Real time physics-based solar wind forecasts for SafeSpace

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SafeSpace

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
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

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

SWiFT framework pipeline
SWiFT with MULTI-VP data-driven solar wind model

Sun surface magnetograms (SWDB)

WSO \rightarrow GONG \rightarrow ADAPT

Coronal field reconstruction (CORFIELD)

MULTI-VP

EUHFORIA \rightarrow HSW1D

Heliospheric propagation, forecast at Earth

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
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
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 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