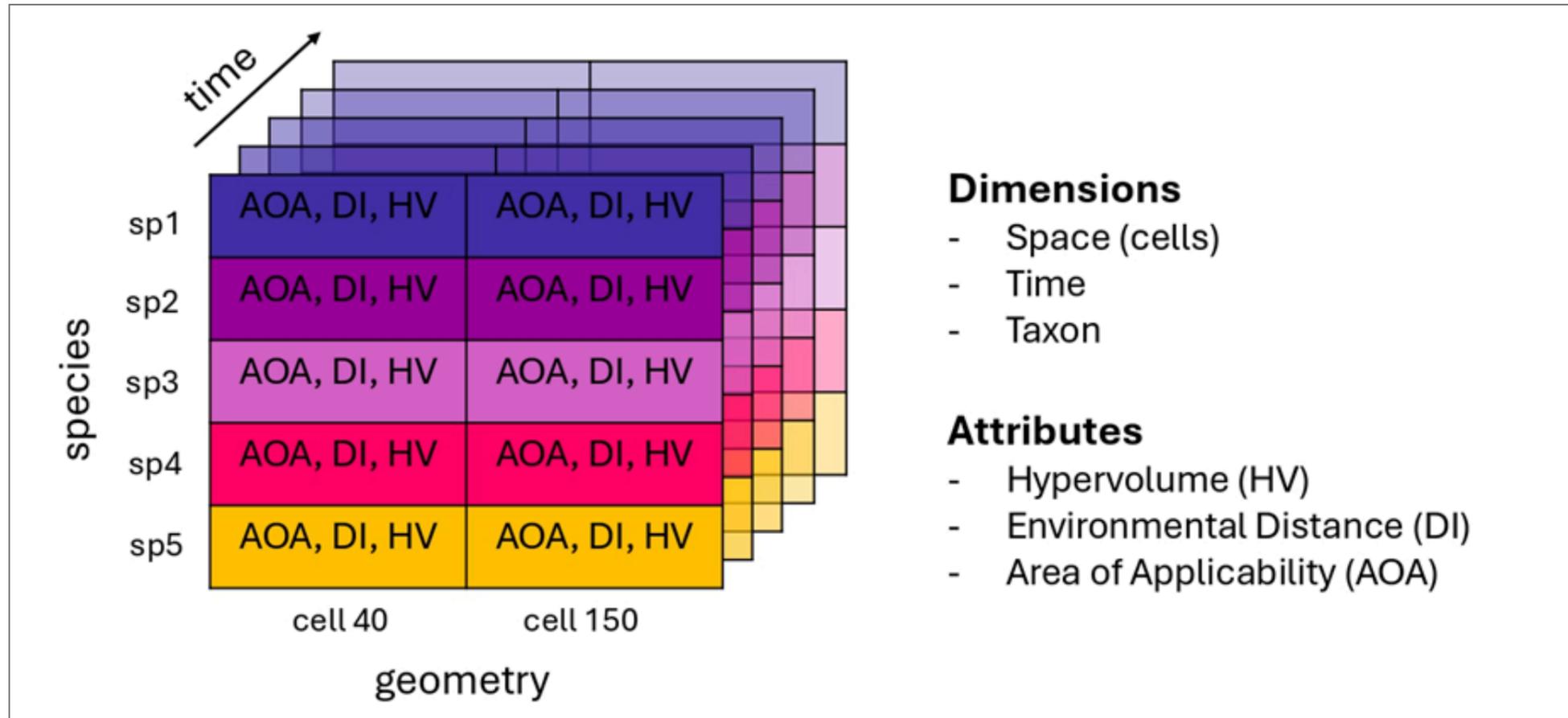


From Data Cubes to Inclusive Views: Color-Blind-Friendly Ecological Mapping

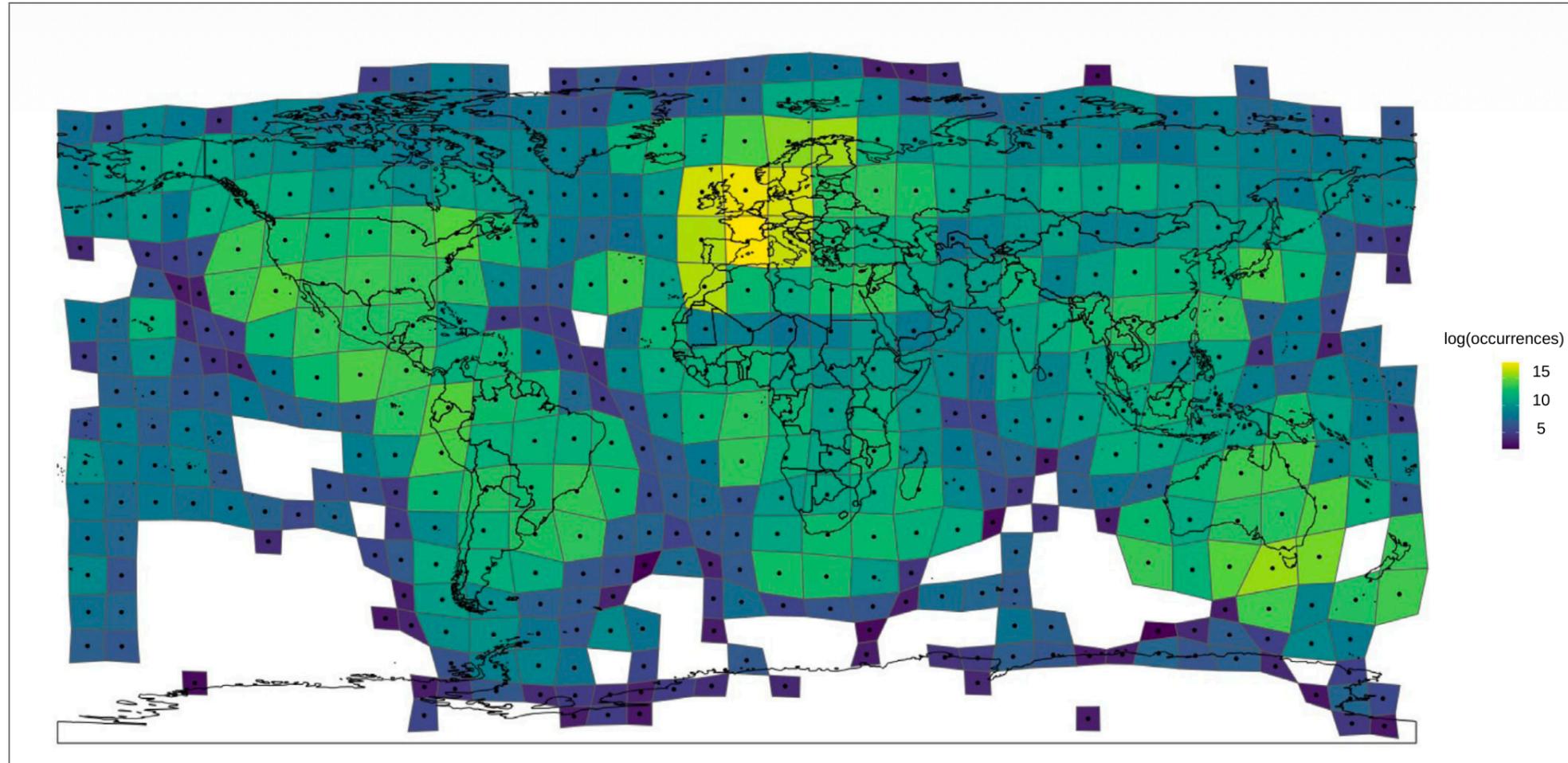
Duccio Rocchini

Cubes in B3

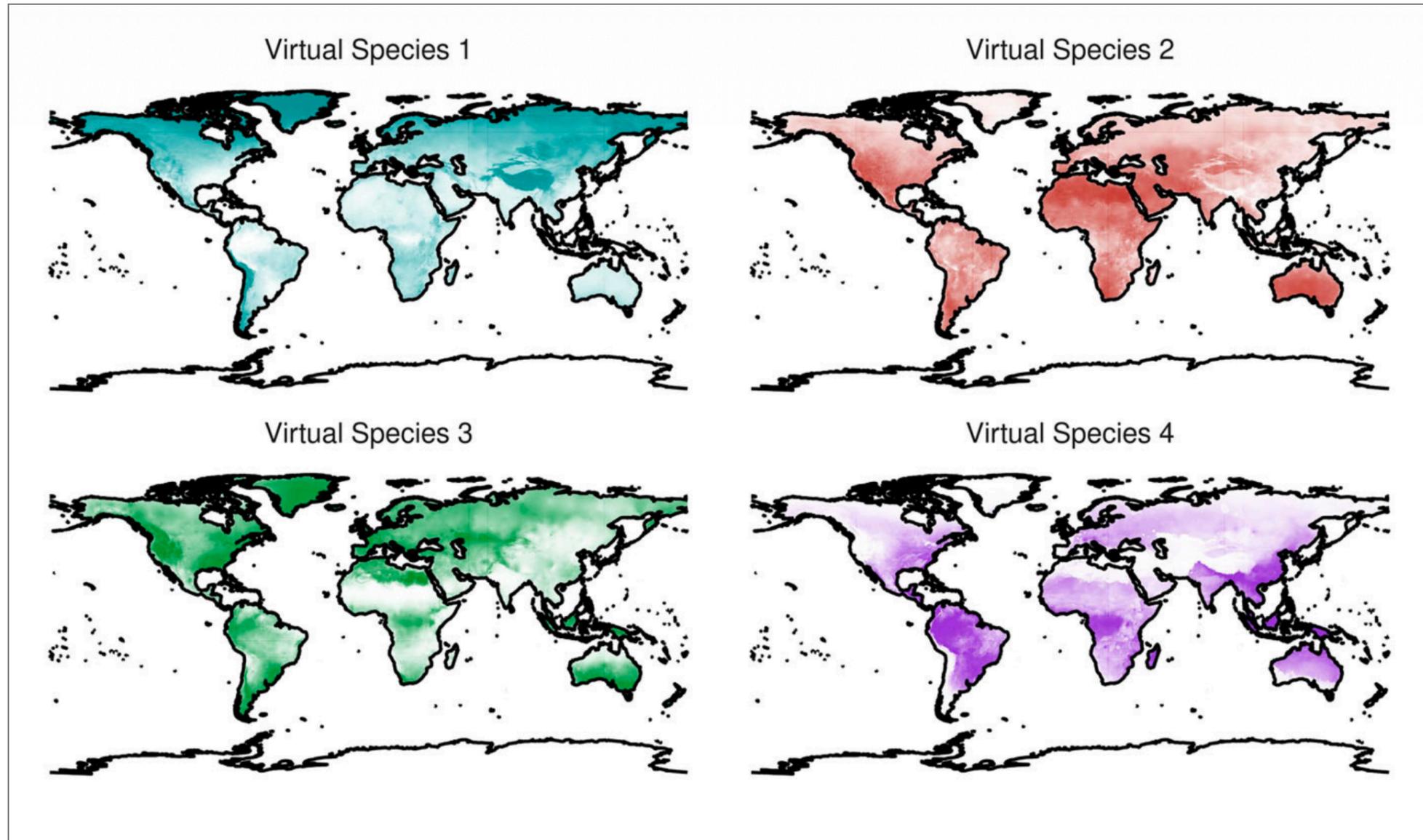
Data cubes



Sampling

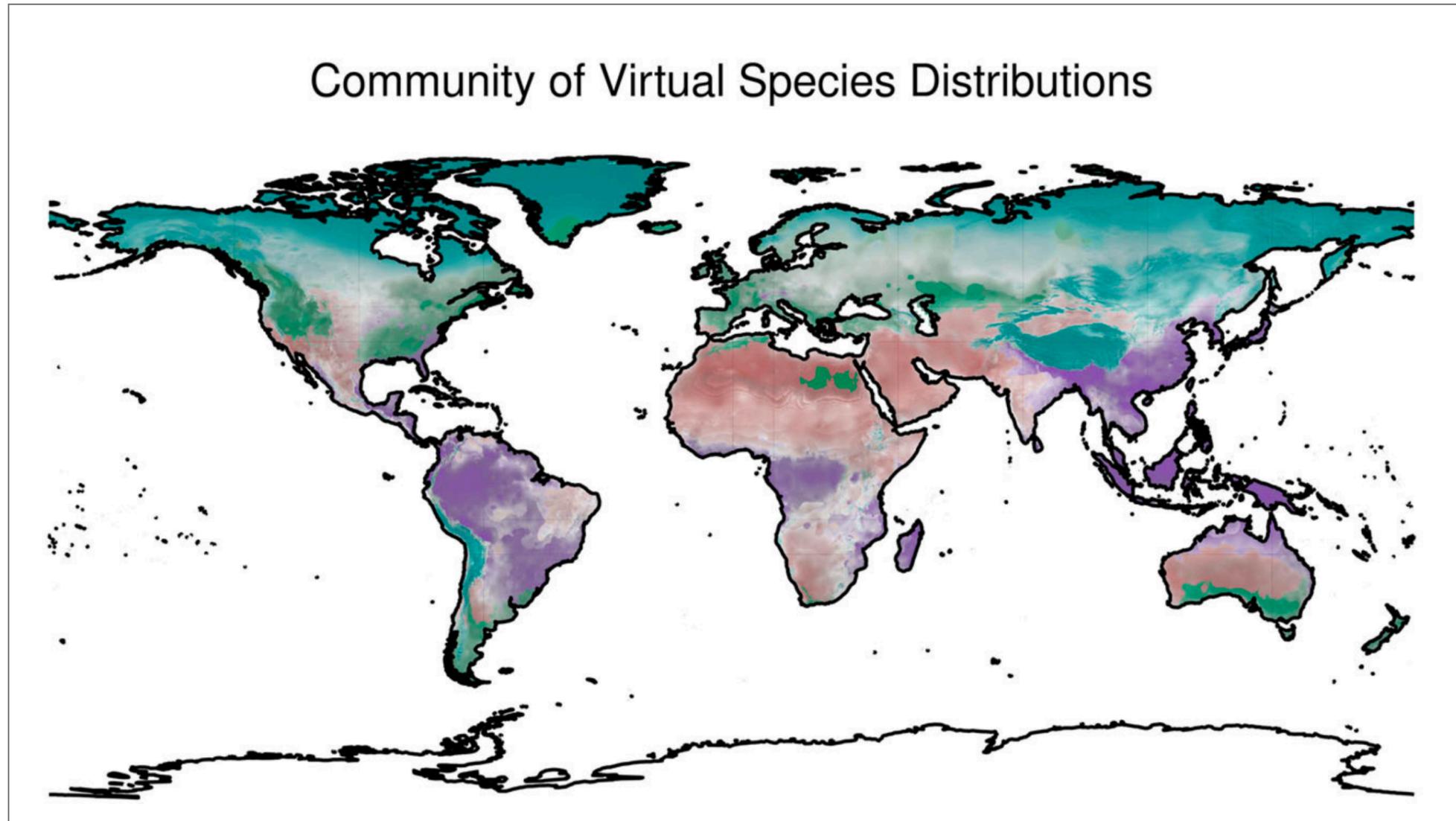


Maps of species distributions



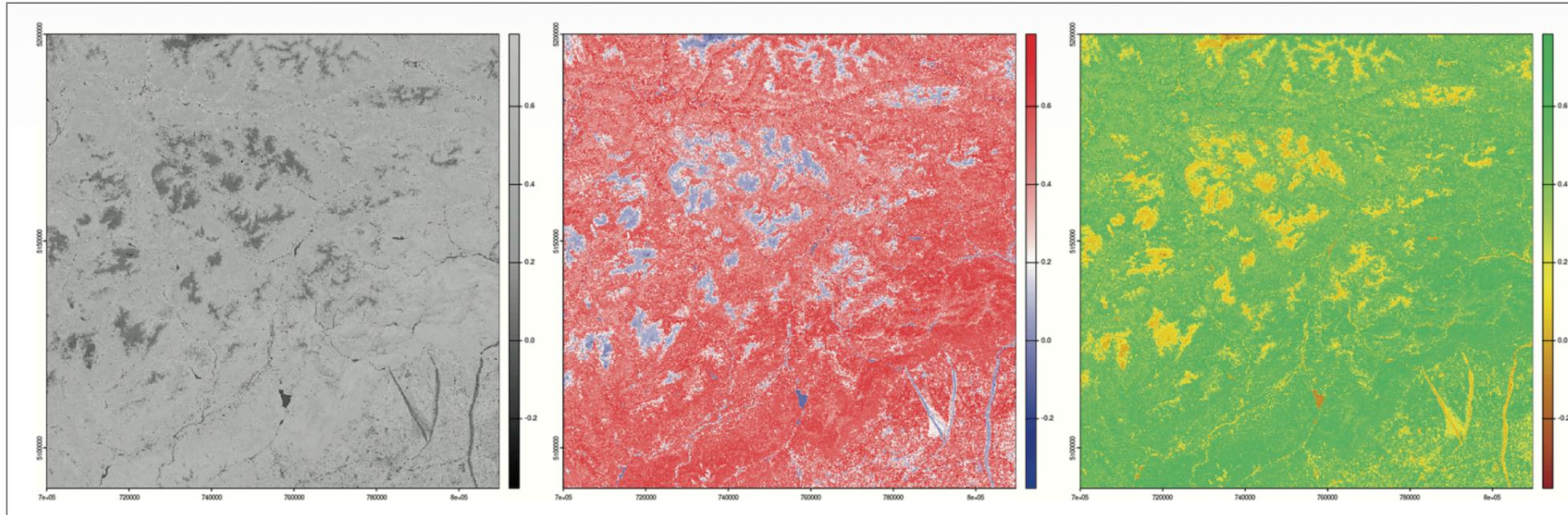
