

Internal tides / mesoscale interactions in a tropical area : plans for an in situ science validation experiment in New Caledonia

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cal/val site in New Caledonia



not a crossover (though part of the « adopt a crossover » initiative)...

but a unique opportunity to study internal waves and their interaction with regional circulation / meso-scale activity in the context of the SWOT fast-sampling phase

Dynamical context of South-Western Tropical Pacific (and New Caledonia)



Mean regional circulation

- complex regional circulation
- complex bathymetry (prone to internal tides generation)

Dynamical context of South-West Tropical Pacific (and New Caledonia)



- strong mesoscale activity (intense coherent eddies with SSH signature > 8cm)
- strong SSH signature of internal waves (> 4 cm) (in particular North and South of Caledonia)

SWOT publications

From meso/submesoscale to internal tides (higher modes and incoherent tides) to their interactions

2019

Zhao et al., Decomposition of the Multimodal Multidirectional M2 Internal Tide Field

2018

Zaron and Rocha, Internal Gravity Waves and Meso/Submesoscale Currents in the Ocean: Anticipating High-Resolution Observations from the SWOT Swath Altimeter Mission
 Zaron, Baroclinic Tidal Sea Level from Exact-Repeat Mission Altimetry
 Qiu et al., Seasonality in Transition Scale from Balanced to Unbalanced Motions in the World Ocean
 Arbic et al., Primer on Global Internal Tide and Internal Gravity Wave Continuum Modeling in HYCOM and MITgcm

2017

Zaron and Ray, Using an Altimeter-derived Internal Tide Model to Remove Tides from In-situ Data Savage et al., Frequency Content of Sea Surface Height Variability from Internal Gravity Waves to Mesoscale Eddies Savage et al., Spectral Decomposition of Internal Gravity Wave Sea Surface Height in Global Models Qiu et al., Submesoscale Transition from Geostrophic Flows to Internal Waves in the Northwestern Pacific Upper Ocean Ponte et al., Low-Mode Internal Tides and Balanced Dynamics Disentanglement in Altimetric Observations: Synergy with Surface Density Observations Magalhaes and da Silva, Satellite Altimetry Observations of Large-Scale Internal Solitary Waves Dunphy et al., Low-Mode Internal Tide Propagation in a Turbulent Eddy Field Buijsman et al., Semidiurnal Internal Tide Incoherence in The Equatorial Pacific

2016

Zhao, Z. (2016). Using CryoSat-2 Altimeter Data to Evaluate M2 Internal Tides Observed from Multisatellite Altimetry
Zhao et al., Global Observations of Open-ocean Mode-1 M2 Internal Tides
Ray and Zaron, M2 Internal Tides and Their Observed Wavenumber Spectra from Satellite Altimetry
Kelly, The Vertical Mode Decomposition of Surface and Internal Tides in the Presence of a Free Surface and Arbitrary Topography

2015

Zaron, Nonstationary Internal Tides Observed Using Dual-Satellite Altimetry Müller et al., Toward an Internal Gravity Wave Spectrum in Global Ocean Models Ansong et al., Indirect Evidence for Substantial Damping of Low-Mode Internal Tides in the Open Ocean

2014

Stammer et al., Accuracy Assessment of Global Barotropic Ocean Tide Models **Shriver et al.**, How Stationary are the Internal Tides in a High-Resolution Global Ocean Circulation Model?

2012

Shriver et al., An Evaluation of the Barotropic and Internal Tides in a High Resolution Global Ocean Circulation Model Richman et al., Inferring Dynamics from the Wavenumber Spectra of an Eddying Global Ocean Model with Embedded Tides Arbic et al., Global Modeling of Internal Tides Within an Eddying Ocean General Circulation Model, Oceanography

2004

Simmons et al., Internal Wave Generation in a Global Baroclinic Tide Model **Arbic et al.**, The Accuracy of Surface Elevations in Forward Global Barotropic and Baroclinic Tide Models

« SWOT in the Tropics : a case study in the SW Pacific » (SWOT-ROSES / TOSCA Project 2016-2019)

Main questions :

- what is the SSH spectral signature in the Tropics ?
- what are the roles of meso-scale activity and internal gravity waves for SSH observability?
- what is the spatio-temporal variability of meso-scale activity in the region ?
- what are the properties of internal tides, and their impact on regional circulation and mixing ?



