

Ocean Sci. Discuss., referee comment RC1
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Comment on os-2021-94

Anonymous Referee #1

Referee comment on "Passive tracer advection in the equatorial Pacific region: statistics, correlations and a model of fractional Brownian motion" by Imre M. János et al., Ocean Sci. Discuss., <https://doi.org/10.5194/os-2021-94-RC1>, 2021

Review of Janosi et al., "Passive tracer advection in the equatorial Pacific region: statistics, correlations, and a model of fractional Brownian motion", submitted to OS.

Using satellite-derived geostrophic velocity data, this study focuses on the westward surface currents close to the equator in the Pacific. Conducting a Lagrangian tracer analysis of particles released in the eastern equatorial Pacific, the authors confirm the general westward drift of particles and its lagged correlation to the El Niño-Southern Oscillation. The authors further show that the diffusive advection process can be mapped into a fractional Brownian motion model which well reproduces the statistical behaviour of the particle trajectories.

With the application of a statistical model, the authors make an interesting effort to investigate the westward motion of water parcels in the equatorial Pacific from an exceptional viewpoint. However, I cannot see how the study as a whole contributes to an enhanced knowledge of the tropical Pacific. The results presented are largely known and what is new is not put into context with the literature. In its current version, I therefore have to recommend to reject this manuscript.

General comments:

1. It is not entirely clear to me what the aim of this study is. The first part is largely a repetition of known results. The application of the statistical model in the second part leaves open the question what the benefit is. It is very important to make clear what the intention and also the significance of entire study is for the research community.

2. What is the benefit of using a fractional Brownian motion model in this context? Can this be applied elsewhere? What conditions have to be fulfilled for the mathematical model to be applied?

3. As vertical advection is not taken into account, I wonder what effect this would have on the results. How would a third dimension alter the fBm-model?

4. As far as I understand, eventually the results show that the westward currents on the equator (SEC and NEC) include an advective term and a diffusive term (super diffusion). This alone is not new. What would be interesting is to have a quantitative measure of the percentage that diffusion contributes to the overall westward advection. Would this be feasible with the applied methodologies?

5. The Northern and Southern advection indices show a largely coherent behaviour in all figures. What is the overall benefit of sub-dividing the trajectories into these two categories?

Specific comments:

Abstract: Some more information about the tracer experiments would be helpful for the reader, e.g., where are the particles released and what is the depth range of interest here.

lines 39-40: The resolution of numerical ocean models can vary substantially, ranging from 2° to $1/20^\circ$ degrees or even higher. The standard resolution of global OGCMs is 1° , thus AVISO has in general a higher resolution, not lower.

lines 40-41: It is unclear which model the authors refer to here. Any ocean model? The km-scale resolution also strongly depends on the latitude of interest. Resolving 3-9 km in the tropics requires a nominally finer grid than resolving 3-9 km in the Mediterranean sea. Please be more specific here.

lines 56-57: As for the abstract, it should be made clear that the focus here is solely on the surface, and thus the particles are traced in 2-D.

lines 60-62: Instead of repeating what is already stated in the figure caption, it would be nice to explain the difference between the two panels in Fig. 1, i.e., the effect of the weakened trade winds during El Niño impacting the surface currents on the equator.

line 64: "from an initial meridional line at the middle of Pacific, north to the equator". Is it unclear to me what this exactly means. Please rephrase.

line 65: I assume this sentence refers to the study by Webb et al., not this one?

lines 72-73: It would be nice to motivate this sentence.

line 73: Using "ensemble mean" and "total mean" might be misleading here. Is there a sub-ensemble of all trajectories? I would assume the mean is in both cases taken over all trajectories. In this case, it would be clearer to refer to the "ensemble mean westward distance" and the "ensemble mean total trajectory length".

Eq.2: Not sure if this equation is really needed as it is widely known.

lines 89-95: This sounds very similar to the classical bootstrapping method. Is there a difference? Otherwise, mentioning the term known "bootstrapping" may help the reader better understand the explanation given in the text.

line 122-128: It seems too early to already talk about limitations of the study before even showing some results. E.g., the sentence "the eastern basin dominates in the statistics" does not really say anything without knowing of any specific numbers and figures.

Also, in terms of the limitations mentioned and the comparison to drifting buoys, to me it seems like this really depends on the aim of the study. At this point, it is still not entirely clear to me what the aim of this study is. Is it to analyse the underlying physical context of the equatorial Pacific current system? Or else, is it to use this region as a test case to later apply the fBm-model?

