

- ✓ Perceptually uniform
- ✓ Perceptually ordered
- ✓ Colour-vision-deficiency (CVD) friendly
- ✓ Readable as black and white print
- ✓ Provided in all major formats
- ✓ Citable & reproducible
- \* Sequential
- \* No white; no black

Crameri, F. (2018), Scientific colour maps, Zenodo, [doi:10.5281/zenodo.1243862](https://doi.org/10.5281/zenodo.1243862)

Crameri, F. (2018), Geodynamic diagnostics, scientific visualisation and StagLab 3.0, Geosci. Model Dev., 11, 2541-2562, [doi:10.5194/gmd-11-2541-2018](https://doi.org/10.5194/gmd-11-2541-2018)

Crameri, F., G.E. Shephard, and P.J. Heron (2020), The misuse of colour in science communication, Nature Communications, 11, 5444. [doi: 10.1038/s41467-020-19160-7](https://doi.org/10.1038/s41467-020-19160-7)

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\* [www.fabiocrameri.ch/lapaz](http://www.fabiocrameri.ch/lapaz)



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## 1 Creators & sources of inspiration

Creator: [Fabio Crameri](#)

Contributors: [Grace Shephard](#) – Conversion to .cpt format, promotion of Scientific colour maps, and other contributions

[Phil Heron](#) – Promotion of Scientific colour maps

[Clint Conrad](#) – Wider compatibility of .cpt format

[Matteo Albano](#) – Conversion to .clr format; QGIS compatibility

[Casper Pranger](#) – Mathematica compatibility

[Alexis Plunder](#) – Wider compatibility of .xml format

[Krister Stræte Karlsen](#) – User instruction for use with python

[Philippe Rivière](#) – Conversion instruction for d3

[Emilia](#) – Plotly versions

[Thomas Lin Pedersen](#) – The ‘scico’ package for use with R

[Paul Wessel](#) – Built-in version for ‘GMT’

[Wolfgang Schwanghart](#) – Built-in version for ‘TopoToolbox’

[Chad Greene](#) – MatLab file exchange version

[Sean Trim](#) – Conversion to .pal format

[George Edward Campbell](#) – Conversion to .lut format

[Christophe Leterrier](#) – NeuroCyto LUTs Fiji add-on

[Kirstie Wright](#) – User instruction for use with Petrel

[Craig Williams](#) – Style file for ArcGIS Pro

[Jennifer Levett](#) – Conversion to SKUA-GOCAD .xcmap format

[Sam Hatfield](#) – Conversion to Ncview .ncmap format

[Patrick Brockmann](#) – Conversion to Ferret .spk format

[Thomas Morrow](#) – Conversion to QPS .cmap format

[Mark Wieczorek](#) – Import init file for Python

[Anthony Jamelot](#) – Additions to import init file for Python

[Andy Emery](#) – Conversion to Kingdom .clm and .clb format

[Benjamin Witschas](#) – Conversion to Originlab .pal format

[Steven Reddy](#) – Conversion to Photoshop .grd format

[Callum Rollo](#) – Python package via pip and anaconda

[Pierre Lanari](#) – Built-in version for ‘XMapTools’

[Kaspar Merz](#) – Importable package for ‘OpendTect’

Sources of inspiration:

The ‘**endrainbow**’ campaign initiated by Ed Hawkins.

The **Colorbrewer** colour maps, the **MPL** colour maps, the **cividis** colour map, the **CMOcean** colour maps, and the **CET** colour maps.

**Peter Kovesi**’s work, in particular, has helped to develop the Scientific colour maps: some of the **many excellent, openly accessible scripts** were used as a basis for the applied colour-map diagnostics and to make the file conversion to .tbl and .act formats.

## 2 Acknowledgement

! → Please acknowledge the free use of the colour maps.

e.g., *"The Scientific colour map lapaz (Crameri 2018) is used in this study to prevent visual distortion of the data and exclusion of readers with colour-vision deficiencies (Crameri et al., 2020)."*

The software : **Crameri, F. (2018a), Scientific colour maps. Zenodo. <http://doi.org/10.5281/zenodo.1243862>**

The research : **Crameri, F., G.E. Shephard, and P.J. Heron (2020), The misuse of colour in science communication, Nature Communications, 11, 5444. doi: 10.1038/s41467-020-19160-7**

## 3 Instructions

### 3.1 ArcGIS Pro

#### 3.1.1 style file

Download the style file for the ArcGIS Pro provided by [Craig Williams](https://www.arcgis.com/home/) on <https://www.arcgis.com/home/>.

