Visualising the Results of ESA's Climate Change Initiative

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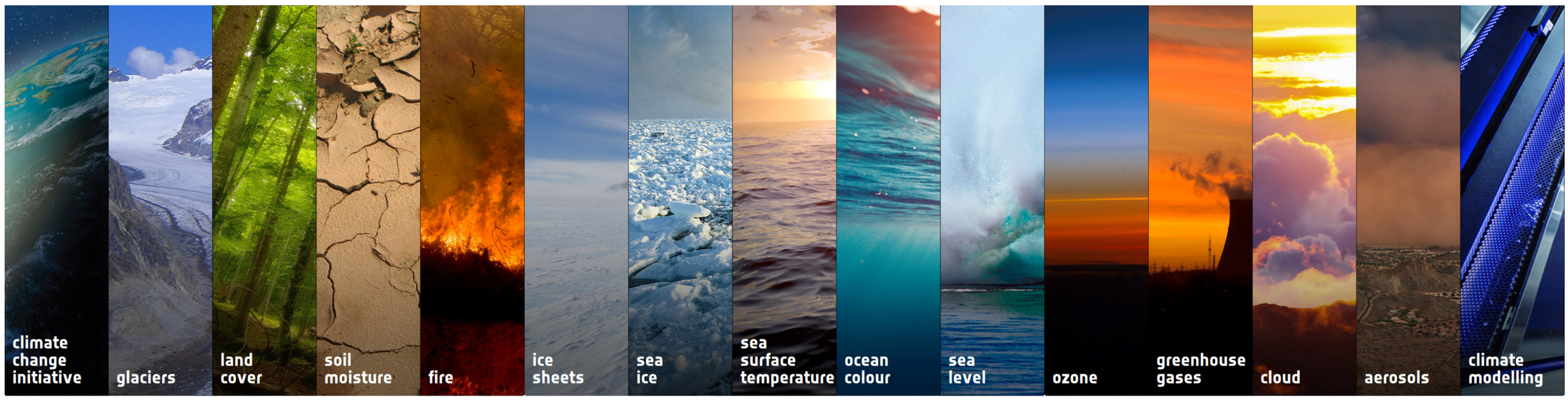


