



Enabling API Access to the Space Weather Services at the Community Coordinated Modeling Center

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Presented at 2024 ESWW

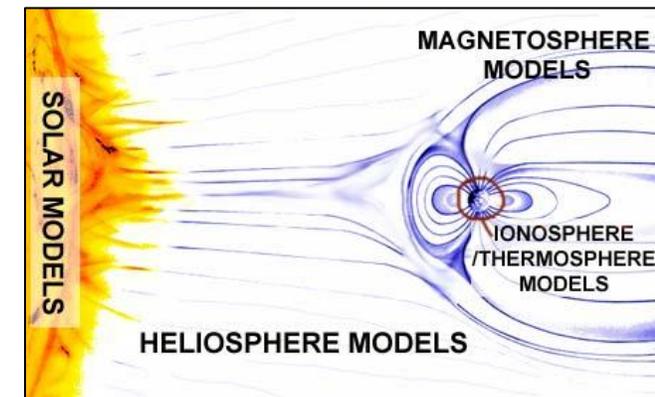
November 4, Coimbra, Portugal



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





Collaborative API Access to Services at CCMC

iSWA (space weather data streams acquisition and display tool)



- Most data streams are available through HTTP archive, time series data streams available through HAPI

<https://iswa.ccmc.gsfc.nasa.gov/IswaSystemWebApp/>

Scoreboards (model intercomparing tools)

- SEP Scoreboard - all data presented in interactive scoreboards can also be downloaded in its original form from the HTTP archive
<https://ccmc.gsfc.nasa.gov/scoreboards/sep/>
- Flare scoreboard - presented data available through HAPI
<https://ccmc.gsfc.nasa.gov/scoreboards/flare/>



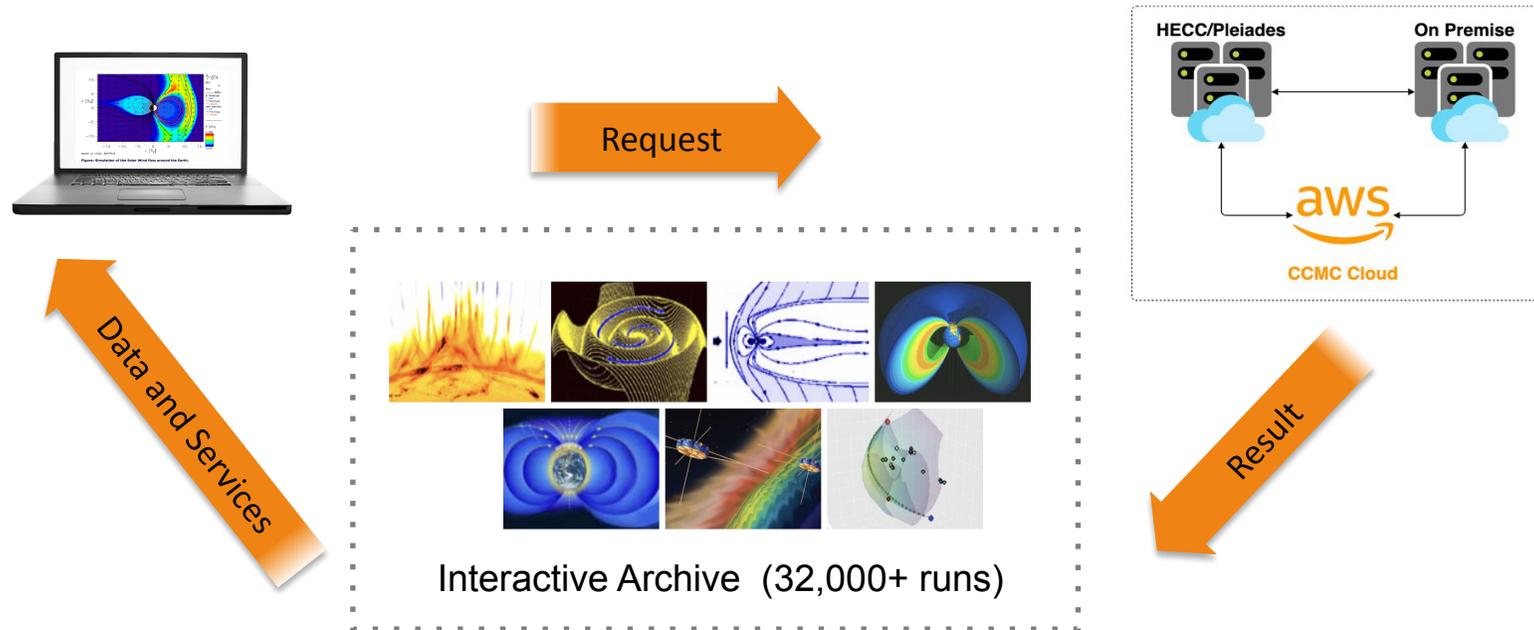
DONKI (online database of space weather events)

