6. USING PALETTES TO ENHANCE DISPLAY AND CREATE THEMATIC MAPS

Aim: To introduce you to using and creating palettes to enhance the display of images and make thematic maps.

Objectives: By the end of this tutorial you will have explored how the *Bilko* palette generator works, learnt how palettes can be used to enhance the display of images on your computer screen, and made a thematic map of global sea surface temperature.

This tutorial investigates the use of colour palettes in image analysis and how they may be used to convey useful information.

About Colour

In order to understand the use of palettes, it may be helpful to give a brief summary of colour and the way in which the human eye discerns colour. Definitions for the terms used in this exercise will also be given. A useful website on colour is: http://www.soc.soton.ac.uk/JRD/SCHOOL/mt/mt001a_2.html

The human eye perceives colour by means of light-sensitive receptors in the retina called cones. There are three types of cones. These contain different photosensitive pigments and thus respond to light of different wavelengths. The three different types of cone are broadly sensitive to wavelengths in the red, green, and blue part of the visible spectrum respectively. This system works because all colours that we can see can be reproduced by adding together red, green and blue (RGB) in different proportions. This is known as Young's tristimulus theory of colour.

Figure 6.1.
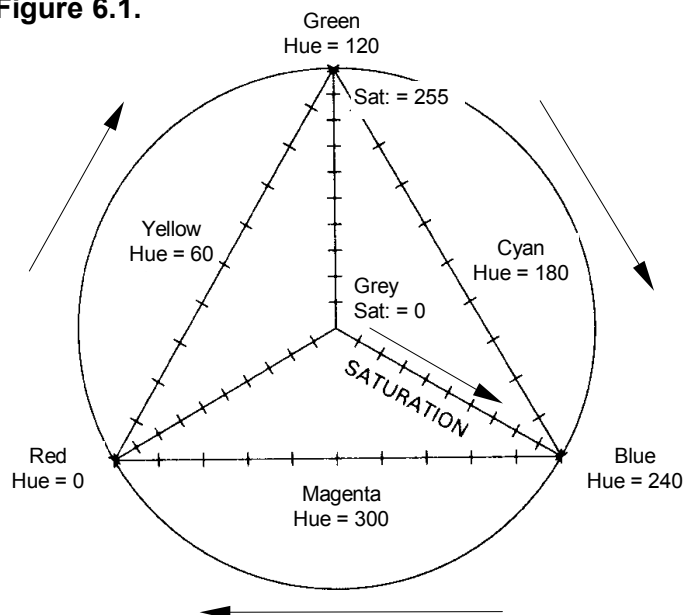
Red, green and blue are known as *primary* colours because none of them can be produced by mixing the other two colours. As well as being used by our eyes, these additive primary colours are used in the screens of colour monitors and televisions, which are coated by regularly spaced dots of red, green and blue phosphors that emit light when bombarded by electrons from the red, green and blue guns respectively.

Figure 6.1 shows the 3 colour theory illustrated diagrammatically as a triangle with the primary colours at each apex. Points along the outlines of the triangle represent mixtures of two primary colours; thus a pure cyan is a 50:50 mixture of blue and green. Points inside the triangle represent mixtures of all three primary colours and include pastel shades such as browns, purples and pinks. Right in the centre of the triangle where you have equal amounts of each primary colour you have the achromatic point where you see a grey. This point is on an axis (the achromatic line) coming out of the page which represents the brightness, or *intensity,* of the colours (and ranges from black to white).

