

Working with color in IDL

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Data visualization is the original core purpose of IDL. Consequently IDL's graphical features are powerful, but they are not kind to beginners. To produce quality figures you may find that you need to learn more about the inner workings of color tables than you wanted; this brief guide is intended to introduce the color manipulation tools available at Harvard from GAMAP.

The color table

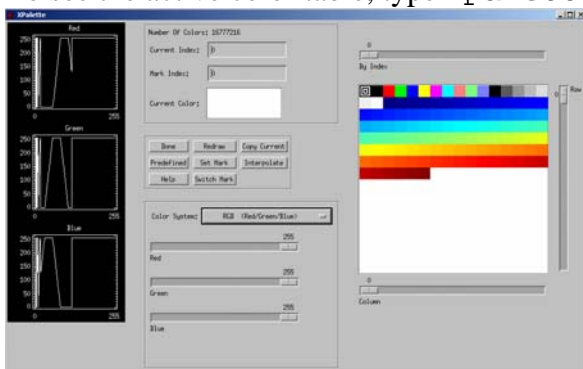
All colors that IDL displays on the screen are taken from the "color table", a configurable palette of colors which is a small subset of the 16.8 million distinct colors that a modern 24-bit monitor can display.¹ Specifying a single color from this universe of options requires separately specifying the 8-bit intensities of the red, green, and blue channels, an unwieldy number of digits. As a programmer, you need a concise way to refer to some of those 16.8 million possible colors while making a figure.

The IDL color table contains just 256 of the possible colors, but that is plenty for most scientific purposes. The table stores the RGB values for each of the 256 colors, so that the user can specify a color using only an index between 0 and 255. When requested, IDL looks up the RGB values for the desired color index, and plots the corresponding color on the screen.

Experiment with different colors

To begin, look at the range of colors in your default color table and try a few alternatives.

To see the active color table, type `xpalette` or `cindex`.



Try a few different color tables. Click 'Redraw' in your `xpalette` window after each one.

```
Myct, /Dial
```

¹ Actually it is possible to specify colors in IDL without using the color table. Since GAMAP and most programmers at Harvard use the color table, that is the scope of this introduction. To guarantee that the color table is active, enter `Device, decomposed=0`.

```
Myct, /WhGrYlRd
Myct, /Diff
Myct, 33 (or any number 0-40)
```

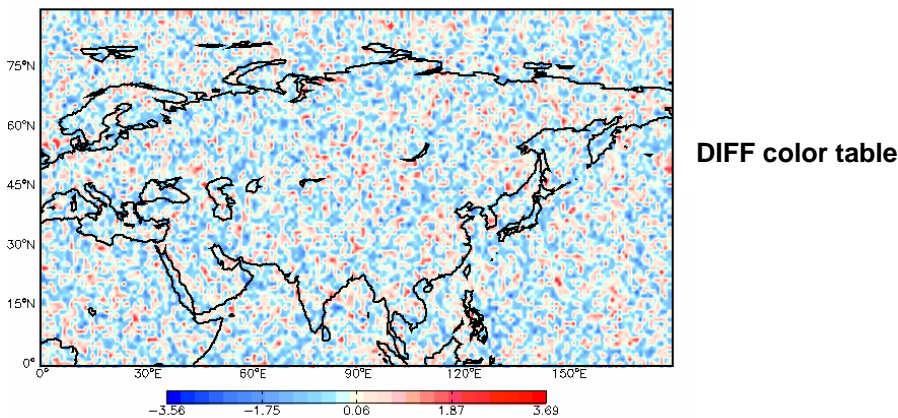
Try adjusting the number of colors.

```
Myct, /Diff, ncolors=100
```

You should find that the first 18 colors don't change with the different color tables. These first colors provide a basic palette for plotting lines and symbols. Color maps of concentration made with GAMAP (e.g. `gamap`, `tvmap`, `tvplot`) will use only the colors 19 through the end.

