The 3D dynamic kinetic model of the plasmasphere BPIM https://esc.pithia.eu/

Viviane Pierrard
Royal Belgian Institute for Space Aeronomy

Provides:

Plasmapause location

Density

Temperature

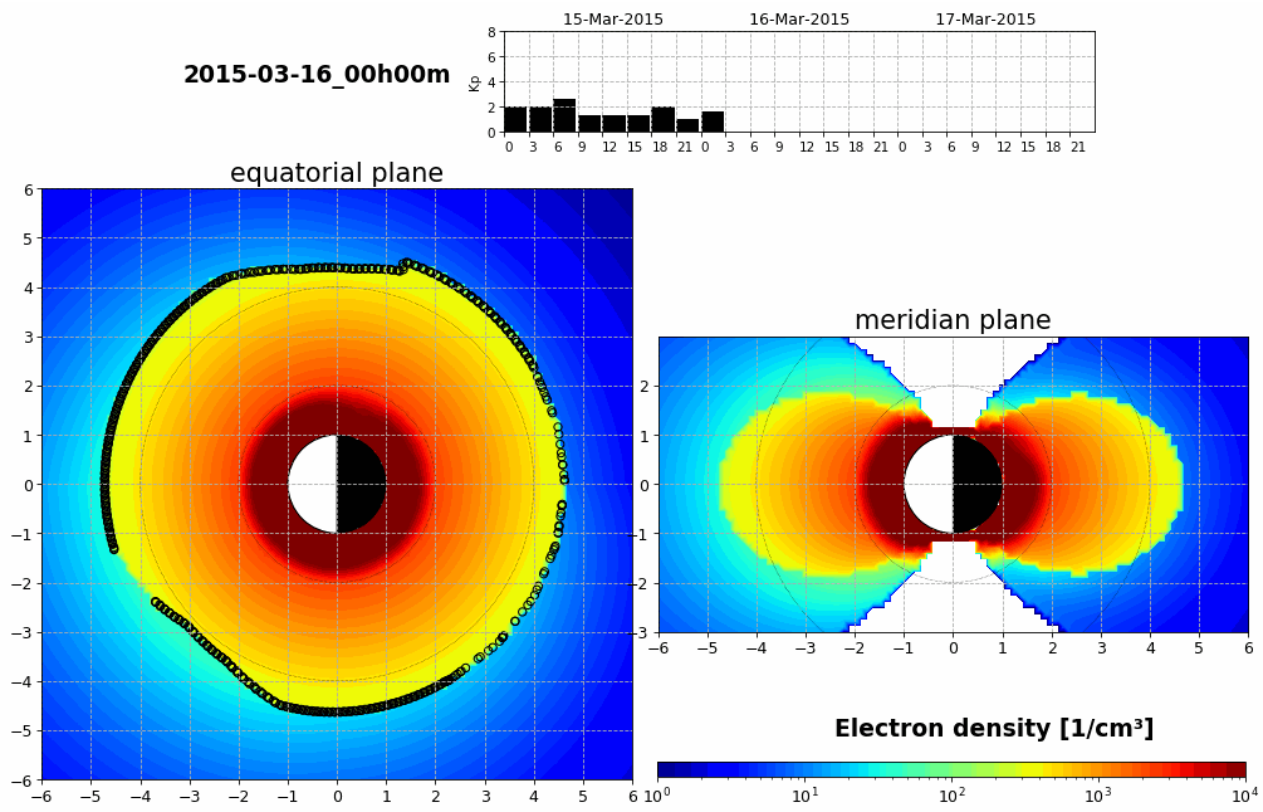
Coupling with ionosphere IRI

Plasmatrough VAP

Plume

Physics-based and semi-empirical

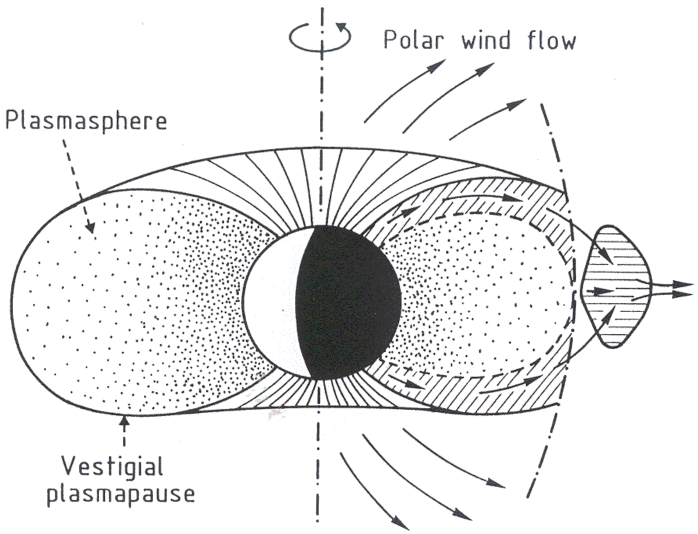
In Python

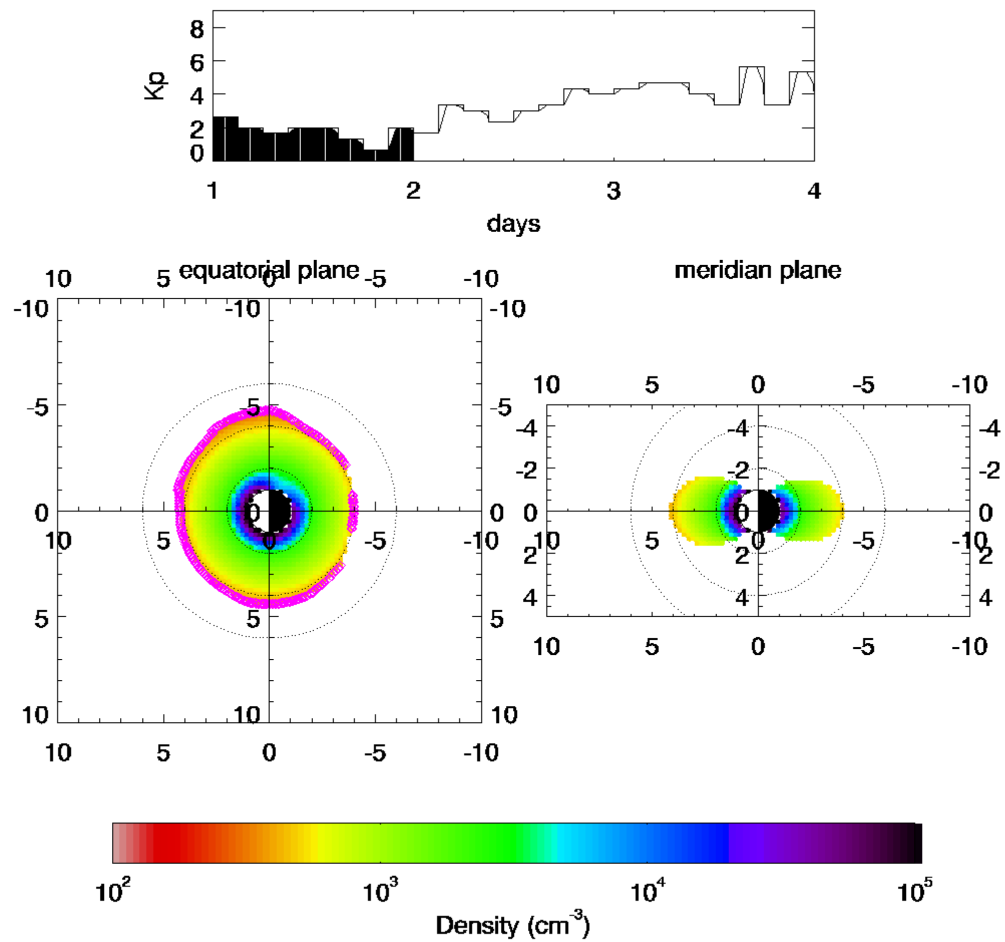


Pierrard and Stegen, JGR, 113, A10209, 2008.
Pierrard and Voiculescu, GRL, 38, L12104, 2011
Pierrard et al., Frontiers. doi:10.3389/fspas.2021.681401, 2021