### 3.2 COMSOL Multiphysics

#### 3.2.1 .txt format

Put the .txt colour map files in **COMSOL4.0a > data > colortables** (adjust version number, if necessary) Then restart COMSOL and the Scientific colour maps should be available within the program.

### 3.3 d3

#### 3.3.1 .xml format

An instruction to convert the .xml format to d3's internal representation is provided by Philippe Rivière at <https://beta.observablehq.com/@fil/colormaps>.

### 3.4 Ferret

#### 3.4.1 .spk format

To use the .spk colour map files in Ferret, follow the instructions given on the official homepage: [https://ferret.pmel.noaa.gov/Ferret/documentation/users-guide/customizing-plots/COLOR#\\_VPID\\_247](https://ferret.pmel.noaa.gov/Ferret/documentation/users-guide/customizing-plots/COLOR#_VPID_247).

### 3.5 Fledermaus & Qimera

#### 3.5.1 .cmap format

To use the .cmap colour map files in the QPS software Fledermaus and Qimera, download the external package from [www.fabiocrameri.ch/colourmaps](http://www.fabiocrameri.ch/colourmaps) or via the direct [link](#).

### 3.6 GIMP/Inkscape

#### 3.6.1 .gpl format

To import the .gpl palettes, launch GIMP and go to **Windows > Dockable Dialogs > Palettes** to open the Palettes dialog. Then right-click anywhere on the list of palettes and select **Import Palette**. In the **\*Import a New Palette\*** dialog, select the **\*Palette file\*** radio button and then the button just to the right of the folder icon.

Then, navigate to and select the desired .gpl file in the corresponding folder. Clicking the **\*Import\*** button will add the scientific colour map to the existing list of palettes.

## 3.7 GMT

**Note:** GMT 6.0.0 and later offers built-in Scientific colour maps (see Section 4).

### 3.7.1 .cpt format

The file `davos.cpt` can be resampled for a given z-value range with the Generic Mapping Tools (GMT; <http://www.generic-mapping-tools.org>) command “makecpt”.

For example to resample for an array from -2000 to 2000 in 100 increments you could generate a new file with:

```
$makecpt -Cdavos.cpt -T-2000/2000/100 > davos_resampled.cpt
```

## 3.8 Gnuplot

### 3.8.1 .pal format

Launch the Gnuplot shell and load the specific .pal file (e.g., `batlow`) into Gnuplot with:

```
user@computer gnuplot
gnuplot> load "batlow.pal"
```

## 3.9 ImageJ/Fiji

### 3.9.1 .lut format

The .lut colour-map file (e.g., `*batlow.lut*`) can be imported to ImageJ or Fiji by placing it in the `*luts*` folder (to reveal folder location in Fiji: **File > Show Folder > LUTs**). Upon restart of ImageJ, the scientific colour map(s) should then be available under **Image > Lookup Tables**.

Alternatively, the colour-map .lut file may be applied using either (a) **File > Open**, (b) **File > Import > LUT**, or (c) drag and drop the .lut file onto the ImageJ window. To view available LUTs: **Image > Color > Display LUTs**.

### 3.9.2 NeuroCyto LUTs add-on

Detailed information about how to use a simple add-on that adds a handy LUTs drop-down menu to the Fiji user interface is given on <https://forum.image.sc/t/neurocyto-luts-update-site/26244>.

## 3.10 Julia

The programming language Julia has built in Scientific colour maps in its colour map libraries, which makes them readily useable. The Julia file containing the colour maps is `scicolor.jl`: [github.com/JuliaGraphics/ColorSchemes.jl/tree/master/data](https://github.com/JuliaGraphics/ColorSchemes.jl/tree/master/data).

## 3.11 Kingdom

### 3.11.1 .clm format

On any screen, select **Show color bar** from the toolbar. Above the colour bar that appears, select **Select?**, then under **Files of type** choose **Color Bars (\*.CLM)**, then navigate to the location the colour-map files are stored.

