# NASA Community Coordinated Modeling Center (CCMC)

## WACCM-X/RoR Overview

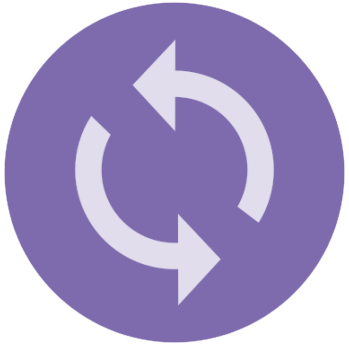
Jack Wang and all CCMC members
Community Coordinated Modeling Center, NASA GSFC
June 25nd, 2025

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



Instant Run

Run-on-Request



Continuous Run

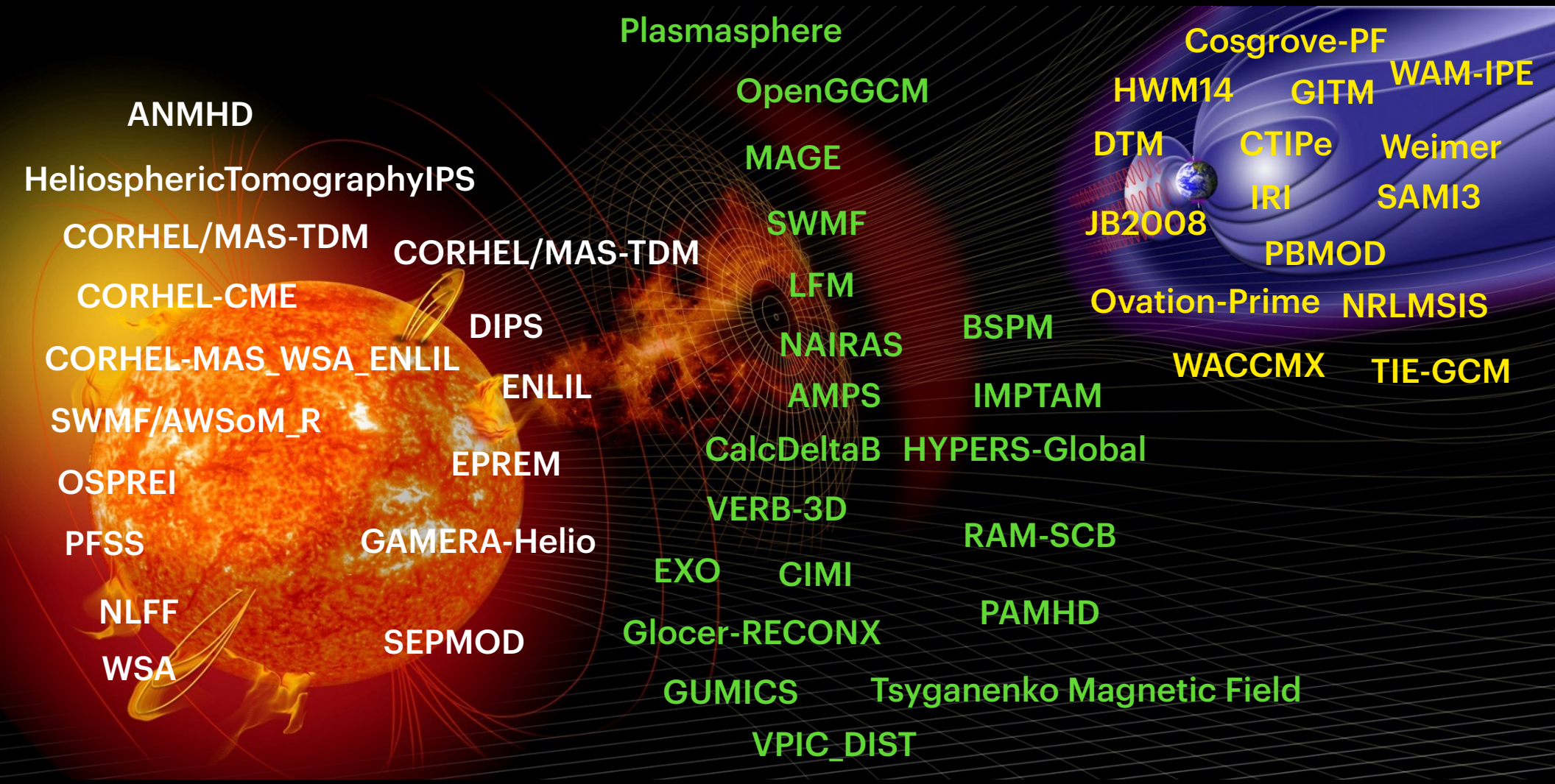
CCMC Model Catalog

# CCMC builds bridges between model developers and end users

V.S.

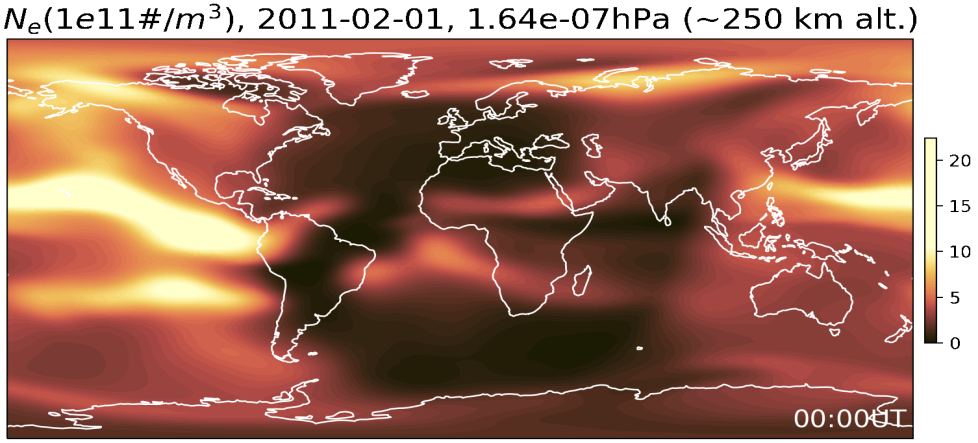
CCMC acknowledges all the model developers for the permission to use the models and software tools at CCMC

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




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

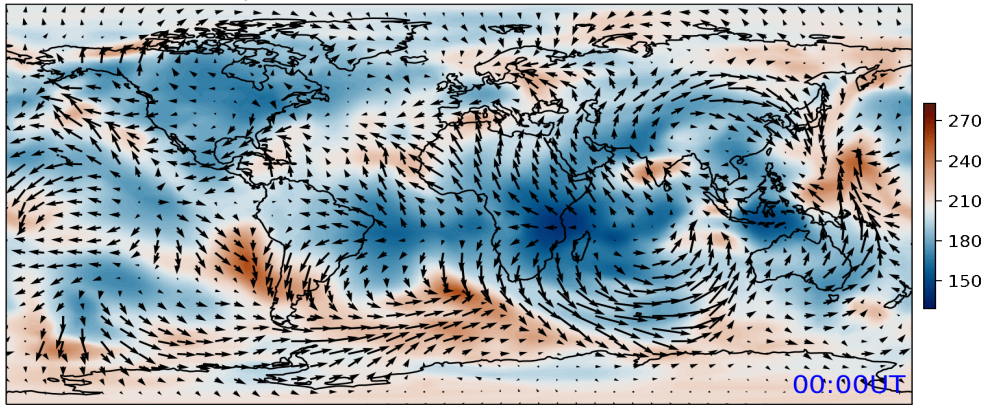
# WACCM-X (CESM2.2.0) is available through RoR since 2023, first whole atmosphere model at CCMC

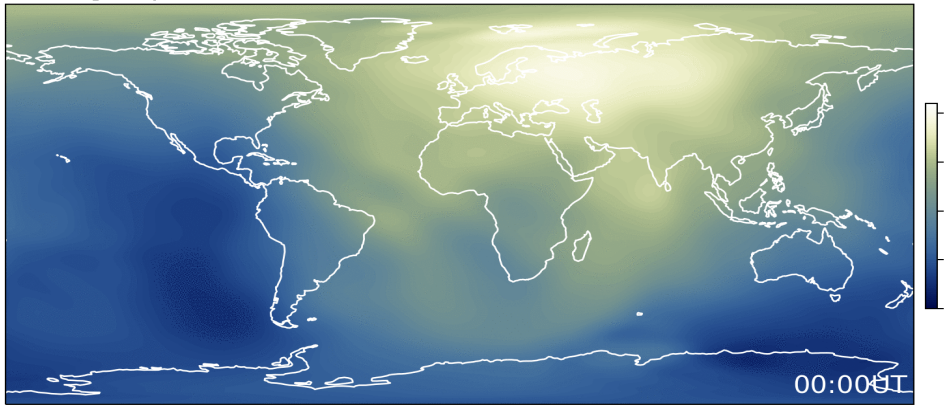



- output cadence: 10 mins.
- resolution: 0.9° Lat. x 1.25° Lon.
- variable: T, U, V, Z, drift, TEC, NE, composition…

