

E E / Mteor / Agron 518 Spring 2008  
Problem Set 10  
Due Tuesday, April 29, 2008

Assigned April 21, 2008  
Updated April 24, 2008

1. Model a bare soil as a homogeneous halfspace with a uniform temperature of 300 K.
  - (a) Plot the horizontally polarized and vertically polarized brightness temperature at 1.4 GHz of the soil as a function of incidence angle for a dry soil (volumetric water content  $0.10 \text{ m}^3 \text{ m}^{-3} = 10\%$ ), a moist soil (volumetric water content  $0.25 \text{ m}^3 \text{ m}^{-3} = 25\%$ ), and a wet soil (volumetric water content  $0.40 \text{ m}^3 \text{ m}^{-3} = 40\%$ ). Use the function `ersoilr8.m` to compute soil relative permittivity and the function `trb.m` to compute soil reflectivity. Vary incidence angle from  $0^\circ$  to  $90^\circ$ .
  - (b) How does the brightness temperature vary with soil water content?
  - (c) Over what range of incidence angles (approximately) is the horizontally polarized brightness temperature most sensitive to soil water content?
  - (d) Over what range of incidence angles (approximately) should the vertically polarized brightness temperature *not* be used to measure soil water content?
  - (e) How does the Brewster angle change with soil water content?
  - (f) Describe a procedure for determining the physical temperature of a soil with a 1.4 GHz radiometer.
2. Model a bare soil as a homogeneous halfspace with a uniform temperature of 300 K.
  - (a) Assume the soil surface is smooth (quasi-specular). Find the sensitivity of the 1.4 GHz horizontally polarized brightness temperature to soil water content at an incidence angle of  $30^\circ$  over the range of realistic soil water content (0% to 40%). Use the `polyfit` function in matlab with  $n = 1$  (linear fit). Report the sensitivity in units of  $\text{K } \%^{-1}$ .
  - (b) Assume the soil surface is slightly rough ( $h = 0.3$ ). Find the sensitivity of the 1.4 GHz horizontally polarized brightness temperature to soil water content at an incidence angle of  $30^\circ$ . Report the sensitivity in units of  $\text{K } \%^{-1}$ .

- (c) Assume the soil surface is rough ( $h = 0.6$ ). Find the sensitivity of the 1.4 GHz horizontally polarized brightness temperature to soil water content at an incidence angle of  $30^\circ$ . Report the sensitivity in units of  $\text{K } \%^{-1}$ .
- (d) What happens to the absolute value of the sensitivity of the 1.4 GHz horizontally polarized brightness temperature to soil water content as the soil surface becomes rough?
3. Model the 1.4 GHz brightness temperature of a grass canopy of water column density  $1 \text{ kg m}^{-2}$ . Use  $\omega = 0$  and  $b = 0.15$ . Assume that the soil surface beneath the canopy is quasi-specular, the soil can be approximated as a uniform halfspace of physical temperature 300 K, and that the temperature of the canopy is also 300 K.
- (a) Plot the horizontally polarized and vertically polarized brightness temperature as a function of incidence angle from  $0^\circ$  to  $60^\circ$ .
- (b) Increase the water column density of the vegetation canopy from  $1 \text{ kg m}^{-2}$  to  $2 \text{ kg m}^{-2}$  and then to  $4 \text{ kg m}^{-2}$ .
- How does the brightness temperature change with incidence angle for a vegetation water column density of  $1 \text{ kg m}^{-2}$ ?
  - How does the brightness temperature change with incidence angle for a vegetation water column density of  $4 \text{ kg m}^{-2}$ ?
  - Does the same thing happen for the vertically polarized brightness temperature? Why or why not?
- (c) Find the sensitivity of horizontally polarized brightness temperature to soil water content at an incidence angle of  $30^\circ$  when the soil (quasi-specular surface) is covered by a vegetation canopy of  $1 \text{ kg m}^{-2}$ . Compare this to the sensitivity of horizontally polarized brightness temperature of a bare soil (Problem 2a).
- (d) Find the sensitivity of horizontally polarized brightness temperature to soil water content at an incidence angle of  $30^\circ$  when the soil (quasi-specular surface) is covered by a vegetation canopy of  $3 \text{ kg m}^{-2}$ . What happens to the absolute value of the sensitivity to soil water content as the vegetation canopy gets larger?
- (e) Find the sensitivities of horizontally polarized brightness temperature to soil water content at an incidence angle of  $30^\circ$  when the soil (quasi-specular surface) is covered by vegetation canopies of  $1 \text{ kg m}^{-2}$  and  $3 \text{ kg m}^{-2}$  at a frequency of 10 GHz. What happens to the absolute value of the sensitivity to soil water content in the presence of vegetation at higher frequencies?
4. Read Chapter 3 of the Decadal Survey on Earth Science and Applications from Space, titled "From Satellite Observations to Earth Information."
- What is the overall goal of the authors in Chapter 3?
  - Contrast exploratory missions and operational missions.
  - Explain the usefulness of climate data records (CDR).

- (d) The report describes some of the differences between NASA, NOAA, and the USGS. What is your opinion: should another federal agency be created to oversee the procurement of some satellite observations that do not appear to be wholly the responsibility of one of these three organizations? Or is there a better solution? For example, like the Landsat observations of optical reflectance of Earth's surface which can be related to land cover.
- (e) Why are Earth surface-based observations of the natural environment, and not only satellite observations, important?
- (f) Give two examples of how airborne observations are useful.
- (g) Can Google Earth play a role in a comprehensive Earth information system? How?
- (h) What recommendation is made in terms of the research and analysis associated with the data collected by NASA satellite missions?
- (i) Refer to Box 3.3 and Figure 3.3.1. Why did satellite observations of weather first degrade weather forecasts? What was created to change this? Why were forecasts for the Southern Hemisphere initially worse than for the Northern Hemisphere, and why are forecasts for the Northern and Southern Hemispheres essentially equally good today?
- (j) What is the last recommendation of Chapter 3?