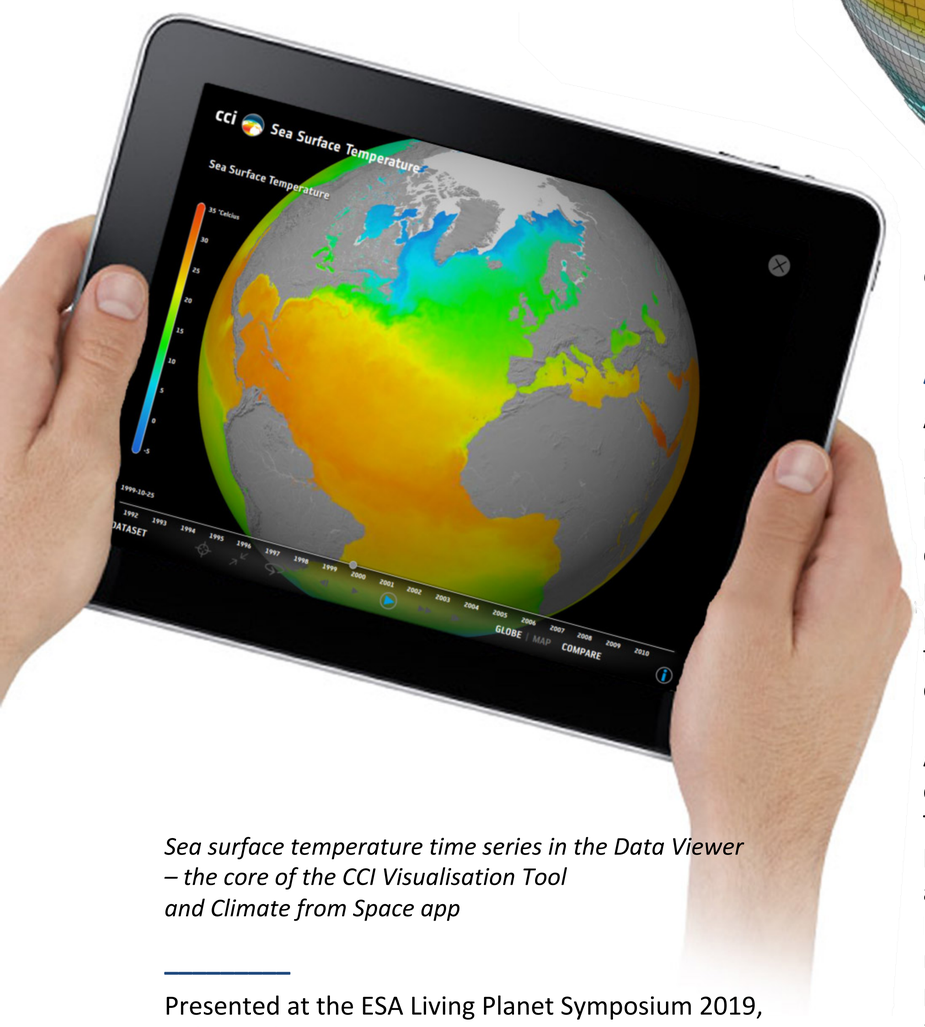
Introduction

Data visualisation software and content has been developed to promote ESA's Climate Change Initiative (CCI) [1] to a broad audience, from scientists to the general public. In the spirit of open science, a novel approach has been applied to put the CCI's results – the evidence of climate change – directly into the hands of decision-makers and the public, using linear and interactive 3D graphics, on desktop computers, tablet devices and the web. Two software products have been developed, with a common interactive graphics engine, and a series of computer graphic animations.

CCI Visualisation Tool

The *CCI Visualisation Tool* is an interactive exhibit, for macOS and Windows, aimed at scientists, project managers, policymakers and other stakeholders. An interactive Data Viewer allows playback of up to 40 years of global satellite observations on a virtual 3D globe or a traditional flat map, and comparison between selected datasets. Care was taken to follow data visualisation best practice, including using perceptual colour schemes [2] that are both intuitive, so easy to understand, and distinct, to aid comparison of related variables [3], and a consistent set of unobtrusive background maps. The data are presented with short explanatory texts and supporting illustrations such as photos, satellite images, diagrams, graphs and animations, as well as headline facts and figures.

The *Visualisation Tool* has been exhibited at 26 scientific, intergovernmental and public conferences, including the Paris Air Show, the UN Climate Conferences (COP 2015-18), the European Geosciences Union (EGU), the American Geophysical Union (AGU), and ESA's Living Planet Symposia (LPS 2013, 2016, 2019).

