Real time physics-based solar wind forecasts for SafeSpace

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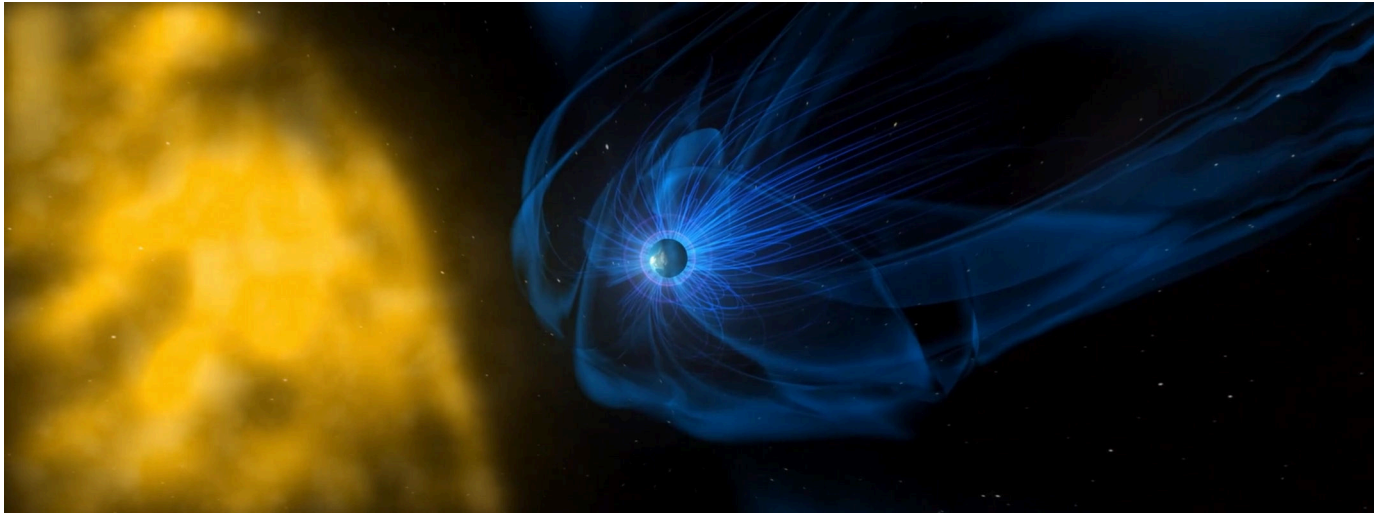


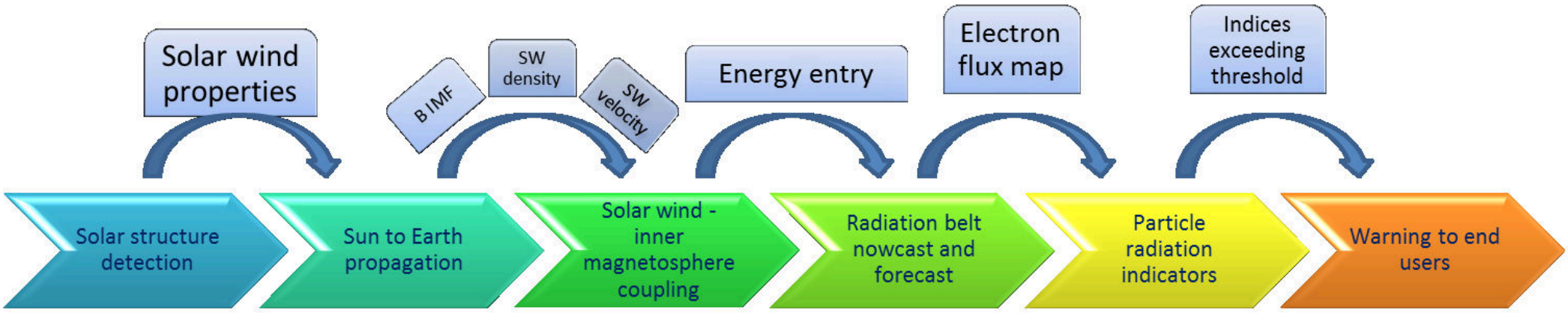
https://www.safespace-h2020.eu/

Radiation Belt Environmental Indicators for the Safety of Space Assets

Space weather nowcasting and forecasting,
full Sun – interplanetary space – Earth's magnetosphere chain

