Internal waves and eddies from gliders and the MITgcm

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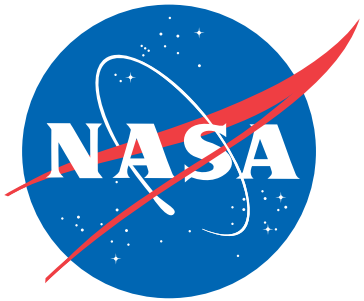

Challenge:

Separating internal waves from geostrophically balanced motions

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Thought experiment:

How well will SWOT get the mesoscale SSH field if we know the internal tides perfectly?

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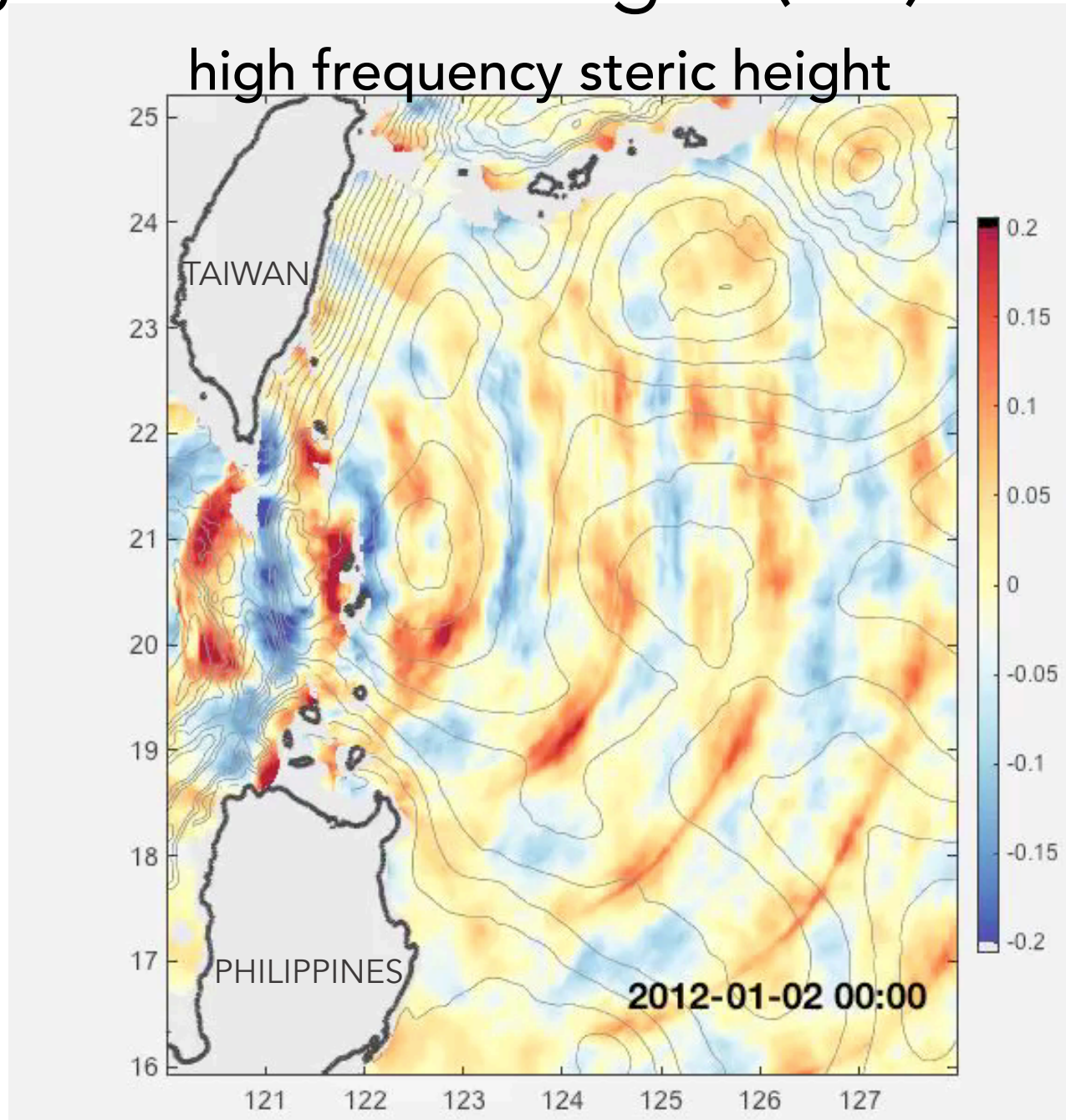
Explore with the MITgcm llc4320 simulation

Separating internal tide signal in steric height (SH) from model or gliders:

Total SH

- mesoscale
- high-frequency = internal tide[1] + residual[2]



1. *Diurnal + semidiurnal + inertial: fit isopycnal displacements to known frequencies.*
2. *Fitting errors, submesoscale, other tidal constituents…*

How well can SWOT get the mesoscale if we know the internal tides?

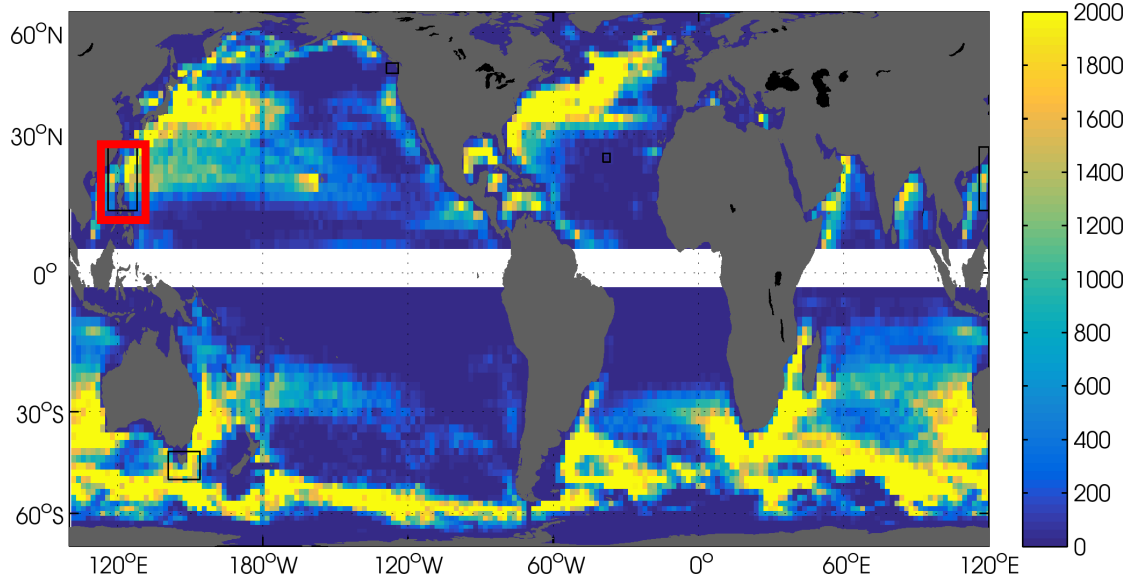
"True" mesoscale = total – internal tide – residual

