The fate of internal tides off the Amazon estuary shelf

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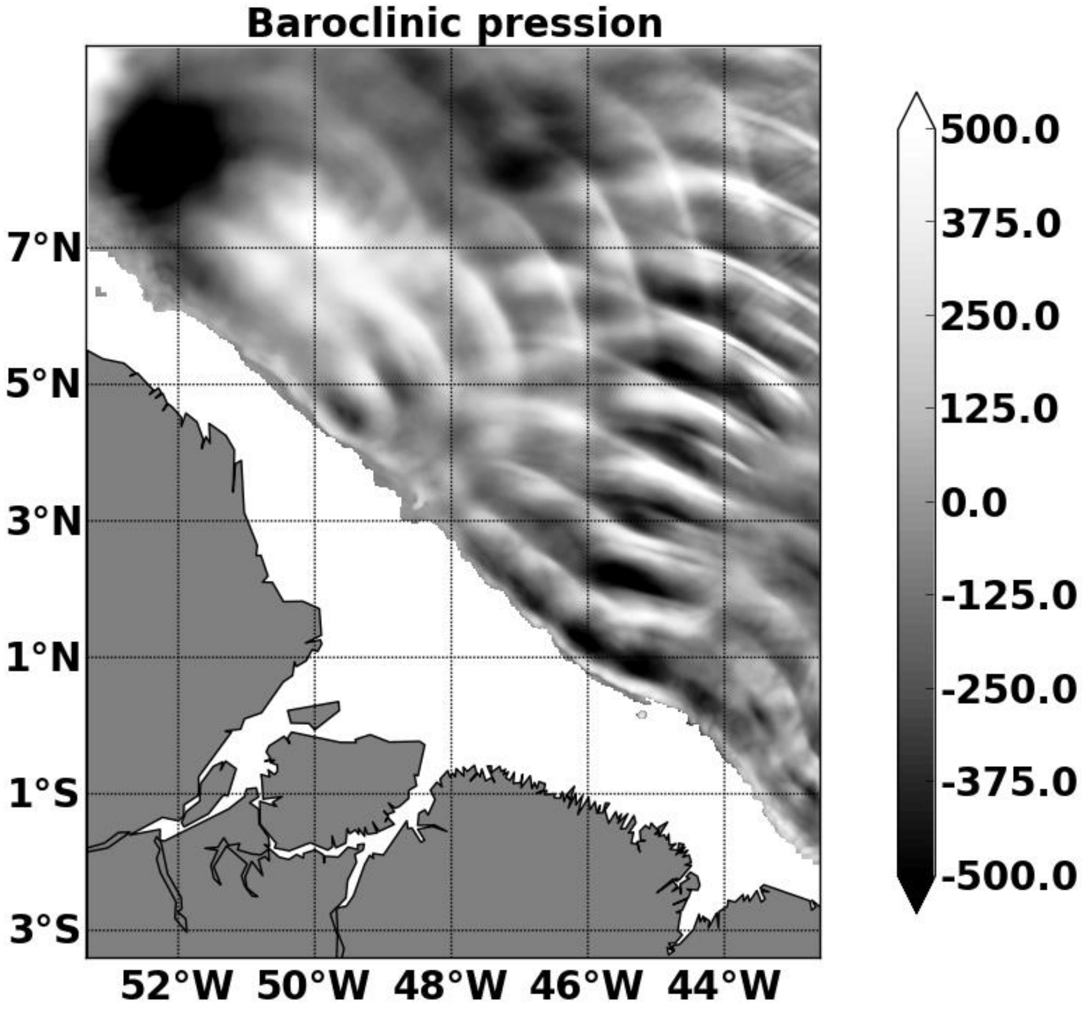
