# The misuse of colour in science communication

## Somewhere over the rainbow

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MC Toolkit - IGE
23 février 2021

# Content

**The misuse of colour in science communication**. *Nat Commun* 11, Crameri, F., G.E. Shephard, and P.J. Heron (2020)

What is it about ?

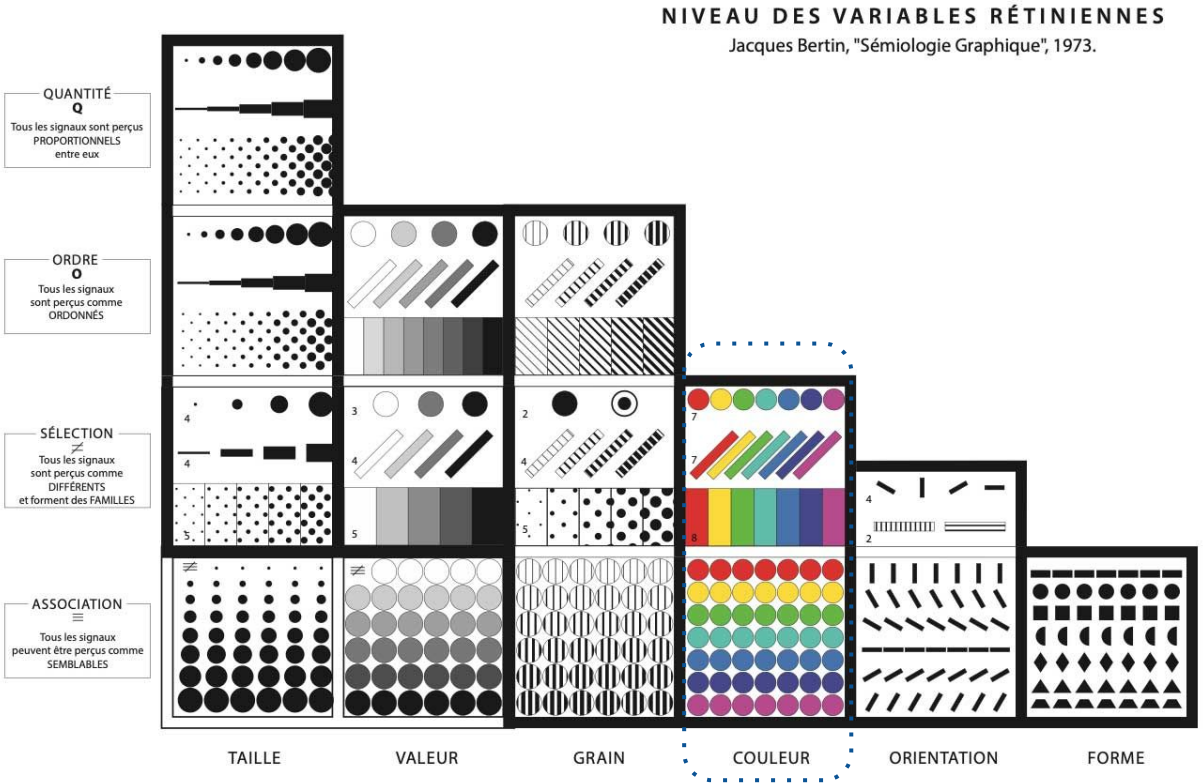
How we see colour ?

The jet/rainbow colour map.

How to choose a *scientific* colour map?

