Helio4Cast - a real-time test environment to enhance space weather prediction at Earth

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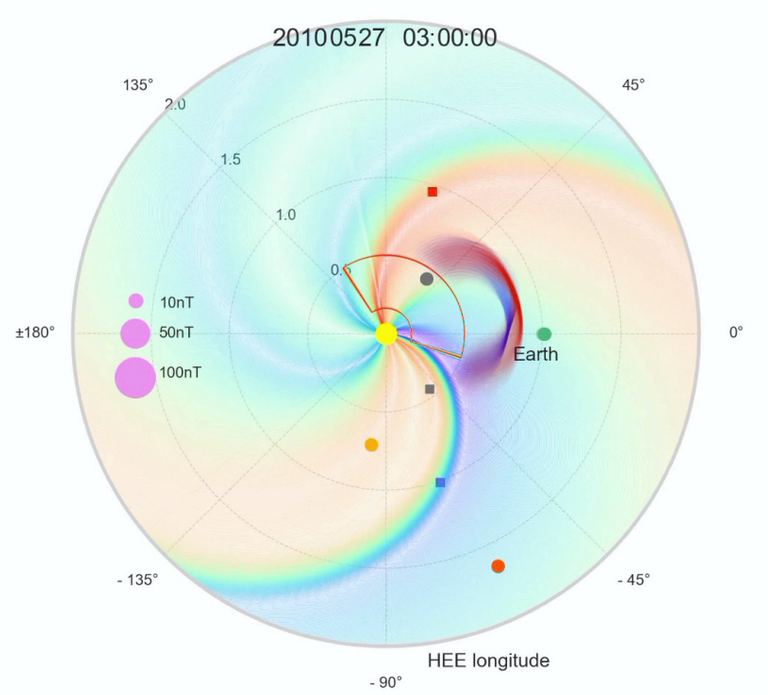
HELIO4CAST

- With ***Helio4Cast*** we strive to bridge the **gap between basic research and real-time space weather forecasts**.
- Modeling of **ICME flux ropes** is done with our own semi empirical method (3DCORE), **CME arrivals** with ELEvoHI.
- Predictions of **high-speed solar wind streams** are based on quasi L5 data and solar wind modeling (THUX).
- We directly check how these fundamental results may enhance real-time space weather forecasts.
- Our focus is on a combination of numerical and empirical modeling, allowing to apply the similar simulations that we use for research also in a real-time setting due to **fast computation of ensembles**.

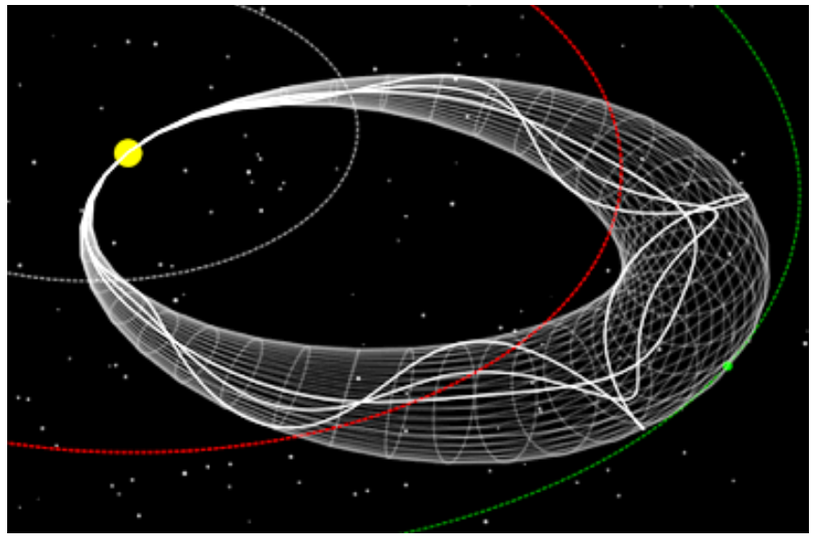


(1) THUX model with ensemble CME fronts from ElEvoHI

[Reiss et al. 2020, ApJ (arxiv)]