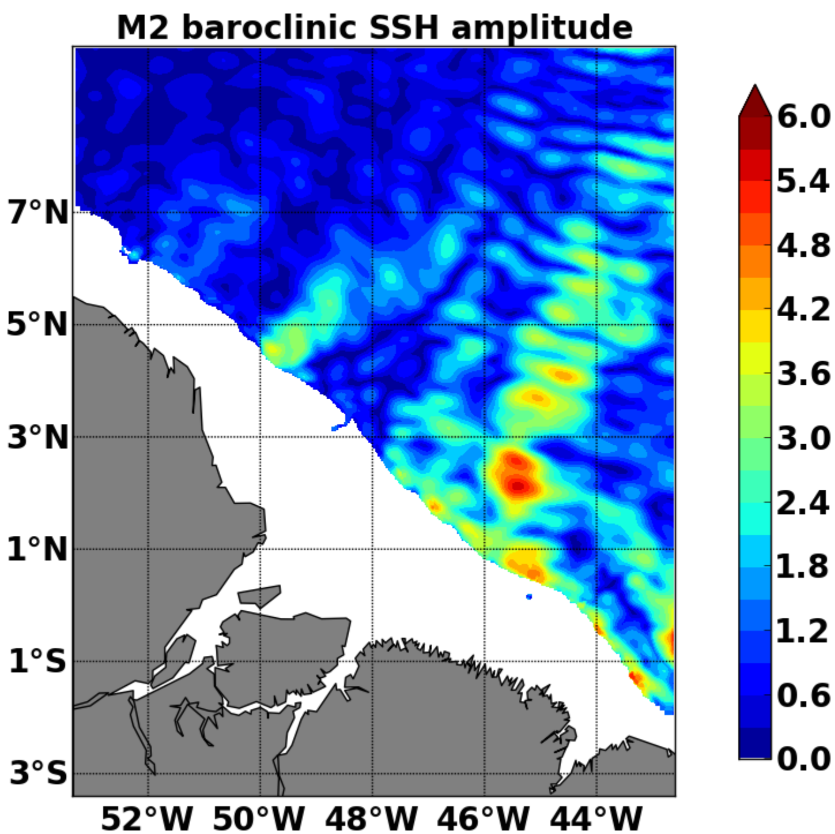
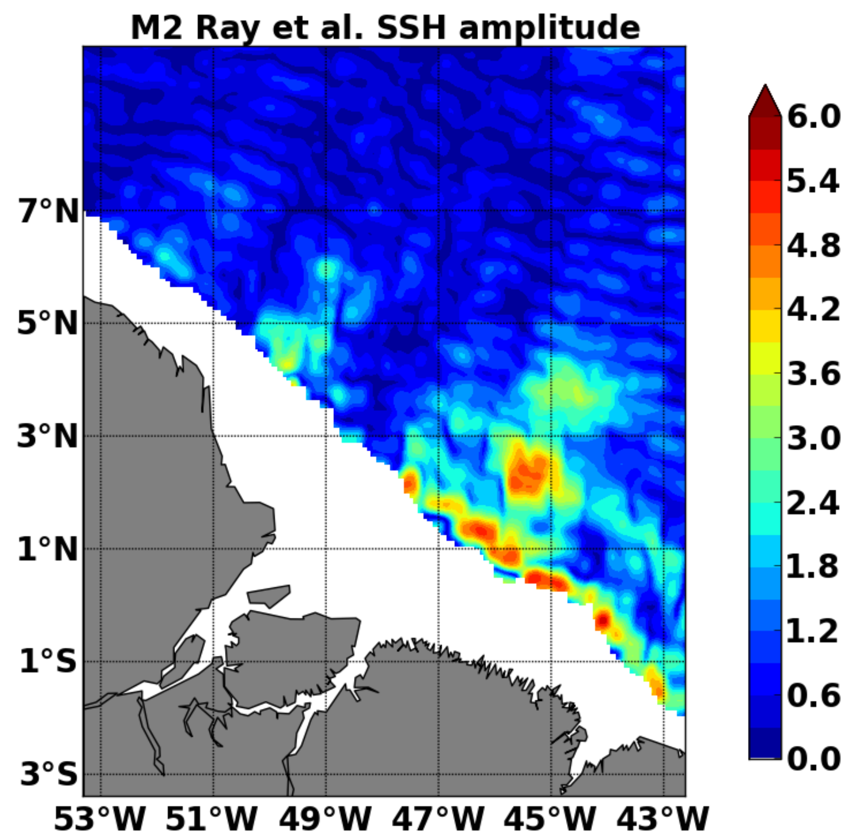
(snapshot) pressure anomaly from a numerical simulation