Focus on the South-Western Pacific

+ OSTST SARAL / MANCAS Project (2017-2020)

« Meso-Scale Activity around New Caledonia : from AltiKa to SWOT »

« SWOT in the Tropics » : insights from a 1/36° regional simulation in Solomon Sea

Regional simulations :

- 1/36° NEMO model configuration
- 2 simulations : with / without tides

Impact of internal tides on SSH spectra



Tchilibou et al. (2019)

Amplitude of the M2 internal tides



Baroclinic tides : generation and energy fluxes



Tchilibou et al. (to be submitted)

« SWOT Tropics » : insights from historical observations (New Caledonia)

2011

2010



• from a temporal viewpoint (moorings)



U Spectra (10 pieces average

Inert

1/2 E

• from a statistical viewpoint (compilation of historical observations)



A unique opportunity to study internal tides / mesoscale interactions





140⁰E

150⁰E

Amplitude of coherent M2 internal tides





CE Frequency (% of time when a CE passed through each bin) Contour lines at 100m (pink) and 1000m depth (black) %

160⁰E

^{170°E} 180^{°W} 170^{°W} *Keppler et al. (2018)* 30

25

20

15

10

5

Strong potential for an in situ experiment in New Caledonia with a special focus on the observation and dynamics of internal waves

• Pros for an in situ experiment in New Caledonia during the SWOT fast sampling phase:

- strong SSH signature of internal waves and mesoscale activity
- follow an intense in situ effort (e.g. Saral/AltiKa validation)
- logistics : Noumea IRD center and R/V Alis



• Key questions for this SWOT cal/val site

- Validation and analysis of the SSH signature of internal waves (coherent and incoherent)
 - \rightarrow Assessment of the possible corrections for internal waves on SWOT data
- Processes associated with internal tides
 - \rightarrow generation and propagation of internal tides
 - \rightarrow vertical structure of internal waves
- Impact of internal waves
 - $\rightarrow\,$ interaction with regional circulation / eddies
 - $\rightarrow\,$ mixing and biological processes

- Analysis of the (sub)meso-scale processes (once interal waves are filtered out)

Internal tides and mesoscale interactions in a tropical area : insights from SWOT

- A modelisation experiment

- To document meso/submesoscale and internal tides activity and their interactions
- To prepare the design of the in situ experiment
- To test the SSH SWOT observability

- An in situ experiment

- To get observations under the SWOT swath during the fast-sampling phase
- To observe meso/submesoscale
- To observe high frequency motions

- SWOT observability

- From the dynamical description of the in situ experiment to the SWOT measurements
- To test the denoising and reconstruction method for SWOT (collab. E. Cosme)

A new project for an situ validation science experiment in New Caledonia

Task #1 : a high-resolution regional model

A collaboration with IGE/OceanNext (J. Le Sommer, J. Verron, L. Brodeau)

- a 1/60° regional model with 150 vertical levels based on NEMO (with and without explicit tides)
- a 2-year simulation (hourly-averaged outputs)
- a bathymetry including a specific high-resolution dataset (ZONECO)
- the FES2014 tidal forcing at the boundaries
- Mercator as the boundary conditions.



ZONECO bathymetry (250 m resolution)

A new project for an situ validation science experiment in New Caledonia

Task #2 : an in situ science validation campaign during the SWOT fast sampling phase

• 1-2 moorings : CTD, currentmeters, chipods? (to be deployed prior to SWOT launch – late 2021 or early 2022)

- <u>Objectives</u> surface and vertical structure of internal waves
 - link with SSH (submesoscale and internal waves)
 - mixing associated with internal waves



• 1-month cruise (en route measurements : uCTD/seasor, S-ADCP, thermosalinograph)

<u>Objectives</u> - repetitive transects the direction of propagation of internal waves

• Additional measurements :

- HF radar ?
- gliders ?
- 1 additional cruise (CTD casts, microstructure, biology) ?
- coastal / lagoon specific measurements ?

A new project to be submitted to the next AO SWOT

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