[Amerstorfer et al. 2018, Space Weather (open access link)]

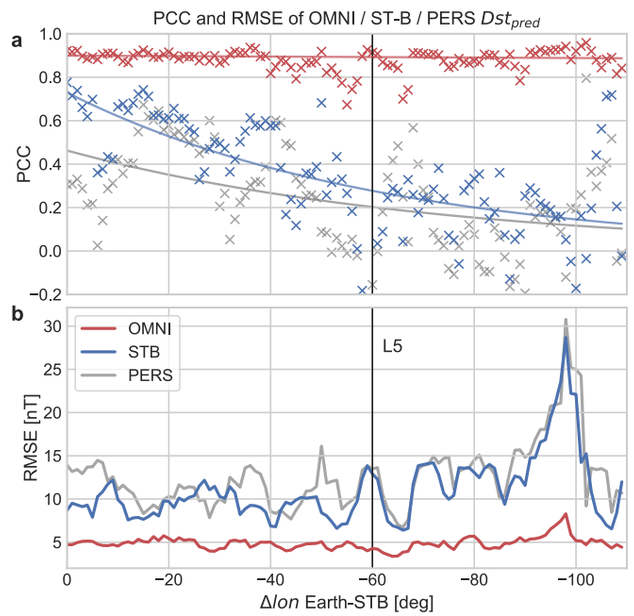
Hinterreiter et al. 2020, in prep.



(2) 3DCORE flux rope model

[Möstl et al. 2018, Space Weather (arxiv)]

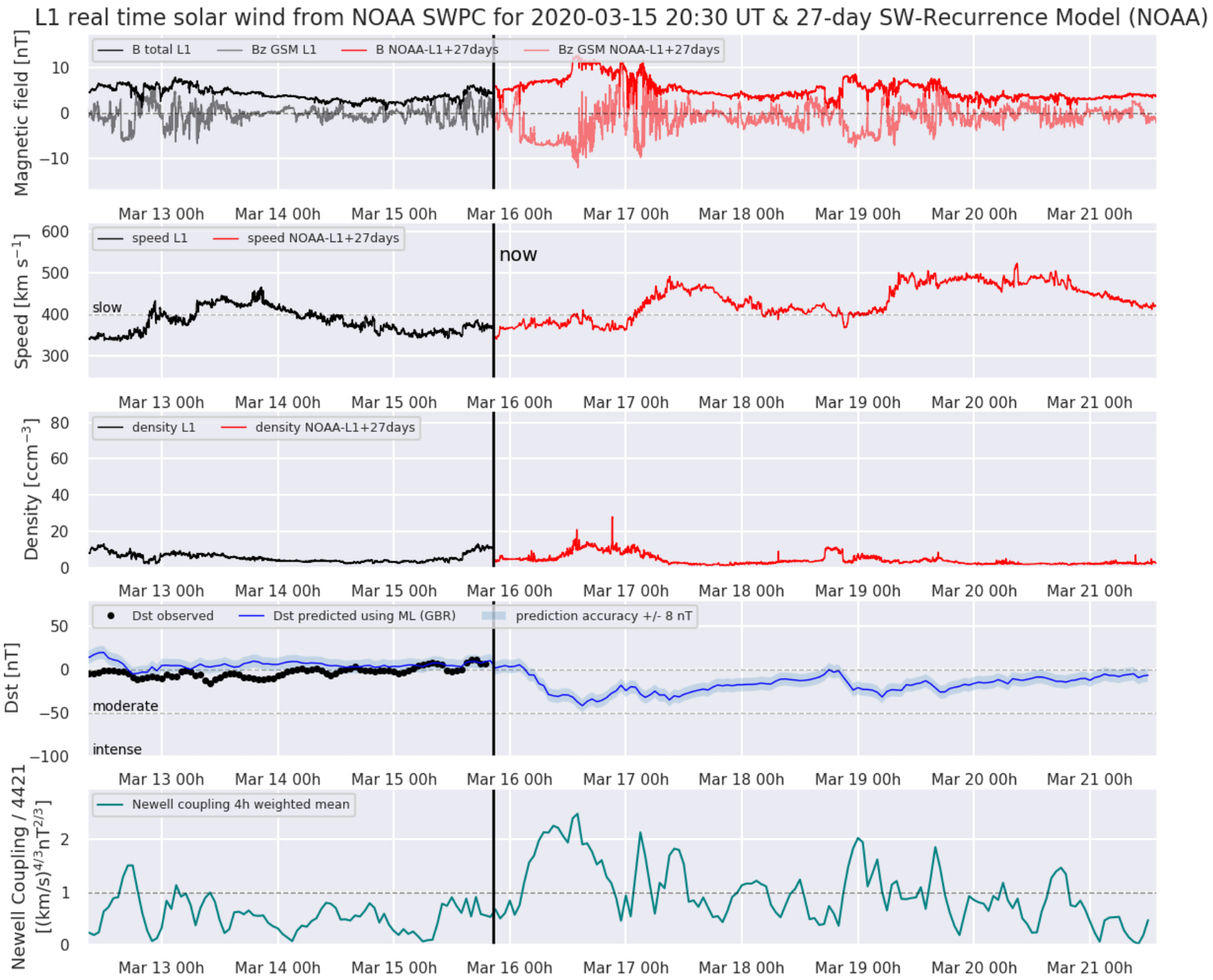
Weiss et al. 2020, in prep.



