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Interactive comment on "Radium-228-derived ocean mixing and trace element inputs in the South Atlantic" *by* Yu-Te Hsieh et al.

Anonymous Referee #2

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General Comments The scientific quality of this paper is very good and the quantitative results seem both robust and oceanographically consistent. The calculations and argument are concise and the purpose of the paper is very clear. The comparison of different methods used for radium calculations is useful and provides confidence in the results. However, it seems like the radium side of the paper is significantly more developed than the trace metal side. A little more context and detail could be given to the scientific significance of calculating trace element inputs, and more discussion given to the implications of the calculated trace metal fluxes. Also, the methods of the trace metal calculations, which are an integral part of the paper and several sentences of the abstract, could be moved from the appendix to the main body of the paper. One calculation, the Co/C, Fe/C, and Zn/C export fluxes are noted for being significantly

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higher than corresponding dissolved inputs. This could be due to the use of laboratory culture metal quota values that were grown under replete conditions. As noted in the paper this region and section has some of the lowest Zn values observed in the euphotic zone from the prior study. Moreover, phytoplankton (and microbes in general) have extraordinary plasticity with respect to metal content, and the lower field and lab scarcity cultures are likely considerably more representative. It would be useful to redo these calculations with metal-carbon values that are more realistic, either using culture studies of phytoplankton grown under scarce rather than replete conditions (e.g. from the relevant Sunda and Huntsman studies) or using particulate metal data from other field expeditions if that data is not available from this section. This would probably help resolve the imbalance in the fluxes compared to the other fluxes calculated and would be more correct in construction of the calculations.

Specific Comments Introduction: Why are we interested in a calculation of Co, Zn, and Fe flux? Why those elements and not others? Please give more context for trace metals in this region, and the significance of the calculations presented here.

Line 40: Define which metals you'll be talking about (Fe, Zn, Co) here, or at least within the first few paragraphs of the introduction, and why they're important in this region.

Lines 83-91: This paragraph should be moved out of the methods section to the introduction or to the results, perhaps as a "hydrographic setting" section in the beginning of the results.

Line 94, 104: Define your trace metal clean technique in more detail. What acids were used and for how long?

Lines 142-5: Useful analysis of the two methods' uncertainty and error differences. I suggest also performing a pairwise t-test to compare the 226Ra data generated from direct observation and from the Si estimation to determine if the two methods are statistically similar, even with the larger error on the estimated method. This would help convince readers that the methods are comparable.

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Line 195: Include sections in the methods to clearly describe how Kz was calculated and the vertical flux of trace metals. They are critical results in your paper and are given prominence in your title and abstract, and their methods should not be buried in your appendix. Perhaps an abbreviated description of the appendix D calculations can be described in the methods, and the full version can be in the appendix.

Lines 211-4: Make this point clearer. You imply but don't clearly state that your results are more similar to Atlantic values than Southern Ocean values. That is an interesting result in this transition zone and should be made more explicit.

Lines 215-22: Expand more on this entire section and convey a more detailed picture of TE distributions in this region. Even if the data has been described elsewhere, this section is too short. Additionally, both Fe and Co do not typically continue to "increase with depth below the mixed layer" because they're scavenged-type elements. Fig. 4 implies that all 3 trace elements increase linearly with depth, which is not necessarily the case beyond the mesopelagic. Give more context to the distribution of all three trace metals here, and qualify that the TEs (specifically Fe and Co) only increase with depth in the upper ocean.

Lines 261-7: Move the description of the Kz calculation to the methods and include the explicit equation for its calculation.

Line 298: As already stated, move at least a brief description of the calculation to the methods section.

Line 317: Briefly expand on low oxygen resulting in higher Co fluxes and provide a citation.

Lines 322-5: Discuss your findings more than just comparing them to other fluxes. Why do you think they are lower than the other reported Fe fluxes you cite?

Lines 327-30: Same as the above comment for Fe. Why do you think this region has a lower Zn flux? Was this expected?

Lines 341-3: This paragraph seems out of place. Either expand on why you're reporting aerosol data and give context for the fluxes (how they compare to the vertical TE fluxes, etc.) or simply move these two sentences to section 4.4 where the numbers are used.

Lines 361-72: Specify which of these 3 hypotheses are supported by your results. It sounds like the particles might be a good answer, but it's only mentioned briefly. Expand a bit on what you think is likely going on.

Figure 3 (lines 745-750) The correlations of metals with salinity is very interesting and worth emphasizing a bit more. Similar observations have been observed on the North American shelf as well observed by Bruland and Franks 1984 and Noble et al. 2017. It could be worthwhile to point out that these observations suggest this is a general feature of Atlantic Western boundaries.

Bruland, K. W., & Franks, R. P. (1983). Mn, Ni, Cu, Zn and Cd in the western North Atlantic. In Trace metals in sea water (pp. 395-414). Springer, Boston, MA.

Noble, A. E., Ohnemus, D. C., Hawco, N. J., Lam, P. J., & Saito, M. A. (2017). Coastal sources, sinks and strong organic complexation of dissolved cobalt within the US North Atlantic GEOTRACES transect GA03. Biogeosciences, 14(11).

Technical Comments

General: Keep formatting choices consistent. Both 1-D and 1D are used to describe the model, and spaces are inconsistently placed between a number value and its unit. (ex. line 140 uses 100L-1 and line 141 uses 100 L-1.)

General: Are significant figures to tens of pM for dCo correct?

Line 102: Define RaDeCC here. It is defined later on line 111, and should be defined at the first use of the abbreviation.

Line 114: Define MC-ICP-MS here.

Lines 116-7: Briefly clarify why it is necessary to convert from Sr(Ra)SO4 to

Sr(Ra)CO3.

Line 119: Briefly describe what AG50-X8 and Sr-Spec are. You describe them as ion exchange columns on line 122, but that should be made clearer when they're first mentioned.

Lines 126-7: This sentence was already stated on line 114, but without mention of 226Ra. Are you restating the analyses used, or is this a different method? It is not clear.

Line 127: Change Ra-228 to 228Ra to be consistent with the rest of the paper.

Lines 138-40: This is a run on sentence despite the use of parentheses. I suggest removing the parentheses and forming two separate sentences.

Line 199: "show" not "shows".

Line 253: Use a period or semicolon between "waters" and "therefore" to avoid the run on sentence.

Line 283: Figure 7 only shows depth, not sigma-t as this line states. Rephrase this sentence or relabel the figure to show the density ranges instead of depths.

Line 297: Is the shelf 228fluxes point a fourth part of this list, or is it a separate point from the 3 approaches list? If it's part of the list, label it as (4). If it's a separate point, put it in its own sentence.

Lines 309-10: Confusing sentence – nothing is being compared here. Rephrase.

Figures: The figures here do a good job of supporting the data and conclusion of the work, but they should be edited for readability. In general, do not rely on color coded axes to label subplots (especially for colorblind people), and include axis labels with units clearly next to the axis number scale. Avoid breaking up the axis label and the axis unit. Also, consider putting some of the regression equations in a table or in the appendix, particularly if they're not referenced in the text.

Fig 1: The stations numbers are crammed into the top plot b and are mostly illegible. The Salinity z-axis label is also in a strange location. I suggest leaving more space between plots a and b to include this information above figure b.

Fig 4: Add y-axis labels for depth. Also, the x-axis labels are difficult to find. Is there a way to make the metal label clearer for each row?

Fig 6: The x-axis labels for the top row of plots are not very readable here. The 228Ra label should be next to its units and ideally should be above the axis like the labels for the bottom row of plots. The subtle color coding for sigma-t and T is also confusing.

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