Heliospheric Cataloguing, Analysis and Techniques Service

EU Project #: 606692

FP7-SPACE-2013-1

HELCATS First Annual Report May 2015

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ACRONYM LIST

AMDA	Automated Multi-Dataset Analysis (software tool)
CIR	Co-rotating Interaction Region
CME	Coronal Mass Ejection
CNRS	Centre National de la Recherche Scientifique
EUV	Extreme UltraViolet
GCS	Graduated Cylindrical Shell model
GMU	George Mason University
HELCATS	Heliospheric Cataloguing, Analysis and Techniques Service
HI	Heliospheric Imager/Imaging
ICME	Interplanetary CME
IMPERIAL	Imperial College of Science, Technology and Medicine, London
IPR	Intellectual property rights
IPS	Interplanetary Scintillation
MGT	Management
MHD	Magnetohydrodynamics
ROB	Koninklijke Sterrenwacht van Belgie
RTD	Research and Technology Development
RAL	Rutherford Appleton Laboratory
OTH	Other
SIR	Stream Interaction Regions
STEREO	Solar Terrestrial Relations Observatory (mission)
STFC	Science and Technology Facilities Council
TCD	The Provost, Fellows, Foundation Scholars & the other members of Board of the College of the Holy and Undivided Trinity of Queen Elizabeth near Dublin
UGOE	Georg-August-Universitaet Goettingen Stiftung Oeffentlichen Rechts
UH	Helsingin Yliopisto
UNIGRAZ	Universitaet Graz
UPS	Universite Paul Sabatier Toulouse III
WP	Work Package

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1 INTRODUCTION

The advent of wide-angle imaging of the inner heliosphere has revolutionised the study of the solar wind and, in particular, transient solar wind structures such as Coronal Mass Ejections (CMEs) and Co-rotating Interaction Regions (CIRs). CMEs comprise enormous plasma and magnetic field structures that are ejected from the Sun and propagate at what can be immense speeds through interplanetary space, whilst CIRs are characterised by extensive swathes of compressed plasma/magnetic field that form along flow discontinuities of solar origin that permeate the inner heliosphere. With Heliospheric Imaging (HI) came the unique ability to track the evolution of these features as they propagate through the inner heliosphere. Prior to the development of wide-angle imaging of the inner heliosphere, signatures of such solar wind transients could only be observed within a few solar radii of the Sun, and in the vicinity of a few near-Earth and interplanetary in-situ probes. HI has, for the first time, filled that vast and crucial observational gap.

The HELCATS project provides an unprecedented focus for world-leading European expertise in the novel and revolutionary, European-led field of HI, in terms of instrumentation, data analysis, modelling and science. HELCATS is a strategic project that empowers the wider scientific community, in Europe and beyond, by providing access to advanced catalogues - validated and augmented through the use of techniques and models - for the analysis of solar wind transients, based on observations from European-led space instrumentation. All beneficiaries are at the forefront of heliospheric research and bring distinct, yet highly complementary, skills to the project. HELCATS adds significant value to the exploitation of existing European space instrumentation, providing a strong foundation for enhanced exploitation and advancement of European heliospheric research.

HELCATS recognises the synergy between solar and heliospheric physics research (both of which are European strengths) and their applied space weather aspect, currently a topic of vigorous debate in many political and scientific arenas. With the impending development of a European space weather capability, HELCATS has real, practical relevance.

The HELCATS consortium is led by STFC's Rutherford Appleton Laboratory. The Coordinator is Professor Richard A Harrison and the Scientific and Technical Manager is Dr Jackie A Davies. The list of beneficiaries is given in Table 1. The HELCATS workpackage (WP) structure is given in Table 2.

Table 1: HELCATS Beneficiaries

No	NAME	SHORT NAME	COUNTRY
1	SCIENCE AND TECHNOLOGY FACILITIES COUNCIL	STFC	United Kingdom
2	UNIVERSITAET GRAZ	UNIGRAZ	Austria
3	UNIVERSITE PAUL SABATIER TOULOUSE	UPS	France
4	GEORG-AUGUST-UNIVERSITAET GOETTINGEN STIFTUNG OEFFENTLICHEN RECHTS	UGOE	Germany
5	KONINKLIJKE STERRENWACHT VAN BELGIE	ROB	Belgium
6	IMPERIAL COLLEGE OF SCIENCE, TECHNOLOGY AND MEDICINE	IMPERIAL	United Kingdom
7	HELSINGIN YLIOPISTO	UH	Finland
8	THE PROVOST, FELLOWS, FOUNDATION SCHOLARS & THE OTHER MEMBERS OF BOARD OF THE COLLEGE OF THE HOLY & UNDIVIDED TRINITY OF QUEEN ELIZABETH NEAR DUBLIN	TCD	Ireland

Table 2: The HELCATS WP structure

WP No	WP ACTIVITY TYPE	WP TITLE
1	MGT	MANAGEMENT
2	RTD	PRODUCING A DEFINITIVE CATALOGUE OF CMES IMAGED BY STEREO/HI
3	RTD	DERIVING/CATALOGUING THE KINETIC PROPERTIES OF STEREO/HI CMES BASED ON GEOMETRICAL AND FORWARD MODELLING
4	RTD	VERIFYING THE KINEMATIC PROPERTIES OF STEREO/ HI CMES AGAINST IN-SITU CME OBSERVATIONS AND CORONAL SOURCES
5	RTD	PRODUCING A DEFINITIVE CATALOGUE OF CIRS IMAGED BY STEREO/HI THAT INCLUDES VERIFIED MODEL- DERIVED KINEMATIC PROPERTIES
6	RTD	INITIALISING ADVANCED NUMERICAL MODELS BASED ON THE KINETIC PROPERTIES OF STEREO/HI CMES AND CIRS
7	RTD	ASSESSING THE COMPLEMENTARY NATURE OF RADIO MEASUREMENTS OF SOLAR WIND TRANSIENTS
8	OTHER	DISSEMINATION

This annual report is broken down into reports from each WP. Thus, to aid the reading of these WP reports, we repeat the WP strategy and structure details here, and refer the reader to the WP structure diagram.

The fundamental aim of the HELCATS project is to start with heliospheric imaging observations and, from that, build up facilities, methods and assessment studies in a logical programme of activities. The work is managed by STFC, involving a total of eight European research groups. The activities of the groups are tailored to their scientific and technical strengths, maximizing the potential scientific return for the project.

WP1: Management - The consortium includes 8 European groups from 7 EU countries and two third parties. The project coordinates work involving observations, cataloguing, modelling, and studies in validation and assessment. WP1 covers the formal management roles of the HELCATS project. This includes administrative tasks, maintaining project infrastructure, coordinating inputs and reporting as required and handling a range of project issues. WP1 oversees the website production and management.

WP2: Producing a definitive catalogue of CMEs imaged by STEREO/HI - This WP provides the foundation for this project (including scientific coordination), namely the production of a catalogue of CMEs in the heliosphere. The catalogue is being produced from manual inspection of STEREO/HI data but use of automated techniques are being investigated. Comparisons with coronal CME catalogues are being made.

WP3: Deriving/cataloguing the kinematic properties of STEREO/HI CMEs based on geometrical and forward modelling - Here we apply recently established geometrical, forward and (prototype) inverse modelling methods to derive CME parameters, which will be added to the catalogue (including back- and forward-projections to 'predict' CME launch and arrivals at various solar system locations). Comparisons will be made between the parameters yielded by the different models.

WP4: Verifying the kinematic properties of STEREO/HI CMEs against in-situ CME observations and coronal sources - This WP catalogues in-situ CME information (at Earth and elsewhere) for comparison to the projected data from WP3 in order to assess the performance of the aforementioned models. Similarly, comparisons are made with solar 'surface' phenomena. These allow a thorough validation of the models.

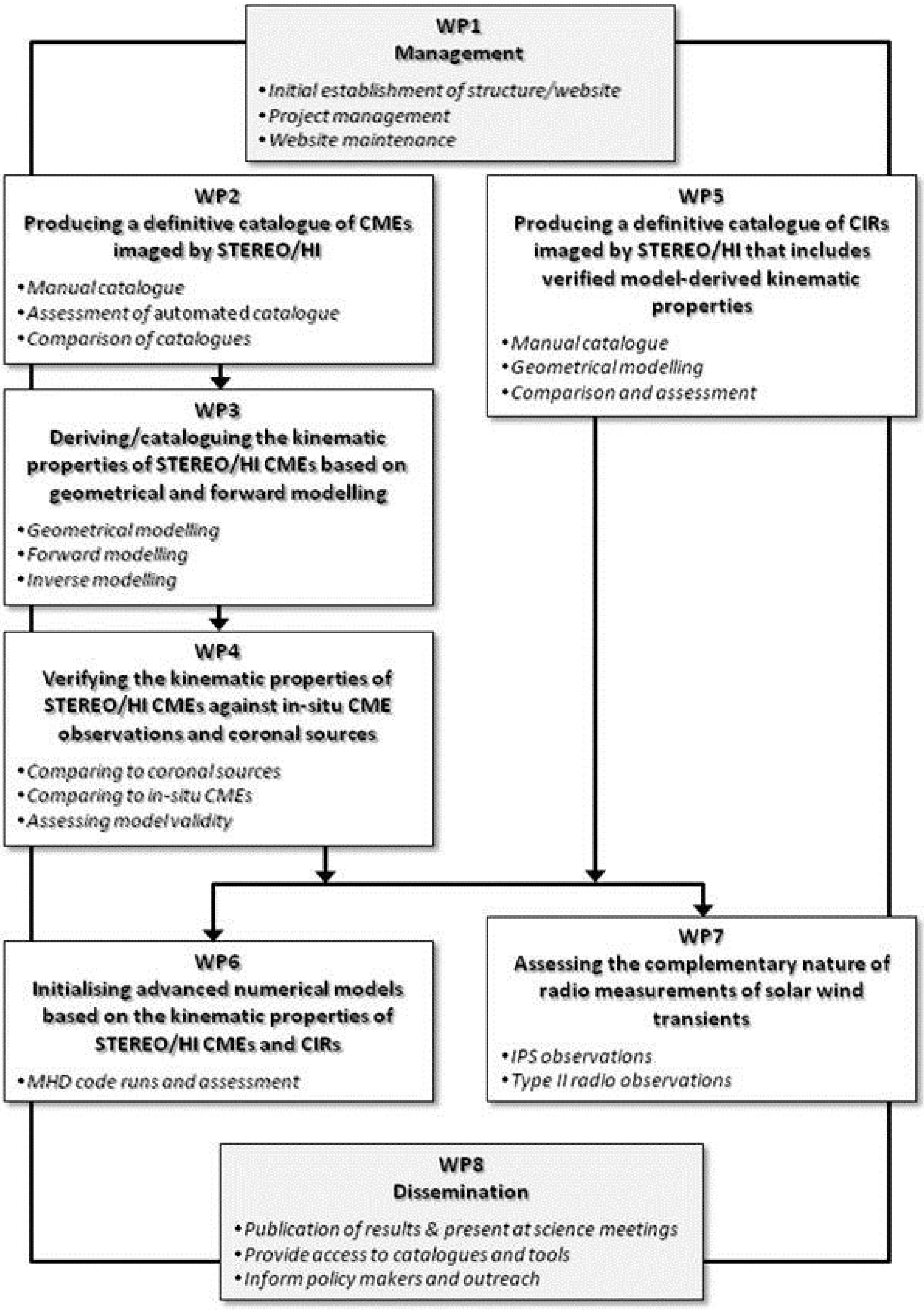
WP5: Producing a definitive catalogue of CIRs imaged by STEREO/HI that includes verified model-derived kinematic properties - In parallel with the CME cataloguing, modelling and model assessment in WP2-4, this WP performs an analogous activity for CIRs, again with cataloguing, geometrical modelling and the validation of results through comparisons to in-situ/solar data.

WP6: Initialising advanced numerical models based on the kinematic properties of STEREO/HI CMEs and CIRs - This WP recognises the potential for using HI data as input to numerical MHD models of the heliosphere (in terms of both CME and CIR phenomena) by considering the use of HI images for initialisation/driving of the ENLIL model. The results will be compared to traditional methods for running such models, based on coronal and photospheric inputs, to assess their potential.

WP7: Assessing the complementary nature of radio measurements of solar wind transients - WP7 explores the value of incorporating radio observations, to augment the HI data. It assesses the value of using interplanetary scintillation (IPS) observations and Type II radio burst data in conjunction with HI data, both of which can provide additional information.

WP8: Dissemination - WP8 brings the results to the community through (1) the publication of results in the open, refereed literature, (2) the running of annual open meetings, (3) the installation of all relevant documentation, catalogues and reports on the website and (4) the dissemination of information to the public and policy makers. This includes ingestion of the products into the AMDA data-mining tool the IRAP (UPS) propagation tool, and integration with projects such as HELIO. This WP coordinates the exploitation of the project outputs, such that they feed into numerous research activities and future space weather applications.

Overall, the HELCATS strategy is to coordinate a range of observational and modelling studies of heliospheric phenomena to provide a foundation for enhancing the scientific discipline and the exploitation of European investment in the hardware involved.



Full details of the HELCATS project can be seen in the description of work documents (606692_DOW_PART_A.pdf and 606692_DOW_PARTB.pdf) agreed with the European Commission in early 2014. The project kicked-off in May 2014. The distribution of work, divided by beneficiary and by WP is given in Table 3.

