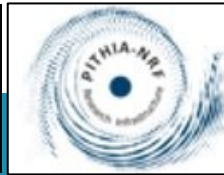# Use Case 1: Access to EUHFORIA data products

Prof.Dr. Stefaan Poedts

CmPA / Dept. Mathematics, KU Leuven (B)

&

Institute of Physics / UMCS, Lublin (PL)
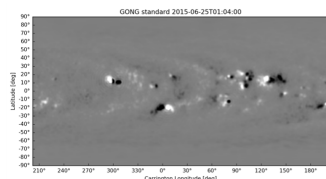
Credit: NASA

Contents

- **EUHFORIA**

- **The VSWMC**

- **EUHFORIA in the VSWMC via the e-Science centre**

EUHFORIA

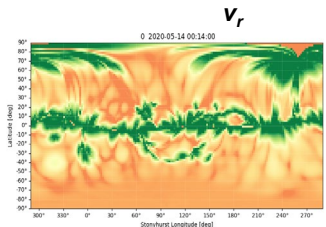## 'European heliospheric forecasting information asset'

Corona:
Semi-Empirical WSA model

Synoptic Magnetogram (1 R_{sun})

v_r

PFSS
(1 - 2.6

SCS m
(2.3 R_{sun} -

MHD parameters (0.1 AU) using empirical relations

Solar wind relaxation

Heliosphere:
3D time dependent ideal MHD model

2015-06-17 01:00

x [HEEQ AU]

y [HEEQ AU]

z [HEEQ AU]

Distance [AU]

vr [km/s]

Mercury Earth STA STB
Venus Mars

Speed [km/s]

EUHFORIA
ACE NRT

Jun 19 Jun 21 Jun 23 Jun 25 Jun 27 Jun 29

Credit: Anwesha Maharana
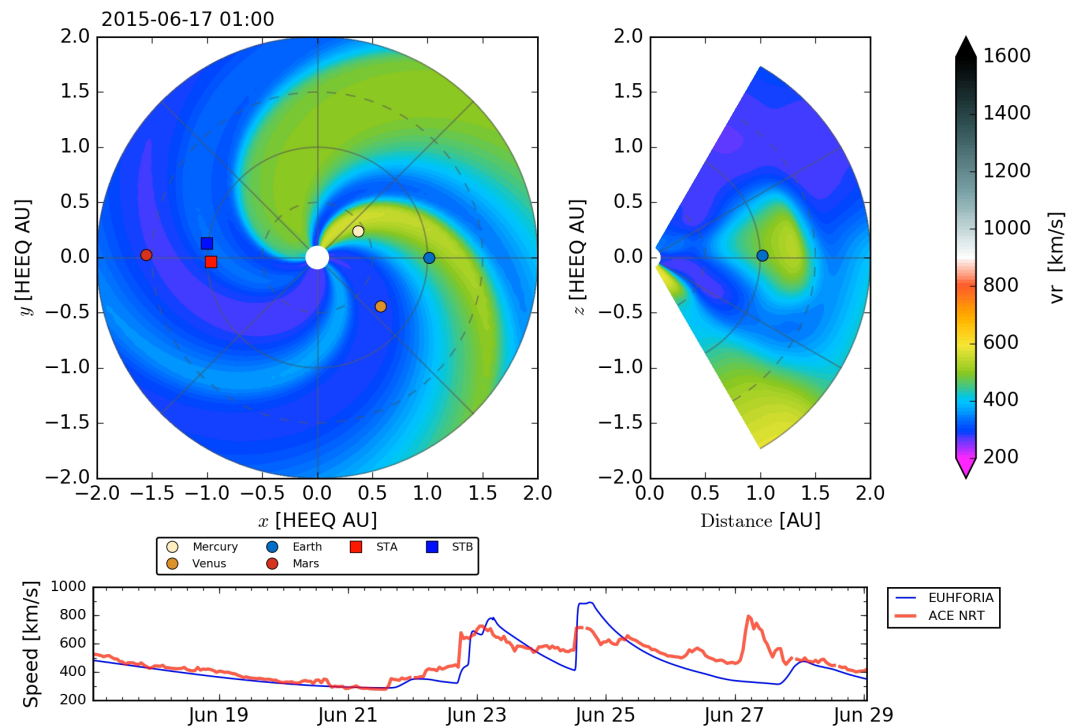
Virtual SWE Modelling Centre

