Interactive comment on "Internal tides in the Solomon Sea in contrasted ENSO conditions" by Michel Tchilibou et al.

Response to reviewer 1

Anonymous Referee #1

Overall this is very interesting work and without a doubt will eventually be a solid contribution. The large differences in baroclinic energy between ENSO states is striking. The major area in need of improvement is to provide a quantitative assessment of what has changed the baroclinic energy between ENSO states. There is a change in eddy energy, which is clearly shown. However, the actual path by which baroclinic energy changes is not identified. A model is used and so a definitive answer should be found. See works by Zilberman et al and Rainville et al for some possible methods to evaluate how energy changes during generation and propagation.

Some obvious model-data comparison is missing. Mode 1 and mode 2 energy flux is calculated. The results could be compared to altimetric observations by Zhao et al, although not for different ENSO states. Another point of observational comparison is Pinkel et al who observed internal waves propagating northward from Solomon St. A new mixing parameterisation is used, but not compared to existing methods in this area (Alberty et al).

We would like to thank the reviewer for his careful reading, and we are pleased that our work has been well received.

The reviewer has two main concerns about 1) a quantitative assessment of what has changed the baroclinic energy between ENSO states, and 2) model-data comparison.

Below, we try to answer on the different comments, and to address the two main concerns.

comments by line

55 - Jeffreys 1920 actually first identified marginal seas as likely sites

Thank to cite the geophysicist Sir Harold Jeffreys that we discover. We do not find the reference Jeffreys (1920) to include it in the paper. We think that Munk and Wunsch (1998) is a strong reference for our purpose.

64 - internal waves originating from this topography is also noted by Pinkel et al (1997, doi:10.1029/97gl01610)

Yes, you are right. This reference was cited in Gourdeau et al. (1998). But we modify the corresponding sentence to include it:

Old:"Internal tides have been observed at 2°S-156°E from a TOPEX/Poseidon crossover and a Tropical Atmosphere-Ocean (TAO) mooring, propagating northeastward from the Solomon Islands (Gourdeau et al., 1998). "

→

New: "). Internal tides with phase locked solitary waves have been observed during the COARE experiment, and they appear to propagate northeastward from the Solomon Islands (Pinkel, 1997; Gourdeau et al., 1998).

100 - ": : :first attempt: : :" I'm not sure this is correct or perhaps it's just a poor choice of words. Robin Robertson has several publications in this area and in general there are mixing parameterizations aplenty.

Yes, you are right: this is a poor choice of words.

The sentence has been modified:

Old: "The parameterization described above is a first attempt to take into account…"

→

New: “This tidal parameterization is applied over the entire marginal sea, and aims to take into account the general effects of internal tides in an ocean model.”

103-113 - The references are inappropriate in some cases here and elsewhere in the manuscript. I suggest referencing the first work and then the latest or most important work in these areas:
Altimetry - Ray & Mitchum
Regional models around Hawaii from the HOME experiment - Merrifield and Holloway paper(s) or Rudnick 2003
Indonesia - Robertson as noted earlier
Ok, we check the references, and replace some by your suggestions:

Old: “A global view of their generation, propagation, and dissipation has emerged in recent years, mainly from satellite altimetry observations **(Dushaw, 2015; Egbert and Ray, 2017; Ray and Zaron, 2016; Zhao et al., 2016, 2018**) and global high-resolution numerical models (**Arbic et al., 2010; Müller et al., 2012; Shriver et al., 2012; Simmons et al., 2004, Niwa and Hibiwa, 2014**). A lot of studies focus on the low mode M2 internal tides, and the Pacific Ocean is particularly investigated because of numerous archipelago are sources of internal tide generation. Numerous regional studies based on insitu/satellite data and regional models have documented internal tides at the Hawaiin ridge (**Zaron and Egbert, 2014; Nash et al., 2006; Chavanne et al., 2010; Zhao et al., 2010**), at the Indonesian archipelago (**Nagai and Hibiya, 2015; Nughoro et al., 2017; Koch Larrouy et al., 2015**), at the East China Sea (Niwa and Hibiwa, 2004; Rudnick et al., 2013).”
→
New: “A global view of their generation, propagation, and dissipation has emerged from satellite altimetry observations (**Ray and Mitchum, 1997; Ray and Zaron, 2016; Zhao et al., 2018**) and global high-resolution numerical models (**Arbic et al., 2010; Shriver et al., 2012; Simmons et al., 2004; Niwa and Hibiwa, 2014**). A lot of studies focus on the low mode M2 internal tides, and the Pacific Ocean is particularly investigated because of numerous archipelago are sources of internal tide generation. Numerous regional studies based on insitu/satellite data and regional models have documented internal tides at the Hawaiin ridge (**Merrifield and Holloway, 2002; Nash et al., 2006; Chavanne et al., 2010; Zhao et al., 2010**), at the Indonesian archipelago (**Robertson and Ffield, 2008; Nagai and Hibiya, 2015; Nughoro et al., 2017**). “

111 - East China Sea is irrelevant here. I don’t know of any tidal studies in the SW Pacific myself, but it would be better to say “As far as we know, no dedicated studies: : :”
Words on the East China Sea has been suppressed
Yes, we agree with your suggestion. The sentence has been changed accordingly.
Old:” No dedicated studies have focused on internal tides in the South West tropical Pacific despite high semi diurnal baroclinic tidal energy (**Niwa and Hibiwa, 2011; Shriver et al., 2012**).”
→
New:”As far as we know, no dedicated studies have focused on internal tides in the South West tropical Pacific despite high semi diurnal baroclinic tidal energy (**Niwa and Hibiwa, 2011; Shriver et al., 2012**).”