"Best guess" mesoscale ≈ total – internal tide

"SWOT" mesoscale ≈ total – internal tide + SWOT noise

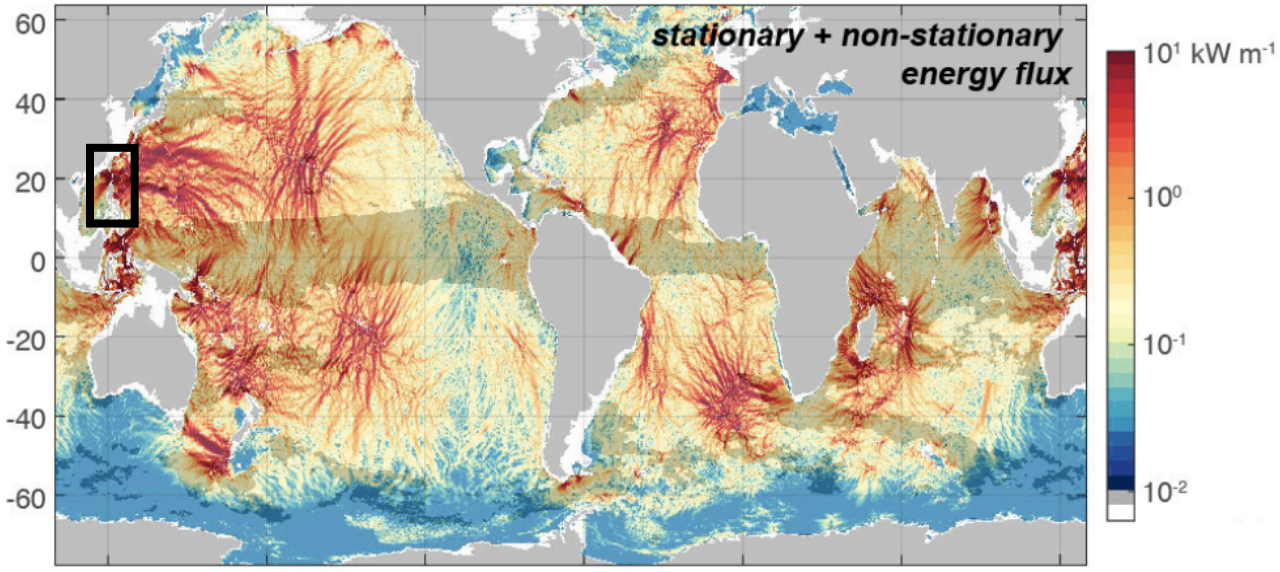
Example from Luzon Strait: strong mesoscale and internal tide region

of mesoscale eddies per 2° box



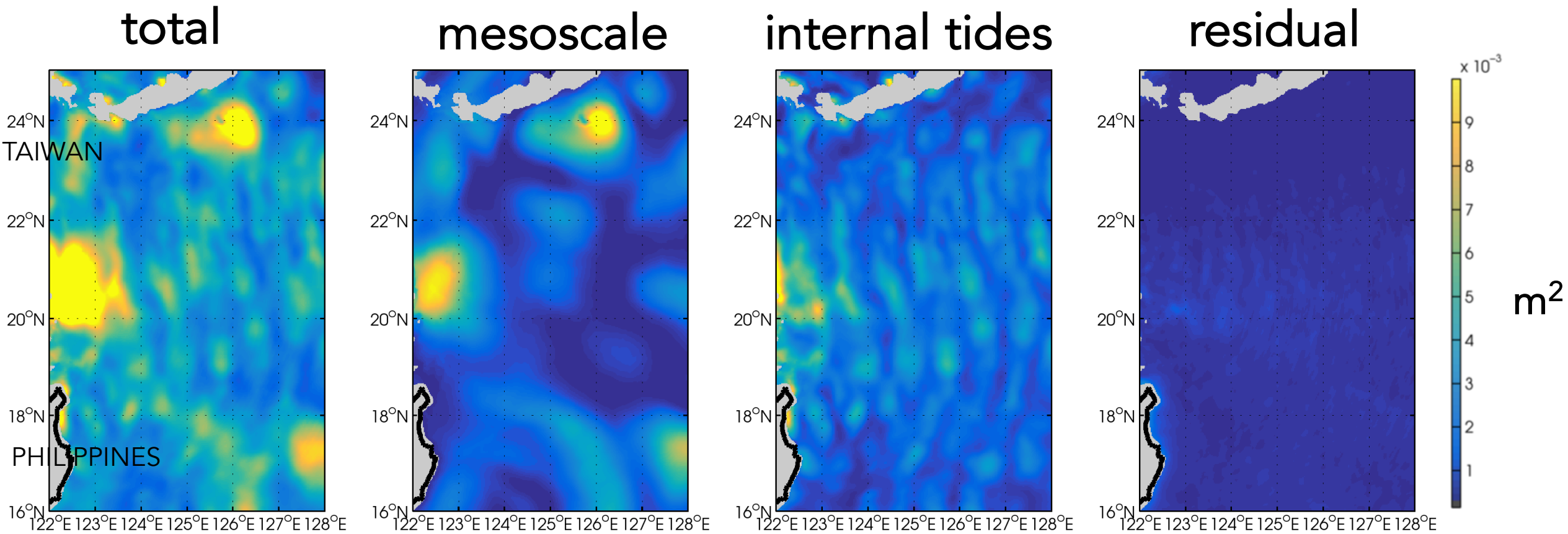
From Chelton eddy database

Energy flux of semidiurnal internal tides



From GOLD model; Rainville and Simmons, in prep.

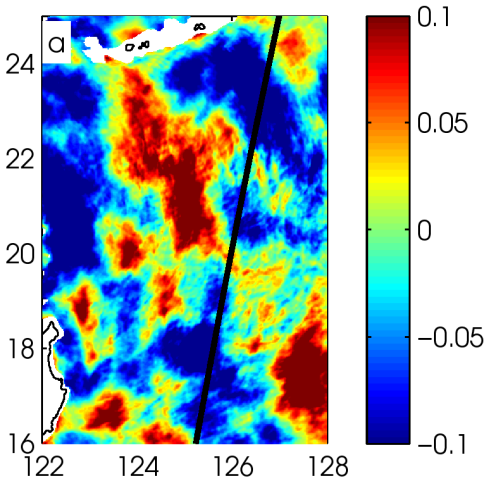
Luzon Strait steric height variance from MITgcm:



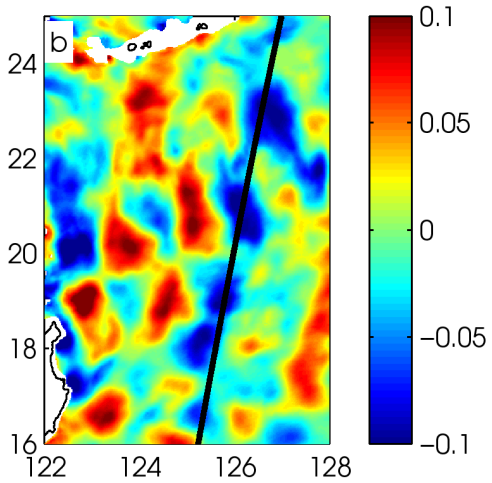
* See our poster for validation of the model using gliders

Example 1: MITgcm snapshot from 24 Jan 2012 Luzon Strait

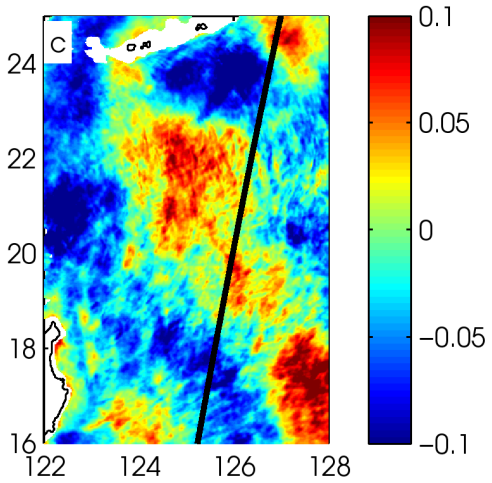
Total SH [m]



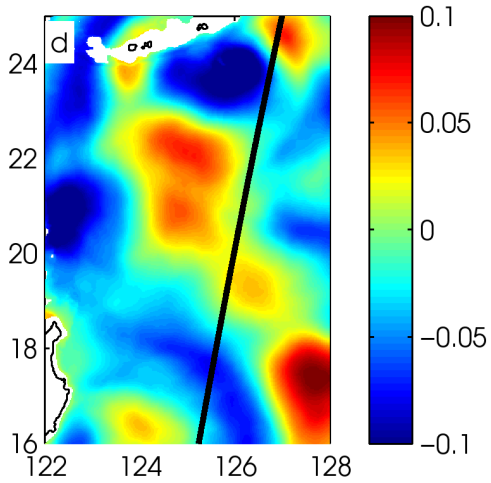
Internal tide (IT) component*



"best guess" of mesoscale = total – IT



"True" mesoscale



** Extract by fitting isopycnal displacements to known frequencies (diurnal, semidiurnal, inertial)*

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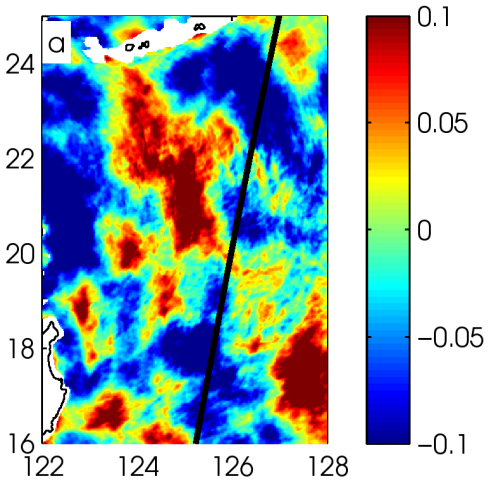

