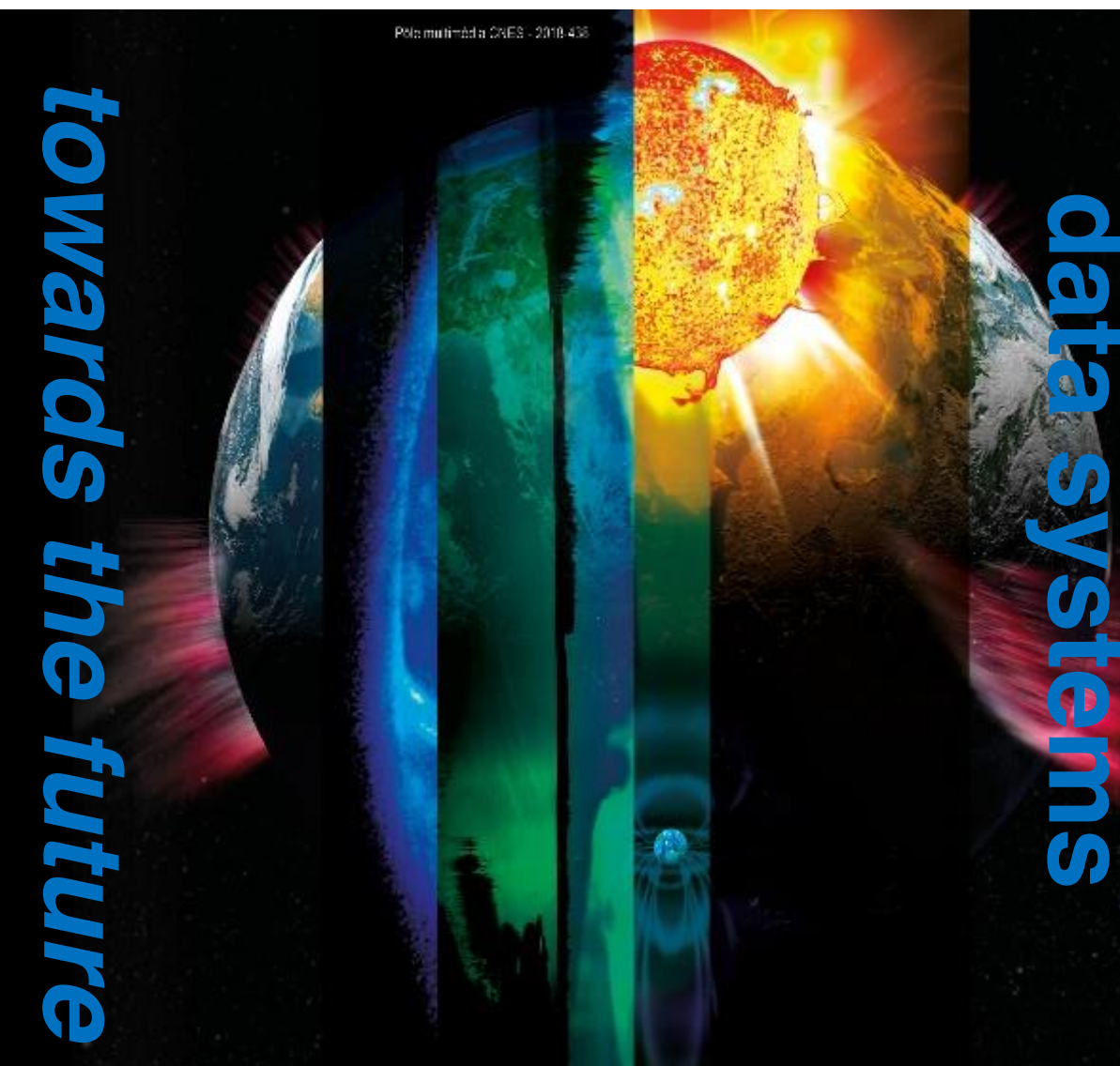# Planetary plasmas data systems

towards the future

V. Génot, C. Jacquey, F. Pitout, B. Cecconi, M. Bouchemit, E. Budnik, M. Gangloff, N. Dufourg, N. André, A. Rouillard, B. Lavraud, D. Heulet, J. Durand, M. Indurain

Pôle multimédia CNES - 2010 436

Outline

- Database activities at the French Centre de Données de la Physique des Plasmas (CDPP)
  - Data, tools, mission support

- Some issues that long term archives are facing
  - And some solutions proposed by interoperability

- Some conclusions based on the ESA document « long term strategy for science archive »

CDPP

Plasma Physics Data Centre

- Established in 1998 from a CNES/CNRS collaboration for natural plasma data distribution and archiving : from the ionosphere to the heliosphere; about 7 FTE, engineers and scientists, main base in Toulouse, south of France

- Since 2006, CDPP is strongly involved in the development of data analysis and visualization tools including simulations

- CDPP expertise in data handling resulted in the participation to several EU and ESA projects aiming at enlarging data distribution via standards (Virtual Observatory concept) including simulations

- Mission support activities : quicklook visualization tool for the Rosetta Plasma Consortium team, role in discussion for Solar Orbiter, Bepi-Colombo and JUICE.

- These activities help promoting science (papers) and education (hands-on, tutorials)

CDPP

Plasma physics data center

http://www.cdpp.eu/

The CDPP is the French national data centre for natural plasmas of the solar system.

Created in 1998 jointly by **CNES** and **INSU**, the CDPP assures the long term preservation of data obtained primarily from instruments built using French resources, and renders them readily accessible and exploitable by the international community. The CDPP also provides services to enable on-line data analysis (**AMDA**), 3D data visualization in context (**3DView**), **propagation tool** and **space weather tool** which bridges solar perturbations to in-situ measurements. The CDPP is involved in the development of interoperability, participates in several Virtual Observatory projects, and supports data distribution for scientific missions (Solar Orbiter, JUICE).

Direct access to our tools
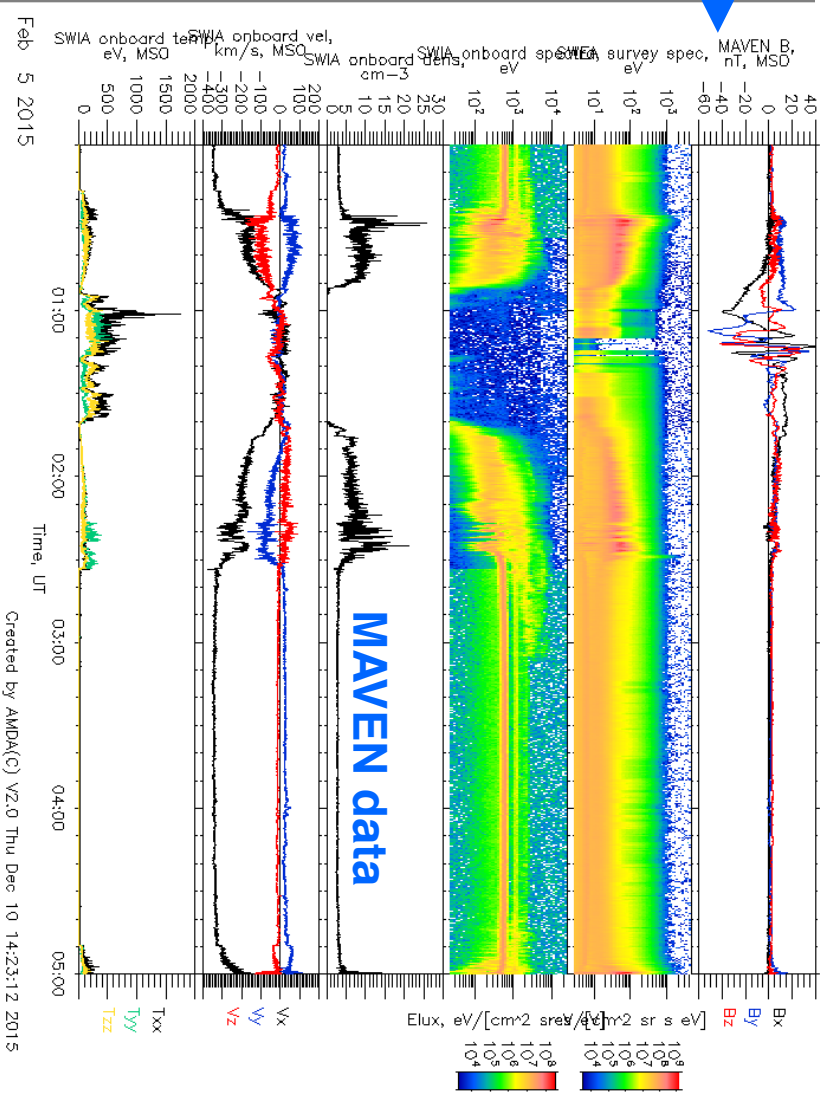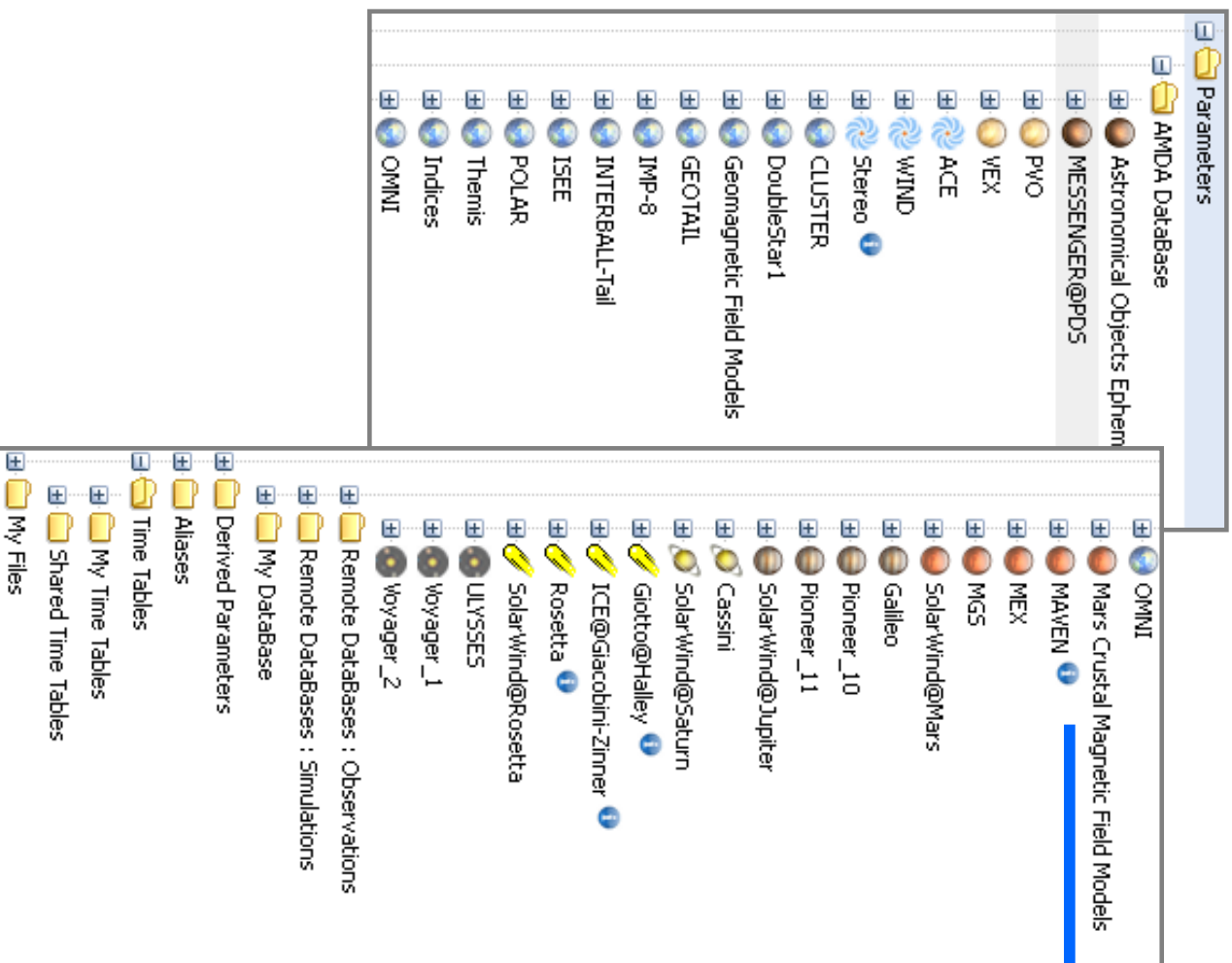
Amda Propagation Tool SpaceWeather Tool TREPS SIPAD 3DView