- Comprehensive Web Service API

<https://kauai.ccmc.gsfc.nasa.gov/DONKI/>



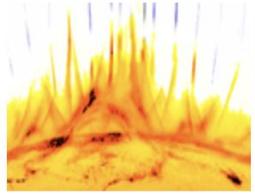
Runs on Request System (ROR) at CCMC



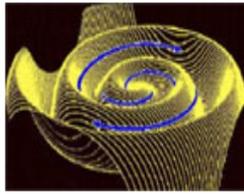
Model run requests are submitted to ROR using a web form, processed by CCMC, and published to an online archive for a subsequent interactive data analysis

- 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

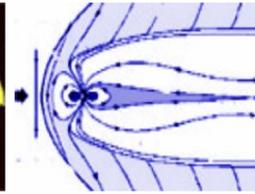
ROR Run Results Archive



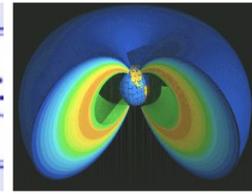
*Solar Models
Results*



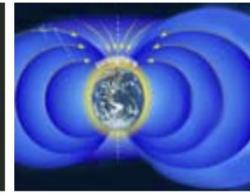
*Heliosphere
Models Results*



*Global
Magnetosphere
Models Results*



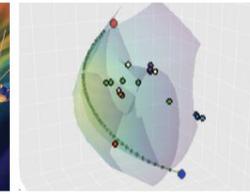
*Inner
Magnetosphere
Models Results*



*Ionosphere /
Thermosphere
Models Results*



*Local Physics
Models Results*



*Post Processing
Request Results*

Open archive of over 32,000 complete runs (~3PB) integrated with **extensive data analysis services** - visualization, run chaining, format 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

Guided User Experience: Pros and Cons

- Highly interactive user interfaces in ROR offer guidance to the users, but become a tedious bottleneck when working with more than a handful of simulations
- Rigid workflow makes the system and data opaque for both the users and the operators

Request a NAIIRAS 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) e.g. John_Smith_032021_01_1

WORK OR SCHOOL EMAIL: maksym.petrenko@nasa.gov
FIRST NAME (GIVEN)*: Maksym
LAST NAME (FAMILY)*: Petrenko
RUN NUMBER*: 1
KEYWORDS*: ESWW

Step 3: SELECT OUTPUT PRODUCTS

Global Dosimetric Quantities (selects all three) Cutoff rigidity maps

Global maps of different types of doses at different altitudes
 Dose quantities along some given flight paths

Trajectory Dosimetric, Differential and Integral Flux and Fluence Quantities under Different Shielding (requires additional input parameters on the next page) Dosimetric Quantities

Integral Flux and Fluence Quantities

Differential Flux and Fluence Quantities

OPTIONAL: SPECIAL REQUEST

JUSTIFICATION:

Sample Run Request Page



Nilam_Bhosale_092424_1
Run Status: Run Complete
Status updated: 2024-09-28T22:59:41+0000

Run Metadata

Model Domain: GM
Model Name: SWMF
Model Version: v20180526
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: 153.7
Corotation: 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), CPCPS (CPCP South), Dst (SymH)
 - SWMF diagnostic log file with geomagnetic indices Kp, K (AL, AU, AU, AO for SWMF version from 2018 and later)
 - Northern hemisphere polar cap flux and area
 - Southern hemisphere polar cap flux and area
 - Magnetopause standoff and closest approach within 30 deg. of Sun-Earth line (local noon)
 - Polar cap boundary at 24 magnetic local times in northern hemisphere
 - Polar cap boundary at 24 magnetic local times in southern hemisphere
 - 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 stations:

