Tutorial

NASA Community Coordinated Modeling Center (CCMC)

Jack Wang and all CCMC members
Community Coordinated Modeling Center, NASA GSFC
June 12th, 2026

Outlines

- Our mission
- Simulation Services
  - Instant Runs
  - Runs-on-Request
  - Continuous Runs
- Post-Processing/Visualization Tools

Installing a model is rarely straightforward without assistance from the model developers

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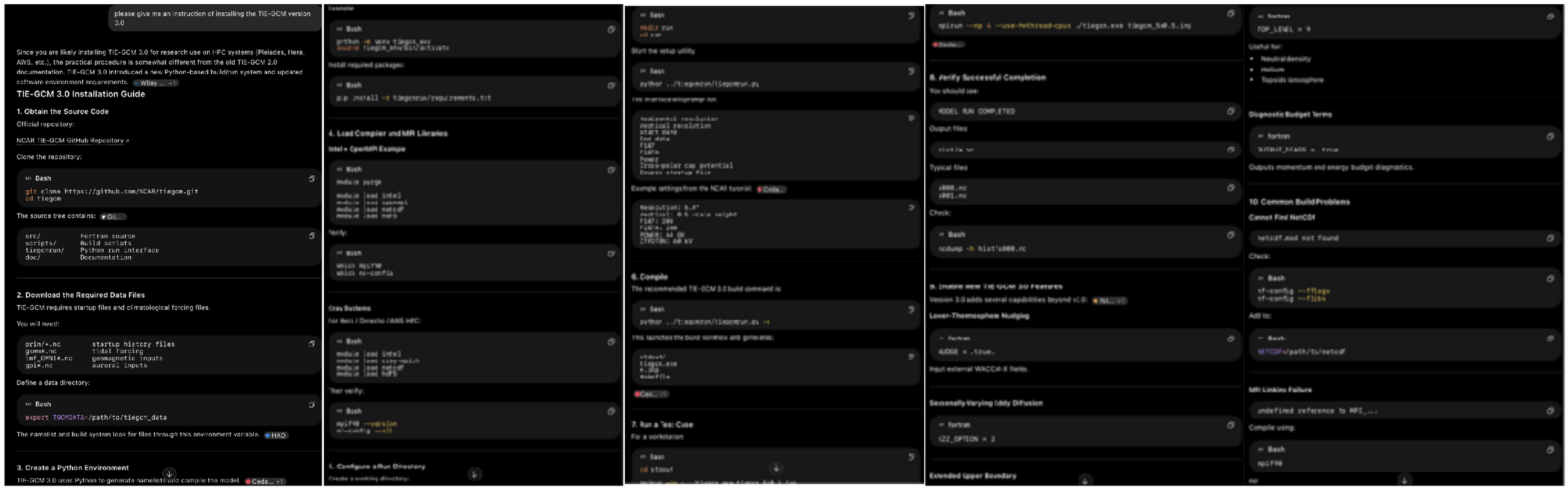
ChatGPT

please give me an instruction of installing the TIE-GCM version 3.0

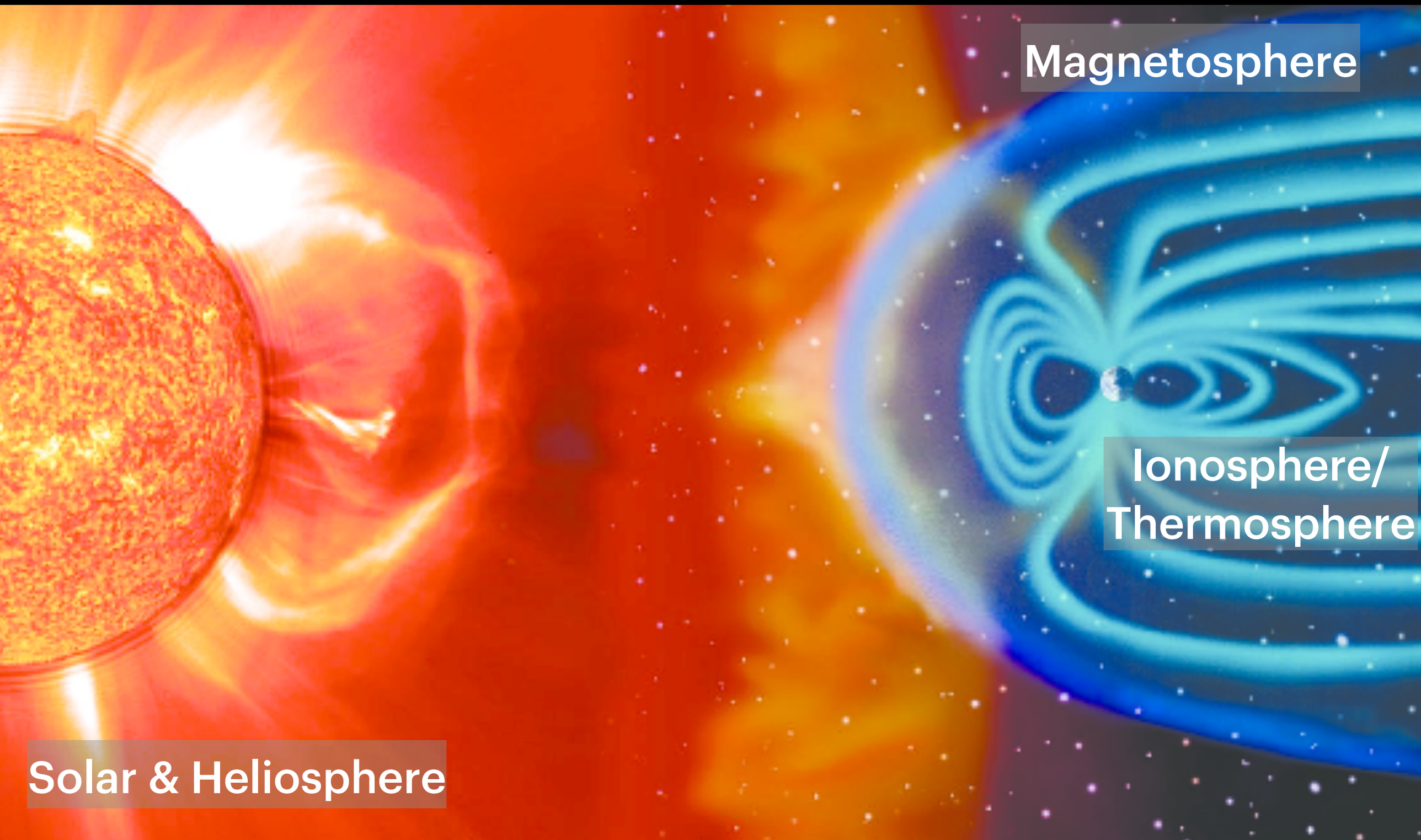


CCMC builds bridges between model developers and end users

V.S.

CCMC acknowledges all the model developers for the permission to use the models and software tools at CCMC

CCMC mission: Bridging the Gap Between Space Weather Model Development and End Users



CCMC Services:
End-to-End Model Support for the Community

Model Implementation Install, configure, and maintain models for community access

Runs-on-Request & Instant runs Provide model simulations on demand for research studies, missions, and event analyses

Validation & Metrics Evaluate model performance through comparisons with observations using standardized metrics

Model Coupling, Visualization Tools, Education & Outreach

Magnetosphere

Ionosphere/
Thermosphere

Solar & Heliosphere

CCMC provides on-demand model simulations to support research studies, missions, and event analyses

Instant Run

CCMC Model Catalog

Run-on-Request

Continuous Run

Instant Run - Play it on your mobile device!

CCMC Instant Run Website

Heliosphere

DBM: predicts ICME propagation and arrival time at any location in the ecliptic plane.

Magnetosphere

IGRF: Standard empirical reference model of internal magnetic field maintained by IAGA for scientific use.
AE-8/AP-8 RADBELT: An updated radiation belt model with AE-8/AP-8 flux maps, interactive driver, and interpolation tools
CM5: Empirical model of the near-Earth magnetic field derived from pre-Swarm satellite and ground data (2000–2013).
Tsyganenko Magnetic Field: Semi-empirical model of the magnetospheric field incorporating major external current systems, based on satellite data.
WINDMI: Low-dimensional physics-based model describing solar wind energy transfer through the magnetosphere-ionosphere system.

Instant Run - Play it on your mobile device!

CCMC Instant Run Website

Ionosphere/Thermosphere

NRLMSIS: neutral density & temp

HWM14: horizontal neutral winds

EXOSpy: H exospheric density

IRI: ionospheric ion and electron density & temperature

GEMSOR: sporadic-E occurrence rates

IBP: ionospheric bubble occurrence probabilities

WBMOD 17: wideband ionospheric scintillation prediction model

SuperDARN Convection Models:

Statistical high-lat. ionospheric plasma convection models

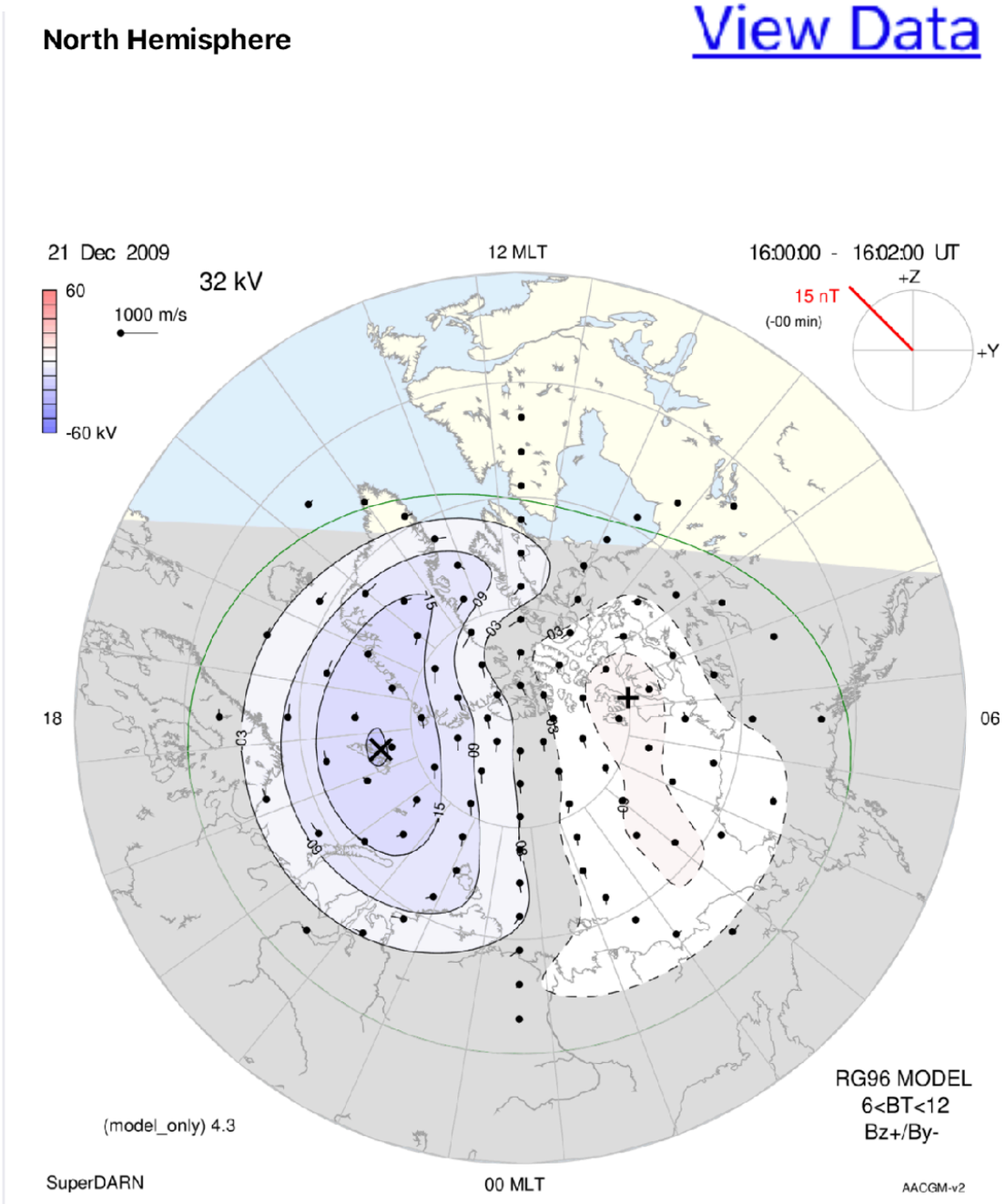
Swipe: high-lat. electrodynamics using Swarm and CHAMP measurements

Weimer: high-lat. electric potential models driven by solar wind and IMF

Zeeman-Stokes: polarimetric radiances near 118.75 GH_z O_2 line

Geoelectric Field Calculation Tool: ground geoelectric fields

CCMC Instant Run: SuperDARN convection model

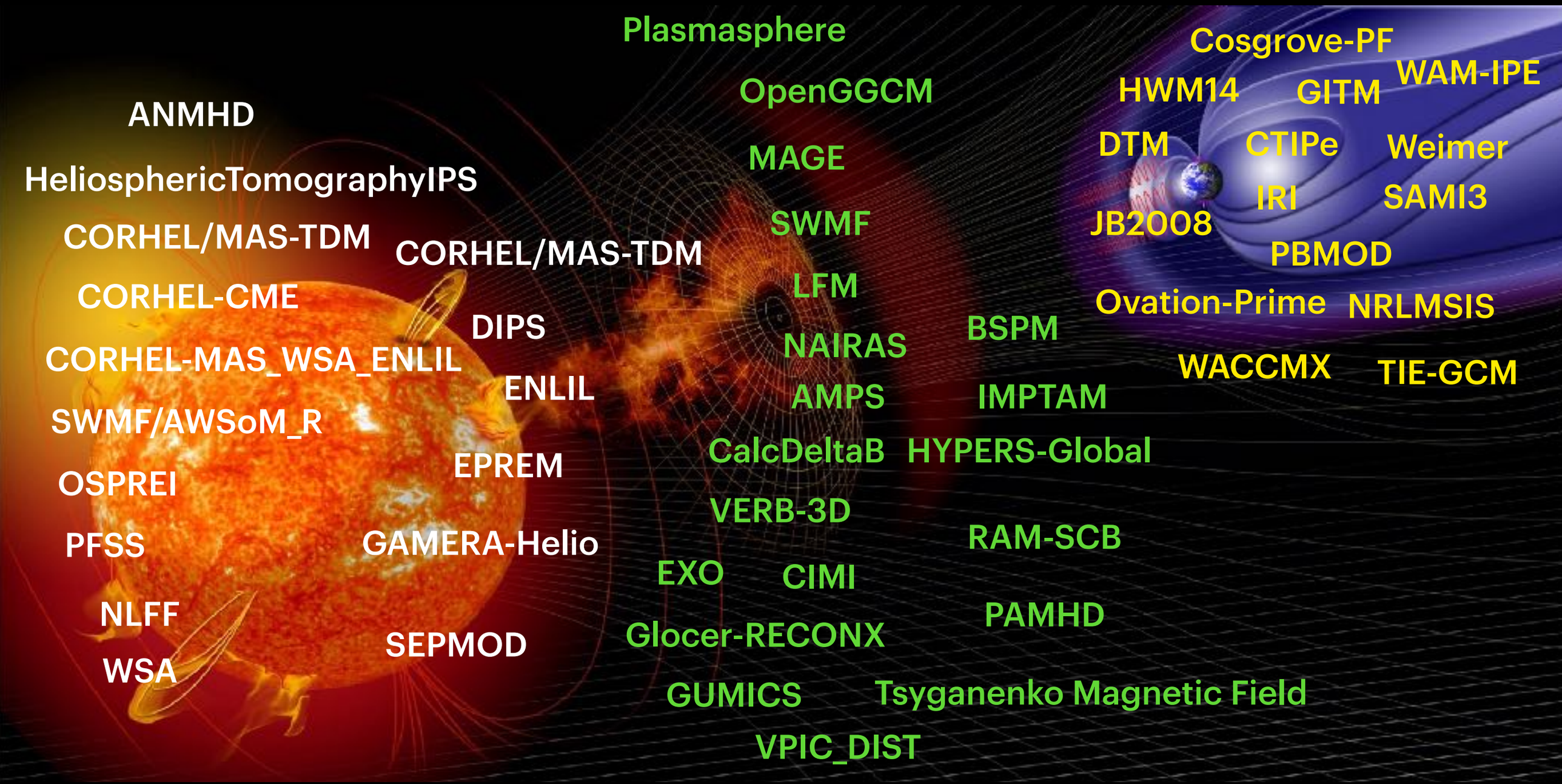


View Data

Date: 2009-12-21 16:00
Model: RG96
Bin: 6<BT<12, Bz+/By-
Grid: Uniform (lat_step: 1.00, lon_step: 2.00 [deg])

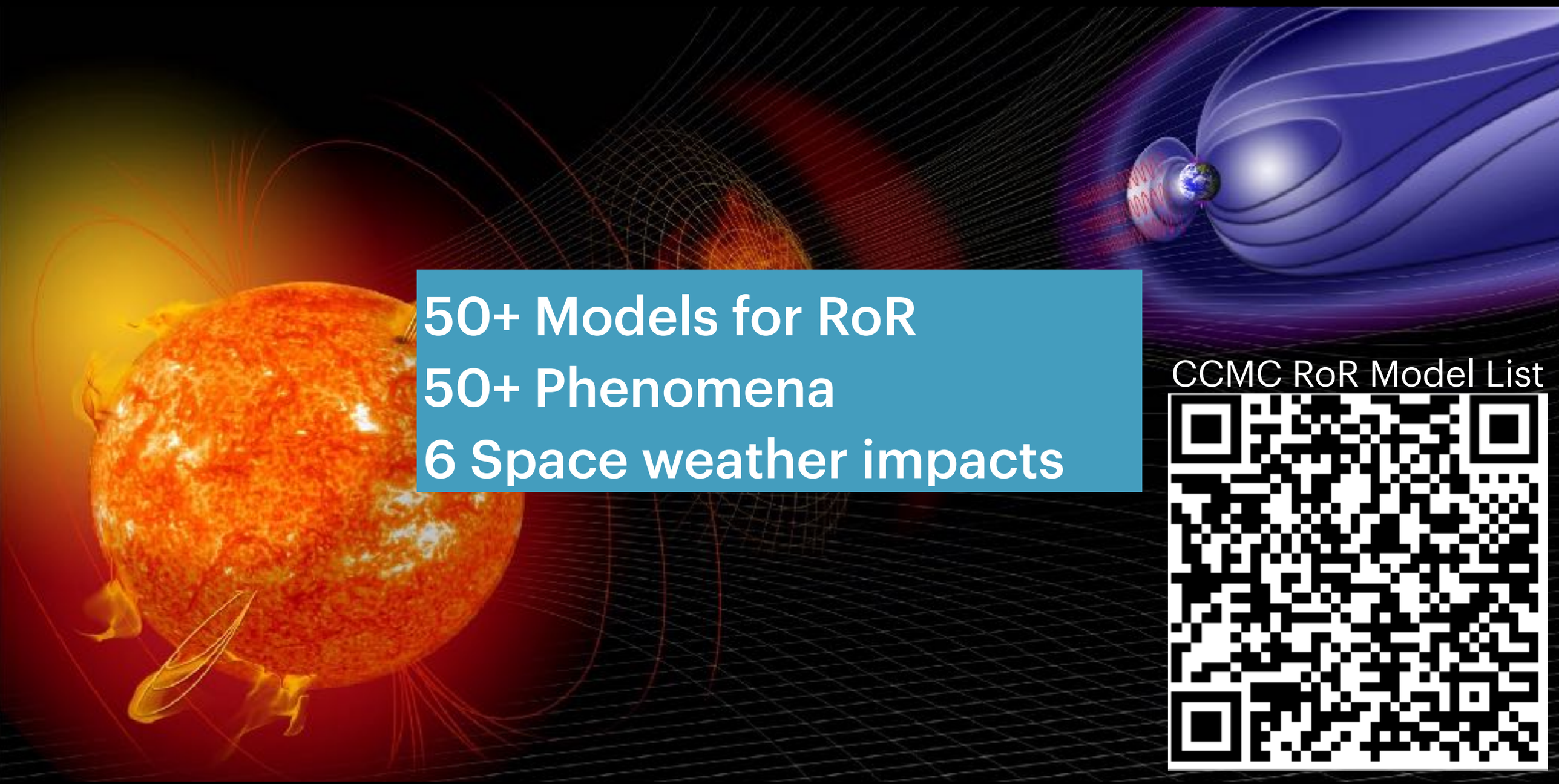
NLAT [deg]	MLT [hr]	Pot [kV]	Vazm [deg]	Vmag [m/s]
60.5000	0.00000	0.577197	91.6187	105.769
60.5000	0.133333	0.593757	91.4927	112.146
60.5000	0.266667	0.609896	91.3796	118.395
60.5000	0.400000	0.625591	91.2774	124.506
60.5000	0.533333	0.640820	91.1844	130.469
60.5000	0.666667	0.655562	91.0991	136.276
60.5000	0.800000	0.669795	91.0204	141.915
60.5000	0.933333	0.683502	90.9473	147.379
60.5000	1.06667	0.696662	90.8792	152.658
60.5000	1.20000	0.709259	90.8154	157.743
60.5000	1.33333	0.721276	90.7553	162.624
60.5000	1.46667	0.732698	90.6985	167.295
60.5000	1.60000	0.743508	90.6445	171.745
60.5000	1.73333	0.753696	90.5930	175.966
60.5000	1.86667	0.763247	90.5438	179.952
60.5000	2.00000	0.772150	90.4965	183.694
60.5000	2.13333	0.780396	90.4510	187.184
60.5000	2.26667	0.787976	90.4070	190.417
60.5000	2.40000	0.794881	90.3643	193.384
60.5000	2.53333	0.801105	90.3228	196.081
60.5000	2.66667	0.806642	90.2823	198.500
60.5000	2.80000	0.811487	90.2427	200.637
60.5000	2.93333	0.815638	90.2038	202.486
60.5000	3.06667	0.819092	90.1656	204.044
60.5000	3.20000	0.821847	90.1279	205.306
60.5000	3.33333	0.823904	90.0906	206.269
60.5000	3.46667	0.825263	90.0536	206.929
60.5000	3.60000	0.825927	90.0168	207.286
60.5000	3.73333	0.825897	89.9801	207.336
60.5000	3.86667	0.825179	89.9435	207.081
60.5000	4.00000	0.823777	89.9068	206.519
60.5000	4.13333	0.821696	89.8699	205.651
60.5000	4.26667	0.818944	89.8328	204.479

Runs-on-Request (RoR) - Execute simulations upon customer request



Corona | Heliosphere | Magnetosphere | Inner Magnetosphere | Ionosphere/ Thermosphere

