SMS-204: Integrative marine sciences. Assignment #4

You have a choice of **one of three**(!) questions. Do one (you can get 10pts of extra credit for the others). It is valued at (60/100).

A. Annual cycle of temperature in the Gulf of Maine as observed from a buoy (60/100): Look at http://gyre.umeoce.maine.edu/buoyhome.php and choose a data buoy for which there are temperature measurements at least at two depths (or surface and air temperature). Go to http://neracoos.org/datatools/climatologies_display, select that buoy on the top left of the graph, select the temperature depth you want (or air) and select the "averaging time period" to be daily (you will have to plot the water data below the surface closest to the surface). Click on "2016" below the graph and on "view climatology data table". Copy the data into a spreadsheet program for ***plotting by yourself***.

Plot the annual cycle that is the change in temperature as function of time of the year near the surface. (10pt)

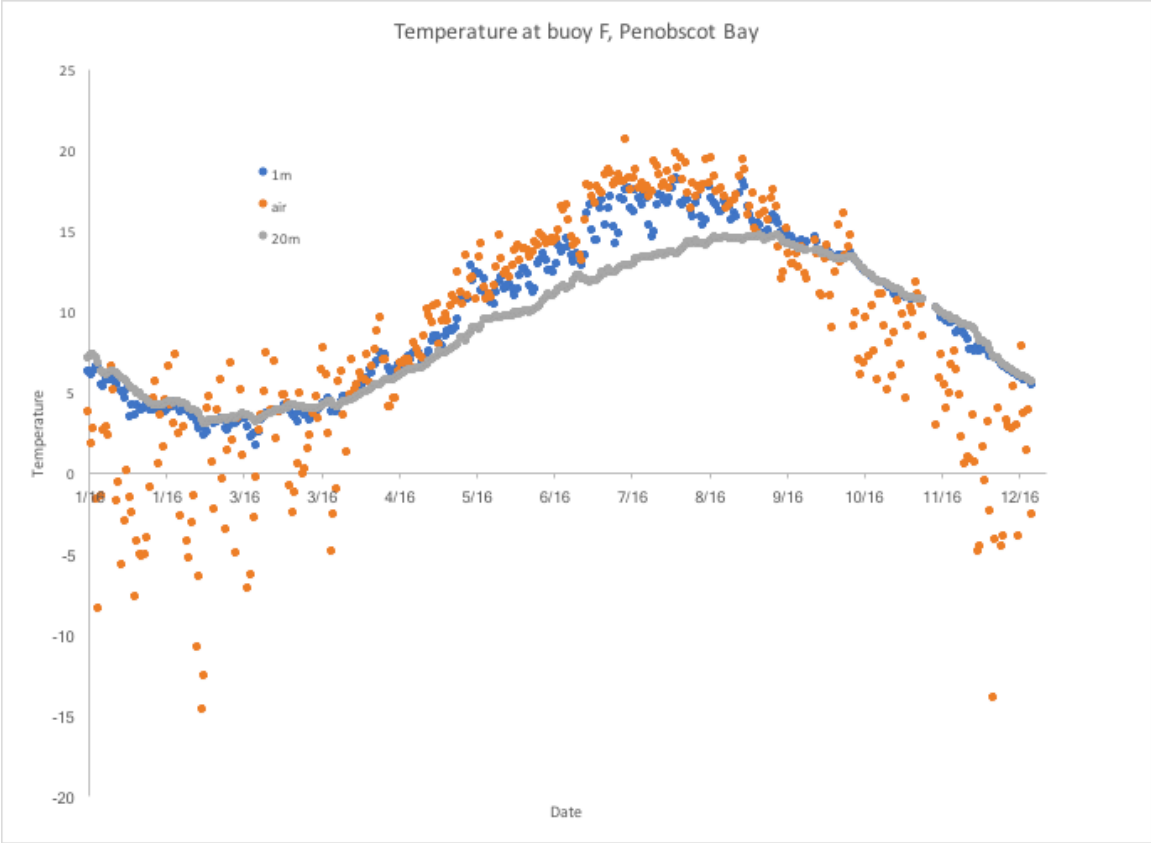

Figure 1. Average daily temperature in air, at 1m and at 20m at Buoy F in Penobscot Bay, 2016.

