Progress on WP4 - Verifying the kinematic properties of STEREO/HI CMEs against in-situ CME observations and coronal sources

HELCATS month 6 meeting Brussels November 2014

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Summary WP4

- WP4 runs months 10-36
- builds on WP2+3
- linked catalogue feeds into WP6+7
- **Tasks:**
  4.1 coronal sources, **Göttingen**: STEREO, SOHO, SDO, Proba2
  4.2 in situ data: **Graz, Helsinki**, Toulouse, Göttingen, Imperial
  categorization of ICMEs with WP3 results (geometrical modeling):
  STEREO, ACE, Wind, MESSENGER, VEX, Ulysses, MSL
  4.3 statistical analysis: **Graz**, Toulouse, ROB, Göttingen, Helsinki

- **Deliverables:**

  M24: Establishing an **online catalogue of potentially associated solar source and in-situ** phenomena for the timeframe 2007-2015
  (this is the first catalogue of its kind; there are many separate CME / ICME lists)

  M30: Report on **statistical analysis and comparison of HI results with coronal and in situ data**; assessment of **forecasting accuracy**.

Progress so far

2nd quarterly Report August - October 2014

WP4 deals with establishing an on-line catalogue of CMEs that connects various solar, heliospheric imaging (HI) and in-situ datasets. A number of the partners have further worked on preparations for this WP.

- At UNIGRAZ, Peter Boakes was hired as a PostDoc researcher. The necessary updates to the HI catalogue from RAL have been provided to calculate CME parameters at in situ spacecraft. We have begun to check how the parameters in this list relate to the CME parameters observed by the different in situ spacecraft.
- At UH, IDL routines provided by CDAWeb were applied to get the in-situ data without manual downloading, and tested by students; software (C++/Python) for creating high quality plots was coded.
- ROB has been preparing the IDL routines that will be used in Task 4.3 in oder to link forward modelling results to in situ data.
- Preliminary work at UPS focused on redetermining Magnetic Cloud boundaries from WIND and STEREO, which will eventually constitute a new MC list for broad usage, to be accessible in AMDA.
- At UGOE, the IDL minimum variance analysis (MVA) routines were further upgraded to derive additional magnetic cloud parameters. More test runs with ACE data were done and the MVA is being applied to sample events. The MVA routine's output were re-formatted for further usage.

First Quarterly report May-Jul 2014:

A number of the partners have commenced preparatory work for this WP.