- An **open end-to-end** (Sun to Earth) space weather modeling system,

- enabling to *interactively* run & "couple" various space weather models in an integrated tool,

- with the models located either locally or geographically distributed (≠ CCMC)
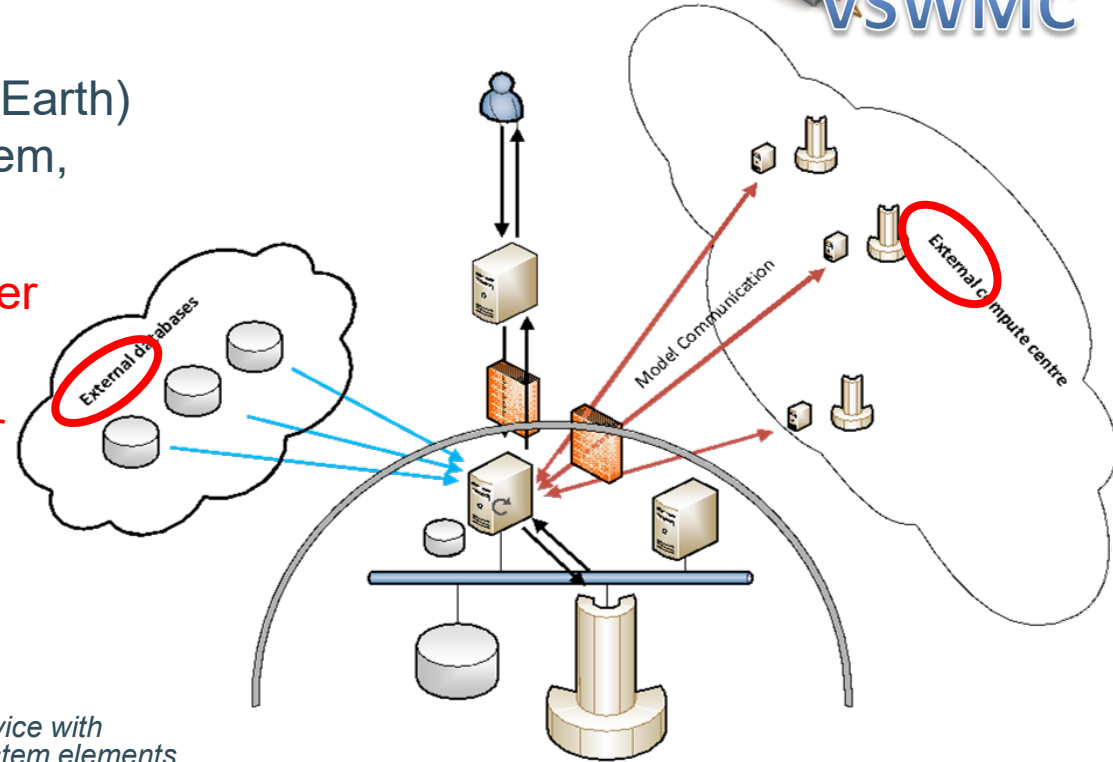
Basic set-up of federated service with geographically distributed system elements

VSWMC models (operational (17) and operational soon (5))

Magnetosphere models:
- GUMICS-4
- GORGON-Space

Inner heliosphere wind and CME evolution models :
- EUHFORIA
- ICARUS

SEP models :
- SPARX
- PARADISE (/ PARASOL?)
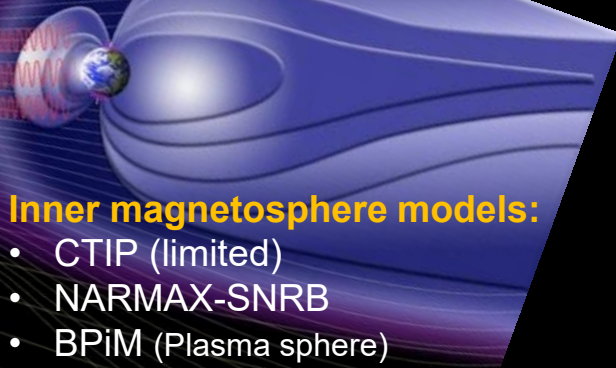
Inner magnetosphere models:
- CTIP (limited)
- NARMAX-SNRB
- BPiM (Plasma sphere)
- NARMAX-SNGI (Kp + Dst)
- Dst, Kp, magnetopause stand-off distance
- MCM-DTM
- *DICTAT & IMPTAM*
- CTIP extended