121 - There are again older references on incoherent tides - Munk and Colosi 1998(?)- and observations showing the deflection of internal tide trajectories - Rainville et al 2003(?).
We don’t find the Munk and Colosi (1998) reference but a Colosi and Munk (2006) paper that effectively deals with the temporal modulation of internal tides by the time-variable density structure from a long time series at the “Venerable Honolulu tide gauge”. We add this reference:
→ “ Several mechanisms contribute to the incoherence of internal tides. First, the internal tide generation may vary in time due to local changes in stratification (**Colosi and Munk, 2006**; Chavanne et al., 2010).”

124 - reference?
We add two references: Ponte and Klein (2015) and Zilberman et al. (2011):
→"Second, the propagation of the low-mode internal tides is modulated by spatial and temporal variability in stratification, currents, and vorticity with detectable changes in tidal SSH (Zilberman et al., 2011; Ponte and Klein, 2015)."

199 - Vertical modes are invalid over sloping topography.
Sloping topography is mostly an issue for w-modes (bottom boundary condition), but not really for u-modes and p-modes (which are the base modes for tidal energy budget). In addition, the w bottom boundary condition (w-BBC) fails only if significant internal tide currents meet a sloping topography, which occurs only on some locations. Finally, the w-BBC does not fundamentally alter the w-mode profiles. So, despite its limitation, the vertical mode approach remains the most efficient ones to separate barotropic and baroclinic dynamics.

210- Here and elsewhere, subscripts are traditionally used.
Ok, done

221 - Nonlinearity of the internal tide in this area is not necessarily small. Large amplitude internal waves are generated (Pinkel et al, 1997). In areas with shallow topography, tidal harmonics are often noted elsewhere.
Regarding this matter, we would like to distinguish between non-linear wave and energy transfer from linear to non linear tides. In particular, we believe that large non-linear internal wave generation does not mean that energy transfer from linear to non-linear tides is also large. We suspect that the reviewer writes about solitary waves that cannot be simulated in such non hydrostatic model. In the paper we refer to the energy equation for baroclinic tides.

231 - Is this not just C = wp' ? Surely there is an earlier reference.
Yes, the conversion term is often written as you suggest but the underlying hypothesis is that w=u(barotrope) grad h. Here we don't degrade the expression that is rigorous when using a modal approach (Kelly and Nash, 2010)
We change the reference Nugroho (2017) to that of Kelly and Nash (2010)

- ➔ "It is defined as in Kelly and Nash (2010):"

231b - Also this relation is often linearized. Is that the case here? wp' is evaluated at a constant depth level z = 0 (neglecting any topography and where the surface would be at z = h). z=-h and grad_h is a bit confusing. Maybe the depth could be H.
In our case the relation is not linearized, and the w is taken at the bottom, z=-h. We agree that the convention H for the bottom topography would be better and we applied it at all equations. Also we change grad_h by ∇H (see following comment)

236 - Please proofread all your equations here and elsewhere and use accepted mathematical notation. Alternate or non-traditional notation distracts unnecessarily. Use nabla ndot vector{F}_{bt}. dz is missing too. Same for tidal components such as M_2 and K_1. Using an overbar for barotropic is unusual and with velocities is taken to mean vector. Are you only considering the u component of velocity or is u intended to be a vector?
Ok, we try to use more traditional notations but such notations vary a lot with papers.
The use of "bt" and " bc" are classically used (e.g. Niwa and Hibiwa, 2004)
We use them now as subscripts.
F, D, and C are also classically used for flux, dissipation, conversion (e.g. Buijsman et al., 2017)
We express the conversion term as in Kelly and Nash (2010).
The divergence of the energy flux is expressed as in Nagai and Hibiya (2015).

M2 and K1 are rewritten in the text as M_2 and K_1.

Old:

"The generation, propagation, and dissipation of the barotropic and baroclinic tide is investigated with the time-averaged and depth-integrated barotropic and baroclinic energy equation (Niwa and Hibiya, 2004; Carter et al., 2008; Nagai and Hibiwa, 2015, Simmons et al., 2004; Buijsman et al., 2014, Nughoro et al. 2017]. In each barotropic and baroclinic equation, the depth-integrated energy is partitioned into tendency, flux divergence, non-linear advection, barotropic to baroclinic conversion, and dissipation. We can ignore the rate of change term as the period of averaging (month and year) makes this term orders of magnitude smaller than the other terms in equations (1 & 2). Similarly, the internal-tide self-advection is also small (Simmons et al., 2004; Buijsman et al., 2014). The non-linear advection terms are assumed to be small in both the barotropic and baroclinic equations. This means that little energy is transferred between tidal harmonics. The equations resume to:

$$\nabla.\mathrm{Fbt} + \mathrm{Dbt} + \mathrm{C} = 0 \qquad (1)$$
$$\nabla.\mathrm{Fbc} + \mathrm{Dbc} - \mathrm{C} = 0 \qquad (2)$$

