Heliospheric Modeling Opportunities at the Community Coordinated Modeling Center
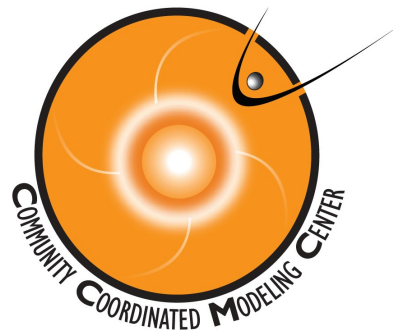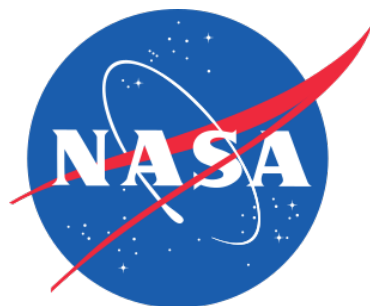
M. Leila Mays, Peter MacNeice, Aleksandre Taktakishvili (NASA GSFC)

CCMC Deputy Director

m.leila.mays@nasa.gov

15 September 2021

Whole Heliosphere and Planetary Interactions Workshop

Models at CCMC

Corona

SWMF.SC+EEGGL+CME
AWSoM   EEGGL   SRPM
PFSS.Petrie   ANMHD
PFSS.Macneice
PFSS.Luhmann
MAG4   UMASEP
ASAP   ASSA   AMOS
WSA   NLFFF
MAGIC   SNB3GEO
GCR   BON   NOVICE
NAIRAS   CARI-7

Heliosphere

WSA-ENLIL
WSA-ENLIL+Cone
WSA-ENLIL+EPREM
WSA-ENLIL+SEPMOD
REleASE
PREDICCS
EMMREM
iPATH
EXO Solar Wind
CORHEL
Heltomo SMEI
Heltomo IPS
BRYNTRN
DBM
SWMF.SH
DIPS

Magnetosphere

LFM-TING   GUMICS
LFM-MIX   GIC
OpenGGCM+CTIM
SWMF+RCM+deltaB
SWMF+RCM
SWMF+RCM+RBE
SWMF+RCM+CRCM
LFM-MIX-TIEGCM
WINDMI   LANLstar
IGRF   Tsyganenko
PS VP   Weigel-deltaB
AACGM   Apex
AMPS

Local Physics

VPIC
PAMHD
PIC-Hesse

Inner Magnetosphere

RCM
Fok.CIMI
Fok.RBE
UPOS RB
AE-8/AP-8
AE-9/AP-9
VERB

Ionosphere/ Thermosphere

TIE-GCM   SAMI-3
GMAT   SAM
CTIPe   IDA4D
USU-GAIM
SWACI-TEC
ABBYNormal
NRLMSISE
GITM
PBMOD
TRIPL-DA
Weimer IE
Weimer-deltaB
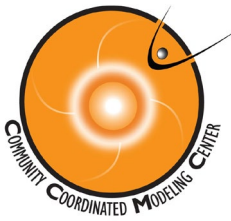IRI   JB2008
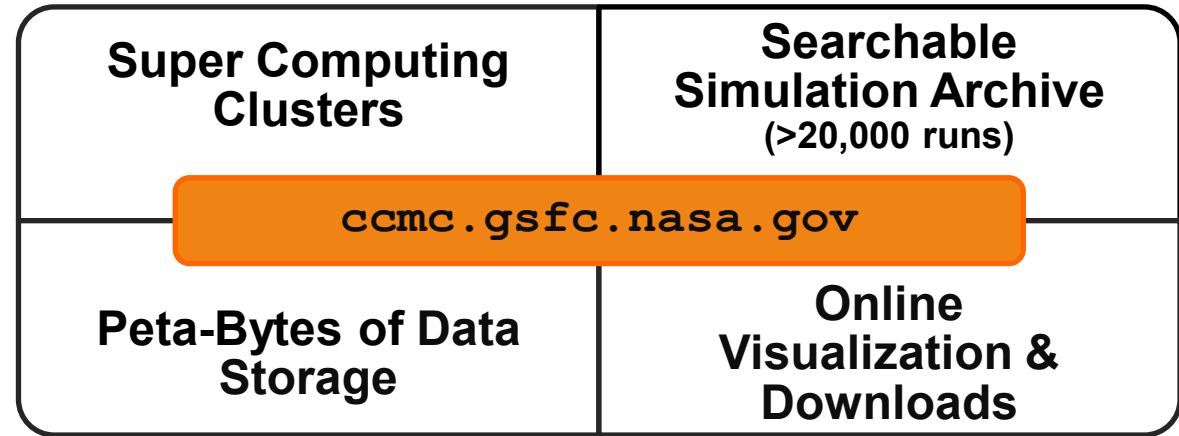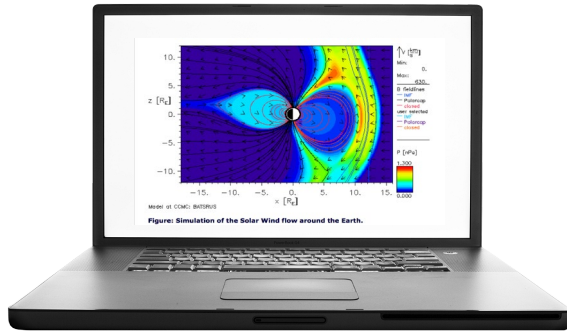IMPACT   DTM
COSGROVE-PF
Ovation Prime

CCMC Simulation Services: Runs-on-Request

REQUESTS

RESULTS

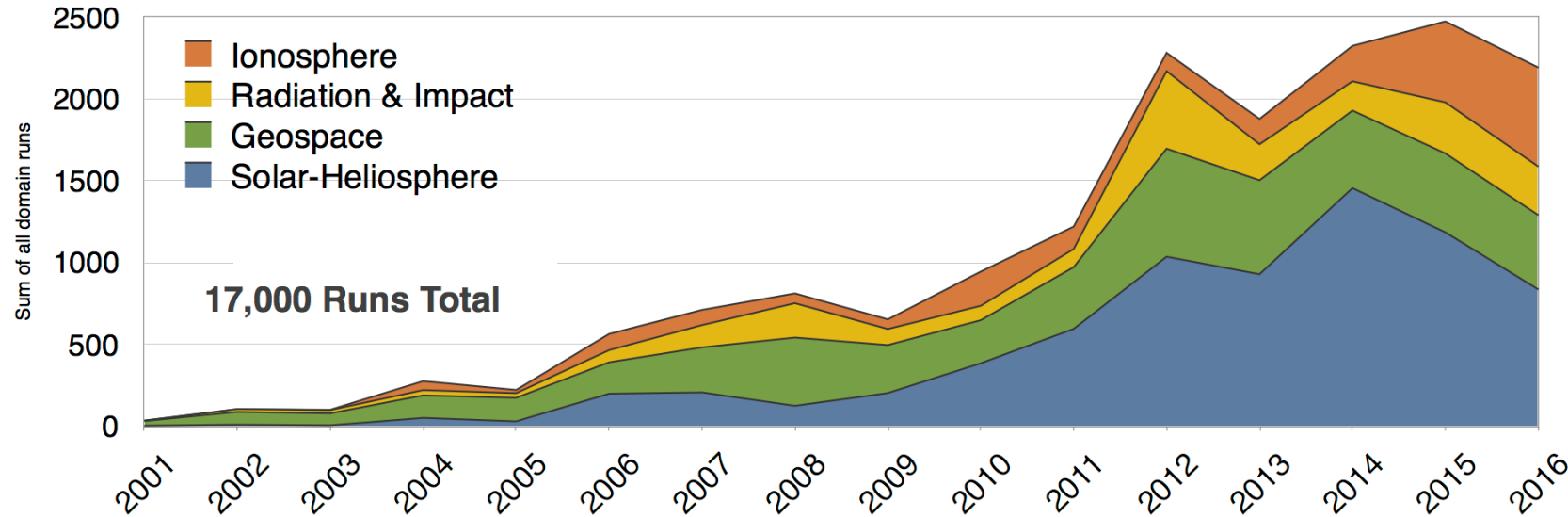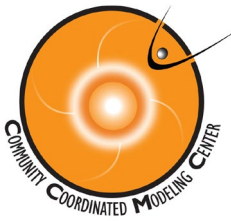| Super Computing Clusters	Searchable Simulation Archive (>20,000 runs)
ccmc.gsfc.nasa.gov	
Peta-Bytes of Data Storage	Online Visualization & Downloads

