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ANNOTATING CLIMATE DATA WITH COMMENTARY: THE CHARME PROJECT

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ABSTRACT

The CHARMe project enables the annotation of climate data with key pieces of supporting information that we term commentary. Commentary reflects the experience that has built up in the user community, and can help new or less-expert users (such as consultants, SMEs, experts in other fields) to understand and interpret complex data. In the context of global climate services, the CHARMe system will record, retain and disseminate this commentary on climate datasets, and provide a means for feeding back this experience to the data providers. Based on novel linked data techniques and standards, the project has developed a core system, data model and suite of open-source tools to enable this information to be shared, discovered and exploited by the community.

***Index Terms*—** Linked data, climate services, data integrity, data sharing, Big Data

1. INTRODUCTION

Users of climate data and services are highly diverse, ranging from research scientists (for example, searching for signals of long-term climate change) through government policy-makers (for example, setting caps on carbon dioxide emissions) to operational decision-makers (for example, planning construction of flood defences). To be able to quickly determine what information is needed would be invaluable for climate services. Ideally these users would have access to a range of additional information - that we term "commentary" - to judge whether a particular dataset is fit for their purpose. Measurements from space are an important component of these climate services, and it is recognized that there is a need for both the satellite data and its metadata to be curated and shared in a systematic manner, including user feedback [1, 2]. The capture, discovery and preservation of diverse and disparate commentary metadata is a Big Data problem, and part of the data lifecycle that has not been significantly addressed previously.

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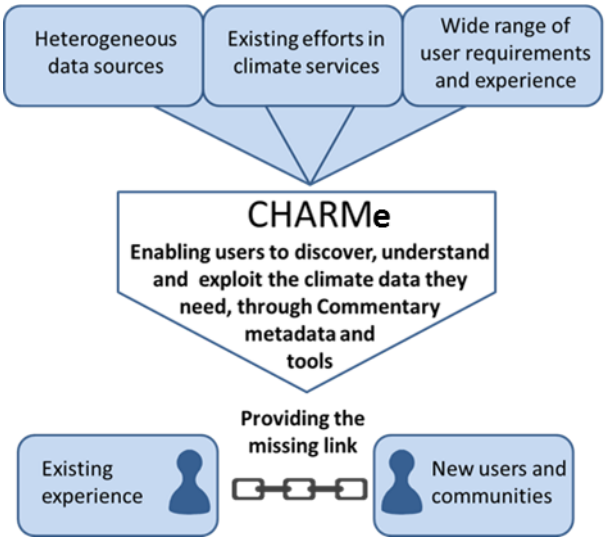

Fig. 1. Graphical abstract of the CHARMe project

This paper describes the developments of the CHARMe project ("Characterisation of metadata to enable high-quality climate applications and services"), which is operated by a consortium of nine European partners, including data providers, infrastructure providers and users of climate data. CHARMe applies the principles of "Linked Data" and adopts the Open Annotation standard to link, search and publish user-derived commentary in a machine-readable way. Two other papers in this proceedings describe the use of CHARMe for specific applications: the Copernicus Quality Control system, and annotating the ECMWF climate reanalyses.

2. WHAT IS COMMENTARY METADATA?

"Commentary metadata" is a term for supporting information about data that is typically provided by users, not by the original data provider. Examples include peer-reviewed publications from the scientific community, technical reports, third-party quality assessments and error characterizations, external events that affect data quality (including instrument failures and volcanic eruptions - we call these significant events)

and more informal material such as websites, blog entries and ad-hoc comments. It complements existing metadata (such as the spatio-temporal coverage and resolution and the data format) that is known by the originator and is already provided through many data infrastructures. A taxonomy of such metadata is provided by [3]; what we term "commentary" is analogous to "character" in this taxonomy. Commentary information is useful for several reasons, for instance:

- It helps new users to select between apparently similar datasets to choose the best dataset for their purpose, in a similar manner to the use of reviews on a shopping or travel website.
- It increases the probability that vital results and lessons concerning the strengths and weaknesses of datasets are retained by the community, avoiding reinvention.
- It provides another view of data quality (in the sense of "fitness for purpose").
- It increases the traceability of conclusions in the literature back to their source data and increases the reproducibility of results (e.g. the draft 3rd US National Climate Assessment [4], refers to the importance of the "line of sight between conclusions and data").
- It provides a new route to data discovery, particularly where users record information about how datasets relate to each other.
- It provides valuable feedback to data providers, as it helps them to improve their data and report back to their own funding agencies.