# What is it about ?

## Visual Encoding

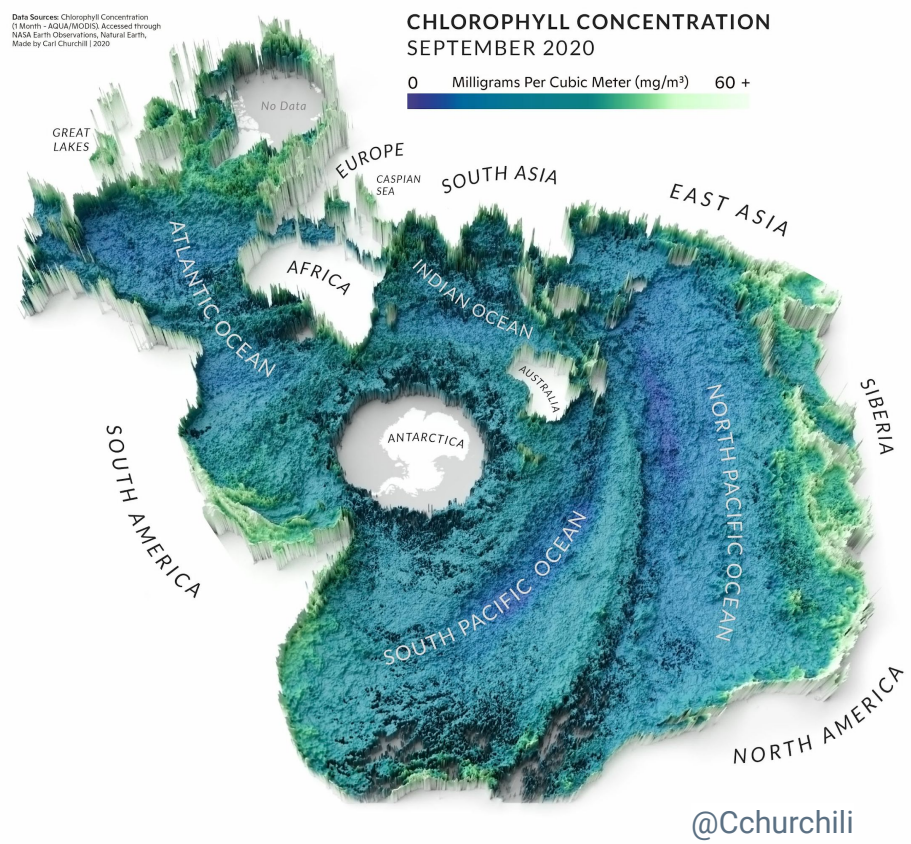


# What is it about ?

## The colour variable

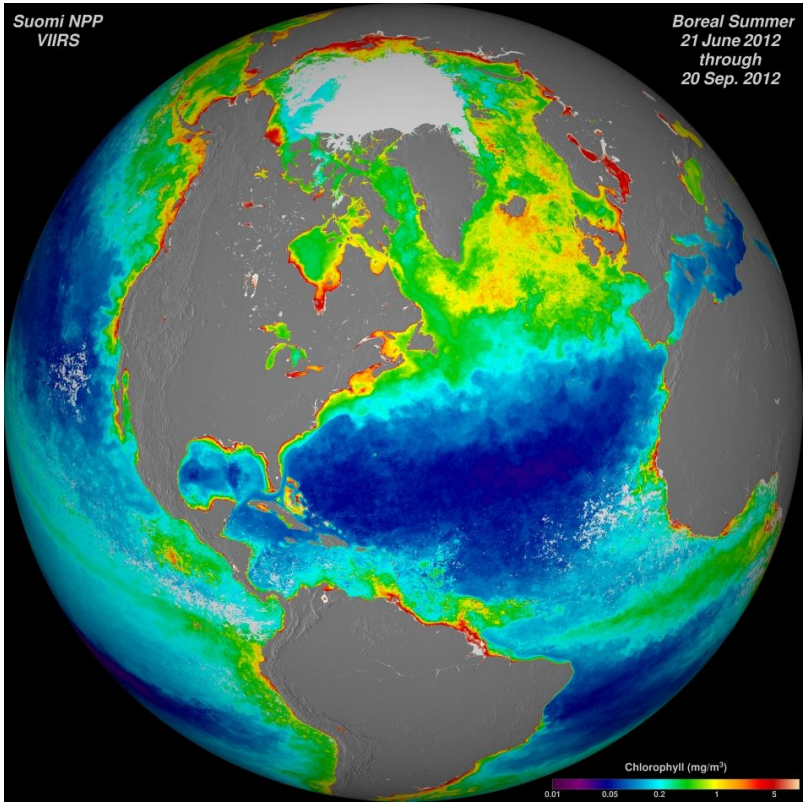
The use of colours to **visually encode** one numerical quantity of interest.

For Geoscientific data, this requires **a colour map**.



# What is it about ?

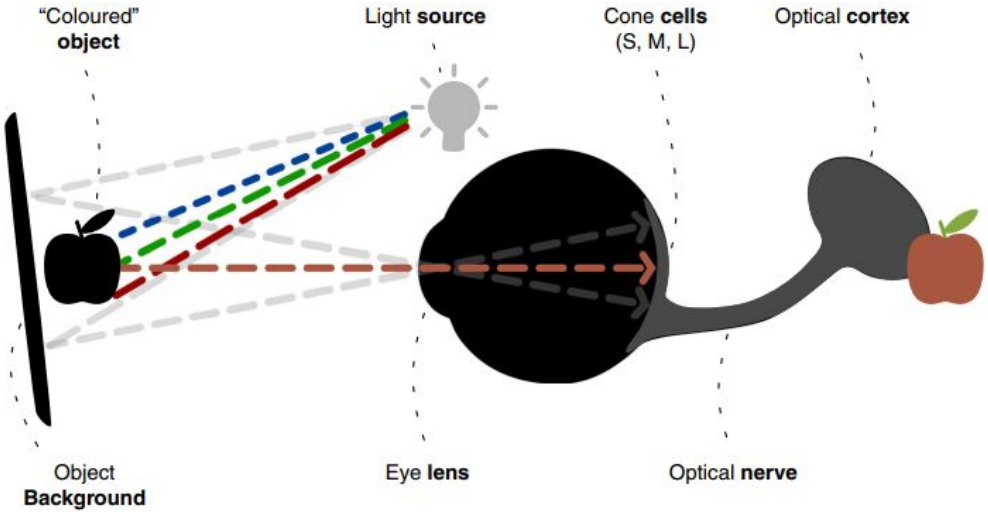
## The jet/rainbow colour map




Ocean Chlorophyll Concentrations - NASA/Suomi NPP/Norman Kuring

# How we see colour ?

## The biology and physics together




(Crameri et al.,2020)

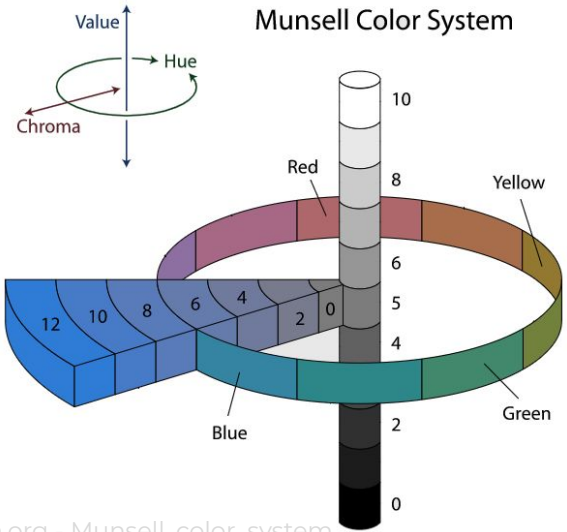
Cone cells transform light energy into neurological information.

No uniform colour perception among individuals.

The human eye can perceive more variations in warmer colors than cooler ones.

