Characterisation of metadata to enable high quality climate applications and services

Deliverable 800.12

Supplement to Final Report

Partners providing input: Met Office, University of Reading, Airbus Defence & Space (Infoterra), DWD, KNMI, SIH

version number	date	comments
0.1	Dec 2014	First draft for comment
0.2	Jan 2015	Second draft
0.3	22 Jan 2015	Final version
1.0	5 Feb 2015	Changed name to “Supplement to Final report”

CHARMe is funded by the EC under its FP7 Research Programme

Contents

1 Introduction

The CHARMe project was carried out over 2013-14 to provide an online system for characterization of metadata to enable high-quality climate applications and services. The motivation was to enable research and other communities to add and edit metadata and share their experience with other data users. In addition, data visualisation and analysis tools were developed to help users explore and evaluate a wide range of environmental datasets, modelled and observed, and catalogue data availability, quality and feature information. CHARMe metadata are machine readable using Open Annotation and Linked Data protocols for efficient search and organisation. Hence CHARMe will help climate data users to identify the most appropriate data for their needs, and satisfy EU objectives e.g. Horizon 2020, to make fullest use of new and existing climate data.

1.1 About this document

This document summarises the CHARMe project outputs, including user tools, key features and functionality. Section 2 provides an Executive Summary while Section 3 outlines project aims and achievements. Section 4 provides an overview of the system as implemented by data providers and identifies sources of data and support. Section 5 summarises the final symposium which explored CHARME's connections with other European climate data projects.

1. 2 Project References

Clifford, D., Blower, J., Alegre, R., Phipps, R., Bennett, V. and Kershaw, P. (2014) *Annotating climate data with commentary: the CHARMe project*. In: Big Data from Space (BiDS'14), pp. 251-254.

Blower, J., Alegre, R., Bennett, V. L., Clifford, D., Kershaw, P. J., Lawrence, B., Lewis, J., Marsh, K., Nagni, M., O'Neill, A. and Phipps, R. (2014) *Understanding climate data through commentary metadata: the CHARMe project*. In: Linking and Contextualizing Publications and Datasets, 26 Sep 2013, Malta, pp. 28-39.

1.3 List of Acronyms

CHARMe - Characterization of metadata to enable high-quality climate applications and services

CCI – The Climate Change Initiative of the European Space Agency

CM-SAF – Satellite Application Facility on Climate Monitoring

DWD – Deutscher Wetterdienst

ECMWF – European Centre for Medium Range Weather Forecasts

ERA – ECMWF Reanalysis (climate observations processed through a climate model by ECMWF)

ESA – European Space Agency

KNMI – Royal Netherlands Meteorological Institute

STFC – Science & Technology Facilities Council

UREAD – University of Reading

2 Executive Summary

This report summarises the outcomes of the CHARMe project and is written in conjunction with the ECAS online "Final project report" template.

CHARMe provides the means for climate data providers and data users to add and respond to metadata annotation attached to climate data sets. It consists of a browser interface which connects users with a database of user annotation, commentary and other information about the data, including links and search functionality, for scientific, research, business and consultancy communities. It offers the potential for enhancing the Copernicus climate change services initiative and other Earth system data set providers such as the ESA CCI and could strengthen the production, availability, delivery and application of science-based climate prediction and services.

The project aims were to improve access to global and regional climate data products, modelled and observed, and outreach aimed to broaden research partnerships by building strategic links with other parties inside and outside Europe, and to ensure that all identified stakeholder groups were targeted with information on the CHARMe system and its benefits.

The CHARMe system was installed at several Data Providers' sites with the intention of going live early in 2015, and a set of user tools, including a significant event viewer and "CHARMe Maps", have been developed to showcase what is possible with a CHARMe system.

3 Project Aims & Achievements

3.1 Aims & Objectives

The work, which started in January 2013, was an EC funded collaborative project between nine partners: the University of Reading, Airbus Defence & Space (formerly Infoterra), STFC, DWD, ECMWF, KNMI, CGI (formerly Logica), TerraSpatium (formerly SIH) and the UK Met Office. It had the following aims and objectives:

- To enable Commentary information for climate-relevant data to be consistently encoded and accessed, ensuring semantic interoperability across systems;
- To develop tools to enable users to access this information to aid decision making and exploitation by the downstream sector;
- To produce applications that show how this information can be used to tackle real scientific problems;
- To apply these processes to the key European investments in this area, specifically Copernicus, CCI, ERA reanalyses and climate modelling, and provide a mechanism for their improvement;
- To advocate the CHARMe concept and processes and set the standard for compliance with them, enabling Europe to drive the international agenda for the provision of climate data and respond effectively to internationally-agreed objectives on data quality;
- To widen the accessibility and usability of climate data, particularly to new user communities;
- To ensure that Commentary metadata are curated to the same degree as the data themselves, following the structures and guidelines of the ESA Long Term Data Preservation initiative.

3.2 Achievements

CHARMe provides a platform for data providers and users to share and annotate metadata improving the amount and quality of information that can be discovered about climate data, and helping users to decide whether a dataset will meet their needs.

It harnesses *Semantic Web* and *Linked Data* technologies, to generate machine readable commentary which can be interpreted by humans and automated software. A generic *Open Annotation* web data model enables data to be universally shared using a unique *Digital Object Identifier* (DOI) or URL. The model also allows specific parts of a dataset, such as specific events (e.g. a dust storm or volcanic ash cloud), or a particular instrument or processing algorithm, to be identified. CHARMe Maps uses *fine-*

grained commentary to enable regions in space to be identified by geographic locations (e.g. point or polygon), or by name (e.g. South Atlantic, Europe, stratosphere, boundary layer). Integration with geographical information systems (*GIS),* *Linked Data* and technologies such as *Jena Spatial* and *Strabon* were also explored.

The technical outcome from the project is an online interface for data providers and users to share expert knowledge and experience with the users of climate observations and model data sets. This will deliver scientific benefits of being able to select the most appropriate datasets, and financial benefits by reducing any duplication of data quality evaluation. Intelligent categorisation and search functions will make it easier to discover and interpret data as more and more data becomes available online.

4 Overview of the CHARMe system

4.1 The CHARMe System

The CHARMe system comprises of a data node and Java script Plug-In hosted by data providers, the former is invisible to data users (Figure 1) with the CHARMe system initiated by users selecting a CHARMe button associated with a specific dataset.