(3) Prediction of Dst for high speed streams with STEREO (quasi L5)

[Bailey et al. 2020 (arxiv)], Space Weather, in press

REAL TIME SOLAR WIND PREDICTION



- Our real time solar wind prediction is called **PREDSTORM.**
- If data from **STEREO-A is not available**, a recurrence model with the NOAA L1 solar wind is used.
- A **Dst prediction** is included - for past times it is based on the observed solar wind.
  For future times, Dst is predicted depending on B, Bz, By, N, V with a new method using gradient based regression (GBR) on the [Temerin & Li (2006)](#) model.
- The Newell coupling function (bottom panel) is a 4h weighted mean, used as an input for the OVATION PRIME aurora model ([Newell et al. 2014](#)).
- A verification of this Dst prediction is shown by [Bailey et al. 2020, Space Weather, in press](#)

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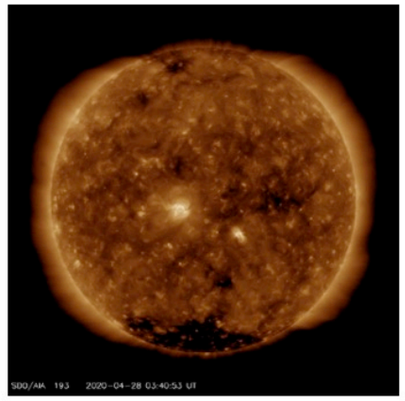
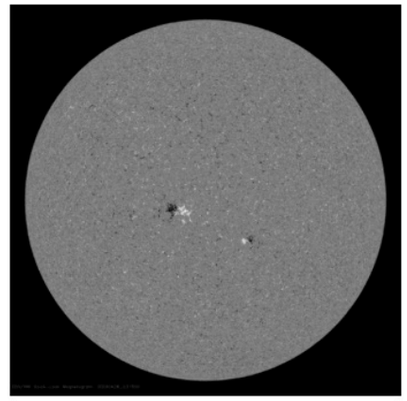
WEBSITE

