IPCC Visual Style Guide
for WGI Authors

Updated June 2022

IPCC WGI Technical Support Unit

ipcc

INTERGOVERNMENTAL PANEL ON **climate change**

Working Group I (WGI) - The Physical Science Basis

An IPCC Visual Style Guide
for
the Working Group I Authors

Creating engaging, user-friendly and understandable data visualisations to convey complex scientific information is a core part of the IPCC's commitment to making scientific knowledge about climate change more accessible to wider audiences.

This document, prepared by the IPCC Working Group I (WGI) Technical Support Unit (TSU), provides guidelines to Authors on preparing data visualisations for the Working Group I contribution to the Sixth Assessment Cycle (AR6). More than just recommendations, this document contains additional guidance that supports your outreach activities after the report approval. It is an updated version of the IPCC's visual style guide from AR5, adapted to include recommendations from cognitive scientists[1] and information designers[2] on creating compelling data visualisations while retaining all aspects of scientific integrity. The guidelines have been widely inspired by research led by Dr Jordan Harold from the University of East Anglia and the Tyndall Centre for Climate Change Research[3,4,5]. The research was supported by the Norwegian Environment Agency and the High-End cLimate Impacts and eXtremes (HELIX Climate) project. These guidelines also convey concepts and tools that were developped by InfoDesignLab[2] and used when co-designing the visuals in the AR6 Working Group I summary for policymakers. This guide also contains general formatting rules and principles that will ensure your figures are consistent with IPCC style and appropriate for use in print and online.

As much as possible, IPCC WGI Authors should aim to apply this style guide from the beginning of their design process. Not only will this keep a consistent and harmonized visual style across the WGI AR6 chapters but also help you create visualisations where your readers can clearly understand the message that you want communicated from your data.

This is an updated version (June 2022) of the initial visual stye guide initially published in December 2018.

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[1] University of East Anglia and Tyndall Centre for Climate Change Research, https://tyndall.ac.uk/datavisuals

[2] InfoDesignLab, an information design firm specialised on visualising science https://infodesignlab.com/

[3] Harold, J., Lorenzoni, I., Coventry, K.R., & Minns, A. (2017). Enhancing the accessibility of climate change data visuals: Recommendations to the IPCC and guidance for researchers. Report published by the Tyndall Centre for Climate Change Research, Norwich, UK.

[4] Harold, J., Lorenzoni, I., Shipley, T. F., & Coventry, K. R. (2016). Cognitive and psychological science insights to improve climate change data visualization. Nature Climate Change, 6, 1080-1089.

[5] http://guidance.climatesciencecognition.com/

AT A GLANCE - What this guide covers

The **M.A.D.E** principle of good visual design

The basic elements of good visual design are encapsulated by the **M.A.D.E** principle - **M**essage, **A**udience, **D**esign, **E**valuation. Developed from cognitive and psychological evidence, these four elements are essential to keep in mind when visualizing complex scientific data.

Message ———• Does the visual communicate a clear message?

Audience ———• Is the visual appropriate for the intended audience(s)?

Design ———• Does the visual use evidence-based design principles?

E valuation —• Has the visual been tested with the audience(s)?

Before thinking of how your visual should look like...

Ask yourself these questions

• What **message** do I want to convey? what is the one (or two) thing you want people to remember out of your data?

• Who is **my audience** and what is my audience's prior knowledge?

• What **information** is essential to communicate the message to my audience in a rigorous, transparent and exhaustive way?

WHO ARE THE IPCC'S AUDIENCES?

The primary target audiences of IPCC are governments and policymakers.
Broader audiences are the United Nations, IPCC observer organizations, the scientific community, educators, non-governmental organizations (NGOs), the business and finance sector and the wider public.

Keep in mind that each individual has their own

• Level of existing knowledge

• Way of thinking

• Landmarks in terms of graphics

• Information needs

Each of the IPCC assessment products has an expected audience:

Assessment report ——➤ expert audience (scientists/researcher in the field)

Technical summary ——➤ non-expert audience with technical knowledge

STEP 1 - Start with your message

Write down, with plain language and as concisely as you can, the main message you want your readers to take away from your figure. We refer to this as 'the intent' of your visual.

The intent is the core message(s) that the figure communicates visually to the reader. It is the goal that the figure aims to achieve. It holds in one sentence and does not share more than two key messages – or the visual will become too complex. The intent is conveyed by the visual presentation of the data and should be apparent to readers when they look at the figure. The intent is not set in stone: it can evolve and be refined during the design process of your figure. However, it serves as a focus throughout the figure drafting process that avoids an over complication of the figures purpose.

This is an **intent**
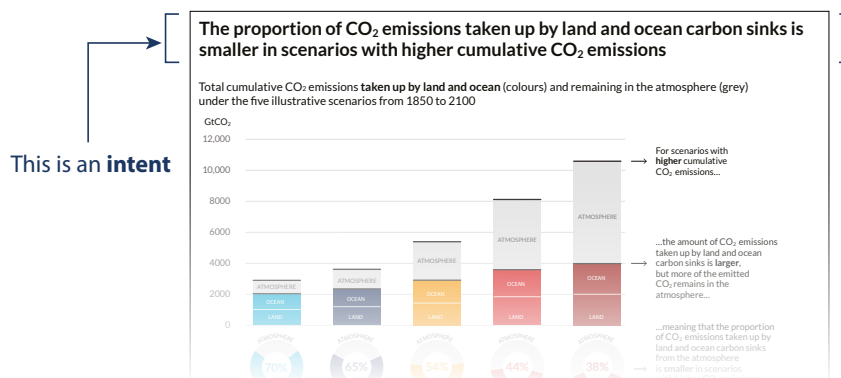
To make your figure even clearer, you can use the intent as a title at the top of your visual. This was done for *all* the visuals in the AR6 WGI Summary for Policymakers

Figure SPM.7, AR6 WGI Summary for Policymakers

Your intent is a benchmark for evaluating your design choices and how effective your visual is in communicating your intended message. You should always refer back to this intent throughout the design process. This can be done by testing prototypes of your visual at different development stages with representatives of your target audience. You can check if the messages they take away from it match what you intended - and use this feedback to improve your figure. You should expect to make several iterations during the design process.
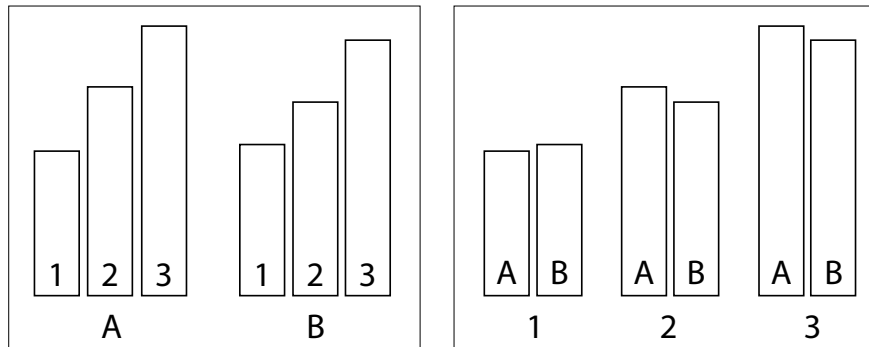
The left and right-hand visuals illustrated above show the same data in different layouts. If, for example, your main message is that there are subtle differences between A and B in the data then the right-hand visual conveys this message more clearly than the left-hand visual

Adapted from Harold et al., 2017

DESIGN TOOLS FROM AR6 WGI CO-DESIGN PROCESS

The visuals from the AR6 WGI Summary for Policymakers were developed through a co-design[6] process involving IPCC authors, information designers, cognitive scientists and the end users (IPCC country delegates and observer organisations). In this context, some key design concepts for figures were developed to have a common understanding and vision between the different parties (e.g., authors and designers). They were used to identify and resolve any visual barriers in the figure that prevent readers from understanding the intent of the figure.