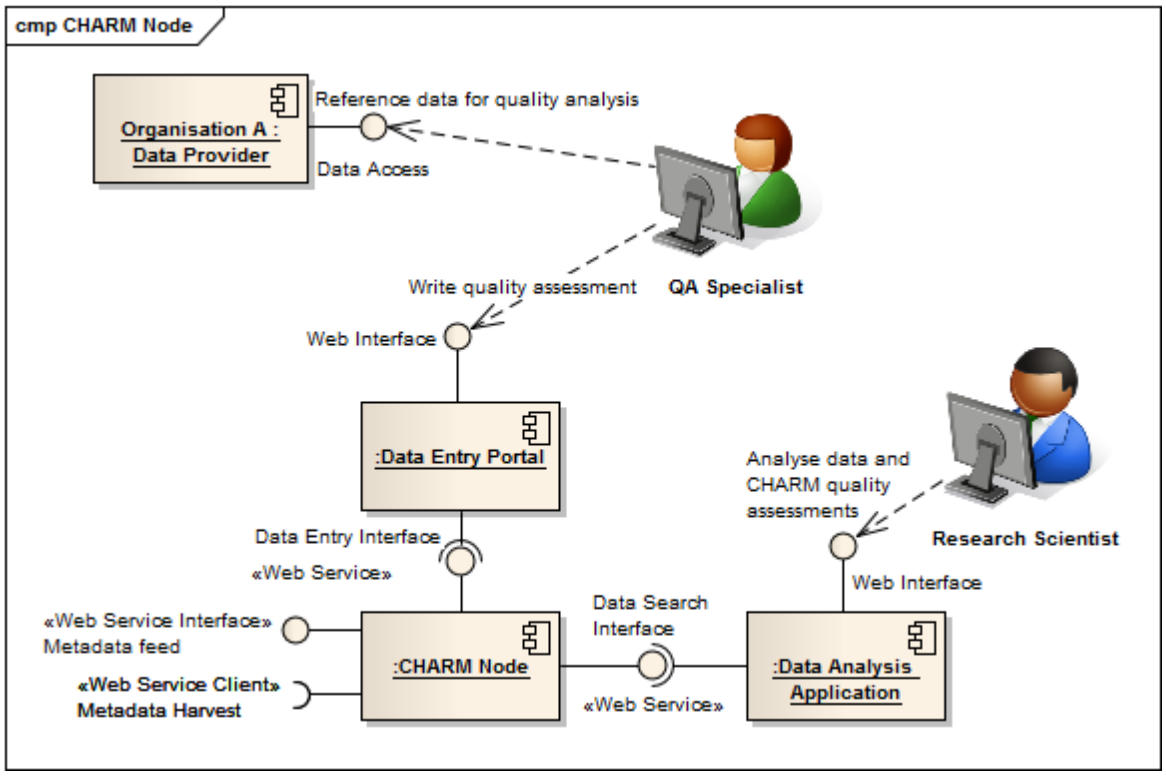

Figure 1: CHARMe System

CHARMe has two different facets which offer the user alternative ways of viewing and analysing climate data. These include a commentary tool for adding and editing annotations and a significant event viewer tool (SEVT) for viewing significant events alongside the data time series. A CHARMe-Maps viewer has also been demonstrated which enables the viewing and tagging of spatial data, although this is outside the project scope and remains as a prototype only.

4.2 User Instructions

User instructions for the Commentary Tool and the Significant Events Viewer Tool are given below. Information about the CHARMe Maps viewer is also presented.

In order to access CHARMe using these tools, registration is required at the data provider website.

4.2.1 Commentary Tool

The CHARMe commentary tool enables users to add and edit annotations which are linked directly to the climate datasets being used. An interactive CHARMe button is used to access the metadata annotation screen (Figure 1). A blue button indicates that annotations exist about that dataset and a white button indicates that none exist. The user can view annotations that already exist on the CHARMe system. In order to add or modify an annotation however, the user must login in to the CHARMe central node. Prior registration with the CHARme node is required and the user will need to agree to the Terms and conditions of use.

User annotations are added to the CHARMe database, and can be accessed and shared with a wide audience.

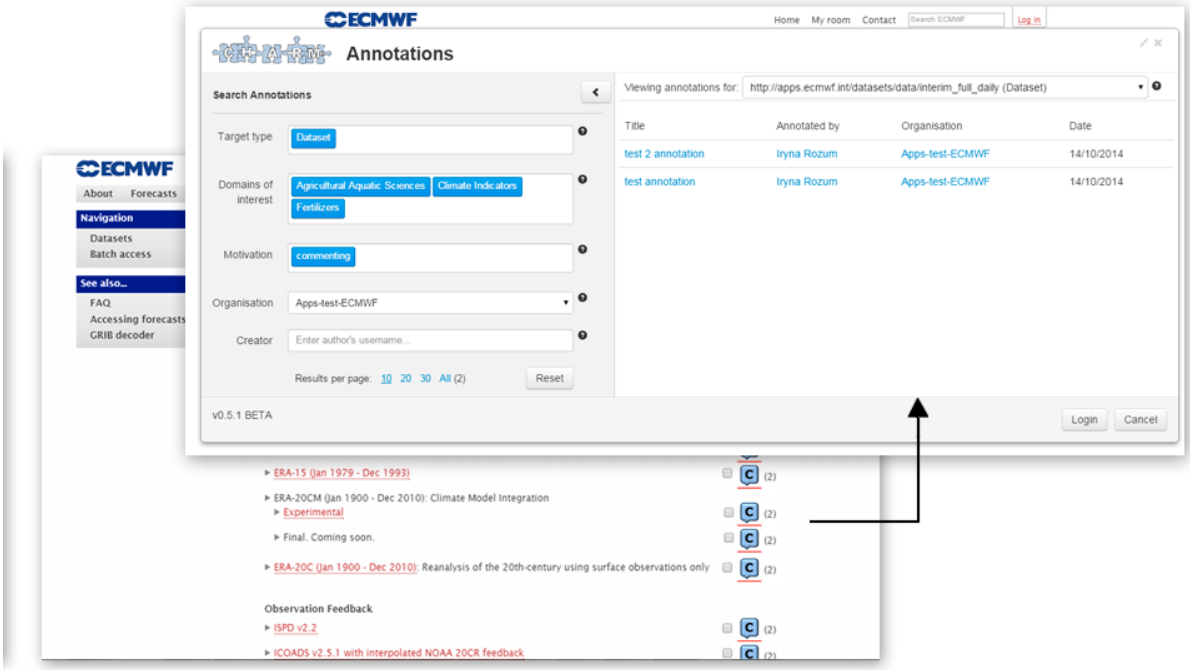

Figure 2: Annotation Screen - ECMWF instance; Data Input

Figure 2 shows the annotation data entry window for the ECMWF data portal. Annotations can be categorised by target type, domain (or scientific area) of interest and the motivation for adding it. The user also records their name and organisation.