Table 3: The distribution of work between beneficiaries and WP

Beneficiary	WP1	WP2	WP3	WP7	WP4	WP5	WP6	WP8	Total per Beneficiary
1 – STFC	8.50	25.00	9.00	19.50	0.00	0.00	0.00	11.50	73.50
2 - UNIGRAZ	0.00	0.00	6.00	0.00	30.00	0.00	0.00	0.00	36.00
3 – UPS	0.00	0.00	0.00	0.00	2.00	25.00	24.00	10.00	61.00
CNRS	0.00	0.00	0.00	0.00	2.00	8.00	3.00	0.00	13.00
4 – UGOE	0.00	6.00	21.00	0.00	12.00	0.00	0.00	0.00	39.00
5 – ROB	0.00	20.50	0.00	3.00	6.00	0.00	0.00	0.00	29.50
6 - IMPERIAL	0.00	0.00	0.00	17.00	3.00	0.00	0.00	0.00	20.00
7 – UH	0.00	0.00	0.00	0.00	13.00	9.00	0.00	0.00	22.00
8 – TCD	0.00	0.00	15.00	0.00	0.00	0.00	0.00	0.00	15.00
Total	8.50	51.50	51.00	39.50	68.00	42.00	27.00	21.50	309.00

In the following pages we address each WP in turn, providing a summary of the WP activities and an update of progress and next steps. HELCATS is a three-year project and we are about to complete the first year of activities. The project has a clearly defined schedule of activities, milestones and deliverables and this report demonstrates that the project is on schedule. The WP summaries have been produced by the WP leaders; this does mean that the reports vary slightly in style and format. However, the aim is to produce a thorough statement on the status of the project and the future steps, and this, we believe has been done effectively.

2 WORK PACKAGE SUMMARIES AND REPORTS

WORK PACKAGE 1 (WP1):
MANAGEMENT

WP1 ACTIVITY TYPE: MGT

WP1 DURATION: MONTHS 1 – 36

WP1 LEAD BENEFITIARY: STFC (1)

WP1 LEADER: Professor Richard A Harrison

WP1 CONTRIBUTORS: n/a

WP1 OVERVIEW: The main tasks of WP1 are the initial establishment of the management structure for the HELCATS project, and its support and communication tools, the general operation of this structure, and its termination at the end of the project together with the delivery of the final reports. The work package consists of two tasks, namely, the HELCATS Project Management and the HELCATS website maintenance. The HELCATS consortium consists of 8 European groups (involving 7 EU counties), plus one third-party group from the USA. The project is a complex coordination of activities involving observations and cataloguing, techniques, the development of models and their application, and exercises in validation and assessment. The objective of WP1 is to provide the necessary management structure to implement the HELCATS project effectively, overseeing all administrative matters, assembling and submitting formal reports, overseeing finance auditing, and arranging meetings as appropriate. WP1 will oversee the scheduling and progress of all activities, and the production and management of the HELCATS website.

WP1 TASK 1.1: HELCATS PROJECT MANAGEMENT (TASK LEAD: STFC)

Task 1 covers the formal management roles of the HELCATS project. This includes administrative tasks, maintaining project infrastructure, coordinating inputs and reporting as required and handling a range of project issues.

At the onset of the project, the Executive Board established the formal communication with the Steering Committee, setting up monthly teleconferences and the kick off meeting. The first draft of the HELCATS website was released. The kick off meeting was held on 14-15 May 2014, hosted at the STFC Rutherford Appleton Laboratory. It was attended by all of the beneficiaries and the EU Project Officer. All WPs were discussed in detail. The meeting schedule and locations, for the Bi-Annual Project Meetings/Workshops and the Annual open Workshops were decided for the entire period of the project, ensuring that most beneficiaries hosted at least one meeting. The website was also discussed in detail and formally released (http://www.helcats-fp7.eu/) after the kick-off meeting. Minutes of the meeting and of all subsequent teleconferences are placed on the website (meeting reports are openly available through a ‘meetings’ tab, under the ‘News’ item; teleconference minutes are held within the project wiki on the same website.

Thus, after the kick-off meeting, the project satisfied the first two deliverables:

D1.1 – HELCATS website launch (delivery date by month 3)

D1.2 – Minutes of the kick-off meeting (delivery date by month 2)

WP progress is discussed at each monthly telecon with the Steering Committee, chaired by the Coordinator or the Scientific and Technical Manager.

The first Biannual Meeting of the project was held a ROB on 5-6 November 2014. WP progress was discussed by the Steering Committee; the meeting details and report were lodged on the HELCATS website (under the

'Meetings' tab). Technical issues relating, in particular, to standards for the cataloguing activities were addressed in some detail due to the increasing cataloguing activities of the WPs.

The Annual Open Workshop and second Bi-annual Meeting of the project have been arranged for the week of the 18th to 22nd of May 2015, hosted at Göttingen, Germany, with the arrangements being led by the HELCATS Coordinator, Scientific and Technical Manager, and the UGOE host (Professor Volker Bothmer), reporting to the Steering Committee. Again, at the Bi-Annual Meeting component of the meeting, the progress of each WP will be reported and any technical issues discussed in detail.

Through this WP, the project maintains contact with the EU through the Project Officer and deals with any formal project communications. We coordinate the production of required documentation and oversee meetings with support for logistical arrangements, information; we set the agendas for meetings and have responsibility for overseeing any formal aspects of the project, if required, such as any legal issues or changes to the project structure (e.g. due to staff changes). However, to date, the basic structure of the project and the progress of the WPs have been established and delivered as planned.

WP1 TASK 2.1: HELCATS WEBSITE MAINTENANCE (TASK LEAD: STFC)

The HELCATS website is used for both internal circulation of information and external dissemination of the projects aims and objectives. All documents are available to all members of the consortium, during the whole project, on the private part of our website. The Project Coordinator has the responsibility to maintain and update the website at least every 2 weeks. Products of the project, such as the catalogues and reports, will be openly available through the website, after their delivery. Note that the Dissemination workpackage, WP8, has responsibility for placing reports, catalogues, publications etc… on the website.

WP1 SUMMARY/NEXT STEPS:

WP1 continues throughout the lifetime of the HELCATS project, overseeing all formal communications, meetings, and the project coordination. Thus, the Steering Committee teleconferences will continue on a regular basis, the Bi-Annual and Annual meetings will proceed as planned and scheduled throughout the project, and reports will be produced as required. After the Göttingen meetings, in addition to the WP progress, with regard to deliverables, the emphasis will be on the next Bi-Annual meeting in the autumn of 2015 in Helsinki, Finland, and production of the 18 month progress report to the Commission, which will be the first major financial report.

WORK PACKAGE 2 (WP2):

PRODUCING A DEFINITIVE CATALOGUE OF CMES IMAGED BY STEREO/HI

WP2 ACTIVITY TYPE: RTD

WP2 DURATION: MONTHS 1 – 36

WP2 LEAD BENEFITIARY: STFC (1)

WP2 LEADER: Dr Jackie Davies

WP2 CONTRIBUTORS: UGOE (4); ROB (5)

WP2 OVERVIEW: WP2, in summary, involves the production of a catalogue of CMEs in the heliosphere through visual inspection of white-light imagery from the HI Instruments on NASA's twin-spacecraft STEREO mission; autonomous cataloguing of STEREO/HI CMEs, based on use of the long-established CACTus software package, is also being investigated within this WP. Once generated, if the latter proved to be successful, these catalogues could be inter-compared, as well as being compared with other, pre-existing, coronal CME catalogues. WP2 is divided into four tasks. Task 2.1, led by STFC, comprises the manual CME cataloguing of STEREO/HI CMEs, while the automatic cataloguing is performed under Task 2.2 (led by ROB); Task 2.3 (led by UGOE) covers the comparison of the resultant CME catalogues, both with each other and pre-existing coronal CME catalogues. Task 2.4 (led by STFC) covers the HELCATS scientific management**.** A summary of the progress in each of these tasks, over the first year of the HELCATS project, is given below.

WP2 TASK 2.1: MANUAL CATALOGUING OF STEREO/HI CMES (TASK LEAD: STFC)

Work Package 2 (WP2) is core to the HELCATS project, in that it provides the fundamental manually-generated coronal mass ejection (CME) catalogue on which the subsequent CME-oriented WPs, such as WP3, are based. It is generated by the visual inspection of heliospheric images from the STEREO/HI-1 observations, from the start of the mission science phase in April 2007. Through extensive discussion within the HELCATS consortium, the format of the manual CME catalogue (Task 2.1 of WP2) contains the following six fields:

- A unique CME identifier.
- The time of first observation of the CME in the HI-1 field of view (UTC).
- The spacecraft (A or B).
- The northernmost position angle extent of the CME (degrees).
- The southernmost position angle extent of the CME (degrees).
- A quality flag indicating whether the CME is considered *poor*, *fair* or *good*.

The unique CME identifier is a string containing both the date on which the CME is first observed in HI-1 and the observing spacecraft, with an additional two-digit number to differentiate between multiple CMEs occurring on the same day. So, for example, a CME observed by STEREO-A on 31 Dec. 2007 will have the identifier "HCME A__ 20071231 01". CMEs that exceed the position angle range of the field of view are indicated with a *greater than ">"* or *less than "<"* symbol in the appropriate field. It should be noted that in recognition of the numerous blob-like transients observed close to the Sun, for the unambiguous identification of CMEs, we demand that CMEs have position angle widths of 20^{o} or more. The quality flag has been introduced to account for the ambiguity that results from using human observers to identify events. This field is used as a means to quantify the confidence of the observer, based on the following criteria. A *poor* event is any object (spanning at least 20° in position angle, as noted), but which poorly resembles a CME. A *fair* event is one that resembles a CME, though not all observers may be convinced that this is the case (due to some limitation in the event observation such as a faint, disjoint or otherwise irregular CME structure). A *good* event is one that is unquestionably a CME. To date, this cataloguing has been completed for the years 2007–2011 and 2013, providing the observational properties of over 1000 events.

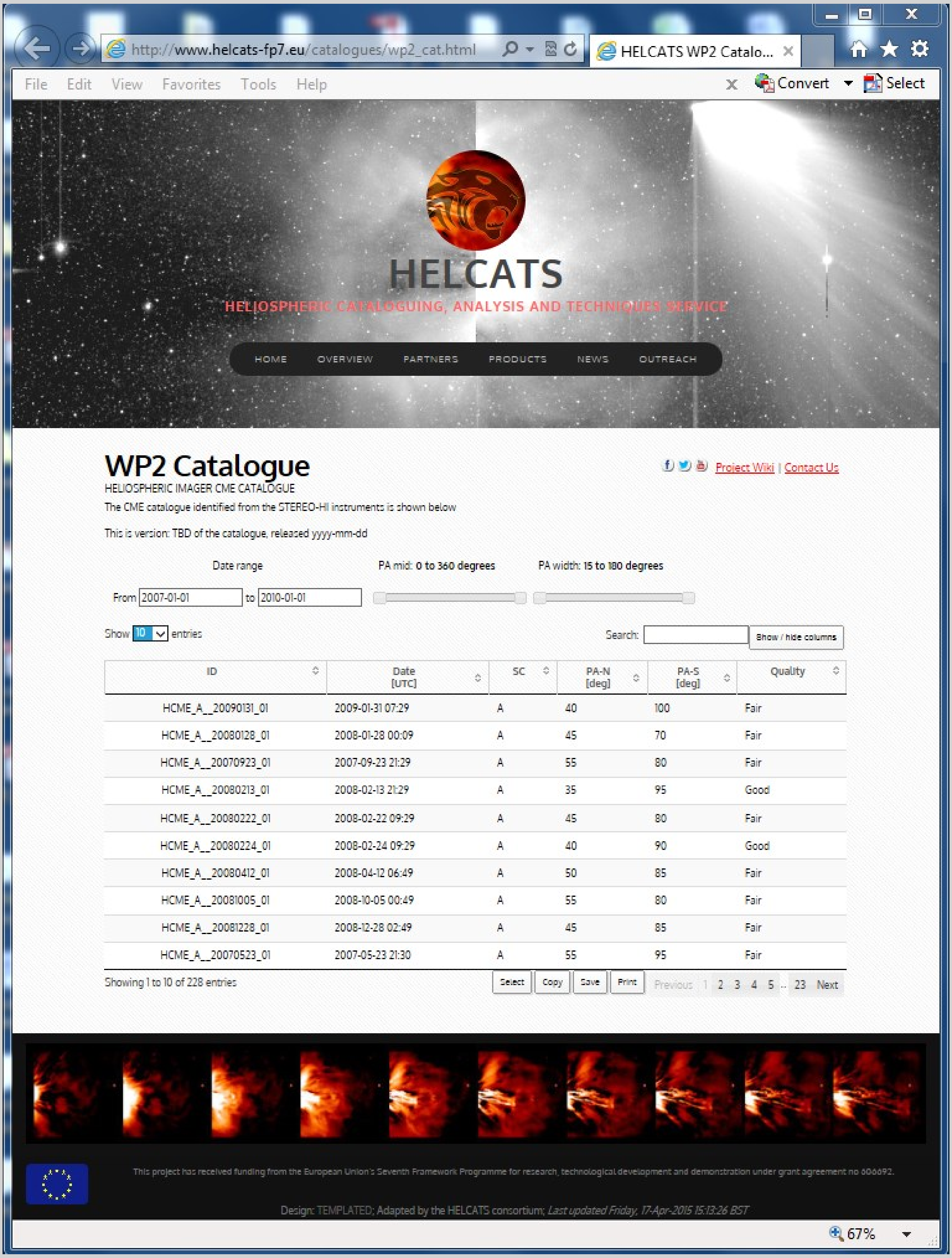


Figure 2.1: The WP2 HI catalogue facility on the HELCATS website

Figure 2.1 shows a snapshot of the HI catalogue facility that resides on the HELCATS website (www.helcats-fp7.eu), under the 'products' tab. The catalogue is updated as events are identified and inspected. The facility includes a capability to select date ranges and specific position angle location and width.