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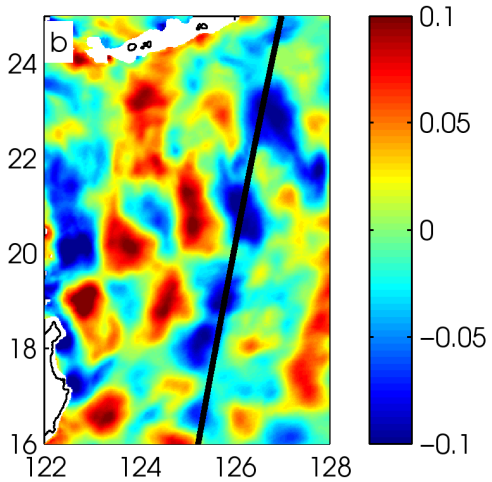

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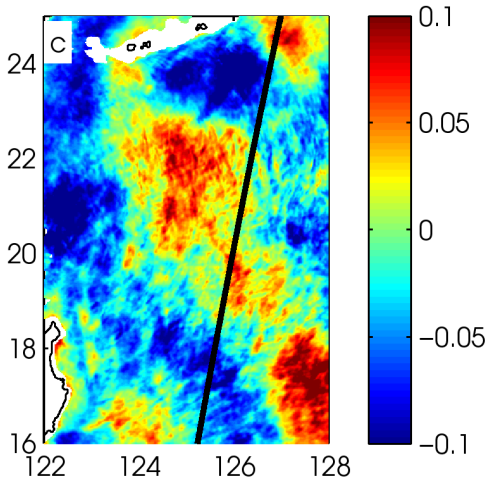

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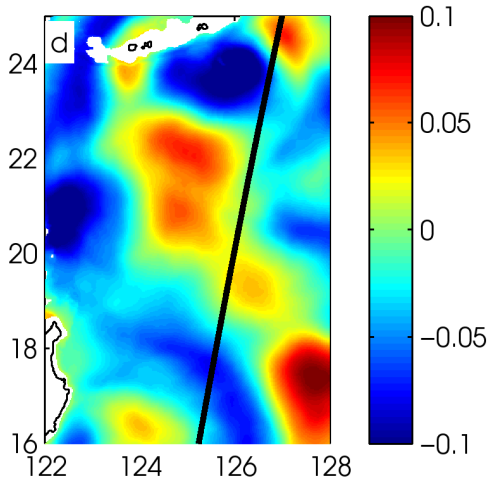
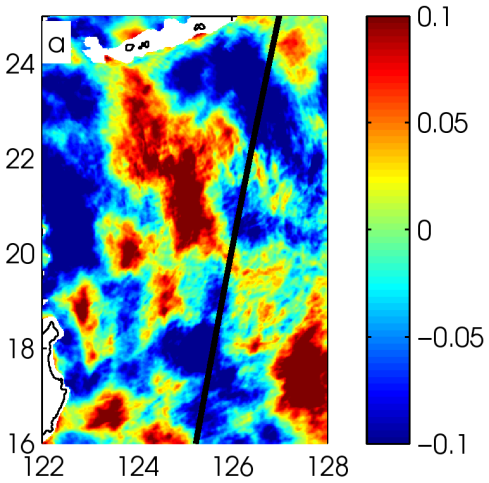


Good agreement (residual is relatively weak)

** Extract by fitting isopycnal displacements to known frequencies (diurnal, semidiurnal, inertial)*

Luzon Strait: What would SWOT see?

Total SH [m]



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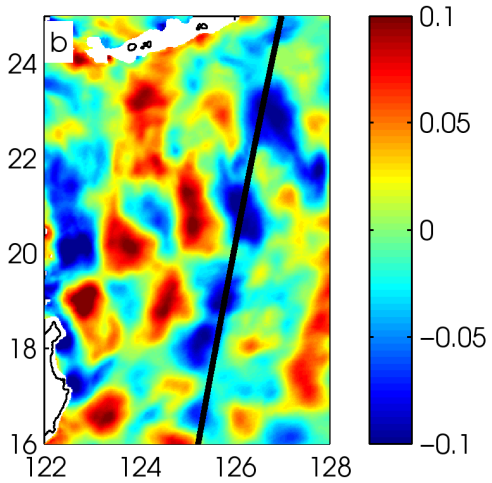
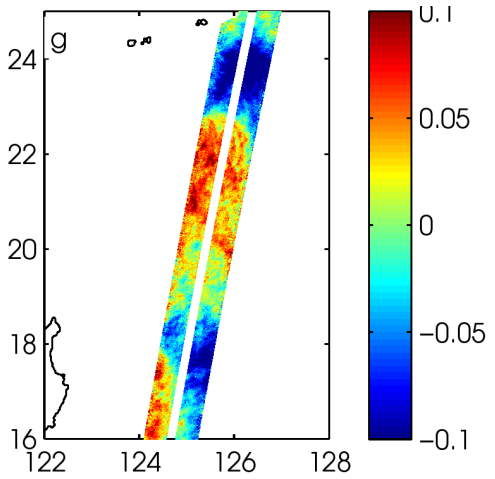


"SWOT mesoscale"



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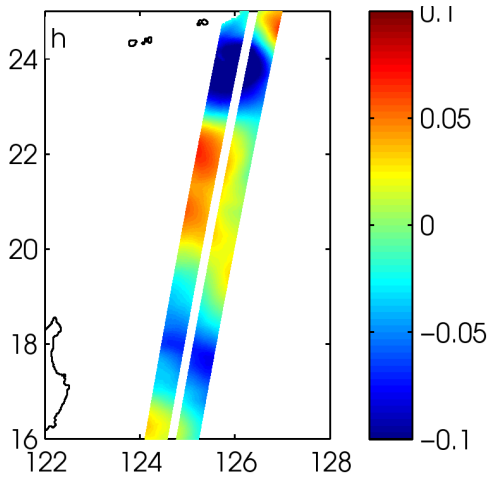
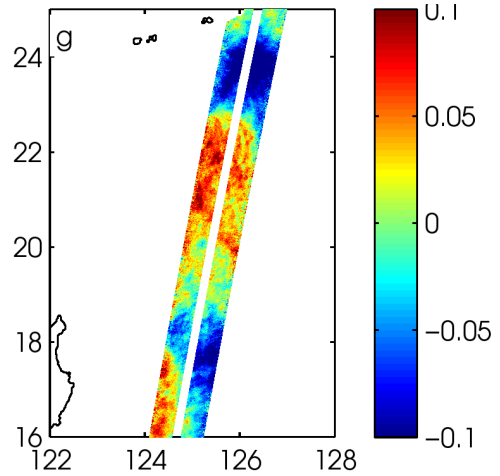


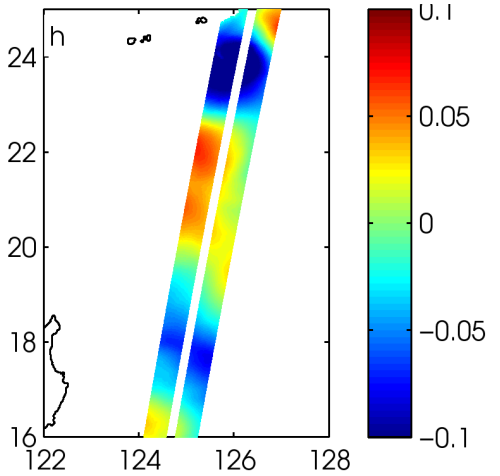
SWOT sampling adds noise, but mesoscale is still clearly separable

