SMS-204: Integrative marine sciences. Assignment #4

1. Annual cycle of temperature in the Gulf of Maine (60/100):
From http://www.neracoos.org/datatools/historical/graphing_download/, figure out how to obtain an annual time series (1/1 to 12/30 for **2014** of ***daily averaged water temperatures*** near the surface from the Penobscot Bay buoy (F01) in the Gulf of Maine (see map at: http://gyre.umeoce.maine.edu/buoyhome.php). Get the data in an excel or ascii format for ***plotting by yourself***. Note the need to update selections.

1. Plot the annual cycle, that is the change in temperature as function of time of the year near the surface (1 or 2m). (10pt)

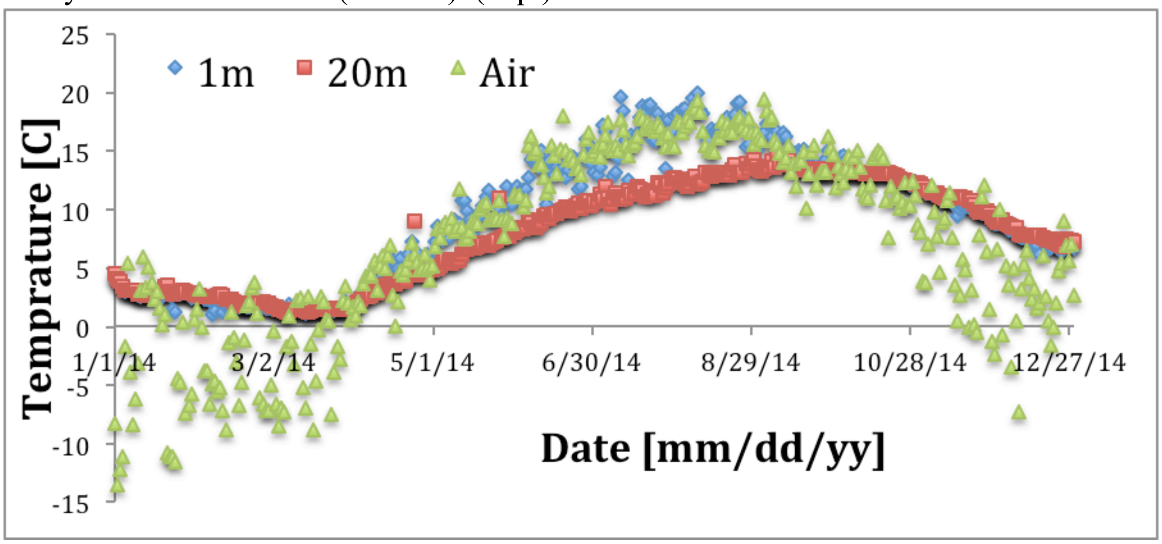

Figure 1. Annual cycle of temperature at buoy F of the air, 1m and 20m depths.

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

	Min value	*date*	*Max value*	*date*
Air	*-13.5*	*1/2/14*	*19.4*	*9/3/14*
1m	*1*	*2/7/14*	*19.9*	*8/9/14*
20m	*1.2*	*3/7/24*	*14.7*	*9/8/14*

Table 1. Values and time when maximum and minimum temperatures were recorded in the air and at 1 and 20m depths.

3. 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.*

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)

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

5. Compare the result obtain in your graph with another graph you generate of:
a. the annual cycle of the temperature in the atmosphere at the same location **OR**
b. the annual cycle of temperature at 20m depth at the same location. (10pt)
Plot **both** on the **same** graph.

See Figure 1.

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

See answer to 3. +
The curves representing the temperature at different depths are displayed in Fig. 1. The temperature at 20m is similar to that at the surface from mid October to early April of the next year, times where the water column is well mixed by surface driven cooling which forces convection (cold surface water are denser than waters below resulting in overturning of the water column) and periodic storms which mechanically force the water column to mix (note in March the short periods of surface warming and in May the mixing to depth event). As net warming near the surface increases in April, the water column stratifies (the warmed surface waters are less dense than the waters below). Salinity, not shown, help contribute to water column stability, as fresh water from snow melt coming down the Penobscot decreases further the surface waters. Surface waters stay warm until the end of August, due to the fact that the net heating is positive or near zero until then. Waters at depth warm mostly through the action of turbulent mixing with waters from above and below, a process that continues until early October. Waters near the surface have started cooling earlier, but since they were warmer by ~5degrees in late August they need to cool significantly before reaching the density of the waters at 20m, a process occurring due to net negative loss of heat driving convection in Sep. and Oct. (wind helps the mixing process to depth by providing additional mechanical energy).

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

- How many ml's are there in $0.2 m^3$? How many litters? How many cm^3?