Solar corona models:
- Multi-VP
- Wind-Predict
- EUHFORIA-corona (WSA)
- COCONUT
- COCONUT-TDm/*RBSL*

www.nasa.gov

artist's impression

EUHFORIA in the e-Science Centre

PITHIA-NRF
e-Science Centre

HOME   SEARCH & BROWSE ▾

Login

EUHFORIA: EUropean Heliospheric FORecasting Information Asset

EUHFORIA (EUropean Heliospheric FORecasting Information Asset) consists of two main parts: a semi-empirical coronal model, the purpose of which is to determine the plasma environment of the solar wind at the location of the inner boundary of the heliospheric module, and the heliospheric model, which provides the dynamics of the background solar wind with superposed CMEs into the inner heliosphere by numerical evolution of the MHD equations. EUHFORIA runs at the Virtual Space Weather Modeling Center (VSWMC) on the ESA Space Weather Network (ESA-SWE) website (https://swe.ssa.esa.int ☑). VSWMC is an interactive modeling system developed for space weather research from the Sun to the Earth. It allows users to run different tools stand-alone or in combination with models that are locally or geographically dispersed.

Interact

Interaction Method	Description	Data Format	Link
Direct Link to Data Collection	The ESA-SWE website requires an account to run. Once received, go to the VSWMC webpage and select: "NEW RUN". From the list of model chains that appear, you can choose those that contain EUHFORIA, or separately the coronal and heliospheric EUHFORIA models. Also, the	image/png (click the link to show information on this ontology term)	Open Latest VSWMC ESA-SWE Landing Page in new tab ☑

Identifier Properties

Local ID	DataCollection_EUHFORIA
Namespace	kul
Version	2
Created	Tuesday 28th Feb. 2023, 01:30:00
Last Modified	Monday 24th April 2023, 18:56:00

6

Short demo *(slide show of screen prints)*

Centre for mathematical Plasma Astrophysics

Coupling of models via the VSWMC

- **New 'trend'** in space weather modelling

- **Enables _better_ predictions**
  - Example: MULTI-VP + EUHFORIA Heliosphere
    - ➤ _Better capturing of HSSs due to improved coronal model (Multi-VP vs WSA)_
  - Example: EUHFORIA + PARADISE (SEP model)
    - ➤ _Using (EUHFORIA) simulated IMF instead of Parker spiral_

- **Enables _earlier_ predictions/warnings**
  - Example: EUHFORIA + OpenGGCM/Gorgon/GUMICS
    - ➤ replacing L1 data by synthetic/simulated data three days ahead
    - ➤ _Enables forecasts 2-3 days ahead instead of nowcasts!_
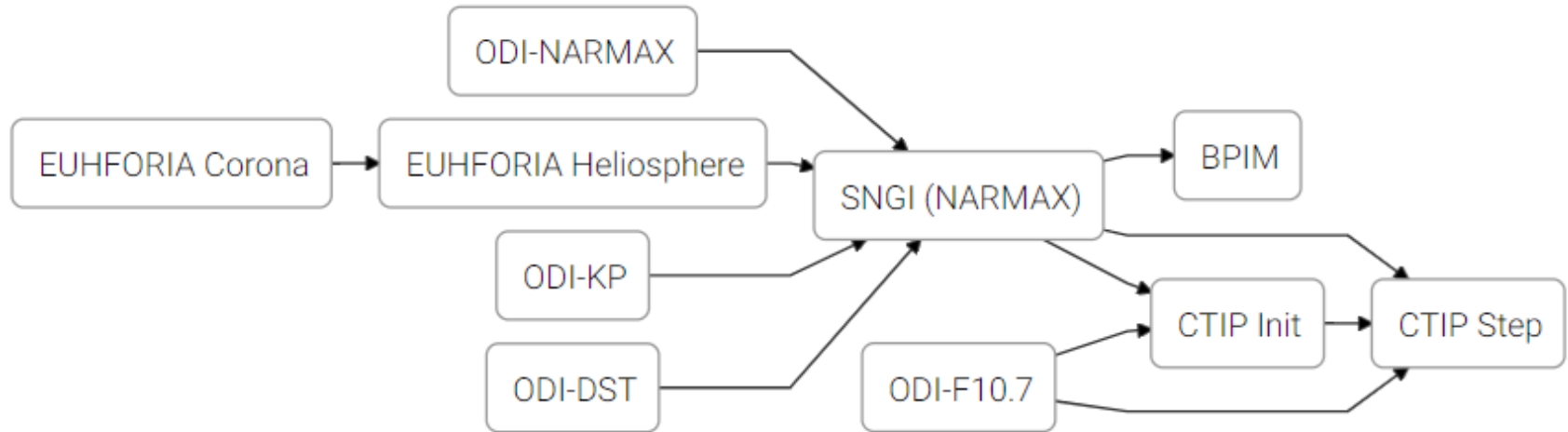
New Sun-to-Earth model chains – daily runs