Harmonic analysis (display coherent internal tides over analysis time span)



NEMO numerical simulation (3 months analysis)



Ray et al. IT atlas (20 years analysis)

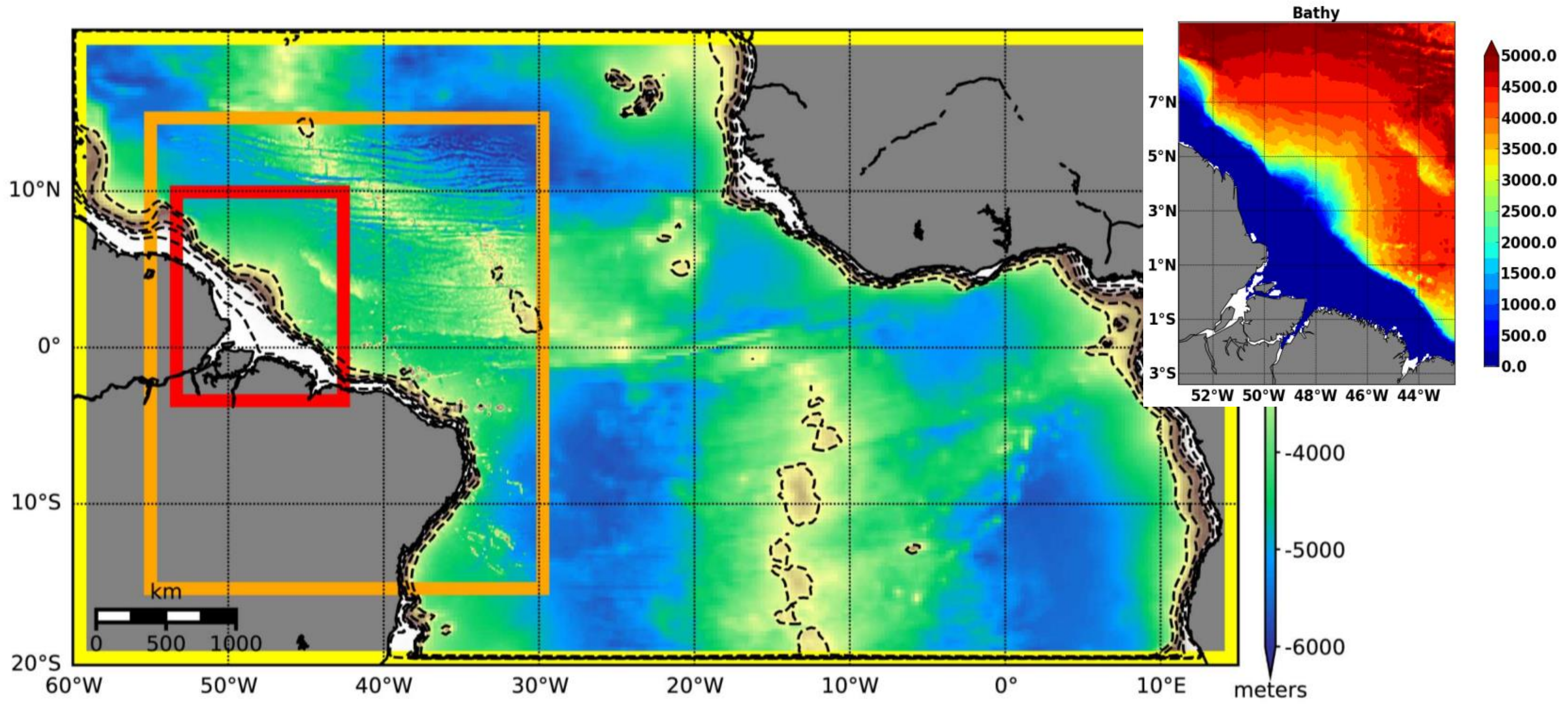
Internal tides

- Traditional, harmonic analysis derived view
  - Internal tides propagate along focused beams
  - Harmonic « constants » depends upon time span (non-coherent component of internal tides)
  - Harmonic « constants » time variability linked with stratification and interactions with ocean circulation variability

- Paradygm change?
  - Internal tides widely radiate from generation sites
  - Internal tides energy fluxes follow focused beams
  - Internal tides become quickly fully uncoherent because of stratification and interactions with ocean circulation variability
  - **EXCEPT if energetic enough (i.e. along energy fluxes beams), consequently captured by harmonic analysis**

- Amazon shelf experiment
  - What are the (proeminent) destabilization mechanism
  - How internal tides modify? How ocean circulation/stratification modify?
  - How much of internal tides surface signature can be predicted for altimetry de-aliasing

