



PLANETARY  
VISIONS

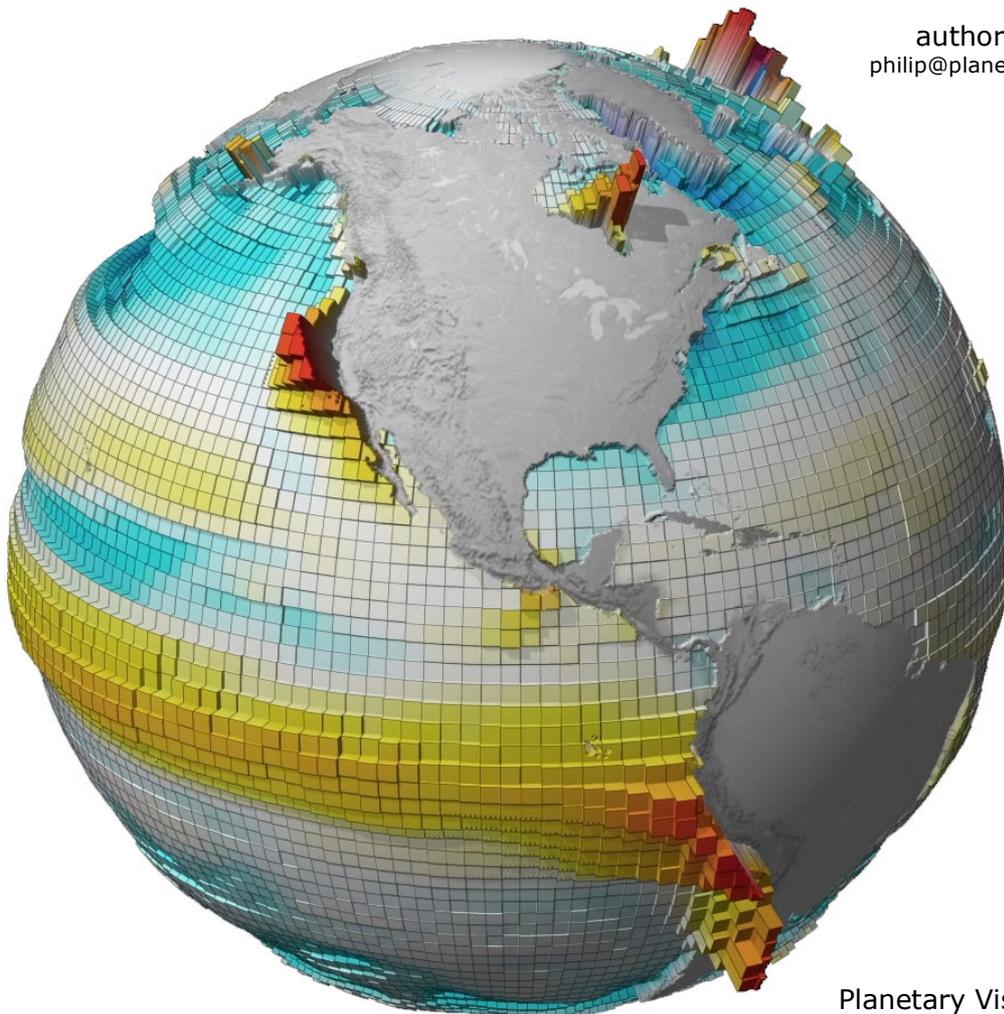
## CCI Visualisation Corner

Presentations of  
ESA's Climate Change Initiative

### *Executive Summary*

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author: Philip Eales  
[philip@planetaryvisions.com](mailto:philip@planetaryvisions.com)



Planetary Visions Limited  
8 Mimosa Drive  
Shinfield, Reading  
RG2 9AQ

[www.planetaryvisions.com](http://www.planetaryvisions.com)

*Carbon dioxide ocean flux from the  
CCI Climate Modelling User Group*

# CCI Visualisation Corner Executive Summary

## 1. Overview

The purpose of this document is to summarise the results of the *CCI Visualisation Corner 2* project, carried out for the European Space Agency (ESA) by Planetary Visions Limited between July 2014 and August 2018 (ESA Contract No 4000111332/14/I-NB). In a wide-ranging science communication project, data visualisation software and content has been developed for ESA's Climate Change Initiative. A novel approach has been applied to put the results of this project directly into the hands of decision makers and the public.

