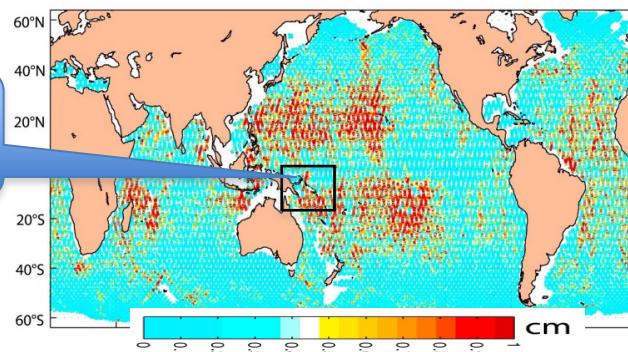


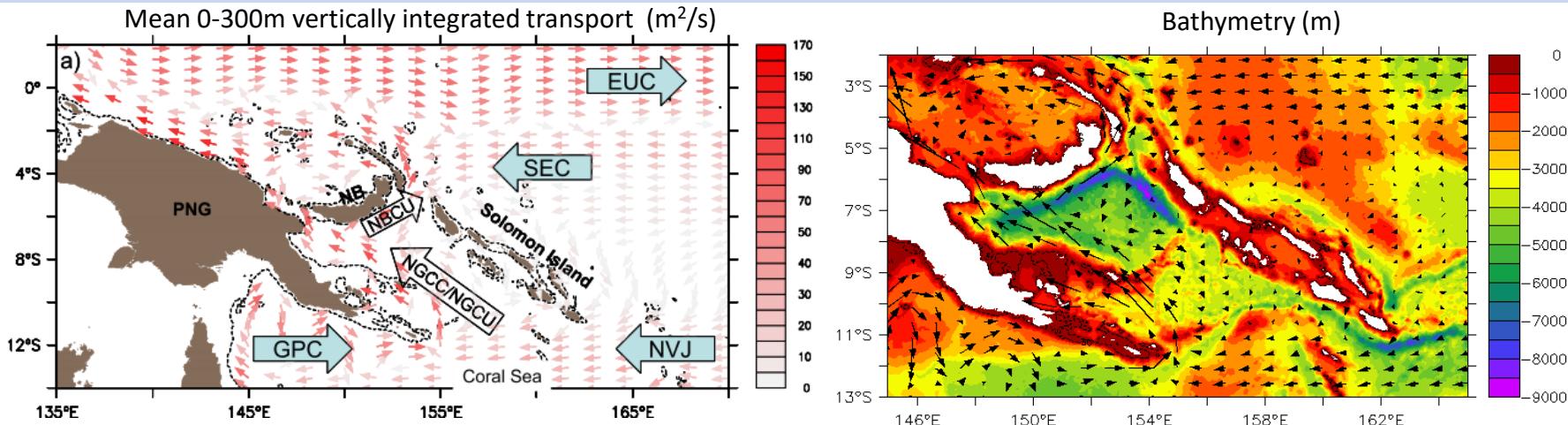
## SSH observability: the problem of internal tides A focus on the Solomon Sea

L. Gourdeau, M. Tchilibou, F. Lyard, D. Allain, R. Morrow

Solomon Sea



- Solomon Sea:**
- A **tropical regional Sea** extending from  $5^{\circ}$  to  $11^{\circ}$  S
  - An area of water mass transformation of importance for **ENSO** (Melet et al., 2011, 2012)
  - Huge LLWBCs → current instabilities → **meso/submesoscale dynamics**
  - A complex bathymetry → **huge internal tides** (Gourdeau, 1998)



# SSH observability: the problem of internal tides

## A focus on the Solomon Sea

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Mesoscale analysis using:

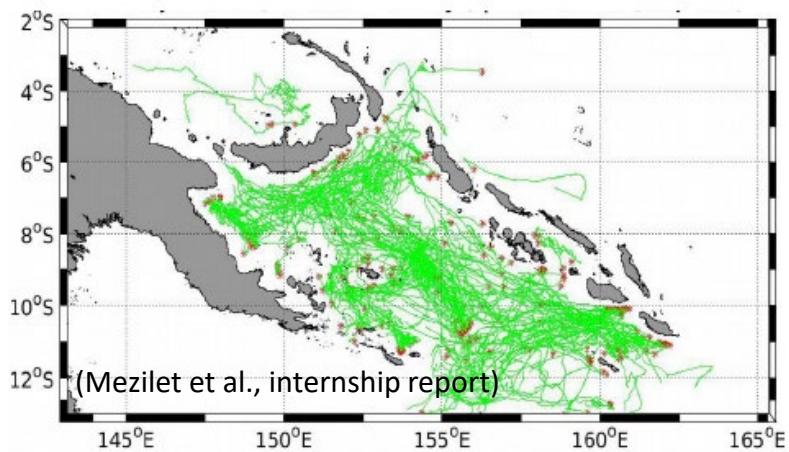
gliders (Davis et al., 2012; Gourdeau et al., submitted)