Figure 3 and

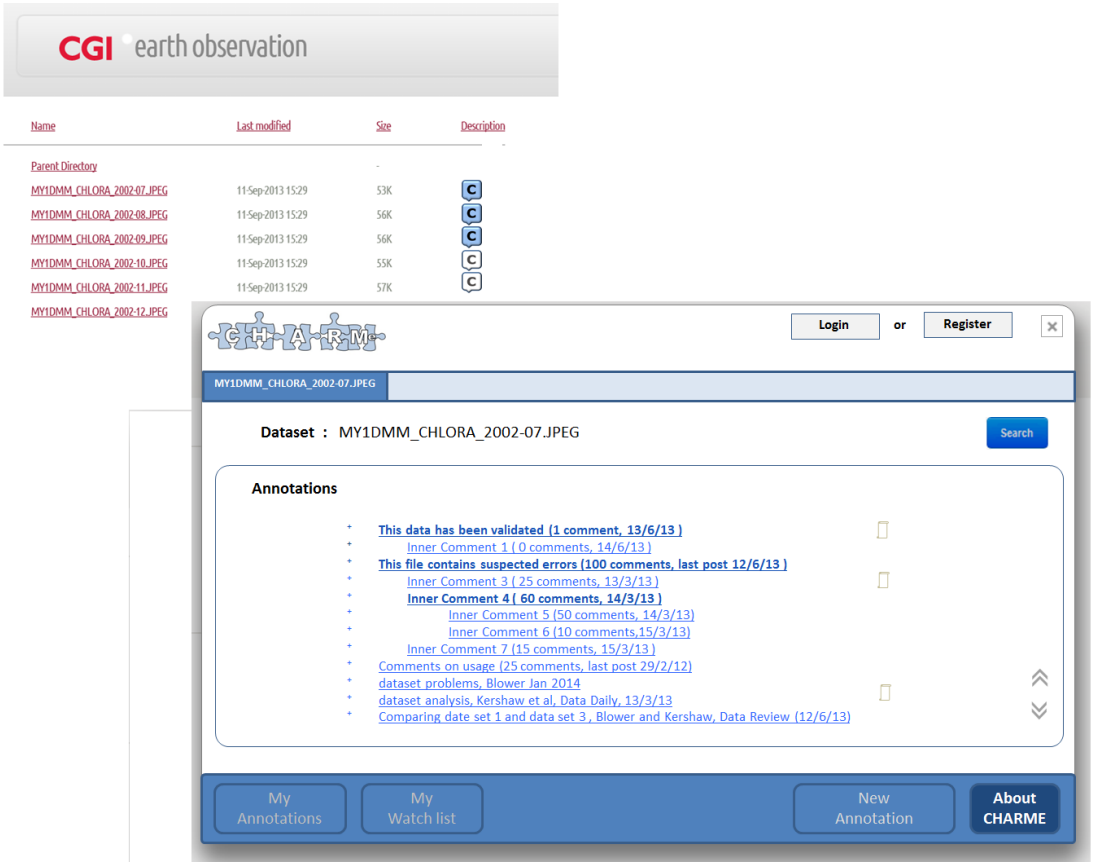

Figure 4 show examples (beta versions) of annotation lists. A search button allows searching by user defined terms in any or all of six categories. All of these are visible without being a registered CHARMe user. A demo of the pre-release CHARMe prototype is available on YouTube at: https://www.youtube.com/watch?v=5MJzPPmc3Fg&feature=youtu.be.

