

5. USING STRETCHES TO OPTIMISE IMAGE DISPLAY

Aim: To introduce you to using stretches to optimise how images are displayed.

Objectives: By the end of this section you will have explored the *Bilko* **Stretch** menu and learnt how stretches can be used to optimise the display of images on your computer screen and make it easier to see objects or patterns of interest. You will also have learnt how to optimise the display of images with data values greater than 255 (non 8-bit data), using the **Redisplay Image** option.

For this section you will be using **AVHRR_Mulls#04.bmp**, the same AVHRR image used in the previous two tutorials. This image records emitted thermal infra-red electromagnetic radiation in the wavelengths 10.50–11.50 μm and 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. You should be familiar with [histograms](#) before attempting this section.

Activity: If the **AVHRR_Mulls#04.bmp** image is not already open (from last section), please open it. If a histogram of the unstretched image is not already open (from [previous tutorial](#)), please open it.



The **Stretch** menu offers seven options:

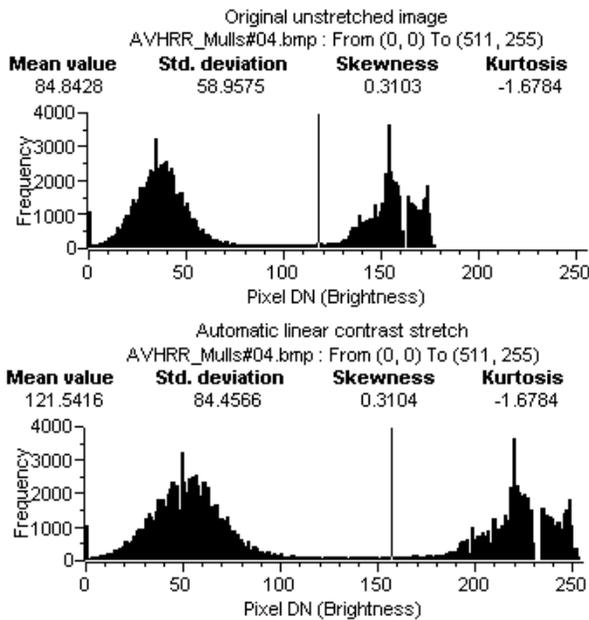
- An Automatic Linear stretch
- A Histogram equalization stretch
- A Gaussian stretch
- A Manual stretch option
- A Clear stretch option (once a stretch has been applied)
- A View option which allows stretches to be viewed graphically
- Options... which control how stretches are applied

For more details of what the different stretches do, see the *Bilko* Help or a remote sensing textbook. In this tutorial, you will look at the results of firstly an **automatic linear stretch** and secondly a **manual stretch** to allow a detailed look at the part of the **AVHRR_Mulls#04.bmp** image that is water. Before doing these stretches, note the relatively poor contrast of the sea in the unstretched image.

Activity: If you do not already have a histogram of the unstretched (raw) image open from the previous tutorial, select all of the image file **AVHRR_Mulls#04.bmp** by clicking on it and pressing **<Ctrl>+A**, or by selecting **Edit, Select All** from the menu. Then select **File, New** and open a new histogram document for the unstretched image.

Before carrying out a stretch, ensure that the **Stretch, Options...** are set such that **AutoLinear Min%** is **0** and **Max%** is **100**, and that the **Apply stretches to charts, clipboard etc.** checkbox is checked.

Make sure that you have selected all of the image file **AVHRR_Mulls#04.bmp** to stretch (by clicking on it and pressing **<Ctrl>+A**). Now click on **Stretch** and then **Auto Linear**. Note how the image immediately brightens and becomes more contrasty. To see the effect on the histogram, click on **File, New** and open a new histogram document for the stretched image.

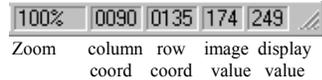


The picture to the left compares the histogram of the unstretched image (upper left) where the maximum pixel brightness was 178 with that of the image after an automatic linear stretch where the pixel DNs have been spread out over the full range of display brightness values (lower left). Thus those pixels that had a brightness value of 178 now have a value of 255. In mathematical terms the original pixel values have been multiplied by $255/178$, this being the simplest way to make use of the full display scale in the present case.