Clear INTENT

The key message you aim to communicate with the figure.

Clear HIERARCHY of the INFORMATION

The hierarchy of information refers to which data variables are included and how they are organised in the figure (e.g. in panels, tables, in which order etc.) to visually communicate the intent clearly.

Clear VISUAL NARRATIVE

This is the use of design and cognive principles, color, typography, layout and annotations to create a final figure where the intent is immediately apparent and understandable for the intended audience.

Adapted from InfoDesignLab https://infodesignlab.com/

[6] Morelli, A., et al. Co-designing engaging and accessible data visualisations: a case study of the IPCC reports. Climatic Change 168, 26 (2021). https://doi.org/10.1007/s10584-021-03171-4

Where possible, choose a visual format that your audience is familiar with. This will help them grasp how the data are structured and move quickly to the main message[7,8].

If you use an unfamiliar data format, consider helping the reader by building up information and/or guiding them through. Could you use multiple panels? Is there a logical order in which they should view the information?

In general, making sure the hierarchy of the information is clear is crucial. The layering of information and the sequence of panels should bring the reader to 'see' the intent. A well-designed figure is recognized by the clarity of its message and readability. Avoid any features that might confuse and distort a reader's interpretation.

Before | a. | b. | c.

After (information sequentially built up)
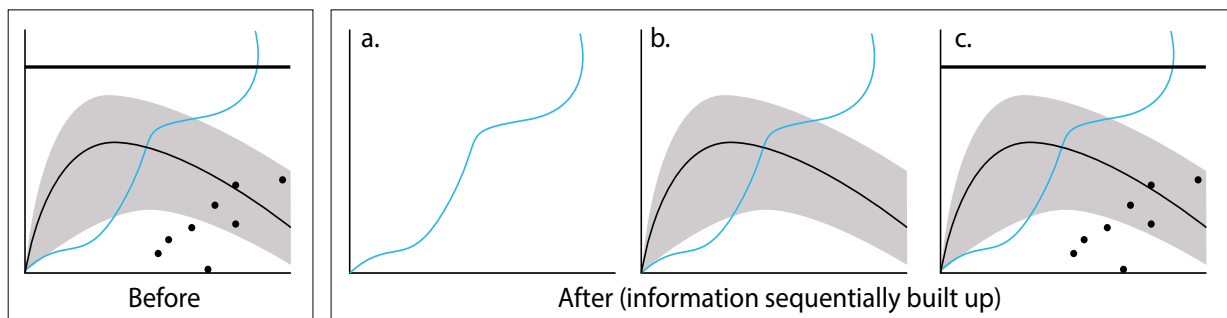
Grouping information into visual chunks can support readers in making relevant inferences about the data.

Adapted from Harold et al., 2017

Also, keep in mind that a reader's comprehension can be influenced by widely-accepted visual metaphors and by their observations of the physical world. Consider these examples:
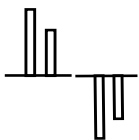
Up tends to be associated with good, down with bad.

Colours often come with intuitive perceptions (see Step 3, page 8)

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[7] Zacks, J., Levy, E., Tversky, B., & Schiano, D. (2002). Graphs in print. In Anderson, M., Meyer, B., & Olivier, P. (Eds). Diagrammatic Representation and Reasoning (pp. 187-206). London, Springer

[8] Gołębiowska, I. (2015). Legend layouts for thematic maps: A case study integrating usability metrics with the thinking aloud method. The Cartographic Journal, 52(1), 28-40

Vertical arrangement can give a stronger sense of positive/negative. Horizontal bars may work better for variables that have a horizontal element (i.e. distance).

N.B: In some situations however, horizontal bars can be preferable to vertical bars, to enable text labels to be legible and appear as horizontal text.

Your visual has to be designed in its intended size from the start to avoid any post-editing and production issues. Please design figures to display in either single-column (9 cm) or double-column (18 cm) width and avoid them being wider than double-column or taller than 22 cm.

Width
Either single-column (9 cm) or double-column (18 cm) wide

Height
Max. 22 cm
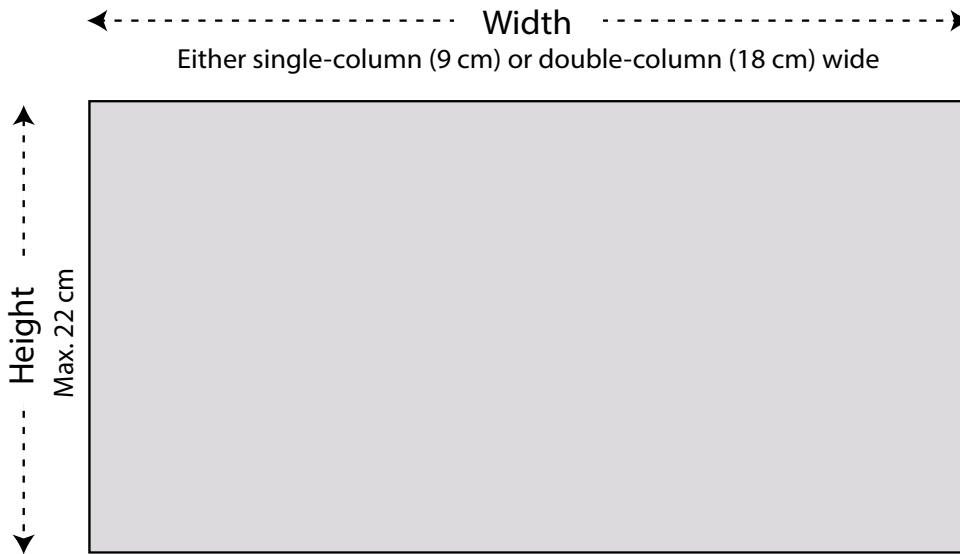
STEP 3 - Which colours to use

Use of colour can be very effective for adding clarity or emphasis to a figure. However, colour should always be used with care. Colours are expected to convey an information (e.g. data, visual cue) rather than make the figure 'nice'. An overly colourful graph can hinder a reader's comprehension and lead to unintended interpretations.

A few points to bear in mind

- Question your choices: What is the purpose of using this colour in this specific place or for this data? Does it enhance your message? For more on this, see the discussion on the use of the rainbow scale (Box #endrainbow on page 8-9).

- Be aware of specific cultural interpretations as well as common perceptions. Red tends to infer warmth, danger or a "stop" signal while blue is associated with cold and water. Green tends to be associated with nature and "go" signal while yellow-brown tones can be associated with dryness. A darker colour tends to indicate "more" of a quantity. Although exceptions to these tendencies can be found across different cultures.

- When it comes to seeing colours, some colours are percieved differently by people. Colour blindness also known as colour vision deficiency, is the decreased ability to see colour or differences in colour.

- Colours displayed on your screen may not be preserved when printed or photocopying (see page 12).

#ENDRAINBOW

Even with effective colour cues, your figure can be misunderstood and be rendered illegible to colour blind readers through a poor choice of colour scale.

The most commonly used « rainbow» colour scale is a good example of misleading data visualisation and should be avoided for the following reasons:

- **A percieved gradient that does not match the underlying data**

https://www.climate-lab-book.ac.uk/2016/why-rainbow-colour-scales-can-be-misleading/
Figure by Sean Davis
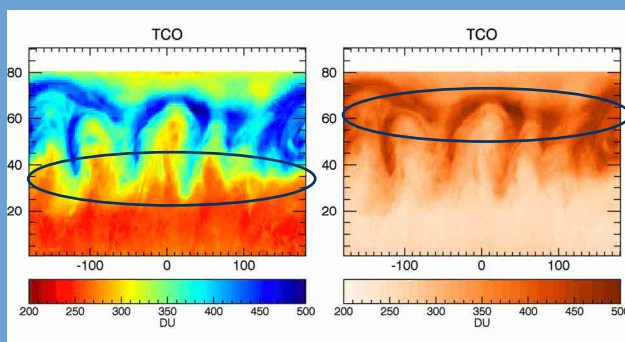
Sharp colour changes (i.e. red/yellow/green/blue) create apparent boundaries that are not necessarily present in the data.
Because yellow is the brightest colour of the palette, it will stand out and create the illusion of a front where there is none and minimize the actual front.

