

## Remote Sensing Homework

Spring 2007

*Always answer in complete, coherent sentences and show all work!*

*Due Wednesday, 21 March 2007*

### Remote sensing of cloud properties

1. Explain how the effective level of emission (the height from which the observed energy appears to emanate), determined from the brightness temperature of a scene that is covered in an optically thin cloud layer, may actually be below the cloud.
2. Briefly explain the following cloud-detection methods, and give a shortcoming in applying each one to the real world:
  - a. Threshold method:
  - b. Split-window method (e.g., difference between 11  $\mu\text{m}$  and 3.7  $\mu\text{m}$  channels):
  - c. Pattern recognition method:
  - d. Adjacent FOV method (i.e., compare radiances in matrix of FOVs):
5. What is a radiative transfer model?
6. Briefly explain the two primary techniques used to estimate cloud-top pressure (or height).
7. Define the following terms:
  - a. cloud fraction (N)
  - b. effective cloud fraction ( $\epsilon N$ )
  - c. clear-column radiances (cloud-clearing)
8. Beginning with Eqns. 8.3a and 8.3b (in Kidder and Vonder Haar), show that:

$$N^* = \frac{\tilde{L}_1 - L_{clr}}{\tilde{L}_2 - L_{clr}} = \frac{N_1 \epsilon}{N_2 \epsilon}$$

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9. Use the  $N^*$  method and the following information to estimate the cloud-cleared radiance in channel 6 ( $13.7 \mu\text{m}$ ) of the High-resolution InfraRed Sounder (HIRS), one of the sensors that compose the TIROS Operational Vertical Sounder (TOVS). This sounding channel has a weighting function that peaks around 800 mb ( $\sim 2 \text{ km}$ ) in the atmosphere.

Using a  $5 \times 5$  matrix of FOVs in the area surrounding two particular FOVs of interest, you determine that the clear-sky radiance at  $11 \mu\text{m}$  (an atmospheric window channel) is  $140 \text{ W m}^{-2} \text{ sr}^{-1}$ . You have also measured the following radiances in the two FOVs:

FOV 1: Satellite-observed radiance at  $11 \mu\text{m} = 90 \text{ W m}^{-2} \text{ sr}^{-1}$   
Satellite-observed radiance at  $13.7 \mu\text{m} = 30 \text{ W m}^{-2} \text{ sr}^{-1}$

FOV 2: Satellite-observed radiance at  $11 \mu\text{m} = 120 \text{ W m}^{-2} \text{ sr}^{-1}$   
Satellite-observed radiance at  $13.7 \mu\text{m} = 50 \text{ W m}^{-2} \text{ sr}^{-1}$

- a. Draw a diagram of the two FOVs with data values below and state the assumptions you are making about the conditions in them.

b. Calculate  $N^*$

c. Calculate the cloud-cleared radiance for HIRS channel 6.