Although many types and sources of commentary metadata currently exist, there has been no mechanism to provide unambiguous links back to the source data, and make this information discoverable alongside it. A flexible, extendable system to provide this functionality is the key innovation of the CHARMe project. Further discussion of commentary and potential CHARMe users can be found in [5].

3. THE CORE CHARME SYSTEM

The core CHARMe system consists of a specialised data store commentary metadata (the CHARMe "node") and a data model that describes the key concepts, structure and vocabulary of commentary metadata.

A central challenge to CHARMe is the variety and complexity of climate data, which makes it impossible to represent every possible use case in one model. The approach followed here has been to develop a data model which is flexible enough to support a broad scope, and can be supported through specialisations to meet the needs of individual use cases. The model is based on W3C's Open Annotation standards [6], and a number of data formats for exchanging information in this data model are also defined. Items of commentary are modelled as annotations, which simply attach new information (the piece of commentary, or "body") to an existing resource (the "target"), such as a climate dataset. In this way, anything that has a unique identifier (for example, a Digital Object Identifer (DOI) or persistent URL) can be annotated with commentary.

The CHARMe node is a server for hosting this commentary information, consisting of a triplestore that is accessed via Web Service APIs (OpenSearch, REST, SPARQL) together with a user interface for user management and moderation of submitted annotations. The node is hosted by the Centre for Environmental Data Archival in Harwell, UK. The tools described in the following section are examples of client programs, hosted elsewhere, which use the APIs to add and retrieve commentary information from this central repository.

4. CHARME TOOLS

CHARMe has developed a suite of tools and applications that demonstrate different ways in which commentary metadata can be used, including a "significant events" viewer (which matches timeseries of climate data with events in time that might have affected the data), a plugin for data providers, and the CHARMe Maps tool, which examines fine-grained commentary and supports data and metadata intercomparison. The plugin and Maps tools will be described further in this section, while the significant events viewer, as applied to climate reanalyses, is the subject of a separate paper in this issue.

The CHARMe plugin is a Javascript component that is designed to be integrated into existing data-provider websites, providing an interface for viewing and entering commentary metadata. The results of a user's search are augmented with a "C" icon, which is coloured when commentary information has already been recorded for that search result. Figure 2 shows a screenshot of the plugin being tested at ECMWF's data archive. Within the project, the plugin is also being tested deployed at KNMI (the European Climate Assessment and Dataset archive), DWD and CEDA. In this way, we are allowing users to discover commentary via the websites that they are already using to access climate data. The plugin has a faceted search interface to search for existing annotations and functionality for adding new annotations.

The CHARMe Maps tool is an expertimental interactive map interface for browsing datasets, and creating commentary information attached to *subsets* of datasets. For example, a user might want to highlight an interesting feature in a satellite image, such as a dust storm or volcanic ash cloud, or flag up a potential problem with a processing algorithm or sensor, which may affect all data in a certain geographic region. This tool is being developed in collaboration with scien-