# How we see colour ?

## Color space and Color Appearance Model




Wikipedia.org - Munsell_color_system

**Hue** — another word for color. **Saturation** (chroma) - more or less grey. **Lightness** (value) - from black to white.

## CIECAM02/16

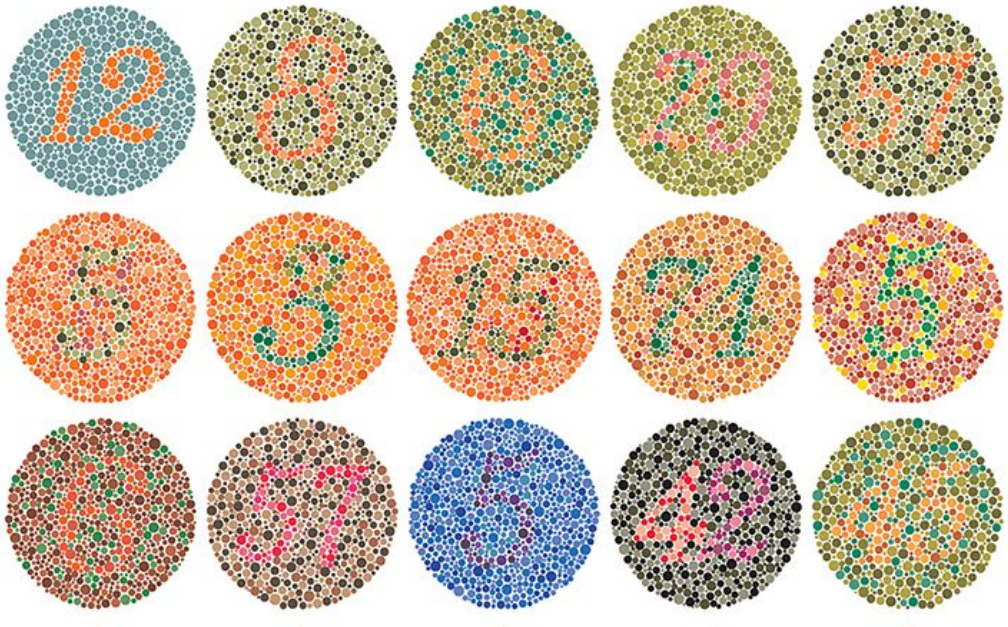
Color Appearance Modelling for Color Management Systems. Commission internationale de l'éclairage (CIE)

Accurate model of color based on six technically defined dimensions of color appearance: brightness (luminance), lightness, colorfulness, chroma, saturation, and hue.

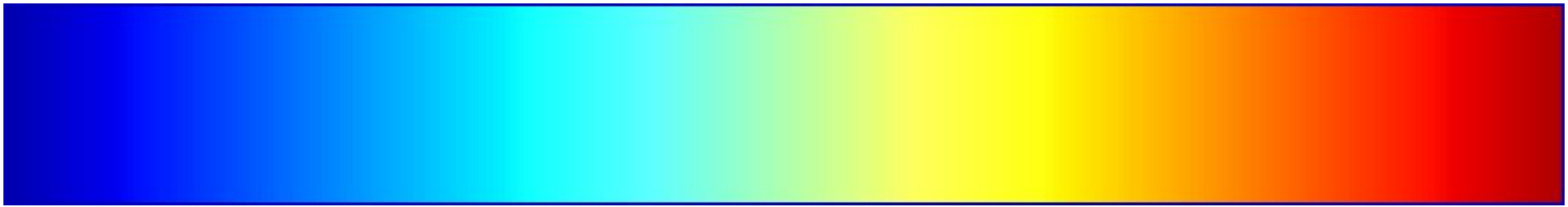
# How we see colour ?

## Colour-vision deficiency

Colour perception isn't uniform amongst individuals.