Where bt indicates the barotropic term and bc indicates the baroclinic terms, F=(Fx;Fy) are the fluxes in the x(east-west) and y(north-south) directions, D is dissipation, and C is the barotropic to baroclinic energy conversion. D is computed as the residual of the flux divergence and conversion terms. The conversion term is identical in the barotropic and baroclinic equations; and it appears as a sink in the barotropic equation and a source in the baroclinic equation. It is defined as in Nughoro et al. (2017):

$$C = (\bar{u}p')_{z=-h}\,\nabla_h d$$

Where p' is the perturbation pressure, $\bar{u}$ is the M2 harmonic fit for the barotropic velocity, h the bottom depth, and d is the total depth (d=h+η, η the surface elevation).

The propagation of barotropic and baroclinic tides are examined through the divergences of the barotropic (Fbt) and baroclinic (Fbc) energy flux, respectively, and defined as in Nughoro et al. (2017):

$$Div(Fbt) = \int_d^\eta \nabla_h\,\overline{up}$$
$$Div(Fbc) = \int_d^\eta \nabla_h\,u'p'$$

The overbar sign is for barotropic velocity (u) and pressure (p), and u', p' is the velocity perturbation and pressure perturbation, respectively."

→

New:

" The generation, propagation, and dissipation of the barotropic and baroclinic tide is investigated with the time-averaged and depth-integrated barotropic and baroclinic energy equation (Niwa and Hibiya, 2004; Carter et al., 2008; Nagai and Hibiwa, 2015, Simmons et al., 2004; Buijsman et al., 2017). In each barotropic and baroclinic equation, the depth-integrated energy (E) is partitioned into tendency, flux divergence, non-linear advection, barotropic to baroclinic conversion, and dissipation. We can ignore the rate of change term since the short averaging period (3-months and 3-years) makes this term orders of magnitude smaller than the other terms. Similarly, the non-linear advection terms are assumed to be small in both the barotropic and baroclinic equations (Simmons et al., 2004; Buijsman et al., 2017). This means that little energy is transferred between tidal harmonics. The equations resume to:

$$\nabla.\mathbf{F}_{\mathrm{bt}} + D_{\mathrm{bt}} + C = 0 \qquad (1)$$
$$\nabla.\mathbf{F}_{\mathrm{bc}} + D_{\mathrm{bc}} - C = 0 \qquad (2)$$

Where bt indicates the barotropic term and bc indicates the baroclinic terms, **F**=(*Fx*; *Fy*) are the fluxes in the x and y directions. Dissipation (D) is computed as the residual of the flux divergence and conversion (C) terms. The conversion term is identical in the barotropic and baroclinic equations; and it appears as a sink in the barotropic equation and a source in the baroclinic equation. It is defined as in Kelly and Nash (2010):

$$C = \nabla H . \overline{\mathbf{U}_{\mathrm{bt}} p_{\mathrm{bc}}}|_{z=H+\eta} \qquad [\mathrm{W/m^2}] \qquad (3)$$

Where $\mathbf{U} = (U,V)$ is the surface-tide velocity with components U and V along the x and y directions, p is the baroclinic pressure, the overbar indicates a tidal average, z = H defines the bottom, ∇H is the topographic gradient, and η is the surface elevation.

The propagation of barotropic and baroclinic tides are examined through the divergences of the barotropic ($\mathbf{F}_{\mathrm{bt}}$) and baroclinic ($\mathbf{F}_{\mathrm{bc}}$) energy flux defined as in Nagai and Hibiya (2015):

$$\nabla . \mathbf{F}_{\mathrm{bt}} = \nabla_h . \int_H^\eta \overline{\mathbf{U}_{\mathrm{bt}}\, p_{\mathrm{bt}}}\, dz \qquad [\mathrm{W/m^2}] \qquad (4)$$

$$\nabla . \mathbf{F}_{\mathrm{bc}} = \nabla_h . \int_H^\eta \overline{\mathbf{U}_{\mathrm{bc}}\, p_{\mathrm{bc}}}\, dz \qquad [\mathrm{W/m^2}] \qquad (5)$$

Where ∇_h is the horizontal divergence.

250 - Complex demodulation or a wavelet transform would be a better way to determine the incoherent fraction.

We agree that complex demodulation is well adapted to analyze the variability of internal tides. Because most of the diagnostics on tides are based on harmonic analysis we don't use a complex demodulation method. We use a similar methodology than Buijsman et al. (2017) or Kumar et al. (2019) that estimate the incoherent fraction as the difference between the band-passed and harmonic times series.

291 - cm^2/s^2 - please use SI convention cm^2 s^-2 or even better 0.2 m^2 s^-2 in this case
Fig 3 - Cm is incorrect, cm is correct. Use letter labels to identify panels.
Fig 4 - psu or S (psu) would be better.
What are the black contours?

Ok, the references have been corrected

Thanks, we have forgotten to mention the black contours in the reference. These contours are just here to highlight the 23.5 and 25.5 density level that characterize the upper thermocline layer.

