Homework 4

due Sept. 22, 2017

[100 pts.]

Problem 1: Professor for a day

For this assignment, **you** are the professor. You have been tasked with teaching 20 Civil Engineering masters students the Coriolis and Centrifigual effects in the context of atmospheric science. Note that these are intelligent students with strong math and physics backgrounds - they just don't typically deal with the large-scales that you do, so, rotation never comes into the picture.

For your lecture, you will prepare a slide show (e.g. Powerpoint, Keynote, etc.) of 7 slides or fewer on the Coriolis and Centrifugal effects. For these slides, your main goal is not to just present the derivation of these terms in a rotating reference frame, but also to provide your students with *why* the terms are what they are - that is - to impart physical intuition. Finally, you may want to include real-world examples to convince the students that these terms actually matter (or don't matter). Finally, I would like a brief "script" to go along with your slides (no need for complete sentences - a few bullets for each slide is fine).

Additional Comments:

- *While may resources online like to use a merry-go-round as a learning tool, note that a merry-go-round is <u>not</u> a sphere, and thus, this example will only get you so far!*
- *I would like your slides and script emailed to me*[1] *in pdf format. I repeat, I want everything in a pdf! If you use Powerpoint and you use layered animations, you will need a separate slide for each layer since Powerpoint will not "print each stage of builds" to pdf. Keynote will.*
- *You will not be asked to present your slides in class, however, if I really like your approach I may ask your permission to use your materials in subsequent years.*

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Problem 2: Coriolis and Centrifugal

1. **Energy budget.** Show mathematically that the Coriolis terms in the momentum equations do not contribute to the kinetic energy budget. Why do you think this is? Do you now see why the Coriolis term involving w in the u equation had to be dropped when making the hydrostatic approximation ($\partial_z p \approx -g\rho$)? Explain.

2. **Lazy Forces.** Show that the Coriolis force does no work (i.e. it is an apparent force).

Problem 3: f-plane and β-plane approximations: how good are they?

(a) At what latitude is the f-plane approximation about 5°N no longer valid/useful[2]?

(b) At what latitude is the f-plane approximation about 45°N no longer valid/useful?

(c) At what latitude is the β-plane approximation about 5°N no longer valid/useful?

(d) At what latitude is the β-plane approximation about 45°N no longer valid/useful?

(e) What general rules of thumb have you learned from (a)-(d) about the usefulness of the f-plane and β-plane approximations centered at different latitudes?

[2] You will need to define what "useful" means. However, I expect justification for your choices which should include plots and supporting text.