

## 4. USING HISTOGRAMS TO INTERPRET IMAGES

**Aim:** To introduce you to using histograms to interpret images.

**Objectives:** You will learn how to create histograms (which show the numbers of pixels of each image data value) and how these can be helpful in interpreting images.

If you completed the previous tutorial ([Using the image cursor and interpreting the status bar](#)) you will have noted that sea pixels differed markedly from land values in their reflectance. A good way of seeing whether pixels fall into natural groupings on the basis of their reflectance/emittance in a particular waveband is to study a frequency histogram of brightness values. In this section you will be examining an AVHRR image, taken in band #4 which senses emitted thermal infra-red electromagnetic radiation in the wavelengths 10.50–11.50  $\mu\text{m}$ . This image has been processed and re-scaled to 8-bits. By convention darker areas are warmer on AVHRR thermal images. Colder parts of the image will thus appear brighter and warm parts dark.

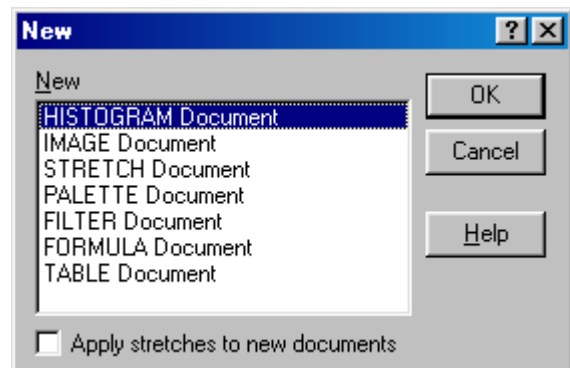
*Activity:* If it is not open already, open the image **AVHRR\_Mulls#04.bmp**. The image was obtained in the daytime in summer. Note that the warm land is generally dark but the sea is brighter with the coldest (brightest) water lying north-east of Malin Head (Figure 4.1).

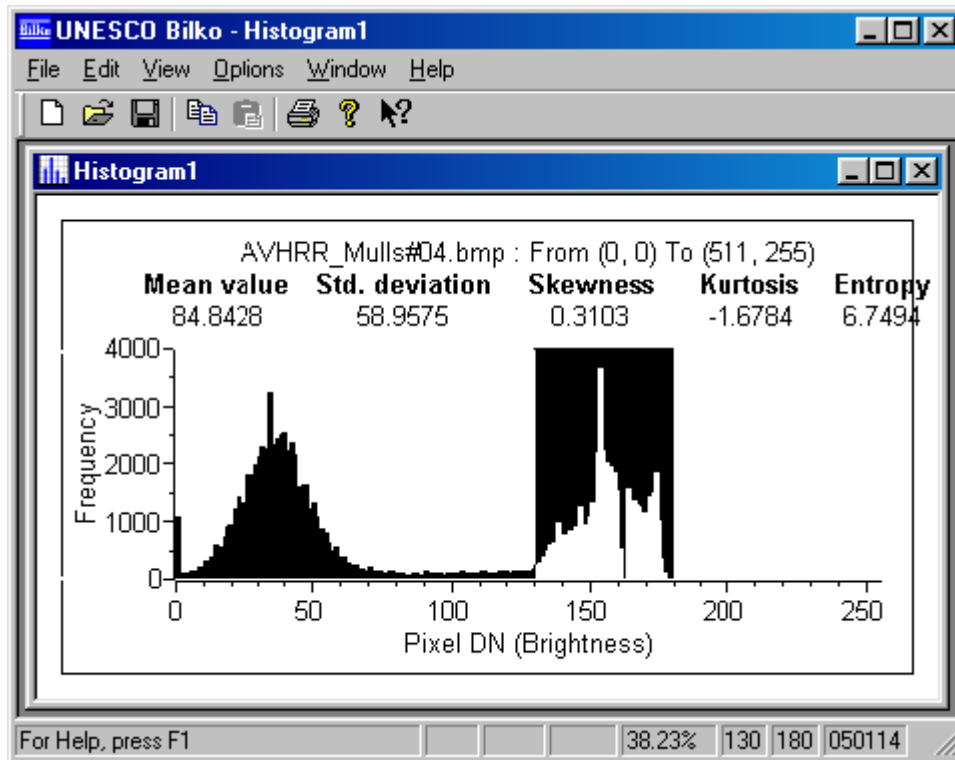


Figure 4.1. Map showing the area covered by the **AVHRR\_Mulls#04.bmp** image.

To create a histogram of all the pixel values in an image you first need to select the whole image file.

*Activity:* Click on **Edit** and then **Select All** or use the short-cut keys **<Shift>+<Spacebar>** (or **<Ctrl>+A**) to select the whole image. Then click on **File** and **New** to bring up the dialog box to the right. Since you want to create a Histogram and the **HISTOGRAM Document** option is already highlighted you can click on **OK** or press **<Enter>** to generate the histogram.





A histogram window will appear in the workspace resembling the **Histogram1** window displayed to the left. The histogram shows the number of pixels in the selected image having given pixel values ( $y$ -axis) versus the set of values (DN) that pixels can take ( $x$ -axis).

