Enabling Collaborative Space Weather Research at the Community Coordinated Modeling Center (CCMC)

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ccmc.gsfc.nasa.gov

SH21E

Abstract

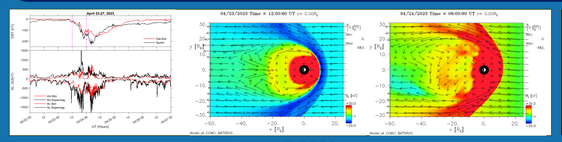
Space weather models have been actively developed by the international research community, covering extensive spatial and physical domains. Still, many of the ground-breaking models remain a granular effort, insulated from a wider research audience, particularly that in different domains, and possible end users. The Community Coordinated Modeling Center (CCMC, https://ccmc.gsfc.nasa.gov) seeks to remove such barriers to collaboration and coordination by providing a convenient platform for hosting space weather models and associated services. Using these services, researchers and other end-users may exercise, evaluate, and intercompare contributed models, as well as collaborate on a continuously updated archive of model run results. Moreover, the multi-disciplinary science support team at CCMC facilitates and enables collaboration across domains.

In our presentation, we will discuss the space weather model services at CCMC, including Runs-on-Request, Real-Time Continuous Runs, and Instant Runs. We will also review new and updated models added to the extensive collection of space weather models hosted at CCMC. We will focus on trends in model, service, and science support utilization at CCMC as a proxy to the most pressing needs of the collaborative modeling community.

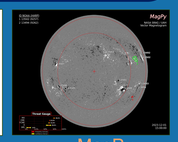
Space Science and Weather Models and Services

- CCMC hosts over 80 Heliophysics models in multiple domains:
  - Solar
  - Heliosphere
  - Global Magnetosphere
  - Inner Magnetosphere
  - Ionosphere / Thermosphere
  - Local Physics
- CCMC's main goals:
  - Facilitate research and model development
  - Support transition of advances in research to space weather OPS
- Services freely available at CCMC for the hosted models:
  - Most models can be requested to **Run on Request (ROR)** with model input parameters specified through a simple Web-based interface and results staged on a public Web-page. **Interactive value-added visualization** and file conversion of the results is available for most models. This enables scientists who are not modelers themselves to utilize state-of-the-art models in their research.
  - A limited set of fast and simple models is available for **Instant Run**, where a model can be executed and visualized while-you-wait.
  - Certain models **continuously run** to generate simulation results over long time periods testing model robustness and long-term performance, while also feeding the perpetual archive and portal of space weather information at CCMC. The results are available to researchers and decision makers in real time, through our signature interactive tools such as **iSWA**, **SEP ScoreBoard**, and others.