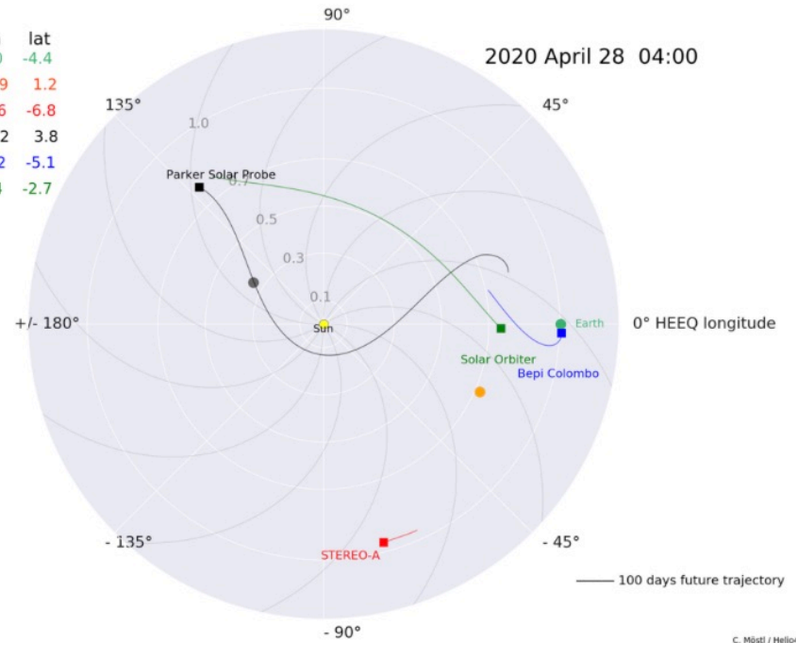




https://helioforecast.space

Most material is **preliminary but close to being finished,** including current data, catalogs of ICMEs and SIRs, and our experimental real-time forecasts for the background solar wind (PREDSTORM), CMEs with HI (ElEvoHI), and aurora (OVATION Prime 2010).

	R	lon	lat
Earth:	1.01	0.0	-4.4
Mars:	1.44	57.9	1.2
STA:	0.97	-74.6	-6.8
PSP:	0.78	132.2	3.8
Bepi:	1.01	-2.2	-5.1
SolO:	0.75	-1.4	-2.7

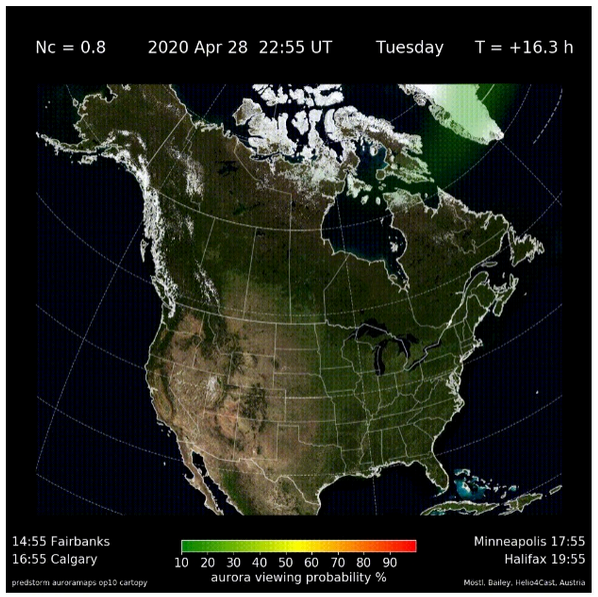


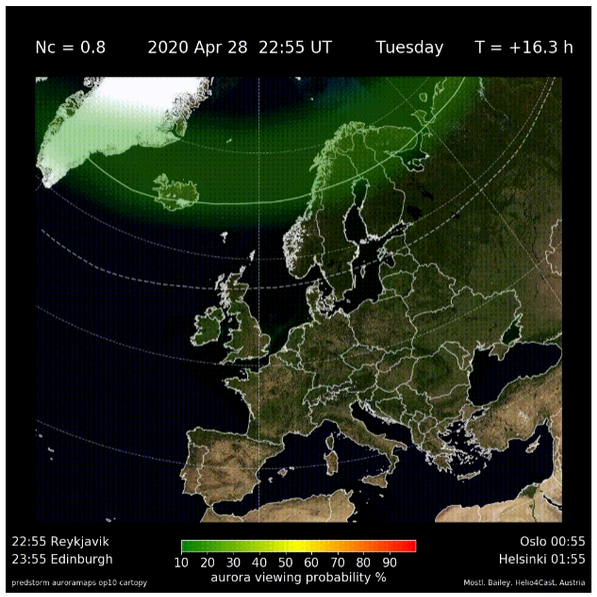
Show 10 entries Search:

#	icmecat_id	sc_insitu	icme_start_time	mo_start_time	mo_end_time	mo_sc_heliodistance	mo_sc_long_heeq	mo_sc_lat_heeq
0	ICME_PSP_MOESTL_20181030_01	PSP	2018-10-30 20:25	2018-10-30 20:25	2018-10-31 08:19	0.2645	24.92	0.12
1	ICME_PSP_MOESTL_20181111_01	PSP	2018-11-11 23:51	2018-11-11 23:51	2018-11-12 05:59	0.2545	178.55	-1.12
2	ICME_PSP_MOESTL_20190315_01	PSP	2019-03-15 09:00	2019-03-15 12:11	2019-03-15 17:49	0.5465	-161.32	3.17
3	ICME_PSP_MOESTL_20190324_01	PSP	2019-03-24 03:45	2019-03-24 03:45	2019-03-24 17:38	0.3858	-148.82	2.03
4	ICME_PSP_MOESTL_20190725_01	PSP	2019-07-25 08:13	2019-07-25 08:13	2019-07-25 23:06	0.7739		
5	ICME_PSP_MOESTL_20190731_01	PSP	2019-07-31 16:02	2019-07-31 16:02	2019-07-31 21:27	0.7076		
6	ICME_PSP_MOESTL_20190910_01	PSP	2019-09-10 10:39	2019-09-10 10:39	2019-09-10 13:41	0.3189		
7	ICME_PSP_MOESTL_20191013_01	PSP	2019-10-13 19:03	2019-10-13 22:47	2019-10-14 08:14	0.8077		
8	ICME_Wind_NASA_20070114_01	Wind	2007-01-14 11:31	2007-01-14 11:44	2007-01-15 07:45	0.9729		
9	ICME_Wind_NASA_20070115_01	Wind	2007-01-15 20:49	2007-01-15 20:49	2007-01-16 04:45	0.9731		

Showing 1 to 10 of 743 entries Previous 1 2 3 4 5 … 75 Next

This catalog has been made by getting the 3 times of each ICME (shock or disturbance begin, magnetic obstacle start and end) from the individual catalogs below, and then calculating all parameters again consistently from the data by us.
The in situ data that were used for the catalog, with a size of 8 GB in total, including extra data files with magnetic field components in RTN coordinates that are not used for producing the catalog, can be downloaded in python pickle format as recarrays from