Regional numerical setup NEMO3.6-AGRIF

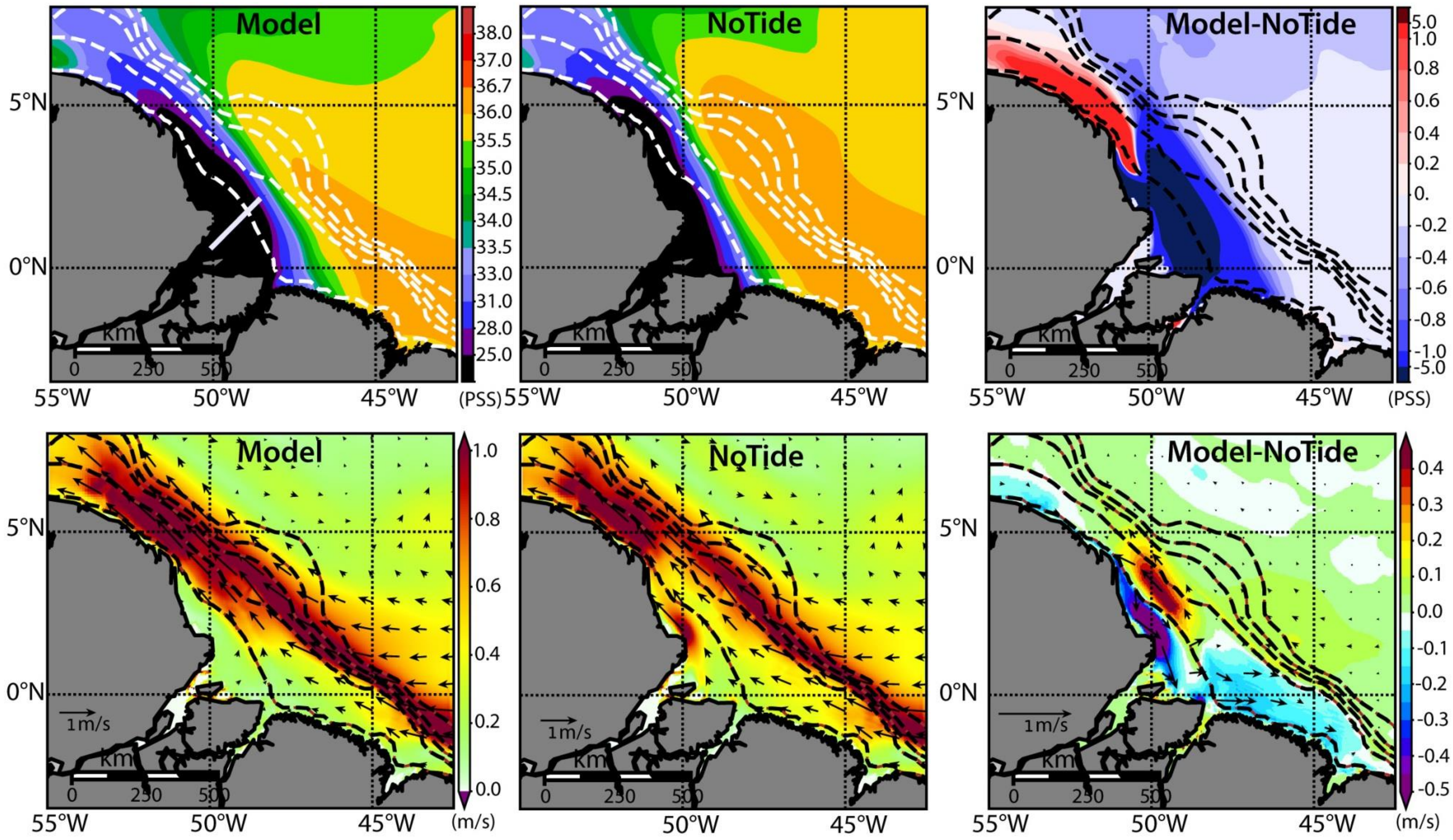


Code: NEMO 3.6 VVL
Boundaries : Mercator Daily GLORYS2V3
Vertical mixing : GLS (default options)
Momentum : UBS (third order scheme)
Free surface : time-spliting (60 sub time steps)
Tracers : TVD + laplacian isoneutral
Initial conditions : T/S from LEVITUS
Period : 2005-2015

Nesting strategy to resolve :

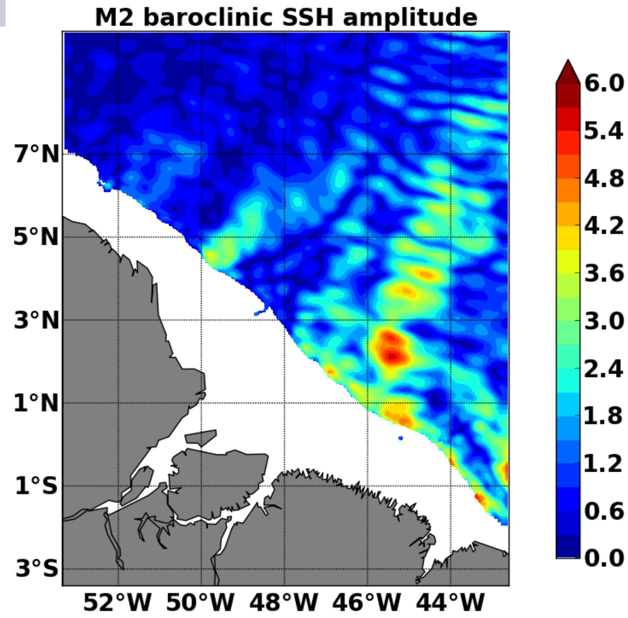
- 1/36° (3 km) Fine scale processes on the shelf
- 1/12° (9 km) Mesoscale dynamics in the retroflection area
- 1/4° (25 km) Basin scale equatorial dynamics