- Advances the community's scientific research

- Mission science/planning support

- Model validation in a research setting

- Model delivery point

Model Runs Per Year by Domain

- Ionosphere
- Radiation & Impact
- Geospace
- Solar-Heliosphere

**17,000 Runs Total**

Sum of all domain runs

CCMC Simulation Services: Continuous Real Time Runs

- CCMC hosts ~100 models, 20 of which are also running in real time, including experimental model chains

- CCMC approach to finding model forecasting value: highlight the forecast possibilities while keeping in mind the model limitations. Experiment.

- Real time model outputs are available via iSWA displays and streaming

Goals include:

- Validation in a real time setting

- Demonstration of operational potential and facilitate entry to R2O pipeline

- Mission science campaign support

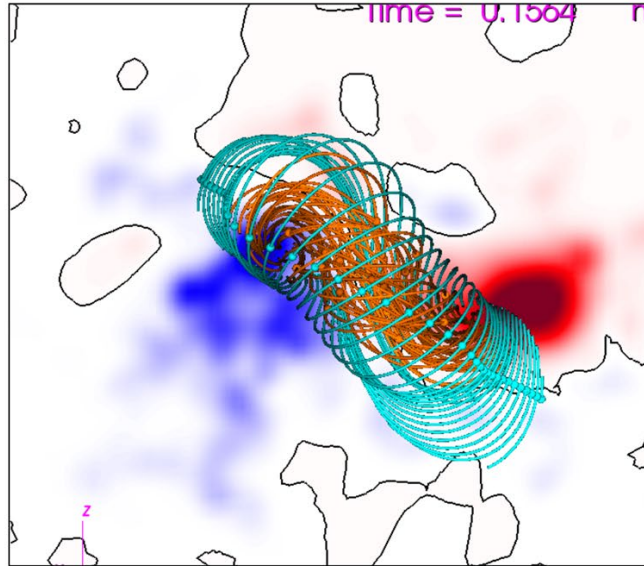- Feedback for the model developer on long term model performance

https://iswa.ccmc.gsfc.nasa.gov
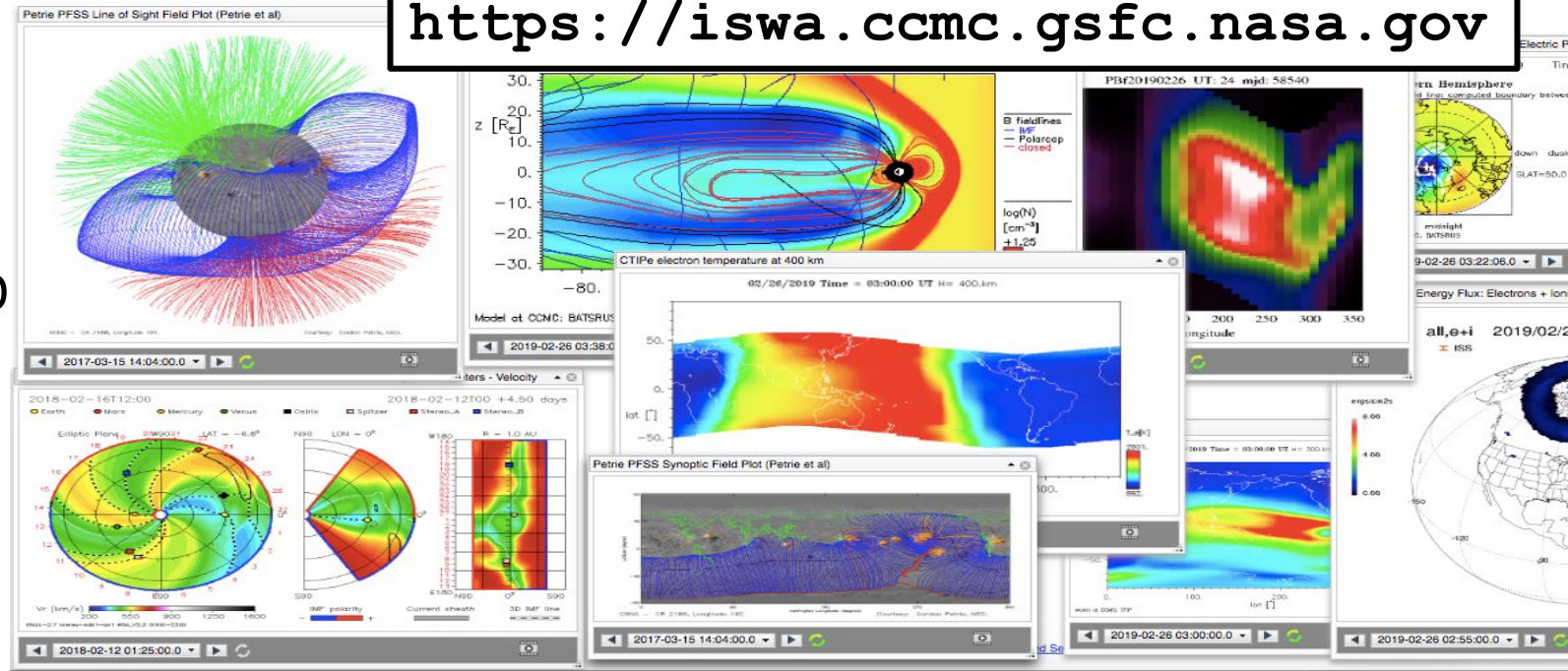
CORHEL/MAS-TDm (Predictive Science Inc.)
## An Interface for Modeling Stable and Unstable Flux Ropes in Realistic Solar Magnetic Fields
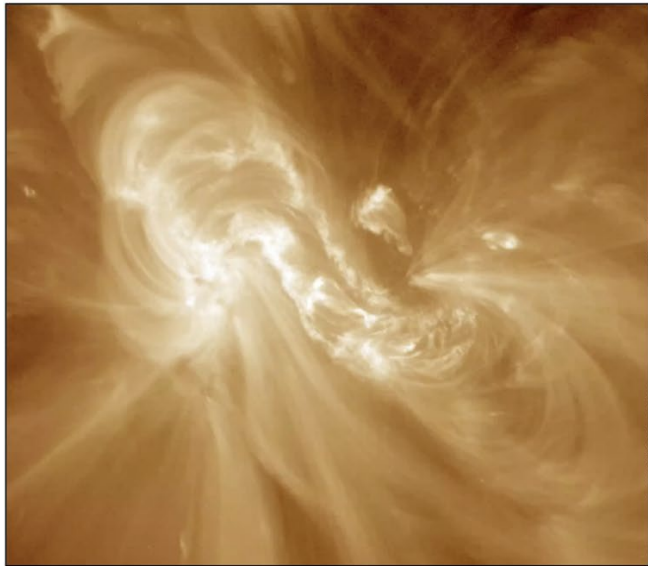

