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Nonlinear Processes in Geophysics
Discussions

Interactive comment on "Modeling the dynamical sinking of biogenic particles in oceanic flow" *by* Pedro Monroy et al.

Anonymous Referee #1

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SUMMARY: The manuscript "Modeling the dynamical sinking of biologenic particles in oceanic flow" presents an interesting study of particle sedimentation in realistic oceanic flows. In particular, it focuses in a simplified dynamics accounting for gravitational settling and also scrutinizes the effect of additional terms such as that due to Coriolis force (accounting for rotation) and inertial terms. The two latter effects are anyhow taken into account only perturbatively in Stokes as the authors mainly focus in the regime of small St number, which is shown (in Sect. 2, which is a nice review on particulate matter in the ocean) to be relevant to a wide range of sediments in the ocean. The manuscript presents numerical simulation of particles advected in Regional Ocean Modelling System simulating the Benguela region. In order to account for the unresolved scales, particles dynamics is also supplemented by a noise term with horizontal and vertical diffusivities appropriately chosen. The main results of the manuscript are as follows:

(1) it is shown that both the vertical and horizontal displacement are well captured by the gravitational settling term, \$v_s\$, with a negligible (at high \$v_s\$) of the Coriolis and inertial term, this appears to be true both for the average displacement and for individual particles trajectories; (2) even considering only the presence of settling speed the particles manifest the presence of clustering in the horizontal dynamics. As for the latter the authors argue that the standard explanation based on particle velocity compressibility cannot hold as the effective (three-dimensional) velocity field is incompressible as the settling speed is constant. However, the authors show that under the hypothesis of constant settling the horizontal dynamics would be effectively controlled by a 2d flow which is compressible, and provide some test, based on integrating the particle density field in such compressible 2d flow, showing that this mechanism can at least partially explain the observed clustering.

GENERAL COMMENTS I found the manuscript interesting and, in general, very well written. In particular, it offers a very nice review on particulate matter in oceanic flows and also on the limit of validity of models for particle dynamics. The presented results are quite interesting and I think relevant both in modeling and interpretation of data. However, though the presented results are quite sounding, I think the paper would benefit of some more specifications in a few points to make clearer the results and their applicability. For this reason here below I expand a short list of specific comments that the authors can use in revising their manuscript.

SPECIFIC COMMENTS

- I think the authors should specify whether eqs 9,10,11 are evolved using the same realization of noise or not. I mean when considering the effect of the different term the comparison is done using the same realization of the noise ? If not what is the impact on the displacement due only to noise?

- Maybe I'm missing something, while I understand that the mean displacement does not depend much on the various term (Coriolis and inertial term) I find a little surprising the fact that also individual displacement seems to be poorly sensitive. The reason is as follows. I do expect the particle dynamics to be chaotic (correct me if I'm wrong) consequently the presence of different term on the dynamics (assuming same noise, otherwise even the simple presence of noise would produce the same effect) should cause at least a small displacement that it is then amplified by chaos, so I cannot properly understand why this effect is not seen. Can the authors please comment on this?

- Fig.5 shows that the effect of Coriolis forces becomes more important for small v_s, moreover the curve seems to be non-monotonic, especially for the vertical displacement it appears like if there is a sort of minimum at $v_s\approx 20$ m/s. Could the authors comment on these aspects.

- The explanation proposed by the authors for understanding particle clustering is quite sounding and interesting. It would be nice if the authors could compare and comment their explanation with that provided in Bec, et al Phys. Rev. Lett., 112, 184 501 and also in K Gustavsson, et al. "Clustering of particles falling in a turbulent flow" Phys. Rev. Lett., 112, 214501 (2014). Essentially the authors argue that in the limit of large St (i.e. for large settling velocities) the particles fall rapidly with respect to the characteristic time of the flow so that effectively is like the flow becomes "delta-correlated" so that inertial dissipative dynamics becomes responsible for clustering instead of the compressibility effect typical of small St. How does clustering depends on v_s here? If I understand the argument by the authors the larger v_s the more appropriate becomes the approximation of vertical shift, then I think the idea of the fluid becoming "delta-correlated" should apply also here and so the dynamics become as in a compressible 2d and delta-correlated flow. Is this correct? if yes less effective clustering should be present for small v_s. Please comment.

- Stratification: I think the authors should specify whether the model used consider stratification or not. In general stratification is present in the ocean and it may impact sensibly particle dynamics (especially when β is not too far from 1) and, in

particular, particle clustering, for a recent study in this direction the authors may refer to

A. Sozza et al "Large scale confinement and small-scale clustering of floating particles in stratified turbulence", Phys. Rev. Fluids 1, 052401 (2016)

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