### 1.1 Background

The Climate Change Initiative (CCI) is an ESA project to develop key datasets based on the best available Earth observation technologies for use in understanding changes to the Earth's climate. The CCI project consists of thirteen essential climate variables (ECVs), each with one or more data products (parameters), stretching back in some cases over thirty years.

### 1.2 Objective

The objective of the Visualisation Corner project was to introduce the CCI project and to visualise the CCI datasets using linear and interactive 3D graphics, on desktop computers and tablet devices. Two target audiences were envisaged: a technical audience familiar with Earth observation data, and the general public.

The project was broken down into three main tasks:

- **Exhibition software** for conferences and scientific meetings.
- **Tablet software** for the public, less data rich with more text and explanation.
- **Linear video animations** of CCI data that help show the inter-linkages between ECVs, to be incorporated into both of the above.



**Fig 1** The CCI Visualisation Corner has three components (left to right): Exhibition software on desktop computers, computer graphic animations, and software for the public on tablet devices.

## 2. Climate Data Visualisation Tool

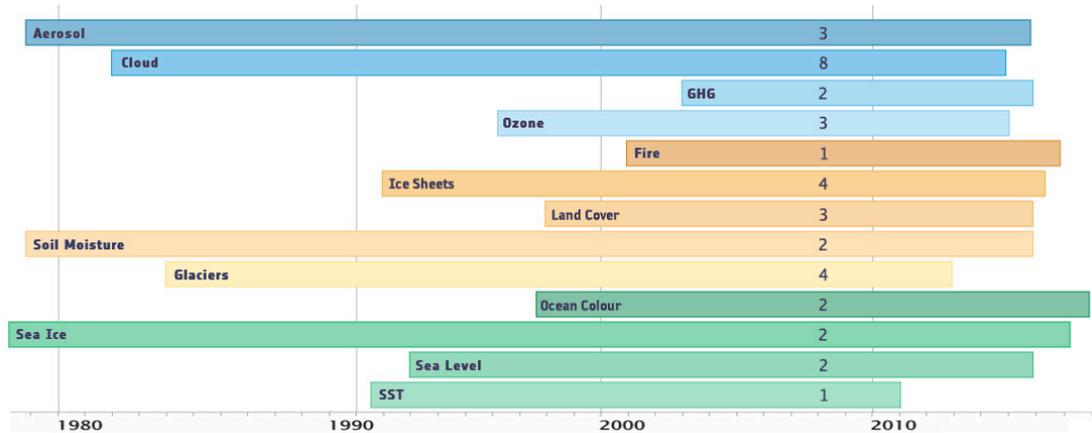
The CCI Visualisation Tool is an interactive exhibit showcasing more than thirty years of global satellite observations of thirteen essential climate variables. This interactive software allows the exploration on a virtual globe of climate variables such as greenhouse gases, ocean temperature and soil moisture. The intention is to showcase the ECV products as fully as possible, showing their full temporal extent and, where possible, spatial detail.



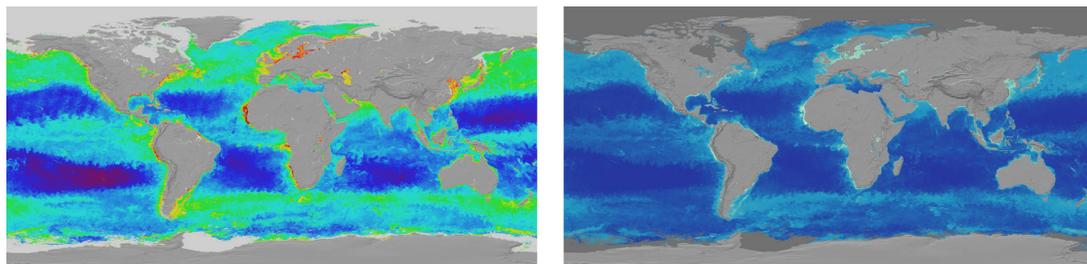
### 2.1 Content Development

Over a terabyte of input CCI data products was processed, giving over 11GB of presentation graphics in the Visualisation Tool. Care was taken to use colour schemes that were both intuitive, so easy to understand, and distinct, to aid comparison of related variables. In

addition to the Earth observation data products, supporting illustrations such as photos, satellite images, diagrams, graphs and animations were prepared. The visuals are presented with short explanatory texts and headline numbers to place the data in context. The software has a separate content folder with an open file structure, enabling the content to be tailored and data and text updates to be rapidly installed. Data updates have been performed on a rolling basis as new versions of the CCI data products have been released.