AAA AAE ABG ABK AIA ALE ALT AMS AND API AQU ARS ASC
ASP ATU BDV BEL BFE BFO BLC BMT BNG BOU BOX BRW BSL

Sample Run Result Page



Martin_Reiss_081924_SH_1
Run Status: Run Complete
Status updated: 2024-08-19T17:26:29+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
case.512x60x180x1.cr2054-g-a4b1	2 files	
bnd.nc	4 MB	2024-08-19 14:17:36
grd.nc	15 kB	2024-08-19 14:17:36
run.512x60x180x1.cr2054-g-a4b1.16-mcp1um1cd-1.g53q6	26 files	
ace_GSE.dat	130 kB	2024-08-19 17:19:22
artemis1_GSE.dat	1 MB	2024-08-19 17:19:26
artemis2_GSE.dat	1 MB	2024-08-19 17:19:29
bnd.nc	4 MB	2024-08-19 16:43:36
cassini_GSE.dat	1 MB	2024-08-19 17:19:30
evo_deep_impact.nc	1 MB	2024-08-19 16:43:36
evo.esarth.nc	1 MB	2024-08-19 16:43:36
evo.epoxi.nc	1 MB	2024-08-19 16:43:36
evo.mars.nc	1 MB	2024-08-19 16:43:36
evo.mercury.nc	1 MB	2024-08-19 16:43:36
evo.messenger.nc	1 MB	2024-08-19 16:43:36
evo.rosetta.nc	1 MB	2024-08-19 16:43:36
evo.spitzer.nc	1 MB	2024-08-19 16:43:36
evo.stereo.nc	1 MB	2024-08-19 16:43:36
evo.stereob.nc	1 MB	2024-08-19 16:43:36
evo.venus.nc	1 MB	2024-08-19 16:43:36
fid_deep_impact.nc	628 kB	2024-08-19 16:43:36
fid.earth.nc	628 kB	2024-08-19 16:43:36
fid.epoxi.nc	628 kB	2024-08-19 16:43:36
fid.mars.nc	628 kB	2024-08-19 16:43:36
fid.mercury.nc	628 kB	2024-08-19 16:43:37
fid.messenger.nc	628 kB	2024-08-19 16:43:37
fid.rosetta.nc	628 kB	2024-08-19 16:43:37
fid.spitzer.nc	628 kB	2024-08-19 16:43:37
fid.stereo.nc	628 kB	2024-08-19 16:43:37
fid.stereob.nc	628 kB	2024-08-19 16:43:37
fid.venus.nc	628 kB	2024-08-19 16:43:37
geotail_GSE.dat	130 kB	2024-08-19 17:19:37
grd.nc	15 kB	2024-08-19 16:43:37
imp3_GSE.dat	275 kB	2024-08-19 17:19:38
isoe3_GSE.dat	26 kB	2024-08-19 17:19:38
jupiter_GSE.dat	1 MB	2024-08-19 17:19:42
l1sat_GSE.dat	1 MB	2024-08-19 17:19:45
mars_GSE.dat	1 MB	2024-08-19 17:19:47
messenger_GSE.dat	1 MB	2024-08-19 17:19:51
moon_GSE.dat	1 MB	2024-08-19 17:19:52
neptune_GSE.dat	1 MB	2024-08-19 17:19:53
newhorizons_GSE.dat	1 MB	2024-08-19 17:19:54
pluto_GSE.dat	1 MB	2024-08-19 17:19:56
rdr_metadata.json		2024-10-28 16:23:41

Sample Model Outputs Page



Opening up ROR via REST APIs: Goals

- Provide easy and uniform automated management of runs series
- Make system, data, and metadata more transparent and observable
- Support online access to individual run result data files
 - Client applications can be built on top of URL-accessible results
 - Don't need to download and store everything if data are readily accessible
- Enable client applications and data pipelines without forcing users to scrape web site for metadata
- Simplify interconnection between ROR services
- Connect to partner organizations through open and reusable interfaces

Machine Discovery

- Entire ROR archive can be now searched both interactively and through API

Community Coordinated Modeling Center
MENU

View Results of Requested ROR Runs

View the results of your requested simulations via ROR, as well as the results of runs submitted by other users.

CCMC Publications Policy

If you use the results from the Runs on Request in a scientific publication or presentation, please acknowledge the originators of the computational model and the CCMC. For more details see the detailed [policy description](#).

Note: For tracking purposes for our government sponsors, we ask that you notify the CCMC whenever you use CCMC results in scientific publications or presentations by [emailing CCMC](#).

Quick ROR search (?) :

Find it!