dynamics-chemistry coupling

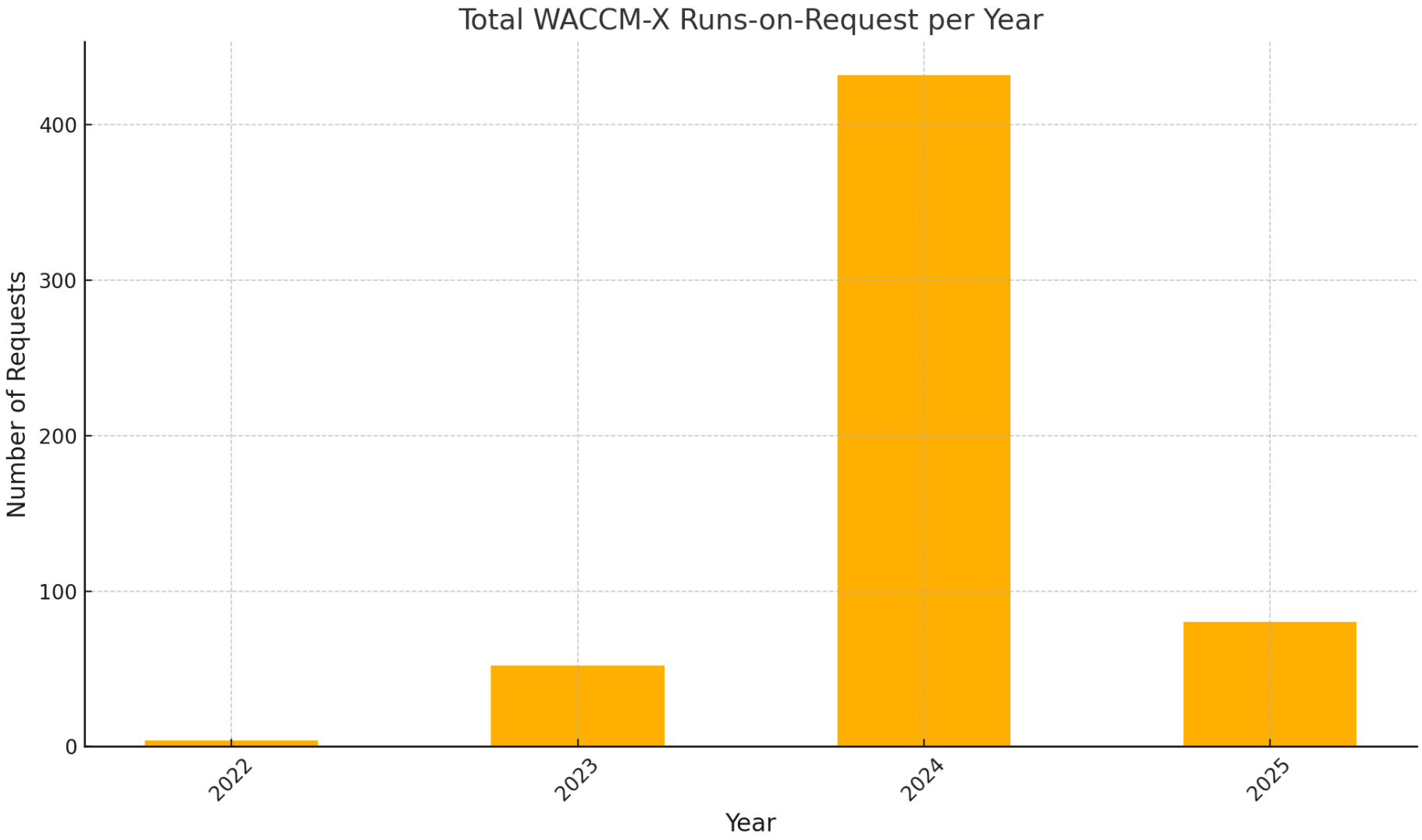
ion-neutral coupling



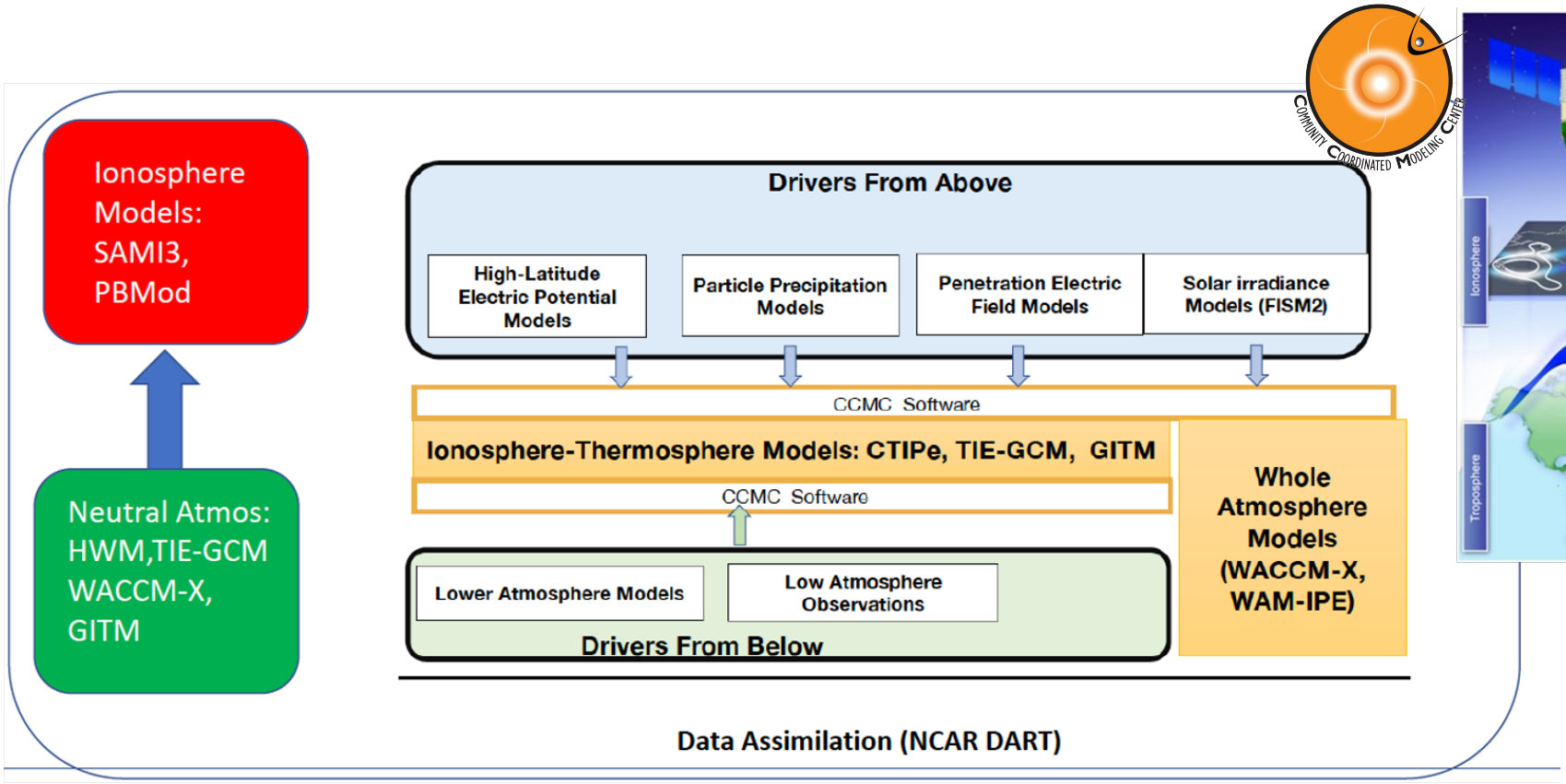



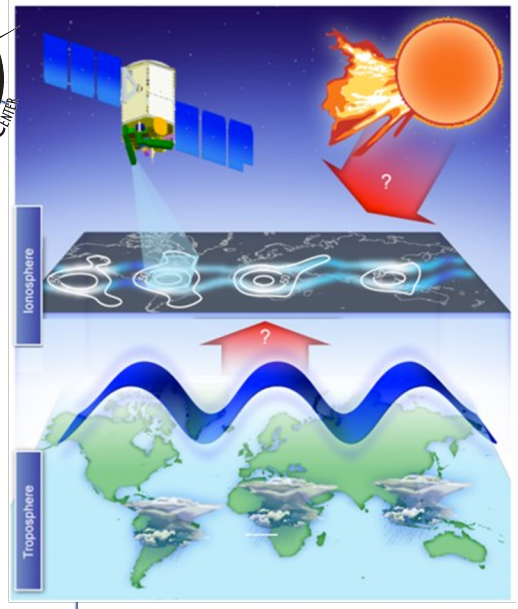

lower-upper atm. coupling

# Over 560 WACCM-X requests since 2023 (from ~100 unique users across > 10 countries)



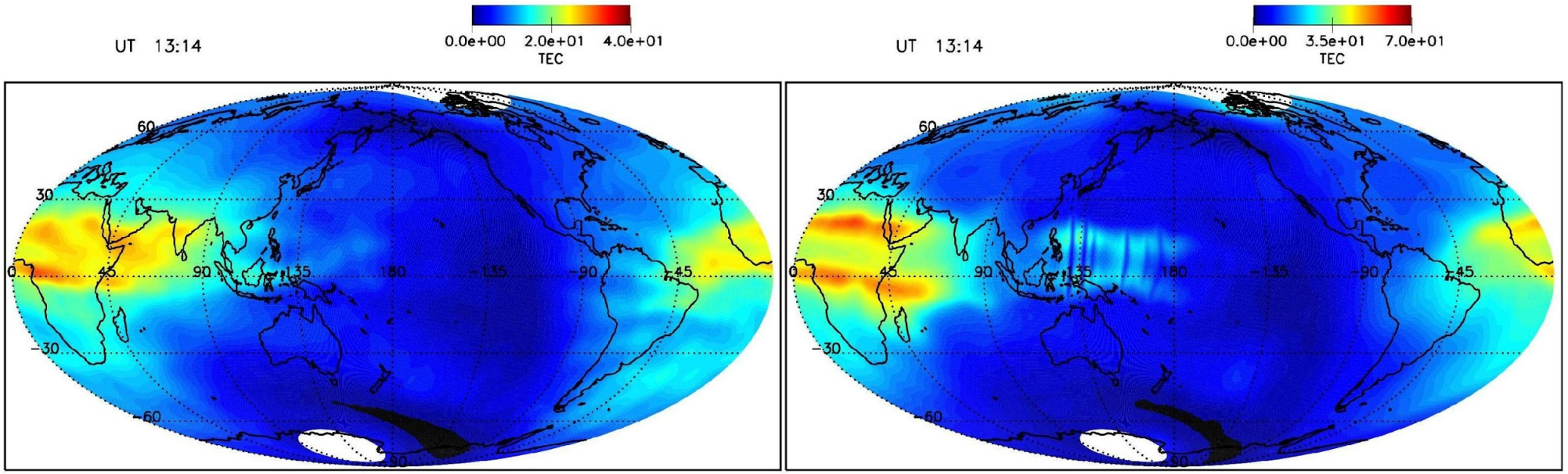
# Models and services available at CCMC (thermosphere/ ionosphere models coupling with magnetosphere MHD and lower atmosphere drivers) -- providing system solution