Best estimate of the mesoscale we could measure with SWOT= $\eta_{total} - \eta_{Internal\ tide}$ + SWOT simulator noise

"True" mesoscale snapshot = low-pass filter of η_{total} (subsampled along the swath)

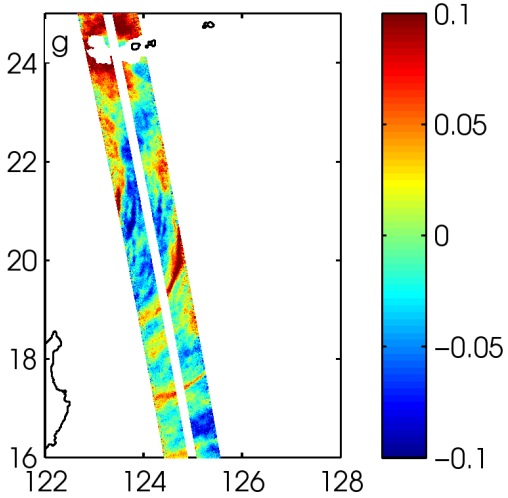
Snapshot 1:
24 Jan 2012
Luzon Strait

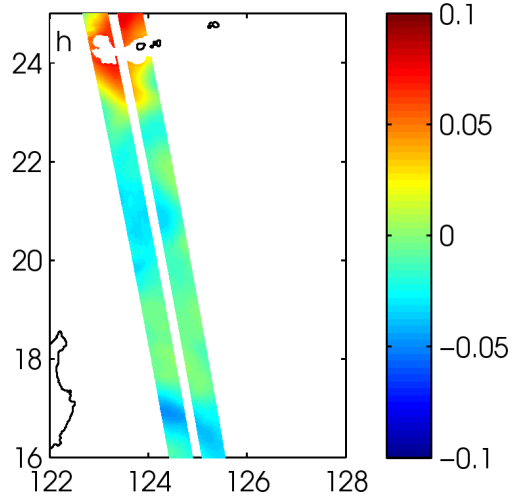




SWOT sampling adds noise, but mesoscale is still clearly separable

Snapshot 2:
17 Jan 2012
Luzon Strait

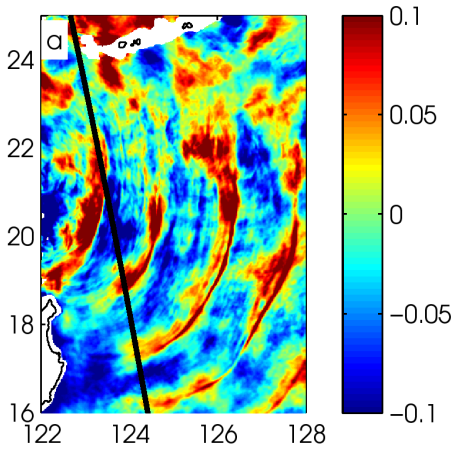




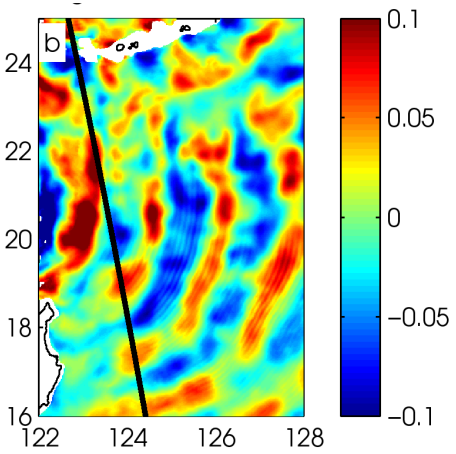
Relatively strong internal waves: residual + noise overwhelms the mesoscale signal.

Example 2: MITgcm snapshot from 17 Jan 2012

Total SH [m]



Internal tide (IT) component



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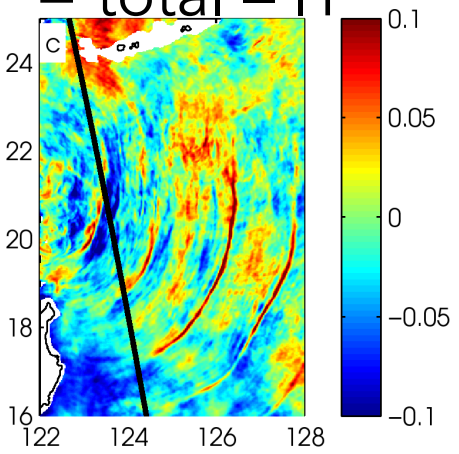
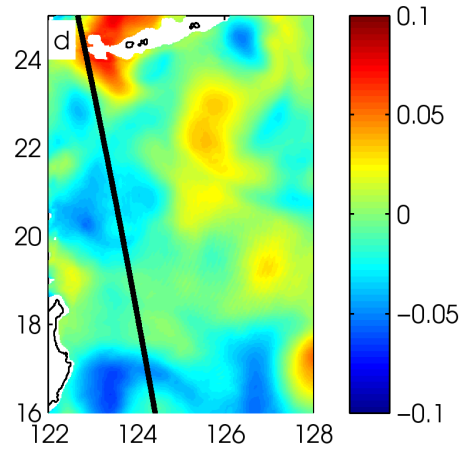
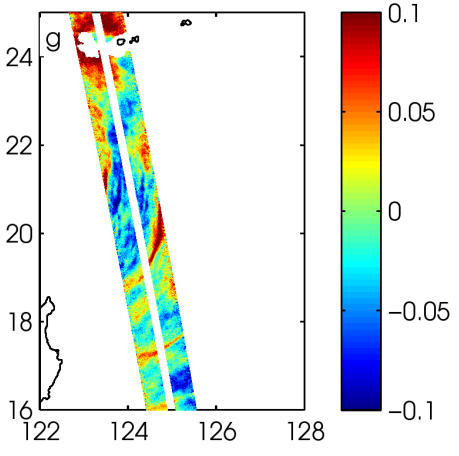


"True" mesoscale



Relatively strong internal waves: residual + noise overwhelms the mesoscale signal.

"SWOT" mesoscale



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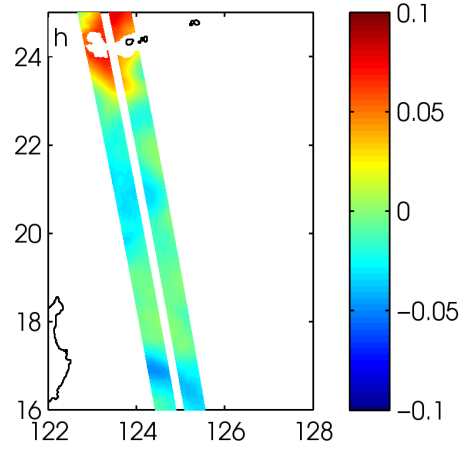
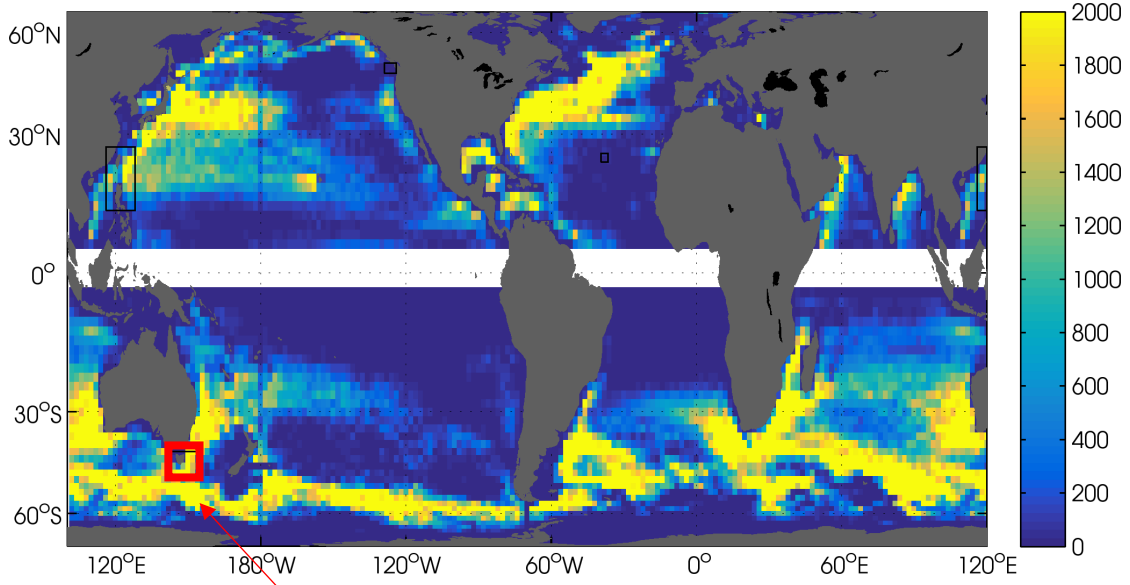