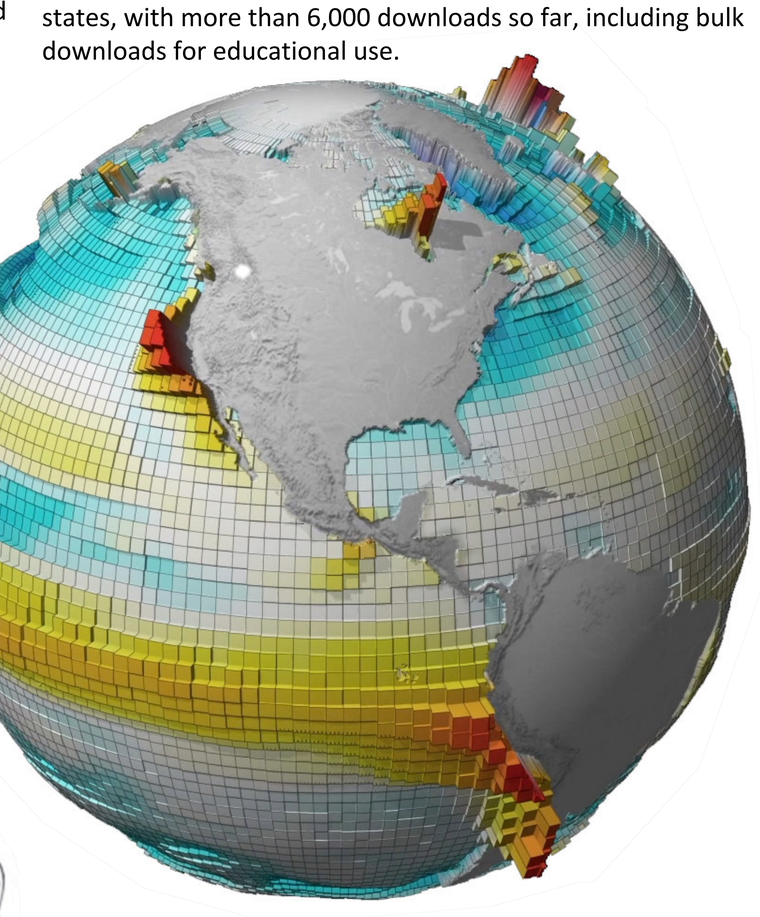


Sea surface temperature time series in the Data Viewer – the core of the CCI Visualisation Tool and Climate from Space app

Climate from Space

The digital book app, *Climate from Space*, builds on the *Visualisation Tool* with a more user-friendly interface and rich text and image content on tablet platforms for the general public. As well as putting the CCI's results literally at the user's fingertips, 16,000 words of text place the work in scientific and societal context. A narrative approach [4] has been followed to engage the reader with creative storytelling that relates each of the CCI's climate variables to real-life experience. Rather than talking about abstract data, these stories are about the air we breathe, the sea we swim in, and the mountains we climb. The text is richly illustrated with eye-catching satellite images, photos, diagrams, video interviews, animations and links to the Data Viewer.

Climate from Space is available for iPad and Android tablets as a free download from the Apple and Amazon app stores. The app has been downloaded to all but two of ESA's 22 member states, with more than 6,000 downloads so far, including bulk downloads for educational use.



Carbon dioxide air-sea flux from CCI Climate Modelling User Group

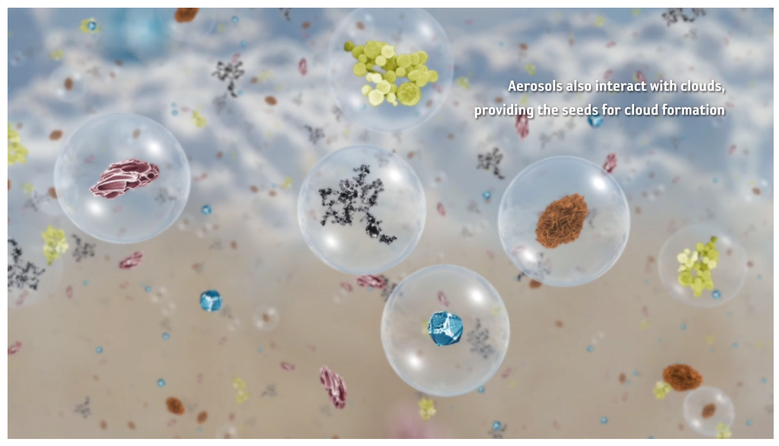
Animations

A series of ten linear computer graphic animations show multiple climate variables together and explain how they interact to form parts of the Earth system. Aimed primarily at a non-technical audience, these animations present unfamiliar data in an engaging and meaningful way. They use a photorealistic natural colour view of the Earth and, where possible, simple visual metaphors, such as transparency rather than pseudocolour, to engage the viewer emotionally and convey meaning more effectively.