Rocchini et al. (2023). A quixotic view of spatial bias in modelling the distribution of species and their diversity. *npj Biodiversity*, 2: article number 10.

Community maps



Background: the issue

Perception of reality through colors



Aim

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

Free and Open Source Software

Trends in
Ecology & Evolution

Letter

Cell
PRESS

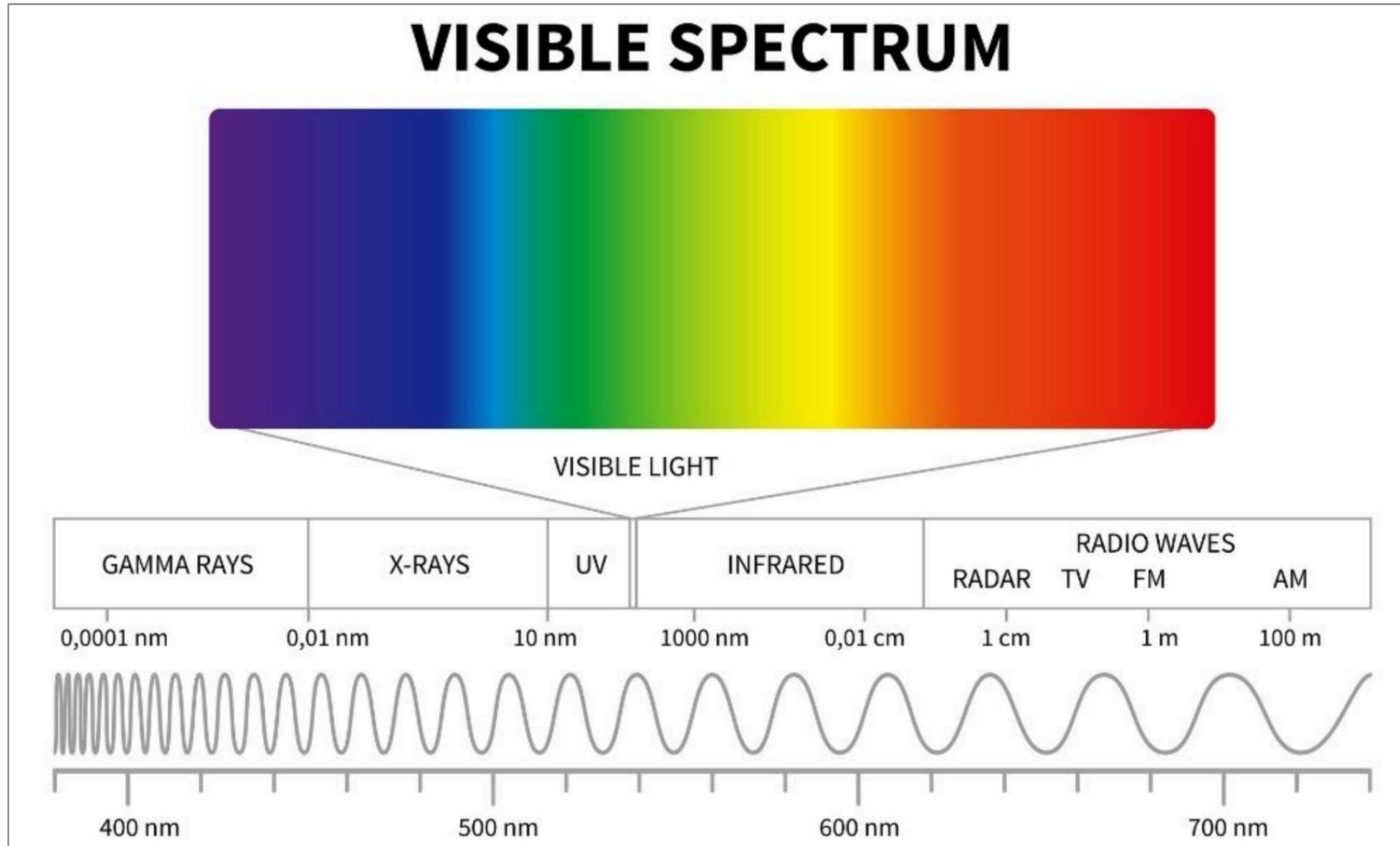
Let the four freedoms paradigm apply to ecology

Duccio Rocchini and Markus Neteler

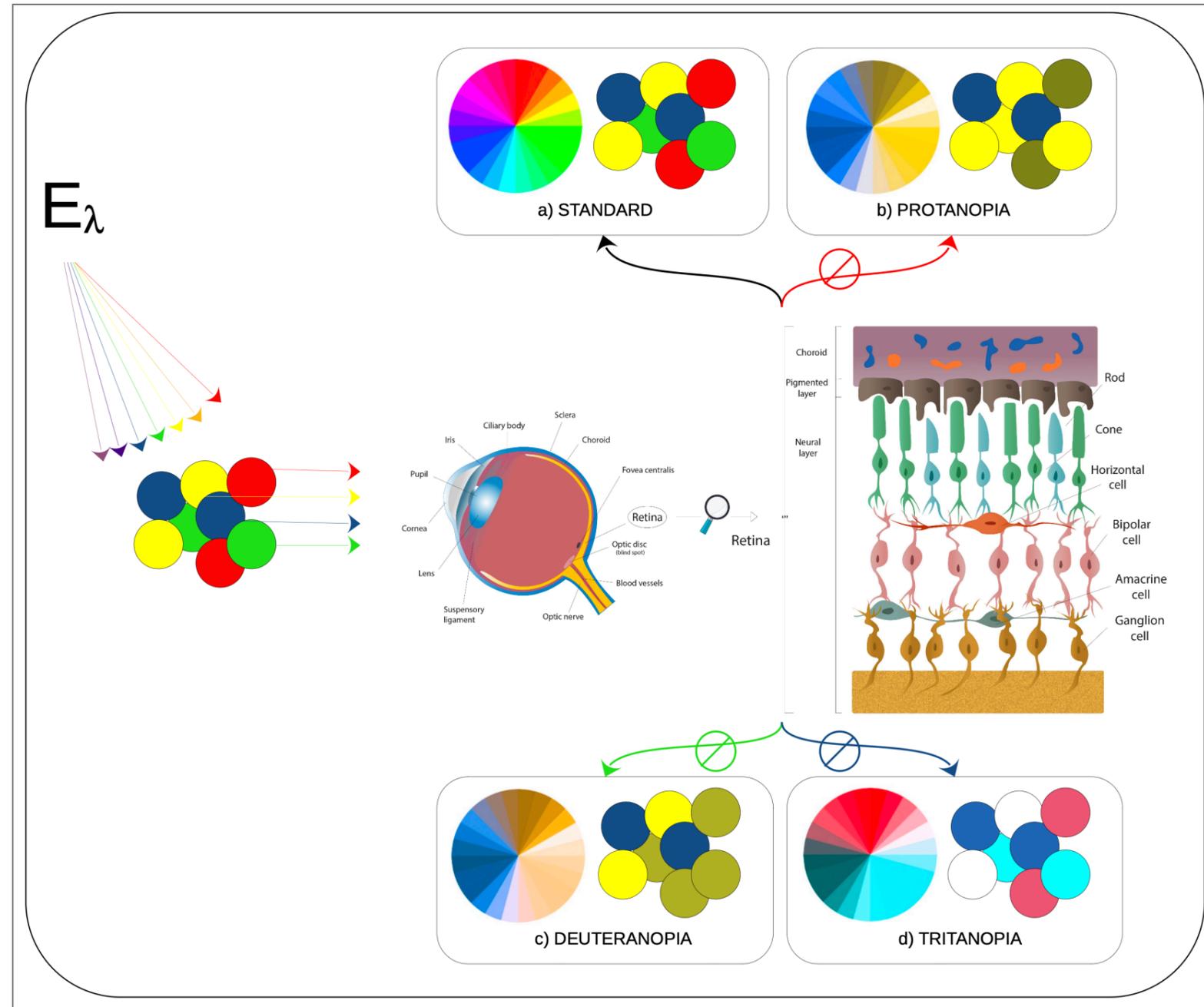
Fondazione Edmund Mach, Research and Innovation Centre, Department of Biodiversity and Molecular Ecology, Via E. Mach 1, 38010 S. Michele all'Adige (TN), Italy