Runs-on-Request (RoR) - Execute simulations upon customer request

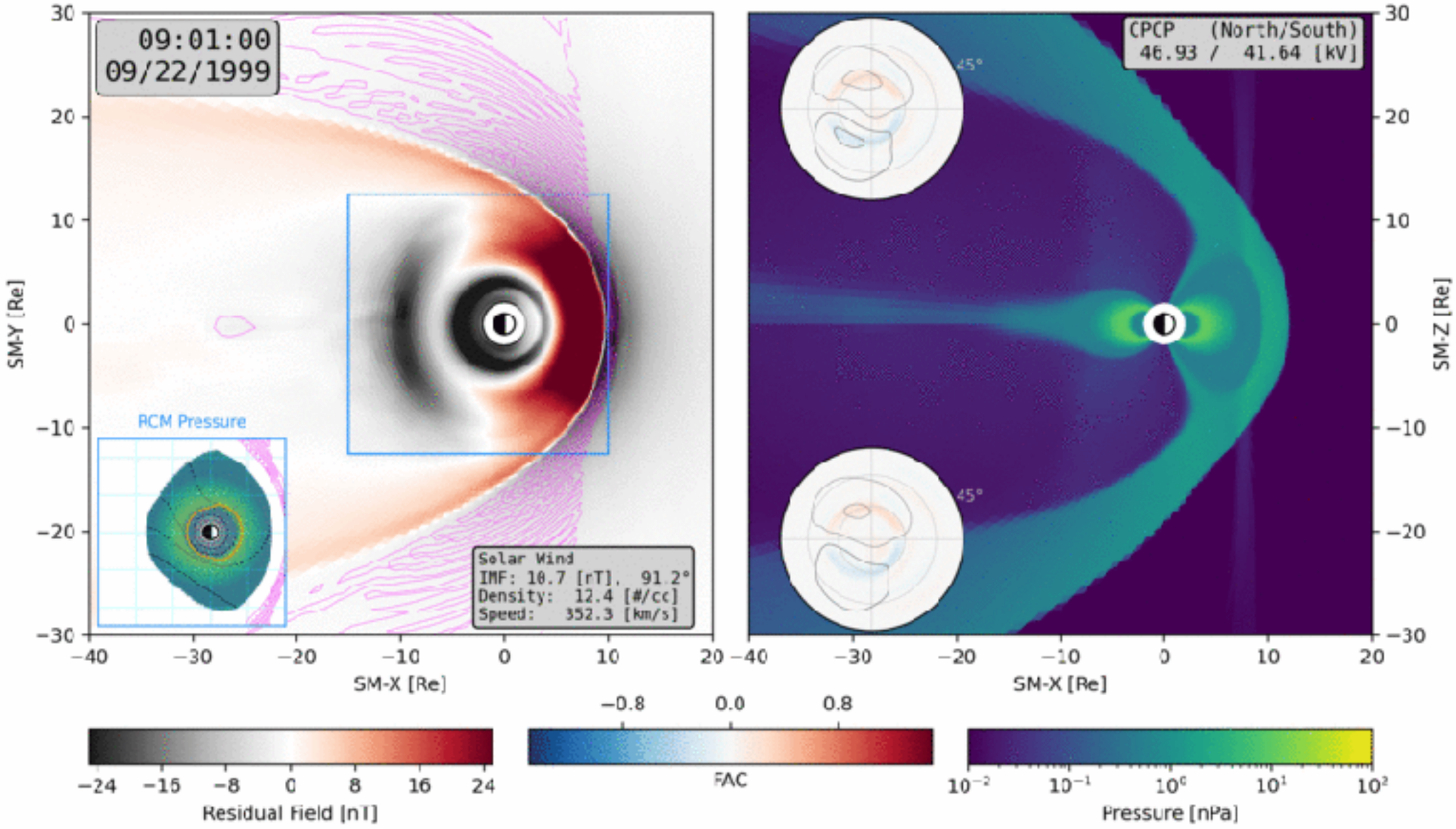


50+ Models for RoR
50+ Phenomena
6 Space weather impacts

CCMC RoR Model List

Corona | Heliosphere | Magnetosphere | Inner Magnetosphere | Ionosphere/ Thermosphere

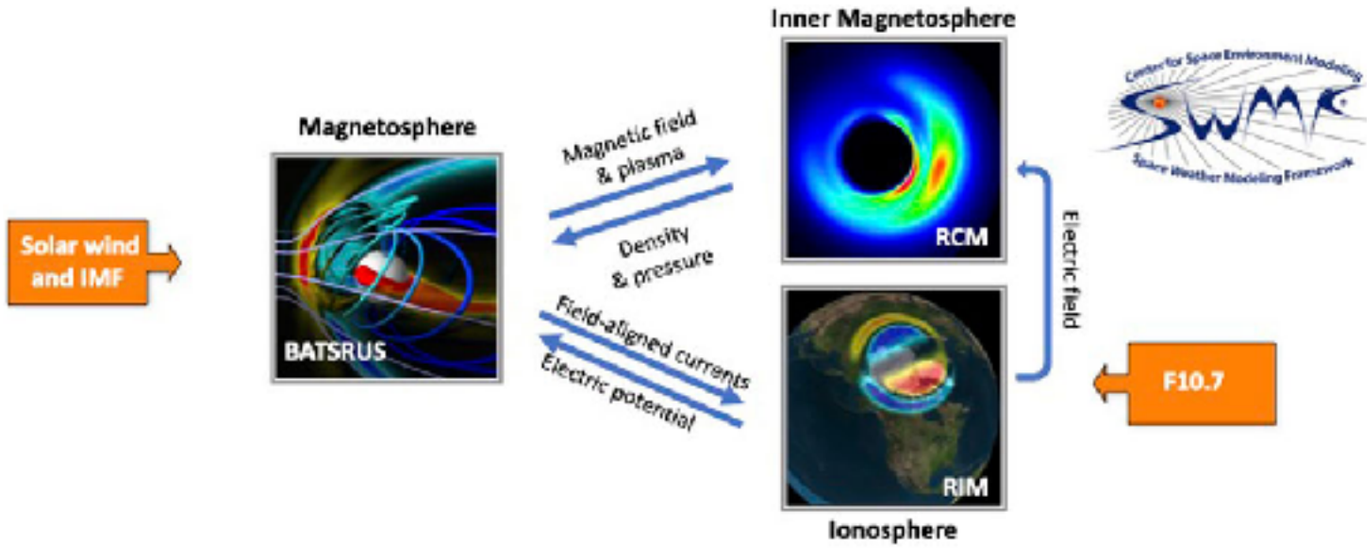
MAGE (Multiscale Atmosphere Geospace Environment model suite) is a comprehensive geospace modeling framework



- coupled GAMERA magnetosphere
- RCM ring current
- ReMIX ionosphere electrostatics solver
- precipitation (Dragon King)

- **Kaipy**, visualization tools developed by CGS, is available at the CCMC.
- Provides on-the-fly visualization w/o requiring dataset downloads

Space Weather Modeling Framework (SWMF) v2023 is upgraded with new interface

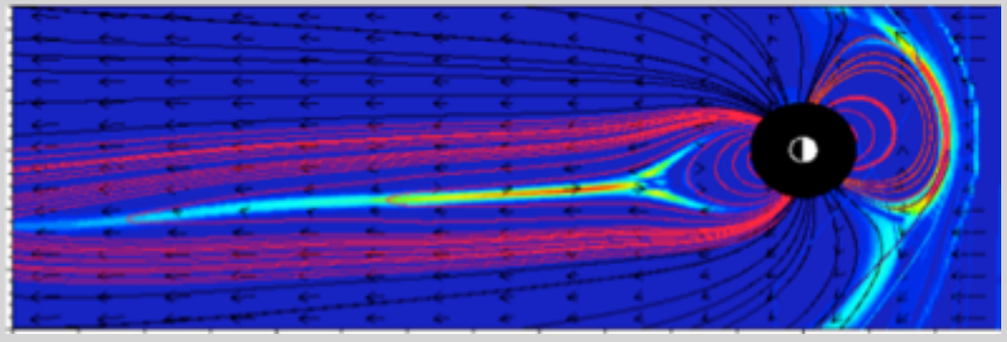


- Offers **preset** and **custom** simulation settings
  - Preset: NOAA/SWPC-like operational settings; high-resolution runs for storms
  - Custom: Ionosphere conductance options (RML, CMEE, COMPASS, ADELPHI) and more

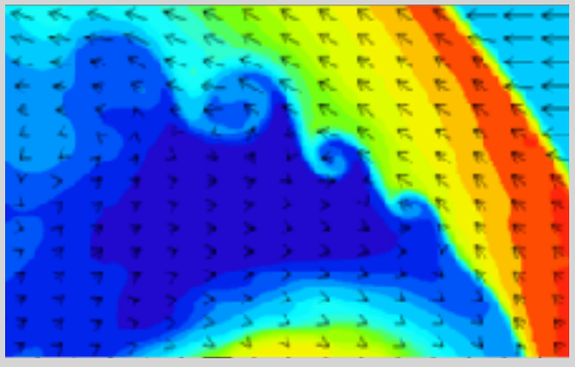
Leveraging the Resolution Input

These refined details are only captured by increasing the resolution.

Thin Magnetotail Current

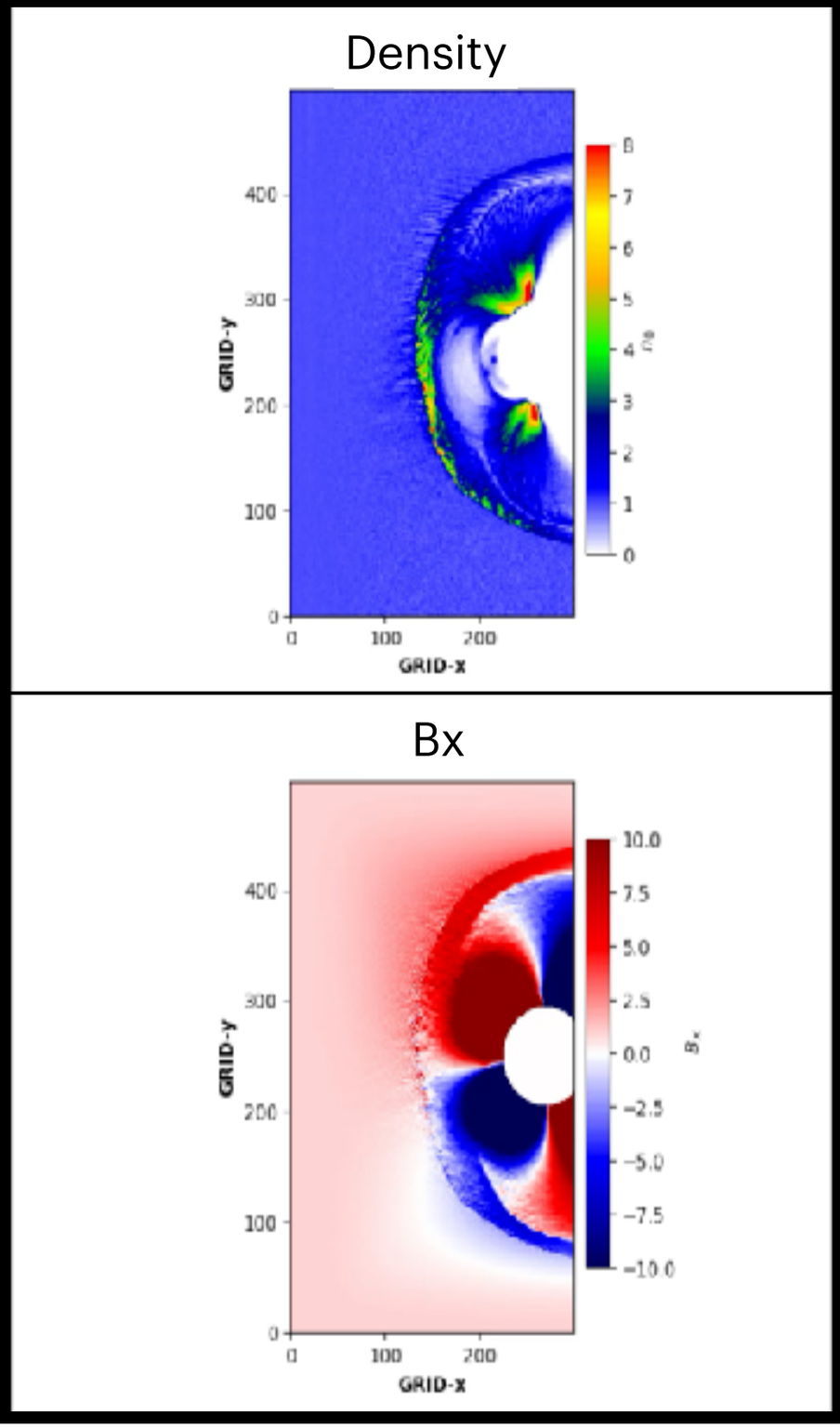


KH Instability (Magnetopause Surface Waves)



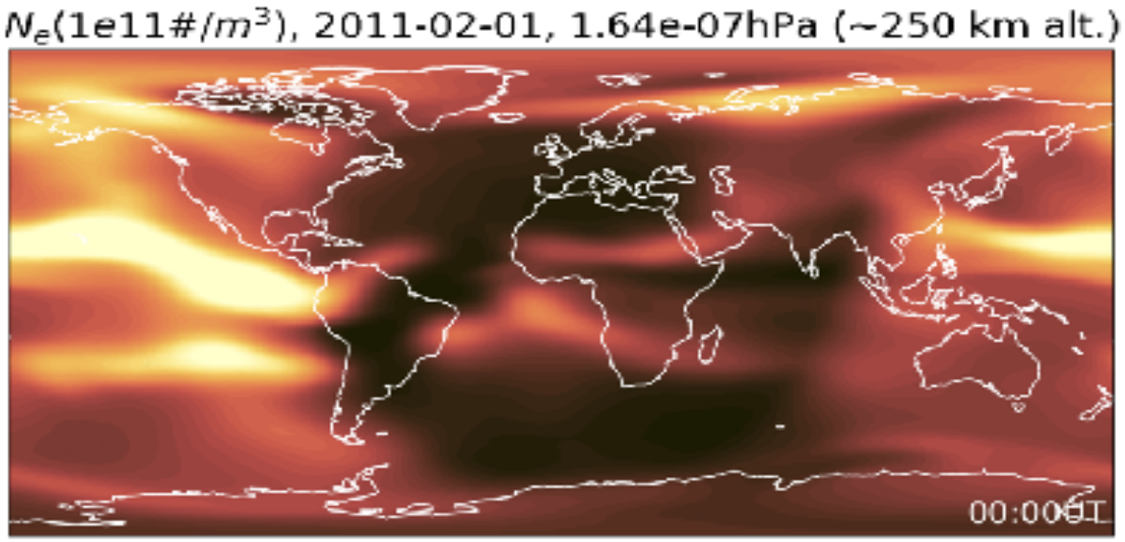
Moving Beyond Single-Fluid MHD

- Hybrid and particle-in-cell (PIC) approaches enable addressing problems such as
  - Reconnection
  - wave-particle interactions
  - particle energization and transport at different regions
- Global hybrid models can address turbulence on multiple scales.



Simulations of solar wind–magnetosphere interaction using **HYPERS** *(Omelchenko)*

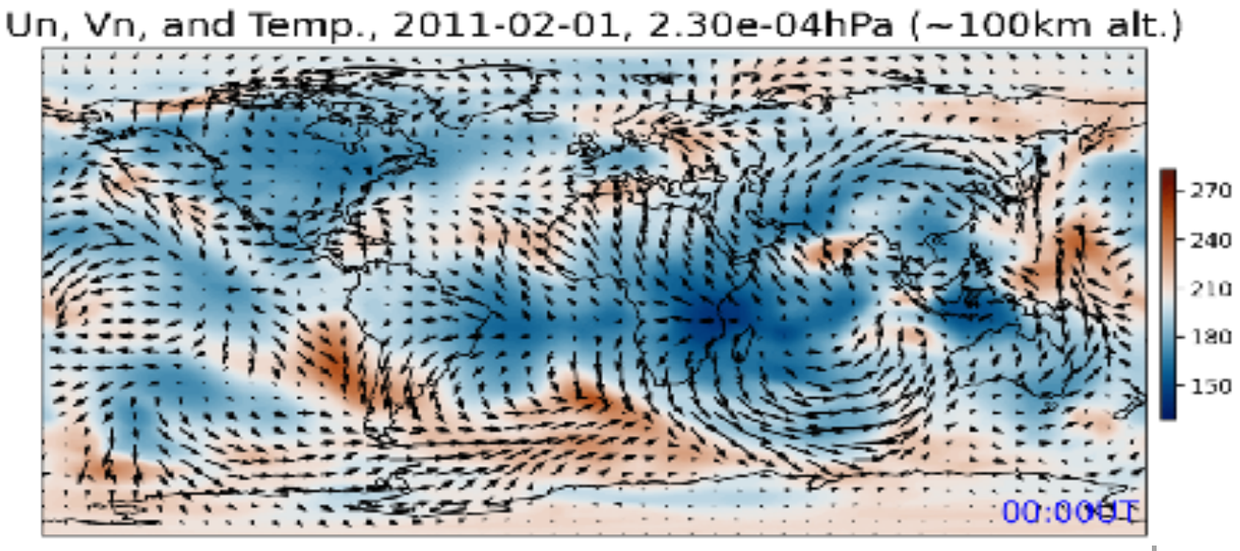
Whole Atmosphere Community Climate Model – eXtended (WACCM-X) is available now, first whole atmosphere model at CCMC

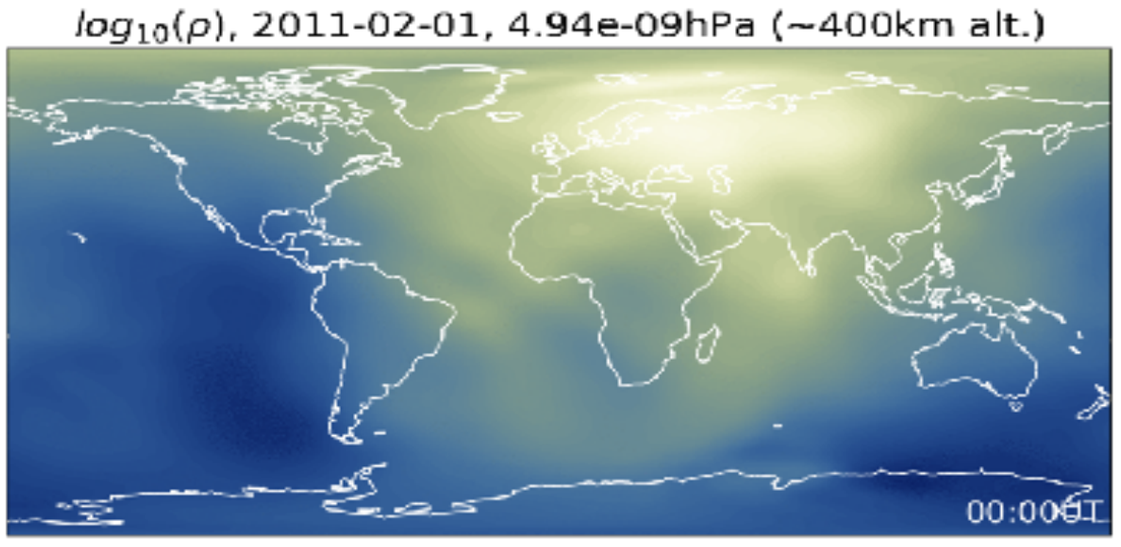


- Model domain from surface to 500 and 700 km
- Couples to ocean, sea ice, and land, enabling studies of thermosphere/ionosphere coupling with the lower atmosphere

dynamics-chemistry coupling

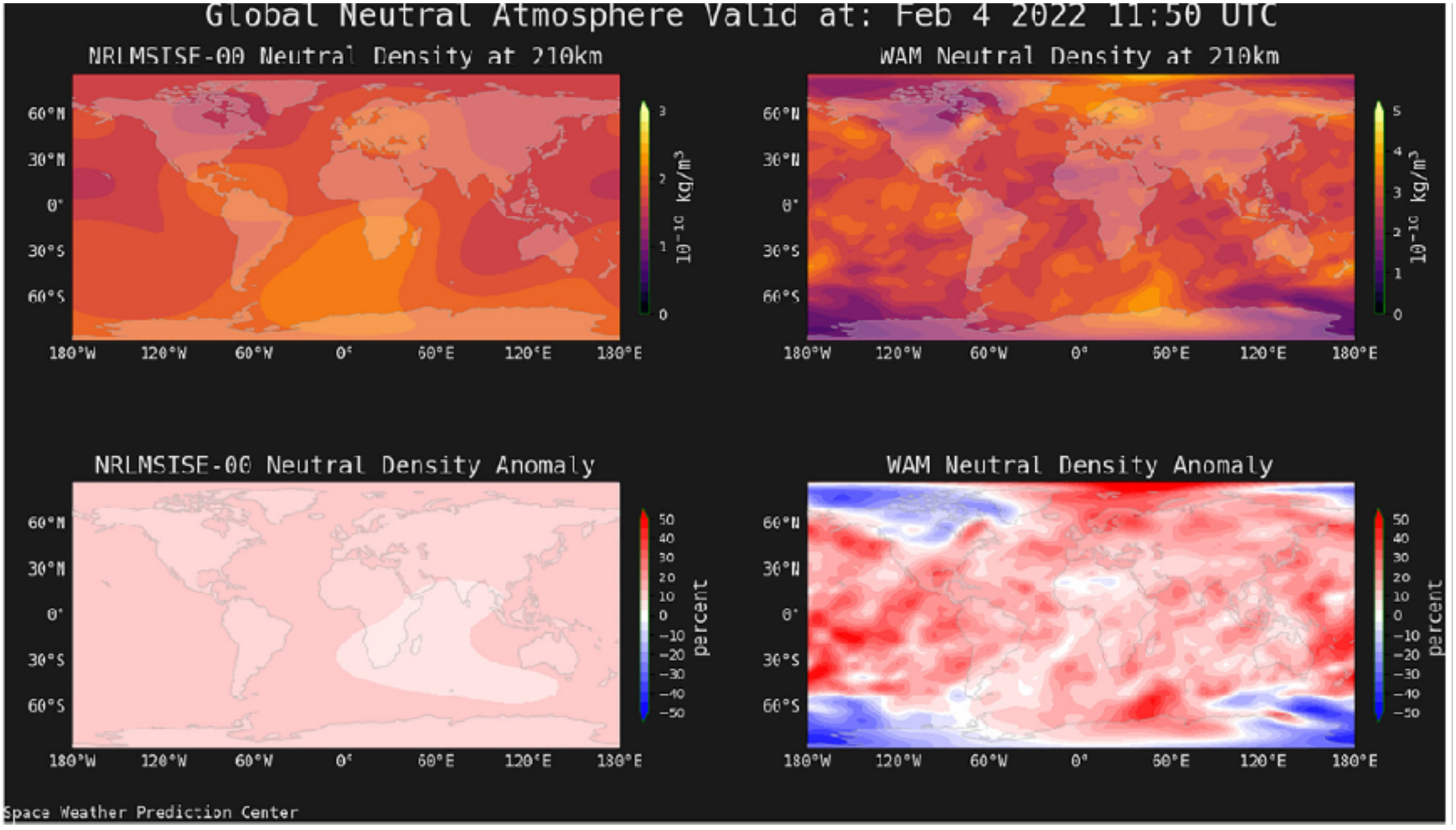
ion-neutral coupling





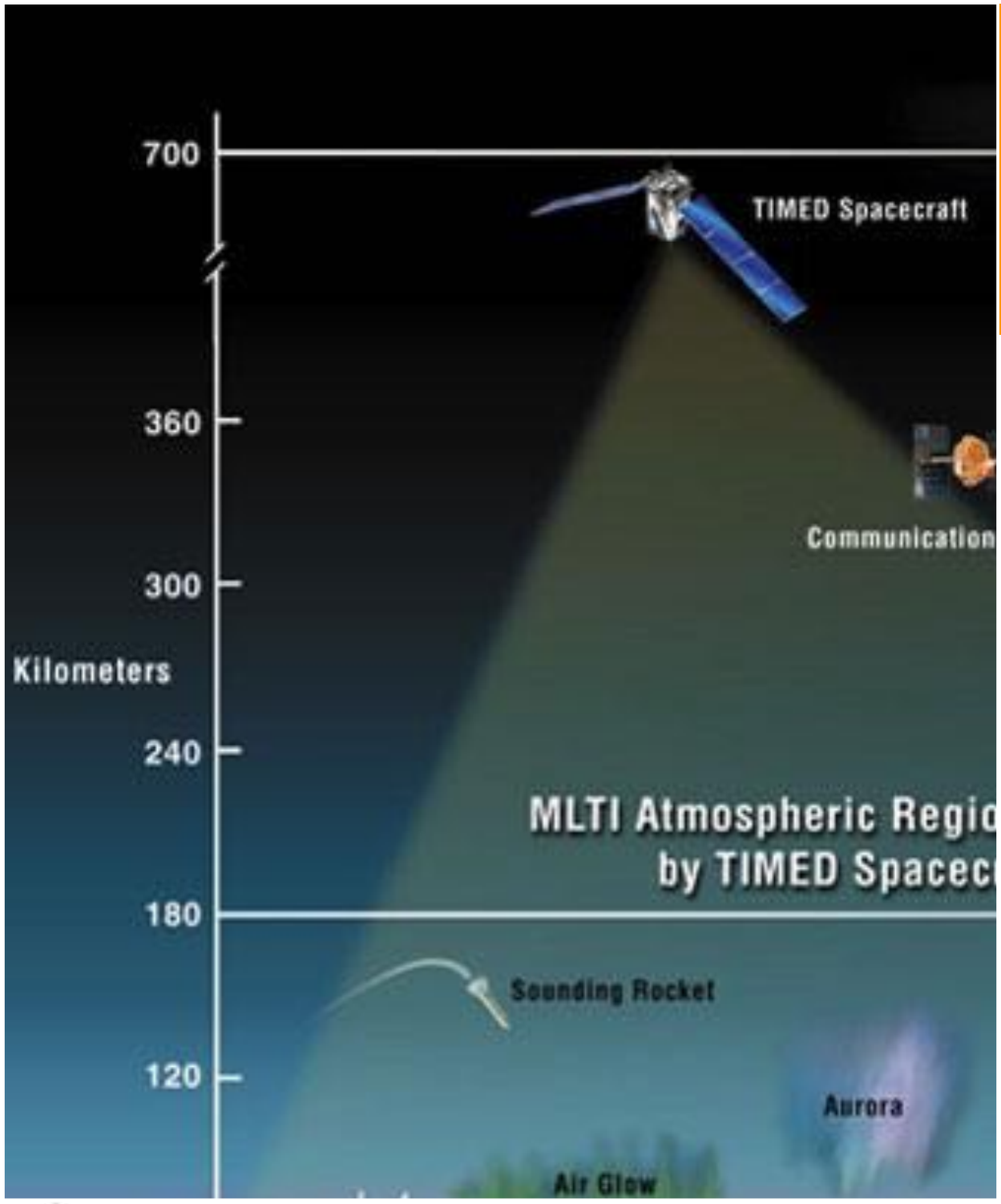
lower-upper atm. coupling

CCMC supports the R2O2R of NOAA/SWPC WAM-IPE by providing WAM-IPE RoR to community and enabling research



Fang et al., Space Weather 2022, Starlink incident

TIE-GCM v3.0 can now be utilized for A-Train and TIMED orbit propagation



1000 km

TIE-GCM V3.0 upper boundary

Most NASA LEO satellite orbits can now be simulated during solar max.