SDO AIA 193 (from jHelioviewer)

TDm Top Down view

- Inserts user designed Titov-Demoulin (TDm) flux rope into observed active region field

- Output drives MAS MHD model of flux rope evolution to simulate CME eruption

- TDm Flux Rope Designer web interface available via CCMC runs on request website

- MHD evolution runs executed locally or on Pleiades

https://ccmc.gsfc.nasa.gov/models/modelinfo.php?model=CORHEL/MAS-TDM
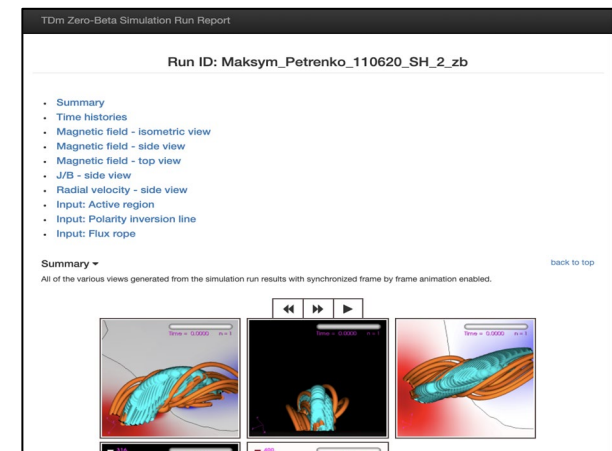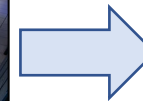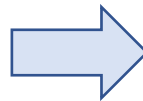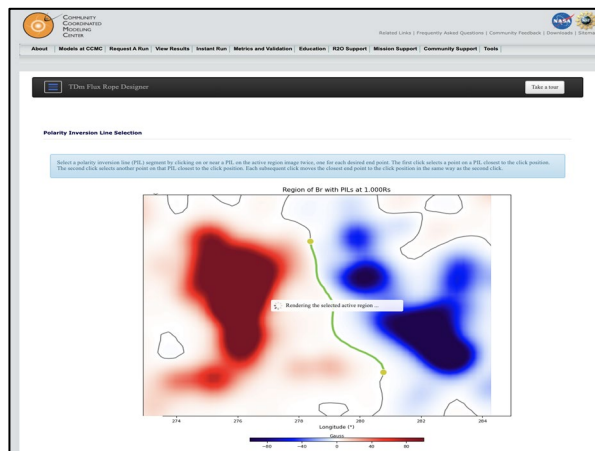
SWMF AWSoM Model of CME Magnetic Structure and Evolution
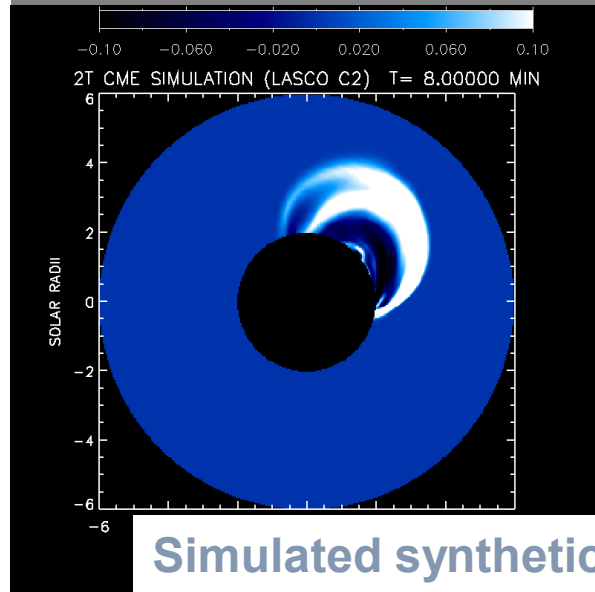

StereoCAT CME Analysis Tool

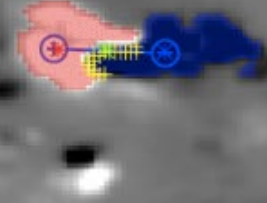**EEGGL Eruption Event Generator by Gibson & Low**

SWMF AWSoM-R

Global MHD simulations of CME plasma and magnetic structure eruption and propagation through space
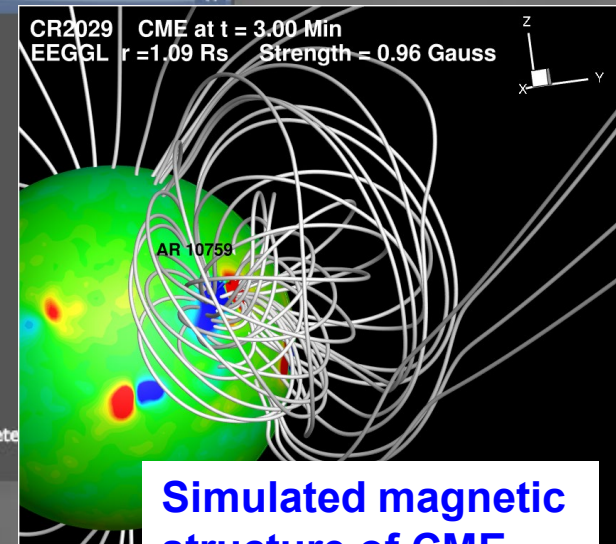
NSO/GONG Magnetogram - processed for SWMF input

2T CME SIMULATION (LASCO C2)   T= 8.00000 MIN

Recommended Parameters

GL Flux Rope Parameters
Longitude: 130.50°
Latitude: 14.50°
Orientation: 358.72°
Radius[Rs]:   1.58
Bstrength[Gs]:   -0.02

