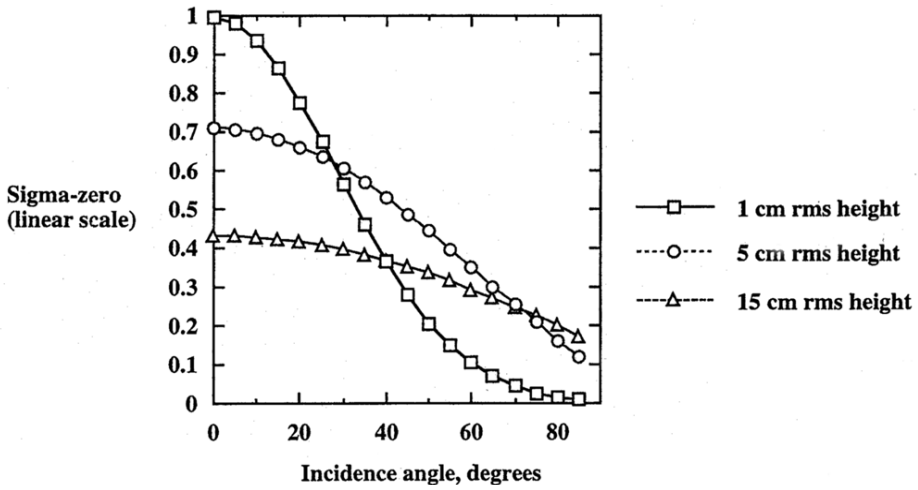
EE/GP140 - Homework Set No 4

Handout 20

Due: Friday, Feb. 8
In class or to homework box or TA by 4:00

1. The following graph gives the response of a particular radar system to surfaces of 1 cm, 5 cm, and 15 cm rms height as a function of incidence angle:



You use this system to measure the backscatter, expressed as σ^0, of a field. You obtain the following measurements:

Incidence angle, degrees:	10°	30°	50°	70°
Sigma-zero:	0.83	0.68	0.45	0.21

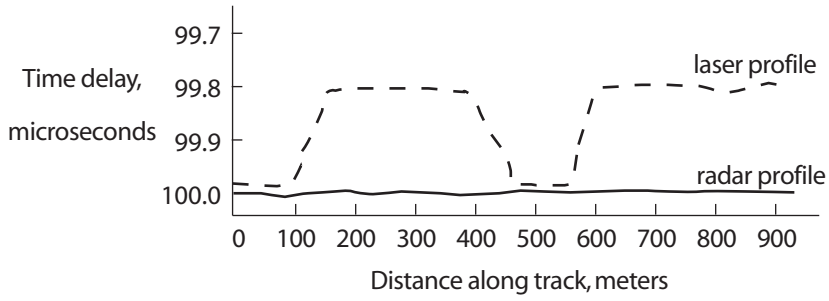
(a) Plot the measurements on a copy of the above graph

(b) Estimate the rms height of the surface you measured, within 1 cm.

2. You want to measure the height of a crop of soybeans, which could range from zero (if there were no plants) to about one meter high. Suppose you want to be able to distinguish bare fields, from a crop 30 cm high, and from a crop 1 m high. In order words, you want about 3 classes in your results. What set of radar wavelengths might you use, and what would your algorithm for analyzing the data be? Once again there are several "correct" solutions. Assume that the radar resolution is 10 m so you cannot identify individual plants.

3. How might you use a multispectral instrument like TM to confirm at least some of your results in Problem 2? State at least one advantage and one disadvantage to using multiple instruments.

4. A satellite containing both a radar altimeter operating at 1 m wavelength and a laser altimeter using visible light is used to study the Amazon rain forest. Sometimes both instruments give the same time delay and sometimes the laser gives less delay. Plotting both signals we see something like this:



A clever student realizes that the laser is reflected from the tops of the trees while the radar signal penetrates to the forest surface, resulting in a greater time delay.

(a) How tall are the trees in this forest?

(b) If the above plot were "typical", what percentage of the forest has been cleared by clear-cutting?

(c) Would you expect the radar signal to be brighter in the forest areas or clear-cut areas? Why?

5. Suppose that the backscatter function $\sigma^0(\theta)$ for a patch of bare ground has the form

$$\sigma^0_{ground}(\theta) = e^{-(\frac{\theta}{10})^2}$$

where θ is in degrees and $e^{-()}$ is the exponential function. Similarly, for a tree in the Amazon rain forest,

$$\sigma^0_{tree}(\theta) = \frac{1}{2} cos(\frac{\theta}{100})$$

(a) Now suppose that the ground area imaged is covered by 50% trees and 50% bare ground. Plot $\sigma^0(\theta)$ for this area, assuming that half the area scatters as $\sigma^0_{ground}(\theta)$ and half as $\sigma^0_{tree}(\theta)$.

(b) Repeat for a region 25% trees and 75% ground.

(c) How about for 90% trees and 10% ground?