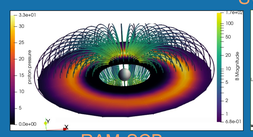
Models Added in 2023



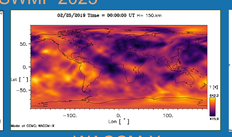
SWMF 2023



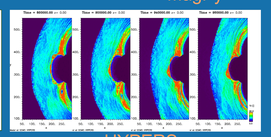
MagPy



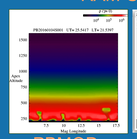
RAM-SCB



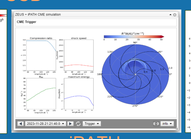
WACCM-X



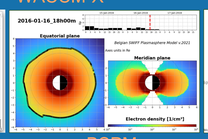
HYPERS



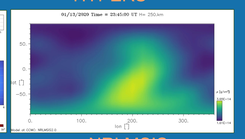
PBMOD



iPATH



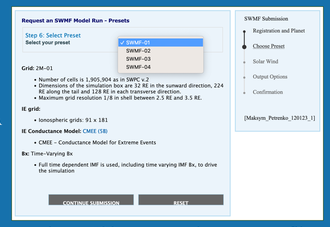
BSPM

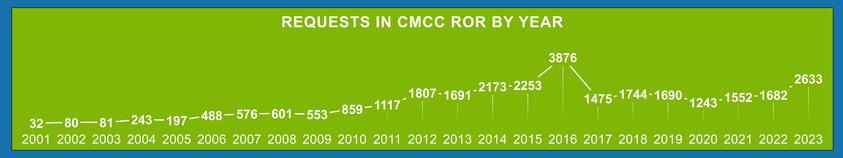


NRLMSIS

New in Runs on Request (ROR) in 2023

- New Model Releases
  - SWMF AWSoM_R/MFLAMPA, HYPERS, WACCM-X, PBMOD, NRLMSIS, RAM-SCB, BSPM, SWMF GM 2023
  - New SWMF submission interface provides 4 presets pre-configuring SWMF for the most popular model use cases
- Currently onboarding
  - CORHEL CME, BSPM, EPREM, OSPREI, GAMERA
- Updated Models
  - TIE-GCM, IRI, WSA, NAIRAS
- New Features
  - Run result file browse feature
  - Automated tarball run result preparation and delivery - about 500 tar complete output files provided a year
  - JSON and SPASE-like API access to metadata, run status, files, etc
  - Quick search of ROR runs
  - Support for model runs in AWS, including GPU instances
  - Setup ROR pipeline for popular compute-heavy models on NAS Pleiades, including TIE-GCM, WACCMX, and SWMF GM, reducing turn-around
  - Testing ROR pipeline for additional on-demand compute in AWS



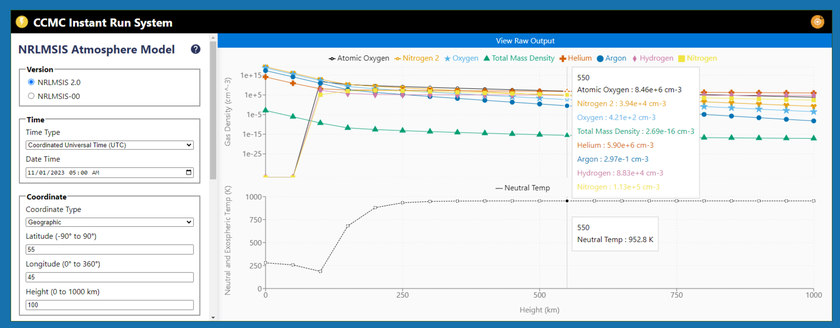


New in Continuous Runs in 2023

- Models
  - Released: MagPy, iPATH, SHELLS
  - Updated: UMASEP, NAIRAS, SESPTER, SEPSTER2D
- New Features
  - Improved onboarding and run pipelines and procedures
  - Containerized first parallel model: WSA (HPC and non-HPC modes)
  - Completed development of Kubernetes cluster prototype using the SEPSTER model as a proof of concept
  - Upcoming: Containerize ENLIL+SEPMOD, real-time log collection, monitoring, and analysis of models (Kafka+Fluentd)

New in Instant Run in 2023

- New version with updated backend and improved frontend
- Transitioned the WEIMER 2000 and 2005 into the new IR system
- Added additional optional parameters for IRI 2007, 2012, 2016, and 2020
- Updated NRLMSIS-00 and NRLMSIS 2.0 to allow requests 5 days from the current date



Enabling Open Science

- Making a model available through CCMC exposes simulation capabilities to researchers and decision makers across the globe, shortening the research-to-operations cycle and maximizing scientific return on investment in model development.
- CCMC ecosystem of model execution and evaluation tools provides a level playground that can be used to compare predictive skill and other parameters of the model against an array of competing models.
- CCMC maintains a free and open interactive searchable archive of model output and metadata, including output generated in ROR and output provided by external groups and collaborators. CCMC works with the community to advance and adhere to the standards, guidelines, and best practices for data access and discovery.
- A few CCMC developed tools/libraries are NASA Open Source projects. Whenever it is beneficial and possible, the CCMC always pushes to make source code developed and owned by the CCMC open to the community. Model developers are also encouraged (but not required) to share source code of the models. Your intellectual property rights are always respected at the CCMC!
- CCMC has developed the tool and framework (e.g., CAMEL) to support open validation efforts within the community

User Support Services at CCMC

"We need to perform 240 runs with a custom input for our model-data comparison studies"

"Pilot interested in radiation levels"