323 - Looks to me more like a NE-SW propagation direction. Perhaps a section in that direction would be better.

Yes, the beam of internal tides is not purely meridional, and the sentence has been changed.

Old: "Because the internal tide propagates meridionally across the central Solomon.."

→

New: "Because the internal tide propagates mainly in the meridional direction across the central Solomon…"

May be it could be a little bit better to use a more complex section than just a meridional one crossing the Solomon Sea from the two generation sites. But we don't think it changes our messages. There are two Figures that illustrate this section. Figure 4 that is used to validate the mean model state and to illustrate the contrast between the two ENSO phases. For this purpose, the choice of the section is not so crucial. Figure 11 shows the meridional flux along the section. The purpose is to illustrate the contrast between El Nino and La Nina for the northward and southward flux inside the Solomon Sea. The last remark of the review is about this figure which shows a flux of same sign on both sides of the topography at Solomon strait. But the strait is large and to the north east there are seamounts (e.g. Fig. 1) and strong internal tide generation propagating on each side (e.g. Fig. 9). We suspect a northward flux to cross the section as suggested by the plot. So we choose to keep this section because we are not sure to find a more suitable section.

326 - CARS is nonstandard climatology. Please explain in methods/data section.
Ok, we add a paragraph on the method/data section

New: "2.2 CARS climatology
CARS is a global ocean climatology on a ½ degree grid of seasonal ocean water properties delivered by CSIRO (www.cmar.csiro.au/cars). CARS differs from other climatologies as it employs extra in-house quality control of input data, and the mapping algorithm uses an adaptive-length scale loess filter to maximize resolution in data-rich regions, and takes into account topographic barriers. The result is an improved definition of oceanic structures and more accurate point values (Dunn and Ridgway, 2002). The CARS climatology will be used to provide some model validation, given the short period of the simulation including two extreme events."

353- Upper ocean N^2 has been mentioned. What about deep N^2? Seems pretty similar and unlikely to affect generation?
Generation occurs mainly in the higher part of the ocean (where geometrical constriction due to topography will trigger the most significant vertical velocity/isopycnal displacements), allowing for changes in internal tide generation (magnitude, mode spectra) even with deep stratification being the same.

Fig 7 - Bathymetry source could be acknowledged or mentioned in the methods section. I does not have to be included in figures: "Isobathymetric lines are from the NOAA/ETOPO2v2 bathymetric file from the Smith & Sandwell database (doi:10.7289/V5J1012Q)"
We agree with you but it is a request of the editor
Fig 7 - I'm not sure a comparison to a nested model is that valuable. Validation with tide gauges or some other data source is better.
The model is forced only at its boundary with FES2014, so it is an essential step to ensure that inside the Solomon Sea the barotropic tide from the model looks like FES2014. It is not really a validation step.
What could be seen as a validation is the comparison of the baroclinic tide from the model with results from altimetry: the figure 8. But the variation of the results over two different periods prevents us from using this as a real validation.
There are very few in situ data available to validate the high frequency signal from the model. We present below some works using different in situ data sources that have been published in the Tchilibou's thesis (http://thesesups.ups-tlse.fr/4209/), but we don't include this work in the paper because we want a reasonable size for the paper, and this part does not bring new physical elements. We just add a sentence in section 2.2 to mention this work:
"Very few in situ data exist to validate the high frequency signal from the model. Some comparisons with tide gauges and a mooring at Solomon Strait present satisfactory results (e.g. Tchilibou, 2018a). "

We looked at the tide gauge located at Honiara during the common time period with the model (Fig. 1). The two SSH time series look alike very much despite a little bit lower standard deviation in the model compared to the tide gauge (16,47 cm and 17,19 cm, respectively) as shown by their SSH frequency spectra. Both spectra exhibit similar peaks at tidal frequency.

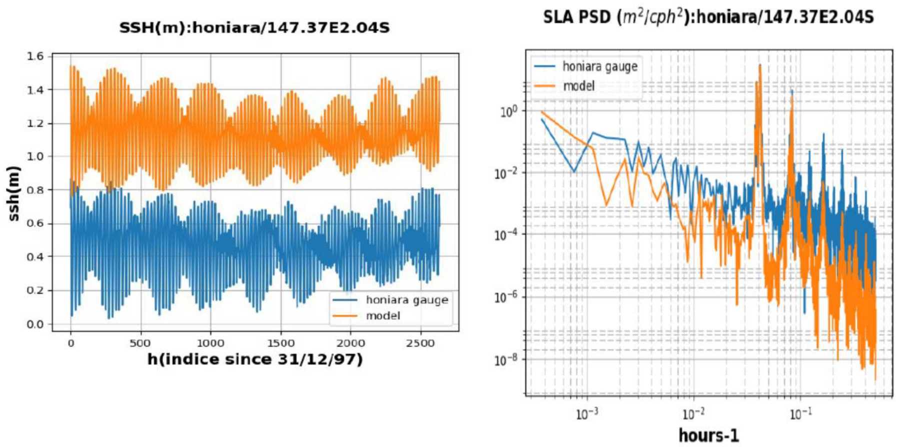

Figure1:Left) SSH time series at the location of the Honiara tide gauge for the model (orange) and the in situ data (blue). Right) the corresponding frequency spectra

Some moorings have been deployed/recovered in the Solomon Sea during the Pandora and MoorSpice cruises in 2013/2014. Only one mooring located at Solomon strait (5,14°S-154,3°E) can be used to infer internal tides. Despite different time periods between the model and the mooring, we can try to compare both. First, the frequency spectra of potential density in the thermocline layer look similar (Fig. 2). The semi diurnal frequency with the M2 component is the most energetic signal. The baroclinic energy flux estimated from the mooring clearly shows the dominance of mode 1 and a South West propagation in accordance with the model results (e.g. Fig 9, 10).