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].

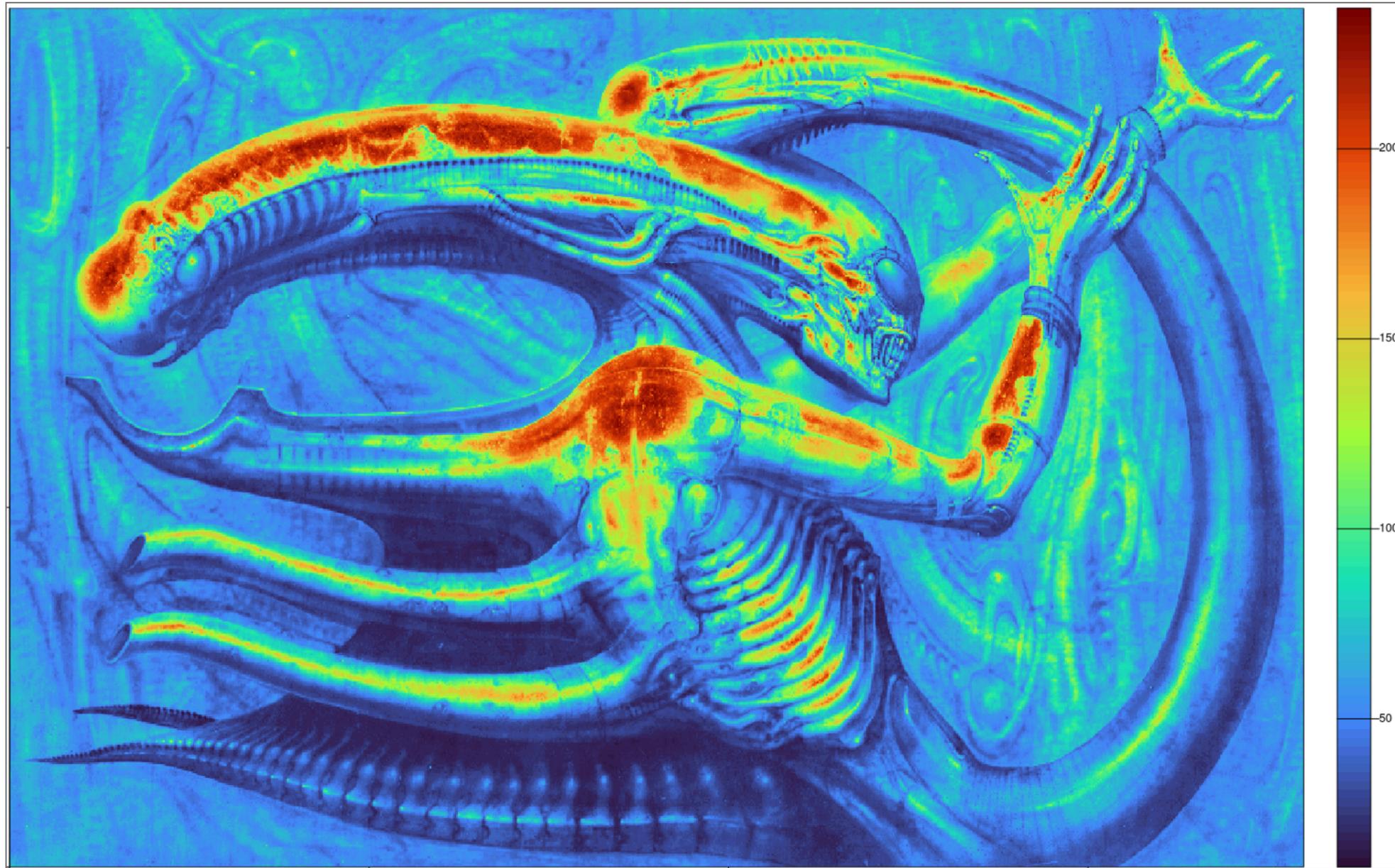
Colors in the electromagnetic spectrum



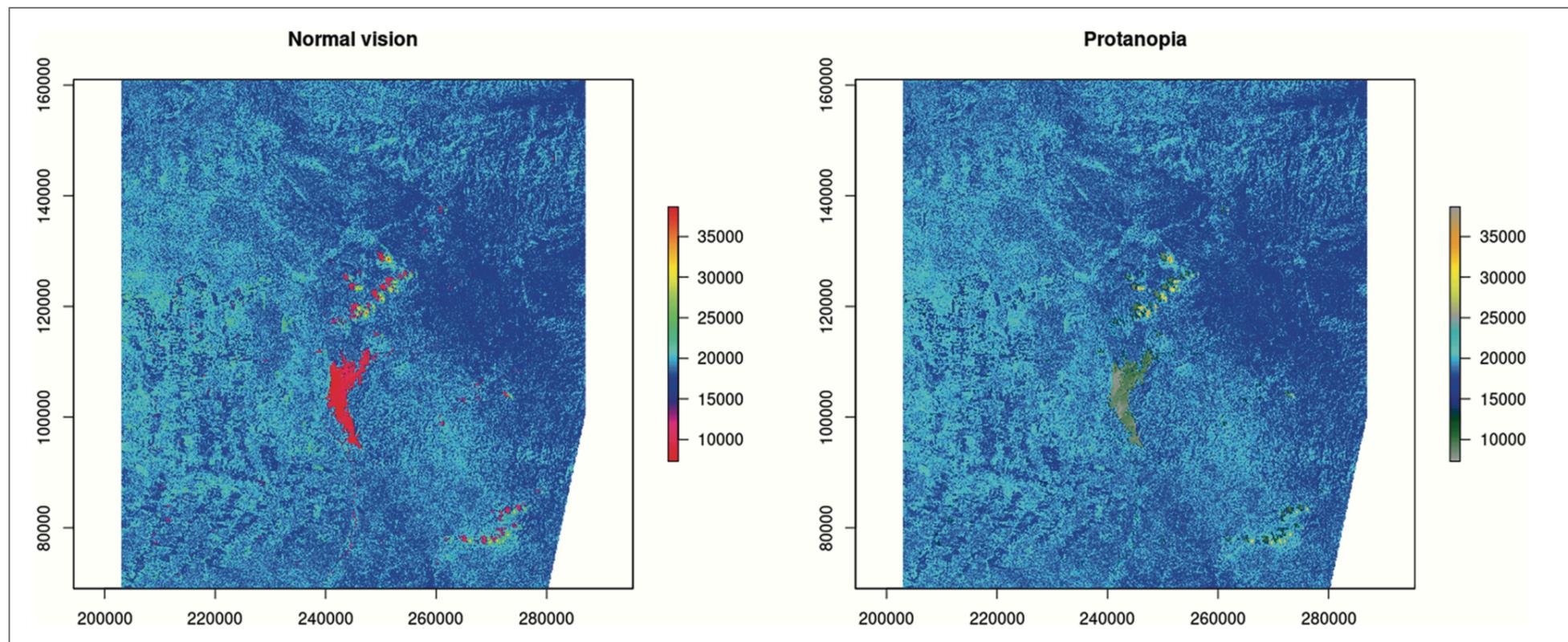
Daltonism



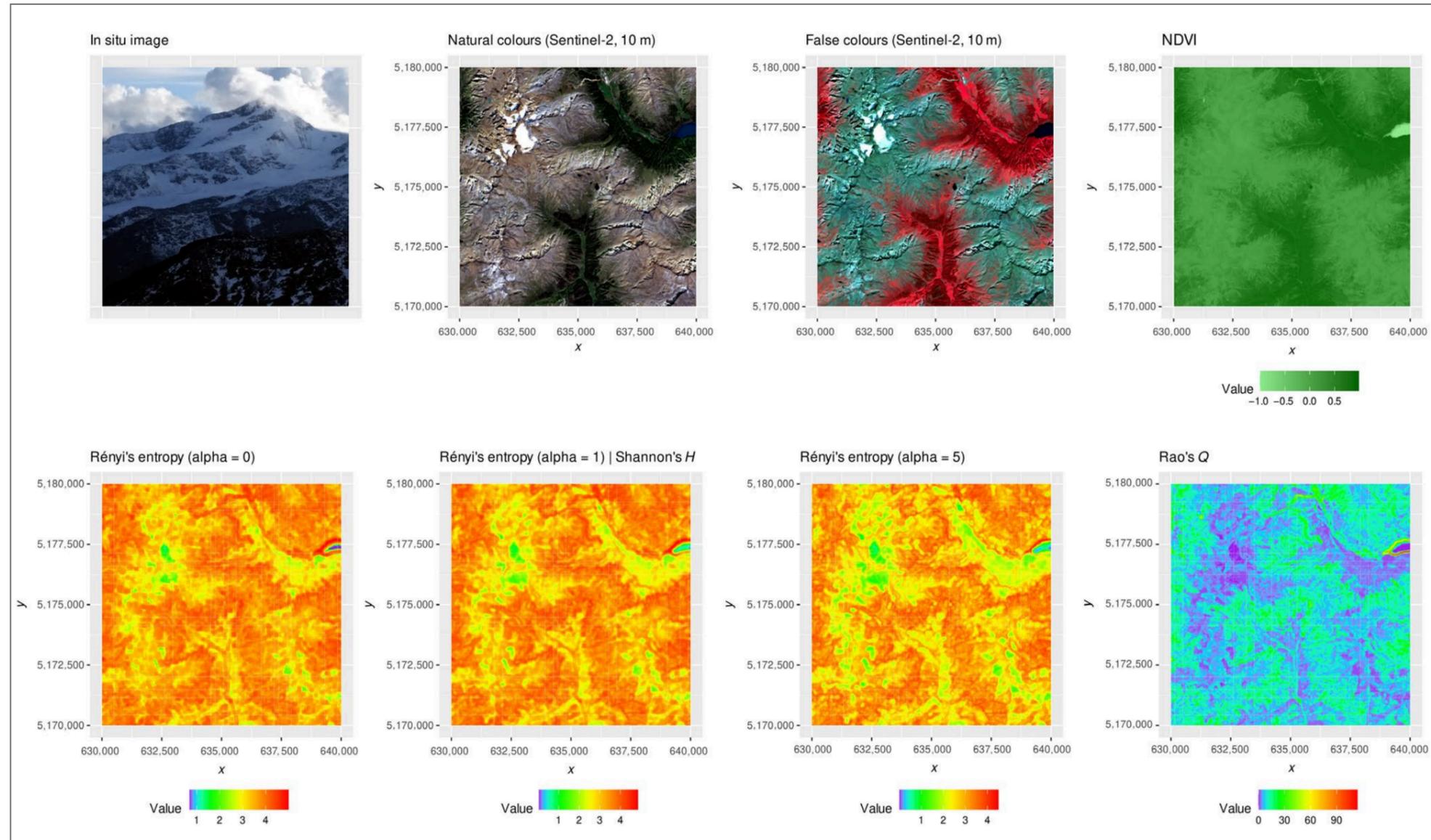
Colors for colorblind people can lead to an “alien” perception of reality



Rainbow color palettes in scientific papers

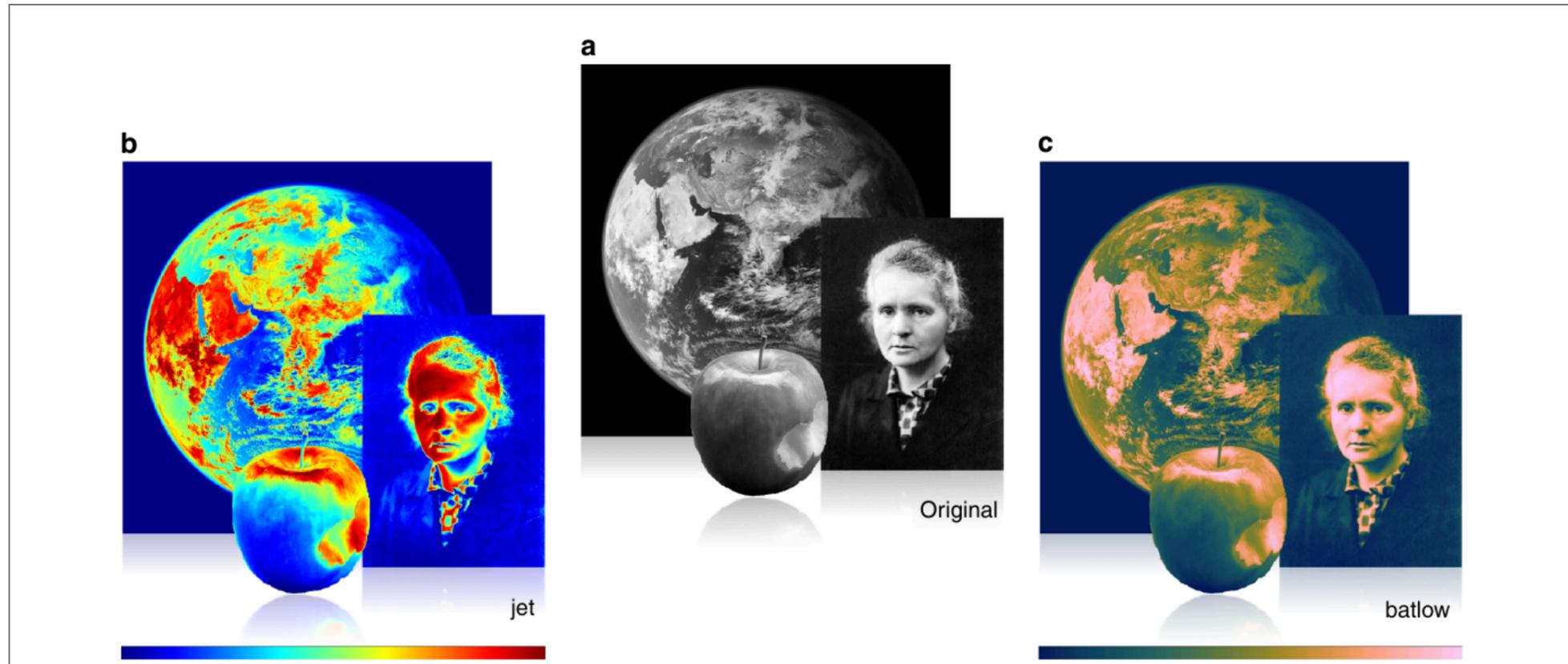


Rainbow color palettes in scientific papers



How to solve the issue

Cramieri et al. - Misuse of colors



The `viridis` R package

```
1 library(viridis)
2 citation("viridis")
```

To cite `viridis/viridisLite` in publications use:

Simon Garnier, Noam Ross, Robert Rudis, Antônio P. Camargo, Marco Sciaini, and Cédric Scherer (2024). `viridis(Lite)` - Colorblind-Friendly Color Maps for R. `viridis` package version 0.6.5.