Operational!
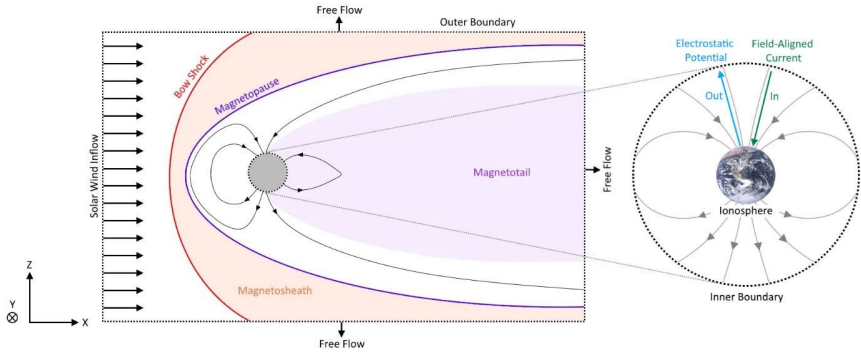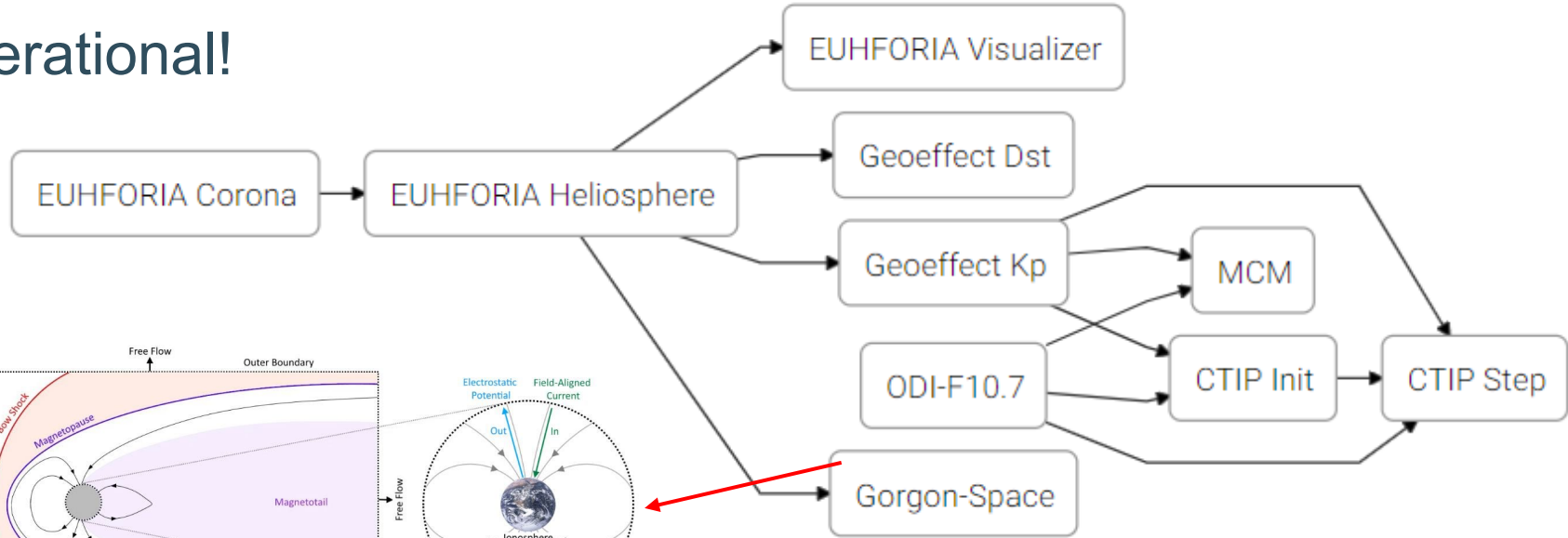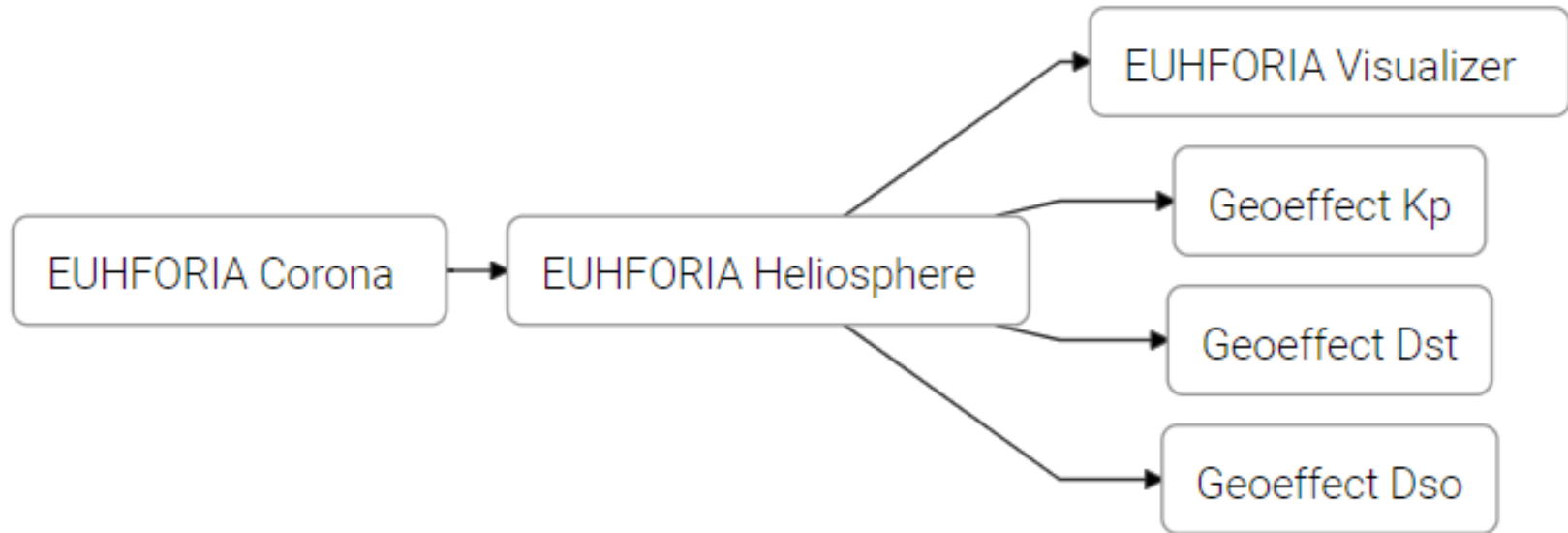
New Sun-to-Earth model chains

