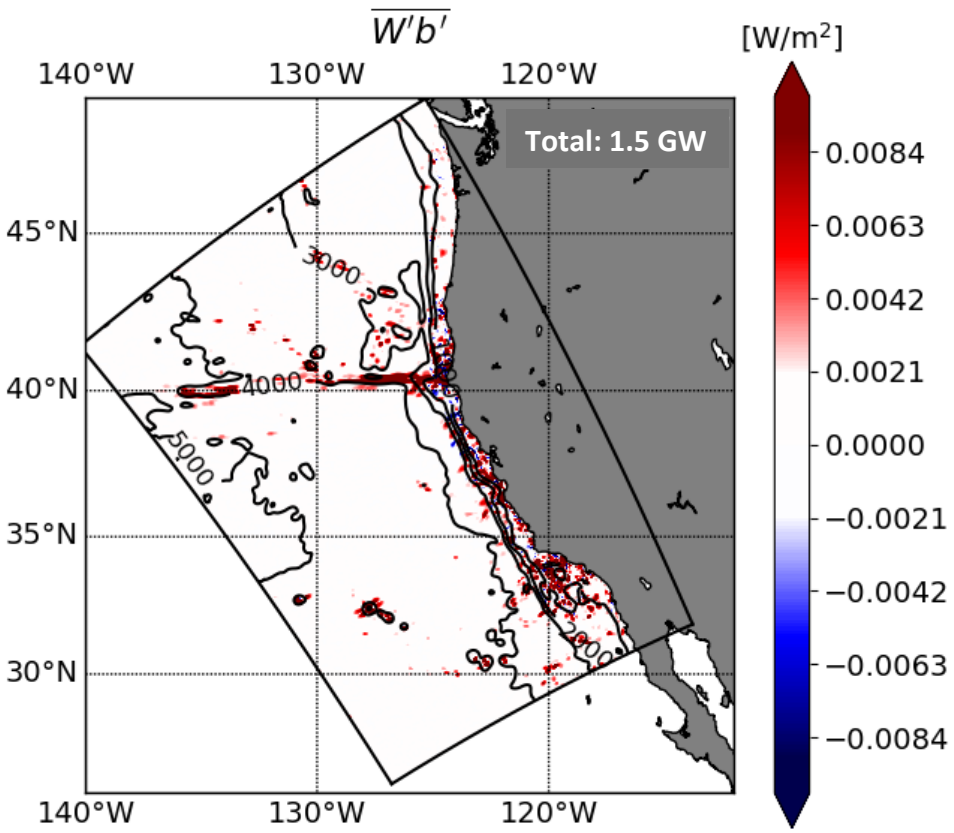
wind-work



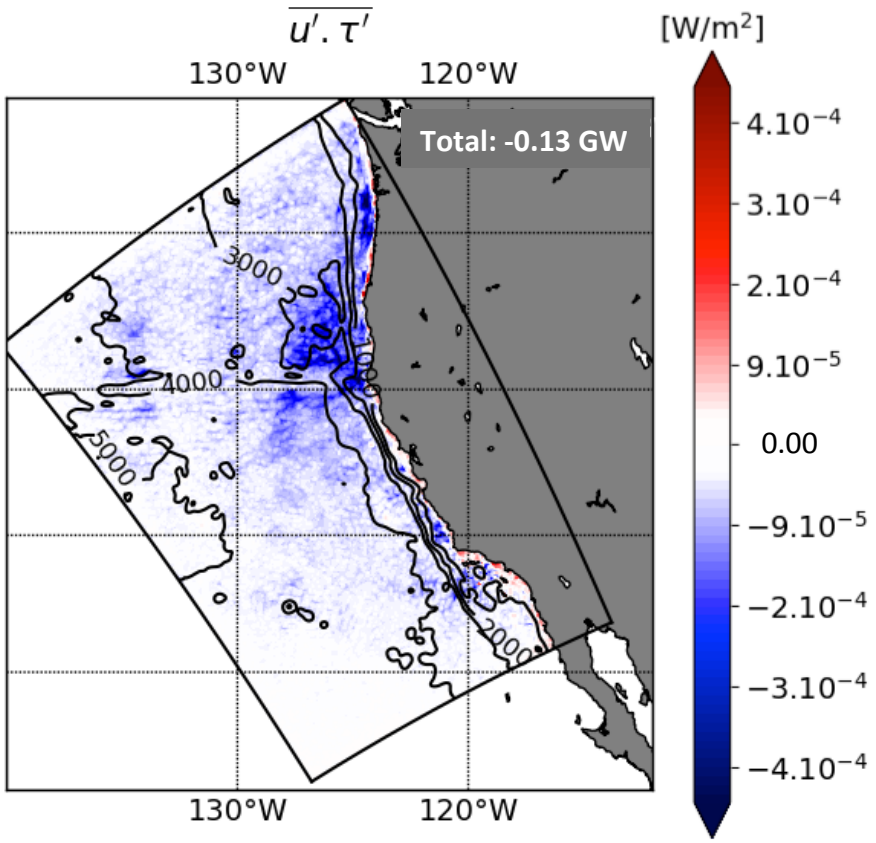
': spatial (<180km) and temporal (bandpass 4h-14h) filtering