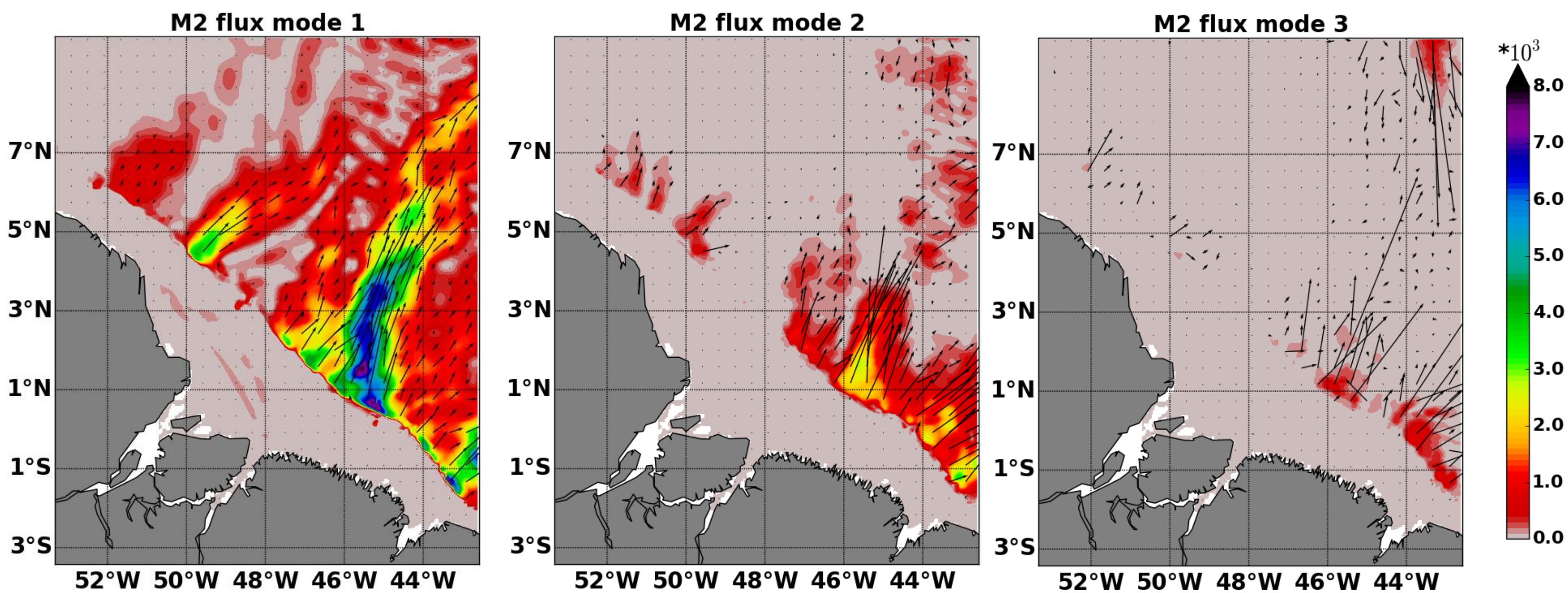
Sensitivity of the plume to tidal forcing



Energy fluxes

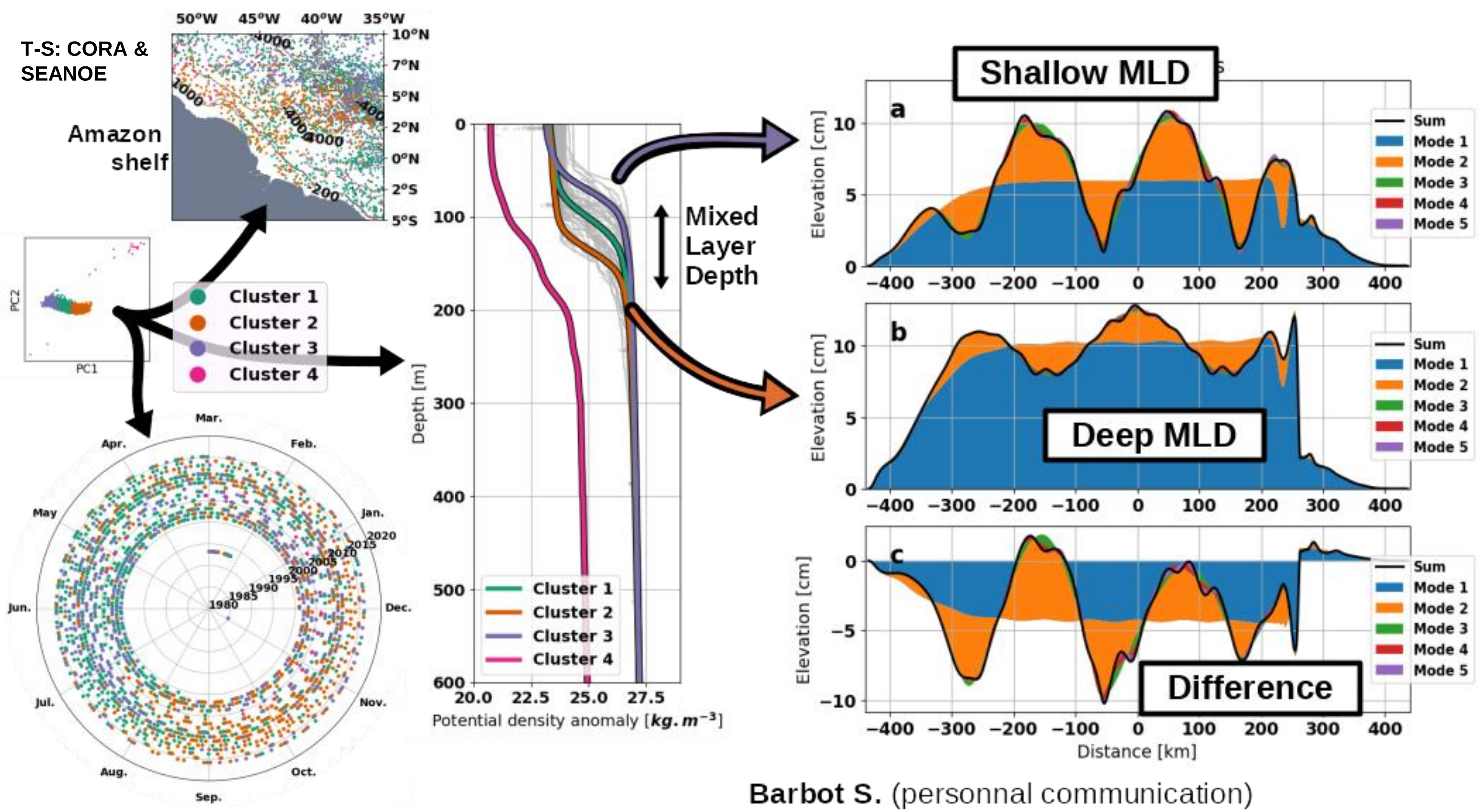
- Vertical (orthogonal) modes decomposition
- Provides barotropic/baroclinic separation
- Allows for mode by mode energy examination