Another 10 model chain example:

Most used model chain (via CLI)

VSWMC Command-Line Interface (1)

https://pypi.org/project/vswmc-cli/

- Install with pip: `> pip install --upgrade vswmc-cli`

This will install a `vswmc` command on your system. The `vswmc` command has a few global options:

`-u USER`

 SSA Username

`-p PASSWORD`

 SSA Password

VSWMC Command-Line Interface (2)

- List available simulations:

  ```
  > vswmc -u username -p password simulations list
  ```

e.g. *(from D. Barnes)*

```
VSWMC CLI version  2.0.6
Session invalid, re-initializing
ID                      NAME                    MODELS
euhforia                EUHFORIA                euhforia_corona, euhforia_helio, euhforia_visualizer
euhforia-geoeffects     EUHFORIA + Indices      euhforia_corona, euhforia_helio, euhforia_visualizer, geoeffect-kp, geoeffect-dst, geoeffect-dso
euhforia-basrbm         EUHFORIA + Indices + BAS-RBM  euhforia_corona, euhforia_helio, euhforia_visualizer, geoeffect-kp, geoeffect-dst, geoeffect-dso, bas-rbm
euhforia-gumics         EUHFORIA + Indices + GUMICS4  euhforia_corona, euhforia_helio, euhforia_visualizer, geoeffect-kp, geoeffect-dst, geoeffect-dso, gumics4
corona                  EUHFORIA Corona         euhforia_corona
odi-ctip                ODI KP + F10.7 + CTIP   odi-ctip, ctip-init, ctip-step
odi-gumics4             ODI OMNI Dataset + GUMICS4  odi-gumics4, gumics4
odi-basrbm              OMNI + Indices + BAS-RBM  odi-kp, odi-dso, geoeffect-dso, bas-rbm
wind-predict            Wind-Predict            wind-predict
```

VSWMC Command-Line Interface (3)

- Start a run:

```
>  vswmc run [--param-file PARAM_FILE] [--param PARAM=VALUE ...] --
SIMULATION
```

This command returns the ID of the new run via stdout. You can use this ID to fetch the log or fetch result files.