# The jet/rainbow colour map



# The jet/rainbow colour map

## A long term discussion in science.

Rogowitz and Treinish 1996
Rogowitz and Treinish 1998
Light and Bartlein 2004

Borland et al., **2007**

Rainbow Color Map (Still)
Considered Harmful

Smith and van der Walt, **2015**

The viridis colormap in matplotlib python package

EGU, **2018**

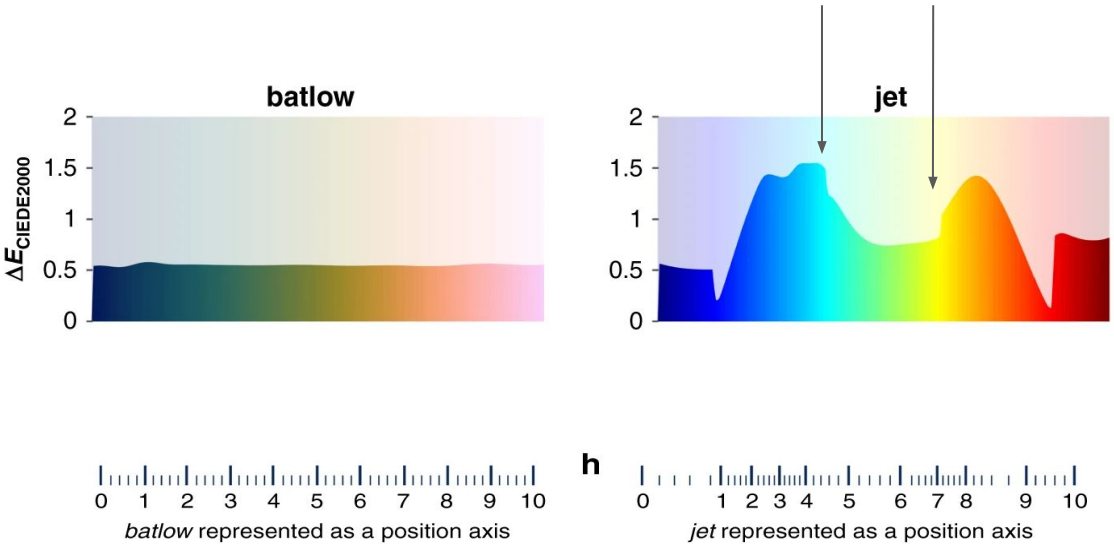
#endrainbow

Crameri et al., **2020**

The misuse of colour in science communication

# The jet/rainbow colour map

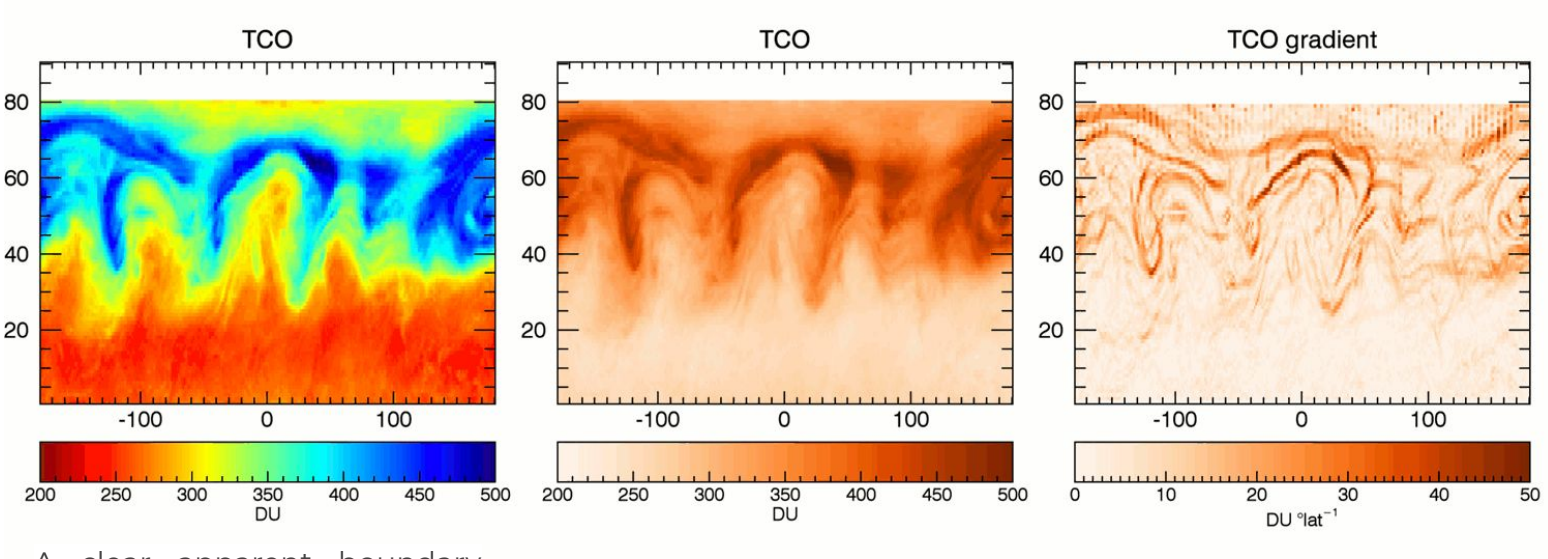
$\Delta E_{CIEDE2000}$ : Incremental perceptual colour difference along a colour gradient.




data is distorted perceptually.

# The jet/rainbow colour map

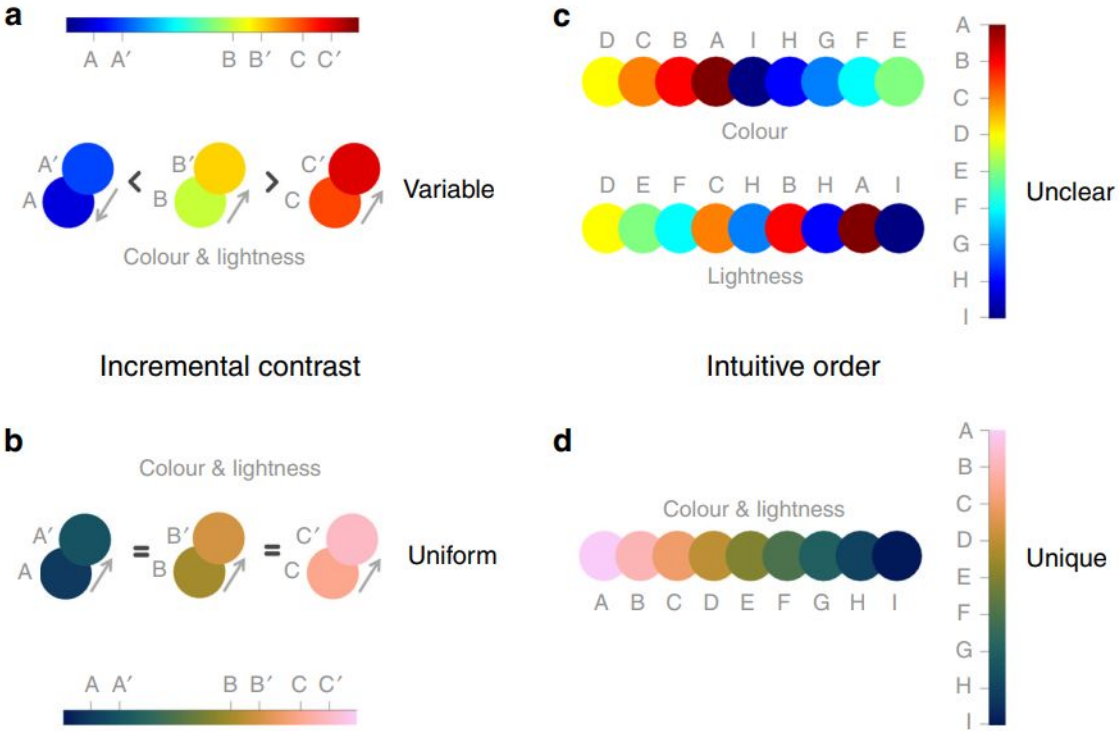
Example: the Total Column Ozone (TCO)




A clear apparent boundary between the yellow and green regions, which was identified as a ‘sub-tropical’ front, and highlighted with a blue line.