Sensitivity to stratification changes

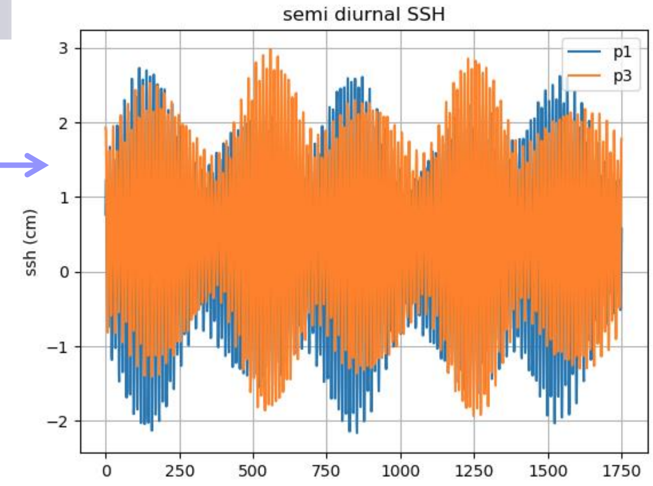
- Mixed layer depth is the controlling parameter
- Changes in 1st mode amplitude, higher modes wavelength

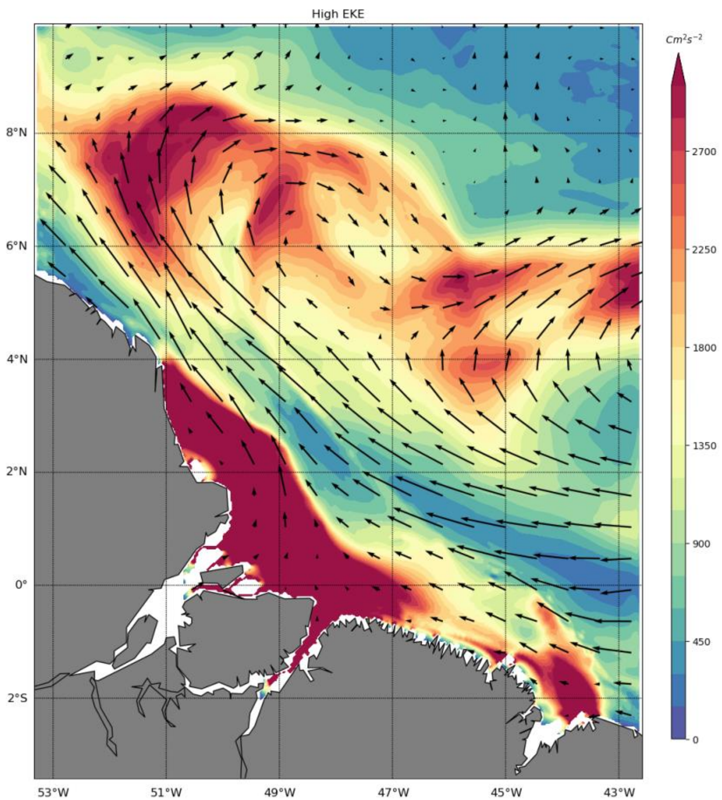


Barbot S. (personnal communication)