A BibTeX entry for LaTeX users is

```
@Manual{,
  title = {{viridis(Lite)} - Colorblind-Friendly Color Maps for R},
  author = {{Garnier} and {Simon} and {Ross} and {Noam} and {Rudis} and {Robert} and {Camargo} and Antônio Pedro and {Sciaini} and {Marco} and {Scherer} and {Cédric}},
  year = {2024},
  note = {viridis package version 0.6.5},
  url = {https://sjmgarnier.github.io/viridis/},
  doi = {10.5281/zenodo.4679423},
}
```

The `viridis` R package palettes



Palette translation



The `cblindplot` R package

```
1 library(cblindplot)
2 citation("cblindplot")
```

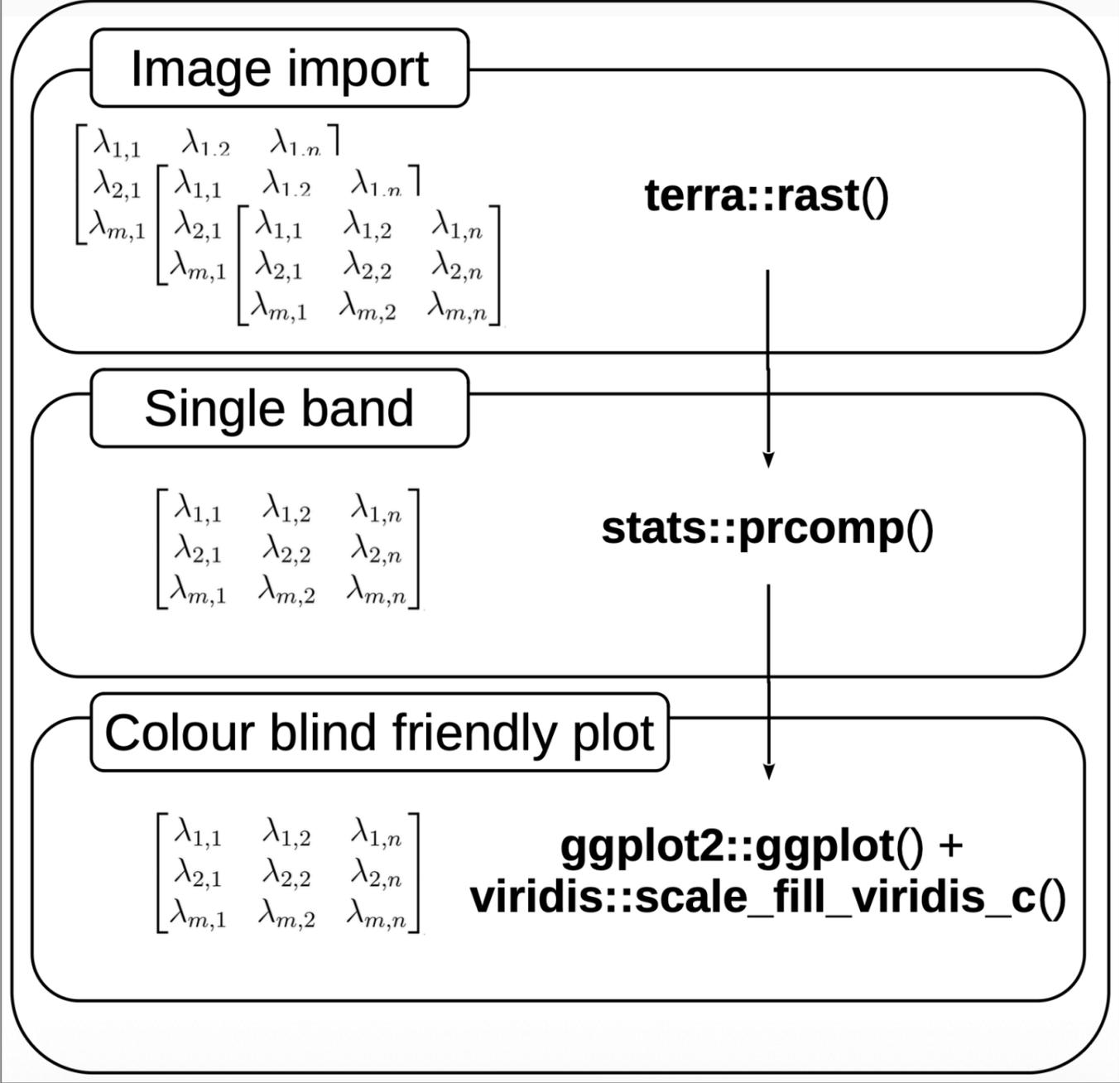
To cite `cblindplot` in publications please use:

Rocchini, D., Nowosad, J., D’Introno, R., Chieffallo, L., Bacaro, G., Gatti, R. C., Foody, G. M., Furrer, R., Gabor, L., Malavasi, M., Marcantonio, M., Marchetto, E., Moudry, V., Ricotta, C., Simova, P., Torresani, M., & Thouverai, E. (2023). Scientific maps should reach everyone: The `cblindplot` R package to let colour blind people visualise spatial patterns. *Ecological Informatics*.
<https://doi.org/10.1016/j.ecoinf.2023.102045>

A BibTeX entry for LaTeX users is

```
@Article{,
  title = {Scientific maps should reach everyone: The cblindplot R package to let colour blind people visualise spatial patterns},
  author = {Duccio Rocchini and Jakub Nowosad and Rossella D’Introno and Ludovico Chieffallo and Giovanni Bacaro and Roberto {Cazzolla Gatti} and Giles M. Foody and Reinhard Furrer and Lukas Gabor and Marco Malavasi and Matteo Marcantonio and Elisa Marchetto and Vitezslav Moudry and Carlo Ricotta and Petra Simova and Michele Torresani and Elisa Thouverai},
  journal = {Ecological Informatics},
  year = {2023},
  url = {https://doi.org/10.1016/j.ecoinf.2023.102045},
}
```