So far when you have been looking at greyscale images you have just been using this achromatic line to display the pixels at 256 different grey levels (i.e. at grey levels ranging in *intensity* from 0 (black) to 255 (white)). The terms *hue* and *saturation* are explained below.
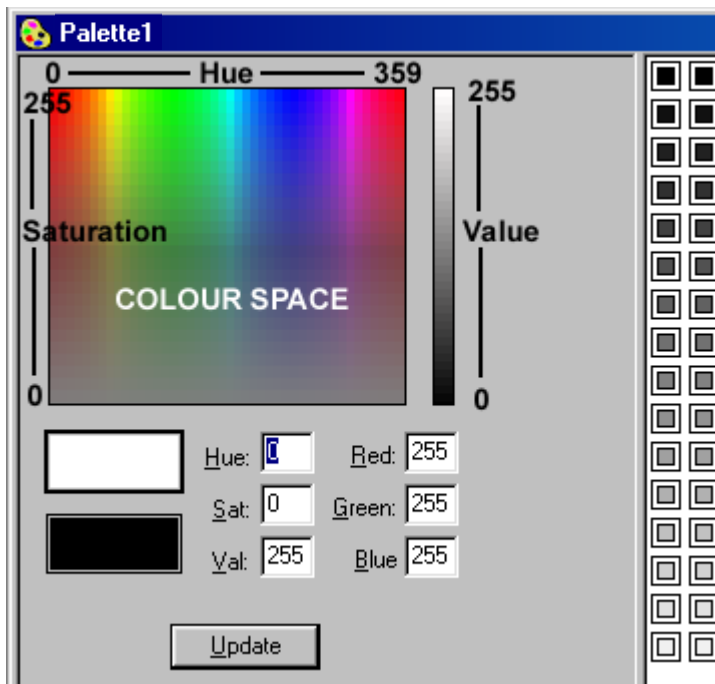
Figure 6.2.
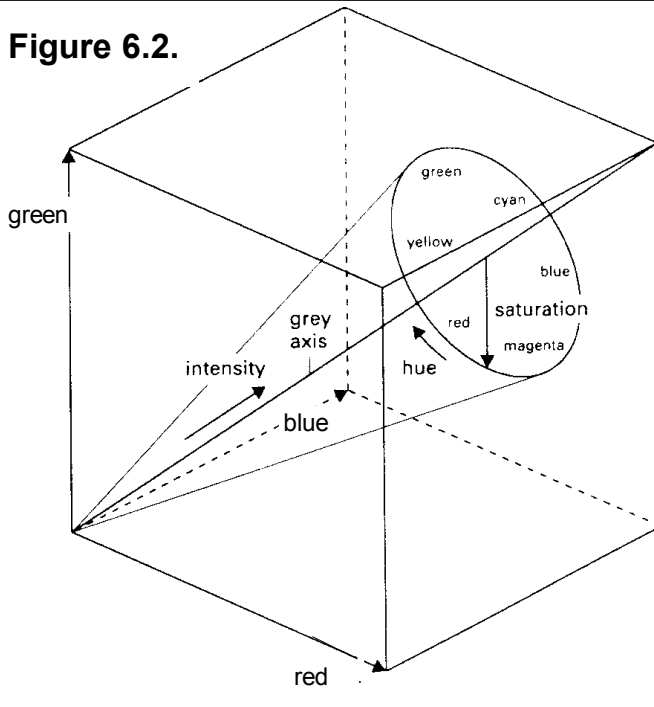
Colours can also be described in terms of three attributes – *intensity, hue* and *saturation* (the IHS system):

Intensity: refers to the brightness of a colour which for 8-bit displays will vary from 0-255.

Hue: refers to the relative amounts of two primary colours making up a colour. In the *Bilko* palette generator hue can take values from 0-359 with primary colours (at full *saturation*) considered to lie along the circumference of a circle (360°). Red, green and blue are thus each 120° (hue units) apart with yellow, cyan and magenta lying half way between them (Figures 6.1 and 6.2).

Saturation: the pureness of a primary colour (expressed as its distance from the central grey point or achromatic line).