**Fig 2. CCI Data Time Spans** The time spans covered by the data in the Visualisation Tool is shown, along with the number of ECV parameters, for each CCI project. All projects originally overlapped for the 'golden year' of 2008, but this now spans eight years 2003-2010.



**Fig 3. Ocean Colour chlorophyll-a concentration** (left) science team colour scheme; (right) intuitive colour scheme used for public presentation. All data are presented against a common geographical reference in the form of a terrain-shaded background map.

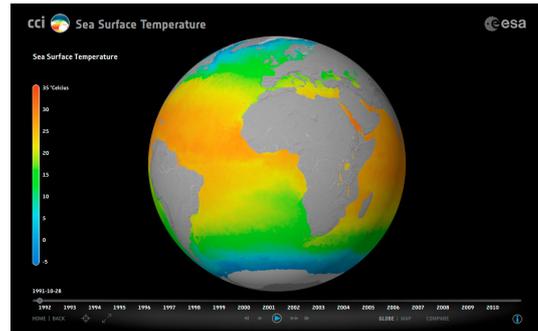
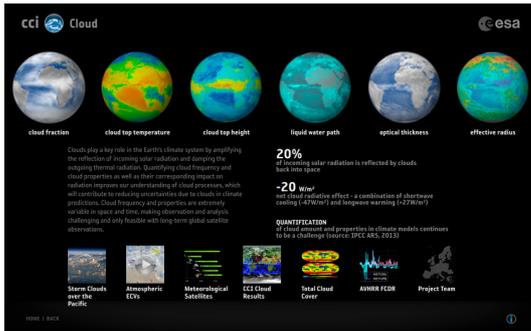
## 2.2 Software Development

The software runs on desktop and laptop computers running MacOS and Windows. A high-spec Mac laptop with solid state drive has been specified to ensure smooth data playback. Software development was undertaken using C++ and OpenGL under the Qt cross-platform development environment on linux. A version was also developed on iPad, with a smaller data package of 3.5GB, to prove the technology ahead of the development of a public-facing tablet app.

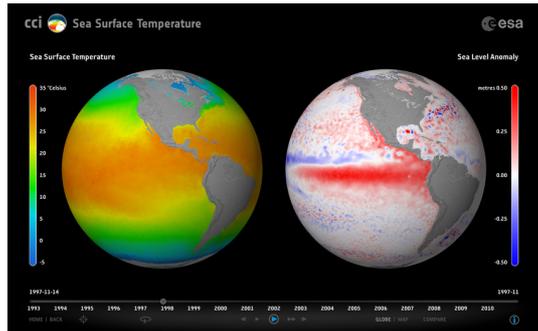
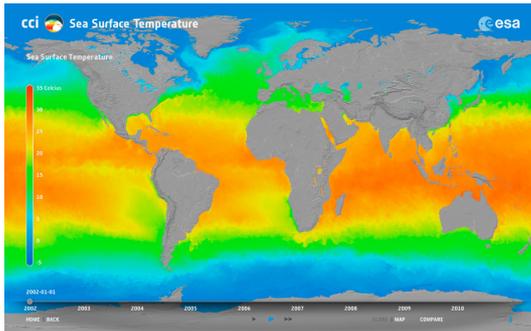
The core of both the exhibition and tablet software is the interactive Data Viewer, which allows playback of the data time sequences on a virtual 3D globe or a traditional flat map, and comparison between selected ECVs.

## 2.3 Deployment

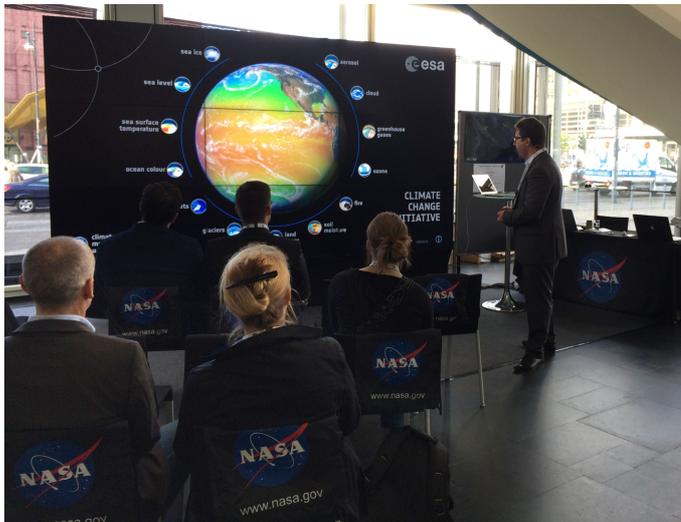
Aimed at scientists, project managers, policymakers and other stakeholders, the Visualisation Tool has been exhibited at trade shows such as the Paris Air Show, intergovernmental meetings including the UN Climate Conferences (COP 2015-17), and scientific conferences including the European Geosciences Union (EGU), the American Geophysical Union (AGU), and ESA's Living Planet Symposia (LPS 2013, 2016).