CDPP News

CDPP and ESA/SSA
Integrating the ESA space weather portal
Read more...

A new web site !
Here a new look on CDPP
Read more...

CDPP is involved in ESA/Athena
Whan plasma physics helps X-ray astronomy
Read more...

All the news

Datasets available in the online tool CDPP/AMDA

http://amda.cdpp.eu/

- Plot
- Data mining and combination
- Cataloguing (event lists)
- Upload / download
- Statistics (long term analysis)

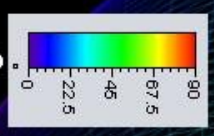# Machine learning approach in AMDA: enhancing data visu & analysis

θ_{Bn}
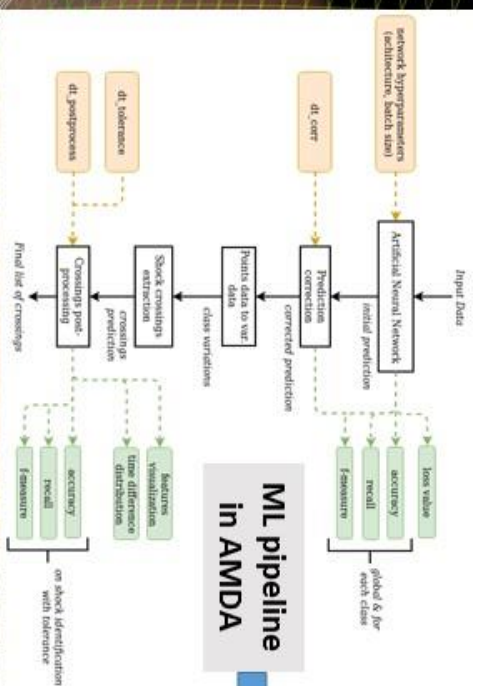
Orbit + shock model in 3DView

Event catalogues

ML pipeline in AMDA

Network hyperparameters (architecture, batch size)

dt_postprocess

dt_tolerance

dt_corr

Input Data

Artificial Neural Network

initial prediction

Prediction corrections

corrected prediction

Points data to var. data

class variations

Shock crossings extraction

crossings prediction

Crossings post-processing

Final list of crossings

f-measure

recall

accuracy

loss value

f-measure

recall

accuracy

global & for each class

features visualization

time difference distribution

on shock identification with tolerance

Spacecraft/Body	Time	X(RM)	Y(RM)	Z(RM)	N_X	N_Y	N_Z
MEX	2016-09-01 02...	-1	0.86	-3.27	-0.57	-0.19	0.8
MEX	2016-09-01 04...	1.46	0.26	0.64	-0.95	-0.12	0.8
MEX	2016-09-01 09...	-0.99	0.86	-3.27	-0.95	-0.19	0.8
MEX	2016-09-01 11...	1.46	0.25	0.65	-0.95	-0.12	0.8
MEX	2016-09-01 16...	-0.99	0.86	-3.27	-0.95	-0.19	0.8
MEX	2016-09-01 18...	1.46	0.24	0.66	-0.57	-0.19	0.8
MEX	2016-09-01 23...	-0.98	0.87	-3.26	-0.95	-0.12	-0.29
MEX	2016-09-02 01...	1.46	0.23	0.66	-0.95	-0.19	0.8
MEX	2016-09-02 06...	-0.97	0.87	-3.26	-0.57	-0.11	-0.29
MEX	2016-09-02 08...	1.46	0.23	0.66	-0.95	-0.19	-0.29
MEX	2016-09-02 13...	-0.97	0.87	-3.25	-0.57	-0.19	0.8
MEX	2016-09-02 15...	1.46	0.22	0.66	-0.95	-0.11	-0.29
MEX	2016-09-02 20...	-0.96	0.87	-3.25	-0.57	-0.19	-0.29
MEX	2016-09-02 22...	1.46	0.21	0.67	-0.95	-0.09	-0.3

MEX

MEX IMA
protons: density, cm-3

MEX IMA
protons: v_mso, km/s

MEX ELS
Energy, eV

MEX bow shock: Martian environment, Shock,

01 Sep 2016

01/10:00

01/20:00

02/06:00

02/16:00

Time, UT

MEX bow shock

counts : sum over anodes, cnts

3D visualisation tool: CDPP/3DView

http://3dview.cdpp.eu/

Ganymede

Hybrid model at Ganymede

JRM09 magnetic field

Juno orbit (SPICE kernels)

Jupiter

HST aurora (access via VESPA/EPN-TAP)

Radiation belt model (Salammbo)