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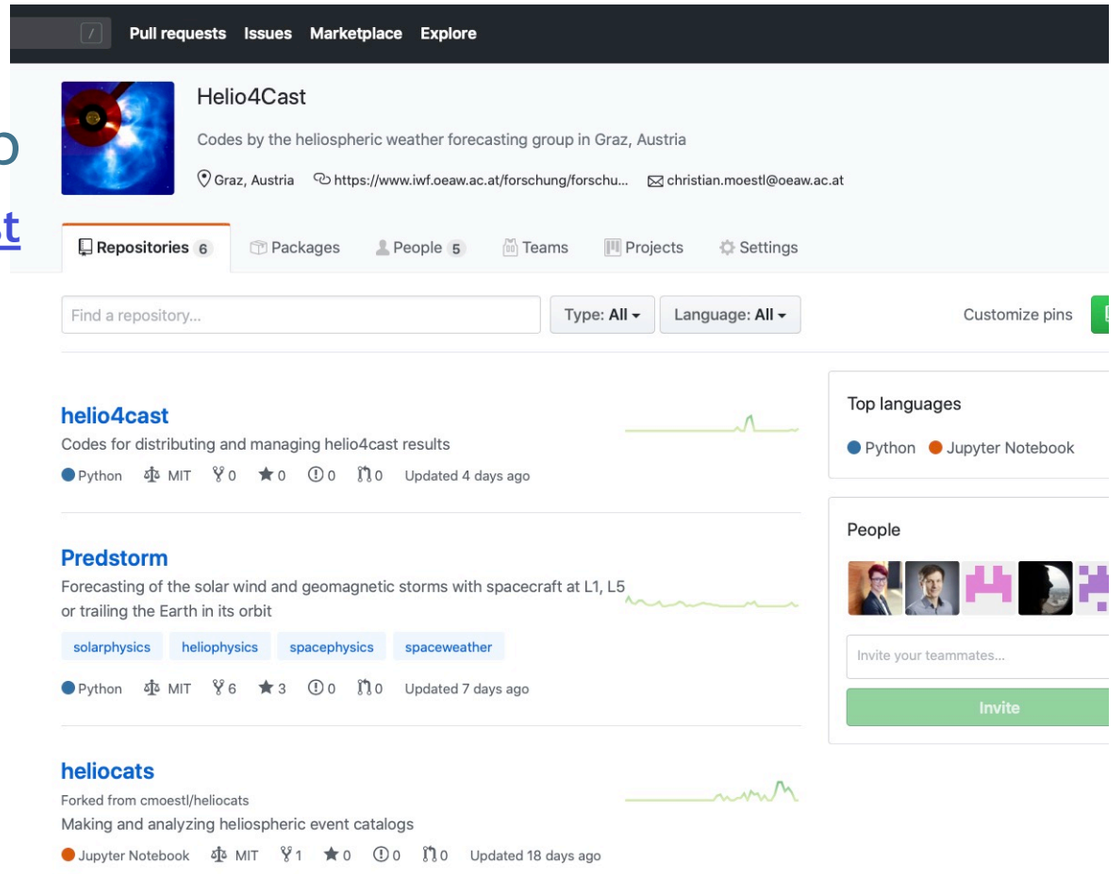
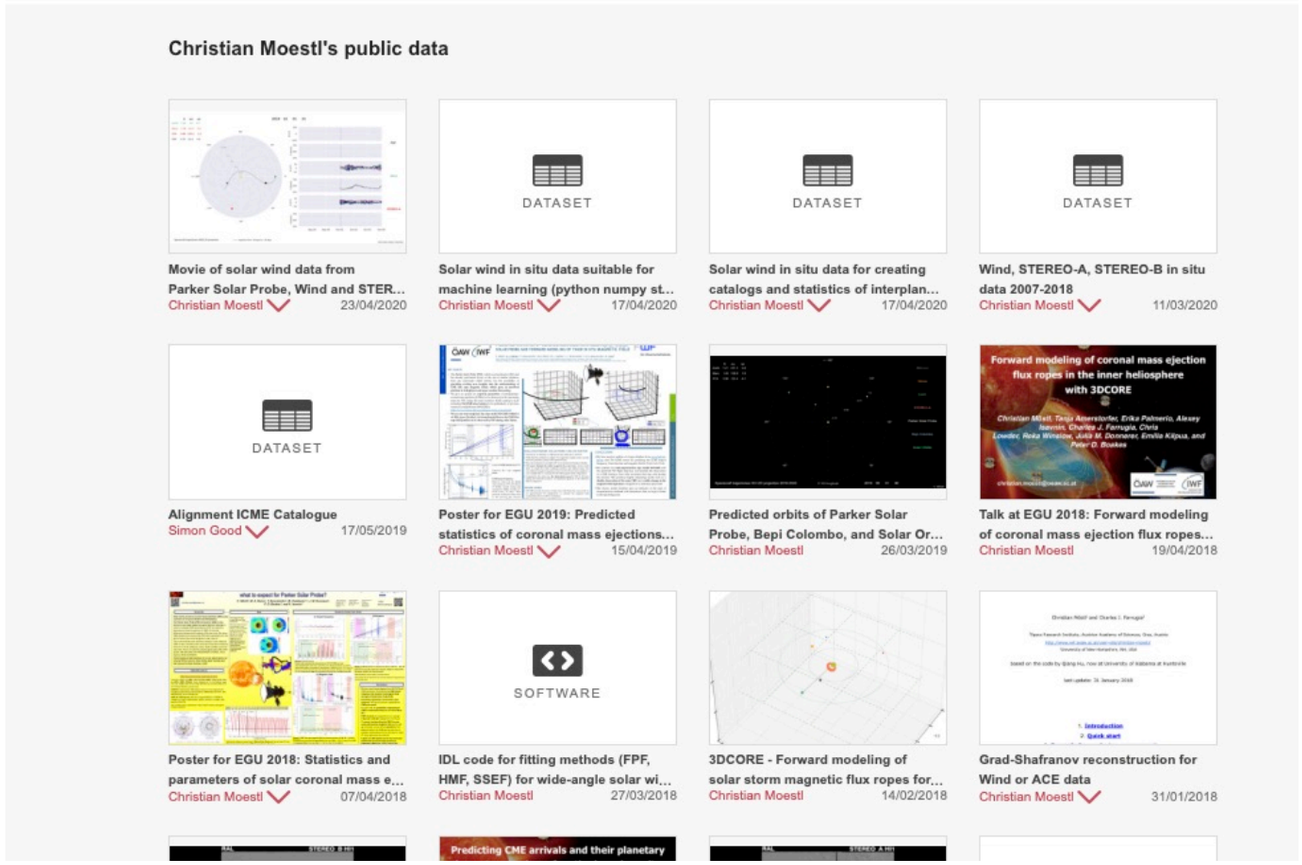
OPEN SCIENCE

