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A Toolbox for Manipulating and Assessing Color Palettes for Statistical Graphics

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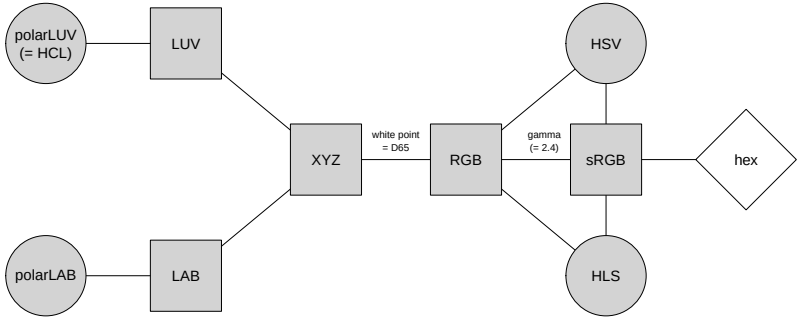
http://colorspace.R-Forge.R-project.org/

Color spaces

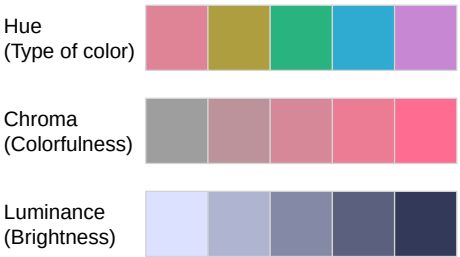
Origin of the package: Convert colors between various three-dimensional representations of color.

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.



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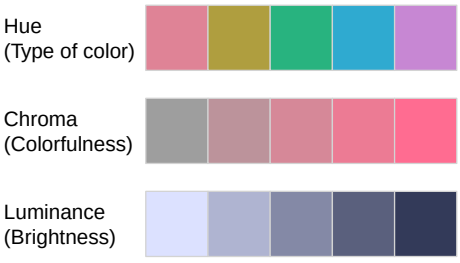
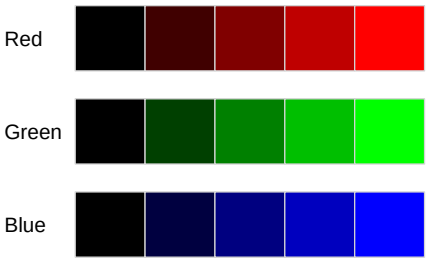
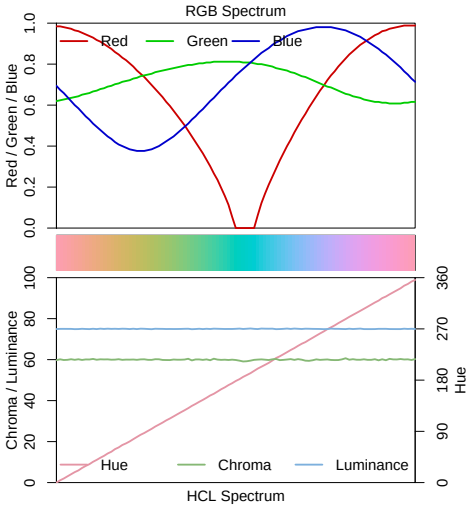


RGB: Motivated by how computers/TVs used to generate and still represent color.



HCL vs. RGB: The End of the Rainbow



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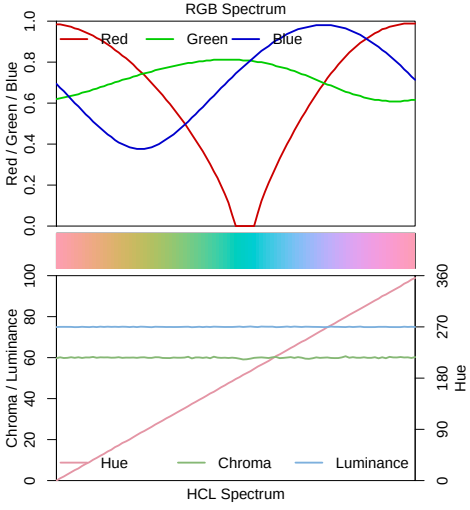
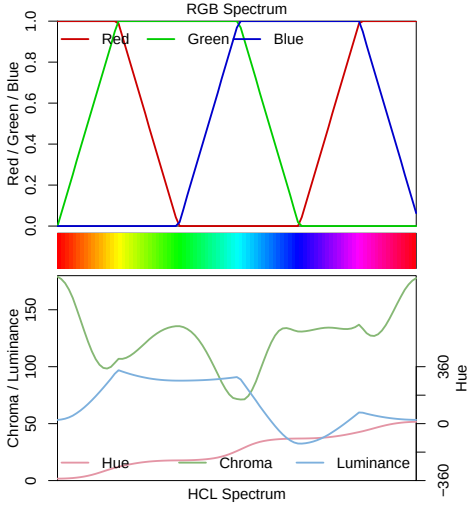




