Supporting Space Weather Modelling at the Community Coordinated Modeling Center (CCMC)

ccmc.gsfc.nasa.gov

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Simulating Space Weather at CCMC

Space weather models are essential to our ability to understand and predict space weather events. Nonetheless, some of the most cutting-edge models may struggle to move past the initial research stage, remaining unknown and inaccessible to a wider research audience, thereby hindering validation, intercomparison and adoption of the models. The Community Coordinated Modeling Center (CCMC, https://ccmc.gsfc.nasa.gov) closes this gap 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 growing archive of model run results.

In this presentation, we will discuss current and planned capabilities in some of the model services at CCMC, including Runs-on-Request, Instant Runs, and Real-Time Continuous Runs. We will also review new models added to the extensive collection of space weather models hosted at CCMC. Finally, we will talk about our efforts at streamlining model delivery to CCMC, including support for containerized models and establishment of an open collaborative environment based on Amazon Web Services (AWS).

Space Science and Weather Models and Services

- CCMC hosts over 60 space weather 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**, **CME ScoreBoard**, and others.
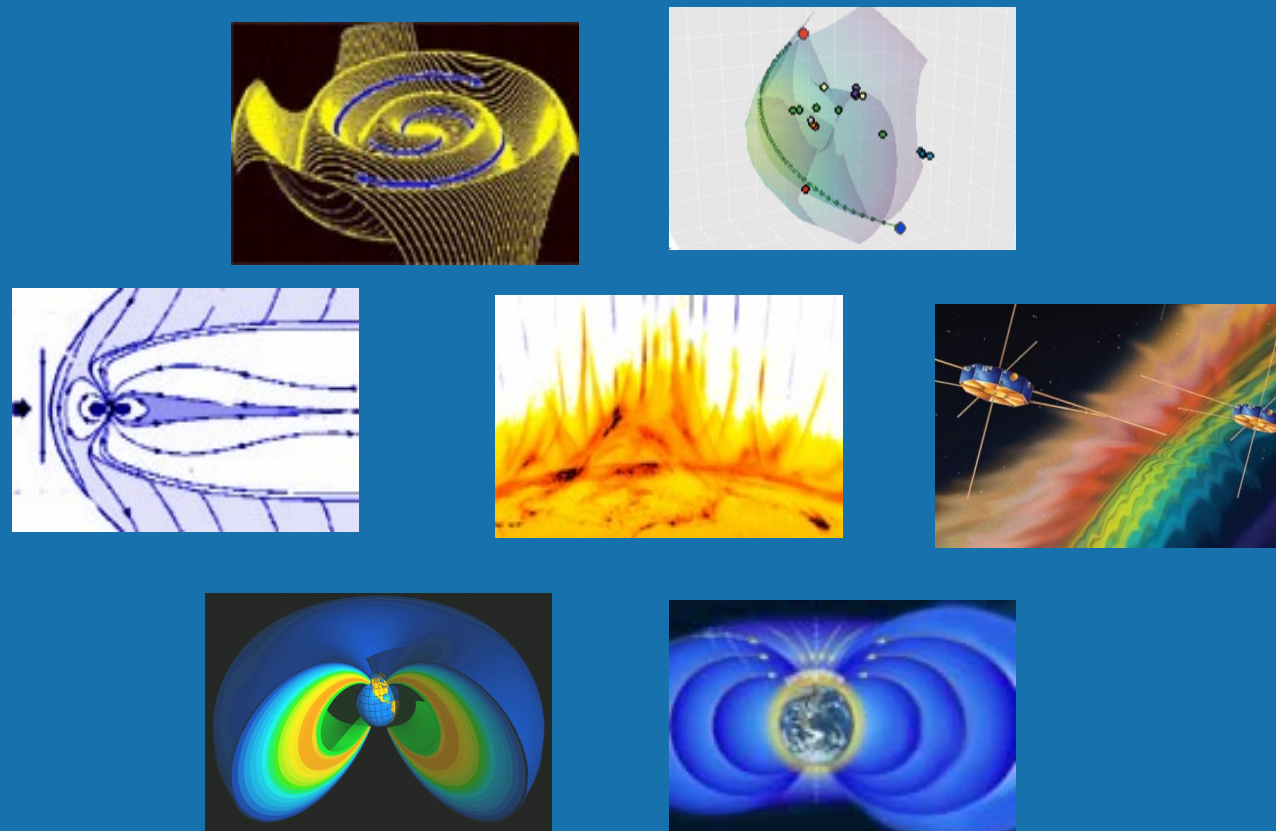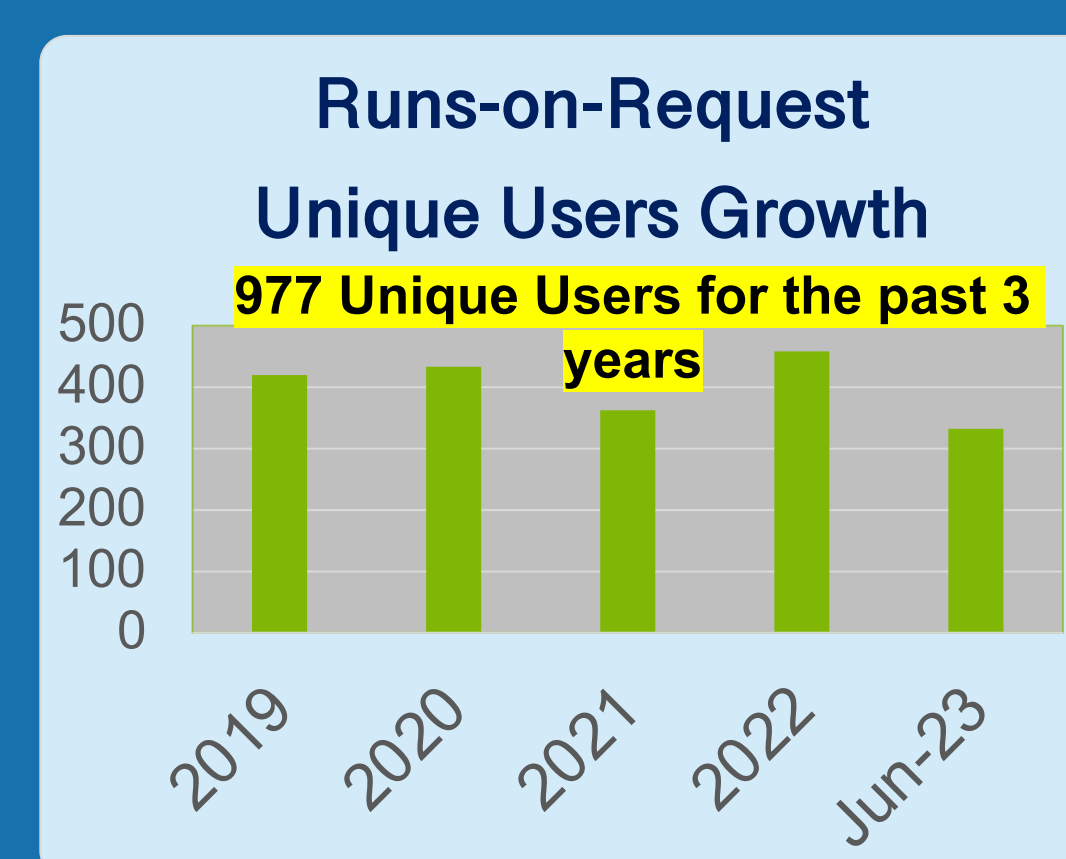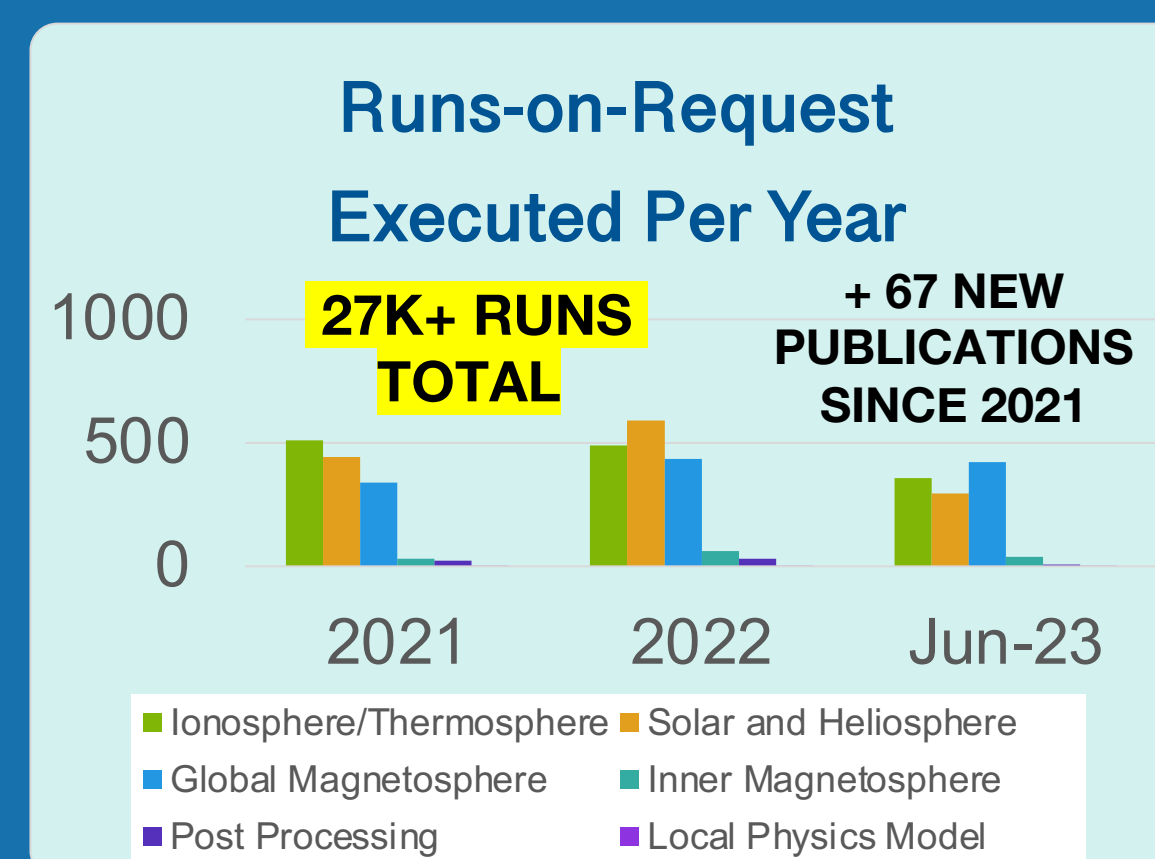
Why Host your Model at CCMC?

