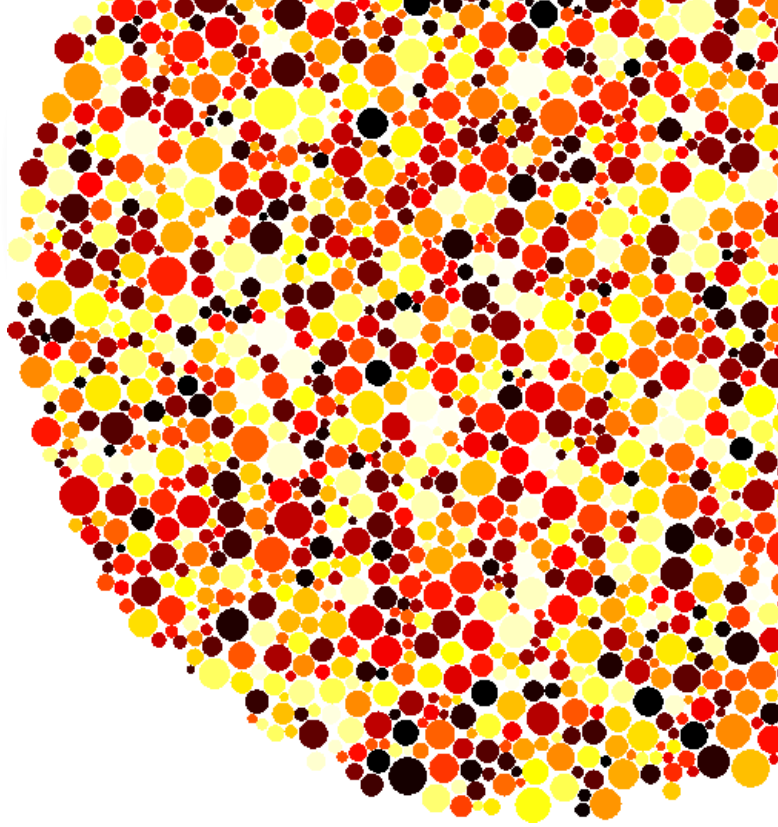
Colour Maps for the Colour Blind



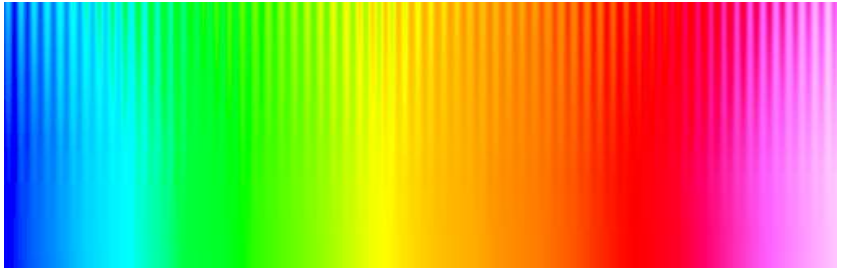
Peter Kovesi

Centre for Exploration Targeting
School of Earth and Environment
The University of Western Australia

THE UNIVERSITY OF WESTERN AUSTRALIA

IAMG 2017

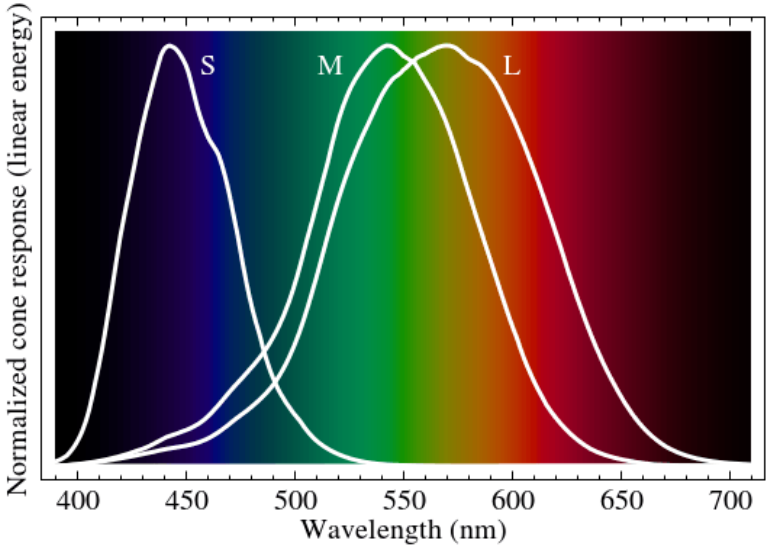
Centre for EXPLORATION TARGETING



protanopia

deuteranopia

tritanopia



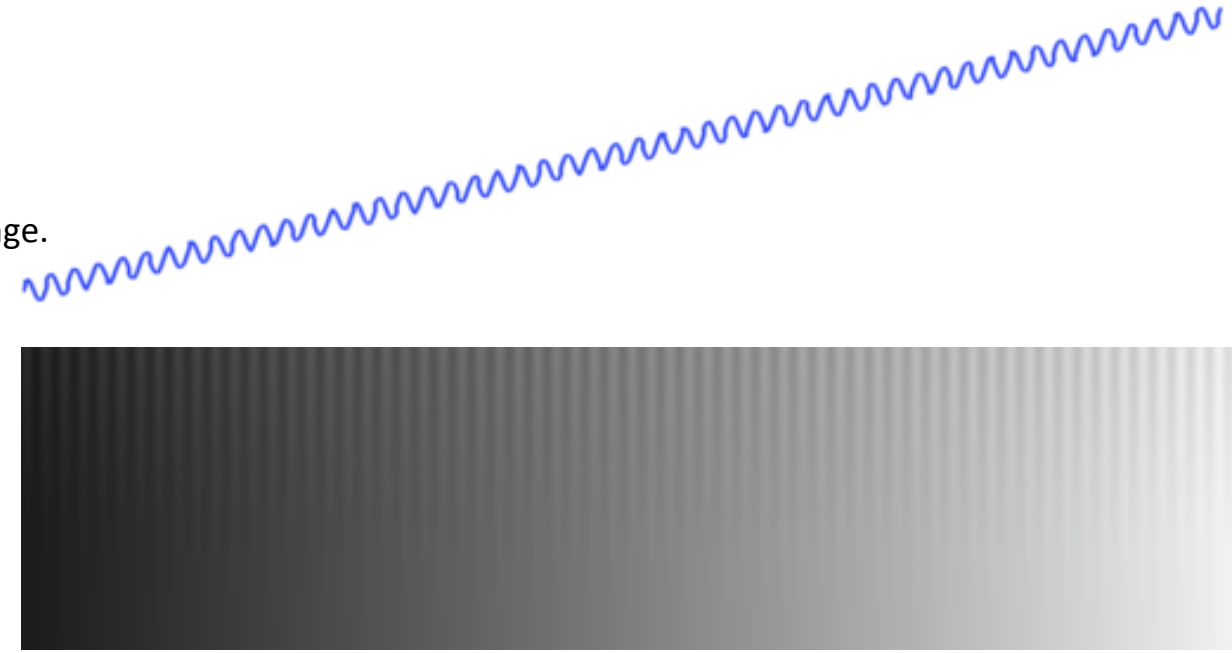
Protanopia / Protanomaly: Red, L cones missing / reduced function.
Red-Green blind. 1-2% males.

Deuteranopia / Deuteranomaly: Green, M cones missing / reduced function.
Red-Green blind. 6-8% males.

Tritanopia / Tritanomaly: Blue, S cones missing /reduced function.
Blue-Yellow blind. Very rare.

Test image for colour maps:
A sine wave superimposed on a ramp

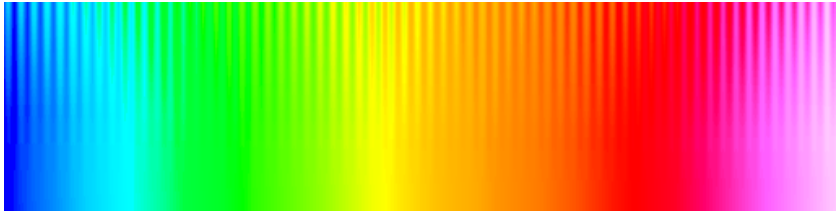
Amplitude is set so that peak to trough is 10% of the full data range.

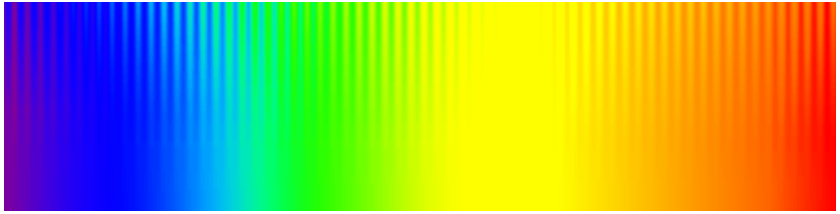


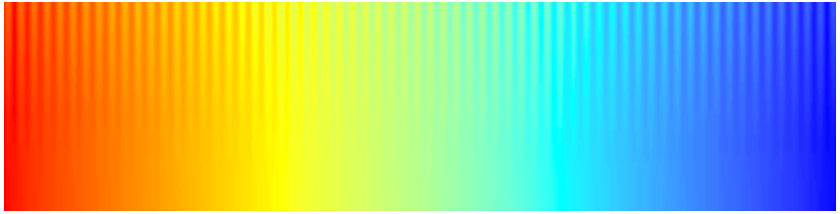
Amplitude is reduced to zero at the bottom of the image.

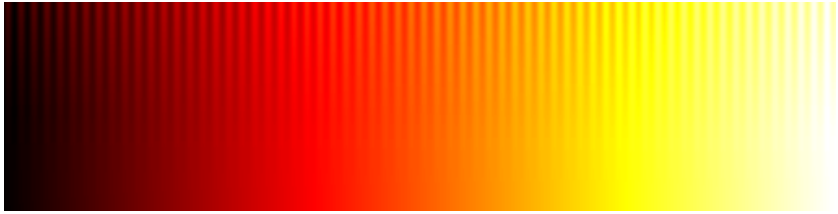
A good colour map will render the sine wave uniformly across the image.

