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

overview

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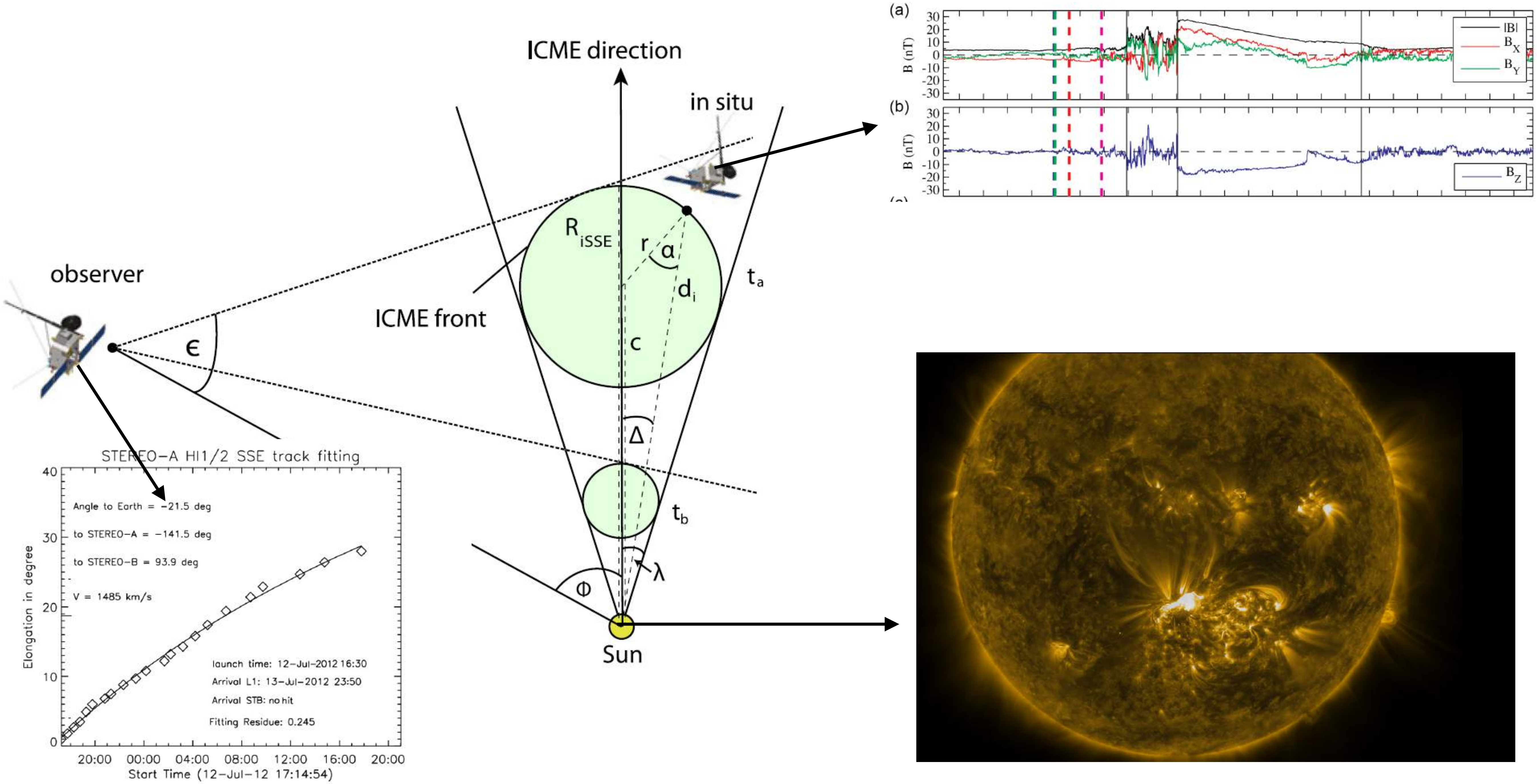
with input from

UGOE, IMPERIAL, ROB, UPS

24 month meeting June 2016

link CMEs: low corona to in situ

- Davies et al. 2012 ApJ, Möstl and Davies 2013 Sol. Phys., Möstl et al. 2014 ApJ



Summary WP4

- **Main goal: Verify the HIGeoCAT with in situ observations**

- 4.1 comparison to coronal sources, UGOE: STEREO, SOHO, SDO, Proba2
  largely done, add magnetograms of LINKCAT CMEs

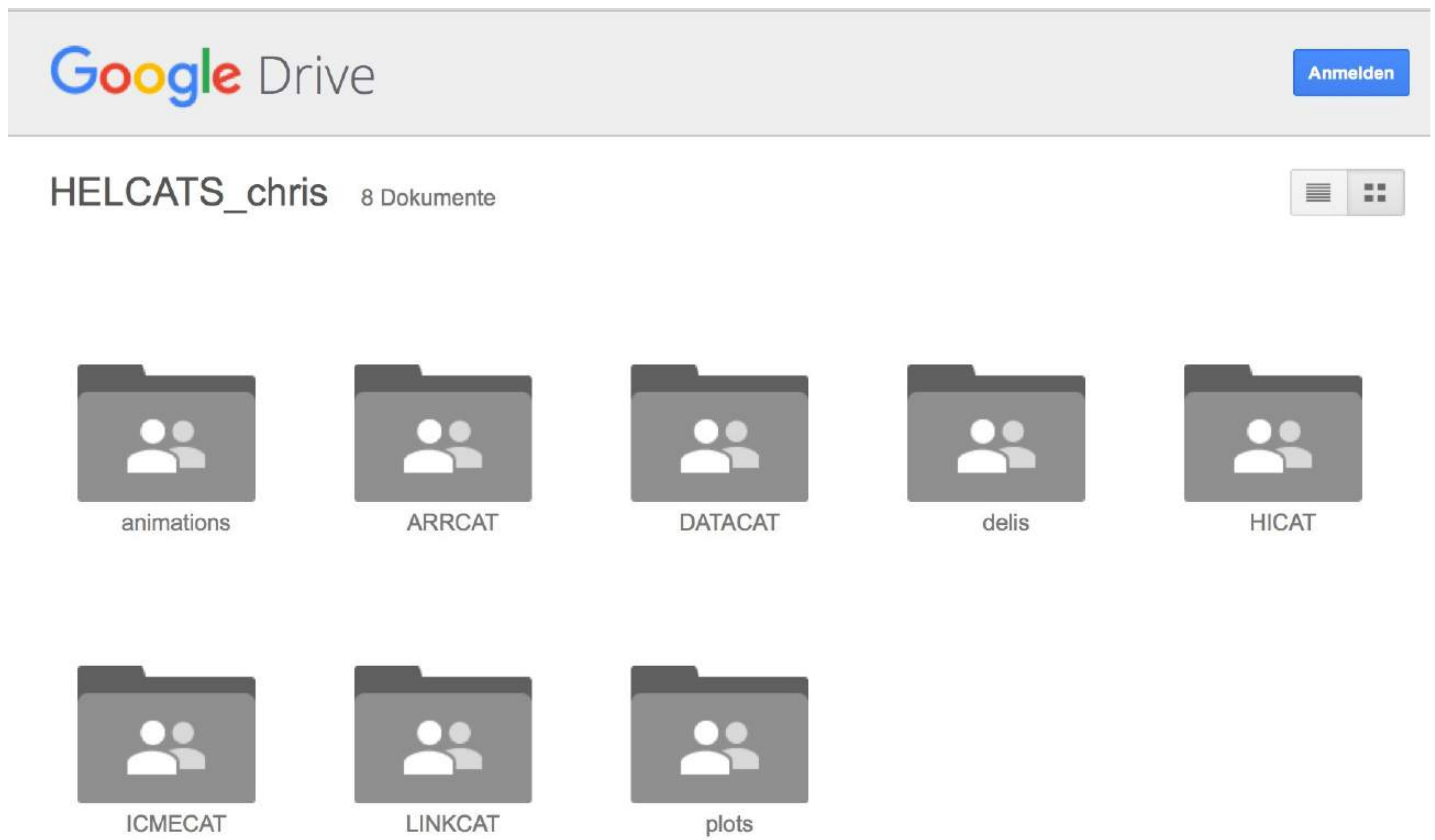
- 4.2 in situ data: UH, UNIGRAZ, UPS, UGOE, Imperial
  categorization of ICMEs and ICME parameters, modeling:
  STEREO, ACE, Wind, MESSENGER, VEX, Ulysses, MSL, MAVEN?
  largely done, needs VEX ICMEs in 2014 and MESSENGER data until 2015