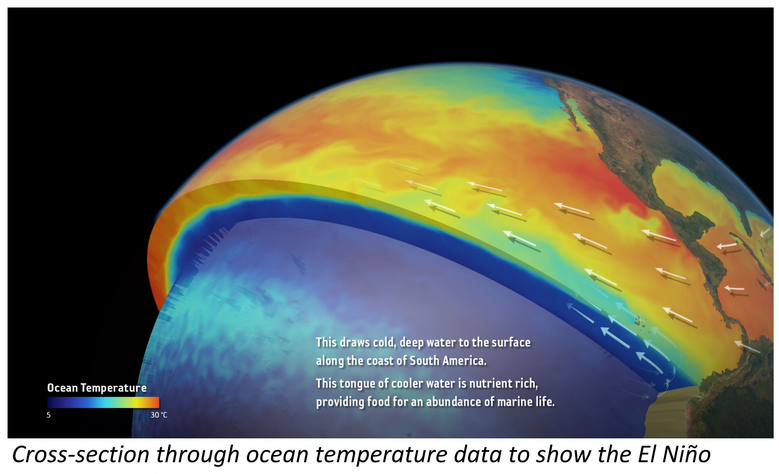
A narrative approach is again used to present the data in context [5], resulting in 2-4 minute visual short stories. Traditional computer graphics techniques are used to show human-scale and microscopic processes, such as carbon absorption in the ocean, bringing the data 'alive' for the viewer. Natural sounds and visual effects, such as lens flare, add realism. The animations have been incorporated into the project's two software products and published on ESA's web and social media channels, where they have been viewed more than 36,000 times.

Further Work

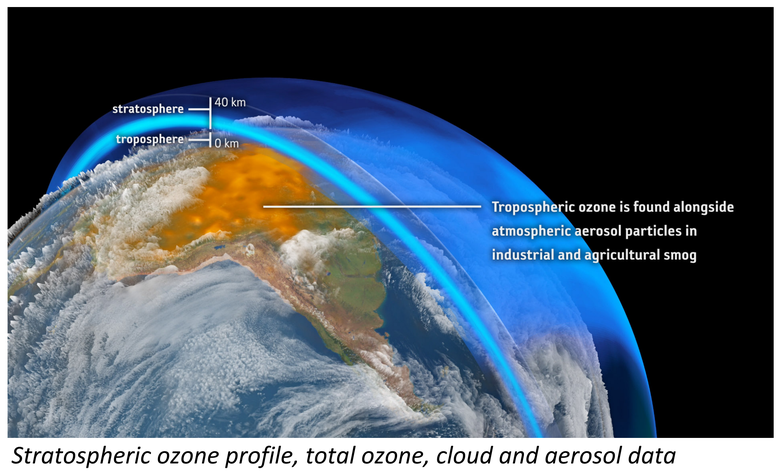
The project has successfully promoted the purpose and achievements of the Climate Change Initiative, helping to secure support for the work to continue for a further five years as CCI+. The CCI+ Knowledge Exchange activity will broaden access with a web implementation of *Climate from Space* and content tailored for educational use in multiple languages. The narrative approach will be extended, with the content structure being story-based, rather than climate variable project-based, and taking advantage of new tools for geodata storytelling, exemplified by *Google Earth Voyager* and ESRI's *ArcGIS StoryMaps*.



Animation stills: Aerosols seeding cloud formation



Cross-section through ocean temperature data to show the El Niño Southern Oscillation



Stratospheric ozone profile, total ozone, cloud and aerosol data

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[3] Phipps, M. & Rowe, S. (2010). Seeing Satellite Data, *Public Understanding of Science* **19** (3) 311-321

[4] Dahlstrom, M. F. (2014). Using Narratives and Storytelling to Communicate Science with Nonexpert Audiences, *Proc. National Academy of Sciences* **111** (Supplement 4) 13614-13620

[5] Eales, P., Wayne, A., Tildsley, K. M., Wilkinson, T., Fernandez Prieto, D. (2013). Presenting Data and Telling Stories, *Proceedings of ESA Living Planet Symposium*, Edinburgh, UK, 9-13 September 2013.

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