# EE/GP140 - Homework Set No 3   **Handout 15**

Due: Friday, Feb. 1

In class or in TA's office

1. Some remote sensing instruments measure only the total amount of ozone in a column stretching from the Earth's surface to the top of the atmosphere. Others retrieve the profile of ozone abundance as a functiion of height. Why is it preferable to be able to measure ozone concentration as a function of height? Comment on the implication of ozone abundance in the lower vs. upper atmostphere.

2. You acquire a remote sensing image of the Crystal Springs reservoir along Hwy 280 north of Stanford, and it looks like the following:
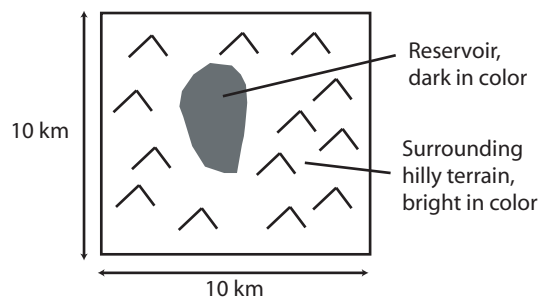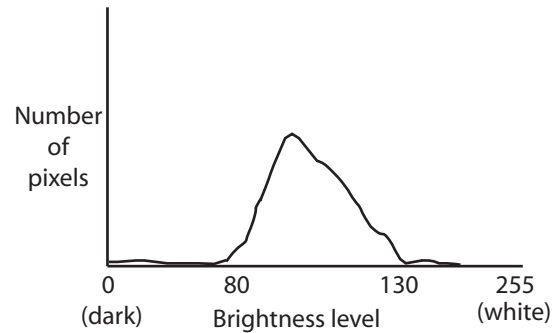

You calculate a histogram of the image as:
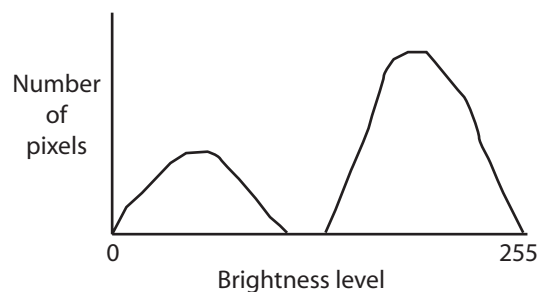
   (a) Why are there two distinct bumps in the histogram?

   (b) Suppose that the area under the first bump is 20% of the total number of pixels in the image. What is the surface area of the reservoir?

3. An image has the following histogram:

You decide to apply a linear stretch to the image to enhance it. You scale the image so that the region from pixel values 80-130 fills the 0-255 range of your computer display.

(a) What happens to pixels with initial values from 0-80? from 130-255?

(b) If you had a feature with average brightness 60 against a background of average brightness 20 before the stretch is applied, will it be more or less detectable after the stretch? Why?

(c) How about a feature of brightness 115 against a background of 100 before the stretch? Calculate the ratio of brightness for $\frac{\text{target}}{\text{background}}$ both before and after the stretch.

4. A radar instrument has a range resolution of 10 m in the slant range direction and an azimuth resolution of 15 m. Suppose that the pixel spacing is exactly equal to the resolution. Data are processed on the satellite and sent to Earth with one byte representing each pixel.

(a) What is the ground range resolution of this instrument if it is operated with an incidence angle of 30°? How about 60°?

(b) At what incidence angle should the radar be operated to obtain "square" pixels on the ground?

(c) At 30° incidence, if the swath width is 100 km and the velocity of the satellite is 7500 m/s, what is the instrument data rate in bytes/second? Bits/second? (A byte is eight bits)

(d) A standard broadcast TV channel transmits about 6×10^6 bits/second. How many channels are needed to transmit the radar picture?

5. You decide to measure ozone concentration above Stanford with a pair of lasers as follows:
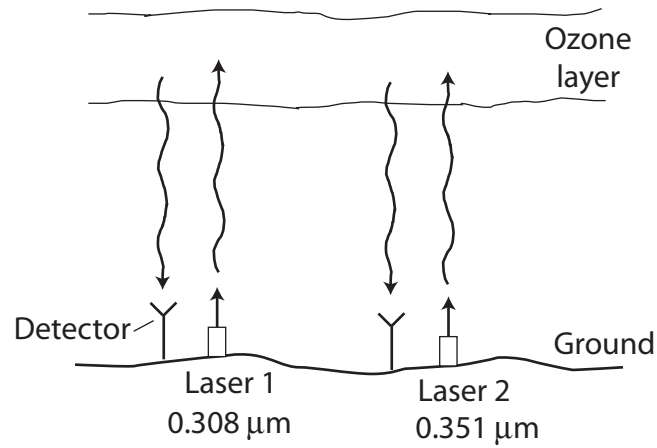
The equipment is calibrated so that the ratio of intensity at $0.351\,\mu$m to that at $0.308\,\mu$m is related to abundance in Dobson units as:
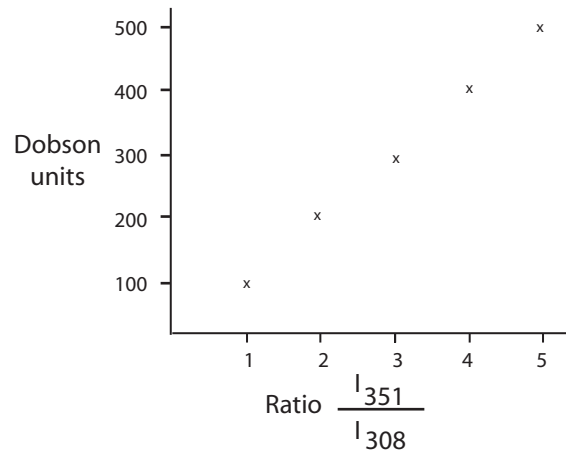
You repeat this experiment once per year with the following results:

Year	Ratio $\frac{I_{351}}{I_{308}}$
1995	3.12
1996	3.11
1997	3.09
1998	3.09
1999	3.07
2000	3.06
2001	3.04
2002	3.02
2003	3.02
2004	3.00
2005	2.99

(a) Plot the abundance of ozone in Dobson units as a function of time.

(b) How much increase in UV over Stanford would be expected from this variation in ozone concentration?

(c) How would you augment this experiment procedure to be able to distinguish stratospheric ozone from tropospheric ozone?

6. Download four remote sensing images entitled hw3prob6a.1024, hw3prob6b.1024, hw3prob6c.1024, and hw3prob6d.1024. These are binary 1024 by 1024 pixel images of our area in three visible and one infrared channel acquired by Landsat Thematic Mapper. Load these into Matlab as we did in the lab exercise.

(a) Display each image and note its contrast and brightness. Combine the red, green, and blue images to form a multichannel image of the surface. Save this picture in jpeg format using the matlab command 'print -djpeg90 filename' where filename is the name of the file you are creating.

(b) Download the linearstretch program and stretch each channel to have a more suitable contrast fir viewing. Create the approximate true color image and save to a jpeg file.

(c) Create a false color image where infrared maps to red, red maps to green, and green maps to blue to obtain an image similar to what we have viewed in class. Use the stretched versions of the data files to get the best picture.