"Please provide hourly Joule heating rate"

"I need Ne values to be more consistent to cosmic2 data in the temporal resolution to be able to use it as input with cosmic2 data in my neural network"

"My LFM simulation will take 45 days to complete, please supervise the run to make sure it is ready by the conference deadline"

"I need TEC map over the region between lat 18-20degrees North and longitude 73-75 degrees East with 0.1x0.1 degrees resolution"

"Please make the output frequency 60 s between 0300 and 0500 UT during the last two hours"

"school project dasds dsadsad asdasd"

"I would like to study the influence of neutral wind, kindly set windscale as zero"

"I need the results for educational purposes. I just need the results for longitude 51 E. I appreciate your time and help"

Multi-discipline staff of 20+ science domain experts and 15+ engineers at CCMC consults end users to guide an adoption and use of the model, while also working with the model authors to troubleshoot and improve future versions of the model. About 1 in 10 ROR runs arrives with a special user request and 1 in 5 ROR runs require a special handling, including input selections, debugging, custom processing etc. CMCC's in-house team of heliophysics domains experts work closely with the users of CCMC services – it is this collaboration that makes the data and science truly open and accessible!

"Re: No solar wind plasma data are available between about 2000/07/14 12:00 and 2000/07/15 02:00. Selected simulation time interval starts in the middle of the time interval when solar wind plasma data are missing. This leads to extrapolations resulting in invalid data that are far outside of the usual range. If you selected ACE-L2 (attached image) or WIND inputs at least the magnetic field data would be available throughout the time interval. Interpolated solar wind plasma values in the valid range can be generated if the start time is set within the last available data (attached image: stated at 11:00 UT on 2000/07/14) so that interpolations are bound by value starting values. We may be able to use the longer time interval and start in the middle at 2000/07/15 00:00 UT as you originally intended."

"Re: The run has RBE component which does not run with the extreme event settings specified in the run. The RBE component can be turned off to complete the run unless RBE output is required for your study. The RBE component does not feed back into the rest of the SWMF framework. It is only one-way coupled to the magnetosphere and ionosphere electrodynamics (reading information from the magnetosphere and ionosphere electrodynamics components)."

"Re: The TEC (total electron content) is an integrated electron density in ionosphere. NRLMSIS is an empirical model of neutral atmosphere, and so it does not include ionosphere. The ionospheric quantities such as TEC or VTEC cannot be derived from output of NRLMSIS. We suggest you try using other models at CCMC that do include ionosphere, such as IRI or TIEGCM"

CCMC Space Weather Research Portals and Forecasting Tools at CCMC

iSWA – Integrated Space Weather Analysis System

- Web-Based Space Weather Dissemination System
- User Configurable,Interactive Products
- Web Services
- Real-Time & Historical Model + Observational Data

Kamodo

- Access, interpolation, and visualization of space weather models and data in Python
- Transparent unit conversion
- Interactive science discovery through Jupyter notebooks

Database Of Notifications, Knowledge, Information

- Catalog of space weather phenomena
- Knowledgebase of interpretations, simulation results, and forecasting analysis
- Online tool for dissemination of forecasts, notifications, & archiving event-focused information

Comprehensive Assessment of Models and Events using Library Tools Framework

CAMEL

- The CAMEL framework is an integrated and flexible framework allowing users to seamlessly compare space weather and space science model outputs with observational data sets.
- The backend of the CAMEL framework takes advantage of Community Coordinated Modeling Center (CCMC) existing services.

SWPC_CAT - SWPC CME Analysis Tool

The primary tool being used by NOAA SWPC in measuring key parameters of a Coronal Mass Ejection (CME) as it emerges from the solar corona.

SEP, CME Arrival Time, Flare, and IMF Bz Scoreboards

EEGGL Eruption Event Generator (Gibson & Low)

- Use observations defining the CME source region (location and flux rope orientation,
- Generate Gibson-Low flux rope parameters for the flux rope emergence models.

StereoCAT CME Analysis Tool

- Determine CME kinematic parameters
- Create CME height-time measurements
- Create an ensemble of CME measurements
- Save and share measurement sessions