OCES 2003 Midterm, Spring 2021

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<u>Set on</u>: Tue 16th Mar; <u>due</u>: Tue 16th Mar

Blurb

- The midterm has a maximum mark out of 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. Consider the following plot of temperature (on the horizontal axis) as a function of depth below sea surface (on the vertical axis; the z-axis is pointing *up*).
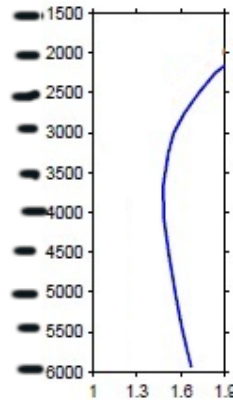
   (a) Do you think this is in-situ or potential temperature? Justify your answer.

   (b) Mark on the regions where $\partial(\text{temperature})/\partial z > 0$ and where $\partial(\text{temperature})/\partial z < 0$.

   (c) Assuming you actually did have a temeprature profile like this, is this state stable, assuming we can represent the fluid's density by a linear equation of state, the thermal expansion coefficient is positive, and that we can take the haline contraction coefficient to be zero?

   (d) Since there is a gradient we expect there to be diffusion. Assuming a temperature diffusivity of 10^{-5} m^2 s^{-1}, work out the diffusion time associated with a transport of 3000 meters. Give your answer rounded to the nearest ten thousand years.

   (e) As above, but what if instead we are talking about a turbulent diffusivity of 10^{-4} km^2 s^{-1} that might be associated with convectice overturns? Give your answer rounded to the nearest day.

   [6 marks]

2. Consider the following sketch where the numbers refers to SSH about the time mean and the contours are isolines of SSH, and we can assume that we are in the Ro $\ll 1$ regime:
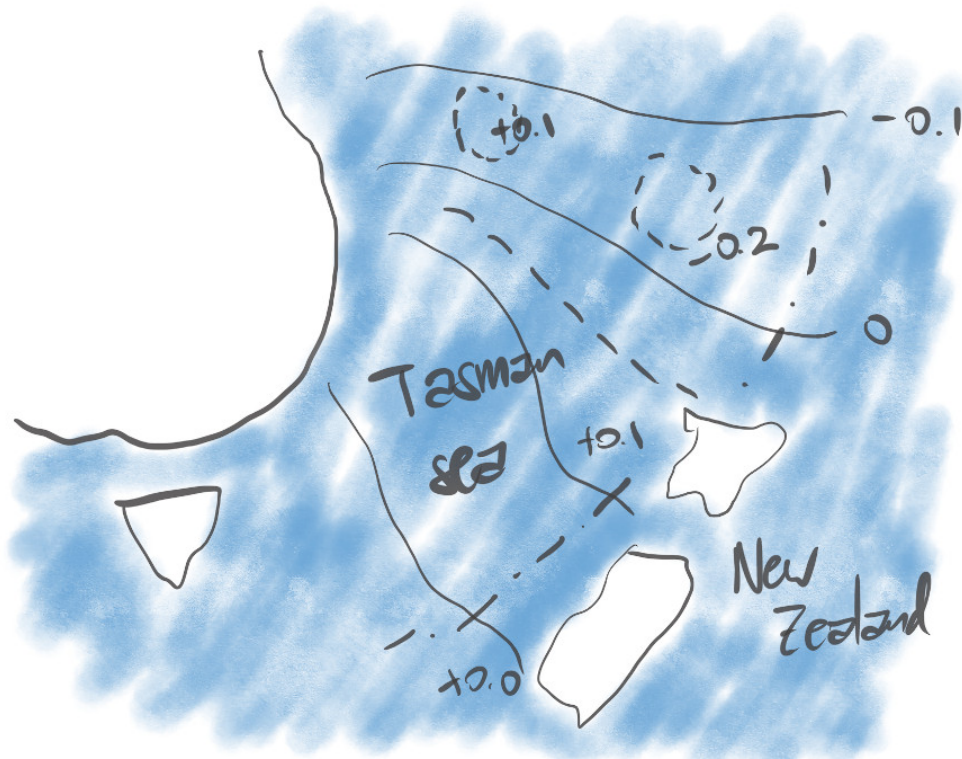
Draw on the arrows (or draw your own copy if you want more space to draw things on) associated with the following:

(a) $-\nabla p$ associated with the two dot-dashed lines $(-\cdot-\cdot-)$
(b) rotation sense associated with the two eddies drawn on as the dashed lines $(---)$
(c) the sense of geostrophic flow along the dashed line $(---)$ between the 0 and +0.1 contour, assuming only those two contours contribute to the geostrophic flow in question

Justify your answer, and note that answers without a justification gets zero credit (so guessing by drawing arrows on by itself gets no marks). Note that none of the actual things drawn on necessarily correspond to what is happening in the region, so even if you look up what actually happens in the region it doesn't necessarily help you.

Are the conclusions valid if we are no longer in the Ro $\ll 1$ regime? Justify your answer.

What happens to the answers you gave above if the Earth rotates around the Sun the other way? Justify your answer.

[7 marks]

3. What happens to gyre dynamics and western boundary currents for a rotating but flat (instead of spherical) Earth? (Assume the Earth is a disk, you are looking down on the North Pole, and the rotation is still pointing out of the North Pole.) Repeat the arguments for the depth-independent gyre in Lec 11 and 12 as appropriate and/or if required, state any similarities and/or differences you do have. For simplicity you can just take the subtropical gyre configuration in Northern Hemisphere. Justify your answers accordingly (no credit for claims that are not justified).

[7 marks]