* note, model tides may have unrealistically strong high-frequency signals

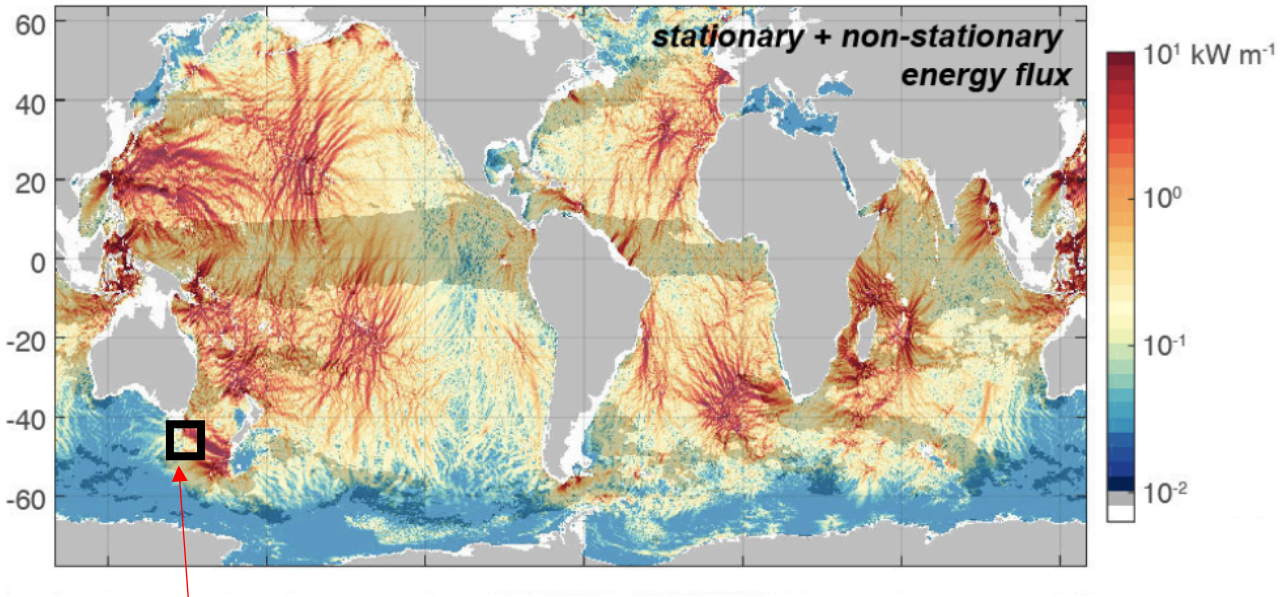
Relative strength of mesoscale and internal tides will affect our ability to interpret SWOT data – regional variability matters.

of mesoscale eddies per 2° box



From Chelton eddy database

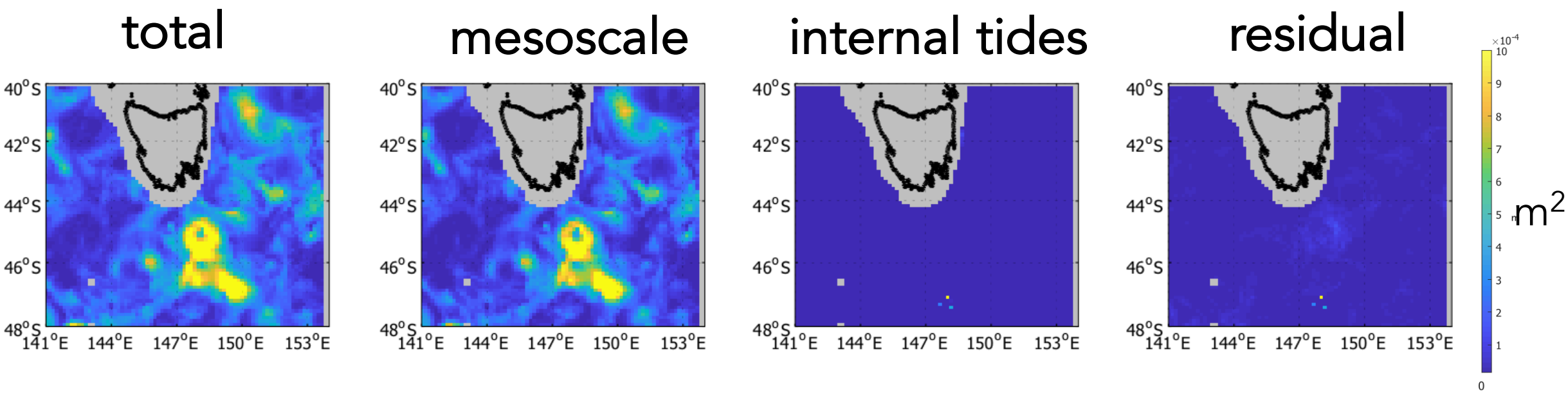
Energy flux of semidiurnal internal tides



From GOLD model; Rainville and Simmons in prep.

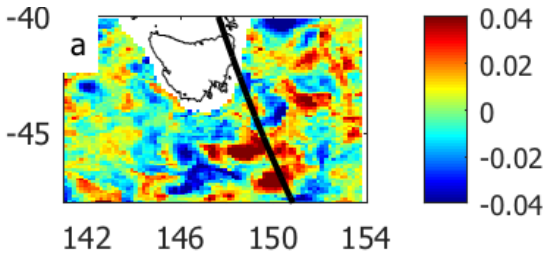
Region 2: Tasmania

Tasmania steric height variance from MITgcm: mesoscale >> internal tides

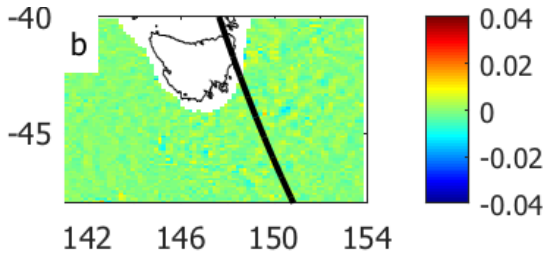


Tasmania:

Total SH [m]



Internal tide (IT) component



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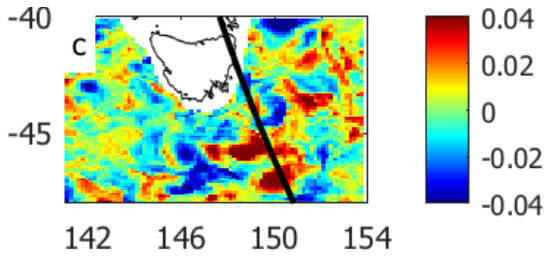
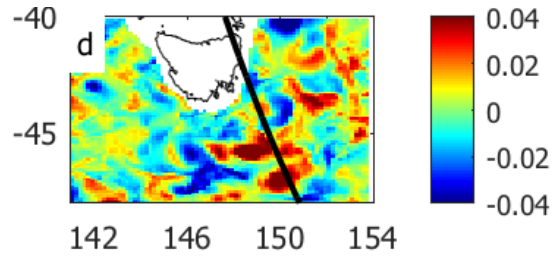
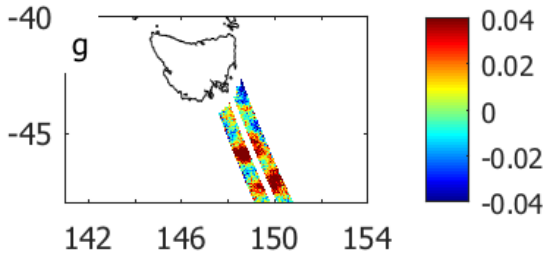