$0.2\ m^3$ = 200 L = 200,000 ml = 200,000 cm^3

- A river is flowing at 1000m/day. How much is it in cm/s?

$1/24\ day\ hr^{-1} \times 1/3600\ hr\ s^{-1} \times 10^2 cm\ m^{-1} \times 1000 m\ day^{-1} = 1.16\ cm\ s^{-1}$

- An organism weighing 0.2kg has a velocity of 15cm/s as it sinks through water. What is its kinetic energy in MKS units?

0.2kg × 0.15^2 m/s /2= 0.00225 Joules

- What are the mass and volume fluxes in MKS units of a stream (density 1g cm^{-3}) flowing at an average speed 0.3m/s with a 300cm width and 4,000mm depth?

Volume flux: 3m × 4m × 0.3 m/s=3.6 m^3/s

Mass flux: 1000kg m^{-3} × 3.6 m^3/s = 3600 kg/s

- What distance (in kilometers) do tuna swimming at 0.5m s^{-1} swim in a day?

24 hr day^{-1} × 3600 s hr^{-1} × 0.5 m s^{-1}=43200 m =43.2km

- 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. Movie analysis (10/100):

Now that you have watched the four parts movie series on drag, explain two of the three strange phenomena seen in the first movie (use the concepts of Reynolds number and boundary layer in your answers).

Now that you have watched the four parts movie series on drag, explain two of the three strange phenomena seen in the first movie (use the concepts of Reynolds number and boundary layer in your answers).

General concepts pertaining to high and low Reynolds number flows around a body.
a. Reynolds number is a property of the flow-body interaction, not the body alone.

b. Drag is made of two contributions: 1. pressure drag directed perpendicular to the object and 2. viscous drag (a stress) directed parallel to the object.

c. Viscous drag is an important contributor at low Reynolds number flows. At very high Reynolds number, when the flow is fully turbulent, pressure drag contributes little to the overall drag. In laminar flows, pressure drag occurs due to the reversal of the pressure distribution around the object from high in its nose to low at its sides and back to high at its back (The pressure gradient is therefore in opposite direction at the back than at the front). This reversal results in little net force on the body. Viscous drag occurs as a result of the no-slip condition. Near the body the fluid moves with the body while at a distance it does not. The change of momentum with distance (shear) in a viscous fluid results in a net force applied on the body moving relative to the fluid (as on a stationary body within a moving fluid). Viscous forces increase with Reynolds number and in even larger amount when turbulence is introduced as turbulence enhance of momentum transfer between the fluid and the body.

d. Flow separation occurs when the Reynolds number is increased under laminar conditions due to the deceleration of the fluid streaming along the body by viscous forces. The fluid stagnates relative to the body and a reverse flow occurs at the back of the body increasing the pressure drag on the body.

Now to the explanations:
Phenomenon 1: The reduction observed in drag as the velocity increases occurs at the transition from laminar to turbulent flows. In the laminar case the drag increased steeply due to the build up of pressure drag as flow separation occurred. Turbulence negates the flow separation as high momentum fluid is brought close to the body such that it does not separate or separates closer to the back to the body. This decreases the pressure drag while increasing the viscous drag. However the decrease in pressure drag is more significant than the increase in the viscous drag resulting in an overall reduction of total drag during the transition.

Phenomenon 2: At low Reynolds number flow a rough ball has more viscous drag (more momentum is exchanged with surrounding fluid due to thicker boundary layer) while the pressure drag is similar for both balls. As the Reynolds number increases the smooth blunt object has a more laminar boundary layer and thus more pressure drag than the rough ball. The Roughness enhances momentum exchange with surrounding fluid helping to reduce flow separation and its associated pressure drag. Thus less total drag is experience at high Reynolds numbers by the rough ball.

Phenomenon 3: At low Reynolds number a streamlined and non-streamlined objects have similar pressure drag, however the viscous drag is proportional to their surface area. For bodies with similar cross section, a sphere has the smallest surface to volume ratio and thus experience less viscous drag. At high Reynolds number a streamlined object experience negligible pressure drag while a sphere, being a blunt object, experience significant pressure drag. The contribution of the pressure drag to the blunt object is larger than that of the added viscous drag experienced by the streamlined object resulting in a higher total drag for the sphere at high Reynolds numbers.

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: $mgh = 5000\text{lb} \times 0.45\text{kg lb}^{-1} \times 9.81\text{m s}^{-2} \times 2\text{m} = 44{,}145\text{J}$.
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)/ $(5000\text{lb} \times 0.45\text{kg lb}^{-1} \times 9.81\text{ m s}^{-2}) \sim 5\text{m}$*!*

This page was last edited on 2/23/2015