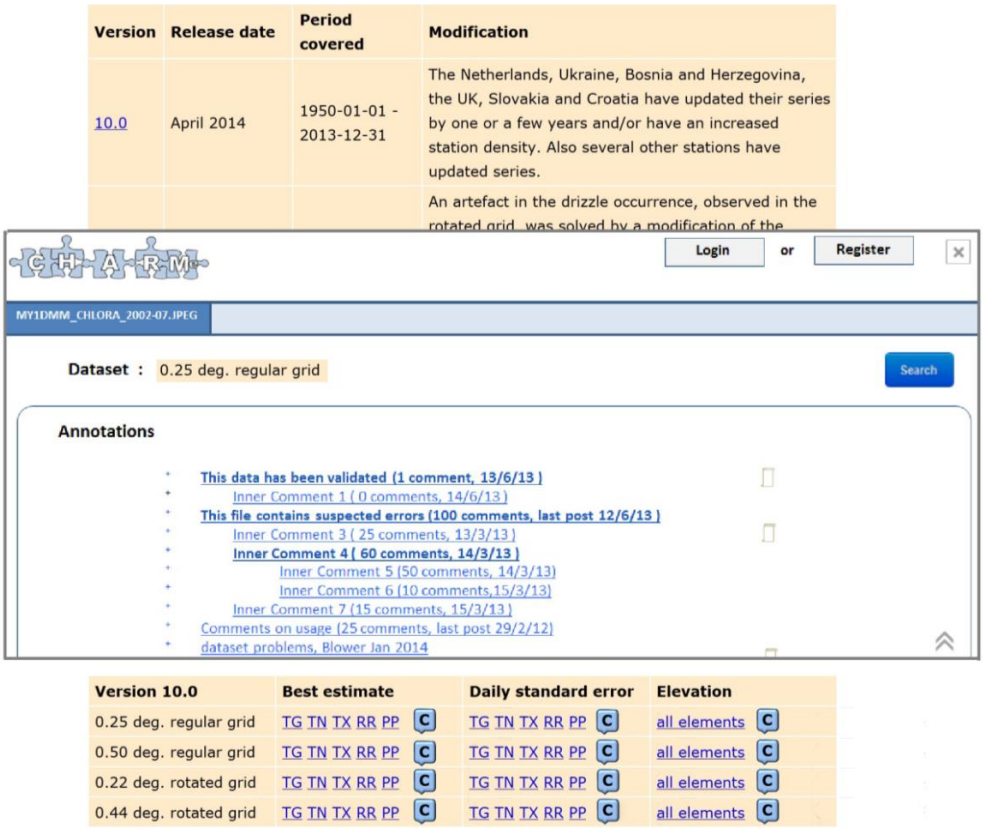

Figure 3: Annotation Screen – KNMI instance – Discovering existing annotations

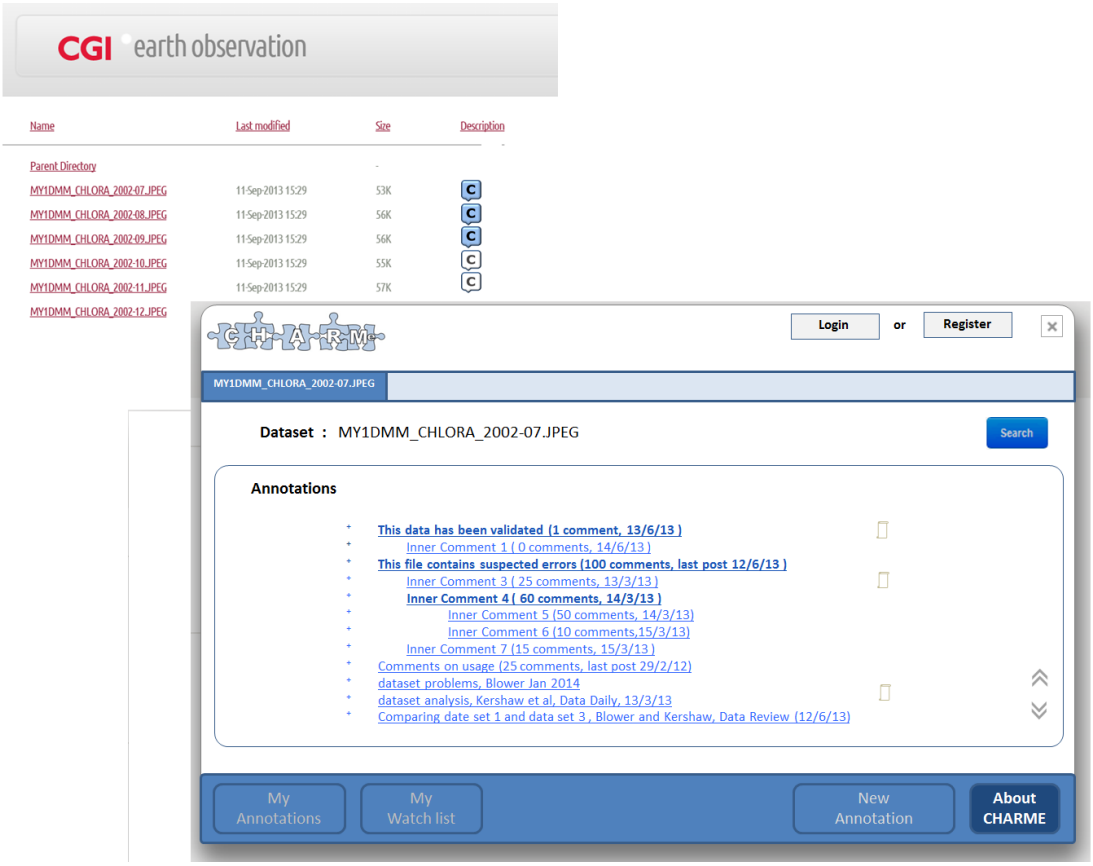

Figure 4: Annotation Screen – CGI instance; Discovering existing annotations

4.2.2 Significant Events Viewer

The significant Events Viewer enables users to show data in relation to significant weather & climate events on a common time series. Significant Events include hurricanes, volcanic eruptions, El-Nino, drought and storms. Different datasets can be examined on a shared axis in relation to significant events. Figure 5 and Figure 6 show examples for soil temperature and storm data respectively.