Plasmapause formed in the equatorial plane in the post-midnight sector due to the mechanism of interchange instability (launch of plasma elements)

Input: Date that determines geomagnetic activity (Kp index during previous 24 h)

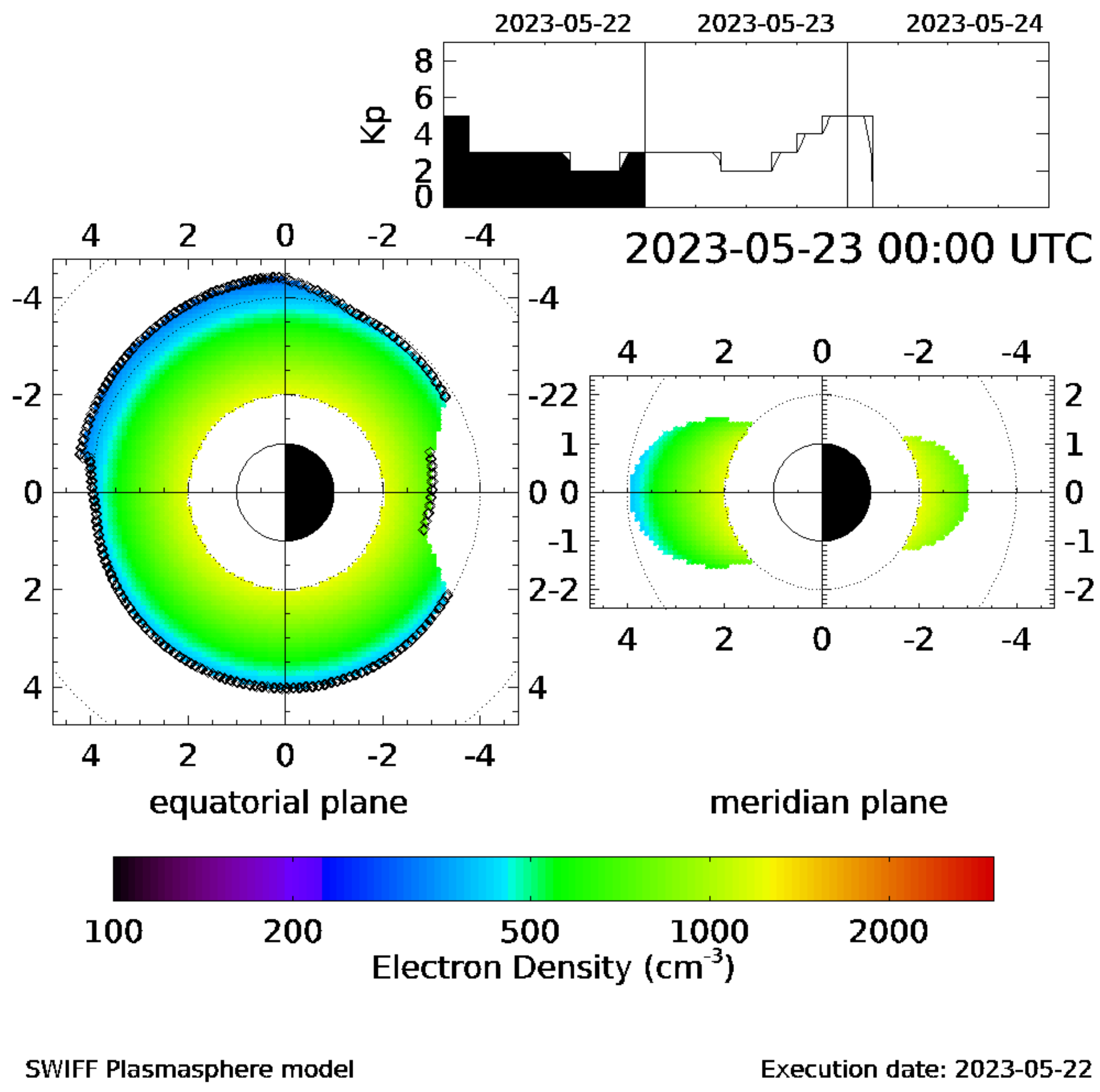




Pierrard and Lemaire, *Geophys. Res. Lett.*, 31, doi: 10.1029/2003GL018919, 2004

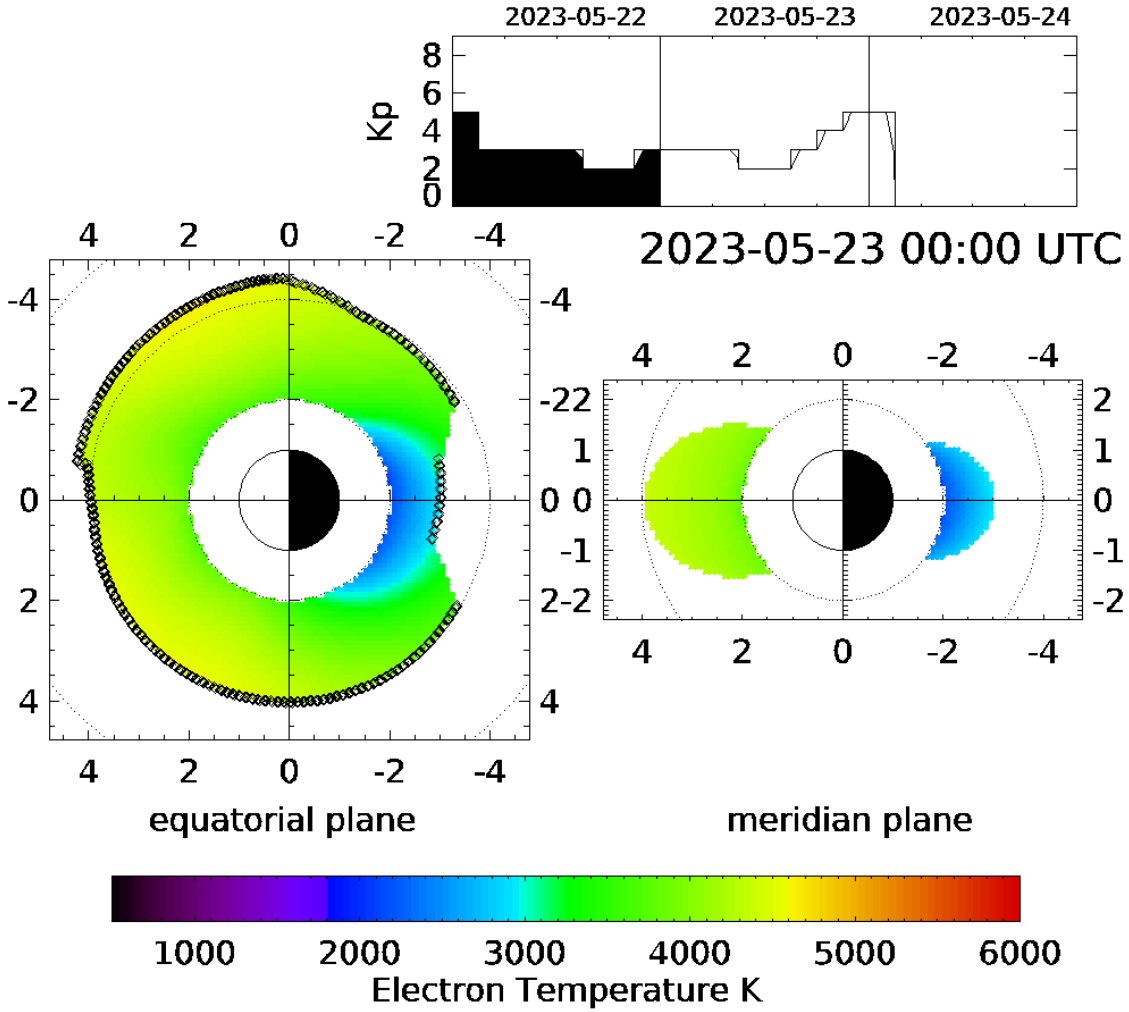
http://swe.ssa.esa.int space radiation

SPM in real time or at a given date after 2017 (Fortran+idl)



