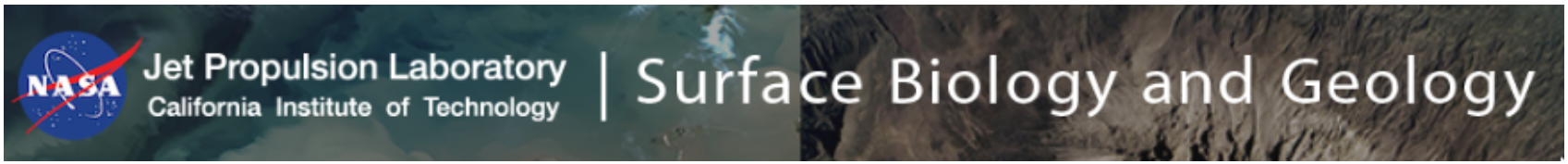
Like Mozart in the Nostromo starship: relaxing the xenomorphic nature of colors for colorblind people

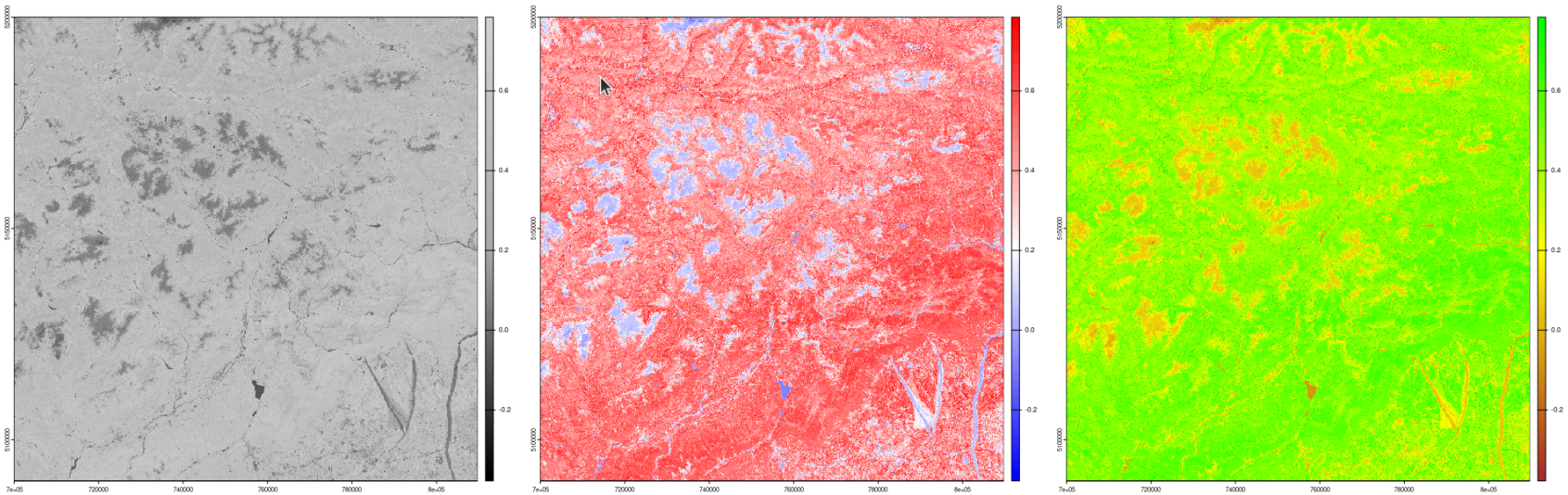
Duccio Rocchini
Alma Mater Studiorum University of Bologna
Czech University of Life Sciences

Talk held online at:



Outline

Perception of reality through colors



Aim

- Introducing the issue of **colorblindness** in remote sensing data outputs
- Proposing algorithms to **solve the issue** in a straightfoward manner

Free and Open Source Software

Trends in Ecology & Evolution

Letter

Cell PRESS

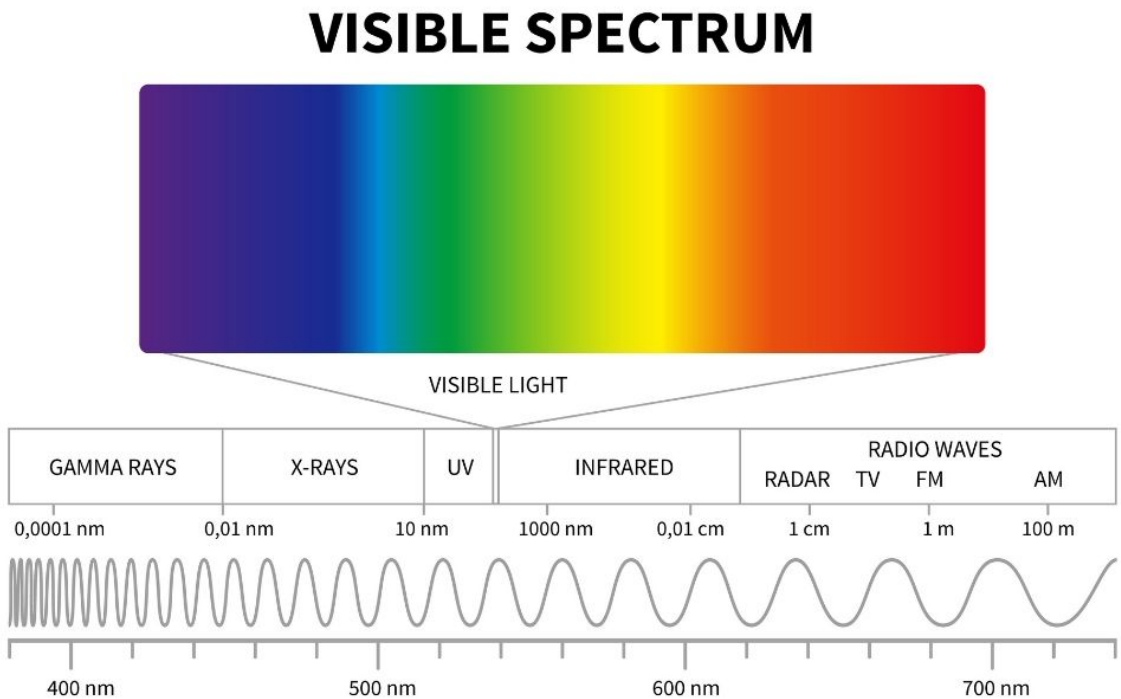
Let the four freedoms paradigm apply to ecology