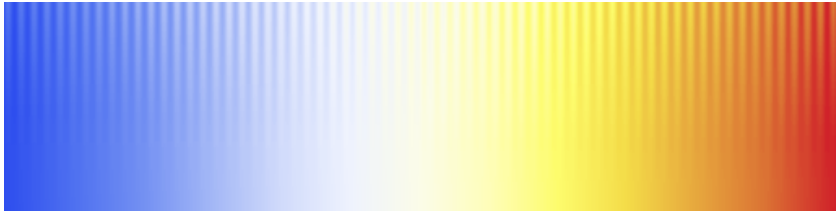
Colour Map Road Test

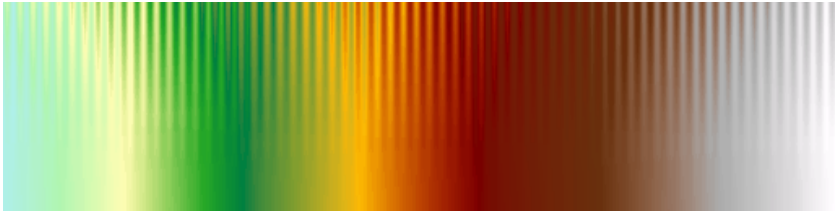




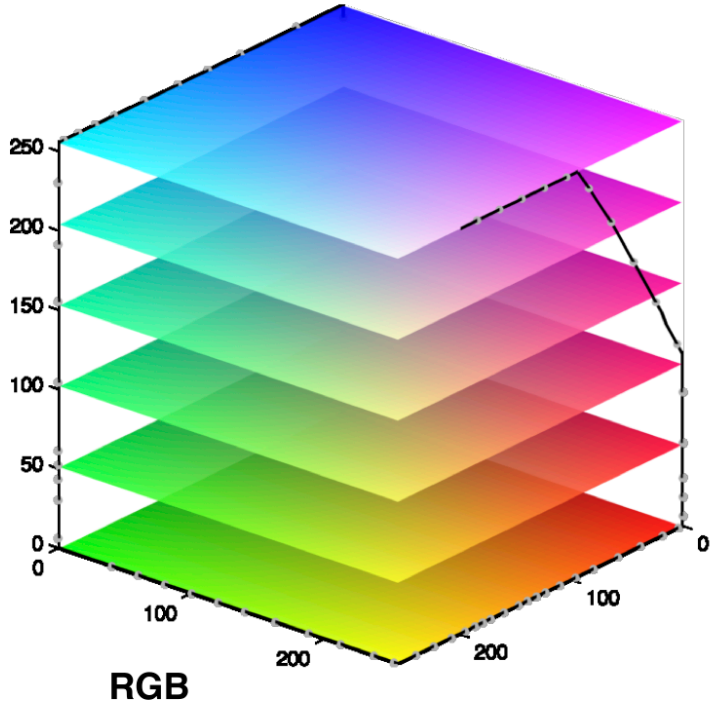


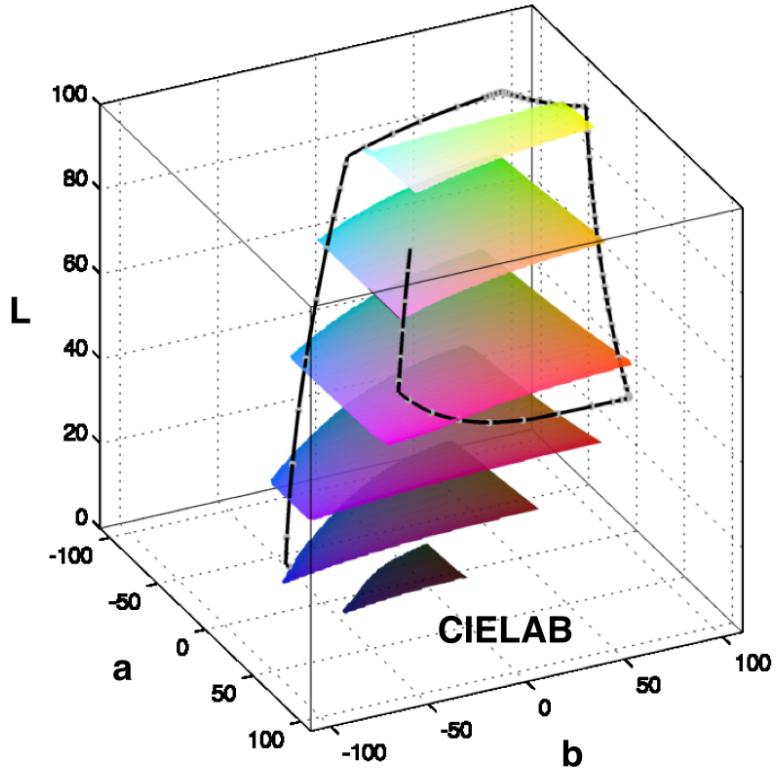




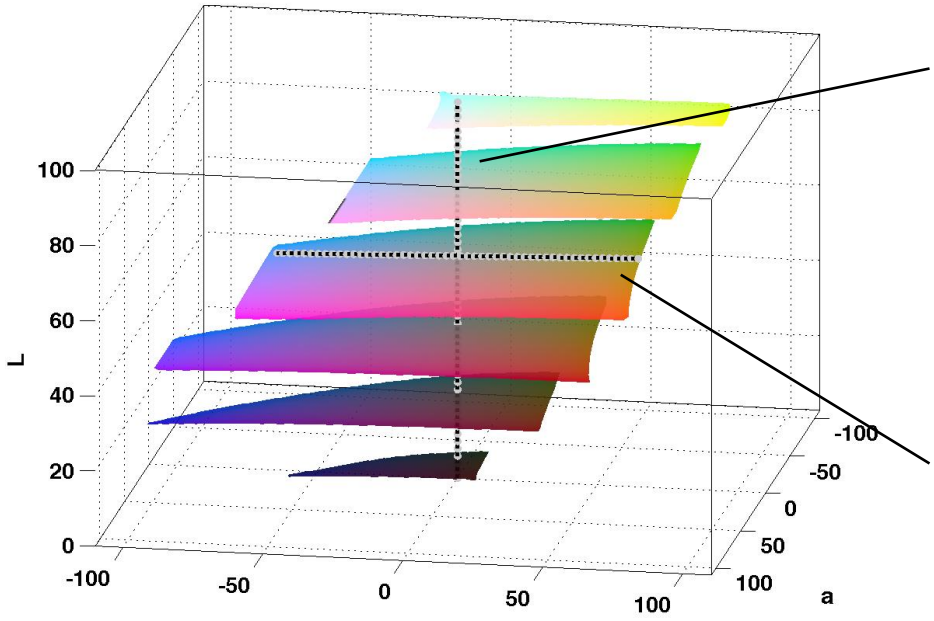


A colour map is a path through colour space





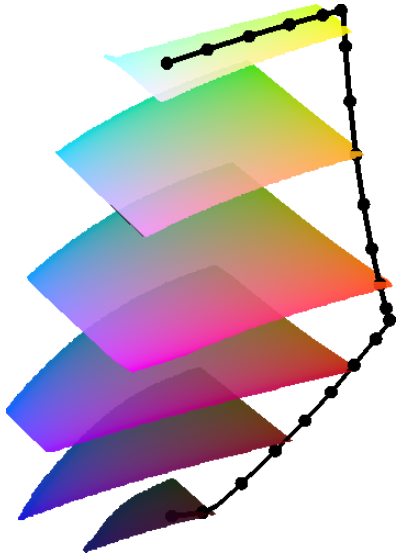
Lightness differences dominates perceptual contrast at fine spatial scales.



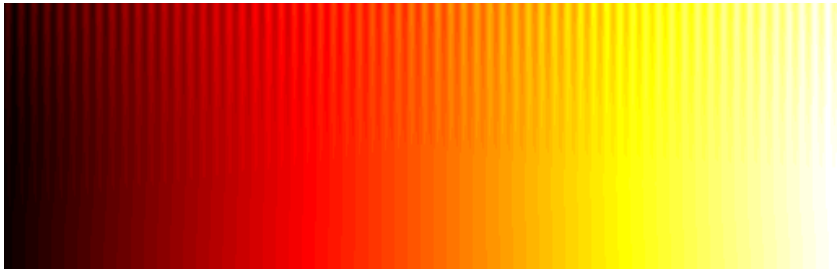
Lab colour space

The Colour Map Design Process

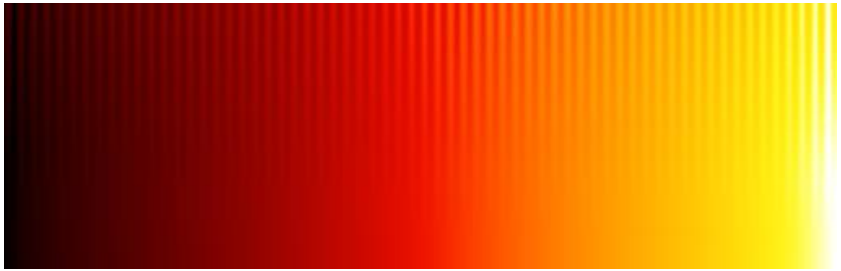
1) Define a colour map path
using line segments or splines.



2) Initial colour map

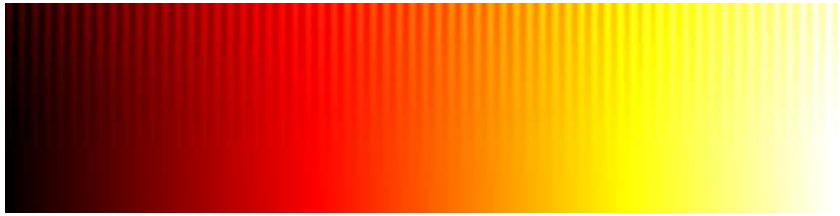


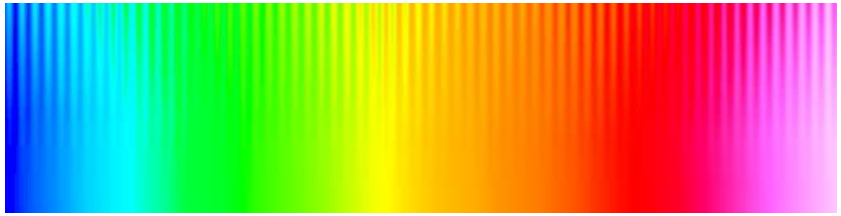
3) Resample colour map path at equal
lightness steps to obtain perceptual uniformity



Vendor Colour Maps

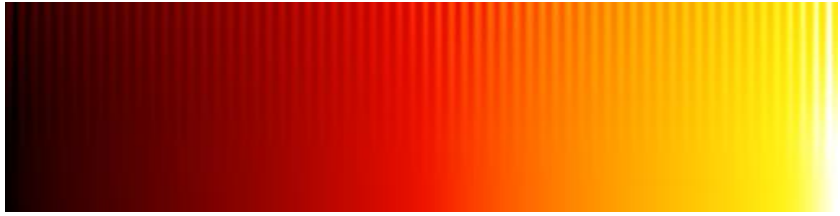
Features disappear at points of low perceptual contrast

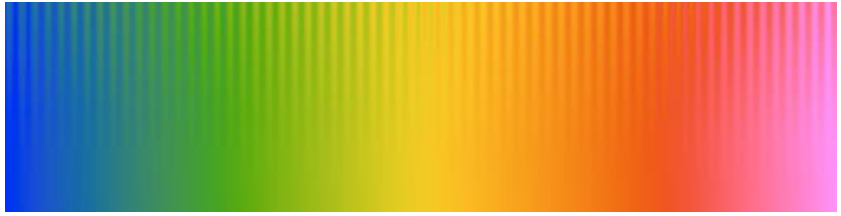




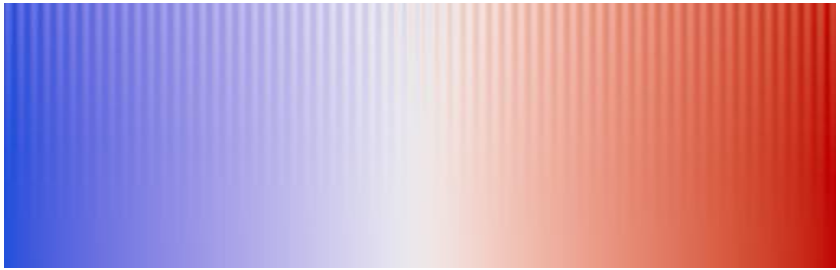
False features that are in the colour map, not in your data