The continuous Scientific colour maps are also provided externally in Kingdom's native file format, .clb, for easier implementation. The .clb files are available separately on [www.fabiocrameri.ch/colourmaps](http://www.fabiocrameri.ch/colourmaps). To import them in Kingdom, select, on any screen, **Show color bar** from the toolbar. Above the colour bar that appears, select **Select?**, then navigate to the location the colour-map files are stored.

## 3.12 Mathematica

### 3.12.1 .mat format

```
ColorMapSuitePath = "/Path/To/ColourMapSuite/";

ColorMapSuite[name_String] := ColorMapSuite[name, -1]
ColorMapSuite[name_String, el_] := With[{
  list =
    Transpose@{Subdivide[0, 1, 255],
      RGBColor @@@
      First@Import[
        ColorMapSuitePath <> "/" <> name <> "/" <> name <> ".mat"]}],
  Blend[list, {##}][[el]]] &
]
```

The function call `ColorMapSuite["name", i = -1]` returns a lambda function whose *i*th argument is used to define color (see the Manual for `ColorFunction` for details). "name" should be replaced with the name (in quotes) of the color scheme, e.g. "davos". Be sure to set the variable `ColorMapSuitePath` to the path where your `ColorMapSuite` is installed.

General rules are:

- 1D plots of 1D functions/data: no (default) argument *\*i\** suffices
- 2D plots of 2D functions/data: no (default) argument *\*i\** suffices
- 3D plots of 2D functions/data: use *\*i\** = 3
- 3D plots of 3D functions/data: use *\*i\** = 4 (results might be worse than default Mathematica color functions, possibly due to lack of surface normal mapping)

```
ContourPlot[Sin[x] Sin[y], {x, 0, 2 Pi},
{y, 0, 2 Pi}, ColorFunction -> ColorMapSuite["davos"]]
```



### 3.13 MatLab

#### 3.13.1 .mat format)

Load the colour map into MatLab, either by adding the .mat file to the MatLab search path and using the command:

```
load('davos.mat');
```

or by specifying the full file path to the .mat file:

```
load('~\work\Colormaps\davos.mat');
```

Then use it, for example, with:

```
figure(1)
colormap(davos)
colorbar
```

#### 3.13.2 File-exchange app

A convenient MatLab package provided by Chad Greene containing the full scientific colour-map suite is available on [MatLab file exchange](#).

### 3.14 Ncview

#### 3.14.1 .ncmap format

The colour map .ncmap files can live in the following places:

1. `NCVIEW_LIB_DIR`, which is determined at installation time. A reasonable choice is `/usr/local/lib/ncview`.
2. In a directory named by the environmental variable `NCVIEWBASE`.
3. If there is no environmental variable `NCVIEWBASE`, then in `$HOME`.
4. In the current working directory.

Then when you open Ncview, it should automatically have all of the colour maps available.

### 3.15 OpendTect

For Import to OpendTect follow these steps:

1. Download the OpendTect package by Kaspar Merz from [this direct link](#) or via the separate link on [www.fabiocrameri.ch/colourmaps](http://www.fabiocrameri.ch/colourmaps) under the section "Usable with:"
2. Click on **Survey/Manage/ColorTables...**
3. Click on **Import...**
4. Select **file**; navigate to directory and open this file
5. Select desired colour maps
6. Import

### 3.16 Originlab

#### 3.16.1 .pal format

To use the .pal colour map files in the Originlab software, download the external package from [www.fabiocrameri.ch/colourmaps](http://www.fabiocrameri.ch/colourmaps) or via the direct [link](#). The .PAL files can then be copied to the

origin palette folder and used similarly to the Originlab default color palettes.

### 3.17 Paraview

#### 3.17.1 .xml format

Using Scientific colour maps in Paraview is done via the following procedure:

Click **Edit** color map panel. Once the colour map settings open, click the folder with the heart (i.e., **Choose Preset**), then **Import**, and then choose the PARAVIEW.xml format (e.g., **batlow\_PARAVIEW.xml**). The colour map is now loaded and saved in Paraview, so one can now simply search for the colour map name (e.g., **batlow**) in the search field for the colour maps. Click on the desired colour map and hit **Apply**.

### 3.18 Petrel

#### 3.18.1 .alut format

To import colour maps, select the **templates** pane and **colour tables** folder.