Horizon 2020
European Union Funding
for Research & Innovation

SafeSpace project overview



This presentation: **solar wind model**

- solar wind formation/acceleration (MULTI-VP)
- high time-cadence background wind, SIR/CIR (HSW1D)
- global wind context, CMEs (EUHFORIA)

SWiFT with MULTI-VP data-driven solar wind model

Sun surface magnetograms (SWDB)

WSO

GONG

ADAPT

Coronal field reconstruction (CORFIELD)

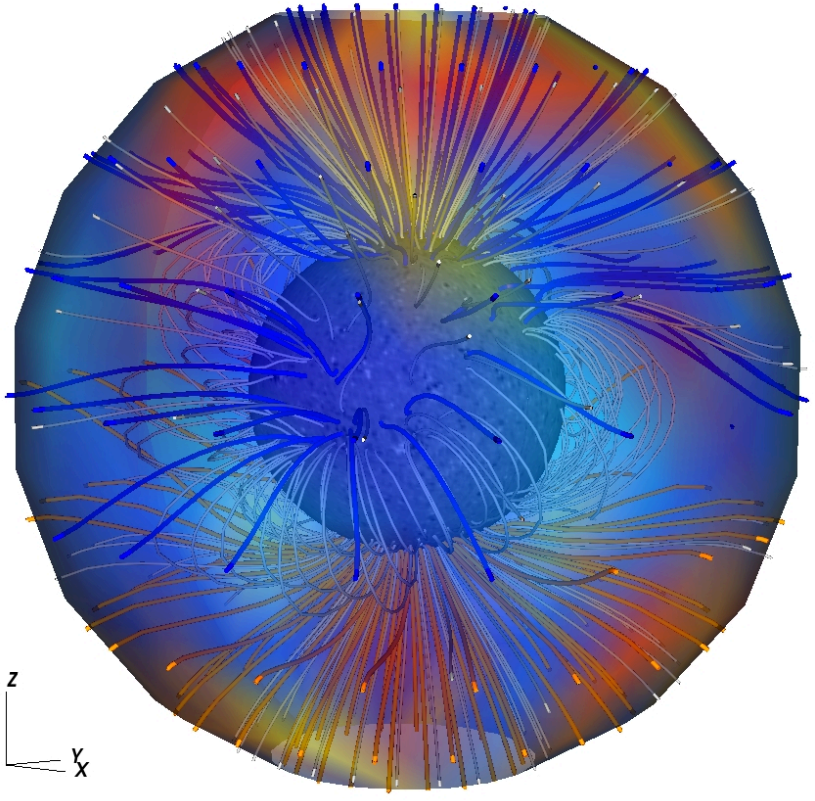
MULTI-VP

EUHFORIA

HSW1D

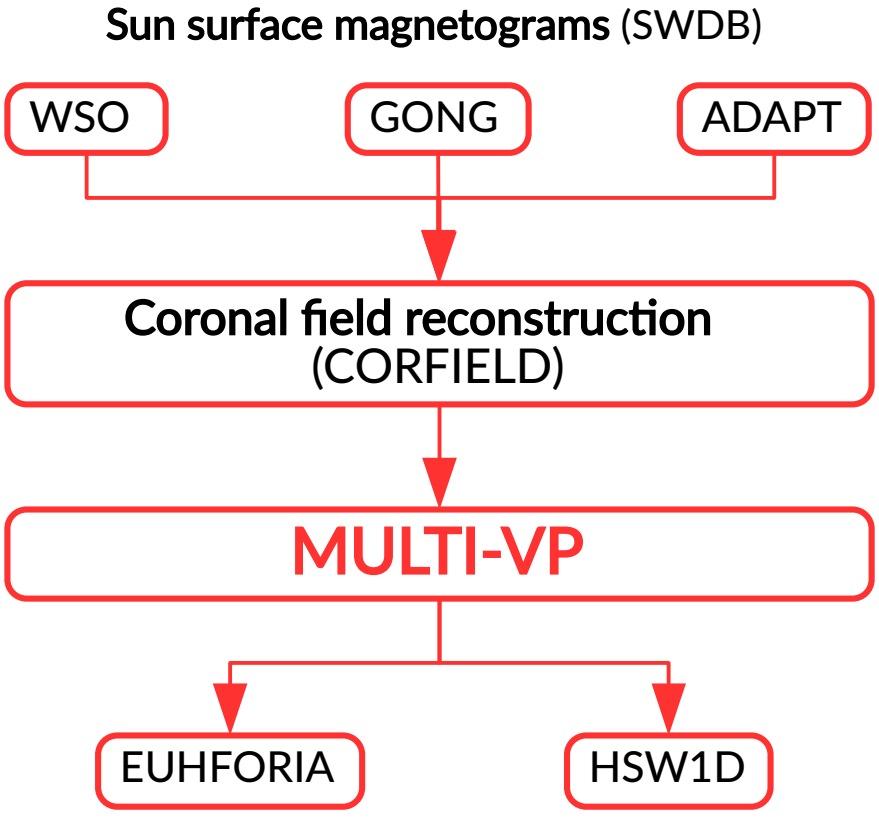
Heliospheric propagation, forecast at Earth