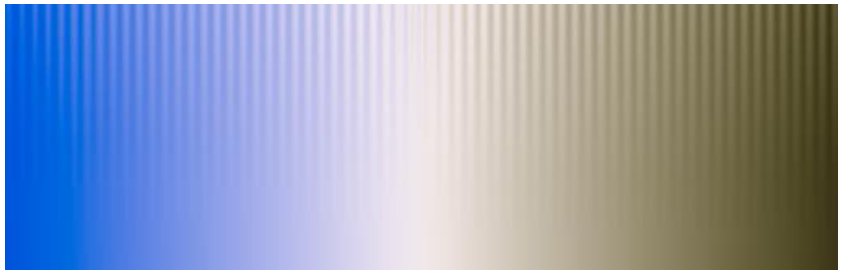
Perceptually Uniform Colour Maps



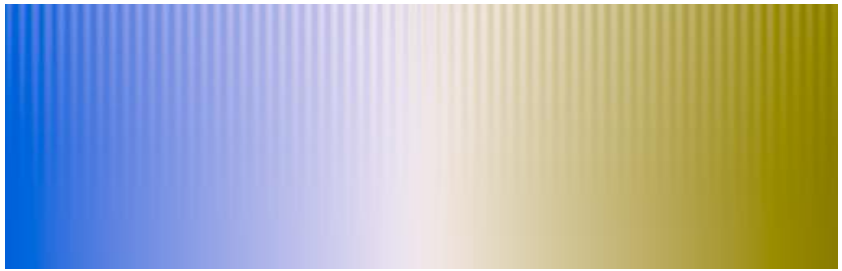


Checking to see if a colour map is ‘colour blind safe’ is not optimal

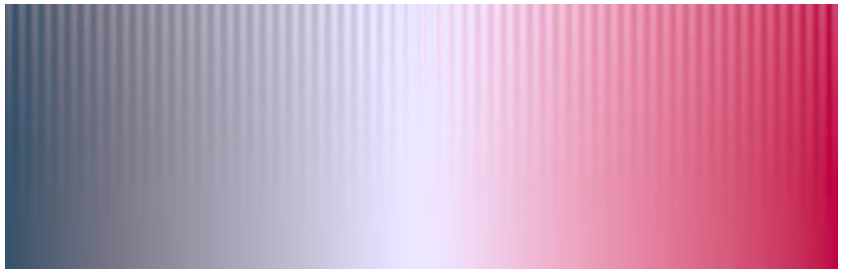




protanopia



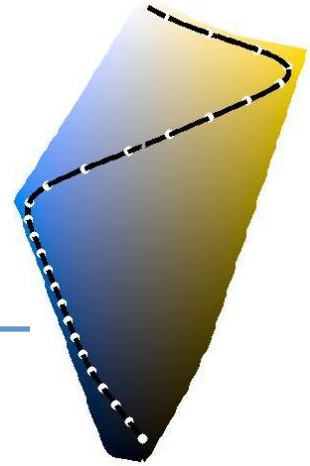
deuteranopia



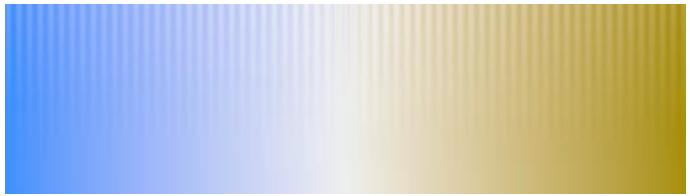
tritanopia

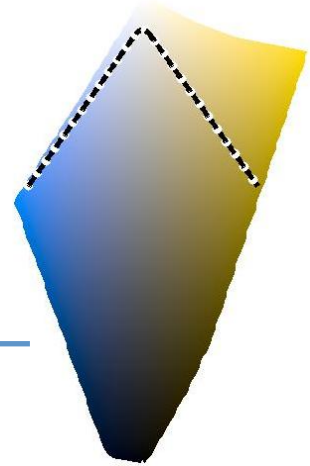
Colour map designed so that red and blue colours are matched in lightness and chroma.

Ideal approach is to design colour maps *within* the colour space of the colour blind



- Ensures maximal use of the colour space.
- Allows everyone to share a common perceptual interpretation of the data.
- Chroma and lightness can be properly used in the design of colour maps.



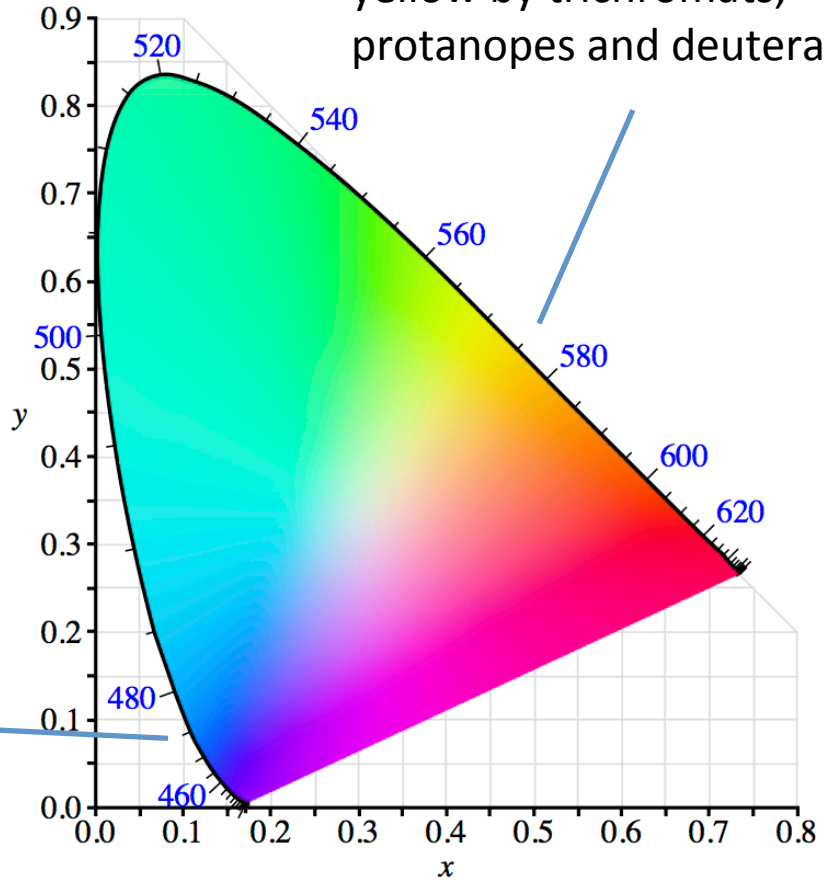


Protananpic/Deuteranopic Colour Space

- Assume the grey scale is perceived in the same way.
- Using data from people who are colour blind in just one eye assume the following:

575nm is perceived as same yellow by trichromats, protanopes and deuteranopes

475nm is perceived as same blue by trichromats, protanopes and deuteranopes



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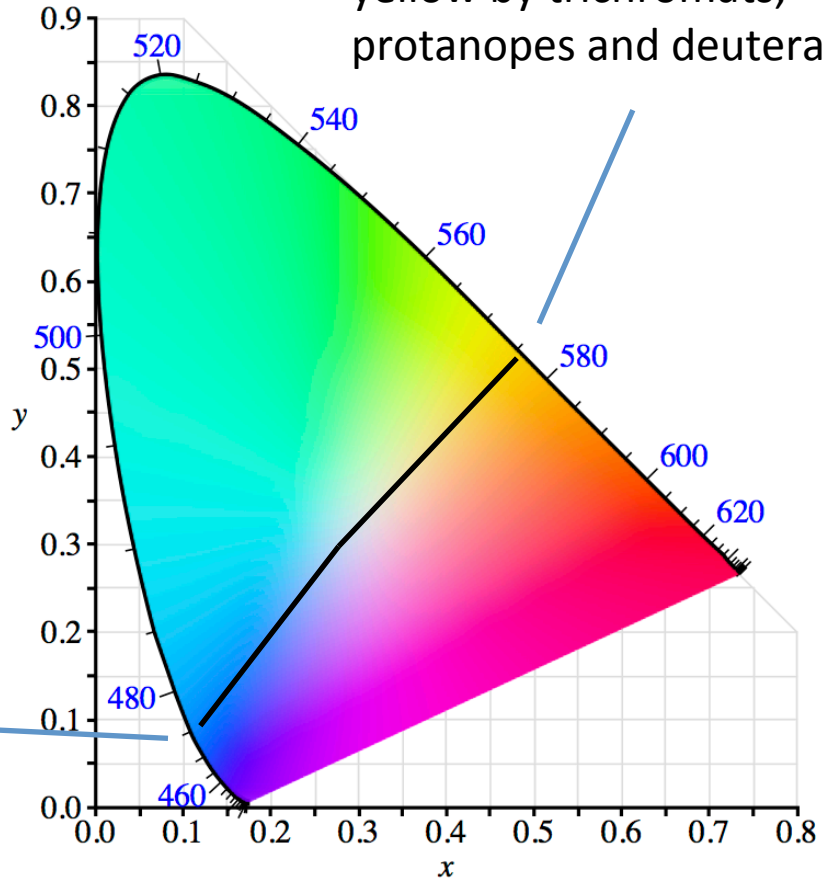
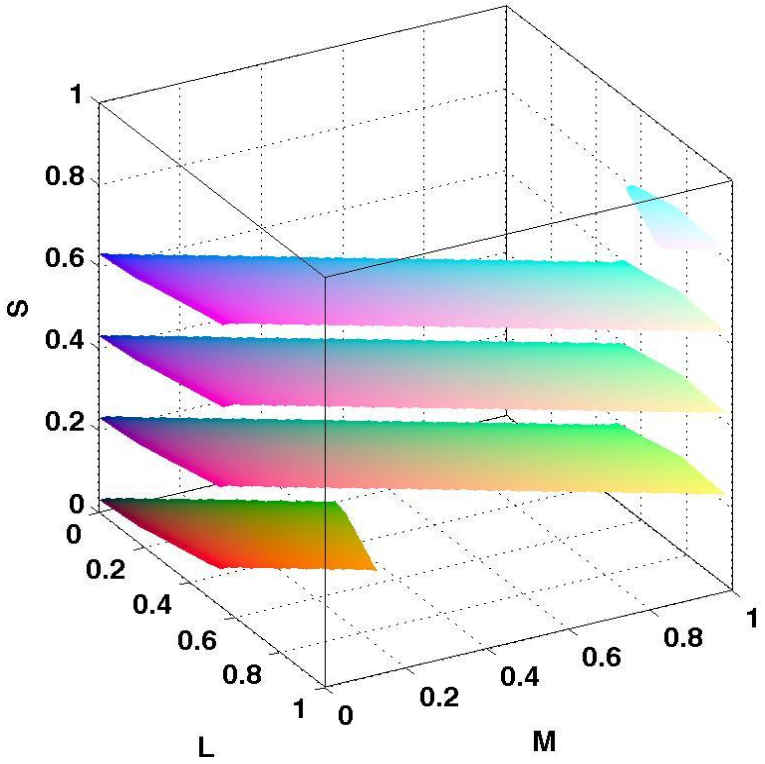
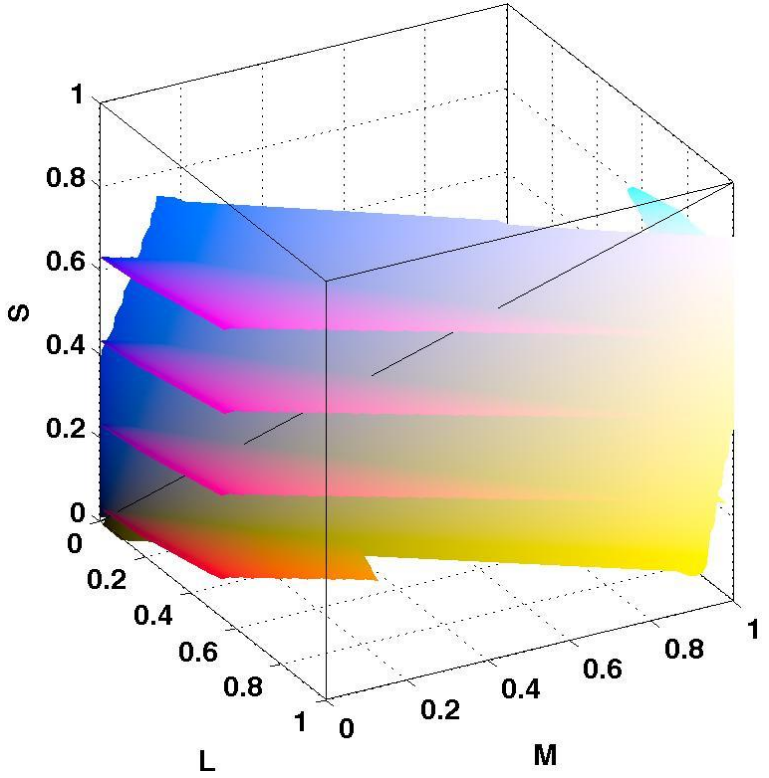