(Hudson et al. ,2006) revisited by Davis S. (NOAA)

# The jet/rainbow colour map




Batlow has intuitive colour order.

sequential ordering is not intuitively possible for jet.

# *Unscientific* colour maps are…

- **distorting** the data,
- **unintuitive,**
- excluding and **discriminating** people with colour-vision deficiencies,
- not readable in black and white.

As a consequence:

Do not use unscientific colour maps in your scientific work,

Don’t accept papers that publish graphics using unscientific colour maps.

# *Scientific* colour maps are…

✓ Perceptually uniform *i.e.*, NOT distorting the data,

✓ Perceptually ordered *i.e.*, intuitively readable,

✓ Colour-vision-deficiency friendly *i.e.*, NOT excluding certain readers,

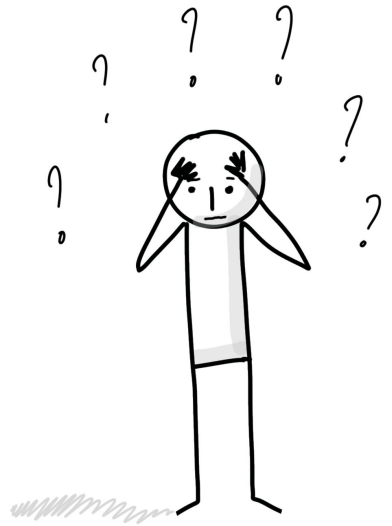
✓ Readable as black-and-white print *i.e.*, convenient,

\+ Available in all major data formats *i.e.*, openly accessible,

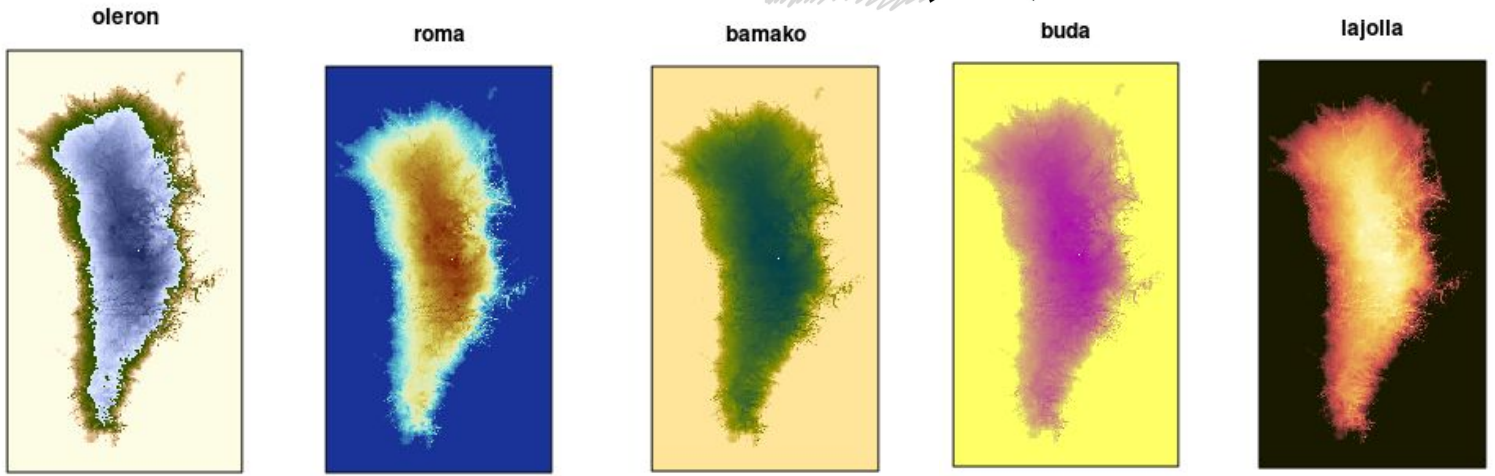
\+ Including diagnostics; peer-reviewed;citable *i.e.*, tested and trustworthy

