OCES 2003 Assignment 2, Spring 2024

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<u>Set on</u>: Wed 6th Mar; <u>due</u>: Wed 13th Mar

Blurb

- Assignments have a maximum mark out of 20, although you will see that there are 22 marks available to get in total, i.e. if you get 22/20 you still only get credit for 20/20

    - 16-17 is roughly around the A- boundary
    - anything below 8 is probably a fail

- Please show working in calculation

    - no working + wrong answer = no credit whatsoever
    - some working + wrong answer = partial credit
    - generically, give things to 2 decimal place and provide the appropriate units (marks are allocated for these), unless otherwise specified

- No answers except the 'hard' ones should need more than a paragraph / half a page, and excess answers that are not to the point will be penalised

- Type up the assignment or send a photo of your written up work in (the former is preferred), and the only request I have is no Microsoft Word documents (you can type up things with Word but export it as a pdf if you do)

    - write in full sentences where appropriate
    - particularly poor and/or scrappy presentation will have a mark that can be taken off

- There will be a rigid mark scheme, and model solutions will be available in due course

    - the TAs only mark the stuff, you should come to the instructor for arguing marks, and note the re-marking can result in marks going up or down

!!! By handing something in, you agree to the usual Academic Honour code and Integrity declarations. For more, see `http://qa.ust.hk/aos/academic_integrity.html`. Cases for plagiarism (whether intended or not, it is the "act" that matters) gets a penalty ranging from

- zero on the question concerned
- a fixed penalty starting from around 1/3 of the total marks
- zero for the whole assignment/midterm/final

The following counts as plagiarism (and is a non-exhaustive list):

- copying word for word *any* (i.e. one or more) sentence without quote marks regardless of whether it is cited or not, e.g. *Yer a Jedi, Harry* (Gandalf of House Stark)
  * use quote marks if need be, e.g. "*Yer a Jedi, Harry*" (Gandalf of House Stark), although don't do it too often, because then one could argue you are not passing any of your thoughts through
  * any more than around three usages in text is probably excessive
- copying without citation or wrong citation, e.g. "*Yer a Jedi, Harry*", or "*Yer a Jedi, Harry*" (Jon Snow of Tatooine)
- changing a few words but sentence largely the same, e.g. *You, Harry, sir, are a Jedi* (Mithrandir of Winterfell)

• Turnitin will pick out most of the aforementioned things

• Cases can be contested but will lead to an official review, where the penalty may go up and/or down, and could result in an Academic Misconduct case being filed (see `https://acadreg.ust.hk/generalreg.html#b`)

Problems

1. Name at least two contradictions to what we know about ocean circulation/dynamics we would expect to get if we use *in-situ* temperature and/or density, as opposed to say potential temperature and density. Justify your answers, and draw pictures or cite courses as appropriate if it helps your point. Keep your answer to under a page of A4; and excessive answers will have marks deducted.

   [4 marks]

2. <u>Estimate</u> the Rossby number Ro = $U/(2\Omega L)$ for the following:

   (a) Jupiter's banded flow,
   (b) Gyre flow on Earth's ocean,
   (c) Atmospheric circulation on Venus,
   (d) Flow in a dust devil on Earth (look up what these are),
   (e) Flow in a toilet.

   For each of these, look up and/or compute some relevant numbers for the U, L and 2Ω. I just need an order of magnitude, i.e. values of U, L and the eventual answer in the form 10^a for some integer a will do. In each of these cases state whether geostrophic balance is applicable. Cite sources as appropriate.

   [5 marks]

   (Hint: Some previous years' assignments may have some relevant numbers there.)