Note that the histogram is bimodal (has two peaks). The lower peak (i.e. that

covering pixel brightness values with DNs from about 10–70) is composed mainly of land pixels, whilst the upper peak (i.e. that covering pixel brightness values with DNs from about 130–175) is composed mainly of sea pixels.

*Activity:* Click on the histogram and a vertical line will appear. You can use the mouse or the left and right arrow keys ( $\rightarrow$   $\leftarrow$ ) to move this line through the histogram. The arrow keys by themselves move the line 10 brightness values at a time to right or left. To move one brightness value at a time hold down the **<Ctrl>** key and then press the appropriate arrow key. Make sure the Status Bar is in view. In the bottom right hand corner you will see four panels which record firstly, the % of pixels in the image with the brightness value (DN) highlighted; secondly, the start and finish values of the range of DN values highlighted (if only one DN value is highlighted, these will be the same); and lastly the absolute number of pixels in the image with values in the highlighted range.

In the example above the upper (sea) peak between DN values of 130 and 180 has been highlighted and the Status Bar shows that there are 50,114 pixels in the image with values of 130–180 and that these account for 38.23% of the **AVHRR\_Mulls#04.bmp** image area.

*Activity:* Move the cursor-line across the histogram and the display will change accordingly. To select a range of DN values, hold the left mouse button depressed and drag the mouse to right or left. Use the vertical line and the Status Bar information to answer the following questions.

*Question 1:* What is the brightness value (DN) of the brightest pixels?

*Question 2:* What percentage is this value of the maximum brightness that could be displayed?

*Question 3:* What is the modal pixel brightness value (DN) of the lower (land) peak and how many pixels in the image have that value?

*Question 4:* What is the modal pixel brightness value (DN) of the upper (sea) peak and how many pixels in the image have that value?


Assume that pixels with DNs between 0 and 62 are land. Now use the mouse to select all these land pixels in the histogram. [Position the vertical line at 0, depress the left mouse button and looking at the Status Bar drag until 62 is reached.]

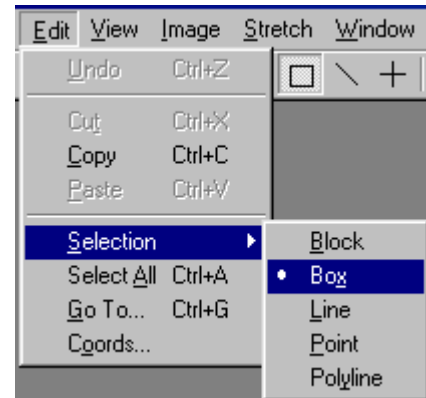
*Question 5:* What percentage of the image is land pixels?

*Question 6:* If the image is 563 km by 282 km, what is the area of land?

So far you have inspected a histogram of the whole image, however, you can select parts of the image in order to discover what the range of pixel brightness values are of particular areas of the image in which you may be interested.

Minimise the histogram window using the minimize button.

*Activity:* Click on **Edit, Selection, Box** or click on the box button (right) on the toolbar. Then click near the top left hand corner of the sea in the  **AVHRR\_Mulls#04.bmp** image and holding down the left mouse button drag the mouse until a rectangular area of sea is outlined with bottom right hand coordinates around pixel (118, 140)<sup>†</sup>. [Look at Status Bar to see the coordinate you have reached]. Then select **File, New** and open a new histogram for the pixels inside the box. You will see a histogram with one peak (unimodal) which shows that the sea pixels in the area you have selected range from a DN of about 129–175 in brightness. Note that the legend above the histogram indicates the top-left and bottom-right pixel coordinates of the `AVHRR_Mulls#04.bmp : From (2, 5) To (118, 140)` box and will look something like the text to the right. Repeat the same exercise with a box of entirely land pixels on the Scottish mainland (see Figure 4.1). You should get a unimodal histogram with pixel brightness values between 0 and about 70.



<sup>†</sup>*Note:* fine positioning of the bottom right hand corner of the box can be achieved using the keyboard. If you need to do this, hold down `<Shift>+<Ctrl>` and use the arrow keys to extend your selection.

*Activity:* When you have done this, close these last two histogram windows of the sea and land pixels (do not save changes) but, if continuing with the next section about using stretches, leave the image open and the histogram of the whole image minimised as you will need this later.

The activities above indicate the kind of information you can find out from studying the histogram (frequency distribution of pixel brightness values) of an image. One of the first things one usually does after loading an image is thus to inspect its histogram to see whether i) all pixels clump together in one peak or whether there are two or more separate peaks which may correspond to different areas of interest on the image, ii) whether pixels are spread over the full range of potential brightnesses or lumped together causing poor contrast.

The histogram of **AVHRR\_Mulls#04.bmp** confirms that the image is not optimally displayed; that is, it is rather dark and it does not utilise the full range of display DN's available and so is somewhat lacking in **contrast**. To rectify this we can adjust how we display the pixel values by a process known as contrast stretching. As the word “stretching” implies, the process causes the pixels to be displayed over the full range of (at least) 256 display brightness values (DN's) available. The next tutorial deals with [using stretches to optimise image display](#).