Then select the folder to import into (or insert a new folder) and right click **import on selection**.

Select **colour tables (alut files) (\*.alut)** to view and select all suitable colour maps for import.

Accept default settings **trim colour control points** and **trim opacity control points** and finally use as any other colour table within Petrel.

### 3.19 Photoshop

#### 3.19.1 .grd format

The .grd format to read into Photoshop provided by Steven Reddy can be found at: [www.geoscienceatomprobe.org/downloads.html](http://www.geoscienceatomprobe.org/downloads.html)

### 3.20 Plotly

#### 3.20.1 .py format

Plotly versions of the Scientific colour maps are provided by Emilia are available at <https://github.com/empet/scientific-colorscales>.

The plotly Scientific colour maps (see the file **scicolorscales.py**) were created by converting the provided .py file of each colour map.

Direct applications and some scientific tests are illustrated in this Jupyter Notebook: <http://nbviewer.jupyter.org/github/empet/scientific-colorscales/blob/master/Tests-for-scientific-colorscales.ipynb>.

## 3.21 Python

### 3.21.1 Package (pip and anaconda)

The convenient python package, <https://pypi.org/project/cmcrameri/>, by Callum Rollo is available through pip and anaconda.

Install with pip:

```
pip install cmcrameri
```

Install with conda:

```
conda config --add channels conda-forge
conda install cmcrameri
```

Usage example:

```
from cmcrameri import cm
import matplotlib.pyplot as plt
import numpy as np
x = np.linspace(0, 100, 100)[None, :]
plt.imshow(x, aspect='auto', cmap=cm.batlow) # or any other colourmap
plt.axis('off')
plt.show()
```

### 3.21.2 init file

A simple init file located in `ScientificColourMaps6/+TOOLS/` can be used to make the whole suite of colour maps readily available in python: Place the `__init__.py` file in the main directory `ScientificColourMaps7/` and update your PYTHONPATH environment like this:

(for linux/bash)

```
export PYTHONPATH=$PYTHONPATH:/full/path/to/ScientificColourMaps7/
```

Then, in any python, you can import the palette collection, by using `import ScientificColourMaps7` as `SCM7`, which allows for example commands like

```
plt.imshow(some_data, cmap=SCM7.berlin)      # Linear palette
plt.imshow(some_data, cmap=SCM7.berlin_r)    # Reversed, linear
plt.imshow(some_data, cmap=SCM7.berlin25_r)  # Reversed, 25 steps, discrete
```

### 3.21.3 .txt format

#### Step 1: Load colour-map data

Load the colour-map data into Python using `numpy.loadtxt()`:

```
import numpy as np
cm_data = np.loadtxt("lapaz.txt")
```

#### Step 2: Set up colour map

Use `matplotlib.colors.LinearSegmentedColormap()` to create a colour map that can be used with matplotlib.

```
from matplotlib.colors import LinearSegmentedColormap
lapaz_map = LinearSegmentedColormap.from_list(?lapaz?, cm_data)
```

### Complete example:

```
import numpy as np
import matplotlib.pyplot as plt
from matplotlib.colors import LinearSegmentedColormap

cm_data = np.loadtxt("lapaz_RGB(0-1).txt")
lapaz_map = LinearSegmentedColormap.from_list(?lapaz?, cm_data)

x = np.linspace(0, 100, 100)[None, :]
plt.imshow(x, aspect=?auto?, cmap=lapaz_map)
plt.axis(?off?)
plt.show()
```

#### 3.21.4 palettable library

The [palettable library](#) provides the Scientific colour maps (and other scientifically-derived colour maps) in a convenient way for use with e.g., matplotlib. Palettable is available on PyPI for installation via pip: `pip install palettable`. Palettable is compatible with Python 2.6, 2.7, and Python 3. For more instructions see [here](#).

## 3.22 QGIS

#### 3.22.1 .xml format

Load the colour map into QGIS in:

```
Settings > Style manager > Import/Export > Import symbol(s)
> select the xxx_QGIS.xml file.
```

## 3.23 R

#### 3.23.1 scico package

'[scico](https://travis-ci.org/thomasp85/scico)' (<https://travis-ci.org/thomasp85/scico>) – pronounced as “psycho” – is a small package developed by Thomas Lin Pedersen that provides access to the Scientific colour maps within R. It provides colour palettes for 'ggplot2') without requiring 'ggplot2' to be installed.