OPTIONS

`--param-file PARAM_FILE`

Read parameters from a file.

`--param PARAM=VALUE ...`

Set parameters.

VSWMC Command-Line Interface (4)

- Input parameters:

```
> vswmc -u username -p password simulations describe euhforia
```

VSWMC Command-Line Interface (5)

- List runs:

> `vswmc ps [--simulation SIMULATION] [-a, --all]`

Filter on simulation

List all runs (default shows only ongoing)

e.g. *(from D. Barnes, with `ps -a`)*

```
VSWMC CLI version  2.0.4
ID                           NAME           STATUS       SUBMITTED                   STARTED                     FINISHED
5f83ff24b16a671f66c842fc     EUHFORIA #600  RUNNING      2020-10-12T07:00:52.937Z    2020-10-12T07:00:53.078904Z
5f82ada3b16a671f66c84122     EUHFORIA #599  TERMINATED   2020-10-11T07:00:51.715Z    2020-10-11T07:00:51.918660Z    2020-10-12T01:44:20.131620Z
5f815c24b16a671f66c83f48     EUHFORIA #598  TERMINATED   2020-10-10T07:00:52.179Z    2020-10-10T07:00:52.357895Z    2020-10-10T12:25:31.541945Z
5f800a8eb16a671f66c83d62     EUHFORIA #597  TERMINATED   2020-10-09T07:00:30.245Z    2020-10-09T07:00:30.360185Z    2020-10-09T15:12:57.647570Z
5f7eb90bb16a671f66c83b88     EUHFORIA #596  TERMINATED   2020-10-08T07:00:27.273Z    2020-10-08T07:00:27.424617Z    2020-10-08T12:07:26.010335Z
5f7dd7c8b16a671f66c839ae     EUHFORIA #595  TERMINATED   2020-10-07T14:59:20.145Z    2020-10-07T14:59:20.279469Z    2020-10-07T21:49:33.961378Z
5f757e8cb16a67e30d5894d0     EUHFORIA #594  TERMINATED   2020-10-01T07:00:28.078Z    2020-10-01T07:00:28.193018Z    2020-10-01T12:11:39.079317Z
5f72dbb8b16a67e30d5893a7     EUHFORIA #593  TERMINATED   2020-09-29T07:01:12.424Z    2020-09-29T07:01:12.605874Z    2020-09-29T08:47:53.989099Z
5f718a36b16a67e30d589282     EUHFORIA #592  TERMINATED   2020-09-28T07:01:10.301Z    2020-09-28T07:01:10.536291Z    2020-09-28T08:48:16.188688Z
5f70388cb16a67e30d58915d     EUHFORIA #591  TERMINATED   2020-09-27T07:00:28.442Z    2020-09-27T07:00:28.662774Z    2020-09-27T08:46:08.123191Z
5f6ee72eb16a67e30d589038     EUHFORIA #590  TERMINATED   2020-09-26T07:01:02.051Z    2020-09-26T07:01:02.184995Z    2020-09-26T08:35:08.945211Z
```

Fetching results

- Checking the status of a run:
  > `vswmc -u USERNAME -p PASSWORD ps -a | grep "5f83ff24b16a671f66c842fc"`

  `5f83ff24b16a671f66c842fc   EUHFORIA #600          TERMINATED`

- Printing the logs of a run:
  > `vswmc -u USERNAME -p PASSWORD logs 5f83ff24b16a671f66c842fc`

- List all results files from a run:
  > `vswmc -u USERNAME -p PASSWORD ls -l 5f83ff24b16a671f66c842fc`

- Copy results files of a run:
  > `vswmc -u USERNAME -p PASSWORD cp 5f83ff24b16a671f66c842fc:euhforia_Earth.dsv $resdir`