**Fig 4. (left) Cloud project page with six ECV parameters across the top and seven illustrations across the bottom of the screen. (right) Interactive data viewer showing sea-surface temperature (SST).**



**Fig 5. Interactive data viewer (left) map mode showing SST; (right) comparison mode showing SST and sea level anomaly during the 1997 El Niño event.**



**Fig 6. The CCI Visualisation Tool design is optimized for full high definition output to large display screens. Here it is presented on NASA's video wall at the 36th International Symposium on Remote Sensing of the Environment, Berlin, 11-15 May 2015.**

### 3. Climate from Space app



*Climate from Space* is a digital book app for a general audience that can be understood by anyone who is not familiar with ESA and does not have a scientific background. It uses the same Data Viewer engine as the Visualisation Tool, but has a more highly refined user interface. The tablet platform allows for deeper reading and the app offers 16,000 words of specially-written text covering background information on each ECV as well as the achievements of the CCI projects.

#### 3.1 Content

The text is richly illustrated with satellite and ground-level images, custom-made diagrams, maps, and animations, video interviews with the CCI science team leaders, and links to the Data Viewer. The app features:

- Interactive, animated globes with 17 key climate data sets
- The ability to scroll through time to see thirty years of change
- 130 illustrations, including satellite images, diagrams and animations
- 14 interviews with project scientists
- Over 16,000 words of text
- 74 pages

Due to the limited performance and storage available on tablet hardware, the maps presented in the app are smaller than in the exhibition software, and the smallest steps in the time sequences are longer, bringing the app size down to 1.7GB. This is comparable to some top-end educational apps and academic textbooks available as Apple iBooks.

#### 3.2 Distribution

*Climate from Space* was published on 5 May 2016 and officially launched by ESA on 9 Aug 2016. The app runs on iPad under iOS8 onwards and on “tablet class” Android devices. Development versions also run on desktop under linux and MacOS. The app is structured with a common content bundle shared between the different platforms, but the content has to be “baked-in” to the app with each new build before submission to each app store’s review process, making it less agile for updates than the exhibition software. Since completion of the initial release versions, updates have been performed roughly every six months, including bugfixes and some user interface improvements.



*Climate from Space* is available for free download from the Apple and Amazon app stores:

<https://itunes.apple.com/us/app/climate-from-space/id1061553589?mt=8>

<https://www.amazon.com/European-Space-Agency-Climate-from/dp/B01NBKKHYK>

The interviews with the science team leaders edited for the app were also released on ESA's website: [http://www.esa.int/spaceinvideos/Sets/Talking\\_climate](http://www.esa.int/spaceinvideos/Sets/Talking_climate)



Fig 7. Climate from Space on iPad Pro and Samsung Galaxy Tab S2.

