

# Real time physics-based solar wind forecasts for SafeSpace



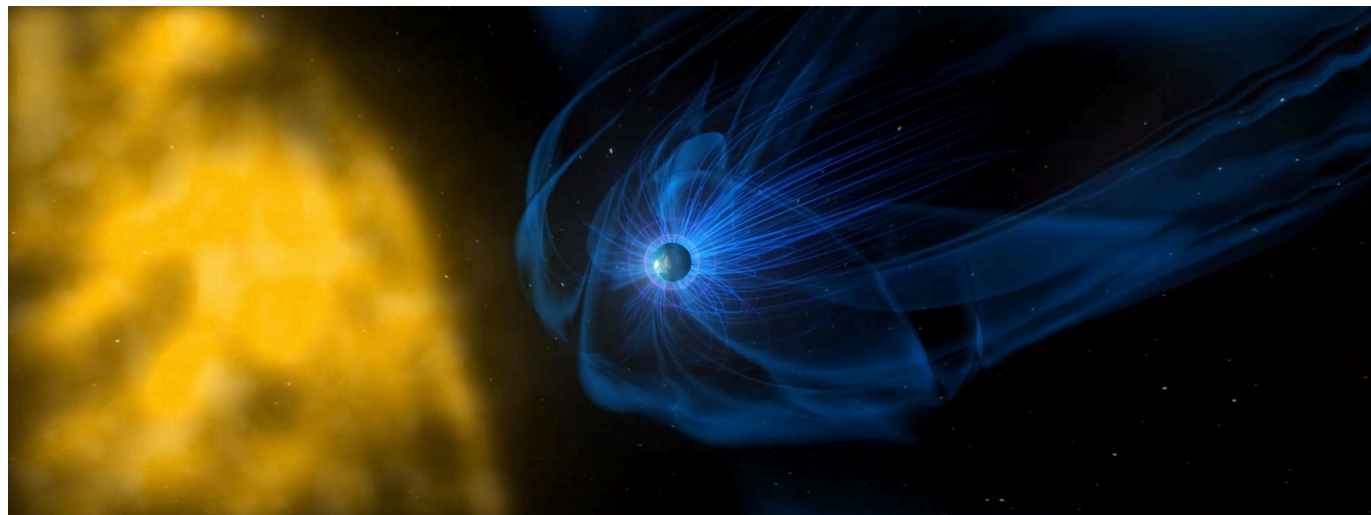
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Radiation Belt Environmental Indicators for the Safety of Space Assets

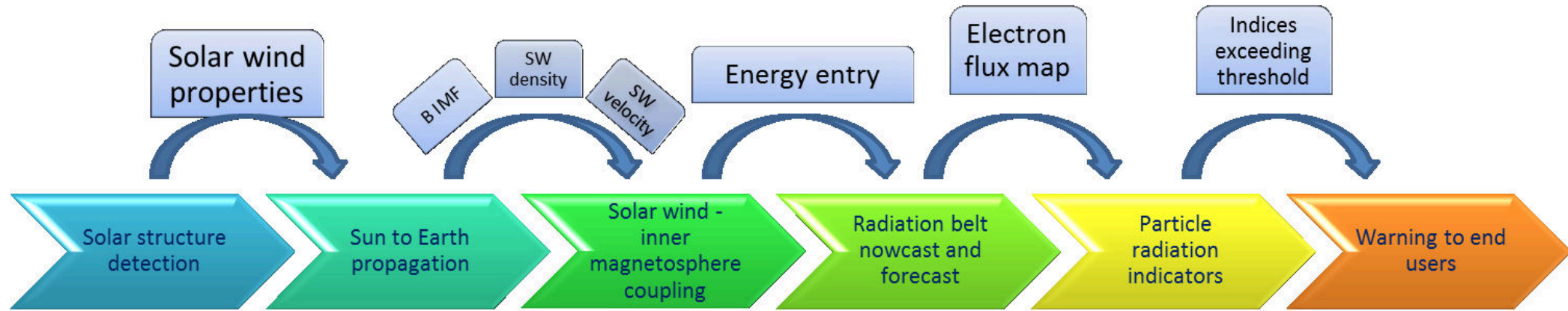
Space weather nowcasting and forecasting,  
full Sun – interplanetary space – Earth's magnetosphere chain

