Escaping RGBland: How to make effective use of colors in meteorological visualizations

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INTRODUCTION

In meteorology, **visualizations are an essential part** of the everyday work. Most figures are containing colors. The **Red-Green-Blue (RGB)** based color palettes provided as default by most common software packages **can lead to** various **problems**.

An alternative is the **Hue-Chroma-Luminance (HCL)** color space. The HCL color space is based on **how we perceive colors**. Based on HCL palettes one can **strongly improve** the visual output with barely no additional effort and **help the end-user** to gather complex data as easy as possible.

HOW COLORS SHOULD BE

- natural & simpel: no highly-saturated colors; manageable number of colors
- guiding: help the reader to gather the information; guide to most important parts
- supportive: lead the reader; reproduce well-known patterns (e.g. water is blue)
- appealing & relaxing: if not: reader can get lost, very strenuous for the eye
- customized: who has to interpret the image? regarding visual constraints?
- work everywhere: screen, projector, color- and gray-scale printers

THE PERCEPTION-BASED HCL COLOR SPACE

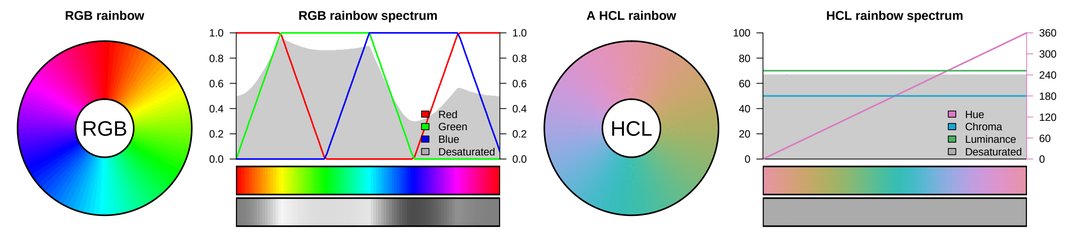
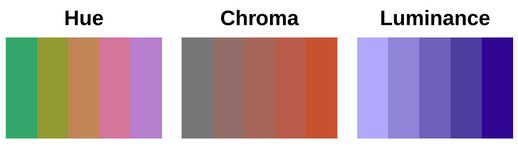


Figure 1: Juxtaposition of the default RGB rainbow scheme and a similar HCL rainbow. Beside the color wheel: dues of either red, green and blue (for RGB) or hue, chroma and luminance (for HCL) which are defining the color palette. Gray shading: desaturated luminance information underlying the color palette.

Most common software packages offer **Red-Green-Blue** color palettes. Each RGB color is defined as a tripled of red, green and blue values. This concept allows to create high saturated images, but is mainly based on how TV screens are working.

The **Hue-Chroma-Luminance** also defines colors by triplets but captures the perception of the human color vision. With the HCL concept you do have full control over the perceptual dimensions.

H: Hue, defines the **color**
C: Chroma, defines the **colorness**
L: Luminance, defines the **brightness**



EXAMPLE I: PRECIPITATION FORECAST

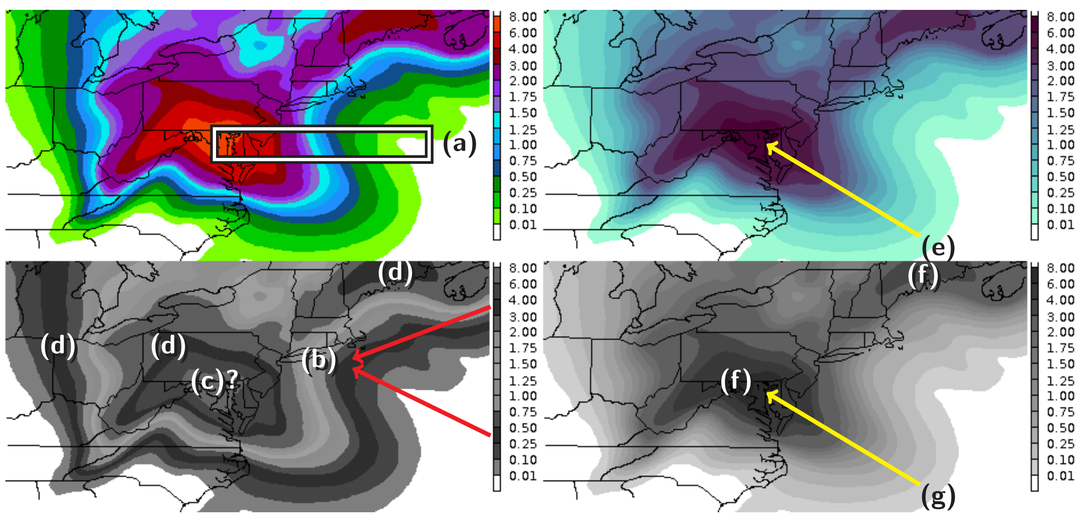


Figure 2: A 120 hour rainfall amount forecast (in inches) during landfall of hurricane Sandy in 2012. *Left:* original colors on top; desaturated version below. *Right:* modified version using HCL color scheme; colorized and desaturated version. *Source:* www.noaa.gov.

