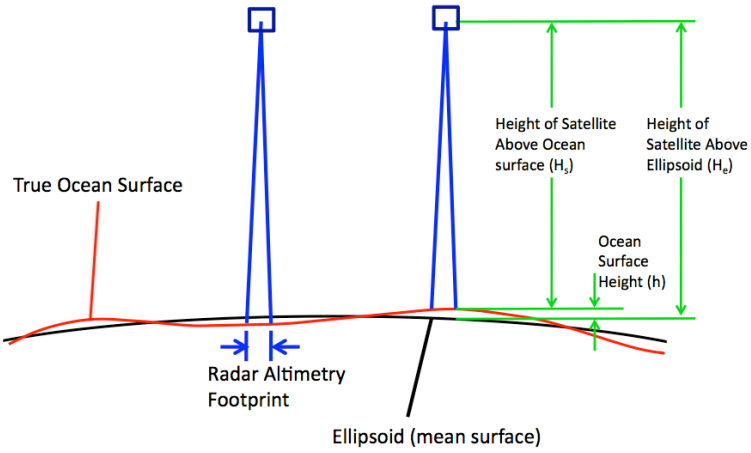
SIO 135-236 Homework - Satellite Radar and Laser Altimetry - Due May 23

1. Radar altimetry

i) What corrections need to be made to estimate the elevation of the surface from the travel time of the radar pulse from the satellite to the ground?

ii) How is the elevation determined from a radar altimeter waveform over (a) the ocean and (b) the ice sheets?

iii) For (iii) and (iv) refer to figure below. The Topex satellite passes over a point on the ocean at a height above the ellipsoid (mean surface height) of 700 km (H_e). The travel time of the pulse from the satellite to the Earth and back (from which we can calculate H_s) is 4.666666 milliseconds. What is the height (h) of the ocean surface?



iv) 30 days later the satellite passes over the same location again. This time the travel time of the pulse is 4.666672 milliseconds. Has the surface gone up or has it gone down? By how much? What might cause the surface to do this?

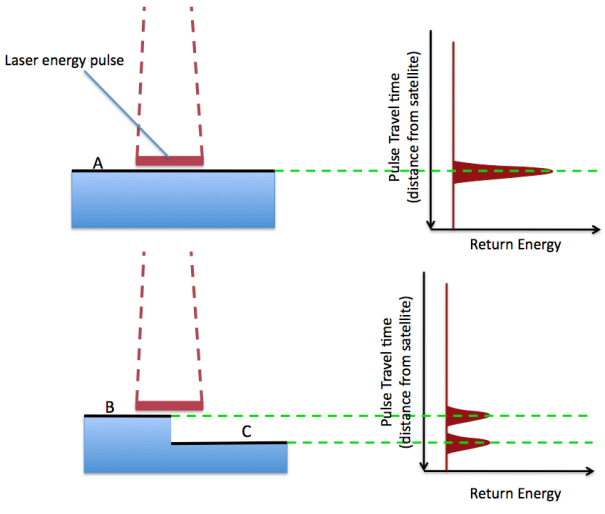
2. Laser altimetry

i. What corrections need to be made to estimate the elevation of the surface from the travel time of the laser pulse from the satellite to the ground?

ii. How is the elevation determined from a laser altimeter waveform (e.g. ICESat)?

iii. For (iii) and (iv) refer to figure below. Why does the bottom figure show two peaks, when the top figure only shows one?

iv. Why is the peak in the top figure stronger than either of the peaks in the bottom figure?



3. Insulation effect of sea ice – (see notes 2, May 16)

Consider the radiative heat loss from an ocean with an emissivity $\varepsilon = 0.98$. Case 1 is an ocean having a surface temperature $T_s = 273^o K$. It is radiating its heat into space where the effective temperature $T_o = 260^o K$. Assume radiative heat loss given by.

$$q_r = \varepsilon\sigma\left(T_s^4 - T_o^4\right)$$

a) What is the radiative heat loss for this case of an ice-free ocean?

b) Now suppose the ocean is covered by a 1-m thick layer of ice and the temperature of the base of the ice/water contact is also 273˚K. What is the temperature at the surface of the ice? What is the heat loss from the ocean in this case? Explain why the reduction in the area of the Arctic sea ice will increase the rate of heating in the Arctic ocean. (See on line notes for a similar example.)

4. Pulse limited footprint

Derive the formula for the pulse-limited radius of a radar altimeter (equation 8.11 in Rees third, 8.16 in second). What is the radius when the pulse length is 3 nanoseconds and the altitude of the satellite is 700 km?