Juno

3DView
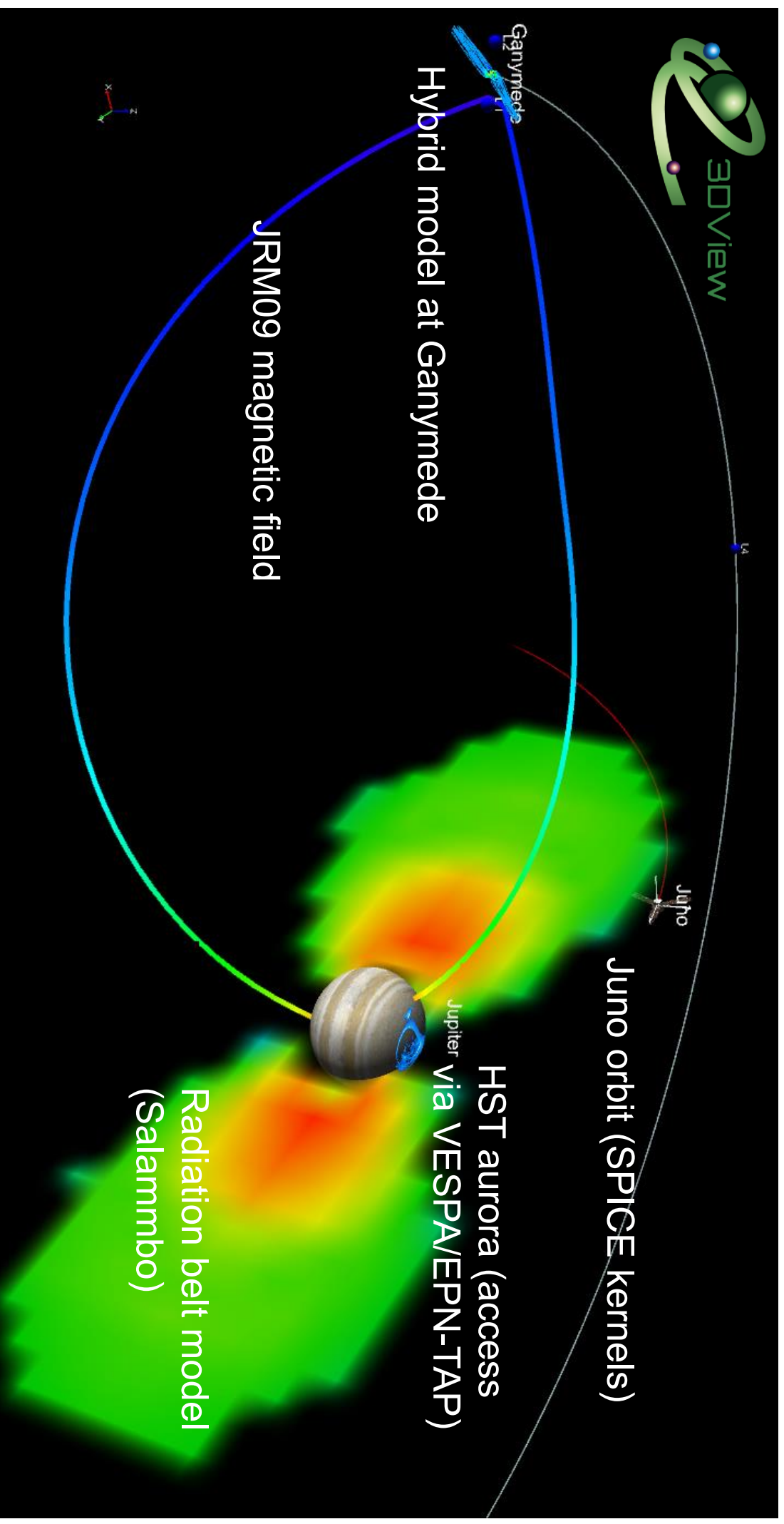
JUICE Ganymede flybys Preparation
JUICE SWT WG3 / Jan 2017
provided by R. Modolo (LATMOS)

information

- Trajectory
  - Files sent by WG3 (A. Masters & N. Krupp)
  - Computed from kernels :
  - **CReMA 3.0 - Consolidated Study Trajectory 141a**
  - juice_mat_crema_3_0_20220601_20330604_v01.bsp (correct ?) ⏐
- Simulation
  - Archived Run in the catalog @
    http://impex.latmos.ipsl.fr/LatHyS.htm
  - Run ID : LatHyS_Gany_19_03_16
 (possibility to download the data cubes (B, n, V)

criteria

- Magnetopause crossings
  - Changes in B (start to be ≠ from jovian mag field)
  - + increases in n_e (planetary plasma)
  - + decreases in U
- Magnetotail current sheet crossings ⏐
  - Change of sign of Bx component
  - Minimum in Btot
- OCFL
  - One footprint on Ganymede, the otherside connected to jovian FL
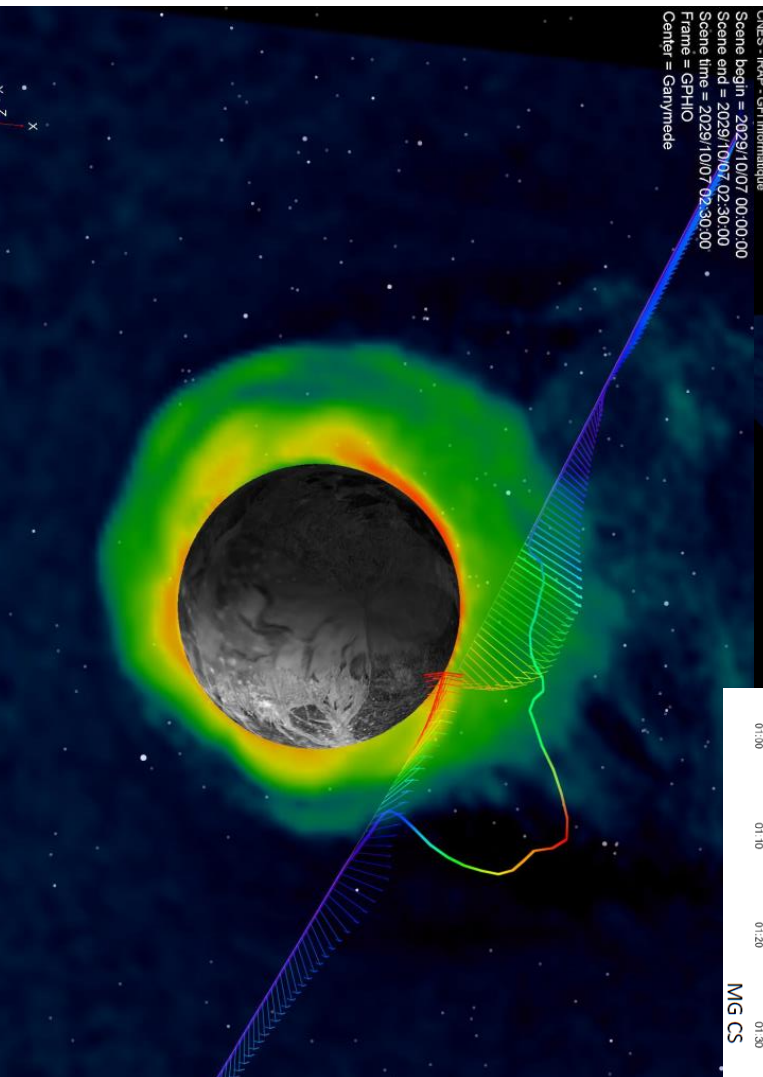 - Close Close FL : footprints on both ends of FL

G1 – CA 07-Oct-2029 01:23:37

Scene begin = 2029/10/07 01:00:00
Scene end = 2029/10/07 02:00:00
Scene time = 2029/10/07 02:00:00
Frame = GPHIO
Center = Ganymede