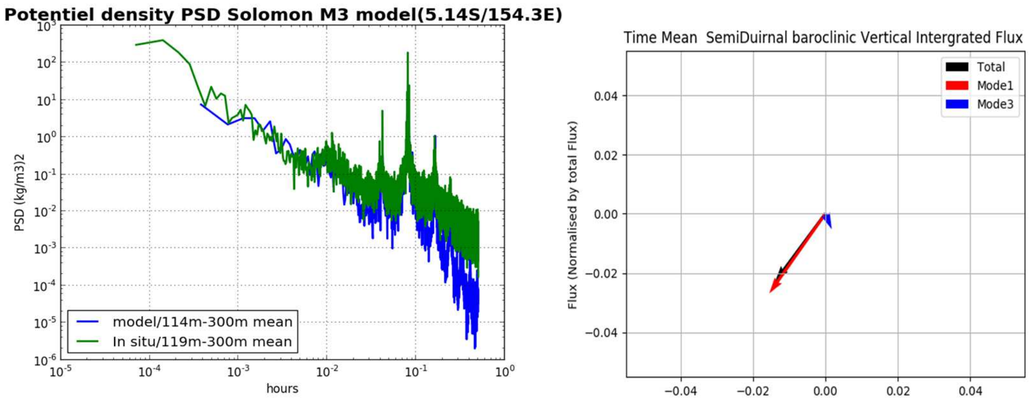

Figure 2: Left) Frequency spectra of the potential density in the thermocline layer at the mooring location at Solomon strait for the model (blue) and in situ data (green). Right) Estimation of the depth integrated M2 baroclinic energy flux from the in situ data (To be compared with model results in Fig. 10 of the paper.

388 - I don't understand this point about coherent SSH being used to correct altimtery. (1) Correct what? (2) Altimetry measures total SSH = coherent internal tides SSH + incoherent internal tides SSH + everything else. Or are you talking about correcting the M2 amplitude?

Yes, we are talking about a M2 amplitude correction in the altimetric data set including both the barotropic and the coherent baroclinic components.

We modify the sentence:

"we access only the coherent part of the internal tides that has the advantage to be predictable, and so provides a correction for altimetric measurements." →

"we access only the coherent part of the internal tide that has the advantage to be predictable, and can thus provide a SSH correction for altimetric measurements."

393 - Solomon Strait not Solomon strait. Also elsewhere.
Ok, we check

403- What is the surface displacement of a mode 1 tide of 10-m amplitude under the conditions in Fig 5? What do the modes for these conditions look like at the generation site? Is the mode-1 maximum aligned with topographic height in some way?
The reviewer addresses several questions on the modal decomposition at the generation sites under the contrasted El Nino/La Nina conditions, and the propagation of mode 1.
For this last point it is expected that mode1 propagate from its source orthogonally to the bathymetry. It is what we observe at Solomon strait by example: The bathymetry is oriented in the northeast/southwest direction (see Fig.1 of the paper) and the mode energy flux is observed to be southwestward (see the plot above).
For the other point, we have performed a modal decomposition of the density energy that is discussed below in 504, 670 and 697.

414 - strong flow is generally associated with high Reynolds number which is generally more turbulent and not more laminar: : :? Perhaps you want to rephrase in terms of mesoscale eddy activity.
Yes, we agree that the sentence needs to be rewritten
Old: "During El Niño, when the LLWBCs are strong and the flow relatively laminar, the coherent baroclinic tides explains 67% of the variance of the full internal tides, and only 50% during La Niña when mesoscale is strongly active."
→
New: "During El Niño, when the LLWBCs are strong and stable and dominate the circulation, the coherent baroclinic tides explains 67% of the variance of the full internal tides. Whereas during La Niña, when the mesoscale activity is stronger because of the interactions between the LLWBCs and the SSI, only 50% of the baroclinic tide is coherent."

Fig 9 - units need a space kW[space]mˆ-1 for example
Done

435 - Do Zhao et al have altimetric fluxes in this area? How do they compare to the model? I believe Zhao now uses modes 1 and 2 in his calculations.
Yes, Zhao's results (2016, 2018) should be valuable sources of information. In this paper, we have used Ray and Zaron's results to compare to the model. It could be a good opportunity to look at Zhao's dataset. We will try to do that in the next time.

