



Making Heliophysics Research More Open and Accessible at the Community Coordinated Modeling Center (CCMC)

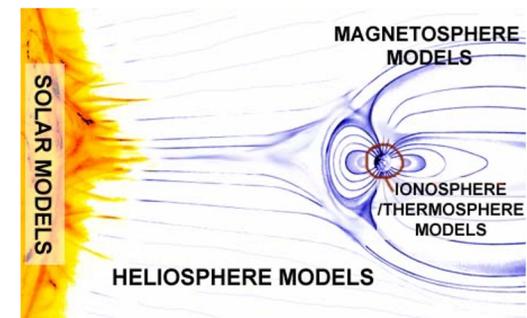
Maksym Petrenko and CCMC team
Presented at 2024 DASH / IHDEA
October 18, Madrid, Spain

Community Coordinated Modeling Center

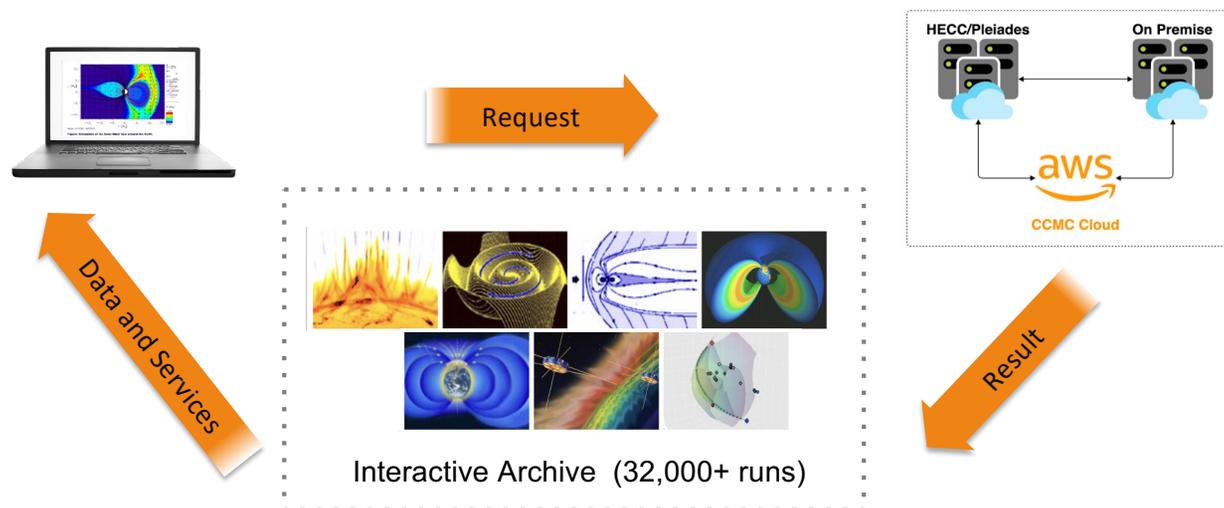


CCMC hosts a unique collection of over 100 contributed models that cover the entire domain from the solar corona to the Earth's upper atmosphere aiming to:

- Provide the scientific community with an access to modern space research models
 - Customized model runs
 - Online analysis and visualization of model results
 - Conversion of model result files to standard data formats
- Provide a platform for unbiased model testing and evaluation
- Support space weather forecasters through Research-to-Operation (R2O) activities
- Support space weather education



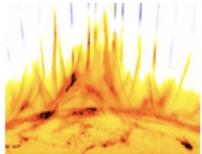
Runs on Request System (ROR) at CCMC



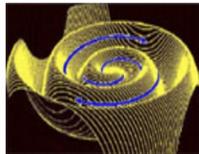
Model run requests are submitted to ROR using a web form, processed by CCMC, and published to an online archive for a subsequent interactive data analysis

- Open and Free system enabling Space Weather and Helio R20
- Test drive ~60 state-of-the-art models without cost of entry barriers
- Opportunity for model evaluations by the entire community
- **Expert CCMC guidance and support** for advanced requests