- 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.

- Multi-discipline staff at CCMC consults end users to guide an adoption and use of the model, while also working with the authors to troubleshoot and improve future versions of the model. About 1 in 10 ROR runs require special handling, including input selections, debugging, custom processing etc. CMCC's in-house team of heliophysics domains experts work closely with the users of ROR. This collaboration is what makes the data and science truly open and accessible!

- CCMC ecosystem 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 archive of model output data, including data generated in ROR and data provided by external groups and collaborators.

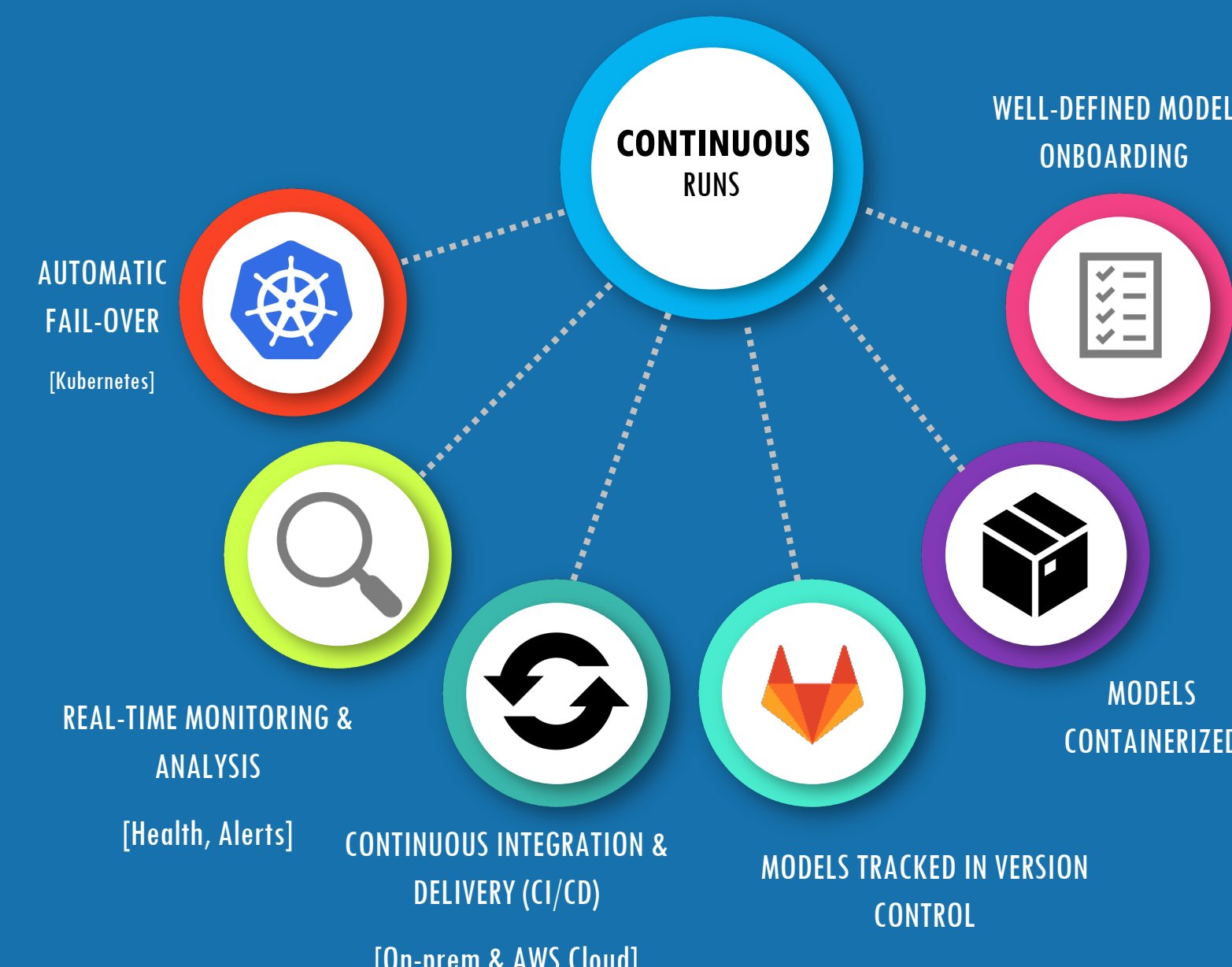## New Models and Capabilities at CCMC in 2023

Runs on Request (ROR)

Runs-on-Request Executed Per Year — 27K+ RUNS TOTAL, + 67 NEW PUBLICATIONS SINCE 2021. Legend: Ionosphere/Thermosphere, Solar and Heliosphere, Global Magnetosphere, Inner Magnetosphere, Post Processing, Local Physics Model.

Runs-on-Request Unique Users Growth — 977 Unique Users for the past 3 years.

- Models
  - Released: SWMF AWSOM/MFLAMPA, HYPERS, WACCM-X, PBMOD, NRLMSIS, RAM-SCB, SWMF GM 2023 (preset version)
  - Updated: TIE-GCM, IRI, WSA, NAIRAS