Using the VSWMC API with scripts
cfr. David Barnes

```bash
#!/bin/bash

IDLDIR="/users/davidbarnes/Documents/Programs/IDL/"
SCRDIR="/users/davidbarnes/Documents/Programs/scripts/"
DATADIR="/users/davidbarnes/Documents/Data/EUHFORIA/testdir/"

#get the start time
YYYY=$(date +"%Y"); MM=$(date +"%m"); DD=$(date +"%m"); hh=$(date +"%H")
YY=$(echo $YYYY | tr "20" "\n") && YY=$(echo $YY | tr " " "\n")

#get the ENLIL cone file and convert to EUHFORIA format
DATADIR=$DATADIR$YYYY"/"$MM"/"$DD"/MHD_COMPARE/"
conein='cone2bc.in' && coneout='euhforia_cone_'$YYYY$MM$DD't'$hh'.txt'
idl << EOD
.r $IDLDIR/euhforia/convert_cone
convert_cone,"$DATADIR","$conein","$coneout"
EOD

#get magnetogram file
file='mrbqs'$YY$MM$DD't'$hh'*.fits.gz'
magfile=$(ls $DATADIR"gong2.nso.edu/"$file)

#submit job to VSWMC and record ID
export id=$(vswmc -u $user -p $pass run  --param magnetogram=$magfile \
grid=medium cmes=$DATADIR$coneout -- euhforia)
```

```bash
#!/bin/bash

info=$(vswmc -u $user -p $pass ps -a | grep "$id")
fields=$(echo $info | tr " " "\n") && i=0
for x in $fields
do
    lines[$i]=$x
    i=$(expr $i + 1)
done
status=${lines[3]}
echo $status

if [ "$status" == "RUNNING" ]
then
    echo $id
fi

if [ "$status" == "TERMINATED" ]
then
    vswmc -u $user -p $pass cp $id:euhforia_Earth.dsv $RESDIR
fi
```
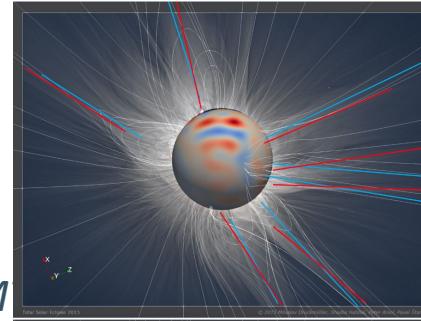
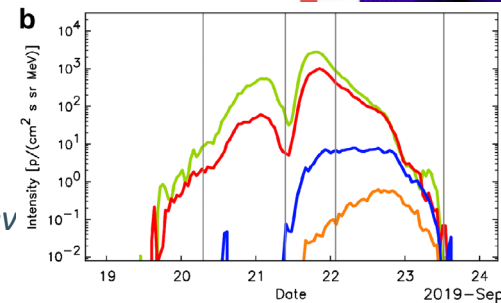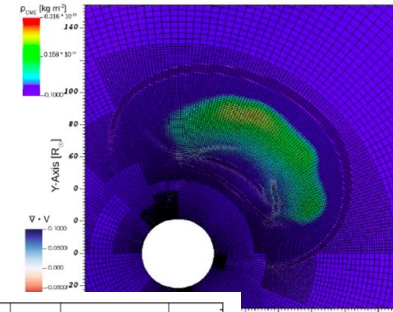# New ESA HMT/EUHFORIA 2.0 models
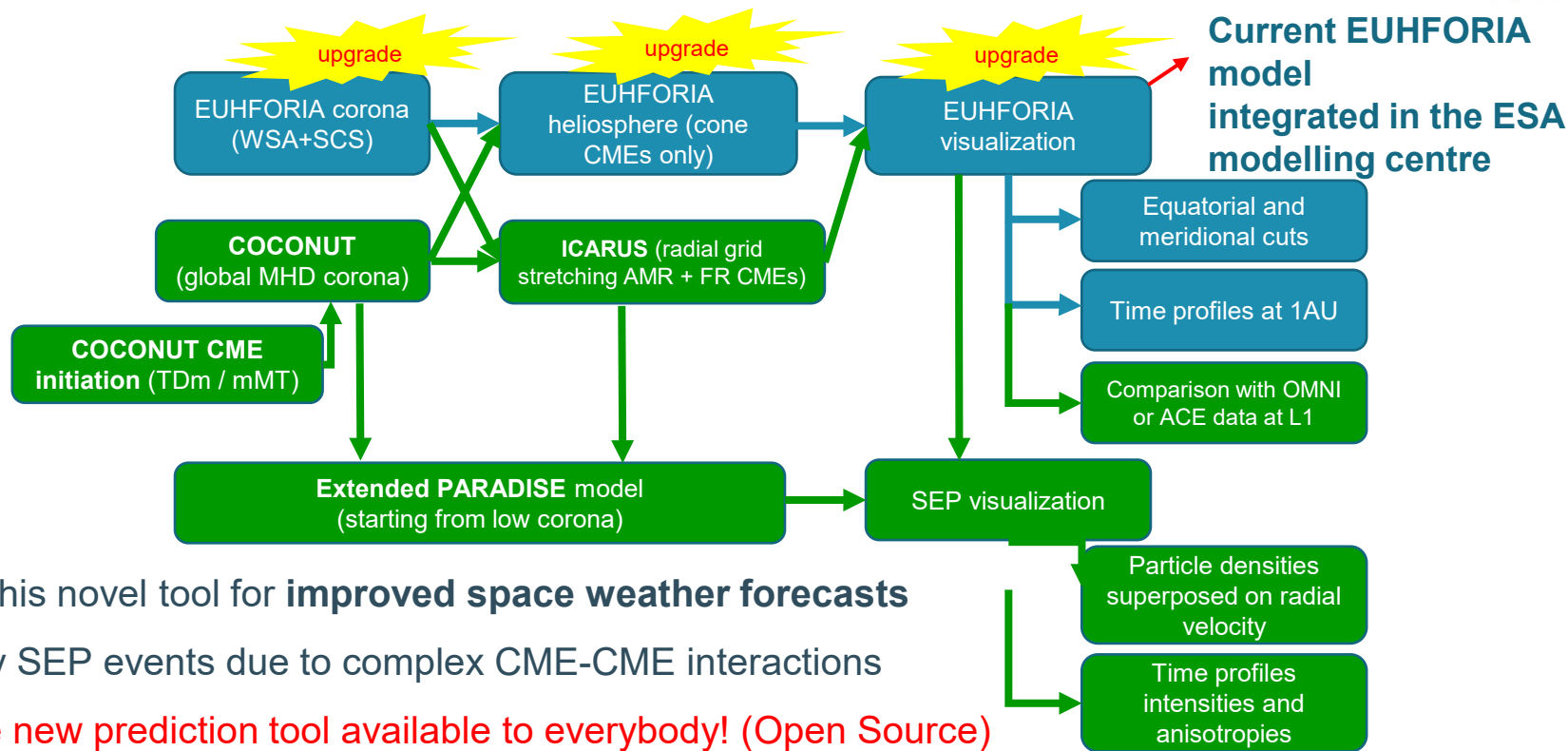