WP2 TASK 2.2: AUTOMATIC CATALOGUING OF STEREO/HI CMES (TASK LEAD: ROB)

In addition to manual CME identification, WP2 (Task 2.2) also comprised an assessment of the potential of autonomous detection of CMEs in the STEREO/HI imagery using ROB's CACTus software application (http://sidc.oma.be/cactus/). CACTus, a long-established algorithm for automatic CME detection and tracking, has, in the past, been applied exclusively to coronagraph images, from SOHO/LASCO and STEREO/COR.

As part of the HELCATS project, in the past year, CACTus was successfully adapted to work with STEREO-HI images. In this process, the Hough transform is applied to distance – time maps. This is then converted to a time vs angle which contains all information about the CME.

An automatic CME catalogue covering the full STEREO mission is under construction and will be used for comparison with the manual catalogue of task 2.1. The catalogue will be available online and its current format is shown in Figure 2.2.

CACTus for STEREO/HI-1

A software package for 'Computer Aided CME Tracking' (adapted from CACTus)

CMEs detected by CACTus - L2_01/A/2008/08/

Show comparison with the Manual catalog and other level images

```
:Issued: Fri Feb 20 10:24:41 2015
:Product: CACTus catalogue for HI
#--------------------------------------------------------------------
# Instrument: SECCHI-A | Detector: hi_1
# Minimal CME width: 0010
#
  first hi_1: 2008-07-31T00:09:01.006   20080731_000901_24h1A_br01.fts
  last  hi_1: 2008-08-31T23:29:01.112   20080831_232901_24h1A_br01.fts
#
#--------------------------------------------------------------------
# Output: Detected cmemap with the following characteristics:
#
#    CME: CME number
#   Flow: Flow number. Flows are suspicious detections,
#         their color in the detectionmap is dark blue
#     t0: first apparition in field of view
#     pa: principal angle, counterclockwise from North (degrees)
#     da: angular width (degrees),
#    NPA: Northernmost propagation angle (degrees),
#    SPA: Southernmost propagation angle (degrees),
#      v: median (projected) velocity (km/s)
#     dv: variation (1 sigma) of velocity over the width of the CME
#   minv: lowest velocity detected within the CME
#   maxv: highest velocity detected within the CME
#
# CME |        t0         | pa | da | NoPA| SuPA|  v  |  dv | minv| maxv
  0015|2008/08/31 10:09| 0100| 016| 0092| 0108| 0350| 0042| 0300| 0431
  0014|2008/08/31 00:09| 0106| 056| 0078| 0134| 0488| 0077| 0354| 0668
  0013|2008/08/21 12:49| 0067| 014| 0060| 0074| 0285| 0035| 0222| 0319
  0012|2008/08/20 11:29| 0085| 010| 0080| 0090| 0181| 0031| 0180| 0240
  0011|2008/08/20 04:49| 0068| 020| 0058| 0078| 0215| 0011| 0208| 0236
  0010|2008/08/20 02:09| 0094| 016| 0086| 0102| 0236| 0080| 0205| 0380
  0009|2008/08/17 22:09| 0083| 010| 0078| 0088| 0300| 0006| 0292| 0307
  0008|2008/08/13 00:09| 0070| 020| 0060| 0080| 1817| 0085| 1770| 1967
  0007|2008/08/11 06:09| 0069| 014| 0062| 0076| 1690| 0149| 1475| 1864
  0006|2008/08/10 18:09| 0080| 016| 0072| 0088| 0367| 0017| 0330| 0384
  0005|2008/08/07 22:09| 0099| 018| 0090| 0108| 0274| 0002| 0272| 0278
  0004|2008/08/07 16:49| 0098| 036| 0080| 0116| 0310| 0024| 0272| 0357
  0003|2008/08/04 06:49| 0121| 014| 0114| 0128| 0405| 0039| 0384| 0485
  0002|2008/08/04 05:29| 0105| 022| 0094| 0116| 0391| 0089| 0240| 0513
  0001|2008/07/31 08:49| 0067| 010| 0062| 0072| 0319| 0021| 0287| 0347
# Flow|        t0         | pa | da | NoPA| SuPA|  v  |  dv | minv| maxv
  0001|2008/08/17 13:29| 0086| 012| 0080| 0092| 0276| 0021| 0245| 0307
```

Figure 2.2: A sample of the CACTus catalogue for the HI data.

In the left panel each CME is marked with a number and the following columns describe the CME parameters, measured automatically. On the right panel, a graphic version of the detections is shown. The user can click on each CME to obtain further details of the event, including movies. The WP 2.2 activity has already shown the feasibility of using the CACTus approach for the exploitation of HI data. The final catalogue will be ready after fine tuning of various detection parameters.

WP2 TASK 2.3: COMPARISON OF CME CATALOGUES (TASK LEAD: UGOE)

A UGOE STEREO/SECCHI/COR2 CME-database was established under the framework of the DLR project STEREO/Corona, the EU FP7 project SOTERIA and continued in the EU FP7 projects AFFECTS. This COR2 database, available online at http://www.affects-fp7.eu/cme-database/, has been updated to cover the period to the end of 2011. Based on clarity of the CME topology in the COR2 field of view (2.5 – 15 R_s) during the time interval 2007-2011, out of a total number of 1071 events, 241 were selected for further analyses, e.g. for applying the Graduated Cylindrical Shell (GCS) modelling method. These events are referred to as being on the STEREO COR2 "Best-of-list". The COR2 "Best-of-list" is being compared with the STEREO/SECCHI/HI1A and B preliminary lists established under WP2 task 2.1. The HI1 A preliminary list contains a total of 821 events for the investigated time interval, the HI1 B list contains a total of 698 events. Comparison of the HI lists with the COR 2 "Best-of" list has yielded a set of 109 CME events that could be uniquely associated in both the HI1A or B and COR2 A or B fields of view without duplicate events. A sample event to which GCS-modelling has been applied in both fields of view is shown in Figure 2.1 for illustration. The comparison lists will be made available at the HELCATS website.

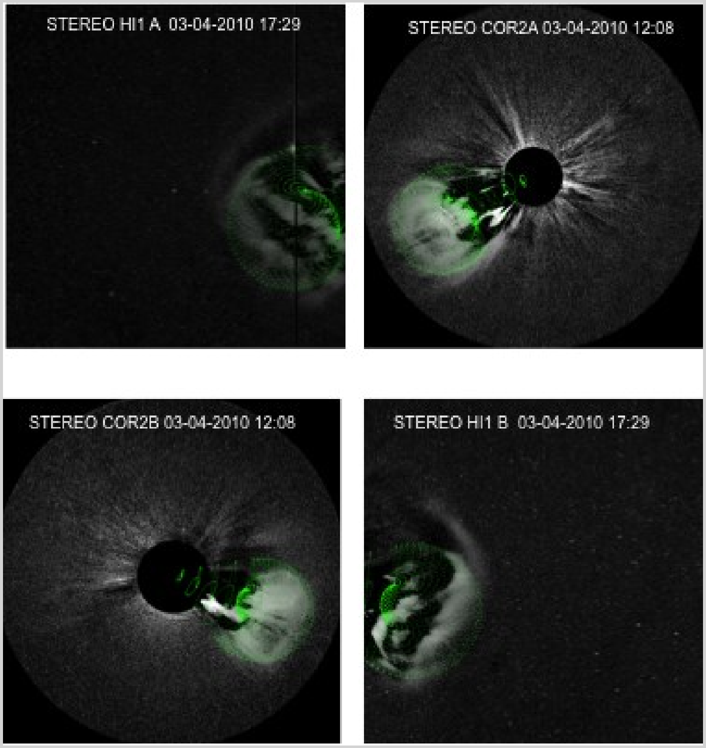


Figure 2.1: Sample CME observed in the STEREO/SECCHI/COR2 and HI1 A and B fields of view on April 03, 2010. The green grids are the CME GCS-fits.

WP2 TASK 2.4: SCIENTIFIC MANAGEMENT (TASK LEAD: STFC)

Whereas WP1 covers the administrative management of the HELCATS project, WP2 includes an element for the scientific and technical management. Thus, whereas WP1 includes aspects such as the oversight of the meeting and teleconference structure, the WP2 effort coordinates the scientific and technical discussion between the WP leaders and the wider team. Throughout the project activities to date, this has focused on the teleconference discussions, the kick-off and six monthly meetings and the technical details of the report writing; it also covers the regular technical communication with the WP teams on a range of issues as the project progresses. Thus, this WP runs in parallel with the logistical management of the project and continues throughout the HELCATS project. It is coordinated by the Scientific and Technical Manager.

WP2 SUMMARY/NEXT STEPS:

The activities of WP2 are well underway, with active cataloguing of HI events, both by manual inspection and by automated processes. In addition, comparisons to coronagraph catalogues are being made. Many of the WP2 activities continue throughout the HELCATS project; the final catalogue deliverables are actually required by month 36 (deliverables D2.1, D2.5). This is a natural consequence of the fact that the STEREO project is still in operation and the event lists will grow throughout the mission. However, there are two deliverables that will be produced in the coming months. Deliverable D2.2 is the formal report on the feasibility of automated CME identification, which is required from month 12. We stress that the feasibility has indeed been well demonstrated. Also, by month 18, deliverable D2.3 should report on the comparison of the manual and automated catalogues. In summary, the cataloguing activities are progressing as planned.

WORK PACKAGE 3 (WP3):

Deriving/cataloguing the kinematic properties of STEREO/HI CMEs based on geometrical and forward modelling

WP3 ACTIVITY TYPE: RTD

WP3 DURATION: MONTHS 1 – 36

WP3 LEAD BENEFITIARY: UGOE (4)

WP3 LEADER: Dr. Volker Bothmer

WP3 CONTRIBUTORS: UGOE (4); TCD (9); STFC (1); UNIGRAZ (2)

WP3 OVERVIEW: The key objectives of WP3 are deriving and cataloguing the kinematic properties of the STEREO/HI CMEs identified and catalogued in WP2, based on geometrical and forward modelling. For these purposes the recently established geometrical, forward (and prototype) inverse CME-modelling methods are applied. The CME parameters will be added to the catalogue, including back- and forward-projections to 'predict' CME launch and arrivals at various solar system locations. Comparisons will be made between the parameters yielded by the different models.

WP3 TASK 3.1: Geometrical modelling of STEREO/HI CMEs (TASK LEAD: STFC)

The STFC contribution to WP3 is principally through Task 3.1, the geometrical modelling of STEREO/HI CMEs. This task involves the derivation of the kinematic properties of those CMEs visually identified in WP2.1. This is achieved by selecting the track made by each CME in a time-elongation map (J-map) and applying the assumptions about its geometry and dynamics summarized in Davies et al. (2012, *Astrophys. J.*, 750, 23). This makes use of three established geometrical approaches, assuming that the CME can be modelled (i) as a point-like feature propagating outwards (known as the Fixed Phi method), (ii) as an expanding circle whose diameter is defined by the CME apex and Sun-centre (known as the Harmonic Mean method), and (iii) as a self similarly expanding circle propagating outward between two fixed position angles (known as the Self Similar Expansion method).

The CMEs are assumed to travel at a constant speed in a fixed. The three different fitting methods are applied to each CME (see Davies et al., for details). For a given CME, the path of its (apparent) leading edge through a J-map is manually tracked at a position angle close to its apex and each of the three fitting procedures is applied to estimate its 3D speed and propagation direction. These values are, in turn, used to derive launch times for each event, which are then applicable to WP4.1, and to generate arrival times at various locations in the heliosphere for comparison with in-situ measurements (WP4.2).

To date, events occurring during the odd-numbered years for both STEREO-A and -B have been analysed in this way. Events identified as poor in WP2.1 are excluded, as are those which are directed at position angles far from the ecliptic, due to the limited number of HI frames in which they appear. A number of small CMEs occur, which quickly become subsumed by subsequent, larger events; these events are also excluded. This process has been completed for a total of 622 events; 323 for STEREO-A and 299 for STEREO-B. Distributions of the speeds of these CMEs are shown in Figure 3.1, separated according to year, spacecraft and fitting technique.

The catalogue of geometrically modelled STEREO/HI CMEs generated in task 3.1 is used by UNIGRAZ to derive a catalogue of CME arrival time estimates at Mercury, Venus, Earth, Mars and Saturn, providing support to European-funded space missions around these planets. Predicted arrivals at the Ulysses spacecraft location are also made. Using initial speeds and directions from the geometrically modelled CME catalogue provided by STFC, UNIGRAZ has applied the Self-Similar Expansion Model results with the correction formulae of Möstl & Davies (2013, *Solar Phys.* 285, 411), which takes into account the angle between geometrically fitted CME initial speed and direction and the planetary in-situ location, to derive estimates of CME arrival time (Fig 3.2).