Colour space in LMS cone response coordinates

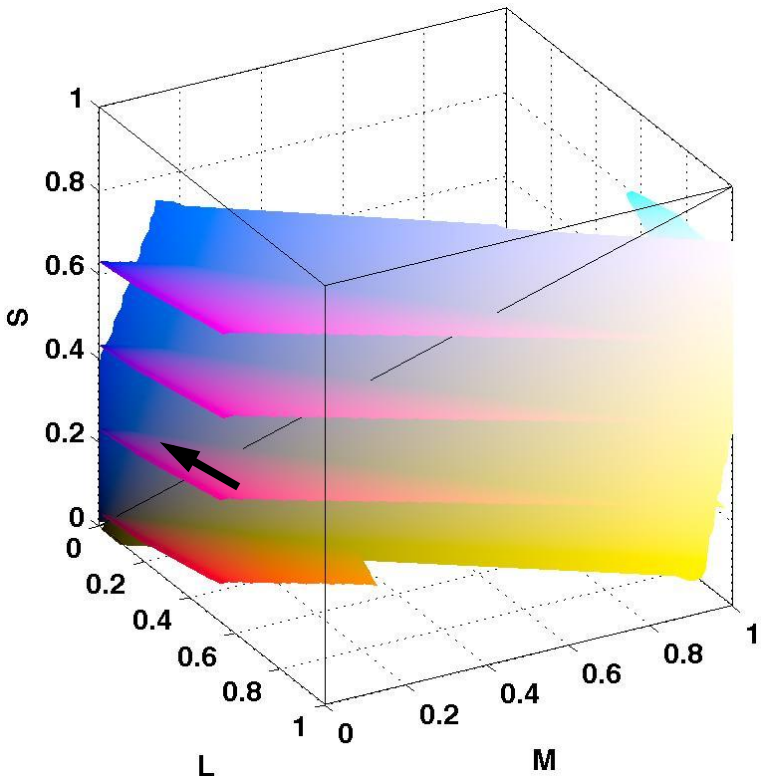


(a distortion of the RGB cube)

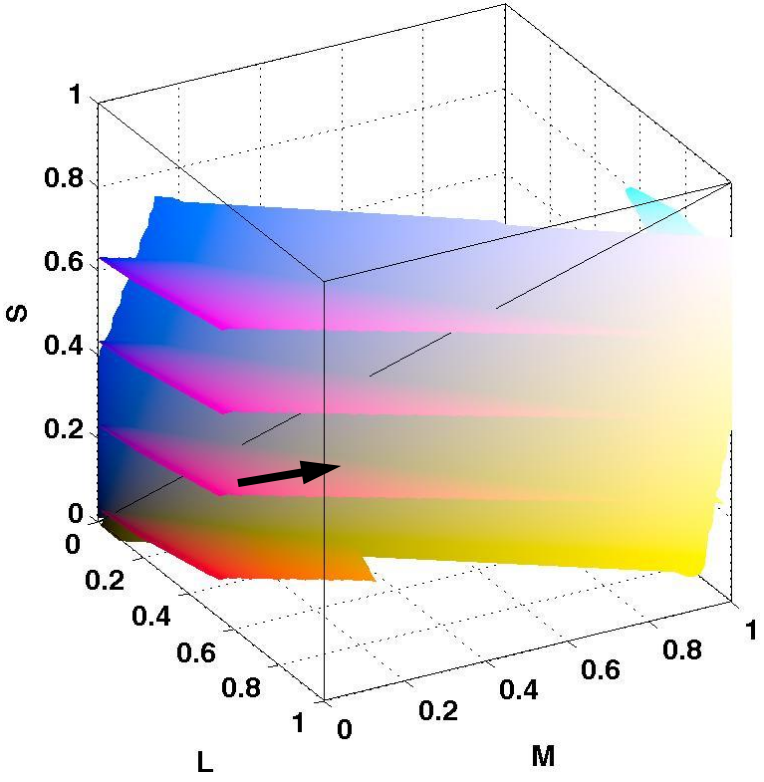
Protananpic/Deuteranopic Colour Space in LMS cone response coordinates



Hans Brettel, Francoise Vienot and John D. Mollon. 1997
"Computerized simulation of color appearance for dichromats"

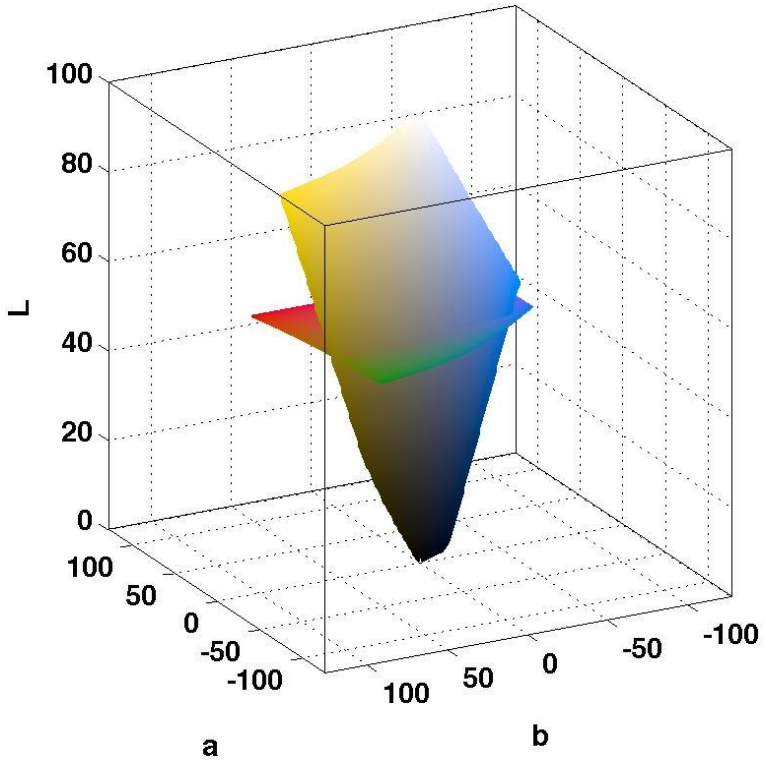


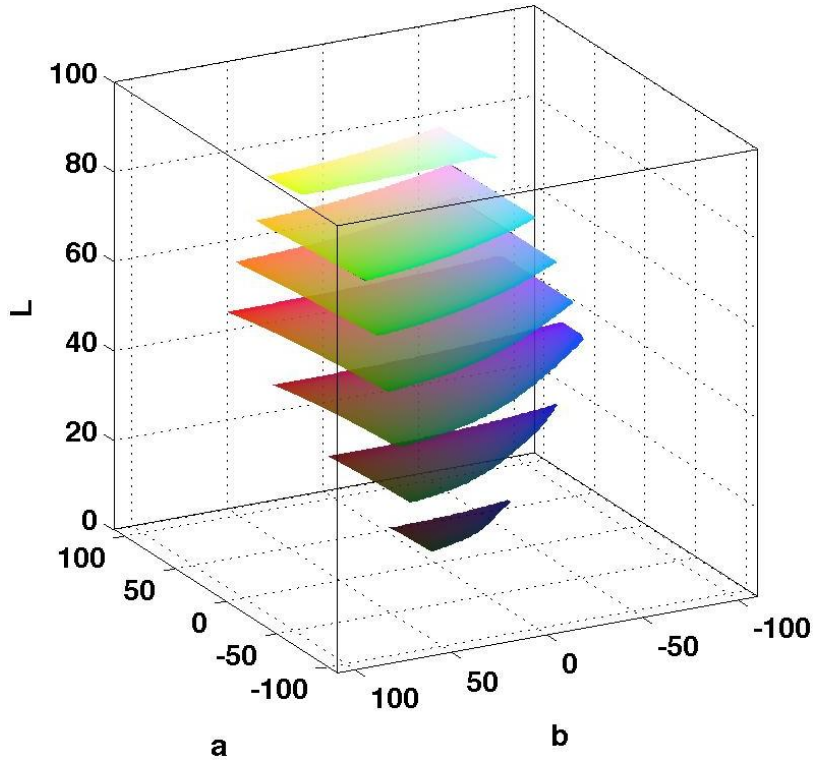
Protanopic projection of colours onto colour space



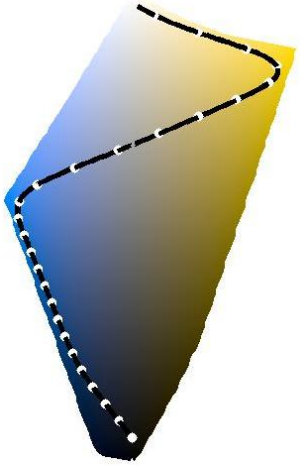
Deuteranopic projection of colours onto colour space