# First global ionosphere model SAMI3 simulates weather of the ionosphere

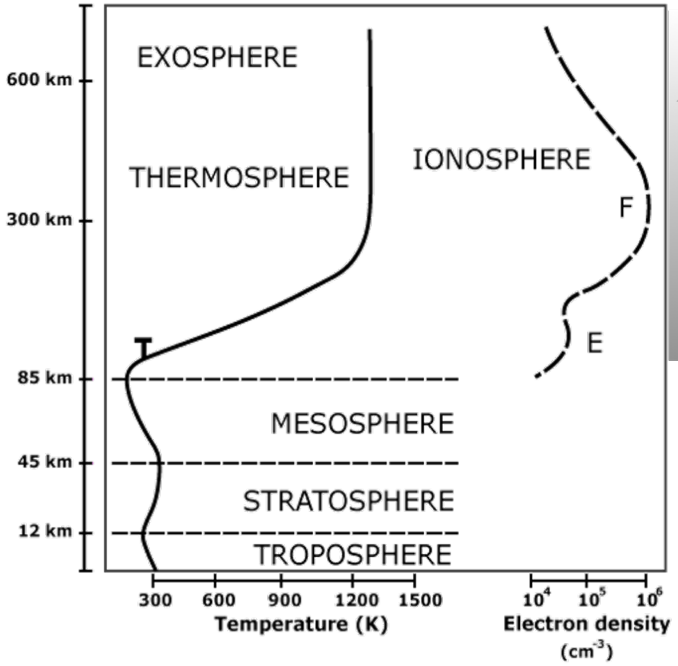
- Options of empirical (HWM/MSIS) or physics-based model inputs (e.g., TIE-GCM, TIE-GCM/ICON, WACCM-X)
- SAMI3/WACCM-X is available through CCMC RoR.
  - enable to study day-to-day variability of plasma bubbles and TIDs

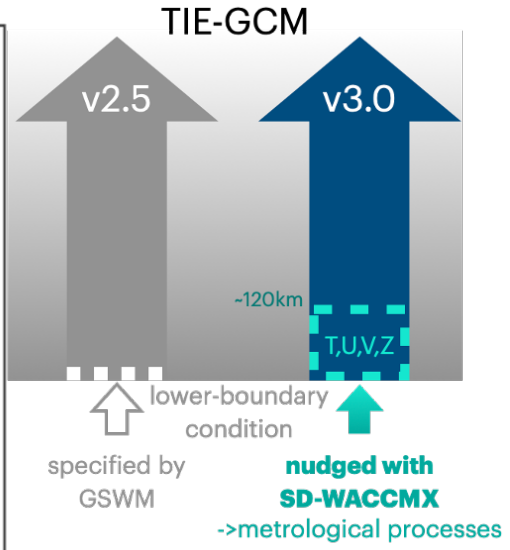


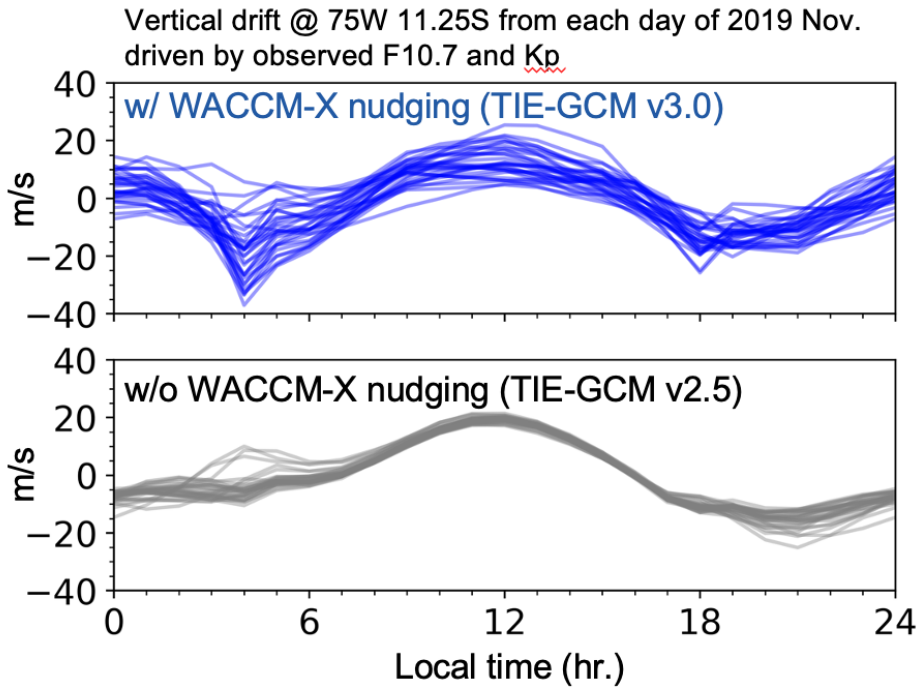

solar min. in Aug.

solar medium in Mar.

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

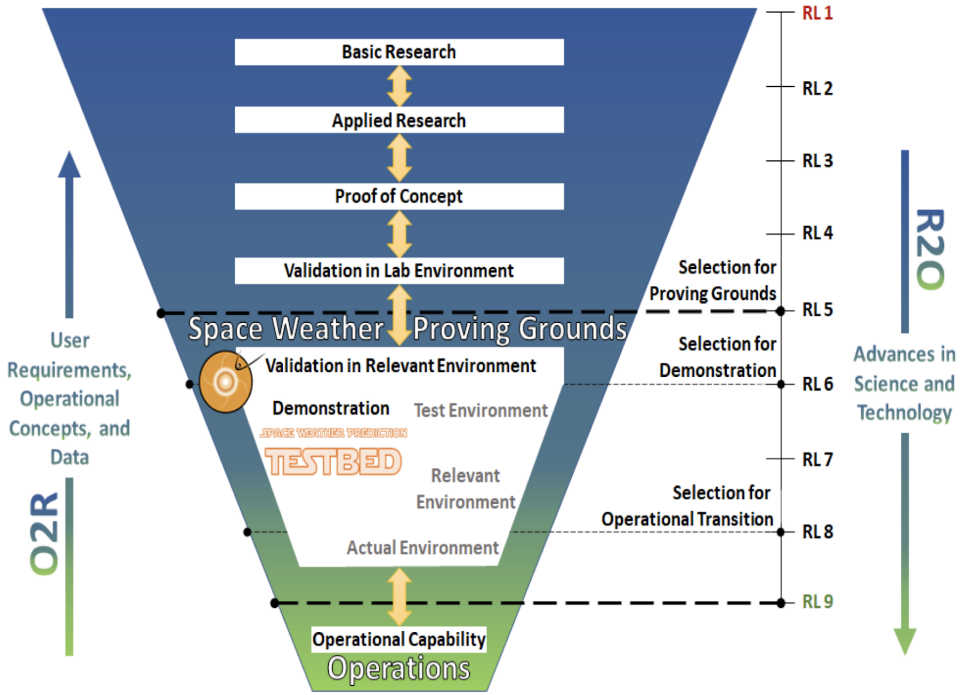


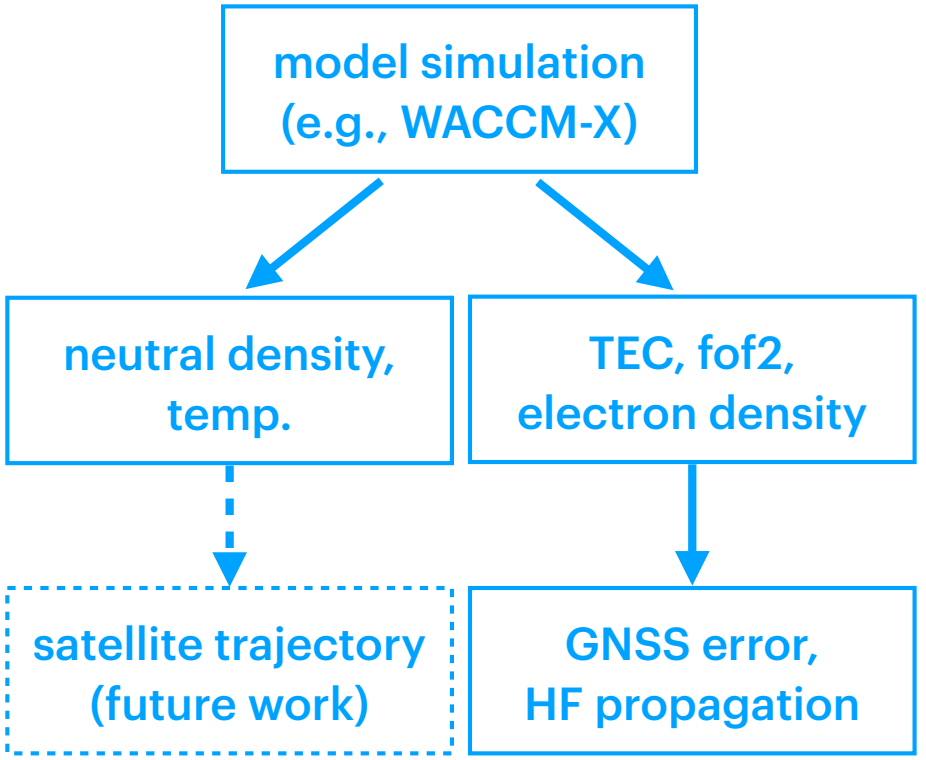




Enhancing the model capability to reproduce variability of the space environment as related to lower atmosphere forcing on day-to-day weather scales.