Grid Refinement Parameters
R_Start[Rs]:   1.15
Longitude_Start: 67.30°
Latitude_Start: -17.10°
R_End[Rs]:   22.00
Longitude_End: 193.70°
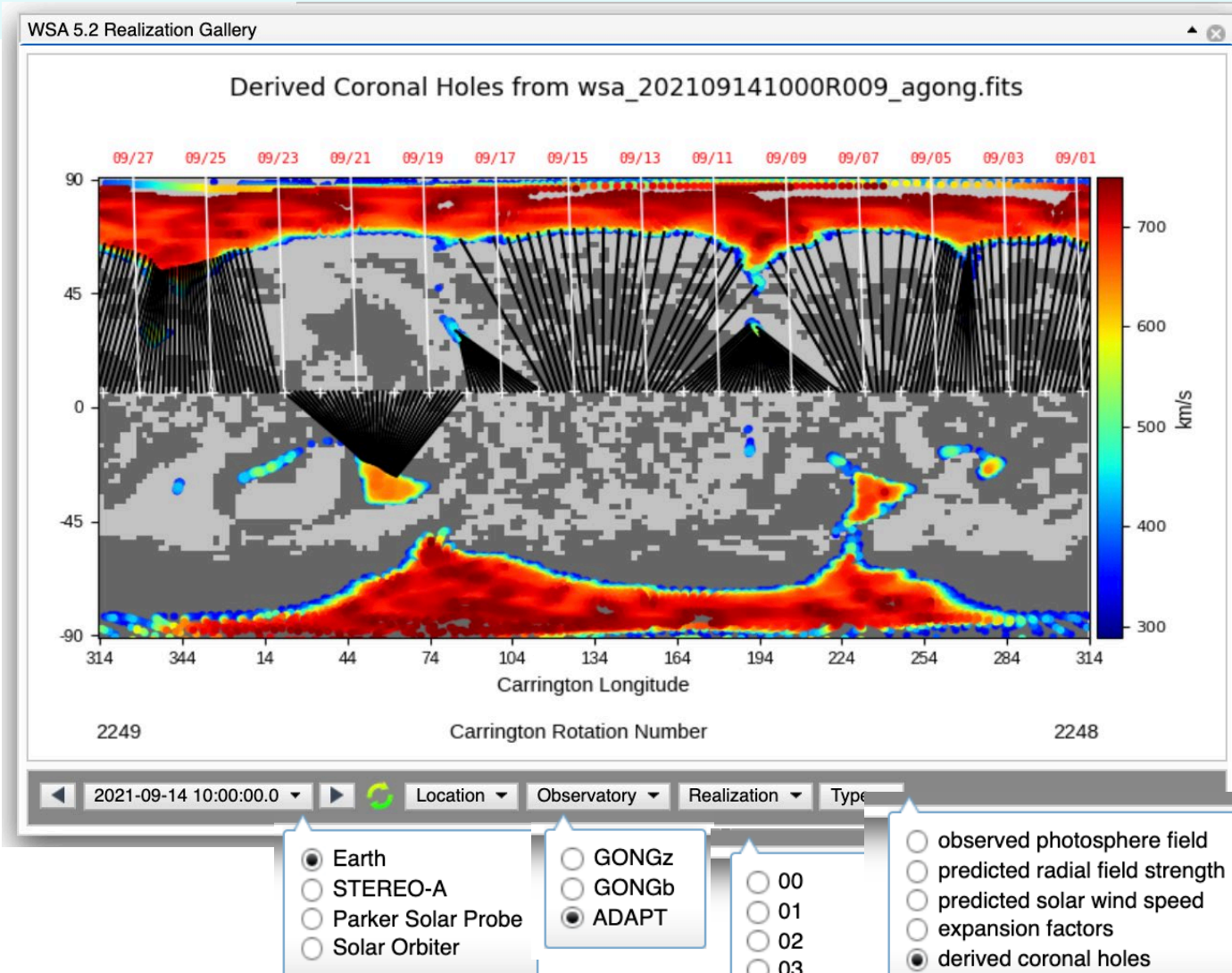Latitude_End: 46.10°

Request SWMF Run Using Parameters

CR2029   CME at t = 3.00 Min
EEGGL r =1.09 Rs   Strength = 0.96 Gauss

AR 10759

Simulated synthetic images as seen from SOHO or STEREO

Simulated magnetic structure of CME

SWMF Team: Igor Sokolov, Lulu Zhao, Meng Jin

CCMC: R. Mullinix, A. Taktakishvili

https://ccmc.gsfc.nasa.gov/models/modelinfo.php?model=SWMF%20AWSoM%20R

WSA on Runs-on-Request and Real-Time
version 5.2

Derived Coronal Holes from wsa_202109141000R009_agong.fits

Coming soon: Probability contour maps of solar wind source tracing:
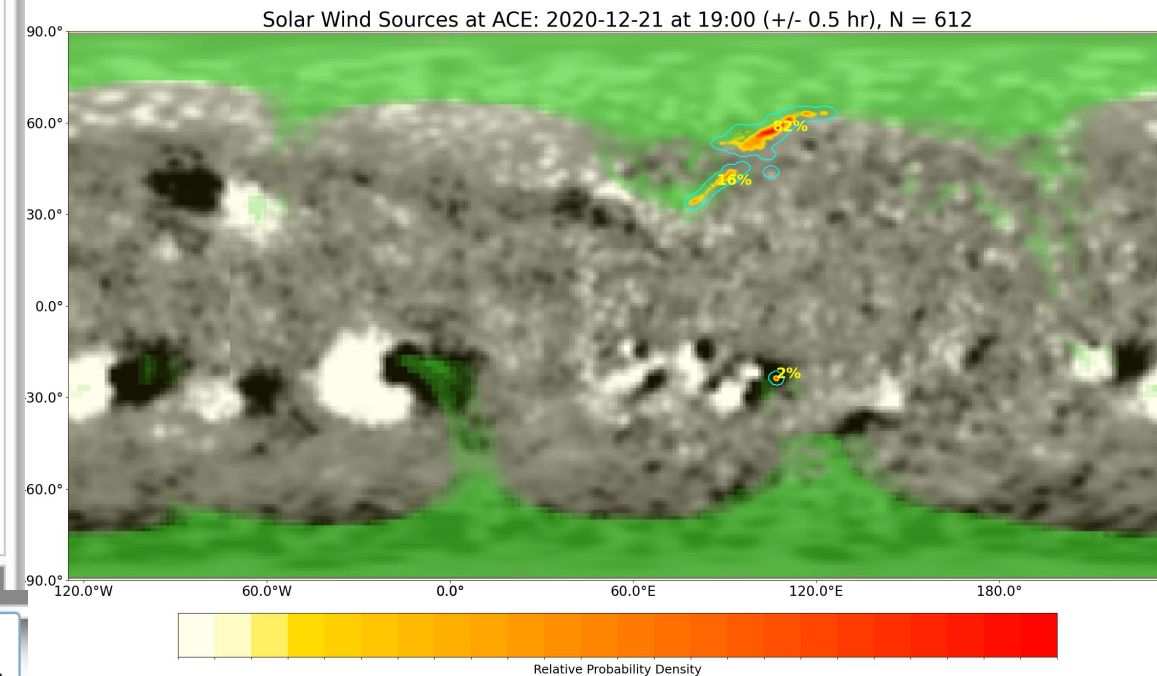
Real time runs on new iSWA gallery cygnet: https://go.nasa.gov/2YUjlL3

