



colorspace

A Toolbox for Manipulating and Assessing Color Palettes for Statistical Graphics

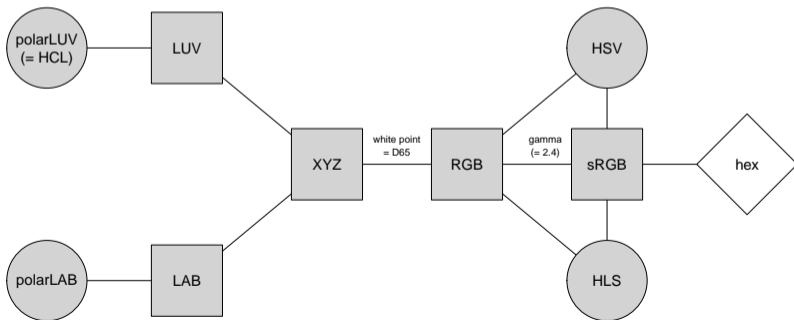
Achim Zeileis, Jason C. Fisher, Kurt Hornik, Ross Ihaka, Claire D. McWhite, Paul Murrell, Reto Stauffer, Claus O. Wilke

<http://colorspace.R-Forge.R-project.org/>

Color spaces

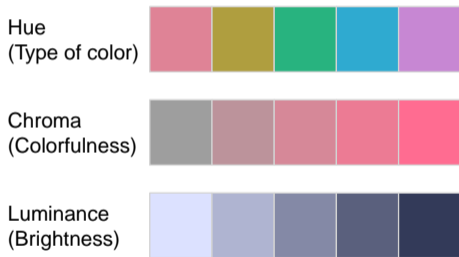
Origin of the package: Convert colors between various three-dimensional representations of color.

In particular: From the perceptually-based HCL (Hue-Chroma-Luminance) to standard Red-Green-Blue (sRGB, and corresponding hex codes) space.



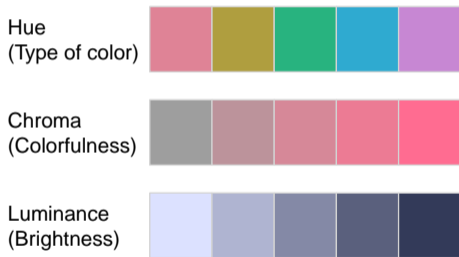
HCL vs. RGB

HCL: Polar coordinates in CIELUV.
Captures perceptual dimensions of
the human visual system very well.

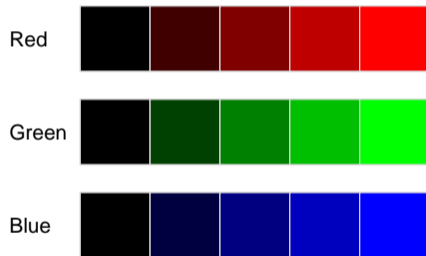


HCL vs. RGB

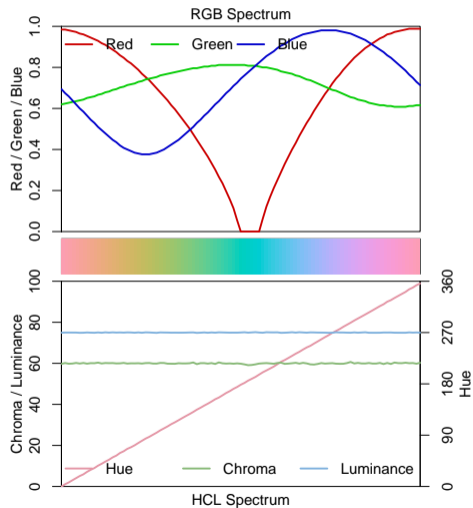
HCL: Polar coordinates in CIELUV. Captures perceptual dimensions of the human visual system very well.