(a) very strong gradients between colors; highly-saturated colors; luminance: bright, dark, bright, dark, ...
(b) color/value pairs no longer unique;
(c) identification of most important information difficult/impossible
(d) eye automatically focuses on dark "artefacts"
(e) "well-known" colors (water ⇔ blue); only two colors (blue/violet); no irritating gradients
(f) luminance guides to most important areas
(g) higher rainfall amount ⇔ lower luminance

EXAMPLE II: WARNING MAP AUSTRIA

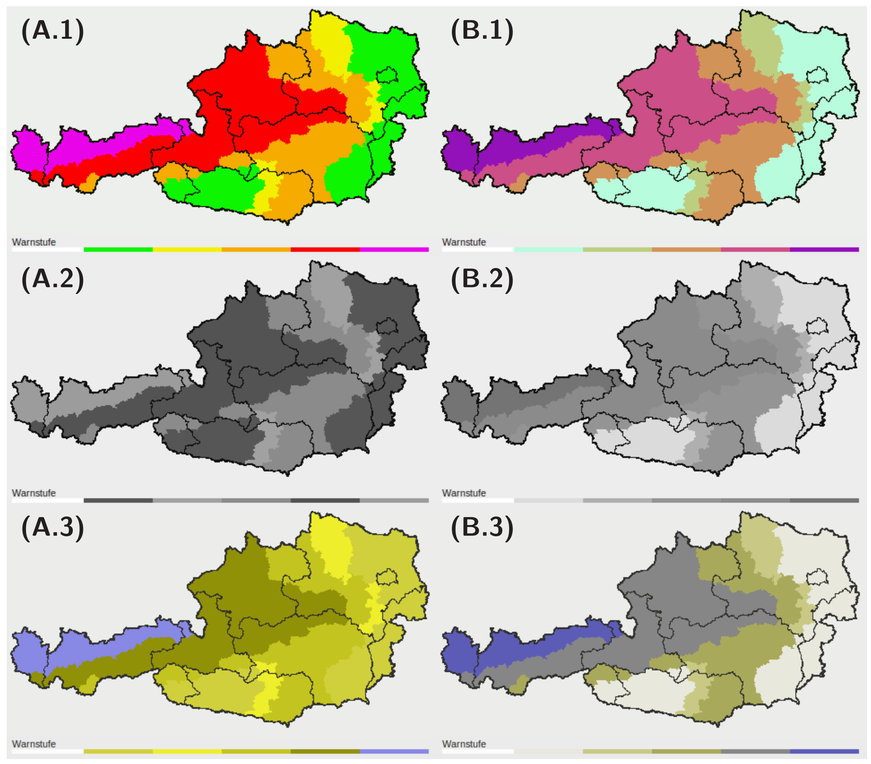


Figure 3: A severe weather alert map (high amounts of precipitation) for Austria, 31th of Mai 2013. Label *(A)* for the original colors, label *(B)* for the modified HCL version. From 1 to 3: colorized version; desaturated version; simulated version for people with Deuteranopia (red-green blindness). *Source:* www.uwz.ch, UBIMET GmbH.

The second example shows an alert map for Austria. The original color palette contains high saturated colors which leads to the same problems as mentioned in *EXAMPLE I*.

Important: The map should be readable for all inhabitants of Austria. About 10% of the European population have red-green weaknesses (Miles, 1943). Hence, one should think of considering this while choosing appropriate colors.

LINKS & TOOLS

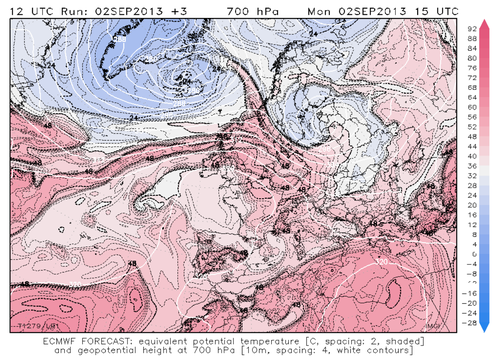


Figure 4: ECMWF equivalent potential temperature forecast on 700hPa to identify air masses and frontal zones. *Source:* http://ertel2.uibk.ac.at.

Links & Tools

http://ertel2.uibk.ac.at: The online version of our internal weather platform with (mainly) HCL based forecast maps.

R programming language: Open source software; a package called "colorspace" is available to create HCL color palettes (Ihaka et al., 2013).

http://www.wetterleuchte.ch: An online interface to the R colorspace package with full functionality; create and export your own HCL palettes.

modules: We have planned to offer the colorspace library (Ihaka, 2005) with an easy-to-use GUI for other programming languages (work in progress).

CONSLUSION

Cost-benefit ratio

You can easily improve your work with nearly no extra work.

Interpretation of the figures

Especially for complex concepts/figures (e.g. for teaching) one can strongly enhance the readability of existing visualizations by choosing effective colors.

Escaping RGBland

As shown, the RGB (Red-Green-Blue) color space can cause several different problems. With the presented HCL (Hue-Chroma-Luminance) concept one can avoid most of the RGB disadvantages.

Take-home message

"We as a visualization community must do better, making the rainbow color map as rare in visualization as the goto statement is in programming." (Borland and Taylor, 2007)

References

Borland, D. and R. M. Taylor, 2007: Rainbow color map (still) considered harmful. *Computer Graphics and Applications, IEEE*, **27**, 14–17.

Ihaka, R., P. Murrell, K. Hornik, J. C. Fisher, and A. Zeileis, 2013: *colorspace: Color Space Manipulation*. R package version 1.2-2.
URL `http://CRAN.R-project.org/package=colorspace`

Miles, W. R., 1943: Color blindness in eleven thousand museum visitors. *The Yale journal of biology and medicine*, **16**, 59–76.

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