  4.3 validation of HI modeling with in situ: UNIGRAZ, UPS, ROB, UGOE, UH
  focus in last project year on this task

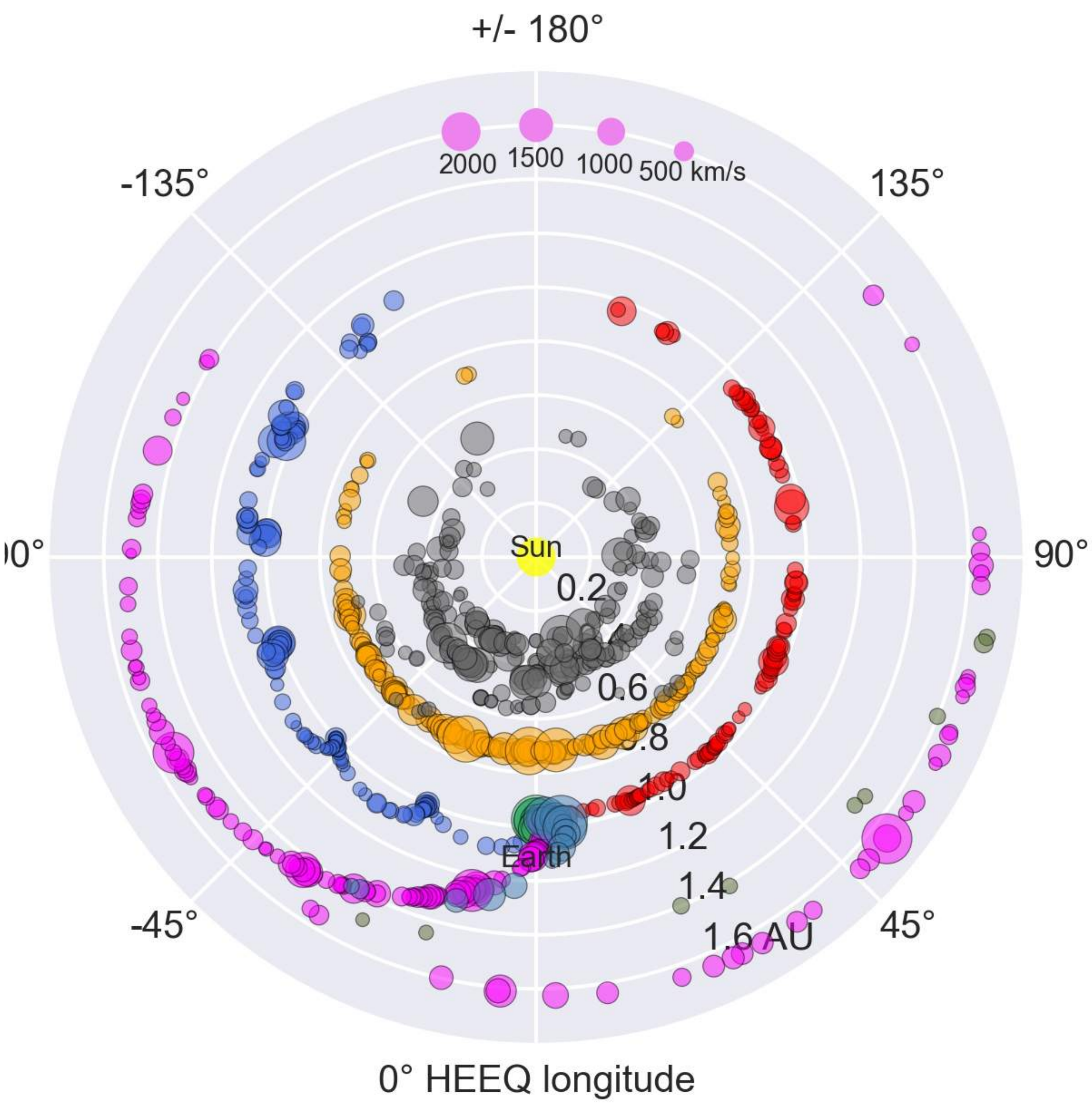
- **Deliverables:**
  1. April 2016, M24: Establishing an online catalogue of potentially associated solar source and in-situ phenomena for the timeframe 2007-2015.
  done, but needs to be submitted
- 2. October 2016, M30: Report on validation of the HI modeling: comparison of HI results with coronal and in situ data; assessment of forecasting accuracy.
  all catalogues ready for analysis