Duccio Rocchini and Markus Neteler

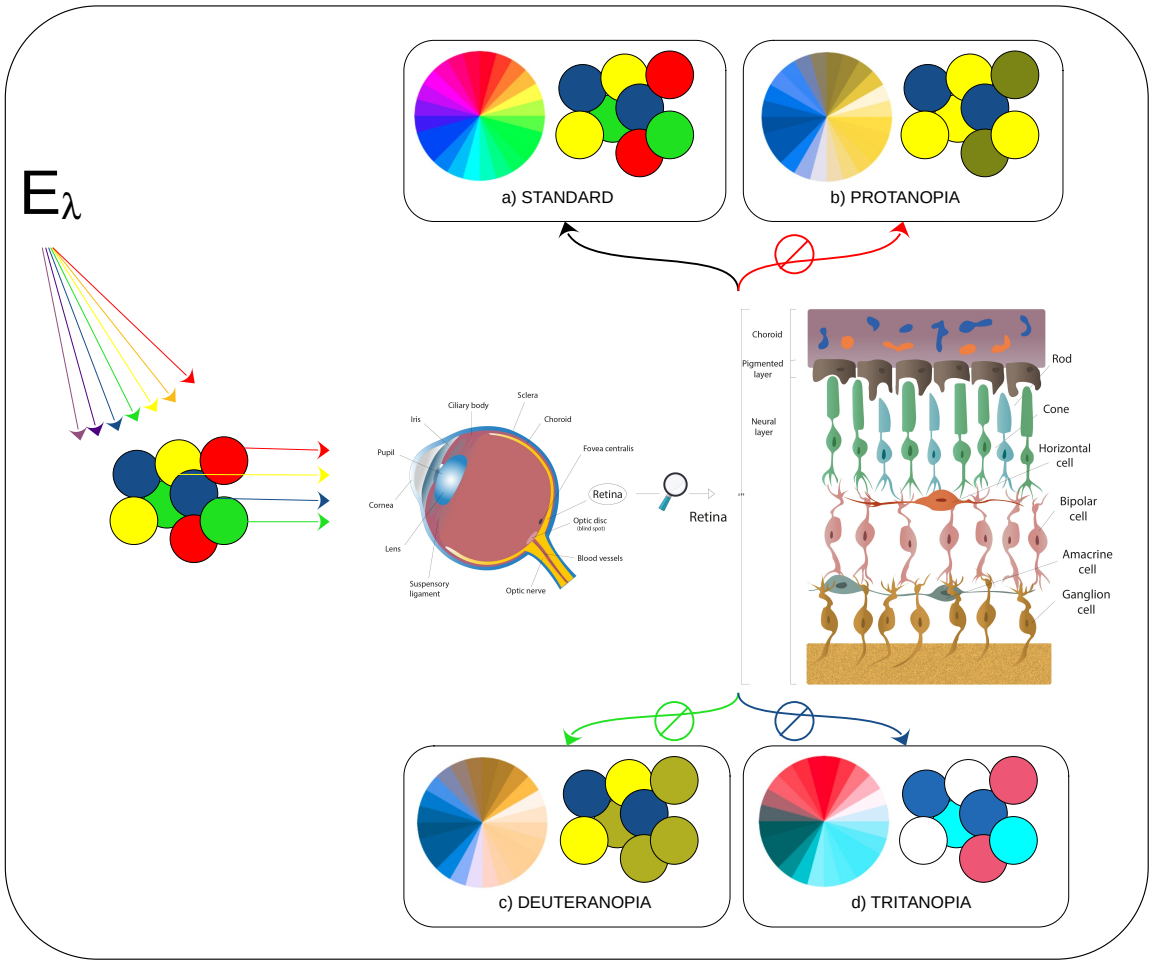
Fondazione Edmund Mach, Research and Innovation Centre, Department of Biodiversity and Molecular Ecology, Via E. Mach 1, 38010 S. Michele all'Adige (TN), Italy

In our view, the explicit use of Free and Open Source Software (FOSS) with **availability of the code** is essential for **completely open science**: 'scientific communication relies on evidence that cannot be entirely included in publications', but '**anything less than the release of source programs is intolerable for results that depend on computation**' [3].