Runs-on-Request: https://ccmc.gsfc.nasa.gov/models/modelinfo.php?model=WSA%205.2
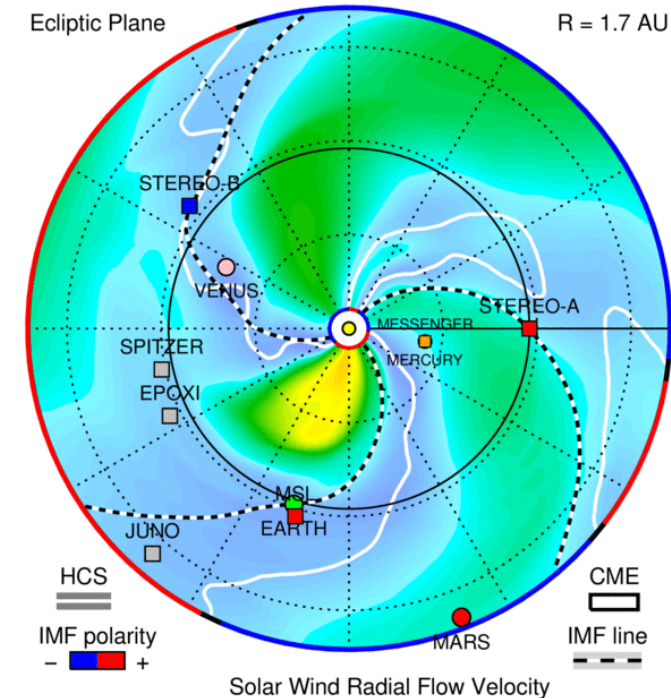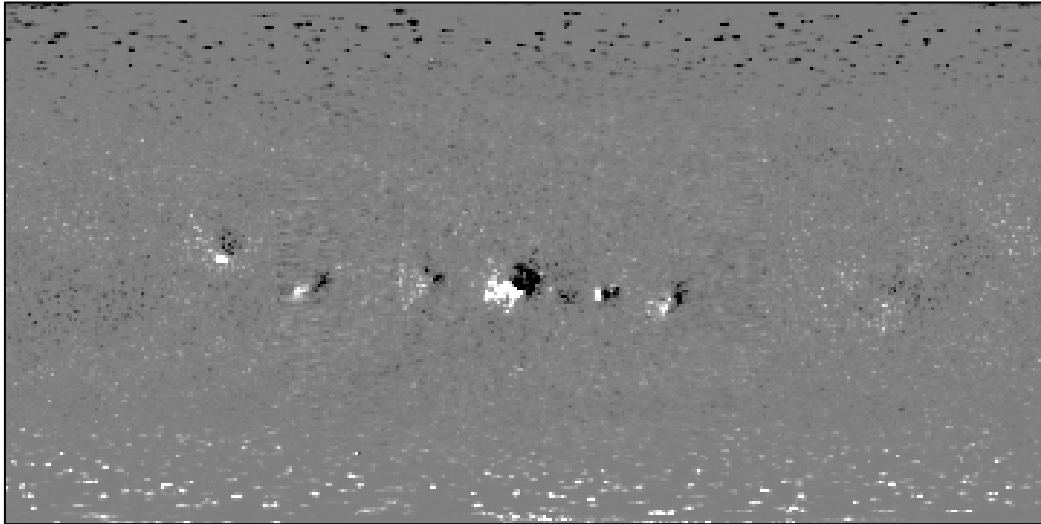
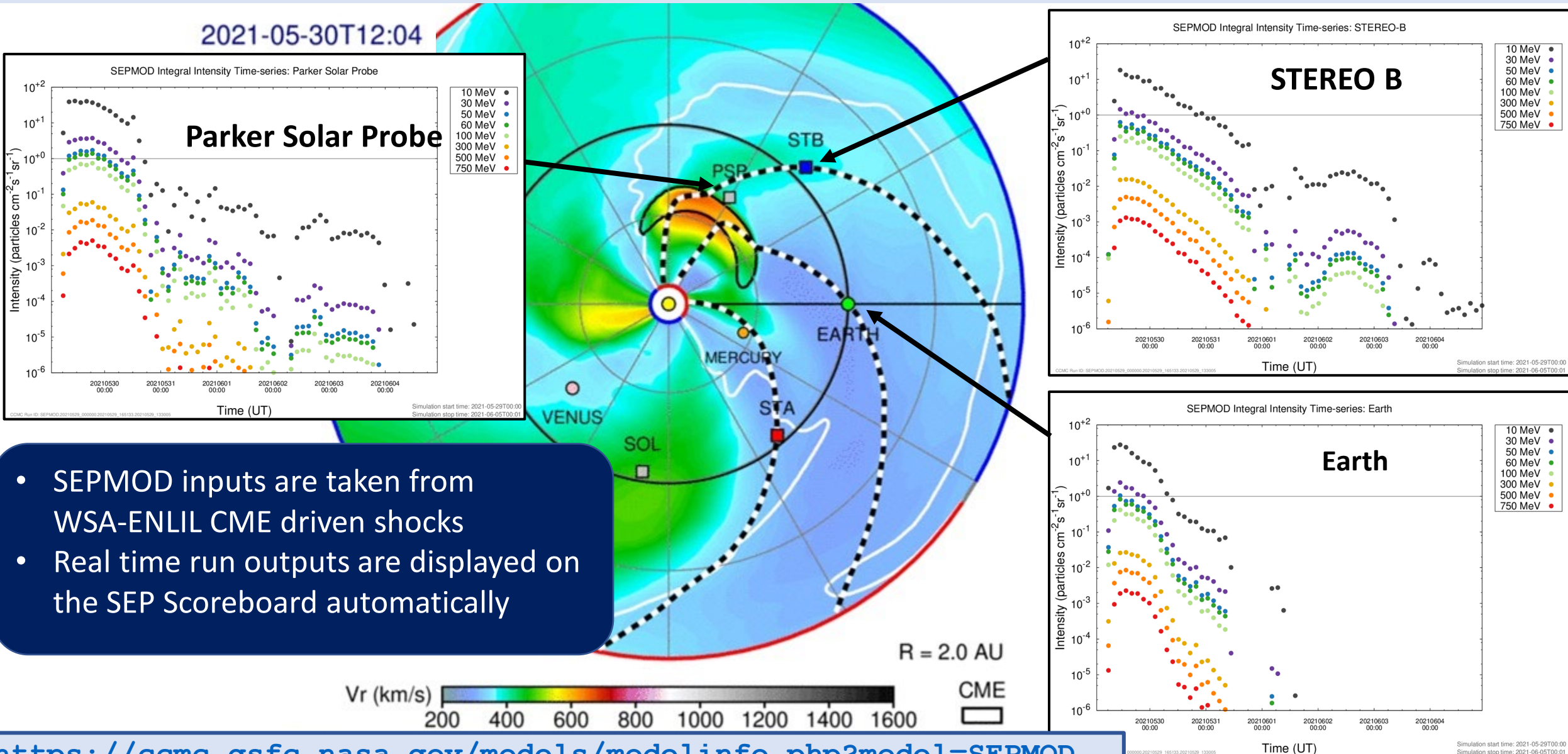- Until recently, models of the global corona and inner heliosphere have been driven by single static photospheric synoptic magnetograms.

- Time evolving models of the global photospheric field are now becoming available.

- CCMC is redeveloping its Runs on Request and real-time systems to offer WSA-ENLIL simulations driven either by a sequence of time-interpolated GONG or ADAPT magnetograms.