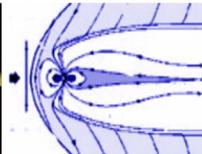
ROR Run Results Archive



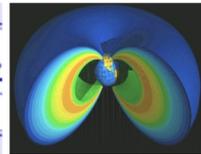
*Solar Models
Results*



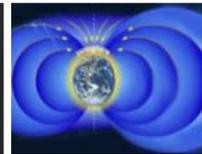
*Heliosphere
Models Results*



*Global
Magnetosphere
Models Results*



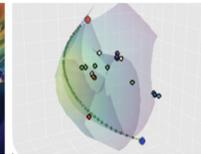
*Inner
Magnetosphere
Models Results*



*Ionosphere /
Thermosphere
Models Results*



*Local Physics
Models Results*



*Post Processing
Request Results*

Open archive of over 32,000 complete runs integrated with **extensive data analysis services** - visualization, run chaining, conversion, etc...

ROR Archive Includes:

- Runs performed by ROR users
- Curated runs performed by CCMC (e.g., >150 geostorms)
- Model validation campaigns
- Outside simulations delivered to CCMC
- Simulations performed through the partners, e.g., VSWMC



Runs on Request and FAIR principles

- ROR has been conceived and grown over 20 years as an open system
 - Anyone can run any model
 - Anyone can interact with any simulation result ('run result page')
 - Many value-added services increases accessibility of the data
 - Simplified user interfaces make complicated models more accessible, lowering the cost of entry for non-experts
- ROR has a number of implicit barriers and pain points due to resource constraints
 - 'Soft' FAIR adherence, where certain tasks require help from CCMC staff

ROR → Open Science

- CCMC has been actively expanding the system to be more 'FAIR' to the users

Findable

- Rich domain-specific metadata has been stored for each run ... but underutilized
- Runs can now be searched via:
 - A common index-based interface
 - Curated domain-specific search interfaces
 - Similar and overlapping requests are identified and displayed automatically, facilitating discovery and cross-linking [and potentially reduce duplicate requests]



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: SH
 Model Name: CORHEL-CME
 Model Version: 1.0
 Key Word: corhel-cme, zb test run, mfr1, mfr2

Observatory: hmi
 Carrington Rotation: 2121
 Carrington Rotation Start Time: 2012-03-04 14:50:17
 Model Options: zb
 Event Date: 2012-03-07 00:00:00

Input Data

- Download Save State File for Restoring a CORHEL-CME Interface Session (Keep this file to save your progress)
- Download Zero-Beta Run Input File

Output Data

- Download Zero-Beta Run Results Offline Report
- View Zero-Beta Run Results Online Report

Run Services

- Request output data as a single archive file
- Browse output data

Runs with Overlapping Dates

Click on model name to expand the list

- + Weimer
- + WACCMX
 - [2012-03-04 - 2012-03-13] WACCMX-Heelis-01_2012-03-TP-01_021824_IT_1
 - [2012-03-06 - 2012-03-12] WACCMX-Weimer-01_2012-03-TP-01_021624_IT_1
 - [2012-03-04 - 2012-03-13] WACCMX-Weimer-01_2012-03-TP-01_021824_IT_1
- + TIE-GCM
- + SWME
- + SEPMOD
- + SAMI3
- + Ovation-Prime
- + NRLMSIS
- + NAIRAS
- + IB
- + IRI
- + HeliosphericTomography
- + GUTM
- + ENLIL
- + CTIPe
- + CIMI

Similar Runs

- Martin_Reiss_101623_SH_3
- Martin_Reiss_101723_SH_1
- Martin_Reiss_101723_SH_2

Click to expand and modify similarity search criteria

Runs in ROR archive are compared field-by-field to the current run, incrementally, in the order of rows in the table. The number of matching runs remaining after each field comparison is indicated in the last column. Runs having all fields matched are further filtered to remove the runs that have more fields than the current run (to eliminate runs performed with additional constraints and modules). You can disable some of the fields to broaden the search criteria.