WP4 catalogues

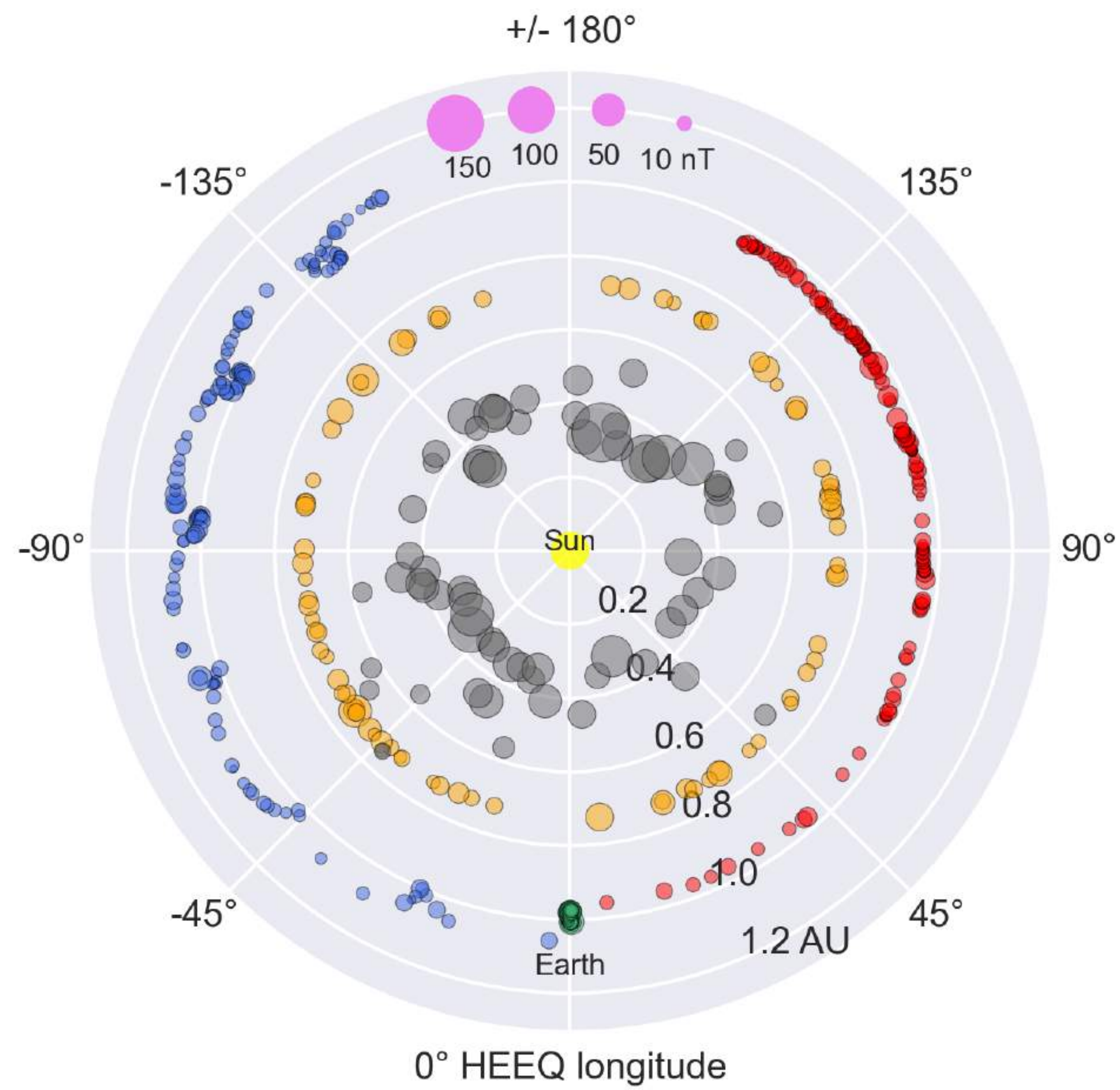
- All the material is on a google drive maintained by Christian Möstl
- https://drive.google.com/open?id=0B1laCSX6no6efm9zNVc4d3U5OEJKWm4zQnlsc2pMRkUzOXhLWWVCR1lhLXpkV1B0WXNKSDQ
- animations, catalogues as .txt + .sav with header files



ARRCAT/ICMECAT



ARRCAT: 1381 events



ICMECAT: 556 events

Möstl et al. 2016 HELCATS deli 4.1 - April 2007- December 2013

LINKCAT

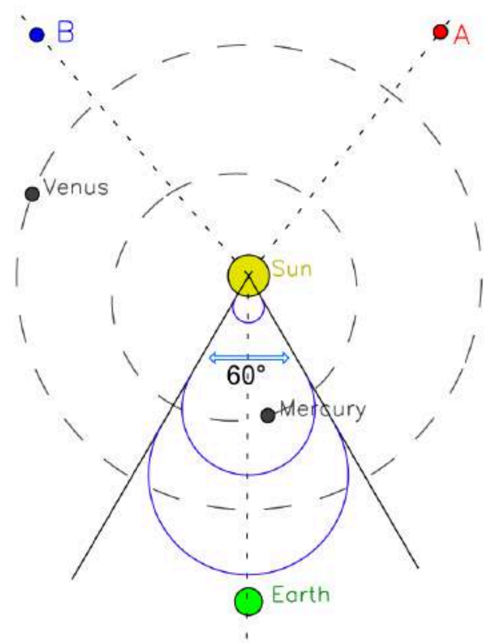
C. Möstl, P. Boakes, A. Isavnin, E. Kilpua, N. Mrotzek, V. Bothmer: **Linked catalogue**
143 events, 39 parameters for each event.

Linking HI to in situ CME observations

Space windows:

At CME launch time,
each spacecraft within
± 30° HEEQ longitude
of the CME SSEF30 direction
is considered to be impacted
(entry in ARRCAT)

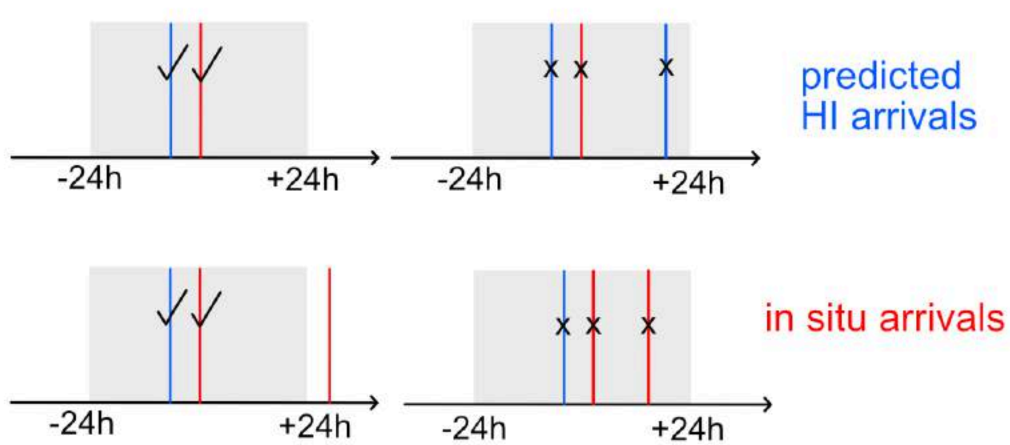
right: arrival entry at Earth
and MESSENGER