Density

http://swe.ssa.esa.int space radiation



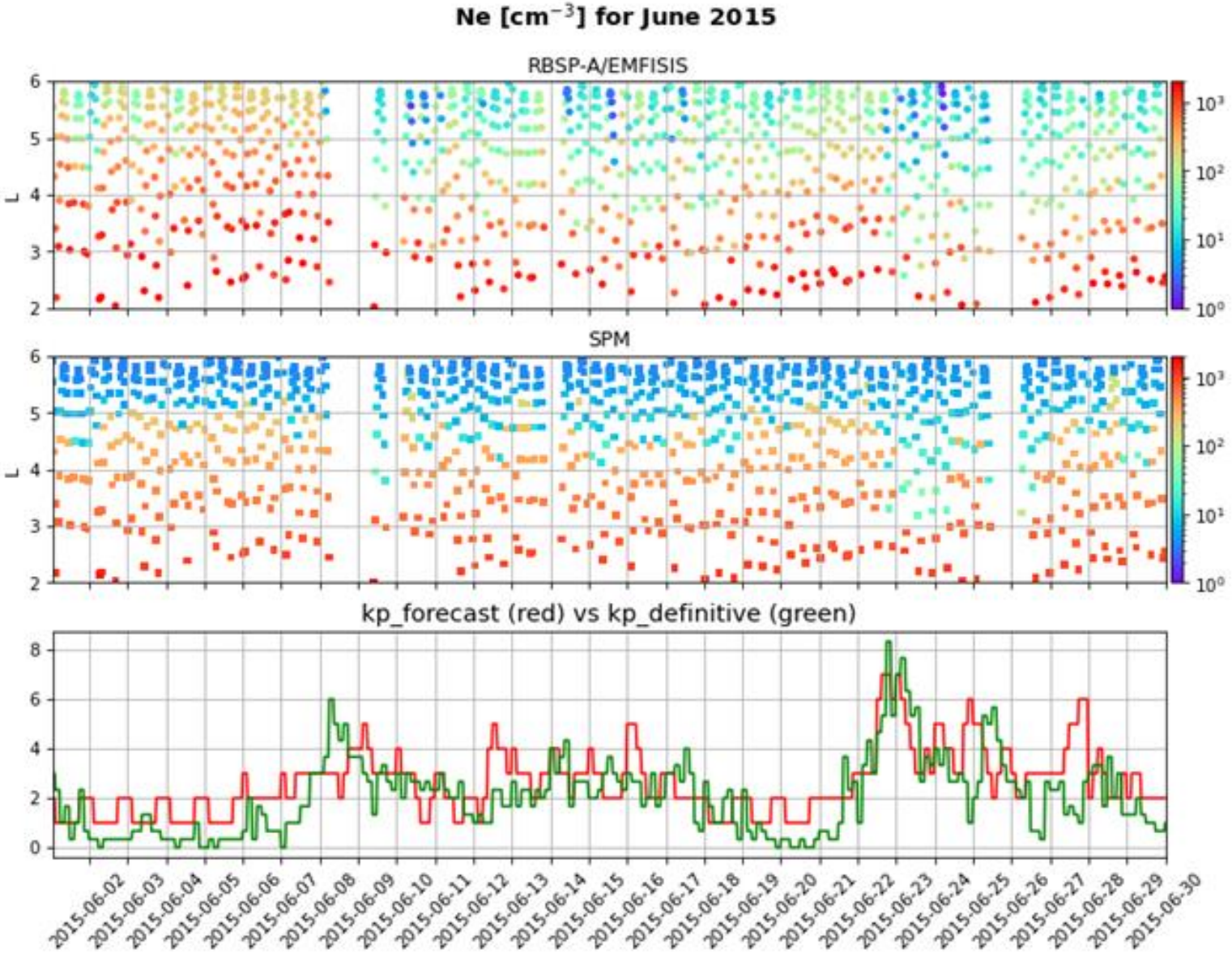
Temperature

SWIFF Plasmasphere model

Execution date: 2023-05-22

New model predictions based on Kp, compared and improved in the trough using RBSP Trough BSPM: CA92 extrapolated to all MLT

Pierrard et al., Front. Astron. Space Sci., doi:10.3389/fspas.2021.681401, 2021



Ne observed by RBSP

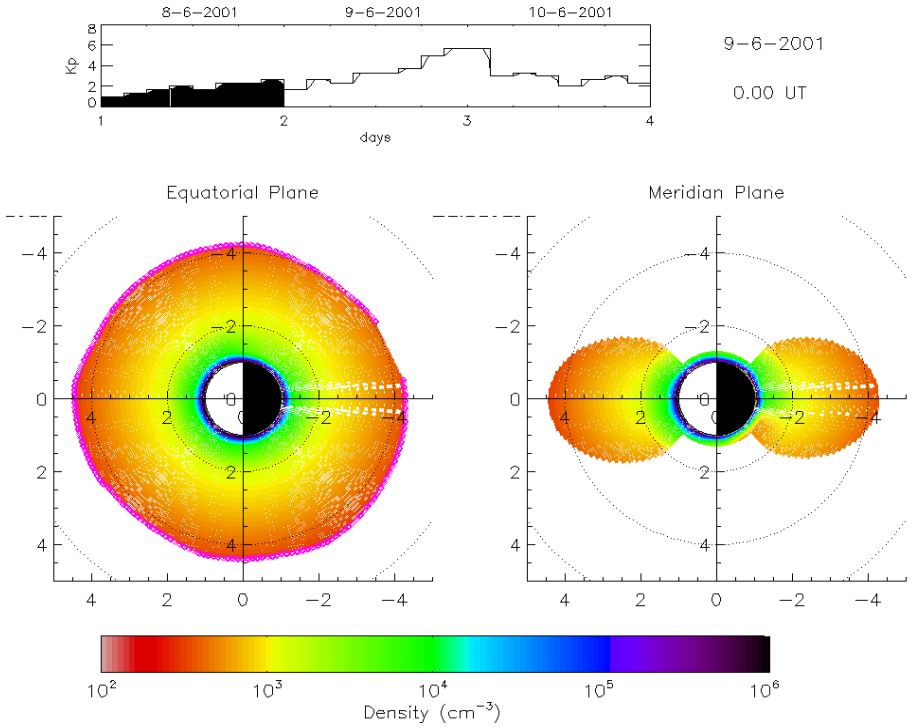
Ne predicted by BSPM model

Kp forecast (NOAA)
Kp definitive (Potsdam)

3D BPIM dynamic model

Number **density** (e, p, He) provided inside and outside the plasmasphere with MLT dependence, from analytical empirical relations, **coupling with ionosphere** (IRI2016) used below 600 km, circulating along B

H2020 PITHIA
https://pithia-nrf.eu
Virtual Space Weather Model Center
https://swe.ssa.esa.int/kul-cmpa-federated
Projects: H2020 SafeSpace
https://safespace.ufa.cas.cz/ (prediction 6h)



Pierrard and Voiculescu, GRL, 38, L12104, 2011

https://esc.pithia.eu/

Search data collection

Earth/magnetosphere/Inner/Plasmasphere search

BPIM 3D kinetic model

https://swe.ssa.esa.int/kul-cmpa-federated/

NEW RUN', Filter chain (right) 'BPIM' in the 'By Model' window.

3 different chains of models where BPIM is available:

1) EUHFORIA + Indices + ODI F10.7 + CTIP + BPIM ;

2) EUHFORIA + SNGI (NARMAX) + ODI F10.7 + CTIP + BPIM ;

3) ODI KP + BPIM.