Algorithmic viewpoint



The `cblind.plot()` function

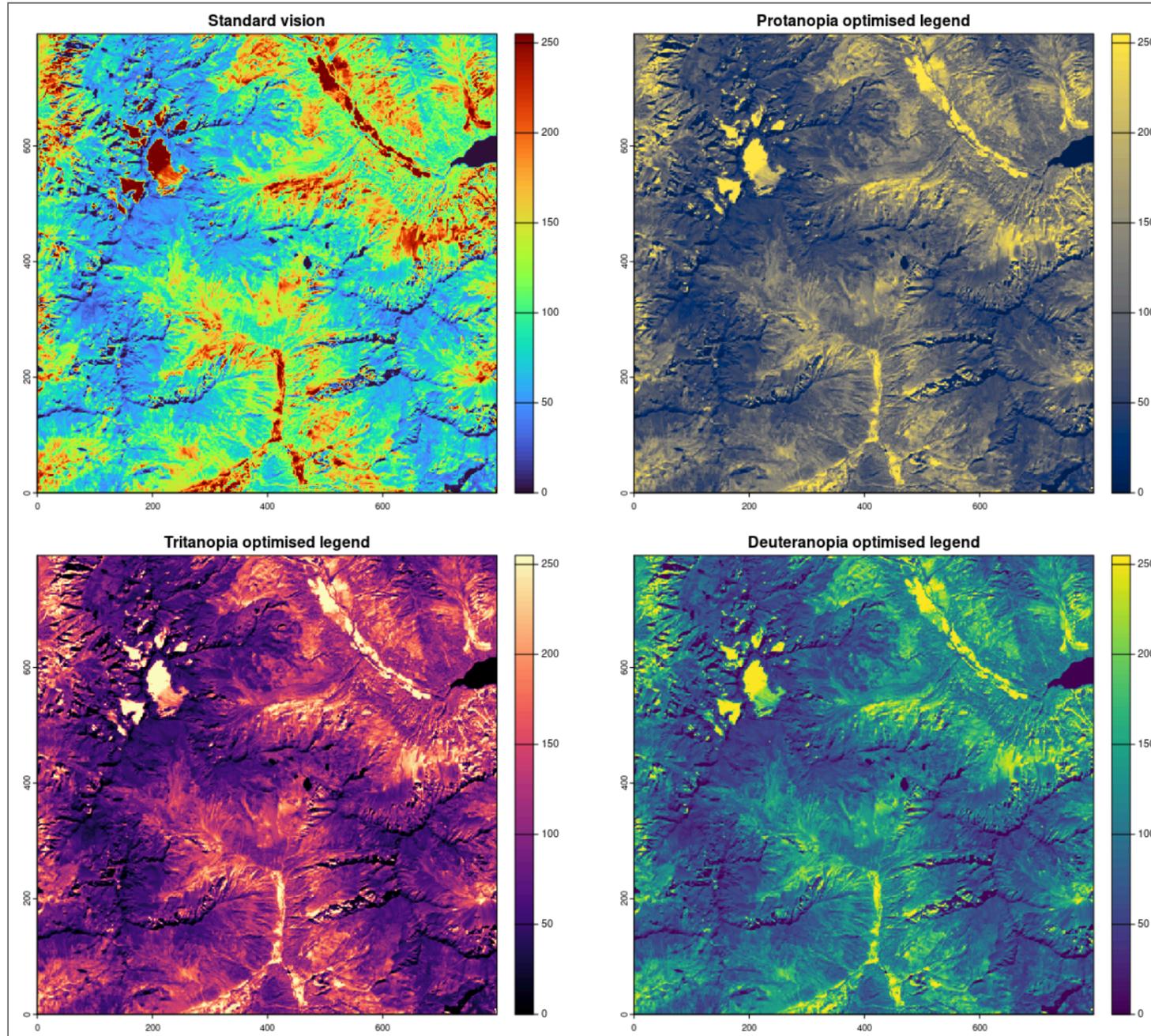
1 `cblind.plot`

```
function (im, cvd, r = 1, g = 2, b = 3, crop_manual = FALSE,
  select_class = FALSE, legend)
{
  if (missing(cvd)) {
    cvd <- "protanopia"
  }
  else if (length(cvd) == 1 && !cvd %in% c("protanopia", "deuteranopia",
    "tritanopia")) {
    stop("Wrong `cvd` value. It can be 'protanopia', 'deuteranopia', 'tritanopia', or a vector of colors")
  }
  im <- cblind.prep.input(im)
  if (missing(legend)) {
    impl <- cblind.prep(im, r = r, g = g, b = b, crop_manual = crop_manual,
      select_class = select_class)
    impl <- as.data.frame(impl, xy = TRUE)[c(1:3)]
    colnames(impl) <- c("x", "y", "values")
    ggt <- ggplot2::ggplot(impl) + ggplot2::geom_raster(ggplot2::aes_string(x = "x",
      y = "y", fill = "values")) + ggplot2::coord_equal() +
      ggplot2::theme_void()
    if (length(cvd) > 1) {
      pl <- ggt + ggplot2::scale_fill_gradientn(colours = cvd,
        na.value = "transparent")
    }
  }
}
```