Altimetry (Gourdeau et al., 2014)

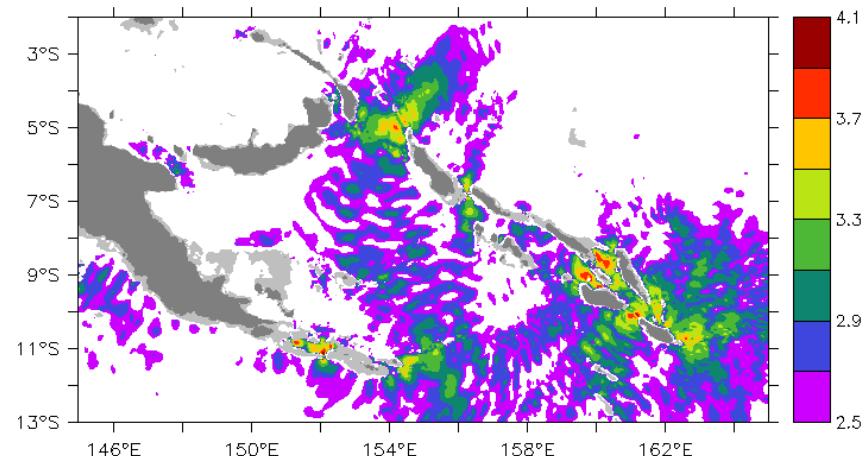
High resolution model (Djath et al. 2014; Histrova and Kessler, 2014)

Internal tides: present studies

Cyclonic Eddy trajectories (1/36° model)



Kenetic energy ( $\text{J m}^{-2}$ ) of the M2 baroclinic tide



(sub)mesoscale/ internal tides interaction

# SSH observability: the problem of internal tides

## A focus on the Solomon Sea

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### A $1/36^\circ$ regional NEMO simulation (Djath et al. 2014) with explicit tides

Interannual forcing: DFS5.2 (1992-2000)

Tidal forcing at the open boundary: nine major constituents from FES2014

Two simulations: with and without tidal forcing

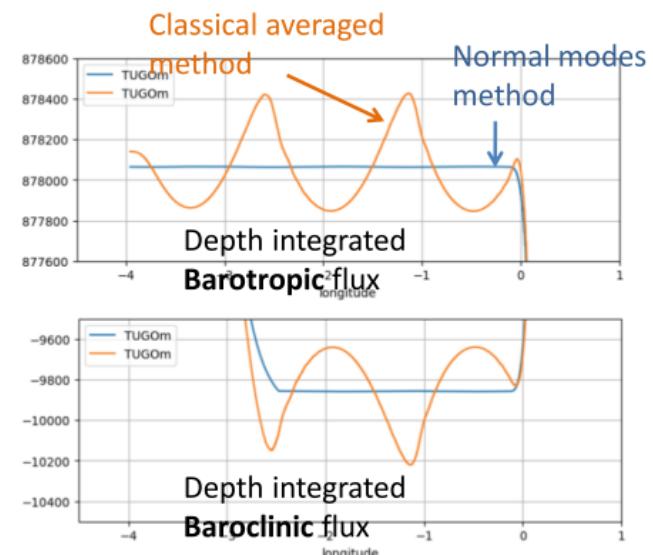
1hr snapshots are analyzed for January to March 1998 to obtain **barotropic and baroclinic harmonic amplitudes and phases** after projection onto the **10 first vertical modes**.

