Algorithm Preparation and Data Availability

for the SDO Investigations in the Context of the UK Virtual Observatory

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SDO Data on the Grid

The SDO project will integrate with UK and European grid projects such as Astrogrid and EGSO to provide access to SDO data and specialist processing to the solar community. Specialist algorithms for processing AIA, HMI global, and HMI local data will be deployed as solar grid applications. Four UK Solar Physics groups have Co-Investigator involvement in the SDO AIA and HMI investigations: MSSL, Imperial College, Rutherford Appleton Laboratory, and the University of Birmingham. The huge SDO data volume (~ 2.5 TBytes/day) requires special measures to ensure effective data handling:

- Specialist algorithms for local and global helioseismology data products and for feature recognition in AIA and HMI images
- Development of data summary formats to allow high speed searches of the SDO databases
- Production of Grid-compatible software to enable distributed processing and storage of SDO data

The UK-based SDO e-Science consortium will be funded by PPARC to assist US SDO investigation teams to extract data products and enable data access by the UK Solar Physics community.

Benefits of Grid Integration:

- provision of SDO data products via web interface
- access to SDO post-pipeline solar grid applications
- registration of SDO data products
- registration of SDO solar grid applications
- display of data product summaries (i.e., thumbnails)

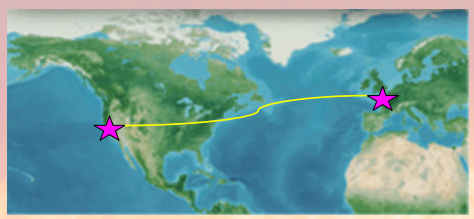
Data Product Summary Formats

An important part of the SDO software project is the development of summary formats for SDO data products such as images and tables, as well as more complex products such as magnetograms and helioseismologic data. SDO product summaries will take two forms: **simple** and **complex**.

Simple data summaries will include image thumbnails and table column headers or minima and maxima for each column. **Complex** data summaries will be developed for vector magnetograms and helioseismology products, e.g. solar movies.

By investing development time in data product summaries, users will benefit from high speed searches, high speed data downloads, and high rapid decisions about which full-size data products are suitable for further investigation.

SDO Data Centre: Integrating with PAL



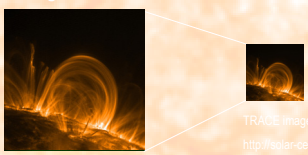
The SDO data centre will use infrastructure developed by the Astrogrid project to make SDO data available to the UK solar community via a web browser. A "Publisher's Astrogrid Library", or PAL, can be installed wherever SDO data products are queried. Although the PAL does not need to be installed at the same physical location as the data, the Astrogrid data centre software works most efficiently when the PAL installation is near the data in terms of network proximity.

For instance, the scenario illustrated with the above map shows these details:

- 1 PAL installed in California where SDO post-pipeline data is located
- 1 PAL installed in UK near location of SDO data processed by specialist solar grid applications

Simple Summary Formats:

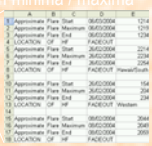
1. **Images:** convert to thumbnails



TRACE image of a coronal loop from http://solar-center.stanford.edu/news/trace.html

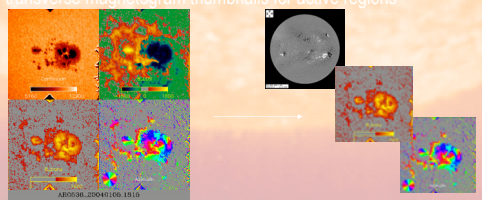
2. **Tables:** extract basic metadata & column minima / maxima

Flare#	Observatory	Start Time/Date
2354	Hawaii	20040312 00:12:45



Complex Summary Formats:

3. **Vector Magnetograms:** compile full-disk line-of-sight magnetograms accompanied by intensity, line-of-sight, and transverse magnetogram thumbnails for active regions



Vector magnetograms of AR0536 on 05/01/04, from http://www.solar.ifa.hawaii.edu, and full disk line-of-sight magnetogram taken on 15/03/04 by the Big Bear GONG+ instrument.

Preparation of Specialist Algorithms

The European Grid of Solar Observatories (EGSO) is developing several relevant tools including algorithms for recognition in white-light images and magnetograms of active regions, sunspots, and filaments. These could be adapted where appropriate given the UK involvement in EGSO. In addition, other feature recognition and data analysis tools will be developed as grid applications for the HMI and AIA instruments.

1. Image Feature Recognition Tools (AIA / HMI)

- Recognition of coronal loops
- Recognition of multiple overlapping loops
- Recognition of coronal dimming regions
- Correlation between coronal voids and CME times
- Distinction between dimming regions and coronal holes
- Recognition of flares
- Recognition of active region outflows
- Detection of "EIT" waves

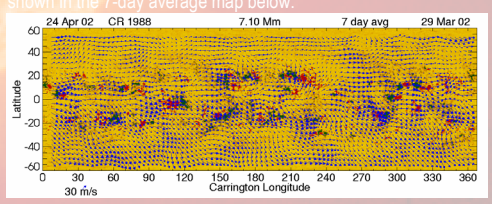
2. Helioseismology Tools – Global (HMI)

- Extrapolation of birth of solar farside activity
- Estimation of wave travel times between a set of points on a Dopplergram
- Distribution of parallel processing load for Dopplergram computations
- Creation of helioseismic subsurface flow maps
- Correlation of active regions and subsurface flow maps with ≤ 24 hour lookback
- Creation of wave speed perturbation maps
- Deduction of magnetic field speed and direction from wave speed perturbation maps

3. Helioseismology Tools – Local (HMI)

- Determination of mode frequencies on timescales matching solar magnetic activity
- Determination of solar rotation profile with radial and latitudinal precision, based on mode splitting.
- Determination of oscillation source locations using mode asymmetry
- Correlation between mode frequency, source location and other oscillation data over short and long timescale
- Combined use of HMI data with GONG and BISON observations

4. Synoptic Flow Maps: extract averages from flow maps showing daily activity over a 26-day Carrington rotation, as shown in the 7-day average map below:



Synoptic flow map showing solar magnetic fields between 29/03/02 and 24/04/02 from http://www.boulder.swri.edu/~deforest/wxmaps/

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