Figure 6.2 is a three-dimensional view of the hue-saturation triangle in Figure 6.1 to show the achromatic line (grey axis) and intensity cone. Try to relate the elements of the palette generator box illustrated below to the diagram above and note that colours are expressed both in terms of amounts of red, green and blue (RGB) and in terms of intensity, hue and saturation. You can set up colours using either system. In the palette box below, the colour being set up is white. This is made by mixing red, green and blue in equal amounts at full intensity; thus under the RGB system we see Red: 255, Green: 255 and Blue: 255. Under the IHS system we think of white as a point at full intensity on the achromatic line, that is with a saturation of 0; thus we see Sat: 0 and Val: 255. The hue value does not matter in this case since saturation is 0 and could be any number from 0–359 (in the palette box below it just happens to be 0). If this puzzles you study Figures 6.1 and 6.2 again.

Intensity: In the palette generator intensity is referred to as *Value* (**Val**:).

Hue: Red is arbitrarily assigned a hue of 0; green has a hue of 120, and blue a hue of 240. Moving around the circumference of the hue circle in Figures 6.2 or 6.3 is equivalent to moving along the top of the colour space rectangle in the palette generator box (left).

Saturation: In the palette generator a fully saturated colour has a saturation of 255, whilst greys on the achromatic line have a saturation of 0. Black thus has a saturation of 0 and a value of 0; white has a saturation of 0 and a value of 255; mid-grey has a saturation of 0 and a value of 127.

Table 6.1. For reference, the RGB mixtures required to make the main full intensity (Val:=255), pure (Sat:=255) colours are shown below along with the attendant Hue values obtained. To obtain dark versions of the same colours (Val:=127), you would replace the 255 values in the Red, Green and Blue boxes by 127.

Colour	Hue	Red	Green	Blue
Red	0	255	0	0
Yellow	60	255	255	0
Green	120	0	255	0
Cyan	180	0	255	255
Blue	240	0	0	255
Magenta	300	255	0	255

The file you will be using in this section is a processed National Oceanic and Atmospheric Administration (NOAA) AVHRR Oceans Pathfinder sea surface temperature (SST) image of the whole world, built up from many images collected during December 2000. To save space the image has been cut down from its original size of 4096 x 2048 pixels to a size of 2048 x 950 pixels. SST in degrees Celsius is equal to 0.15 x (pixel DN − 3.0). Thus a pixel value of 188 means a sea surface temperature of 27.75°C.

Activity: Open the image file **Global_SST_Dec2000.gif** (using **File, Open**). Use **View, Zoom** (*or* right-click on the image and select **Zoom**) to set the zoom to 45% of full size so that you can see the whole image at once. Study the image, noting that all land is set to black (0) and the sea to varying shades of grey.

Before assigning colours to various pixel brightness values in the image it is useful to view a histogram of the image to see whether some SST values dominate or whether they are fairly evenly distributed throughout the range of pixel values.

Activity: To view a histogram of the **Global_SST_Dec2000.gif** image, click on the image window to make it active and use *<Ctrl>+A* to select the whole image. Now click on **File, New** and select **HISTOGRAM Document** in the **New** dialog box. Since all land is displayed with a DN of 0 there are over 830,000 pixels with value 0 in image so the histogram is not very well displayed. To adjust the scales so that you can see the distribution of the water pixels, click on **Options, Scale** (*or* right-click on the histogram and select the **Scale** option). In the **Scale** dialog box you can either set **Maximum:** to 16000, **Major Unit:** to 2000 and **Minor Unit:** to 1000, or just click on the **Ignore zero** box, and click on ⬚ OK ⬚ to show the improved display. Size or move the histogram window so that you can see both it and most of the image clearly at the same time.

In the histogram you can clearly see the distribution of the brightness values of water pixels. The pixels are reasonably evenly distributed between pixel values of 1 and about 230, with a bulge of pixels around a value of 200 due the large areas of warm water in the tropics. This suggests that you can assign different colours to a series of equal brightness bands and get a reasonable result. Before continuing, minimise the histogram window.

Activity: Click on the **Global_SST_Dec2000.gif** image to make it active and then click on **File, New** and select **PALETTE Document** in the **New** dialog box. A palette generator box like that discussed earlier appears. The grid of 256 cells range from 0 = black to 255 = white with 254 intermediate shades of grey. Click on the cells and note that **Red:**, **Green:** and **Blue:** values are identical and always equal to **Value:** and that saturation (**Sat:**) remains zero since only greys are displayed. The cells can be considered as lying along the central intensity grey axis in Figure 6.2.