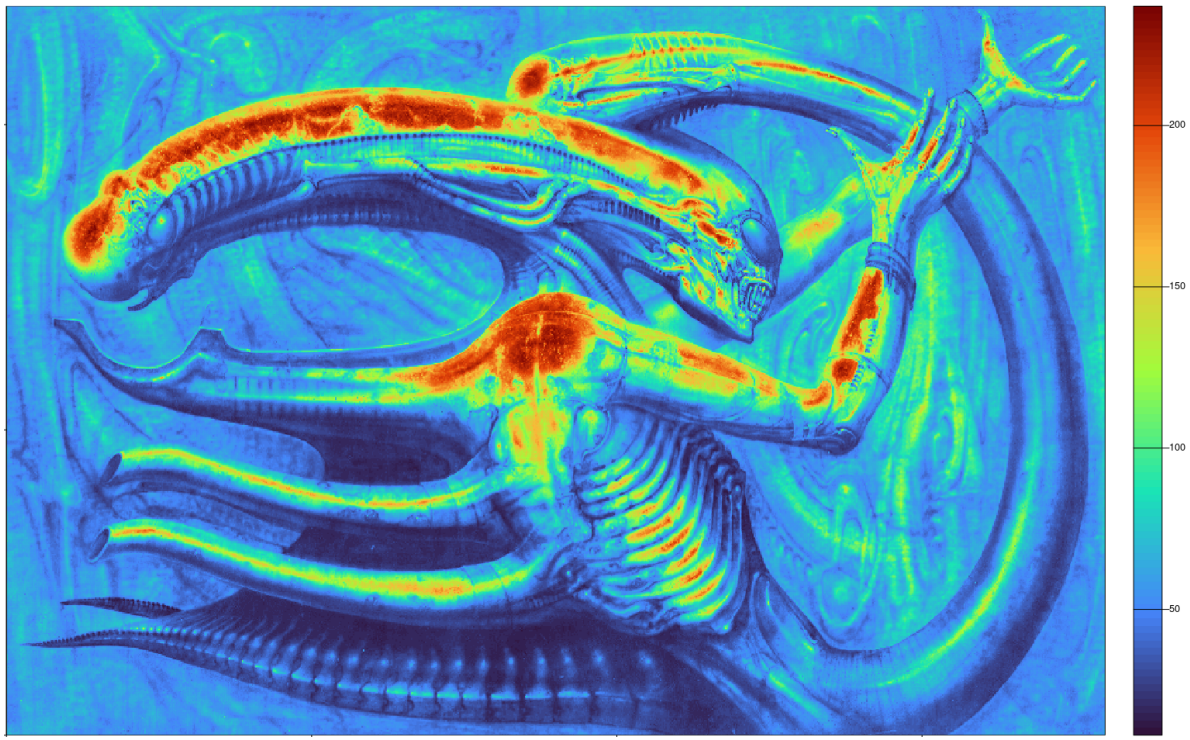
Colors in the electromagnetic spectrum



Daltonism

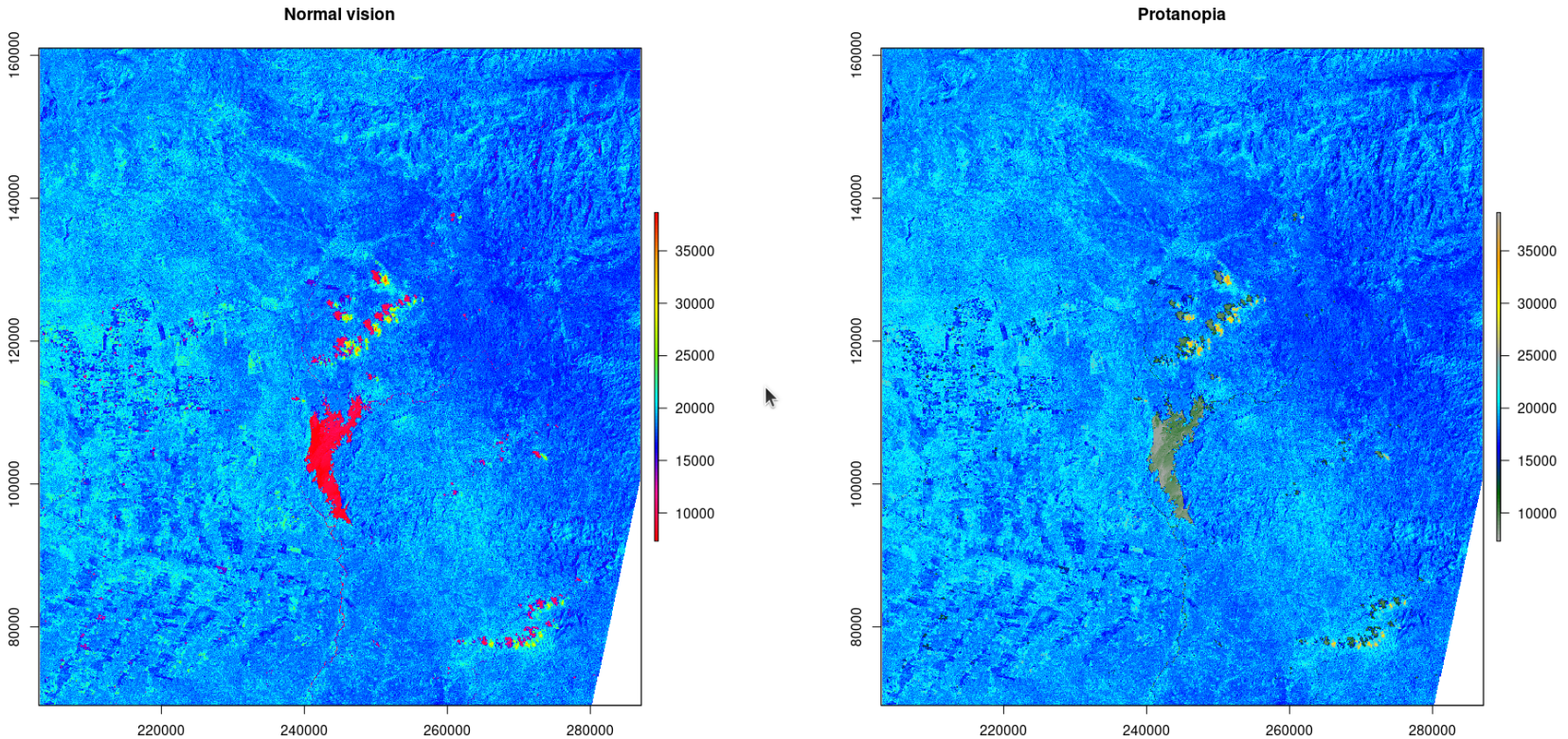

E_λ
a) STANDARD
b) PROTANOPIA
c) DEUTERANOPIA
d) TRITANOPIA
Retina
Choroid
Pigmented layer
Neural layer
Rod
Cone
Horizontal cell
Bipolar cell
Amacrine cell
Ganglion cell
Sclera
Ciliary body
Iris
Choroid
Pupil
Fovea centralis
Cornea
Retina
Optic disc
(blind spot)
Lens
Blood vessels
Suspensory ligament
Optic nerve