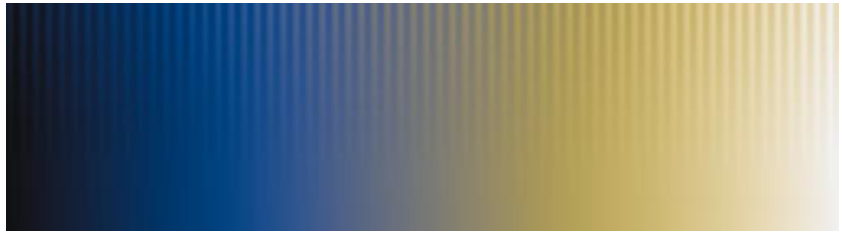
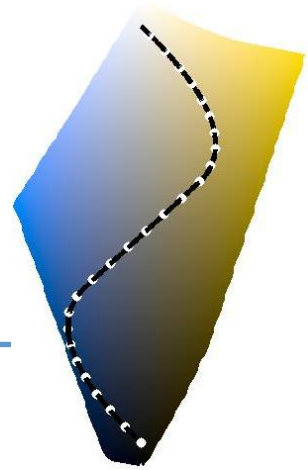
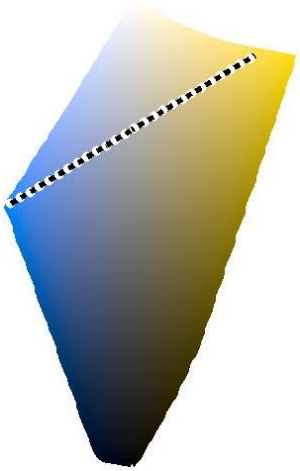
Protananpic/Deuteranopic Colour Space in CIELab coordinates