470 - doubles is not accurate
Ok, the text has been modified
Old: "The baroclinic flux radiating out of the box doubles during El Niño (1.27 GW against 0.75 GW strait during La Niña)"
→
New: "The baroclinic flux radiating out of the box increases during El Niño (1.27 GW against 0.75 GW strait during La Niña)"

479 - The overall difference in internal tide energy and dissipation between the 2 states is established nicely. The explanation though is not so clear.
This remark was also done by reviewer 2.
We have rewritten this summary, and hopefully it is now clearer:

Old: “In summary, there are three areas where a large part of the barotropic flux energy is converted into baroclinic energy (63 to 79%), and a considerable fraction of the excited baroclinic energy is dissipated locally (46 to 80%). The two main generation sites radiating baroclinic tidal energy into the Solomon Sea are at Solomon strait and at the Southeast extremity of PNG. The generation box at Solomon strait radiates most of the baroclinic energy, especially during the La Ni.a state with a 27% increase of the energy flux compared to El Ni.o. There is a strong modification of the circulation at this site between the two periods, since the strong northward LLWBC current exiting the Solomon Sea during El Ni.o is replaced by the southward SSI current during the La Ni.a period that favors the advection of the tidal baroclinic energy inside the Solomon Sea. Most of this baroclinic energy is dissipated in the northern Solomon Sea as illustrated by Figure 9f, showing higher dissipation in the northern Solomon Sea during La Ni.a compared to El Ni.o. Indeed, the higher EKE level during La Ni.a than during El Ni.o (Fig. 2) favors stronger interactions between eddies and internal tides. This appears to render the internal tide more incoherent (e.g. Fig. 3gh) and to increase the tidal dissipation. The impact of ENSO is particularly visible at the southern Solomon Sea with a 70% increase of the baroclinic flux radiating away from this generation site during El Ni.o compared to the La Ni.a period. The EKE is strongest in this area duringLa Ni.a with higher dissipation and in consequence, there is a lower baroclinic energy flux radiating away.”

→

New: “In summary, there are three areas where a large part of the barotropic flux energy is converted into baroclinic energy (63 to 79%). Most of the excited baroclinic energy is dissipated locally (46 to 80%), and only two generation sites at Solomon Strait and at the Southeast extremity of PNG radiate significant baroclinic tidal energy into the Solomon Sea.

Solomon Strait radiates most of the baroclinic energy into the Solomon Sea, especially during the La Niña state with a 27% increase of the energy flux compared to El Niño. Most of this baroclinic energy is dissipated in the northern Solomon Sea as illustrated by Figure 9f, with higher dissipation here during La Niña compared to El Niño. This is likely to be impacted by the contrasted circulation and mesoscale activity in this area between the El Niño and La Niña periods. The strong northward LLWBC current exiting the Solomon Sea during El Niño is replaced by the southward SSI current during the La Niña period (see Fig. 2) that favors the advection of the tidal baroclinic energy inside the Solomon Sea. Also, the higher EKE level during La Niña than during El Niño (Fig. 2) favors stronger interactions between eddies and internal tides. This appears to render the internal tide more incoherent (e.g. Fig. 3gh) and to increase the tidal dissipation (Fig. 9f).

At the Southeast extremity of PNG (Fig. 9f, blue) crossed by the strong NGCU the tidal baroclinic energy exhibits no contrasted situations between the two ENSO phases.”

504 - “One explanation for such a difference is the change in stratification between the two ENSO states, with stratification closer to the surface during El Niño that favors the excitation of higher order modes (Fig. 5).” This explanation is a little vague. You have calculated the various source and sink terms. Which ones does it affect? Once you have determined that, which quantity is affected p’ or u’ or something else? And by what? Eddies, changes instratification, changes in currents, etc? See: Zilberman et al (2011) doi: 10.1175/JPO-D-10-05009.1âˇA´l

The analysis is limited to the main terms of the energy equations and the respective contribution of the two first modes. It is beyond the scope of this paper to go too much further on the analysis of each terms. As suggested in the next remark, energy density is a helpful scalar to look at the contribution of the modes. We present below the energy density for mode 1 and mode 2 during El Nino and La Nina. We retrieve the result of the paper based on the energy flux that is the dominance of mode 1 inside the Solomon Sea, but also a clear mode 2 propagation during El Nino not visible during La Nina. The difference in mode 2 during El Nino compared to La Nina is mainly the contribution of kinetic energy (KE) and not of potential energy (PE). The large scale condition during El Nino with a stratification close to the surface could favor the propagation of energy by higher modes.