An unsuitable palette for colour blind vision

Rainbow colours when together are not easily distinguished by colour blind readers (i.e. red/green, magenta/turquoise) and may lead to distorted perceptions of the data and altered meaning.
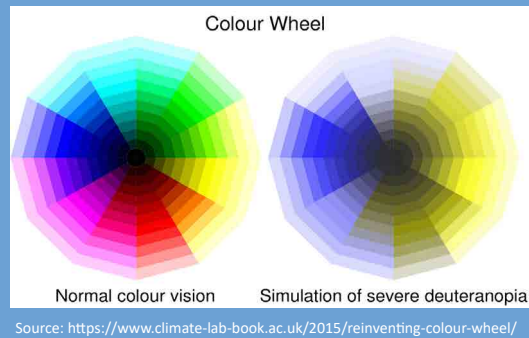
Colour Wheel

Normal colour vision   Simulation of severe deuteranopia

Source: https://www.climate-lab-book.ac.uk/2015/reinventing-colour-wheel/

For standard formats (e.g. line graphs, maps) and for visualisation of the Representative Concentration Pathways (RCPs) and socio-economic pathways (SSP), please follow the IPCC's colour palettes displayed below. These colour guides have been developed to be accessible for readers with common forms of colour blindness. Online tools[9] can help you check what your graphic will look like to someone who is colour blind.

Line and bar charts

For line and bar graphs, please use the colours below in the order in which they appear. The order can be skipped if your variable matches the culturally accepted perception of one of the colour below (i.e. «blue» for water masses, «green» for biomass, see Step 2 on page 6). This selection is adapted for accessibility from previous IPCC Visual Identity Guidelines (AR5).

1 colour	R	G	B	C	M	Y	K	2 colours	R	G	B	C	M	Y	K	3 colours	R	G	B	C	M	Y	K
	0	0	0	91	79	62	97		0	0	0	91	79	62	97		0	0	0	91	79	62	97
									112	160	205	60	28	6	0		112	160	205	60	28	6	0
																	196	121	0	19	55	100	9

4 colours	R	G	B	C	M	Y	K	5 colours	R	G	B	C	M	Y	K	6 colours	R	G	B	C	M	Y	K
	0	0	0	91	79	62	97		0	0	0	91	79	62	97		0	0	0	91	79	62	97
	112	160	205	60	28	6	0		112	160	205	60	28	6	0		112	160	205	60	28	6	0
	196	121	0	19	55	100	9		196	121	0	19	55	100	9		196	121	0	19	55	100	9
	178	178	178	0	0	0	30		178	178	178	0	0	0	30		178	178	178	0	0	0	30
									0	52	102	100	82	35	21		0	52	102	100	82	35	21
																	0	79	0	89	42	100	45

- Representative Concentration Pathways (RCPs) and Socio-economic Pathways (SSPs) -

RCP	Line	R	G	B	C	M	Y	K
8.5		149	27	30	10	95	96	28
6.0		196	121	0	13	51	100	5
4.5		84	146	205	70	30	0	0
2.6		0	173	207	78	3	11	0

SSPs	Line	R	G	B	C	M	Y	K
SSP5-8.5		149	27	30	10	95	96	28
SSP3-7.0		231	29	37	0	96	94	0
SSP2-4.5		247	148	32	0	45	95	0
SSP1-2.6		23	60	102	100	76	21	15
SSP1-1.9		0	173	207	78	3	11	0

Note: these are the SSPs used by AR6 WGI. For colour palettes extended to more SSPs, please consult with Working Group III TSU

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[9] Color Oracle https://colororacle.org/

Maps

Diverging data

To represent data diverging from a central value, such as temperature change/anomaly, it is best to use two contrasting hues, where the central value is represented by a light colour and an increase in colour darkness either way indicates a more positive or negative value. Please note that multi-hue sequences in general will not render properly in black and white photocopy or print. Also, note that further divisions within the scheme that go beyond 11 colours lead to a set of adjacent colours that are hard to distinguish from each other[10].

For any other variables, coordinating choices with your co-authors on common styles and colours will help a reader navigate seamlessly through your chapter. Alternatively, contact the Technical Support Unit (TSU) for advice.

Non-diverging data

When your data is not divergent and you want to order your data from low to high, use the sequential schemes with a gradient effect from light (i.e. low values) to dark (i.e. high values) colours.
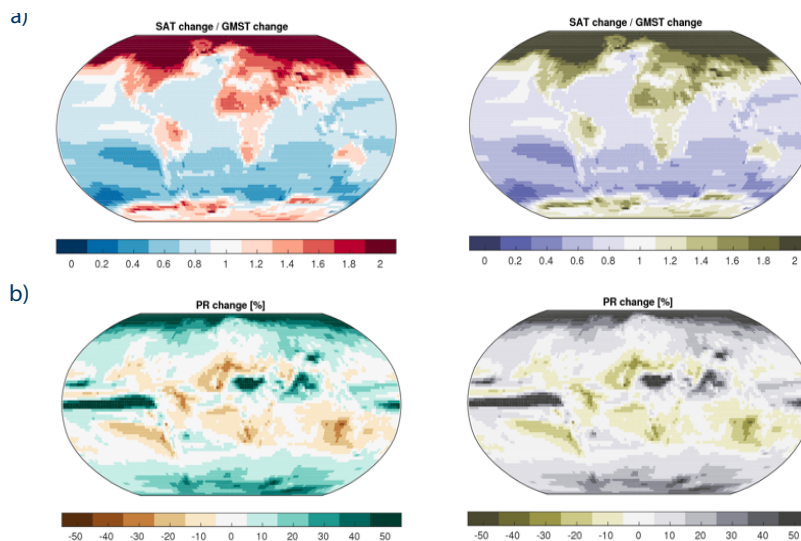
The images on the left are examples of (a) temperature and (b) precipitation maps using the IPCC colour palette. The images on the right are how a severely (deuteranope) colour blind person would see them.

When applicable, chose the colour that intuitively represents the most your variable (e.g. blue for «water», green for «biomass», red for «temperature»). If you decide to use more than one colour scheme in your figure, do not use blue/purple or green/red together as this combination is not distinguishable for colour blind vision, specially for divergent schemes.

All palettes proposed are colour-blind friendly, are perceptually uniform and ordered to represent data both fairly, without visual distortion, and intuitively.[11,12]

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[10] Mark Harrower & Cynthia A. Brewer (2003) ColorBrewer.org, DOI: 10.1179/000870403235002042

[11] Crameri, F. (2018a), Scientific colour-maps. Zenodo. DOI: 10.5281/zenodo.1243862

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

Schemes in the table below are available in two format:

- A continuous/gradual formats (full gradient) that allows you to define the amount of steps you wish (RGB files retrievable through this link), but we recommend to not exceed 10 steps each side, as neighbouring colours become hard to distinguish beyond this amount.

- A discrete/distinct format that provides the corresponding colours in the gradient at a given amount of steps (RGB files retrievable through this link). Visual examples on how colour gradients are perceived depending on the amount of steps are available through this link).