  - In the pipeline: CORHEL CME, BSPM, EPREM, OSPREI, GAMERA
- New Features
  - Run result file browse feature
  - Automated tarball run result preparation and delivery - about 300 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

Continuous Runs (CR)

- Models
  - Released: MagPy, SHELLS
  - Updated: UMASEP, NAIRAS, SESPTER
- New Features
  - Established ACE (Architecture for Collaborative Evaluation) environment in the AWS to simplify onboarding and evaluation of models
  - Improved onboarding and run pipelines and procedures

CONTINUOUS RUNS — WELL-DEFINED MODEL ONBOARDING; AUTOMATIC FAIL-OVER [Kubernetes]; REAL-TIME MONITORING & ANALYSIS [Health, Alerts]; CONTINUOUS INTEGRATION & DELIVERY (CI/CD) [On-prem & AWS Cloud]; MODELS TRACKED IN VERSION CONTROL; MODELS CONTAINERIZED.

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

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

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

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

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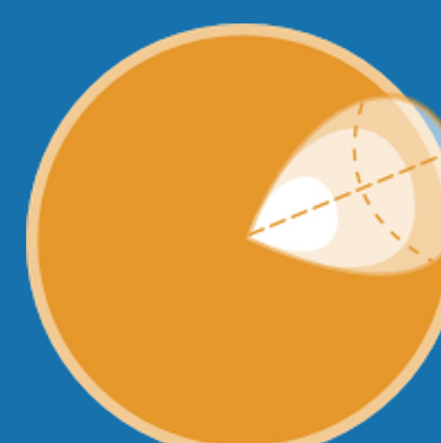- Interactive science discovery through Jupyter notebooks

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.

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.