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



Horizon 2020  
European Union Funding  
for Research & Innovation

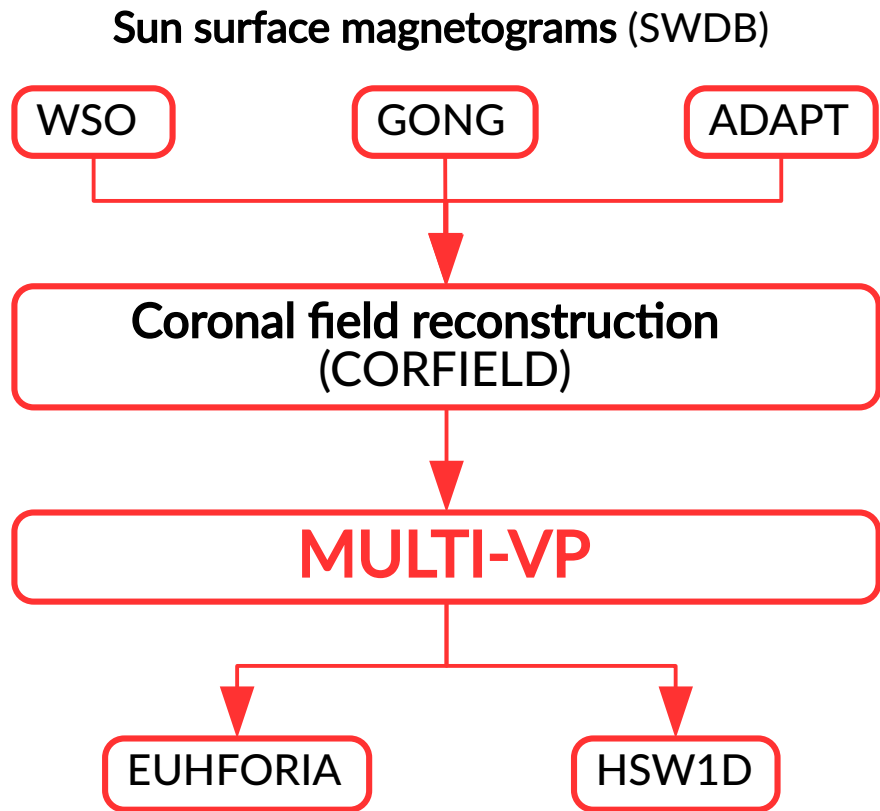




→ This presentation: **solar wind model**

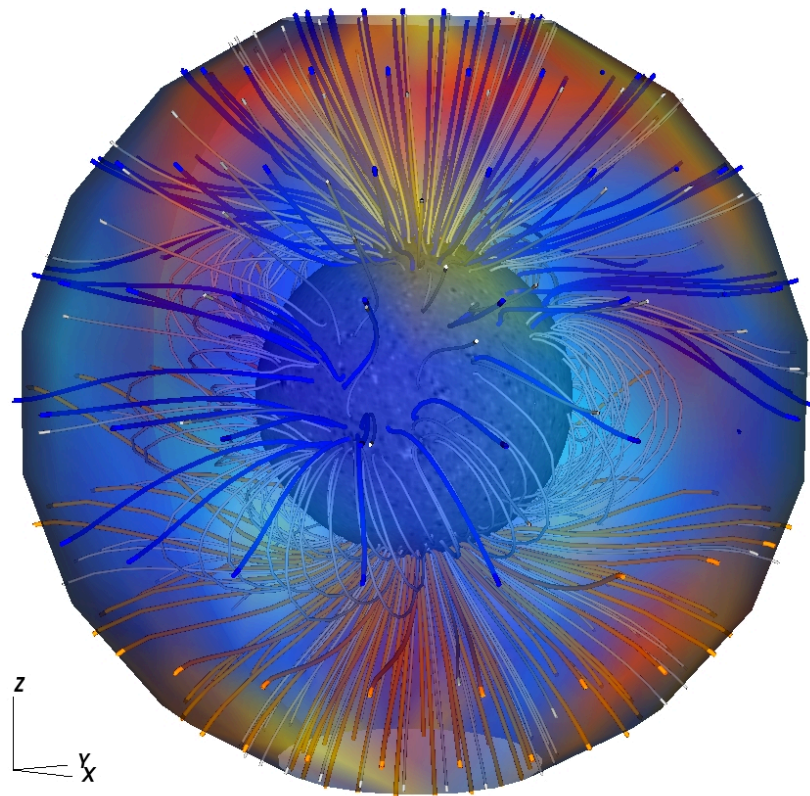
- solar wind formation/acceleration (MULTI-VP)
- high time-cadence background wind, SIR/CIR (HSW1D)
- global wind context, CMEs (EUHFORIA)