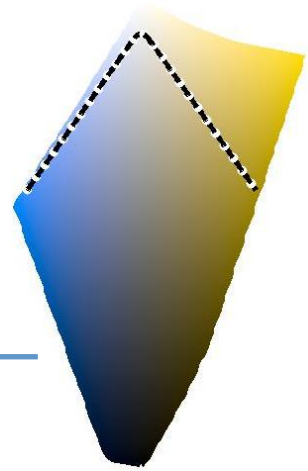


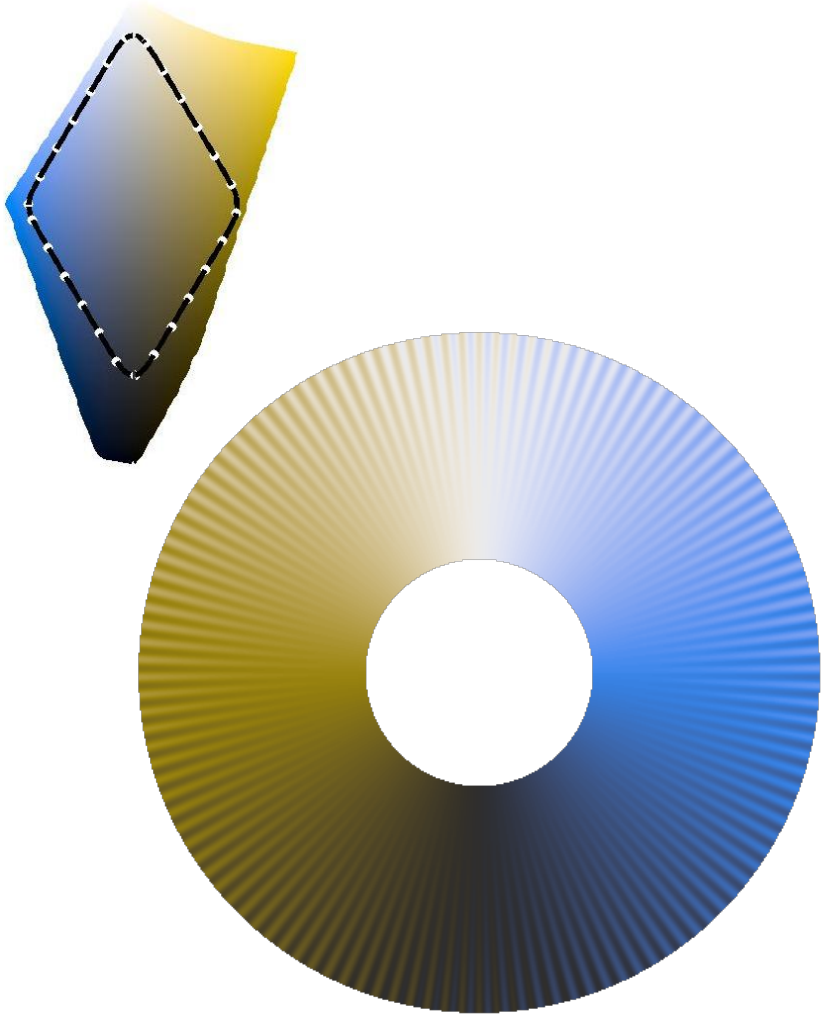


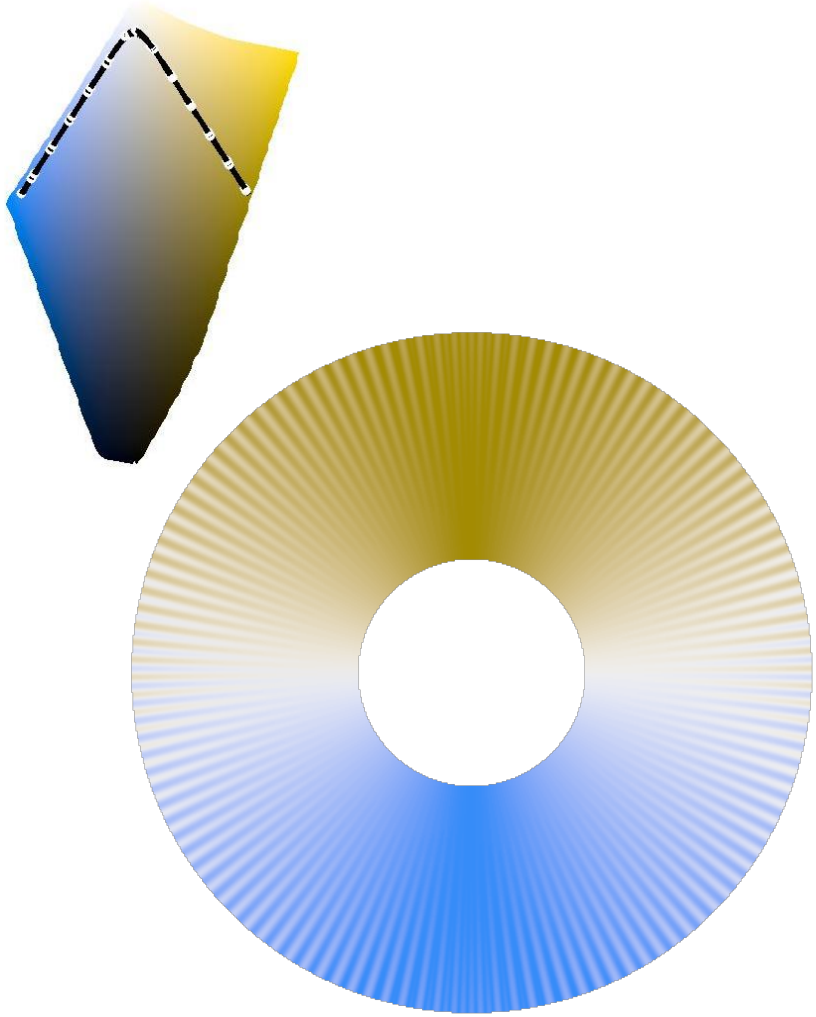
Full colour space



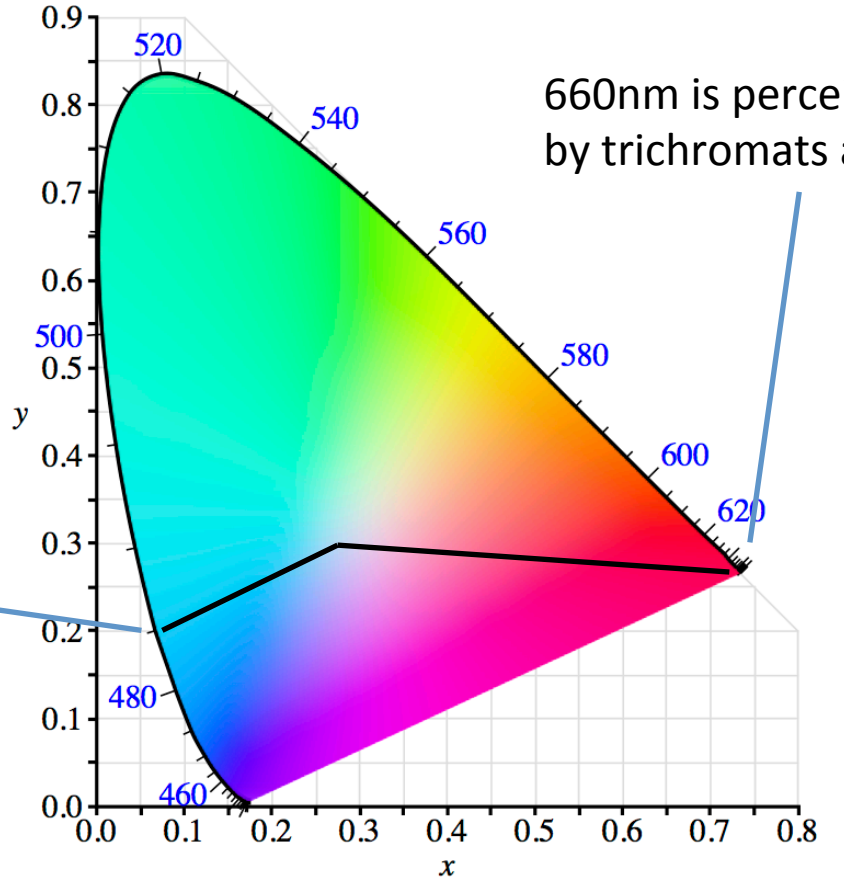




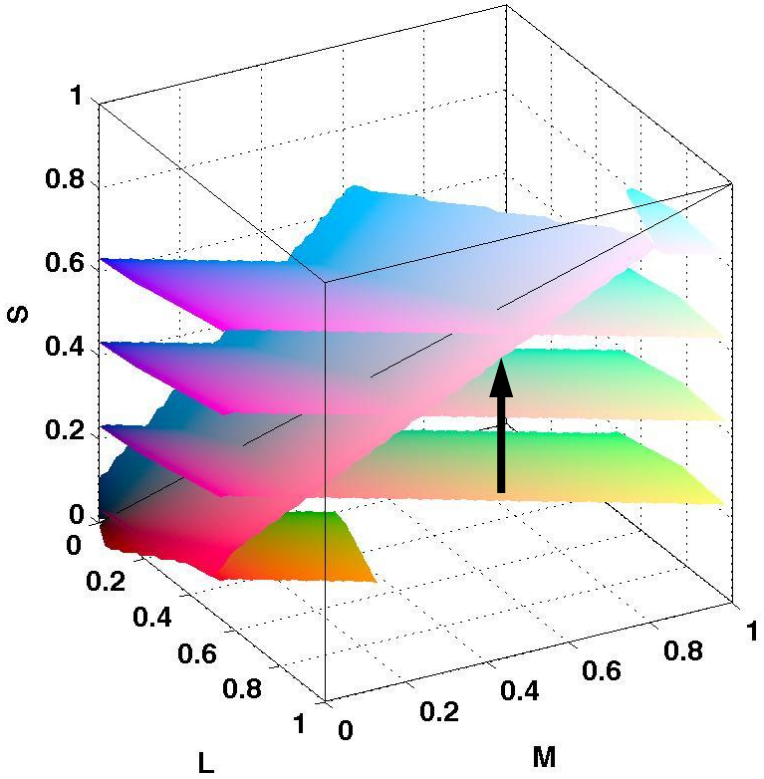
Tritanopic Colour Space

660nm is perceived as same red by trichromats and tritanopes

485nm is perceived as same blue/green by trichromats and tritanopes

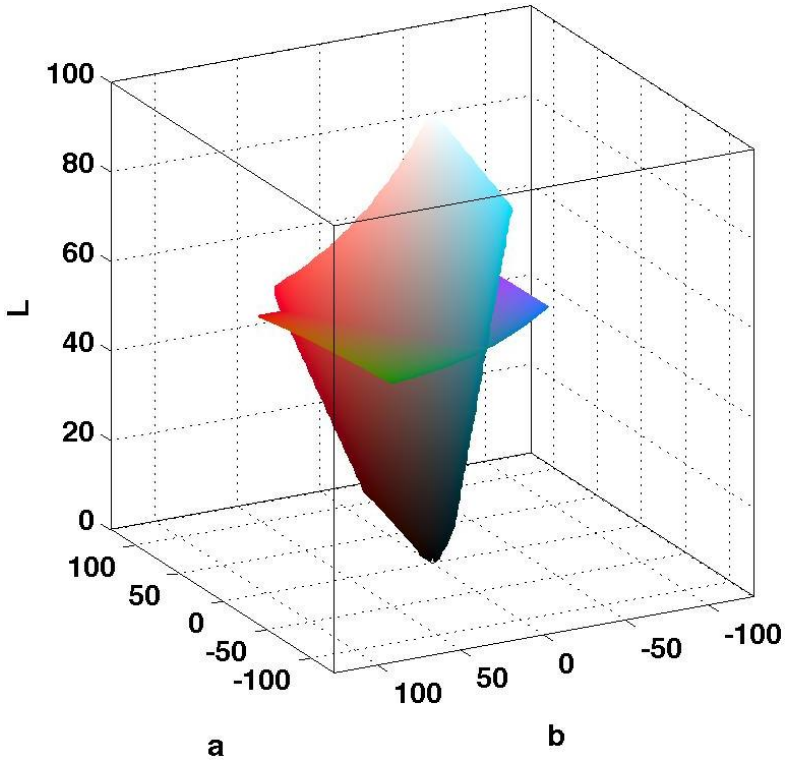


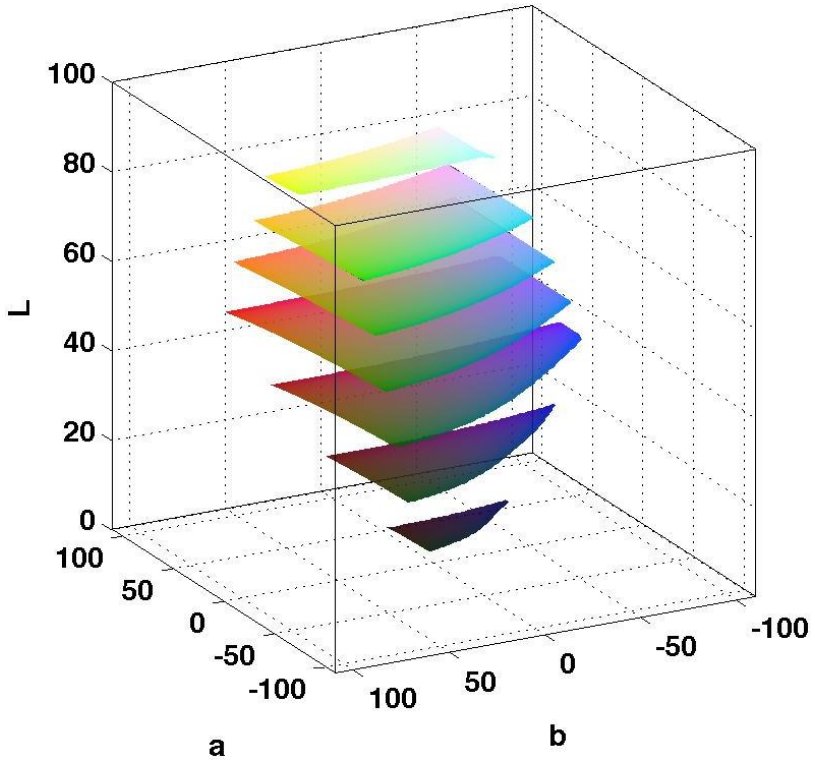
Tritanopic Colour Space in LMS cone response coordinates



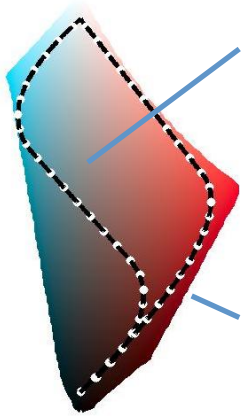
Tritanopic projection of colours onto colour space

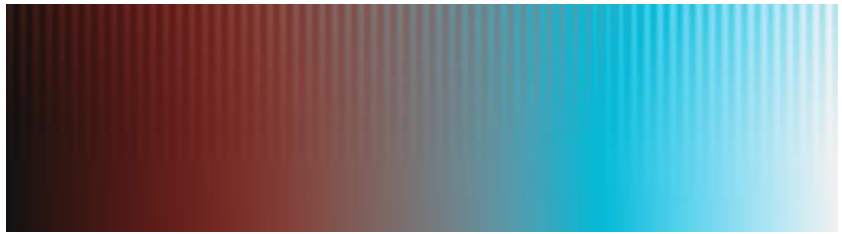
Tritanopic Colour Space in CIELab coordinates