Color palettes: Somewhere over the Rainbow

Qualitative (Set 2)

Color

Desaturated

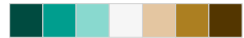
Sequential (Blues 3)

Color

Desaturated

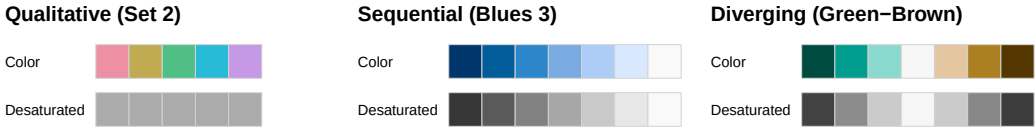
Diverging (Green–Brown)

Color



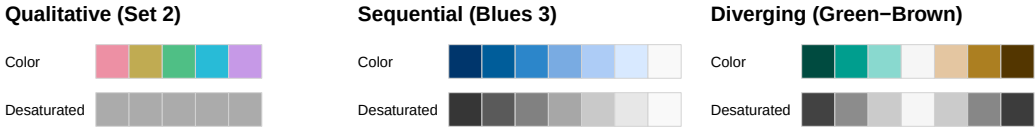
Desaturated

Color palettes: Somewhere over the Rainbow



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

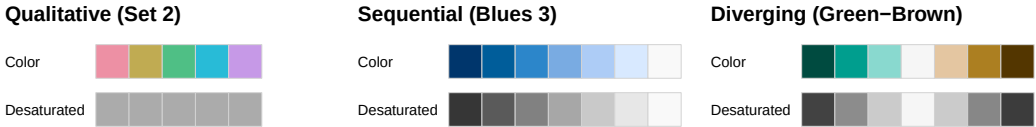
Color palettes: Somewhere over the Rainbow



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



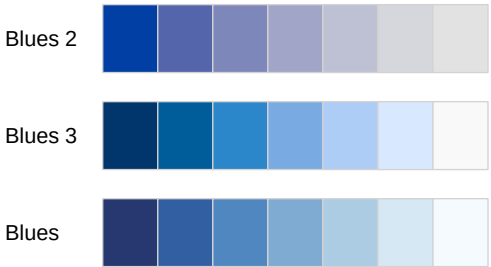
Qualitative: For categorical information, i.e., where no particular ordering of categories is available. Function: `qualitative_hcl()`.

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()`.

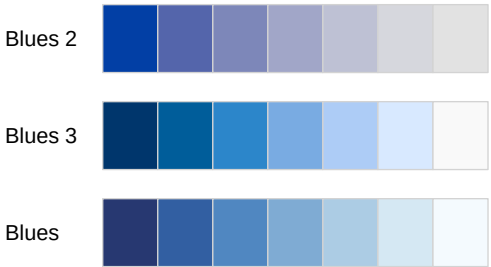
Color palettes: Somewhere over the Rainbow

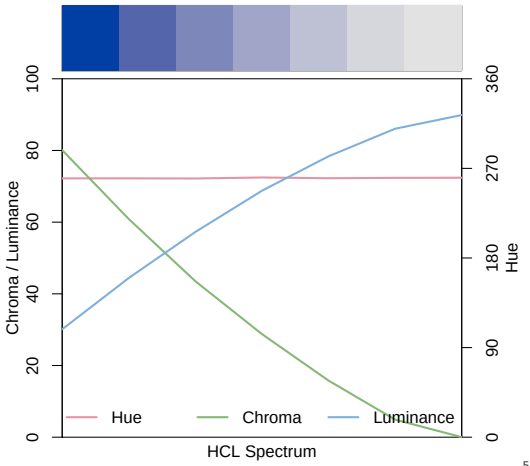
Sequential: Luminance contrast is crucial (dark to light or vice versa).