SWiFT framework pipeline



PFSS field lines: positive / negative polarity
Wind speed: 300 / 700 km/s

SWiFT with MULTI-VP data-driven solar wind model



Modules are automated autonomously

Each module:

- polls and outputs database to common database
- follows its own update cycle, spawns its own ensemble members
- has its own cron job
- checks “oldness” of available data, acts accordingly

Benefits

Robustness against data gaps and code crashes

Easier to manage, improve and update

MULTI-VP Data-driven solar wind model

Solar minimum

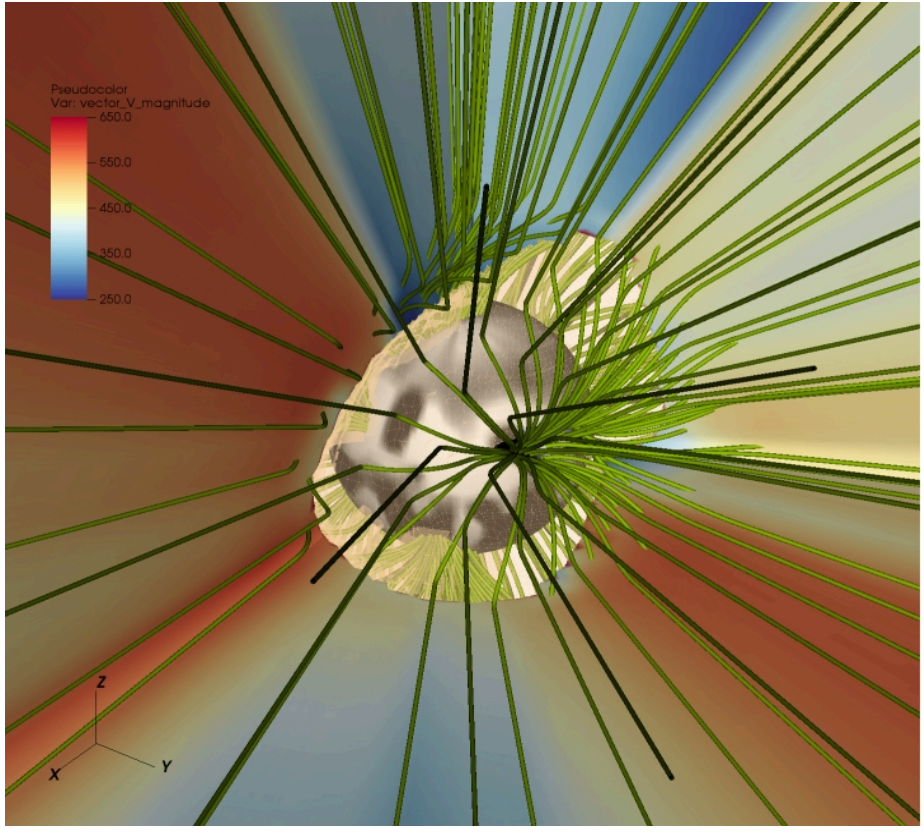
Solar maximum

PFSS magnetic field extrapolations
(but could be PFSS-+SCS, NLFFF, SolarModels, etc)
Open magnetic fieldlines ("coronal holes")
Streamer / coronal hole boundaries