1. Note the maximal and minimal temperatures and when they occur. (10pt)

Minimal temperatures (-14.7, 1.7, 3.0), at (Jul 27, Aug 15, Sep 24), maximal (20.6, 18.2, 14.6) at (Feb 14, Mar 6, Feb 16) in the air, at 1m and at 20m respectively.

2. Explain the observation with regards to the annual cycle of the sun radiation in Maine (10pt).

Maine is in the mid-latitudes of the Northern Hemisphere. The sun angle and hence day-length varies a lot between winter and summer. Sun radiation is near maximum near the longest day of the year (6/21) and least during the shortest day of the year (12/21). These are periods of maximal heating and cooling respectively. However, the air/ocean continue to warm/cool after them, but more slowly. Maximal/minimal temperatures occur near when the net heat flux is close to zero, and about to change sign. Air has more extreme temperatures compared to water, likely due to having sources of wind with wide range of temperatures. Near surface waters exhibit larger fluctuations than deep waters as it is in closer contact with the atmosphere and the air-sea interface (where evaporative cooling, convection, conduction and radiation occur). Water at depth is only affected by convection and conduction.

3. Is the coldest day also the shortest? Is the warmest day the longest? If the answer is no, why do you think it is not? (10pt)

Coldest day is not the shortest and the warmest day is not the longest. Reason is that the ocean continues to be cooled after the shortest day of the year and warmed after the longest day of the year.

4. Compare the result obtain in your graph with another graph you generate of:

a. the annual cycle of the temperature in the air at the same location **OR**

b. the annual cycle of temperature at 20m depth or deeper at the same location. (10pt)

Plot **both** on the **same** graph.

5. Based on what ***you have learned*** regarding heat and temperature explain why there are (or are not) differences between the two temperature time series? (10pt)

See Figure 1 and answers above.

B. Annual cycle of temperature at the two opposite ends of the Gulf of Maine as observed by satellite (60/100). Go to NASA's remote sensing portal, Giovanni at: https://giovanni.gsfc.nasa.gov/giovanni/

Select 'Oceanography', and 'Sea Surface Temperature at 11 microns (day)' by clicking the square near it. At the top of the page, click on 'Time-series' within which select 'Area-averaged'. Select 'Date Range' from Dec, 2015->Dec. 2016. Then 'Select Region': one within the Bay of Fundy and the NE Gulf of ME and one in the SW Gulf of ME in front of MA/NH/Southern Maine. Do it by using the map tool, moving to and focusing in on the region and drawing a bounding box within it. Plot data by pushing the 'Plot Data' button at the bottom of the page. Once the figure plotted, use the 'download' button on the left to download the data for your own plotting.

1. Plot the annual cycle that is the change in temperature as function of time of the year at both locations on the same graph, with a label for each. (20pt)