"True" mesoscale



Weak internal tides → good estimate of ocean mesoscale is possible from SWOT

"SWOT" mesoscale



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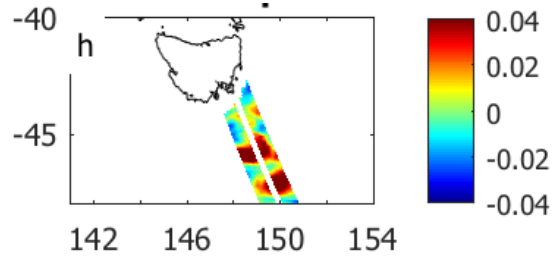
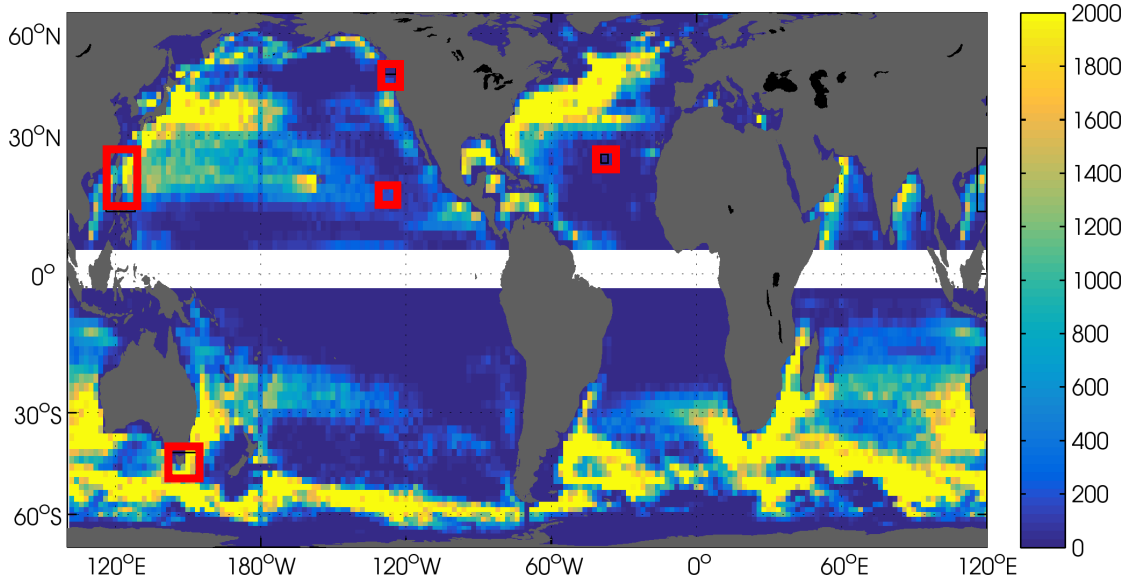


Ongoing work: quantify mesoscale/IT characteristics with glider data & MITgcm in other regions

of mesoscale eddies per 2° box



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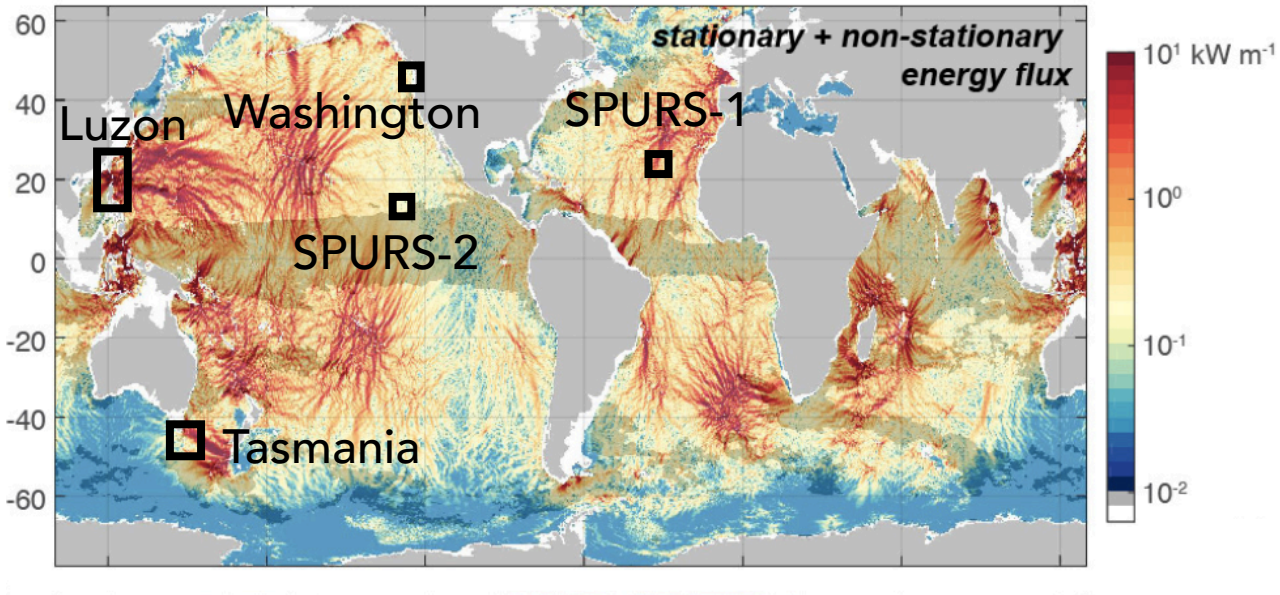

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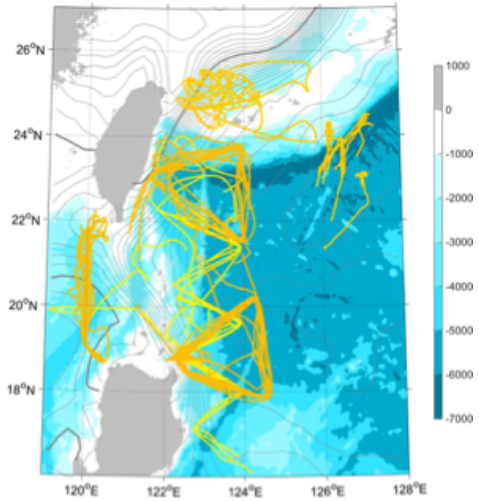
A note on spatial sampling from gliders

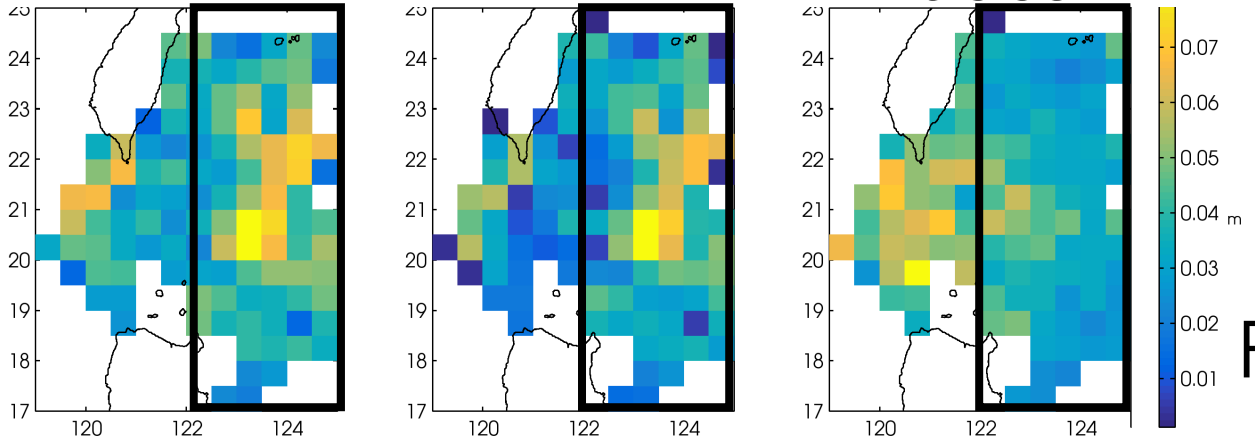


From 42 glider missions:

