Response to reviewers

Anonymous Referee #1

[Referee] This manuscript discusses nitrous oxide in the ETSP and the impact that El Nino has on this important trace gas. The authors have a lot of experience on this topic and consequently a high quality is expected of this manuscript. At the moment, this manuscript needs improving in a number of areas that are outlined below.

[Referee] The biggest technical issue with this manuscript is that it covers two topics. The first topic is an overall expedition report from 2015 including measurements of N2O concentrations, fluxes, inventories, and isotopes. The second topic is an evaluation on the impact that El Nino has on N_2O dynamics which necessitates an in-depth comparison of previous datasets. Both of these topics are very worthy of publication and the authors have the intellect and experience to document the new insights and perspectives gained from both topics. However, at the moment, I feel that 75% of the manuscript is about the 2015 expedition and 25% is about an analysis of the effects of El Nino on N_2O. For example, the comparison between 2015 and previous years is limited to the final section of the discussion. This is not consistent with the title of the manuscript which indicates to a reader that a more in-depth comparison will be provided. It's up to the authors whether they address this by providing a greater comparison with El Nino years or whether they save this for a later manuscript.

[Response] We agree with the reviewer that the manuscript has two major components: an overall expedition report and a comparative study of El Nino effects on N2O dynamics. We think the two are closely interlinked and cannot be separated into two topics or even two manuscripts. We disagree with the reviewer's point about "75% of the manuscript is about the 2015 expedition and 25% is about an analysis of the effects of El Nino on N_2O"; it is necessary to first introduce methods and dataset (N2O isotopes, substrates availabilities and temporal dynamics), then move on to comprehensive presentation of the effects of El Nino on N2O dynamics, which is in line with the title. The current dataset suggests that change of water column physical structure explains the N2O depth distribution and flux dynamics during a strong El Nino event. We also observed, for the first time, higher water column N2O inventory during El Nino. We will improve the clarity of the manuscript, e.g. describing the main contents of the manuscript in the last paragraph of the Introduction section, so readers can navigate the manuscript more easily.

[Referee] Another issue that I would like the authors to deal with is the absence of precision and accuracy values. The authors state that triplicate samples were collected, but no error bars are present on the vertical profiles and no values of analytical precision are provided. This is a problem when trying to compare measurements from separate years.

[Response] Good point. The typical analytical precision of N2O concentration measurement during 2015 cruise is < 2 nmol/L; and the precision from previous cruises were generally < 5%, which we will add onto the figures in the revised manuscript. The precision of our measurements are lower than El Nino variability and we think the conclusion of higher water column N2O inventories during El Nino will hold.

Specific comments

[Referee] Line 16 – what region

[Response] This region refers to the Eastern Tropical South Pacific (ETSP)

[Referee] Line 17. This sentence need re-writing

[Response] We rewrite the sentence as follows: "In October 2015, a strong El Niño event was developing in the ETSP; we conduct field observation to investigate (1) the N2O production pathways and (2) the effects of El Niño on water column N2O distributions and fluxes using data from previous non-El Niño years."

[Referee] Line 18. I am not sure why you include this single summary sentence when in the discussion you highlight four water parcels with different pathways.
[Response] We included this sentence because we want to highlight that both nitrification and denitrification are contributing N2O production in the near surface waters, which contribute to effluxes to the atmosphere.

[Referee] Line 20 level of sea surface N2O supersaturation. I understand what you mean, but a quick glance indicates you are talking about sea levels.
[Response] We rewrite the sentence as follows: "Higher than normal sea surface temperatures were associated with a deepening of the oxycline. Within the shelf region, surface N2O supersaturation was nearly an order of magnitude lower than those of non-El Niño years."