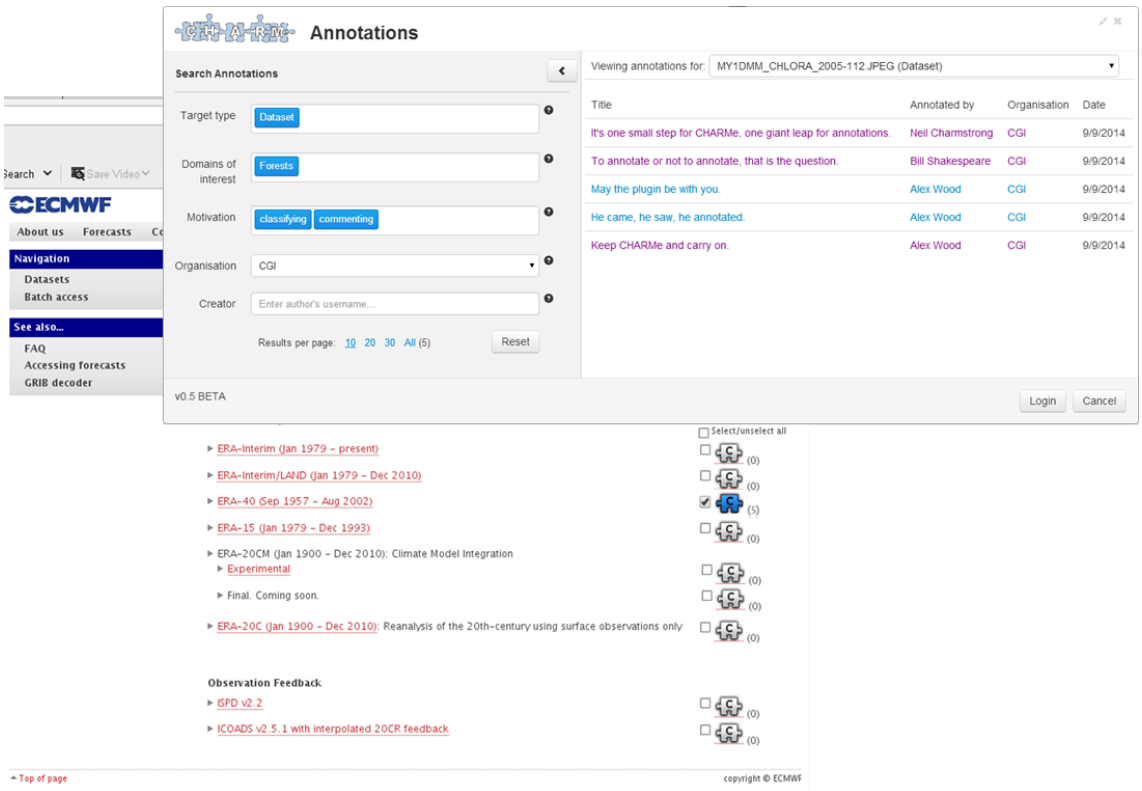

Fig. 2. Screenshot of the CHARMe plugin being tested at the ECMWF archive. The "C" icon is coloured-in to indicate that a dataset has already been annotated with commentary.