You can check this by examining the pixel brightness values at which the modes in each peak *now* occur. If you look at the mode in the upper peak (sea pixels) you should find that it now occurs at a pixel brightness value of 219 ($= 153 \times 255/178$). Similarly the lower peak (land pixels) mode has moved from a pixel brightness value of 34 to one of 49 ($= 34 \times 255/178$).

Having stretched the image, you have only changed the display values of the pixels, which will now be different from the underlying data values.

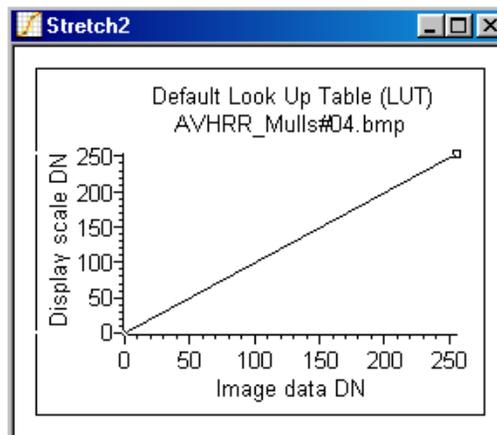
Activity: Click on the  (Point selection) button and select **Edit, Go To** to put the cursor on (x, y) or (column, row) coordinates 90, 135. Note that now the last panel on the Status Bar shows that this pixel now has a display value of 249 ($= 174 \times 255/178$). The underlying image data values, however, remain unchanged.



Close the histogram of the automatic linear stretched image (without saving it). Then select the **AVHRR_Mulls#04.bmp** image window and use **Stretch, Clear** (or just press the **<Delete>** key) to remove the stretch before the next exercise.

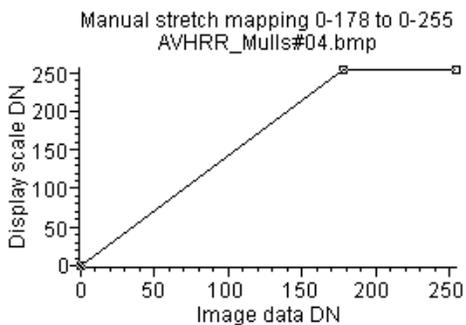
Often one is interested in just one part of an image, for example, an oceanographer is not interested in the land pixels but only the sea pixels. In such a case the person processing the image may wish to preferentially stretch the pixels of interest and largely ignore those not of interest. This may be achieved using a **manual stretch**.

Activity: Make sure the image file **AVHRR_Mulls#04 .bmp** is the active window, then from the **Stretch** menu choose **Manual**. The graph that appears (right) is the default Look Up Table (LUT) and shows that the pixel brightness values (grey tones) in the image (x-axis) are mapped linearly onto the display scale (y-axis) with no change. Thus an image pixel with value 0 is displayed with brightness 0 whilst one with value 178 is displayed with brightness 178.



Stretching involves changing this mapping to take full advantage of the 256 grey levels available on the display.

Activity: Position the mouse pointer on the stretch graph on the $y = x$ line running from (0, 0) to (255, 255) at around coordinates (175, 175) and double-click on the line. A small flashing box should appear on the line. (If it doesn't, try again). This is called a **'knee-point'** and can be used to change how the image data is mapped to the display (computer monitor). As a first try we will mimic the automatic linear stretch you have just performed. This involves increasing the slope of the line so that although pixels with value 0 in the image still map to 0 on the display scale, the maximum image pixel value of 178 maps to 255. To do this the knee-point should be dragged upwards until the Status Bar shows it to be at coordinates (178, 255) and it look like the inset to the right. 178 255 Note how the image changes interactively as you move the knee-point. The image immediately brightens and becomes more contrasty as the stretch is applied.

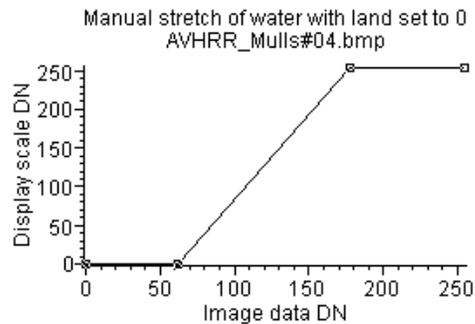


The picture to the left shows how your simple manual stretch should look. It is mapping image pixels with DN's of 0–178 (x -axis) onto a display scale of 0–255 (y -axis). Thus any pixels with DN values of greater than 178 in the image (of which there are none in this case) would map to 255. This is the type of stretch carried out by the automatic linear stretch algorithm. Check this by looking at the histogram of your stretched image.