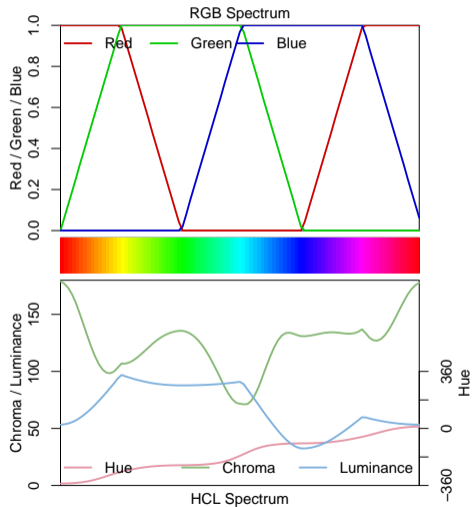
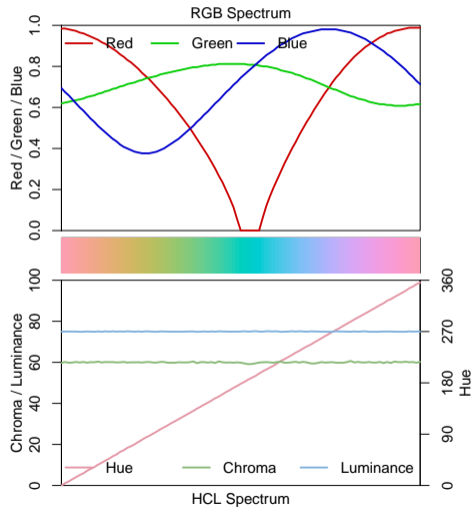
RGB: Motivated by how computers/TVs used to generate and still represent color.



HCL vs. RGB: The End of the Rainbow



HCL vs. RGB: The End of the Rainbow



Color palettes: Somewhere over the Rainbow

Qualitative (Set 2)



Sequential (Blues 3)



Diverging (Green–Brown)



Color palettes: Somewhere over the Rainbow

Qualitative (Set 2)



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Diverging (Green-Brown)



Qualitative: For categorical information, i.e., where no particular ordering of categories is available. Function: `qualitative_hcl()`.

Color palettes: Somewhere over the Rainbow

Qualitative (Set 2)



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Diverging (Green–Brown)



Qualitative: For categorical information, i.e., where no particular ordering of categories is available. Function: `qualitative_hcl()`.

Sequential: For ordered/numeric information, i.e., where colors go from high to low (or vice versa). Function: `sequential_hcl()`.

Color palettes: Somewhere over the Rainbow

Qualitative (Set 2)



Sequential (Blues 3)



Diverging (Green–Brown)



Qualitative: For categorical information, i.e., where no particular ordering of categories is available. Function: `qualitative_hcl()`.

Sequential: For ordered/numeric information, i.e., where colors go from high to low (or vice versa). Function: `sequential_hcl()`.

Diverging: For ordered/numeric information around a central neutral value, i.e., where colors diverge from neutral to two extremes. Function: `diverging_hcl()`.

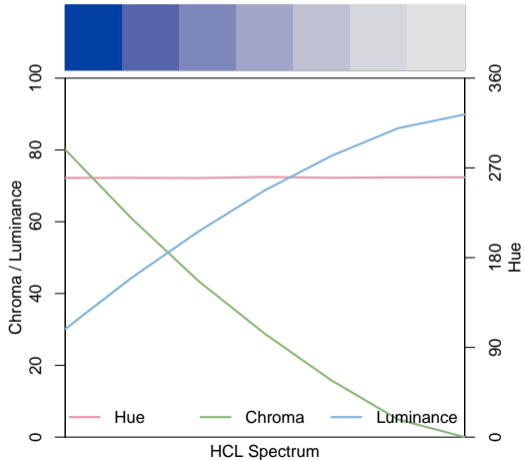
Color palettes: Somewhere over the Rainbow

Sequential: Luminance contrast is crucial (dark to light or vice versa).



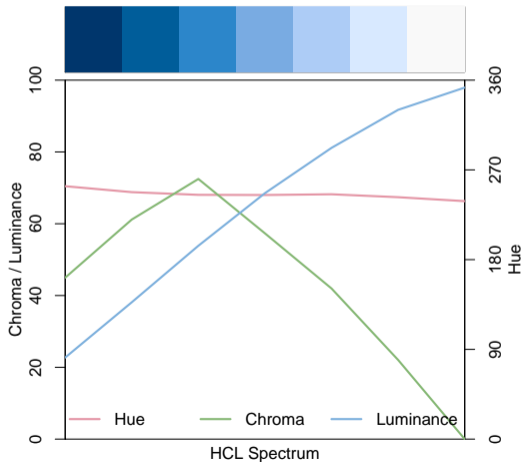
Color palettes: Somewhere over the Rainbow

Blues 2: Single hue. Decreasing chroma with increasing luminance.