# CCMC performs unbiased testing and validation of hosted models

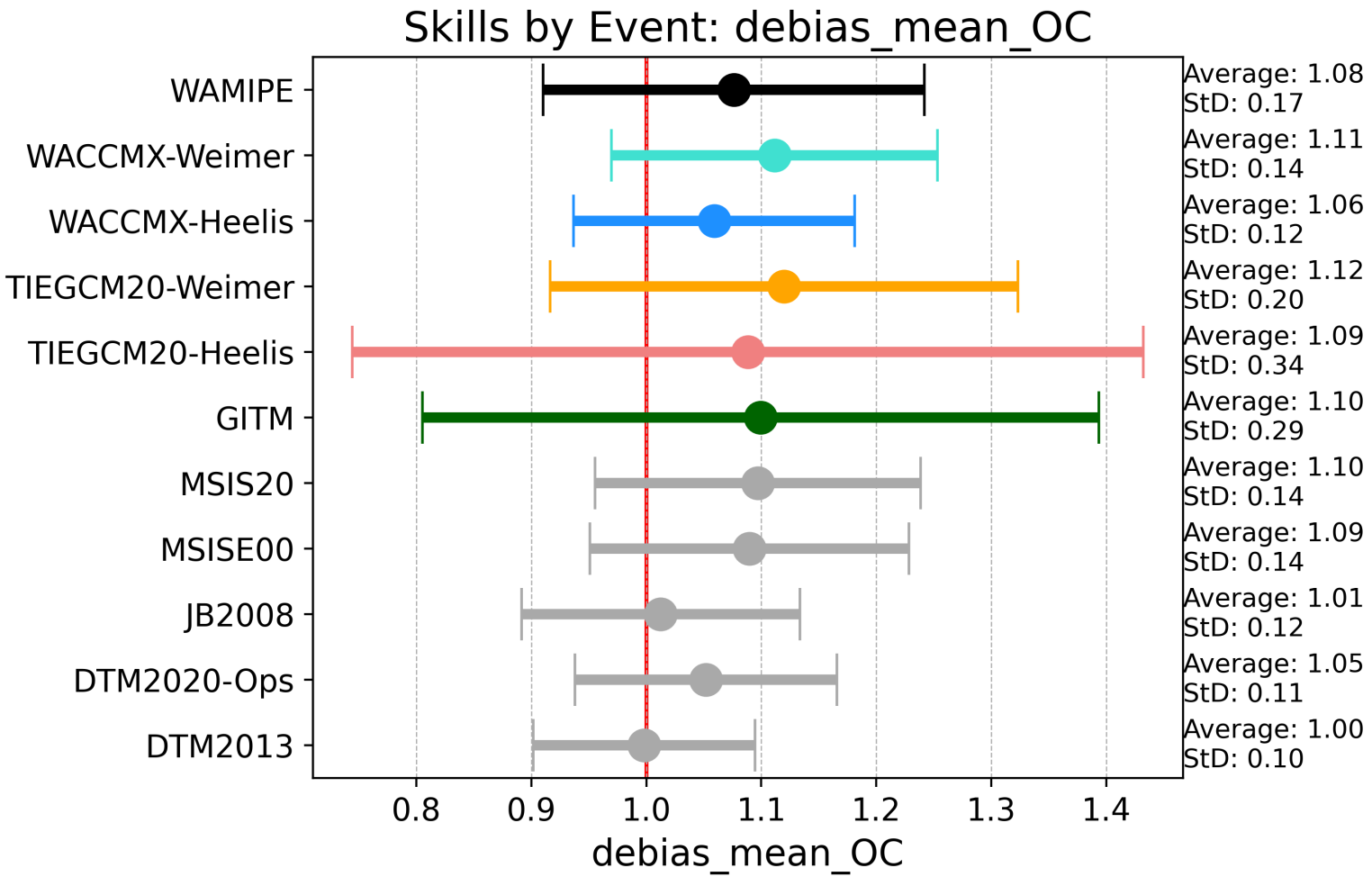



**impact-based validation**

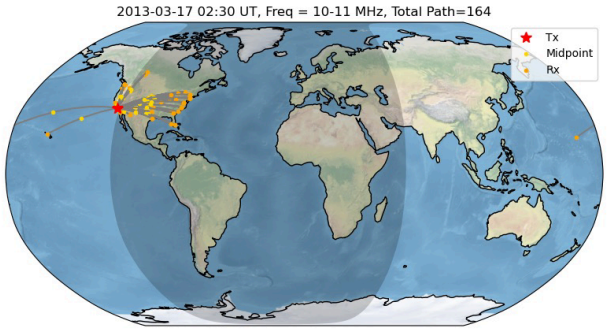
# Validation of neutral density during 151 storm events from 2001 to 2023

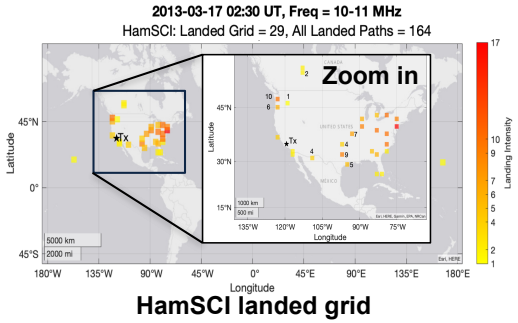
O/C = 1, no model bias on average (best)
> 1, underestimate
< 1, overestimate



# Ionosphere Model Validation with Amateur Radio Community (HamSCI), led by Dr. Min-Yang Chou

**Goal:** To reproduce the **HF propagation** from the **HamSCI data**, we will be able to use HamSCI data for ionospheric research and **model validation**.




HamSCI landed grid

## HamSCI

- An official NASA citizen science project
- allows researchers to collaborate with the amateur radio community in scientific investigations

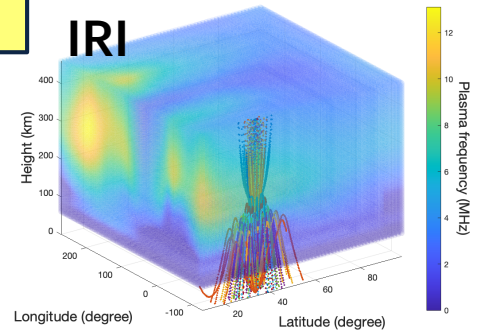
## PHaRLAP (Ray tracing tool)

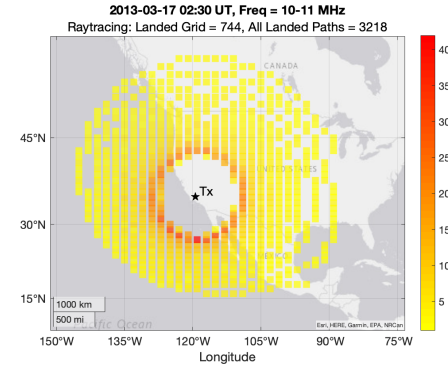
- Developed and controlled by Dr. Manuel Cervera, DoD, Australian Government.
- Matlab toolbox for modeling of the propagation of High Frequency (HF) radio waves
- Semi-open source (some of the key codes are precompiled.)

