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# SWOTtropics: Regional modeling of internal tide dynamics around New Caledonia


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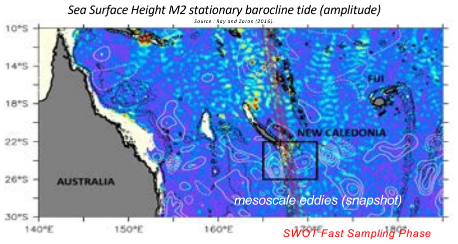
## 1. Motivation

The New Caledonia area in the South West tropical Pacific ocean is characterized (**Fig. 1**) by:

- Intense meso/submesocale features (Keppler et al., 2018)
- Hot spots of internal tide generation (Ray and Zaron, 2016)
- A swath SWOT crossing its southern part during the FSP

The modeling approach presented here is a main issue of the SWOTtropics project in addition with the SWOTALIS cruise detailed in poster XX.

This poster summarized two recent papers, one dedicated to coherent internal tide characteristics and sea surface height signature (Bendinger et al., 2023), and the second to the tidal incoherence in link with the mesocale activity (Bendinger et al., submitted)




Figue1: M2 stationnary tide amplitude ( shading, Ray and Zaron, 2016) superimposed on a snapshot of mesoscale eddies from AVISO (white contours). In red, the swath SWOT crossing the southern Caledonia area during the Fast Sampling Phase.

## 2. Nested regional simulation (NEMO)

- High-resolution simulation (CALEDO60, 1/60°, 125 vertical levels, current-feedback, non-linear free surface) embedded in a 1/12° domain (TROPICO12, **Fig.2**).
- Two runs: one with (M2, S2, N2, K1, O1), one without explicit barotropic tide forcing to study the impact of internal tides on the eddy field (here, we focus on the tidal run)
- Ttidal analysis performed on one year of data (2014).

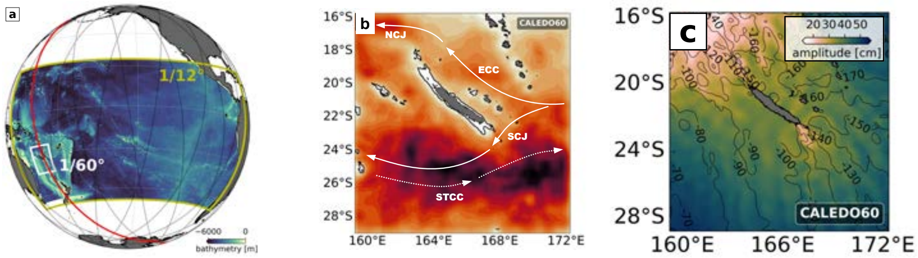



Figure 2. (a) Model setup showing the host grid domain (TROPICO12, yellow box) and the nesting grid (CALEDO60, white box) including the bathymetry (shading) and the SWOT CalVal orbit (black transparent lines) with the highlighted ground track (red line) that crosses the CALEDO60 domain. (b) Surface mesoscale EKE derived from SSH for CALEDO60; (c) M2 SSH amplitude (shading) and phase (contour) for) CALEDO60 showing mainly the barotropic component.

## 3. Coherent internal tide characteristics and sea surface height signature (Bendinger et al., 2023)

- 15.27 GW of barotropic tidal energy is transferred to baroclinic tidal energy (**Fig. 3**).
- Baroclinic energy is generated in shallow waters above 500 m depth and on critical to supercritical slopes, highlighting the limitations of linear semi-analytical models in those areas
- Baroclinic tidal energy flux expressed mainly two predominant tidal beams (North (1) and South (2))
- South (2) is located under the swath SWOT.
- The M2 SSH amplitude may reach more than 6 cm

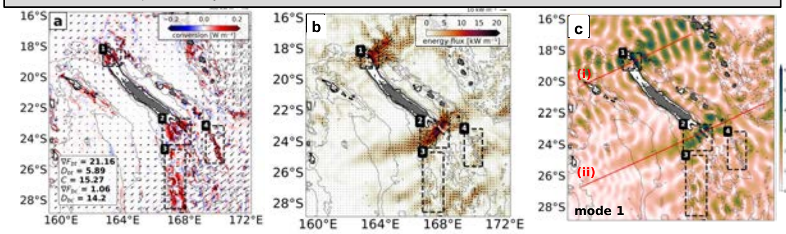



Figure 3: (a) M2 barotropic-to-baroclinic conversion including barotropic energy flux vectors and the full-domain area integral of the barotropic energy flux divergence (∇Fbt), barotropic energy dissipation (Dbt), barotropic-to-baroclinic conversion (C), baroclinic energy flux divergence (∇Fbc), and baroclinic energy dissipation (Dbc) in gigawatts (GW). (b) M2 coherent energy flux (shading) including flux vectors.. (c) CALEDO60 M2 SSH amplitude for mode 1.

- Balance and unbalanced regimes are delineated by the transition scale (Lt) defined as the intersection of subinertial and superinertial spectra.
- For scales smaller than 200 km, SSH variance is governed by superinertial processes, which are largely dominated by the coherent internal tide (**Fig. 4**).
- The correction of the total SSH for the coherent internal tide reduces Lt from 204 km to 92 km for North (I) and from 163 to 83 fort South (II).