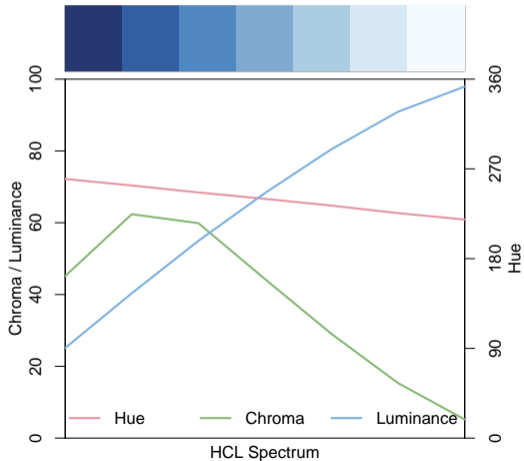
Color palettes: Somewhere over the Rainbow

Blues 3: Single hue. Triangular chroma to achieve higher luminance contrast.



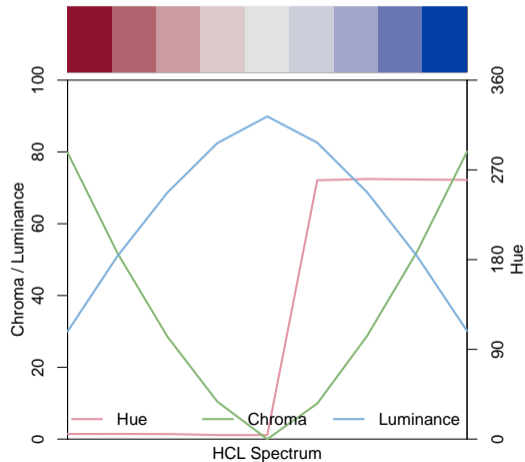
Color palettes: Somewhere over the Rainbow

Blues: Multi hue. Triangular chroma. High luminance contrast.



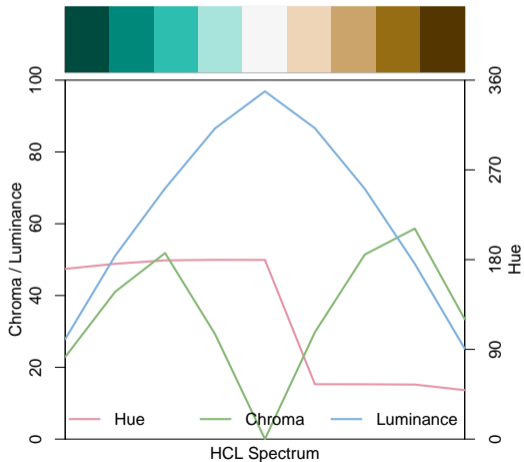
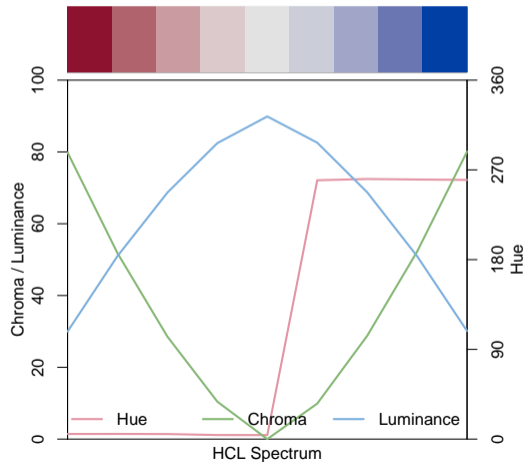
Color palettes: Somewhere over the Rainbow

Diverging: Combine two sequential palettes with balanced chroma/luminance.