Color map
n_e from 1 to 475 cm-3 in log scale

G1

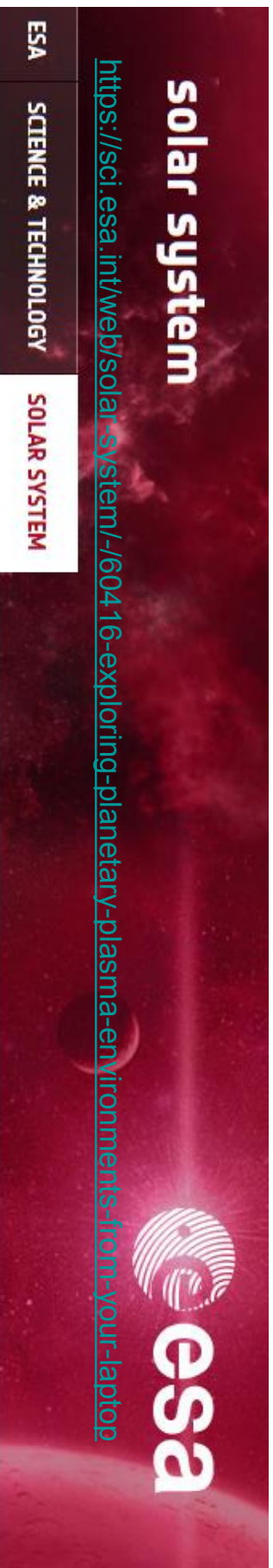CNES - IRAP - GFI informatique

3Dview
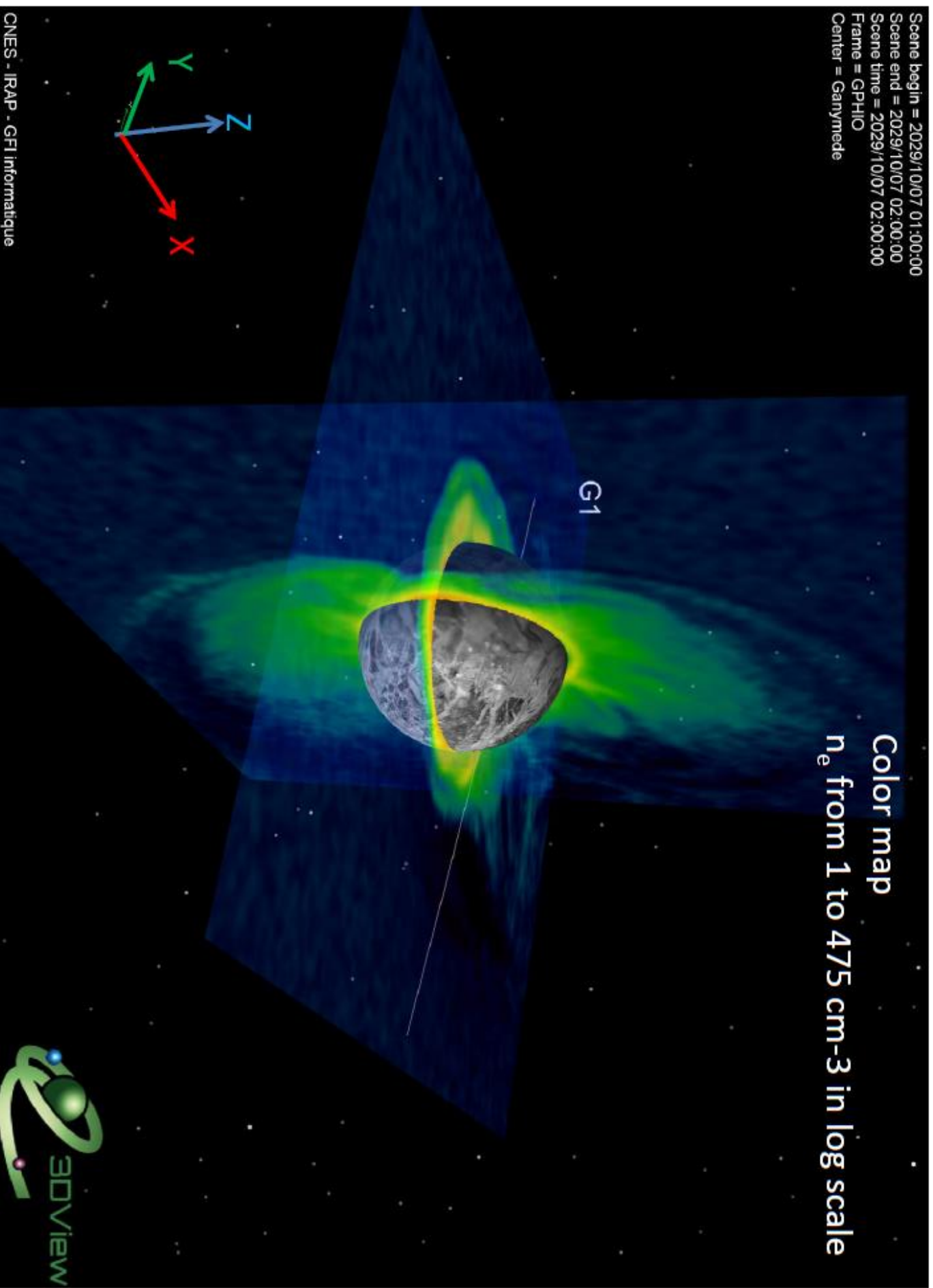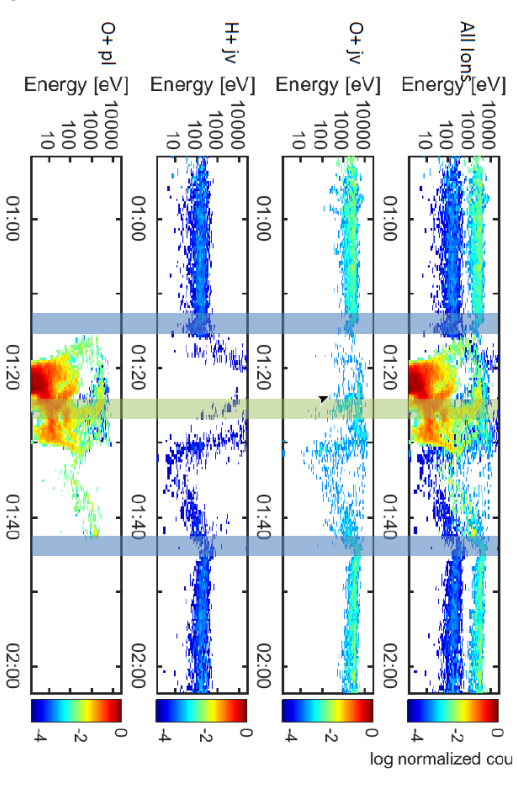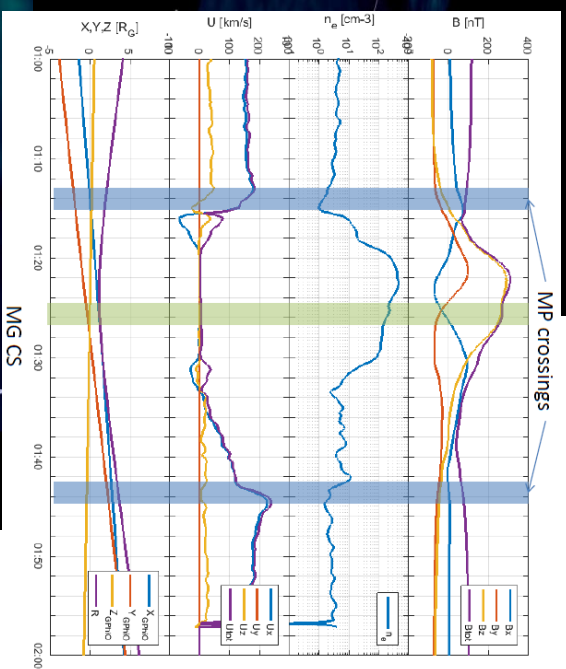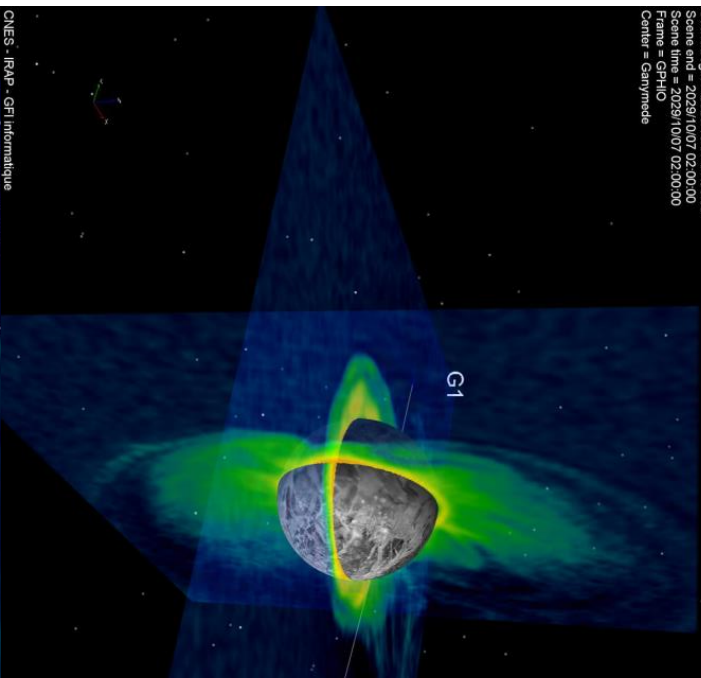
G1 – CA 07-Oct-2029 01:23:37

- Magnetopause crossings
  - Inbound : ~01:13 – 01:15
  - Outbound : ~01:42:30-01:44:30
- Magnetotail current sheet crossings
  - ~01:24:30 – 01:26:30
- OCFL
  - Inbound 01:14-01:16
  - Outbound 01:34 – 01:37
  - CCFL : 01:17-01:33

MP crossings

MG CS

Courtesy R. Modolo

ESA story on how to explore plasma environments with online tools

https://sci.esa.int/web/solar-system/-/60416-exploring-planetary-plasma-environments-from-your-laptop

solar system

esa

ESA | SCIENCE & TECHNOLOGY | SOLAR SYSTEM

Search here

12-Sep-2019 11:07 UT

EXPLORING PLANETARY PLASMA ENVIRONMENTS FROM YOUR LAPTOP

14 June 2018

Shortcut URL
https://sci.esa.int/s/ApEdDGw

A new database of plasma simulations, combined with observational data and powerful visualisation tools, is providing planetary scientists with an unprecedented way to explore some of the Solar System's most interesting plasma environments.

This digital space exploration story starts with the Integrated Medium for Planetary Exploration (IMPEx), a collaborative project to create a common data hub for space missions.

While planetary missions are crucial to understand how the solar wind interacts with the magnetospheres of planets and moons in our Solar System, numerical models are, in turn, essential to fully comprehend the measurements and improve our knowledge of planetary plasma environments.