Make some artificial data and plot it with several different color tables.

```
Data = randomn( seed, 180, 90 )
Lon = findgen( 180 )
Lat = findgen( 90 )
Tvmap, data, lon, lat, /coasts, /cbar
```



Myct

`Myct` and other GAMAP routines simplify the process of loading and changing color tables. They exploit a user-defined global variable named `!MYCT` that stores critical information about the current color table so that you don't need to pass this information at the command line each time you plot a figure.²

`!MYCT.Black` gives the color table index of the color black. Similarly, `!MYCT.Magenta` gives the index of the color magenta. To plot a magenta line on a black grid,

```
Plot, indgen(10), color=!MYCT.Black
    Or, equivalently Plot, indgen(10), /color
OPlot, indgen(10), color=!MYCT.Magenta
```

² The `!MYCT` variable is part of the GAMAP package, although other routines may freely use it. The variable is created by `Myct_Define`, which is generally called by the `idl_startup.pro` script.

Type `help, !MYCT, /str` to find the other available colors.

In addition `!MYCT` also stores the index, `!MYCT.Bottom`, of the first color which is used by `TVMMap` and `TVPlot`. `!MYCT.NColors` stores the number of colors that `TVMMap` and `TVPlot` should use. If you want to use the `WhGrYlRd` color table for your data, but want to reserve white for missing data rather than zero concentration, then do the following

```
Myct, /WhGrYlRd
!MYCT.Bottom = !MYCT.Bottom+2 (start at what was the 3rd color, i.e. not white)
!MYCT.NColors = !MYCT.NColors-2 (now we have two fewer colors)
Tvmmap, data, lon, lat, /coasts, /cbar
```

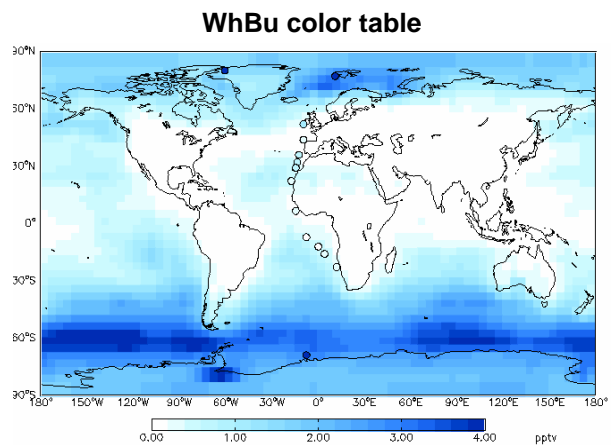
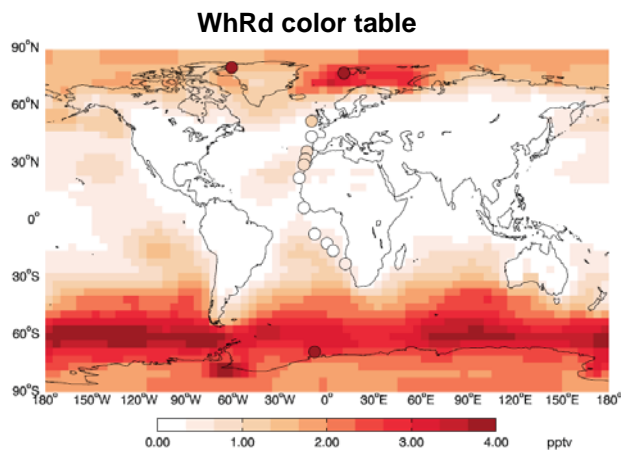
If you find `Myct` too restrictive, you can exercise complete control over the color table using `loadct`.