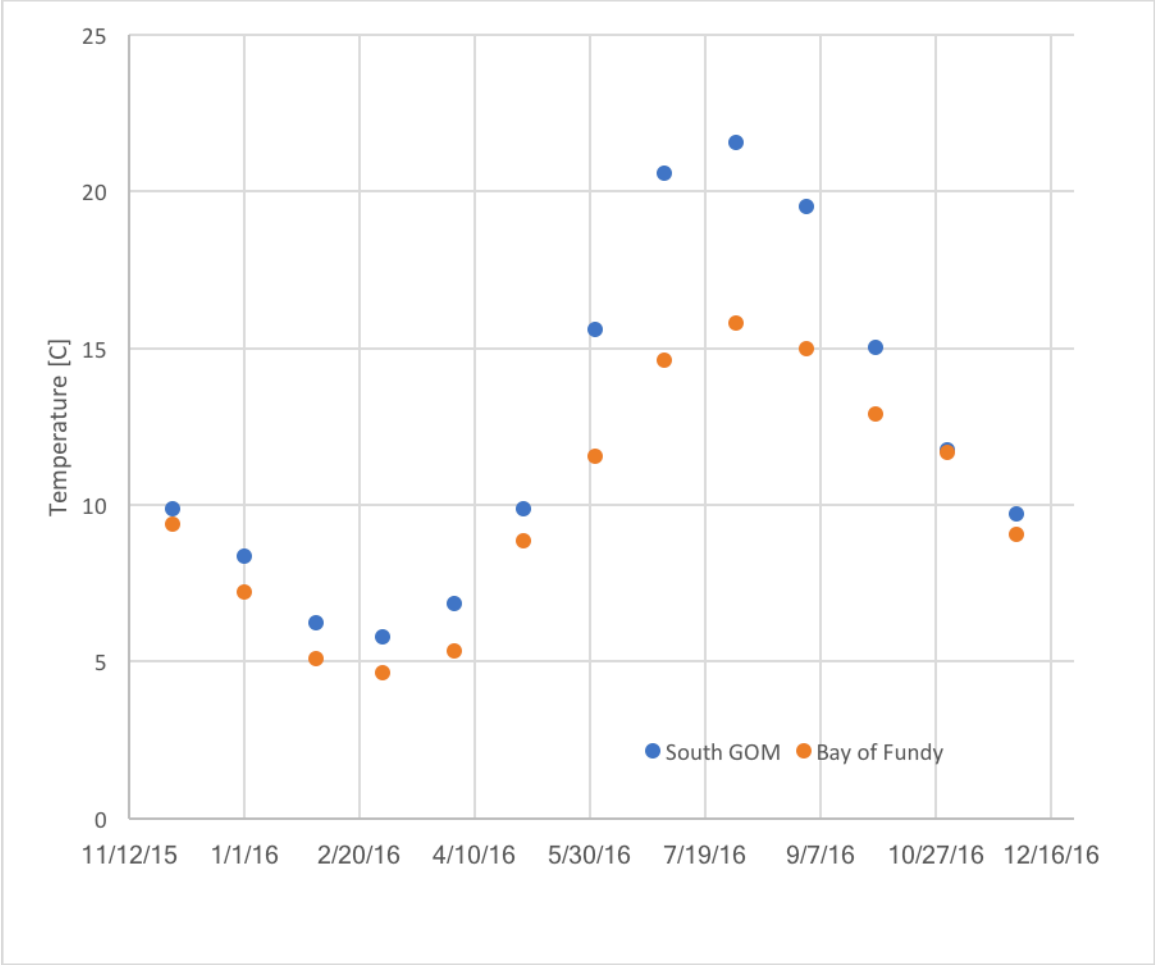

Figure2. Monthly temperature as function of date for the southern Gulf of Maine and Bay of Fundy.

2. Note the maximal and minimal temperatures and when they occur. (10pt)

Minimal temperatures (4.65, 5.77) occur in February while maximal temperatures (21,57, 15.79) in August and the Bay of Fundy and the Southern Gulf of Maine respectively.

3. Explain the observation with regards to the annual cycle of the sun radiation in Maine (10pt).

The GOM is in the Northern Hemisphere. Maximal flux of radiation is near June 20th and minima is near Dec. 20th. However, the ocean keeps warming after the maximum and keeps cooling after the minimum. The days of maximum and minimum temperature are the days when the net heat flux is zero.

4. Is the coldest day also the shortest? Is the warmest day the longest? If the answer is no, why do you think it is not? (10pt)

No. No. Because these days are near the day of maximal flux but they keep cooling/heating following the shortest/longest days.

5. Based on what ***you have learned*** regarding heat and temperature explain why there are (or are not) differences between the two temperature time series? (10pt)

The Bay of Fundy is colder throughout the year because it is further North (sun is at a more oblique angle all year around) and because it experiences vigorous tidal mixing with cold water from below all year (Strongest tides in the world. I did not expect you to know this).

C. Annual cycle of temperature at the top 1000m of the ocean as measured with a profiling float. Go to http://www3.mbari.org/chemsensor/floatviz.htm. Choose a float that has at least profiled for a year (you will need to plot temperature as function of date to see that).

1. (10pts) Use the tool to plot:
   a. The float trajectory (x-axis longitude, y-axis: latitude).
   b. Temperature (y-axis) as a function of date (x-axis).
   c. Temperature (y-axis) as a function of depth (x-axis). You can download the figure by right clicking on it and saving the image. Include the plots in your homework.