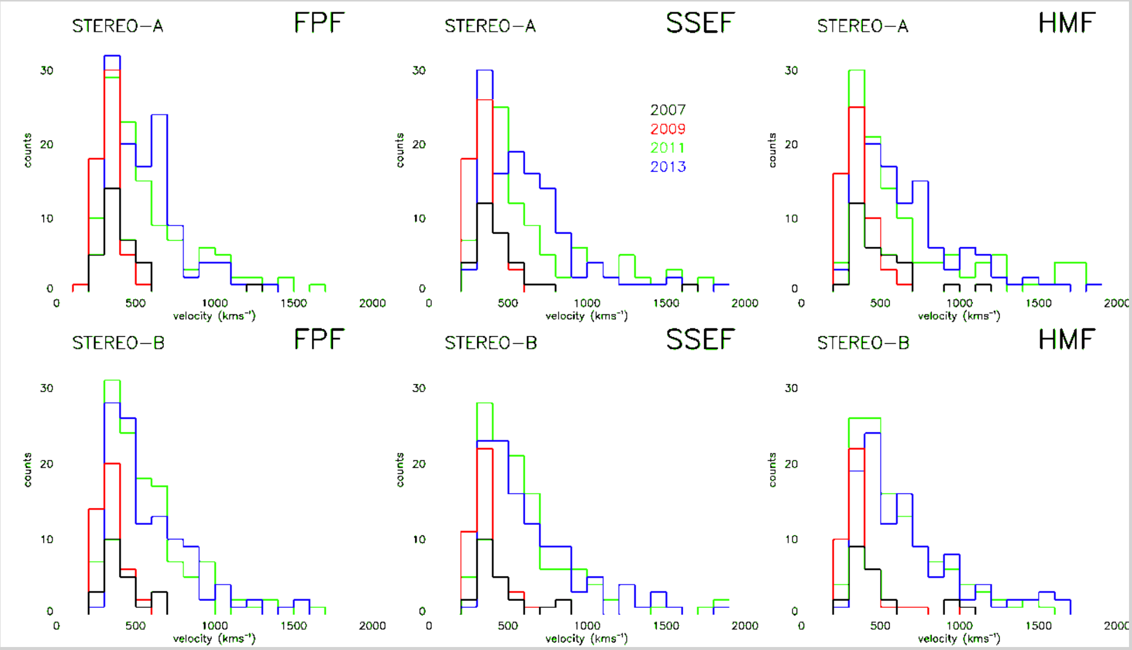


Figure 3.1: Distributions of the speeds of the modelled CMEs, separated according to year, spacecraft and fitting technique (Fixed Phi Fit (FPF), Self Similar Expansion Fit (SSEF), Harmonic Mean Fit (HMF)).

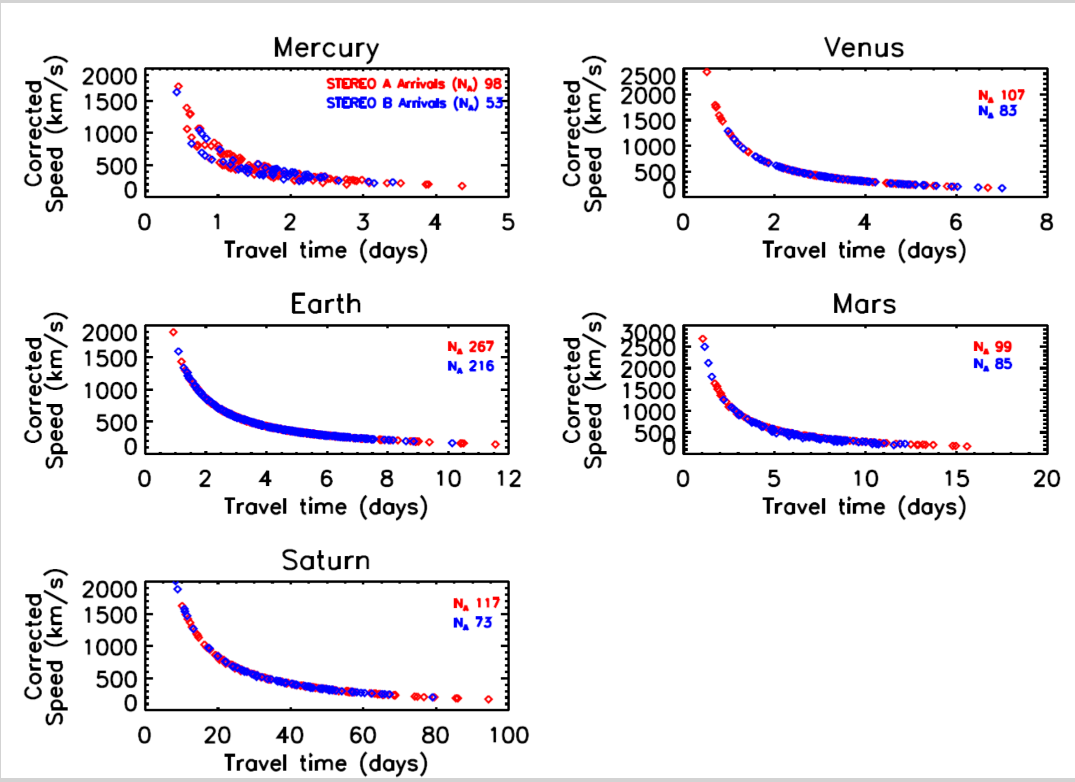


Fig. 3.2: SSEF ICME speed vs. Transit time to different planetary locations.

This model also allows one to estimate whether, and to what degree, each CME will 'hit' any in-situ location, and this is provided as a parameter in the catalogue, along with speeds and arrival times. A user friendly package in the IDL programming language has been created to read in the geometrically modelled CME catalogue files and output the predicted arrival time files (Figure 3.3) for any of the in situ locations. The initial catalogue contains over 400 predicted arrivals at Earth, and over 100 for Mercury-, Venus-, Mars- and Saturn-directed CMEs. The arrival times will be compared to other model results and in situ data in WP4.

STEREO-A_EARTH_ARRIVALS_SSEF30_V01.txt - Notepad

File Edit Format View Help

```
VARIABLES:
        1: id-Unique CME identifier
        2: delta of CME apex to target (which is difference in longitudes between central
        CME direction and target location)
        3: ICME corrected speed at target location
        4: ICME arrival time at target location
        5: target distance from Sun in AU
        6: target latitude in degrees HEEQ
        7: target longitude in degrees HEEQ


HCME_A__20071220_01   20.0   260   2007-12-26T15:10Z 0.98381397   -1.49703   -0.00000
HCME_A__20080213_01   23.0   271   2008-02-19T22:16Z 0.98730455   -6.74196   -0.00000
HCME_A__20080409_01   25.0   214   2008-04-17T14:31Z 1.00178489   -5.99623    0.00000
HCME_A__20080521_01   20.0   266   2008-05-28T09:35Z 1.01229287   -1.84155    0.00000
HCME_A__20080602_01   28.0   261   2008-06-08T22:02Z 1.01429036   -0.48398    0.00000
HCME_A__20080607_01   24.0   277   2008-06-14T05:50Z 1.01505733    0.20600   -0.00000
HCME_A__20080721_01    4.0   363   2008-07-26T08:32Z 1.01602762    4.95954   -0.00000
HCME_A__20080807_01   29.0   194   2008-08-16T15:02Z 1.01405248    6.24936   -0.00000
HCME_A__20080820_01   27.0   194   2008-08-28T15:08Z 1.01189079    6.85920    0.00000
HCME_A__20080913_01   21.0   282   2008-09-19T23:37Z 1.00592248    7.21837    0.00000
HCME_A__20081004_01   26.0   221   2008-10-12T15:21Z 1.00007217    6.51011    0.00000
HCME_A__20081010_01   15.0   301   2008-10-16T01:45Z 0.99845856    6.17808   -0.00000
HCME_A__20081013_01   13.0   242   2008-10-19T23:40Z 0.99772329    6.00601    0.00000
HCME_A__20081103_01   21.0   383   2008-11-07T14:54Z 0.99195488    4.13042   -0.00000
HCME_A__20081202_01   17.0   240   2008-12-08T15:15Z 0.98597380    0.77709   -0.00000
HCME_A__20081212_01   29.0   312   2008-12-17T23:52Z 0.98444476   -0.63029   -0.00000
HCME_A__20081218_01    6.0   304   2008-12-23T14:26Z 0.98394015   -1.32583   -0.00000
HCME_A__20081228_01    3.0   318   2009-01-01T23:12Z 0.98341889   -2.51562   -0.00000
HCME_A__20090101_01   25.0   228   2009-01-09T01:10Z 0.98329567   -3.10690    0.00000
HCME_A__20090107_01    9.0   272   2009-01-13T12:04Z 0.98329136   -3.74771    0.00000
HCME_A__20090109_01   16.0   332   2009-01-14T04:52Z 0.98332847   -3.94857   -0.00000
HCME_A__20090131_01    6.0   363   2009-02-04T14:36Z 0.98519745   -5.95568    0.00000
HCME_A__20090308_01   21.0   308   2009-03-13T10:06Z 0.99250875   -7.24928    0.00000
HCME_A__20090310_01   10.0   289   2009-03-16T04:23Z 0.99312888   -7.23474   -0.00000
```

Fig. 3.3 Sample Arrival Time File.

WP3 TASK 3.2: Forward modelling of STEREO/HI CMEs (TASK LEAD: UGOE)

The HI-COR2 event list established in WP2 contains 109 events. Out of these, 96 have been modelled with the GCS-method. Self-similar expanding modelling of the CMEs was performed with the GCS-method to determine directional propagation velocities and source region positions and also to derive estimates of their total masses. The data analysis methods were developed in collaboration with the STEREO/SECCHI PI institution at the Naval Research Laboratory, Washington, DC, USA (A. Vourlidas, R. Howard, A Thernisien, N. Savani). The results will be made available through an online database catalogue under development. Results for a sample CME event are shown in Figure 3.4.

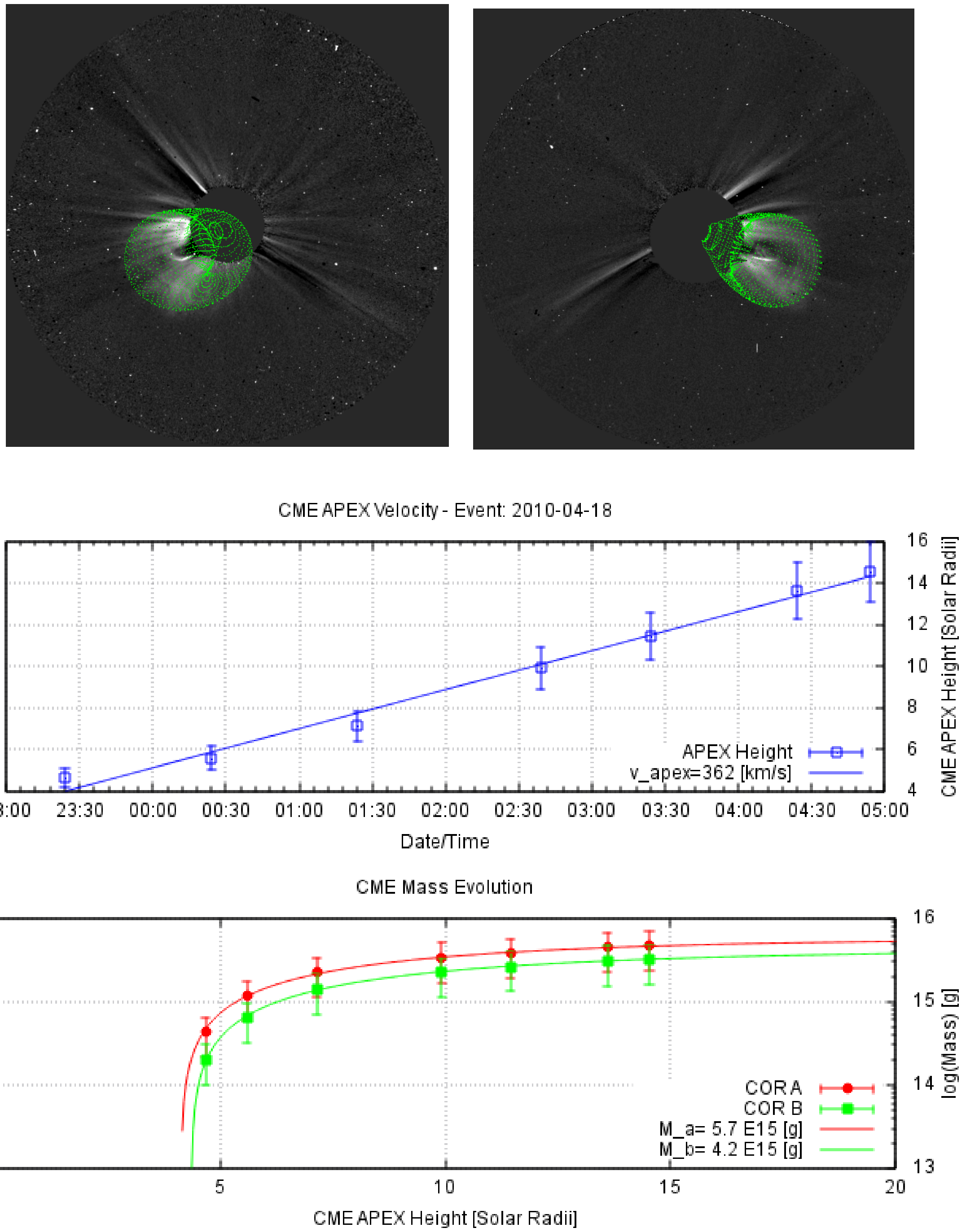


Fig. 3.4 Sample mass and velocity determination for a CME observed on 19 April 2010. Forward Modelling fits are shown superimposed on the STEREO-A and B COR images (top).

WP3 TASK 3.3: Inverse modelling of STEREO/HI CMEs (TASK LEAD: UGOE)

UGOE has established an "Inverse Modelling List" (Figure 3.5), based on inspection of STEREO coronagraph and EUV data, which has been used by TCD to provide a "Low Coronal Event Catalogue" available online at http://grian.phy.tcd.ie/helcats/ (Figure 3.6), aimed at establishing structure and activity in the solar atmosphere associated with the CMEs listed. It contains information on CME source region magnetic field configurations and various activity parameters, such as EUV wave properties and Alvén speeds.