Activity: With the last cell (bottom right) selected, position the mouse pointer in the Colour Space area and click. Depending where you have pointed the colour of the upper rectangle beneath the left hand side of the Colour Space area will change to the colour to which you have pointed. At the same time the hue, saturation, and red, green and blue boxes will change their values. However, the **Value:** box will remain set at 255. Explore the Colour Space briefly by clicking in different parts of it and noting how the hue, saturation and RGB mix change.

It is particularly instructive:

i) to click at the top left of Colour Space and holding down the left mouse button to slide the pointer along the top of Colour Space (**Sat:**=255) and see how both the Hue value and colour in the upper rectangle changes; and

ii) to click at the bottom left of Colour Space and holding down the left mouse button to slide the pointer up an down the left hand boundary of Colour Space (**Hue:**=0) and see how Saturation changes.

When you have seen how Colour Space is structured in terms of Hue and Saturation, click on cell 255 again. Now position the mouse pointer over the intensity or value bar to the right of the Colour Space area and click. Note that the numbers displayed in the **Value:**, **Red:**, **Green**:, and **Blue:** boxes change in unison. Holding the left mouse-button depressed, slide the mouse-pointer up and down the intensity bar. This is equivalent to moving up and down the achromatic line or grey axis of Figure 6.2 and the values change from 0 to 255 as the colour in the upper rectangle beneath the Colour Space changes from black to white.

The brief exploration of the palette generator above should give you a reasonable grasp of the concepts behind the palette generator. You will now apply this knowledge to colour the land in **Global_SST_Dec2000.gif** green. At present all the land is black with a DN value of 0. Thus all we have to do is make the first cell of the palette dark green.

Activity: Click on the first cell (cell 0) in the top left hand corner. All values (except **Hue:**) should be zero. We want a dark green so click on the Green: box and type in 127 to indicate a half-intensity pure green. Note that as you type in, the other boxes change so that Hue:=120, Sat:=255 and Val:=127. This makes sense because under the HSI system, dark green is a fully saturated colour with a hue of 120 and intensity of 127. Click on ⟦ Update ⟧ to effect the colour change and note that cell 0 now shows as dark green.

Congratulations! You have now succeeded in making your first change to the palette. To apply this change to the image you need to copy the changed palette to the image.

Activity: To apply the altered palette to the image, click on the Copy toolbar button 🗐, then click on the **Global_SST_Dec2000.gif** image and click on the Paste toolbar button 📋. Note that all the land (and some areas which were cloud covered throughout December 2000) is dark green. You can now close the greyscale palette without saving it as you will not need it further.

Now you are ready to do the main exercise. In this you will be assigning a different colour to every 16 cells according to the scheme in Table 6.2. This will create 16 different coloured temperature bands. To save you time a half-finished palette has been created with only six rows of 16 cells still left as grey.

Activity: Open the palette **SST_Exercise.pal** after making sure that the **Apply** checkbox in the **Open** dialog box is <u>NOT</u> checked. Note that the palette has two series of grey cells interspersed by coloured cells. If the 256 cells are not arranged as a grid of 16 x 16 cells adjust the size of the palette generator window until they are. This makes it easier to work with them. **The instructions below assume this layout.**

Question 1: What are the Saturation, Value, Red, Green, and Blue values displayed for cell 64 at the beginning of row 5 in the palette?

Each row (except first and last rows which begin with a white cell and end with a black cell respectively) should now be either a single colour or in the case of 6 rows a series of grey shades. You will firstly see the effect of applying the palette and then fill in the missing rows of colour. To apply the half finished palette to the ***Global_SST_Dec2000.gif*** image you need to copy it and paste it to the image.

Activity: Copy the palette and paste it to the image.