# SWiFT with MULTI-VP data-driven solar wind model

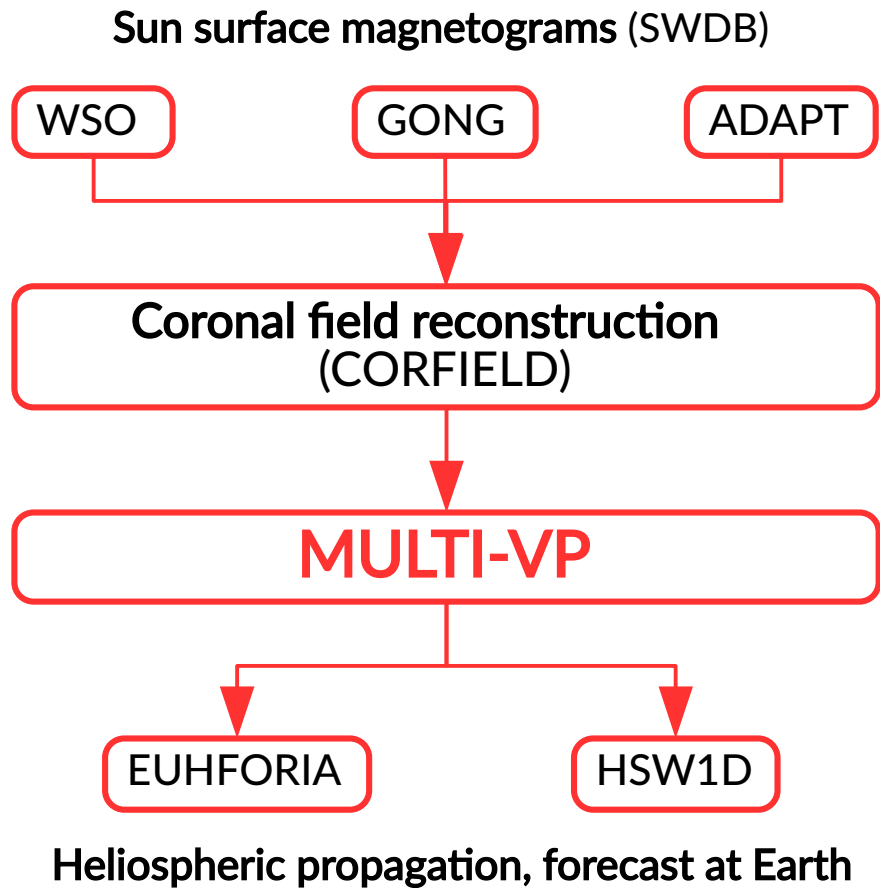


Heliospheric propagation, forecast at Earth

SWiFT framework pipeline



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



## 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



Solar minimum



Solar maximum



PFSS magnetic field extrapolations

(but could be PFSS+SCS, NLFFF, SolarModels, etc)

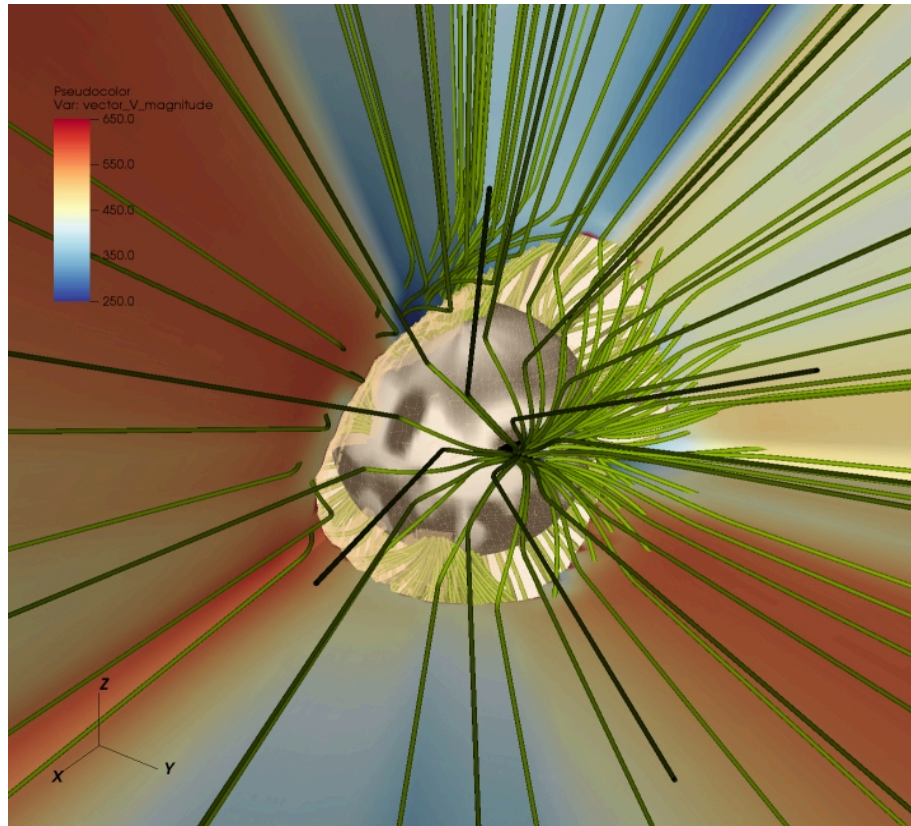
Open magnetic fieldlines ("coronal holes")