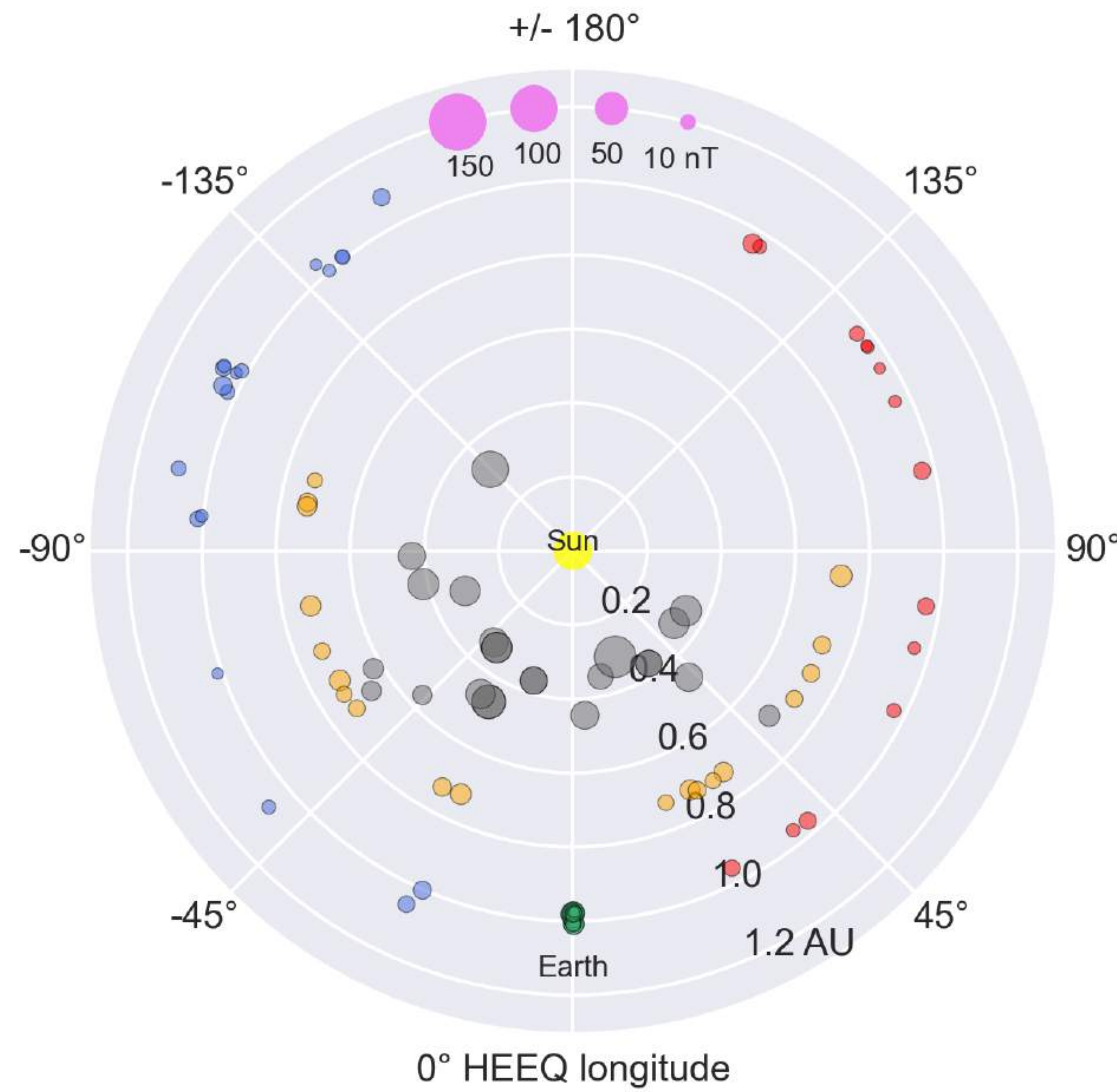


Time windows:

selection 1:
only 1 HI arrival
± 24 hrs of ICME

selection 2:
no other ICME
± 24 hrs of ICME





LINKCAT: 143 events

Möstl et al. 2016 HELCATS deli 4.1

Header file

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Niclas Mrotzek, Volker Bothmer, University of Goettingen, Germany.

Time window for selection of linked events from predicted arrivals to in situ observations: +/- 24 hours

Number of events in LINKCAT: 143

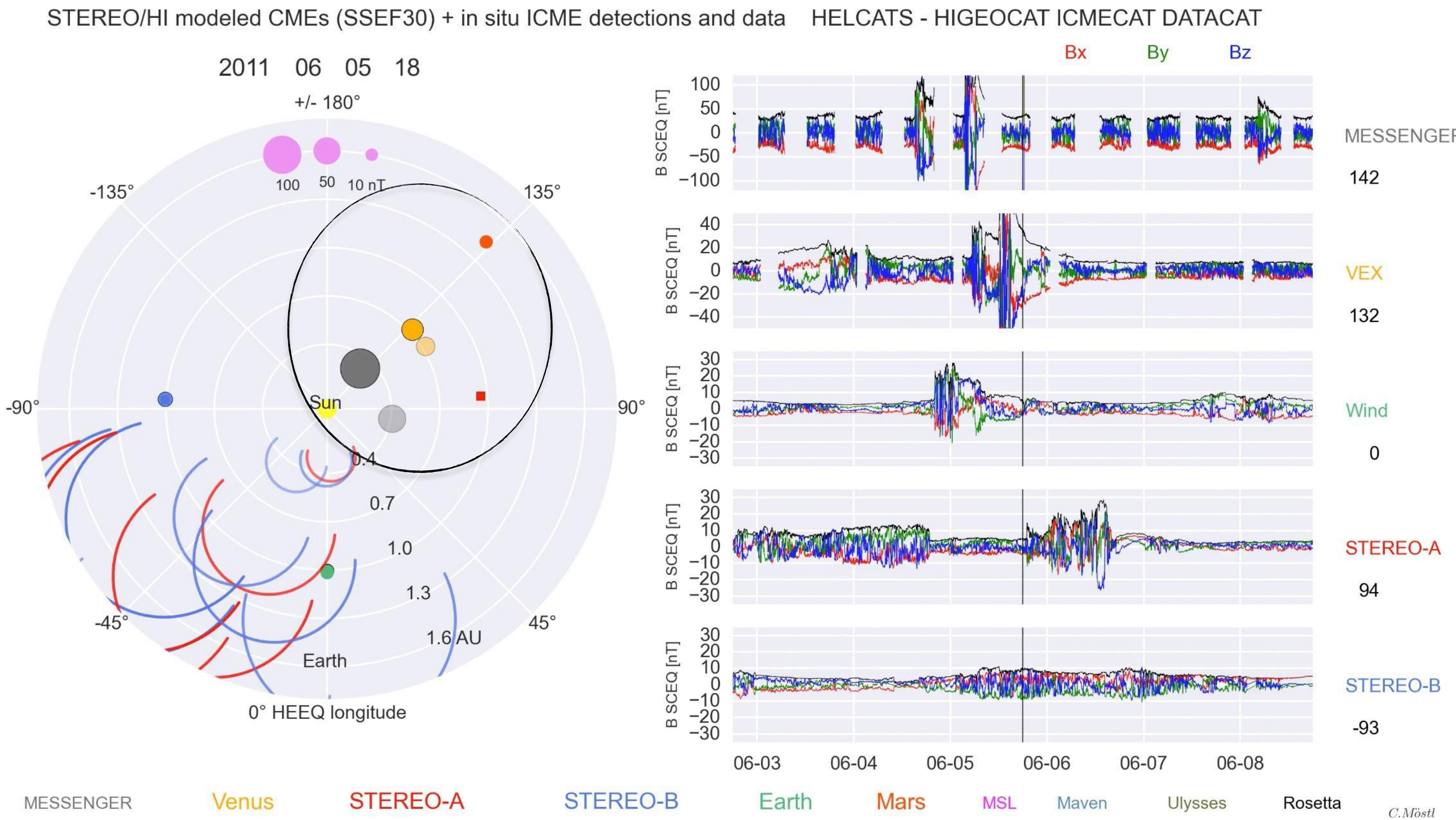
Remote observatories: STEREO-A/B SDO SOHO Proba2