Found 5 matching runs:

Edith_Botek_101824_IM_5	MotherDay	BSPM 2021
Balazs_Heilig_100124_IT_1	Mother's Day	WAMIPE 1.2.4
RAJESH_BARAD_082824_IT_1	MOTHER'S DAY STORM	TIE-GCM 2.0
Josh_Pettit_061124_IT_1	Mothers Day Super Storm	GITM 21.11
Bernhard_Haas_052424_IM_1	First run of Super Storm	Mother Day Storm VERB 2.5

[Reset the search](#)

Accessibility
Privacy Policy
Curator: Tyler Schiewe

CCMC Data Policy
Contact
NASA Official: Dr. Masha Kuznetsova



```

0:
  run_num: "Bernhard_Haas_052424_IM_1"
  link: "https://ccmc.gsfc.nasa.gov/results/viewrun.php?runnumber=Bernhard_Haas_052424_IM_1"
  metadata: "https://ccmc.gsfc.nasa.gov/results/api/run_metadata.php?runnumber=Bernhard_Haas_052424_IM_1"
  files: "https://ccmc.gsfc.nasa.gov/results/run_files.php?runnumber=Bernhard_Haas_052424_IM_1&format=json"
  request_date: "2024-05-24"
  domain: "IM"
  keyword: "First run of Super Storm"
  title: "Mother Day Storm"
  model: "VERB"
  meta_string: "VERB 2.5"
  start: "2024/05/08 00:00"
  end: "2024/05/15 00:00"

1:
  run_num: "Edith_Botek_101824_IM_5"
  link: "https://ccmc.gsfc.nasa.gov/results/viewrun.php?runnumber=Edith_Botek_101824_IM_5"
  metadata: "https://ccmc.gsfc.nasa.gov/results/api/run_metadata.php?runnumber=Edith_Botek_101824_IM_5"
  files: "https://ccmc.gsfc.nasa.gov/results/run_files.php?runnumber=Edith_Botek_101824_IM_5&format=json"
  request_date: "2024-10-18"
  domain: "IM"
  keyword: "MotherDay"
  title: ""
  model: "BSPM"
  meta_string: "BSPM 2021"
  start: "2024/05/11 15:00:00"
  end: "2024/05/11 16:00:00"

2:
  run_num: "Josh_Pettit_061124_IT_1"
  link: "https://ccmc.gsfc.nasa.gov/results/viewrun.php?runnumber=Josh_Pettit_061124_IT_1"
  metadata: "https://ccmc.gsfc.nasa.gov/results/api/run_metadata.php?runnumber=Josh_Pettit_061124_IT_1"
  files: "https://ccmc.gsfc.nasa.gov/results/run_files.php?runnumber=Josh_Pettit_061124_IT_1&format=json"
  request_date: "2024-06-11"
  domain: "IT"
  keyword: "Mothers Day Super Storm"
  title: ""
  model: "GITM"
  meta_string: "GITM 21.11"
  start: "2019-05-09"
  end: "2019-05-12"

3:
  run_num: "Balazs_Heilig_100124_IT_1"
  link: "https://ccmc.gsfc.nasa.gov/results/viewrun.php?runnumber=Balazs_Heilig_100124_IT_1"
  metadata: "https://ccmc.gsfc.nasa.gov/results/api/run_metadata.php?runnumber=Balazs_Heilig_100124_IT_1"
  files: "https://ccmc.gsfc.nasa.gov/results/run_files.php?runnumber=Balazs_Heilig_100124_IT_1&format=json"
  request_date: "2024-10-01"
  domain: "IT"
  keyword: "Mother\\s Day"
  title: ""
  model: "WAMIPE"
  meta_string: "WAMIPE 1.2.4"
  start: "2024-05-10"
  end: "2024-05-12"

4:
  run_num: "RAJESH_BARAD_082824_IT_1"
  link: "https://ccmc.gsfc.nasa.gov/results/viewrun.php?runnumber=RAJESH_BARAD_082824_IT_1"
  metadata: "https://ccmc.gsfc.nasa.gov/results/api/run_metadata.php?runnumber=RAJESH_BARAD_082824_IT_1"
  files: "https://ccmc.gsfc.nasa.gov/results/run_files.php?runnumber=RAJESH_BARAD_082824_IT_1&format=json"
  request_date: "2024-08-28"
  domain: "IT"
  keyword: "MOTHER\\S DAY STORM"
  title: ""
  model: "TIE-GCM"
  meta_string: "TIE-GCM 2.0"
  start: "2024-05-08"
  end: "2024-05-17"
  
```

https://ccmc.gsfc.nasa.gov/results/api/find_runs.php?search=mother



Metadata and Provenance

- 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!