500 km

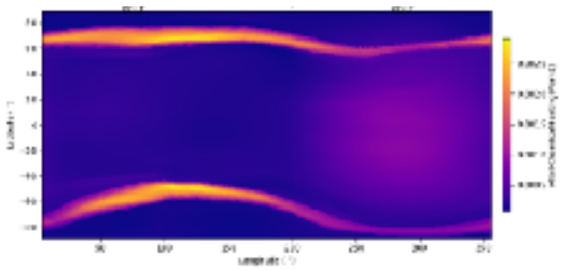
TIE-GCM V2.0 upper boundary

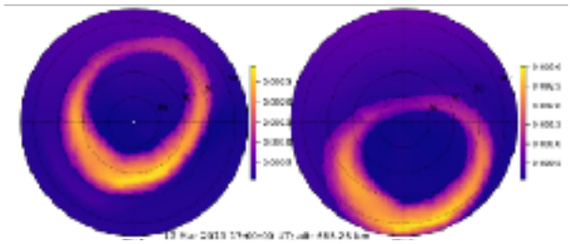
97 km

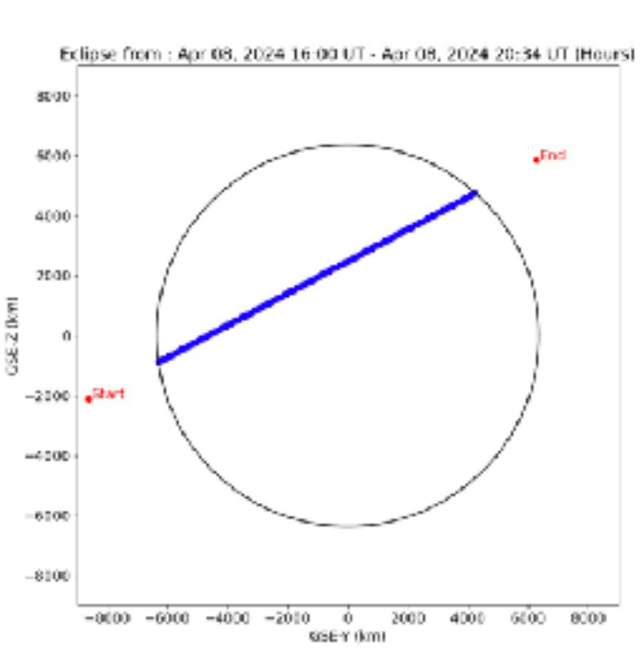
The Global Ionosphere Thermosphere Model (GITM Update)

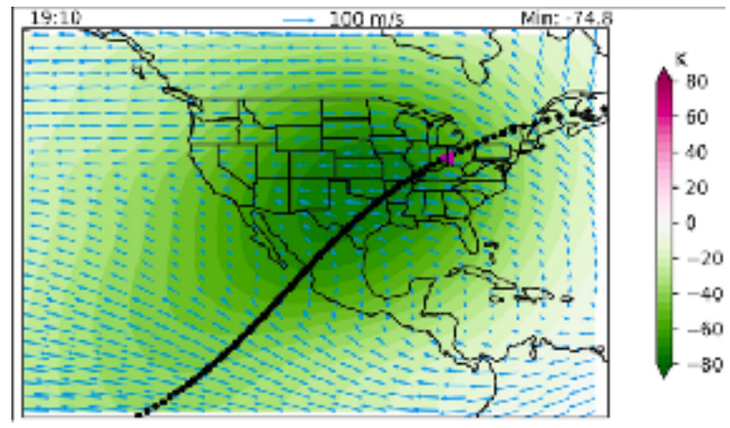
- v25.11
- High lat. precipitation driver default is now **FTA** model for event simulations
- Custom runs: solar eclipse

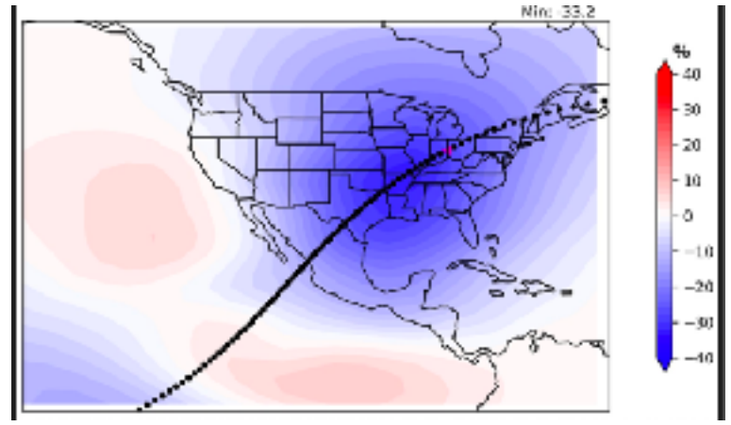
FTA: A Feature Tracking Empirical Model of Auroral Precipitation (Wu+, Space Weather, 2021)







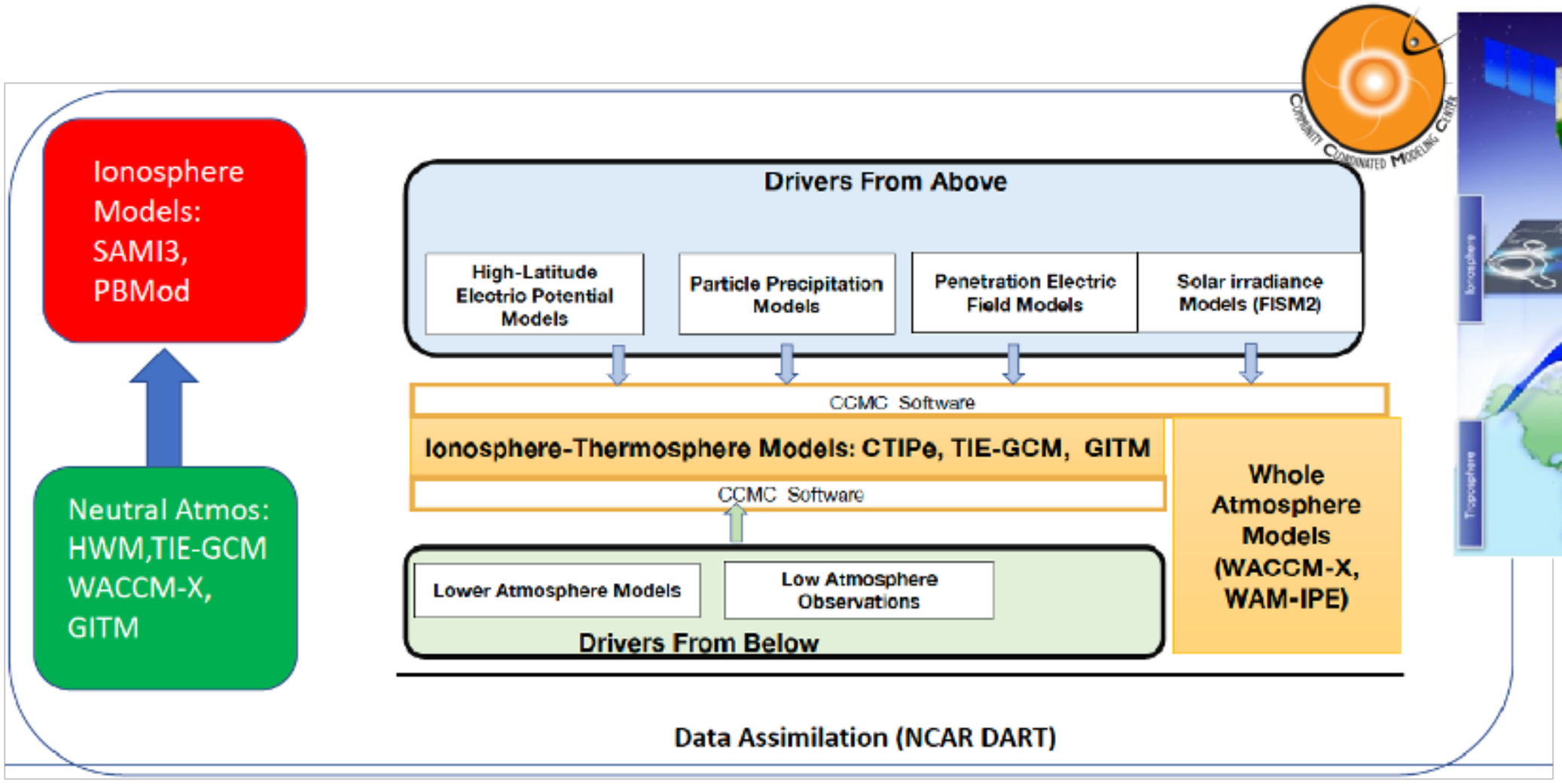


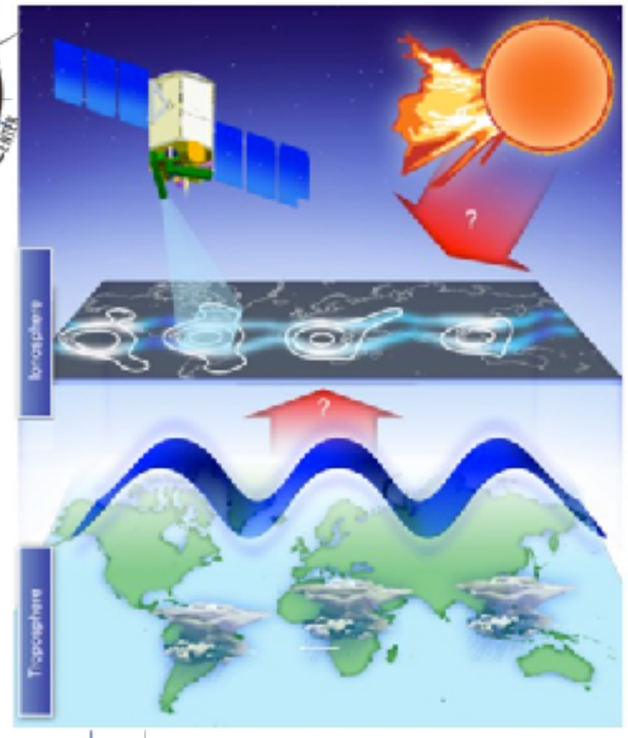


https://github.com/GITMCode/GITM

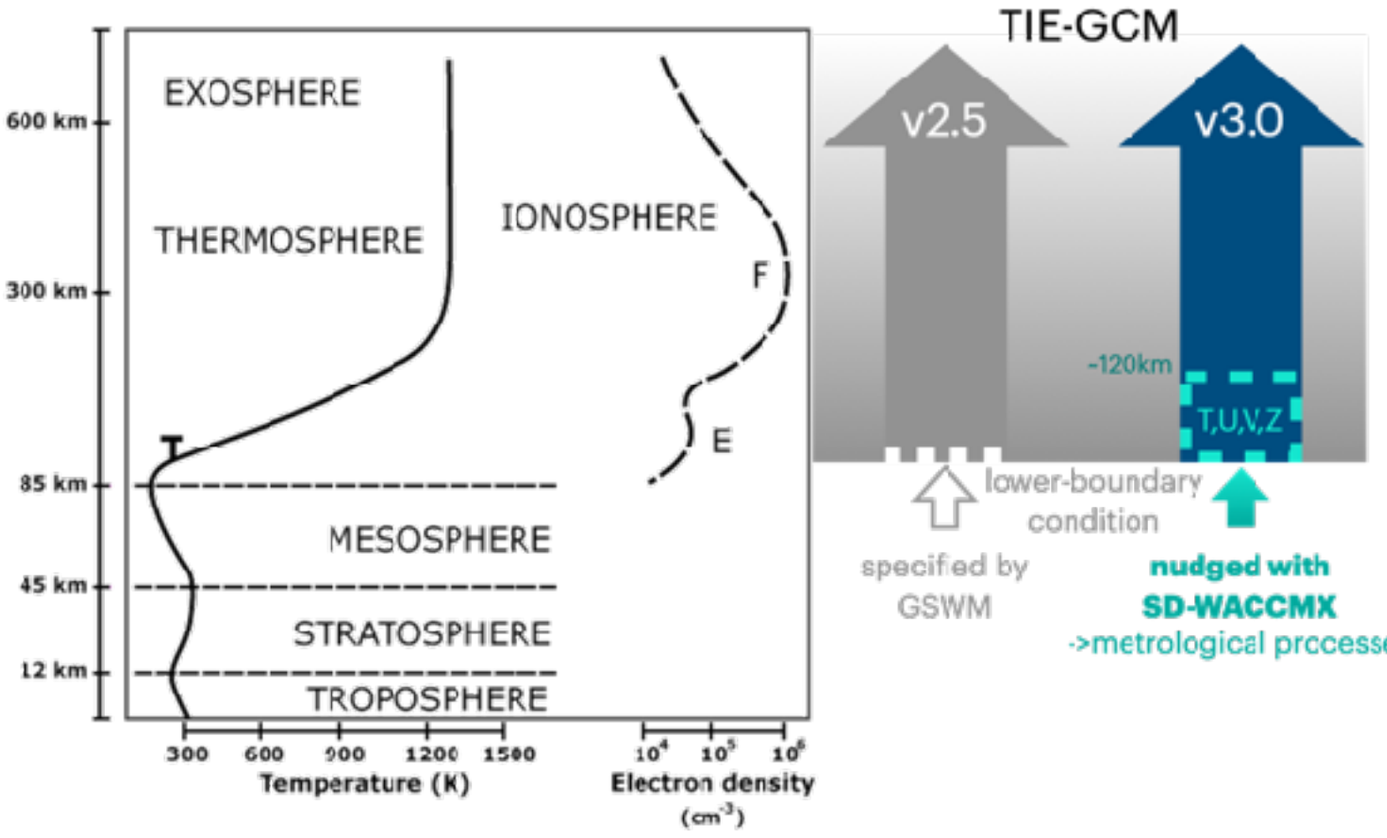
(Ridley et al., 2026)

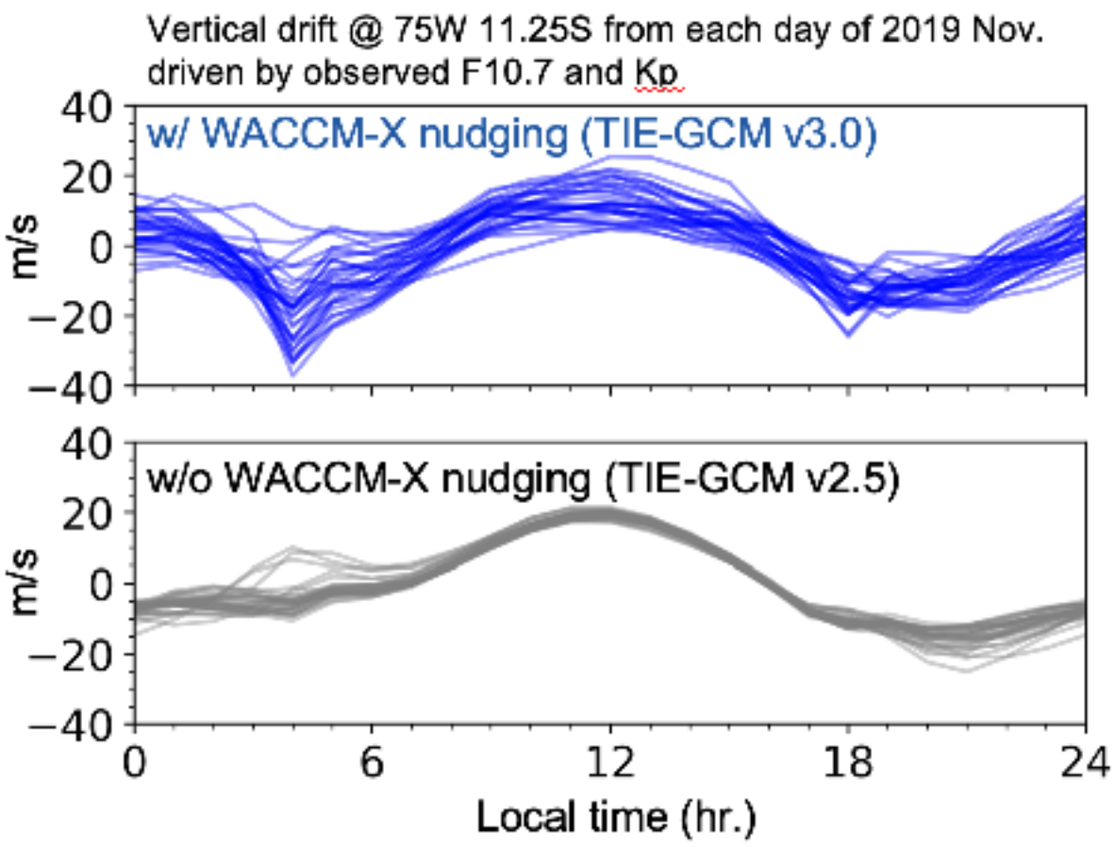
Models and services available at CCMC (thermosphere/ ionosphere models coupling with magnetosphere MHD and lower atmosphere drivers) -- providing system solution





TIE-GCM v3.0 nudged with SD-WACCMX captures day-to-day variability in the Ionosphere/Thermosphere

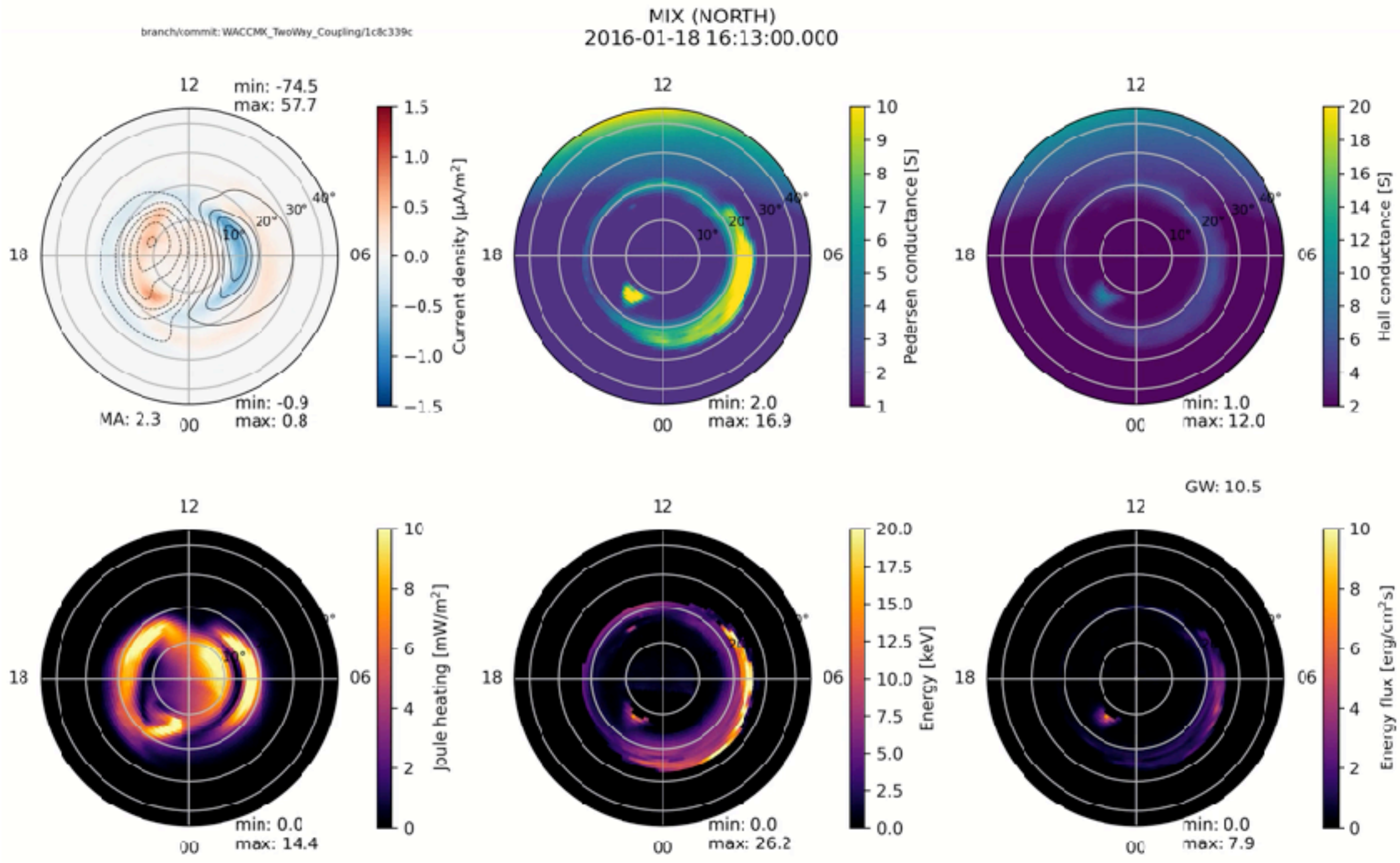




Enhancing the model capability to reproduce variability of the space environment as related to lower atmosphere forcing on day-to-day weather scales.