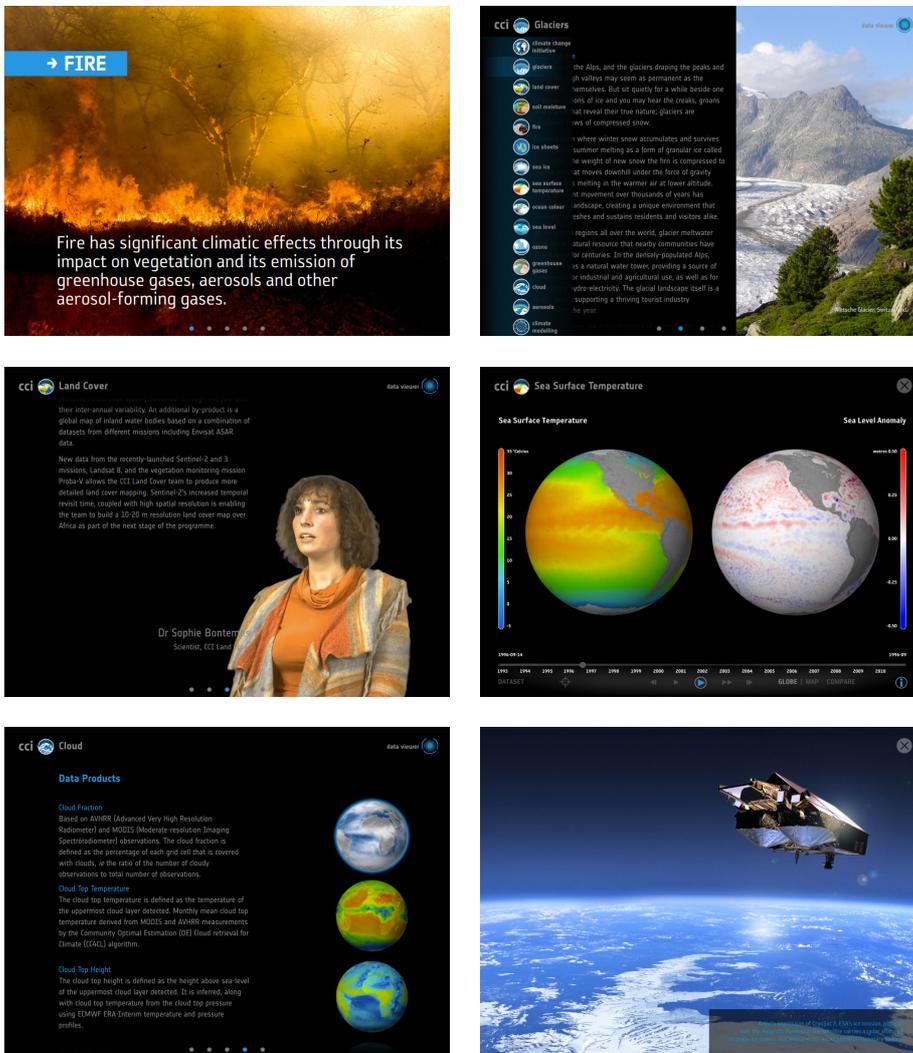


Fig 8. Climate from Space chapter pages (from top left to bottom right): chapter opening image; first text page; second page with interview; data viewer; data products; full-screen illustration.