Colors for colorblind people can lead to an “alien” perception of reality

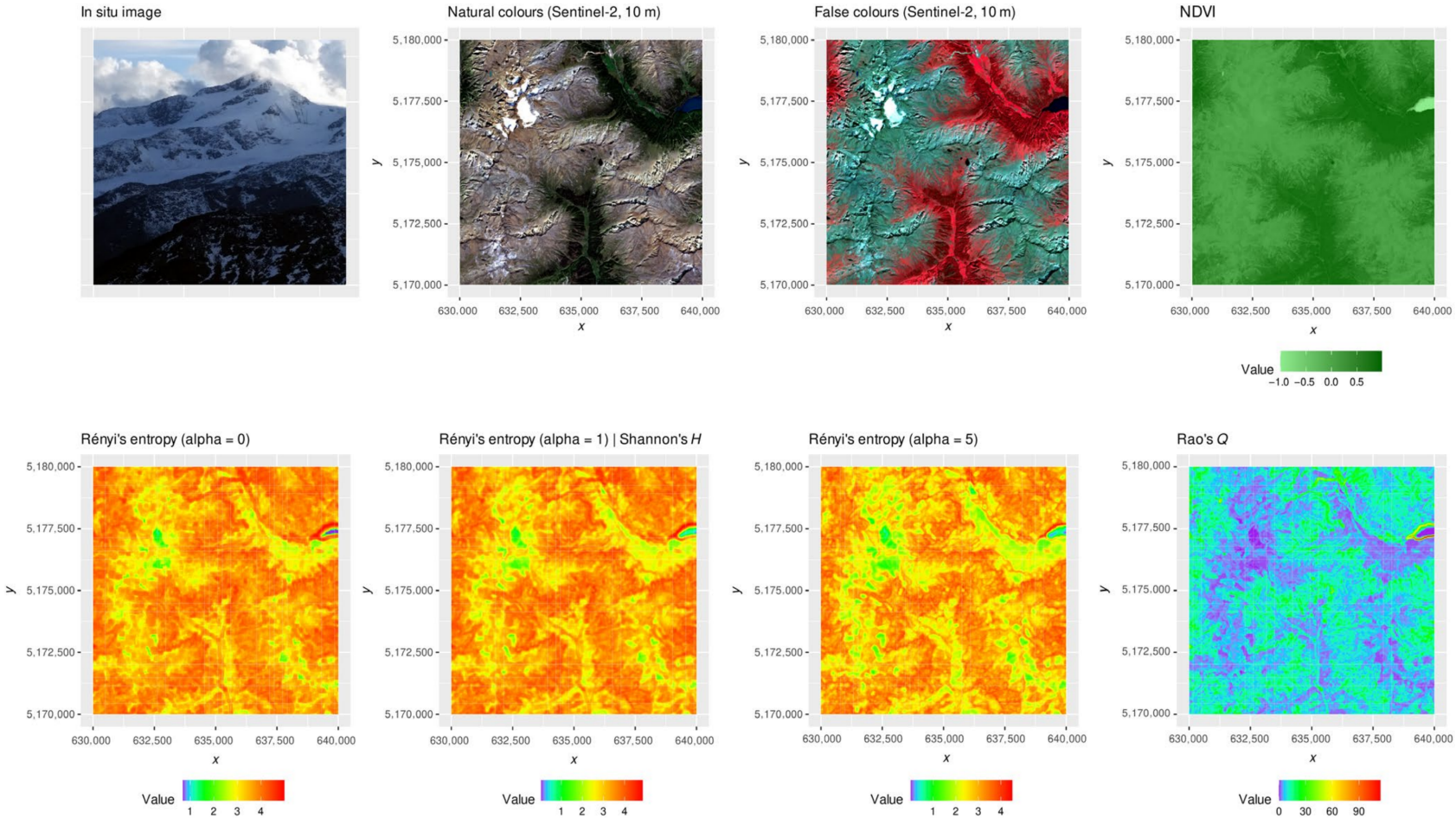


Redrawn from: Hans Ruedi Giger, Necronom IV, 1976.

Rainbow color palettes in scientific papers



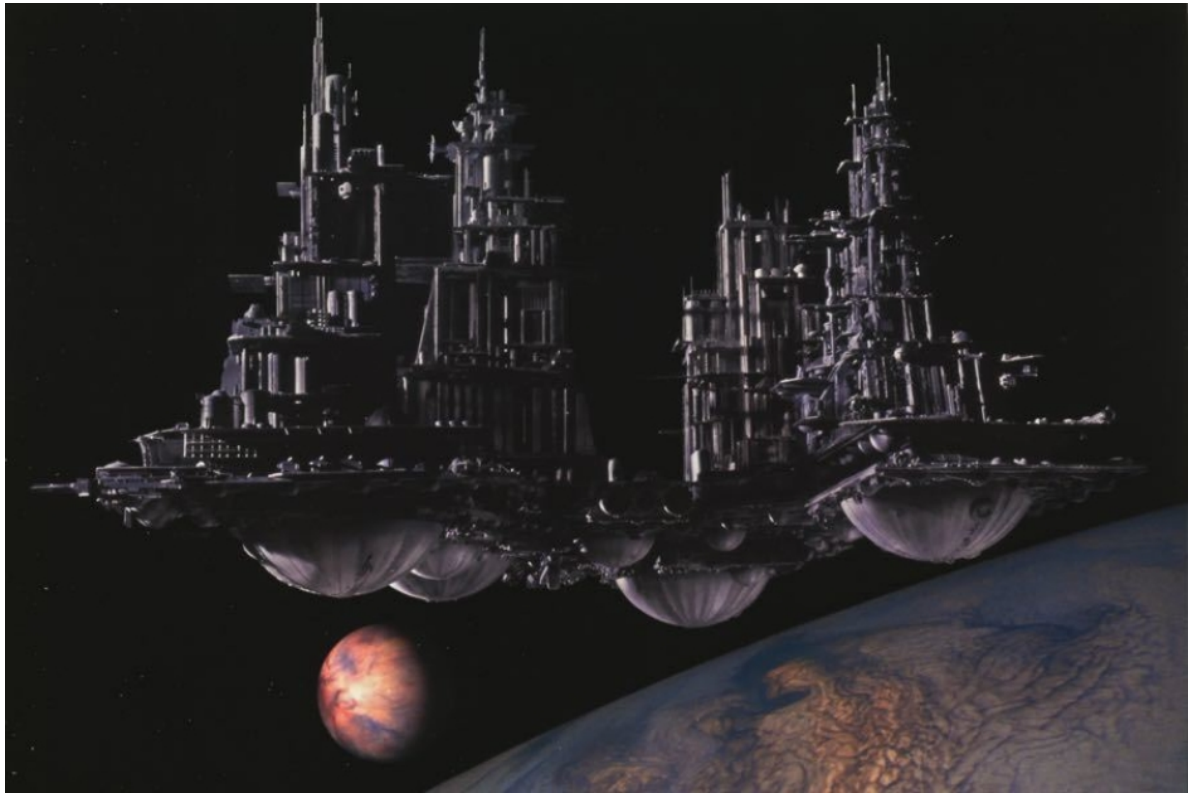
Rainbow color palettes in scientific papers



Rocchini et al. (Methods Ecol. Evol., 2023)

Outline

Like Mozart in the Nostromo starship



https://www.youtube.com/watch?v=oy2zDJPIgwc

Wolfgang Amadeus Mozart (1756-1791) - Eine Kleine Nachtmusik

Cramieri et al. - Misuse of colors

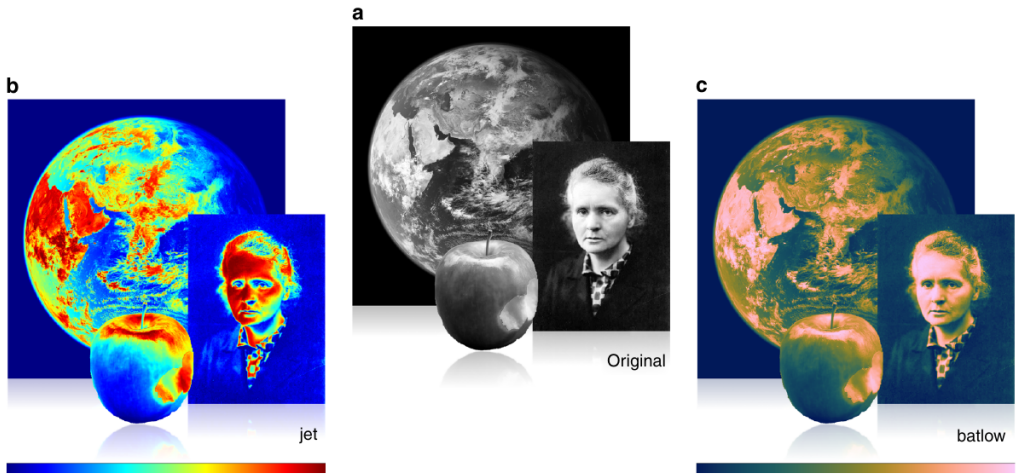
nature COMMUNICATIONS

PERSPECTIVE

https://doi.org/10.1038/s41467-020-19160-7 OPEN

The misuse of colour in science communication

Fabio Crameri[1✉], Grace E. Shephard[1] & Philip J. Heron[2]



The viridis R package

https://CRAN.R-project.org/package=viridis

The `viridis` R package

`https://CRAN.R-project.org/package=viridis`

Color blindness

Duccio Rocchini @ducciorocchini · 13 apr 2023

A new package to let colour blind people see all maps!