MAGE Coupled with TIE-GCM

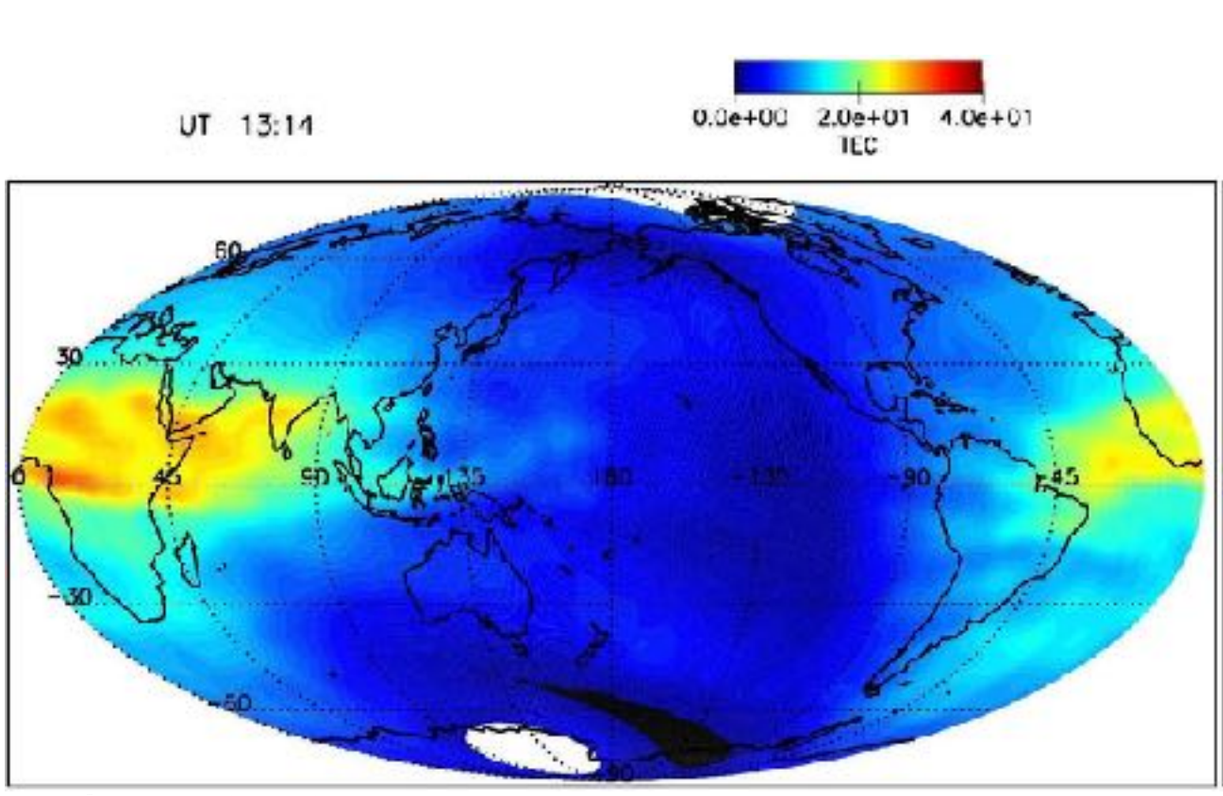
Coupling geospace and atmosphere



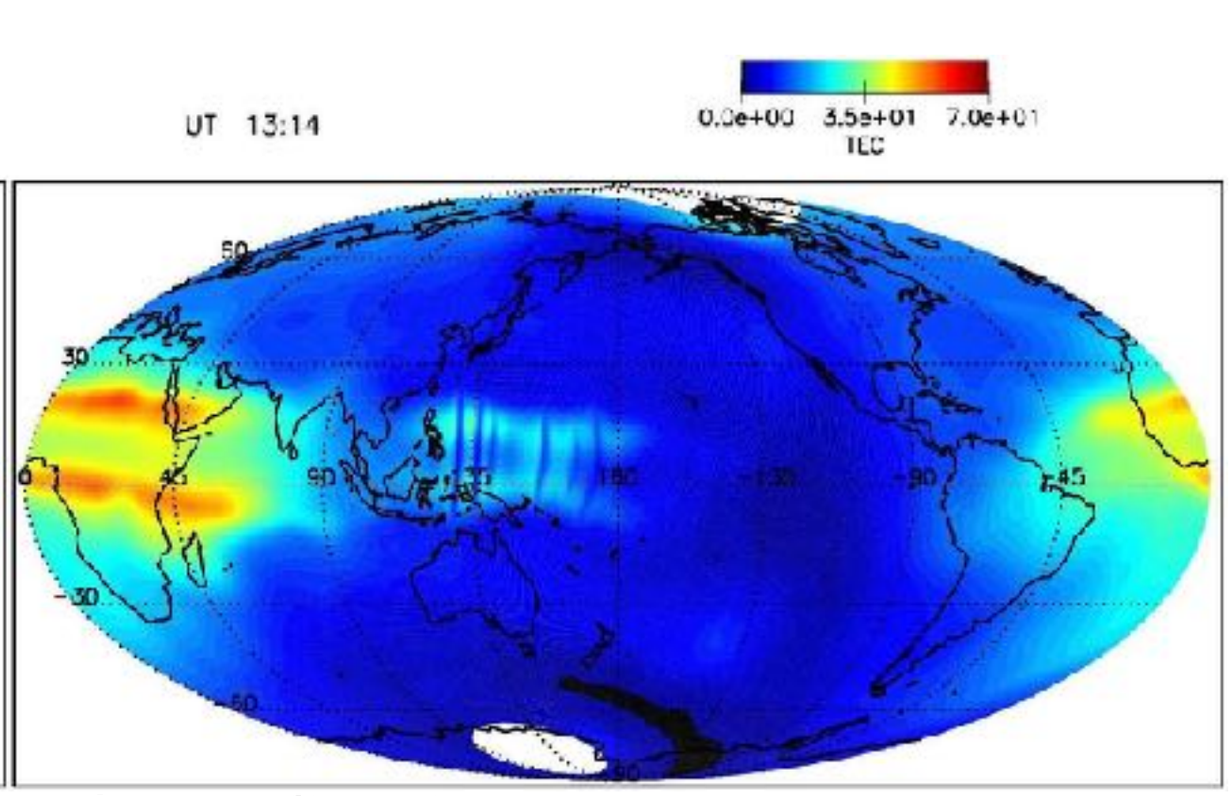
Animation courtesy of Kevin Pham.

First global ionosphere model SAMI3 simulates weather of the ionosphere

- Options of empirical (HWM/MSIS) or physics-based model inputs (e.g., TIE-GCM, TIE-GCM/ICON, WACCM-X)
- SAMI3/WACCM-X is available through CCMC RoR.
  - enable to study **day-to-day variability** of plasma bubbles and TIDs



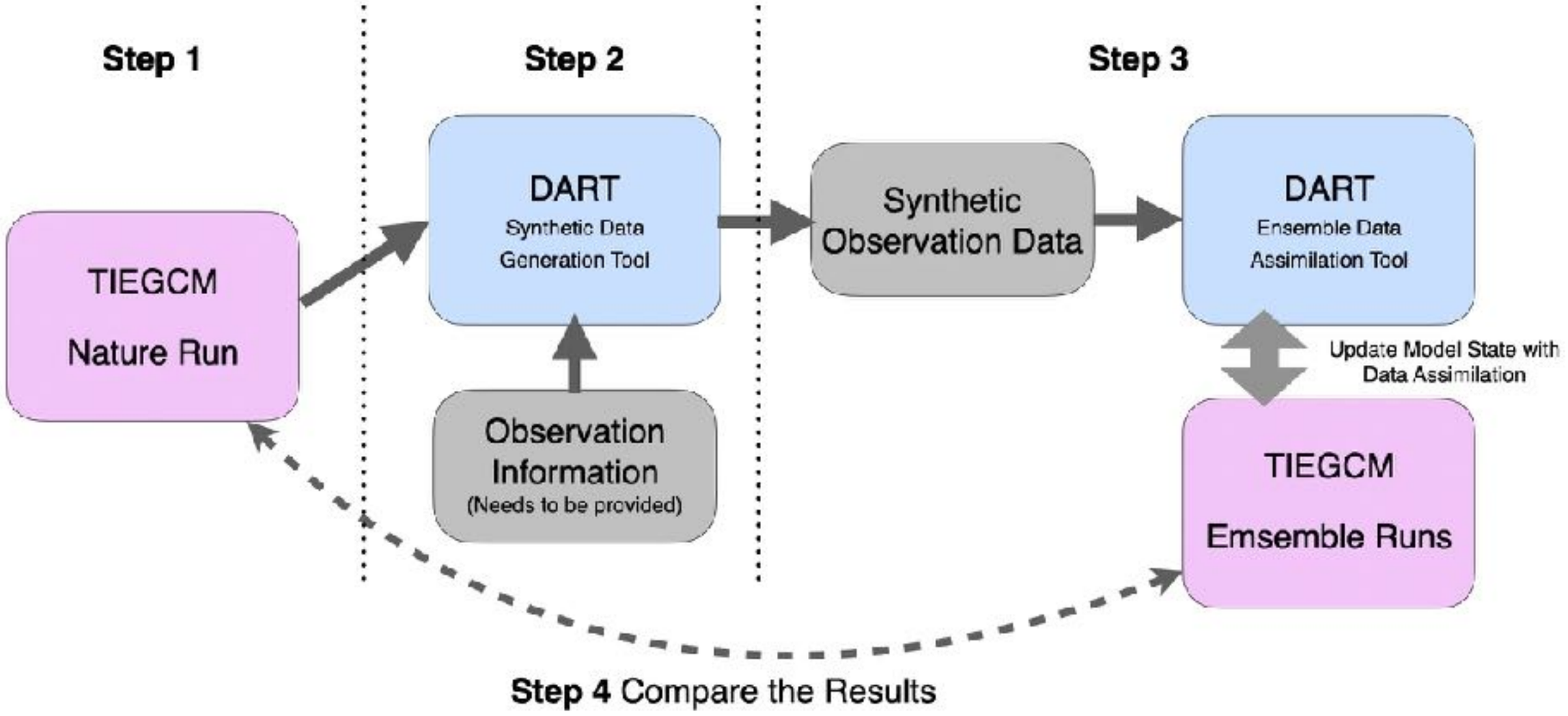
solar min. in Aug.



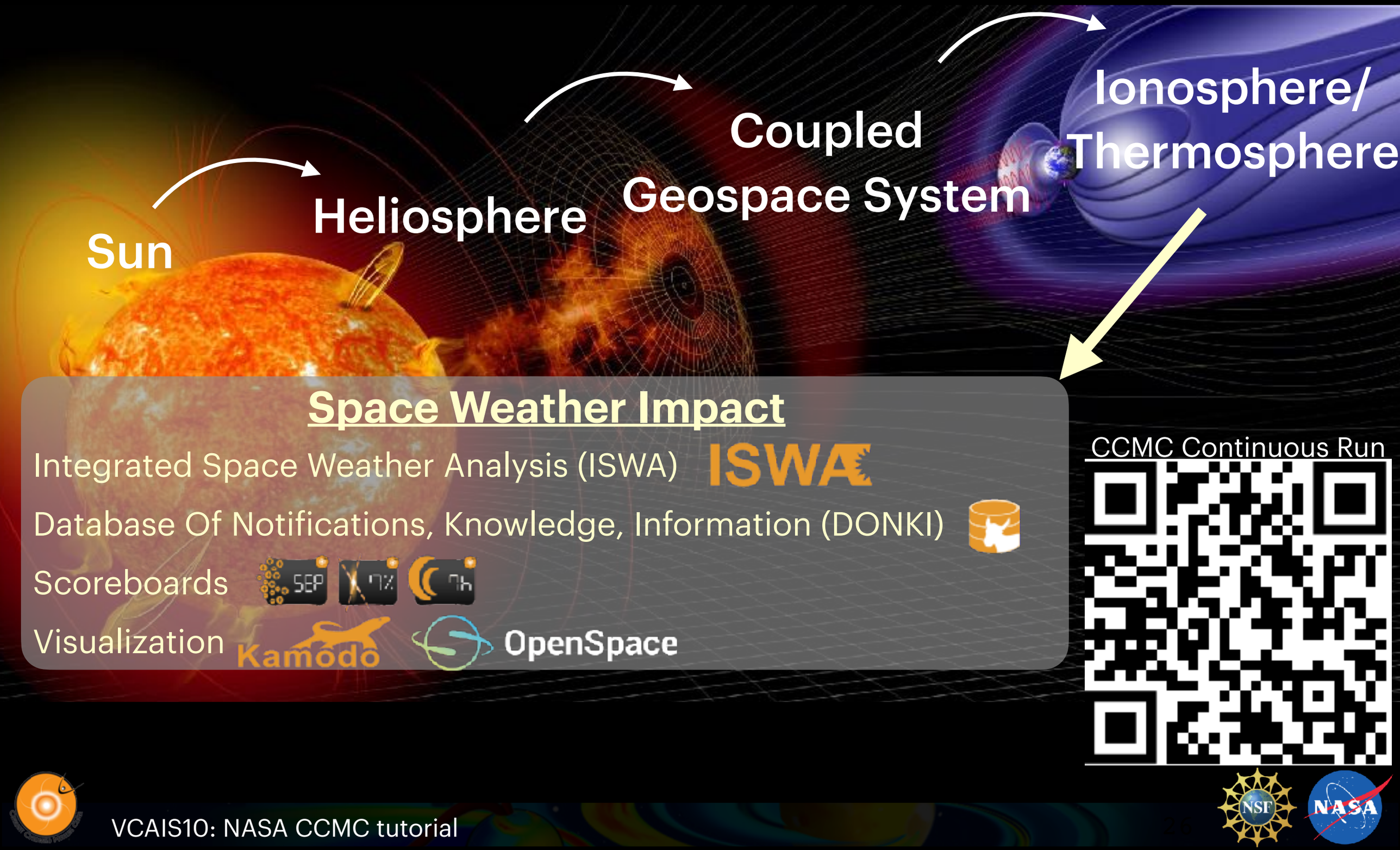
solar medium in Mar.

Observing System Simulation Experiment (OSSE) capability using TIE-GCM and Data Assimilation (DA) Research Testbed is available at CCMC

collaboration with Chih-Ting Hsu & Jeff Anderson (NCAR), Tomoko Matsuo (CU Boulder)



Continuous Run - model runs using near real-time observation data for space weather monitoring and display



Space Weather Impact

Integrated Space Weather Analysis (ISWA) ISWA

Database Of Notifications, Knowledge, Information (DONKI)

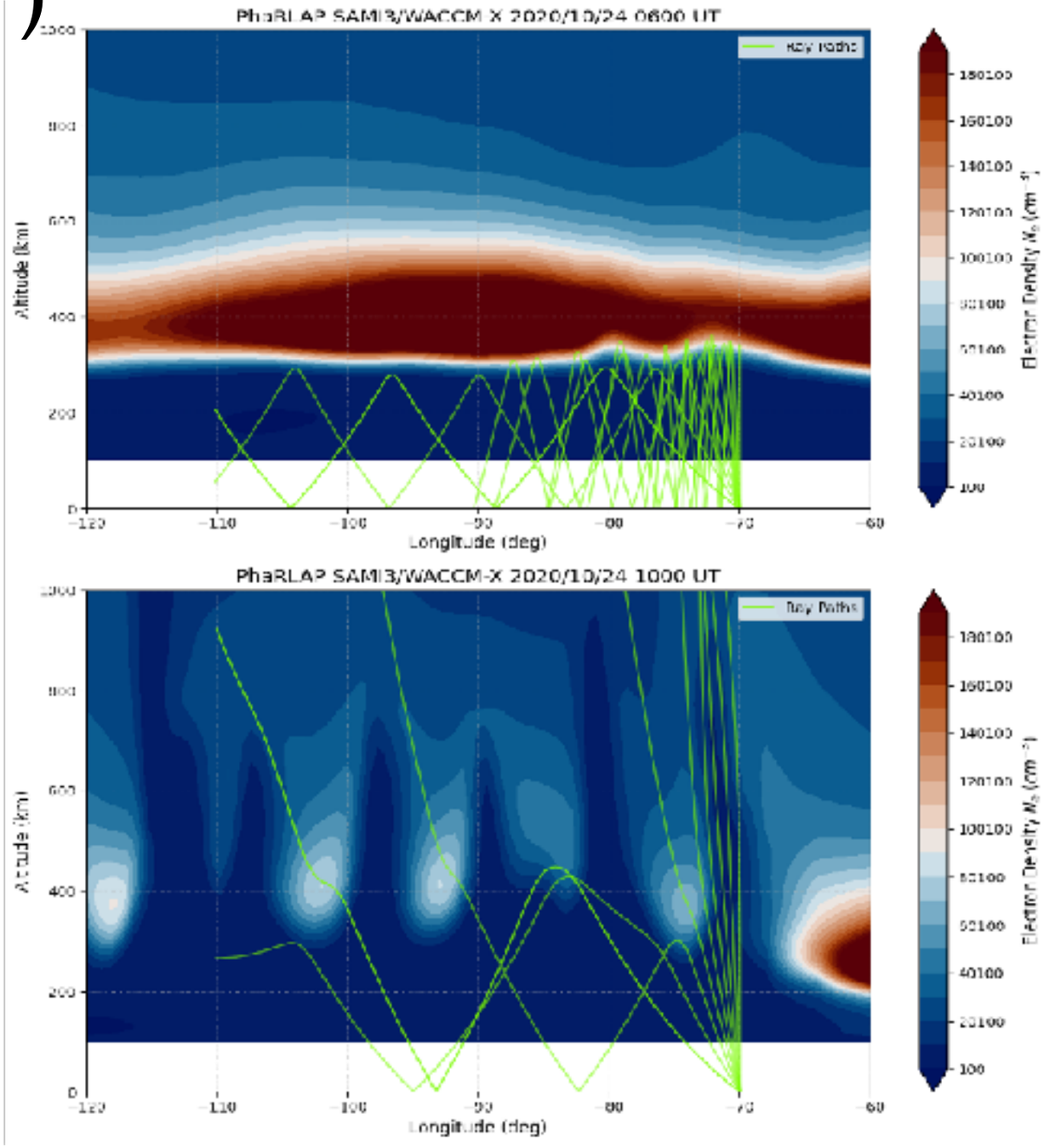
Scoreboards

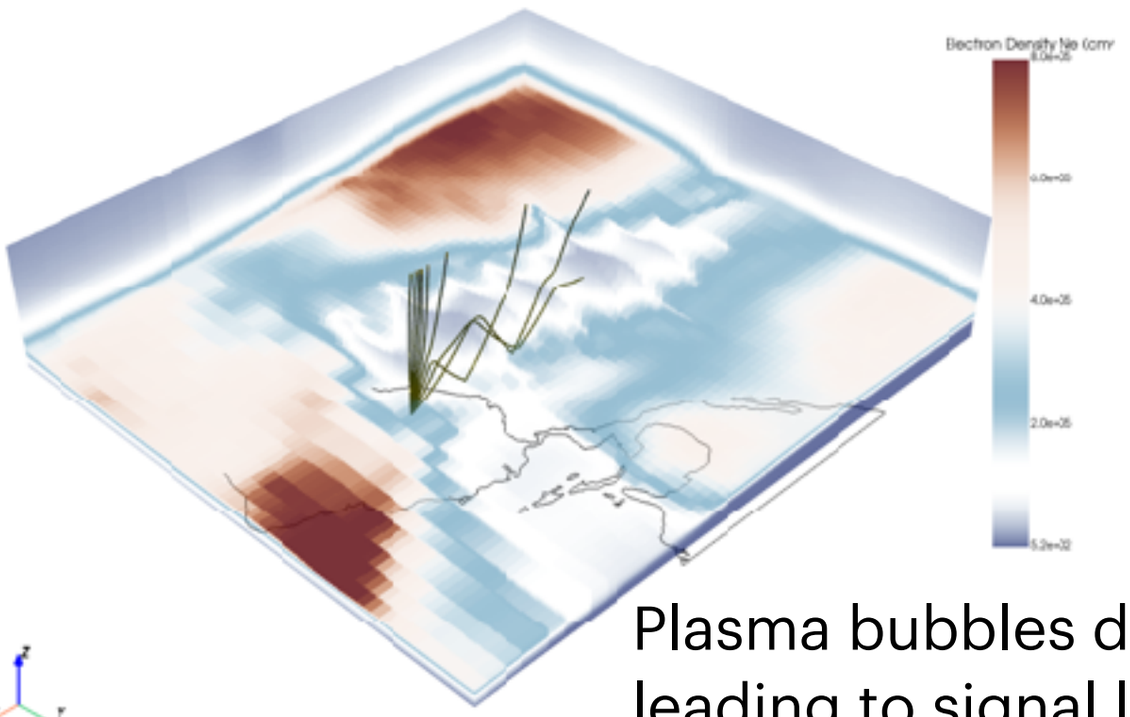
Visualization Kamodo OpenSpace

CCMC Continuous Run

Beyond simulations: Impact-based simulations
HF Signal Propagation (PhaRLAP)

- Developed by Department of Defence, Australia.
- Coupled PhaRLAP with CCMC ionosphere models.
  - PhaRLAP+IR
  - IPhaRLAP+SAMI3





Plasma bubbles distort HF radio wave paths, leading to signal loss and skip zone shifts