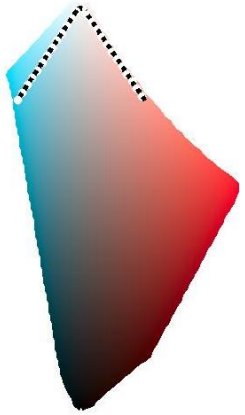


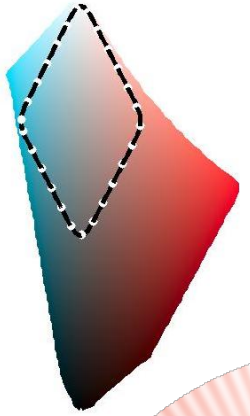


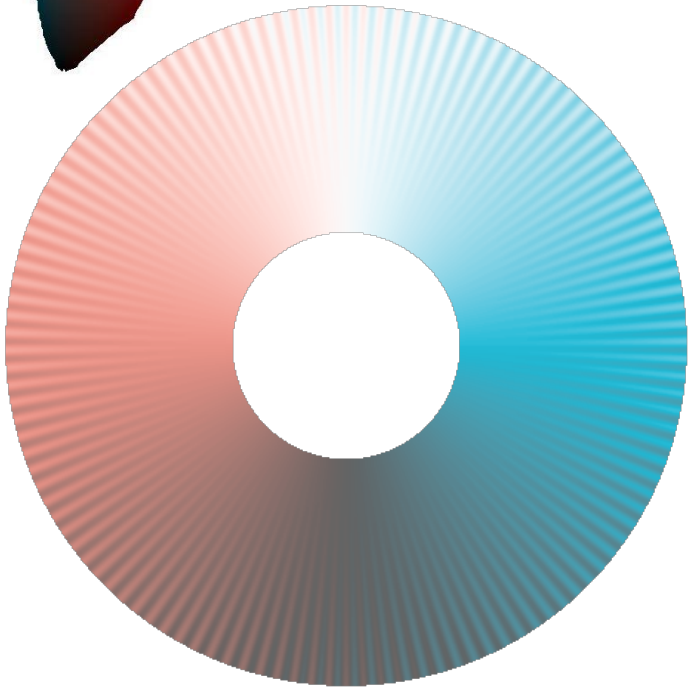
Full colour space

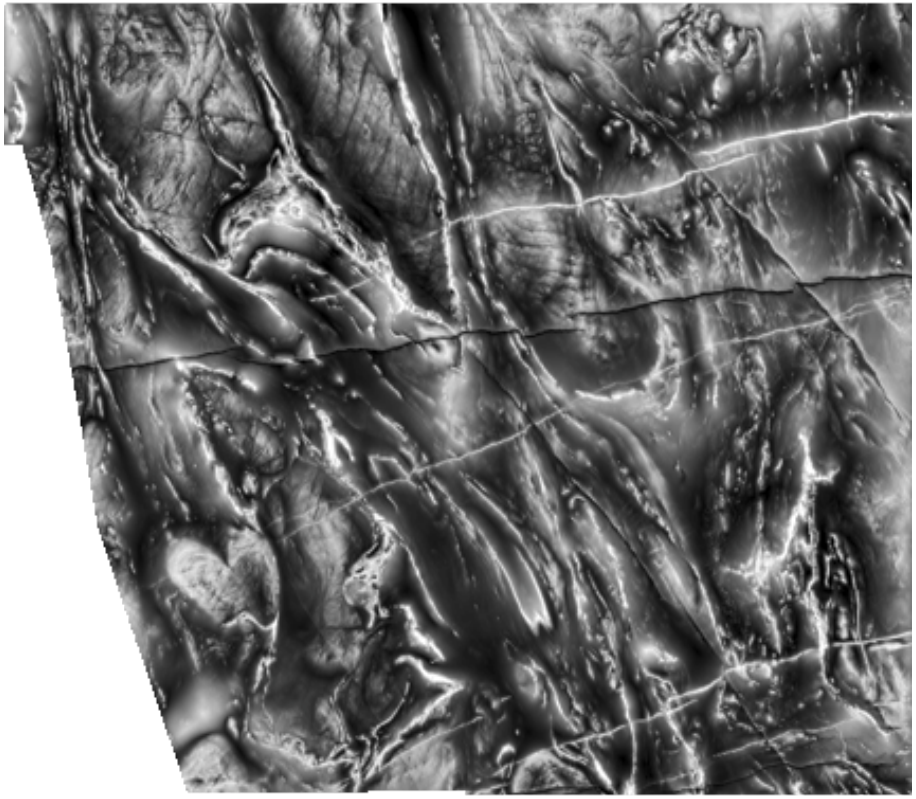


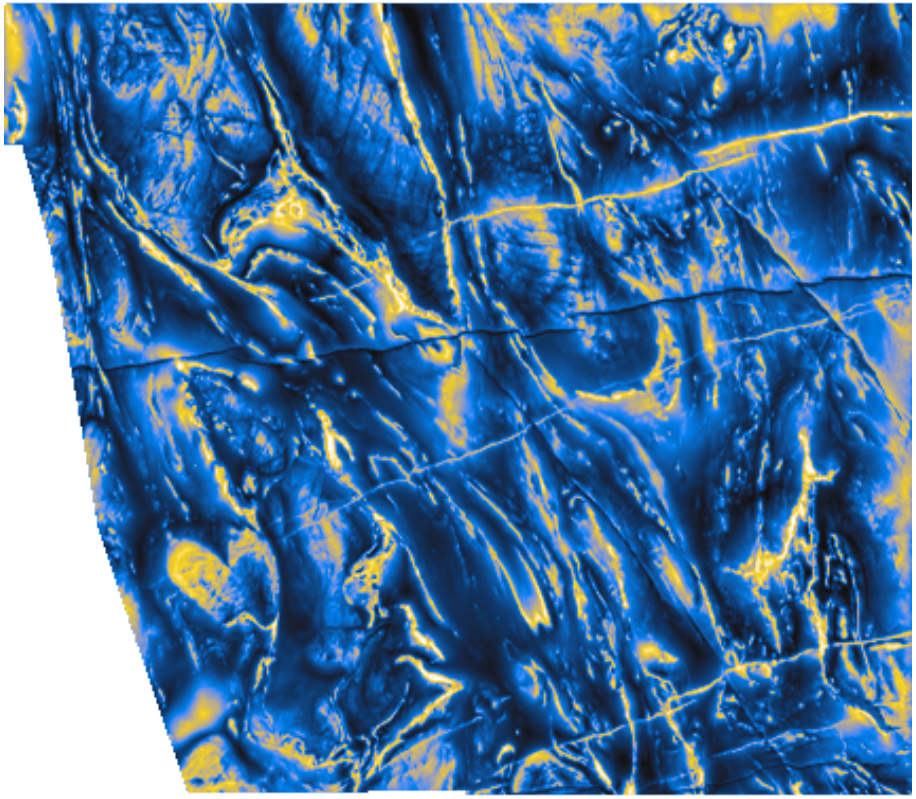




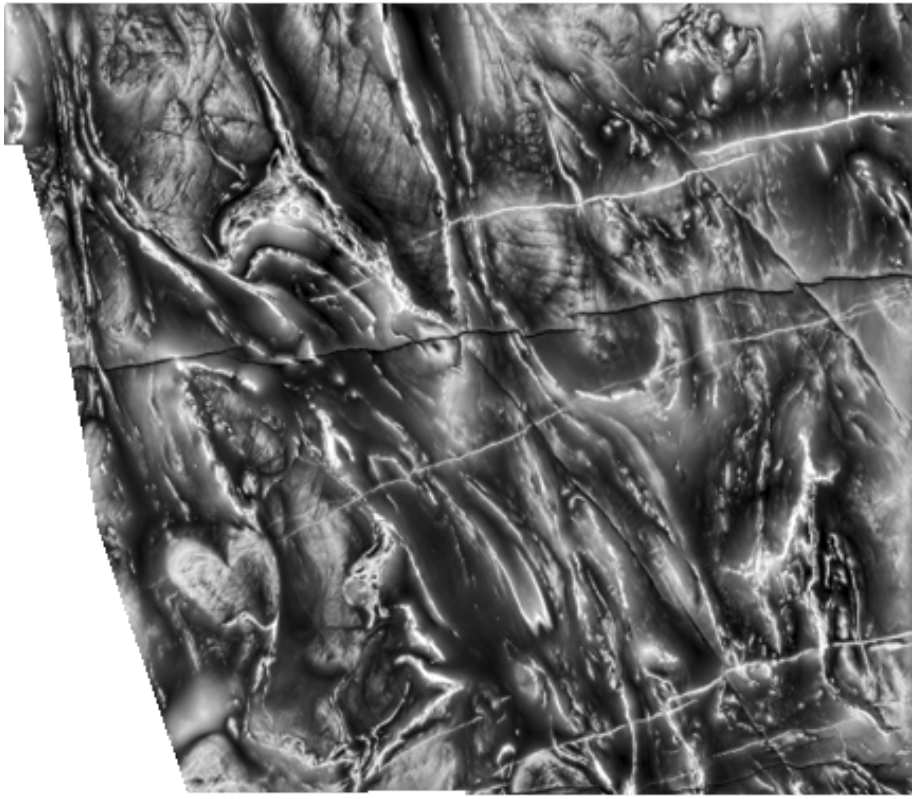


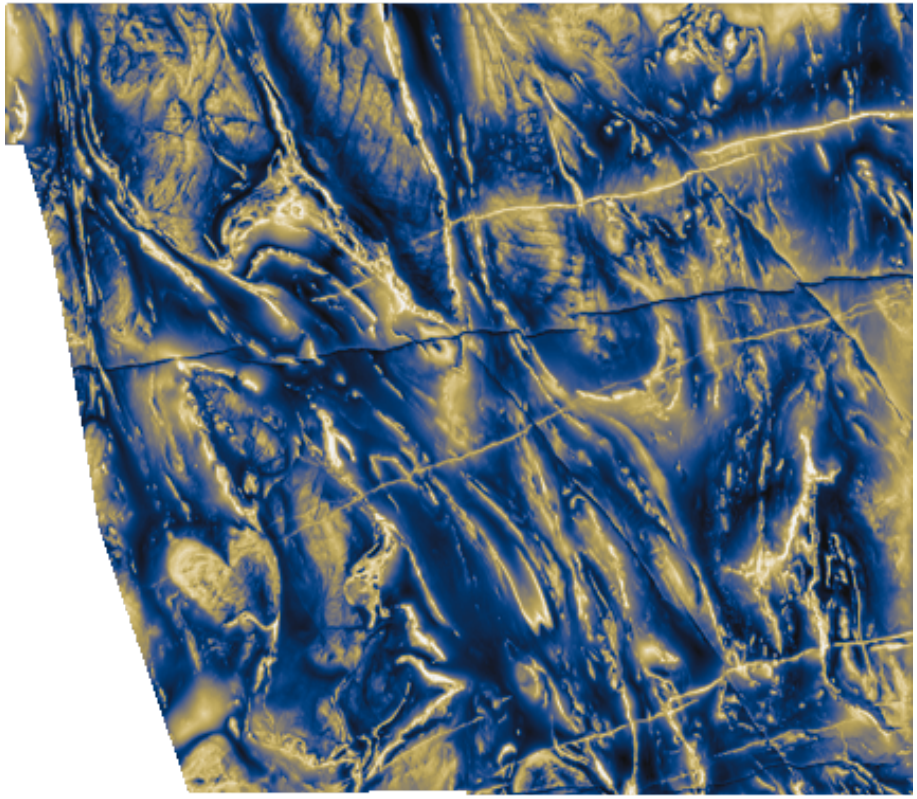


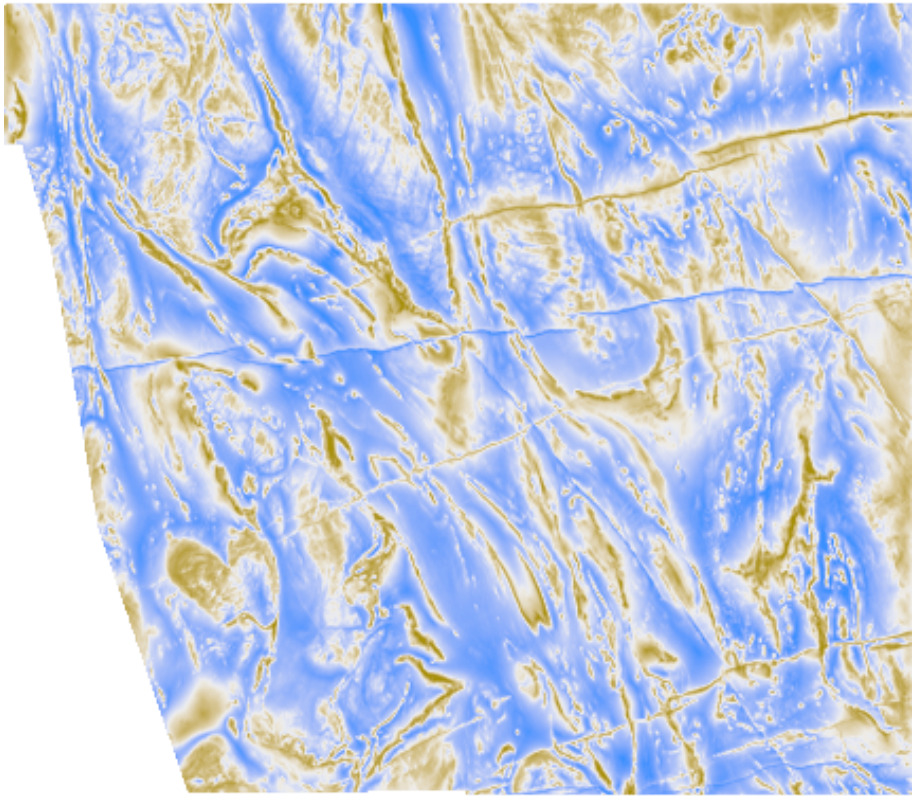


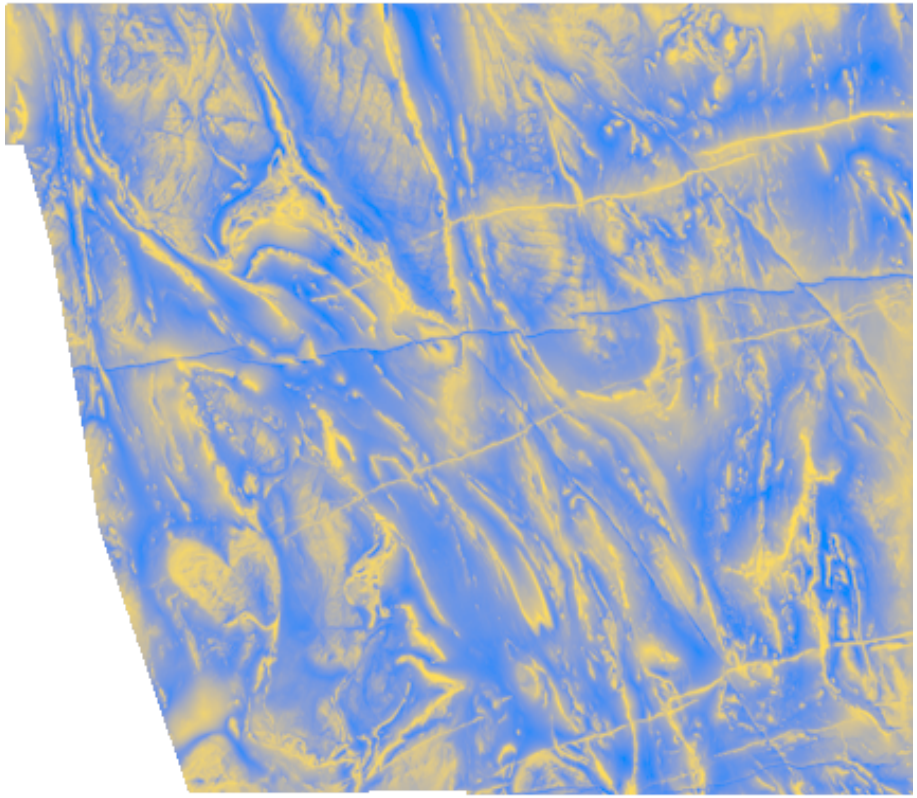


Data: Property of Fugro Airborne Surveys Pty Ltd
Processing: Phase Preserving Dynamic Range Compression