In situ observatories: Wind STEREO-A STEREO-B VEX MESSENGER

Time range: May 2007 - December 2013.

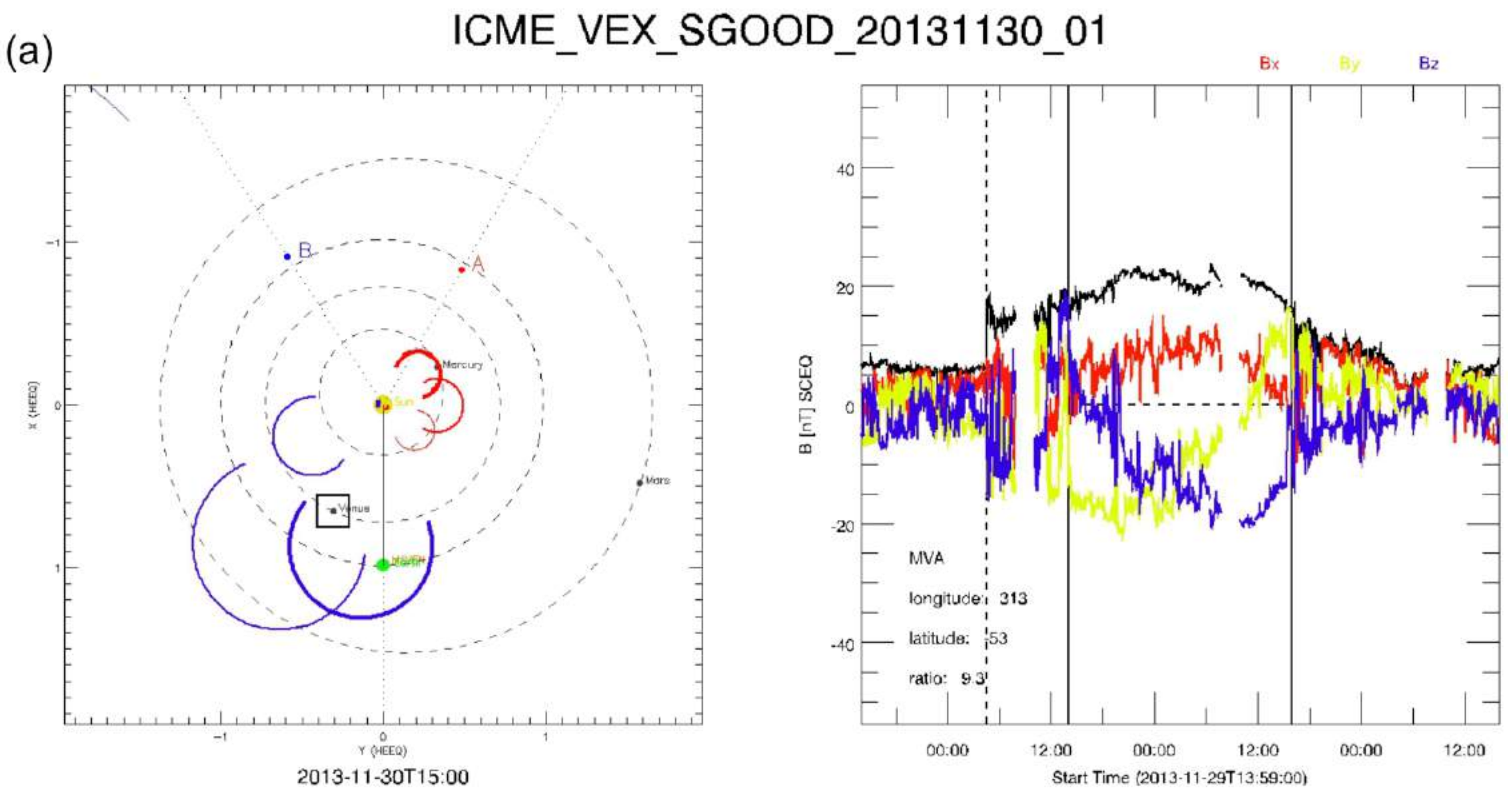
HEEQ coordinates are used for CME direction and spacecraft positions (variables 10-22).
SCEQ coordinates are used for in situ results at all spacecraft (variables 23-39).
For an explanation of coordinate systems, see below.