### Separate Barotropic/baroclinic tides via Normal modes (Lyard, Nurgocho, Koch-Larrouy, 2017)

Classical averaged method leads to spurious signal

Normal modes method cleaner

→ Precision important for future SWOT mission



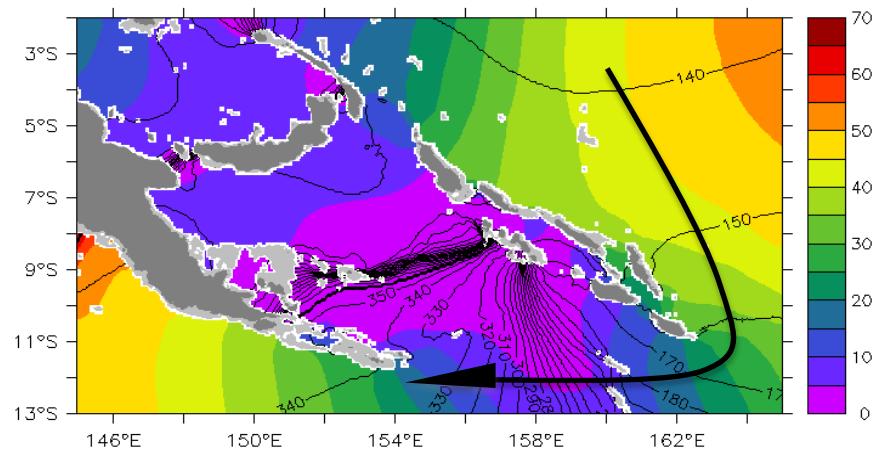
# SSH observability: the problem of internal tides

## A focus on the Solomon Sea

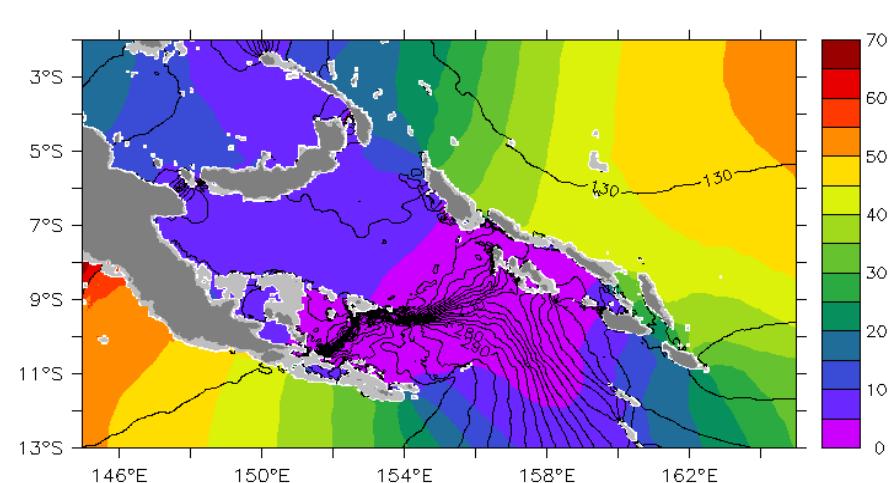
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### Validation of the M2 barotropic tide