# How to choose ?

## Scientific color maps



Greenland ice thickness



# How to choose ?

## They made them for us.

Colobrewer

MPL Colour Maps

Cividis colour map

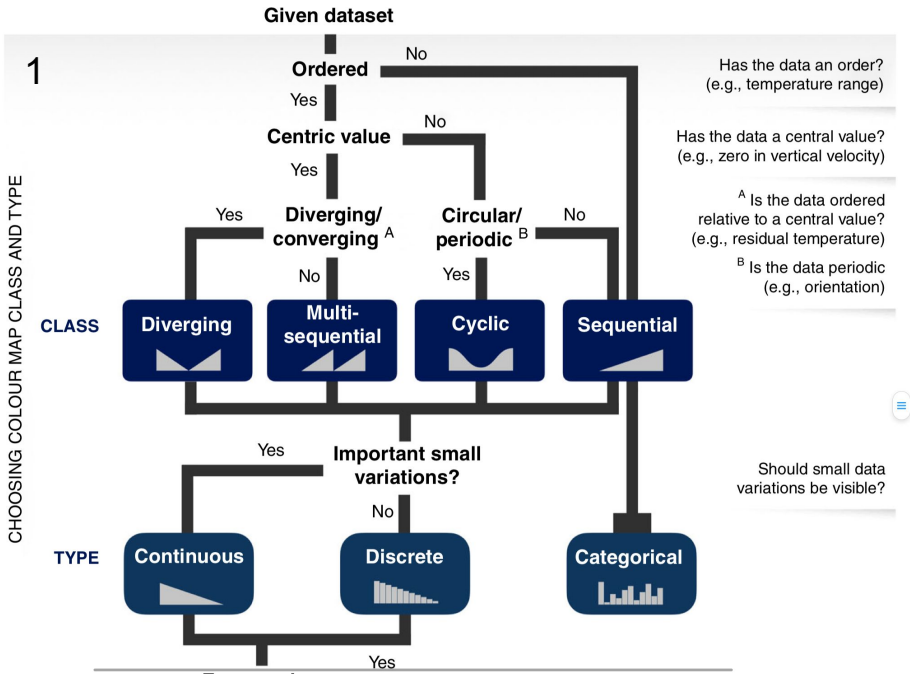
CMOcean Colour Maps

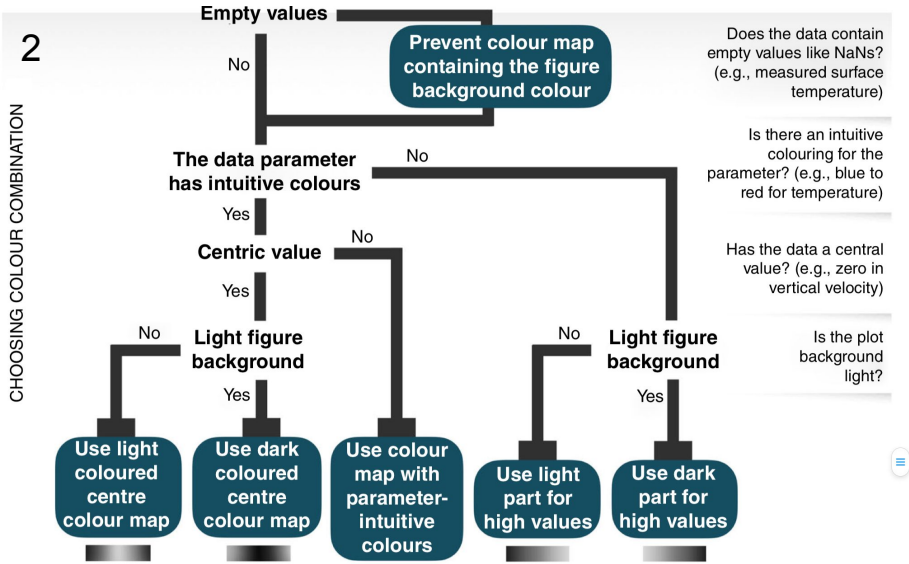
CET Colour Maps

Scientific colour maps → on Zenodo

# How to choose ?

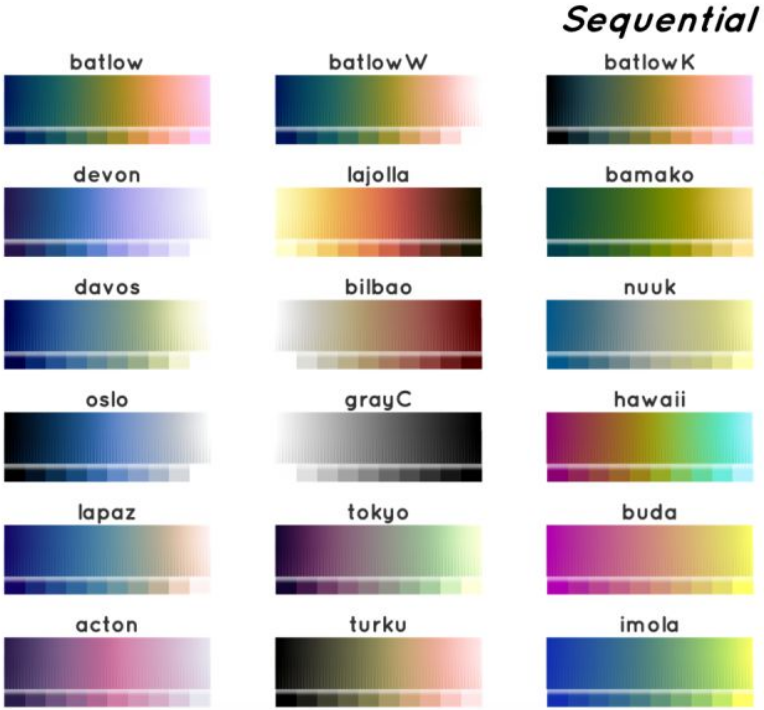
## Authors methodology

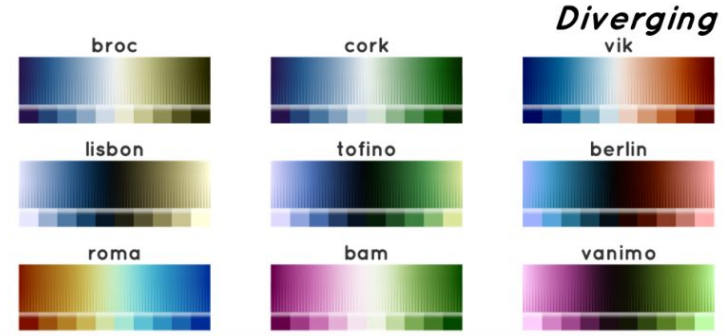


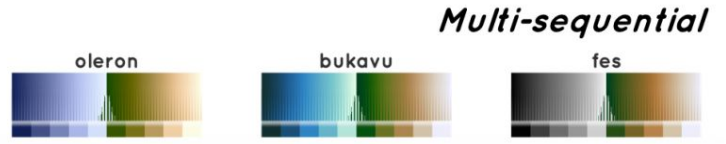



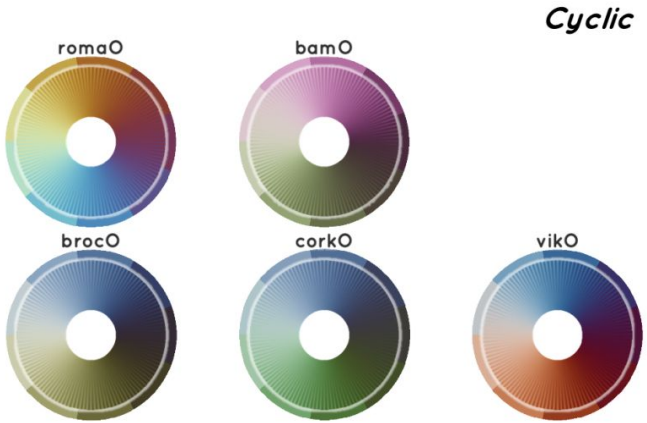
# How to choose ?