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_origina
Key Word:	Storm_origina

Run type: Real event sim
Inflow Boundary Conditions: Time-depende
Start Time: 2004/11/04 00
End Time: 2004/11/04 23
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 pot
Grid: overview grid
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 clight factor:	0.01

Input Data

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

```

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: "2004-11-04T23:59:00+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"
  withCRCM: "False"
  withRBE: "True"
  Provide_Output_Alone_Satellite_Trajectory: "False"
  Provide_CDF_Output_files: "False"
  Provide_HDF_Output_files: "False"
  Provide_MAGNETOMETER_Output_Files: "True"
  EXO: "0"
  satellite_names: ""
  SSCWeb_satellite_names: ""
  satellite_output_time_interval: "5"
  solarwind: "var"
  sw_source: "OMNI"
  desprike_solar_wind_data: "True"
  desprike_threshold: "3"
  desprike_number_of_samples: "5"
  setting_option_for_Bx: "user"
  constant-Bx: "0"
  By-coefficient: "0"
  Bz-coefficient: "0"
  b_abs: "8.44"
  b_angle: "-34.35"
  Bx: "0"
  By: "-4.765"
  Bz: "6.972"
  Vx: "-403.613"
  Vy: "-33.138"
  Vz: "13.625"
  N: "22.725"
  T: "41462.1"

```

Accessibility

- 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

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

Model Domain: ...
Model Name: ...
Model Version: ...
Title/Introduction: ...
Key Word: ...

Run type: ...
Inflow Boundary: ...
Start Time: 11/04/2024
End Time: 11/04/2024
Dipole Tilt at noon: ...
Dipole Tilt at sunrise: ...
Dipole Update: ...
Ionospheric: ...
Radio Flux: ...
Co-rotation: ...
Grid: ...
Coordinate System: ...
Solar wind: ...
Ring current: ...

Magnetospheric

GM solver: ...
GM limiter: ...
GM limiter: ...
GM implicit: ...
GM timestep: ...
GM Boris: ...

Input Data

- View solar
- List solar wind

Output Data

- View Magnetospheric
- Create Timeseries
- View 2D Ionosphere
- New: Create Timeseries
- View

Run Services

- Request output data as a file
- Browse output data

Runs with Overlapping Data

Click on model name to expand the list

+ WSA

Quick Look Graphics (?)

Magnetic perturbation calculated by SWMF on grid of positions:

- View SWMF Magnetometer grid data
- Create timeseries of SWMF Magnetometer grid data

IE_overview_PHI_V

IE

IE

Run Services

- Request output data as a file
- Browse output data

Runs with Overlapping Data

Click on model name to expand the list

+ 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

```
run_number: "Nilam_Bhosale_092424_1"
files:
  0:
    file: "GM/102/3d_var_1_e20041104-000000-000.info"
    link: "https://ccmc.gsfc.nasa.gov/e20041104-000000-000.info"
    size: "2039"
    updated: "2024-09-28 22:45:40"
  1:
    file: "GM/102/3d_var_1_e20041104-000000-000.out"
    link: "https://ccmc.gsfc.nasa.gov/e20041104-000000-000.out"
    size: "76580064"
    updated: "2024-09-28 22:45:39"
  2:
    file: "GM/102/3d_var_1_e20041104-000000-000.tree"
    link: "https://ccmc.gsfc.nasa.gov/e20041104-000000-000.tree"
    size: "161996"
    updated: "2024-09-28 22:45:40"
  3: {...}
  4: {...}
```



Current State

Benefits

- Made the system more open and transparent
- Exposing metadata through an API allowed for a more straightforward interconnection between highly distributed services in ROR
- Public API opened up doors for external clients and collaborations
- A dedicated API allows changing the front end and implementing new features without breaking downstream clients

Challenges

- Rethinking legacy code is hard
- API takes away some flexibility
- Opening the system invites more use, putting a strain on existing infrastructure
- Hard to gauge user interest



Future Work

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

- Conform to the popular standards (OpenAPI, Schema.org)
- Document the API and write up examples
- Continue integration with partner services, such as VSWMC and HDRL
- Implement run submission API
- Implement support for other popular interfaces, e.g. HAPI



Questions?