Raytracing landed grid

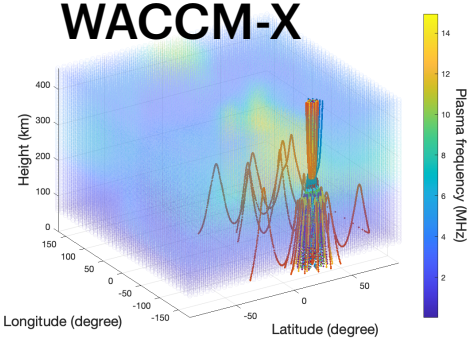
Same landed grid

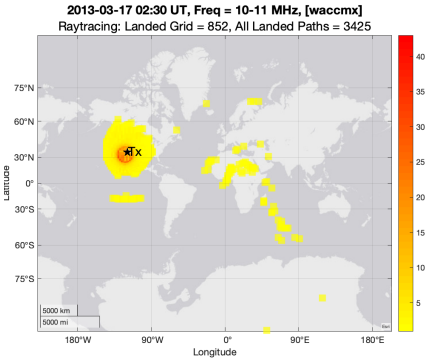
IRI



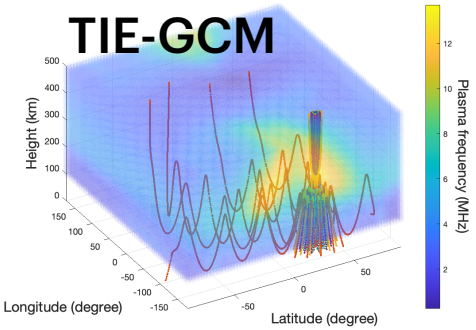



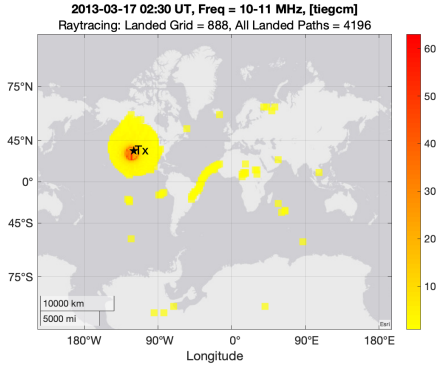

WACCM-X



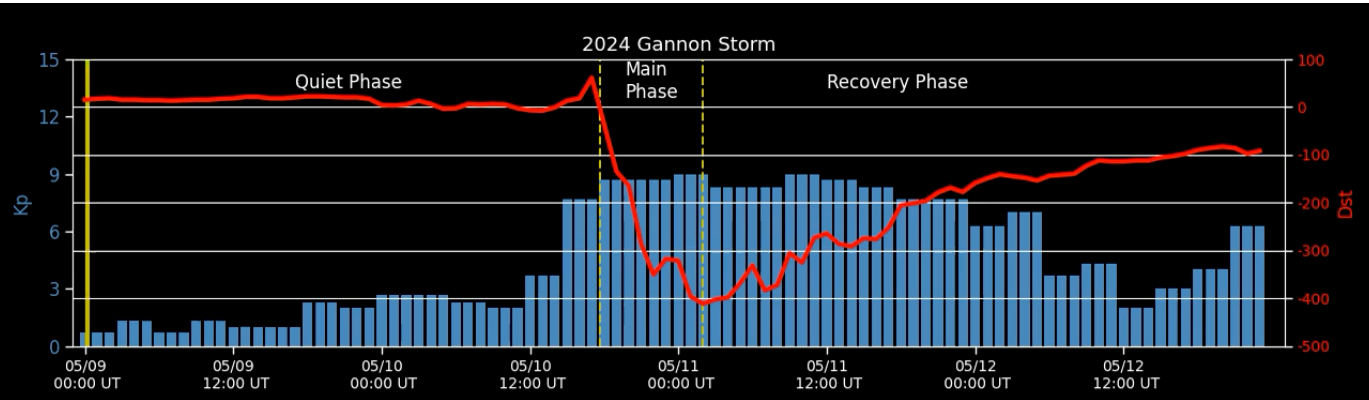



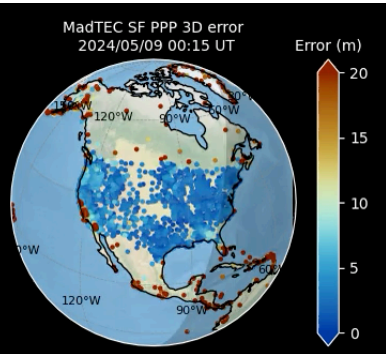

TIE-GCM

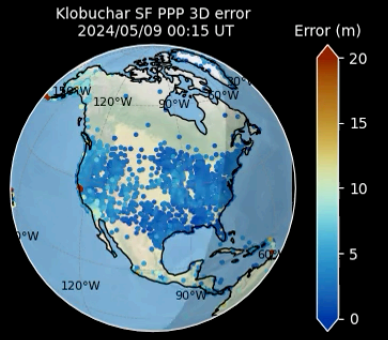



(not all raypaths)


2024 Gannon Storm
Quiet Phase
Main Phase
Recovery Phase
Kp
Dst
05/09 00:00 UT
05/09 12:00 UT
05/10 00:00 UT
05/10 12:00 UT
05/11 00:00 UT
05/11 12:00 UT
05/12 00:00 UT
05/12 12:00 UT


MadTEC SF PPP 3D error
2024/05/09 00:15 UT
Error (m)


Klobuchar SF PPP 3D error
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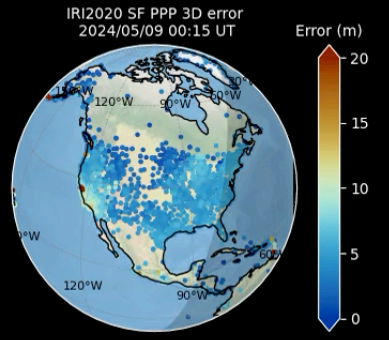
Error (m)


IRI2020 SF PPP 3D error
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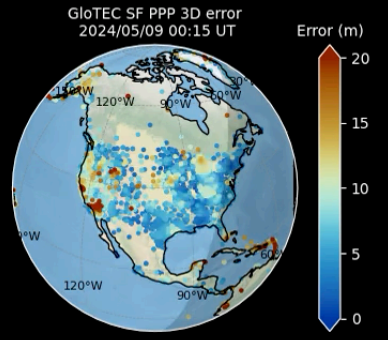
Error (m)


GloTEC SF PPP 3D error
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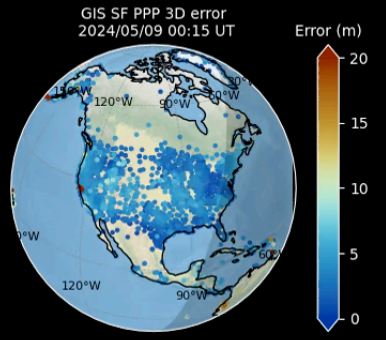
Error (m)


GIS SF PPP 3D error
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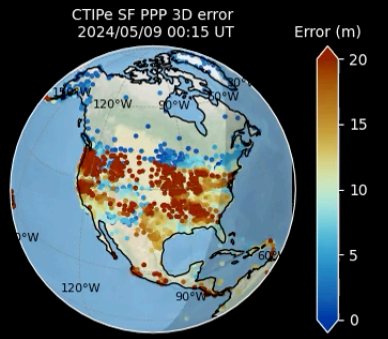
Error (m)


CTIPe SF PPP 3D error
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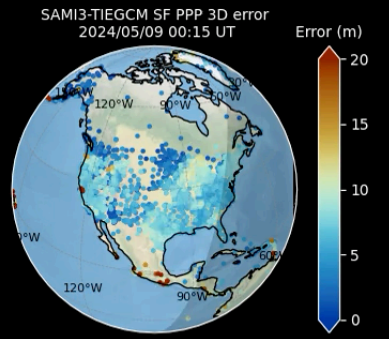
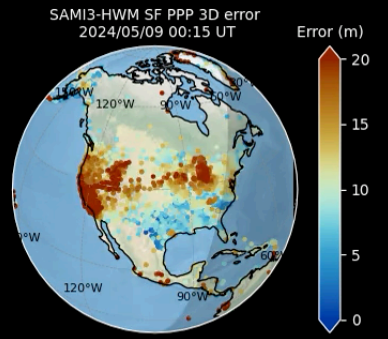
Error (m)


SAMI3-TIEGCM SF PPP 3D error
2024/05/09 00:15 UT
Error (m)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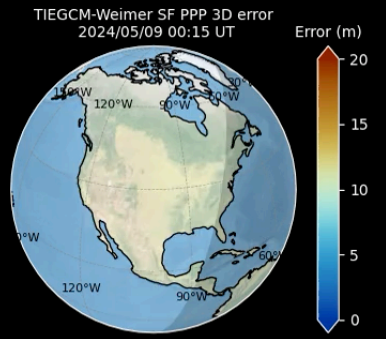
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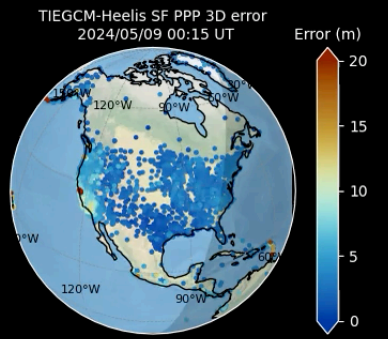
Error (m)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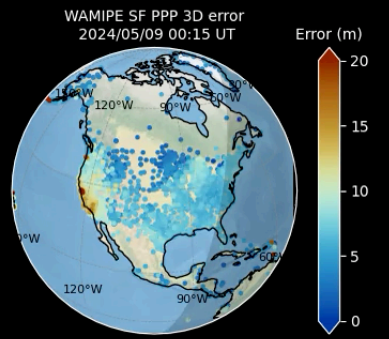
Error (m)


WAMIPE SF PPP 3D error
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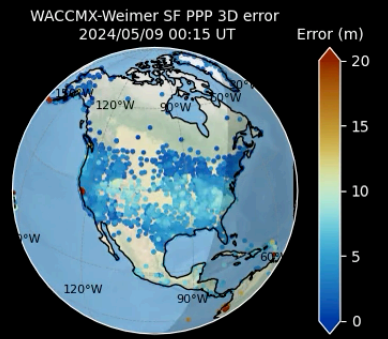
Error (m)


WACCMX-Weimer SF PPP 3D error
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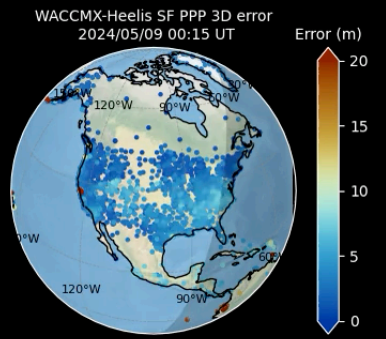
Error (m)