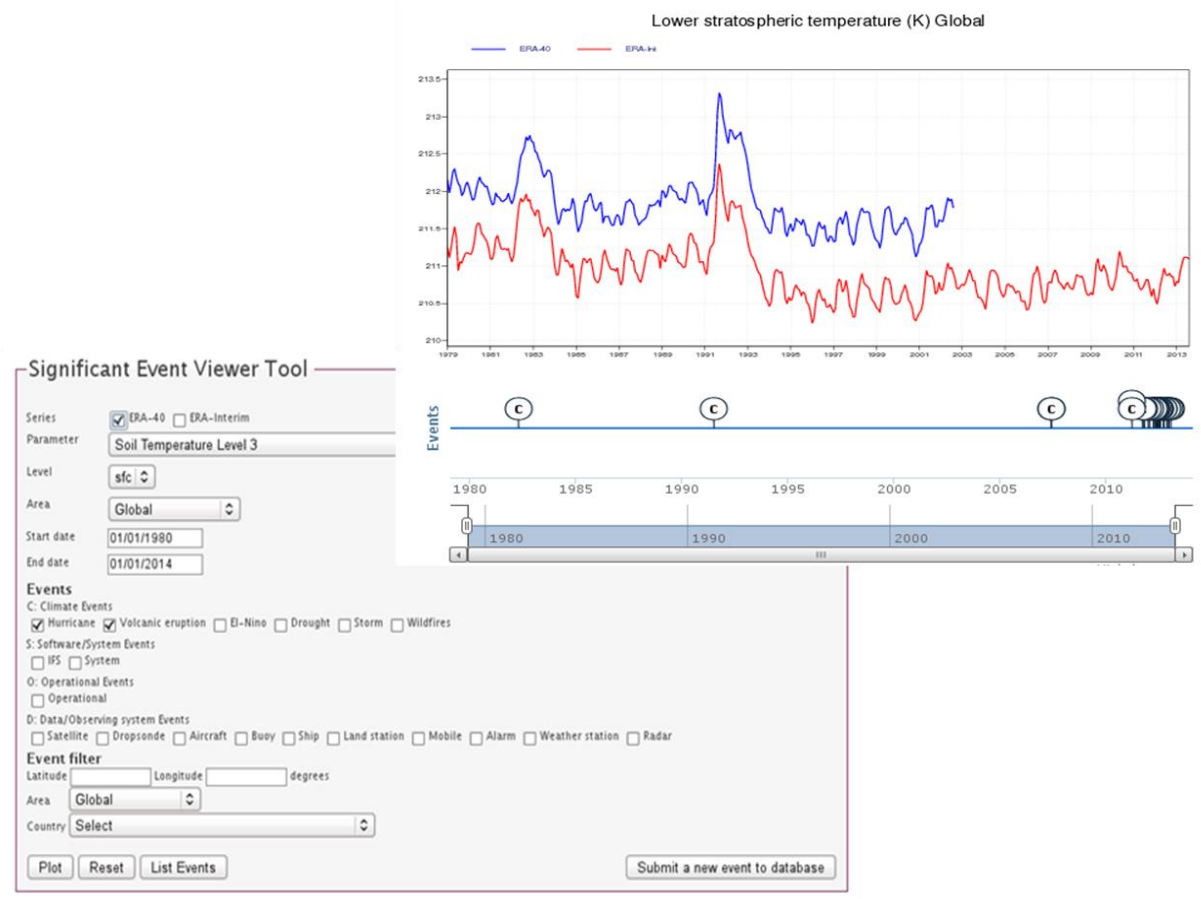

Figure 5: Significant Event Viewer

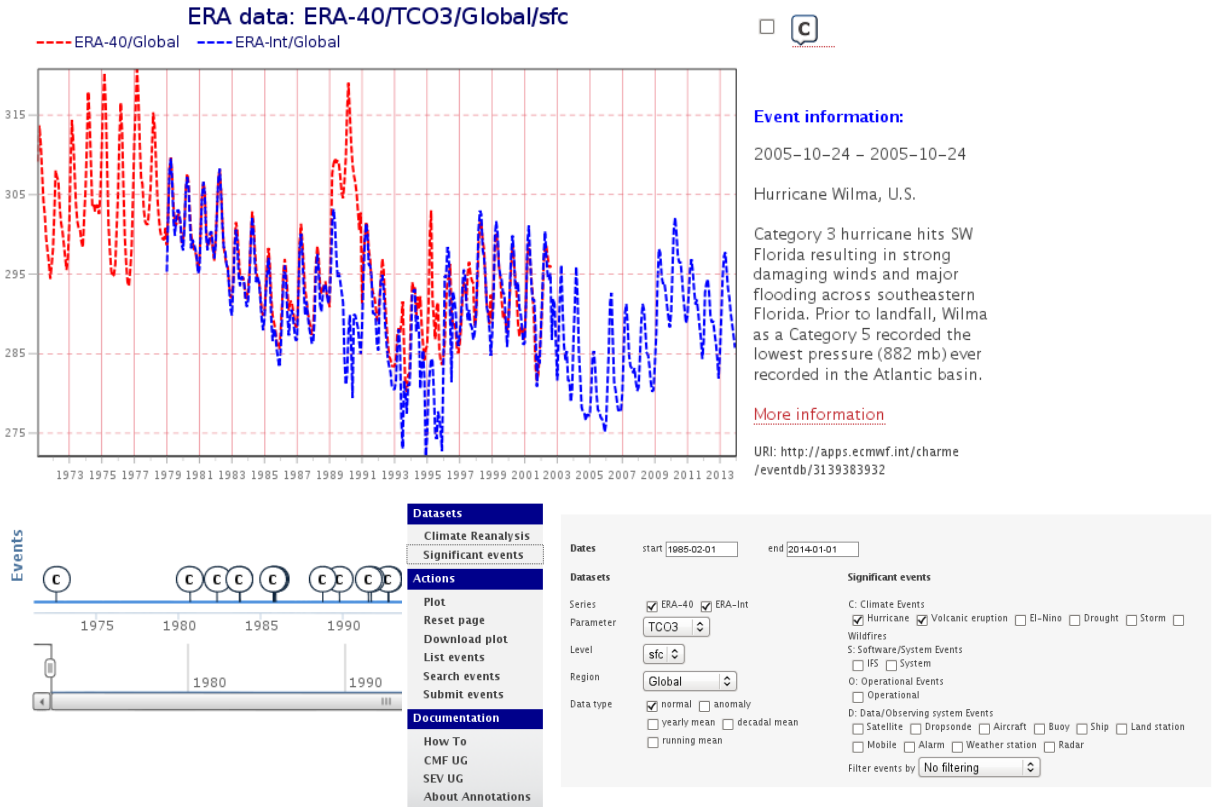

Figure 6: Significant Event Viewer

4.2.3 Map Viewer

CHARMe Maps is a web-based prototype tool that has been developed that allows a side-by-side visual comparison of datasets and their CHARMe metadata. One or more datasets from a pre-configured Web Map Server can be selected and the CHARMe metadata are displayed alongside the visualised dataset. The interface could allow the user to browse through the dataset and explore its metadata. Exploring the metadata of a dataset can be achieved by using the integrated faceted search and pre-configured categories. If more than one dataset is displayed, the browsing and navigating through the datasets and their metadata categories can be synchronized on demand, in order to facilitate an inter-comparison. Figure 7 shows a beta version of the CHARMe Maps visual comparison tool.

Additionally, the CHARMe Maps tool enables the annotation of particular points or domains and the ability to add fine grained commentary. Figure 8 shows an example of the CHARMe Maps fine grained commentary functionality, and shows the intercomparison viewer (under development).