The IMPEx project brought together experts

Images And Videos

- Animated simulation of Mercury's plasma environment
- Animated simulation of Mars' plasma environment
- Visualisation of Mars' plasma environment

Missions
· Show All Missions

Science Programme
· Cosmic Vision 2015-2025
· Future Missions

· Collaborative Missions
Department
· Director's Desk

Community Areas
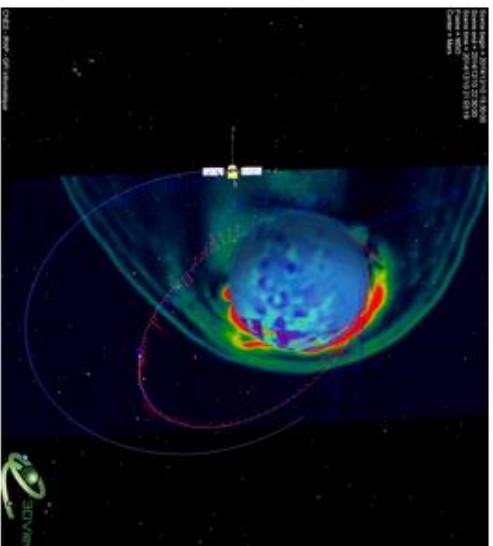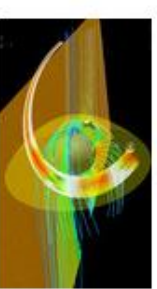· Astrophysics
· Fundamental Physics
· Solar System

Resources
· News Archive
· Multimedia gallery
· Publication Archive

Solar wind prediction at planets and probes:

http://heliopropa.irap.omp.eu/
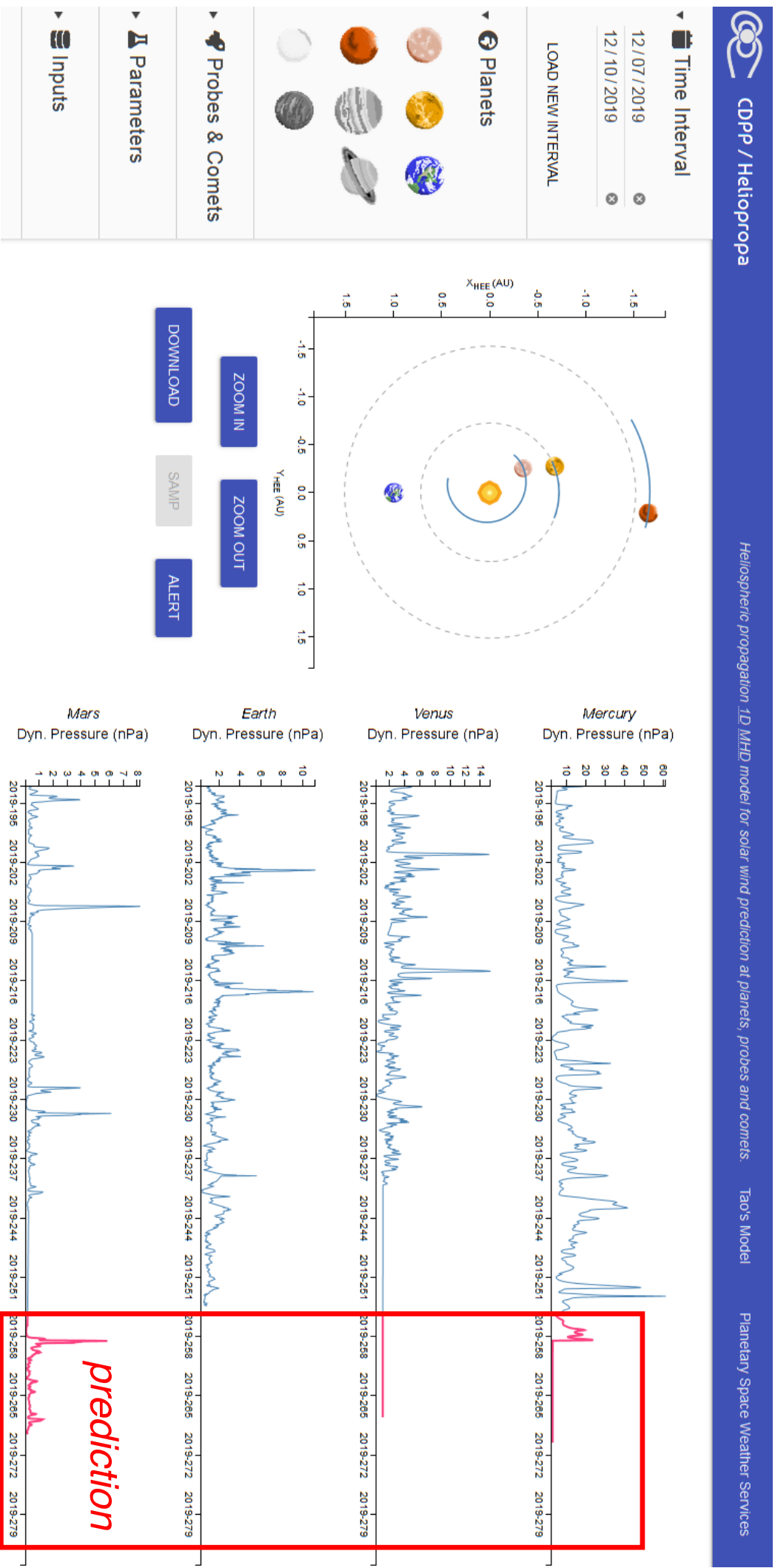
- *Based on Tao's 1D MHD model, updated daily, ACE RT as inputs*
- *Funded by Europlanet*
- *Used for an alert service*

ESA/Space Situational Awareness

ESA Space Situational Awareness

esa
space situational awareness

European Space Agency

| ESA | SSA | SWE | NEO | SST |

About SWE

What is Space Weather

SSA Space Weather Activities

Current Space Weather

Contact

Service Domains

Spacecraft Design

Spacecraft Operation

Human Space Flight

Launch Operation

Transionospheric Radio Link

Space Surveillance and Tracking

Power Systems Operation

Airlines

Resource Exploitation System Operation

Pipeline Operation

Auroral Tourism Sector

General Data Service

Expert Service Centres

ESC Solar Weather

ESC Space Radiation

ESC Ionospheric Weather

ESC Heliospheric Weather

Other Resources

Documents

SWWT

SWEN Newsletter

Upcoming Events

Sign-In

You are not signed in.