Event	SR ID and location	Flare	EUVI wave	EUVI dimming	Filament eruption	Post eruptive arcade	Average COR2 speed (km/s)	Average HI speed (km/s)
2008-12-12	-	-	y	y	y	y	426 (λ =0°)- 361 (λ =90°)	514 (λ =0°) 502 (λ =90°)
2010-04-03	NOAA AR 11059 (S25W03)	B7.4 09:04UT	y	y	y	y	1517 (λ =0°) 804 (λ =90°)	1039 (λ =0°) 999 (λ =90°)
2011-06-07*	NOAA AR 11226 (S22W66)	M2.5 06:16UT	y	y	y	y?	1042 (λ =0°) 534 (λ =90°)	809 (λ =0°) 667 (λ =90°)
2011-08-03	NOAA AR 11261 (N16W28)	M6.0 13:17UT	y	y	-	-?	972 (λ =0°) 974 (λ=90°)	879 (λ =0°) 832 (λ=90°)
2012-01-19	NOAA AR 11402 (N32E27)	M2.6 13:43UT	y	y	y	y	2984 (λ =0°) 877 (λ =90°)	1375 (λ =0°) 856 (λ =90°
2012-01-23	NOAA AR 11402 (N29W21)	M8.7 03:38UT	y	y	y	y	1617 (λ =0°) 1534(λ=90°)	1588 (λ =0°) 1299 (λ=90°)
2012-03-07	NOAA AR 11429 (N18E31)	X5.4 00:02UT	y	y	-	y?	2701 (λ =0°) 1156 (λ=90°)	1752 (λ =0°) 1302 (λ=90°)
2012-04-23*	NOAA AR 11461 (N13W17)	C2.0 17:38UT	y	-	-	-	1634 (λ =0°) 1467 (λ=90°)	1008 (λ =0°) 866 (λ =0°)
2012-07-08	NOAA AR 11515 (S14W86)	M6.9 16:23UT	y	y	y	-	1402 (λ =0°) 1128 (λ=90°)	875(λ =0°) 751(λ=90°)
2012-07-12	NOAA AR 11520 (S13W03)	X1.4 15:37UT	y	y	-	y?	1445 (λ =0°) 1356 (λ=90°)	1238 (λ =0°) 824 (λ=90°)
2013-03-15	NOAA AR 11692 (N09E06)	M1.1 05:46UT	y	y	-	y	tbd	tbd

The velocities are estimated along the ecliptic plane, assuming the CME to be a point source (λ =0°) and a sphere anchored at the Sun (λ =90°). These are mean values in the COR2 field of view, between 2.5 and 15 solar radii, and in the HI1 and (sometimes) HI2, starting at about 15 solar radii and extending beyond 1 AU.
* The events marked with a star are events not observed in-situ.
The events in blue are the one requested for comparison with simulations

Fig. 3.5 Prototype "Inverse Modelling List".

Low Coronal Event Catalogue

Catalogue of events occuring the low corona which were associated
with CMEs detected with the Heliospheric Imagers on board the STEREO spacecraft.

<1> No.	<2> Date and Time (Start/Peak/End UT)	<3> GOES Class	<4> LMSAL (Latest Events)	<5> NOAA Region (Location)	<6> Hale Class	<7> EUV Wave (EUV Filter Å)	<8> CME (Time, speed, Catalogues)*	<9> Radio (NRH, DAM, Callisto)	<10> X-ray (RHESSI, FERMI)	<11> Maps (Density, PFSS, Alfvén speed)
1	2010-Apr-03 (09:04, hh:mm, hh:mm)	B7.4	N/A	11059 (S25W03)	β	None	10:33 UT 668 km/s CME Catalogue	Type II(?) Type III NRH 150 MHz	FERMI	N/A
2	2011-Jun-07 (06:16, 06:30, 06:41)	M2.5	gev_20110607_0616	11226 (S22W66)	β	HEK AIA 171, 193, 211	06:49 UT 1255 km/s CDAW Cactus CORIMP	Complex	RHESSI FERMI	MAPS
3	2011-Aug-03 (13:17, 13:48, 14:10)	M6.0	gev_20110803_1317	11261 (N16W28)	βγδ	HEK AIA 211	14:00 UT 610 km/s CDAW Cactus CORIMP	Type II, III, IV NRH 150 MHz NRH 445 MHz	RHESSI	MAPS
4	2012-Jan-19 (13:43, 15:30, 16:30)	M2.6	gev_20120119_1343	11402 (N32E27)	βγ	None	14:36 UT 1120 km/s CDAW Cactus CORIMP	Type II, III NRH 150 MHz NRH 432 MHz	N/A	MAPS
5	2012-Jan-23 (03:38, 03:59, 03:59)	M8.7	gev_20120123_0338	11402 (N33W21)	βγ	None	04:00 UT 2175 km/s CDAW Cactus CORIMP	S/WAVES, WAVES (?)	N/A	MAPS
6	2012-Mar-07 (00:02, 00:24, 00:40)	X5.4	gev_20120307_0002	11429 (N18W31)	βγδ	HEK AIA 171, 193, 211	00:24 UT 2684 km/s CDAW Cactus CORIMP	Type II/III S/WAVES, WAVES Type II/IV Learmonth	FERMI	MAPS
7	2012-Apr-23 (17:38, 17:51, 18:05)	C2.0	gev_20120423_1738	11461 (N18W31)	β	HEK AIA 171, 193, 211	18:24 UT 528 km/s CDAW Cactus CORIMP	Type III Callisto Birr	FERMI	MAPS
8	2012-Jul-08 (16:23, 16:32, 16:42)	M6.9	gev_20120708_1623	11515 (S14W86)	βγδ	None	16:54 UT 14:95 km/s CDAW Cactus CORIMP	Type II/III S/WAVES WAVES Complex Birr Complex Blein Complex??? Phoenix	RHESSI Imaging FERMI	N/A

Fig. 3.6 Prototype "Low Coronal Event Catalogue".

WP3 TASK 3.4: Comparison of modelling results (TASK LEAD: UGOE)

The results of the COR2 CME speed determinations derived under WP3 task 3.2 are being compared with the speeds derived with the HI results derived from geometrical modelling under WP3 task 3.1. Furthermore the determined COR2 CME source region positions will be compared with the positions derived from HI modelling. This is on-going work that will mature as the cataloguing and kinematic fit activities progress.

WP3 SUMMARY/NEXT STEPS:

In the next steps we will establish access to the online COR2 database providing speed and mass results to which further processed additional events from WP 2.3 will be added. The results from the COR2-HI comparisons will be analysed statistically. TCD will analyse the photospheric magnetic field properties of the identified CME source regions and coronal activity features such as EUV wave propagation directions and speeds. In terms of deliverables, WP3 has three major deliverables that will be completed at the end of the project (month 36), namely (deliverable D3.2) completing the incorporation of the forward modelling results into the catalogues (although this is an on-going activity), (D3.3) reporting on the model results and (D3.4) reporting on the prototype inverse model activities. However, a major deliverable is D3.1, which is provision of the time-elongation maps and incorporating the fits for the geometrical modelling into the HI CME catalogue (from WP2). This is due month on 12 but would also be updated as events are detected with the on-going STEREO mission.

WORK PACKAGE 4 (WP4):

Verifying the kinematic properties of STEREO/HI CMEs against in-situ CME observations and coronal sources

WP4 ACTIVITY TYPE: RTD

WP4 DURATION: MONTHS 10 – 36

WP4 LEAD BENEFITIARY: UNIGRAZ (2)

WP4 LEADER: Dr Christian Möstl

WP4 CONTRIBUTORS: UNIGRAZ (2), UPS (3), UGOE (4), ROB (5), IMPERIAL (6), UH (7)

WP4 OVERVIEW: The primary goal of WP4 is to provide researchers with a catalogue which links CME signatures observed in the low corona, coronagraphs, and heliospheric images with their *in situ* ICME counterpart. To this end, individual lists of CMEs and their parameters in the low corona (EUV), coronagraphs, heliospheric imaging (HI) and in situ data need to be established first, covering the timeframe April 2007 to December 2015. This work is currently underway. Windows in time and space for which associations between different phenomena in different datasets have been established, such that the lists can be linked. First guidelines on these windows can be taken from two recent papers by Möstl et al. (2014, *Astrophys. J.* 787, 17) and Tucker-Hood et al. (2015, *Space Weather* 13)). It is planned that the “linked catalogue“ will be presented as a catalogue website similar to the examples that are available for WP2. A summary of the progress in each of these tasks is given below.

WP4 TASK 4.1: Comparing to coronal sources (TASK LEAD: UGOE)

A list of low coronal CME signatures is included in the current UGOE catalogue:

http://www.affects-fp7.eu/cme-database/database.php

Work on comparing the low coronal signatures of the HI CMEs will commence after the time and space windows for the back-projections from the HI geometrical modeling results have been discussed and established. For example, concerning the time windows, it has been shown by Möstl et al. (2014, *Astrophys. J.* 787, 17) that the launch times given by HI geometrical modeling are consistent, on average, within 1.7 hours of the appearance of a CME in COR2, which corresponds to a CME distance of slightly above 2.5 solar radii.

WP4 TASK 4.2: Comparing to in-situ measurements (TASK LEAD: UH)

The goal of the Task 4.2 is to construct a comprehensive catalogue of Interplanetary CMEs (ICMEs) measured *in situ* and to list their key parameters and the results of modeling based on *in situ* data. Later, these will be compared to the projected arrivals of CMEs modelled from HI data. Here, we consider the status of data and cataloguing activities of this WP.

Data: *In situ* magnetic field and plasma data from the MESSENGER, Venus Express (VEX), STEREO-A and B, Wind and Ulysses spacecraft have been converted to similar formats (as IDL .sav files) and time resolution. At VEX and MESSENGER there is a need to exclude intervals when the spacecraft are inside the planetary magnetosphere, so that we see only solar wind intervals. This has been solved for VEX but not entirely for MESSENGER. In addition to the datasets mentioned, it might be possible to replace the planned use of Forbush decreases from the Mars Science Laboratory (MSL)/RAD data for ICME detection in exchange for MAVEN data, when they become available, as MSL/RAD data are not in a format currently available that is straightforward to process.

Cataloguing: In general, the ICME list should include only those events in which an *in situ* identification of an ICME is unambiguous, so we select only clear ICME events. As a first step we put together a list of ICMEs using the following publicly available catalogues:

- ICMEs measured *in situ* by STEREO and provided by UCLA (by Lan Jian).
- ICMEs measured *in situ* by Wind (NASA, by Nieves-Chinchilla *et al.*).
- ICMEs measured *in situ* by VEX and MESSENGER (IMPERIAL, by Simon Good).

This initial ICME catalogue has been brought to a normalized format and saved in IDL .sav and ASCII files and is available to download from the HELCATS WP4 wiki site, including a .txt file explaining the currently included parameters. The catalogues cover the times from April 2007 to the end of 2013. The basis for each ICME list is three specific times:

- The start time of an ICME (variable ICME_START_TIME), which is either an interplanetary shock or a sheath signature, the latter signaled by elevated density and temperature.
- The start time of a magnetic obstacle (MO_START_TIME). Magnetic obstacles are defined by elevated magnetic fields over a long duration and can contain ordered or disordered magnetic fields. Categorizations of magnetic obstacles are: flux ropes (FR, elevated, smooth rotating fields), flux-rope-like (FRL, elevated, smooth constant fields), and ejecta (elevated but disordered fields).
- The end time of a magnetic obstacle (MO_END_TIME).

These times are currently all available for the Wind and STEREO-A/B lists. For the VEX and MESSENGER lists, magnetic obstacle start and end times are given. An algorithm for automatic detection of interplanetary shocks was developed by UH to add shock times as ICME start times to the list for those two spacecraft. UNIGRAZ has made IDL codes for adding and updating the ICME catalogues manually, and has started to update the VEX ICME list for 2012.

At UGOE, the IDL routines for minimum variance analysis (MVA) have been installed and adapted to the different time resolution of ACE spacecraft data (at L1), upgraded to derive additional magnetic cloud parameters, and the output was re-formatted for further usage. MVA was applied to a sample event list for testing and will then be applied to all the flux ropes in the ICME lists, which yields their orientation of their axes in 3D.

We note that, at UPS, a study has been published (Ruffenach et al. 2015, *J. Geophys. Res.* 120, 43) which demonstrate that a significant fraction of ICMEs show signatures of reconnection with the solar wind at 1 AU.

WP4 TASK 4.3 Assessing the validity of the HI modelling (TASK LEAD: UNIGRAZ)

In this task we will validate the modeling methods used in WP3 to extract CME parameters from HI with multipoint *in situ* data. To this end, visualisations of magnetic field vectors and the total field along with the spacecraft positions have been made as movies, covering April 2007 to end of 2014, though not all data are yet available for this full time-range (for a screenshot example, see Figure 4.1). Another visualisation (Figure 4.2) of the geometrical modeling (SSEF30) results of the preliminary WP3 CME HI catalogue has been made, covering April 2007 to July 2013. About 600 CMEs on each spacecraft can be seen propagating as circles away from the Sun, which will be of use for many WPs in the HELCATS project.

Concerning hit and miss predictions, we studied a CME event on January 7 2014, which led to a major false alarm as a fast CME was predicted to be very geoeffective but, in fact, did not hit the Earth. We were able to synthesize data from SOHO, STEREO, Wind, Mars Express and MSL to show that a CME may erupt in a direction that is about 40° different in heliospheric longitude compared to the position of the source region (Möstl et al. 2015, *Nature Communications*, in press).