(these models are being added now)

1. **COCONUT** (global MHD EUHFORIA-corona)
     + FR CME models *(TDm, mM*

2. **ICARUS** (more efficient EUHFORIA-heliosphere)
     + advanced FR CME models
          (FRi3D, Gibson & Low, torus CMEs)

3. **PARADISE** (SEP acceleration and transport,
          using EUHFORIA as background wind and CME ev

Next upgrade (ESA HMT project)

- Use this novel tool for **improved space weather forecasts**
- Study SEP events due to complex CME-CME interactions
- Make new prediction tool available to everybody! (Open Source)

Summary

- EUHFORIA models the environment from Sun to Earth and beyond
- VSWMC integrates different models
- Since 6 October 2022 the VSWMC was extended:
  - *15+ operational models*
  - *many extra model chains operational*
- *The VSWMC GUI functionality is accessible via a CLI*
- *Simulations can be requested via scripting*
- *More models and model couplings will be added soon*

THANK YOU!

References:

S. Poedts: "Forecasting space weather with EUHFORIA in the Virtual Space Weather Modeling Centre", *Plasma Physics and Controlled Fusion*, **61**, 014011 (6pp) (2018). DOI: 10.1088/1361-6587/aae048

S. Poedts, A. Kochanov, A. Lani, C. Scolini, C. Verbeke, S. Hosteaux, E. Chané, H. Deconinck, N. Mihalache, F. Diet, D. Heynderickx, J. De Keyser, E. De Donder, N.B. Crosby, M. Echim, L. Rodriguez, R. Vansintjan, F. Verstringe, B. Mampaey, R. Horne, S. Glauert, P. Jiggens, R. Keil, A. Glover, G. Deprez, J.-P. Luntama: "The Virtual Space Weather Modelling Centre", *J. of Space Weather and Space Climate*, **10**, Art. 14 (2020). Open Access DOI: 10.1051/swsc/2020012