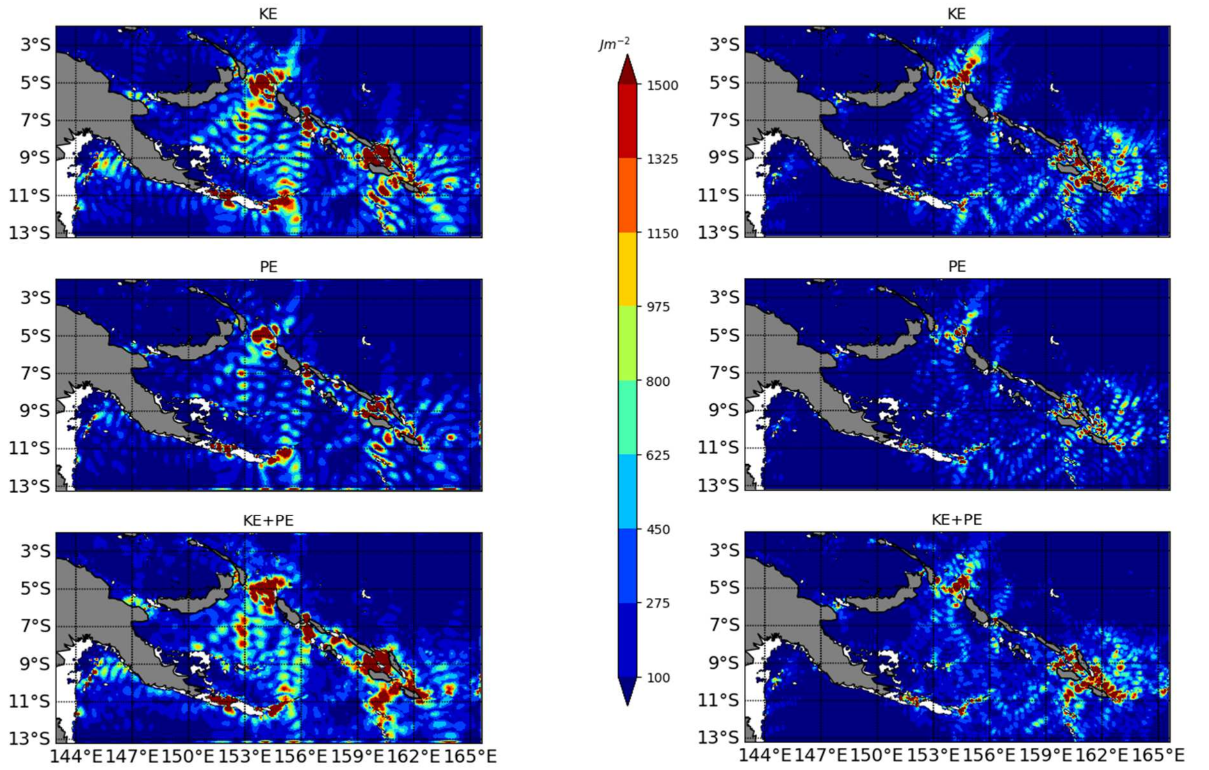

Figure 3: Energy density and the respective contribution of KE and APE during El Nino priod for left) mode 1 and right) mode 2.

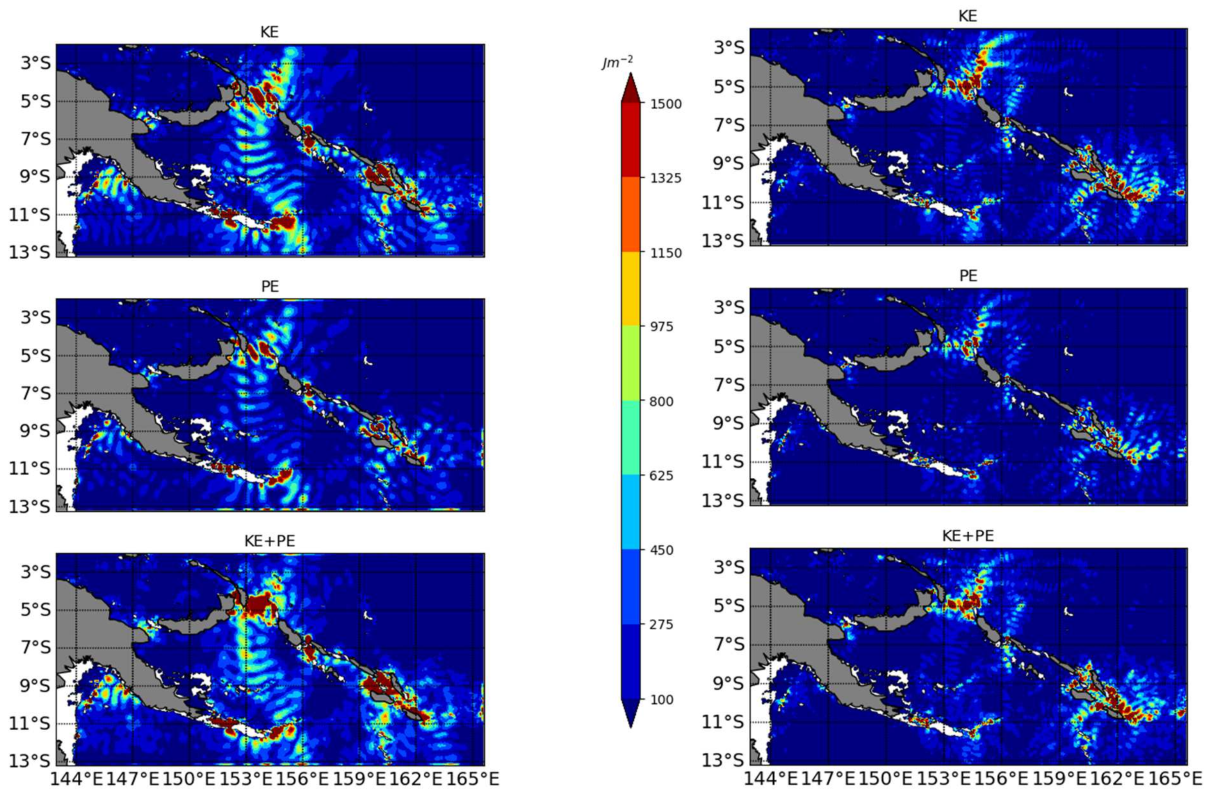

Figure 4: Energy density and the respective contribution of KE and APE during La Nina priod for left) mode 1 and right) mode 2.