Streamer / coronal hole boundaries

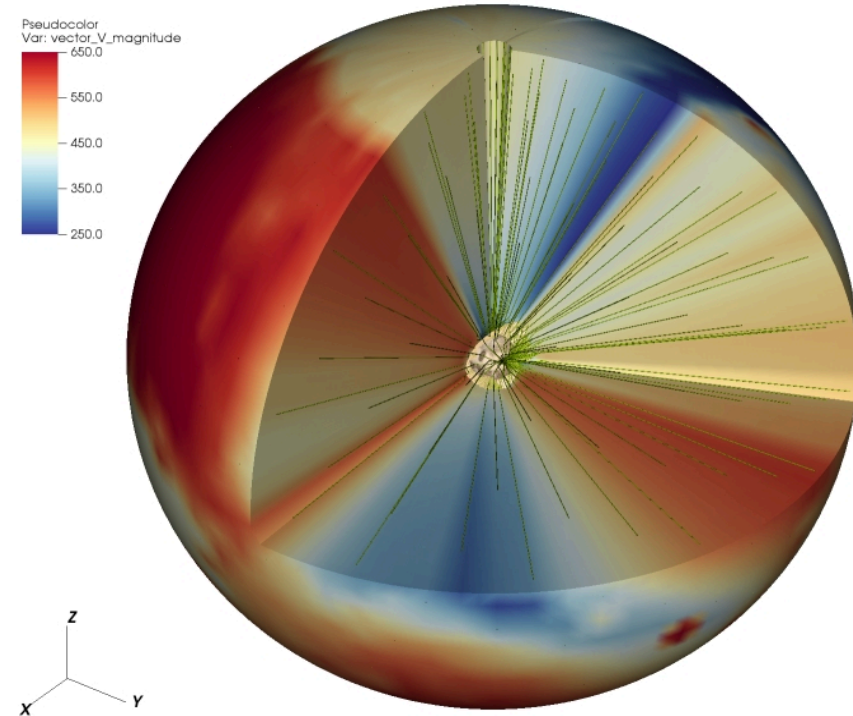


# MULTI-VP Data-driven solar wind model

## Solar wind speed



Low corona (close-up view)