WACCMX-Heelis SF PPP 3D error
2024/05/09 00:15 UT
Error (m)

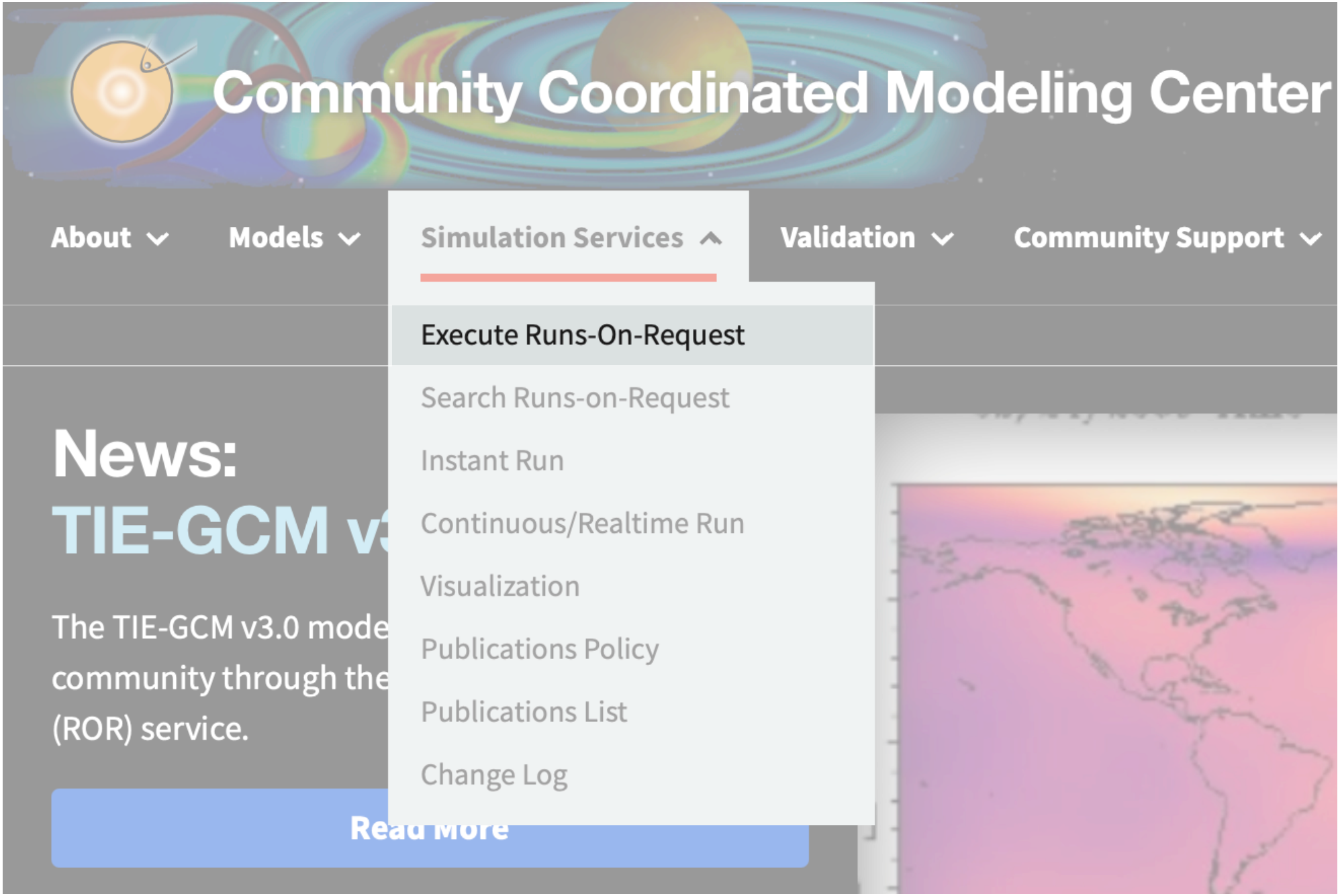
# Future outlook

- Onboarding CESM3 as soon as it becomes available
  - 0.5-deg resolution, dynamical core to SE:
    resolving GWs is particularly important for plasma bubble seeding
- New NO scheme should improve neutral density
- SWMF/WACCM-X; WACCM-X/PBMOD
- Expand validation activities (e.g, satellite trajectories, see Jia Yue's science highlight talk on Thursday for an example)

# NASA Community Coordinated Modeling Center (CCMC)

## WACCM-X/RoR Demo

Jack Wang and all CCMC members
Community Coordinated Modeling Center, NASA GSFC
June 25nd, 2025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The TIE-GCM v3.0 mode
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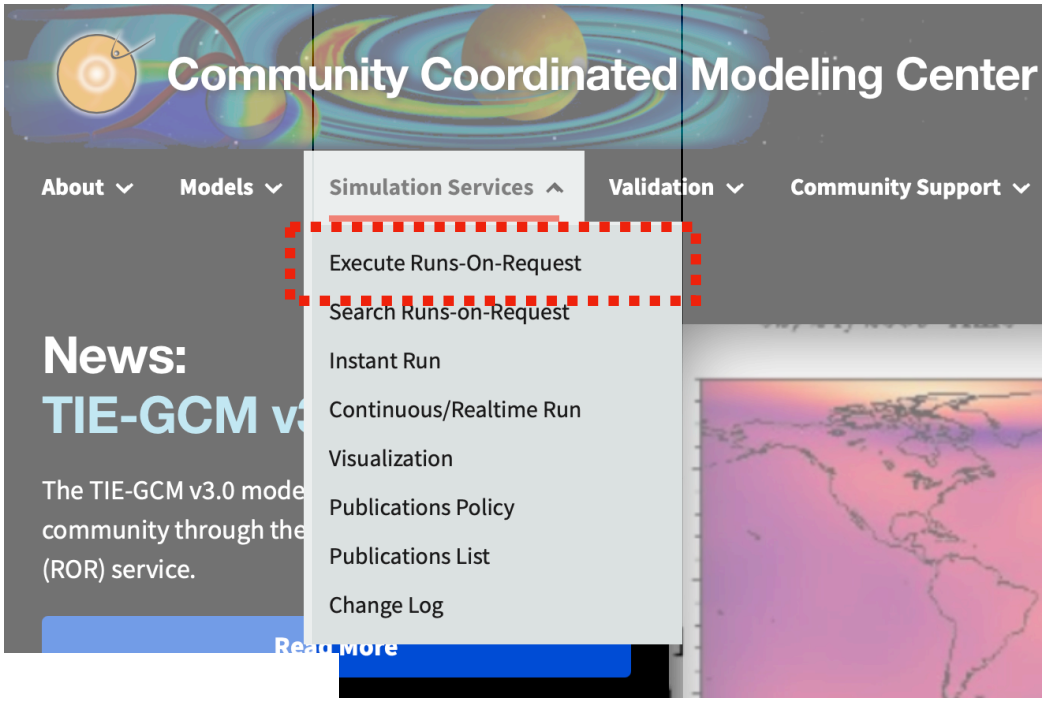


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# CCMC Runs on Request System

Runs on Request (ROR) is a simulation service accessible to anyone wishing to execute space science and space weather models hosted by the CCMC.

**View all models available for Runs on Request (ROR) →**

**Track current active request progress on the ROR Requests Dashboard →**

**Search ROR Archive →**

Home

# Model Catalog

WACCMX

*Found 2 models*

Reset Filters

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## WACCMX

Whole Atmosphere Community Climate Model With Thermosphere and Ionosphere Extension

Version: 2.2

**Status:** Production

Runs-on-Request | Public Repository

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# WACCM-X RoR submission interface

E-field model
- Weimer
- Heelis

Solar EUV model
- EUVAC
- FISM2 daily band

**Request an WACCMX Model Run**

Please complete the form below. * Indicates a required field.

****You must agree to the CCMC Data Policy in order to submit a run****

**Do you give your consent?**
☑ **YES**

Step 1: GENERATE YOUR REQUEST

Your run results will be published online *under your Run Registration Number* (FirstName_LastName_MMDDYY_ModelType_RunNumber)

| | | |
|---|---|---|
| **WORK OR SCHOOL EMAIL**<br>how to contact you | | Enter a valid work or school email address |
| **FIRST NAME (GIVEN)***<br>your given name | | Enter your given name |
| **LAST NAME (FAMILY)***<br>your family name | | Enter your family name |
| **RUN NUMBER***<br>max 15 runs per day | choose run number for today | Unless you want to overwrite it |
| **KEYWORD/S***<br>helps to sort and search the results of simulations | | Enter a keyword |

Step 2: Dates Range

Select start and end dates of your simulation spanning at least 1 and at most 10 days.

| | | |
|---|---|---|
| **Start date**<br>YYYY/MM/DD | | Select or type a valid date in the suggested format, e.g. 2016/01/15 |
| **End date**<br>YYYY/MM/DD | | Select or type a valid date in the suggested format, e.g. 2016/01/15 |