670 - This describes energy flux. If you wish to better see the contribution by higher modes, energy density is a helpful scalar. Flux = Energy x c. Fluxes emphasize mode1 because c_1 is about 2 x c_2.

Fluxes near the source regions may be confusinge. g., 2 oppositely directed fluxes give flux = 0 even though there is plenty of energy.

Yes, the discussion is on energy flux. We agree that energy density is well suited to discuss on high modes. This is of particular interest near the source regions where most the energy of the high modes is supposed to locally dissipated. We show above the figures for the modal partition of energy density for modes 1 and 2 during El Nino and La Nina conditions. But we chose not to add this figure in the paper because it doesn't bring new information with regard to Figure 10 (which has been improved to be more readable). Compared to La Nina, we clearly the propagation of mode 2 inside the Solomon Sea during El Nino.

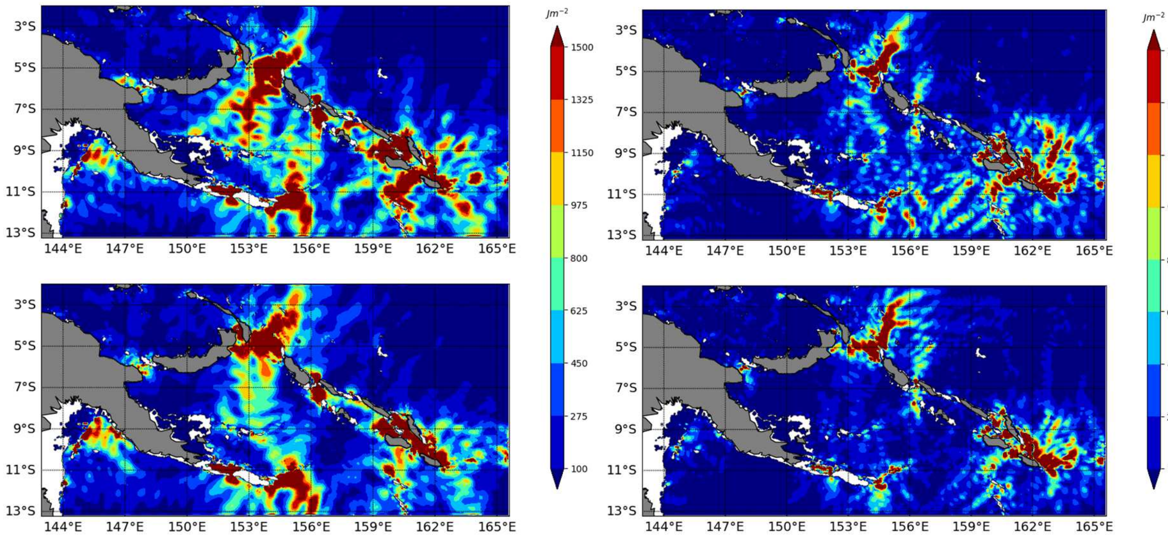

Figure: Energy density maps for mode 1 (left) and mode 2 (right) during El Nino (top) and La Nina (bottom) conditions.

697 - *It's noted that local dissipation is considerable, while for other topography (Hawaii) very little energy is dissipated. Even in the Solomon Sea area there are some ridges that are dissipative and others that are far less dissipative. Explanation is not really provided as to why.*

The low modes (especially the first one) show stronger far propagation capabilities. Also interaction of internal tides with local topography conditions (especially for higher modes as their horizontal scales are much shorter) will modulate the rate of energy that will be dissipated near generation location, and symmetrically the rate of energy available for far propagation. Depending on the topographic features, most of baroclinic energy propagate (low modes) or is locally dissipated (high modes) from the generation sites. By example, Hawaii is the location where internal tides energy propagates far away from the source, whereas the mid-Atlantic ridge is more favorable for local dissipation of the internal tides (Vic et al., 2018). Such variations are function of different parameters such as the ratio of the topographic slope to the slope of the internal characteristic, the Froud Number (Legg et al., 2008)… We don't investigate this point in the paper because it is far from the main motivation of the paper that is to illustrate internal tides in two contrasted ENSO conditions.

736 - *Kida & Wijffels (2012) doi: 10.1029/2012JC008162 also note surface cooling in the Maritime Continent on a fortnightly cycle.*

Yes, we add this reference

Fig 11- *I'm not sure this makes sense. Flux is of the same sign on both sides of the topography. Either the figure does not go deep enough or the meridional direction is not really suitable to show what the authors intend. Perhaps a more NE orientation? Or deeper coverage?*

This comment looks like the comment at l.323. See the corresponding response.