Beyond simulations: Impact-based simulations
Orbit propagators

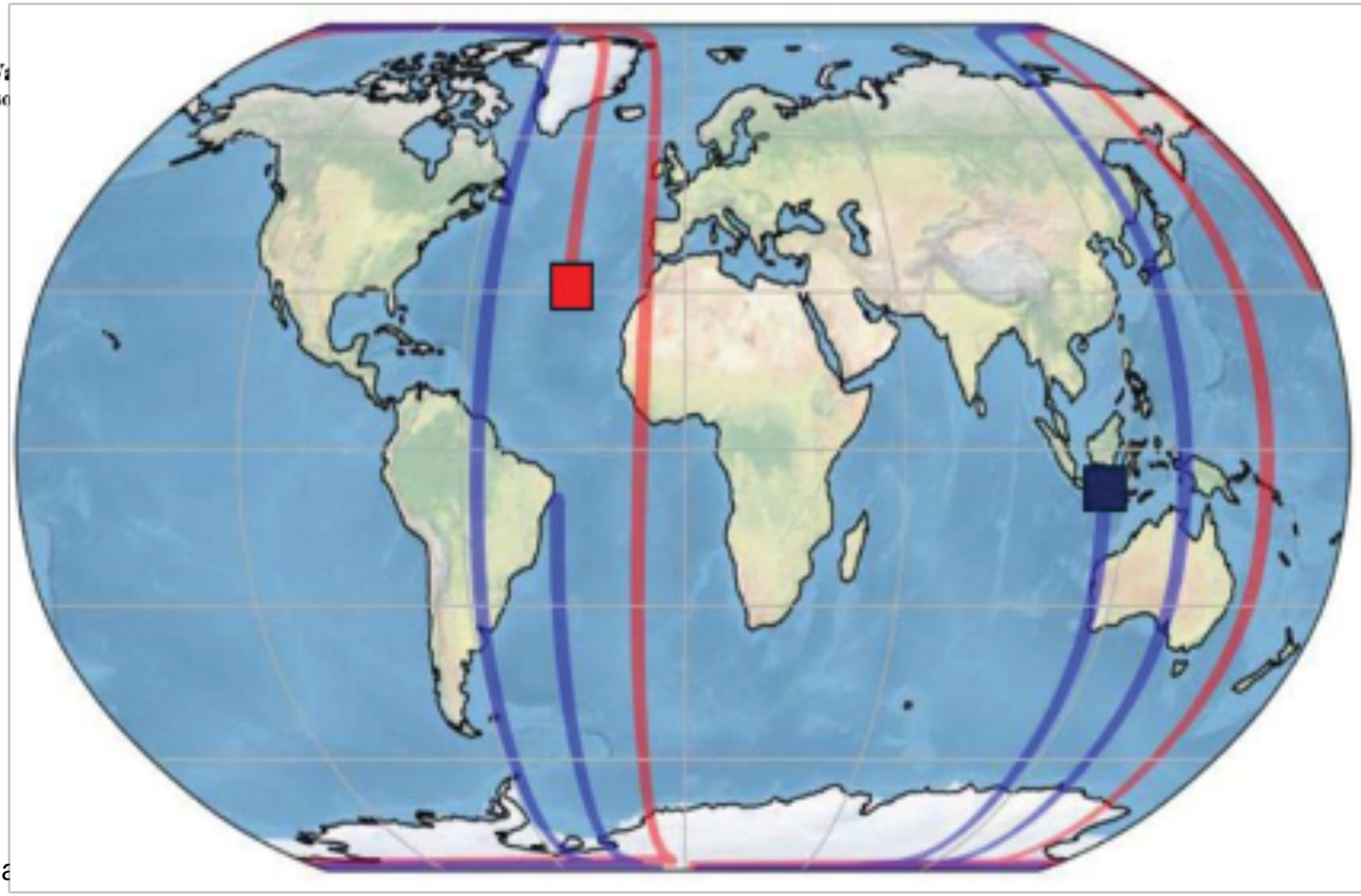
Space Weather

RESEARCH ARTICLE
10.1029/2025SW004835

Special Collection:
Coupling Processes from Space to Earth

Satellite Reentry Predictions During Sudden Stratospheric Warmings

Jia Yue[1,2], Sean Bruinsma[3], Jack W
Jean-Charles Marty[3], and Maria Kuznets

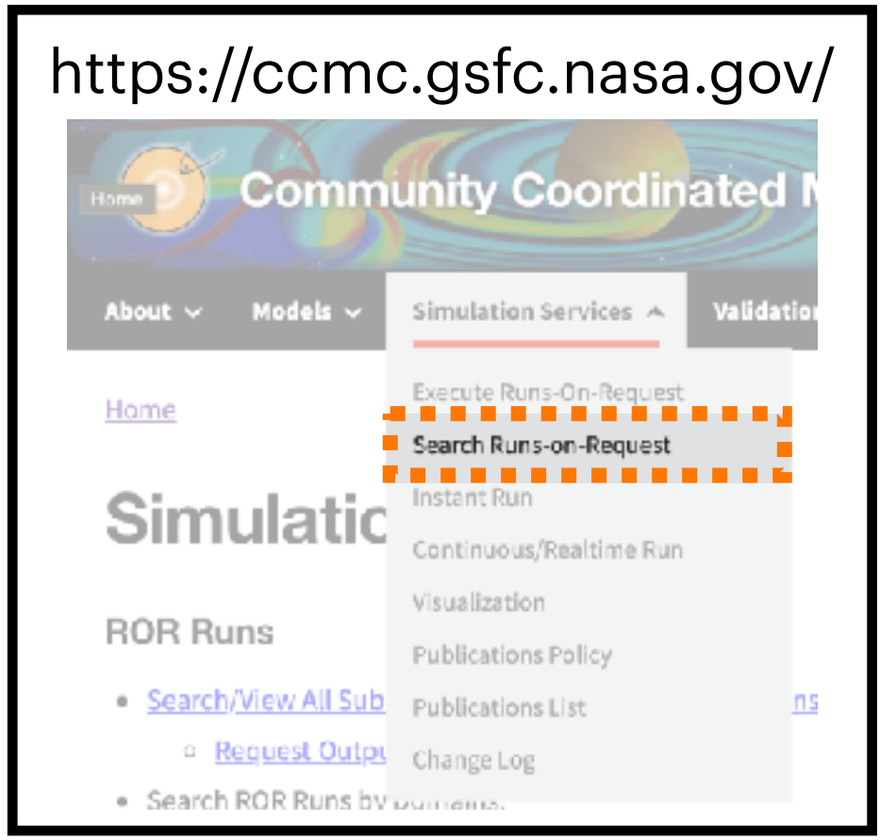


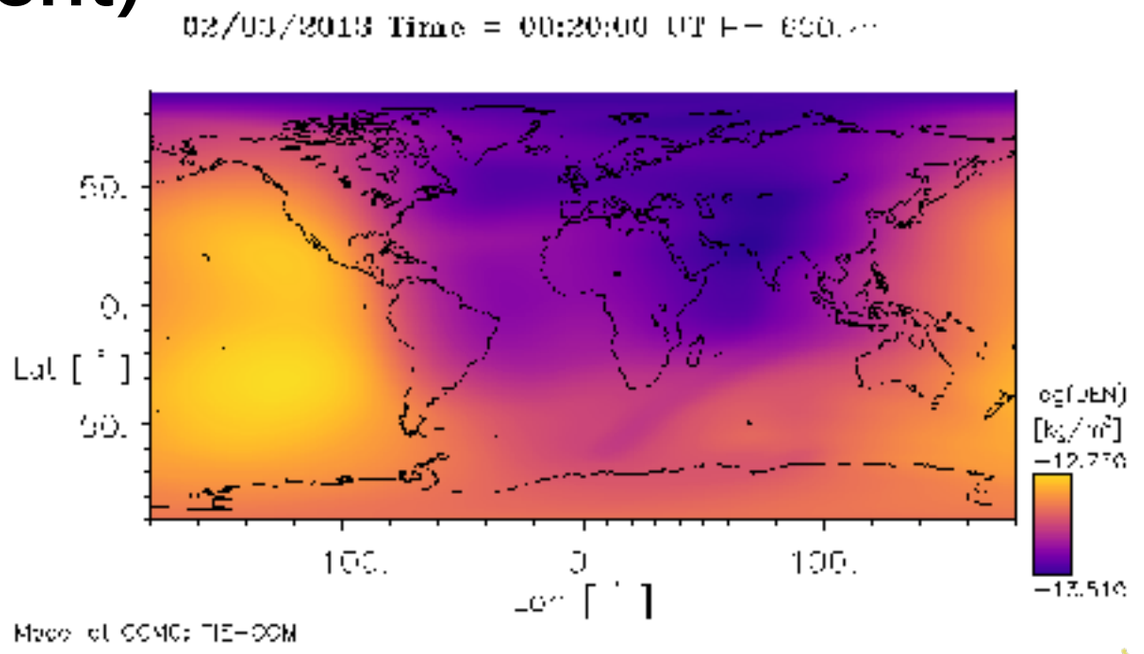
Last reentry orbits for a sta
Red: WACCM-X with realistic Kp and F10.7
Blue: WACCM-X with constant Kp and F10.7
Red and blue rectangles denote the reentry impact locations.

(Yue et al., 2026)

Beyond simulations: Post-Processing and Visualization Tools

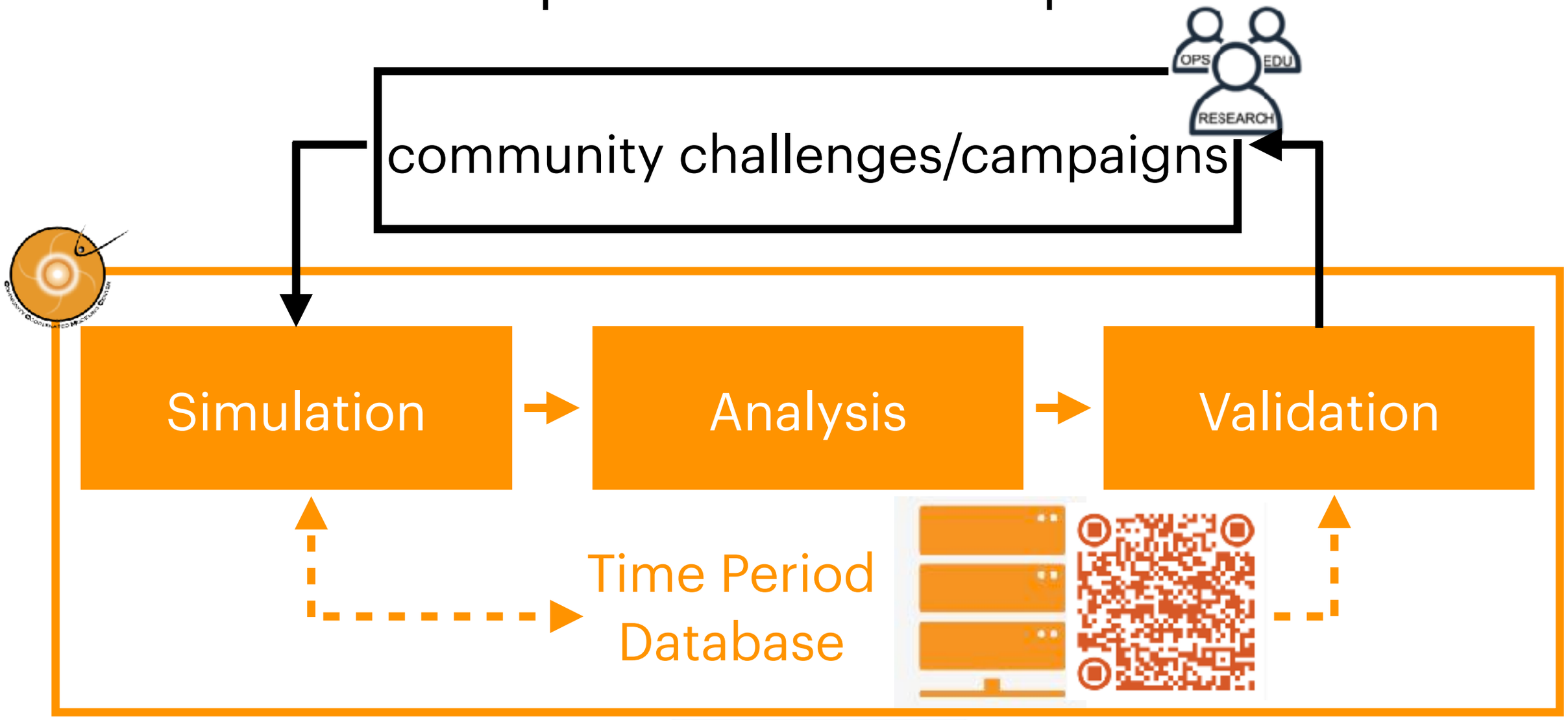
- **Access model output archive**
  - Download model output
  - Visualization
  - Post-processing tool
- **Time Period (e.g., storm event)** database





Beyond simulations: Validation

CCMC serves as an independent evaluator of space weather models

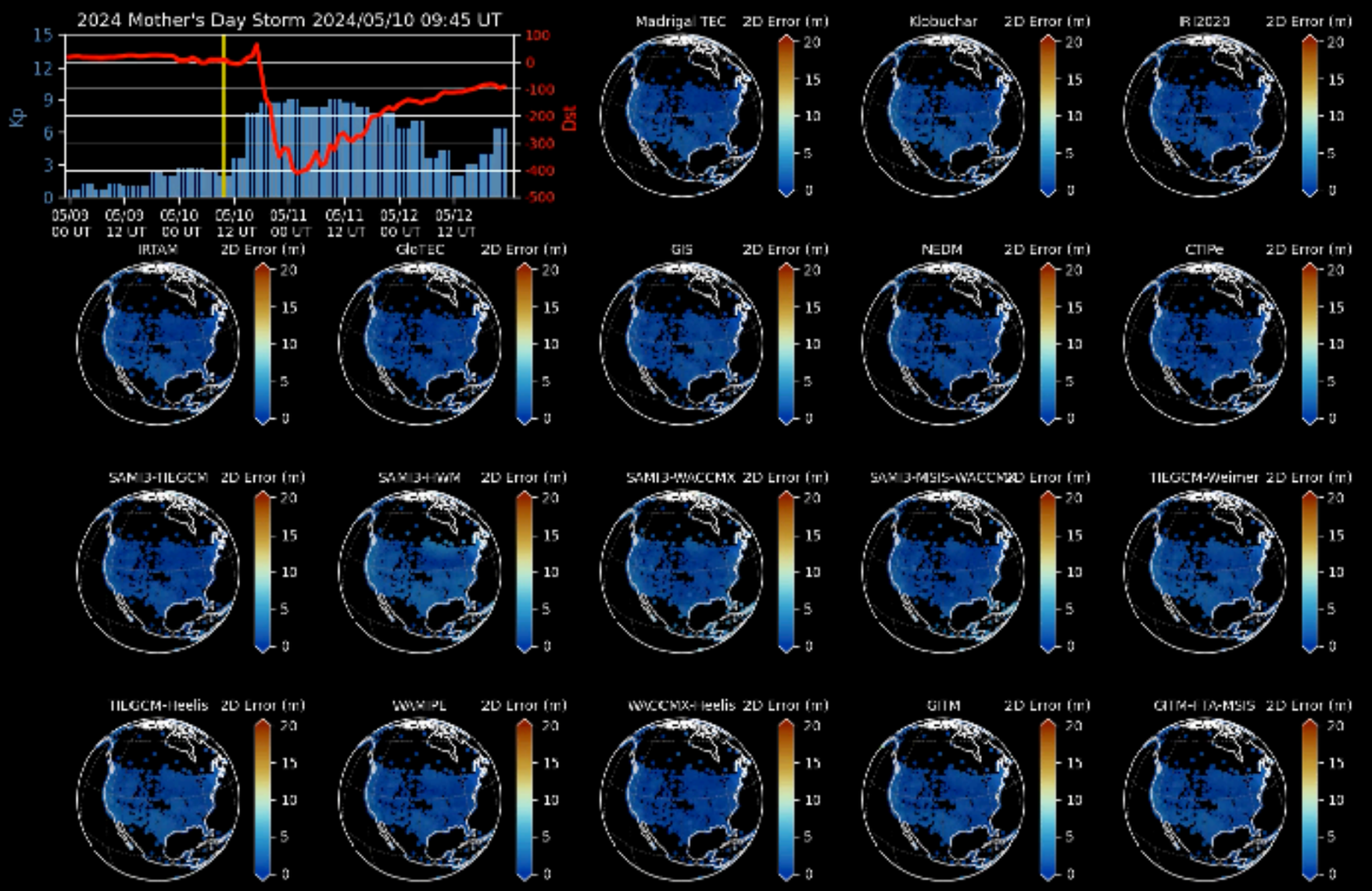


CCMC validation platform

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

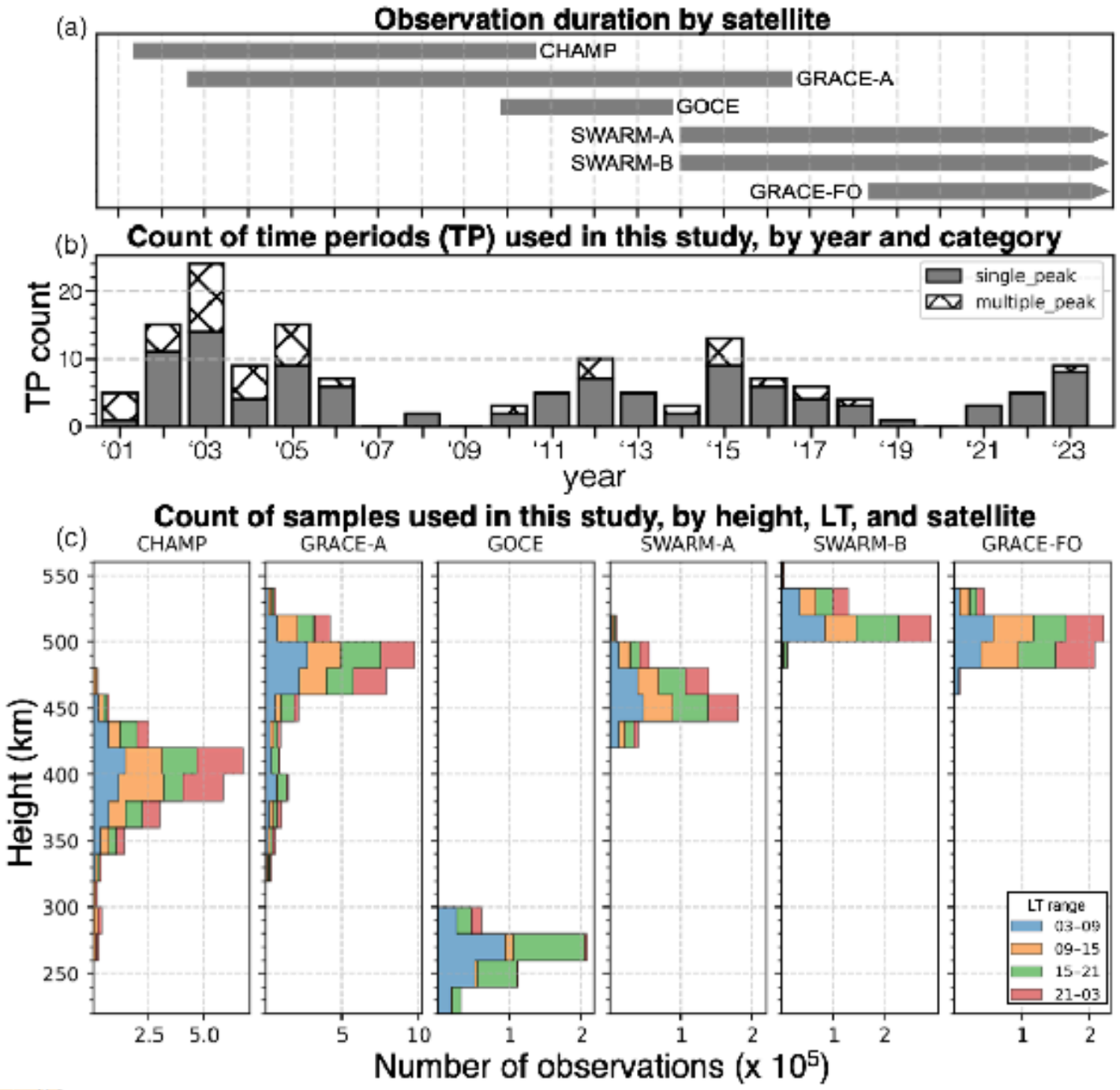
Beyond simulations: Validation
Model Performance in Single Frequency (SF) GNSS Positioning

- Ionosphere is the primary error source for SF GNSS positioning.
- Accurate ionosphere model can mitigate the positioning error
- SF GNSS positioning technique can be used as a technological metric to evaluate model performance in real-world application



Beyond simulations: Validation

Thermospheric neutral density assessment during geomagnetically disturbed periods



151 storm intervals (Time Period) identified based on observation availability and ap index from 2001-2023.

We acknowledge TU Delft for providing the neutral density dataset.

Beyond simulations: Validation, neutral density scorecard

Heelis-driven runs outperform their Weimer-driven counterparts

Skills By Phase

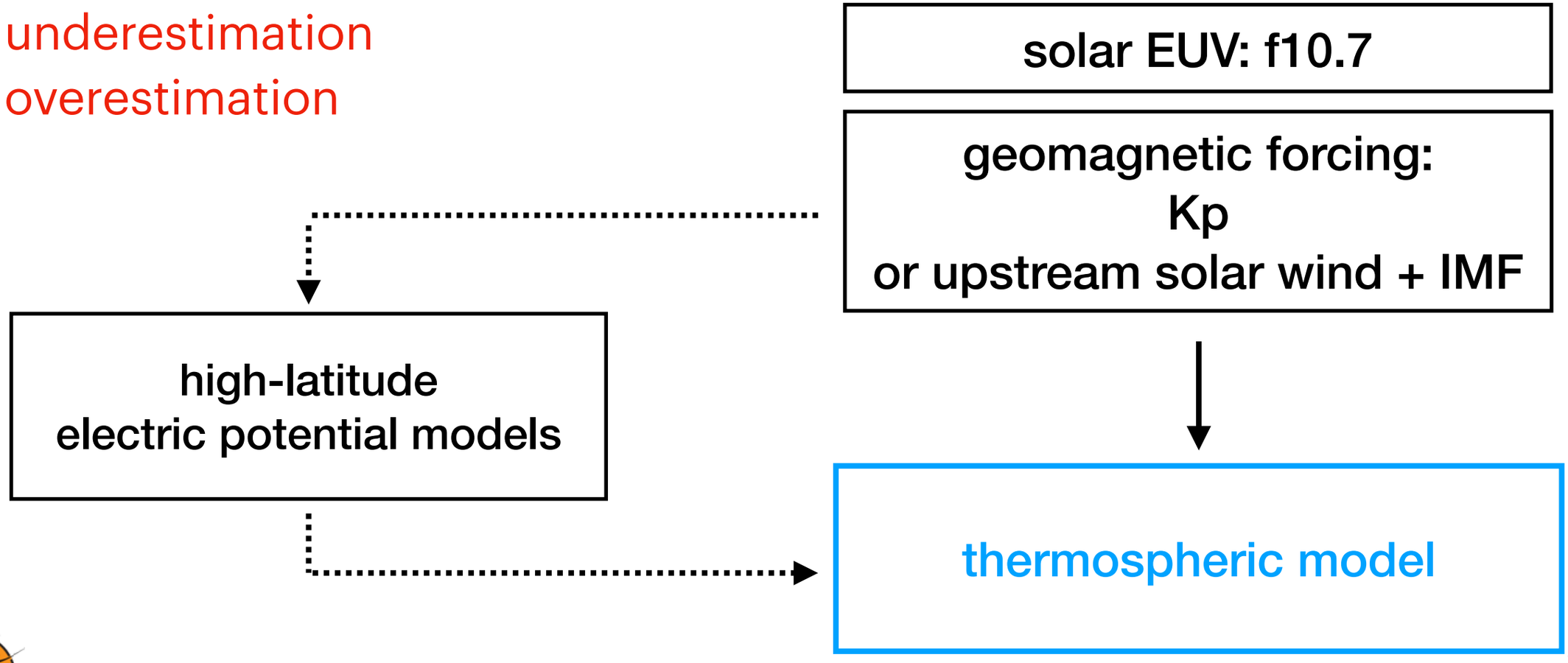
model	total	onset	main_recovery	post_storm
TIEGCM-Heelis	1.14 ± 42.0%	1.13 ± 24.2%	1.19 ± 51.3%	1.05 ± 53.6%
TIEGCM-Weimer	1.18 ± 29.3%	1.13 ± 21.2%	1.27 ± 40.5%	1.05 ± 23.6%
WACCMX-Heelis	1.08 ± 15.7%	1.09 ± 14.8%	1.12 ± 19.0%	0.98 ± 16.6%
WACCMX-Weimer	1.15 ± 18.1%	1.11 ± 15.4%	1.21 ± 22.7%	1.02 ± 16.7%

1 = best

>1: underestimation

<1: overestimation

drivers

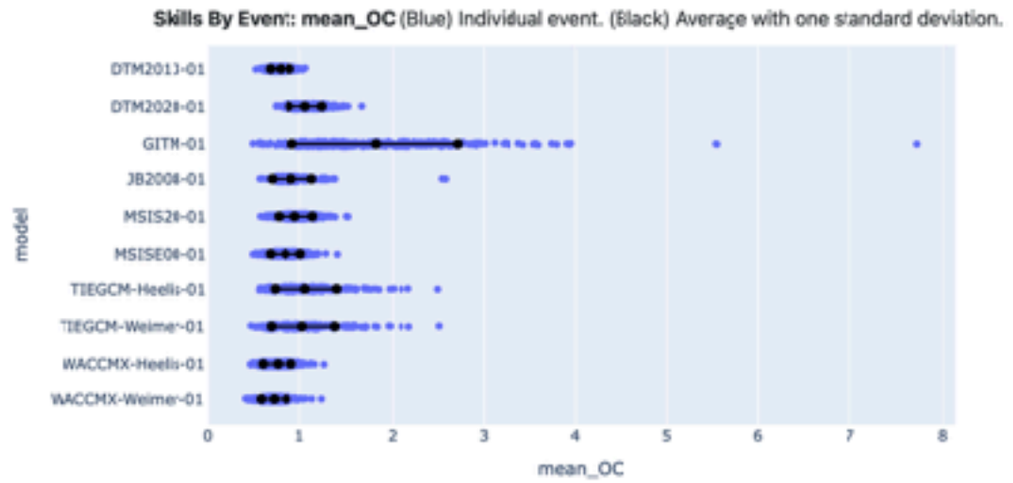


Beyond simulations: Validation

- User-friendly frontend to explore and compare validation result.
- Trace progress over time by incorporating newer model versions, run settings, and latest events

CCMC validation platform

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



Skills By Phase

model	total	pre_storm	onset	main_recovery	post_storm
DTM2013-01	0.78	0.79	0.8	0.79	0.76
DTM2020-01	1.07	1.03	1.08	1.11	1.02
GITM-01	1.82	1.76	1.84	1.86	1.81
JB2008-01	0.91	0.91	0.94	0.91	0.89
MSIS20-01	0.98	0.9	0.89	1.06	0.94
MSISE00-01	0.86	0.8	0.78	0.93	0.83
TIEGCM-Heelis-01	1.08	1	1.1	1.14	0.99
TIEGCM-Weimer-01	1.05	0.94	1.03	1.14	0.96
WACCMX-Heelis-01	0.76	0.73	0.78	0.79	0.7
WACCMX-Weimer-01	0.73	0.66	0.72	0.77	0.66

Storm IDs

Space Weather

RESEARCH ARTICLE
10.1029/2025SW004782

Comprehensive and Open Assessment of Thermospheric Models During Geomagnetic Storm Times Within CCMC Framework

Key Points:

- Thermospheric models hosted at the Community Coordinated Modeling Center are assessed against neutral density observations across 151 geomagnetic storms from 2001 to 2023
- DTM2020 shows the best overall skill

Jack C. Wang[1,2], Jia Yue[1,2], Sean Bruinsma[3], Masha Kuznetsova[2], Joseph Sypal[1], Richard Mullinix[2], Chiu Wiegand[2], Paul Dimarzio[1], Min-Yang Chou[1,2], Maksym Petrenko[2], Christian Siemes[4], and Sophie Laurens[3]

Space Weather

RESEARCH ARTICLE
10.1029/2025SW004835

Special Collection:
Coupling Processes from Space to Earth

Satellite Reentry Predictions During Sudden Stratospheric Warmings

Jia Yue[1,2], Sean Bruinsma[3], Jack Wang[1,2], Nicholas Pedatella[4], Wandi Yu[5], Jean-Charles Marty[3], and Maria Kuznetsova[1]

Space Weather

RESEARCH ARTICLE
10.1029/2025SW004868

Special Collection:
Space Weather Events of 2024 May 9-15

Assessment of Ionospheric Model Performance Over the US During the Extreme G5 2024 Mother's Day Geomagnetic Storm

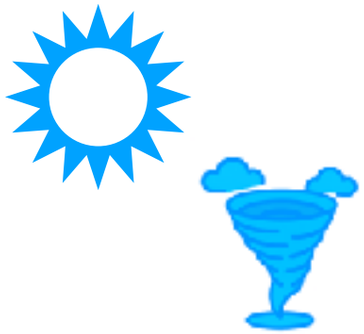
Key Points:

- A comprehensive assessment of 17

Min-Yang Chou[1,2], Jia Yue[1,2], Deimos Ibáñez Segura[3], J. D. Huba[4], Tzu-Wei Fang[5], Charles Lin[6], Chi-Yen Lin[7], Aaron Bukowski[8], Aaron Ridley[8], Ivan Galkin[9], Dieter Bilitza[10], Jack Wang[1,2], Mohammed Mainul Hoque[11], Maksym Petrenko[1], Paul Dimarzio[2], and Maria M. Kuznetsova[1]

Time Period database: a curated collection for consistent model evaluation

carefully selected geospace events



based on science criteria

unified model inputs

F10.7, Kp, ...

applied to all models

multiple models runs consistently

TIE-GCM
GITM
WACCM-X

SWMF
MAGE
Weimer

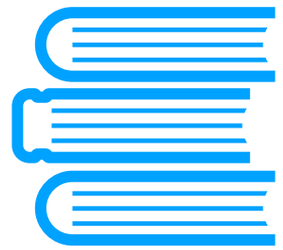
output archived

Standardized outputs & metadata

Σ, ρ,
electric field
TEC

public access

used for model validation & inter-comparison



All model simulation output are publicly available on CCMC TP database. (https://kauai.ccmc.gsfc.nasa.gov/CMR/TimeInterval/viewAllTI)

Table S1. Summary of thermospheric model outputs and associated Runs-on-Request (RoR) links in this study for each storm event, including event timing parameters (t0–t4), observing instrument, storm type (SP: single-peak event, MP: multiple-peak event), and links to model outputs from multiple thermosphere-ionosphere models (e.g., DTM, GITM, CTIPe, JB2008, TIEGCM, WACCMX, WAM-IPE) hosted via CCMC RoR.