total

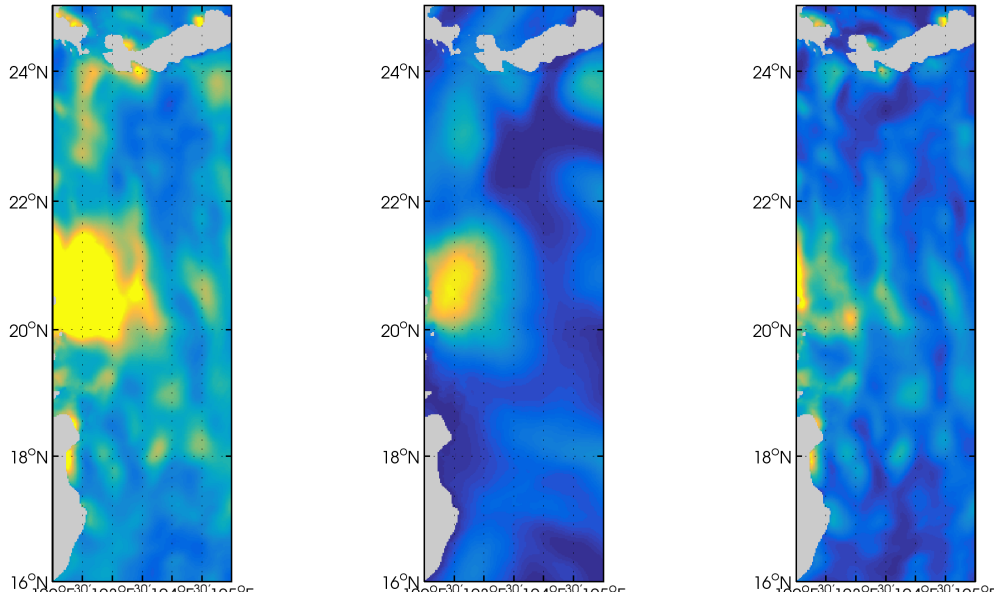
mesoscale

internal tides



RMS steric height (m)

From MITgcm:



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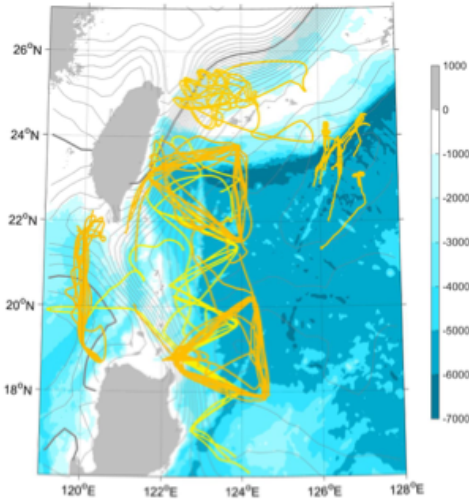

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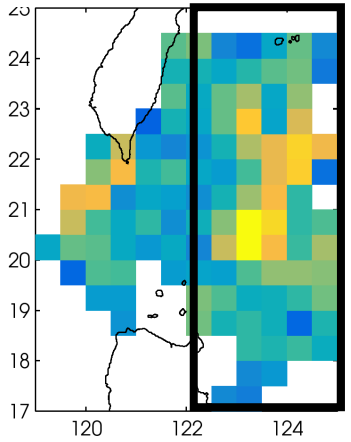
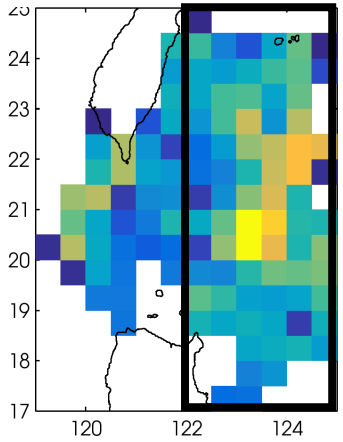
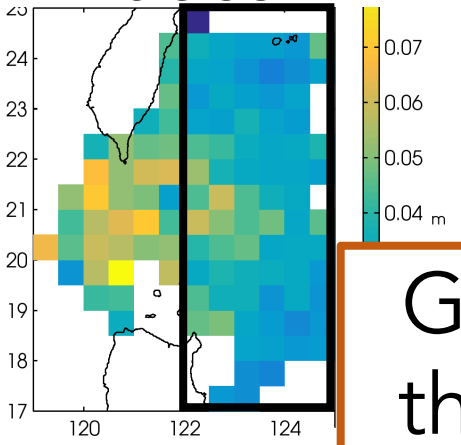


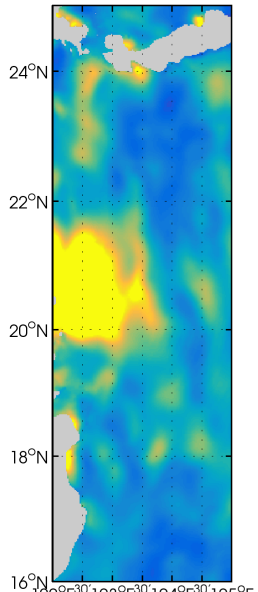
mesoscale

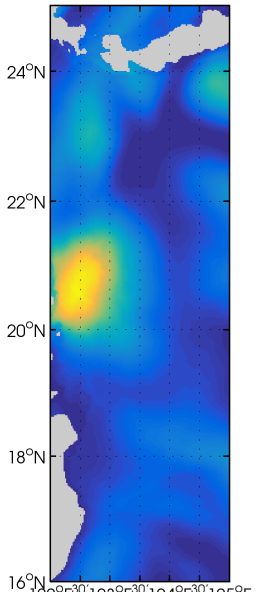


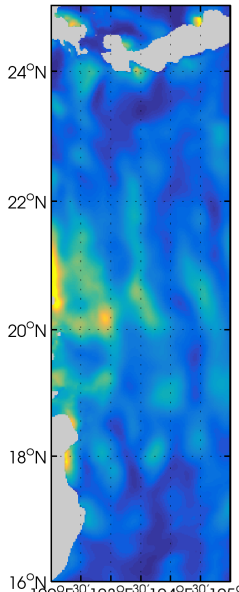
internal tides



From MITgcm:







Gliders can map out the spatial variability of steric height components, including internal tides – this can be exploited for SWOT validation.