All corresponding colour RGB files (.xlsx and .txt) are available in the IPCC WGI github repository[13]. Continuous formats are available by directly clicking on the name files in the table below. We strongly encourage you to use these colour palettes for consistency accross chapters. Shall you need different combinations of colours, you can explore the work from Fabio Crameri or Cynthia brewer, from whom most of the colour schemes proposed below are taken from.

Variable	Type	Colour gradient	Continuous	Discrete	Reference[14,15]
Temperature (atmosphere, ocean, etc)	divergent		temp_div.txt	temp_div_disc.txt	Color Brewer
	sequential		temp_seq.txt	temp_seq_disc.txt	Lajolla by Fabio Crameri
Precipitation (inc. rainfall, P-E, etc)	divergent		prec_div.txt	prec_div_disc.txt	Color Brewer
	sequential		prec_seq.txt	prec_seq_disc.txt	custom
Wind (Curl, speed, etc)	divergent		wind_div.txt	wind_div_disc.txt	Cork by Fabio Crameri
	sequential		wind_seq.txt	wind_seq_disc.txt	Speed from Matplotlib cmocean
Cryosphere (Ice/ snow/glacier area/ cover/ extent/ mass, etc)	divergent		cryo_div.txt	cryo_div_disc.txt	Broc by Fabio Crameri
	sequential		cryo_seq.txt	cryo_seq_disc.txt	Oslo by Fabio Crameri
CO_2/CH_4/aerosols (emissions,concentrations budget, flux, etc)	divergent		chem_div.txt	chem_div_disc.txt	Color Brewer
	sequential		chem_seq.txt	chem_seq_disc.txt	Tokyo by Fabio Crameri
Sea level (sea surface height, sea level rise, etc)	divergent		slev_div.txt	slev_div_disc.txt	Custom
	sequential		slev_seq.txt	slev_seq_disc.txt	Davos (reversed) by Fabio Crameri
Other variables	divergent		misc_div.txt	misc_div_disc.txt	Custom
Other variables (e.g. salinity, pH, %, etc)	sequential		misc_seq_1.txt	misc_seq_1_disc.txt	Imola by Fabio Crameri
Other variables (e.g. mixed layer depth, density, sea level pressure)	sequential		misc_seq_2.txt	misc_seq_2_disc.txt	Dense from Matplotlib cmocean
To replace rainbow colour map	sequential		misc_seq_3.txt	misc_seq_3_disc.txt	Batlow from Fabio Crameri

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[13] https://github.com/IPCC-WG1/colormaps
[14] Copyright (c) 2019, Fabio Crameri All rights reserved.
[15] Copyright (c) 2002 Cynthia Brewer, Mark Harrower and the Pennsylvania State University

If you are dealing with qualitative data, using contrasting colours allows to clearly separate the different categories. We suggest you to use the same colour schemes as proposed for line and bar charts on page 9 as they are accessible for colour blind vision and black/white printing.

Choose the right colour mode

The colours you see on your computer monitor and in a printed image are based on two different colour mixing systems. Digital devices create colours with the RGB (Red Green Blue) method while professional printers apply mostly the CMYK (Cyan Magenta Yellow Black) system. RGB mode covers a wider colour range than CMYK, which results in tone and brightness differences between the printed version of a figure and its digital rendering on screen.

RGB
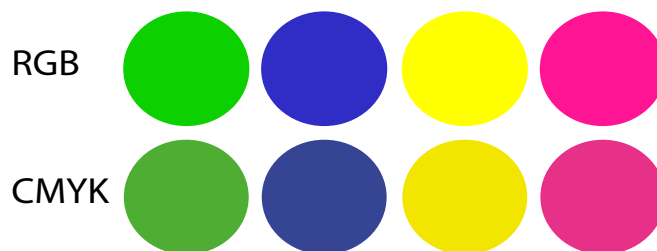
CMYK

N.B: when printed, this figure displays no difference between both colour modes as the printer automatically converts RGB into CMYK. To see the difference, please check on screen the PDF file of the Visual Style Guide.

As a rule of thumb, figures to be displayed on screens (web, Powerpoint) should be formatted in RGB. Those intended for printing should be formatted in CMYK. Modern printers can convert RGB files into CMYK automatically but some colour accuracy will be lost during the printing.

For IPCC purposes and if supported by your software, please design and submit your figures to the TSU in CMYK format, with an additional version converted into RGB (Step 12 on page 21). If you are working with black and grey shades only, you can save your figure in greyscale mode.

STEP 4 - Formatting text and axes

For IPCC purposes, please use sans-serif fonts (Arial, preferably - note that Arial narrow is the closest to the official IPCC's font, Frutiger) for any text within graphics. Avoid bold, italic or underlined text. Except for Y-axis title, avoid rotating text through 90°, wherever possible[16]. In general, use 9 pt font size for text on smaller panels (single-column wide) and 11 pt font size for larger panels (double-column wide).

Please keep axes black and use a line thickness of 0.5 pt. All axes should be clearly labelled with the quantity being represented, including its unit in parenthesis (not square brackets) e.g., temperature change (°C).

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[16] Evergreen, S. D. H. (2014). Presenting Data Effectively: Communicating Your Findings for Maximum Impact. London, Sage.

If your title contains chemical formulae, use majuscules and subscript numbers (i.e. CH_4) and specify the chemical name first (see Step 7 on page 15). For powers (i.e. m^3), use superscript numbers. The X and Y axes should have a neat intersection and cover the full range of values. If your Y axis goes below zero, you can place a horizontal line on the chart to indicate the zero level.

If your figure is composed of several graphics, ask yourself if any of the axes are redundant and if they could be combined to facilitate comparison between the variables. If the Y-axes cannot be combined, try to keep the same scale, where possible. Consider dual axis charts only when comparing two data sets with different measures.
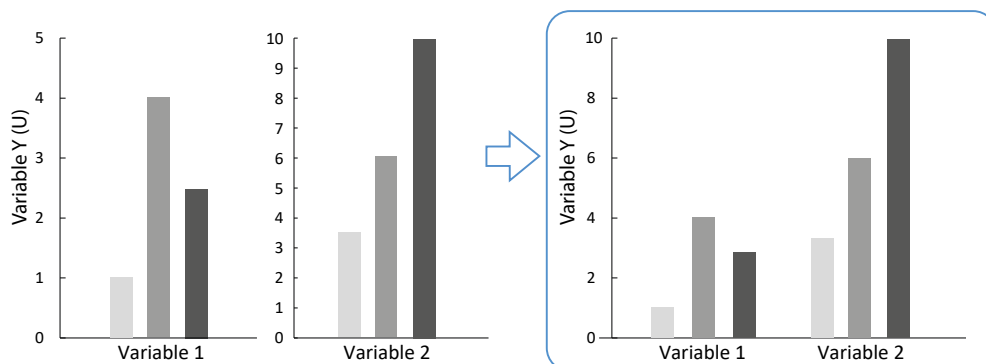
Combining two charts into one facilitates the comparision between variables and unclutters the figure. Note, however, that in this specific example, small differences in variable 1 are then harder to detect. The choice of your design comes always down to the message you want to convey.

Using tick marks can facilitate a reader's understanding. However, too many can be distracting. Use major tick marks for linear scales and add minor ones for logarithmic scales. Place them on the outside edges of your axes.

Adding a grid can help relate the data to the axis tick marks and compare absolute values. However, use grids only when they facilitate your audience ability to grasp your message. In this respect, use transparency or grey for these lines, depending on the density of your data. Also, chose a transparent/white background for the plane and do not frame the graph.

STEP 5 - Legends and colour bars

A reader will typically look back and forth continuously between the data and the legend to make sense of a graphic. Integrating annotations and labels in the graphic rather than putting them in a separate legend can help a reader match up information with the relevant part of the visual (Step 7 on page 15)[17]. But it is important not to make the visual too busy. Include only annotations that are essential to communicate your message and avoid 'visual clutter' that may impair understanding. If adding annotations brings too much unnecessary complexity, use a legend.

