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HELIO: The Heliophysics Integrated Observatory

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Abstract

Heliophysics is a new research field that explores the Sun–Solar System Connection; it requires the joint exploitation of solar, heliospheric, magnetospheric and ionospheric observations.

HELIO, the Heliophysics Integrated Observatory, will facilitate this study by creating an integrated e-Infrastructure that has no equivalent anywhere else. It will be a key component of a worldwide effort to integrate heliophysics data and will coordinate closely with international organizations to exploit synergies with complementary domains.

HELIO was proposed under a Research Infrastructure call in the Capacities Programme of the European Commission's 7th Framework Programme (FP7). The project was selected for negotiation in January 2009; following a successful conclusion to these, the project started on 1 June 2009 and will last for 36 months.

Keywords: Heliophysics; HELIO; Virtual observatory; Sun; Solar system; Heliosphere; Magnetosphere; Ionosphere; Services; Semantics; Ontology; Workflow; Metadata; Data access; Distributed data systems; Interoperability; Interdisciplinary

1. Introduction

Heliophysics is the study of the effects of the Sun on the Solar System and it addresses problems that span a number of existing disciplines – solar and heliospheric physics, and magnetospheric and ionospheric physics. The discipline is closely related to the study of space weather and the phenomena that affect it, but heliophysics is more generalized covering all parts of the Solar System rather that just the Sun–Earth connection.

The Heliophysics Integrated Observatory (HELIO) will provide the most comprehensive integrated information system in this domain. HELIO will deploy a distributed network of services that will address the needs of a broad

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community of researchers in heliophysics. It will coordinate access to the resources needed by the community, and will provide access to services to mine and analyze the data.

Of necessity HELIO needs to provide access to data archives scattered around the world. This is required in order to ensure the greatest possible coverage of events and effects – individual ground-based observatories cannot provide continuous observations and space-based platforms have been funded by different combinations of nations.

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2. Overview

In order to facilitate the study of this new discipline, HELIO needs to address issues in a number of areas related to two basic requirements, to:

- Provide integrated access to data from all the domains of heliophysics that are held in archives around the world.
- Provide the means to conduct searches across the domains to identify data-sets of interest.

There are a limited number of protocols that can be used to access data over the Internet and the principal issues related to access that HELIO needs to address are how the data are stored in files and how these are made available to users.

The communities involved in heliophysics have evolved independently over decades and even centuries. Even though the links between the effects observed in the domains are now evident, there have been virtually no attempts to coordinate the way the communities conduct their data analysis. As a consequence, there are considerable differences in the way the communities store, describe and think about data. HELIO must therefore be able to provide integrated access to a range of file formats with contents that differ in content and terminology, and completeness and quality.

The ways files are named and stored in an archive can affect how easily the data can be accessed. Since the capabilities of archives vary, HELIO must be able to accommodate these differences without placing any excessive requirements on the providers.

There are similar issues related to the metadata used to identify data sets of interest, but there are also additional considerations.

In order to conduct a search across the domains we need to be able to relate parameters in their data sets; the most basic of these are coordinate systems used to describe when and where a phenomena was observed. Time can be expressed in a number of ways but fundamentally these are all closely related. However, the spatial coordinates used can relate to different bodies within the Solar System as a phenomenon propagates – this may require translation between and rationalization of the systems that are used.

Most effects are caused by phenomena that originate on the solar surface and, when a phenomenon is in its onset phase, a heliographic coordinates system is required. Since many observations of the Sun are remote-sensed images, they are described in a heliocentric system – a translation to heliographic coordinates (and vice versa) will, therefore, be needed. As the phenomenon propagates through interplanetary space, an extended form of heliographic coordinates is required so that effects can be tied back to events on the solar surface. When the phenomenon interacts with a planetary environment the effects become related to planetary coordinate systems and depend on whether the planet has a magnetic field and/or atmosphere. It is, therefore, necessary to be able to translate seamlessly through a series of geomagnetic and geographic coordinate systems as the phenomenon approaches the planetary surface.

Effects caused by photon emissions require line-of-sight view of the source and any delays are related to light travel times; those that are caused by particles occur with much longer delays and in most cases the effects are only experience if the propagating phenomena passes the observer. Knowing which effect will be observed when and where requires the solution of a 4-dimensional problem (see Fig. 1).

In order to undertake a search, not only do we need to know how to track a phenomenon as it moves between coordinate systems, we also need to understand how it propagates through interplanetary space, i.e. the path it follows and the time scales involved. HELIO will, therefore, provide access to a propagation model to help determine which observatories making the required type of observations are located where they could satisfy the user's search criteria (at the required time).

3. Project implementation

HELIO will address the challenges it faces following the Integrated Infrastructure Initiative (I3) activities model of the Framework Programmes; this is split into three components:

- Networking – We will cooperate closely with the community to define the required capabilities of the HELIO infrastructure and develop new standards for heliophysical data.
- Joint Research – We will develop search tools that span disciplinary boundaries and explore new types of user-friendly interfaces.