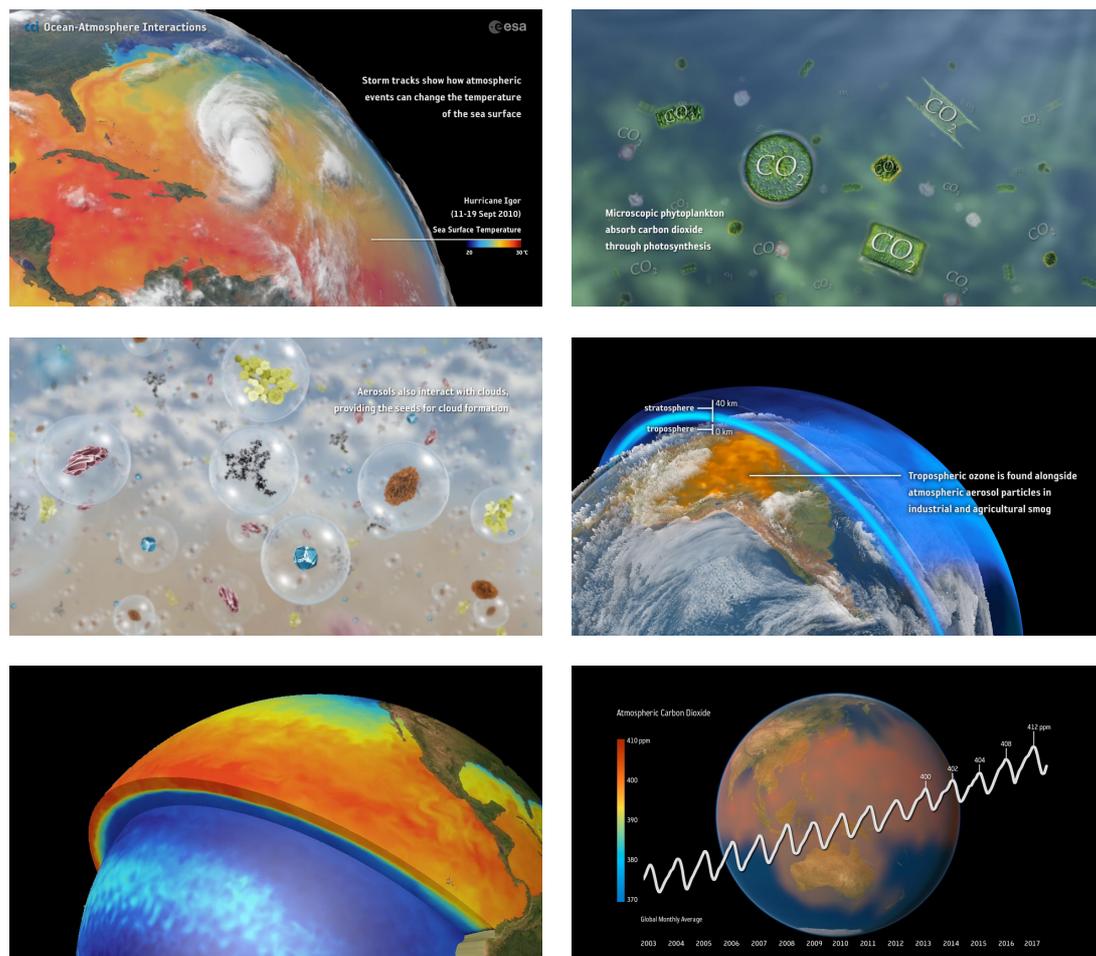
## 4. Animations

A series of linear computer graphic animations was produced, giving the opportunity to show multiple climate variables together and explain how they combine to form parts of the Earth system, for instance the carbon cycle. Some animations help explain scientific concepts, such as calculating the sea level budget, but others are more general, explaining how the climate variables being measured affect the daily lives of the public.

As well as the visualisation of the global satellite-derived data, traditional computer graphics techniques were used to show human-scale and microscopic processes, relating the data to the viewer. A 3-minute looping promotional video shows all thirteen CCI climate variables, and eight animations of 2- to 4-minute length show: *Sea Level Rise Contributions*; *Ocean-Atmosphere Interactions*; *Carbon Dioxide Ocean Flux*; *Atmospheric Climate Variables*; *Monitoring Ozone*; *Mapping Land Cover*; *The Carbon Cycle*; *El Niño*. A total of 25 minutes of 3D computer graphics has been completed to broadcast quality in full high definition HD1080.

The animations have been incorporated into the project's two software products and published on ESA's web and social media channels under the following titles:

5 June 2017	<a href="#">Contributors to sea-level rise</a>
14 Nov 2017	<a href="#">Monitoring ozone</a>
11 Dec 2017	<a href="#">Carbon dioxide ocean-atmosphere exchange</a>
8 Jan 2018	<a href="#">Ocean and atmosphere interactions</a>
19 Jan 2018	<a href="#">Changing lands</a>
5 Feb 2018	<a href="#">Change in atmosphere</a>
21 Feb 2018	<a href="#">Carbon cycle</a>



**Fig 9.** CCI animations (top left to bottom right): *Ocean-Atmosphere Interactions*; *Carbon Dioxide Ocean Flux*; *Monitoring Ozone*; *Atmospheric Climate Variables*; *El Niño*; *The Carbon Cycle*

## 5. Further Development

A number of options have been proposed for further development that would broaden the reach and ease the distribution of the software products:

- **Climate from Space Desktop**, on MacOS and Windows, would broaden the reach of the app by making it available on desktop systems, which are more readily available than tablets in both the classroom and the home.
- **Smartphone Version**, focusing on the interactivity of the data viewer, with minimal explanatory text, and smaller and fewer maps to reduce the data volume. More people have access to a smartphone than to a tablet.



- **Android Distribution** through the Google Play store is now possible using a post-install extension file up to 2GB. Currently the Amazon app store is used due to its higher permitted size for apps, but Google Play is more popular so would considerably broaden the reach of the Android version.
- **Visualisation Tool Distribution** could be streamlined with an installer/updater, making it easier to tailor and update the content.
- **An Online Version** could reach a much larger audience, without the need for a single large data download and large amounts of local storage, and would be easier to keep up-to-date.

## 6. Summary

The science communication objectives of the project have been met by developing two software products, with a common interactive graphics engine, aimed at different target audiences. The *Climate Data Visualisation Tool* was rapidly developed for use by scientists to communicate to experts in different fields, programme managers and decision makers at scientific meetings. The *Climate from Space* app built on this work with a more user-friendly interface and rich text and image content on tablet platforms for the general public. Computer graphic animations developed as part of the content for the apps are also available for stand-alone use as part of ESA's web-based public communication activities.

The project has successfully promoted the Climate Change Initiative, helping to secure support for the work to continue for a further five years as CCI+, allowing the maintenance of all 14 current ECVs in addition to adding nine new ones.