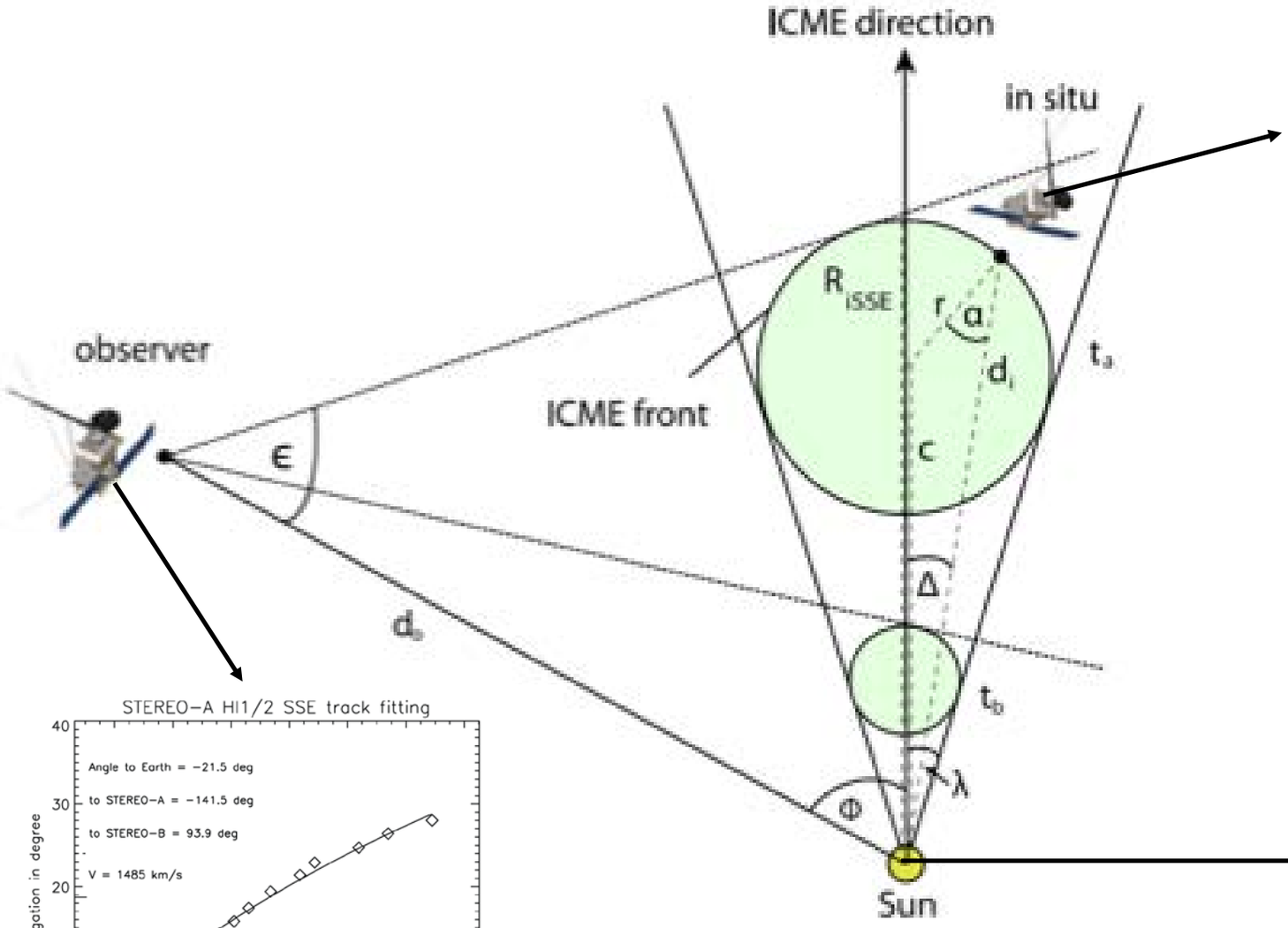
- UNIGRAZ and UH, where the in-situ data will mainly be processed, have started to download portions of data from the Wind, ACE, STEREO-A and B, Venus Express, MESSENGER, and Ulysses spacecraft. UNIGRAZ, UH and IMPERIAL have carried out initial tests of software in IDL to analyse and process the in-situ data into different formats.

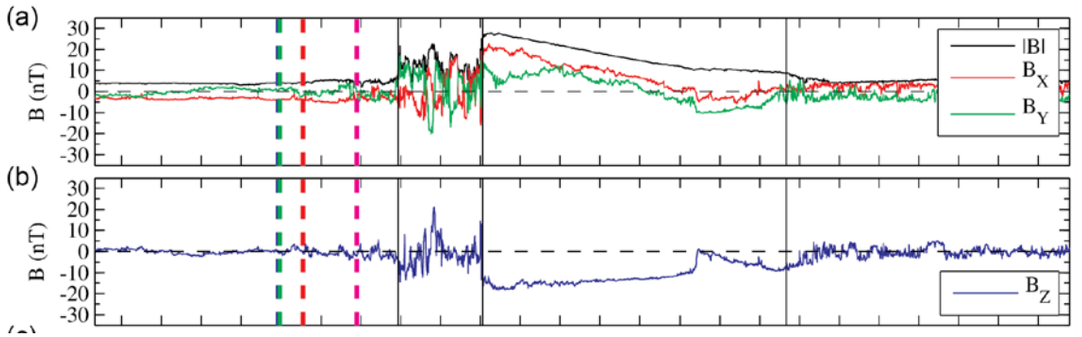
- A future incorporation of the in-situ time series, in the appropriate format, into the online AMDA tool has been discussed with UPS.

