Problem Set 7  
ECE 5010 Autumn 2018

Problem 1
For the following applications, state whether optical or microwave sensing would be more appropriate, and explain why. For microwave sensing, describe whether a altimeter, scatterometer, or SAR would be more applicable.
(a) It is desired to provide satellite imagery at resolution 20 cm from space. Obstructions due to clouds are not considered a major problem.
(b) It is desired to measure the height of the sea surface in all weather conditions. Spatial resolutions of 10 km are acceptable.
(c) It is desired to measure the soil moisture of land surfaces from space at 100 m spatial resolution in all weather conditions.
(d) Show that a satellite in a circular orbit at altitude ~35,900 km will have a 24 hr orbital period.
(e) For a satellite orbiting at altitude 680 km in a polar orbit, find the spacing in km between the subsatellite points at equatorial crossings. What does this indicate about swath widths to achieve daily global coverage?

Problem 2
NASA’s SMAP radar measures backscatter from the Earth surface at 1.26 GHz and 40 degrees incidence angle. SMAP orbits at a 680 km altitude; consider SMAP in a “sidelooking” configuration in this problem. The SMAP antenna has a circular aperture of 6 m diameter, the radar transmits 200 Watts in a 1 MHz bandwidth, and the receiver noise figure is 2 dB.
(a) Estimate the size of the illuminated area on the Earth’s surface; note this is determined by the range resolution in one dimension and the antenna footprint in the other.
(b) If the range resolution is degraded to be comparable to that in the cross-range direction, how many “looks” are achieved?
(c) Find the expected value of the power received when SMAP observes a terrain surface having an NRCS of -20 dB.
(d) What is the corresponding signal-to-noise ratio for this observation? How could the signal-to-noise ratio be improved?

Problem 3
(a) Compare the HH and VV NRCS predictions of the SPM and Dubois models for backscattering from soil at 1.5 GHz and incidence angle 40 degrees. Do this by plotting the NRCS as a function of soil moisture for rms height 0.5 cm and rms height 2 cm (note Matlab functions are available on course website). Discuss the similarities and differences in the two models.
(b) Examine the frequency dependence of the two models (this can be done by comparing equations). How are they similar or different?
(c) Examine the dependence on rms height for the two models. How are they similar or different?
(d) Find a way to “decouple” the influence of permittivity and surface roughness in the SPM through the use of HH and VV measurements. What would the advantages or disadvantages be of such an approach?
Problem 4
In this problem we will investigate soil moisture retrieval performance under the SPM or Dubois models. A program for this purpose is available on the course programs website.

(a) Use the program to produce plots of retrieval performance under the default parameters (1.5 GHz, 40 degrees, 100 looks, 1.5 cm rms ht, SPM model.) How does the retrieval performance vary with soil moisture?

(b) Repeat (a) using 1000 looks. How do your results compare to part (a)? Explain.

(c) Repeat (a) using the Dubois model. How do your results compare to part (a)?

(d) Use your problem 3(a) results to examine the “sensitivity” of the SPM and Dubois NRCS values to soil moisture, i.e. the derivative of NRCS with soil moisture. Do these results provide any insight regarding parts (a)-(c) of this problem?