FES 2014



Model



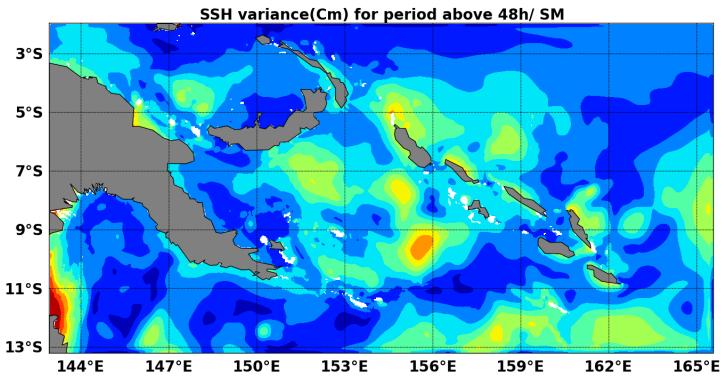
Tidal forcing well simulated

Low amplitude of the M2 barotropic tide

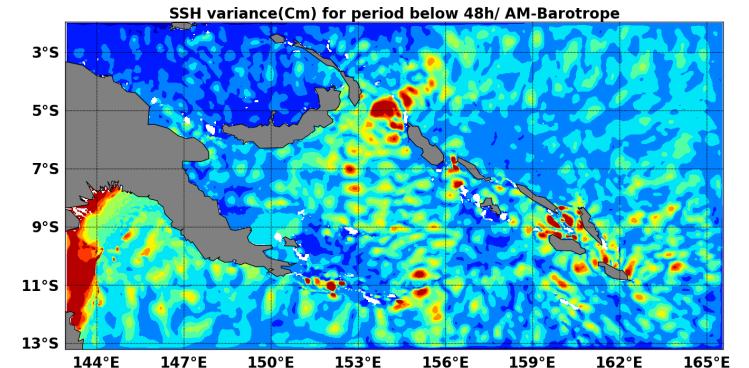
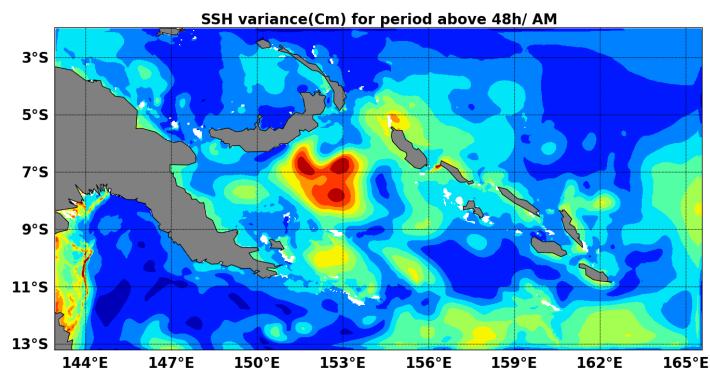
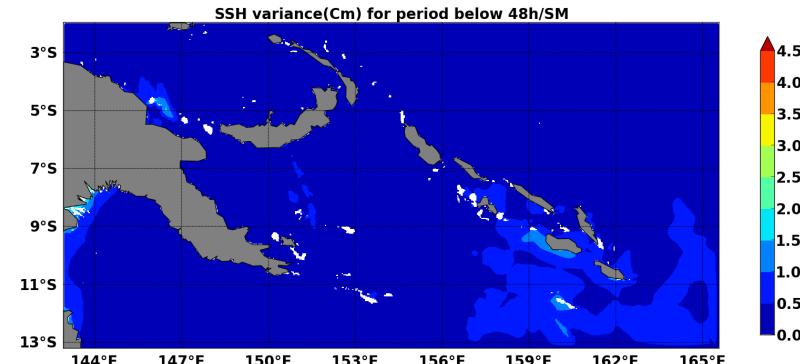
In the following, barotropic tides are removed

# SSH baroclinic variability in different spectral bands

Mesoscale variability  
(Low frequency: >48hr, cm)



Internal waves  
(High frequency: < 48hr, cm)



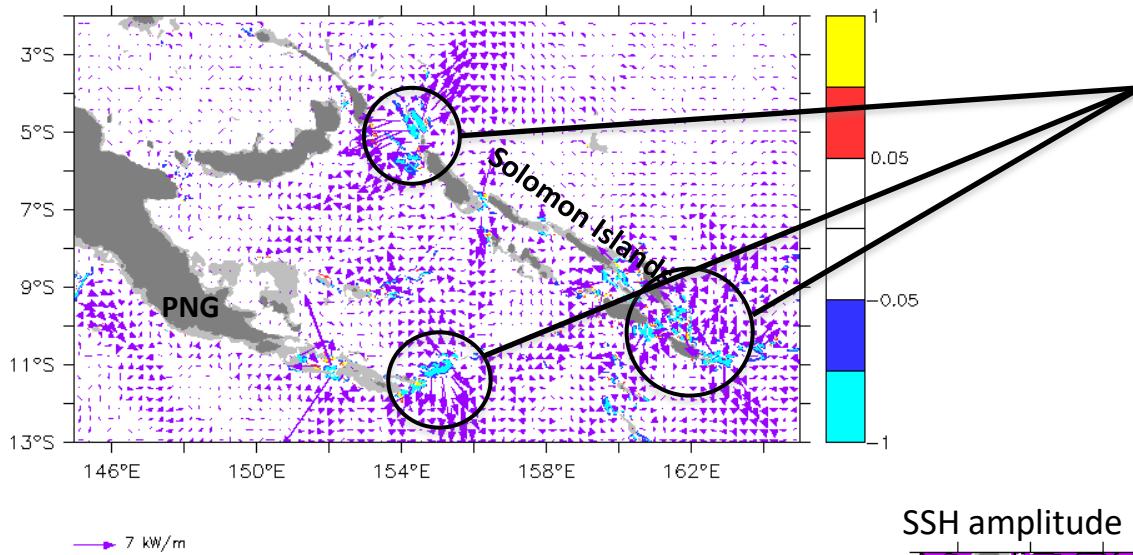
Huge internal tides signal in the Solomon Sea

Interaction between mesoscale and internal tides

# Stationary internal tides

## Most of the energy for the M2 harmonic

M2 generation (shading,  $\text{W m}^{-2}$ ) and depth integrated energy flux (vector,  $\text{kW m}^{-1}$ )