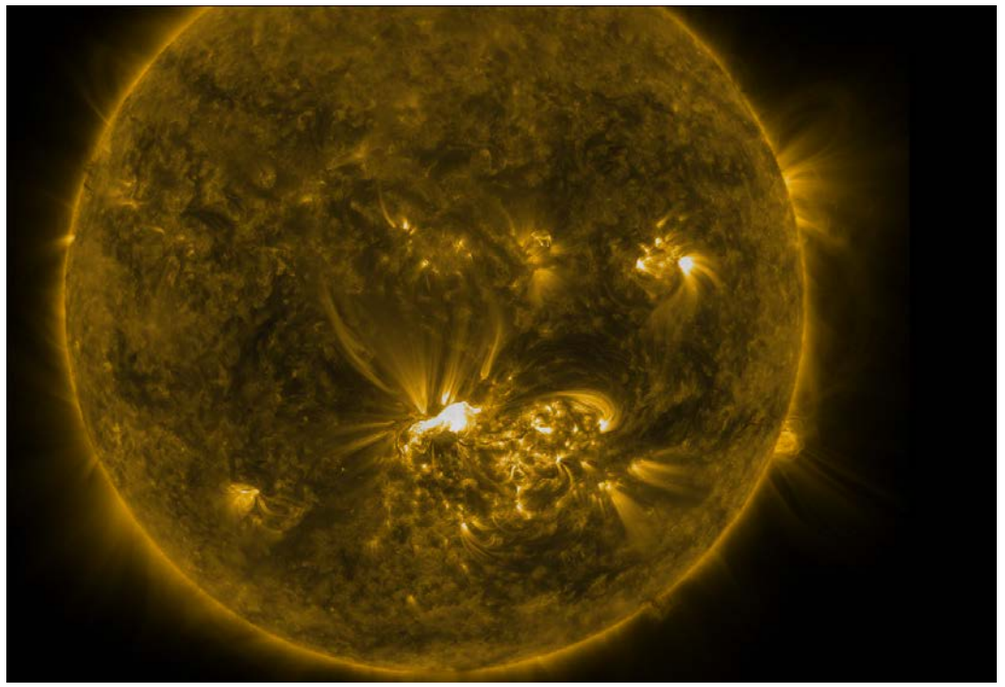
- At UGOE, the IDL minimum variance analysis (MVA) routines were installed. The routines were adapted to process ACE data with different time resolution. Some test runs with ACE data were done, and the MVA is being applied to sample events.
- A sample of the HI catalogue (from WP2 and WP3) has been checked by UNIGRAZ for comparison to the in situ data, and necessary updates to the HI catalogue have been discussed with STFC.

CME modeling with HI

- Self Similar Expansion Fitting technique (for the moment we use 30° half width)
- Davies et al. 2012 ApJ, Möstl et al. 2013 Sol. Phys.







CME parameters (see wiki)

parameters will likely include:

solar+coronagraph (some taken from WP3)

- flare class and peak time (if flare happened)
- position of source region (if identified)
- source region characterization (e.g. AR neutral line orientation, phenomena observed like EUV wave, post-eruption arcades) (if identified)
- time of first image of CME in coronagraphs
- initial CME speed
- initial CME direction

HI (arrival times, hits, speeds taken from WP3)

- CME speed
- CME direction
- CME arrival time at each spacecraft
- CME launch time

The final product of the online catalogue (Deli in April 2016) will likely consist of these 3 lists + the link between them through the CME event number (better designs always welcome!)

in situ

- spacecraft that detected the ICME, and its heliospheric position
- shock arrival time
- start and end times of any magnetic ejecta
- shock stand-off distance
- average magnetic field and plasma parameters (density, temperature) in sheath and ejecta
- max amplitude of magnetic field
- size of ejecta
- expansion speed of ejecta (Demoulin parameter)
- categorization of surrounding solar wind (HCS, high speed streams)
- general categorization of ejecta (e.g. magnetic clouds, flux ropes, magnetic cloud like, complex ejecta)
- flux rope type (SEN, NWS etc.) and chirality (if flux rope present)
- flux rope axis orientation (flux rope model needed)
- impact parameter (FR model)
- magnetic flux content of MCs (poloidal/toroidal, with FR model)
- supra thermal electron behavior

Lists for WP4 product

The ISEST Master CME List

We encourage all users of the wiki to add to this list to create a list compiled from everybody for community use. For information on how to add an event, go to Editing the ISEST Master List.