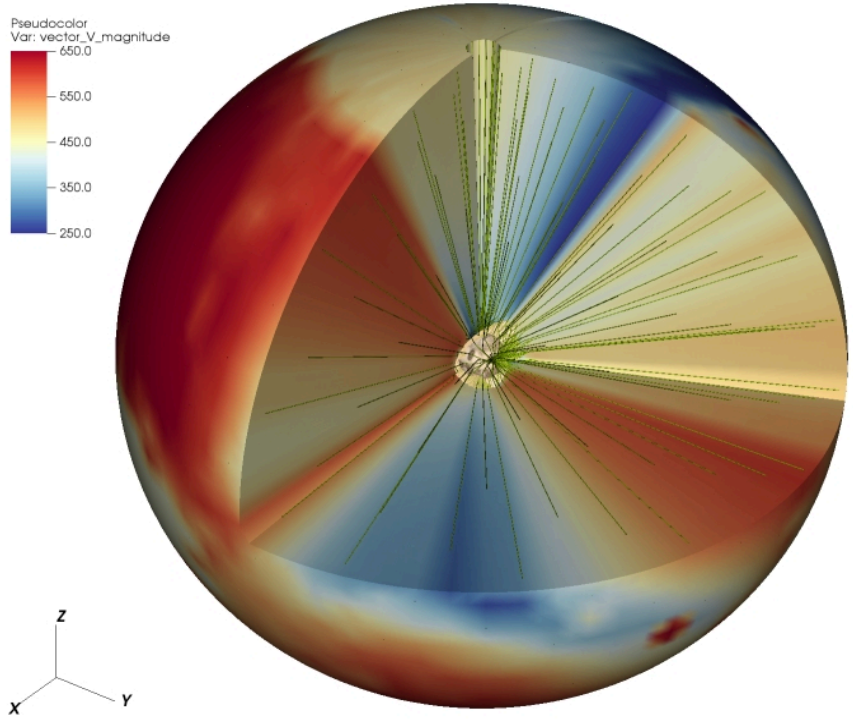
Pinto, Rouillard, ApJ (2017)

MULTI-VP Data-driven solar wind model

Solar wind speed



Low corona (close-up view)



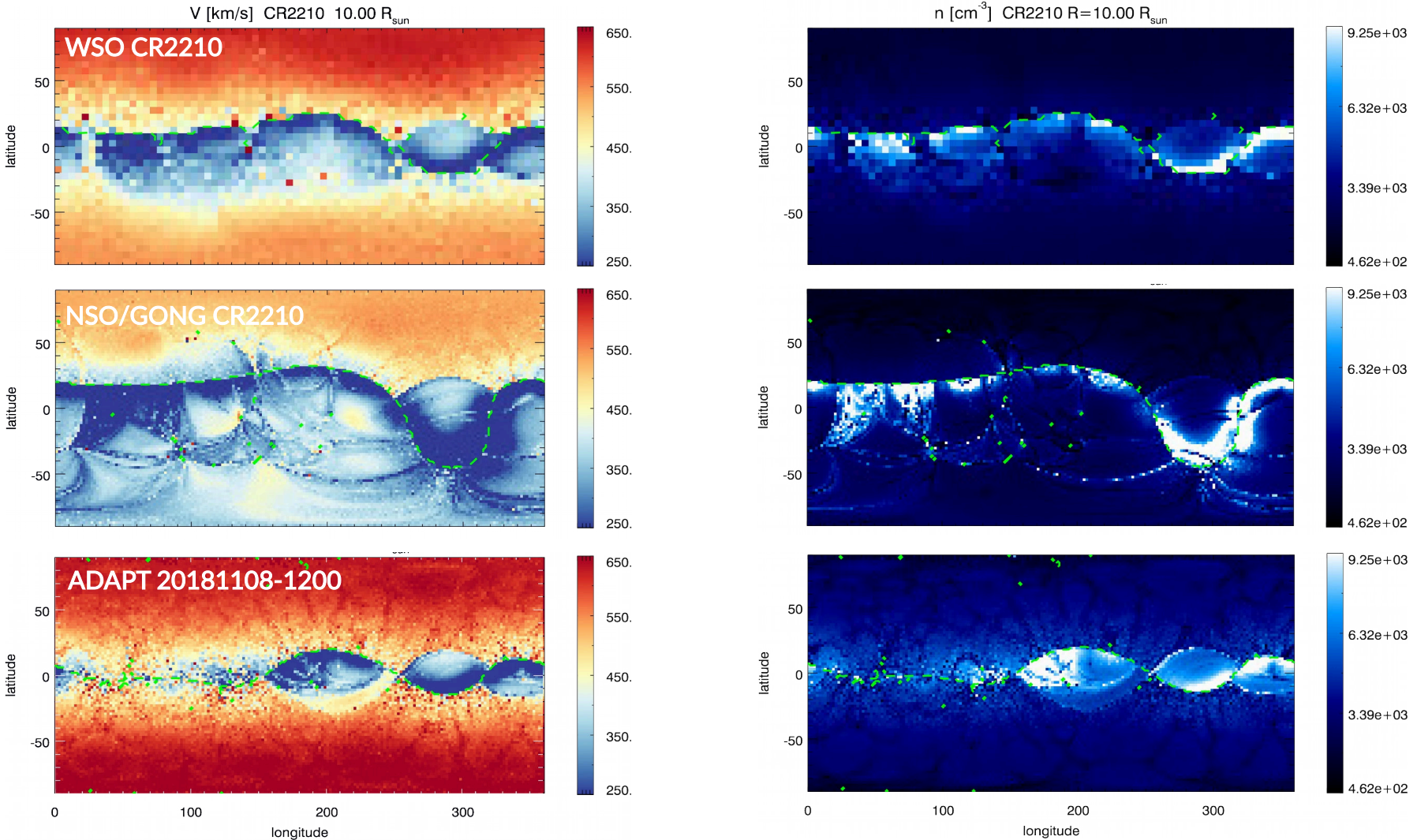
High corona (1 – 15 R_{sun})