Available in GitHub: github.com/ducciorocchini...

Install it by: install.packages("devtools")
devtools::install_github("ducciorocchini/cblindplot")
And here is the description: doi.org/10.1016/j.ecoi...

Contents lists available at ScienceDirect

Ecological Informatics

journal homepage: www.elsevier.com/locate/ecolinf

ELSEVIER

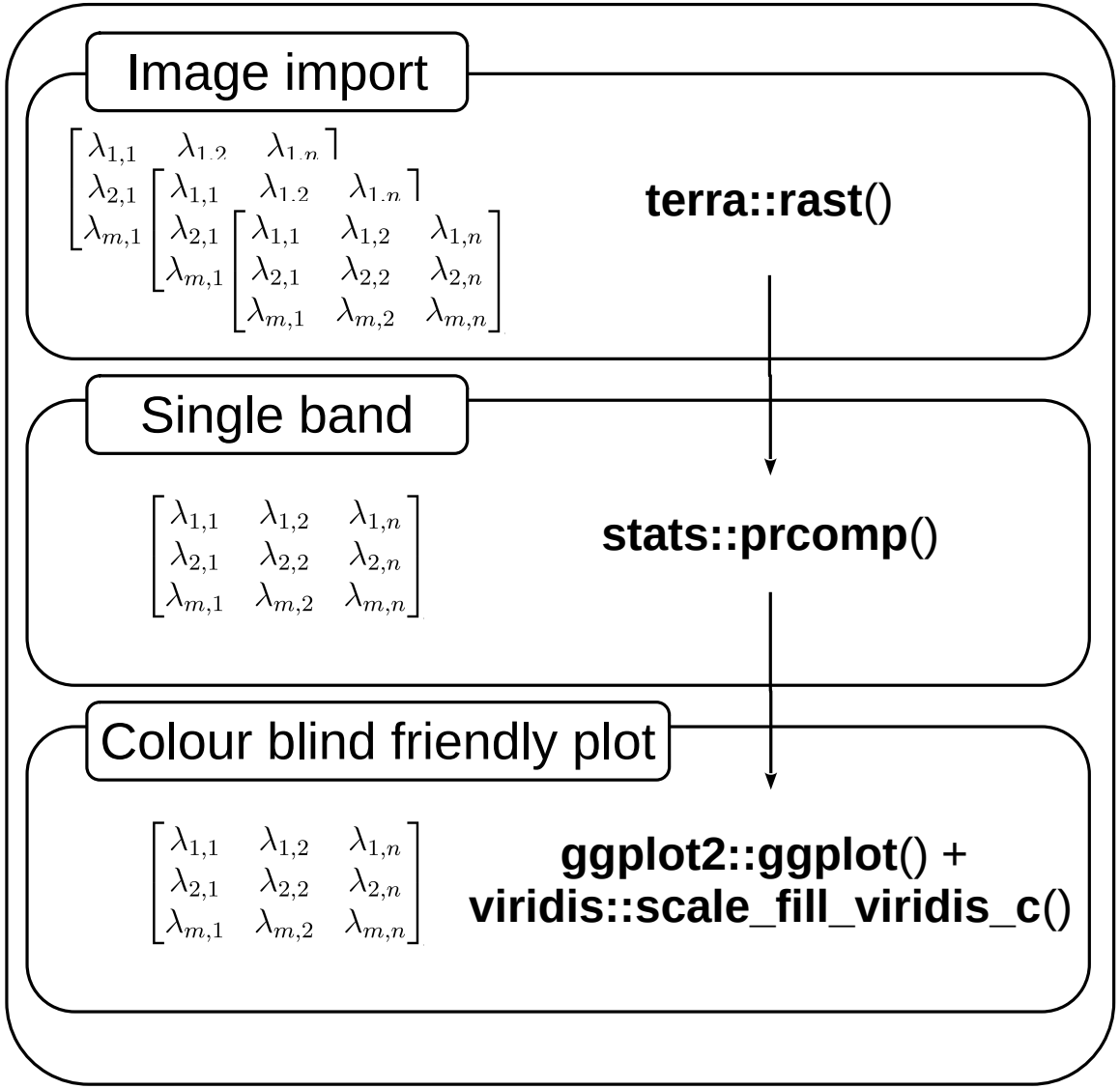
Scientific maps should reach everyone: The `cblindplot` R package to let colour blind people visualise spatial patterns

Duccio Rocchini [a,b,*,1], Jakub Nowosad [c,1], Rossella D'Introno [d], Ludovico Chieffallo [a], Giovanni Bacaro [e], Roberto Cazzolla Gatti [a], Giles M. Foody [f], Reinhard Furrer [g,h], Lukáš Gábor [i,j], Marco Malavasi [b,k], Matteo Marcantonio [l], Elisa Marchetto [a], Vítězslav Moudrý [b], Carlo Ricotta [m], Petra Šímová [b], Michele Torresani [n], Elisa Thouverai [a]

7 346 908 68.916

`https://github.com/ducciorocchini/cblindplot`

The algorithm



The cblind.plot() function

```
cblind.plot <- function(im,
                cvd=c("protanopia", "deuteranopia", "tritanopia"),
                r=1, g=2, b=3,
                crop_manual=FALSE,
                selectclass=FALSE)
```

What do colorblind people see?

