

Response: Minor changes

Referee #1:

1) On p.12 at the end of the page the authors write:

"To assess the impact of the Coriolis and of the inertial effects we compare the positions $r^{(co)}(t)$, and $r^{(in)}(t)$ with the simpler dynamics $r^{(in)}(t)$ for each time t . " If I understood correctly the second $r^{(in)}$ should be a $r^{(0)}$.
Please check.

We have corrected this sentence:

"To assess the impact of the Coriolis and of the inertial effects we compare the positions $r_i^{(co)}(t)$ and $r_i^{(in)}(t)$ with the simpler dynamics Eq. (9) which gives $r_i^{(0)}(t)$ for each time t ."

2) I have still a remark on the issue of chaoticity. More than a remark is that I would like to understand better the point made by the authors.

As far as I understood the authors provide evidence with new fig.4 that the root mean square difference between the horizontal particle position computed by using the simple settling model Eq. (9) and the refined one including the Coriolis term grows exponentially in time. Moreover the comment that the exponential rate of about 0.08days is in agreement with the order of magnitude of the Lyapunov exponent calculated using the same ROMS velocity model and region.

This seems to agree with my comment expressed in the previous report.

Now the issue is the following. Suppose you compute the root mean square deviation between the horizontal position of particles that all follow the same simple dynamics (9) but considering two sets of particles with the positions that are initially slightly different, by a small amount similar to what would be the displacement induced by the Coriolis term, say in 1day.

What would be the behavior of the root mean square displacement?

Since the system is chaotic the root mean square will be growing exponentially with the Lyapunov exponent (I think) close to 0.08 days^{-1} . Therefore the net result would be a displacement after 180 days similar to that observed in fig.4.

In other terms my doubt can be restated with the following question. Is the effect of the Coriolis term the same as the effect of a small displacement of the simpler settling dynamics (9)? If yes I think it is difficult to conclude about that "the inclusion of the Coriolis term would be required to properly model slowly sinking particles at high latitudes".

The referee has understood well our results, and the answer to last question is yes.

In fact it is a general result in chaotic systems that, after a transient time of the order of λ^{-1} (λ is the Lyapunov exponent), the effect of a perturbation on the dynamics could be well approximated by a change in the initial condition. This can be seen heuristically by thinking in the linearized evolution of the difference z between two dynamics: $\frac{dz}{dt} \approx \lambda z + f(t)$, where $f(t)$ is the difference between the two dynamics, here the Coriolis term. The solution is $z(t) = \exp(t\lambda)[z_0 + \int_0^t \exp(-s\lambda)f(s)ds]$. For $t \gg \lambda^{-1}$ and if $f(s)$ does not grow too fast, the upper limit in the integral can be approximated by ∞ , so that the effect of the different dynamics $f(t)$ is equivalent to an effective initial difference $z_0 \rightarrow z_{\text{eff}}$.

Our aim with the sentence “the inclusion of the Coriolis term would be required to properly model slowly sinking particles at high latitudes” was to stress that the effect of Coriolis (or equivalently, the change in this effective initial condition) is larger at high latitudes. But since this is clear from the results presented here, and to avoid further confusion, we have deleted this sentence in the revised version.