Date 31/01/2023

Start the run

History: success results r(RE), MLT (h), density (cm^{-3})

+ movie (gif file)

PITHIA-NRF e-Science Centre

Search & Browse Metadata

Search Data Collections

Browse Data Collections

Browse Catalogues

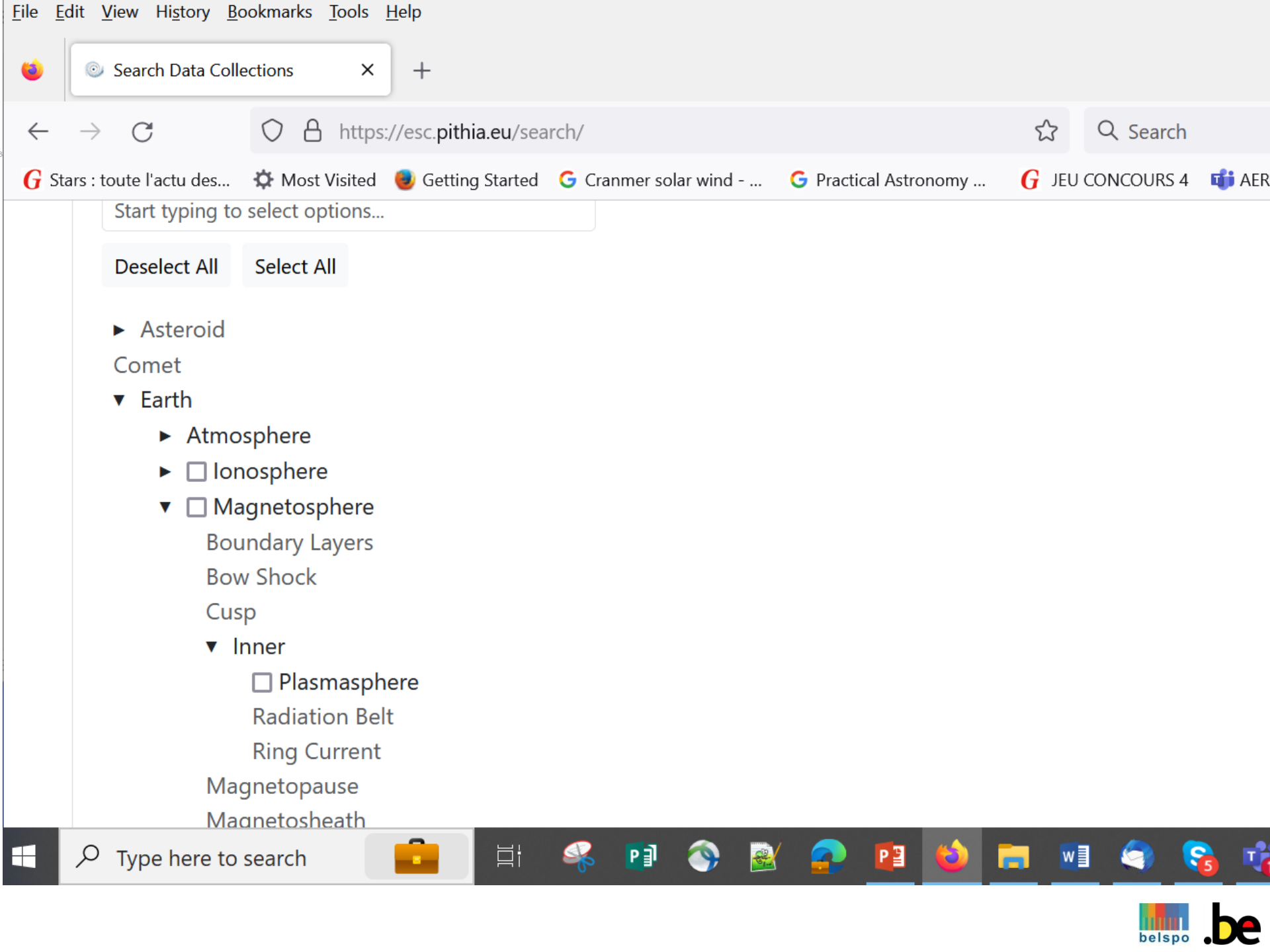
Browse Metadata

Space Physics Ontology

Data Collections

Top-level definition of a collection of the model or measurement data, with CollectionResults pointing to its URL(s) for accessing the data. Note: data collections do not include begin and end times, please see Catalogue

- ActivityIndicator: Collection of Hp30 and ap30 indices by GFZ
- ActivityIndicator: Collection of Hp60 and ap60 indices by GFZ
- ActivityIndicator: Collection of Kp, ap, and Ap indices by GFZ, with F10.7 from DRAO and Sn from WSC SILSO
- B0B1_qModel
- BPIM: 3D-Kinetic plasmasphere model
- DIDBase: Digital Ionogram DataBase, autoscaled records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Ionosphere
Magnetosphere
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Bow Shock
Cusp
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Plasmasphere
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Magnetopause
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BPIM: 3D-Kinetic plasmasphere model

The BPIM is a 3D-Kinetic semiempirical model of the plasmasphere developed by the Solar Wind Division of the Royal Belgian Institute for Space Aeronomy. Based on physical mechanisms for the plasmapause formation and trajectories of particles trapped in the Earth's magnetic field, it provides the number density and the temperature of the electrons and protons inside and outside the plasmasphere, as well as the position of the plasmapause, as a function of the geomagnetic activity driven by the Kp index. During geomagnetic storms, the plasmasphere is eroded and structures like plasma plumes and channels can appear. During quiet times, the ionosphere refills the plasmasphere. The model is coupled to the International Reference Ionosphere (IRI) model used to determine the number density and temperatures of the particles between 60 and 600 km of altitude (http://irimodel.org/). The values at 600 km are used as boundary conditions to provide the density and temperatures up to 10 Earth radii inside and outside the plasmasphere. The model is running in a near-real-time basis by the name of 'SPM' at the Space Situational Awareness site (https://swe.ssa.esa.int/bira-swiff-federated/) of ESA (European Space Agency) using a previous IDL-Fortran version that evaluates the electron density and temperature without the ionosphere coupling, and providing animations of the equatorial and meridian plasmasphere dynamics for all the archived dates since 2017. In the present implementation, a PYTHON-Fortran version is used, which is essentially the same model version as the IDL-Fortran one. This implementation is available in the frame of the ESA Virtual Space Weather Modeling Center (https://swe.ssa.esa.int/kul-cmpa-federated/) for on-demand executions

Identifier Properties

Local ID	DataCollection_BPIM_2Dmaps
Namespace	pithia
Version	1
Created	Tuesday 21st Feb. 2023, 23:40:00
Last Modified	Tuesday 21st Feb. 2023, 23:40:00

Party *(from Related Party* ***(2/2)*** *> Responsible Party Info)*	Royal Belgian Institute for Space Aeronomy (click the link to show information on this metadata registration)
Result Time	*Not used*
Name *(from Collection Results > Source > Online Resource)*	BPIM Landing Page
URL *(from Collection Results > Source > Online Resource > Linkage)*	https://swe.ssa.esa.int/kul-cmpa-federated/
Protocol *(from Collection Results > Source > Online Resource)*	HTTPS

https://swe.ssa.esa.int/kul-cmpa-federated/

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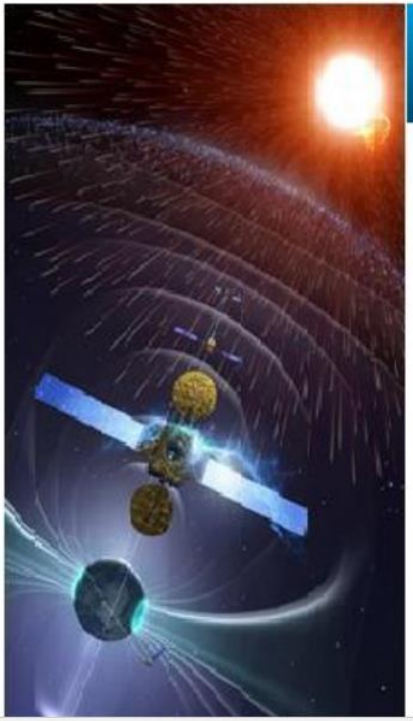

esa space situational awareness

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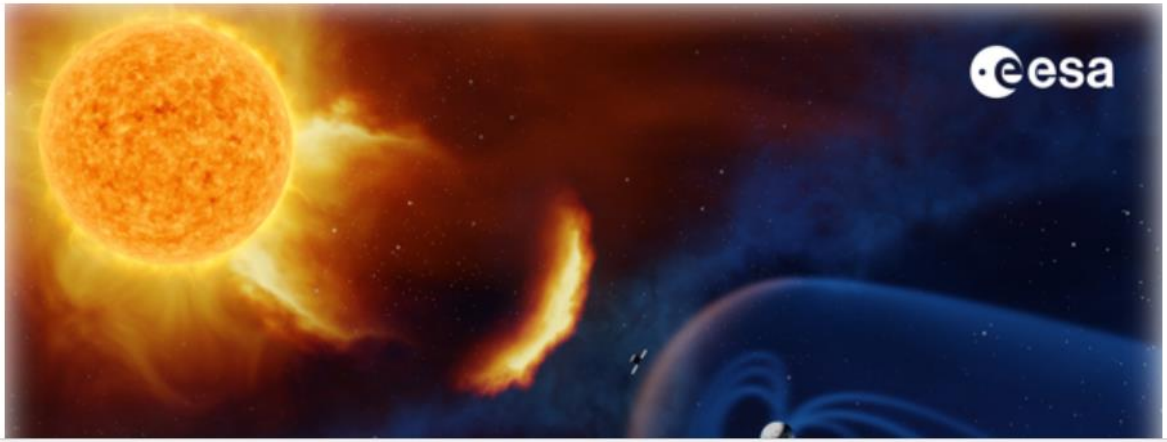
Virtual Space Weather Modelling Centre HISTORY NEW RUN