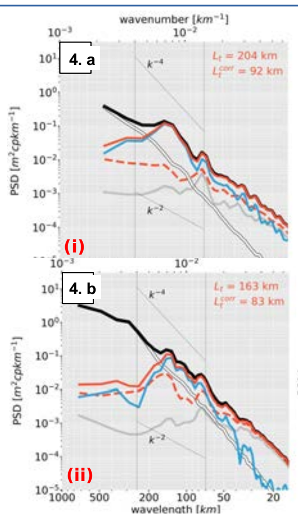
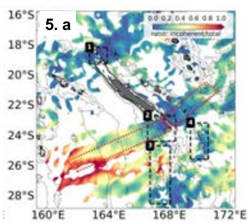



Figure 4. SSH wavenumber spectra (black) with regard to the different dynamics: mesoscale and submesoscale dynamics (ω < f, subinertial, white), internal gravity waves (ω > f, superinertial, solid red) decomposed into the coherent internal-tide component (blue) and supertidal frequencies (ω > 1/10 h, grey) for (a) the transect (i) and (b) the transect (ii). The SSH spectra corrected for the baroclinic tide and filtered for motions at superinertial frequencies (SSHcorr_superinertial, dashed red) is also given.

## 4. Incoherent internal tide in link with the mesoscale activity (Bendinger et al., to be submitted)

- Incoherent internal tide is presented as the ratio to the total semidiurnal energy flux (Fig. 5a).
- North eastward tidal beams emerging from *North* (1) and *South* (2) are largely coherent.
- Along the Southwestward tidal beam emerging from *South* (2) the incoherent part explains about 25 % of the total semidiurnal signal beyond 200 km distance to the generation site (0 km), before being dominant at > 500 km distance (Fig. 5b).



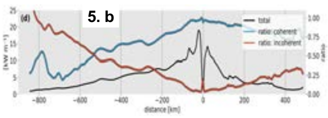




Figure 5. (a) The incoherent semidiurnal baroclinic energy flux is expressed as the ratio to the total semidiurnal internal tide. Regions with a total semidiurnal energy flux of <1.5 kW m−1 are masked. (b) Total semidiurnal energy flux and the ratio of the coherent/incoherent tide to the total tide as a function of distance to the generation site and averaged for the red box as indicated in (a).

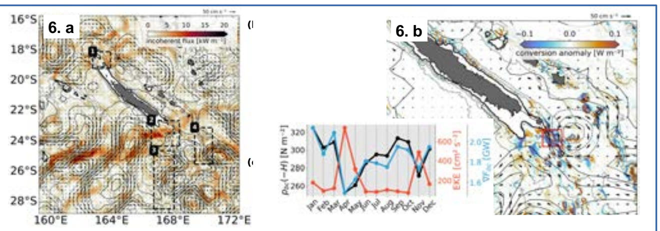
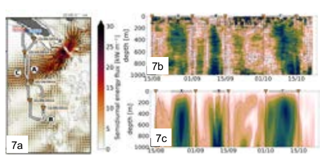
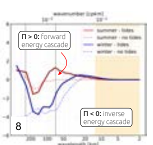



Figure 6. (a) Snapshot of the 5-day mean semidiurnal incoherent energy flux (shading) overlaid by the associated snapshot of the mesoscale eddy field from January 31 2014. (b) M2 barotropic/baroclinic conversion anomaly (shading) for April 2014 overlaid by a representative snapshot of the 5-day mean mesoscale eddy field from 26 April 2014. The monthly baroclinic pressure amplitude at the ocean bottom averaged for the red box as well as the mesoscale EKE are also shown in the inlet of (b).

- Incoherent energy levels are clearly linked with mesoscale eddies (Fig. 6a).
- Negative conversion anomaly governed by baroclinic pressure amplitude variations clearly coincides with the passage of a mesoscale eddy which expresses by elevated levels of EKE (Fig. 6b).

## 5. Perspective (Bendinger et al., in preparation)




This work is a first modeling approach to characterize internal tide dynamics around New Caledonia. The results will be usefully confronted to in-situ observations from the SWOTALIS experiment (See SWOTROPICS poster). But a preliminary study based on a glider experiment is underway (Fig. 7) showing the good consistency between model results and observations.

In addition, comparing simulations with and without tidal forcing will help understand how tides impact the meso and submesoscale fields, and the forward and inverse energy cascades among spatial scales (Fib.8).

Figure 7. (a) The glider track south of New Caledonia superimposed on the depth-integrated semidiurnal energy flux. Semidiurnal amplitude for (b) glider observations and (c) coherent semidiurnal amplitude deduced from the model. (Bendinger et al., in preparation).

Figure 8: Wavenumber spectra for energy flux for the simulations with (line) and without (dash) tides giving evidence of direct and inverse energy cascade depending on the seasons and illustrating impacts of tides. (Bendinger et al., in preparation)


References :

Bendinger A., S. Cravatte, L. Gourdeau, L. Brodeau, A. Albert, M. Tchilibou, F. Lyard, and C. Vic, Regional modeling of internal tide dynamics around New Caledonia. Part I: Coherent internal tide characteristics and sea surface height signature, EGUsphere, https://doi.org/10.5194/egusphere-2023-361, 2023

Bendinger A., S. Cravatte, L. Gourdeau, L. Brodeau, A. Albert, M. Tchilibou, F. Lyard, and C. Vic, Regional modeling of internal tide dynamics around New Caledonia. Part II: Tidal incoherence, to be submitted

Bendinger A., S. Cravatte, L. Gourdeau, K. Druska, C. Vic, To what extent can we use glider observations to infer internal tides and their surface signature south of New Caledonia? To be submitted