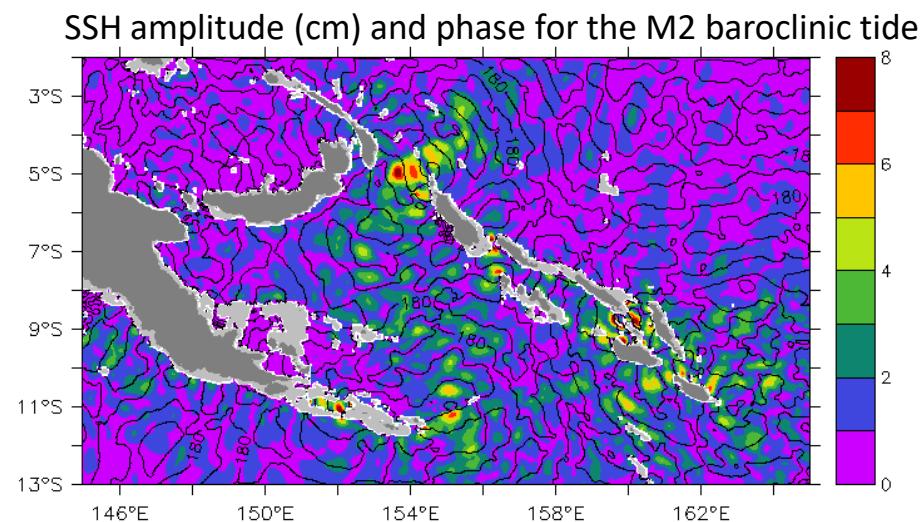
Maximum conversion rate from barotropic to baroclinic.

The M2 baroclinic energy flux radiates inside and outside the Solomon Sea.

**Amplitude** of M2 internal tides is about **4-5 cm**.

The associated wavelength is about 100 km.

The signature is dominant in the Solomon Sea

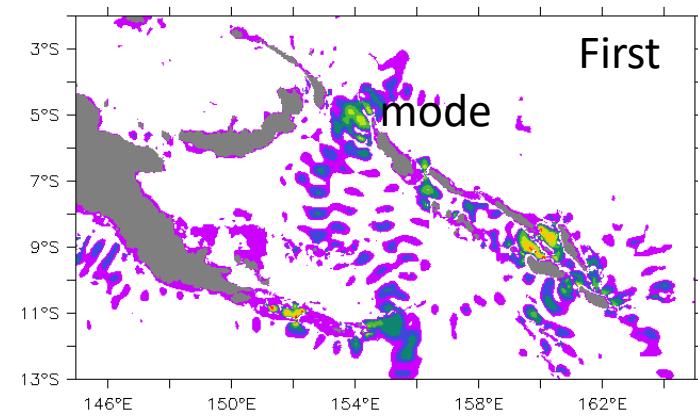
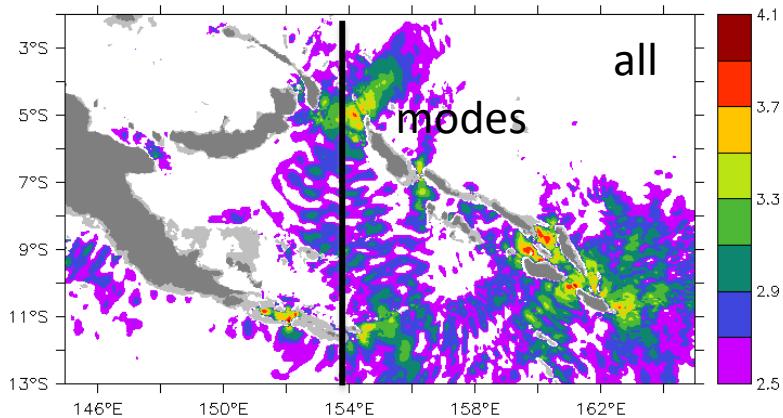