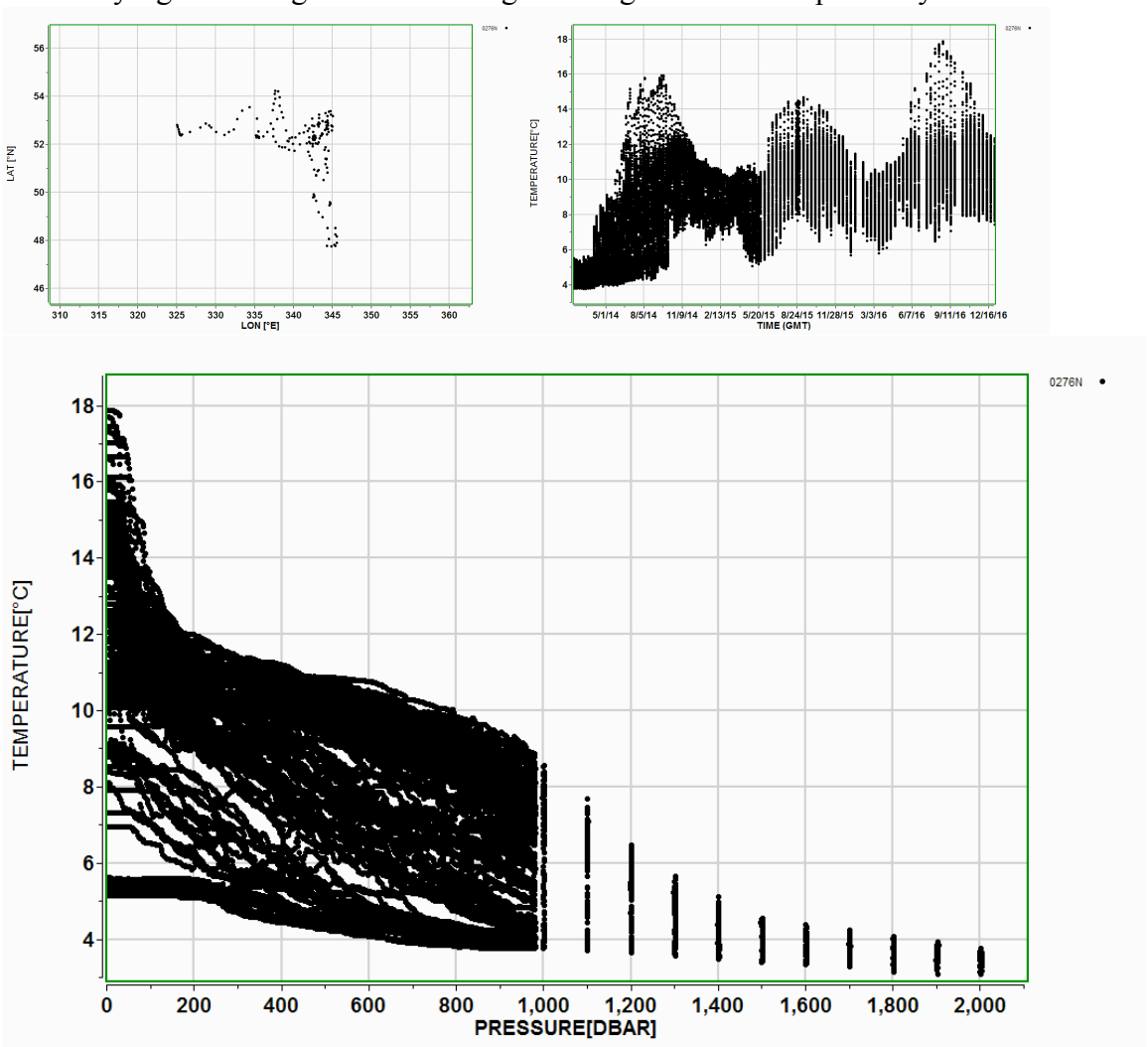

Figure 3. Position, temperature as function of time and depth for float 0276NoAtlantic.

2. How does the amplitude of the temperature seasonal change varies with depth? Why (10pts)?

Amplitude is larger in the summer due to warming near the surface.