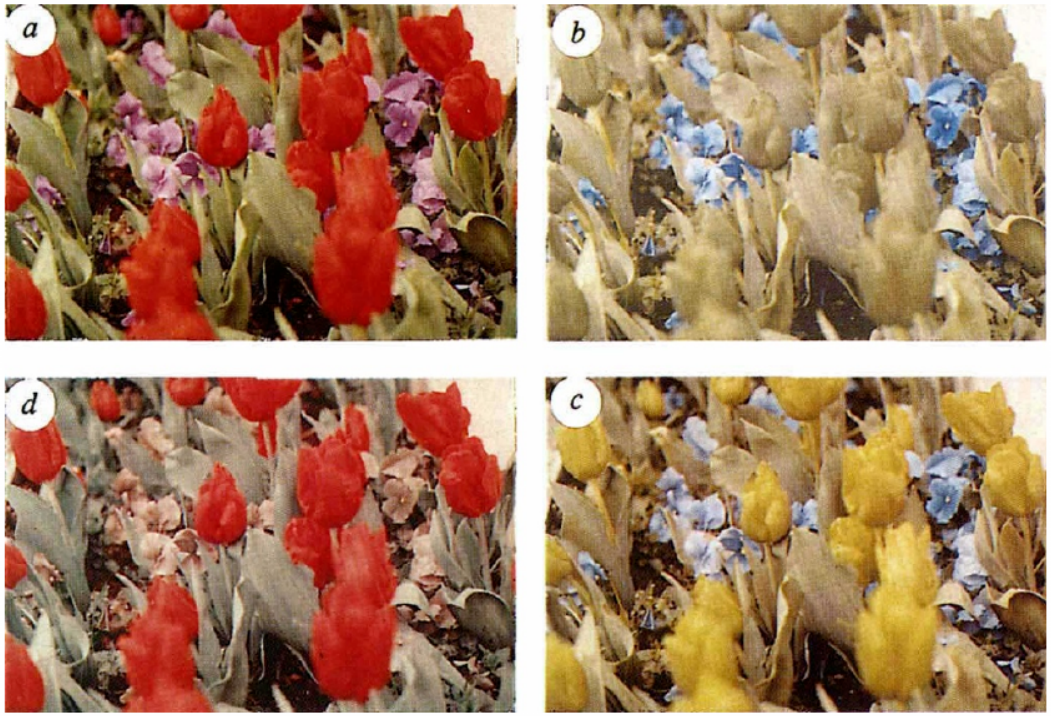
cryospheric components, including snow cover, permafrost and ice sheets, together with temperature data, to help detect the fingerprints[9] of greenhouse global warming.

Ola M. Johannessen*
Martin Miles
Einar Bjørgo
Nansen Environmental and Remote Sensing Center,
Edvard Griegsvei 3a,
5037 Solheimsvik/Bergen, Norway

*Also at Geophysical Institute, University of Bergen, 5007 Bergen, Norway.

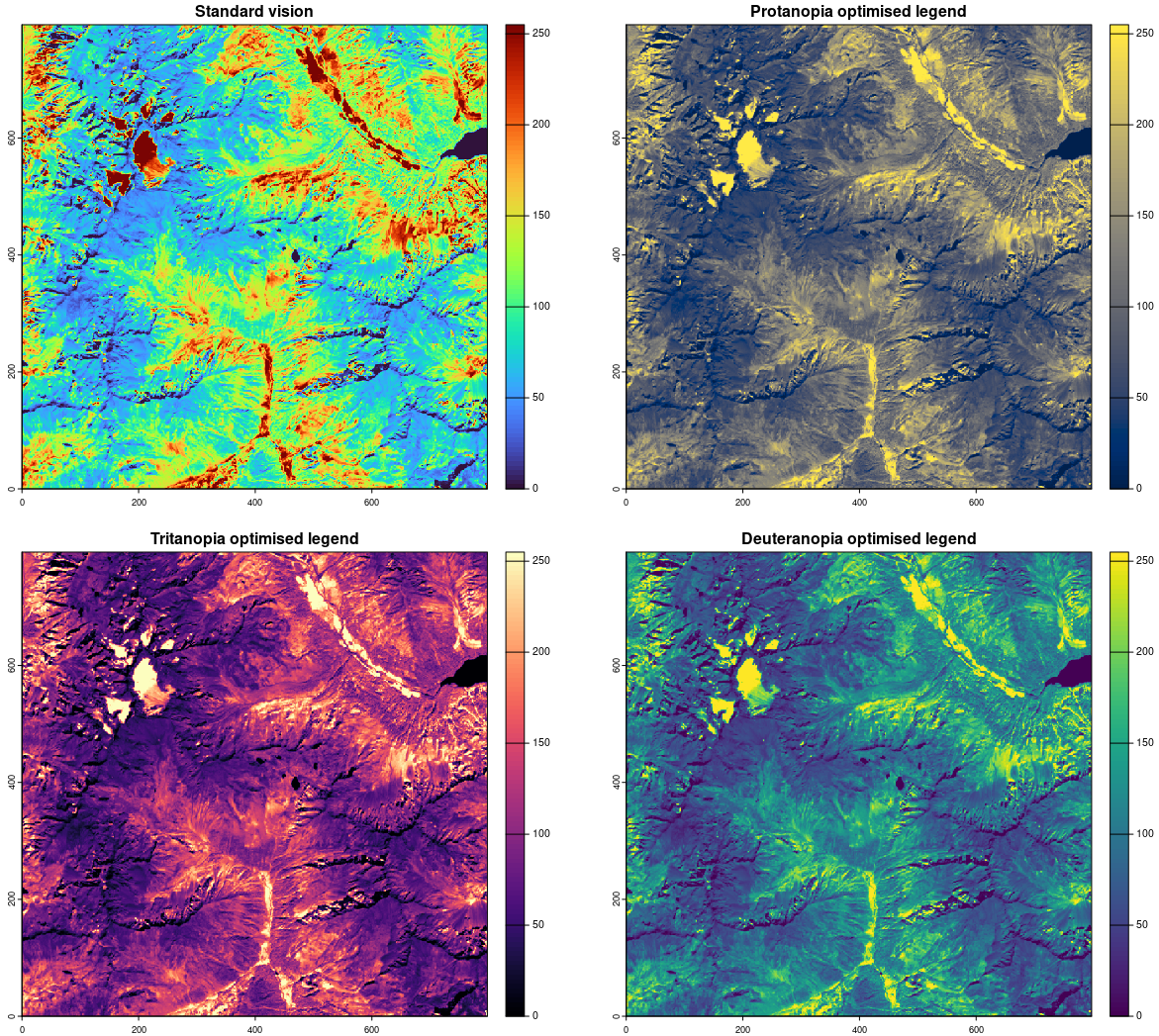
What do colour-blind people see?