Color palettes: Somewhere over the Rainbow

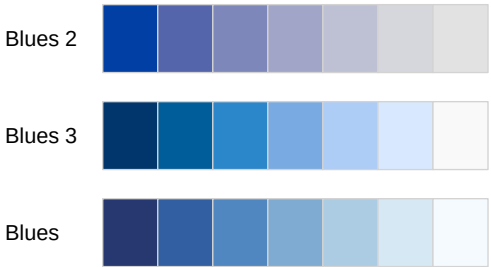
Blues 2: Single hue. Decreasing chroma with increasing luminance.

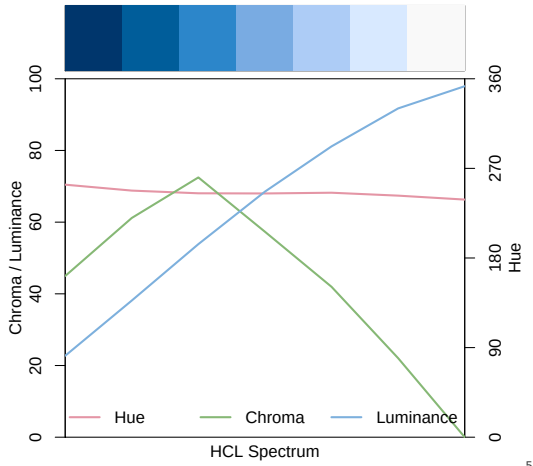




Color palettes: Somewhere over the Rainbow

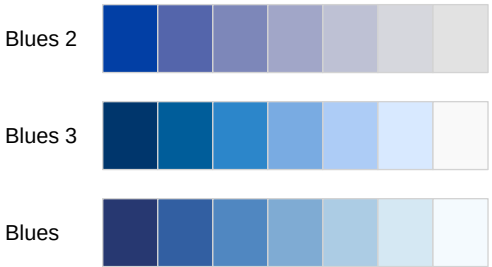
Blues 3: Single hue. Triangular chroma to achieve higher luminance contrast.

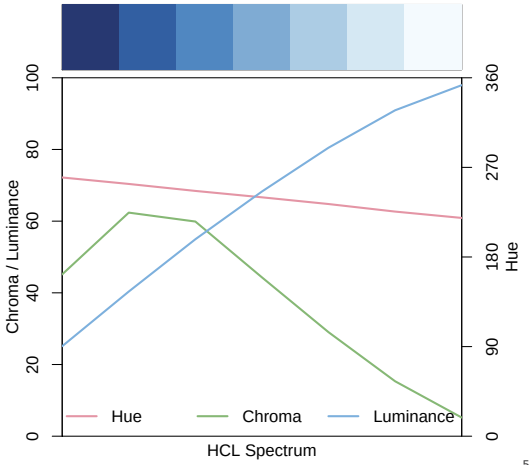




Color palettes: Somewhere over the Rainbow

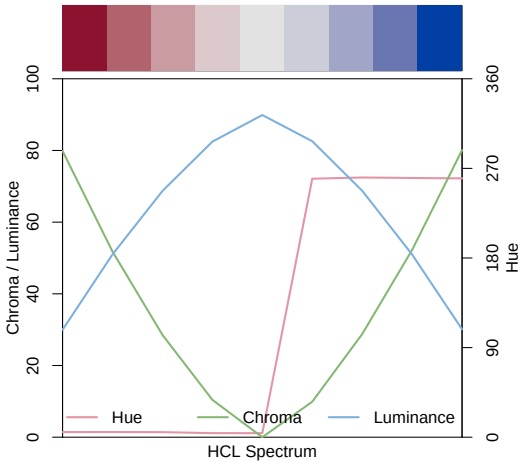
Blues: Multi hue. Triangular chroma. High luminance contrast.