	TPID	instrument	storm_type	t1	t2	t0	t3	t4
0	2001-09-TP-01	CHAMP	MP	2001-09-22 13:30:00	2001-09-23 01:30:00	2001-09-23 19:30:00	2001-09-27 10:30:00	2001-09-27 22:30:00
1	2001-09-TP-02	CHAMP	MP	2001-09-29 22:30:00	2001-09-30 10:30:00	2001-10-01 04:30:00	2001-10-05 04:30:00	2001-10-05 16:30:00
2	2001-10-TP-01	CHAMP	SP	2001-10-10 19:30:00	2001-10-11 07:30:00	2001-10-12 01:30:00	2001-10-13 13:30:00	2001-10-14 01:30:00
3	2001-10-TP-02	CHAMP	MP	2001-10-20 10:30:00	2001-10-20 22:30:00	2001-10-21 16:30:00	2001-10-24 10:30:00	2001-10-24 22:30:00
4	2001-11-TP-02	CHAMP	MP	2001-11-04 19:30:00	2001-11-05 07:30:00	2001-11-06 01:30:00	2001-11-08 10:30:00	2001-11-08 22:30:00
5	2002-02-TP-01	CHAMP	SP	2002-02-27 16:30:00	2002-02-28 04:30:00	2002-02-28 22:30:00	2002-03-02 10:30:00	2002-03-02 22:30:00
6	2002-03-TP-01	CHAMP	SP	2002-03-22 22:30:00	2002-03-23 10:30:00	2002-03-24 04:30:00	2002-03-25 16:30:00	2002-03-26 04:30:00
7	2002-04-TP-01	GRACE	MP	2002-04-16 04:30:00	2002-04-16 16:30:00	2002-04-17 10:30:00	2002-04-22 04:30:00	2002-04-22 16:30:00
8	2002-04-TP-01	CHAMP	MP	2002-04-16 04:30:00	2002-04-16 16:30:00	2002-04-17 10:30:00	2002-04-22 04:30:00	2002-04-22 16:30:00
9	2002-04-TP-02	CHAMP	SP	2002-04-22 01:30:00	2002-04-22 13:30:00	2002-04-23 07:30:00	2002-04-24 19:30:00	2002-04-25 07:30:00
10	2002-04-TP-02	GRACE	SP	2002-04-22 01:30:00	2002-04-22 13:30:00	2002-04-23 07:30:00	2002-04-24 19:30:00	2002-04-25 07:30:00
11	2002-05-TP-01	GRACE	SP	2002-05-10 07:30:00	2002-05-10 19:30:00	2002-05-11 13:30:00	2002-05-13 01:30:00	2002-05-13 13:30:00
12	2002-05-TP-01	CHAMP	SP	2002-05-10 07:30:00	2002-05-10 19:30:00	2002-05-11 13:30:00	2002-05-13 01:30:00	2002-05-13 13:30:00
13	2002-05-TP-02	CHAMP	SP	2002-05-22 04:30:00	2002-05-22 16:30:00	2002-05-23 10:30:00	2002-05-24 22:30:00	2002-05-25 10:30:00
14	2002-07-TP-01	GRACE	SP	2002-07-31 19:30:00	2002-08-01 07:30:00	2002-08-02 01:30:00	2002-08-03 13:30:00	2002-08-04 01:30:00
15	2002-07-TP-01	CHAMP	SP	2002-07-31 19:30:00	2002-08-01 07:30:00	2002-08-02 01:30:00	2002-08-03 13:30:00	2002-08-04 01:30:00
16	2002-08-TP-01	CHAMP	SP	2002-08-19 16:30:00	2002-08-20 04:30:00	2002-08-20 22:30:00	2002-08-22 10:30:00	2002-08-22 22:30:00
17	2002-08-TP-01	GRACE	SP	2002-08-19 16:30:00	2002-08-20 04:30:00	2002-08-20 22:30:00	2002-08-22 10:30:00	2002-08-22 22:30:00
18	2002-09-TP-01	GRACE	SP	2002-09-02 22:30:00	2002-09-03 10:30:00	2002-09-04 04:30:00	2002-09-05 16:30:00	2002-09-06 04:30:00
19	2002-09-TP-01	CHAMP	SP	2002-09-02 22:30:00	2002-09-03 10:30:00	2002-09-04 04:30:00	2002-09-05 16:30:00	2002-09-06 04:30:00
20	2002-09-TP-03	GRACE	SP	2002-09-06 10:30:00	2002-09-06 22:30:00	2002-09-07 16:30:00	2002-09-09 04:30:00	2002-09-09 16:30:00
21	2002-09-TP-03	CHAMP	SP	2002-09-06 10:30:00	2002-09-06 22:30:00	2002-09-07 16:30:00	2002-09-09 04:30:00	2002-09-09 16:30:00
22	2002-09-TP-04	GRACE	MP	2002-09-30 07:30:00	2002-09-30 19:30:00	2002-10-01 13:30:00	2002-10-06 07:30:00	2002-10-06 19:30:00
23	2002-09-TP-04	CHAMP	MP	2002-09-30 07:30:00	2002-09-30 19:30:00	2002-10-01 13:30:00	2002-10-06 07:30:00	2002-10-06 19:30:00
24	2002-10-TP-01	CHAMP	SP	2002-10-06 22:30:00	2002-10-07 10:30:00	2002-10-08 04:30:00	2002-10-09 16:30:00	2002-10-10 04:30:00
25	2002-10-TP-01	GRACE	SP	2002-10-06 22:30:00	2002-10-07 10:30:00	2002-10-08 04:30:00	2002-10-09 16:30:00	2002-10-10 04:30:00
26	2002-10-TP-02	GRACE	MP	2002-10-23 04:30:00	2002-10-23 16:30:00	2002-10-24 10:30:00	2002-10-26 13:30:00	2002-10-27 01:30:00
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28	2002-11-TP-01	GRACE	MP	2002-11-19 13:30:00	2002-11-20 01:30:00	2002-11-20 19:30:00	2002-11-22 19:30:00	2002-11-23 07:30:00
29	2002-11-TP-01	CHAMP	MP	2002-11-19 13:30:00	2002-11-20 01:30:00	2002-11-20 19:30:00	2002-11-22 19:30:00	2002-11-23 07:30:00
30	2002-12-TP-01	GRACE	SP	2002-12-25 22:30:00	2002-12-26 10:30:00	2002-12-27 04:30:00	2002-12-28 16:30:00	2002-12-29 04:30:00
31	2002-12-TP-01	CHAMP	SP	2002-12-25 22:30:00	2002-12-26 10:30:00	2002-12-27 04:30:00	2002-12-28 16:30:00	2002-12-29 04:30:00
32	2003-03-TP-01	GRACE	SP	2003-03-15 13:30:00	2003-03-16 01:30:00	2003-03-16 19:30:00	2003-03-18 07:30:00	2003-03-18 19:30:00
33	2003-03-TP-01	CHAMP	SP	2003-03-15 13:30:00	2003-03-16 01:30:00	2003-03-16 19:30:00	2003-03-18 07:30:00	2003-03-18 19:30:00
34	2003-03-TP-02	GRACE	SP	2003-03-30 10:30:00	2003-03-30 22:30:00	2003-03-31 16:30:00	2003-04-02 04:30:00	2003-04-02 16:30:00
35	2003-03-TP-02	CHAMP	SP	2003-03-30 10:30:00	2003-03-30 22:30:00	2003-03-31 16:30:00	2003-04-02 04:30:00	2003-04-02 16:30:00
36	2003-04-TP-01	CHAMP	MP	2003-04-28 13:30:00	2003-04-29 01:30:00	2003-04-29 19:30:00	2003-05-02 13:30:00	2003-05-03 01:30:00
37	2003-04-TP-01	GRACE	MP	2003-04-28 13:30:00	2003-04-29 01:30:00	2003-04-29 19:30:00	2003-05-02 13:30:00	2003-05-03 01:30:00
38	2003-05-TP-01	GRACE	SP	2003-05-08 19:30:00	2003-05-09 07:30:00	2003-05-10 01:30:00	2003-05-11 13:30:00	2003-05-12 01:30:00
39	2003-05-TP-02	CHAMP	SP	2003-05-20 16:30:00	2003-05-21 04:30:00	2003-05-21 22:30:00	2003-05-23 10:30:00	2003-05-23 22:30:00
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41	2003-05-TP-03	GRACE	MP	2003-05-28 07:30:00	2003-05-28 19:30:00	2003-05-29 13:30:00	2003-06-01 04:30:00	2003-06-01 16:30:00
42	2003-05-TP-03	CHAMP	MP	2003-05-28 07:30:00	2003-05-28 19:30:00	2003-05-29 13:30:00	2003-06-01 04:30:00	2003-06-01 16:30:00
43	2003-06-TP-01	GRACE	SP	2003-06-08 16:30:00	2003-06-09 04:30:00	2003-06-09 22:30:00	2003-06-11 10:30:00	2003-06-11 22:30:00
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45	2003-06-TP-02	GRACE	MP	2003-06-15 13:30:00	2003-06-16 01:30:00	2003-06-16 19:30:00	2003-06-19 22:30:00	2003-06-20 10:30:00
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51	2003-07-TP-02	GRACE	SP	2003-07-15 04:30:00	2003-07-15 16:30:00	2003-07-16 10:30:00	2003-07-17 22:30:00	2003-07-18 10:30:00
52	2003-07-TP-02	CHAMP	SP	2003-07-15 04:30:00	2003-07-15 16:30:00	2003-07-16 10:30:00	2003-07-17 22:30:00	2003-07-18 10:30:00
53	2003-07-TP-03	CHAMP	SP	2003-07-25 13:30:00	2003-07-26 01:30:00	2003-07-26 19:30:00	2003-07-28 07:30:00	2003-07-28 19:30:00
54	2003-07-TP-03	GRACE	SP	2003-07-25 13:30:00	2003-07-26 01:30:00	2003-07-26 19:30:00	2003-07-28 07:30:00	2003-07-28 19:30:00
55	2003-08-TP-01	GRACE	SP	2003-08-06 13:30:00	2003-08-07 01:30:00	2003-08-07 19:30:00	2003-08-09 07:30:00	2003-08-09 19:30:00
56	2003-08-TP-01	CHAMP	SP	2003-08-06 13:30:00	2003-08-07 01:30:00	2003-08-07 19:30:00	2003-08-09 07:30:00	2003-08-09 19:30:00
57	2003-08-TP-02	CHAMP	SP	2003-08-16 22:30:00	2003-08-17 10:30:00	2003-08-18 04:30:00	2003-08-19 16:30:00	2003-08-20 04:30:00
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61	2003-09-TP-01	GRACE	MP	2003-09-16 04:30:00	2003-09-16 16:30:00	2003-09-17 10:30:00	2003-09-19 22:30:00	2003-09-20 10:30:00
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66	2003-10-TP-02	GRACE	MP	2003-10-13 13:30:00	2003-10-14 01:30:00	2003-10-14 19:30:00	2003-10-16 19:30:00	2003-10-17 07:30:00
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74	2003-11-TP-02	GRACE	SP	2003-11-03 01:30:00	2003-11-03 13:30:00	2003-11-04 07:30:00	2003-11-05 19:30:00	2003-11-06 07:30:00
75	2003-11-TP-03	CHAMP	SP	2003-11-10 01:30:00	2003-11-10 13:30:00	2003-11-11 07:30:00	2003-11-12 19:30:00	2003-11-13 07:30:00
76	2003-11-TP-03	GRACE	SP	2003-11-10 01:30:00	2003-11-10 13:30:00	2003-11-11 07:30:00	2003-11-12 19:30:00	2003-11-13 07:30:00
77	2003-11-TP-04	CHAMP	MP	2003-11-12 07:30:00	2003-11-12 19:30:00	2003-11-13 13:30:00	2003-11-16 19:30:00	2003-11-17 07:30:00
78	2003-11-TP-04	GRACE	MP	2003-11-12 07:30:00	2003-11-12 19:30:00	2003-11-13 13:30:00	2003-11-16 19:30:00	2003-11-17 07:30:00
79	2004-01-TP-01	GRACE	SP	2004-01-05 16:30:00	2004-01-06 04:30:00	2004-01-06 22:30:00	2004-01-08 10:30:00	2004-01-08 22:30:00
80	2004-01-TP-01	CHAMP	SP	2004-01-05 16:30:00	2004-01-06 04:30:00	2004-01-06 22:30:00	2004-01-08 10:30:00	2004-01-08 22:30:00
81	2004-01-TP-02	CHAMP	MP	2004-01-21 04:30:00	2004-01-21 16:30:00	2004-01-22 10:30:00	2004-01-25 04:30:00	2004-01-25 16:30:00
82	2004-01-TP-02	GRACE	MP	2004-01-21 04:30:00	2004-01-21 16:30:00	2004-01-22 10:30:00	2004-01-25 04:30:00	2004-01-25 16:30:00
83	2004-02-TP-01	GRACE	SP	2004-02-10 10:30:00	2004-02-10 22:30:00	2004-02-11 16:30:00	2004-02-13 04:30:00	2004-02-13 16:30:00
84	2004-02-TP-01	CHAMP	SP	2004-02-10 10:30:00	2004-02-10 22:30:00	2004-02-11 16:30:00	2004-02-13 04:30:00	2004-02-13 16:30:00
85	2004-03-TP-01	CHAMP	MP	2004-03-08 22:30:00	2004-03-09 10:30:00	2004-03-10 04:30:00	2004-03-13 07:30:00	2004-03-13 19:30:00
86	2004-03-TP-01	GRACE	MP	2004-03-08 22:30:00	2004-03-09 10:30:00	2004-03-10 04:30:00	2004-03-13 07:30:00	2004-03-13 19:30:00
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157	2011-08-TP-01	GRACE	SP	2011-08-04 13:30:00	2011-08-05 01:30:00	2011-08-05 19:30:00	2011-08-07 07:30:00	2011-08-07 19:30:00
158	2011-08-TP-01	GOCE	SP	2011-08-04 13:30:00	2011-08-05 01:30:00	2011-08-05 19:30:00	2011-08-07 07:30:00	2011-08-07 19:30:00
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170	2012-07-TP-01	GOCE	SP	2012-07-14 01:30:00	2012-07-14 13:30:00	2012-07-15 07:30:00	2012-07-16 19:30:00	2012-07-17 07:30:00
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175	2012-10-TP-01	GOCE	MP	2012-10-07 01:30:00	2012-10-07 13:30:00	2012-10-08 07:30:00	2012-10-10 16:30:00	2012-10-11 04:30:00
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181	2013-06-TP-01	GOCE	SP	2013-06-27 22:30:00	2013-06-28 10:30:00	2013-06-29 04:30:00	2013-06-30 16:30:00	2013-07-01 04:30:00
182	2013-06-TP-01	GRACE	SP	2013-06-27 22:30:00	2013-06-28 10:30:00	2013-06-29 04:30:00	2013-06-30 16:30:00	2013-07-01 04:30:00
183	2013-09-TP-01	GRACE	SP	2013-09-30 22:30:00	2013-10-01 10:30:00	2013-10-02 04:30:00	2013-10-03 16:30:00	2013-10-04 04:30:00
184	2013-12-TP-01	SWARMA	SP	2013-12-06 19:30:00	2013-12-07 07:30:00	2013-12-08 01:30:00	2013-12-09 13:30:00	2013-12-10 01:30:00
185	2013-12-TP-01	GRACE	SP	2013-12-06 19:30:00	2013-12-07 07:30:00	2013-12-08 01:30:00	2013-12-09 13:30:00	2013-12-10 01:30:00
186	2014-02-TP-02	GRACE	MP	2014-02-17 22:30:00	2014-02-18 10:30:00	2014-02-19 04:30:00	2014-02-21 19:30:00	2014-02-22 07:30:00
187	2014-06-TP-01	GRACE	SP	2014-06-07 01:30:00	2014-06-07 13:30:00	2014-06-08 07:30:00	2014-06-09 19:30:00	2014-06-10 07:30:00
188	2014-06-TP-01	SWARMA	SP	2014-06-07 01:30:00	2014-06-07 13:30:00	2014-06-08 07:30:00	2014-06-09 19:30:00	2014-06-10 07:30:00
189	2014-09-TP-01	GRACE	SP	2014-09-11 16:30:00	2014-09-12 04:30:00	2014-09-12 22:30:00	2014-09-14 10:30:00	2014-09-14 22:30:00
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197	2015-04-TP-02	SWARMA	SP	2015-04-15 16:30:00	2015-04-16 04:30:00	2015-04-16 22:30:00	2015-04-18 10:30:00	2015-04-18 22:30:00
198	2015-06-TP-01	SWARMA	SP	2015-06-07 01:30:00	2015-06-07 13:30:00	2015-06-08 07:30:00	2015-06-09 19:30:00	2015-06-10 07:30:00
199	2015-06-TP-02	SWARMA	SP	2015-06-21 13:30:00	2015-06-22 01:30:00	2015-06-22 19:30:00	2015-06-24 07:30:00	2015-06-24 19:30:00
200	2015-08-TP-01	SWARMA	SP	2015-08-14 04:30:00	2015-08-14 16:30:00	2015-08-15 10:30:00	2015-08-16 22:30:00	2015-08-17 10:30:00
201	2015-08-TP-01	GRACE	SP	2015-08-14 04:30:00	2015-08-14 16:30:00	2015-08-15 10:30:00	2015-08-16 22:30:00	2015-08-17 10:30:00
202	2015-08-TP-02	SWARMA	MP	2015-08-25 22:30:00	2015-08-26 10:30:00	2015-08-27 04:30:00	2015-08-29 10:30:00	2015-08-29 22:30:00
203	2015-08-TP-02	GRACE	MP	2015-08-25 22:30:00	2015-08-26 10:30:00	2015-08-27 04:30:00	2015-08-29 10:30:00	2015-08-29 22:30:00
204	2015-09-TP-01	GRACE	MP	2015-09-06 10:30:00	2015-09-06 22:30:00	2015-09-07 16:30:00	2015-09-13 04:30:00	2015-09-13 16:30:00
205	2015-09-TP-01	SWARMA	MP	2015-09-06 10:30:00	2015-09-06 22:30:00	2015-09-07 16:30:00	2015-09-13 04:30:00	2015-09-13 16:30:00
206	2015-09-TP-02	SWARMA	SP	2015-09-19 01:30:00	2015-09-19 13:30:00	2015-09-20 07:30:00	2015-09-21 19:30:00	2015-09-22 07:30:00
207	2015-09-TP-02	GRACE	SP	2015-09-19 01:30:00	2015-09-19 13:30:00	2015-09-20 07:30:00	2015-09-21 19:30:00	2015-09-22 07:30:00
208	2015-10-TP-01	SWARMA	MP	2015-10-05 22:30:00	2015-10-06 10:30:00	2015-10-07 04:30:00	2015-10-09 10:30:00	2015-10-09 22:30:00
209	2015-11-TP-01	SWARMA	SP	2015-11-05 22:30:00	2015-11-06 10:30:00	2015-11-07 04:30:00	2015-11-08 16:30:00	2015-11-09 04:30:00
210	2015-12-TP-01	SWARMA	MP	2015-12-18 22:30:00	2015-12-19 10:30:00	2015-12-20 04:30:00	2015-12-22 16:30:00	2015-12-23 04:30:00

	DTM2013	DTM2020	GITM	CTIPe	JB2008	TIEGCM-Heelis	TIEGCM-Weimer	WACCMX-Heelis	WACCMX-Weimer	WAMIPE
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1	https://ccmc.gsfc.nasa.gov/ror/results/viewrun.php?runnumber=DTM2013-01_2001-09-TP-02_112324_IT_1	https://ccmc.gsfc.nasa.gov/ror/results/viewrun.php?runnumber=DTM2020-01_2001-09-TP-02_112324_IT_1	https://ccmc.gsfc.nasa.gov/ror/results/viewrun.php?runnumber=GITM-01_2001-09-TP-02_011125_IT_1	https://ccmc.gsfc.nasa.gov/ror/results/viewrun.php?runnumber=CTIPe-01_2001-09-TP-02_112324_IT_1	https://ccmc.gsfc.nasa.gov/ror/results/viewrun.php?runnumber=JB2008-01_2001-09-TP-02_112324_IT_1	https://ccmc.gsfc.nasa.gov/ror/results/viewrun.php?runnumber=TIEGCM-Heelis-01_2001-09-TP-02_042225_IT_1	https://ccmc.gsfc.nasa.gov/ror/results/viewrun.php?runnumber=TIEGCM-Weimer-01_2001-09-TP-02_042225_IT_1	https://ccmc.gsfc.nasa.gov/ror/results/viewrun.php?runnumber=WACCMX-Heelis-01_2001-09-TP-02_112324_IT_1	https://ccmc.gsfc.nasa.gov/ror/results/viewrun.php?runnumber=WACCMX-Weimer-01_2001-09-TP-02_072424_IT_1	https://ccmc.gsfc.nasa.gov/ror/results/viewrun.php?runnumber=WAMIPE-01_2001-09-TP-02_033125_IT_1
2	https://ccmc.gsfc.nasa.gov/ror/results/viewrun.php?runnumber=DTM2013-01_2001-10-TP-01_110624_IT_1	https://ccmc.gsfc.nasa.gov/ror/results/viewrun.php?runnumber=DTM2020-01_2001-10-TP-01_110624_IT_1	https://ccmc.gsfc.nasa.gov/ror/results/viewrun.php?runnumber=GITM-01_2001-10-TP-01_112124_IT_1	https://ccmc.gsfc.nasa.gov/ror/results/viewrun.php?runnumber=CTIPe-01_2001-10-TP-01_111324_IT_1	https://ccmc.gsfc.nasa.gov/ror/results/viewrun.php?runnumber=JB2008-01_2001-10-TP-01_111324_IT_1	https://ccmc.gsfc.nasa.gov/ror/results/viewrun.php?runnumber=TIEGCM-Heelis-01_2001-10-TP-01_101324_IT_1	https://ccmc.gsfc.nasa.gov/ror/results/viewrun.php?runnumber=TIEGCM-Weimer-01_2001-10-TP-01_101324_IT_1	https://ccmc.gsfc.nasa.gov/ror/results/viewrun.php?runnumber=WACCMX-Heelis-01_2001-10-TP-01_110524_IT_1	https://ccmc.gsfc.nasa.gov/ror/results/viewrun.php?runnumber=WACCMX-Weimer-01_2001-10-TP-01_072324_IT_1	https://ccmc.gsfc.nasa.gov/ror/results/viewrun.php?runnumber=WAMIPE-01_2001-10-TP-01_033125_IT_1
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4	https://ccmc.gsfc.nasa.gov/ror/results/viewrun.php?runnumber=DTM2013-01_2001-11-TP-02_112324_IT_1	https://ccmc.gsfc.nasa.gov/ror/results/viewrun.php?runnumber=DTM2020-01_2001-11-TP-02_112324_IT_1	https://ccmc.gsfc.nasa.gov/ror/results/viewrun.php?runnumber=GITM-01_2001-11-TP-02_011125_IT_1	https://ccmc.gsfc.nasa.gov/ror/results/viewrun.php?runnumber=CTIPe-01_2001-11-TP-02_112324_IT_1	https://ccmc.gsfc.nasa.gov/ror/results/viewrun.php?runnumber=JB2008-01_2001-11-TP-02_112324_IT_1	https://ccmc.gsfc.nasa.gov/ror/results/viewrun.php?runnumber=TIEGCM-Heelis-01_2001-11-TP-02_042225_IT_1	https://ccmc.gsfc.nasa.gov/ror/results/viewrun.php?runnumber=TIEGCM-Weimer-01_2001-11-TP-02_042225_IT_1	https://ccmc.gsfc.nasa.gov/ror/results/viewrun.php?runnumber=WACCMX-Heelis-01_2001-11-TP-02_112324_IT_1	https://ccmc.gsfc.nasa.gov/ror/results/viewrun.php?runnumber=WACCMX-Weimer-01_2001-11-TP-02_112324_IT_1	https://ccmc.gsfc.nasa.gov/ror/results/viewrun.php?runnumber=WAMIPE-01_2001-11-TP-02_033125_IT_1
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11	https://ccmc.gsfc.nasa.gov/ror/results/viewrun.php?runnumber=DTM2013-01_2002-05-TP-01_110624_IT_1	https://ccmc.gsfc.nasa.gov/ror/results/viewrun.php?runnumber=DTM2020-01_2002-05-TP-01_110624_IT_1	https://ccmc.gsfc.nasa.gov/ror/results/viewrun.php?runnumber=GITM-01_2002-05-TP-01_112824_IT_1	https://ccmc.gsfc.nasa.gov/ror/results/viewrun.php?runnumber=CTIPe-01_2002-05-TP-01_111324_IT_1	https://ccmc.gsfc.nasa.gov/ror/results/viewrun.php?runnumber=JB2008-01_2002-05-TP-01_111324_IT_1	https://ccmc.gsfc.nasa.gov/ror/results/viewrun.php?runnumber=TIEGCM-Heelis-01_2002-05-TP-01_101324_IT_1	https://ccmc.gsfc.nasa.gov/ror/results/viewrun.php?runnumber=TIEGCM-Weimer-01_2002-05-TP-01_101324_IT_1	https://ccmc.gsfc.nasa.gov/ror/results/viewrun.php?runnumber=WACCMX-Heelis-01_2002-05-TP-01_110724_IT_1	https://ccmc.gsfc.nasa.gov/ror/results/viewrun.php?runnumber=WACCMX-Weimer-01_2002-05-TP-01_110724_IT_1	https://ccmc.gsfc.nasa.gov/ror/results/viewrun.php?runnumber=WAMIPE-01_2002-05-TP-01_033125_IT_1
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For Model Developers!!!

