Final Exam Remote Sensing (GEO4-4408)
20 April 2007

1. Visual image interpretation of satellite images using colours is an important activity in remote sensing. Colours comprise three primary colours and three complimentary colours. In physical terms colours can be described by 3 variables: intensity, hue and saturation.
    a. What are the three complimentary colours and what is their primary use in Remote Sensing?
    b. Draw a colour cone and indicate the position of the three variables: intensity, hue and saturation in this cone; indicate also in this colour cone the position of the three primary colours and the three complimentary colours.
    c. Explain why a car can have a red colour in a true colour film (TC) and why the same car will have a yellow colour on a colour infrared film (CIR). I encourage you to make drawings to explain your answer.

2. a. What does the term 'training' mean in remote sensing? Give a detailed description.
    b. What is cubic convolution resampling in remote sensing? Give a detailed description.
    c. In object based remote sensing stratification and segmentation are both used to assist image analysis. What is image segmentation in remote sensing? What is image stratification in remote sensing? And what is the difference between the two? How are segmentation and stratification used in remote sensing image analysis?

3. Laser altimetry, or LIDAR, is a fast developing remote sensing technique to create Digital Elevation Models (DEM) or Digital Surface Models (DSM).
    a. Describe in maximum 12 sentences how laser altimetry works.
    b. Explain the terms first pulse, last pulse, support and foot print in case of laser altimetry. Use drawings to explain your answer.
    c. Suppose you have full waveform digitizing laser altimetry system and this system has acquired an image over a group of trees. Sketch and explain the registered response signal of a tree in the winter situation and a tree in the summer situation.
    d. Laser altimetry is mostly used to produce elevation products. Explain in what case vegetation is a disturbing factor and explain in what case vegetation is a signal of interest?

4. A comet approaches earth and is heated by the sun until the total radiance exitance reaches $3.0*10^2$ W/m^2. A researcher aims at investigating the surface of the comet by sending a satellite with a sensor aboard. The researcher wants to position the spectral band of the sensor at the wavelength of maximum spectral radiant exitance of the comet. Assume that the comet behaves like a blackbody. See also attached formulae sheet.
    a. What is a blackbody and what are its most important properties?
    b. If the comet heats up until it starts radiating in visible wavelengths, what is the sequence of colours that we will see? Explain why.
    c. Compute the wavelength of maximum spectral radiant exitance of the comet. Show how you did your computation. Discuss any assumptions you have to make.
    d. How does the comet's wavelength of maximum spectral radiant exitance relate to that of the earth?

5. Radiometric correction of images is a necessary image processing step in remote sensing.

a. Radiometric correction of raw DN satellite images normally corrects for three factors. Name and describe all three of these factors.

b. Two formulae are given below which are normally used for radiometric correction of satellite imagery.

Formula 1: $$R(\lambda) = \frac{\pi L(\lambda)}{E_o(\lambda)(1/r^2)\cos(\theta_o)}$$

Formula 2: $$L(\lambda) = G \cdot DN + B$$

What is the meaning of each of the 9 symbols used in formula 1 and 2? Give a concise but complete description.

c. What is computed by formula 1?

d. What is computed by formula 2?

Below three situations of the use of remote sensing images in Geography are described.

I. The production of a land cover map of the province of Utrecht on the basis of an ASTER image of 15 June 2005.

II. A crop growth model simulates leaf development of sugarbeets on agricultural fields in the Flevopolder. A time series of multi-spectral, airborne images are collected for the months of May, July, August and October. These images are used, together with a spectral vegetation index, to calibrate and validate the model simulations of leaf growth.

III. A Landsat TM image of the French Alps is acquired. A Principle Component Transformation is applied to this image. The image is projected in a RGB space for geological mapping of faults and structural forms (syncline, anticline) present in this area.

e. Describe for each of the three given situations, why or why not, a radiometric correction of the remote sensing image(s) is necessary. Give a detailed motivation for your answer.

Annex 1: Formulae remote sensing exam

$Q = h * \nu$

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

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

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

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

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

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

$E = h * f$

$y = f_2 (X,Y)$

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

$M = \varepsilon * \sigma * T^4$

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

$c = l * f$

$h = dH/r$

$P = 2 * (t + 14)$

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

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

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

$Etot = Er + Ea + Et$

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

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

$DN = GL + B$

$x = f_1 (X,Y)$

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