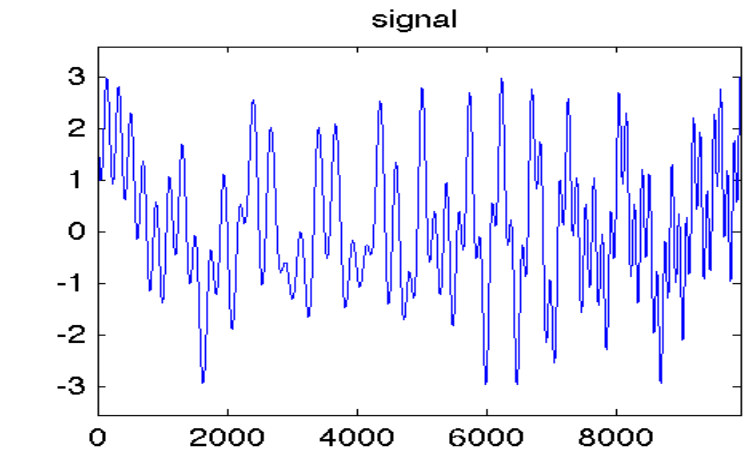








diverging maps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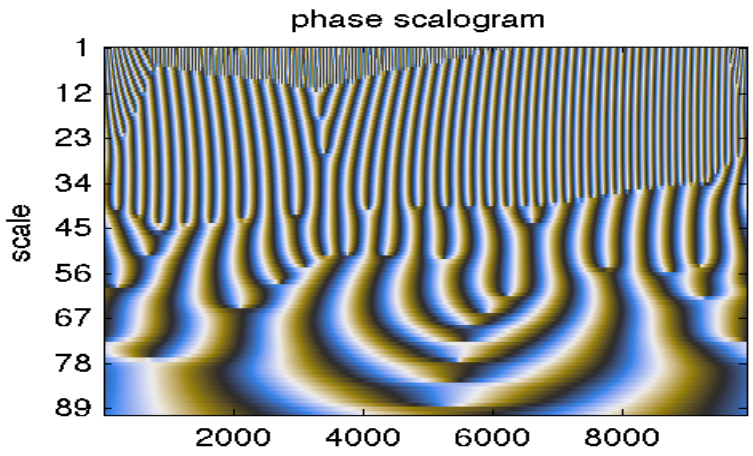
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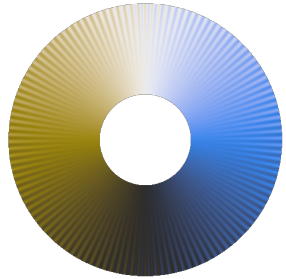

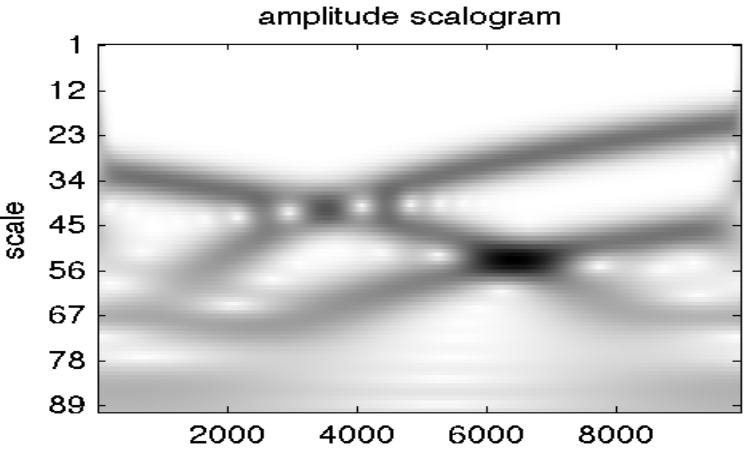
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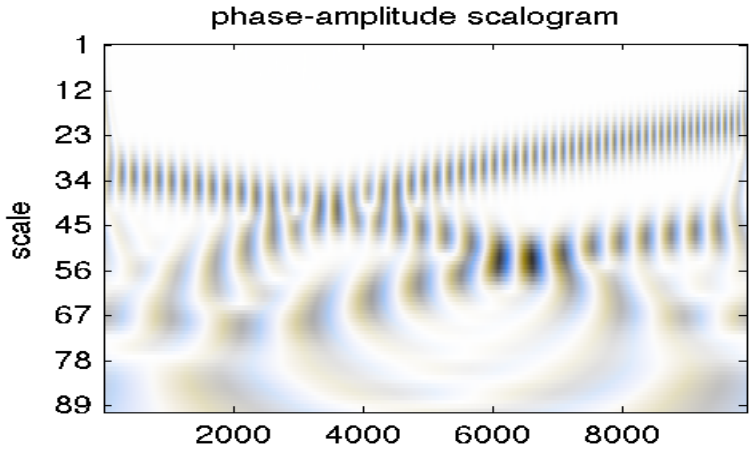
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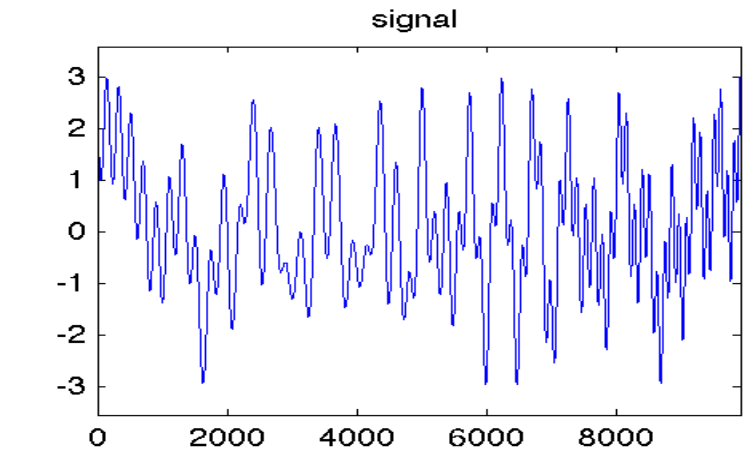
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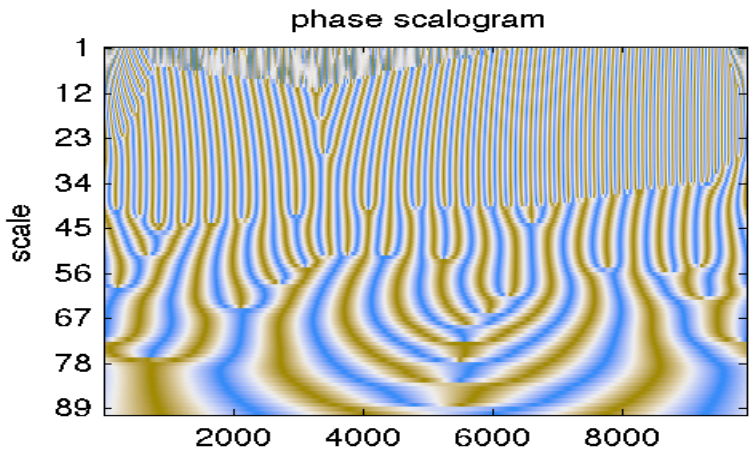
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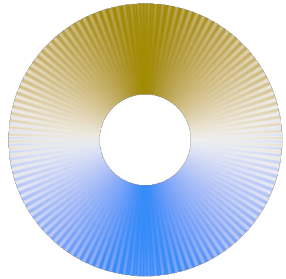

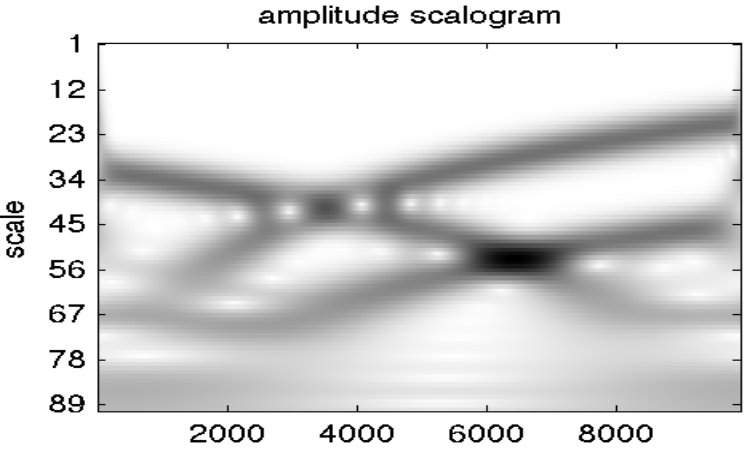
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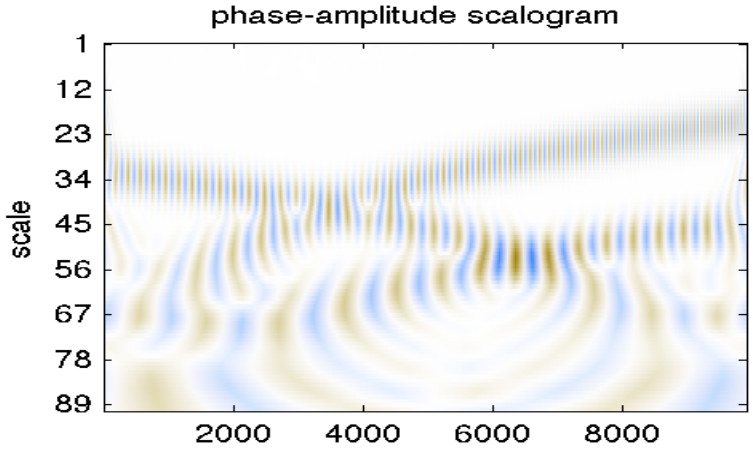
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Conclusions

The colour maps are untested, but I propose the following:

- It is best to design colour maps *within* the colour space of the colour blind, rather than test a map for colour blind 'safeness'.
- Working within the colour space of the colour blind allows everyone to share a common perceptual interpretation of the data.
- Ensures maximal use of the available colour space.
- Chroma and lightness can be properly used in the design of colour maps.

Colour maps can be downloaded from:
peterkovesi.com/projects/colourmaps