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[17] Tufte, E. R. (2006) Beautiful Evidence. Cheshire, Connecticut, Graphics Press.
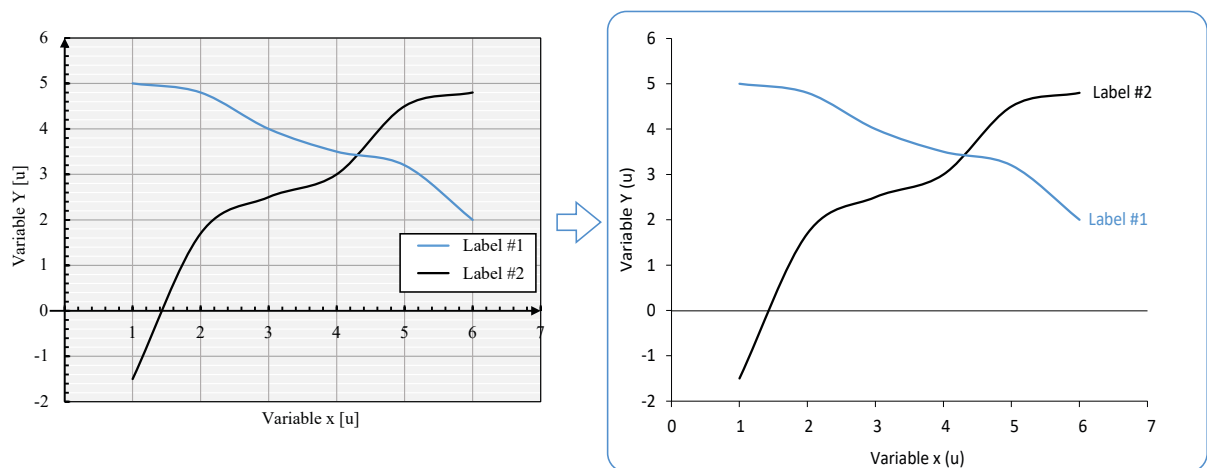
If using a legend or colour bar, locate it clearly on the figure. You can use a bounding box (0.5 line thickness, black) to distinguish it from surrounding elements. If there is sufficient white space within a plot area, move the legend/colour bar there rather than using additional space below or to the side of the figure. This will liberate space that you can use for the graph itself.
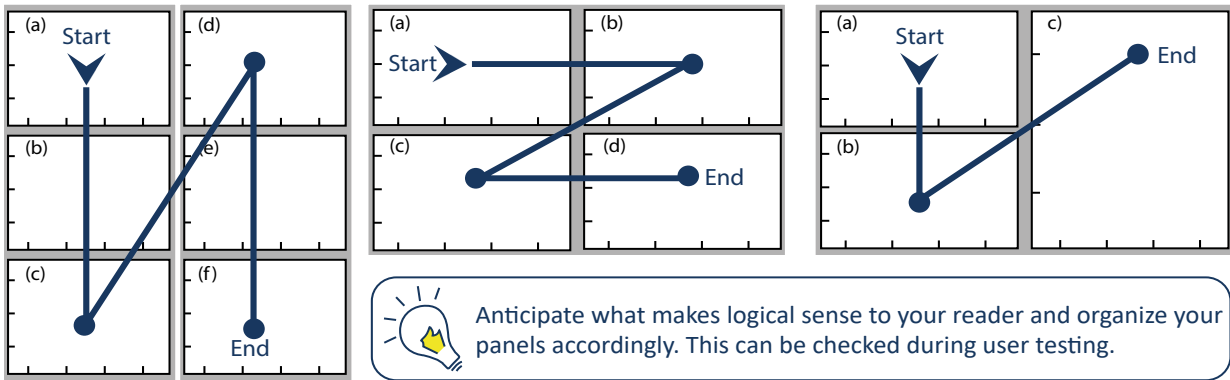
Please ensure colour bars are at an appropriate size and that all relevant units and scales are given. Any colours or symbols on a map that are not in the colour bar should be explained in the caption or the figure itself (e.g. grey shading, patterns, white areas). To choose which colour to use, please refer to Step 3 on page 8.

STEP 6 - Size, positioning and numbering

As mentioned in Step 2, your visual should be designed in its intended size to avoid any post-editing and production issues. When submitting your final visual, dimensions should be either single-column (9 cm) or double-column (18 cm) wide and maximum 22 cm high. If you need to resize your visual to meet the layout requirements stated above, ensure all information remains legible and that font sizes and line thicknesses do not fall below the minimum requirement of 9 pt and 0.5 pt, respectively.

Figures should be numbered consecutively, using the chapter number as a prefix (e.g., "Figure 5.1", "Figure 5.2", …). For figures in boxes or part of an FAQ, please include the Box/FAQ number and restart the figure numbering from 1 (e.g. "Box 5.1, Figure 1"; "FAQ 5.1, Figure 1").

Multiple panels should always be labelled "(a)", "(b)", "(c)" (e.g., "Figure 5.2a", "Figure 5.2b"…). Remember to refer to them this way within the caption too. As long as it does not interfere with your data, place the label at the upper left corner of each panel. Think where the reader's eyes will naturally go and order the panels accordingly.

Anticipate what makes logical sense to your reader and organize your panels accordingly. This can be checked during user testing.

STEP 7 - Using labels and annotations

Try to avoid jargon when labelling visuals, wherever possible[18], specially in IPCC products intended for a non-experts audience (see Box page 3-4). Avoiding unfamiliar acronyms and abbreviations and using lay terms in place of technical jargon as far as possible will help make your figure accessible for different audiences.

Where a technical term is used that your intended audience might not understand, try to explain its meaning in the visual rather than assume readers will know where to look it up. Spell out an acronym on first use and give the shortened version in brackets. After that, use the abbreviated form only.
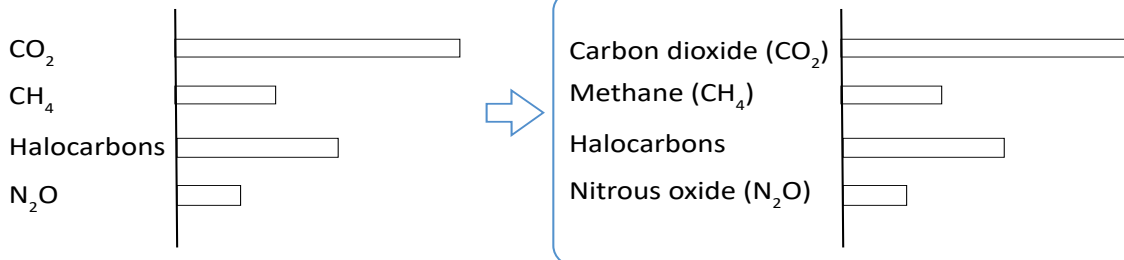
Unfamiliar acronyms and abbreviations can aleniate readers, because they require the reader to locate and interpret their meaning.

Adapted from Harold et al., 2017

Annotations are short text labels embedded directly in a graphic to add clarity, to lead a reader through different sequential elements or to highlight a specific aspect of your key message. Always place annotations close to the element of interest to avoid splitting a reader's attention.

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[18] Hales, A. H., Williams, K. D., & Rector, J. (2017). Alienating the audience: How abbreviations hamper scientific communication. Association for Psychological Science Observer, 30(2), 22-24.

Following a few simple cognitive and perceptual design techniques can help direct readers' visual attention in a way that enhances their understanding of the data and of the message you are trying to convey. Using contrasting colours or sizes can highlight were a reader should focus their attention (i.e. bright or dark colour for the most salient information and soft/grey colour for the rest).[19] Visually link connected information by grouping data together or using the same colour for an annotation and the data it refers to (Step 5 on page 13). Arrows can also help direct visual attention.