Color palettes: Somewhere over the Rainbow

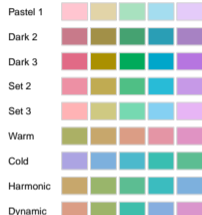
Diverging: Combine two sequential palettes with balanced chroma/luminance.



Color palettes: Somewhere over the Rainbow

```
R> hcl_palettes(plot = TRUE)
```

Qualitative



Sequential (single-hue)



Sequential (multi-hue)



Statistical graphics

Base:

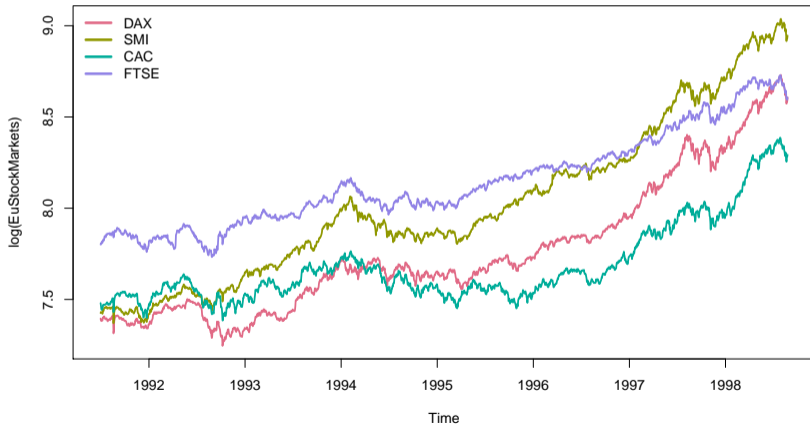
- HCL palette functions return hex color vector.
- Typically passed to `col =` argument of base plotting functions.

ggplot2:

- Scales of type `scale_<aesthetic>_<datatype>_<colorscale>()`.
- `<aesthetic>` is `fill` or `color/colour`.
- `<datatype>` is `discrete` or `continuous`.
- `<colorscale>` is `qualitative`, `sequential`, `diverging`, or `divergingx`.

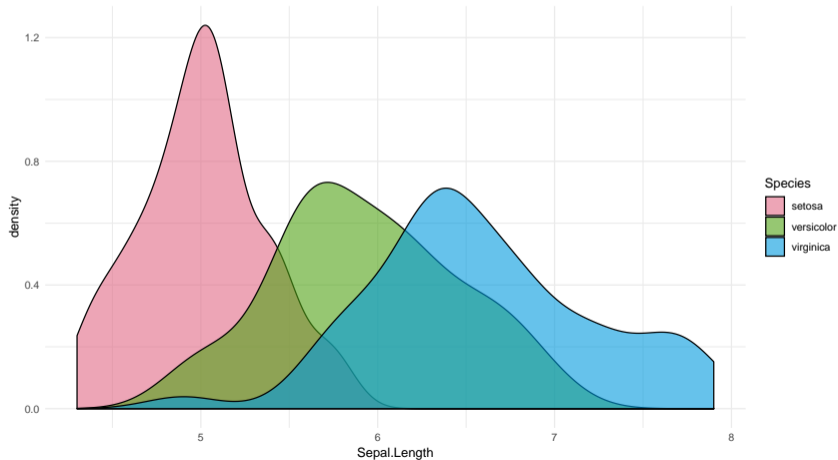
Statistical graphics: Base

```
R> q4 <- qualitative_hcl(4, palette = "Dark 3")  
R> plot(log(EuStockMarkets), plot.type = "single", col = q4, lwd = 2)  
R> legend("topleft", colnames(EuStockMarkets), col = q4, lwd = 3, bty = "n")
```



Statistical graphics: ggplot2

```
R> library("ggplot2")  
R> ggplot(iris, aes(x = Sepal.Length, fill = Species)) + geom_density(alpha = 0.6) +  
+   scale_fill_discrete(palette = "Dark 3")
```



Visualization and assessment

Visualizations: Based on vector of colors.

- `swatchplot()`: Color swatches.
- `specplot()`: Spectrum of HCL and/or RGB trajectories.
- `hclplot()`: Trajectories in 2-dimensional HCL space projections.
- `demoplot()`: Illustrations of typical (and simplified) statistical graphics.