Step 3: E-Field Model

**Choose E-Field model**
Parameters of the solar and E-field inputs are based on the observational dataset

Weimer

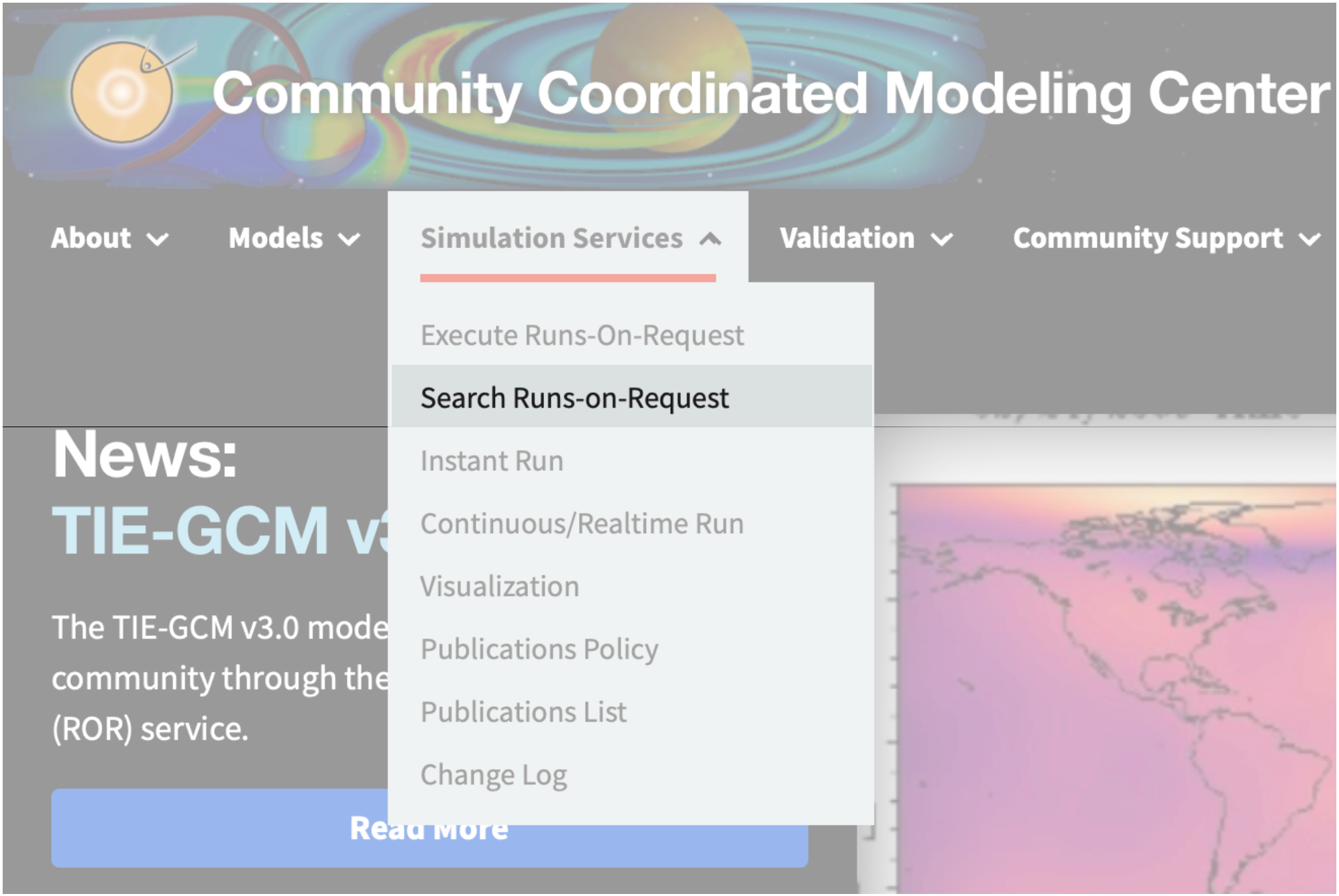
**Please, select a valid model for the selected dates range or adjust the dates**

Weimer: 1996/01/01 - 2024/06/01
Heelis: 1960/01/01 - 2024/06/01

Step 4: Solar EUV model

**Choose EUV model**

EUVAC (default)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Change Log
News:
TIE-GCM v
The TIE-GCM v3.0 mode
community through the
(ROR) service.
Read More

| Status | Run Number | Key Words | Model | Model Version | Validation Level | Year | DoY at Start | F10.7 at Start | F10.7 (three year average) | Run Type | Input Type | Event Date |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| running | Dr_SC_062325_IT_1 | test_run | WACCMX | 2.2 | -- | 2024 | 131 | 0.00000 | 0.00 | event | -- | May 10, 2024 |
| Published | Huang_Guo-wei_062025_IT_1 | Guo | WACCMX | 2.2 | -- | 2024 | 151 | 0.00000 | 0.00 | event | var | 2024-05-30 |
| Published | Dmytro_Kotov_061425_IT_1 | Ionospheric storms | WACCMX | 2.2 | -- | 2023 | 150 | 0.00000 | 0.00 | event | var | 2023-05-30 |
| Published | Dmytro_Kotov_061325_IT_4 | Ionospheric storms | WACCMX | 2.2 | -- | 2023 | 150 | 0.00000 | 0.00 | event | var | 2023-05-30 |
| Published | Huang_Guo-wei_061325_IT_1 | Guo | WACCMX | 2.2 | -- | 2024 | 142 | 0.00000 | 0.00 | event | var | 2024-05-21 |
| Published | Shrivansh_Panwar_060825_IT_1 | Meridional Wind | WACCMX | 2.2 | -- | 2004 | 203 | 0.00000 | 0.00 | event | var | 2004-07-21 |
| Published | Huang_Guo-wei_060525_IT_1 | Guo | WACCMX | 2.2 | -- | 2024 | 132 | 0.00000 | 0.00 | event | var | 2024-05-11 |
| running | Huang_Guo-wei_060425_IT_1 | Guo | WACCMX | 2.2 | -- | 2024 | 132 | 0.00000 | 0.00 | event | -- | May 11, 2024 |
| Published | Swati_Chowdhury_060225_IT_1 | meridional wind | WACCMX | 2.2 | -- | 2020 | 337 | 0.00000 | 0.00 | event | var | 2020-12-02 |
| Published | Huang_Guo-wei_052825_IT_1 | Guo | WACCMX | 2.2 | -- | 2024 | 122 | 0.00000 | 0.00 | event | var | 2024-05-01 |
| Published | chaneMoges_Seid_052725_IT_1 | temperature | WACCMX | 2.2 | -- | 2019 | 339 | 0.00000 | 0.00 | event | var | 2019-12-05 |
| Published | Meenakshi_S_052625_IT_2 | wave4 | WACCMX | 2.2 | -- | 2020 | 14 | 0.00000 | 0.00 | event | var | 2020-01-14 |
| running | Huang_Guo-wei_052325_IT_1 | Guo | WACCMX | 2.2 | -- | 2024 | 122 | 0.00000 | 0.00 | event | -- | May 01, 2024 |
| Published | Sophia_Laranja_052325_IT_1 | WACCMX_10032014_Weimer_EUVAC | WACCMX | 2.2 | -- | 2014 | 276 | 0.00000 | 0.00 | event | var | 2014-10-03 |
| Published | Sophia_Laranja_052325_IT_3 | WACCMX_11202013_Weimer_EUVAC | WACCMX | 2.2 | -- | 2013 | 324 | 0.00000 | 0.00 | event | var | 2013-11-20 |
| Published | Sophia_Laranja_052325_IT_4 | WACCMX_11202013_Heelis_EUVAC | WACCMX | 2.2 | -- | 2013 | 324 | 0.00000 | 0.00 | event | var | 2013-11-20 |
| Published | Sophia_Laranja_052325_IT_2 | WACCMX_10032014_Heelis_EUVAC | WACCMX | 2.2 | -- | 2014 | 276 | 0.00000 | 0.00 | event | var | 2014-10-03 |
| Published | Sophia_Laranja_052225_IT_3 | WACCMX_01172012_Heelis_EUVAC | WACCMX | 2.2 | -- | 2012 | 17 | 0.00000 | 0.00 | event | var | 2012-01-17 |
| Published | Min-yang_chou_052225_IT_1 | gannon storm for sami3 | WACCMX | 2.2 | -- | 2024 | 130 | 0.00000 | 0.00 | event | var | 2024-05-09 |

Runs on Request | 37,855 View Results | 90 View Active Runs

## Fatemeh_Bagheri_042225_IT_1

Run Status: Run Complete
Status updated: 2025-04-24T21:40:58+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: | WACCMX |
| Model Version: | 2.2 |
| Key Word: | tides |
| | |
| CS output: | GEO |
| Run type: | event |
| Boundary condition type: | var |
| Year run: | 2017 |
| DOY: | 272 |
| Start time: | 2017/09/29 00:00:00 |
| End time: | 2017/09/30 00:00:00 |
| E-field model: | weimer |