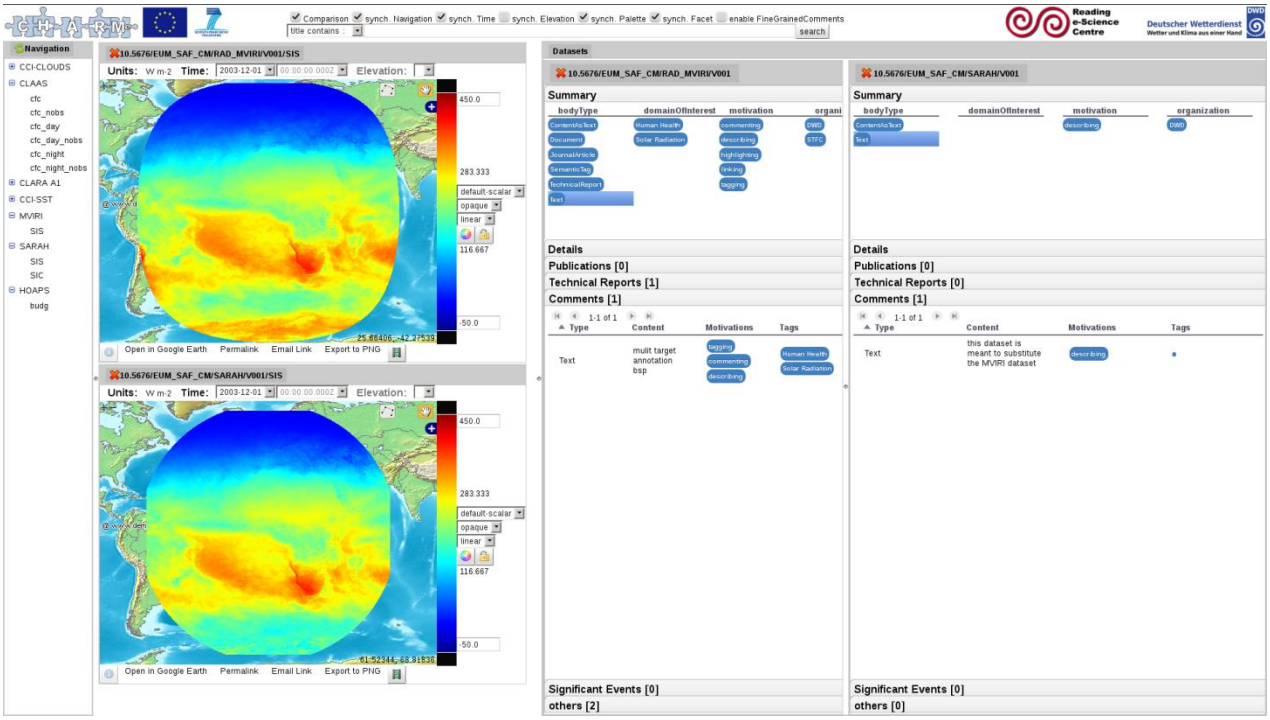

Figure 7: CHARMe Map Viewer – Annotation

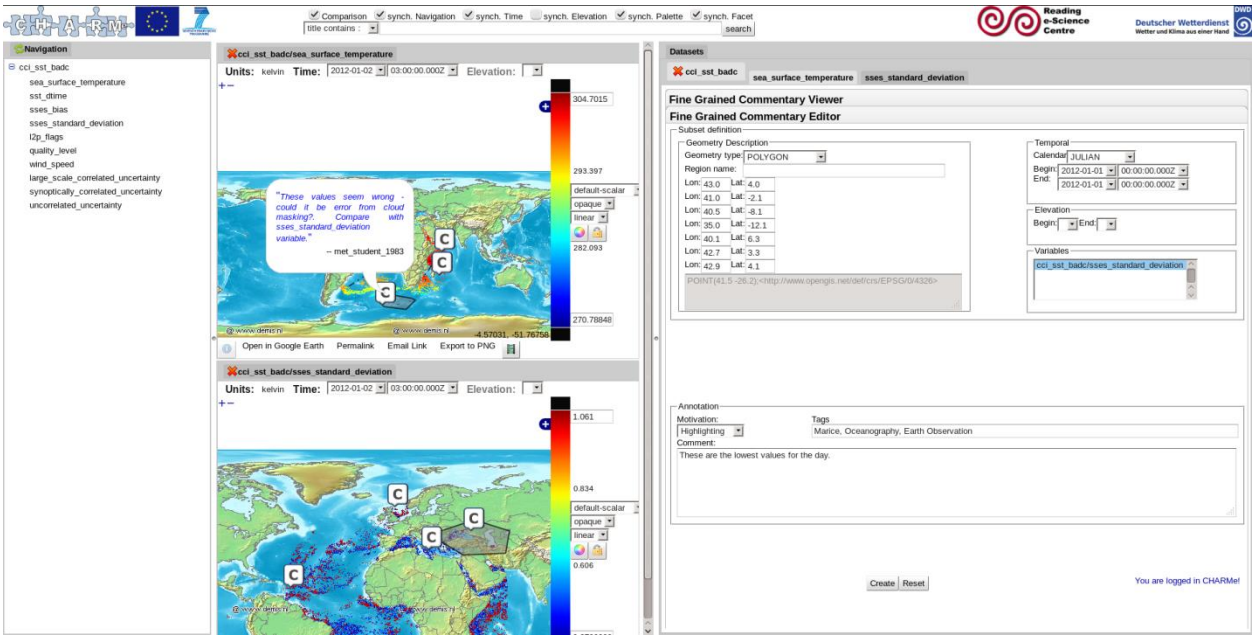

Figure 8: CHARMe Map Viewer – Fine Grained Commentary

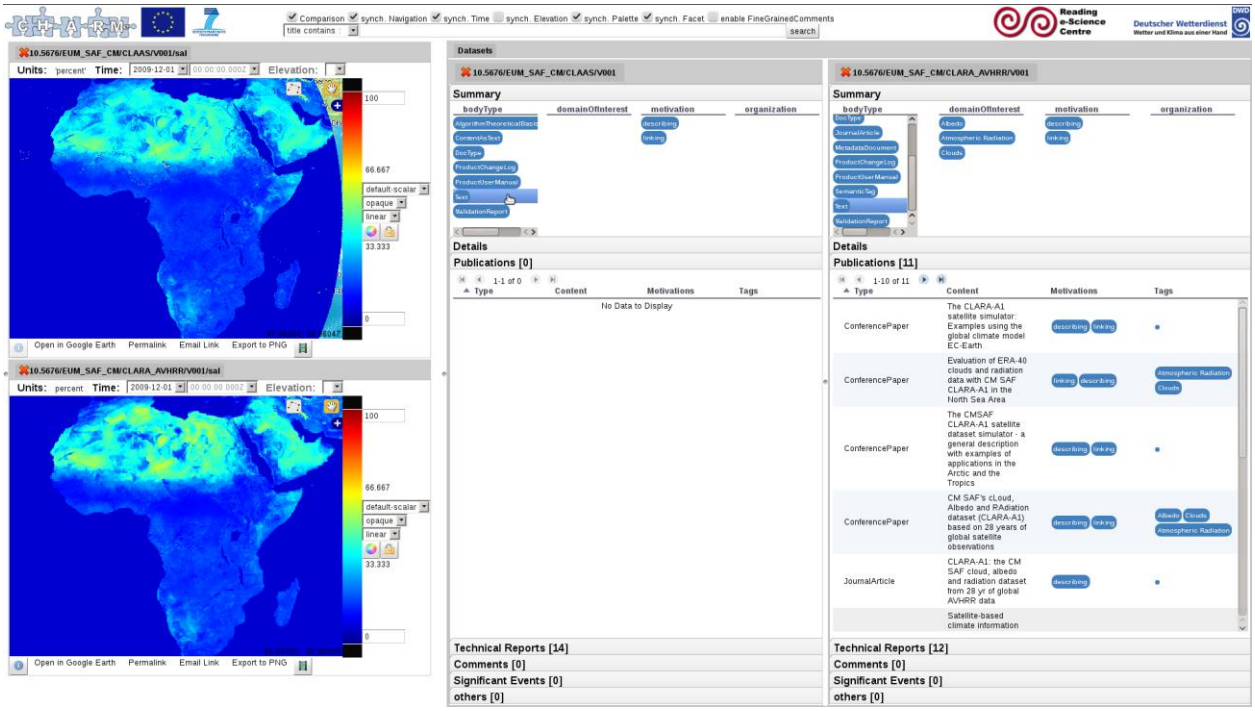

Figure 9: CHARMe Map Viewer – Intercomparison viewer

4.3 Data Archives with CHARMe enabled

CHARMe is now in place at the following European-based climate data centres providing user-relevant information for over 30 individual datasets, by early 2015 this will rise to four centres, details as follows:

- European Climate Assessment and Dataset (ECAD) which contains over 60 years of European climate observations and is hosted by KNMI now has CHARMe on its key datasets: http://www.ecad.eu/download/ensembles/download-charme.php
- The global reanalyses and Observation feedback datasets of ECMWF now feature the CHARMe system at: http://apps-test.ecmwf.int/datasets/ (prerelease migrating soon to http://apps.ecmwf.int/datsets). Latest plug-in available at: https://github.com/charmeproject/charme_plugin/tree/master/CHARMe_plugin/dist
- *The CMSAF data library hosted by DWD will enable CHARMe on selected datasets throughout 2015:* http://www.cmsaf.eu/doi
- CEDA, the Centre for Environmental Data Archival, currently provides online access to more than 300 digital data products, for which CHARMe support is being rolled out: http://www.ceda.ac.uk/data-centres/

4.4 Support for Data Providers

CHARMe will benefit data providers by providing a means to add significant commentary on data availability, quality and updates, etc. For example, the Centre for Environmental Data Archival (CEDA) manages Earth Observation data archives for the environmental research community. Their helpdesk team handles up to 400 queries per quarter for over 300 different datasets. These include observations data from space, from aircraft, in situ, and from model analysis in a variety of formats and structures. CHARMe will enable Helpdesk staff to upload important information on data availability, outages, quality issues and planned updates, etc., to complement their data catalogue. CHARME will also enable expert users to upload comments and information to assist new and less experienced users, freeing up the helpdesk team to, for example, annotate frequently queried datasets.

4.5 Support for Data Users

The CHARMe system is a java script based web service which is simple and intuitive to use. A help button will directs users to FAQs and no special technical knowledge of datasets is required. Moderation is in place to ensure that CHARMe annotations are helpful and appropriate, responsibility for which lies with the data provider host site.

Technical support will be maintained via an email link on the website, and a commitment to respond to enquiries within an agreed time period. The website will also host announcements regarding software upgrades, outages and issues.

4.5 Commercial information: licensing and terms of use policy

The CHARMe node software and the CHARMe Java script plugin is licenced under a BSD licence. The code is available for use at Github:

https://github.com/charmeproject/charme_plugin/tree/master/CHARMe_plugin/dist

For a user to add an annotation, they must first register with the CHARMe node using the "Login in" button.

For new users, they have to accept the terms and conditions by "ticking the box".

Data Usage policy

For the central node/ distributed Java script plugin system, we determined a usage policy describing acceptable behaviour and informing the user of any consequences as a result of malicious action.

Also for data protection reasons, as the CHARMe node (hosted at STFC on the JASMIN system) was storing email addresses, the CHARMe user had to be informed of this. Details are included below:

"Data Protection:

On registering with the CHARMe node, STFC will store your email address. The username you select will be made public. Your email will also be made public, if you have selected this option in your user profile.

The annotation data will be stored at STFC, however STFC are not responsible for the content of the annotation, nor for any comments/ views held therein.

Inappropriate content will be reported to the moderators. Users who abuse the Usage Policy Appendix A1.2 may have their accounts barred/ removed.

Usage Policy:

By registering with the CHARMe node, you are agreeing to be held responsible for the information you provide and confirming that you accept and understand the following rules of use:

- Annotations will be free from malicious, abusive or obscene comments/ links
- Annotations will not contain any links to services relating to marketing, advertising or recruitment
- All annotations reflect the views of the author of the annotation. STFC will not be held responsible for the content of any annotation.
- The author of an annotation retains the copyright of his/her annotation.