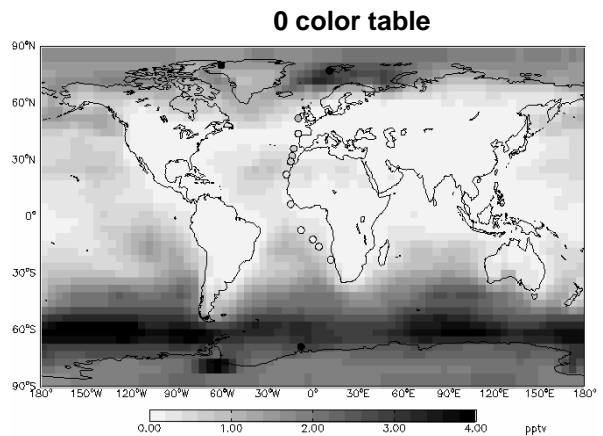
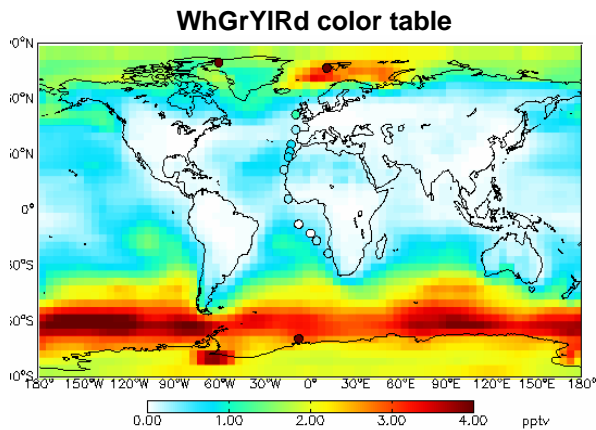
Color schemes for particular applications

Data with magnitude

Primer on design generally recommend that sequential data should be displayed using only one hue (“color”). e.g. a grayscale, or a light-to-dark scale of any color. The eye naturally interprets changing saturation (“intensity”) or value (“darkness”) of one hue as a series. Color blind viewers (up to 10% of men) will never be confused by such a simple color scale. By contrast, the eye does not necessarily interpret the change from green to orange as a sequence or magnitude. Furthermore, color blind viewers may not be able to distinguish red and green colors, or sometimes others. Nevertheless, rainbow or spectral color schemes are very popular.

Good options for `Myct`: `/WhRd`, `/WhBu`, `/WhGrYlRd`, `/BuYlRd`,
`/ModSpec, 0, 33`

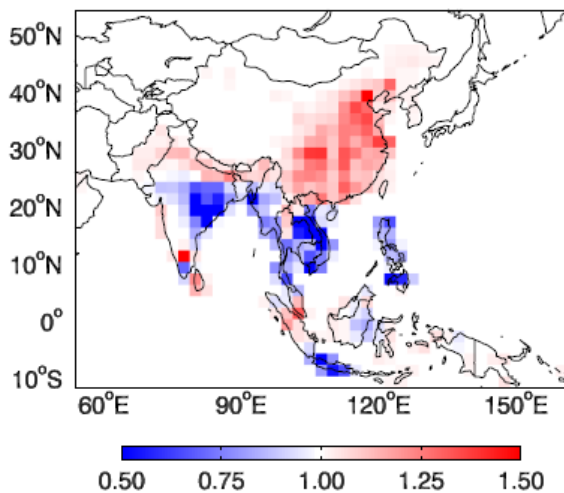




Diverging data with magnitude and sign

When data diverge from a reference level (e.g. increase or decrease around zero), joining two sequential scales works well. Use a neutral middle color, like white, between two distinct hues like red and blue.