VARIABLES:
1: HICAT_ID: From HIGeoCAT, the unique identifier for the observed CME. unit: string.
2: SSE_LAUNCH: From HIGeoCAT, back-projected launch time of the CME on the Sun. unit: UTC.
3: TARGET_NAME: From ARRCAT, the name of the in situ target. unit: string.
4: TARGET_ARRIVAL: From ARRCAT, the predicted CME arrival time at the target location, corrected for SSE shape. unit: UTC.
5: ICMECAT_ID: From ICMECAT, the unique identifier for the observed ICME. unit: string.
6: SC_INSITU: From ICMECAT, the name of the in situ observatory. unit: string.
7: ICME_START_TIME: From ICMECAT, the shock arrival or density enhancement time, can be similar to MO_START_TIME. unit: UTC.
8: ARRIVAL_DIFFERENCE: TARGET_ARRIVAL minus ICME_START_TIME (i.e. calculated - observed). unit: hours.
9: SC_HELIODISTANCE: From ICMECAT, average heliocentric distance of the spacecraft during the magnetic obstacle (MO). unit: AU.
10: SC_LONG_HEEQ: From ICMECAT, average heliospheric longitude of the spacecraft during the MO. unit: degree (HEEQ).
11: SC_LAT_HEEQ: From ICMECAT, average heliospheric latitude of the spacecraft during the MO. unit: degree (HEEQ).
12: SOURCE_TYPE: flare (F) or filament eruption (FE). unit: string.
13: SOURCE_LONG_HEEQ: source region Stonyhurst longitude. unit: degree (HEEQ).
14: SOURCE_LAT_HEEQ: source region Stonyhurst latitude. unit: degree (HEEQ).
15: FLARE_CLASS: For Flares (F): HEC (Heliophysics Event Catalogue) GOES soft-xray (SXR) flares from SSW Latest Events. For FE: observed with "SDO", STEREO-A "A" or S
16: FLARE_START_TIME: Start time of the flare, from HEC GOES SXR flares, SSW Latest Events. unit: UTC.
17: FLARE_END_TIME: End time of the flare, from HEC GOES SXR flares, SSW Latest Events. unit: UTC.
18: FLARE_PEAK_TIME: Peak time of the flare, from HEC GOES SXR flares, SSW Latest Events. unit: UTC.
19: CME_SSE_LONG_HEEQ: From HIGeoCAT, CME longitude using Self-Similar Expansion fitting (30 deg half-width). unit: degree (HEEQ).
20: CME_SSE_LAT_HEEQ: From HIGeoCAT, CME latitude using Self-Similar Expansion fitting (30 deg half-width). unit: degree (HEEQ).
21: CME_SSE_SPEED: From HIGeoCAT, speed of CME apex, unit: km/s.
22: CME_TARGET_SPEED: From ARRCAT, CME arrival speed at target location, corrected for SSE shape. unit: km/s.
23: MO_START_TIME: The start time of the magnetic obstacle, including flux ropes, flux-rope-like, and ejecta signatures. unit: UTC.
24: MO_END_TIME: The end time of the magnetic obstacle. unit: UTC.
25: MO_BMEAN: From ICMECAT, the mean total magnetic field during the magnetic obstacle. unit: nT.
26: MO_BSTD: From ICMECAT, the standard deviation of the total magnetic field during the magnetic obstacle. unit: nT.
27: MO_BZMEAN: From ICMECAT, the mean magnetic field Bz component during the magnetic obstacle. unit: nT.
28: MO_BZMIN: From ICMECAT, the minimum magnetic field Bz component during the magnetic obstacle. unit: nT.
29: MO_MVA_AXIS_LONG: From ICMECAT, longitude of axis from Minimum Variance Analysis (MVA), X=0 deg, Y(west)=90 deg, range [0,360]. unit: degree (SCEQ).
30: MO_MVA_AXIS_LAT: From ICMECAT, latitude of axis from MVA. +Z(north)=90 deg, -Z(south)=-90 deg, range [-90,90]. unit: degree (SCEQ).
31: MO_MVA_RATIO: From ICMECAT, ratio of eigenvalues 2/3 as indicator for success of MVA, must be > 2, NaN otherwise. unit: number.

