OCN 420/720: Introduction to Physical Oceanography
Spring 2015, Asst. Prof. Alexander Stine

Lab 07: Using the Seawater Toolbox

In the last lab we used a linearized version of the equation of state to consider the stability of the water column. Today we will get setup to look more deeply at some observations of the ocean. To do this we will first download and setup the seawater toolbox which we will use in our analysis.

0. Goal of Lab

In this lab we will learn to use the seawater toolbox and use it to look at a CTD profile.

If you have not installed the seawater toolbox yet, then you need to go back and do the lab on installing the seawater toolbox.

1. Download getting started script from iLearn.

Create a directory called “Lab07” inside your <u>class directory</u> to keep material for this lab in one place.

I’ve put an example file for this week’s lab in iLearn called “lab_07_getting_started.m”.

Download this and put it in your Lab07 directory.

Remember that the “.m” at the end is a way of telling MATLAB that this is a script, but you omit the ‘.m’ when you run the script at the command line.

Once you’ve downloaded this file and put it in your working directory you can open it in the MATLAB editor by typing

```
>> edit lab_07_getting_started.m
```

though you probably want to rename it to something more personal. Read through the script to see what it will do and then execute the script. This should produce temperature and salinity plots that we saw in a previous lab.

For many weeks, the getting_started script will be an important bridge to get you up and going. However, this lab picks up where the CTD lab left off. If you wrote clean code for the CTD lab, you might want to just copy your script from that lab into your Lab07 folder, rename it and then use that as your getting_started script. I’ll remind you of that when you get to the questions that ask about the profiles.

2. Some seawater toolbox commands

This is a list of commands in the seawater toolbox you should know about.

sw_ptmp Potential temperature
sw_dens Density of sea water
sw_pden Potential density
sw_dpth Depth from pressure
sw_alpha Thermal expansion coefficient (alpha)
sw_beta Saline contraction coefficient (beta)

To see the nomenclature of each command, use the help function. For example:

```
>> help sw_ptmp
```

To see a list of all the commands in the seawater toolbox, type:

```
>>  help seawater_ver3_3
```

(if you have a version other than 3.3, then the command might be slightly different).

3. Lab logistics

We are going to use these profiles to ask a few questions about the ocean. **You should write a brief but clear (typed) statement of the conclusions you can draw from each calculation and include any plots you need to demonstrate each of these conclusions.** You will upload the completed lab as a .pdf file to iLearn.

Use the seawater toolbox to answer questions 1-2. Use the getting started script and/or the seawater toolbox to answer questions 4:end.

Problem 1:

Consider two water parcels in a vertical column. Both water parcels have a salinity of 35 (psu). The first water parcel is at a depth of 300 meters and is 5.0 °C. The second water parcel is at depth 310 meters and is 5.1 °C. Note that temperature increases with depth, which puts immediately makes us worry about the possibility that this water column is unstable.

(a) Does potential temperature increase or decrease with depth?
(b) Does density increase or decrease with depth?
(c) How about potential density?

For each problem above, include your answer in full sentences, the MATLAB the code that you used to answer the question, and the output of that code. In your code, do all your calculations with variables, and then do any calculations you want to do on those variables.

(d) Is the water column stable? Why or why not?

Problem 2:

Again consider two water parcels in a vertical column. Both water parcels have a salinity of 35 (psu). The first water parcel is at a depth of 5000 meters and is 1.1 °C. The second water parcel is at depth 6000 meters and is 1.2 °C. Again note that temperature increases with depth, which puts immediately makes us worry about the possibility that this water column is unstable.

(a) Does potential temperature increase or decrease with depth?
(b) Does density increase or decrease with depth?
(c) How about potential density?

For each problem above, include your answer in full sentences, the MATLAB the code that you used to answer the question, and the output of that code. In your code, do all your calculations with variables, and then do any calculations you want to do on those variables.

(d) Is the water column stable? Why or why not?

Problem 3:

Based on your answers to question 2 and 3, discuss why potential temperature and potential density are preferable to temperature and density as oceanographic variables.

In questions 4:end, you can use the "getting_started_lab07.m" script. However, you don't have to. If you wrote clean code for the CTD lab, you might want to just copy your script from that lab into your Lab07 folder, and edit that.

Problem 4:

In a previous lab, we used a linearized equation of state to calculate a vertical profile of density in the ocean. In this question, I'd like you to test how good of an approximation that was. On a single figure panel, plot a vertical profile of density using your linearized equation of state and a vertical profile of density calculated using the seawater toolbox. Make sure to distinguish which line is which. You can do this using color or linestyles or both. If you don't know how to add a legend, you can ask Zan.

How well did the linearized equation of state do? How does the skill of the approximation change with depth? Can you explain why the errors have the vertical structure they do?

Your answer should include a figure and a discussion of all of the questions above. You don't need to include any MATLAB code for this question.

Problem 5:

If we mixed the entire water column without changing the heat content of the ocean, what would the density profile look like? And how different would it look than the observed density profile? Plot this "isothermal, isosaline" profile on top of the actual density profile. What does this tell you about the processes that control density?

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HINT: if you multiply a vector by zero and then add a constant, all of the values in the vector will be replaced by that constant. i.e.

```
>> x = [3 5 7  2 5 6];

>> x*0 + 5

ans =

     5     5     5     5     5     5
```

So you can replace a vector with it's average by writing:

```
x = mean(x) + 0*x;
```

]

Problem 6: In practice we are usually more concerned about the contribution to density from temperature and salinity than from pressure. If the only reason that a particular water parcel is denser than the water above it is that it is under more pressure, then a small perturbation (say a passing wave) may move the water up at which point the pressure keeping the parcel dense would be removed and there would be no force to push the water parcel back down again. To isolate just the effects of temperature and salinity on density, we typically calculate what the density would be if all the water were the same pressure.

(a) On a single figure panel, plot a vertical profile of density and of potential density. Make sure to distinguish which line is which. You can do this using color or linestyles or both, but you should include a legend.

(b) Discuss why the vertical profile of pressure and density look so different.

(c) By approximately how much does the weight of the water above contribute to the increase the density of seawater with depth. Express your answer in percent per km. Explain your logic.

(d) Is the water column stable? Why or why not?

Problem 7.

We said in class potential temperature and temperature were not that different in the ocean. Test this assertion by plotting temperature and potential temperature profiles on a single figure panel. Using this plot estimate how much the weight of the water above increases the temperature of seawater. Express your answer in units of °C per km. Explain your logic.