ICME EVENT START	ICME EVENT END	CME IN LASCO	ICME TYPE	AR	SURFACE LOCATION	FLARE MAGNITUDE	FLARE ONSET TIME	CDAW VEL C2	SEEDS VEL C2	SEEDS VEL A	SEEDS VEL B	AVG. VEL.	VELOCITY	TRANSIT TIME	DST PEAK	DST PEAK TIME	EJECTA START TIME	QUA
05/21/2007 21:00:00																		
11/19/2007 17:00:00																		
12/17/2008 03:30:00																		
01/26/2009 05:00:00																		
02/03/2009 19:00:00																		
09/30/2009 01:00:00																		
10/29/2009 02:00:00																		
11/14/2009 00:00:00																		
01/01/2010 22:00:00																		
04/05/2010 08:00:00																		
04/11/2010 12:30:00																		
05/28/2010 02:00:00	05/28/2010 21:00:00	05/28/2010 18:30:00	Multiple															
06/21/2010 08:00:00	06/22/2010 13:00:00	06/16/2010 15:07:00	MC	-	S24 W24	-	-	km/s	-	km/s	km/s	366.64	360.4 km/s	112:33:00	-	-	08:00:00	2
08/03/2010 17:00:00	08/05/2010 08:00:00	08/01/2010 03:54:00	SH+Multiple EJ	11092	N20 E36	C3	08/01/2010 08:26:00	850 km/s	-	670 km/s	528 km/s	529.92	511.5 km/s	61:06:00	-70	08/04/2010 05:00:00	08/04/2010 10:00:00	1
12/28/2010 10:00:00	12/28/2010 15:00:00	12/23/2010 05:12:00	ICME LIKE	-	S15 W18	-	-	286 km/s	152 km/s	251 km/s	274 km/s	331.63	353.7 km/s	124:48:00	-43	12/28/2010 18:00:00	12/28/2010 10:00:00	3

STEREO-A_EARTH_ARRIVALS_SSEF30.txt - Notepad

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HCME_A__20080820_
HCME_A__20080913_
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HCME_A__20081010_
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HCME_A__20081103_
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STEREO-A_VENUS_ARRIVALS_SSEF30.txt - Notepad

File Edit Format View Help

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```

Boakes & Möstl initial tests on in situ arrivals from HI / WP3

entification number
ex in degrees

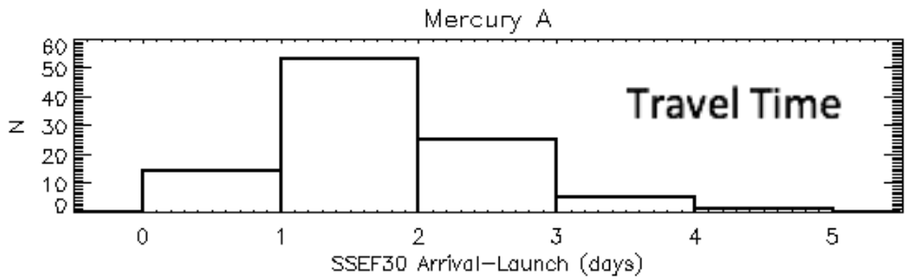
(9) min B_z	(10) min Dst
−9.5	...
−8.6	...
−11.3	...
−7.6	...
−6.7	...
−9.4	...
−14.6	−81
−8.6	−51
−12.9	−85
−2.8	...
−30,2	...
−11.2	−67
31.8	−24.3	...
10.1	−8.1	−107
23.3	−21.4	−69
24.3	−22.1	−132
30.8	−27.9	−69
30.5	−15.7	−73
18.8	−18.2	−74
30.4	−18.4	−131
29.2	−23.6	−50
15.9	−15.3	−108
41.0	−21.0	−71
27.7	−18.3	−127

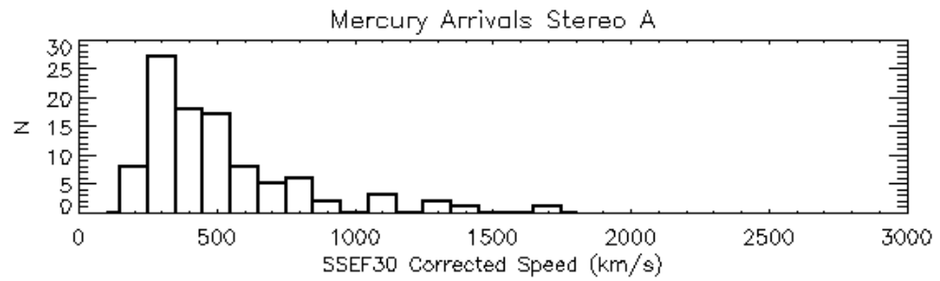
092	20071231	17	*Wind*	0.9841	36	2012 Jan 22 05:28	415 ± 18	26 ± 17
093	20080102	18	*Wind*	0.9844	33	2012 Jan 24 14:36	638 ± 34	8 ± 2
095	20080122	19	*Wind*	0.9924	41	2012 Mar 7 03:28	501 ± 65	14 ± 5
096	20080129	20	*Wind*	0.9927	42	2012 Mar 8 10:24	679 ± 44	12 ± 4
100	20080212	21	*Wind*	0.9938	6	2012 Mar 12 08:28	489 ± 23	24 ± 9
		22	*Wind*	1.0055	20	2012 Apr 23 02:14	383 ± 8	24 ± 7
		23	*Wind*	1.0160	28	2012 Jun 16 19:34	494 ± 29	50 ± 24
		24	*Wind*	1.0165	22	2012 Jul 14 17:38	617 ± 39	16 ± 6