SIR — Most human observers enjoy trichromatic vision: a three-dimensional colour space represents all the light that they can discriminate[1]. Two per cent of the male population are dichromats, that is, they lack one class of photopigment and have a colour gamut that can be represented in a two-dimensional space. Here we offer to the normal trichromat a



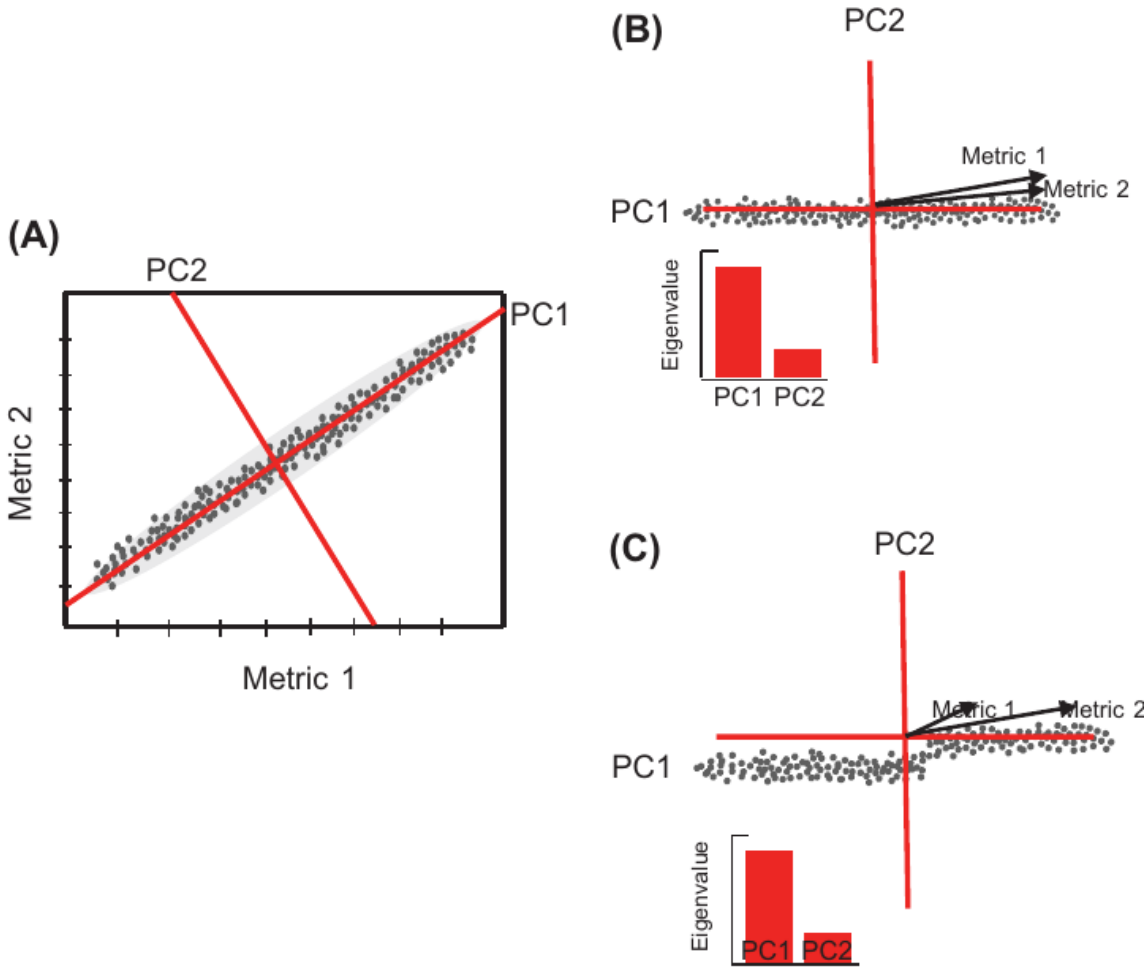
Reproduction of the video monitor display that simulates the reduced colour gamut of dichromatic colour-defective observers. *a*, Photograph of the 'Jardin des Plantes' (photo: Jean Le Rohellec; Grande Galerie, FNAC). The contrast was reduced to allow for all three projections onto the reduced stimuli surfaces to exist. *b*, *c*, *d*, Simulations of how *a* is seen by a protanope, deuteranope and tritanope, respectively. (A colorimetrically exact reproduction of the video display cannot be guaranteed in the printed version.)

The output


Standard vision
Protanopia optimised legend
Tritanopia optimised legend
Deuteranopia optimised legend
0
200
400
600
0
50
100
150
200
250

Outline

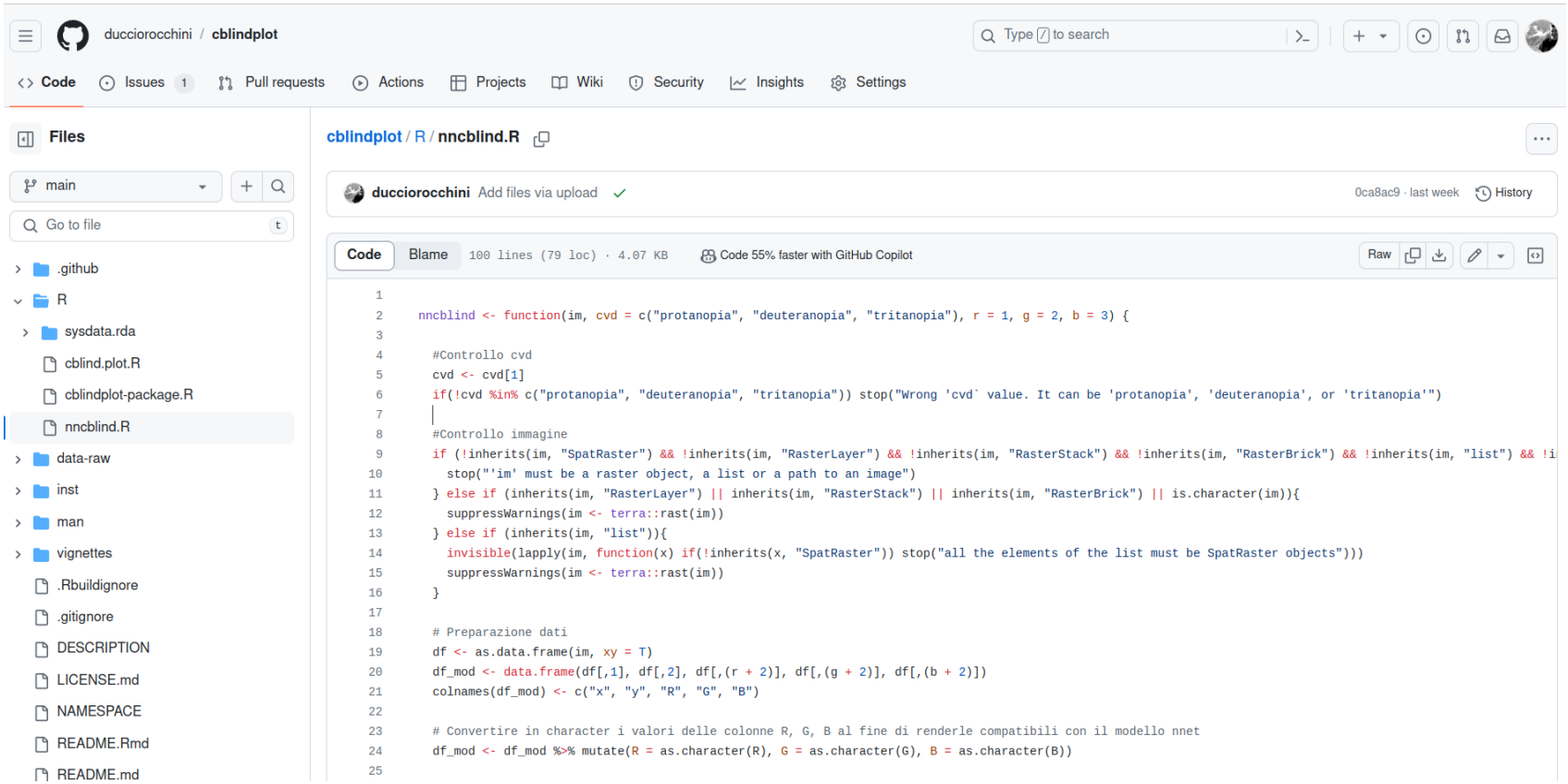
PCA problems in managing minima and maxima



