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Comment on egusphere-2022-831

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Referee comment on "Extension of Ekman (1905) wind-driven transport theory to the β plane" by Nathan Paldor and Lazar Friedland, EGUsphere, https://doi.org/10.5194/egusphere-2022-831-RC2, 2022

Review of `Extension of Ekman (1905) wind-driven transport theory to the beta-plane' by Paldor and Friedland

This manuscript provides solutions to a vertically-integrated version of the equations of motion on a beta-plane, subjected to constant eastward (or westward) wind stress. I was a bit surprised to find that these solutions had never been derived, but not shocked. Indeed, I have come to realize that Ekman's theory has not been extended as much as one would think, in light of its fundamental influence on our representation of how the ocean moves. Of course, the model is crude: it is a beta-plane that claims to describe motions as far away as 30º around the equator at least, and the structure of the dominant east- and westerlies that gives the ocean its gyre structure is completely absent. But to tackle these problems, one would have to start with the present analysis.

The derivations are not technically difficult. Rather, the difficulty seems to have lied in casting the equations in a useful form, and to have the appropriate strategy to solve them. Therefore, I enjoyed reading the mathematical developments in section 3, 'Analysis'.

My main comments are about the presentation: figures could be improved, and the order of the presentation got me confused at times.

A. I was confused by why the authors presented their numerical simulations in figure 2 before solving the equations in section 3. For example, I could not wrap my head around why the red curves in figure 2 oscillated and the blue curves did not. In section 3, I finally understood the idea behind the potential well, and how starting at the bottom of it (y=0) vs. slightly off of it (y=0.05) yielded oscillations in the latter and not the former. Maybe deriving first, and showing solutions later, might help.

B. A point that is probably closely related to my previous one, is that I still do not understand what y=0 represents. It seems easy enough at first: it is the point, around which you start the expansion, and it is located 1/b away from the equator. But when I start digging, I don't understand how this point was chosen: it is not the initial latitude, and I do not understand why starting from y≠0 yields oscillations and not y=0. If I started at y=0.05, why couldn't I re-define y=0 and b to be located at the new starting point, and still see oscillations? I believe some magic happens when introducing the pseudo angular momentum (l. 69) and the phrase 'We note that (…) to the latitude' (ll. 70-71), but to expand on it could help the reader understand faster.

Some specific comments:

1. Ll. 32-33: the first sentence of point 4 should be rewritten, I understand the general meaning, but I suspect that command that the word 'that' are being misused.

2. Figure 1 does not need to be so big, but font sizes would need to be increased.

3. Ll. 42-45: my first reaction was to think that there is no such thing as in the ocean, since the dominant zonal winds alternate latitudinally with the atmospheric circulation cells. You mention this in the discussion, but a word about what this is meant to simplify (or, equivalently, how far away from the equator are winds more or less in the same direction) would be welcome here.

4. Ll. 53-55: I believe that only Gill (1982) covers the time-dependent problem.

5. L. 83: 'f_0=10^{-4}1/s' should be 'f_0=10^{-4}\ s^{-1}' (unit)

6. L. 84: 'to b of (1)' should be 'to b of O(1)'. Besides, I am not sure what this sentence really brings. At the risk of unfairly exaggerating, I read 'b=O(1) and Gamma<<1 so the theory should be applicable to b=O(1) and Gamma<<1'. If it is a condition, it is never assessed later.

7. Figure 2 is a bit confusing: two curves have the same colour (green), and I believe that on the left panel, the two green curves superpose. Furthermore, I believe that those green curves are <x> and y_m, which should be specified in the caption or legend. Also, I would flip the order of the panels: placing y before x is counter to standard usage.

8. Like in figure 2, panels in figure 3 should be flipped. Having later times on front of

earlier times is also counter to standard usage.

9. L. 166: ‘In the 1’ should be ‘In section 1’ (I think)

10. L. 187: ‘beta’ should be ‘b’ (I think); delete ‘clearly’ at the end of the line (no offence; my personal opinion is that it is for the reader to decide if it is clear).

11. L. 188: ‘illustrates’ should be ‘illustrated’

12. L. 195 and 198: I don’t really see the point of the bold fonts.