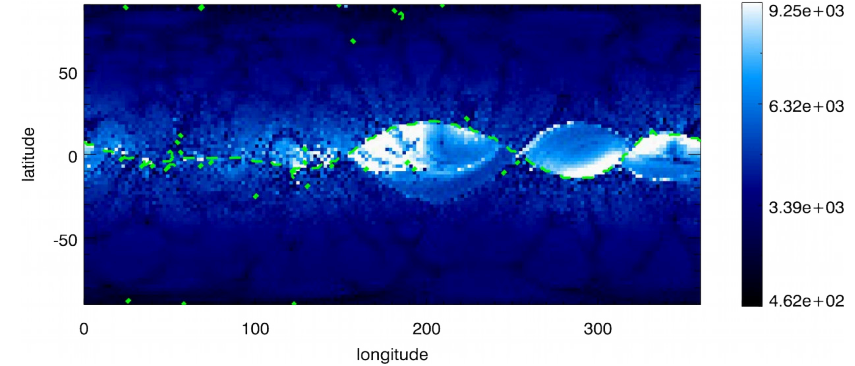
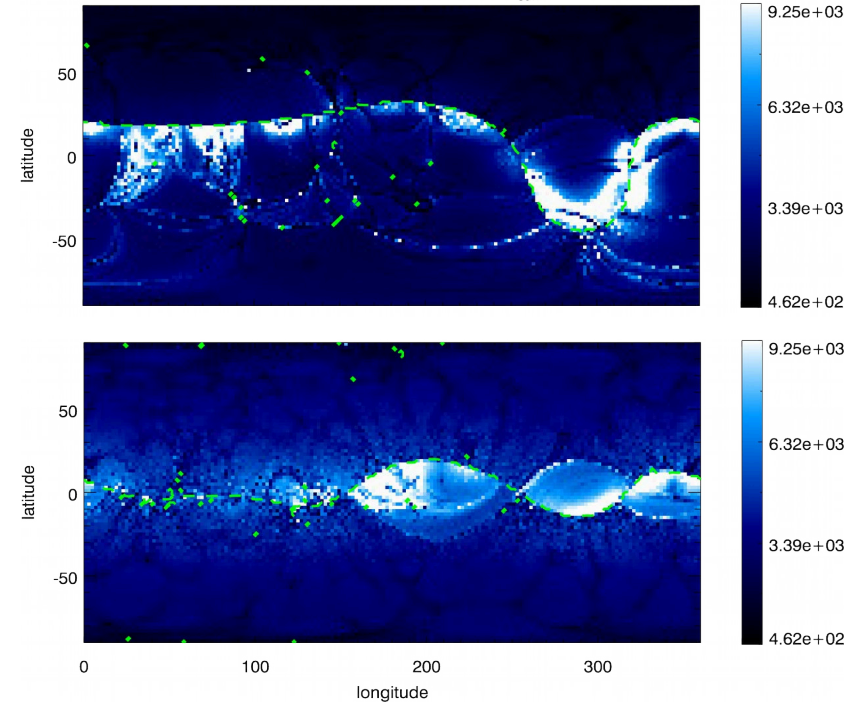
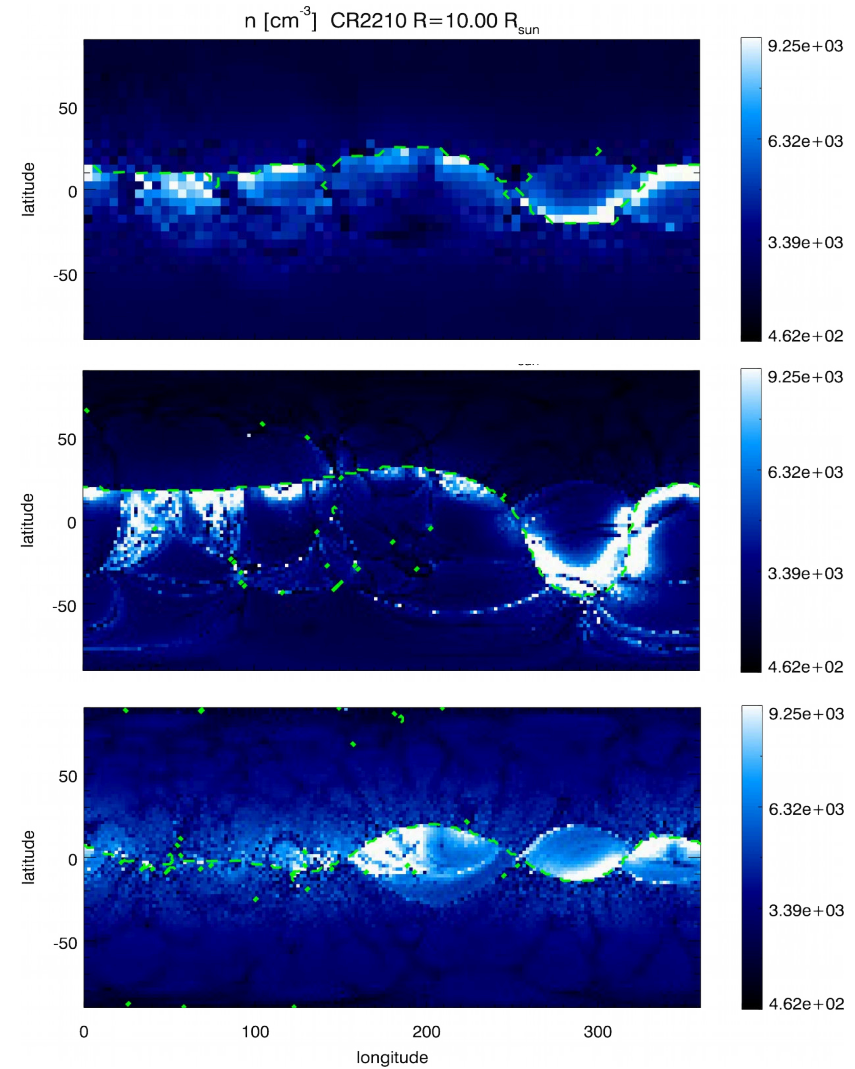