# Stationnary M2 internal tides: Vertical signature

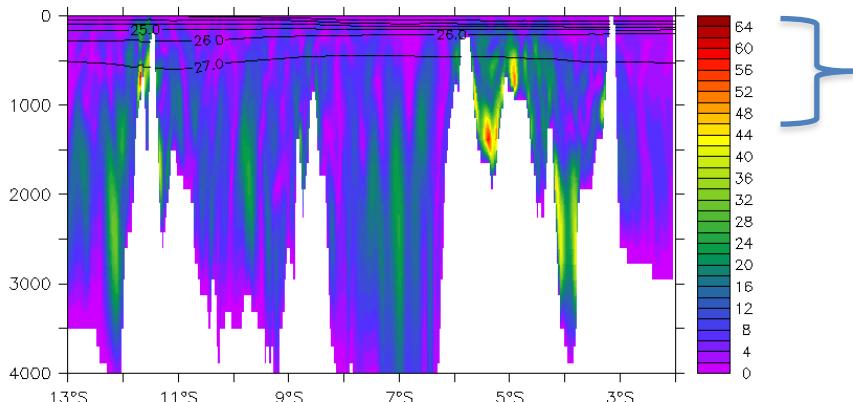
## A zoom at 154° E

Dominance of the first baroclinic mode

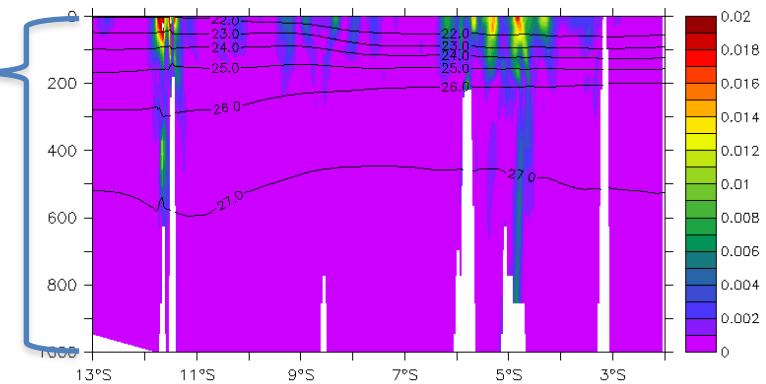
Depth integrated kinetic energy ( $J \text{ m}^{-2}$ )



Vertical displacement (m)



Kinetic energy ( $J \text{ m}^{-3}$ )



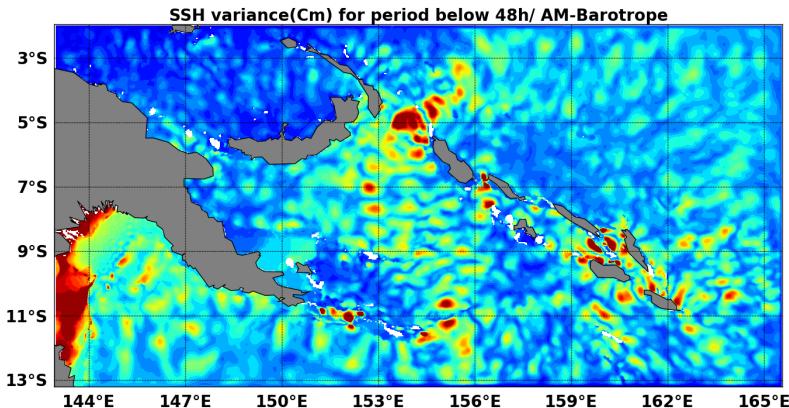
A tropical signature:

Energy of the M2 tides in the surface layers

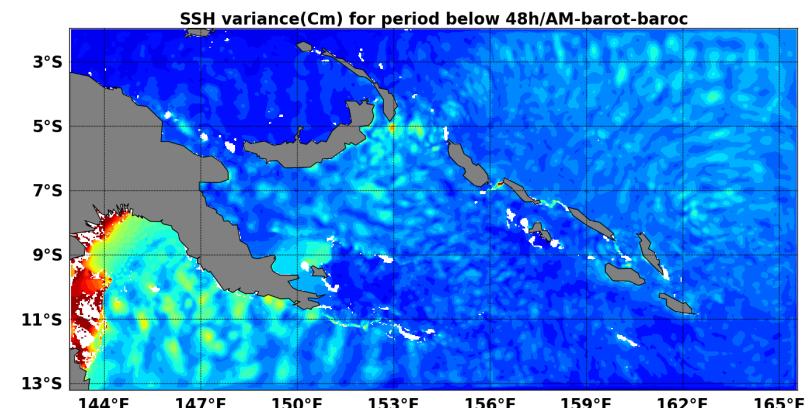
# Non stationary internal tides

SSH variability (cm)