Good options for Myct: /Diff

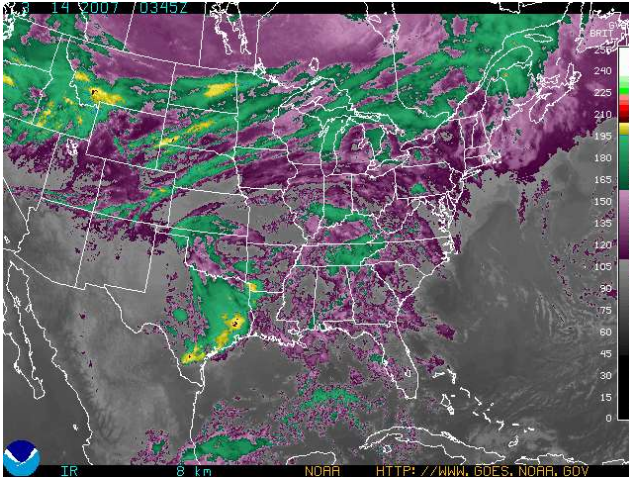


DIFF color table

Data varying over orders of magnitude and data with critical values

When some data are so large or small that they require a change in the color scale, a break in the color scheme is appropriate. The scale may switch from linear to logarithmic at the upper or lower end of the data in order to show extreme values. DIAL can work well for this purpose.

Breaks in the color scheme can also highlight important changes in the data, such as exceeding a critical value. The National Weather Service uses discontinuous color schemes for satellite images to highlight the distinctions between low, intermediate, and high altitude clouds. If you use a broken color scale, make sure that the break in the color scheme corresponds with a significant change in your data.



Sample “broken” color table from NOAA

<http://www.goes.noaa.gov/ECIR2.html>

Categorical data

Maps of non-sequential categorical variables like land cover should use non-sequential color scales. In IDL, use the colors in the first 18 positions of the color table.

More information

Fanning, D. “Working with Color” in *IDL Programming Techniques, 3rd Edition*.

http://www.dfanning.com/color_tips/working_with_color.pdf

Fanning is *the* authority on IDL. This chapter is both comprehensive and complicated.

Light, A and P.J. Bartlein (2004), The end of the rainbow? Color schemes for improved data graphics. *EOS Transactions of the American Geophysical Union* 85(40):385

<http://geography.uoregon.edu/datagraphics/EOS/Light&Bartlein.pdf>

For some examples of how color blind viewers may perceive color schemes, see Light and Bartlein. They also suggest alternative color palettes, some of which are not implemented in GAMAP.

www.colorbrewer.org

Experiment with lots of alternative color schemes for mapping. These can be easily implemented in GAMAP.

Some useful color tables available with MYCT

Name or Number	Description	Type	Color Blind Safe?
0	Greyscale	Sequential	X
WhGyBk	Greyscale	Sequential	X
WhRd	White to dark red	Sequential	X
WhBu	White to dark blue	Sequential	X
DIFF	Blue to white to red	Diverging	X
BuWhRd	Same as DIFF	Diverging	X
33	Blue to red rainbow with dark edges	Spectral	
34	Blue to red rainbow with bright edges	Spectral	
WhGrYIRd	White to blue to red spectrum	Spectral	
MODSPEC	Spectrum without green	Spectral	X
BuYIRd	Blue to red spectrum	Spectral	X
DIAL	DIAL/LIDAR	Spectral, Broken	

The /REVERSE keyword will load any color table in reverse order.

e.g. `Myct, 0, /Reverse`

General guidelines for selecting and using color

These guidelines were written especially for scientific figures, but should also apply to non-technical illustrations, slides, and posters. Above all your goal is to *show your data* while minimizing visual distractions, doing whatever is necessary to achieve this end. These guidelines, which are in no particular order, will generally help realize that goal.

1. Bright saturated colors have high impact. Use them selectively to highlight important parts of your data. Conversely, neutral colors work well for data extending over large areas. Mimic a good map.
2. Use contrasting and complementary colors carefully. Borders between areas of contrasting colors naturally attract attention. Consider whether you want this.
3. Use a color scheme appropriate for the data: sequential, diverging, or categorical.
4. Follow conventions if they exist. e.g. A blue-to-red scale is customary for temperature, with blue for cold temperatures. Defying conventions may disorient some readers.
5. Subtle changes of saturation or value are often enough to show a quantitative difference on a map. (e.g. ocean depth in shades of blue) A thin line on the border allows even finer visual distinctions.