Sign In

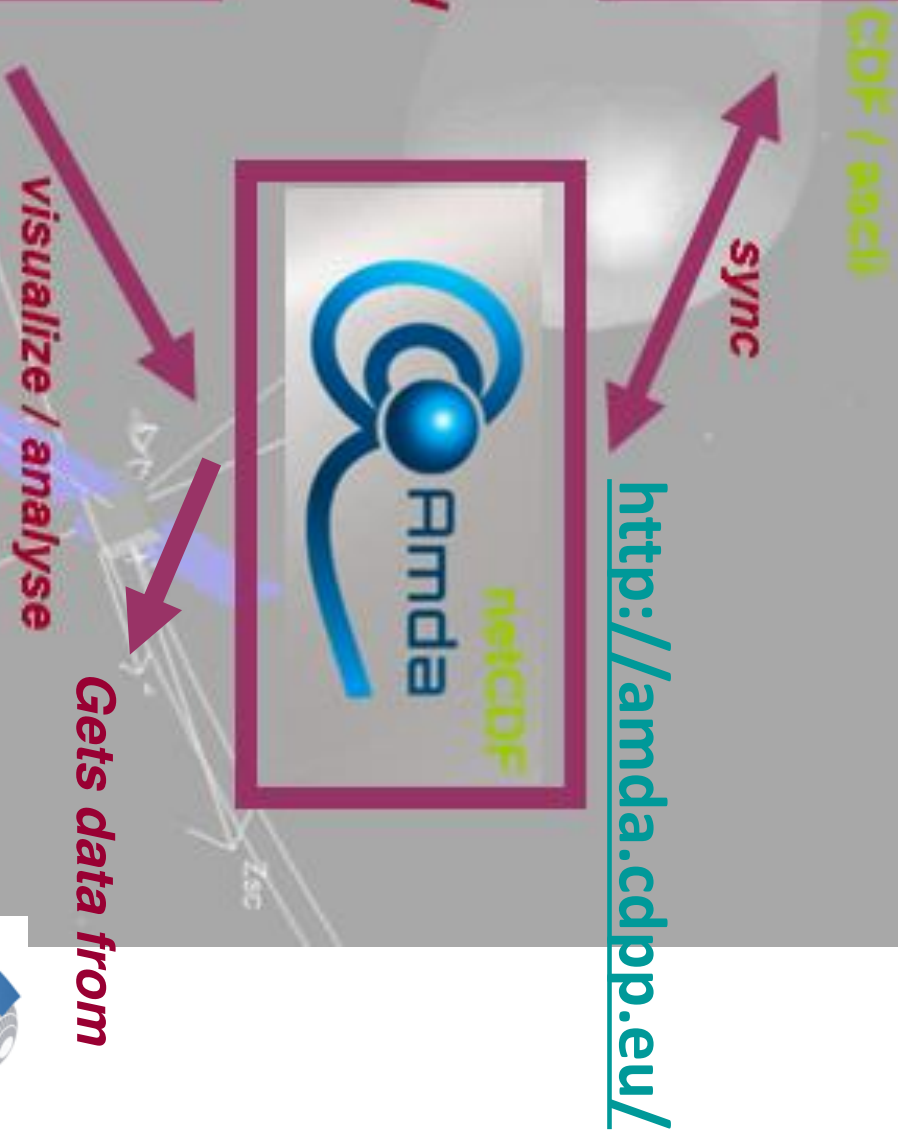Request For Registration

Heliospheric Weather Expert Service Centre
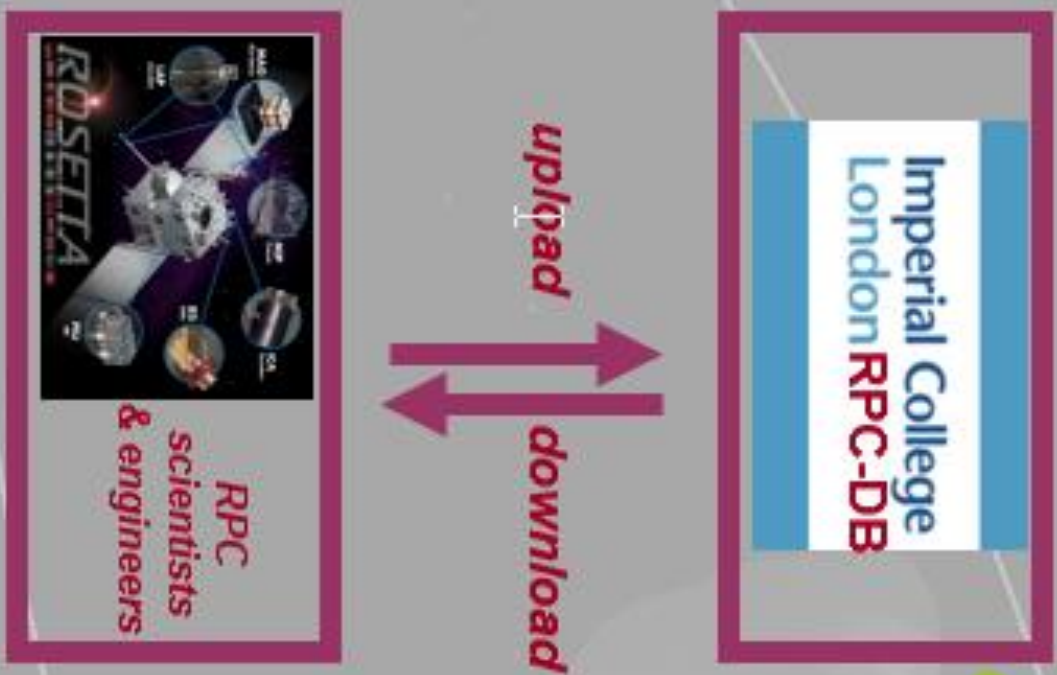
This page provides access to the latest data, products and analysis tools from the SSA SWE Heliospheric Weather Expert Service Centre.

Temperature

Speed

Density

IMF

Amda

Propagation Tool

Mission support

- The involvement of CDPP in Rosetta Plasma Consortium data visualization from 2014 has been a test-bed for further developments

- CDPP is formally involved
  - in the data distribution and archiving (in connexion with ESA) of
    - Solar Orbiter / SWA (ions & electrons)
    - JUICE / RPWI (fields & waves)
  - In environment modeling (plasma at L2) for
    - Athena / X-IFU

Data distribution : Rosetta/RPC data during the proprietary phase

RPC scientists & engineers

upload
download

Imperial College London **RPC-DB**

CDF / ascii

sync

visualize / analyse
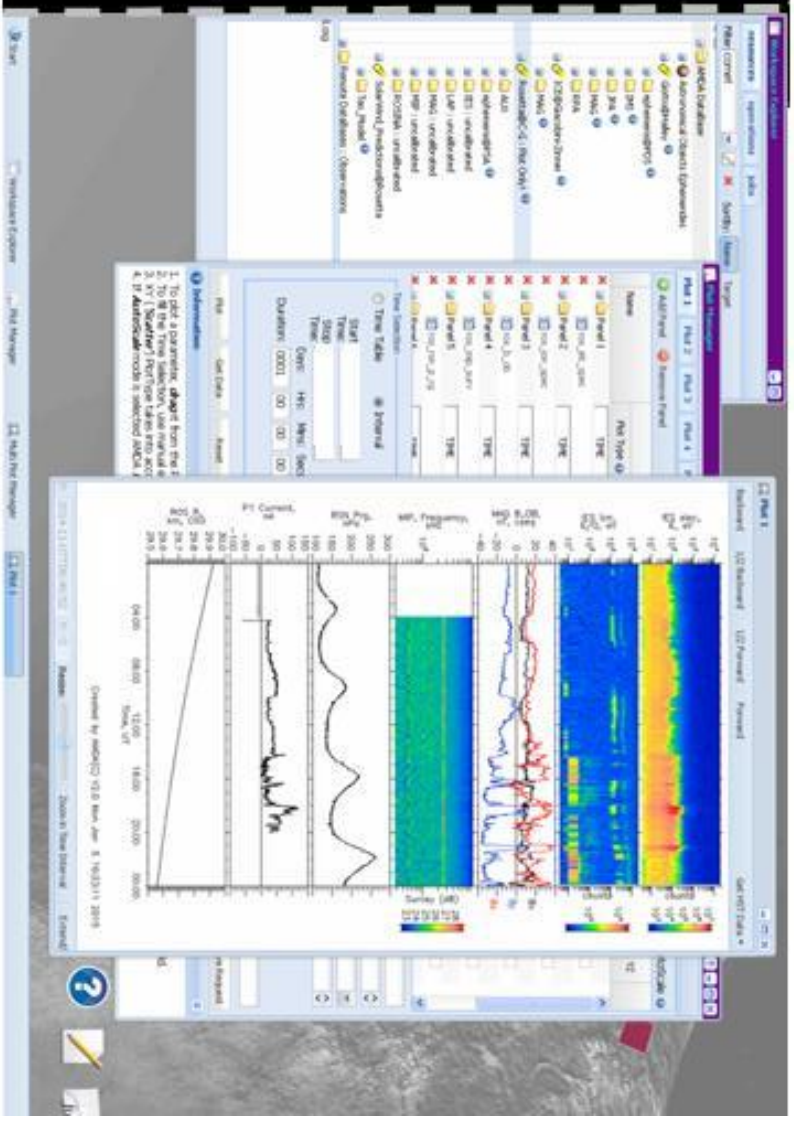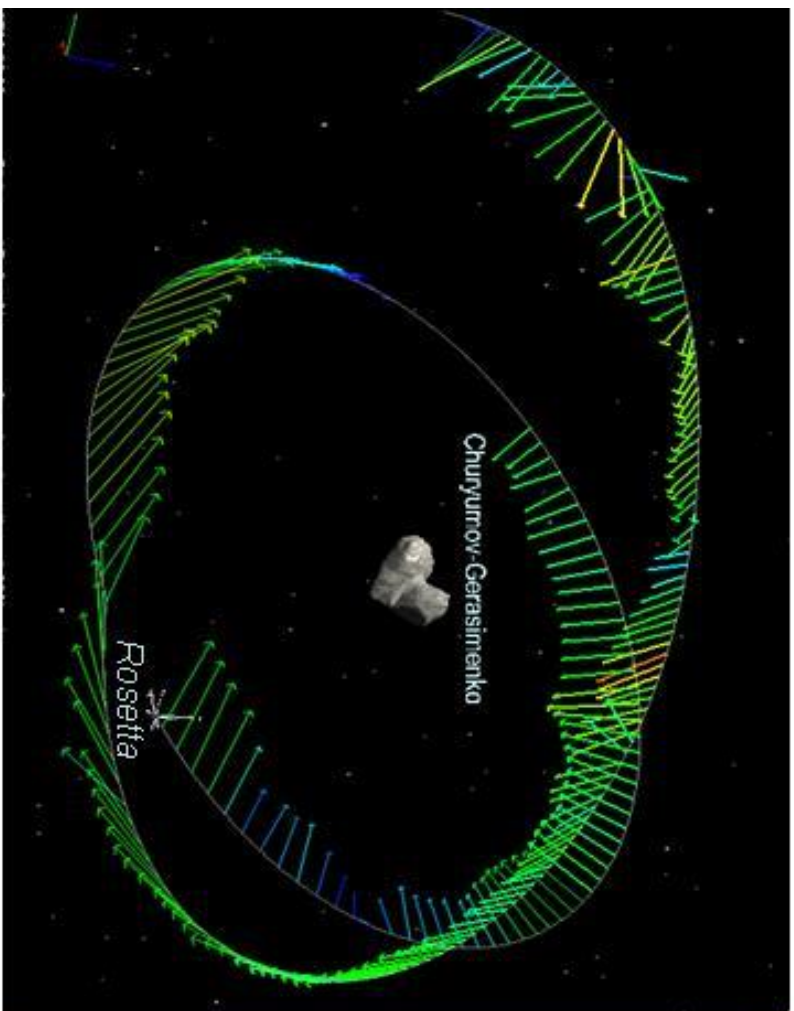
Gets data from

Amda netCDF

http://amda.cdpp.eu/

Use of the CDPP tools in the Rosetta context

- About 25 papers were published with the help of CDPP tools during the 2y of operation
- Uses: dataset combination, data mining, …

in-situ and model data
in 3D interactive scenes
3dview.cdpp.eu

3DView

Amda

database and analysis tool
amda.cdpp.eu

Churyumov-Gerasimenko

Rosetta

ESA / PSA

planetary science archive
PSA 5.7.1

START SEARCHING YOUR DATASET!

PSA

Type a Target, Mission or Instrument, such as Mars, Rosetta, HRSC...

https://archives.esac.esa.int/psa/

The European Space Agency's Planetary Science Archive (PSA) is the central repository for all scientific and engineering data returned by ESA's Solar System missions: currently Giotto, Huygens, Mars Express, Rosetta, SMART-1, ExoMars 2016 and Venus Express, as well as several ground-based cometary observations. Future missions such as ExoMars RSP and BepiColombo will also be hosted in the PSA. The PSA uses Planetary Data System standards as a baseline for the formatting and structure of all data contained within the archive... Learn more HERE.