All our models will eventually be open source python packages (some are already open), all developed within our group, in order to be as reproducible as possible and to ease collaboration on codes.

Github

https://github.com/helioforecast





Figshare

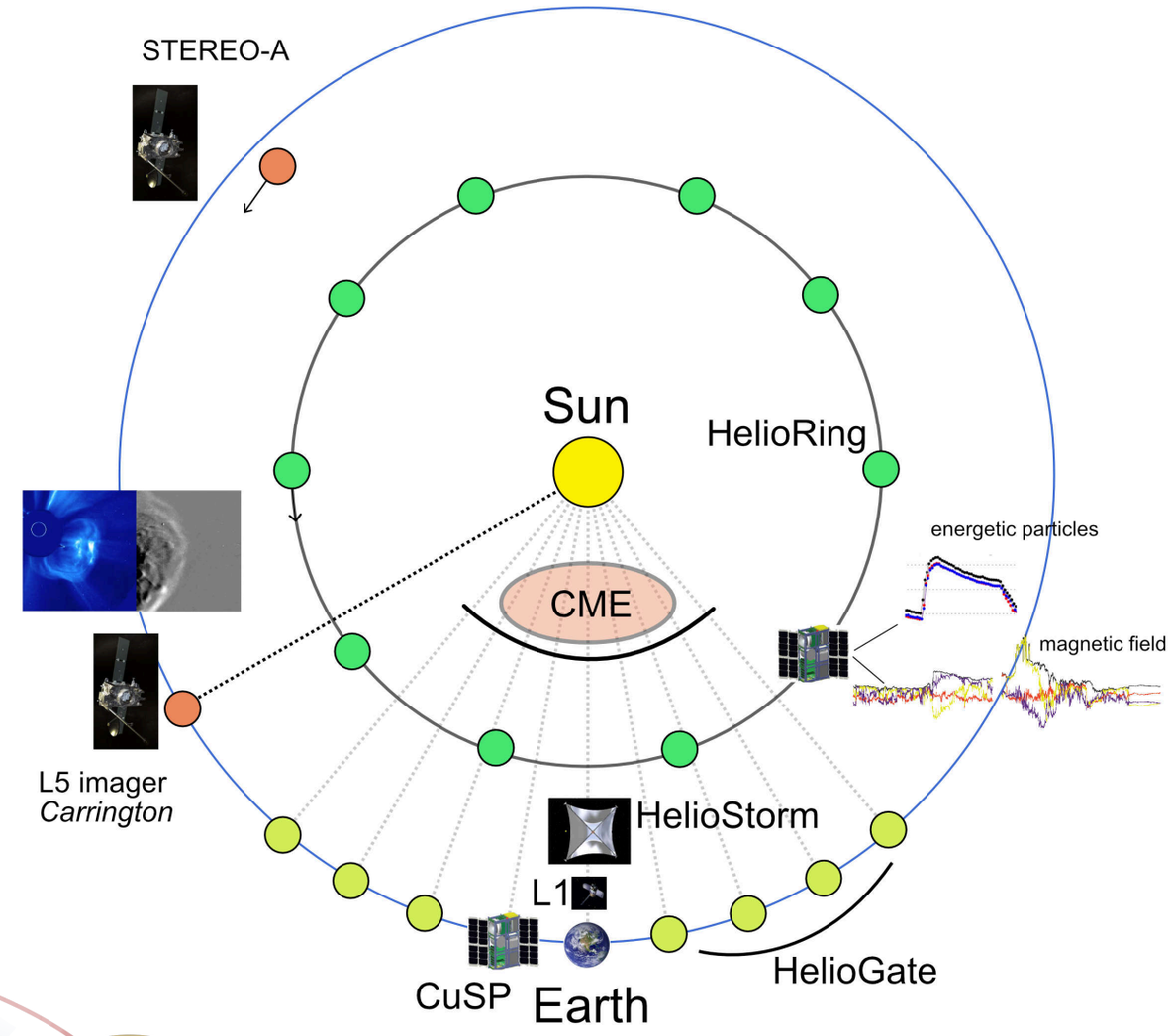
https://figshare.com/authors/Christian_Moestl/3695146