Visualization and assessment

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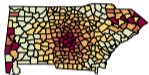
Emulation: Color vision deficiency.

- `deutan()`: Deuteranopia (green deficient).
- `protan()`: Protanopia (red deficient).
- `tritan()`: Tritanopia (blue deficient).

Visualization and assessment: demoplot()

```
R> cl <- sequential_hcl(5, palette = "Heat")  
R> demoplot(cl, type = "...")
```

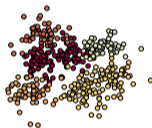
map



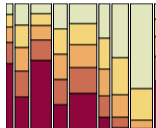
heatmap



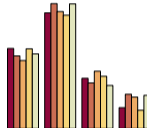
scatter



spine



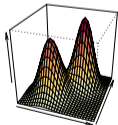
bar



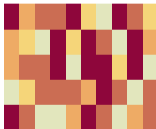
pie



perspective



mosaic

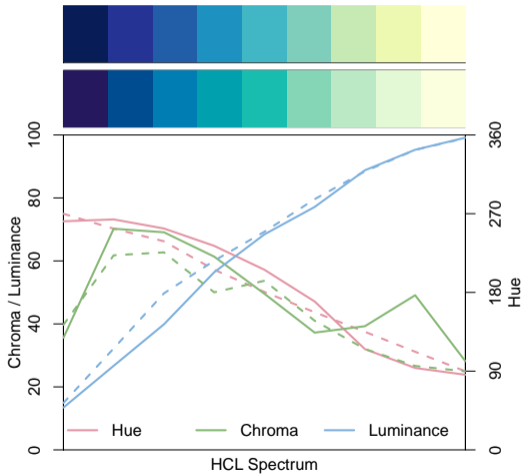


lines



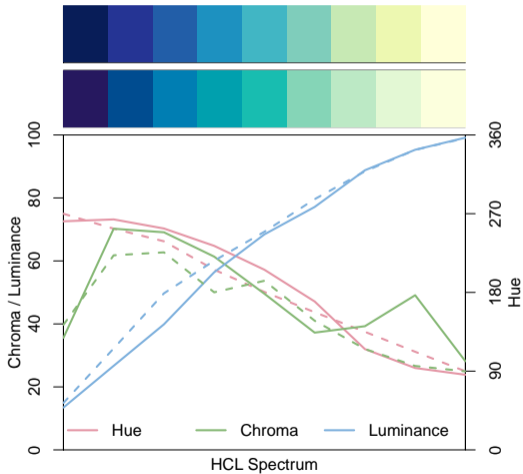
Approximations of other palettes

ColorBrewer.org: YlGnBu

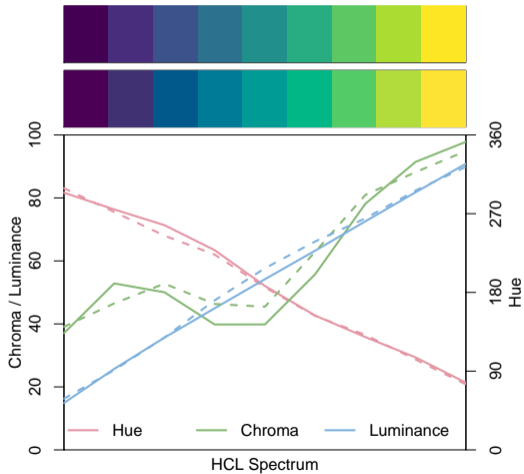


Approximations of other palettes

ColorBrewer.org: YlGnBu



Viridis



Color apps

Facilitate exploration: Graphical user interfaces as shiny apps.

- *Palette constructor:* `choose_palette()` or `hclwizard()` (also in `tcltk`).
- *Color picker:* `choose_color()` or `hcl_color_picker()`.
- *Color vision deficiency emulator:* `cvd_emulator()`.