[Referee] Line 25 Depth-integrated concentrations, change to water-column inventories?
[Response] Yes. We rewrite part of the sentence as follows: "Water-column inventories of N2O within the top 1000 m were 0 – 160% higher than those measured in non-El Niño years,"

page 2
[Referee] Line 1 This sentence is a lazy description of El Nino, La Nina, and neutral. A schematic diagram would be great here to orientate the reader
[Response] This sentence points out the most contrasting feature of El Nino vs. La Nina events, and we don't think a schematic diagram is needed.

[Referee] Line 15, But what was the results of the modeling? Higher or lower nitrous oxide? Do your observations match the modeled predictions? An evaluation of El Nino on N2O would benefit greatly from the use of model predictions and I am not sure why the authors did not leverage this information better
[Response] The modelling studies showed lower water column denitrification (Yang et al., 2017, GBC) and higher nitrification, lower N2O fluxes (Mogollón and Calil, 2017) during El Nino. The citation of Carrasco et al. is a typo. We will briefly introduce these model results in the revised text.

Page 3
[Referee] Line 10 Here you say ODZ (and do not spell out), while on the previous page you say OMZ
[Response] The ODZ refers to 'oxygen deficient zone', which is defined as dissolved < 5 micromoles per liter. We added the full name in the revised manuscript.

[Referee] Line 15-18. The method needs to contain values of analytical precision and accuracy. This is particularly important for this study as you are comparing data from separate cruises, conducted several years apart. For example, Figure 8 does not have any error bars and how is the reader supposed to make an informed decision about differences between the separate expeditions.
[Response] Good point. The analytical precision of N2O concentration measurement is < 2 nmol/L, and we will add the error bars for 2015 data on Figure 8. The precision of previous dataset was generally < 5%. The precision of the measurements are lower than El Nino

variability and we think the conclusion of higher water column N2O inventories during El Nino will hold.

Page 5.

[Referee] Line 15 Why are concentrations reported moles per liter rather than moles per kg?

[Response] We chose to report all the concentrations in moles per liter because of consistency within this manuscript, and with earlier dataset that employed the same unit.

[Referee] Line 23 This should be in the methods section, close to Equation 1, which is the equivalent calculation for N2O

[Response] Indeed. We will rework the sentence at the revised manuscript.

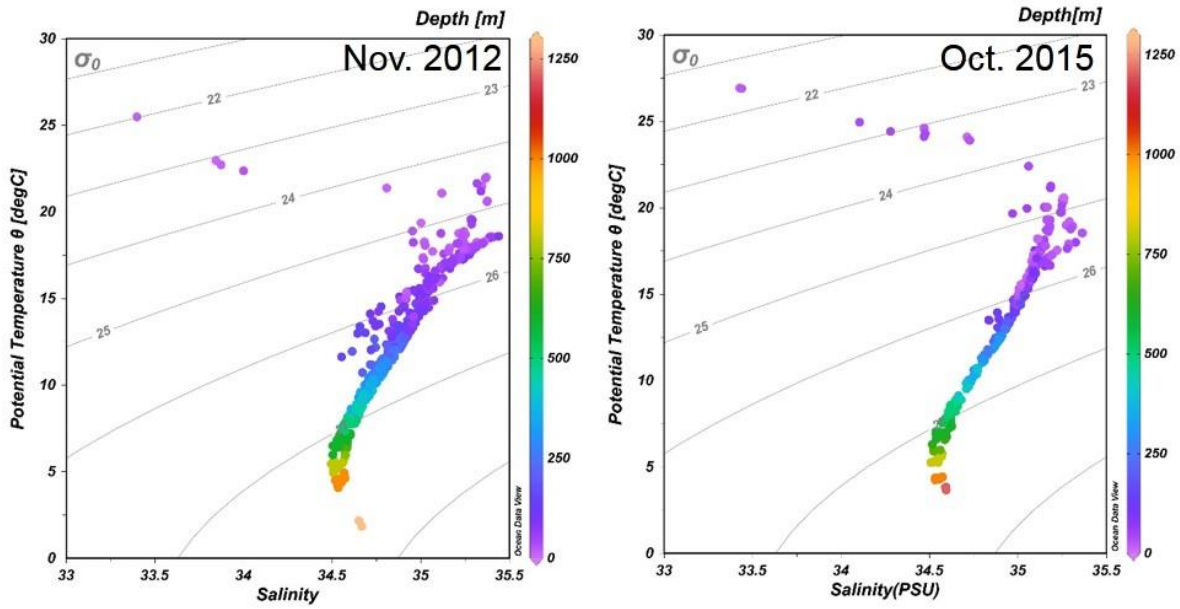
[Referee] Figure 1. Its not clear to me why you do not show the El Nino index against time and indicate along the timeline when the cruises were conducted. This would be easier to read that the current figure?