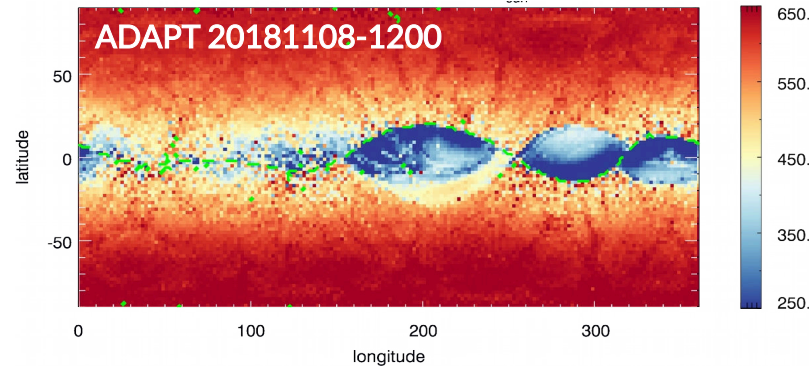
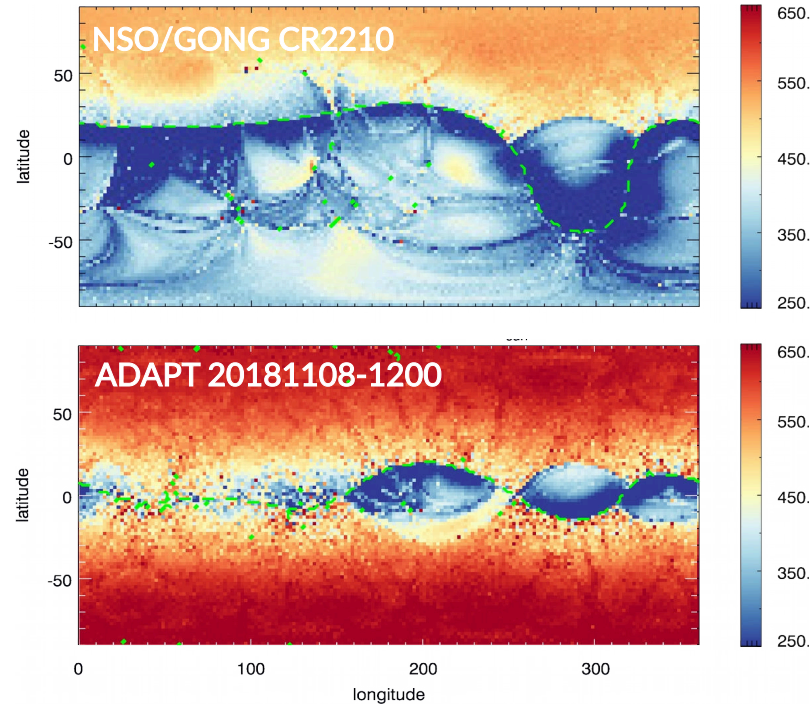
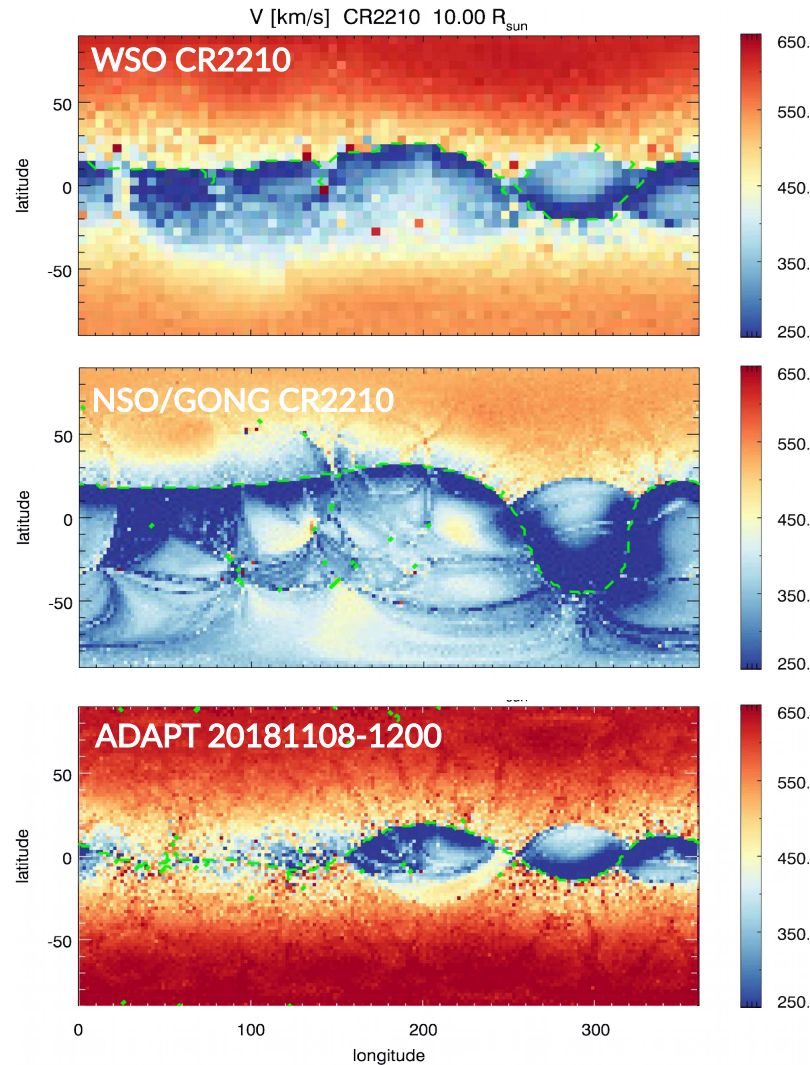