## Scientific colour map 7.0



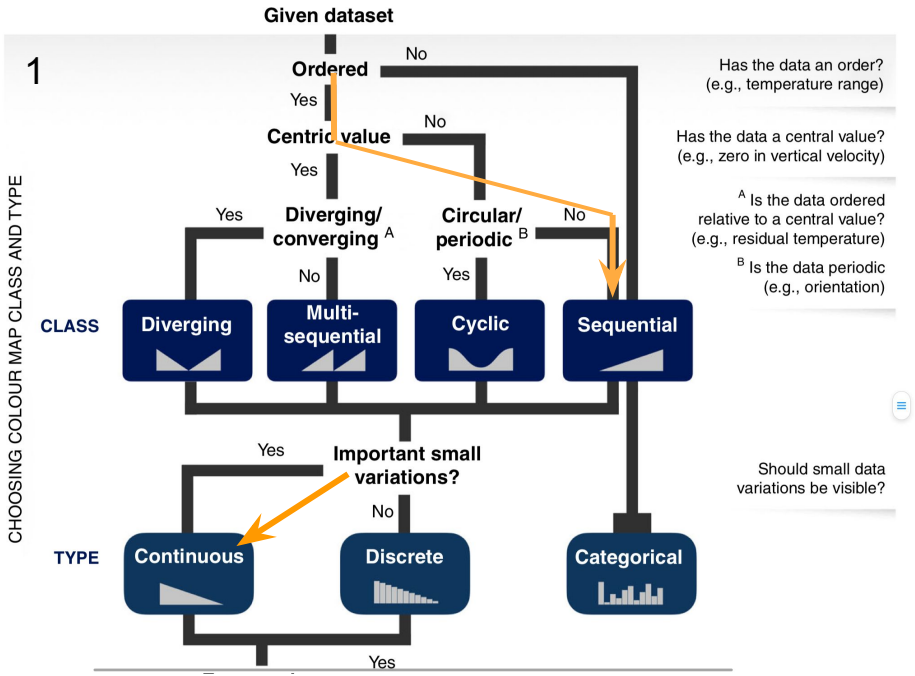



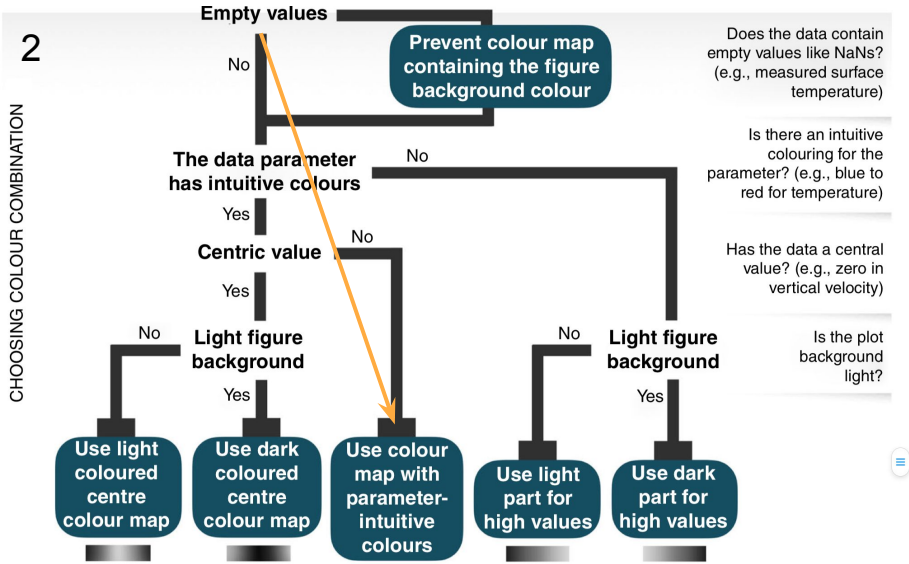



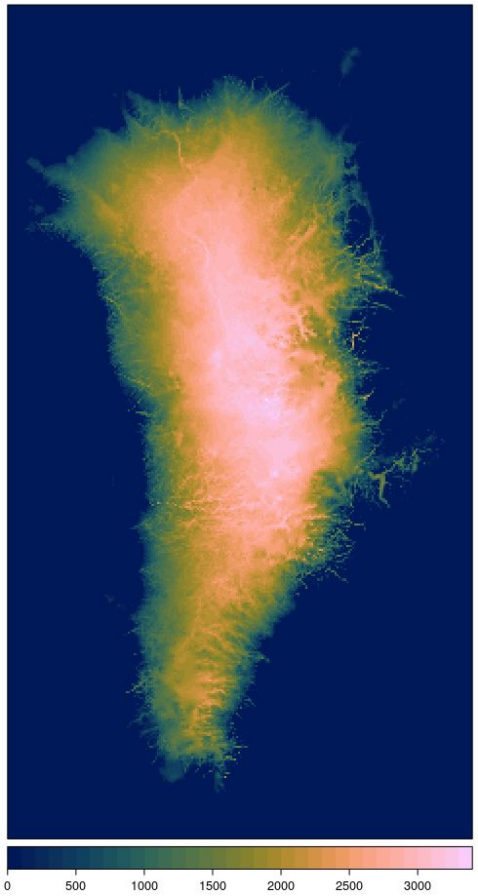



# How to choose ?

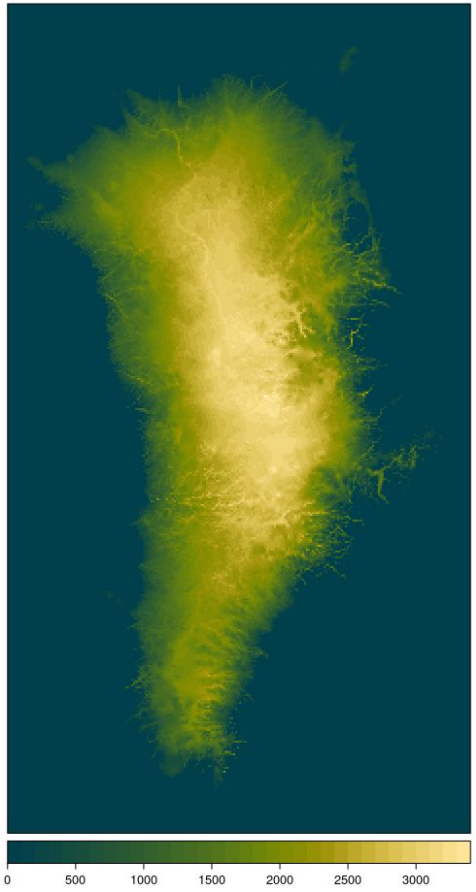
## Methodology applied to the Greenland ice thickness



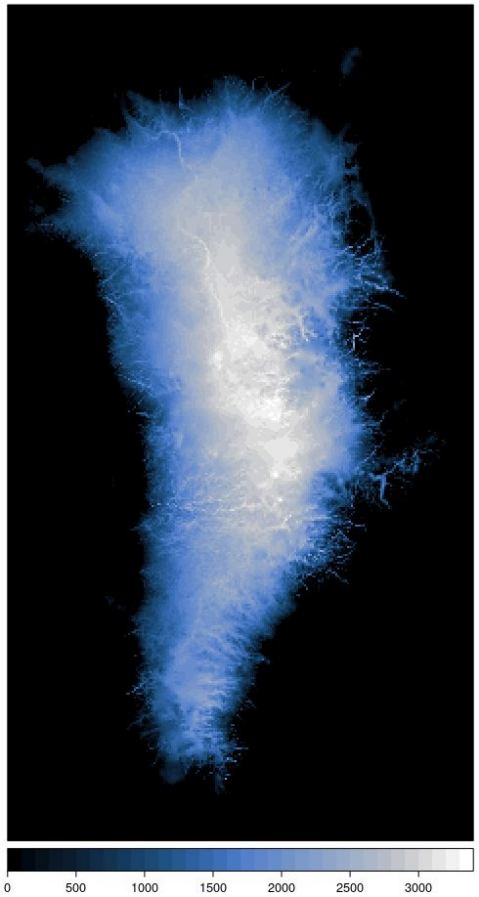






Batlow




Bamako




Oslo

# How to choose ?

Ensure a perceptual relationship between the colour scale and the data,

Understand audience cultural expectations,

Use intuitive perception :

- Plant growth : green/greener
- High temperature : red
- Darker = ‘more’

# But, what if I like rainbow colour?


2020 monthly temperature blanket- @susie_hailey

# Ressources

## From Author

Crameri's website
The scientific material: https://zenodo.org/record/4491293#.YCaXIGhKiUk
Presentation of the paper by its author

## Colour-vision deficiency

https://blog.datawrapper.de/colorblindness-part1/
https://blog.datawrapper.de/colorblindness-part2/
https://blog.datawrapper.de/colorblindness-part3/