Open magnetic fieldlines ("coronal holes")
Streamer / coronal hole boundaries

Fast wind
Slow wind

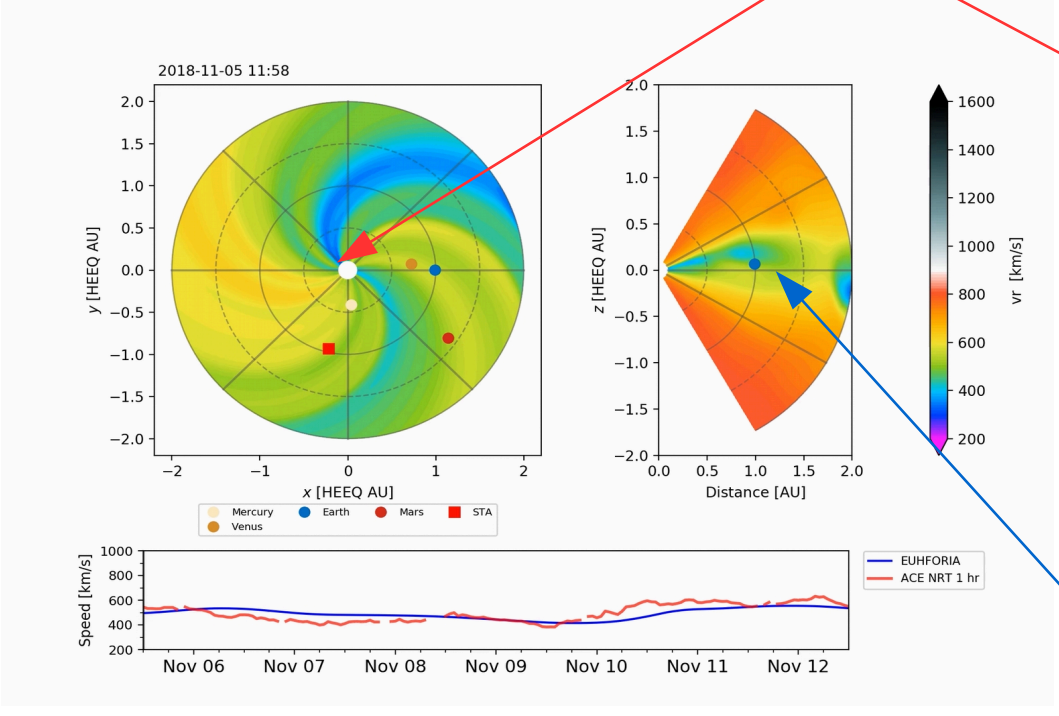
Pinto, Rouillard, ApJ (2017)