Please contact us if you're interested in making your models accessible to the community through CCMC services

Our goal: Make it easier and faster to onboard new models or upgrades and deliver them to the community more efficiently

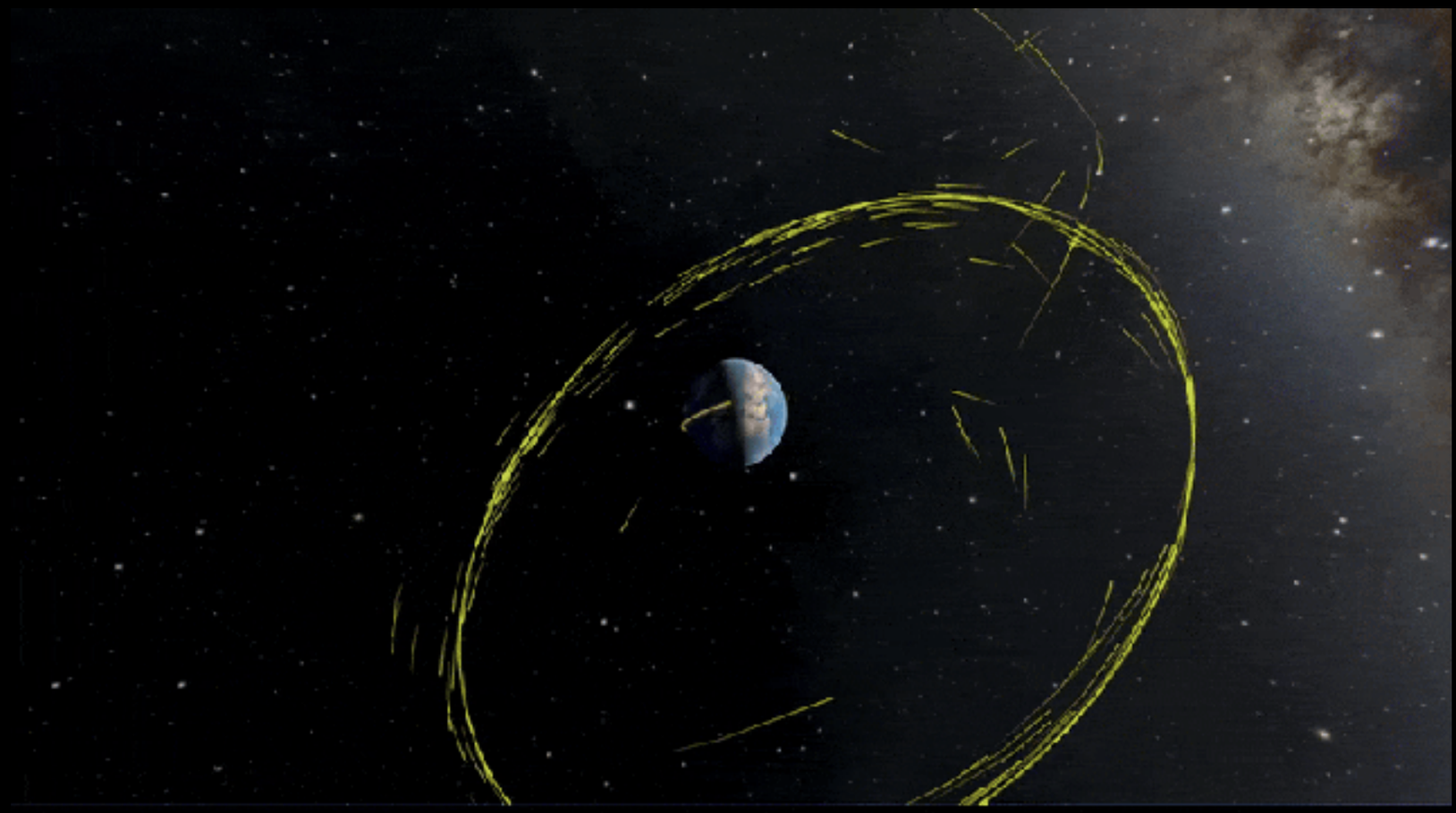
Please contact us if you have any suggestions or questions
jack.c.wang@nasa.gov; jia.yue@nasa.gov; min-yang.chou@nasa.gov

Visualization - OpenSpace

Yellow - satellites

Blue - field line

White - solar wind



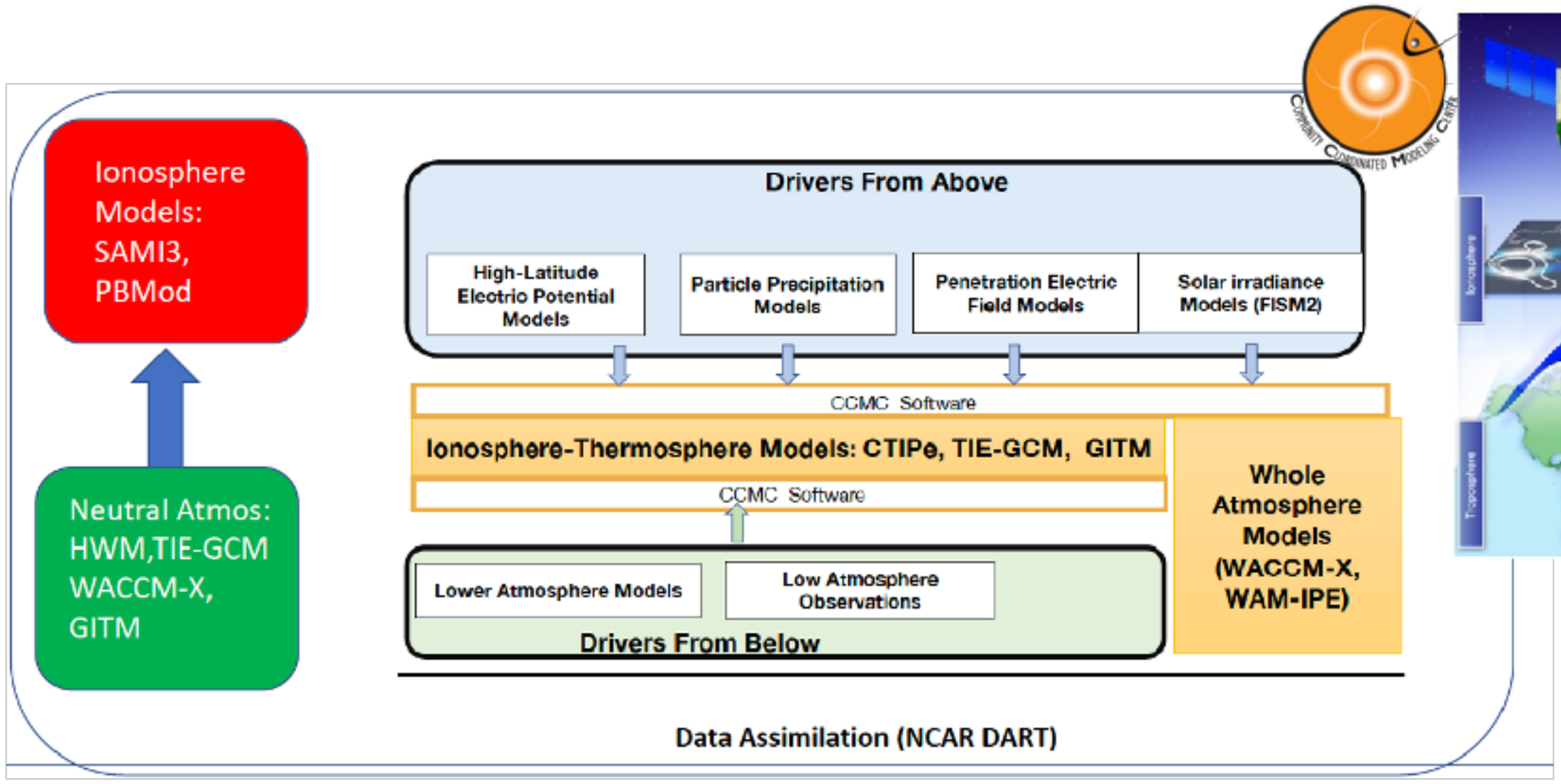
OpenSpace

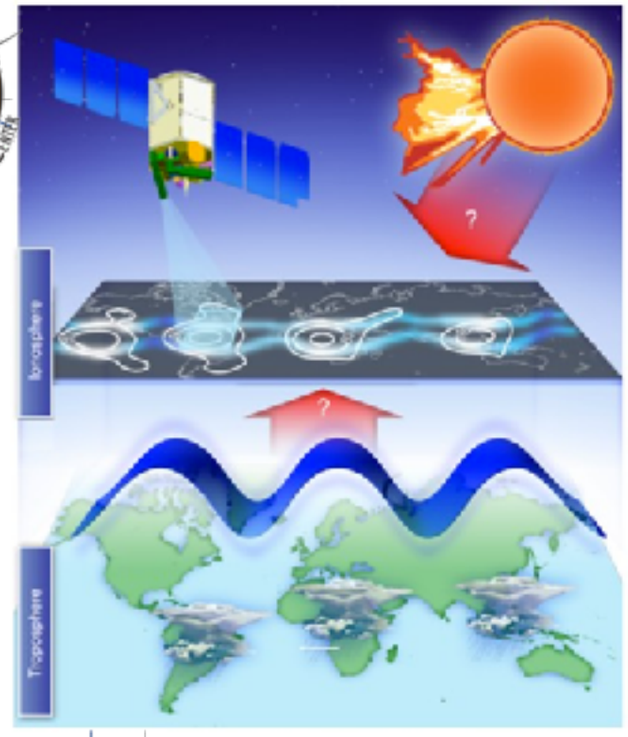
Back-ups

Space weather societal impact

- Ionosphere variability (navigation, communications)
- Atmosphere variability (satellite/debris drag)
- Geomagnetically induced currents - GICs (electric power systems)
- Near-earth radiation and plasma environment (aerospace assets functionality)
- Solar energetic particles - SEPs (human exploration, aviation safety, aerospace assets functionality)
- Galactic cosmic rays - GCRs (human exploration, aviation safety, aerospace assets functionality)

Models and services available at CCMC (thermosphere/ ionosphere models coupling with magnetosphere MHD and lower atmosphere drivers) -- providing system solution





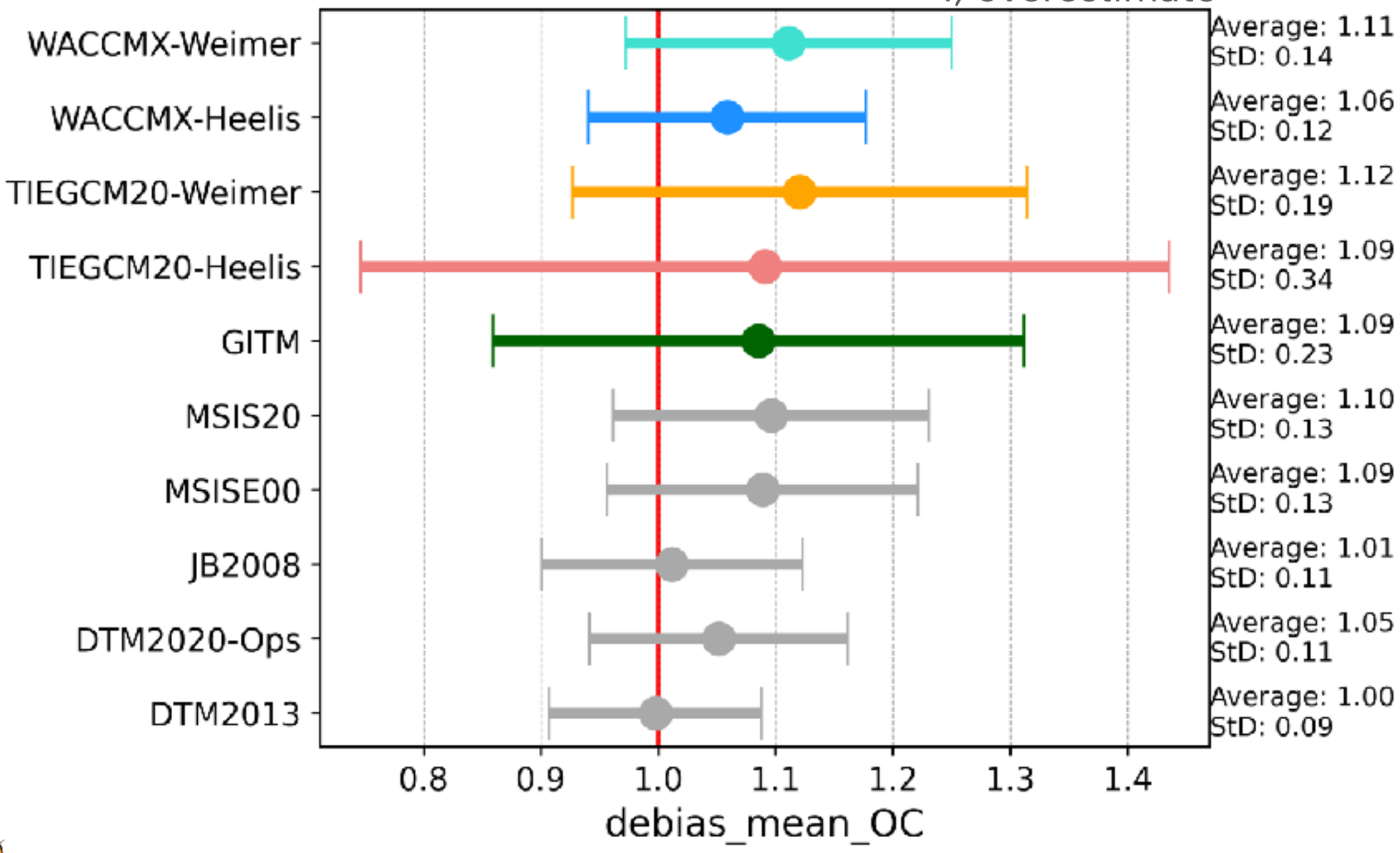
Result: debiased Observed-to-Computed density ratios (O/C ratio)

n=151 events, averaged over all phases (w/o pre-storm)

O/C = 1, no model bias on average (best)