Welcome to the VSWMC

The Virtual Space Weather Modelling Centre (VSWMC) is a full scale, open end-to-end (meaning from weather modelling, enabling to combine (*couple*) various space weather models in an integrated to either locally or geographically distributed. Hence, the VSWMC brings together models for differer weather in an integrated environment that enables to run them and to couple them.



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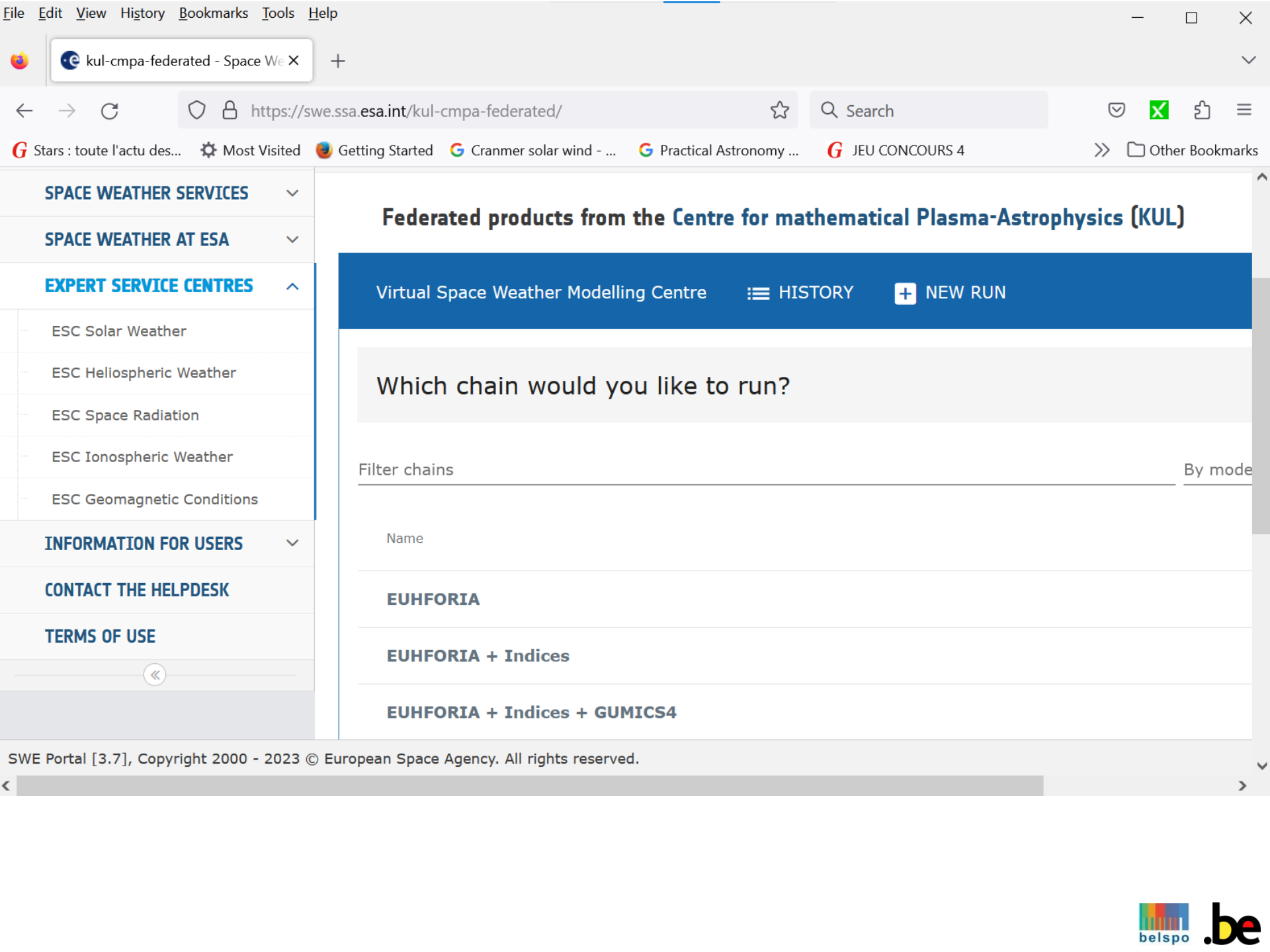
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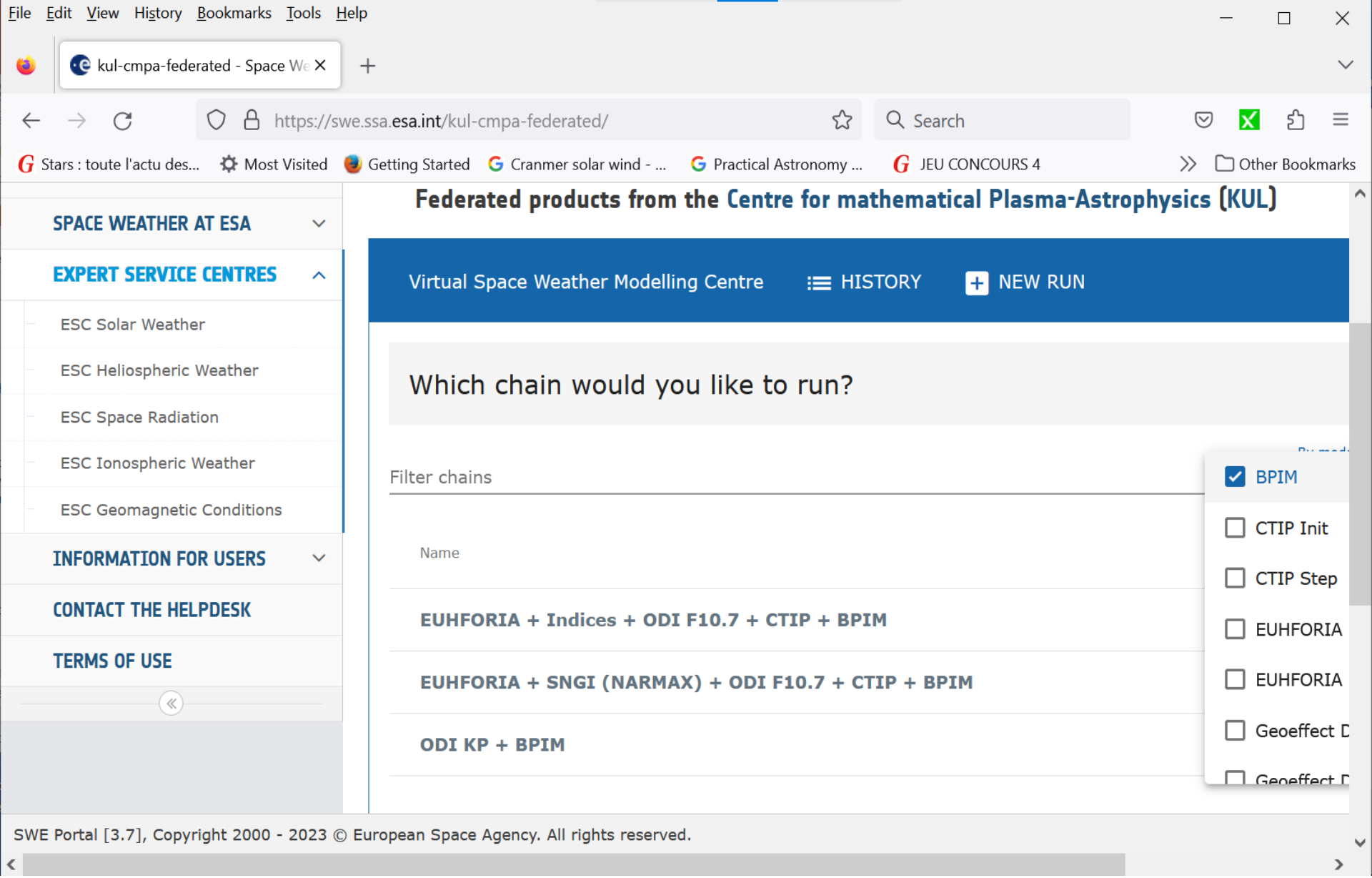