[scico](#) can be installed from CRAN with `install.packages('scico')`. If you want the development version then install directly from GitHub:

```
# install.packages("devtools")
devtools::install_github("thomasp85/scico")
```

For further details and user instructions are included in a README file within '[scico](#)'.

## 3.24 SKUA-GOCAD

#### 3.24.1 .xcmap format

To import a colormap into a SKUA-GOCAD project, navigate to `File > Import > GOCAD Resources > Colormaps`.

Alternatively, for advanced users, to include a colormap as a resource in all new projects, insert the .xcmap text into the \*colormaps.xml\* file located in \*/Gocad/lib/app-defaults.

### 3.25 VisIt

#### 3.25.1 .ct format

The file davos.ct can be imported to VisIt by placing the .ct file in the .visit directory, which can be found on macOS under e.g.,:

```
/Applications/VisIt.app/Contents/Resources/ ...  
... 2.12.3/darwin-x86_64/resources/colortables
```

The colour map should appear in the built-in list after VisIt has been restarted.

## 4 Software with built-in versions

- [GMT](#) 6.0 and later
- [TopoToolbox](#) 2.2 and later
- [StagLab](#) 3.0 and later
- [SubMachine](#)
- [Geoscience ANALYST](#) 2.80 and later
- [Igor Pro](#) 9.0 and later
- [XMapTools](#) 3.4.2 and later
- [KDE LabPlot](#) 2.9 and later

## 5 References

Included colour-map diagnostics are based on:

**Kovesi (2015)**, Good Colour Maps: How to Design Them, CoRR, abs/1509.03700, <http://arxiv.org/abs/1509.03700>\* and related MatLab functions available at <https://www.peterkovesi.com/matlabfns/index.html#colour>.

For further details see:

**Crameri, F. (2018)**, Geodynamic diagnostics, scientific visualisation and StagLab 3.0, *Geosci. Model Dev.*, 11, 2541-2562, [doi:10.5194/gmd-11-2541-2018](https://doi.org/10.5194/gmd-11-2541-2018)

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

## 6 Version history

- Version 1 : Original colour-map suite (*bilbao, broc, cork, davos, devon, grayC, lajolla, oslo, vik*)
- Version 2 : Additional colour-map file formats (.ct, .py, .svg)
- Version 3 : Additional colour-map file format (.txt)
- Dark background palettes (*berlin, lisbon, tofino*)
- Additional sequential palettes (*lapaz, tokyo, turku*)
- Surface topography special palette (*oleron*)
- Seismic tomography special palette (*roma*)
- Version 4 : Additional sequential palettes (*acton, bamako, buda, hawaii, imola, nuuk*)
- Scientific rainbow palette (*batlow*)
- Additional colour-map file formats (xmlQGIS, .clr)
- Version 5 : **Discrete colour maps** (e.g., *batlow10*)
- Improved perceptual uniformity of the original (v1) palettes
- Minor colour adjustment to vik

Additional colour-map file formats (.alut, .ct, .lut, .ncmap, .pal, .spk, .xcmap)

Version 6 : **Categorical colour maps** (*batlowS, devonS, davosS, osloS, lapazS, actonS, lajollaS, bilbaoS, grayCS, tokyoS, turkuS, bamakoS, nuukS, hawaiiS, budaS, imolaS*)

**Cyclic colour maps** (*romaO, brocO, corkO, vikO*)

Improved colour-map diagnostics for perceptual uniformity

Additional colour-map file formats (.clm)

Improved User guide

Change to MIT License

Version 7 : Additional diverging palettes (**bam**, **vanimo**)

Additional cyclic palette (**bamO**)

Additional multi-sequential palettes (**bukavu**, **fes**)

**batlowW**: batlow with white ending

**batlowK**: batlow with black ending

*cork*: Improved lightness symmetry

*roma*: Improved lightness symmetry

More formats (e.g., .pal for OriginLab)

Updated `__init__.py` to flip colour gradients by Tobias Staal

New Python package by Callum Rollo

Colour map type and class flow chart

## 7 License

### **The Scientific colour maps are licensed under a [MIT License](#)**

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