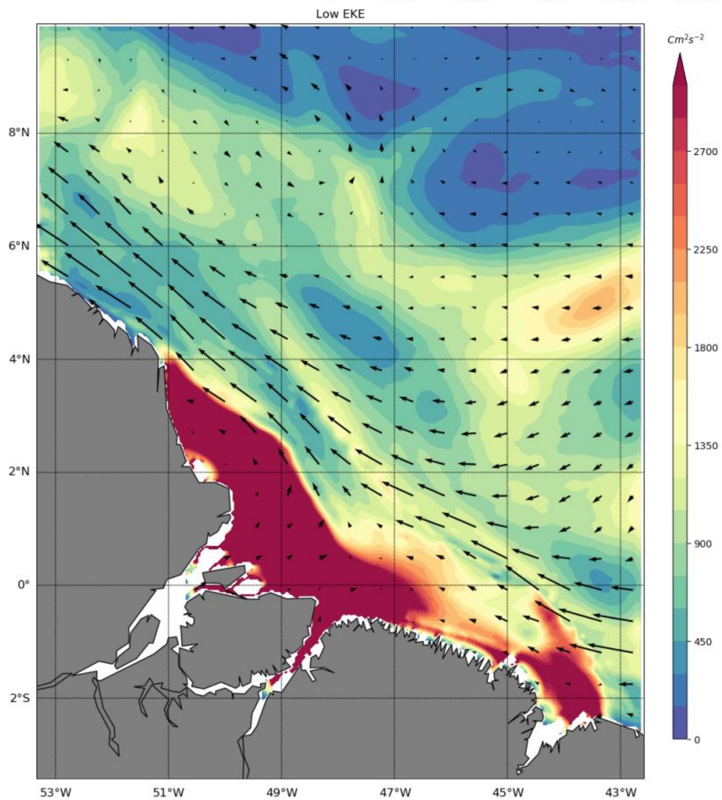
Sensitivity to meso-scale dynamics

Choosing 2 contrasted seasons: high/low EKE with similar (barotropic) tidal regime



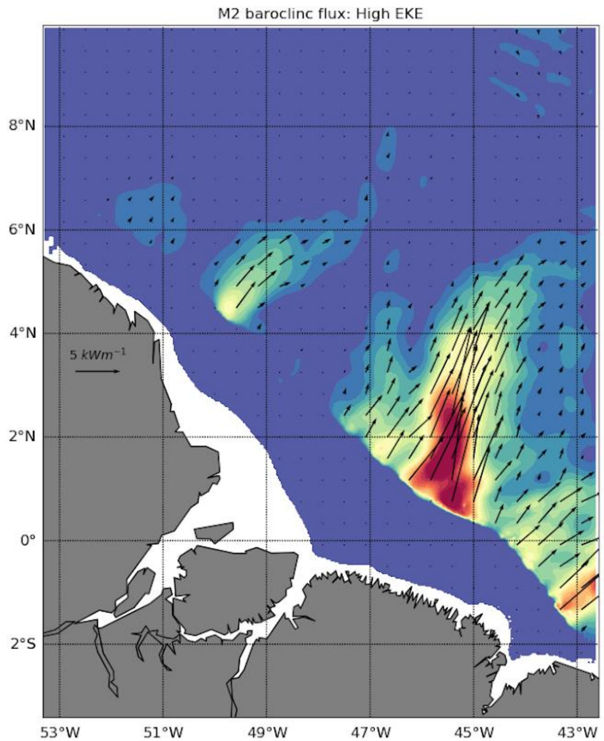


Mean surface EKE (color) and current (arrows)
high EKE season (months 08/09/10)

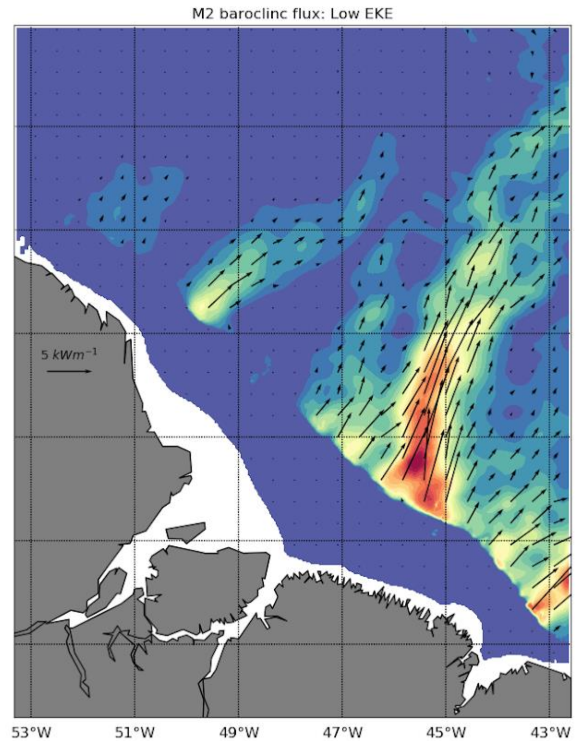


Mean surface EKE (color) and current (arrows)
low EKE season (months 03/04/05)

Sensitivity to meso-scale dynamics



M2 baroclinic energy flux
high EKE season / deep MLD



M2 baroclinic energy flux
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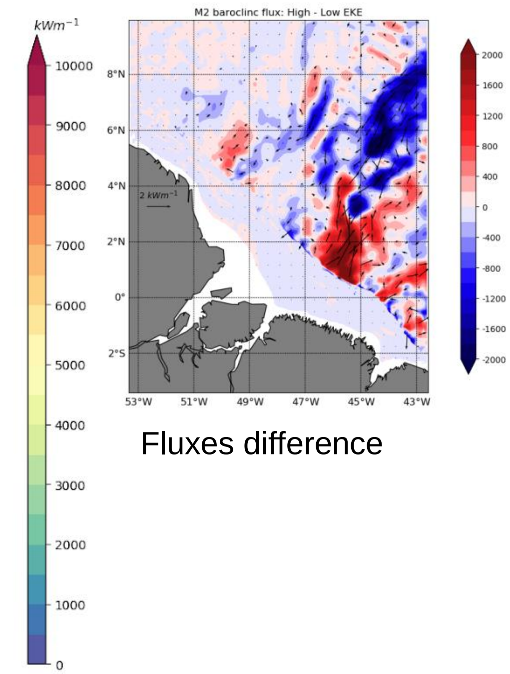
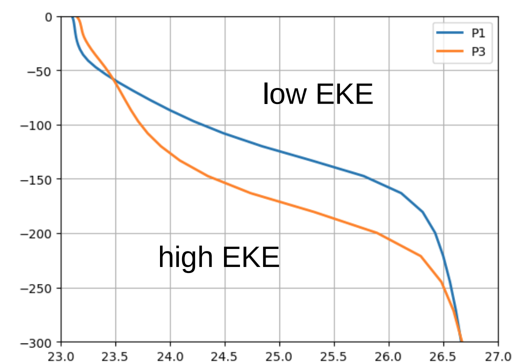