Color palettes: Somewhere over the Rainbow

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



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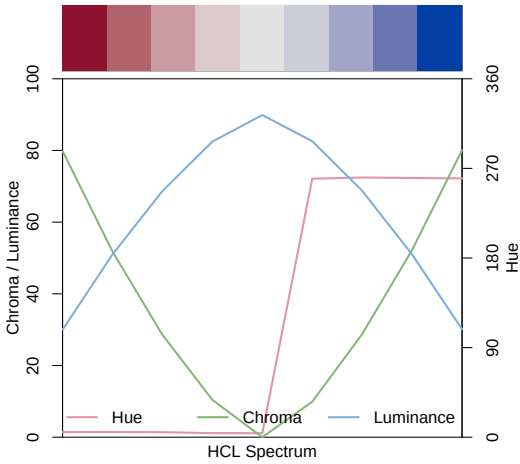
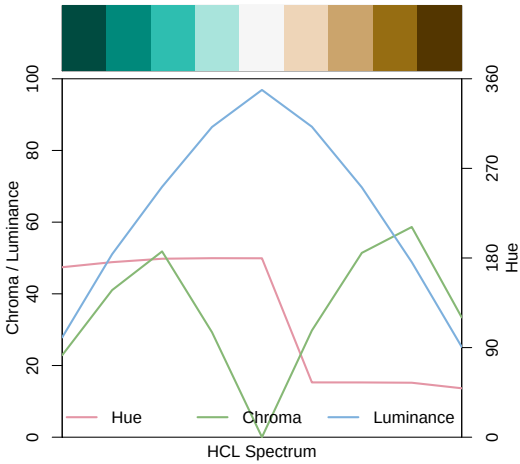




Color palettes: Somewhere over the Rainbow

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

Statistical graphics

Base:

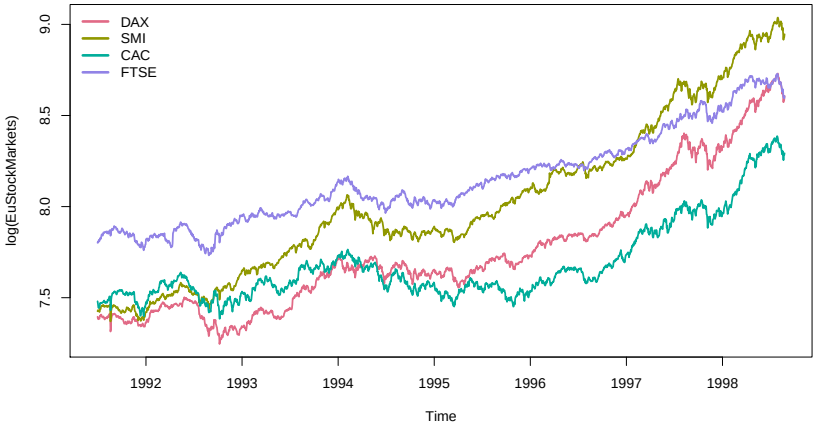
- HCL palette functions return hex color vector.
- Typically passed to `col =` argument of base plotting functions.

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`.

