OCES 2003 Assignment 1, Spring 2023

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Set on: Fri 17th Feb; due: Fri 24th Feb

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 places 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. Recall that 1 Sverdrup is 1 million cubic meters per second, i.e. 1 Sv = 10^6 m^3 s^{-1}. In these units, the Gulf Stream has a transport of around 30 Sv (numbers rounded for simplicity).

   (a) Suppose the Gulf Stream having that transport above is travelling through a cross-section that is 100 km wide and 1500 m deep. What is the average speed of the Gulf Stream in *knots* (use 1 knot = 0.514 m s^{-1})? Give your answer accurate to two decimal places in the form *a.bc*. [2 marks]

   (b) Now, suppose under climate change the *prevailing westerlies* strengthens, driving a larger flow so that the Gulf Stream now has an average speed of 0.3 m s^{-1} but only over the top 100 meters, and the average speed in the 1400 meters below is still whatever you calculated in the previous part. What is the transport of the Gulf Stream now in units of Sv? Give your answer accurate to the nearest integer Sv. [2 marks]

   (c) As above, but if the overall transport didn't actually change and is still 30 Sv, calculate the average speed in the bottom 1400 meters. Give your answer in standard units and accurate to three decimal places in the form *a.bcd*. [2 marks]

2. Suppose you were given some temperature data from some observation, and when you draw it ends up looking like Fig. 1 (assume that it has been drawn correctly, we are dealing with positive temperatures $T > 0$, the temperature is increasing to the right in a linear fashion, although the exact values are not overly important).

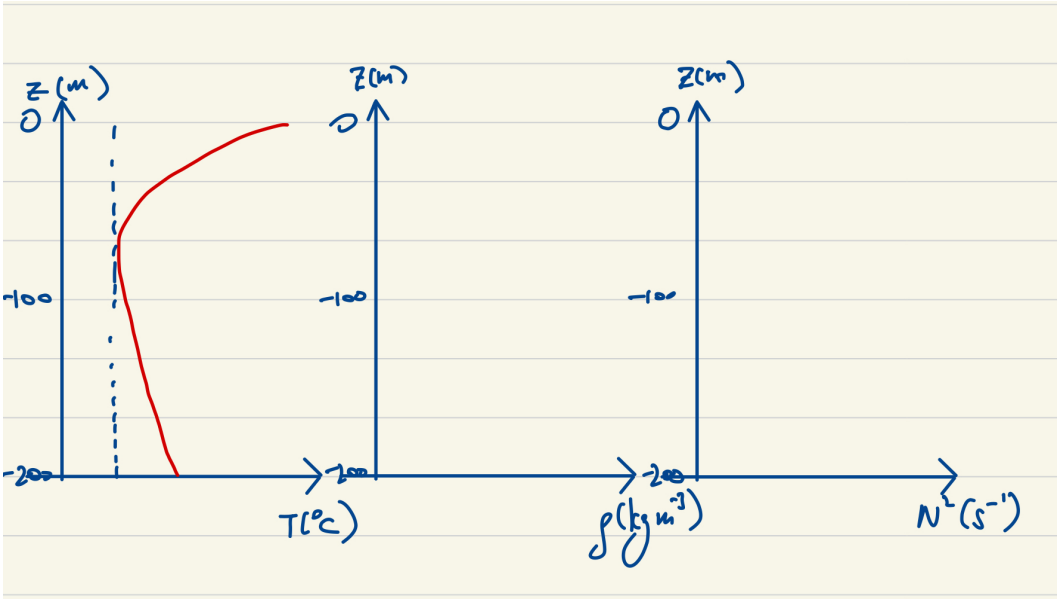

Figure 1: Temperature as a function of depth. Note that depth is given on the vertical axes, while the thing being measured is on the horizontal axes (normally it would be the other way round).

   (a) Mark on the regions where $dT/dz > 0$ and $dT/dz < 0$ as appropriate. [2 marks]

   (b) Sketch out the implied density ρ assuming $\rho \sim \rho_0 - \alpha T > 0$, where $\alpha > 0$. (Hint: It may help working out the implied gradients in ρ first.) [2 marks]

(c) The *Brunt-Väisälä frequency* which we will encounter later in Lecture 15 and 16 is given by

$$N^2 \sim -\frac{\mathrm{d}\rho}{\mathrm{d}z}.$$

Sketch that out as well given your answers in the previous parts. Where appropriate, Be very precise about where $N^2 > 0$, $N^2 < 0$, $N^2 = 0$, and the relative values of the N^2. [2 marks]

(d) Suppose the instrument repeatedly gives you the same kind of temperature profile with depth even with repeated sampling over many different times and locations (different values but same shape essentially), so that what you are seeing is statistically significant. Assuming we are dealing with constant salinity here throughout the water depth, does it make physical sense to see what you are seeing? Regardless of choice of answer, provide a reason and/or an explanation to what you are seeing. [2 marks]

3. To mirror Q1, we are going to do some calculations for the Eastern Boundary Currents (EBCs). Let's take the Peru Current (or Humboldt Current) for concreteness; you can find some information about the Peru Current on Wikipedia.

(a) Let us take for concreteness the numbers given in `https://www.britannica.com/place/Peru-Current` for the width and transport. How do these numbers compare with Western Boundary Currents such as the Gulf Stream, with data as given in Q1 above? Given these numbers, might you expect EBCs to flow faster, slower, roughly the same, if the EBC vertical extent is about the same as a WBC (it isn't but for sake of this question assume it is)? Briefly justify your answer without doing any calculations. [2 marks]

(b) The EBCs are actually shallower, say down to about 600 m depth for this Peru Current. Taking the lower end of the transport in the webpage given in the previous part of the question, calculate the average flow speed given the available information. Give your answer in standard units and accurate to three decimal places in the form *a.bcd*. [2 marks]

(c) Briefly describe the physical consequences of the EBC (or the overall Peru Eastern Boundary Upwelling System) as well as its associated biogeochemical, ecological and/or economical consequences due to ONLY one of the following: (*i*) seasonally shifting winds; (*ii*) strengthening winds under climate change; (*iii*) El-Niño / La-Niña. Cite any sources you use, and don't make it too long (around half a page maybe, a page if including diagrams). [4 marks]

(Hint: Wikipedia and/or Google is your friend here. You are allowed to cite Wikipedia in my course.)

!? (No marks bonus question) Speculate what might happen to the physical characteristics of the ocean surrounding the Med Sea if the sill at the Strait of Gibraltar suddenly didn't exist (geological activity, someone blowing it up, whatever). Cite sources accordingly.

(This question somewhat mirrors Q.8 in OCES 2003 assignment 1 in the 20/21 academic year.)