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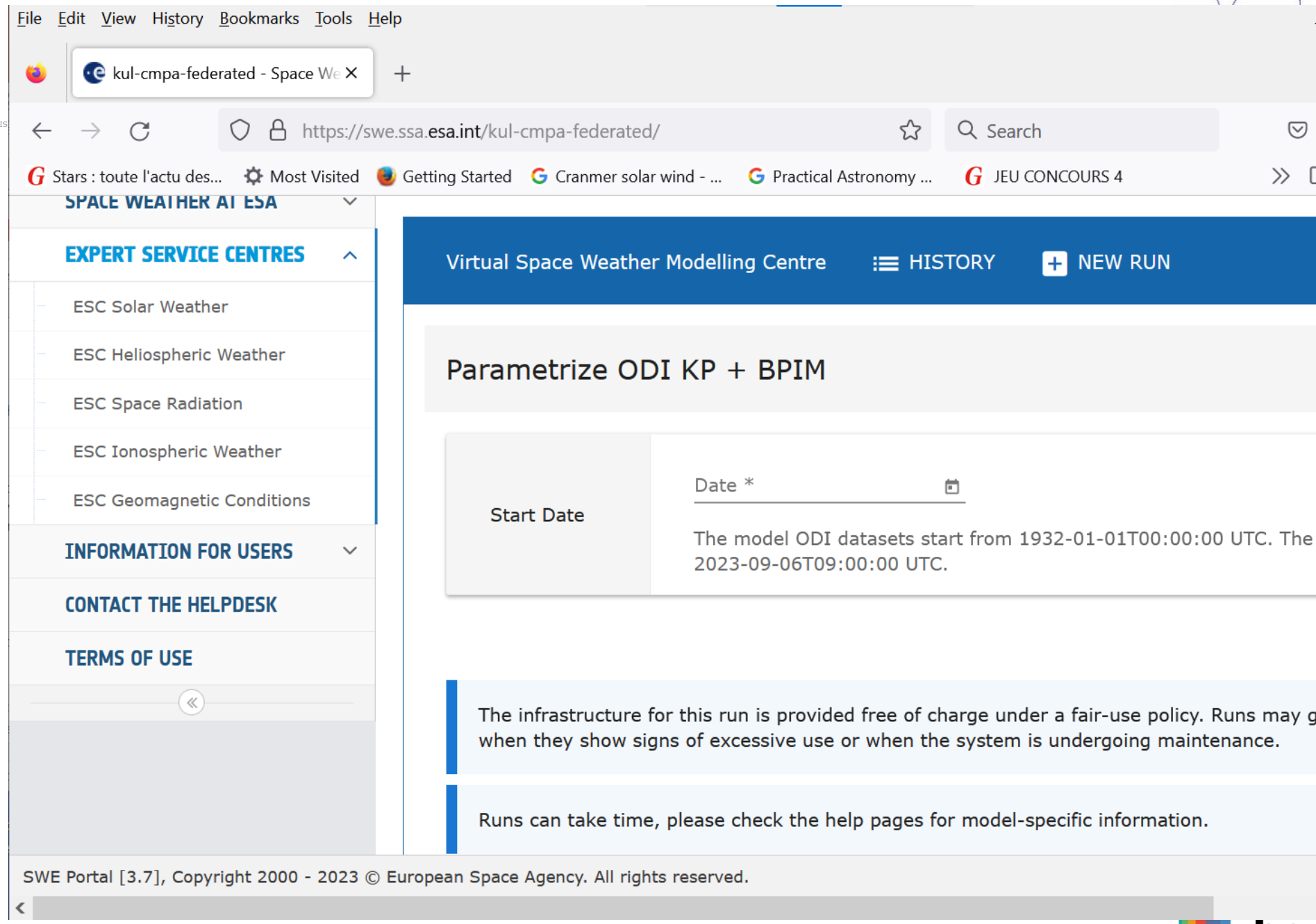
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Date *
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2023-09-06T09:00:00 UTC.
The infrastructure for this run is provided free of charge under a fair-use policy. Runs may g
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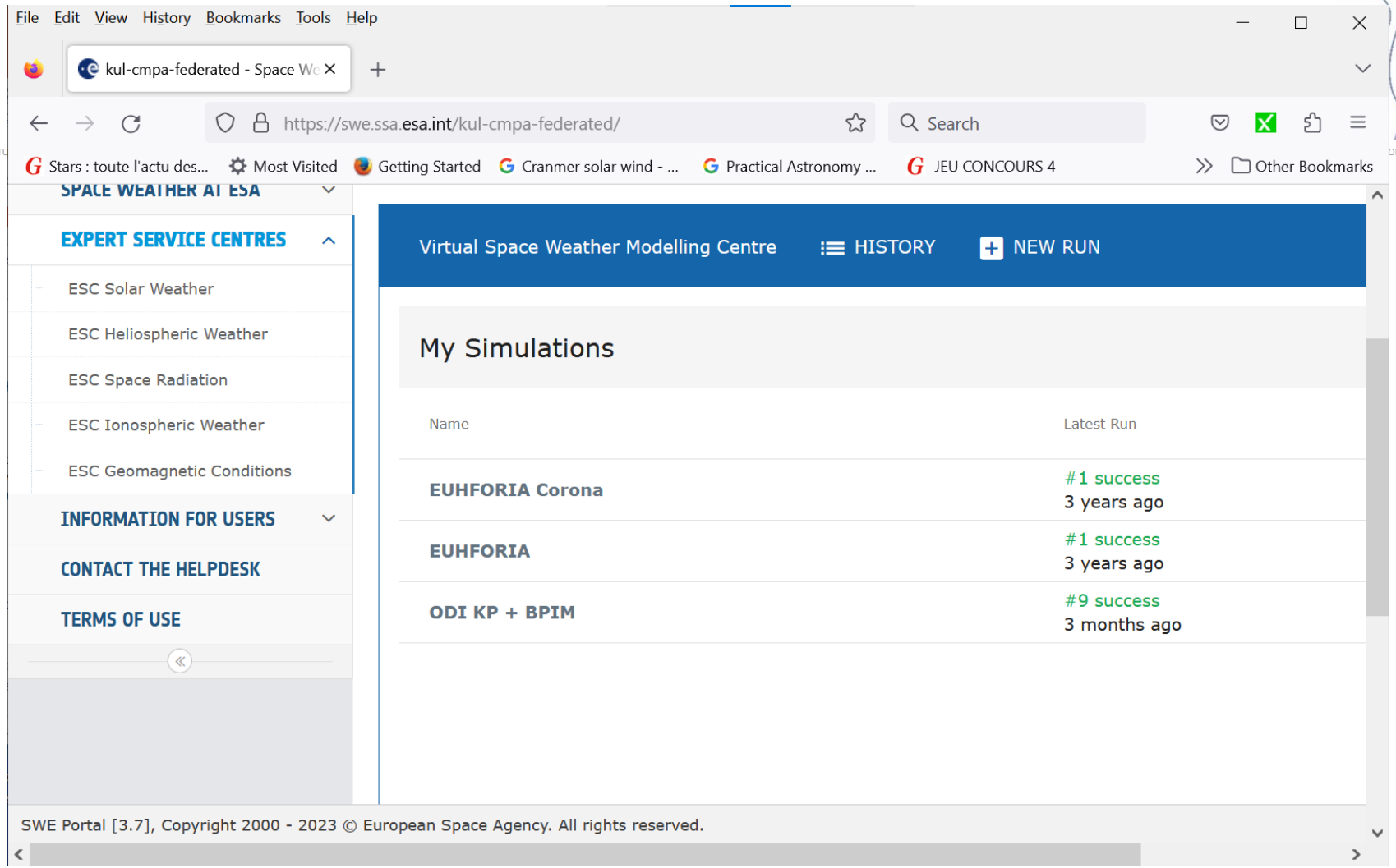
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3 years ago
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#9 success
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RUN HISTORY | LAYOUT