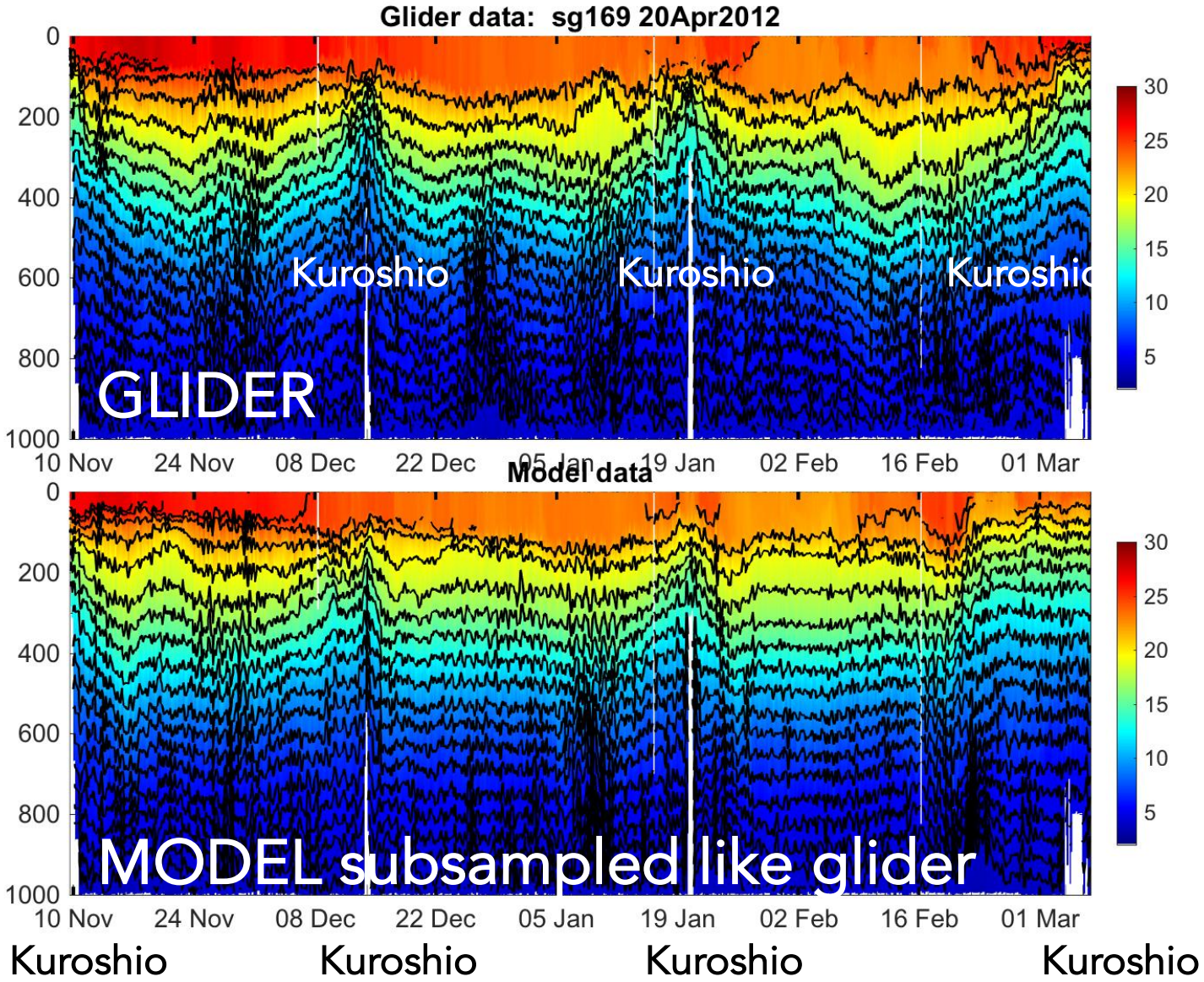
Summary: combining model, in-situ observations, and remote sensing is key to interpreting spatial structure of steric height

1. Given a good internal tide model, SWOT should capture the mesoscale field (when the mesoscale is relatively strong).
   - Caution in interpreting data where internal tides are strong/incoherent!

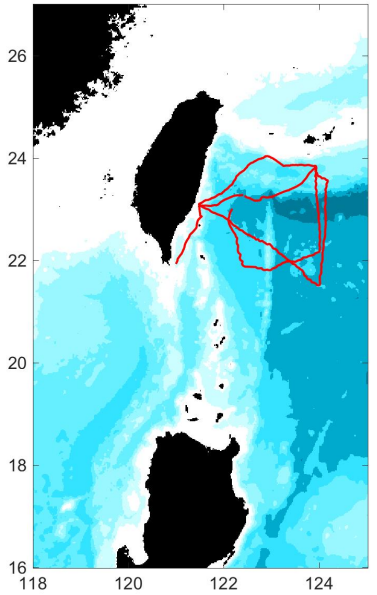
2. The regional and temporal variability in the relative mesoscale/internal tide strength will affect our ability to extract the mesoscale.

3. The MITgcm reproduces the partitioning of internal tide and mesoscale steric height well compared to gliders.
   - Gliders can be used to map out this partitioning: a useful tool for SWOT cal/val.

Previously: data from one glider mission used to validate the internal tide field in the 1/48° MITgcm



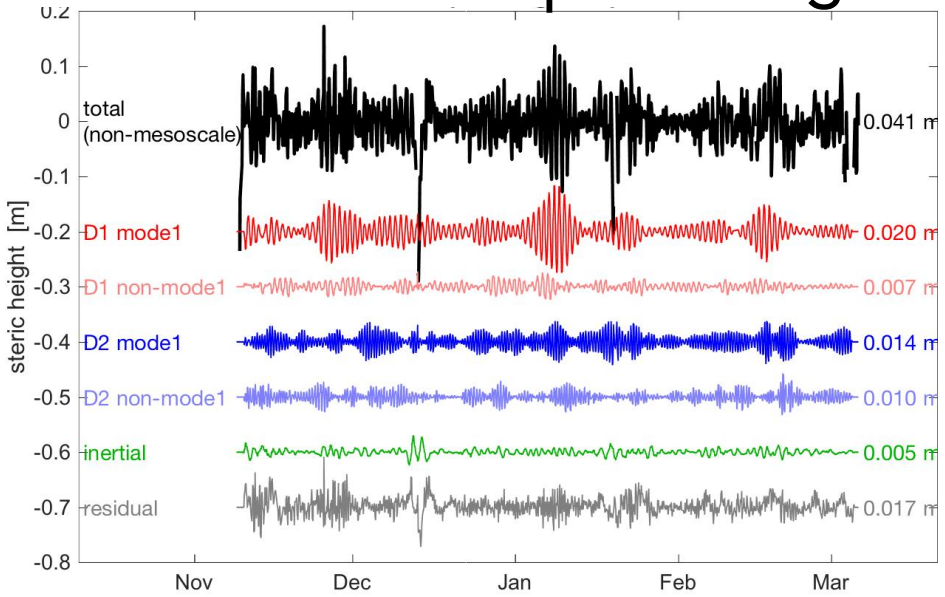
Glider track
Nov 2011–Mar 2012



Temperature, °C

MITgcm gets the internal tide components right

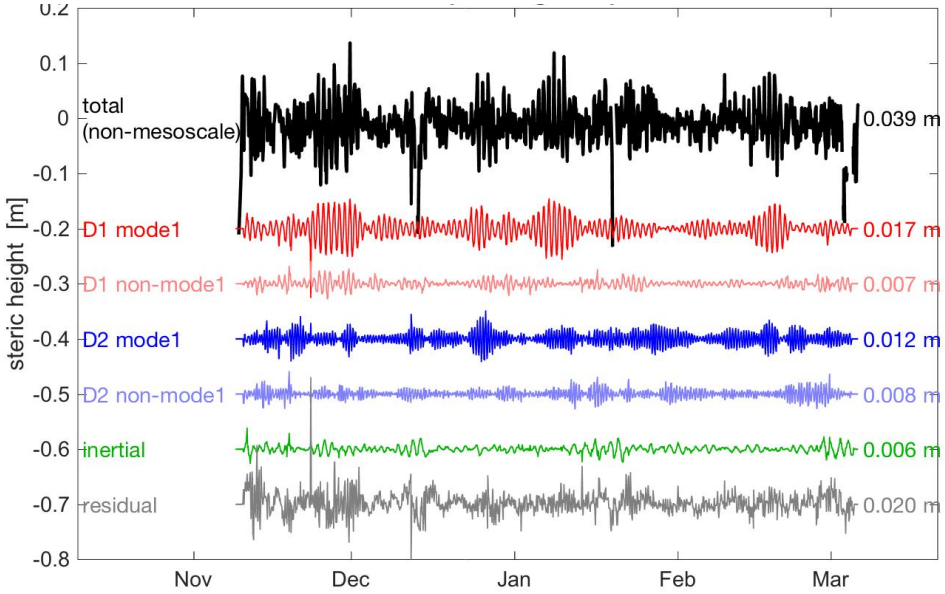
MODEL subsampled like glider



Non-mesoscale steric height (4.1 cm)

- Diurnal, mode 1 (2.0 cm)
- Diurnal, non-mode1 (0.7 cm)
- Semidiurnal, mode 1 (1.4 cm)
- Semidiurnal, non-mode1 (1.0 cm)
- Inertial motions (0.5 cm)
- Residual (1.7 cm)

GLIDER



Non-mesoscale steric height (3.9 cm)

- Diurnal, mode 1 (1.7 cm)
- Diurnal, non-mode1 (0.7 cm)
- Semidiurnal, mode 1 (1.2 cm)
- Semidiurnal, non-mode1 (0.8 cm)
- Inertial motions (0.6 cm)
- Residual (2.0 cm)