Exam Remote Sensing GEO4-4408
18 April 2008

Question 1:
Give a precise and complete description with sketches (!) of the following concepts in Remote Sensing:

a. Training, the entire chain of steps.
b. Feature space.
c. Lambertian reflector.
d. Error Matrix, give/draw an example and discuss its most important properties.

Question 2:
Given the information and theory provided during the course, can you describe what happens to electromagnetic radiance between its source (the Sun) and a sensor (a camera mounted on a satellite and looking down at the ground).

Question 3:
Using the Rayleigh criterion for surface roughness, what do you think would be the difference in the nature of microwave reflection from a flat sandy plain and a surface covered in 2 cm diameter pebbles, for:

a. L-band (25 cm wavelength) microwaves with an incidence angle of 60°, and
b. X-band (3 cm wavelength) microwaves with the same incidence angle.

Show your computations in a clear and concise way.

Question 4:

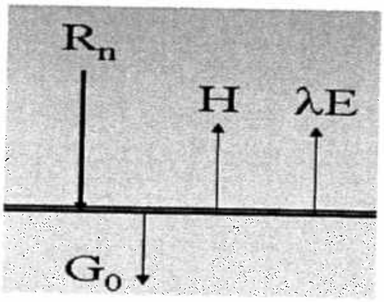
a. All objects warmer than the absolute zero emit radiance. Consider the following surfaces and compute the wavelength of peak thermal exitance and show your computations:

- An artic snowfield of -20°C;
- A hot desert sand surface at 50°C;
- Molten lava at 1150°C;

b. Now compute for each of these three surfaces the radiant exitance using the following values of emissivity and show your computations:

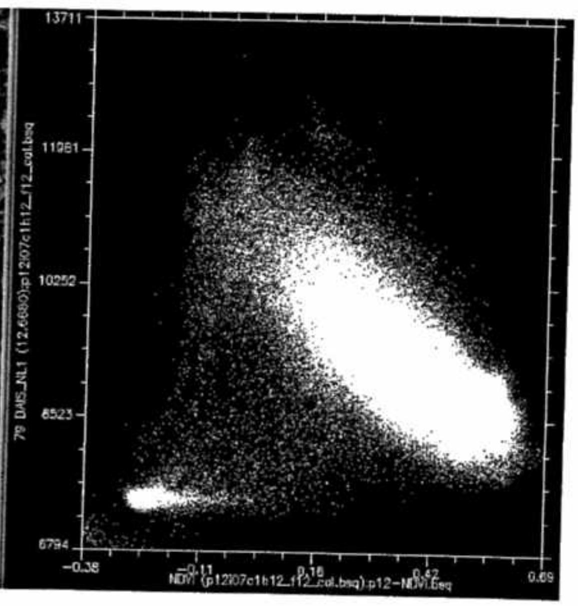
- Artic snowfield: $\varepsilon = 0.95$;
- Hot desert sand surface $\varepsilon = 0.40$;
- Molten lava $\varepsilon = 0.8$;

c. Thermal remote sensing is also used to simulate the surface energy balance. The basic surface energy balance is given below. Name and describe each of these components, discuss their dynamics and their importance for hydrological studies.



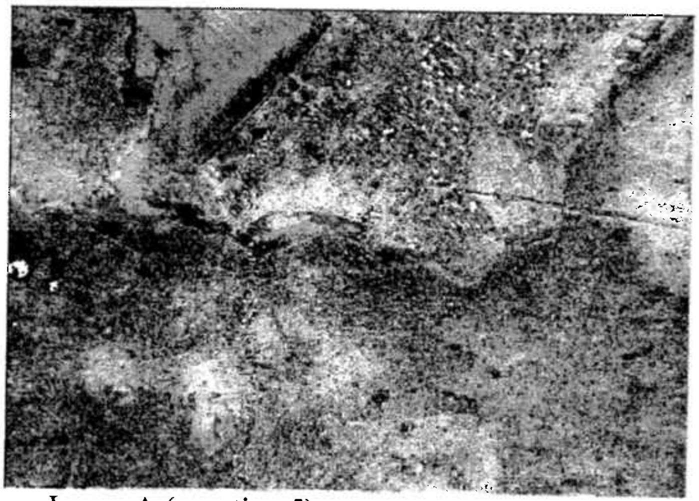
d. The two figures presented below show an image of an area in France and a corresponding feature space of de NDVI (x-as) and radiant temperature.

- What is radiant temperature?
- Copy a sketch of the feature on your exam paper and indicate in this feature space



Question 5:
Principal Component Analysis is an often used image processing method in remote sensing image analysis.

a. A Principal Component Transform (PCT) is applied to the ASTER image of the central Netherlands used during the computer exercises. The three images A, B, C show the PC1, PC2 and PC6 images. Indicate which of the images (A, B, C) is the PC1 image, the PC2 and the PC6 image? Motivate your answer.
b. Give two reasons, and a motivation, why a researcher would like to perform a Principal Component Transform of a remotely sensed image.
c. The Principal Component Transform is based on the statistical distribution of the pixels in the multi-dimensional space. With respect to remote sensing image analysis this has certain disadvantages. What are these disadvantages? What kind of solution is available in remote sensing image analysis to overcome these problems?
d. Draw a feature space on paper of red reflectance and near infrared reflectance for this ASTER scene, label the axes and indicate pixel locations of water, green vegetation, senescent vegetation, bright soils, dark soils and clouds. Next, draw the position of the first and second Principal Component axes in this feature space.