Please get in touch with us (e.g. christian.moestl@oeaw.ac.at) if you want to use these materials for your own work or contribute to our codes.

FUTURE WORK

- Study *Solar Orbiter, Parker Solar Probe, CuSP, BepiColombo* **CME lineups with 3DCORE**
- Real time modeling of the background wind and CME flux ropes optimized with **machine learning**
- Coupling to models of **geomagnetically induced currents**
- Check how different **interplanetary CubeSat** concepts would enhance the predictions
- Lay the groundwork for solar wind prediction based on data from a **mission to the L5 point**

Space Weather interplanetary CubeSat mission concepts



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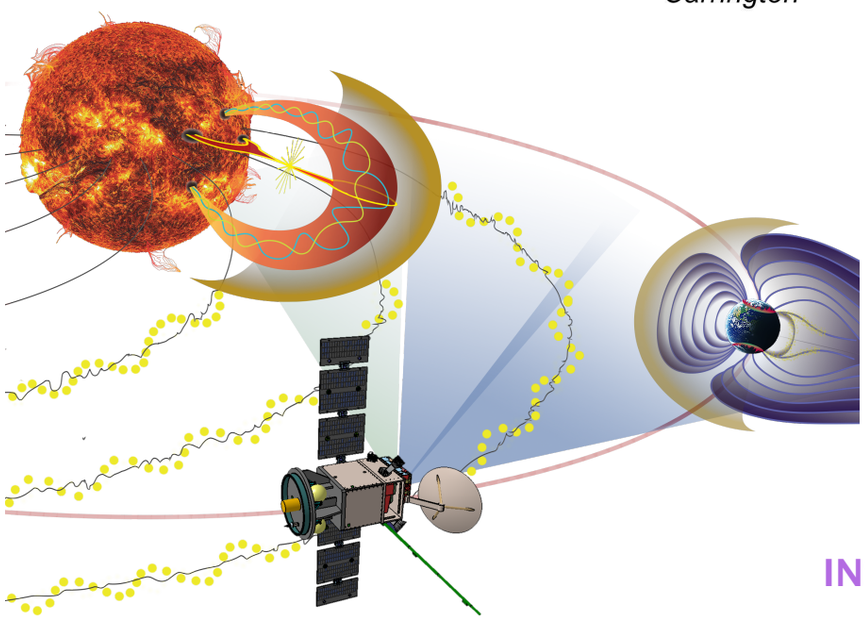

INSTANT: Lavraud, Liu et al. 2016