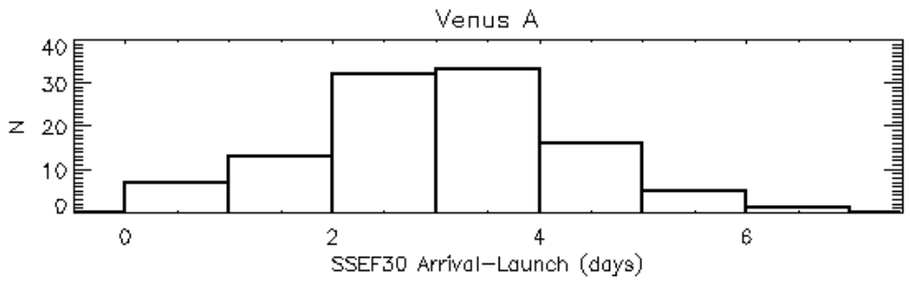
Samples from WP3

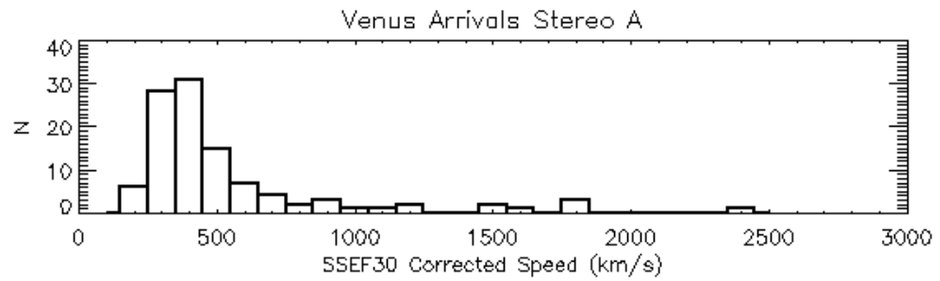
Peter and I made a first list of arrival time calculations from the HI catalogue - this is the basis for comparison to in situ in WP4