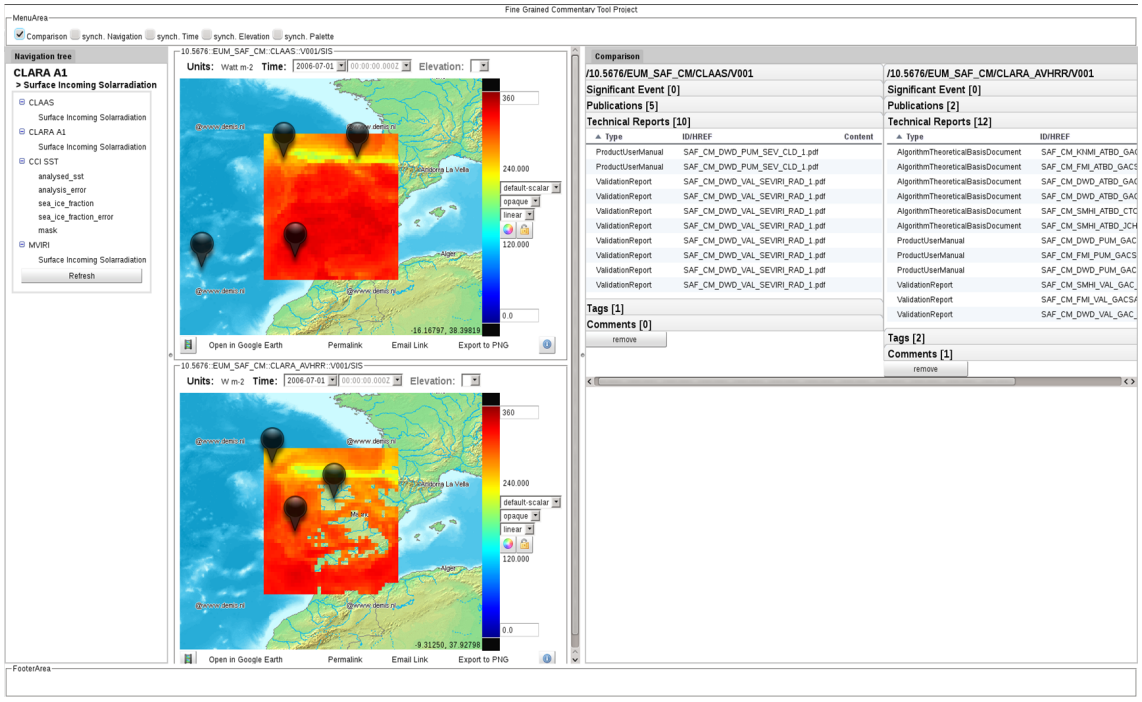

Fig. 3. Screenshot of the CHARMe Maps tool, showing a user browsing several datasets at once via an interactive map, with intercomparison of their associated commentary information (in this case comprising publications and technical reports) in the right-hand panel.

tists working on projects within ESA's Climate Change Initiative, which is producing long-term, high-quality climate data records. CHARMe Maps includes functionality for data intercomparison: users can load several datasets in parallel and visualize the available commentary annotations at the same time. A screenshot of the tool is shown in figure 3.

The CHARMe Maps tool is being developed as a proof-of-concept for fine-grained annotations and the ability of the data model to support geographical information, and will not be fully operational at the end of the project. However, since the early design stages of the tool, different international science and user groups have showed an interest in testing the tool for future integration in their work, including ESAs Climate Change Initiative (CCI) Sea Surface Temperature group at University of Reading (UK), the CCI Clouds group at DWD (Germany) and the US National Climate Predictions and Projections Platform, formed by scientists from NOAA, NASA and JPL (USA).

5. HOW DOES CHARME HELP IN A "BIG DATA" FUTURE?

The climate science community has to deal with many issues relating to Big Data, including volume (e.g. the state of the art climate model output database is of petabyte scale), velocity (e.g. 8TB/day from ESA's Sentinel series of climate monitoring platforms), variety (e.g. satellite, in situ and model output) and veracity (i.e. data quality). This project is making particular contributions to the understanding of Big Data variety and veracity, by linking disparate information and enabling users to make judgments about the applicability of datasets to different problems.

CHARMe is harnessing the power of the Semantic Web and Linked Data, which enables us to publish commentary metadata widely in a way that can be interpreted both by humans and by automated software. The project is not attempting to alter the entire approach, formats and standards used by the climate and EO community, but rather to engender a different way of working so that the vital commentary metadata can be understood from a common perspective, allowing users (from whatever origin) to be able choose data appropriate to their needs. Although CHARMe has a particular focus on products derived from Earth observation, the open-source technologies developed in the project could readily be applied to other fields. All CHARMe software will be open-source, released under a liberal licence, permitting future projects to re-use the source code as they wish.

The CHARMe system provides a means of making climate data comprehensible to new communities, as well as serving the existing user community with tools for the inter-comparison of metadata records and best practice for their generation and preservation. In future, climate data users should start to expect a CHARMe-button at their data provider, giving access to the diverse commentary relevant to their chosen dataset. Behind this small button, that at first may not look like much, is the start of a new functionality serving the rapidly-growing area of climate services.

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