High corona (1 - 15  $R_{\text{sun}}$ )

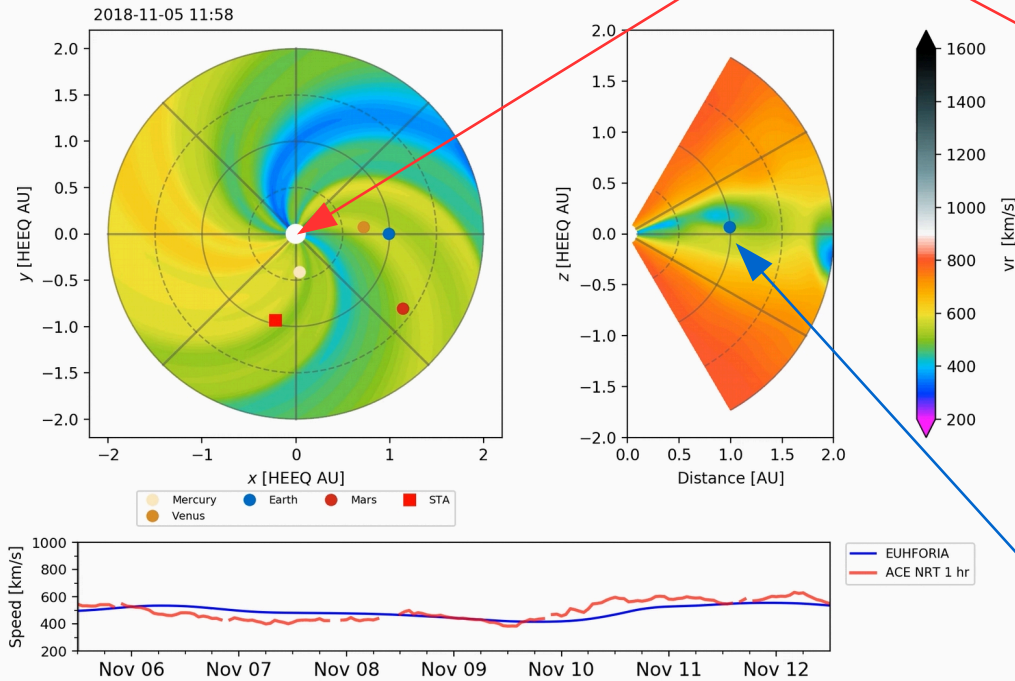
Open magnetic fieldlines ("coronal holes")  
Streamer / coronal hole boundaries

Fast wind  
Slow wind

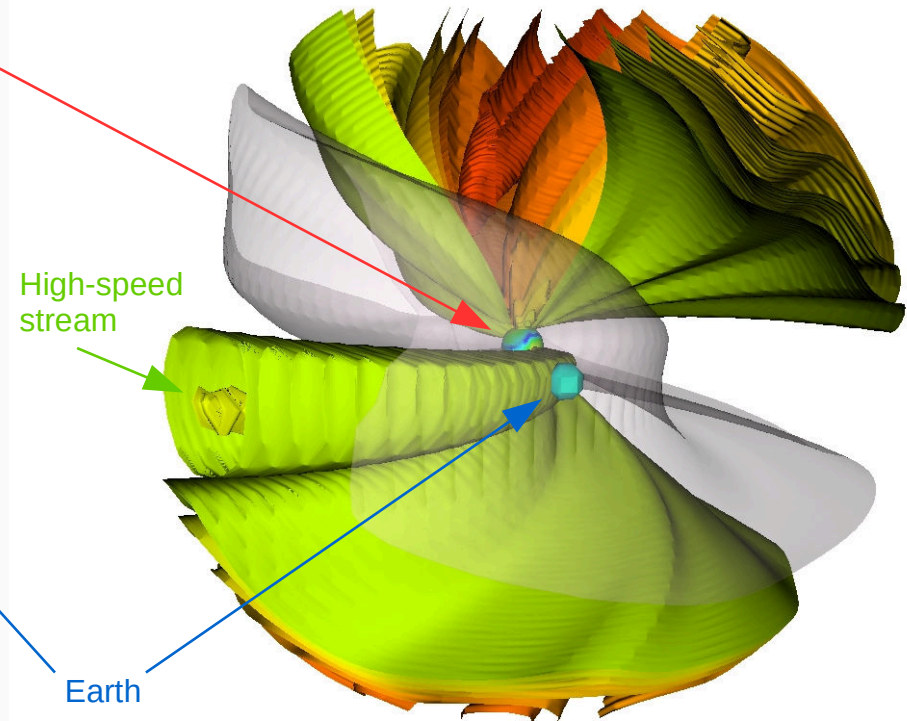
# Solar wind maps, different magnetogram sources