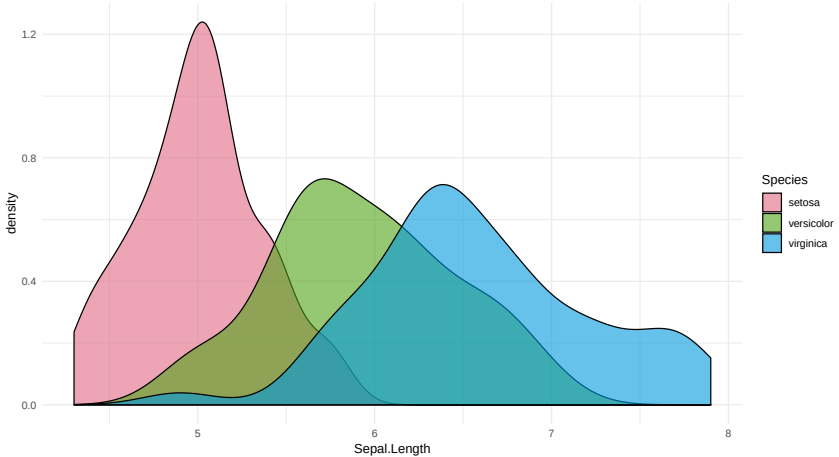
Statistical graphics: Base

```
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_qualitative(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.

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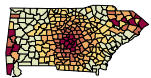
Emulation: Color vision deficiency.

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

Visualization and assessment: `demoplot()`

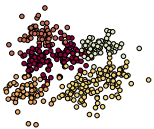
```
R> cl <- sequential_hcl(5, palette = "Heat")
R> demoplot(cl, type = "...")
```

map

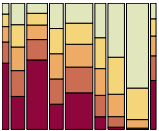


heatmap

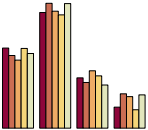
scatter



spine

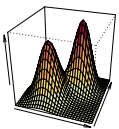


bar

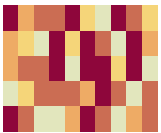


pie

perspective

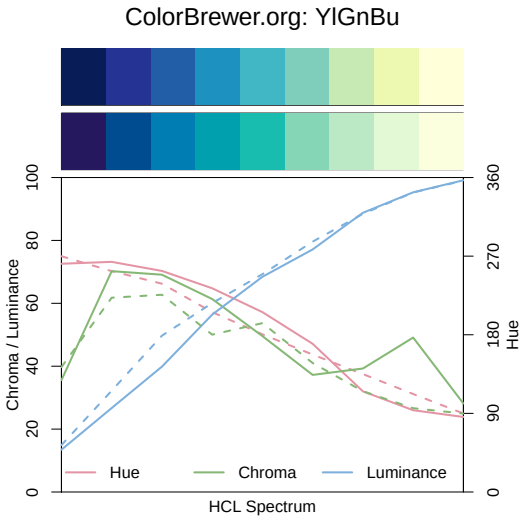


mosaic



lines