http://ccmc.gsfc.nasa.gov/requests/SH/E28/enlil_options.php

CCMC serves 1st real-time physics-based SEP forecast with **WSA-ENLIL-SEPMOD** Also available for community use via Runs-on-Request
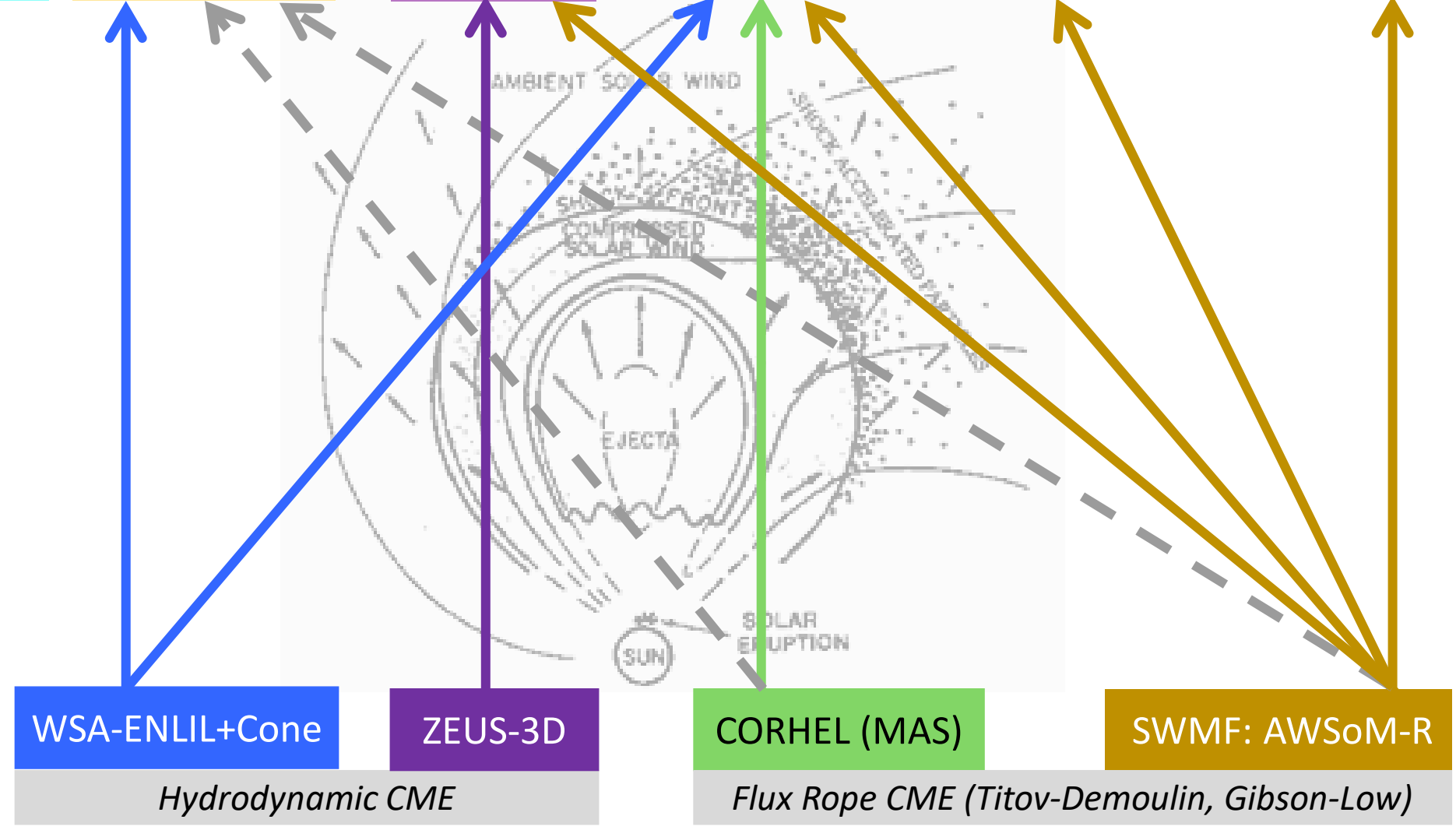

- SEPMOD inputs are taken from WSA-ENLIL CME driven shocks
- Real time run outputs are displayed on the SEP Scoreboard automatically

https://ccmc.gsfc.nasa.gov/models/modelinfo.php?model=SEPMOD

Coupled Heliosphere and SEP models

SEP MODELS

Zhang model | SEPMOD | iPATH | EPREM | SWMF:-M-FLAMPA | SWMF: Kota SEP | SPARX

SOLAR-HELIOSPHERE MHD MODELS

WSA-ENLIL+Cone | ZEUS-3D | CORHEL (MAS) | SWMF: AWSoM-R

Hydrodynamic CME | *Flux Rope CME (Titov-Demoulin, Gibson-Low)*

Modelers: N. Arge, D. Odstrcil, J. Luhmann, J. Linker, N.Schwadron, M. Gorby, I.Sokolov, G. Li, S. Dalla, M. Zhang
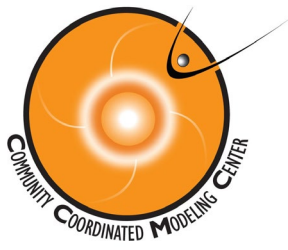
Validation: CCMC community scoreboards

https://ccmc.gsfc.nasa.gov/challenges/

Flare Scoreboard — Upload your Flare Predictions for Full Disk and/or Active Regions.

Leads: **Trinity College Dublin** (S. Murray), **ROB** (J. Andries)

SEP Scoreboard — Under development Help us plan and design.

Leads: **NASA SRAG**, **CCMC** (L. Mays), **BIRA-IASB** (M. Dierckxsens)

CME Scoreboard — Submit your CME arrivable time predictions and compare with others.
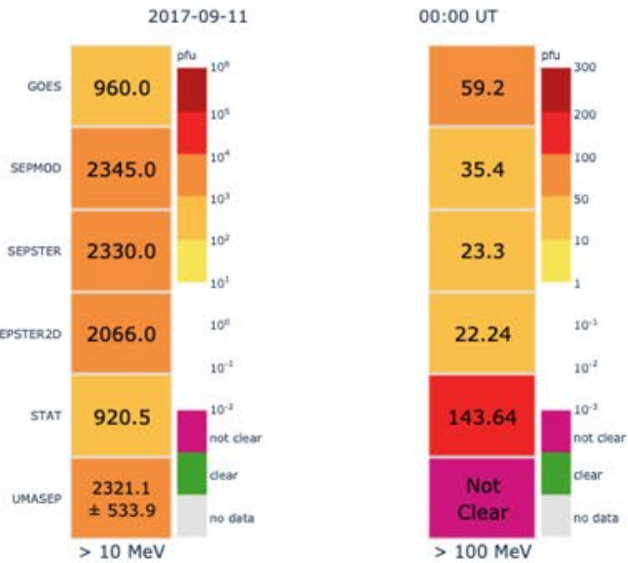
Leads: **CCMC** (L. Mays), **UK Met Office**

IMF Bz Scoreboard

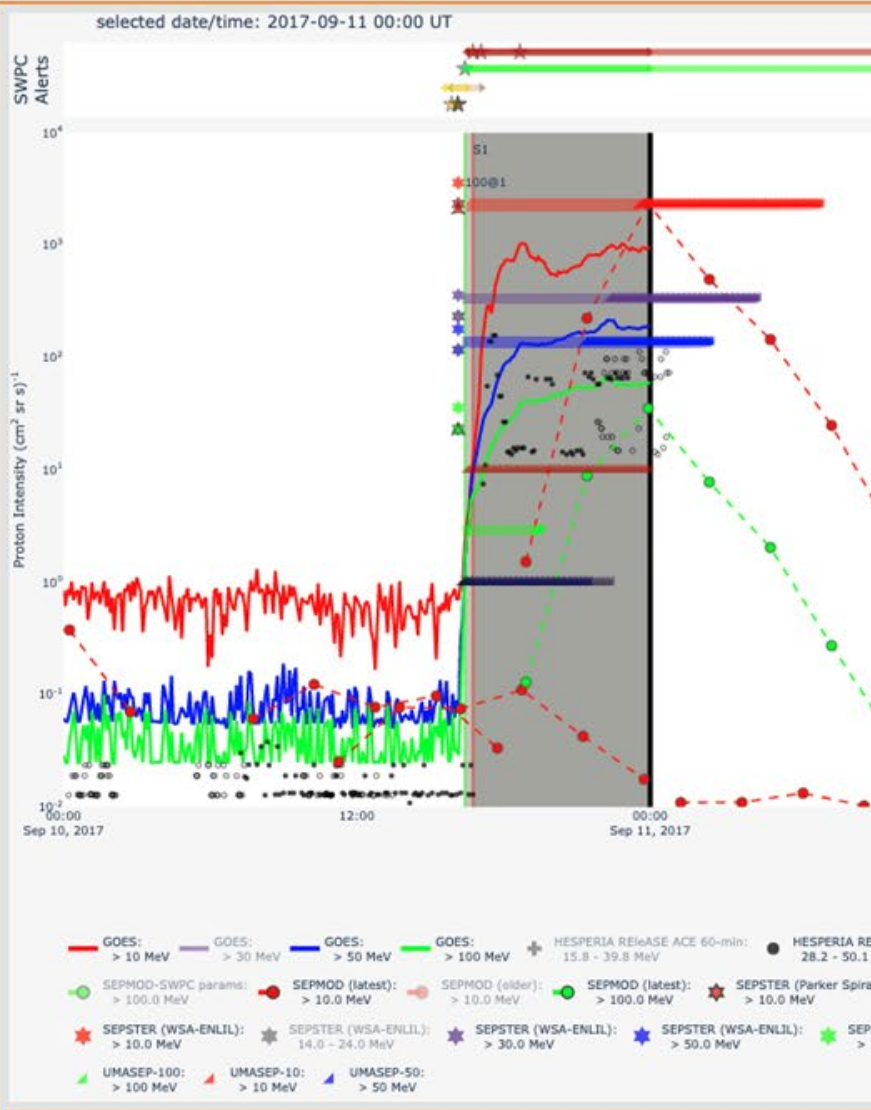Leads: **PredSci** (P. Riley), **University of Reading** (M. Owens)