a. Image A (question 5)

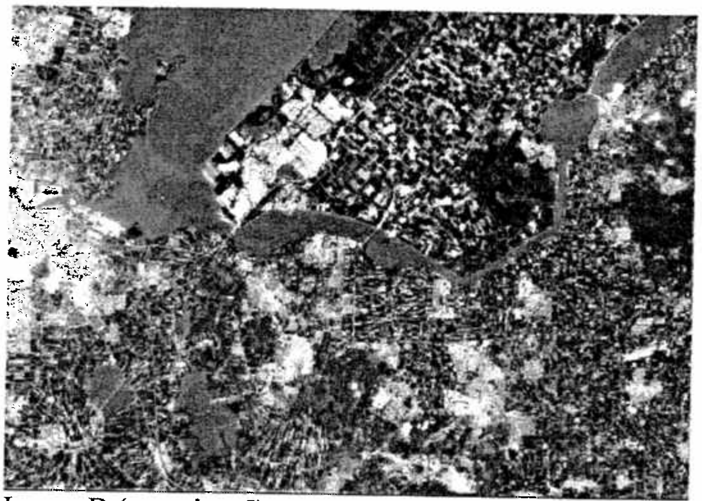


Image B (question 5)


Image C (question 5)

Question 6:

The image shown below is a digital image of infinite size. No deformation occur at the edges when digital filters are applied to this image.

1	1	0	0	1	1	0	0	1	1	0	0	1	1	0	0	1	1	0	0	1	1	0	0	1	1	0	0	1	1	0	0
0	0	1	1	0	0	1	1	0	0	1	1	0	0	1	1	0	0	1	1	0	0	1	1	0	0	1	1	0	0	1	1
1	1	0	0	1	1	0	0	1	1	0	0	1	1	0	0	1	1	0	0	1	1	0	0	1	1	0	0	1	1	0	0
0	0	1	1	0	0	1	1	0	0	1	1	0	0	1	1	0	0	1	1	0	0	1	1	0	0	1	1	0	0	1	1
1	1	0	0	1	1	0	0	1	1	0	0	1	1	0	0	1	1	0	0	1	1	0	0	1	1	0	0	1	1	0	0
0	0	1	1	0	0	1	1	0	0	1	1	0	0	1	1	0	0	1	1	0	0	1	1	0	0	1	1	0	0	1	1
1	1	0	0	1	1	0	0	1	1	0	0	1	1	0	0	1	1	0	0	1	1	0	0	1	1	0	0	1	1	0	0
0	0	1	1	0	0	1	1	0	0	1	1	0	0	1	1	0	0	1	1	0	0	1	1	0	0	1	1	0	0	1	1
1	1	0	0	1	1	0	0	1	1	0	0	1	1	0	0	1	1	0	0	1	1	0	0	1	1	0	0	1	1	0	0
0	0	1	1	0	0	1	1	0	0	1	1	0	0	1	1	0	0	1	1	0	0	1	1	0	0	1	1	0	0	1	1
1	1	0	0	1	1	0	0	1	1	0	0	1	1	0	0	1	1	0	0	1	1	0	0	1	1	0	0	1	1	0	0
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1	1	0	0	1	1	0	0	1	1	0	0	1	1	0	0	1	1	0	0	1	1	0	0	1	1	0	0	1	1	0	0
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1	1	0	0	1	1	0	0	1	1	0	0	1	1	0	0	1	1	0	0	1	1	0	0	1	1	0	0	1	1	0	0
0	0	1	1	0	0	1	1	0	0	1	1	0	0	1	1	0	0	1	1	0	0	1	1	0	0	1	1	0	0	1	1

a. Describe the concept of digital filters in remote sensing?

b. What will be the effect of a 3 by 3 Median filter applied to this image? Motivate your answer.

c. What will be the effect of a 5 by 5 Median filter applied to this image? Motivate your answer.

d. What will be the effect of the following vertical Sobel filter applied to this image

```
-1 0 1
-2 0 2
-1 0 1
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Please, motivate your answer.

Annex 1: Formulae remote sensing exam

$Q = h * \nu$

$Q = (h * c)/\lambda$

$R_r = c * \tau / (2 * \cos\theta_d)$

$\beta = \lambda / (A * L)$

$\lambda_m = T/A = T/2898\ \mu m$

$\lambda_m = A/T = 2898/T\ \mu m$

$p * V = (N * (m*v5))/3$

$E = h * f$

$y = f_2\ (X,Y)$

$M = \varepsilon * \sigma * T^4 = 5.67 * 10^{-8} * T^4\ W/m^2$

$\varepsilon = F_{real\ material} / F_{black\ body}$

$c = l * f$

$h = dH/r$

$P = 2 * (t + 14)$

$(1-\alpha) * R_s = R_l + G + H + LE$

$h < \lambda/(25 * \sin\gamma)$

$h > \lambda/(4.4 * \sin\gamma)$

$ht < \lambda/(8 * \sin\gamma)$

$Etot = Er + Ea + Et$

$\alpha = 0.525*r(TM2) + 0.362*r(TM4) + 0.112*r(TM7)$

$ET(Ts) = -0.125*Ts - 0.085*\alpha + 43.73$

$DN = GL + B$

$x = f_1\ (X,Y)$

$T_s = -12.58 + 0.2919DN - 0.000233DN^2$