3. The question concerns geostrophic balance, various curls/vorticities and Ekman upwelling. Below is an extremely detailed map that I spent a very large amount of nano-seconds making, noting that the map is centred about the equator (so watch out for sign changes in the Coriolis parameter):
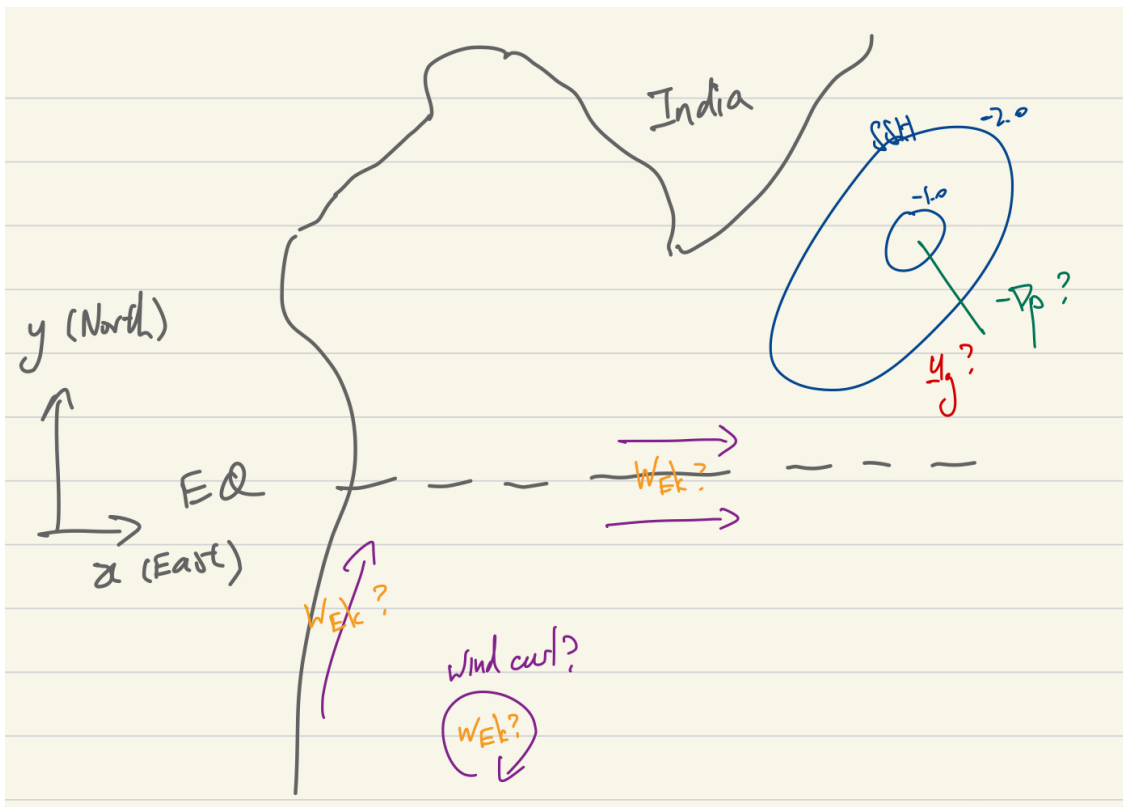
For the following subquestions, you could make a copy of the map and draw on the answers, but I still want a one line explanation to your answer somewhere. Use the convention that anti-clockwise flow is positive vorticity, and that positive w_{Ek} means upwelling.

- State or draw on the direction of the negative pressure gradient associated with the green line, taking the blue lines and numbers to mean lines of constant SSH (in meters if you like).
- With that, state or draw on the direction of the geostrophic velocity in red. Is the SSH anomaly thus a cyclonic or anti-cyclonic eddy relative to the relevant hemisphere?
- The purple lines are to denote wind forcings. State whether the wind curl furthest south has cyclonic or anti-cylonic curl relative to the relevant hemisphere.
- State the signs of the secondary vertical Ekman flow in orange, where positive means Ekman upwelling, and negative otherwise.

Again, justify all your answers: answers without a justification gets zero credit (so guessing by drawing arrows by itself gets no marks).

[6 marks]

4. In lecture 8 I made quite a big deal about how I was talking about the *horizontal* component of the Coriolis effect. Going to expand a bit on that here.

   (a) From the full Coriolis effect given by $2\mathbf{\Omega} \times \mathbf{u}$, where $\mathbf{\Omega}$ is the rotation axis pointing north, argue pictorially or otherwise why, at the equator, the Coriolis effect on a purely meridional velocity $\mathbf{u} = (0, v, 0)$ is zero.

   [1 mark]

   (b) As above, but argue why there is no *horizontal* Coriolis effect on a purely zonal velocity $\mathbf{u} = (u, 0, 0)$ at the equator. Argue also why we might ignore whatever Coriolis effect associated with the purely zonal flow anyway.

   [2 marks]

   (c) Look up what the *traditional approximation* is, why it might hold over most dynamical scenarios on Earth, but also state and/or argue under what circumstances (geographical, dynamical, or otherwise) when such an approximation might not be so applicable. Cite sources as appropriate, but don't write more than a page of A4 on this; and excessive answers will have marks deducted. (Hint: Try a Google search, or failing that, contents in the Vallis book, or Gerkema *et al.* (2008) in Reviews of Geophysics.)

   [4 marks]

!? (No marks bonus question) Look up the differences between TEOS-10 and UNESCO EOS-80, the different standards for the equation of state for sea water. A key difference is in the definition of the *conservative* temperature (denoted Θ, capital theta). The references on the Wikipedia page is a good place to start; the TEOS-10 webpage has some tutorial slides on the left hand bottom corner, which might be more accessible than the original paper of McDougall (2003).