[Response] It is a good suggestion. We tried to plot as the reviewer suggested, and realized there was a large gap between 1985 and 2009 with no cruise being conducted. We think the current presentation is informative because it clearly shows the contrasting feature of 2015 El Nino comparing to the rest of periods.

[Referee] Figure 2a is an anomaly yet Figure 2b isn't. If you wanted to compare 2015 with other years you should show how the water masses vary with El Nino.

[Response] We compared the T-S diagram between Oct. 2015 and Nov. 2012; the main difference was shallow water was warmer in Oct. 2015. Below the thermocline, water masses are apparently similar. We will add a panel to Figure 2 in the revised text.

Figure T-S diagram of November 2012 (left) and October 2015 (right)



[Referee] Figure 3. This Figure needs improving.
1 The units should be in moles per kg.
2. I am not sure you need to show depths of 500-1000 m since this takes up half the plot and is not discussed much in the text.
3. Please highlight the stations better.
4. I suggest you start other programs to make contour plots in the future (e.g. R) as the ODV palette is not helpful for highlight the data trends that you have here.
[Response] To be consistent with previous measurements, we will keep the unit, mole per liter for chemical constituents. We will keep the offshore data from 0 – 1000 m because the El Nino effect is thought to occur in the upper 1000m, and the discussion (Figure 7 and 8) compared the top 1000 m of water column properties.

[Referee] Figure 4. I cannot see the individual points in the offshore stations so it's hard to determine the extrapolation that has been applied
[Response] We'll increase the contrast of the data points in the revised manuscript.

[Referee] Figure 5. I am not sure this Figure adds value. Figure 5A and Figure5b are very similar to Figure 4a and 4e (identical patterns, just different units. Figure 5c takes up a lot of space and only the bottom right hand section of the chart has any useful data.
[Response] Figure 5 shows N2O excess and associated surface fluxes. From there we can see that although surfaces fluxes are low, water column is still oversaturated with N2O, suggesting change of hydrography. Our feeling is that it will be more confusing for the readers not to show Figure 5.

[Referee] Figure 6. You should connect this figure to the water masses identified in Table 1
[Response] Good point. Some water masses (oxycline and offshore > 500 m samples) are identified in Table 1. We will add some clarifying sentences in section 4.2.

[Referee] Figure 8. With no error bars, it is not possible for the reader to know when there is a statistical difference between two depth profiles. On Page 3, Line 13 you say that triplicate measurements were taken, so they should be included.
[Response] Good point. The analytical precision of N2O concentration measurement is < 2 nmol/L, and we will add the error bars for 2015 data on the plot. The precision of previous dataset was generally < 5%.

[Referee] Table 1. This Table needs improving. 1. Please number the water parcels so they can be easily cross-referenced with the text. 2. Please report depth, O2, and nitrite concentrations for all four identified water parcels. 3. There is no column heading for the third column. 4 What is produced N2O?
[Response] We will number the water parcels so that readers can cross-reference in the text. We will report depth, oxygen and nitrite concentrations for all water parcels. The heading of third column should be "statistical properties". The term "Produced N2O" is defined in the first paragraph of section 4.1, as "isotopic signature of N2O produced within the water mass".