Fig. 29: The coincidence between the two indices is remarkable and interesting. It is not really obvious from Fig. 1, where the meridional component is also clearly visible. I am wondering if it is in fact the difference in the mean of the indices that indicates the measure of pure zonal advection? However, by standardizing the time series the mean is not considered anymore. For my personal understanding, I would be very interested in a figure with the non-standardized raw time series of AdI1 and AdI2.

Apart from that, another question: Are parcels with an initial eastward component excluded from the analysis of the trajectories?

line 131: No need for brackets here. However, I would rather expect this sentence in the methods section.

lines 135-136: Isn't this "decoupling" just a consequence of the shifting ITCZ which is located at 5°N in the mean? What would the indices look like if the NH and SH subsets were splitted at the ITCZ instead of the geographical equator? The coincidence would probably be much higher.

lines 137-140: The correlation plot also confirms that the seasons do not play a major role in the tropics, otherwise the 6-month lagged correlation would be the dominant peak.

lines 140-141: Is there an expectation that they should follow the periodicity of one calendar year? If yes, what is the reason they do not? Please explain.

Fig. 6: I do not think this figure is necessary as this is widely known and the according statement in

the text (lines 146-147) does not need to be supported by an extra figure.

lines 149-156: While this might be an interesting side note for an ENSO review paper, this entire paragraph outlining the historic evolution of the discovery of ENSO does not belong into a research paper.

lines 158-163: I agree that the physics behind the time lag might not be trivial, however, it is quite well known that the subtropical cells (STCs) are very closely connected to interannual changes in equatorial Pacific SST, i.e. ENSO. The advection indices of this study are essentially representing the North and South Equatorial currents (NEC and SEC) which can be seen as a part of the overturning circulation. Various studies have dealt with the relationship between the different branches of the STCs and ENSO (e.g., Izumo 2005, Capotondi et al. 2005). Representatively citing Izumo 2005, the findings basically provide the following picture:

“The variations of all the branches of the cells are strongly correlated to ENSO (a slowdown during El Niño events and a strengthening during La Niña events). For an El Niño event (and conversely during a La Niña event), anomalous westerly zonal wind at 5°N (i.e., a decrease of the usual easterlies) cause a decrease in poleward Ekman meridional transport, leading chronologically to decreases in surface divergence, SEC, equatorial upwelling, and finally in EUC and in geostrophic meridional transports, thus in pycnocline convergence. These mass transport decreases strongly affect the heat balance and cause later an increase in SST of the eastern Pacific.”

I am surprised that the authors find the SST to lead the advection indices which contradicts previous findings (e.g., as stated above). Might there be a sign error in the calculation? Or is this in fact an expression of the baroclinic adjustment through westward propagating Rossby waves?

Fig. 8: I'm a bit confused by the x-label. Does the plot show MSD or time averaged MSD (TAMSD), as explained in the methods section? Also, I thought MSD already includes the ensemble mean, so what does EAMSD mean then (this also applies to Fig. 9)? Please explain.

Fig. 10: The same colours should be used for the different longitudes in both panels. Also, there is no need to use different symbols.

line 205: The estimated diffusion coefficients of $k_H=5,800 \text{ m}^2/\text{s}$ (SH) and $k_H=11,600 \text{ m}^2/\text{s}$ (NH) are one to two orders of magnitude larger than typical diffusion coefficients used in OGCMs which range roughly from $10 \text{ m}^2/\text{s}$ to several hundreds m^2/s . Do these results suggest that the horizontal diffusion is highly underestimated in models? Could the methodology presented here be used to better estimate diffusion coefficients globally that can then be applied to ocean models?

lines 226-227: How do the authors come to the conclusion that the drift is slower than the diffusion? Please explain.

lines 237-238: Is the super-diffusive character not just a consequence of the underlying strong westward drift of the particles? Or has this drift been removed before computing the statistics (I did not notice anything like this in the text)?

Technical points:

line 3: missing article: ...the equatorial Pacific...

line 4: Typo: 20S

line 21: Typo: ...flow fields...

line 126: Typo: ...starting...

line 174: Typo: remove one "the".

line 212: "Actually" not needed.

line 216: "Actually" not needed.

Line 232: Typo: ...Pacific...