Status	Run	Elapsed	Submitted
success	ODI KP + BPIM #9	18m 59s	30/5/2023, 17:37:25
success	ODI KP + BPIM #8	19m 54s	29/5/2023, 15:47:54
success	ODI KP + BPIM #7	19m 31s	25/5/2023, 20:03:55
success	ODI KP + BPIM #6	15m 56s	23/5/2023, 14:44:23
success	ODI KP + BPIM #5	15m 19s	23/5/2023, 14:17:20
success	ODI KP + BPIM #4	15m 55s	23/5/2023, 13:54:14
success	ODI KP + BPIM #3	17m 38s	22/5/2023, 19:39:19

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ODI KP + BPIM #6

Started by viviane at 23/5/2023, 14:44:23

PARAMETERS | LOG | RESULTS

ODI.txt	23/5/2023, 14:44:29	452 Bytes	Plain Text
dens (24 files...)	-		- Slideshow
dens_eq_2015-10-09_00h00m_at_2023-05-23_14h46m.csv	23/5/2023, 14:47:09	194.1 KB	-
dens_eq_2015-10-09_01h00m_at_2023-05-23_14h47m.csv	23/5/2023, 14:47:42	194.1 KB	-
dens_eq_2015-10-09_02h00m_at_2023-05-23_14h48m.csv	23/5/2023, 14:48:45	194.1 KB	-
dens_eq_2015-10-09_03h00m_at_2023-05-23_14h48m.csv	23/5/2023, 14:49:18	194.1 KB	-
dens_eq_2015-10-09_04h00m_at_2023-05-23_14h48m.csv	23/5/2023, 14:49:51	194.2 KB	-
dens_eq_2015-10-09_05h00m_at_2023-05-23_14h49m.csv	23/5/2023, 14:50:24	194.2 KB	-

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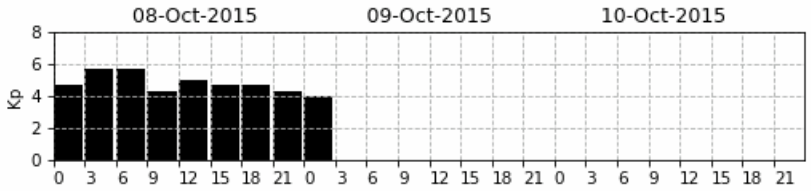

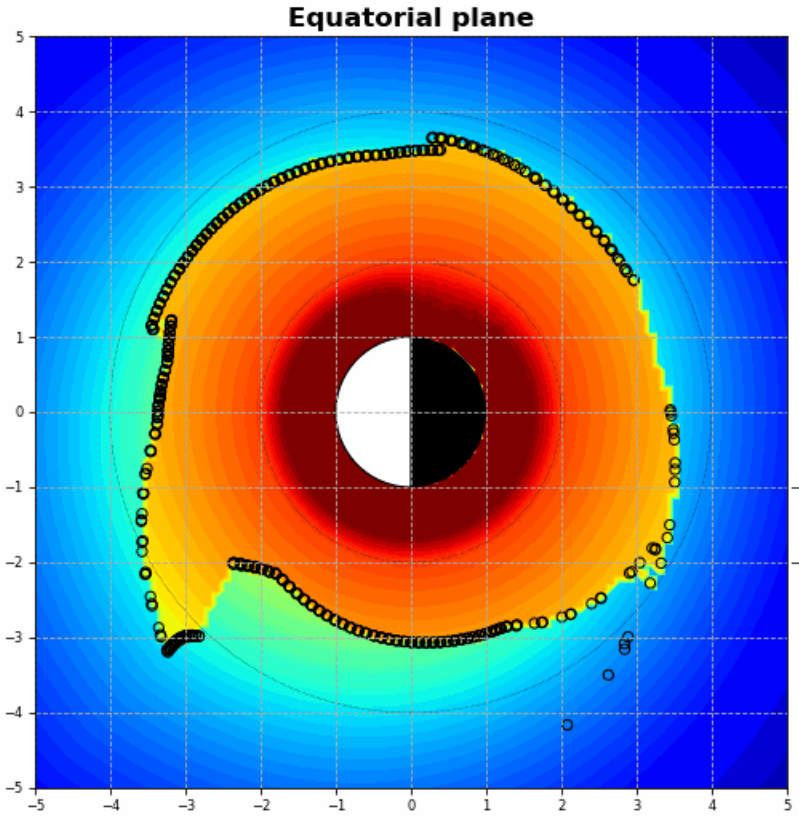

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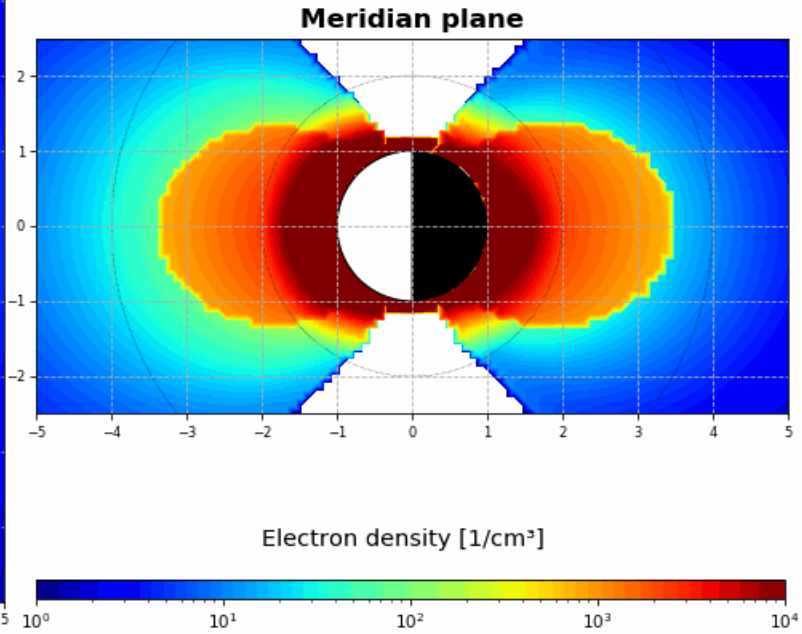