2. Quantification of the energy sink

BT to BC conversion



wind-work



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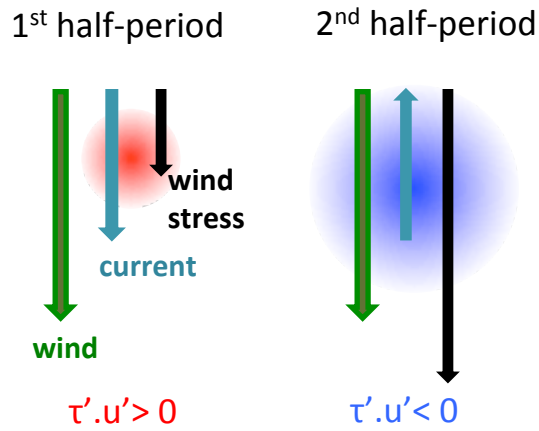
energy sink due to wind-work = 9% of BT to BC conversion at HF

3. Current Feedback on internal waves

wind stress definition
with **CFB**

$$\boldsymbol{\tau} = \rho_a C_d |\mathbf{u}_\mathrm{w} - \mathbf{u}| (\mathbf{u}_\mathrm{w} - \mathbf{u})$$

CFB from IW (periodic signal)



<τ'.u'> < 0

- Similar mechanism as for the 'eddy killing'
- eddies are isoptropic while IW are polarized, especially at HF