Enabled	Metadata Key	Field Value	Runs with Same Value	All Fields Match (Incremental)
<input checked="" type="checkbox"/>	bc_type	Time-Dependent	251	251
<input checked="" type="checkbox"/>	Carrington_Rotation	2121	269	11
<input checked="" type="checkbox"/>	cs_output	TBD	504	7
<input checked="" type="checkbox"/>	event_date	2012-03-07 00:00:00	7	7
<input checked="" type="checkbox"/>	modeltype_SH	Solar	1910	7
<input checked="" type="checkbox"/>	model_input_file	archive_zb/zb_multi_run_parameters.in	42	3
<input checked="" type="checkbox"/>	model_options	zb	42	3
<input checked="" type="checkbox"/>	model_SH	CORHEL-CME	67	3
<input checked="" type="checkbox"/>	model_type	SH	652	3
<input checked="" type="checkbox"/>	observatory	None	52	3
<input checked="" type="checkbox"/>	request_year	2023	2078	3
<input checked="" type="checkbox"/>	run_type	Date of Interest	362	3
<input checked="" type="checkbox"/>	validation_level	0	28065	3
<input checked="" type="checkbox"/>	version	1.0	973	3

Accessible

- Result files can be downloaded in bulk or individually
- ‘Quick-look’ graphics and interactive visualization are available for most models
- Data conversion services make data accessible in familiar formats
- API access streamlines access to multiple runs and large outputs on slower connections
- CCMC leads a number of tools for working with the data



Nilam_Bhosale_092424_1

Run Status: Run Complete
Status updated: 2024-09-28T22:59:41+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: GM
Model Name: SWMF
Model Version: v20180525
Title/Introduction: Storm_original
Key Word: Storm_original

Run type: Real event simulation
Inflow Boundary Conditions: Time-dependent
Start Time: 2004/11/04 00:00
End Time: 2004/11/04 23:59
Dipole Tilt at Start in X-Z Plane: -19.23 °
Dipole Tilt in Y-Z GSE Plane: -7.84 °
Dipole Update With Time: yes
Ionospheric Conductance: auroral
Radio Flux 10.7 cm: 133.7
Co-rotation: Corotation potential is being applied
Grid: overview grid with 1,007,616 cells
Coordinate System for the Output: GSM
Solar wind input source: OMNI
Ring current model: RCM

Magnetosphere Run Parameters:

GM solver: Sokolov
GM limiter name: mc3
GM limiter beta: 1.2
GM implicit: part-implicit
GM timestep: 2.0
GM Boris drift factor: 0.01

Input Data

- View solar wind input data
- List solar wind input data in ASCII format (see [format description](#) here)

Output Data

- View Magnetosphere
- Create Timeseries in Magnetosphere
- View 2D Ionosphere Electrodynamics
- **New:** Create Timeseries in 2D Ionosphere
- View pre-computed timeseries data:
 - SWMF diagnostic log file with CPCPN (CPCP North), CP
 - SWMF diagnostic log file with geomagnetic indices Kp, K
 - Northern hemisphere polar cap flux and area
 - Southern hemisphere polar cap flux and area
 - Magnetopause standoff and closest approach within 30 deg
 - Polar cap boundary at 24 magnetic local times in northern
 - Polar cap boundary at 24 magnetic local times in southern
 - Ionospheric dissipation
 - View Rice Convection Model data
 - View Rice Convection Model data mapped to ionosphere
 - View Radiation Belt Electrons
 - View Quick look graphics for the run
 - View Magnetic perturbation calculated for magnetometer s

AAA AAE ABG ABK AIA ALE ALT AM
ASP ATU BDV BEL BFE BFO BLC BM

TEO THL THY TIK TRO TRW TSU TUC UMQ UPN UPS VAL VIC
VSS WMQ WNG YAK YKC

- Magnetic perturbation calculated by SWMF on grid of positions:
 - View SWMF Magnetometer grid data
 - Create timeseries of SWMF Magnetometer grid data

Quick Look Graphics (?)

1 / 04 / 2024 Time = 01:38:00
Northern Hemisphere Southern Hemisphere
[mV] [nT]

IE_overview_PHL_V

1 / 04 / 2024 Time = 01:38:00
Northern Hemisphere Southern Hemisphere
[mV] [nT]

IE_overview_SigH

1 / 04 / 2024 Time = 00:38:00
Northern Hemisphere Southern Hemisphere
[mV] [nT]

IE_overview_SigP

Run Services

- Request output data as a single archive file
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WSA

Nilam_Bhosale_092424_1

Run Status: Run Complete
Status updated: 2024-09-28T22:59:41+0000

[Get this list of files as JSON](#)

[Get this list of files as Plain Text](#)

NOTE: Please use the **Bulk Output Request** feature to download the entire output as a single tar file and/or to request NetCDF conversion services.