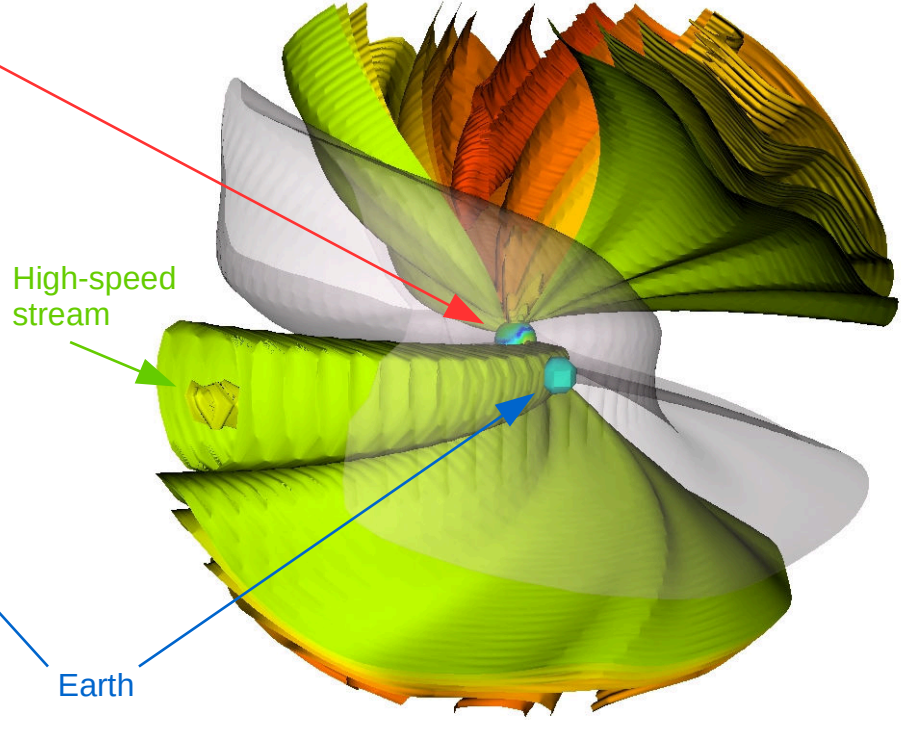
Solar wind maps, different magnetogram sources



Interfacing with EUHFORIA

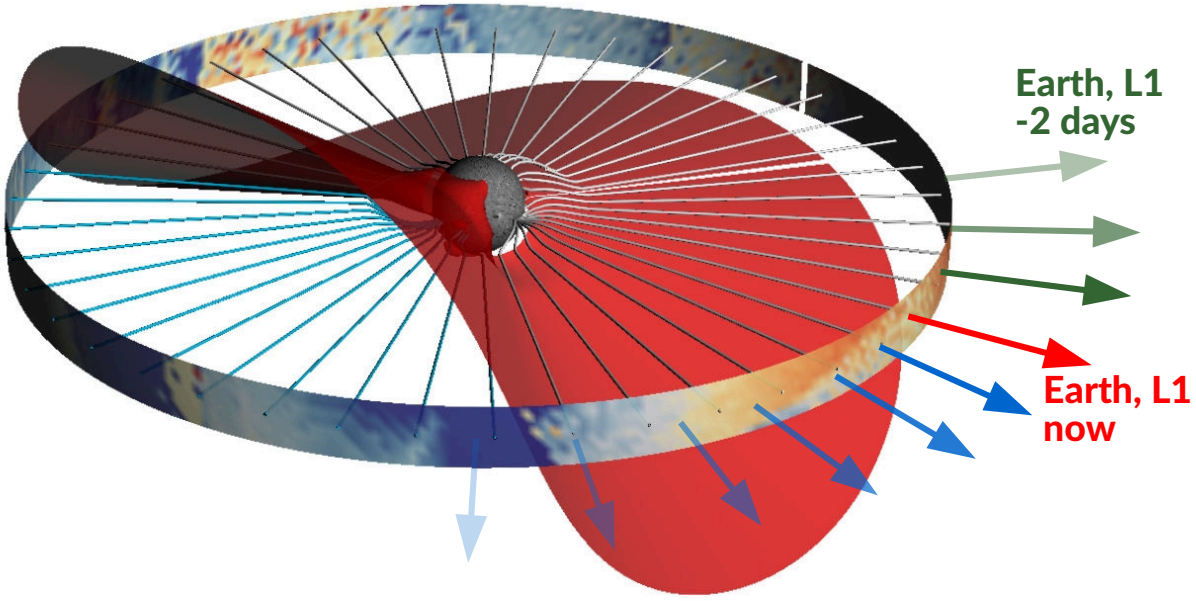
MULTI-VP (2D solar wind map of V, N, T, B at 0.1 AU) → **EUHFORIA (0.1 – 2 AU)**