### Output Data

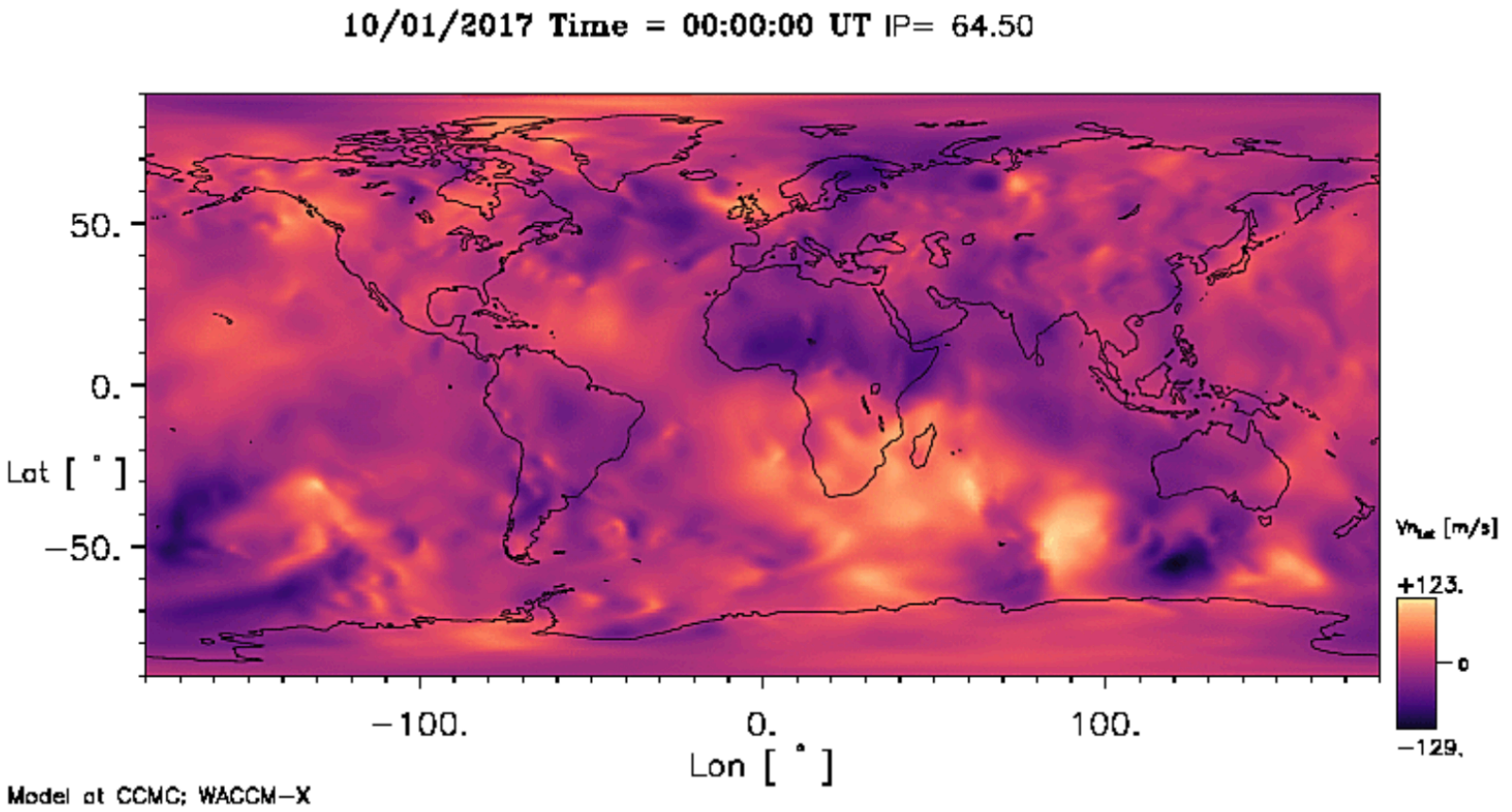
- View 3D Ionosphere/Thermosphere
- Create Timeseries in 3D Ionosphere/Thermosphere

### Run Services

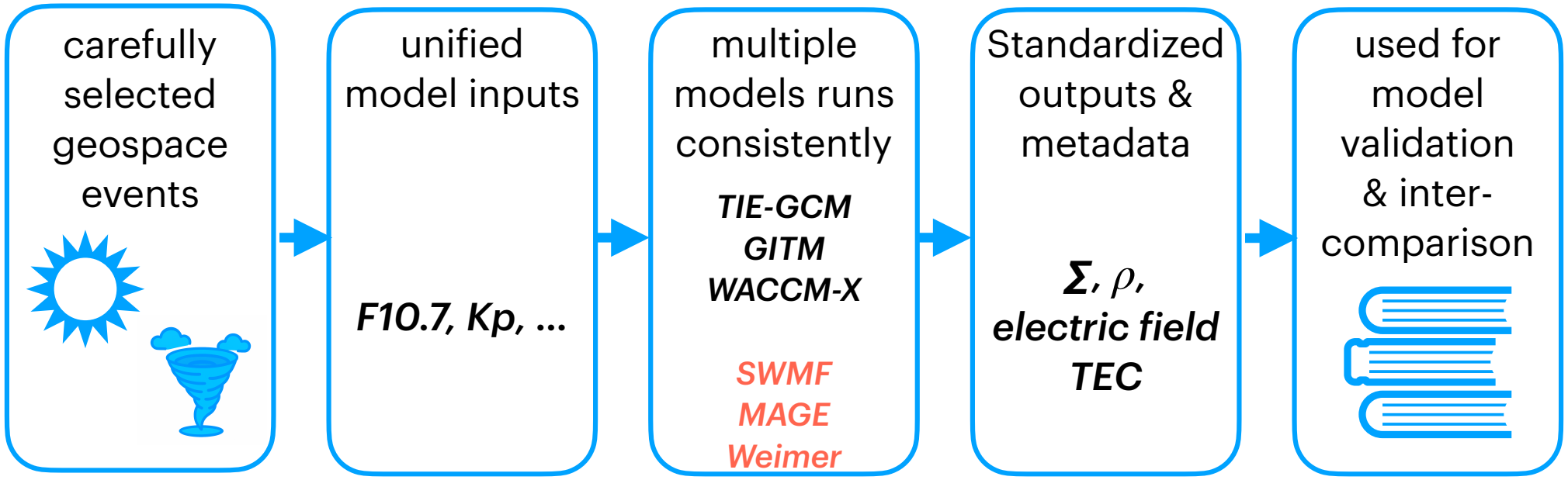
- Request output data in bulk
- Browse individual output files

### Supplementary Services

- CCMC DONKI notifications during the run period:



# **Time Period** database: a curated collection for consistent model evaluation




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

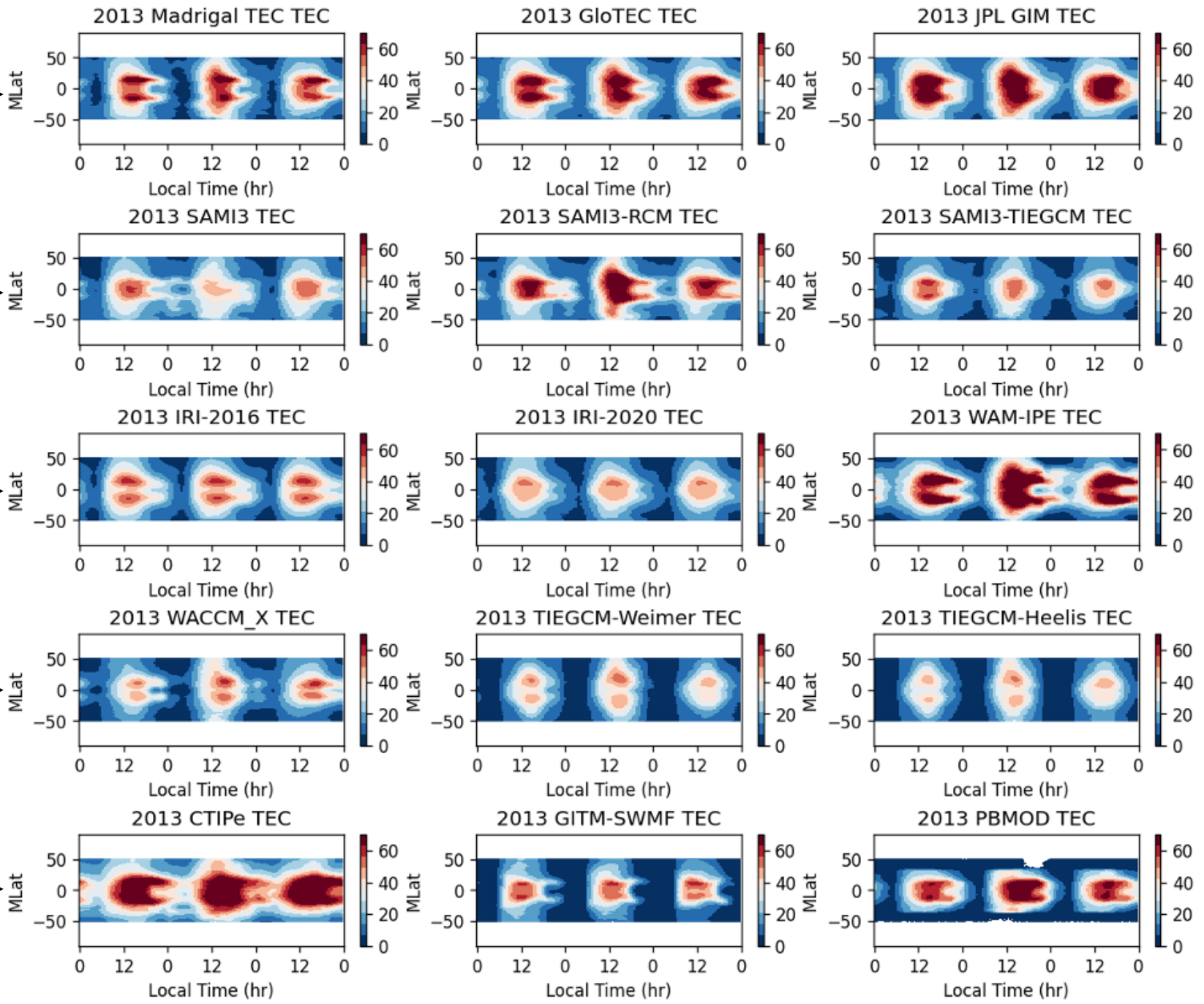
# Back-ups

# 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)

# TEC 2013 March Storm, Lat x LT. map

Madrigal
GloTEC
JPL GIM




SAMI3

IRI
WAM-IPE

WACCM-X
TIE-GCM

CTIPe
GITM
PBMOD