File	Size	Date
GM	4321 files	
IE	1440 files	
IM	295 files	
IO2	1841 files	
IONO-2D	1440 files	
MAGNETOMETER	174 files	
MAGNETOMETER_on_GRID	2882 files	
ror_metadata.json		2024-10-09 15:16:45

Interoperable

- Runs on Request tabulates metadata on each result page and now provides metadata for all runs in both **SPASE** and a simple **JSON** formats
- There are several 'known' clients
 - Virtual Model Repository (VMR) tools (started by scraping ROR pages)
 - Flux fly-by-tool
 - ROR itself is a client!



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 GM timestep: 2.0
 GM Boris clight factor: 0.01

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```

domain: "GM"
status: "Run Complete (Status updated: 2024-09-28T22:59:41+0000)"
progress: 100
filesJSON: "https://ccmc.gsfc.nasa.gov/results/run_files.php?runnumber=Nilam_Bho"
model: "SWMF"
modelVersion: "20180525"
description: "CCMC ROR run for SWMF 20180525 with RORID Nilam_Bhosale_092424_1"
runSubmissionTime: "2024-09-24T05:05:35+00:00"
runExecutionStartTime: "2024-09-28T19:10:43+00:00"
runPublicationTime: "2024-09-28T22:59:41+00:00"
nprocs: ""
simulationStartTime: "2004-11-04T00:00:00+00:00"
simulationEndTime: "2004-11-04T23:59:59+00:00"
outfreq: "60"
keyword: "Storm_original"
inputParameters:
  Run_Ring_Current_Model_or_Not: "False"
  Calculate_Oval_Position_or_Not: "True"
  withRCM: "True"
  withCIMI: "False"
  withCROM: "False"
  withRBE: "True"
  Provide_Output_Along_Satellite_Trajectory: "False"
  Provide_CDF_Output_files: "False"
  Provide_HDF_Output_files: "False"
  Provide_MAGNETOMETER_Output_Files: "True"
  EXO: "gm"
  satellite_names: ""
  SSOweb_satellite_names: ""
  satellite_output_time_interval: "5"
  solarwind: "var"
  sw_source: "OMNI"
  despike_solar_wind_data: "True"
  despike_threshold: "3"
  despike_number_of_samples: "5"
  setting_option_for_Bx: "user"
  constant-Bx: "gm"
  By-coefficient: "gm"
  Bz-coefficient: "gm"
  b_abs: "8.44"
  b_angle: "-34.35"
  Bx: "gm"
  By: "-4.765"
  Bz: "6.972"
  Vx: "-403.613"
  Vy: "-33.138"
  Vz: "13.625"
  N: "22.725"
  T: "41462.1"
    
```



Reproducible

- Provided metadata includes all of the model input parameters **set** in the simulation
- Input data and model configuration files are also provided for select models

... but **defaults** can be [very] hard to capture

- Currently a manual effort, where CCMC staff works with users to replicate / modify existing runs
- Some of the more popular run configurations have been codified and **can be reproduced by using presets** – curated bundles of metadata and model input parameters
- Automated reproducibility is in the works, but can be hard in the context of the actively developed models as both inputs and outputs vary with the versions



[Un] Surprising Benefits to CCMC

- Taking CCMC staff out of the loop made the system more transparent and observable to both the end users and the CCMC staff
 - More time to work on other features
 - Easier to manage the system
- Exposing metadata through an API allowed for a more straightforward interconnection between highly distributed services in ROR
- A stable API allows changing the front end and implementing new features without breaking downstream clients

Future Work



Development and priorities are largely driven by the community. Some of our near-future plans for the Runs on Request include:

- Explore standardizing JSON-based APIs
- Continue integration with partner services, such as VSWMC
- Implement a pilot hands-off process for reproducing runs