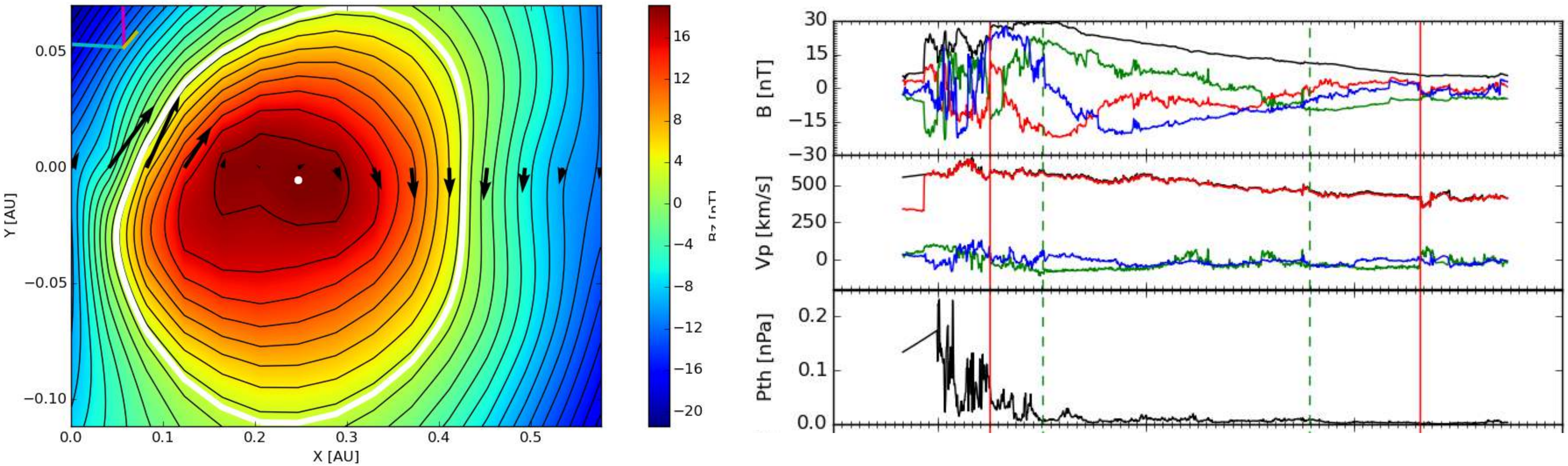


Isavnin, Kilpua et al. work in progress – also animations available of this plot

2 LINKCAT events



Möstl et al. 2016
HELCATS deli 4.1



A. Isavnin Grad-Shafranov reconstruction for LINKCAT STA/B, Wind

Papers

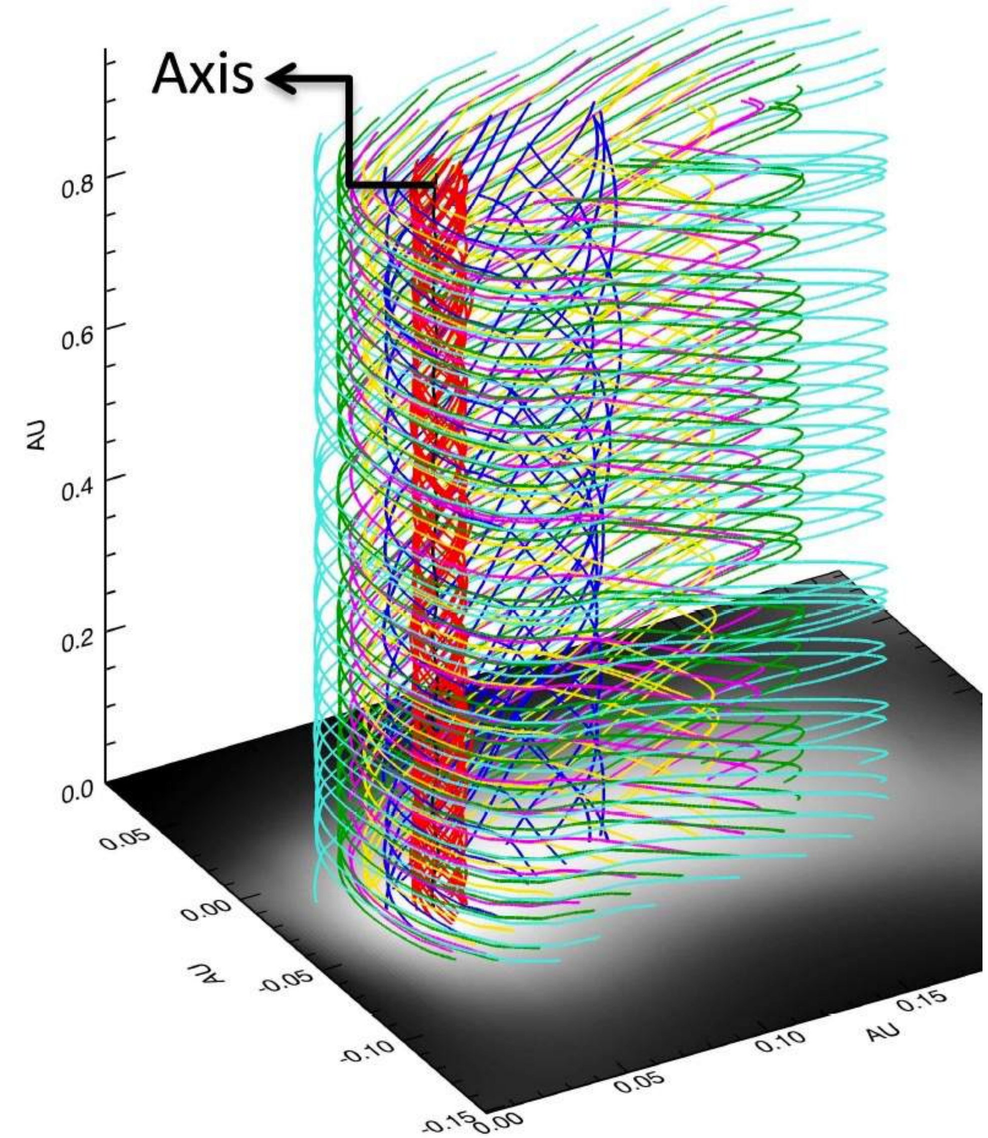
- **(i) directly from HELCATS products:**

  paper for deli 4.1 later this year:

  Möstl et al. + WP4 teams at UH/UGOE/IMPERIAL/ROB/ UPS, A linked catalogue of solar coronal mass ejections observed with the Heliophysics System Observatory, submission planned in 2016, likely ApJSS

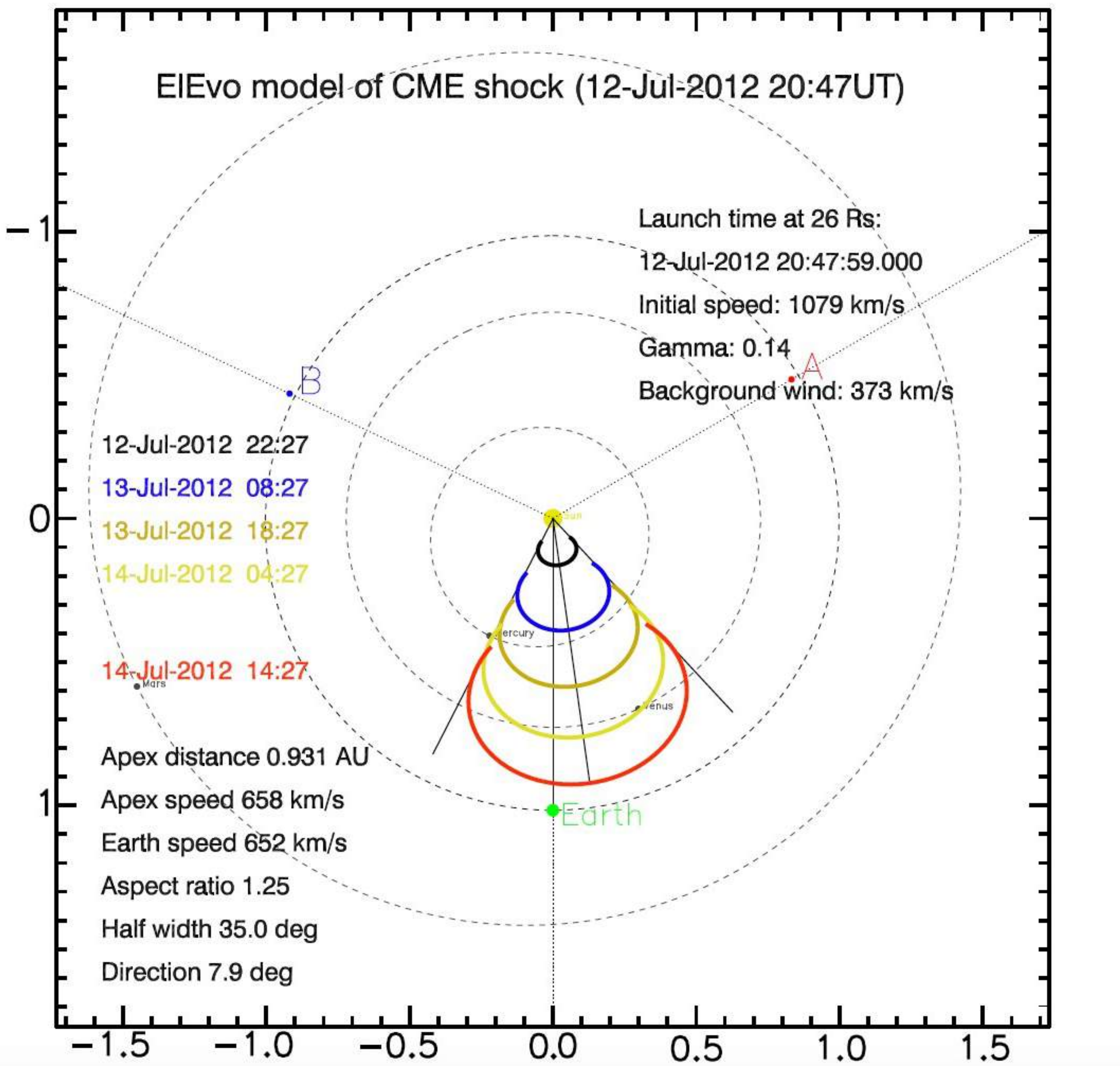
- **(ii) new papers related to HELCATS:**