Once you are satisfied that the stretch has altered the histogram as expected, close the histogram window.

Pixels with brightness values between 0 and about 62 on the **AVHRR_Mulls#04.bmp** image are land. If we were not interested in the land, we could map all these pixel values to 0. The remaining pixels in the image with values from 62–178 represent freshwater lakes (loughs in Ireland and lochs in Scotland) and sea. We can stretch these even more if we make a second knee-point.

Activity: Click on your manual stretch document to make it the active window again. When you have done this double-click on line above a value of about 60 on the x -axis to make a second knee-point. Drag this one downwards to the x -axis until the Status Bar shows the mapping (62, 0) (it will read 062 000). The stretch should now look like the one shown to the right.



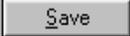
Note that the land now goes completely black with inland freshwater areas standing out well and the sea showing a lot more detail than the ordinary stretch.

You can further refine this stretch for oceanic water pixels by inserting a third knee-point and reducing the amount of the display scale used by non-oceanic water pixels with DN values between 62 and about 130. This then allows maximal stretching of image pixels in the sea with values from 130–178.

Activity: Experiment with this interactively, seeing at what point the Lough Neagh freshwater pixels become dark on the image as you move the third knee-point on the stretch along the x -axis towards a value of 130. This markedly improves the sea pixel contrast, with sea areas now stretched over the full range of display scale values.

This stretch may be useful and is worth saving.

Activity: Make your manual stretch the active window, if it isn't already. Before you save your stretch you should label it so it is clear what it is, so *either* click on the **Options** menu and select the **Names** option, *or* right-click on the stretch and select the **Names** option. This brings up the **Names** dialog box. This has three boxes to fill in: **Chart Name**, **X Axis Name**, and **Y Axis Name**. You can move between these by clicking in them with the mouse or by using the <Tab> key. In the **Chart Name:** box, type [without the quotes] "Stretch of sea with land set to 0", in the **X Axis Name:** box type "Image data DN" as these are the underlying digital numbers in the image, and in the **Y Axis Name:** box type "Display scale DN" as these are the digital numbers which are actually displayed on the screen for pixels with these values in the image. When you have done this click on OK.

Now click on the **File** menu and select **Save**. In the **File, Save As** dialog box type **AVHRR_Mulls#04.str** in the **File Name:** box and click . Your stretch is now saved for future use. To clear the workspace click on **Window, Close All**.

In Tutorial 2 on [opening, viewing and saving images](#) you were briefly introduced to the **Redisplay Image** dialog box but asked to "ignore it for now". For images with pixels recorded at more than 8-bits (i.e. those with image data values > 255) this function acts both to map and to stretch the underlying image data to the 8-bit display scale. It offers a basic **Linear** and **Logarithmic** option for how the data are displayed as well as three options, which correspond to the various stretches (Auto linear, Equalize and Gaussian) in the **Stretch** menu. You will now briefly explore how the **Redisplay Image** option works with a 16-bit integer AVHRR image (recorded as 10-bit data (i.e. DNs between 0 and 1024), but stored as 2 bytes = 16-bits per pixel) of West Africa recorded in the thermal infra-red at same wavelengths as the **AVHRR_Mulls#04.bmp** image. In this case the actual sea surface temperature (SST) in degrees Kelvin is $273.15 + 0.01 \times \text{pixel DN}$ in the image.

Activity: Open the image **AVHRR_West_Africa#04.dat** without altering the **Redisplay Image** dialog box. The result is an unrecognisable mess of black (most of the image) and white (actually cloud). Disappointing!

To see why this is, you need to examine a histogram of the image.

Activity: Select the whole of the image (<Ctrl>+A), click on **File, New** and select **HISTOGRAM document**. Make sure the **Apply stretches to new documents** checkbox is **not** checked. The histogram shows image data values between 0 and approximately 65550 with frequencies displayed for 50 DN value wide "bins". Inspect the histogram. Then click on the far right of the "Image data DN" axis (x-axis). Note that the last four panels in the Status Bar (right) show  that 0.08% of the image pixels occur in the last bin, that this bin records the number of pixels with DN values between 65,500 and 65,549 and that there are 372 pixels in the image with these high values. Note that pixels are clustered into two areas of the histogram. Use the histogram to answer the following questions.