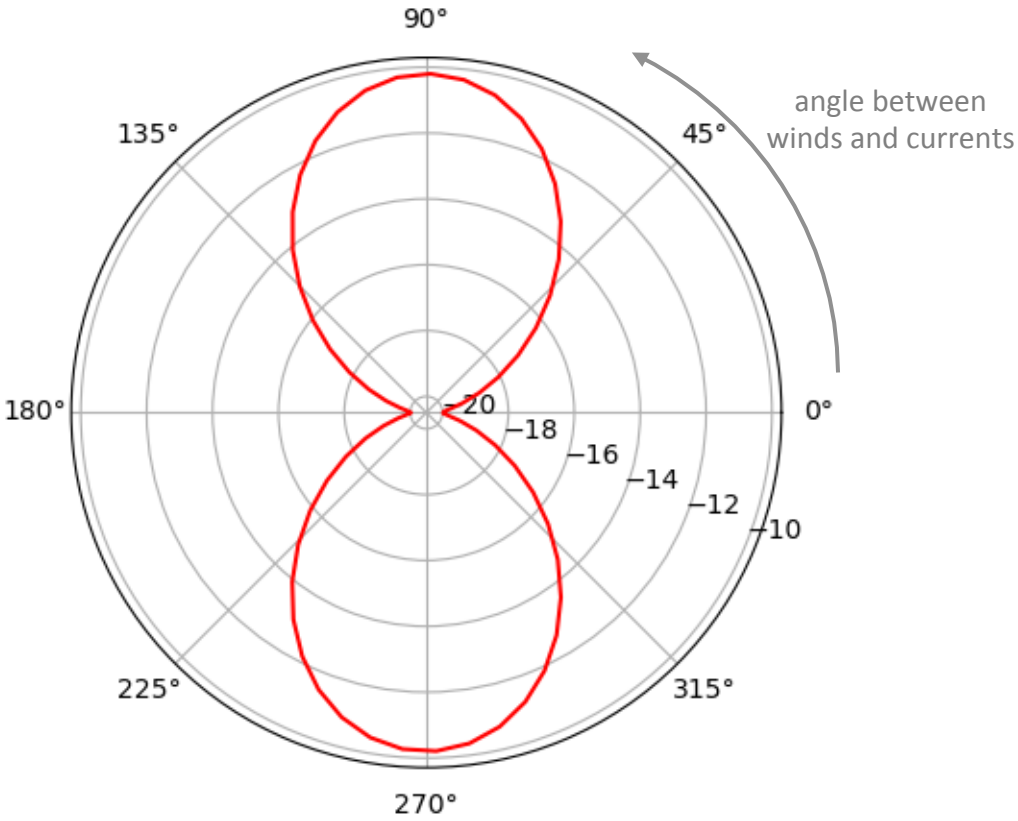
3. Current Feedback on internal waves

wind – work definition

$$\boldsymbol{\tau} \cdot \mathbf{u} = \rho_a C_d |\mathbf{u}_\mathrm{w} - \mathbf{u}| (\mathbf{u}_\mathrm{w} - \mathbf{u}) \cdot \mathbf{u}$$

constant

Efficiency of the wind work as a function of the relative direction between the wind and currents



Can the wind modulates the « internal wave killing » and the associated energy sink ?

4. Variability of the energy sink

- Variability of wind work on M_2 internal tide across seasons
- **Variability of wind work on M_2 internal tide across baroclinic modes**

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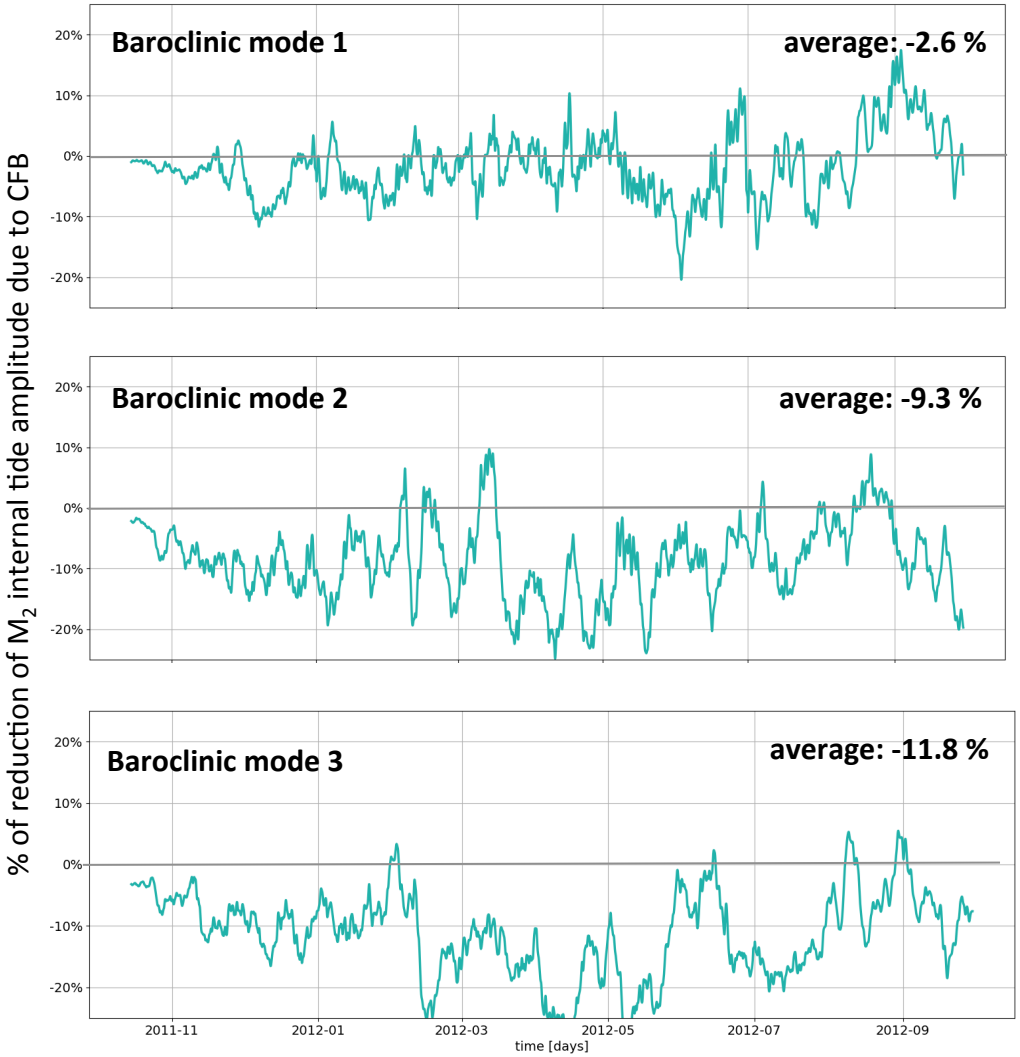
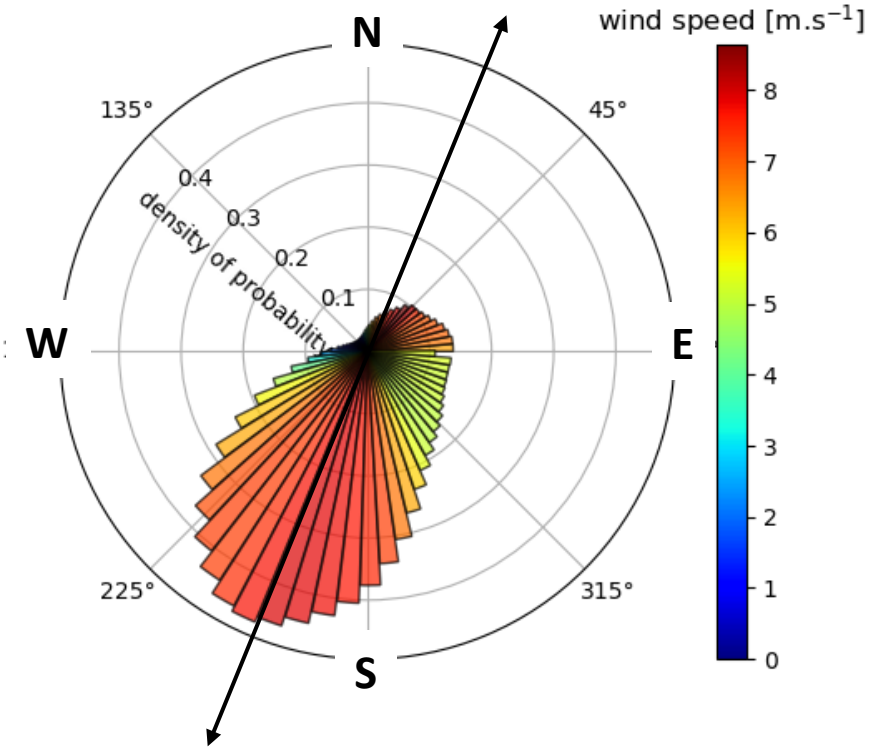