When using such visual cues, think about the 'visual hierarchy' of your figure (see Box on page 5). Readers do not look at visual in the same way they read a text, linearly. They can choose their own path. Make sure the hierarchy of the information is clear. Which elements do you want a reader to see first (see Step 2 on page 6 - building up the information)? Which features should be kept in the background as supporting elements? You do not want the reader to be distracted.

from your key message. For this reason, you could also consider using a different line thickness or transparency/grey level compared to your data.

The production rate of A is the highest among the tested group.
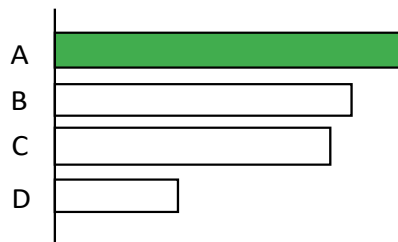
Contrast in colour can direct reader's visual attention. Matching elements, e.g. text and data.

Adapted from Harold et al., 2017

REPRESENTING UNCERTAINTY AND CONFIDENCE

It is important to convey uncertainty and confidence in your visual as this is often an inherent part of the outcome of your assessment. Think carefully about different ways to do this - and preferably test them out on your target audience. There is no one-size-fits-all rule and different formats will be appropriate in different contexts. For example,

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[19] Kosslyn, S. M. (1989). Understanding charts and graphs. Applied Cognitive Psychology, 3(3), 185-225

you could use an error bar, a shaded range or patterns (diagonal lines, dots) on top of the color layer which represents your data.[20] Consider whether adding short text labels could help a reader understand how uncertainties should be interpreted.

To represent uncertainty on maps, an updated approach that develops on the previous cycle was established for this 6th assessment cycle. The approach is described in the Cross-Chapter Box Atlas.1 starting page 1945 of the AR6 WGI Atlas chapter.

Five visual representations of uncertainty/confidence
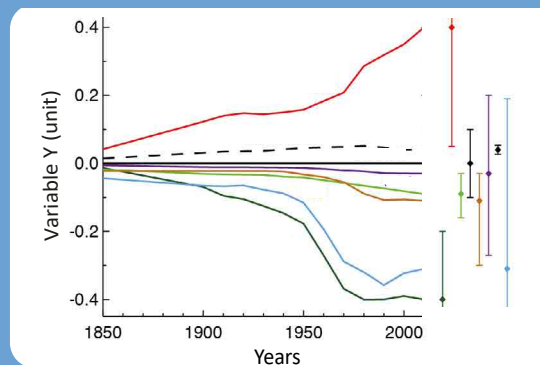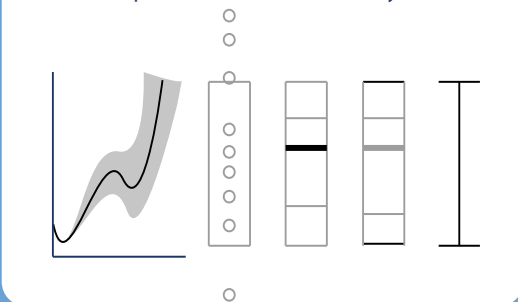
There is no single 'correct' way to represent uncertainties in data. Be aware, however, that different representations may affect interpretation differently in different audiences.

Harold et al., 2017

Variable Y (unit)

Adapted from Figure 8.8, WGI AR5.

Representing uncertainty outside of the x/y plane can unclutter the graphic and present all information in a clear way.

STEP 9 - Create a caption

Captions should be as concise as possible, explaining only what is needed to understand the graphic (e.g., lines, symbols, shading, colours, etc.). As with many scientific journals, we recommend captions of 250 words or less, where possible. Make sure that the caption starts right after the figure on the same page. Ideally, it should fit fully on this same page.

Captions should be able to act as a standalone explanation of a figure, giving the reader the information they need to understand the message and what stands in the figure. They should not just be a technical description that leaves the reader to make sense of the information for themselves. Neither should they provide extensive scientific interpretation, which is usually better placed in the main text. Consider which elements could be integrated into the figure itself, to help a reader match up information with the relevant part of the visual (Steps 5 on page 13 and Step 7 on page 15). These include variable names, units, time period, spacial coverage, etc. For more information on IPCC WGI Figure caption guidelines, please refer to page 8 of the AR6 Working Group I FAIR Supplementary Material.[21]

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[20] Retchless, D.P. and C.A. Brewer, 2016: Guidance for representing uncertainty on global temperature change maps. International Journal of Climatology, 36(3), 1143–1159, doi:10.1002/joc.4408
[21] DOI 10.5281/zenodo.645113

You can think of the first sentence of the caption as an overarching title of the figure. The aim is to clarify upfront what the main message of the figure is, it helps readability. The caption should include the sources of the underlying data. Any references cited in figure captions has to be included in the reference list of the chapter.

DESIGNING GRAPHICS IN THE SUMMARY FOR POLICYMAKERS

The Summary for Policymakers (SPM) is a distillation of the most policy-relevant findings from an IPCC report, and is often the highest-profile and most-read part. More so than the graphics in the underlying chapters, those in the SPM will need to be easily understood and convey a core message concisely and engagingly.

Think carefully about your audience.

Engaging with a user is a powerful technique to dive into the needs of your audience. Rather than constructing a fictitious profile in your head of an average person representing your audience, get in touch with one or two people that could potentially belong to this audience, interview them and understand their needs in relation to the information you have to communicate. In the context of the SPM, engaging with the audience is done through the official review process but also through additionnal activities such as the user testing and in-depth conversations with volunteering IPCC country delegations and observer organisations.

Identify the intent and the peak of your story.

Building on from the 'visual hierarchy' of your figure, think carefully about your core message, the peak of your visual journey, that you should be able to summarize in no more than one sentence (i.e. the intent, see Step 1 on page 4 and Box on page 5). Once this peak is set, consider what information is essential to understand the core message and build the visual elements around this to support your readers' understanding. The 'intent' is used alongside the drafting of the SPM headline statements to communicate clearly the key findings of the SPM in a coherent narrative.

Headings, subheadings, annotations, arrangement of the visual elements on the page, colour and visual cues can direct the visual attention and provide explanation when readers need it.
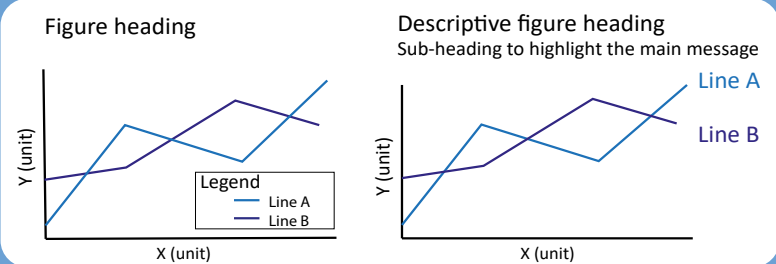
When a visual and associated text are separated, visual attention is split. Readers need to exert more cognitive effort and the risk of comprehension difficulties increases.

Adapted from Harold et al., 2017

How things are perceived visually affects how things are understood.

You should be aware that the way you organize or group different elements on a page or computer screen carries meaning and is an important visual affect. The Gestalt Principles of Visual Perceptions can help identify which elements in your visualisation are necessary and which might be noise.

STEP 10 - Testing on your audience

Ideally, test early versions of your figure on your target audience. If that is not possible, test it with people who have a similar level of prior knowledge to your audience. Avoid testing successive versions on the same person. It is better to get a fresh perspective each time.

A simple way to test your graphic is to ask people what they think is the main message and see if their interpretations match what you intended. More rigorous testing, such as eye-tracking, can help diagnose the reasons for comprehension problems, but these are unlikely to be necessary in most cases. Contact the TSU for more information about audience testing.