Online versions: <http://hclwizard.org/>

Color apps: choose_palette() / hclwizard()

Mozilla Firefox

File Edit View History Bookmarks Tools Help

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127.0.0.1:5604

Search

Base Options

Type of palette
Advanced: Sequential (single-hue)

Base color scheme
Blues 3

Example
Heatmap

Control Options

Reverse
 Correct colors
 Dark mode
 Desaturated

Vision

Normal
 Deutan
 Protan
 Tritan

Color Settings

HUE 1: 240 SET

CHROMA 1: 20 SET

MAX CHROMA: 50 SET

LUMN. 1: 20 SET

LUMN. 2: 95 SET

POWER 1: 1.2 SET

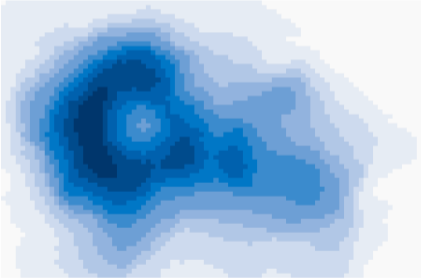
POWER 2: 1.4 SET

NUMBER: 11 SET

Return to R

Example Plot

Spectrum Color Plane Export Info



R colorspace 1.4.5

Color apps: choose_color() / hcl_color_picker()

The screenshot shows a web application for color selection. On the left, there are three sliders: Hue (set to 270), Chroma (set to 50), and Luminance (set to 60). Below these is an input field for the RGB hex color, showing #9189C7. A 'Selected color' bar displays the chosen purple color. At the bottom left are 'Actions' buttons: 'Pick', 'Unpick', 'Clear', and 'Return to R', along with a 'Dark mode' checkbox.

The main area features a 'Luminance-Chroma plane' diagram. The y-axis is Luminance (0-100) and the x-axis is Chroma (0-125). A color gradient is shown within a triangular shape. Below the diagram are three horizontal color bars: Hue (0-360), Chroma (0-150), and Luminance (0-100). A 'Color palette' at the bottom shows four color swatches: #E2E2E2, #B9B5D5, #9189C7, and #5F4FB1.

R colorspace 1.4.0

Color apps: cvd_emulator()

Mozilla Firefox


File Edit View History Bookmarks Tools Help

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127.0.0.1:5604

Upload Original Desaturated Deuteranope Protanope Tritanope


All Info



Severity

0 10 20 30 40 50 60 70 80 90 100


Different levels of severity for the color vision deficiency can be emulated. A value of 100% means maximum deficiency, a value of 0% no deficiency at all. This value has to be adjusted before uploading the image.



Upload Image

Browse... No file selected

Select an image from your local disc (PNG/JPG/JPEG) for which the color vision deficiency should be emulated. Please note that the file size is limited to 50.0 Megabyte.



© colorspace 1.4.0

Mozilla Firefox

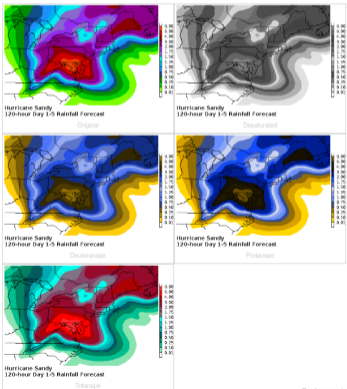
File Edit View History Bookmarks Tools Help

127.0.0.1:5604/ x +

127.0.0.1:5604

Upload Original Desaturated Deuteranope Protanope Tritanope

All Info



Hurricane Sandy 120-hour Day 1-5 Rainfall Forecast

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References

Ihaka R, Murrell P, Hornik K, Fisher JC, Stauffer R, Wilke CO, McWhite CD, Zeileis A (2019). *colorspace: A Toolbox for Manipulating and Assessing Colors and Palettes*. <http://colorspace.R-Forge.R-project.org/>

Zeileis A, Hornik K, Murrell P (2009). "Escaping RGBland: Selecting Colors for Statistical Graphics." *Computational Statistics & Data Analysis*, **53**, 3259–3270. doi:10.1016/j.csda.2008.11.033.

Stauffer R, Mayr GJ, Dabernig M, Zeileis A (2015). "Somewhere over the Rainbow: How to Make Effective Use of Colors in Meteorological Visualizations." *Bulletin of the American Meteorological Society*, **96**(2), 203–216. doi:10.1175/BAMS-D-13-00155.1