➡ Higher baroclinic modes loose more energy due to CFB on IW.

4. Variability of the energy sink

- Variability of wind work on M_2 internal tide across seasons
- **Variability of wind work on M_2 internal tide across baroclinic modes**

wind polar density of probability
1 year time series



main wind direction: S-SW

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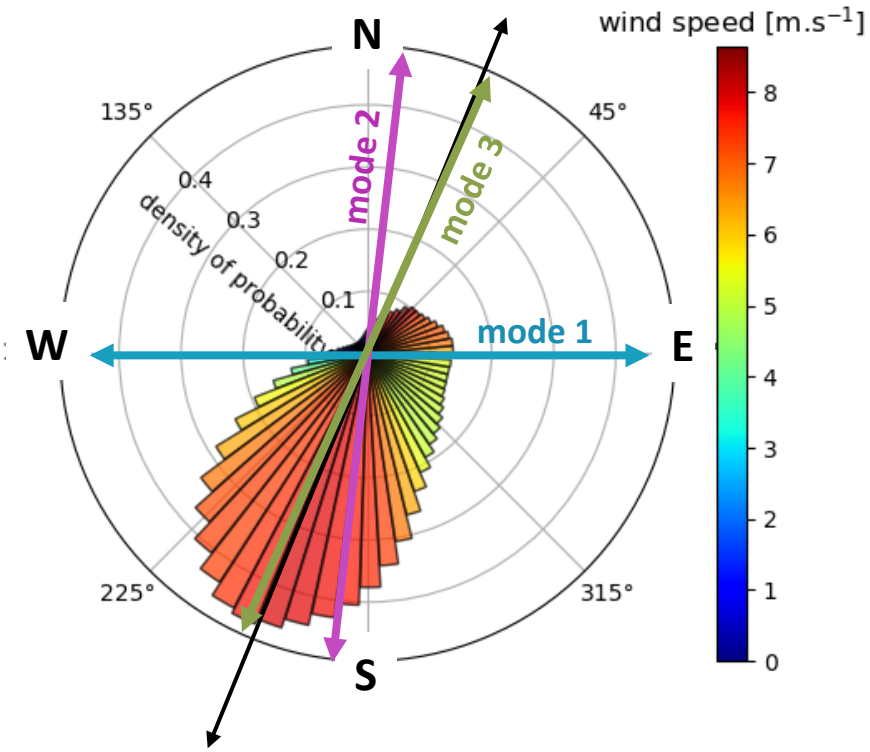
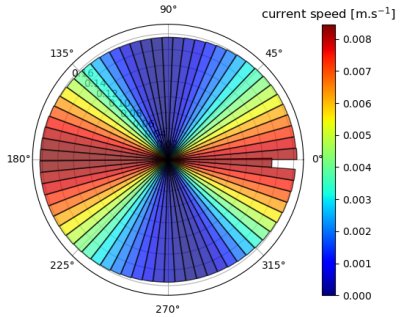
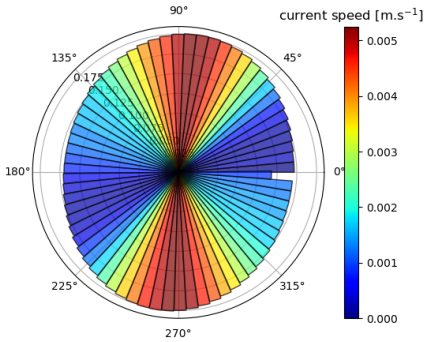