1. Plan your visual using the guidance

2. Create your visual

Iterative design cycle

3. Test your visual
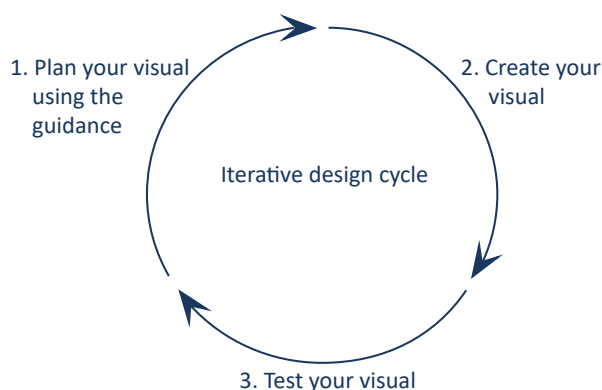
Peoples' intuitions of what constitutes an effective design for a visual don't always match what people find easiest to understand.

Adapted from Harold et al., 2017

STEP 11 - Metadata and code

What lies behind your figure and how it was created is not necessarily obvious to your audience when reading the report. The provision of the metadata, the underlying code, and data management can help enhance transparency on how your figure was generated, and can facilitate the reproducibility and accessibility to the figure and data.

For the management and curation of the data and codes underpinning the visuals, IPCC follows the implementation of FAIR (Findable, Accessible, Interoperable, Reusable) data principles and

best practices[22]. The goal is to increase transparency and accessibility of the assessment, and allow the reproduction of visuals. The material (the metadata, code used to develop the figure and data) will be stored in an open source repository (for example GitHub), open to scrutiny by the scientific community and the general public. It will be also made available alongside the figure on the report website.

In addition to data and codes, for your adapted, redrawn or original figures, we ask Authors to supply the following information

- Contact information of the responsible author

- Software used to generate the figure

- Design software used to edit the figure

- How was the figure adapted from the original

- Copyright weaver and citation (if adapted or redrawn figure)

- Intendes size

The information is stored in an online figure manager, managed by the TSU. At every drafting stage, you should also upload the figure files there. This will facilitate direct design support from the TSU, help identify at a glance gaps and overlaps across and within chapters, and ultimately keep track of the history of the development of the visual until the very final draft. Although some information are only needed for the final government draft (e.g. copyright wavers, softwares), we recommend you to start gathering this information from the start.

USING FIGURES FROM OTHER PUBLICATIONS

In general, developping your own graphics that match your text is preferable to reproducing figures from published articles. In cases where you do use somebody else's figure, please ensure you obtain copyright permission from the copyright holder or the adapted or reproduced figure and send it to the TSU (see copyright flowchart on page 26). Failing to obtain the correct copyright permission could result in plagerism and even prosecution.

Where possible, try to obtain graphics files (.eps, vector pdf) from the authors of the original publication. Please do not extract the figures from the article using the print screen key or the snapshot tool on Adobe as this will result in poor quality raster files. If you have a vector editor such as Adobe Illustrator or Inkscape (an open access, free software), you can extract the graphics in vector format, provided it was embedded as such in the original pdf article. If these options are not possible, it is usually best to recreate the graphics yourself or contact the relevant TSU for advice.

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[22] Anna Pirani, et al. (2022). The implementation of FAIR data principles in the IPCC AR6 assessment process. Zenodo. https://doi.org/10.5281/zenodo.6504469

STEP 12 - File formats and submitting your figures

For IPCC purposes, please generate standard 2-D plots, contour plots, bar charts, etc. as an encapsulated postscript (EPS) or PDF files using the original graphics/ visualisation software (e.g., MATLAB, Python, R, IDL, GrADS, etc). For schematics and illustrations, please use a vector-based drawing program such as Adobe Illustrator, Adobe InDesign or Corel Draw and save in .eps, vector pdf or .ai format. If you don't have access to any of the paid software, you can use Inkscape[23], a free graphics editor. Avoid creating graphics with raster-based software designed for pixel images, such as Adobe Photoshop and Microsoft Paint, unless absolutely necessary. Please submit these files in the online Figure Manager (see Step 11 page 20).

If you are designing a figure that displays both photos and schematics together, please make sure the photo is embedded in your vector design as a TIFF format with a minimum resolution of 350 pixels per inch (ppi). The photo should not be vectorized. Saving such figures as PDF will ensure both raster and vector objects are retained. Where it is necessary to create a fixed size pixel image, please save it at resolution of at least 350 ppi.

For all drafts (First Order Draft, Second Order Draft, Final Government Distribution), place easily readable versions of each figure in a Word document and submit it separately to the chapter text. Since Word does not read EPS files, embed the figures as .jpg with an acceptable resolution to avoid large file size. The figure file should be ordered as the figures appear in the chapter, with one figure per page and the caption immediately below.

For the Final Government Distribution of an IPCC report, the TSU will require figures submitted individually as .eps or vector PDF format. Please make sure all files are in CMYK mode. The TSU will also require versions of the figures for publishing online. Please export your .eps and .pdf figures (RGB mode) into .jpg or .png format. It is very important to have the figure in its intended size (see Step 2 on page 7) before setting the resolution and saving the file.

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[23] https://inkscape.org/en/

THE ABC OF IMAGE FILE FORMATS

There are two main types of image files:
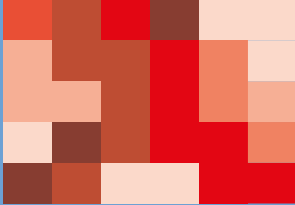
Raster (or Bitmap) figures, in which the visual information is encoded in a grid of pixels, where each pixel is a colour. The higher the amount of pixels, the sharper the image. A scanned figure or a photo taken with a digital camera will be automatically saved as a raster image.
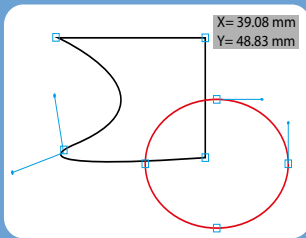
Vector figures, in which the visual information is encoded in a series of vectors describing shapes and colours and is therefore mathematical by nature. A vector image can be converted into raster without losing visual information. This is not the case when vectorizing a raster image.

Both file types have their strengths and weaknesses. Good quality raster graphic files are generally larger than their vector counterpart and cannot be modified or edited.

In addition, raster files are affected by resolution, as opposed to vector images. This means that when rescaling the original can result in a jagged or pixelated image. Vector format, on the other hand, is not suitable for complex images such as high-resolution photographs, where preserving the colour information is crucial.

Because vector images are composed of lines and shapes, in which color and placement are calculated by mathematical formulas, they can be sized, scaled and modified repeatedly without losing sharpness. They are therefore ideal format for illustrations, graphs and line art.
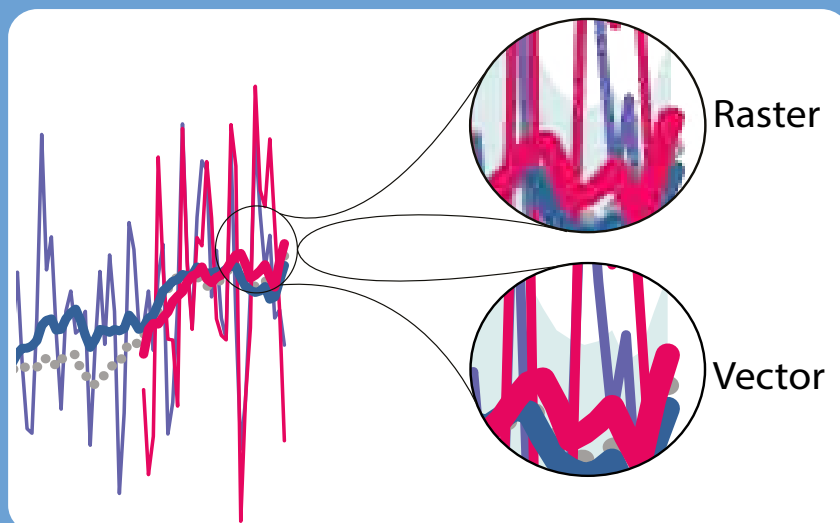
Graphic adapted from IPCC AR5 Chapter 3

WHAT NEXT? Animate and present your figures

Using your figures in a presentation

Avoid transferring a figure exactly as it appears on paper into your presentation slides. The way the audience interacts with it will be different: the figure will be bigger on screen but the audience has less time to look at it, and there is no option to zoom in.