Question 1: How many pixels in the image have values between 10,000 and 60,000?

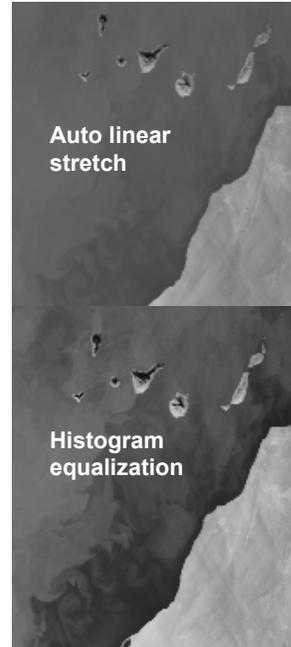
Question 2: What is the highest bin (state lower and upper values) of the lower cluster that contains pixels and how many pixels are in this bin?

The lower cluster (with pixels < a DN value of 5000) represents thermal infra-red emittance from the sea and land; the upper cluster (with pixels > a DN value of 60,000) represents thermal IR emittance from thick clouds. The HUGE difference in brightness between land/sea and cloud pixels means that the former display as black and the latter as white. To see the sea and land properly you need to configure the **Redisplay Image** mapping to the display scale so that the high value cloud pixels are ignored.

Activity: Firstly, ensure that the **Stretch, Options...** are set such that **AutoLinear Min%** is **5** and **Max%** is **95**, and that the **Apply stretches to charts, clipboard etc.** checkbox is checked. Then, right-click on the **AVHRR_West_Africa#04.dat** image and select **Redisplay** from the menu. In the **Redisplay Image** dialog box you want to set all pixels ≥ 4150 (which is the highest value of lower, land/sea cluster) as “null values” so that they are ignored when the image is stretched and redisplayed. Select **\geq** from the drop-down list, enter 4150 in the **Null value(s):** box and then check the **Null value(s):** checkbox. In the Stretch Settings’ **Use:** box, select **Auto linear stretch**. Once all this is done, click on  to apply the mapping. Close the **Redisplay Image** dialog box.

You now have a reasonable greyscale image with different SSTs displayed as different shades of grey. If you scroll down the image (use mouse wheel if you have one) you can now see considerable SST structure in the sea south of the Canary Islands (see upper right). Note also that thick cloud is now set to white. To improve the SST discrimination still further you can try a Histogram Equalization stretch.

Activity: Right-click on the **AVHRR_West_Africa#04.dat** image again and select **Redisplay** from the menu. This time, in the **Redisplay Image** dialog box you want to set the Stretch Settings’ **Use:** box to **Equalize**. Once this is done, click on Apply and then Close. This produces an even better image (see lower right) with sea of different temperatures very clearly delineated. Adjusting the “redisplay” further so that land areas are all mapped to white further improves the contrast in the sea. You can do this by adjusting **Null value(s):** value (try ≥ 2150). [Note: You need to uncheck and recheck the **Null value(s):** checkbox to change]. When you have finished close all files.



With images like the 16-bit **AVHRR_West_Africa#04.dat**, you have seen that optimising display is slightly more complicated than for simple 8-bit images. However, similar results can be achieved using the

Redisplay Image option and final adjustments can still be made interactively using a manual stretch.

Often you know before opening an image that certain pixel values are Null. For example, land or sea might be “masked” in an image and set to zero. In this case, when the **Redisplay Image** dialog box appears you would set **Null value(s):** **\equiv** to **0** and these “background” pixels would be ignored when the image is redisplayed; this would usually improve the display of the image. For some AVHRR images the value -32768 is used as a “fill” value and would upset the display of such images even more. In this case you would want to set **Null value(s):** **\equiv** to **-32768** when opening the images.

So far you have displayed the images as a set of grey scales and in this section you have seen how to optimise the display of these to emphasise features of interest. You can also control the display so as to assign colours to pixels with certain brightnesses (display scale values) to create thematic maps. In the next part of the introduction, [using palettes to enhance display and create thematic maps](#), you can investigate how to do this.