main wind direction: S-SW

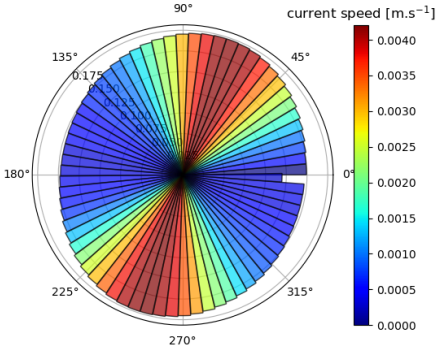
Mode 1



Mode 2



Mode 3



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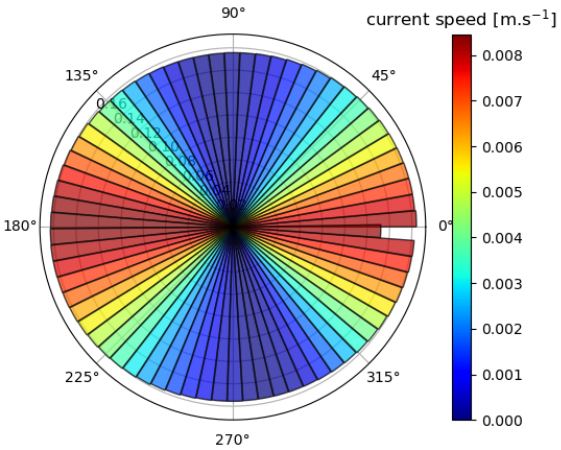
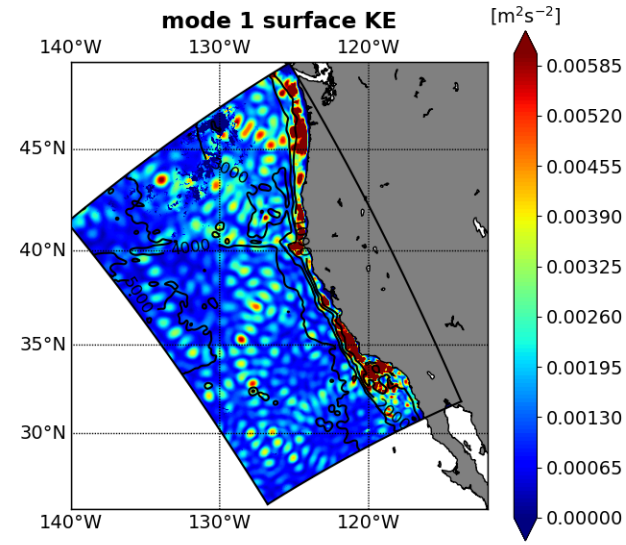
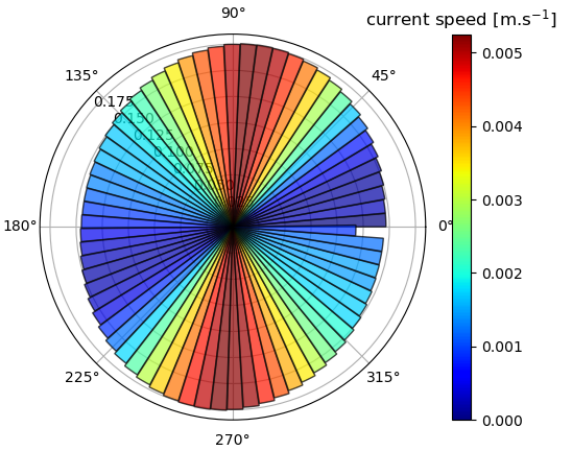
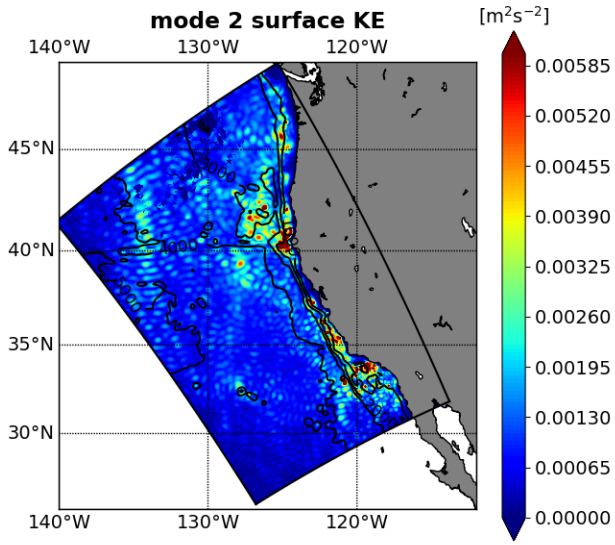