- Scoreboards collect forecasts from the community before event is observed

- Allows a consistent **real-time** comparison of various operational and research forecasts.

SEP Scoreboard

★ Publicly available Dec 2020
★ Supports SRAG console operators and M2M analysts
★ Forecasts from multiple models are collected and uniformly displayed in real time
★ Ability to go back in time
★ Engages participation from the scientific community
★ 8 participating models

https://sep.ccmc.gsfc.nasa.gov/intensity/
https://sep.ccmc.gsfc.nasa.gov/probability/

Recent SEP activity: May 29, 2021
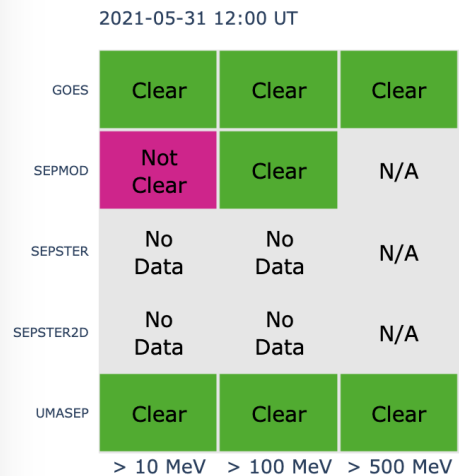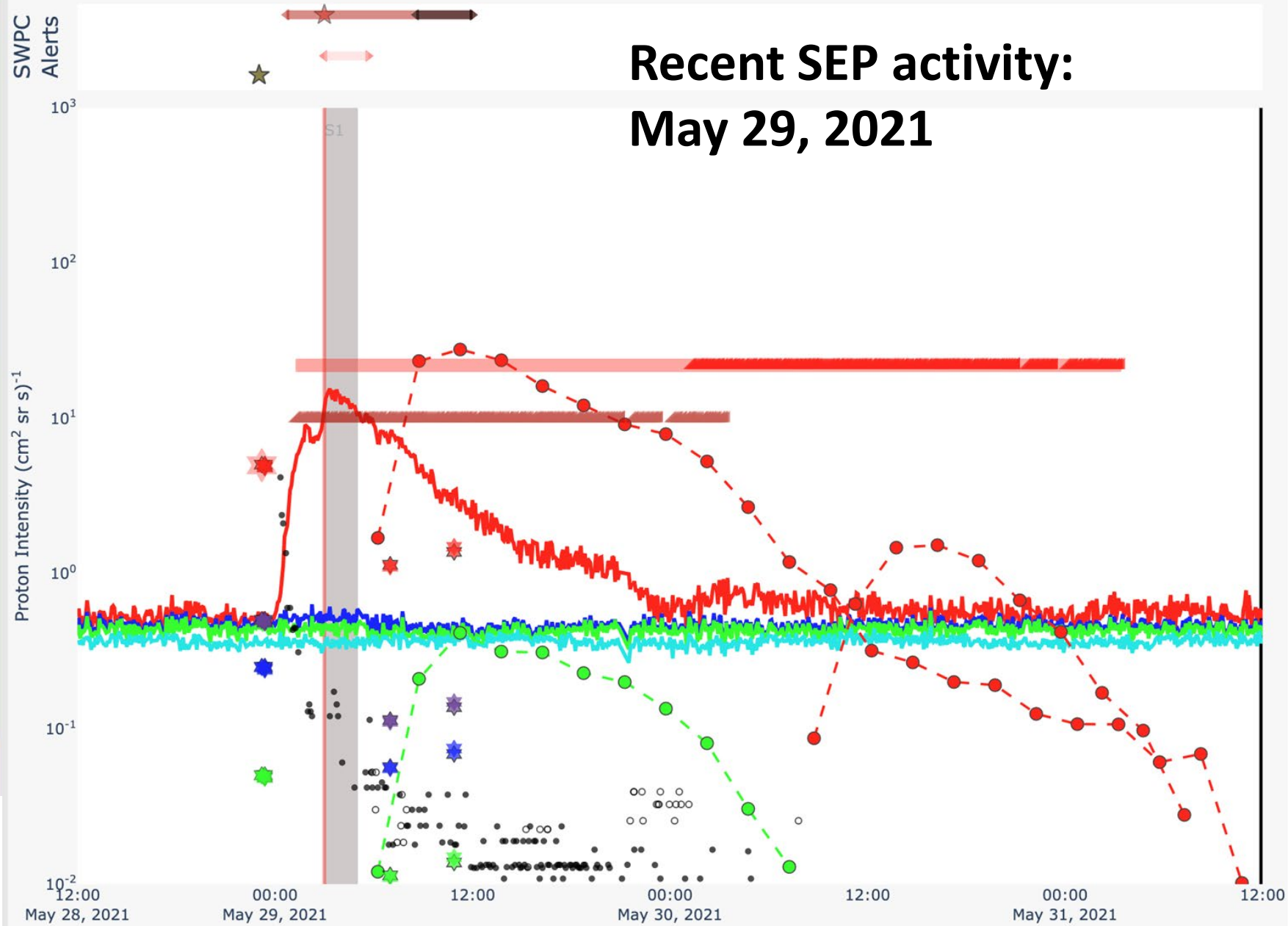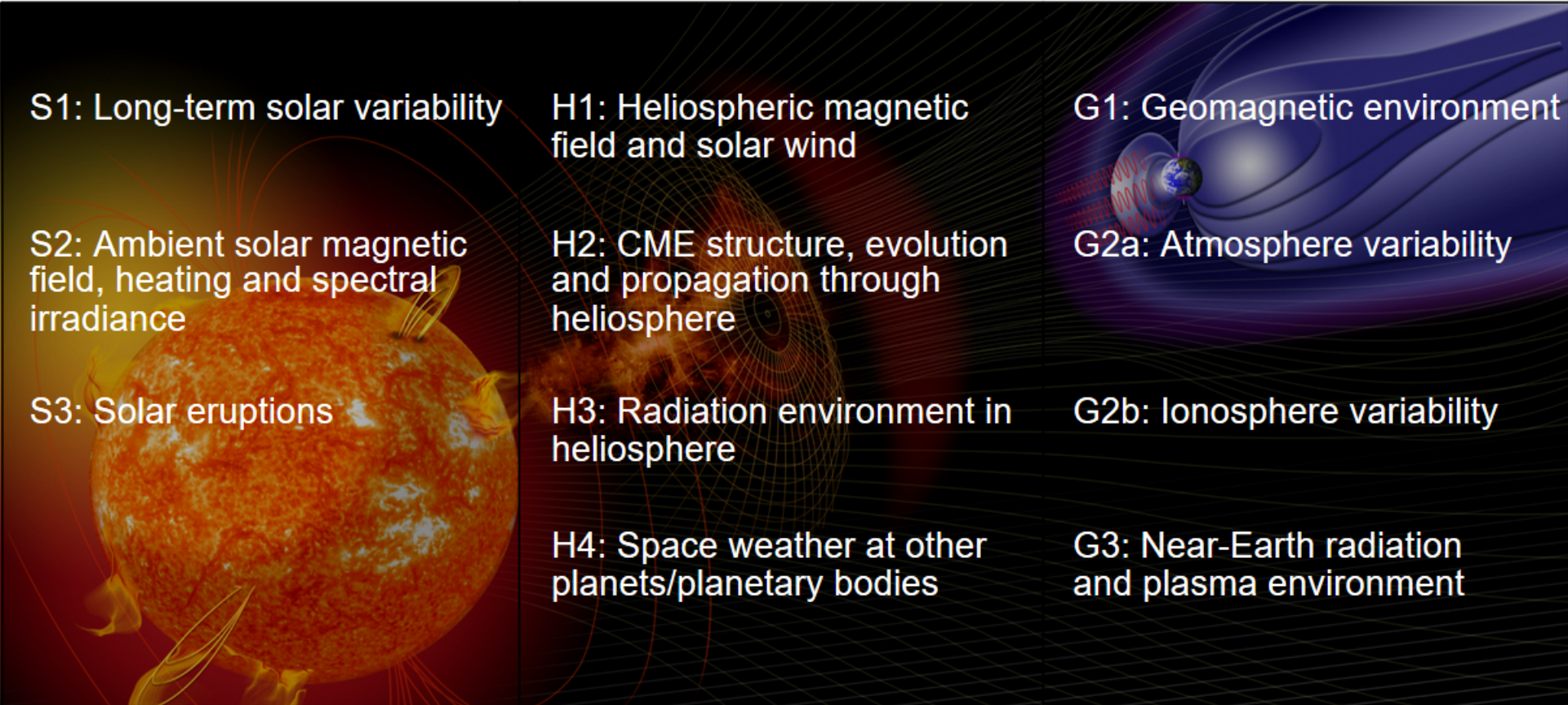
The COSPAR ISWAT initiative is a global hub for collaborations addressing challenges across the field of space weather.