- Any user who attempts to cause technical problems for the system will be reported to the moderator and will be barred.
- STFC reserves the right to store the annotations and make available to other users according to this Usage Policy.
- The author grants STFC permission to, without changing content, translate the data to any medium or format for the purpose of future preservation and accessibility.

Note that

- the CHARMe node is not responsible for maintaining the permanence of URL's. The CHARMe node shall not monitor for permanence of URLs or broken links.
- STFC accepts no responsibility for the network connection between the CHARMe node and the CHARMe plugin.

5 Final Symposium

The final symposium was held at ECMWF over 10-11th December 2014. It included the CHARMe launch and a symposium to explore its context in relation to a number of other European Projects. The launch and symposium were attended by 42 delegates from 21 organisations including remote connections with ESA, NOAA & NASA.

5.1 CHARMe Launch

The CHARME Launch was held on 10th December and was attended by the project team, project stakeholders, and potential users. The programme is shown in Table 1. Presentations summarised the outcomes of the project and included a demonstration of the CHARMe system and tools, plug-in and user interface.

Table 1: Programme for CHARMe Launch **Time**	**Discussion topic**	**Lead by:**
14:00 - 14:30	Coffee and registration	
14:30 - 14:40	Welcome and introduction	Alan O'Neill
14:40 - 15:00	Reminder of CHARMe project – aims, objectives, setting the scene	Rhona Phipps
15:00 - 15:10	CHARMe for Data Providers, Scientists, Copernicus Services, Consultants	Debbie Clifford
15:10 - 15:30	Implementation - CHARMe in operation	Tom Lankester, Airbus Ge Verver, KNMI
15:30 - 16:10	Demonstration of CHARMe system and tools	Andrew Henry, CGI I Rozum, ECMWF Jon Blower, UREAD
16:10 - 16:25	CHARMe for 2015: Access, use and support	Alison Pamment, STFC Phil Harwood, CGI Rhona Phipps, UREAD
16:25 - 16:35	CHARMe's place in the landscape and relevance to climate services	Mark Dowell, JRC

16:35 - 16:55	Q&A session	

After Alan O'Neill and Rhona Phipps (both University of Reading) introduced the session, Jon Blower (University of Reading) and Frank Kratzenstein (DWD) explained the underlying principles of using 'fine-grained' machine-readable commentary and faceted data search, Open Annotation standards, and bibliographic database ontologies. Iryna Rozum (ECMWF) demonstrated the Significant Events Viewer which enables users to plot data time series concurrently in relation to significant weather and climate events. Jon also demonstrated the CHARME Maps viewer which allows users to view and annotate geospatial data (Photo 1).

Photo 1(a) – CHARMe Final Symposium

Photo 1(b) – CHARMe Final Symposium

Steven Hubbard (Airbus), and Phillip Harwood (CGI) explained the system architecture and its integration with data serving of the Copernicus Climate Change Service. Jan Willem Noteboom (KNMI) explained the significance of CHARMe in relation to WMO's Global Framework for Climate Services (GFCS) and its Climate Service Information System (CSIS). It aims to make more of the data from regional data centres (e.g. national hydrological and meteorological services) available to the wider community.

The benefits of CHARMe to data providers were outlined by Alison Pamment for STFC. The CHARMe plug-in has been added to STFC's four data centres: the British Atmospheric Data Centre (BADC), the NERC Earth Observation Data Centre (NEODC), the IPCC Data Distribution Centre (IPCC DDC) and the UK Solar System Data Centre (UKSSDC). CHARMe will complement existing metadata including data source, model or instrument details, measurement techniques, and the geospatial and temporal extent of the data. It will allow users to record observed anomalies, bias, missing data and other experience. In her blog, Victoria Bennett (STFC) outlined specific benefits of CHARMe which will assist the STFC helpdesk team by enabling them to post metadata and commentary, and by allowing 'superusers' to help other users directly. Ge Verver and Frank Kratzenstein explained the application of CHARMe by data providers. Ge Verver demonstrated the use of CHARMe for KNMI's EC&D data, Frank Krazenstein showed it working with EUMETSAT's CM-SAF datasets.

CHARMe supports the EU's Climate Information Stewardship programme, helping to maximise benefits from the investments made, and the H2020 Regulation by increasing the exploitation of data from European satellites. It is expected to assist policy decision making by adding value at the analysis and applications stage (Figure 10).

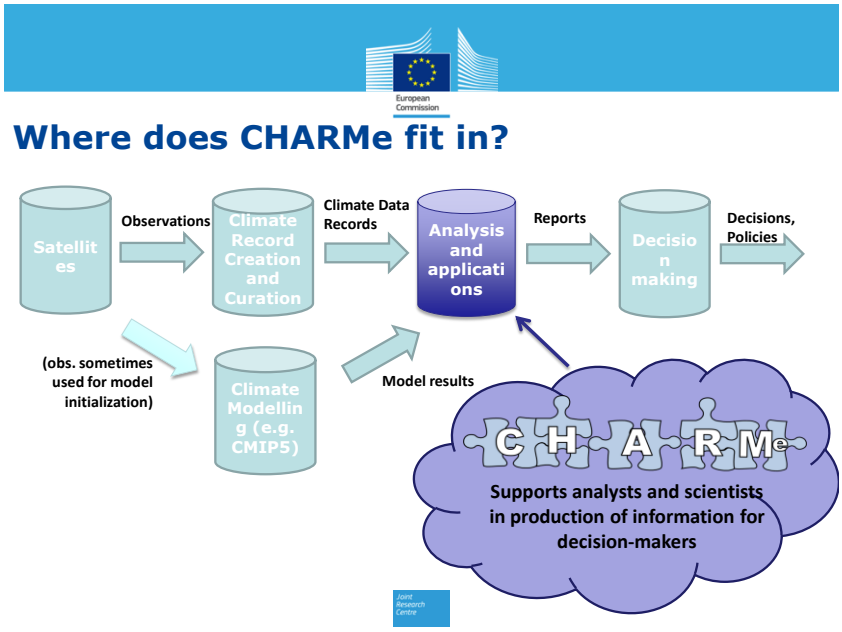

Figure 10: Schematic diagram of CHARMe implementation (Mark Dowell)

5.2 CHARMe Symposium

The symposium explored CHARMe's shared collective experience', or linkages with other projects and programmes (Table 2).