3. Note the maximal and minimal temperatures and when they occur. (10pt)

Warmest in late August early September and coldest in end of February early March.

4. Explain the observation with regards to the annual cycle of the sun radiation in the location where the float was (10pt).

The float is in the North Atlantic. Maximal flux of radiation is near June 20th and minima is near Dec. 20th. However, the ocean keeps warming after the maximum and keeps cooling after the minimum. The days of maximum and minimum temperature are the days when the net heat flux is zero.

5. Is the coldest day also the shortest? Is the warmest day the longest? If the answer is no, why do you think it is not? (10pt)

No. No. Because these days are near the day of maximal flux but they keep cooling/heating following the shortest/longest days.

6. Based on what ***you have learned*** regarding heat and temperature explain why there are (or are not) differences between surface and depth? (10pt)

The ocean warms from above hence the high temperatures near the surface. The waters at depth were created at higher latitudes during winter and have slide down to the location of the float. When local heating is negative, the mixed layer deepens cooling waters below, down to the maximal mixed layer in depth occurring sometimes in Feb/March (with a depth of about 300m).

2. Unit conversion (MKS stands for meter, kilogram, seconds) (30/100):

- How many ml's are there in 0.25m^3? How many litters? How many cm^3?

0.25 m^3 = 250 L = 250,000 ml = 250,000 cm^3

- A river is flowing at 500m/day. How much is it in cm/s?

1/24 day hr^{-1} × 1/3600 hr s^{-1} × 10^2cm m^{-1} × 500m day^{-1}=0.58 cm s^{-1}

- An organism weighing 0.4kg has a velocity of 20cm/s as it sinks through water. What is its kinetic energy in MKS units?

0.4kg × 0.2^2 m/s /2= 0.008 Joules

- What are the mass and volume fluxes in MKS (= SI) units of a stream (density 1g cm^{-3}) flowing at an average speed 0.2m/s with a 200cm width and 40,000mm depth?

Volume flux: 2m × 40m × 0.2 m/s=16 m^3/s

Mass flux: 1000kg m^{-3} × 16 m^3/s = 16,000 kg/s

- What distance (in kilometers) does a tuna swimming at 0.7m s^{-1} swim in a day?

24 hr day^{-1} × 3600 s hr^{-1} × 0.7 m s^{-1}=60480m=60.5km

- What is, approximately, the density of water in g/ml, g/cm^3 and kg/m^3?

1 g/ml = 1 g/cm^3 = 1000 kg/m^3

3. Watch the NASA's short movie on the greenhouse effect (https://www.youtube.com/watch?v=ZzCA60WnoMk) and other materials you can find to answer the following (10/100):

- What is the difference between the incoming/outgoing radiation into/from the Earth surface?

The radiation coming in is short wavelengths (visible radiation). The outgoing radiation is at longer wavelength (near infrared radiation) which are absorbed by greenhouse gases. The outgoing radiation is absorbed by the atmosphere while the incoming radiation can pass through greenhouse gases.

- How different would the Earth temperature be w/o the greenhouse effect? Would it be more or less suitable to life?

Without a greenhouse effect the temperature of the Earth will be 30 degrees C which will make the Earth less suitable to life as it is today.

4. Extra credit, 10pts: Scientists have found that a Hershey kiss has 26 Calories (= 26,000 calories) and claim that if we can convert this energy to mechanical energy, without loss, it could lift an SUV 2m up in the air (see: http://www.npr.org/templates/story/story.php?storyId=6700905&sc=emaf).
Evaluate this claim and calculate how high you could lift a 5000lb heavy SUV.

Energy in a kiss = 26Cal = 26 × 4184 Joules = 108,784 J.
Potential energy of a 5000lb SUV 2m above ground: mgh = 5000lb × 0.45kg lb^{-1} × 9.81m s^{-2} × 2m = 44,145J.
Since the energy in the Hershey kiss > the potential energy in the lifted SUV the scientists claim is correct!
The height to which one could lift it:
108,784 Joules (=26,000calories x4.18Joules/calorie)/ (5000lb × 0.45kg lb^{-1} × 9.81 m s^{-2})~5m!

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