## MULTI-VP (2D solar wind map of V, N, T, B at 0.1 AU)

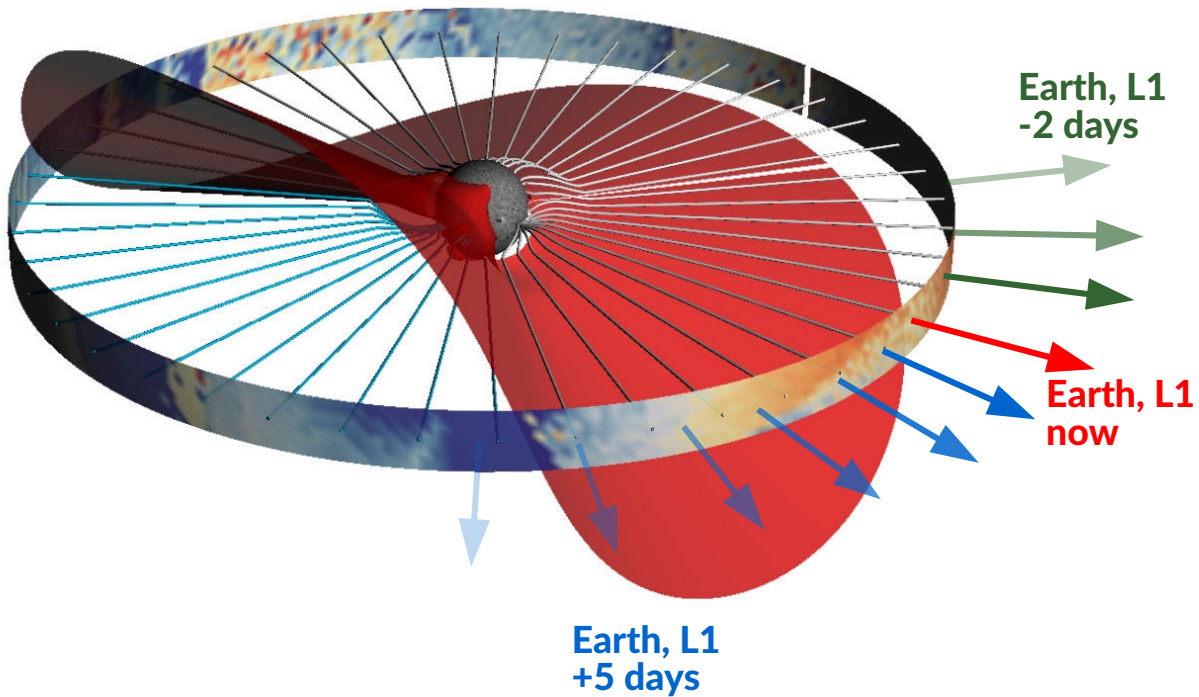


## EUHFORIA (0.1 - 2 AU)





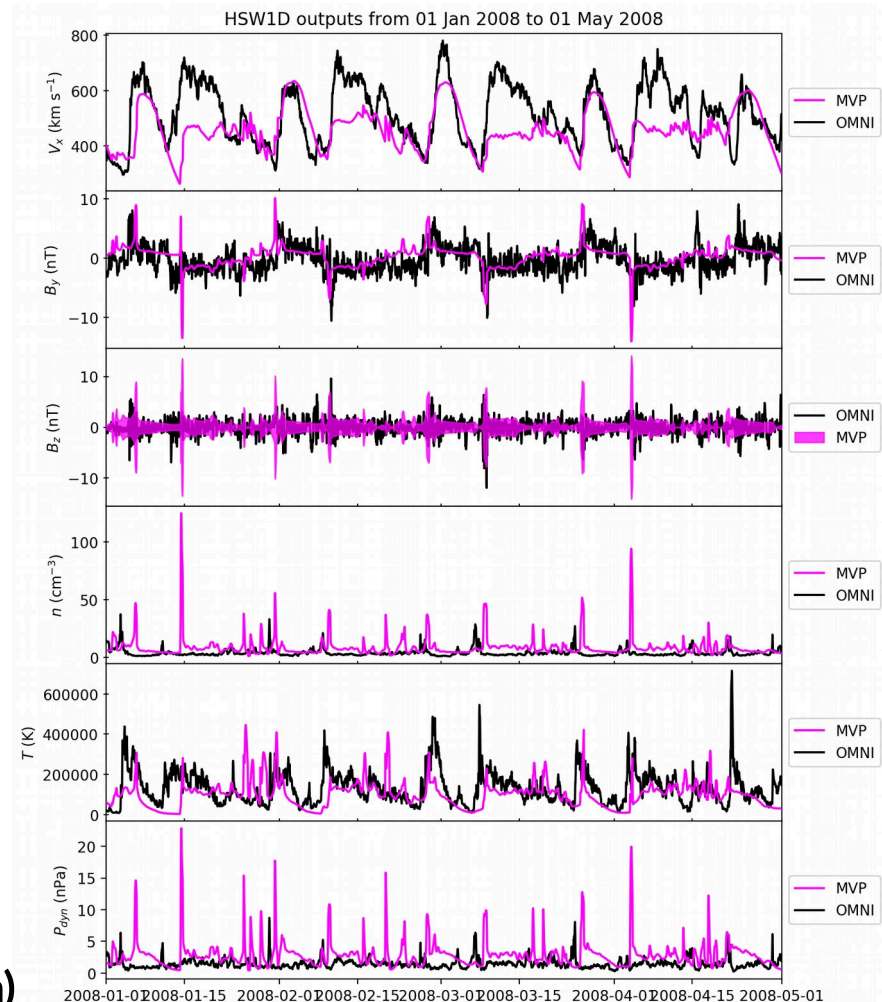
# MULTI-VP + HSW1D: continuous solar wind forecasting



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



HSW1D (output time-series at L1, Earth)



## Implementation of the solar wind forecasting 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