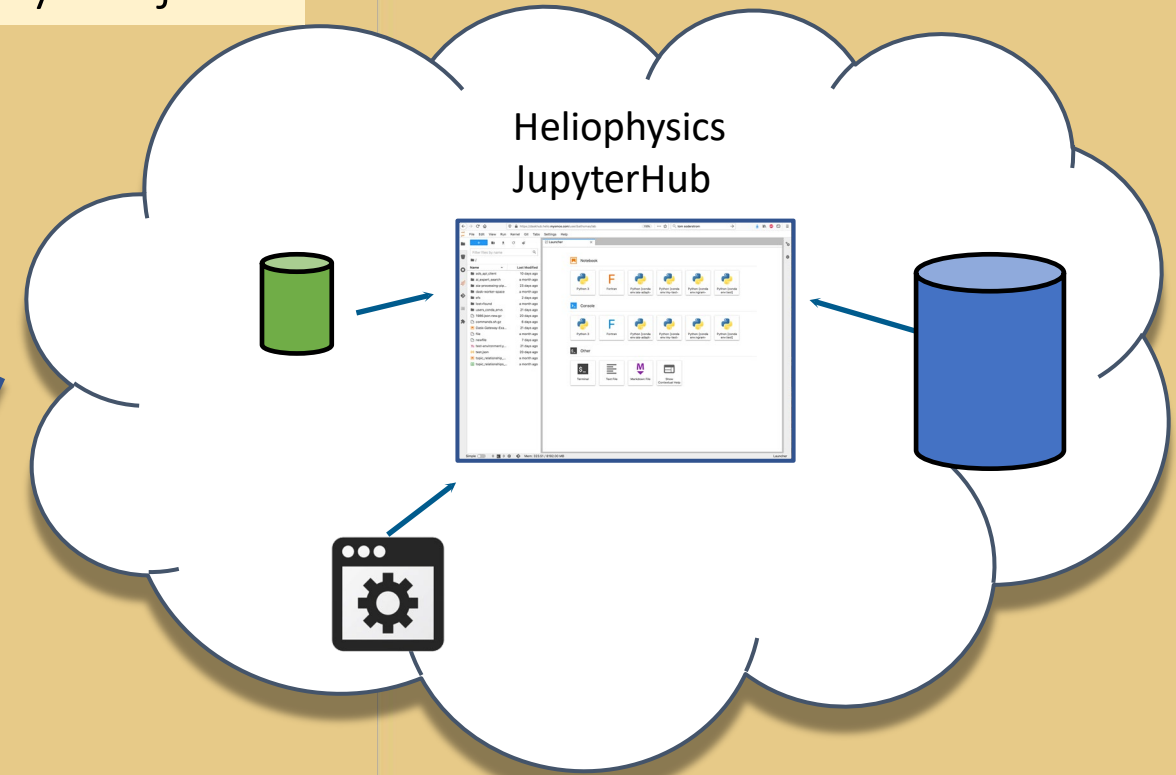| S: Space weather origins at the Sun	H: Heliosphere variability	G: Coupled geospace system	Impacts
S1: Long-term solar variability	H1: Heliospheric magnetic field and solar wind	G1: Geomagnetic environment	Climate
S2: Ambient solar magnetic field, heating and spectral irradiance	H2: CME structure, evolution and propagation through heliosphere	G2a: Atmosphere variability	Electric power systems/GICs
S3: Solar eruptions	H3: Radiation environment in heliosphere	G2b: Ionosphere variability	Satellite/debris drag
	H4: Space weather at other planets/planetary bodies	G3: Near-Earth radiation and plasma environment	Navigation/ Communications
			(Aero)space assets functions
			Human Exploration

Overarching Activities:

Assessment   Information Architecture   Data Utilization   Education/Outreach

https://iswat-cospar.org/

New NASA GSFC Heliophysics Digital Resource Library Project:

Use case for co-hosting observational and model data in the Cloud

Heliophysics JupyterHub

The code, models and data are easily imported and used in the cloud-based analytics platform (such as the Heliophysics JupyterHub).
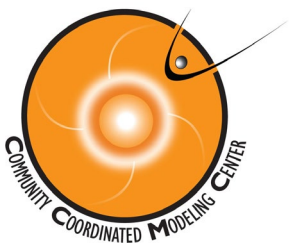*Users can work with much larger datasets and greater compute than available on their laptop.*

Community feedback is requested on what data should be made available for this project!
https://go.nasa.gov/2XpXQkQ

Solar/Heliosphere Models coming soon to CCMC

- CORHEL upgrade

- GAMERA Solar Helio

- ENLIL upgrade

- iPATH

- SWMF M-FLAMPA

- EPREM

Thank you
&
feel free to get in touch with questions!

m.leila.mays@nasa.gov