

OCES 2003 Assignment 4, Spring 2023

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Set on: Wed 3rdth May; due: Wed 10th May

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):

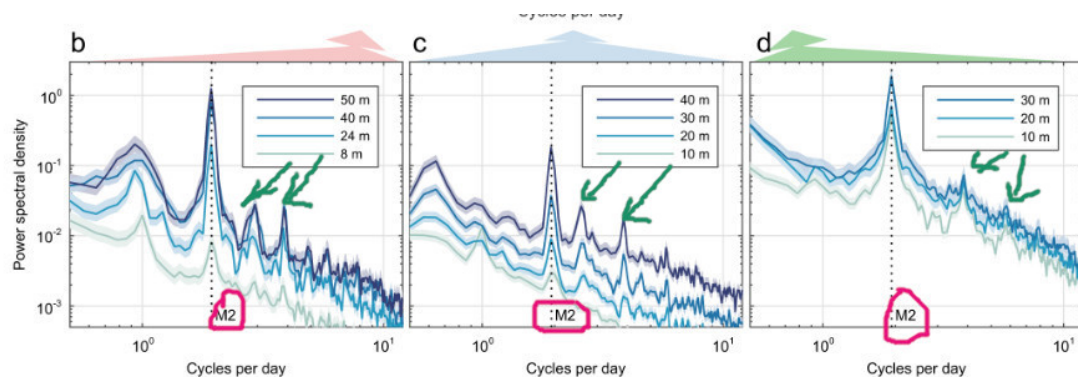
- copying word for word *any* (i.e. one or more) sentence without quote marks regardless of whether it is cited or not, e.g. *Yer a Jedi, Harry* (Gandalf of House Stark)
 - * use quote marks if need be, e.g. “*Yer a Jedi, Harry*” (Gandalf of House Stark), although don’t do it too often, because then 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

- This question is an example of how smaller-scale dynamics can have a larger-scale impact.
 - It is known one of the prime sites for watermass transformation of direct relevance to the North Atlantic Deep Water (NADW) is in the Labrador sea around Greenland, where some of the lukewarm but salty water is exposed to particularly cold atmospheric temperatures. Describe what that exposure to cold atmospheric temperature does to the water's buoyancy/density, and why this leads to deep water formation. [2 marks]
 - Suppose in the event of global warming there is a tipping point where there is significant ice melt from the Greenland ice sheet, so a substantial amount of *freshwater* is dumped into the region that would normally form deepwater in the Labrador sea. What implication would this have on deep-water formation? (Hint: read the wording of this and the previous question very carefully.) [2 marks]
 - Speculate on the impact on NADW, the general Atlantic Meridional Overturning Circulation (AMOC) strength and consequences for the overall global MOC if there is substantial melting of ice from the Greenland ice sheet, in light of your answer in the previous part. Keep this to less than 150 words, and cite any sources you do end up using if you use them. [4 marks]
- This question is related to work by Alex Wyatt, on internal waves and impact on coral reef ecosystems; essentially internal waves bring up cold water to reduce the heat stress on corals, which can help corals survive. There is a suggested reference below, but reading the paper probably won't help you that much here.

Wyatt, A. S. J., Leichter, J. J., Toth, L. T., Miyajima, T., Aronson, R. B., and Nagata, T (2020)
Heat accumulation on coral reefs mitigated by internal waves
 Nature Geosci., **13**, 28–34, doi: 10.1038/s41561-019-0486-4

- The following graph is from the supplementary material (Fig. S1) of Wyatt *et al.* (2020), which shows the power spectrum of internal waves:



What does M2 within the red circles refer to? With your answer, work out the standard frequency (rather than angular frequency) in units of Hz corresponding to that largest peak, giving your answer accurate to five decimal places in the form *a.bcd ef*.

[2 marks]

- (b) The graph shows what is called the *power spectrum* (or *power spectrum density*), which you can think of as energy or wave amplitude. If the tidal forcing is only at the M2 frequency (it isn't but roll with this assumption), then we should only have power at the M2 frequency, and the fact there is power at the higher frequencies is suggestive that there is something leading to a transfer of power from the M2 to the higher frequencies. What processes can cause these kind of transfers?

[2 marks]

- (c) The graph is either a power spectrum of the temperature or the vertical velocity (it doesn't really matter). Describe a piece of observation equipment that you might use to measure the in-situ vertical velocity, and another piece of equipment you might use to measure the in-situ temperature in the ocean interior (noting that the above graph shows measurements at 8 m depth and below). Justify your answer, and discuss a little about the relative advantages and disadvantages of the two piece of equipment you select (e.g. one is probably more robust than the other), and the frequency of measurements you might need to actually measure the internal waves (e.g. measuring every second will drain the battery quickly, but is measuring once a day enough?)

[2 marks]

3. Look up how satellites are used to measure the sea surface temperature (SST) and salinity (SSS), and describe your interpretation in no more than two pages. Marks are mainly given for describing the methodology, challenges in measuring the relevant quantities, and sources of uncertainties in the measurements, although some minor credit for name of satellites, product resolution, further technical details, etc. can be given. Comment in particular on why the satellite measures of SST are at a much high spatial resolution than SSS (~ 10 km vs. ~ 50 km respectively).

Use figures and equations as appropriate, and provide citation to sources you do use. Extremely irrelevant and/or wrong details as well as going over the page limit will result in marks being deducted (although you can't get an overall negative mark for this question).

For the record, the model answer I provide is half a page with no figures.

[8 marks]

! (Bonus question, no marks + for interest only)

Tangentially related to Q1., look up and describe how and where *brinicles* (i.e. underwater fingers of death) form.