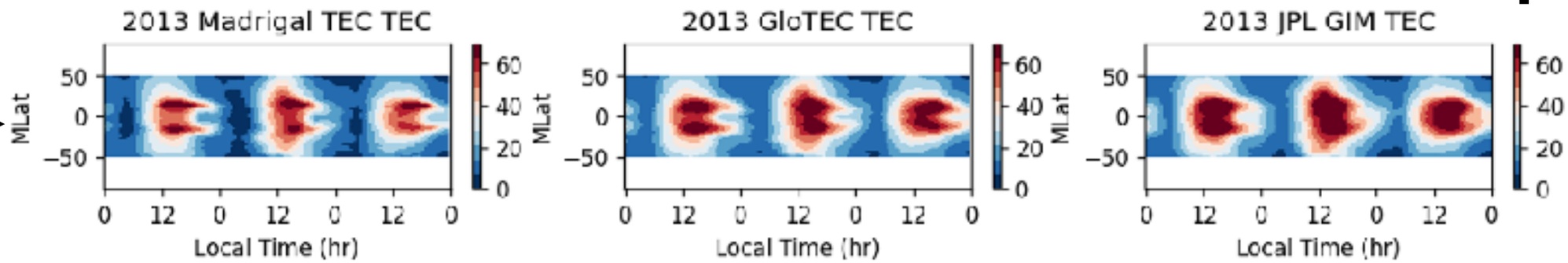
> 1, underestimate

< 1, overestimate

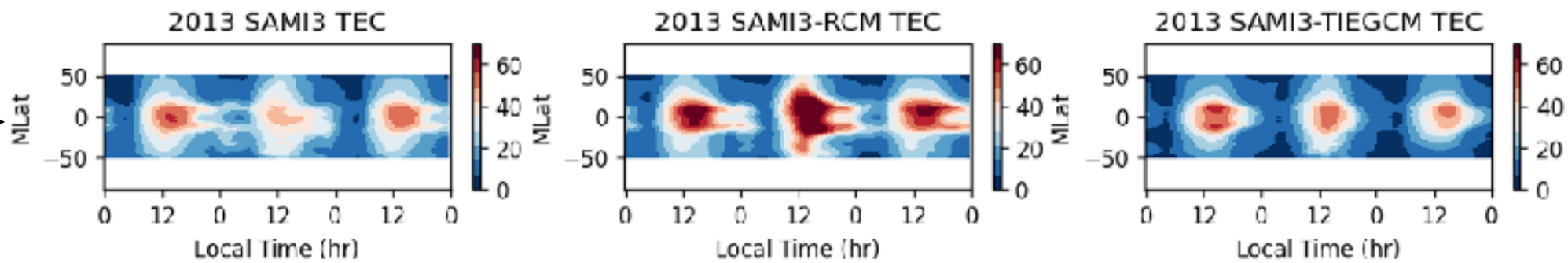


TEC 2013 March Storm, Lat x LT. map

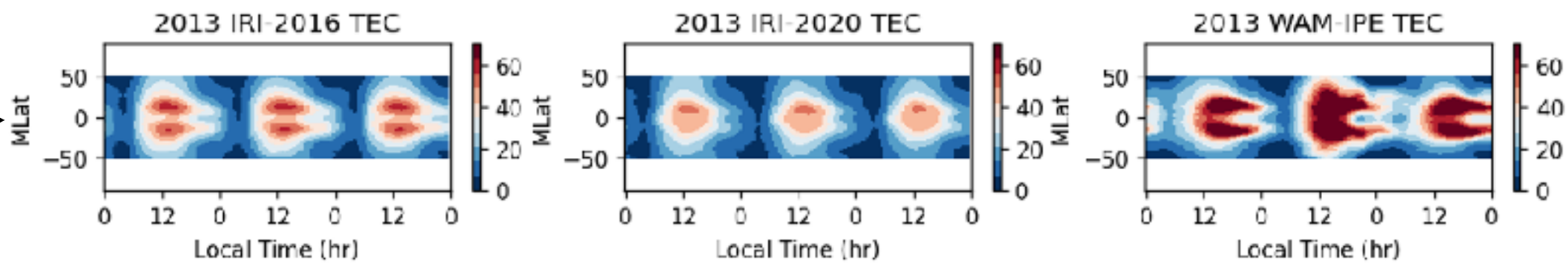
Madrigal
GloTEC
JPL GIM



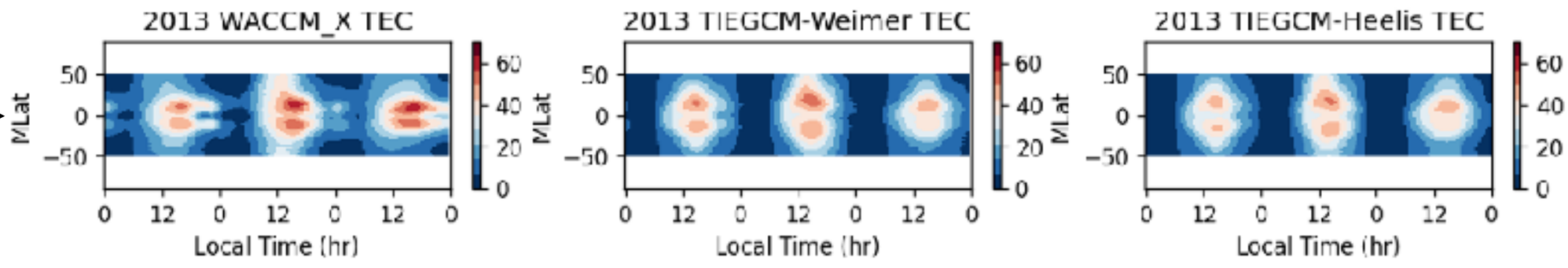
SAMI3



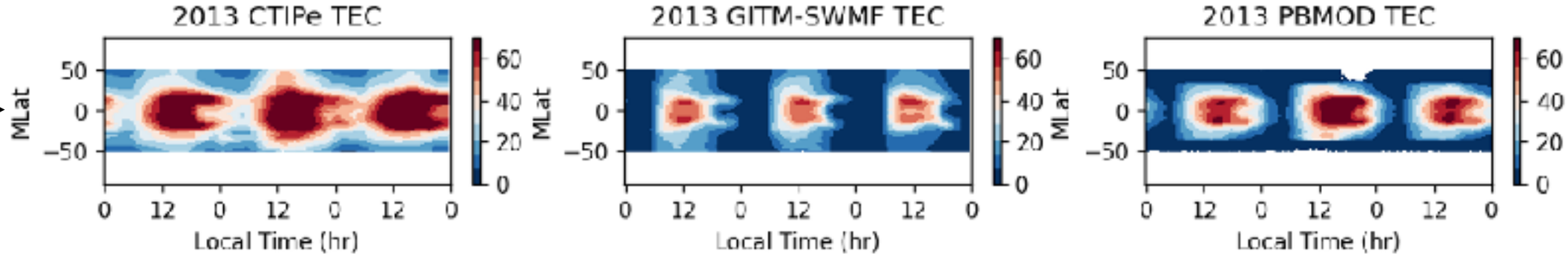
IRI
WAM-IPE



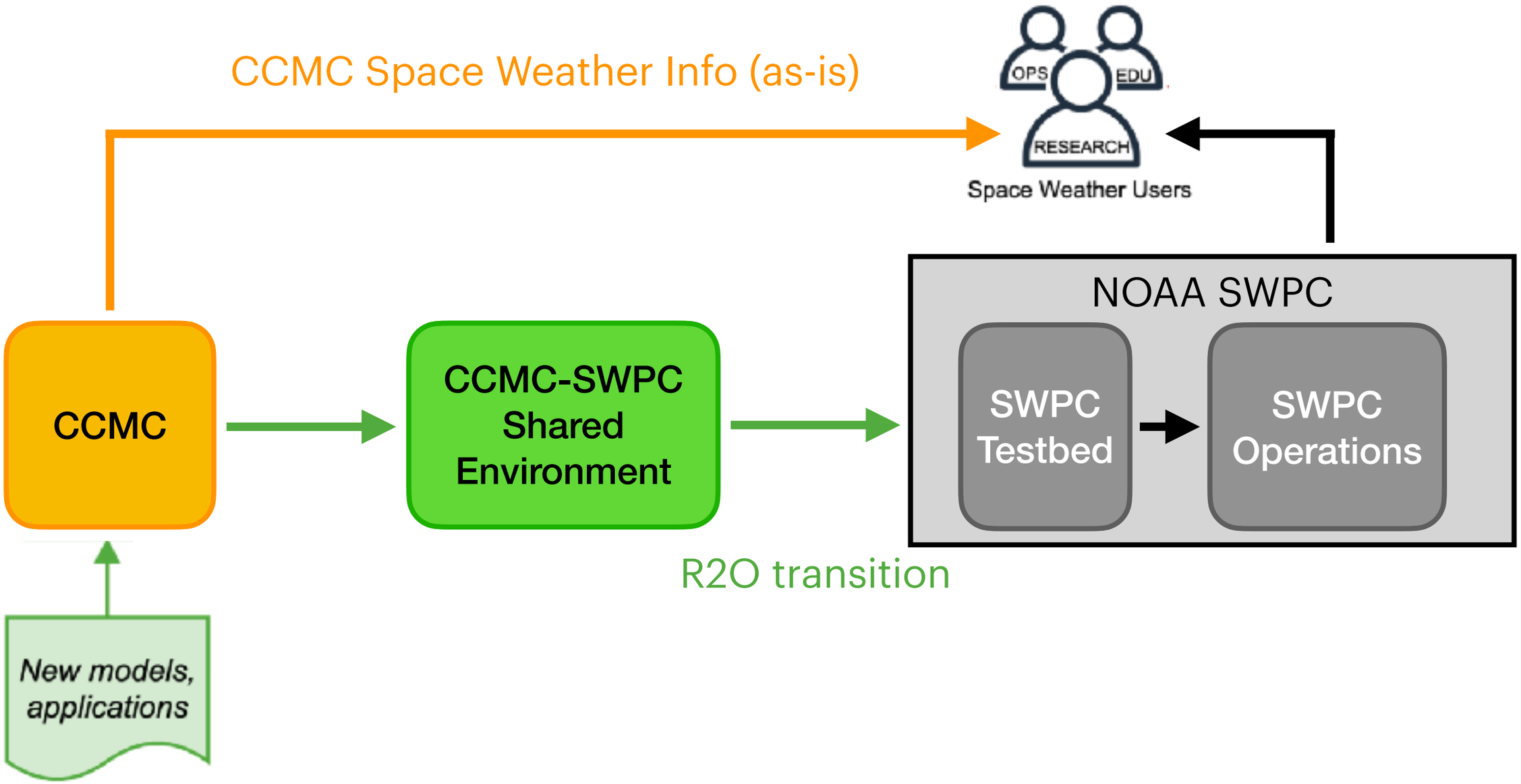
WACCM-X
TIE-GCM



CTIPe
GITM
PBMOD



Research->Operations (R2O) Pipeline



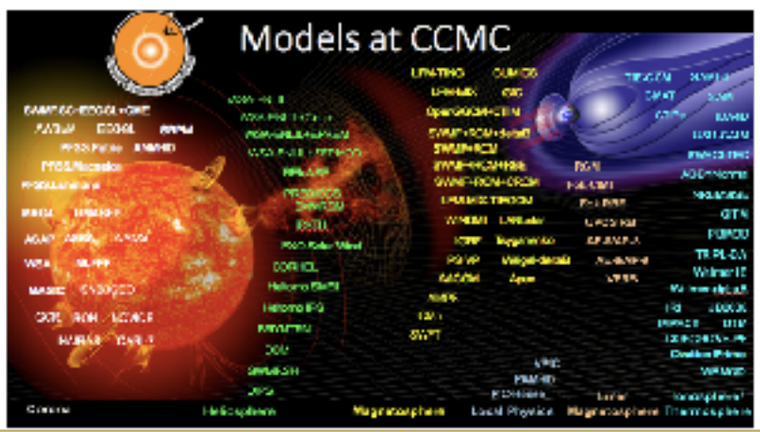
“ModelWeb Catalogue and Archive” provides a list of heliophysics models dating back to before 1979

https://git.mysmce.com/ccmc-share/modelwebarchive

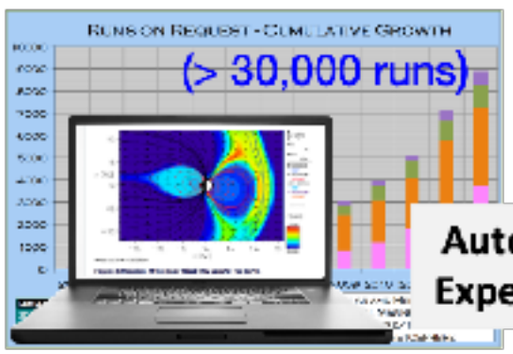
- Archived-Models-InfoPages
- Auroral-Oval-Representation
- CIRA
- Chiu-Ionospheric-Model
- Exospheric-H-Model
- GSFC-Model-Coefficients
- Geomagnetic-Cutoff-Rigidity
- Heppner-Maynard-Rich_Electric-Field-Mo...
- ISR-Ion-Drift-Model
- Jacchi-Reference-Atmosphere
- Jensen-Cain-Model-Coefficients
- LWS
- MET-Model
- MGST-Model-Coefficients-All
- PV-Ionosphere-Mode
- PV-Thermosphere-Model
- RADBELT
- Revised-SERF2-Solar-EUV-Flux-Mode
- SHIELDOSE
- SOLPRO
- Xu-Li-Neutral-Sheet-Model

CCMC Core Functions

Models

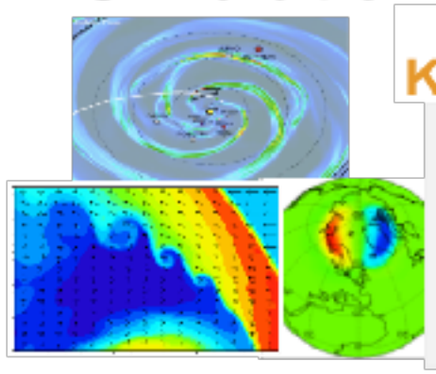


Simulation Services Open Use of Models



Automated & Expert-Guided

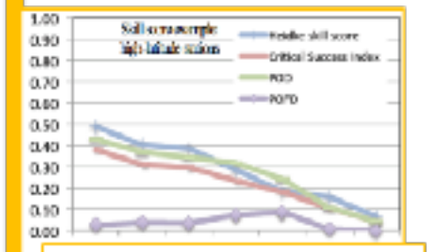
Open Use of Simulation Results



Kamodo

Post-processing
Visualization
Metadata
Databases with
'Search by ...'

Validation & Community Support



Modeling Challenges

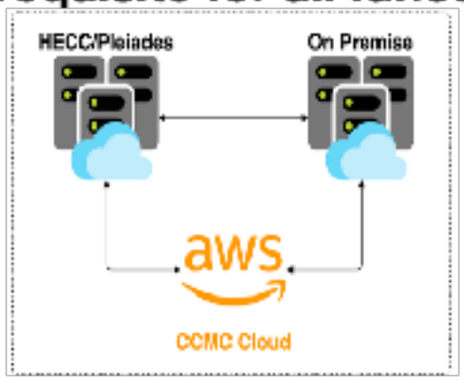
Heliophysics Big Year

Enable, Support

NASA Missions Support

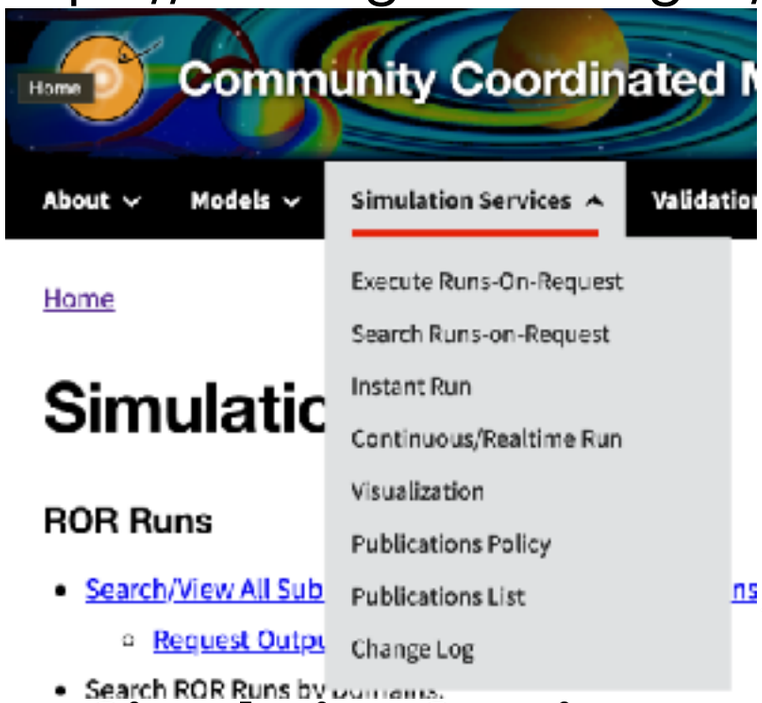
Infrastructure

(prerequisite for all functions)



Access simulation archive

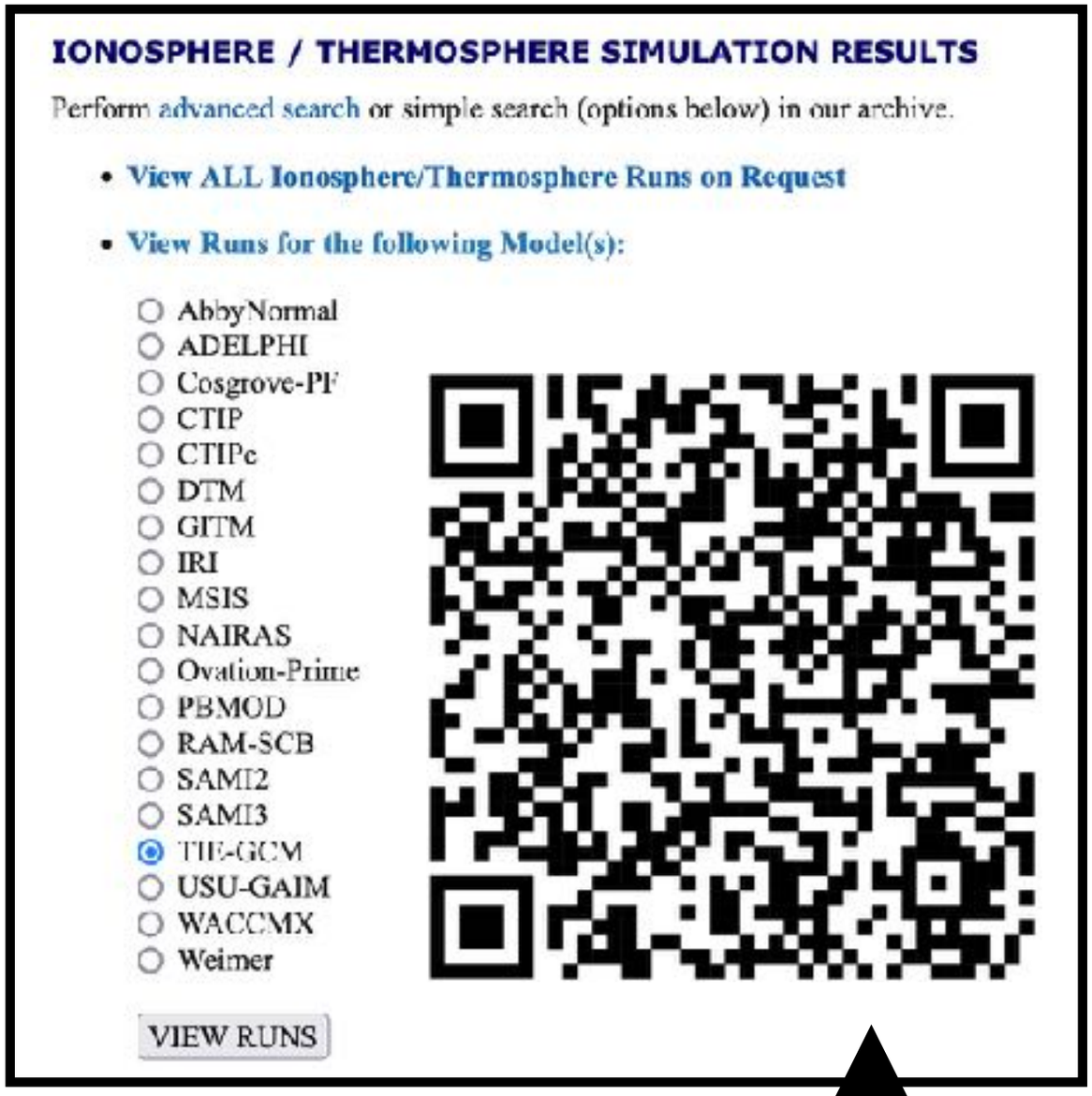
https://ccmc.gsfc.nasa.gov/

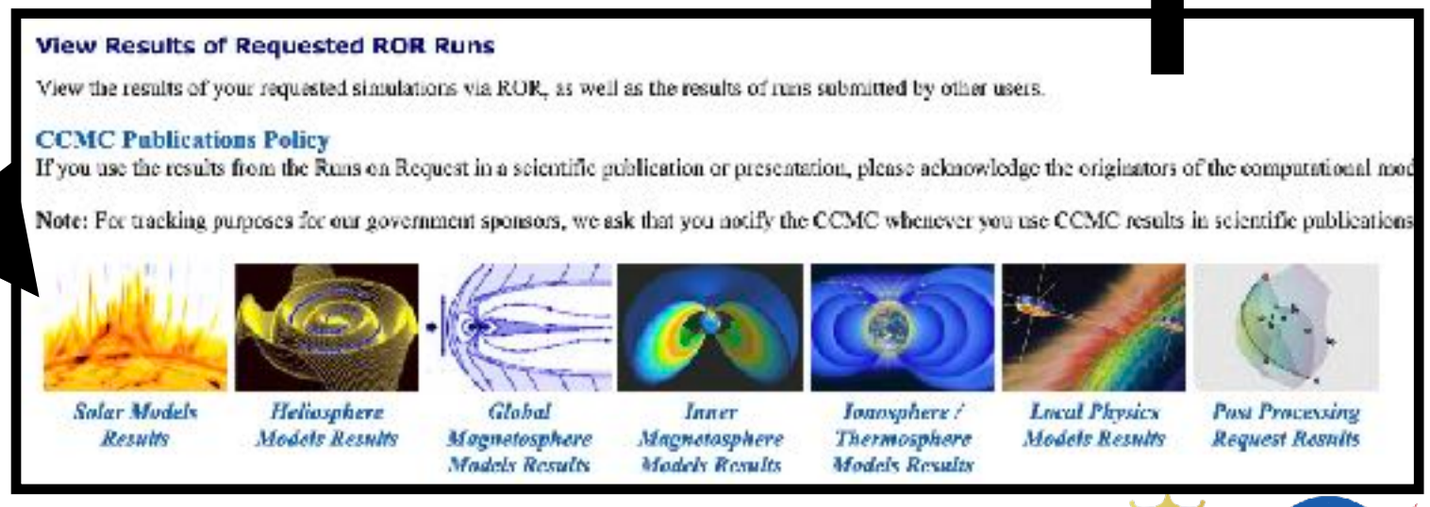


Simulation Services

↓

Search Runs-on-Request





Choose a published one

Status	Run Number
running	Anistah_Udhin_062323_IT_2
running	Vanshika_Rambukus_062323_IT_2
running	Wang_Li_062023_IT_1
running	Wang_Li_062023_IT_2
running	Tikemani_Bag_061923_IT_4
Published	Tiku_Bag_061923_IT_3
running	wei_wang_061623_IT_1
running	wei_wang_061623_IT_2
running	wei_wang_061623_IT_3
running	wei_wang_061623_IT_4
Published	Ian_Collett_061323_IT_1
running	Pengyu_Zhang_061123_IT_1
running	Pengyu_Zhang_061123_IT_2

Ian_Collett_061323_IT_1

Run Status: Run Complete

Status updated: 2023-06-14T15:45:55+0000

Run Metadata

Metadata Record:	View Full Run Metadata in the CCMC Metadata Registry (CMR)
Metadata as JSON:	View Full Run Metadata as JSON
Model Domain:	IT
Model Name:	TIE-GCM
Model Version:	2.0
Key Word:	13mar2022_storm
CS output:	GEO
Run type:	event
Boundary condition type:	var
Year run:	2022
DOY:	71
Start time:	2022/03/12 00:00:00
End time:	2022/03/19 00:00:00
E-field model:	WEIMER

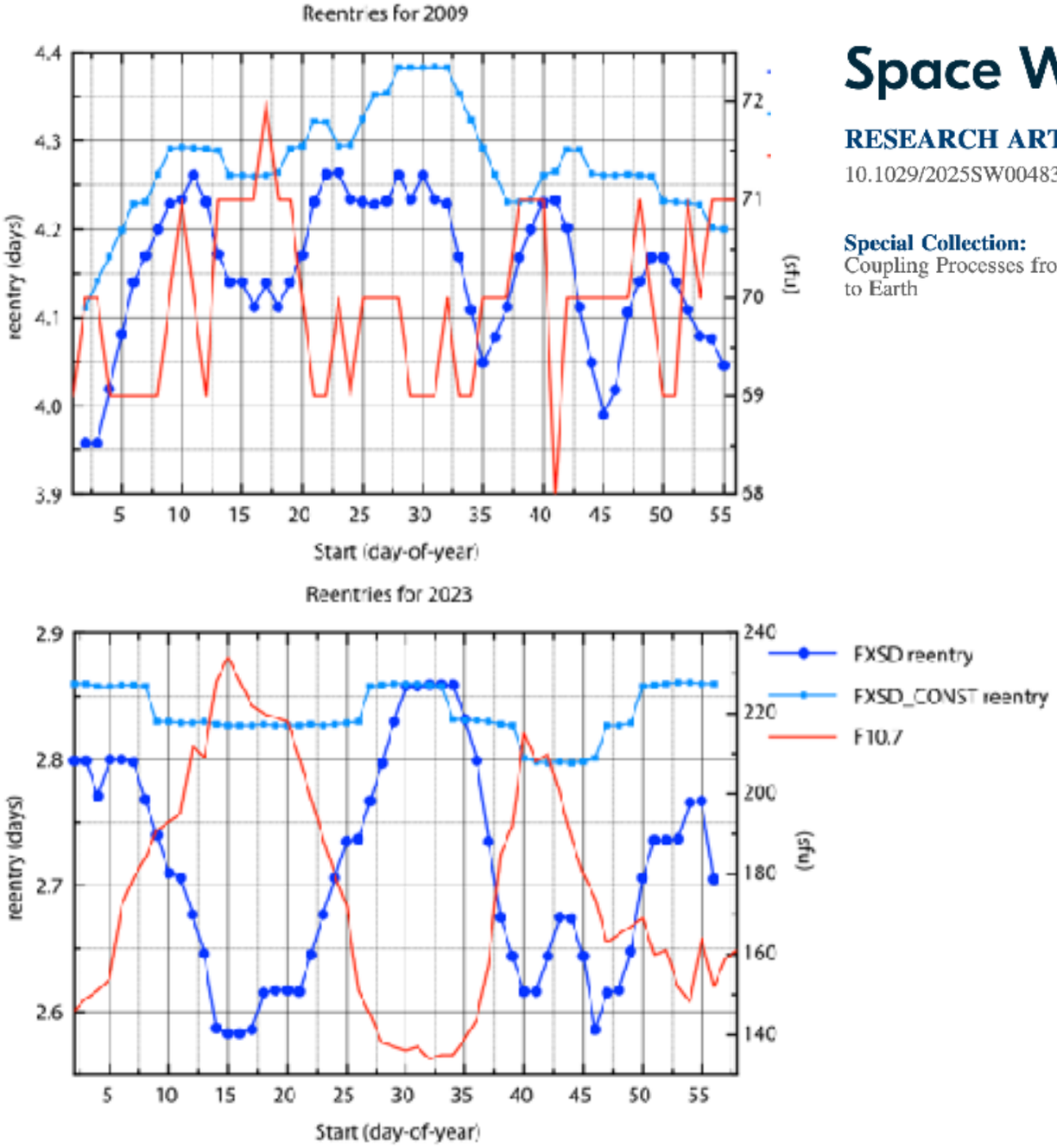
Output Data

- View 3D Ionosphere/Thermosphere
- Create Timeseries in 3D Ionosphere/Thermosphere

Choose “View 3D Ionosphere”

Beyond simulations: Impact-based simulations

Orbit propagators



Predicted reentry duration versus start day of year for (a) the 2009 and (b) 2023 SSW case with an initial altitude of 200 km

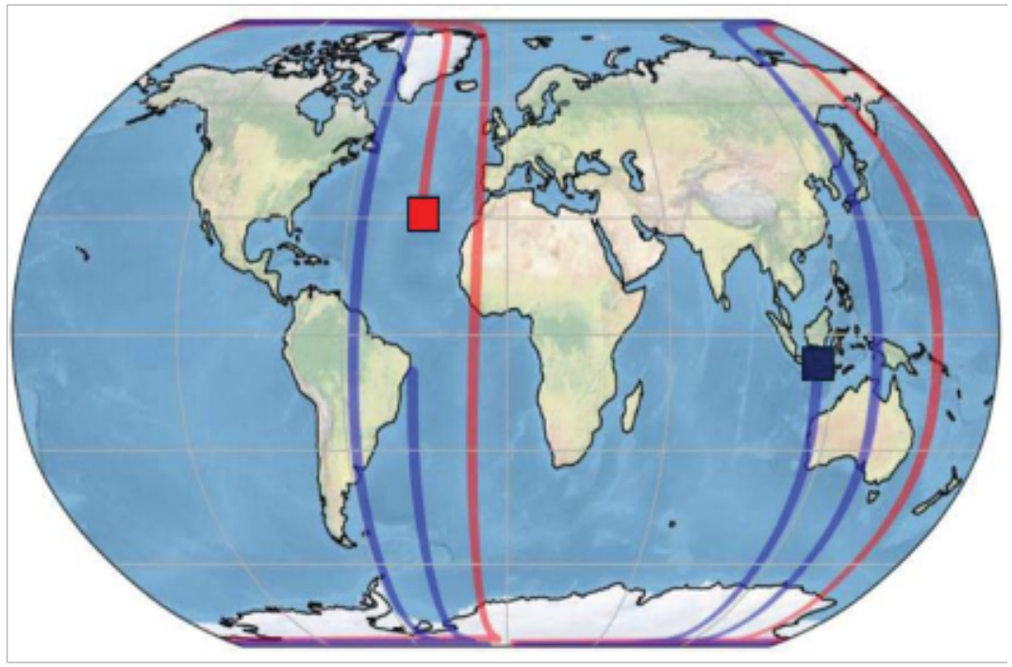
Space Weather

RESEARCH ARTICLE
10.1029/2025SW004835

Special Collection:
Coupling Processes from Space to Earth

Satellite Reentry Predictions During Sudden Stratospheric Warmings

Jia Yue[1,2], Sean Bruinsma[3], Jack Wang[1,2], Nicholas Pedatella[4], Wandi Yu[5], Jean-Charles Marty[3], and Maria Kuznetsova[1]



Last reentry orbits for a start date of January 25, 2009, during the SSW.
Red: WACCM-X with realistic Kp and F10.7
Blue: WACCM-X with constant Kp and F10.7
Red and blue rectangles denote the reentry impact locations.

(Yue et al., 2026)