## Rainbow color scale

The rainbow is dead ...long life to the rainbow

## Climate science

Constructive criticism of the graphics of climate science

## Talks - Video

Perceptual Color Maps in matplotlib for Oceanography (K. Thyng - 2015)
A Better Default Colormap for Matplotlib (N.Smith and S.van der Walt - 2015)

# Bibliography

**Borland** D. and R. M. Taylor Ii, "Rainbow Color Map (Still) Considered Harmful," in I*EEE Computer Graphics and Applications*, vol. 27, no. 2, pp. 14-17, March-April **2007**, doi: 10.1109/MCG.2007.323435.

**Crameri**, F., Shephard, G.E. & Heron, P.J. The misuse of colour in science communication. *Nat Commun* 11, 5444 (**2020**). https://doi.org/10.1038/s41467-020-19160-7

**Hudson**, R. D., Andrade, M. F., Follette, M. B., and Frolov, A. D.: The total ozone field separated into meteorological regimes – Part II: Northern Hemisphere mid-latitude total ozone trends, *Atmos. Chem. Phys.*, 6, 5183–5191, https://doi.org/10.5194/acp-6-5183-2006, **2006**.

**Kovesi**, P. Good Colour Maps: How to Design Them. arXiv:1509.03700 [cs.GR] **2015**