Fluxes difference

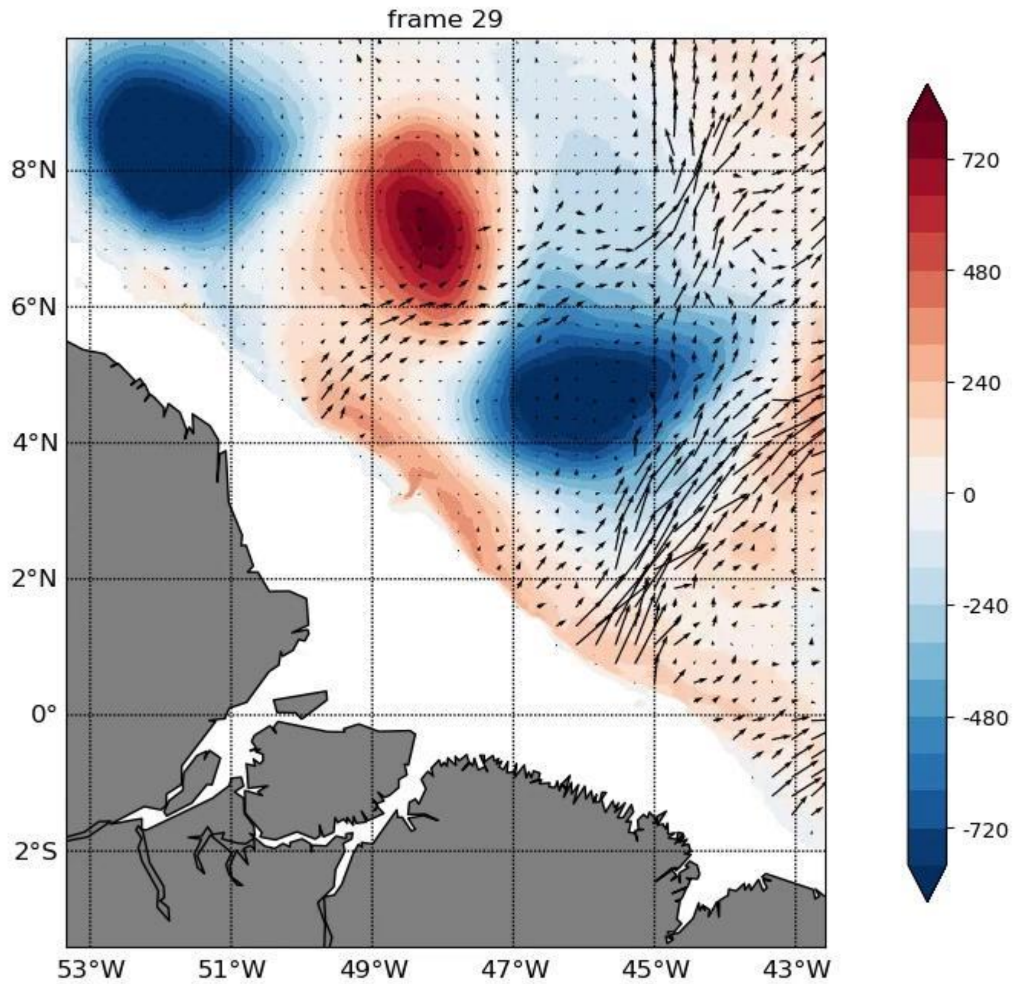


Potential density profile

- IT generation stronger in high EKE/**deeper mixed layer** regime
- Despite originally stronger, energy flux extension diminishes in high EKE regime (i.e. high meso-scale dynamics)

Cyclonic/anti-cyclonic eddies interactions

Cyclon: blue
Anticyclon: red



100 m baroclinic pressure (color) and baroclinic energy fluxes (arrows - 25h filtering)

Conclusions/further work

- Amazon shelf study
  - Internal tides show a wide range propagation
  - Harmonic analysis capture only energetic internal tides (supporting the energy flux)
  - Both stratification and meso-scale circulations destabilize/modify internal tides
  - Interaction with anti-cyclonic and cyclonic eddies show significant differences

- Next steps
  - Continue the study over an extended period (10 years, simulations to be done)
  - Potential vorticity to be added to diagnostics to scrutinize internal tides/eddies interactions
  - Internal tides-induced mixing still to be investigated