Stationnary + non stationnary internal tides



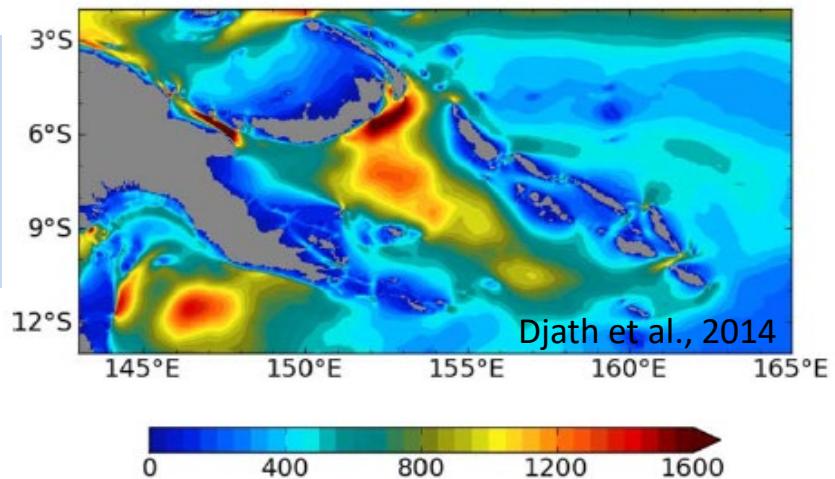
Non stationnary internal tides



A significant incoherent internal tide signal in the northern Solomon Sea

The effect of strong mesoscale activity

Low frequency kinetic energy ( $\text{cm}^2/\text{s}^2$ )



Djath et al., 2014



# Wavenumber spectra

Model without tides

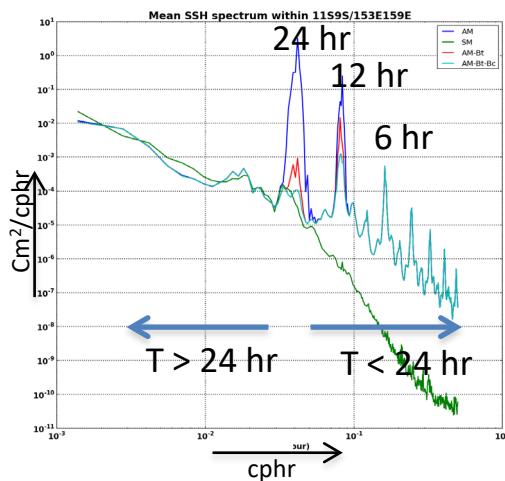
Model with tides:

full signal

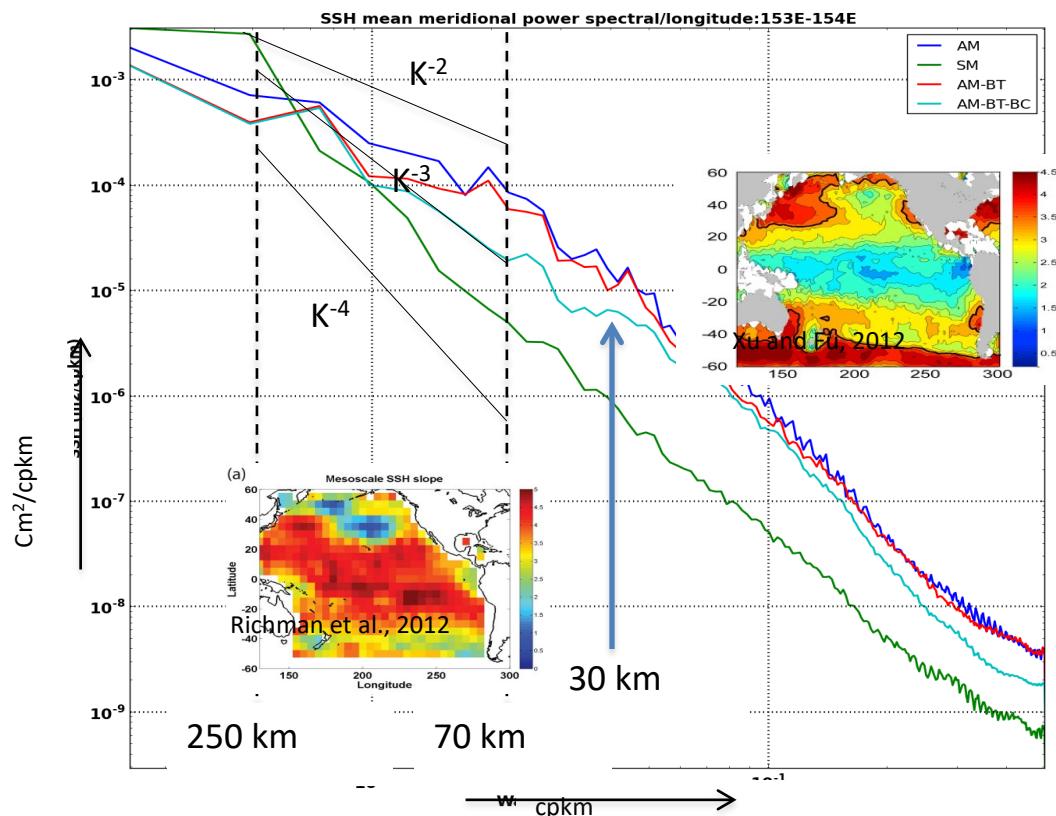
baroclinic tides

incoherent baroclinic tides

Frequency spectrum



Wavenumber spectrum



Baroclinic tides: dominant signal in the IGW continuum.