ESA / PSA

planetary science archive
PSA 5.7.1

https://archives.esac.esa.int/psa/

START SEARCHING YOUR DA...

PSA

Type a Target, Mission or Instrument, such as Mars, Rosetta, HRSC...

The European Space Agency's Planetary Science Archive (PSA) is the central repository for all scientific and engineering data returned by ESA's Solar System missions: currently Giotto, Huygens, Mars Express, Rosetta, SMART-1, ExoMars 2016 and Venus Express, as well as several ground-based cometary observations. Future missions such as ExoMars RSP and BepiColombo will also be hosted in the PSA. The PSA uses Planetary Data System standards as a baseline for the formatting and structure of all data contained within the archive... Learn more HERE.

The Planetary Science Archive

cassini huygens

mars express

venus express

exomars 2016

rosetta

giotto

smart-1

Future Archives

bepicolombo

exomars rsp

NASA / PDS

8 nodes

NASA / PDS

8 nodes

PLANETARY PLASMA INTERACTIONS
UCLA

ENGINEERING
JPL

SMALL BODIES
U. Maryland

GEOSCIENCES
Washington U.

Project Management Office
GSPC

ATMOSPHERES
New Mexico State U.

RING-MOON SYSTEMS
The SETI Institute

CARTOGRAPHY & IMAGING SCIENCES
U.S.G.S. Flagstaff

NAVIGATION & ANCILLARY INFORMATION FACILITY
JPL
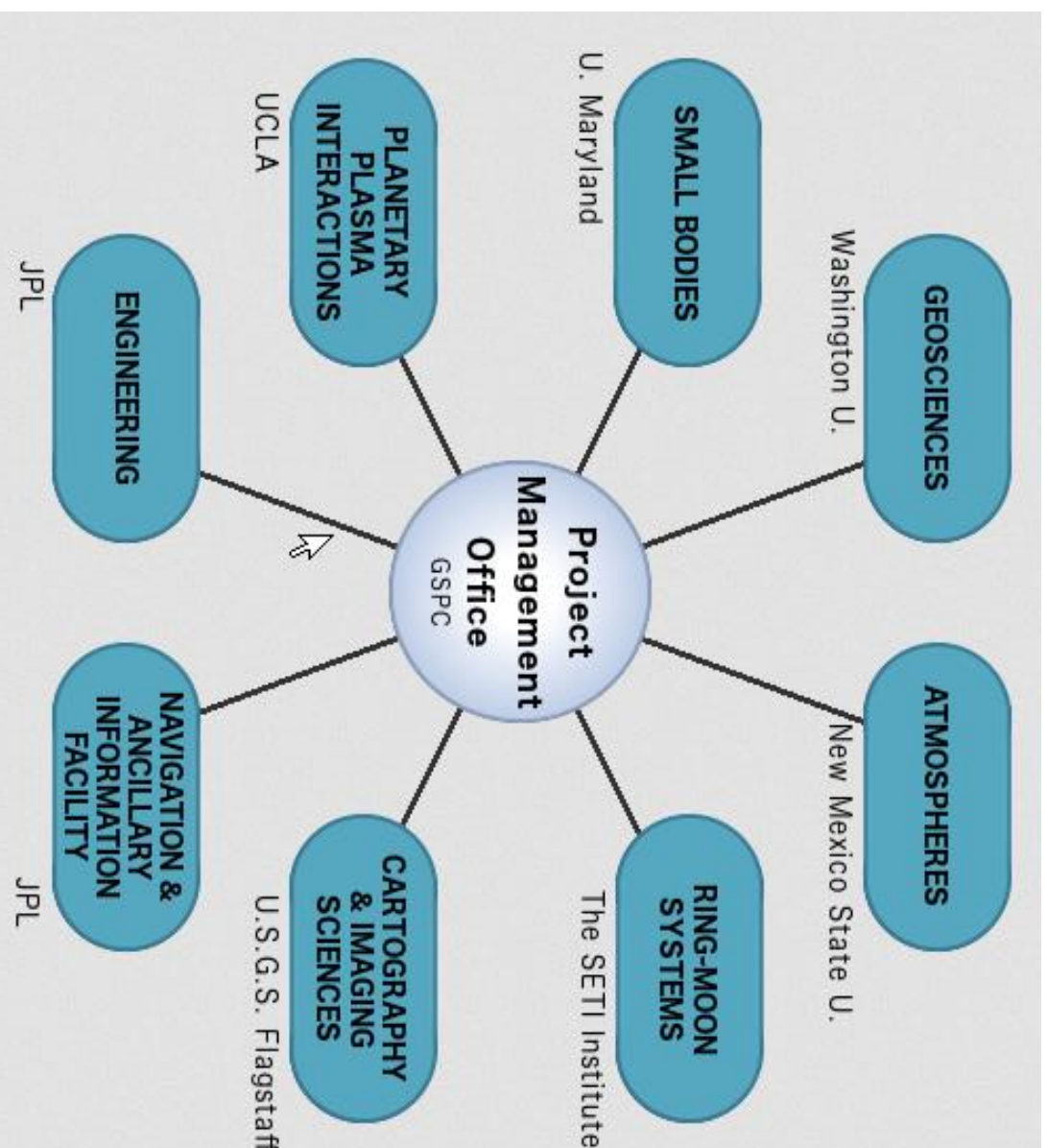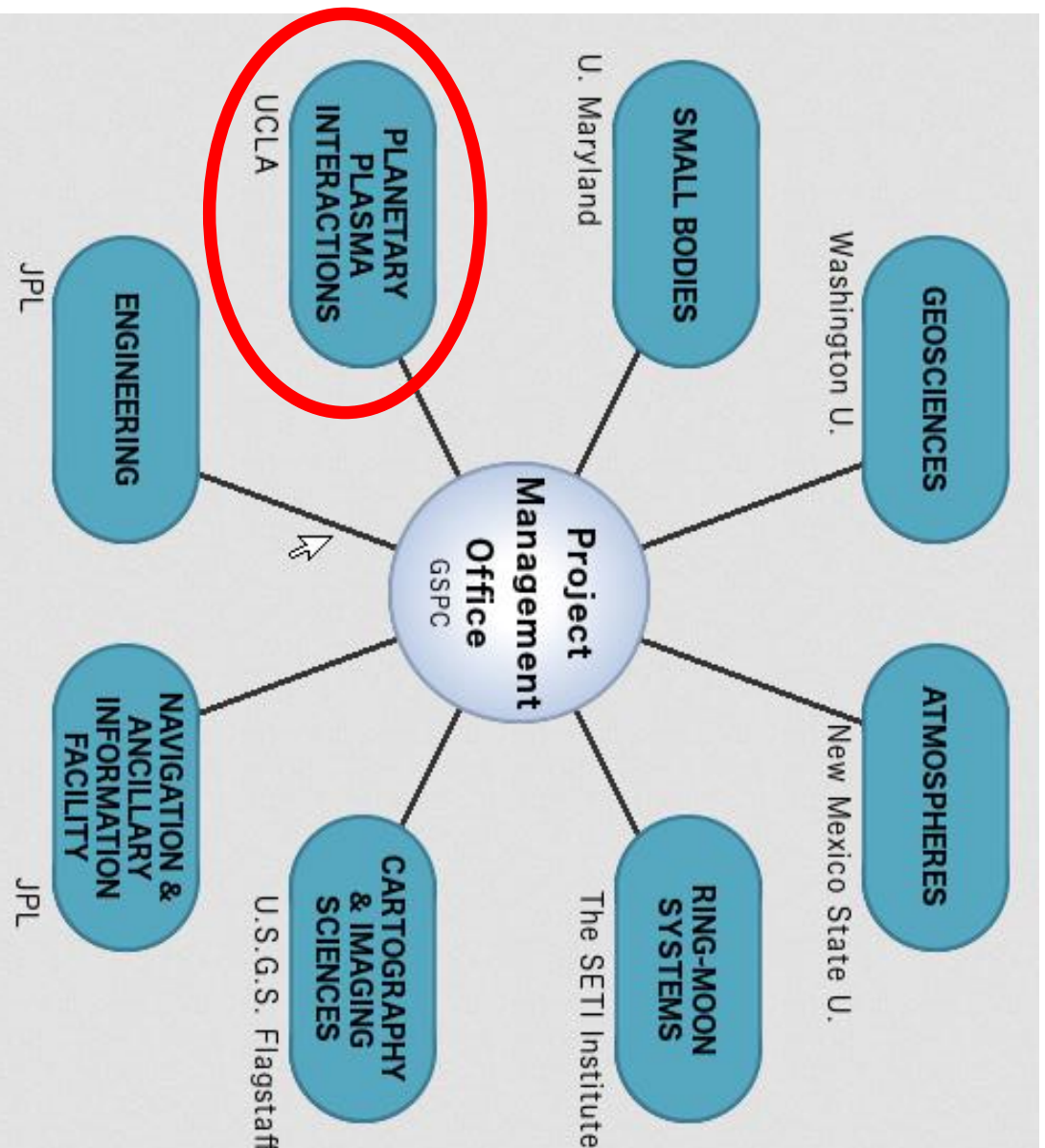
NASA / PDS / PPI

PDS: PLANETARY PLASMA INTERACTIONS

- Nasa Portal
- Site Help
- Feedback
- Phone Book

HOME | OVERVIEW | DATA | DOCUMENTS | SOFTWARE | PERSONNEL | RELATED SITES | ABOUT PDS

Search For:

in | PPI Data Holdings ▼ | Go

QUICK SEARCH

- Advanced Search
- List By Instrument
- List By Missions

- Mercury
- Venus
- Earth(Moon)
- Mars
- Jupiter
- Saturn
- Uranus
- Neptune
- Pluto
- Asteroids
- Comets
- Dust
- Solar Wind

Welcome to the PDS
Planetary Plasma Interactions Node

PDS PPI Recently Released Data

Juno FGM Jupiter Perijoves 1 & 3 Magnetic-Field Release

CASSINI ORBITER MAG CALIBRATED SUMMARY V2.0 Release

Lunar Reconnaissance Orbiter Data Release 38

Juno FGM	2019-08-22
MAG	2019-06-17
CRaTER	2019-06-15

More....