Approximations of other palettes



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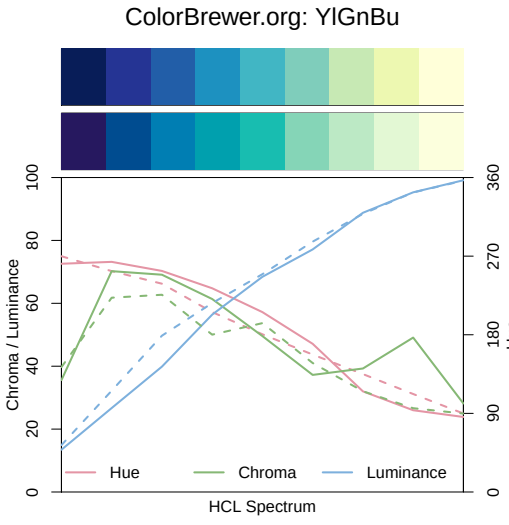
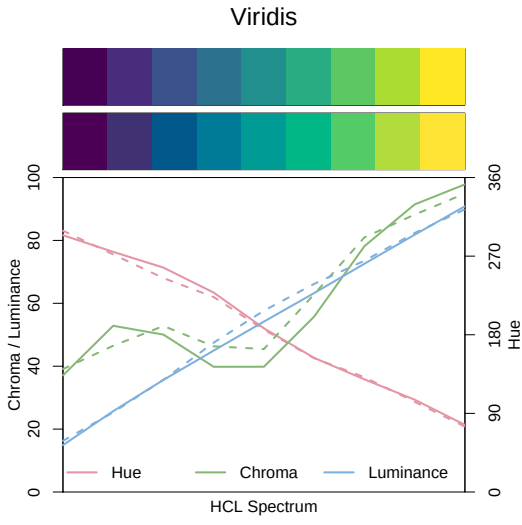




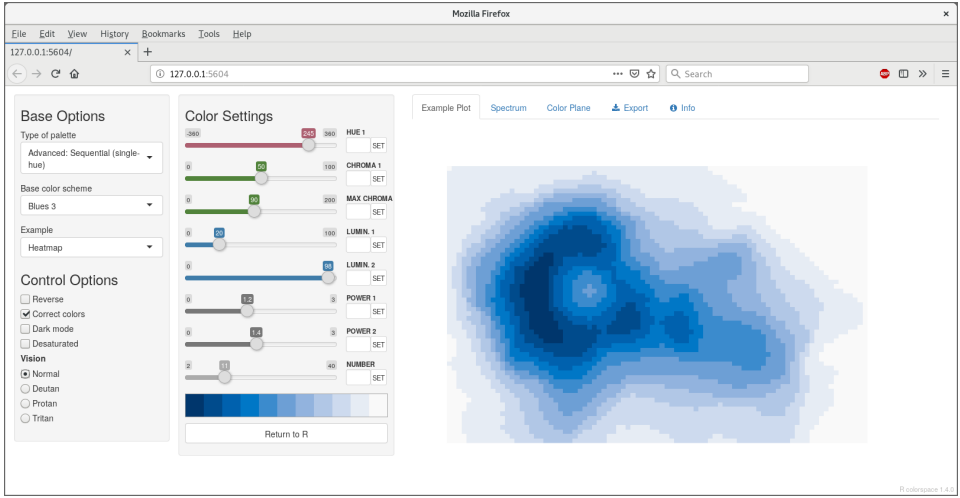
Color apps

Facilitate exploration: Graphical user interfaces as shiny apps.

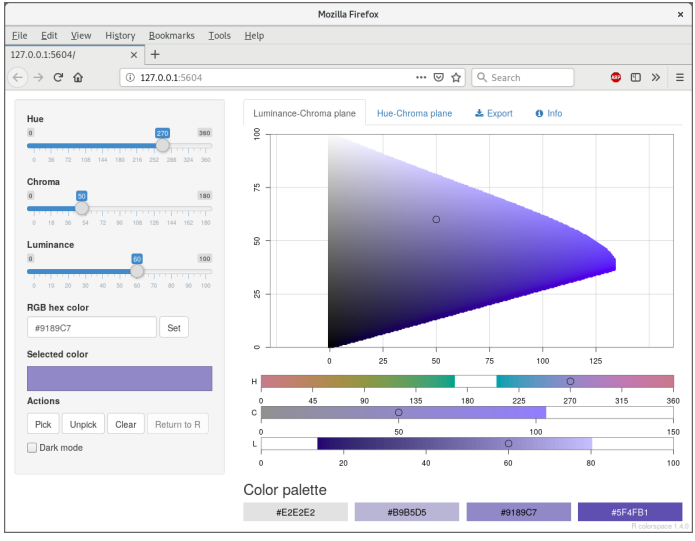
- *Palette constructor:* `choose_palette()` or `hclwizard()` (also in tcltk).
- *Color picker:* `choose_color()` or `hcl_color_picker()`.
- *Color vision deficiency emulator:* `cvd_emulator()`.

Online versions: `http://hclwizard.org/`

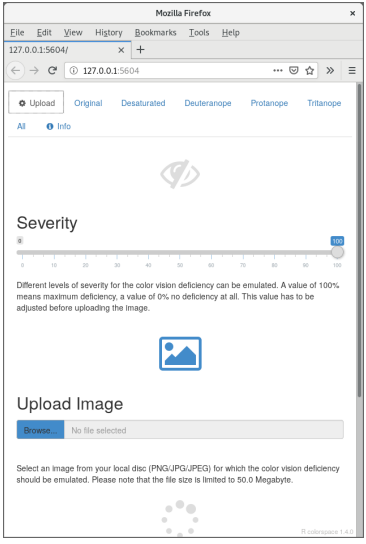
Color apps: `choose_palette()` / `hclwizard()`

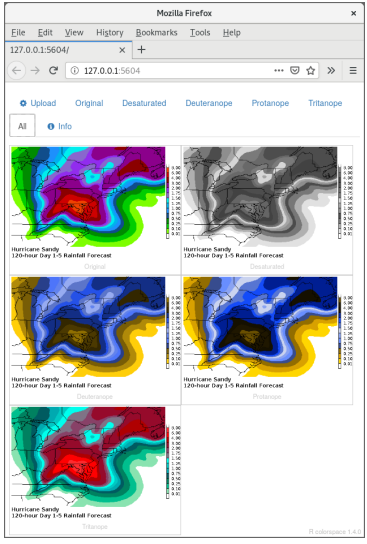


Color apps: `choose_color()` / `hcl_color_picker()`



Color apps: `cvd_emulator()`





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