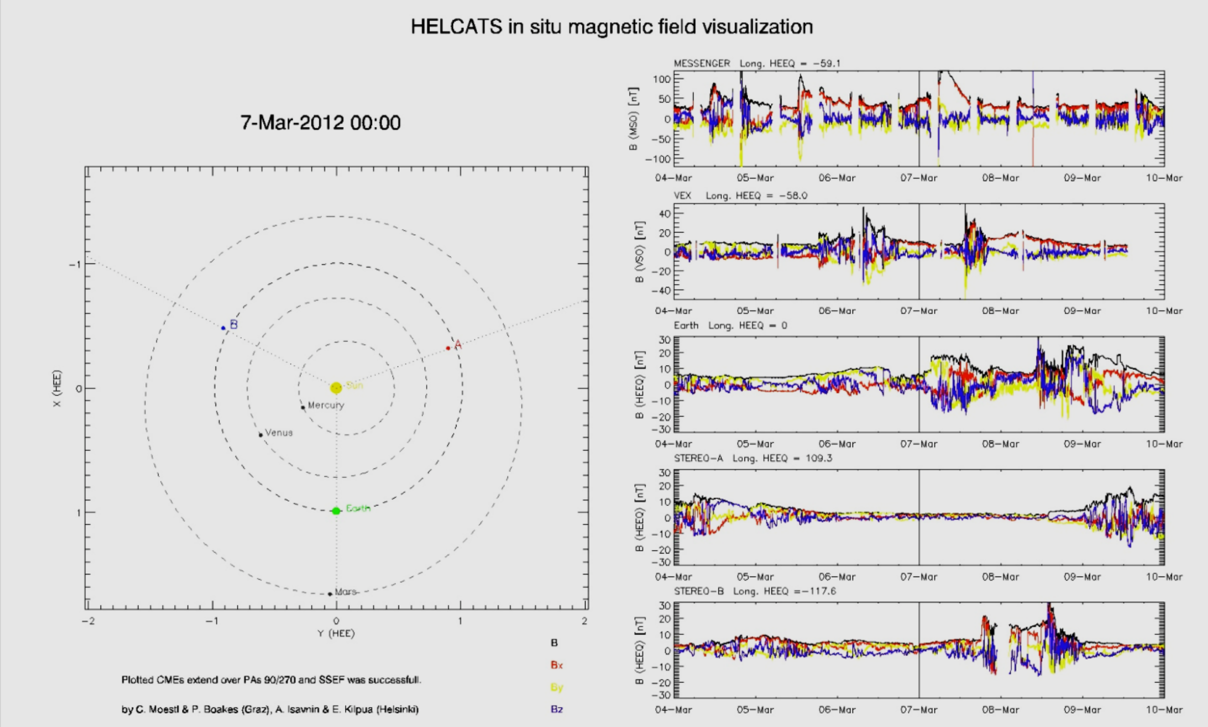


Figure 4.1: In situ magnetic field visualisation. On the left panel the position of the spacecraft and planets, up to the orbit of Mars, as well as the current time, is shown. On the right panel, the total magnetic field (black) and the vector components (Bx red, By green, Bz blue) can been seen as obtained from the 5 spacecraft MESSENGER, Venus Express, STEREO-A/B, Wind. The current time is given as a vertical solid line in each plot. UNIGRAZ has made yearly movies for 2007-2014, including all the data that is currently available. A sample for 2012 can be found here:

http://www200.uni-graz.at/%7Emoestlc/helcats/helcats_B_insitu_2012.mp4

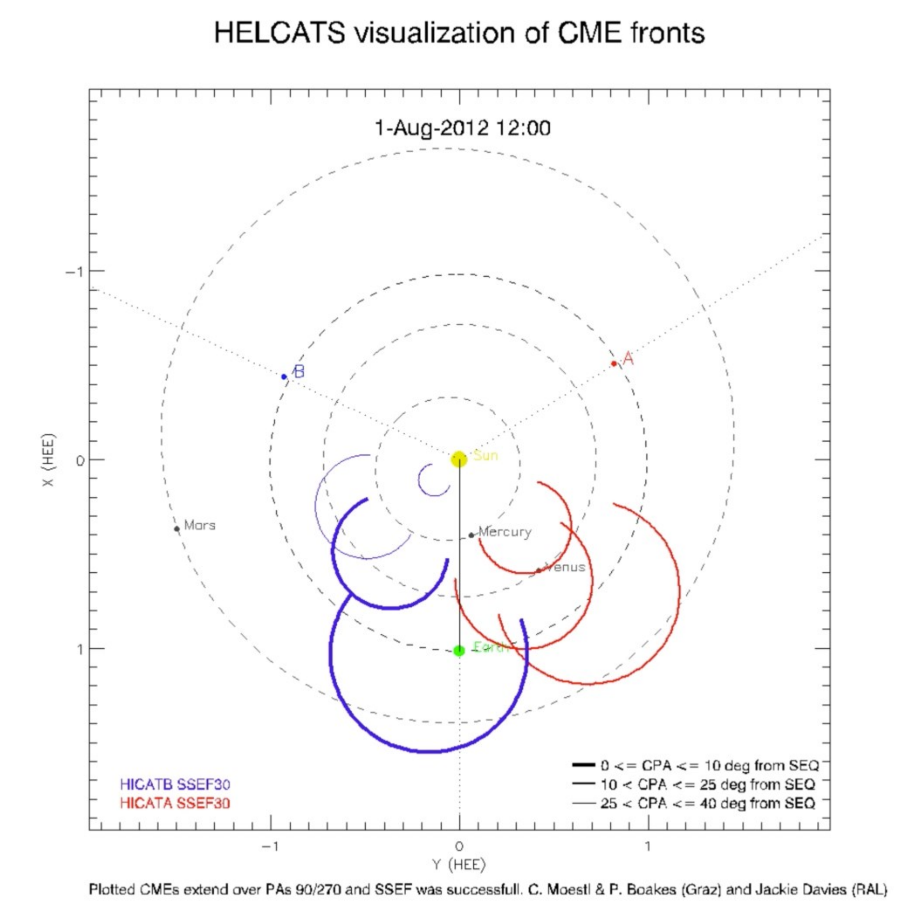


Figure 4.2: Screenshot of a visualization of the CME fronts (blue = from HI on Behind, red = from Ahead) as given in the preliminary WP3 catalogue, with CME constant directions and speeds taken from the SSEF30 code results. The movie from which this is taken covers April 2007 to July 2013. It contains those CMEs which propagate with some part in the solar equatorial plane (SEQ), so they extend over the position angle of 90 or 270, for STEREO A and B, respectively. Thick lines indicate that the CME central position angle is close the SEQ, while thin lines indicate CMEs propagating away from the SEQ. This movie is available at:

http://www200.uni-graz.at/%7Emoestlc/helcats/hicat_ssef30_visual_pa.mp4

WP4 SUMMARY/NEXT STEPS:

In summary, the data needed for this WP are in principle almost all readily available and have been brought into normalized formats. The lists of solar, heliospheric and in-situ phenomena related to CMEs are currently being established, which will form the basis for the linked catalogue and the validation of the HI CME catalogue with *in-situ* data. These will be the two main outputs of this WP. The next steps are:

4.1: The CME-ICME event lists from Möstl et al. (2014) and the lists from UGOE and TCD on low coronal signatures can be used for assessing the values to define the spatial and temporal windows, which will then be used for obtaining the low coronal signatures related to the CMEs in the HI CME catalogue. UGOE will update the low coronal event list (currently available until the end of 2011).

4.2: The ICME catalogue will be further revised and checked. ICME parameters (e.g. maximum total magnetic field) will be re-determined in a centralized way for all the events in the ICME catalogue. The parameters listed in the reference catalogues (listed above) will not be reused to avoid differences in the way they were defined. Categorization of ICMEs (into flux-rope/non-flux-rope ICMEs, complex ICMEs, *etc.*) will be performed, preferably in an automatic fashion. For that purpose the algorithms for categorizing ICMEs will be developed.

Grad-Shafranov reconstruction will be applied to the events for which such an analysis is possible.

4.3: First tests on the predicted vs. actual ICME arrivals will be undertaken by UNIGRAZ, in a similar way as Möstl et al. (2014) and Tucker-Hood et al. (2015) but for a much larger set of events and *in situ* spacecraft (using skill scores for arrival time differences, hits vs. misses etc.). A list of ICME arrival times predicted by the SSEF technique but not existent in the ICME catalogue will be composed. UH and UNIGRAZ will check i*n situ* data for possible signatures of ICMEs during the predicted arrival time ranges, and may augment the ICME catalogues or make a new ICME catalogue that does not depend on (subjective) visual identification of ICMEs in *in situ* data. ROB is planning to use the forward modelling parameters obtained in WP3 in order to asses if a CME should arrive to a spacecraft or not (Rodriguez et al., 2011, *Solar Phys.* 270, 561). A more refined analysis can be done starting from this point by directly comparing forward modeling and *in situ* parameters.

WORK PACKAGE 5 (WP5):

PRODUCING A DEFINITIVE CATALOGUE OF CIRs IMAGED BY STEREO/HI THAT INCLUES VERIFIED MODEL-DERIVED KINEMATIC PROPERTIES

WP5 ACTIVITY TYPE: UPS

WP5 DURATION: MONTHS 1 – 36

WP5 LEAD BENEFITIARY: STFC (1)

WP5 LEADER: Dr Alexis Rouillard

WP5 CONTRIBUTORS: UH (7)

WP5 OVERVIEW: The primary goal of WP5 is to provide a catalogue of the spatial and temporal evolution of Stream Interaction Regions (SIRs) (and their substructures) observed by HI in 3-D, following their complete formation process using different observations (mainly imaging but also in-situ) from the Sun out to 1 AU. The output of the solar wind stream advanced catalogue will be optimized to help the space physics community in the search for clues on the origin, propagation, 3D morphology, and the planetary effects of CIRs and the slow solar wind.

WP5 Task 5.1: CATALOGUING THE OCCURRENCE OF CIRs (TASK LEAD: UPS)

Using the STEREO Heliospheric Imager (HI) time-elongation 'J-maps' and optimized running-difference images, we are comiling a list of the times of observations of each Corotating Interation Region (CIR) in HI images. To date this has been done for much of the STEREO-A data. In addition, from the CIR fitted trajectories, we will provide a catalogue of the arrival times of CIRs at Mercury, Venus, Mars, Earth, Saturn, thereby providing support to European-funded space missions around these planets. This has largely been done for the STEREO-A catalogue. Due to the synergy between the tasks of this WP, we refer the reader to an extended description under Task 5.4.

WP5 Task 5.2: DERIVING/CATALOGUING THE KINETIC VARIATION OF CIRs (TASK LEAD: UPS)

In this task, we are fitting the leading edge of each CIR in HI J-maps, derived at all available latitudes, to obtain the spatial/temporal evolution of each CIR over ~180^{o} longitude (this has largely been done for STEREO-A) and ~90^{o} latitude. Again, see the extended description under Task 5.4.

WP5 Task 5.3: COMPARING BACK-PROJECTED CIR TRACKS WITH CORONAL SOURCES (TASK LEAD: UPS)

Using the derived trajectories and kinematic properties of CIRs and their small-scale transients, we are determining, for each CIR observed in white-light images, if there is an associated coronal hole observed in EUV. This has largely been done for STEREO A. Again, see the extended description under Task 5.4

WP5 Task 5.4: COMPARING FORWARD-PROJECTED CIR TRACKS WITH IN-SITU MEASUREMENTS (TASK LEAD: UPS)

In this WP, we are tracking small-scale transients to 1 AU and making a list of predicted impacts at points in the heliosphere where in-situ measurements are taken. This activity has been started for STEREO A.

The intimacy between the WP5 tasks means that it is useful to provide a combined report here :

Using time-elongation 'J-maps' derived from running-difference images of HI data, Illya Plotnikov (recruited in May 2014) has listed the times of passage of each Stream Interaction Region (SIR) in the field of view of HI images obtained from STEREO-A (Goal 1 in T5.1). We then used our technique to determine the location of each SIR in the ecliptic plane as a function of time. In order to determine the time-dependent evolution of the 3-D trajectory of each SIR, the characteristic tracks left by these SIRs in the J-maps were fitted manually by clicking on J-maps produced with HI-1 and HI-2 images from STEREO-A (and in the future STEREO-B). For each SIR, we fitted first the clearest tracks associated with individual density irregularities entrained by the SIR. We then used the fact a SIR corotates during its passage in the heliospheric imagers, thereby leaving a characteristic pattern in the J-map. This pattern was then computed theoretically and superposed onto the real J-map. The algorithm to trace this SIR pattern folds in a correction for the orbital motion of the spacecraft. This orbital motion changes the location of the viewpoint of the probe (STEREO-A) and can have an important effect when the SIR pattern is considered over a 180^o of corotation in the HI field of view lasting up to 18 days. To validate a fitting we use two criteria (1) we require that the correspondence between the simulated and measured SIR patterns are satisfactory, (2) we require that the fitting technique ('fixed-point technique') of the trajectory of individual small-scale transients entrained by the SIR gives small errors in both speed (<40 km/s) and direction ($<20^o$). Both of these criteria usually impose that the SIR be well observed by the heliospheric imagers over a large range of elongations (>40 degrees). SIRs that are poorly observed because (1) the white-light signature is too weak, (2) too many CMEs passed in the field of view are not fitted.

Once a SIR is fitted, we assign it a time that corresponds to the launch time of the small-scale transient entrained by the SIR that is best observed during the event. We adopted this definition of the onset time because it guarantees that if a future user wishes to find this SIR in the heliospheric imagers, the single feature will be most easily spotted as a bright signature in the images (especially with the 'propagation tool': c.f. WP8 for more details). The Carrington longitude and latitude of the source region of the SIR was also recorded and was systemically compared with EUV images. For each event, we recorded whether a coronal hole was present less than 20^o of longitudinal separation to the East of the SIR source region and recorded its location in Carrington coordinates (Goals 1 and 2 of T5.3). It should be noted that this first SIR catalogue is along the ecliptic plane only.