Scientific basis

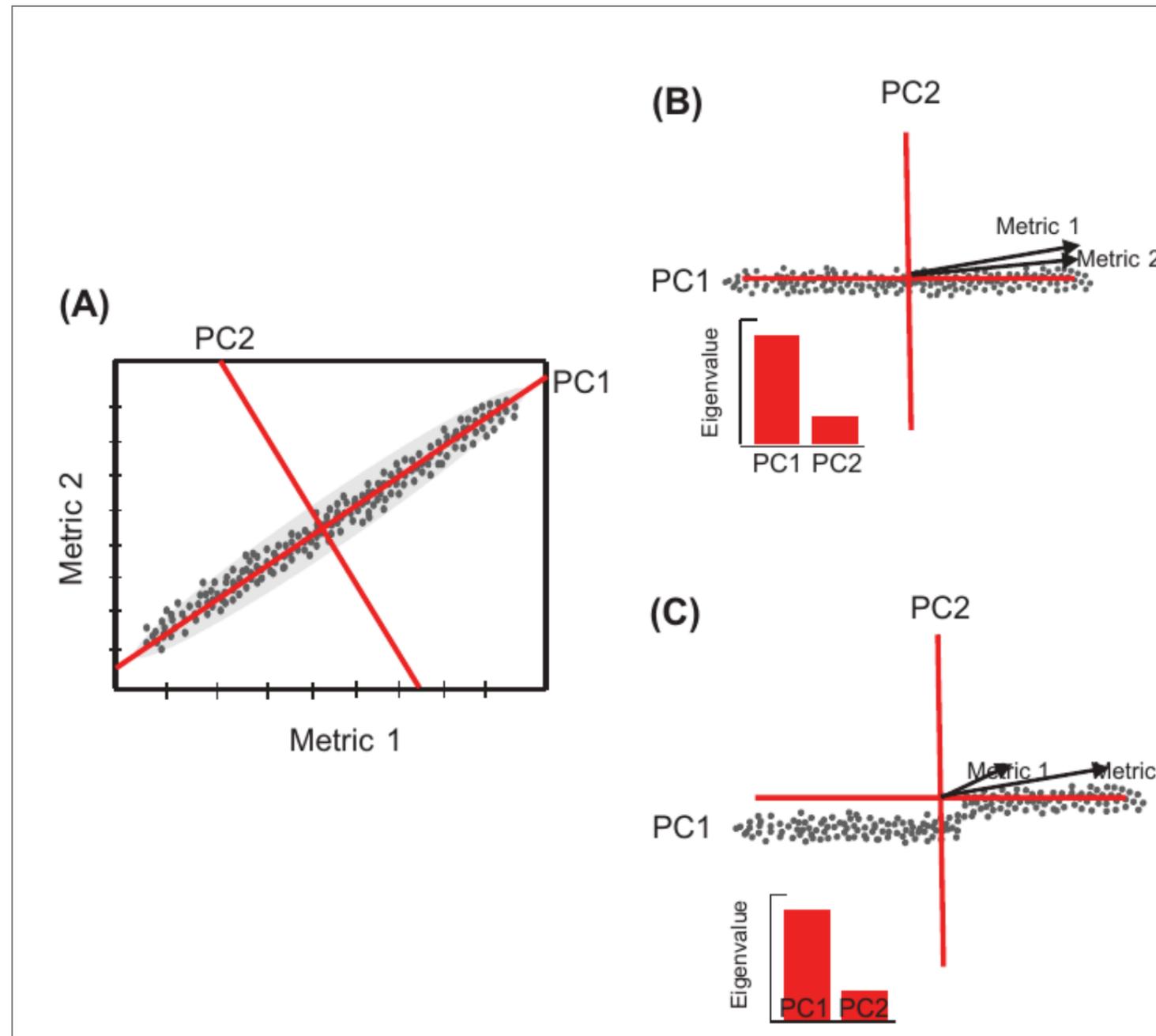


The output



Challenges

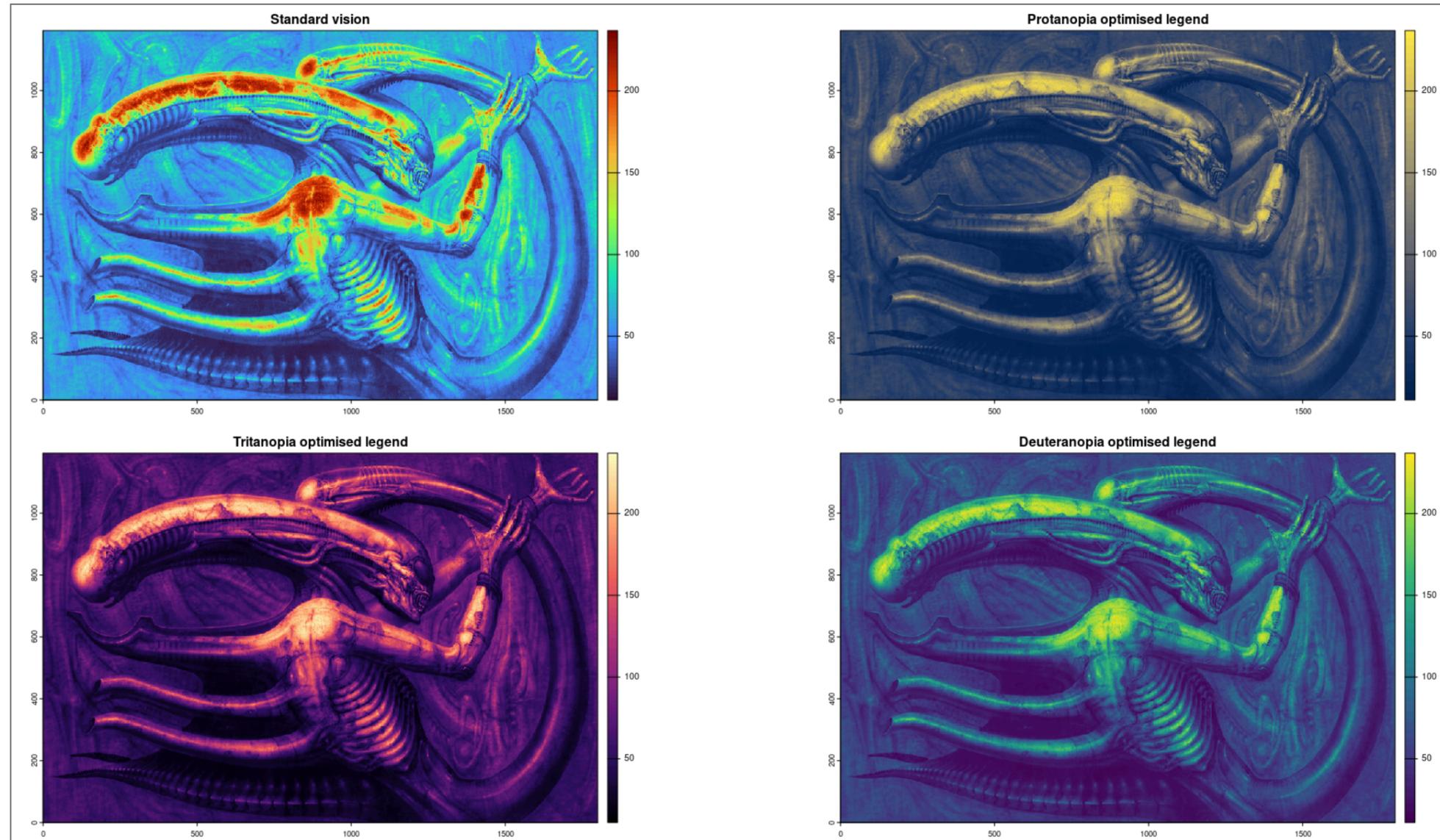
PCA problems in managing minima and maxima



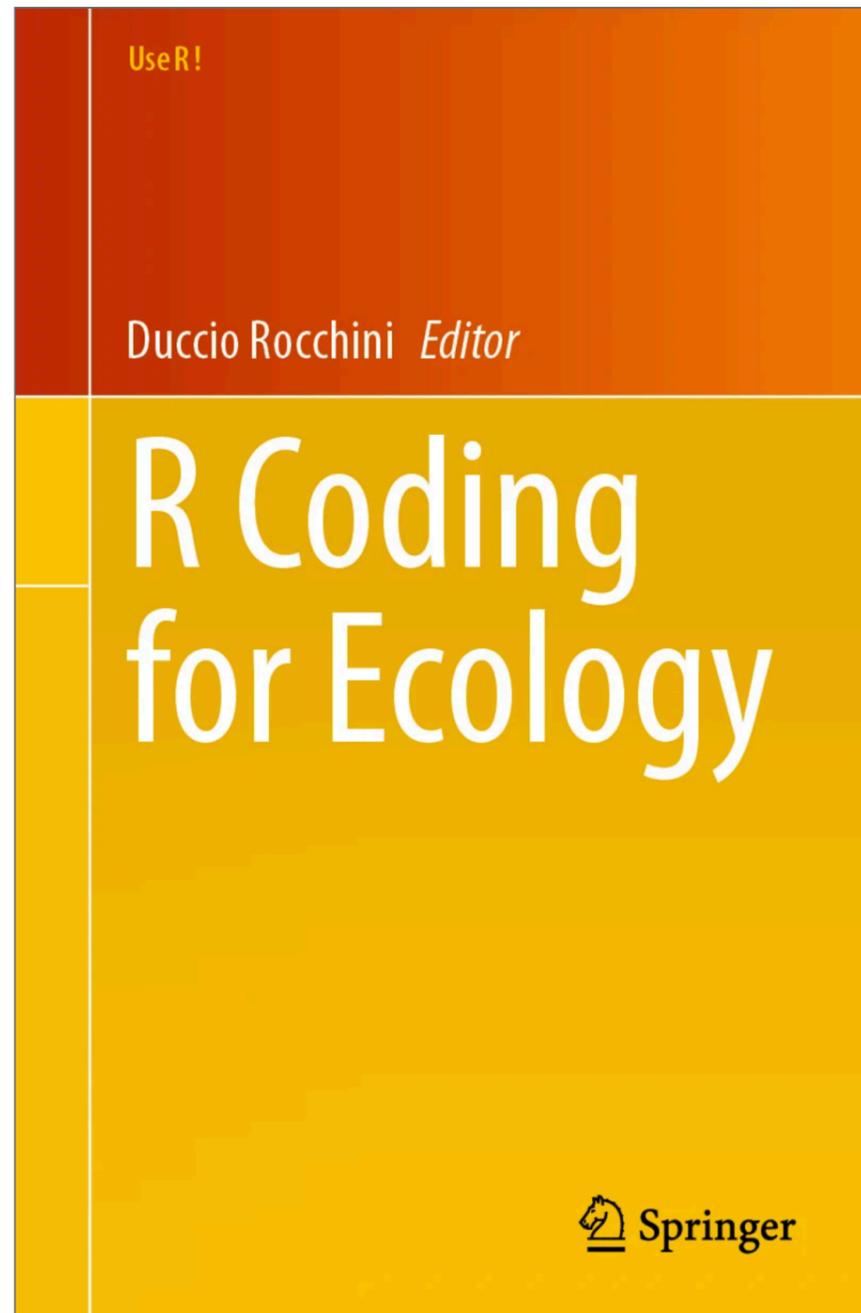
Neural networks by the `nncblind()` function

```
1 nncblind <- function(im, cvd = c("protanopia", "deutanopia", "tritanopia"), r = 1, g = 2, b = 3) {
2
3   #Controllo cvd
4   cvd <- cvd[1]
5   if(!cvd %in% c("protanopia", "deutanopia", "tritanopia")) stop("Wrong 'cvd` value. It can be 'protanopia', 'deutanopia', or 'tritanopia'")
6
7   #Controllo immagine
8   if (!inherits(im, "SpatRaster") && !inherits(im, "RasterLayer") && !inherits(im, "RasterStack") && !inherits(im, "RasterBrick") && !inherits(im, "list") && !inherits(im, "
9     stop("'im' must be a raster object, a list or a path to an image")
10  } else if (inherits(im, "RasterLayer") || inherits(im, "RasterStack") || inherits(im, "RasterBrick") || is.character(im)){
11    suppressWarnings(im <- terra::rast(im))
12  } else if (inherits(im, "list")){
13    invisible(lapply(im, function(x) if(!inherits(x, "SpatRaster")) stop("all the elements of the list must be SpatRaster objects")))
14    suppressWarnings(im <- terra::rast(im))
15  }
16
17  # Preparazione dati
18  df <- as.data.frame(im, xy = T)
19  df_mod <- data.frame(df[,1], df[,2], df[,r + 2], df[,g + 2], df[,b + 2])
20  colnames(df_mod) <- c("x", "y", "R", "G", "B")
21
22  # Convertire in character i valori delle colonne R, G, B al fine di renderle compatibili con il modello nnet
23  df_mod$R = as.character(R)
24  df_mod$G = as.character(G)
25  df_mod$B = as.character(B)
26
```

Coda



Additional insights



Many thanks!

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duccio.rocchini@unibo.it

This presentation has been developed using R, Markdown, and Quarto. The open-source code is available at:



Speaker notes