Remotely generated at the Hawaiian ridge – proagating eastward into the domain

Mode 2





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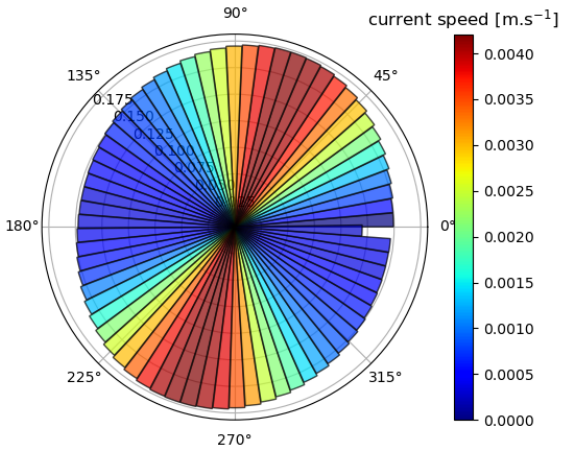

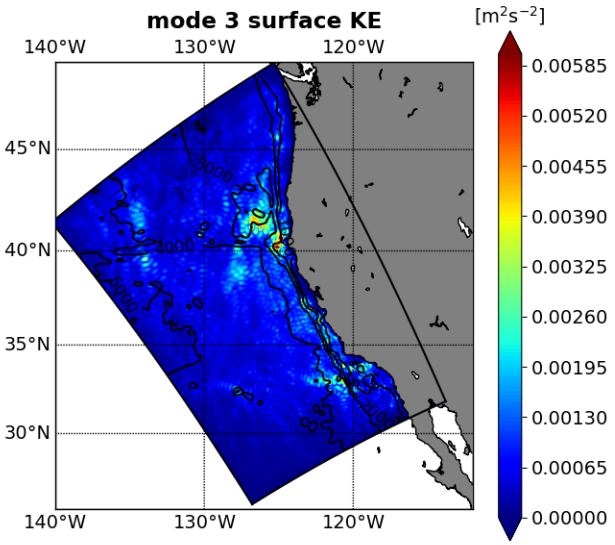

Locally generated at the Mendocino ridge propagating north and southward

Summary

- The IW associated currents feedback on wind generates a negative wind-work inducing a net energy sink for IW.
- For internal tides (IT) in the CCS, the energy sink is estimated to be ~ 10% of the production of barotropic to baroclinic conversion
- Modal variability in the magnitude of the energy sink : higher modes (2 and 3) loose more energy than mode 1 due to the wind-work.

→ Can be explained by the local configuration of the IT polarization and wind directions. The wind is more efficient at extracting energy from the IT when it is aligned with the currents.

→ Will likely be different in other regions.

➡ **Perspective :** assess the wind-work on internal tides in different regions and in coupled simulations