The catalogue in currently extends from 2007 to 2014, it lists:

- a unique SIR identifier*, e.g. HSIR_A__20070419_191210
- the spacecraft making the white-light observations (STEREO-A or STEREO-B),
- The 'reference launch time' of the most clearly observed density irregularity embedded in the SIR along the ecliptic plane: Format: YYYY-MM-DDTHH:MM:SS,
- Rotation period of the SIR assumed fixed at 25,38 days,
- The radial velocity (in km/s) of the SIR along the ecliptic plane,
- The error in radial velocity (in km/s) of the SIR along the ecliptic plane,
- The longitudinal separation (called 'beta', in degrees) between the observer and the most easily tracked density feature embedded in the SIR along the ecliptic plane,
- The error in the longitudinal separation (in degrees) between the observer and the most easily tracked density feature embedded in the SIR along the ecliptic plane,
- The Carrington longitude (in degrees) of the SIR source (tracked along the ecliptic plane),
- The HAE longitude (in degrees) of the SIR source (tracked along the ecliptic plane),
- The Carrington longitude (in degrees) of the coronal hole in EUI identified near the source region of the SIR in Carrington coordinates,
- The Carrington rotation number of the identified source.

An extract of the catalogue is given here:

SIR Identifier	Observer	Reference launch time	CoRot. Period	Velocity	Err velocity	beta	err beta	Carr Source Long.	HAE Source Long.	Carr CH Long.	Carr. CH. Lat.	Carr Rot
	Observer		(days)	(km/s)	(km/sec)	(deg)	(deg)	(deg)	(deg)	(deg)	(deg)	
HSIR_STA_20070619_155931	STEREO-A	2007-06-19T15:59:31	25,38	292	11	44	4	355,7	242,4	10	-24	
HSIR_STA_20070624_073810	STEREO-A	2007-06-24T07:38:10	25,38	326	27	44	8	294,2	246,6	292	-20	
HSIR_STA_20070628_073032	STEREO-A	2007-06-28T07:30:32	25,38	245	23	68	7	221,2	230,7	235	0	
HSIR_STA_20070711_083535	STEREO-A	2007-07-11T08:35:35	25,38	284	5	42	1	72,8	267,3	102	-20	
HSIR_STA_20070718_203106	STEREO-A	2007-07-18T20:31:06	25,38	323	7	54	6	323	263,4	295	-12	
HSIR_STA_20070729_125707	STEREO-A	2007-07-29T12:57:07	25,38	287	4	32	1	203,6	295,7	203	8	
HSIR_STA_20070806_035723	STEREO-A	2007-08-06T03:57:23	25,38	279	27	67	8	71,1	271,7	105	-18	
HSIR_STA_20070814_182817	STEREO-A	2007-08-14T18:28:17	25,38	288	17	90	18	297,1	259,4	NaN	NaN	NaN
HSIR_STA_20070823_013231	STEREO-A	2007-08-23T01:32:31	25,38	277	9	31	2	242,6	322,7	243	0	
HSIR_STA_20070903_192613	STEREO-A	2007-09-03T19:26:13	25,38	266	12	53	3	68,3	315,1	NaN	NaN	NaN

For each fitted SIR from STEREO-A between 2007 and 2014, we are producing a catalogue of arrival times at each planet and probe (Goal 3 of T5.1), these arrival times are retrieved from the catalogue by using the unique SIR identifier: HSIR_STA_20070619_155931_TI, TI for targeted impact. They can also be retrieved via our web-based interface: 'the propagation tool' (see WP8).

Target	Arrival Time	Distance (AU)	Angle of corotation
SUN	2008-02-12T15:42:28	0	
Probes			
MESSENGER	2008-03-07T04:56:25	0.6063	26
VEX	2008-03-14T13:36:40	0.7225	122
STEREO-A	2008-03-08T08:03:11	0.9602	12
WIND	2008-03-06T17:53:48	0.978	348
ACE	2008-03-06T17:20:47	0.9764	348
STEREO-B	2008-03-05T01:34:34	0.9964	323
SOHO	2008-03-06T17:37:46	0.9755	348
MEX	2008-03-07T20:35:55	1.635	309
ROSETTA	2008-03-09T05:07:43	1.2158	3
CASSINI	2008-03-04T06:01:14	9.2747	337
Planets			
MERCURY	2008-03-09T07:57:39	0.4484	72
VENUS	2008-03-14T13:37:44	0.7226	122
EARTH	2008-03-06T19:01:13	0.9864	348
MARS	2008-03-07T20:35:40	1.635	309
JUPITER	2008-03-14T07:04:49	5.221	99
SATURN	2008-03-04T05:51:49	9.2737	337
URANUS	2008-03-05T15:18:50	20.0898	170
NEPTUNE	2008-03-11T18:30:31	30.036	143

In terms of deliverables, the principal deliverable, D5.1 is the establishment of the online catalogue of CIRs by month 12.

WP5 SUMMARY/NEXT STEPS:

In year 2, WP5 will extend the SIR catalogue analysis to higher latitudes. Emphasis to date has been non the ecliptic plane. Also, upon completion of the catalogue of impacts, we will carry out an analysis of the merit of the CIR catalogue at predicting the arrival time of CIRs at the different spacecraft located in the inner heliosphere (those that record in-situ measurements of the solar wind). We anticipate that this study will be finished in July and we plan to write a paper to be submitted to one of the journals of Space Weather.

One of our next step after that is to list all the small-scale transients entrained by CIRs that may have impacted a spacecraft, and collaborate with UH to analyse the in-situ signatures of this small-scale. This study is to be done by Eduardo Sanchez-Diaz (recruited in Nov. 2014); he has already found that these small-scale transients retain very slow speeds up to 0.3-0.4AU and investigated whether HELIOS-measured such low speeds in solar cycle 22. These speeds are indeed measured in situ up to 0.6 AU, this provided additional confidence that our speed calculations are correct. He is drafting a paper on this topic that will be submitted in May 2015.

Future deliverables include the fitting of the leading edge of CIRs and determination of their latitudinal extend. This is deliverable D5.2, due by month 24. Progress towards this is well in hand. The remaining deliverables for WP5 are due by month 36, at the end of the project.

We note two papers related to the HELCATS work in this WP:

Sanchez-Diaz, E., Segura, K., Rouillard, A.P., Lavraud, B., Chihiro T., The very slow solar wind: origin, variability and properties, to be submitted to GRL, 2015.

Plotnikov, I., Rouillard, A.P., Pinto, R., Using heliospheric imaging to predict the arrival time of CIRs at various points in the inner heliosphere, to be submitted to Space Weather Journal, 2015

WORK PACKAGE 6 (WP6):

INITIALISING ADVANCED NUMERICAL MODELS BASED ON THE KINETIC PROPERTIES OF STEREO/HI CMEs AND CIRs

WP6 ACTIVITY TYPE: UPS

WP6 DURATION: MONTHS 7 – 36

WP6 LEAD BENEFITIARY: UPS (1)

WP6 LEADER: Dr Alexis Rouillard

WP6 CONTRUBUTORS: GMU (Third-party)

WP6 OVERVIEW: The primary goal of WP6 is to transform the catalogues of CMEs and CIRs observed by HI, accomplished in WP2/3 and WP5, into more advanced catalogues of simulations results of CIRs and CMEs. This advanced database will provide to the space community a set of simulation results optimised by assimilating direct images of the solar wind into ENLIL simulations. The delivery of these advanced catalogues will enhance forefront research on the 'background' solar wind (fast and slow solar wind) and on the spatial and temporal evolution of CIRs and CME shocks, and will provide unique material to study and interpret particle radiation measurements in the inner heliosphere.

WP6 TASK 6.1: ASSIMILATING HI IMAGES TO MODEL THE BACKGROUND SOLAR WIND (TASK LEAD : UPS)

The combination of the catalogues of CIRs derived in WP5.1 and WP5.2, J-maps derived from HI images and movies will be compared with synthetic J-maps and movies of CIRs derived from numerical simulations of the background solar wind. This has been started for STEREO-A. See Task 6.3 for an expanded description.

WP6 TASK 6.2: ASSESSING THE USE OF HI TO INITIALISE ENLIL (TASK LEAD : UPS)

Following on from Task 6.1, we then modify the coronal input of the heliospheric MHD code, ENLIL, until synthetic and observed J-maps are in good agreement. Again, see Task 6.3 for an expanded description.

WP6 TASK 6.3: CONTINUAL ASSIMILATION OF HI DATA IN ENLIL AND COMPARISON WITH STANDARD IMPLEMENTATION TECHNIQUES (TASK LEAD : UPS)

Again, following on from Tasks 6.1 and 6.2, we then quantify the improvement in the predicted simulations by a statistical comparison of results with in-situ measurements of CIRs. This has been started.

As with WP5, the different tasks of WP6 are intimately related and an expanded description is given here :

We have started comparing real J-maps derived from STEREO-A and STEREO-B heliospheric images with synthetic J-maps created from numerical results from the ENLIL 3-D MHD model. The synthetic J-maps are produced by computing the white-light heliospheric images that STEREO-A and STEREO-B should see from their vantage points. These images are derived by applying the equations of Thomson scattering from the simulated 3-D volume of electronic densities. The code computes running-difference images and like ordinary J-maps, a band of pixels is extracted along the ecliptic plane. These J-maps have so far been produced for 2012 and 2013. We integrated them in our software tool and can switch from these maps to real J-maps. In the tool, we can now superpose the catalogue of J-maps derived in WP5. This allows us to compare the trajectories and patterns left by CIRs derived from observations with the trajectories of CIRs derived from numerical simulations. An example of the functionalities developed as part of our goals in WP6 is shown below (Figure 6.1):

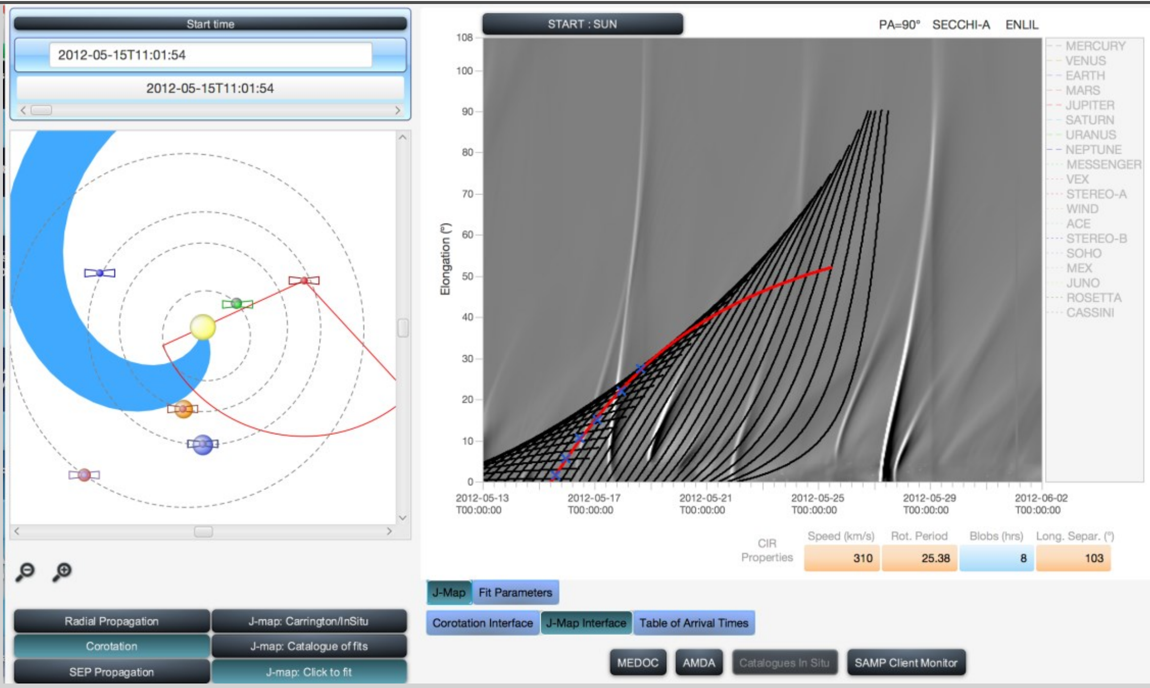


Figure 6.1: A snapshot of the propagation tool that has been adapted as part of WP6 to ease the comparison between observations and simulated CIR patterns in the J-maps. A view of the ecliptic plane is shown on the left and a simulated J-map from ENLIL is shown to the right. Superposed on this synthetic J-map is the result of identifying the location of a CIR in real observations (black tracks) and comparing these tracks to those derived from ENLIL simulations.

<u>Modelling the internal magnetic field of CMEs:</u> Anthony Bourdelle, recruited for 3 months, between June and September 2014, did some preparatory work to triangulate CME extents (here the entire shock-flux rope system) in white-light images for future inclusion in the ENLIL model (preparatory work for Tasks 6.2 and 6.3). We wanted to crosscheck whether just fitting the flux rope as done in WP3 will be enough to derive the extent of the CME to be injected in ENLIL as part of WP6. Anthony also worked briefly on including a magnetic flux rope inside CMEs simulated semi-analytically between 1 and 21.5Rs by adapting the IRAP (UPS) flux rope model and writing a module to extract 3-D magnetic field components of the flux rope over the inner boundary of ENLIL. The inclusion of a magnetic field would be a bonus to the HELCATS as we plan to simulate a handful of events, not only with a hydrodynamic ejecta (as defined in Tasks 6.2 and 6.3), but also with a full magnetic flux rope. Preliminary work has been carried out with Dusan Odstrcil to include this flux rope in ENLIL simulations.