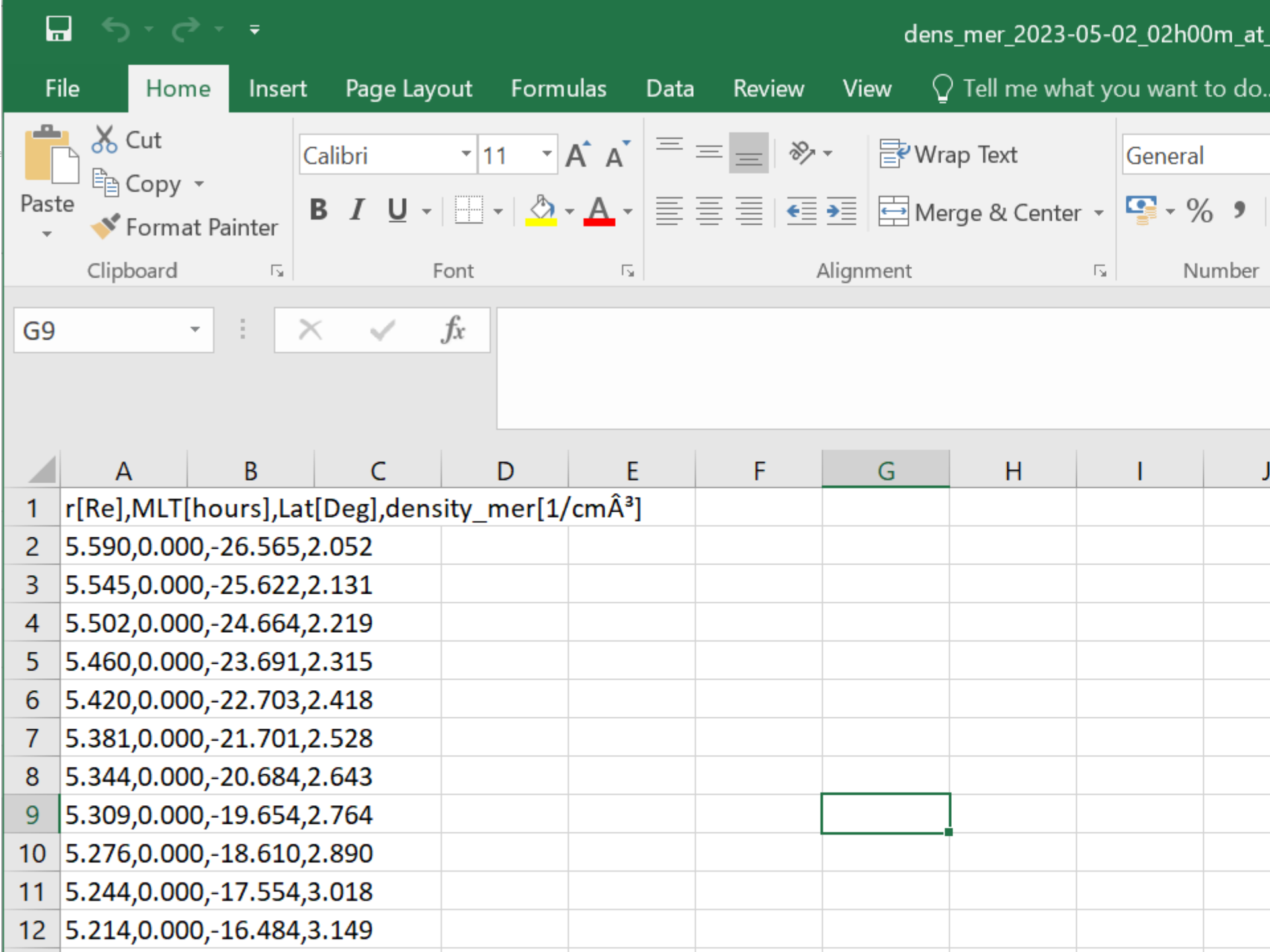
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5.590,0.000,-26.565,2.052
5.545,0.000,-25.622,2.131
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5.460,0.000,-23.691,2.315
5.420,0.000,-22.703,2.418
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5.276,0.000,-18.610,2.890
5.244,0.000,-17.554,3.018
5.214,0.000,-16.484,3.149

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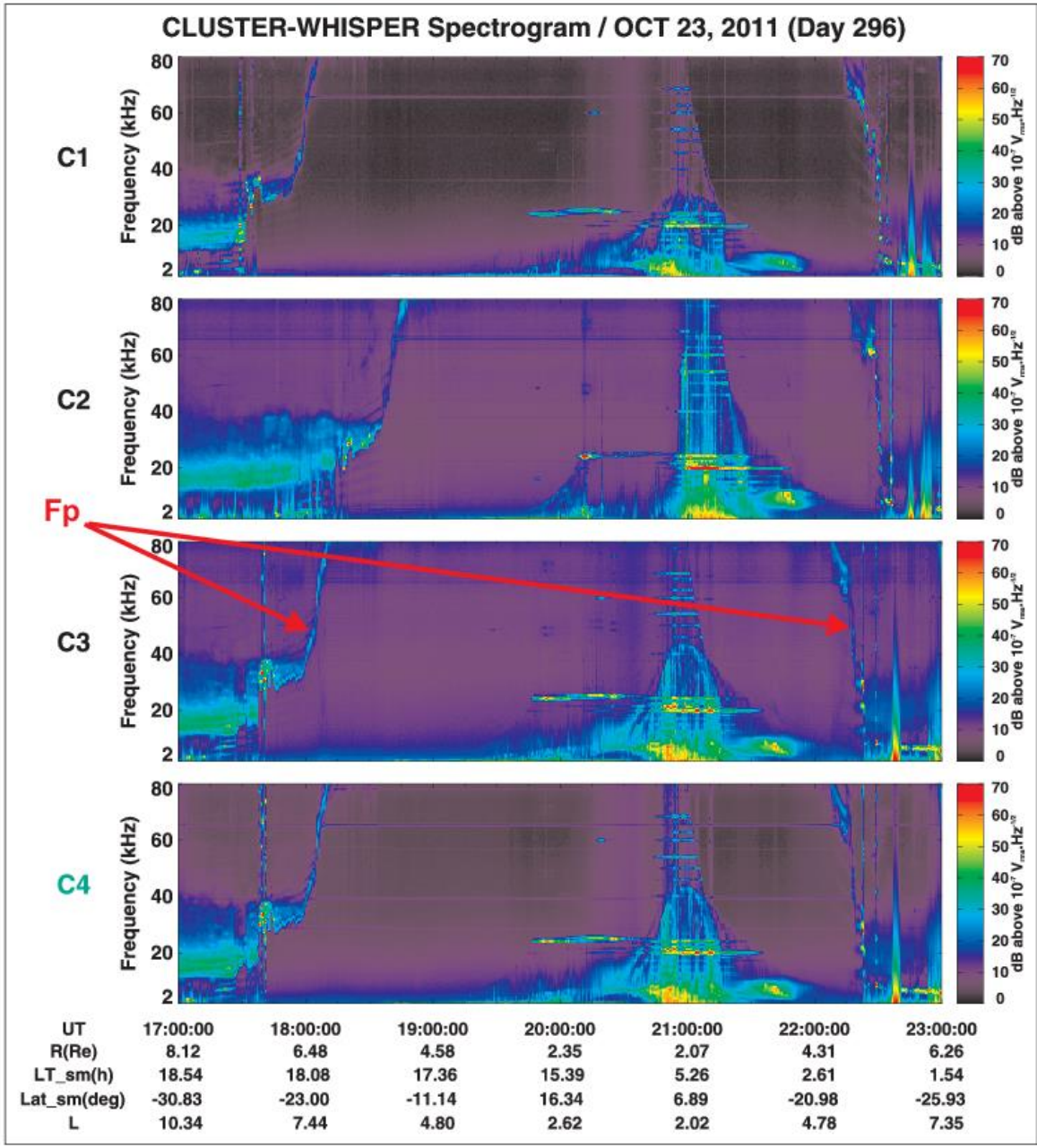
Plasmapause

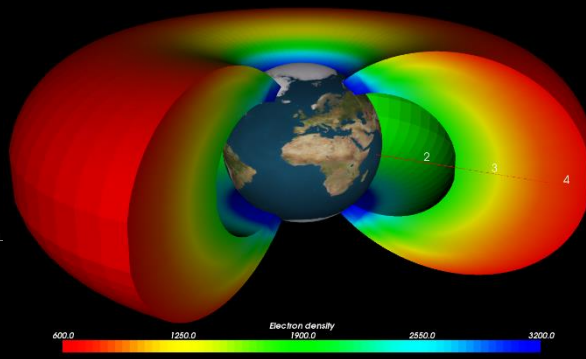
Waves of HIgh frequency and Sounder for Probing of Electron density by Relaxation

$N(cm^{-3}) = f_p^2(kHz)/81$

Time-frequency electric field spectrograms for a plasmasphere crossing



Conclusions



Plasmasphere model available on https://esc.pithia.eu/
http://swe.ssa.esa.int/space-radiation

- Input: date, time (for Kp PP and coupling with IRI)

- Output: Density, temperature inside PS, outside (trough)
- Plasmapause by interchange instability
- Animated PS in equatorial and meridian planes + data files
- Semi-empirical Kp dependent McIlwain E-field
- Plasmaspheric wind and refilling on request

Pierrard, Botek, Darrouzet, Front. doi:10.3389/fspas.2021.681401, 2021 (PS)
Botek et al., JGR, doi: 10.1029/2021JA029737, 2021 (trough)
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