(cf. ST1.8, Samara et al)

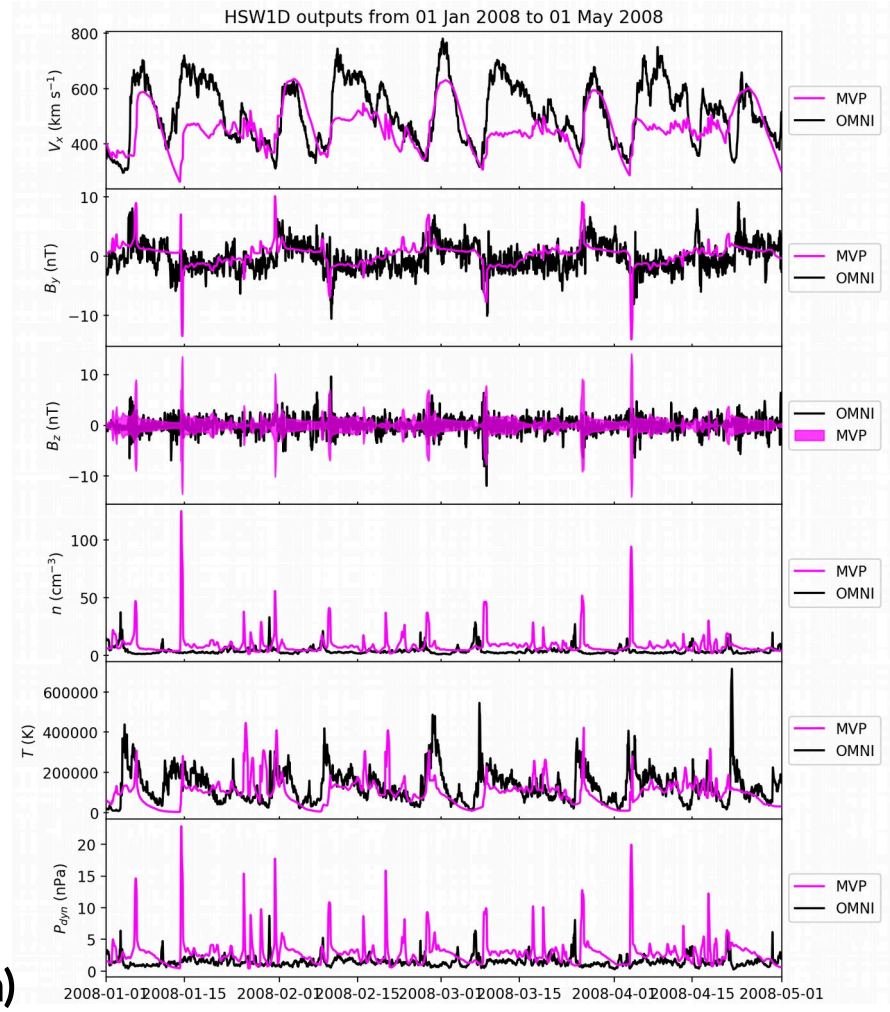
MULTI-VP + HSW1D: continuous solar wind forecasting



MULTI-VP (V, N, T, B time-series at 30 R_{sun})

↓

HSW1D (output time-series at L1, Earth)



Conclusions

Implementation of the solar wind forecating model for SafeSpace

- **taking advantage of SWiFT modelling framework at IRAP**
  deals with multiple and non-uniform input data,
  provides a robust modeling environment

- **MULTI-VP wind model produces two data products / interfaces**
  . ”point data” → time-series used to drive **HSW1D** (1D propagation paths)
  . 2D solar wind maps → drive the background solar wind on **EUHFORIA**

- **ensemble modeling**
  ensembles built from:
  . magnetogram forecast ensembles
  . heuristic mapping of positional uncertainties (global magnetic field)

- **forecasts run daily**
  . time-cadence for EUHFORIA updates: 1 day
  . time-series: daily updated forecast, but intrinsic time-sampling is hourly
  forecast lead time set initially to ~3-5 days