*Table 2 – Programme CHARME Final Symposium*Time	Discussion topic	Lead by:
09:00 - 09:20	Coffee and registration	
09:20 - 09:30	Welcome and introduction to "Sharing our Collective Expertise"	Jean-Noel Thepaut
09:30 - 10:00	Strategy towards an Architecture for Climate Monitoring from Space	Mark Dowell
10:00 - 10:20	Response to this strategy; data informatics big data and visualisation – using CHARMe	Jon Blower
	Project initiatives in progress, how CHARMe could help	
10:20 - 10:40	- QA4ECV	Joerg Schulz
10:40 - 11:00	- CORE-CLIMAX	David Tan
11:00 - 11:20	Coffee	

	Response to the project initiatives – how they can/could be used	
11:20 - 11:40	- Clip-C	Martin Juckes
11:40 – 12:00	- ERA-CLIM2	Paul Poli
12:00 – 12:20	- Copernicus Quality Control	Thomas Lankester
12:20 - 13:20	Lunch	
13:20 – 13:40	- DWD-CM SAF	Frank Kratzenstein
13:40 – 14:00	- Obs4Mips	Jon Blower on behalf of Robert Ferraro
14:00 – 14:40	Panel discussion	Jon Blower (Chair)
14:40 – 14:50	Wrap up and seminar close	

After an introduction by Jean-Noel Thepaut (ECMWF), Mark Dowell explained how CHARMe will support European climate data services such as Copernicus, EUCLIA, as well as satellite observation data services such as CEOS (Committee on Earth Observations satellites). CHARMe supports Horizon 2020 objectives and WMO's GCOS (Global Climate Observing System) guidelines by cross cutting other climate science projects such as ESA's inventory of essential climate variables (ECV) and UNFCCC's OASIS. Jon Blower emphasised the need to document research and experience, formal & informal, and explored broader applications for CHARMe for the wider scientific community and organisations with global spatial interests in research and operations. He exampled global agriculture organisations (e.g. fooddeserts.com) who might be interested in the International Satellite Cloud Climatology Project (ISCPP) database, and CoreClimax (Coordinating Earth Observation Data Validation for Re-analysis for Climate Services) for assessing the likely impacts of climate change on crop production and food security.

Joerg Schulz (EUMETSAT) emphasised the value of CHARMe in supporting EU FP7's data quality assurance and attribution initiative for essential climate variables (QA4ECV) and cited work by Neil Massey at University of Oxford, Peter Stott at the Hadley Centre, and Tim Palmer at ECMWF. David Tan (ECMWF) considered CORECLIMAX tools such as data inventories and system maturity & performance indices in relation to CHARMe. Martin Juckes (STFC) pointed to a potential CHARMe application with CLIP-C (Climate Information Platform for Copernicus) which will be a one-stop-shop for climate data and supports an impacts toolkit for decision makers. Paul Poli (ECMWF), Thomas Lankester (Airbus), and Frank Kratzenstein (DWD) outlined technical achievements and future directions associated with harvesting, discovering and archiving large environmental datasets. Jon Blower delivered Robert Ferraro's presentation summarising parallel work at NASA's Center for Climate Simulation on facilitating

connections between global model and observations data (e.g. Obs4MIPs (Observations for Model Intercomparison Projects)and NASA's earth system grid federation.

In discussion, significant challenges were identified in marshalling, annotation and mapping increasingly large model and observations datasets, for which CHARMe will undoubtedly make a significant contribution.

6 Project Outreach

6.1 Website & Blog

The CHARMe website is maintained to include project information, links to data sets, news updates and a team blog. The current version will be maintained after the project end to provide technical information and other information. The team blog includes a number of contributions explaining how CHARMe will benefit data providers and users.

Project outreach aims to increase CHARMe's public profile and it was represented at a number of international symposia and conferences shown in Table 3.

Table 3: Conferences 'attended' by CHARMe in 2014

Date	Event
15-19th December 2014	Abstract on CHARMe submitted to the Improving Data Interoperability and Usability session at the AGU meeting, San Francisco, USA.
10-11th December 2014	CHARMe Final Workshop for users and stakeholders. Reading, UK.
12-14th November 2014	Paper on CHARMe significant event viewer at the ESA Big Data from Space conference, ESRIN, Italy.
20-22nd October 2014	Victoria Bennett gave a presentation on CHARMe to data providers at the ESA CCI colocation meeting, ESRIN, Italy.
13-17th October 2014	CHARMe attended the Climate Research and Earth Observations from Space conference, Darmstadt, Germany, and presented its brochure.
6-10th October 2014	A CHARMe poster was presented at the 10th European Conference on Applied Climatology (ECAC), Prague, Czech Republic.
22-26th September 2014	CHARMe presentation at the annual EUMETSAT Meteorological Satellite Conference, Darmstadt Germany.
22nd August 2014	CHARMe Newsletter no.3 issued
22-25th May 2014	CHARMe work presented at the SENTINEL-2 for Science Workshop, ESRIN, Italy.
16th and 28th May 2014	CHARMe scientists write articles for the CHARMe blog site.
27th April - 2nd May 2014	A CHARMe poster was presented, and a presentation on the Contextualization of visualizations of climate data given at EGU, Vienna, Austria.
27th April 2014	CHARMe brochure circulated to stakeholders and researchers.
2nd April 2014	CHARMe paper presented at the W3C workshop on Open Annotation, San Francisco, USA.
2-8th April 2014	CHARMe scientist visits NOAA and NCPP in the USA to promote the CHARMe system.
26th March - 1st April 2014	CHARMe poster presented at the International TOVS Study Conference XIX (ITSC XIX), Jeju Island, South Korea.
20-21st March 2014	CHARMe representation by STFC at LTDP working group meeting, Spain.
19-20th March 2014	CHARMe research results circulated at the European Data Forum, Greece.
13-14th March 2014	CHARMe presentation at the Copernicus Big Data Workshop, Brussels, Belgium.
10-12th March 2014	CHARMe poster at the CMSAF 4th User workshop by DWD, Badersee, Germany.
17-18th February 2014	CHARMe interaction at the ECMWF Climate Change Service Workshop, Reading, UK.

Future presentations about the benefits and utility of the CHARMe system could be conducted by the project partners on a case by case basis.

6.2 Other Potential Applications

There is potential for CHARMe to be used on other climate datasets. One example is Obs4MIPS which has more than 60 observational datasets covering a variety of (mostly) CMIP5 output variables and is a key set of climate information for climate researchers and modelers.

6.3 Lessons learned from the project

The CHARMe project delivered the key requirements and was completed within the agreed timescales. There were, however some items that we will learn from:

(i) Have clearly defined pathways in the project plan for dealing with software components that deliver late or, due to changes in the project, will not be delivered.

(ii) Ensure that effort is made at the beginning of the project to identify and engage with, the different stakeholder groups.

(iii) Ensure good links between each WP and the comms activity.

(iv) Ensure each WP has the responsibility for feeding material to the comms WP for use in outreach.

6.4 CHARMe Support in 2015 (STFC/ CGI/ UK Met Office/ ECMWF/ UREAD)

An on-line user manual, available from the CHARMe website will be provided to include how to register, access and use the system.

STFC have agreed to provide maintenance support for the CHARMe node in 2015.

CGI have agreed to provide maintenance support for the Java script plugin in 2015.

The Met office will maintain the website and the blog. As well as contacts for technical support, this will keep users up to date with technical developments and encourage new adopters. Users and data providers will be invited to contribute a blog, approximately quarterly.

ECMWF have included the Significant Event Viewer Tool in their apps store and this will be included in their general applications support.

It is hoped that the project team will encourage and enable further outreach and dissemination regarding the following activities:

(i) A high level discussion needs to be held with ECMWF about using CHARMe in the Copernicus(C3S) operational climate change service and with ESA about using CHARMe in C3S/CCI data portal.

(ii) Assisting Earth System Grid Federation (ESGF) in implementing CHARMe in the new front end user interface (CoG) .

In order to encourage other data centres to take up CHARMe, documentation support will need to be provided alongside the code with installation/ integration instructions.