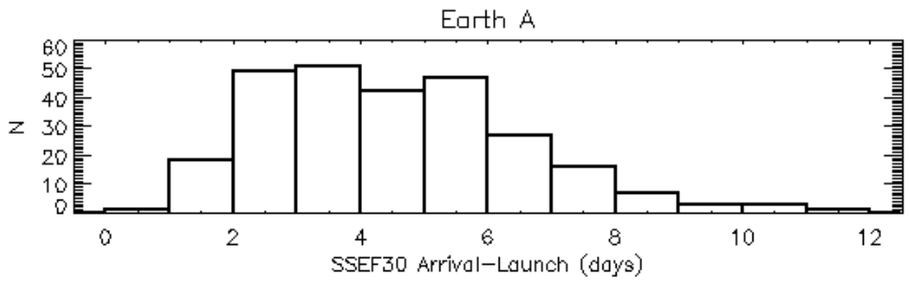
Corrected Speed

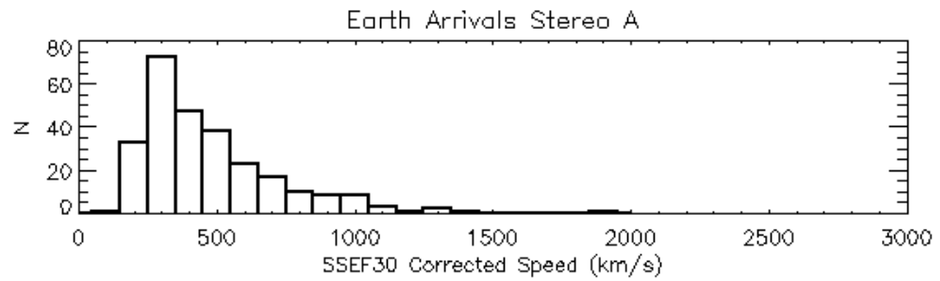


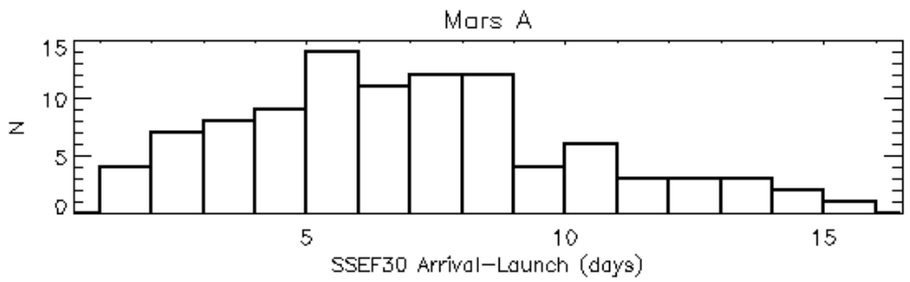


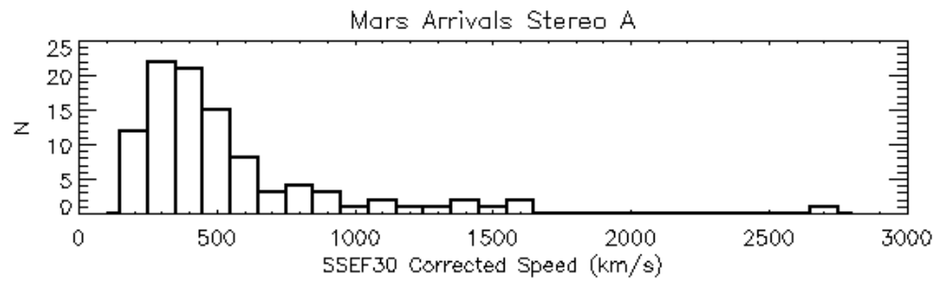


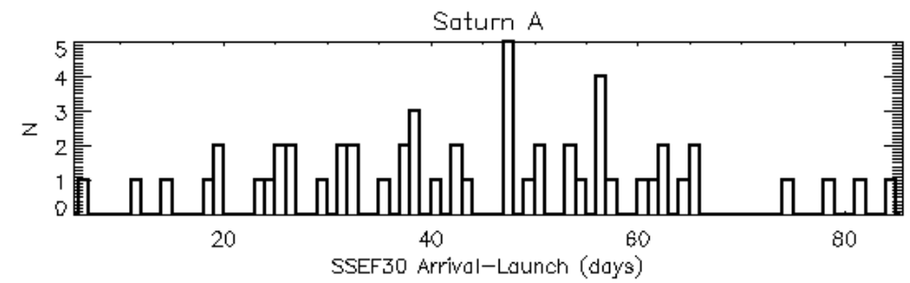


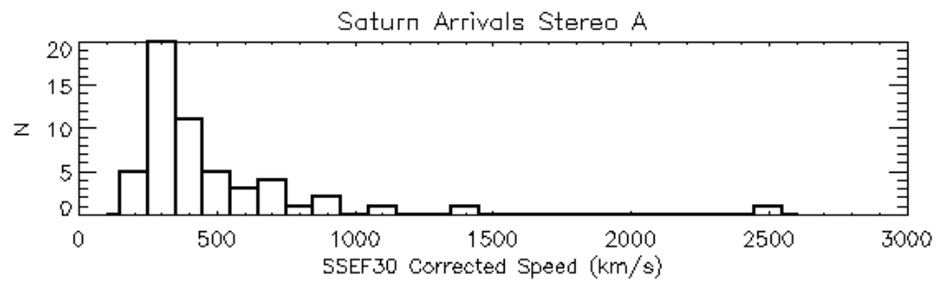






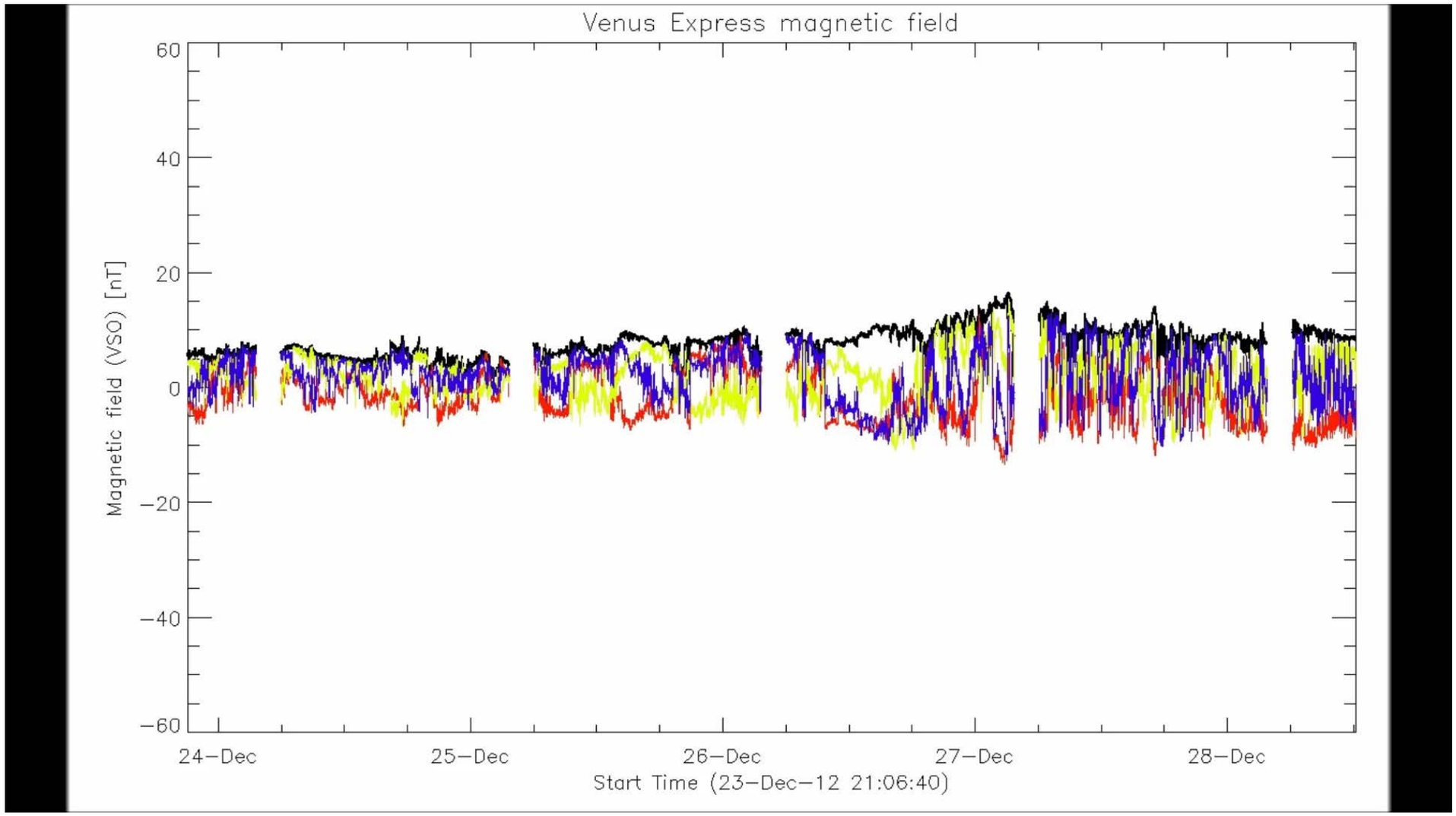






Venus Express / MAG 2012

Sample how processed VEX data looks like - here the intervals inside Venus bow shock are removed, so only solar wind is plotted



Technical issues

- **Data sources**
  STEREO: CDAweb (UH)
  ACE, Wind: CDAweb (UH)
  MESSENGER: 1 min resolution from PDS website at UCLA (UNIGRAZ)
  VEX: 1 min res. ftp in house at SRI, Graz (UNIGRAZ)
  ULYSSES: 1 hour res. ftp at NSSDC or SPDF (UNIGRAZ)
  MSL, MAVEN: To be decided, MAVEN available mid 2015 (UNIGRAZ)

- **Availability (2007-2015)**
  STEREO-A/B, L1 (ACE, Wind): 2007- (mag and plasma)
  MESSENGER: 2007- (mag, in orbit at Mercury from 3/2011)
  VEX: 2007 - (mag)
  Ulysses: 2007 (mag/plasma, last ecliptic pass)
  MSL/MAVEN: 2012 / 2015 - (radiation experiment / mag /plasma)

- data to plots/analysis: in **IDL** for MESSENGER, VEX, ULYSSES to do: MSL
- data to plots/analysis: Wind, STEREO-A/B Helsinki CDAweb -> IDL

- **WP5** CIRs (Toulouse) will use similar in situ data, processed data will be available as **IDL save files, ASCII for AMDA, … or any other format you like!**

Upcoming tasks

until February 2015

- (1) process all the (level 2) in situ data until end of Feb 2015 into IDL

- (2) start testing on how connect the „arrival catalogue“ to the solar + in situ data