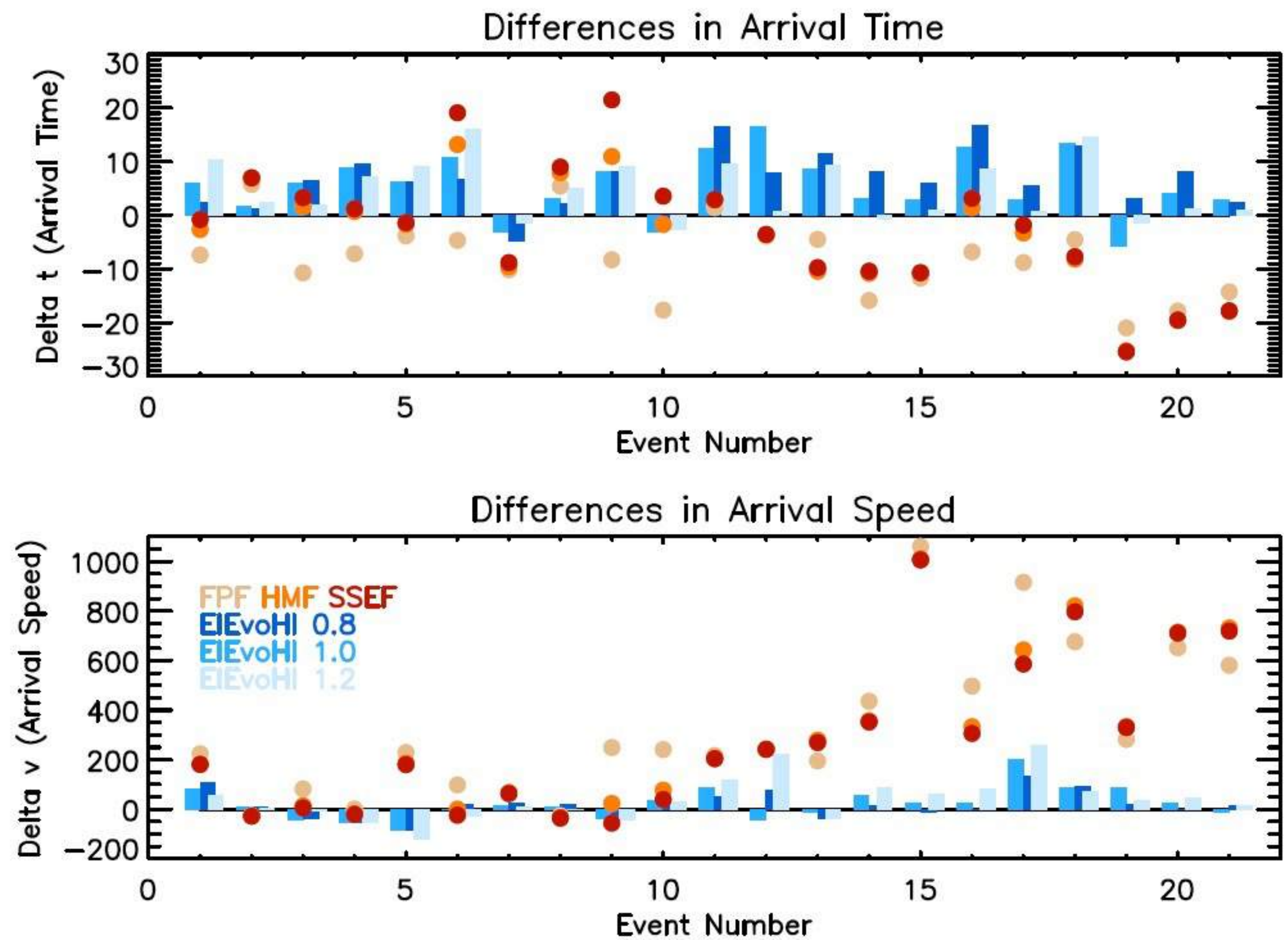
- **Rollett, T., C. Möstl, A. Isavnin, J. Davies … R. Harrison:** ElEvoHI: a novel CME prediction tool for heliospheric imaging combining an elliptical front with drag-based model fitting, ApJ, in press, (2016).
- Vemareddy, P., **C. Möstl et al.**, Comparison of magnetic properties in a magnetic cloud and its solar source on April 11-14 2013, ApJ, in revision, 2016.
- Vršnak, B.,… **C. Möstl, … , A. Isavnin,** Heliospheric Evolution of Magnetic Clouds, The Astrophysical Journal Supplement Series, in revision, 2016.
- **M. Kubicka, C. Möstl, … P. D. Boakes, … J. P. Eastwood,** Prediction of Geomagnetic Storm Strength from Inner Heliospheric In Situ Observations, ApJ, in revision, 2016.



magnetic cloud modeling, Vemareddy et al. 2016

Related to HELCATS: ElEvoHI





ElEvoHI: <Δt>= 6.4 +/− 5.3 h <Δv>= 16 +/− 53 km/s

SSEF: <Δt>= −2.3 +/− 11.4 h <Δv>= 328 +/− 295 km/s

strong improvement in arrival speed, arrival time slightly too late

Rollett et al. 2016 ApJ in press (see arXiv)

WP4 Summary

Current Status:

- The linked catalogue LINKCATv1.0 is ready
- Deli 4.1 will be submitted by end of June after a last round of revision by all the institutes, and the LINKCATv1.0 will be placed online

For Months 24-30:

For Deli 4.2, analyses of ARRCAT/ICMECAT/LINKCAT will made concerning ….

(1) the capability of CME prediction with HI SSEF30: hit/miss confirmed or rejected by in situ data – very important for possible L5 mission.

(2) relationships between e.g. in situ magnetic field and CME speed (for 0.3 – 1 AU)

(3) distribution of magnetic field **along the CME front**, e.g. total B as function of distance to apex

New studies:

- Isavnin et al.: in situ observation of CME-CME interaction June 2011 (MES, VEX, STA, no HI)
- Rodriguez et al.: direct comparison GCS modeling to ICMEs (no HI)
- **Newly started collaboration:** MESSENGER to STEREO/L1 lineups with R. Winslow, N. Lugaz, C. Farrugia, UNH, USA