Nakamura et al. (Ecography, 2020)

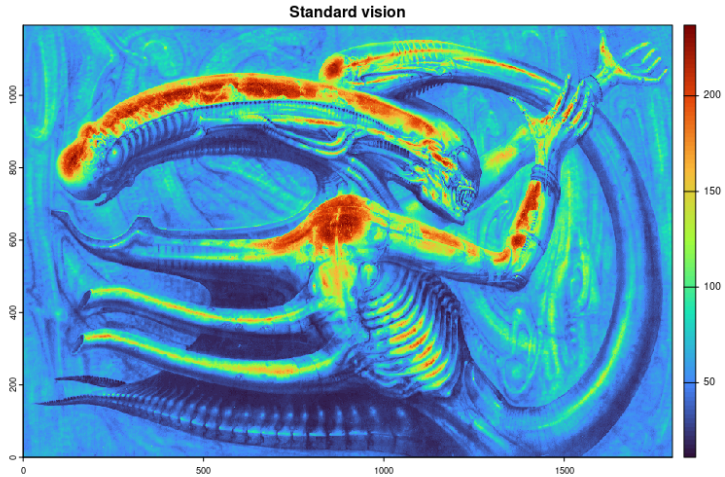
Neural networks

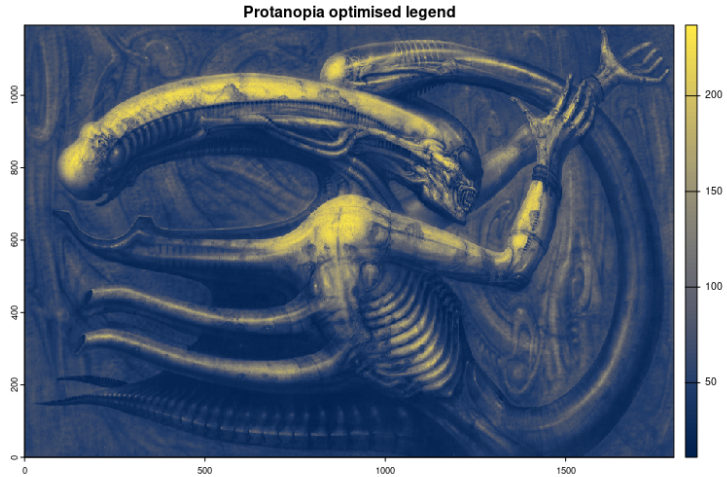
The `nncblind` neural networks algorithm

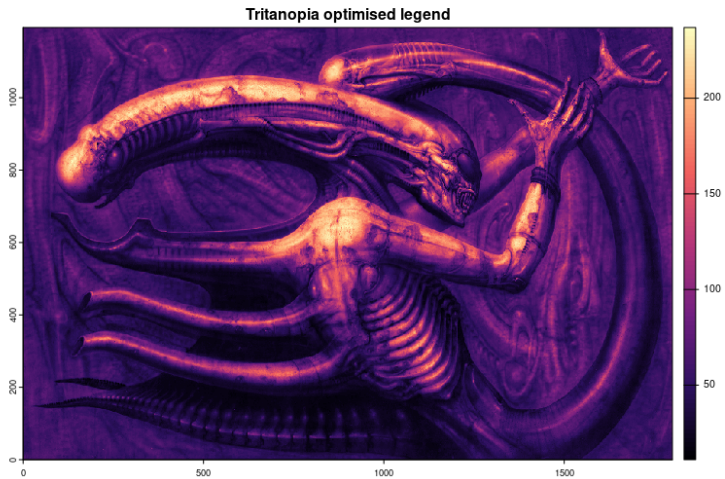


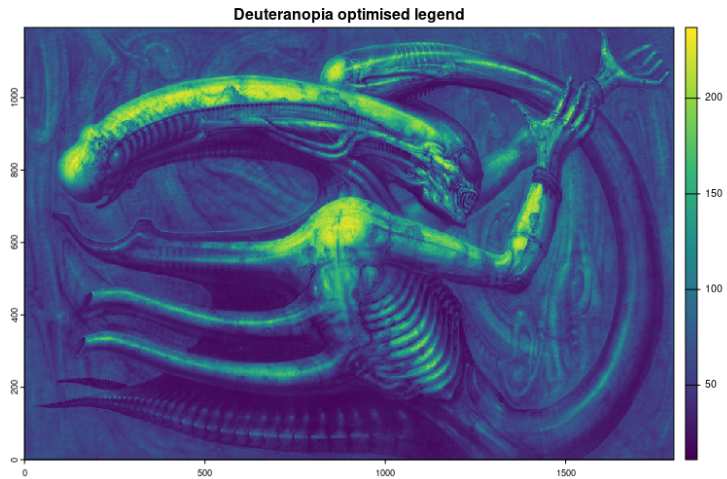
https://github.com/ducciorocchini/cblindplot/blob/main/R/nncblind.R

Coda


Standard vision
0
500
1000
1500
200
400
600
800
1000
50
100
150
200


Protanopia optimised legend
0
500
1000
1500
200
400
600
800
1000
50
100
150
200


Tritanopia optimised legend
0
500
1000
1500
200
400
600
800
1000
50
100
150
200


Deuteranopia optimised legend
0
500
1000
1500
200
400
600
800
1000
50
100
150
200

Coda

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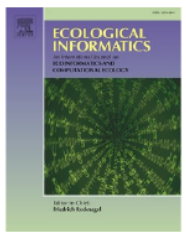

Check for updates

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Many thanks!

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Contact:
Duccio Rocchini, PhD - Full Professor @:
BIOME Lab, Dept. Biological, Geological and Enviromental Sciences,
Alma Mater Studiorum University of Bologna, Italy
duccio.rocchini@unibo.it - https://www.unibo.it/sitoweb/duccio.rocchini/en

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