Polar and warm temperate seas are now coloured. Cold temperate and tropical oceans remain to be coloured. Note that the land and cloudy areas are now white.

Table 6.2. Scheme for colour palette for SST image. The cells in rows 5-7 and 12-14 need to have their colours assigned. Row numbers assume that cells are arranged in a 16 x 16 matrix.

Cell # = greyscale	Row	Red	Green	Blue	Colour
0	1	255	255	255	White
1-15	1	63	0	63	Very dark purple
16-31	2	127	0	127	Dark magenta
32-47	3	255	0	255	Magenta
48-63	4	175	0	255	Violet
64-79	5	0	0	255	Blue
80-95	6	0	140	255	Blue-cyan
96-111	7	0	255	255	Cyan
112-127	8	0	255	160	Green-cyan
128-143	9	0	255	75	Bluish green
144-159	10	75	255	0	Yellowish green
160-175	11	175	255	0	Lime green
176-191	12	255	255	0	Yellow
192-207	13	255	140	0	Orange
208-223	14	255	0	0	Red
224-239	15	175	0	0	Dark red
240-254	16	120	32	16	Red brown
255	16	0	0	0	Black

Activity: Click on the palette generator. Then click on the cell 64 at the start of row 5 and holding the left mouse-button down drag the mouse across to cell 79 on the right had end of the row, then release the mouse-button. [Note that the Status Bar shows the start and finish cell numbers]. The upper rectangle under the Colour Space will be dark grey and the bottom rectangle mid-grey. Click on the upper large rectangle under the left side of the Colour Space and then type the value 0 in the **Red:** box, 0 in the **Green:** box and 255 in the **Blue:** box (row 5 values from Table 6.2). The upper rectangle turns blue. Now click on the bottom rectangle and do the same. It too turns blue. Click on the ⬚ Update button and all the highlighted cells turn blue.

Using the same technique, methodically set up the colours for the five remaining rows of cells. Refer to Table 6.2 for the RGB values for the colours and remember that BOTH the upper and lower rectangles have to be set to the colour before the palette is "updated".

When all colours have been updated on the palette, copy the palette and paste it to the image. Note the colour bar beneath the image, which shows how the colours are assigned as a series of bands. When you have done this successfully, save the palette as ***SST.pal***.

Congratulations, you have created a palette similar to the standard temperature palette used by NOAA for AVHRR Oceans Pathfinder SST images! The image is now **thematically** coloured with land white, and water ranging from very dark purple where coldest to red, where warmest. To see what the actual NOAA palette looks like you can apply this.

Activity: Make sure that ***Global_SST_Dec2000.gif*** is the active document by clicking on it. Select **File, Open** and then, after having checked the **Apply** checkbox of the **Open** dialog box, open the palette ***SST_Pathfinder.pal***. This opens and immediately applies the stretch to the image.

To view the palette itself, uncheck the **Apply** checkbox in the **Open** dialog box and re-open it. Click on the cells of the palette to see what their values are.

You will see that the NOAA palette is very similar to the palette you created but that each cell is slightly different in colour to its neighbours (check RGB values to see this). If you look at the colour bar beneath the image you will see that the colours now blend rather than forming distinct bands. Remember that the palette just alters how the image is displayed on the screen but does not alter the image itself. However, if you wanted to save a picture of the coloured image you could save it as a coloured CompuServe gif file.

Activity: Select all (*<Ctrl>+A*) of the ***Global_SST_Dec2000.gif*** image and then select **File, New** and IMAGE Document in the **New** dialog box. This creates a copy of the image, which contains the colour information. You can save this new image and when you re-open it, the image will be coloured. However, if you close and re-open the ***Global_SST_Dec2000.gif*** image it will still be a greyscale image. You may wish to satisfy yourself of this. When finished close all the images.

Many images are not georeferenced when received, that is, they are not linked into any geographical coordinate system such as latitude and longitude or the Universal Transverse Mercator (UTM) grid system. To properly orientate such images and link pixels to geographical coordinates requires that the image be **rectified and resampled.**