<u>Modelling the background solar wind:</u> Rui Pinto, recruited in November 2014 to work on WP6, has started working on the initialisation of ENLIL and improving on the well-known Wang-Sheeley-Arge empirical technique that is currently used by space weather centers (Task 6.1). He has developed a new code to compute profiles of solar wind acceleration based on hydrodynamic models along individual magnetic field lines starting from the chromosphere up to the source surface. The magnetic model used so far to derive the magnetic field lines is the potential field source surface model. He has discovered since his start on the project that the expansion factor of magnetic flux tubes is not the only important component for determining the terminal speed of the solar wind. The inclination of the field line relative to the solar surface that typically occur around helmet streamers has also a strong influence. He has developed the code to run on thousands of open magnetic field lines simultaneously to compute the 3-D distribution of solar wind speed, temperature and density at 21.5 solar radii, the inner boundary of ENLIL. The next step is to compare these new predictions systematically with in-situ measurements and to fully couple these computations with ENLIL. Rui Pinto is preparing a paper on the influence of the inclination of field lines on the terminal speed of the solar wind.

WP6 SUMMARY/NEXT STEPS:

WP6 activities described above continue into the second year as this WP progresses. These lead to two deliverables expected by month 24, namely D6.1, which is an assessment of how well ENLIL predicts the properties of CIRs using HI data input, and D6.2, which is a catalogue of the optimised ENLIL simulations. Clearly, much progress has been achieved towards these two. In addition by month 36, at the end of the project, tis WP will deliver D6.3, which catalogues the shocks obtained from ENLIL modelling, and D6.4 which assessing the use of HI data with ENLIL for space weather forecasting.

We note two papers in preparation from this WP, namely:

Pinto, R., Rouillard, A.P., Wang, Y.-M., Grappin, R. The acceleration of the solar wind along magnetic flux tubes of varying geometries, to be submitted to Astrophys. J., 2015.

Rouillard, A.P., Pinto, R., Plotnikov, I., The expansion of coronal pressure waves in 3-D during Coronal Mass Ejections, to be submitted to Astrophysical Journal, 2015.

WORK PACKAGE 7 (WP7):

ASSESSING THE COMPLEMENTARY NATURE OF RADIO MEASUREMENTS OF SOLAR WIND TRANSIENTS

WP7 ACTIVITY TYPE: RTD

WP7 DURATION: MONTHS 10 – 36

WP7 LEAD BENEFITIARY: IMPERIAL (6)

WP7 LEADER: Dr Jonathan Eastwood

WP7 CONTRIBUTORS: STFC (1); ROB (5)

WP7 OVERVIEW: The main goal of HELCATS WP7 is to assess the potential for combining white-light imaging of the inner heliosphere with both ground- and space-based radio data, in particular Interplanetary Scintillation (IPS) and Type II radio bursts. WP7 is divided into two activities. Task 7.1, led by STFC, comprises the identification and analysis of potentially-geoeffective solarwind events that have been observed by both the STEREO Heliospheric Imager (HI) and IPS observations. The goal of Task 7.2 (led by IMPERIAL) is to identify and analyse solarwind transients that are observed by both HI and in Type II radio burst emission, principally detected by the STEREO/WAVES instruments. A summary of the progress in each of these tasks, over the first year of the HELCATS project, is given below.

It should be noted that this work package did not start until month 10, as planned, and so its activities remain at a relatively undeveloped level, although rapid progress is projected based on plans already set in place.

WP7 TASK 7.1: IDENTIFYING AND ANALYSING POTENTIALLY GEOEFFECTIVE SOLAR WIND EVENTS THAT ARE OBSERVED BY BOTH HI AND IPS (TASK LEAD: STFC)

It should first be recognised that IPS data are not uniformly available (the radio-telescope systems used here run on a campaign basis only for observations of IPS) and so it is first necessary to establish the data availability working from the catalogues of CMEs and CIRs/SIRs provided by WP2 and WP5, respectively. Provisional catalogues have recently been made available for use in WP7, as starting points.

The first goals of this task, after complete and consistent analyses of all the IPS data available at RAL Space (STFC) during the STEREO mission (primarily from the EISCAT/ESR and LOFAR systems), is the development of a catalogue of CMEs and CIRS/SIRS observed using IPS. Subsequently, the interaction and influence of the ambient solar wind on transient propagation direction and speed will be investigated, together with exploring how IPS may be used to aid interpretation of complex interacting CME events.

Initial case studies have been identified, and these will be first to be investigated in detail (this is discussed also in 7.2).

WP7 TASK 7.2: IDENTIFYING AND ANALYSING SOLAR WIND TRANSIENTS THAT ARE OBSERVED BY BOTH HI AND IN TYPE II RADIO BURST EMISSION (TASK LEAD: IMPERIAL)

The goals of this task are to firstly develop a joint catalogue of CMEs observed in HI, and associated Type II radio observations from S/WAVES and Wind/WAVES data, extending the catalogue with ground-based radio observations to examine more closely the source region of each CME. Height-time statistics will then be constructed, and the usefulness of radio data in constraining modelling of CME onset will be systematically studied. Interacting CME events will be explored in detail to examine how radio data can be used to decipher event kinematics and improve forecasting.

To accomplish these goals, the first requirement is to survey the radio data in the context of the main event list provided by WP2. This work is now underway, focussing on the first part of the mission to establish the appropriate procedures and identify any unexpected difficulties before continuing through the remainder of the database. A second important issue which is ongoing is to establish the parameters that should be included in the radio data catalogue. This will be iterated with the team via the steering committee before committing to the full cataloguing of the data.

Initial assessment of the data has shown the existence of Type II radio emission where no event is apparently reported in the WP2 database. This somewhat unexpected result could be due to the fact that the event was out of the field of view; was too faint; or that indeed the radio emission occurred in the absence of a detectable emission by HI. This continues to be explored. In terms of detailed case studies of individual events, several powerful techniques can be brought to bear, particularly goniopolimetry (direction finding), and we intend in the first instance to follow the procedures implemented in the recent paper by Magdalenic *et al*., Astrophys. J., **791**, 115 (2014) (nb Magdalenic is the leading ROB activities on this work-package) which is a case study of the 5 March 2012 event (now part of the WP2 database).

WP7 SUMMARY/NEXT STEPS: In the next 12 months it is expected that:

7.1: Once a complete and consistent analysed data set of the available EISCAT/ESR and LOFAR IPS data throughout the STEREO mission period to date is completed, the first step is to look at each IPS campaign time interval and extract from the WP2 and WP5 provisional catalogues (with set ID naming already in place) the events seen by the white-light instruments. Cases where data are then available from the observations of IPS that match events in the catalogues will be catalogued separately (noting the typical features seen in the IPS analysis for identification of CMEs or interacting streams) for forming the more-detailed comparative analyses and comparisons with the HI imagery and coronagraph data to determine where the geometries of the observations allow for this direct comparison easily. Select parameters from each of the cases of confirmed data overlap will then be populated into an enhanced provisional catalogue once it is established that the same event/feature is being detected in both the IPS and the white-light imagery. Personnel from STFC RAL Space, led by Dr Bisi, will be responsible for these steps and significant progress is expected to take place following the 12-month open meeting taking place in May 2015.

7.2: The initial cataloguing of events will be completed based on the provisional CME list from WP2 and updated as appropriate in the context of progress on the project as a whole. This will enable top-level statistics to be constructed concerning occurrence, duration, brightness *etc*. The catalogue will enable the selection of appropriate case studies for further detailed study. Regarding personnel, as projected a post-doctoral research associate with considerable experience in the analysis of radio data will join IMPERIAL in July 2015 to begin work on WP7 (and WP4).

WORK PACKAGE 8 (WP8):
DISSEMINATION

WP8 ACTIVITY TYPE: OTH

WP8 DURATION: MONTHS 1 – 36

WP8 LEAD BENEFITIARY: STFC (1)

WP8 LEADER: Dr Chris Perry

WP8 CONTRUBUTORS: UPS (3)

WP8 OVERVIEW: WP8 oversees the logistics of the dissemination of data and information to the project, the Commission and the wider community, with the website as the principal tool (www.helcats-fp7.eu). Although the website is formally the responsibility of WP1, the posting of information through material posted on the website, including the basic format and information on the website, posted documentation, links etc… is the job of WP8 and this has been done, to allow efficient running of the project and the distribution of information as required. This includes the project (private) wiki page. Meeting minutes and reports are posted as required. WP8 also oversees documentation standards and formatting, including the catalogue structure. Information distributed outside the webpage such as press releases are also managed through WP8. Dissemination is also concerned with the running of the HELCATS meetings such as the six monthly project meeting in ROB in November 2014 and the Annual Workshop and project meeting in UGOE in May 2015. The WP also includes the ingestion of products into the AMDA data-mining IRAP (UPS) propagation tool, and integration with projects such as HELIO. This WP coordinates the exploitation of the project outputs, such that they feed into numerous research activities and future space weather applications.

WP8 TASK 8.1- PUBLICATION OF RESULTS AND CONCLUSIONS (TASK LEAD: STFC)

This WP Task focuses on the publication of documents relevant to the project, including posting on the website. In the reporting period, this includes meeting reports and minutes, teleconference minutes, the catalogues that are being constructed as the project progresses. We also note that some scientific papers are in preparation and will be submitted soon, and some papers have indeed appeared in the professional literature (see WP reports above).

WP8 TASK 8.2 – ANNUAL OPEN MEETINGS WITH THE SCIENCE COMMUNITY AND PRESENTATION AT MAJOR SCIENCE MEETINGS (TASK LEAD: STFC)

This report coincides with the first Annual Open Workshop of HELCATS, where the HELCATS community and the wider scientifc community will engage in scientific discussion on project-related science. The Open Workshop will include key presentations from the HELCATS team and from the community (see the details on the website) and is a major tool for advertising HELCATS progress and activities. A full programme of talks has been scheduled and a healthy attendance from within the project and beyond guarantees that this will be major event for heliospheric physics.

Whilst a number of preject-related publications are listed in the WP descriptions above, some HELCATS participants have presented HELCATS results at major meetings, e.g. Eduardo Sanchez-Diaz has presented his results on the very slow solar wind at EGU in April 2015, and Rui Pinto showed the results of work on solar wind acceleration at the AIC meeting in Tampa, Florida in April 2015.

WP8 TASK 8.3 – INSTALLATION OF RELEVANT DOCUMENTS, CATALOGUES, PUBLICATIONS ON THE PROJECT WEBSITE (TASK LEAD: STFC)

The website has been actively utilised from the start of the HELCATS project with basic information, but also with posted meeting information, documents, reports and minutes of meetings and teleconferences. This includes the catalogues themselves. Most of the site is public, but there is a private project area where some telecon minutes are lodged.

WP8 TASK 8.4 - INTEGRATE WITH RELEVANT, ESTABLISHED COMMUNITY FACILITIES AND WEBSITES (TASK LEAD: STFC)

The WP descriptions, above, have discussed the progress of the catalogues as they develop, and this includes the use and links to existing catalogues and websites for comparisons. The comparison of HI and coronagraph CME catalogues is a case in point, as is the integration of the catalogue facilities at RAL (STFC) with the UK Solar System Data Centre. Another facility that is key to the HELCATS work, for WP5 and 6, is the AMDA facility at UPS. The ENLIL work is also linking to an established MHD model and we have integrated ENLIL simulations to the propagationtool.cdpp.eu so that the community can also have access to the synthetic J-maps. Thus, the project has many ‘integration’ activities in progress and we refer the reader to the relevant WP sections.

WP8 TASK 8.5 – DISSEMINATION OF INFORMATION TO THE PUBLIC AND POLICY MAKERS (TASK LEAD: STFC)

The website is openly available to the public with information about the project and access to most of the project documentation and activities. The website includes news items, events, tweets and information on meetings. There is much background information for the non-professional, interested reader. The HELCATS team members are very active in ‘live’ space projects (e.g. STEREO, Cluster, Hinode) and in the increasing space weather activities, such as ESA’s Space Situational Awareness (SSA) space weather programme. The HELCATS project has been widely discussed, especially in space weather fora, because it is seen as pioneering and spearheading the assessment of HI observations along with associated data and modelling methods in a way that can have a major influence on future space weather strategic applications. Many members of the Steering Committee, including the Coordinator and the Scientific and technical Manager, are actively involved in SSA projects. In the UK this has involved close involvement with the Met Office, which is now an established space weather forecasting facility for the UK Government.

WP8 SUMMARY/NEXT STEPS:

The WP8 descriptions, above, are clearly defining an on-going process in terms of the varying aspects of dissemination. The activities, as described will continue throughout the project. The basic activities that are described relate to deliverables D8.1 to D8.8, all of which run through the entire project and are formally ‘delivered’ by month 36.

3 SUMMARY

The WP reports, above, describe a multifaceted project with clear aims and a focus on transients in the heliosphere. As planned, at the end of the first year, there are numerous elements to the work underway with clear paths to bringing aspects together as the project progresses. In terms of the project deliverables HELCATS is on track and we are seeing impressive results in bringing together a unique set of catalogues and the assessment of a range of key methods. Thus, the project is functioning well and we anticipate, already, a solid legacy for the future.

The WP descriptions provide specific summaries and pointers to the future but we bring out one point here, that is mentioned in the WP8 summary. The growth of the ESA Space Situational Awareness space weather programme is something that has taken place in parallel with the conception of HELCATS through to its implementation. It is abundantly clear that HELCATS is a thoroughly unique, global assessment of the added value of HI observations, of related data and of modelling methods, and the results will undoubtedly be fundamental to the application of HI observations in any future HI programme within a European space weather programme.

Having said that, the careful coordination of HI and associated data with the key modelling codes means that the project is well set to provide a truly unprecedented view of the heliosphere for the scientific community.