Wavenumber spectrum impacted for wavelengths up to 100 km

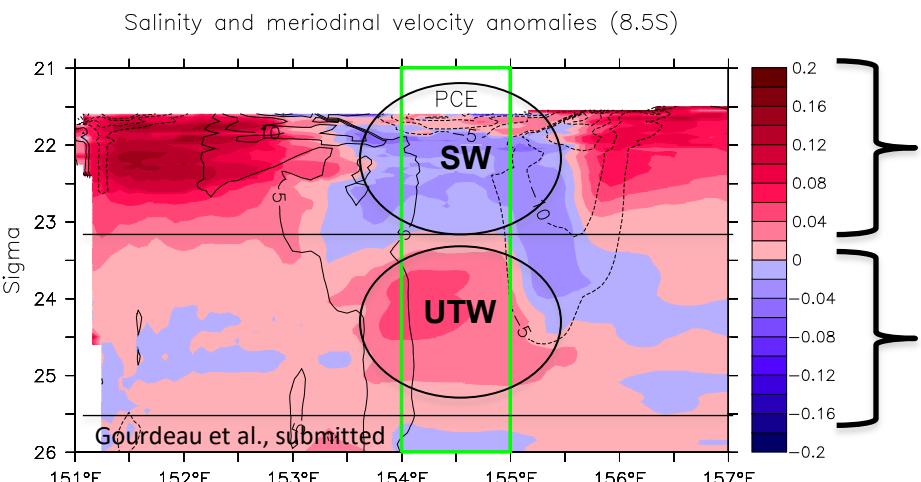
50% of the internal tides variability can be corrected

# Water mass transformation

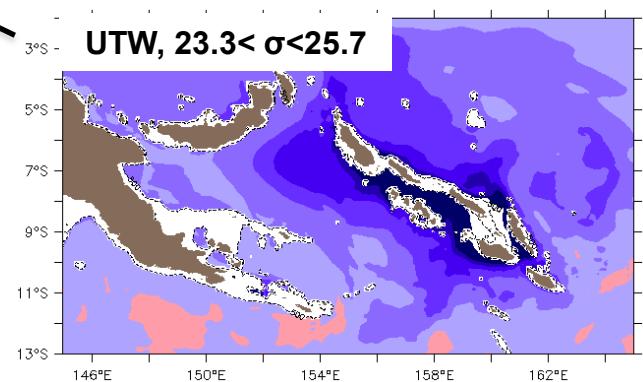
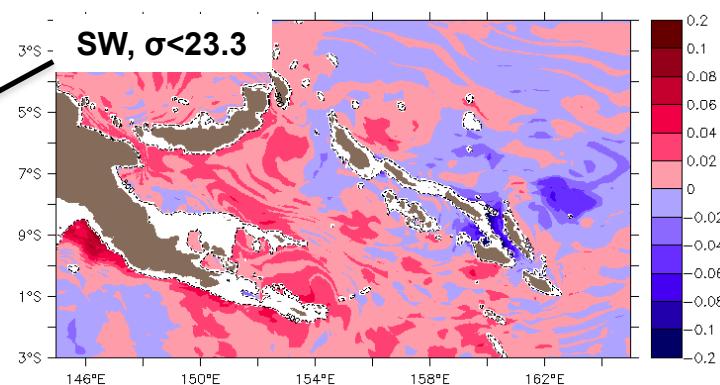
## Mesoscale dynamics/Internal tides

salinity anomalies function of density

### Mesoscale cyclonic eddies



### Internal tides



Mesoscale dynamics/Internal tides:

→ Compensating effects

## SSH observability: the problem of internal tides

### A focus on the Solomon Sea

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#### A challenging area for SWOT: WBCs, (sub)mesoscale/internal tides interaction

- A normal mode method to separate barotropic and baroclinic signals
- The baroclinic energy flux concentrated in the surface layers
- Non stationnary baroclinic components related to mesoscale activity
- mesoscale/internal tides mixing
- Spectrum signatures:
  - baroclinic tides explain the  $k^{-2}$  SSH mesoscale slope in the tropics
  - Correction of the wavenumber spectrum by the stationnary baroclinic tides

Next step: evaluation of model results from moorings, gliders data

High frequency signals off New Caledonia: Poster of G. Sarrazin

**SSH variance(Cm) for period below 48h/AM-barot-baroc**