Think about modifying your figure for a presentation as follow

- Simplify the design to emphasize the key message.

- Remove any details that are not necessary to understand your message or that you'll be mentioning orally.

- Avoid too many annotations (your voice will do the work) and use design features that is easy to refer to (e.g. the dashed line, the yellow circle)

- Make the graphic elements (lines, fonts, dashes) thicker and larger so that your audience can see them from a distance.

- Guide your audience through your graph by using simple animations in your slides.
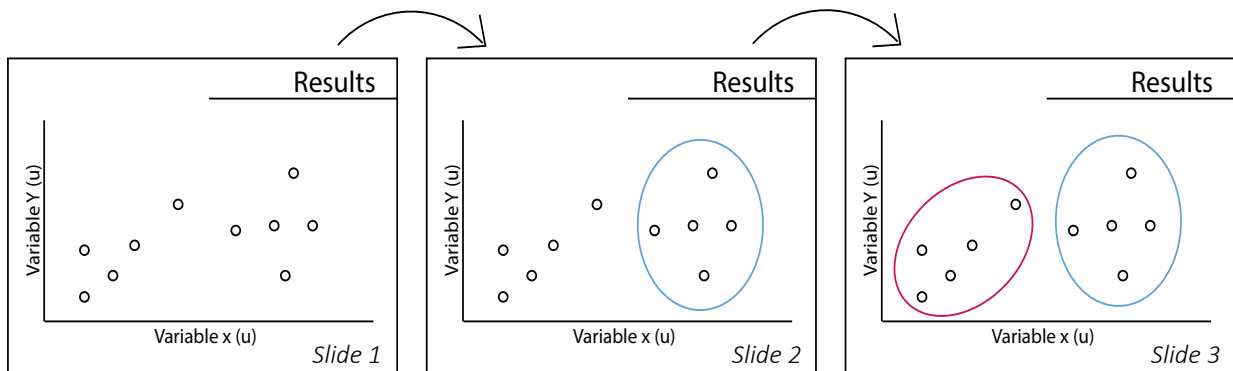
Creating animations

For presentations and online use, animating your figure or making it interactive can enhance the message you are trying to convey. In other cases, however, it might impair a reader's understanding. Ask yourself whether creating an animated or interactive visual will strengthen your message or whether a series of carefully crafted static visuals might be more effective[24].

[24] Tversky, B., Morrison, J. B., & Betrancourt, M. (2002). Animation: Can it facilitate? International Journal of human-Computer Studies, 57(4), 247-262

If you do choose to produce an animation, aim to give the reader control over playback (stop/start) and the speed of animation[25], and use an intuitive or familiar interface. If your animation is not controllable by the user, keep the length to a few seconds.

Small multiples (sequences of static visuals) may work better than animations

Provide users controls for animation

Animated visuals can be difficult to comprehend if they are too complex or move too quickly for the reader, because information can be difficult to accurately perceive.

Animations tend to work better with a narration than with written text. Using an embedded audio file of a recorded voice alongside animated graphs during presentations can be effective. Consider adding cues to signal where the audience's attention should be focused.

Do not over-complicate. It is better to animate few elements in a subtle and simple way. Presentation softwares usually have simple animation tools to guide your audience through your graphics and build up the information. Just as for static graphics, consider testing early prototypes of your animations and refining them based on the feedback.

[25] Betrancourt, M. (2005). The animation and interactivity principles in multimedia learning. In Mayer, R. E. (Ed.) The Cambridge Handbook of Multimedia Learning (pp. 287–296). Cambridge, Cambridge University Press

Summary flowchart

C R E A T E

S A V E

S U B M I T

Is this your own figure? —— No —— • Obtain copyright proof for TSU
• Ask the original authors for the vector file

Yes

See p. 3 —→ • Apply the M.A.D.E principle
• Create your figure in its intended size for the report (9 cm or 18 cm wide and max. 22 cm high)
See p. 7-11 —→ • Use the RGB/CMYK colour palettes provided in this style guide
• Check additional colour choices are suitable for colourblindness
• Use plain sans-serif fonts (e.g., 'Arial narrow' rather than 'Times New Roman')
See p. 12 —→ • Avoid bold, italic or underlined text
• Use font size 9 pt for small figures and 11 pt for large figures
• Axis line thickness is 0.5 pt
See p. 12-14 —→ • Check your labels, annotations and axis title

Does your figure contain a photo? —— Yes —— Embed the photo in your vector design as a TIFF, resolution of 350 ppi as a minimum

No

Is it for print or for web?

Print

Web

• Set your colour space to CMYK
• Resolution (for raster only): 350 ppi

What to upload on the figure manager? (see p. 20-21)

• Set your colour space to RGB

For animated figures

FOD[1] • All figures in a word doc as JPG at acceptable resolution

• Upload vector and png files to the figure manager and indicate responsible author

SOD[2] • All figures in a word doc as JPG at acceptable resolution

• Upload vector and png files in the figure manager

FGD[3] • All figures in a word doc as JPG at acceptable resolution

• Upload vector and png files in the figure manager
• Upload all remaining information (e.g. figure intended size, copyright, etc.)

• JPG (RGB mode)   • mp4 (HD)

[1] First Order Draft, [2] Second Order Draft, [3] Final Government Distribution

Are you re-using an already existing figure?

Yes   **No**

Permission may be required   Permission not required

Are you the author of the already published figure?

Yes   **No**

Where is the figure from

I am the author of the existing figure
If you wish to reuse a figure that was originally created by yourself or a co-author and that has been previously published elsewhere, it will depend on the original publisher's policy whether permission is required or not. Some publishers allow authors to reuse their own work, some do not. you will need to check with the original publisher who will let you know if permission is needed.

I have adapted the figure based on the original one
When a figure has been redrawn or modified that does not mean permission is no longer needed. Copyright protects against copying so unless the new figure has not been significantly changed from the original, you will most likely need permission. You will need to check with the original publisher.

Not published elsewhere previously
If the figure has been reused but has not been previously published you will need to seek permission from the original author where possible

Journal/Book
If the figure has been taken from another journal or book then you will need the publisher's permission in order to reuse it. In most cases, permission can be obtained by going to the article's page online and clicking on a link for permissions or copyright. Otherwise permissions can be obtained through RightsLink

Open Access
If a figure comes from an open access (OA) article you will still need to cite it correctly in your reference list and your figure captions, including the name of the OA license applied. Permis-sion is not required if an article was published under either the CCBY (CC = Creative Common) or CC BY-SA licence, citation will still be needed. Any other OA licence means you will need to check with the publisher to obtain permission. Because IOP Publishing is a commercial entity, permission will still be needed for OA papers with any of the following licences: CC BY-NC, CC BY-NC-SA, CC BY-NC-ND, CC BY-ND. This should be stated on the publisher's website.

Flowchart adapted from:
http://publishingsupport.iopscience.iop.org/wp-content/uploads/2017/11/Flowchart-journalsV4.sds_.pdf