- (3) use the wiki for a platform of the discussions

start of WP4 in month 10 = March 2015:

- take available ICME (UNIGRAZ and UH) and solar lists (UGOE), decide on parameters and criteria
- process all in situ data to final versions of IDL .sav files, visualize in situ data
- make ICME list for each spacecraft with decided parameters
- link small portions of catalogue solar - HI - in situ, iterate from there

initial versions of **complete linked catalogue**: fall of 2015; iterate until February 2016 (Deli for catalogue: 30 April 2016 with description)

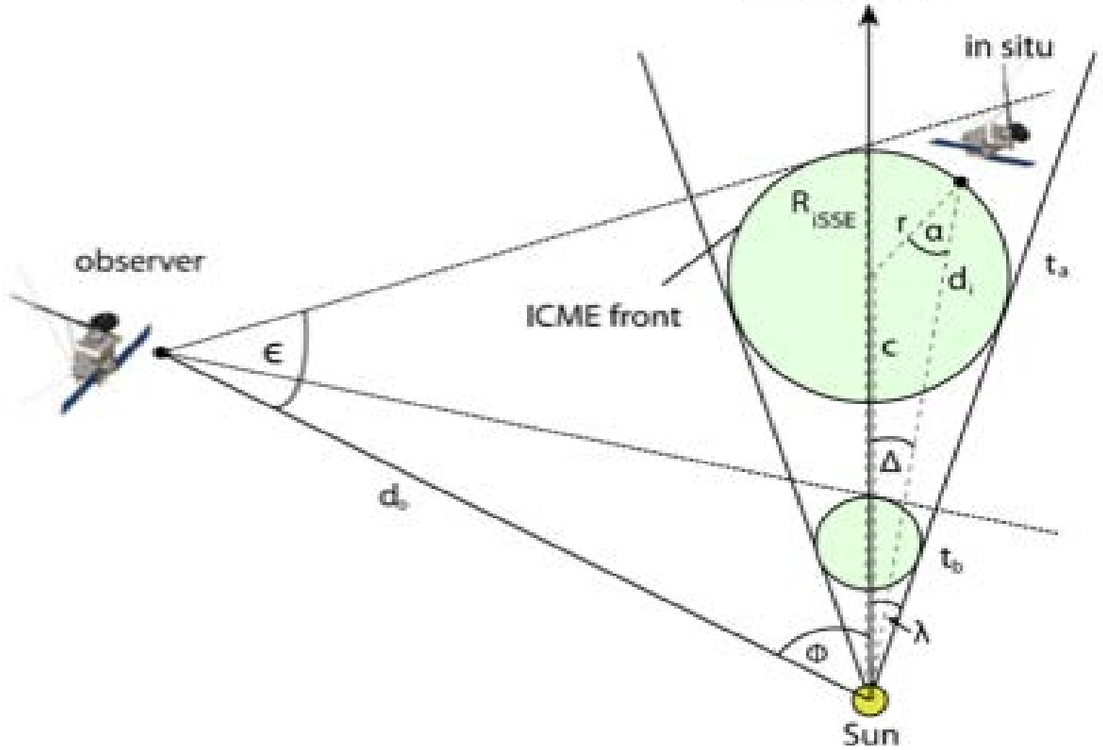
Mind **KISS principle,** start simple, and level of complexity can be increased later, also look at learning curve for outsiders for using the products!

THANKS!

Arrival Time Catalogue

- Using CME catalogue of WP2, and geometric fitting results of WP3.1
- Derive arrival times at Mercury, Venus, Earth, Mars & Saturn
- Using SSEF lambda of 30 degrees
- Hits (delta<lambda)
- Corrected speed Möstl & Davies, 2012
- Arrival = distance/speed

$$V_{iSSE} = V_{SSE}\frac{\cos\Delta + \sqrt{\sin^2\lambda - \sin^2\Delta}}{(1+\sin\lambda)}.$$



Arrival Time Catalogue

Filename-Stereo A or B, target, model and lambda

CME Identifier (WP 3/2 CME list)

Distance to Apex

Arrival speed (km/s)

Arrival Time

Target location in HEEQ

STEREO-A_EARTH_ARRIVALS_SSEF30.txt - Notepad

File Edit Format View Help

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
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HCME_A__20090131_01	6.0	363	2009-02-04T14:36Z	0.98519745	-5.95568	0.00000

- **HI** (arrival times, hits, speeds taken from WP3)
- • CME speed
- • CME direction
- • CME launch time