The Planetary Plasma Interactions (PPI) Node of the Planetary Data System (PDS) archives and distributes digital data related to the study of the interaction between the solar wind and planetary winds with planetary magnetospheres, ionospheres and surfaces. The PPI Node is located at the Department of Earth, Planetary, and Space Sciences at the University of California, Los Angeles (UCLA).

NEW RELEASES

More......

PDS RESOURCES

- Archive Planning Guide
- Individuals
- Missions
- Data Dictionary Search
- Lookup Tool
- Document
- PDS4 Standards
- Documents
- PDS Subscription Service
- PDS3 Standards

OTHER RESOURCES

- ADS Search

Long term archives

- Have **difficulty** (funding) dealing with or improving **past/old mission archives**
- Have **difficulty** to cope with both **long term preservation** on one side and offering **user friendly analysis environments** on the other side
  – Ex.: at CDPP 2 different systems are in place
- But **interoperability** is helping by
  – Distributing the efforts
  – Promoting opportunity for different actors to meet and discuss: IVOA, IPDA, IHDEA, …

VESPA

VESPA
Virtual European Solar and Planetary Access

- A community Europlanet-funded initiative
- An IVOA protocol (TAP) tailored to planetary science needs → EPN-TAP
- 50+ services: from small lab databases to mission archives
- Implementation during workshops
- Will be continued during Europlanet 2024

http://vespa.obspm.fr/

VESPA
Virtual European Solar and Planetary Access
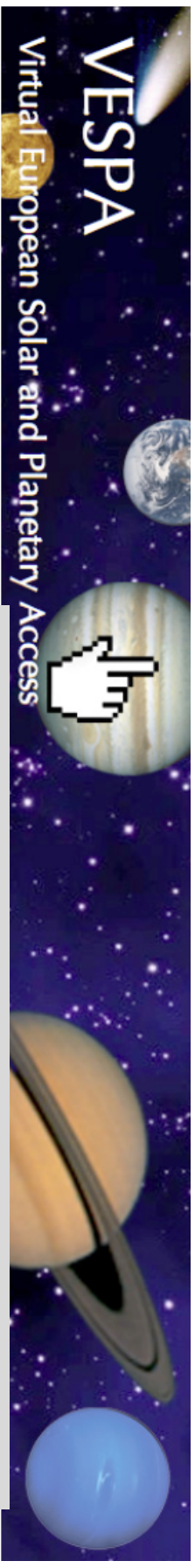
A specificity of VESPA is that all services present a uniform interface and are by default queried together. This is intended to favor data discovery and to provide more visibility to smaller services.

Main Parameters

| Form | Query | Custom Service |

EPN-TAP Services

Target Name

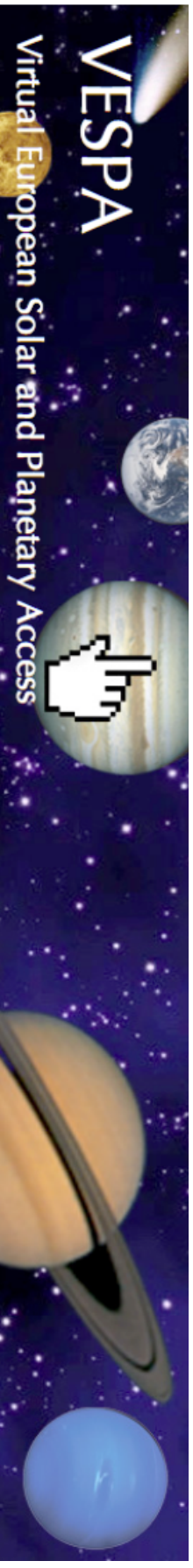**Target Class**

Dataproduct Type

Instrument Host Name

Instrument Name

Processing level = ◄ ◄►

---

meteor_showers - Meteor Shower predictio

mpc - Minor Planet Center - Asteroid Orbita

NDA Obs. Database - Nancay Decameter Ar

ndcs - NASA cosmic dust catalogues 3315 r

omega_cubes - L3 Omega Cubes from PSU

omega_maps - L3 Omega Maps from PSUP 10 results

pds_speclib - PDS spectral library 2260 results

planets - Main characteristics of solar system planets 8 results

PlanetServer_CRISM - Subset of CRISM/MRO georeferenced cubes 20722 results

PlanetServer_M3 - Moon Mineralogy Mapper georeferenced cubes 584 results

PSA - ESA Planetary Science Archive 9326525 results

PSWS Transplanet - Magnetosphere Ionosphere coupling simulation runs 1395 results

pvol - PVOL 42764 results

RadioJOVE - RadioJOVE Data Archive 12 results

spectro_planets - Spectra of planets and satellites 136 results

http://vespa.obspm.fr/

VESPA
Virtual European Solar and Planetary Access

Form	Query

EPN-TAP Services · Custom Service

Main Parameters

Target Name

Target Class

Dataproduct Type

Instrument Host Name

Instrument Name

= ▾

Processing level

◂▸

Data			
meteor_showers - Meteor Shower predictions 1045 results	◉	⊕	⊟
mpc - Minor Planet Center - Asteroid Orbital Data 796411 results	◉	⊕	⊟
NDA Obs. Database - Nancay Decameter Array observation database 28116 results	◉	⊕	⊟
ndcs - NASA cosmic dust catalogues 3315 results	◉	⊕	⊟
omega_cubes - L3 Omega Cubes from PSUP 7038 results	◉	⊕	⊟
omega_maps - L3 Omega Maps from PSUP 10 results	◉	⊕	⊟
pds_speclib - PDS spectral library 2260 results	◉	⊕	⊟
planets - Main characteristics of solar system planets 8 results	◉	⊕	⊟
PlanetServer_CRISM - Subset of CRISM/MRO georeferenced cubes 20722 results	◉	⊕	⊟
PlanetServer_M3 - Moon Mineralogy Mapper georeferenced cubes 584 results	◉	⊕	⊟
PSA - ESA Planetary Science Archive 932625 results	◉	⊕	⊟
PSWS Transplanet - Magnetosphere Ionosphere coupling simulation runs 1395 results	◉	⊕	⊟
pvol - PVOL 42764 results	◉	⊕	⊟
RadioJOVE - RadioJOVE Data Archive 12 results	◉	⊕	⊟
spectro_planets - Spectra of planets and satellites 136 results	◉	⊕	⊟

ESA Science Archives Long Term Strategy (2018 edition)

Overview document presenting a top-level long-term strategy for the ESA Space Science Archives resulting from ESA's space science missions

The conclusion presents **2 areas of** development with **high impact**

SCIENCE EXPLOITATION

A — (illegible)

B — STORE SIMULATIONS ALONGSIDE THE DATA

C — CROSS-LINK ESASKy w/ PSA w/ HELIO ARCHIVE

D — Metres on data usage

E — (illegible)

F — How missions like PLATO, ESA Archives need to consider Ground-based observation data

G — ask young people to come up with ideas for cross-mission archives

H — PROVIDE D.O.I.s

I — SCATTER PLOTS IN ARCHIVES

J — EASY WAY TO VISUALIZE THE DATA

K — WHAT IS THE SITUATION WITH THE VO?

L — DATA VISUALISATION LIKE FOR COMMUNICATION

M — PRIORITIZE HIGH LEVEL PRODUCTS PROVISION

N — GIVE GRANTS FOR DATA MINING / EXPLOITATION

O — ADD ATMOSPHERIC VISUALISATION TO PSA

P — TRACK EVERY CLICK FROM ALL USERS?

Q — COPY GALAXY-ZOO!

R — GATHER IDEAS FROM YOUNGSTERS AT CONFERENCE

S — CREATE A VISITOR PROGRAM FOR DATA SCIENCE

SCIENCE EXPLOITATION

brainstorming held at ESTEC on 15 September 2017

ESA Science Archives Long Term Strategy (2018 edition)

G. de Marchi et al., 2018

1

- Analysis tools integrated in the archives
  - Online **data mining and analysis tools**
  - **Cross-mission** data selection in space, energy, time
  - User interfaces based on **science themes**

ESA Science Archives Long Term Strategy (2018 edition)

- SEPP : Science Exploitation and Preservation Platform

  – Collaborative **research environments**, including JupyterLab

  – Ability for users to **upload their analysis code** to the archives

  – Inclusion in the archives of calibrated data and **community-generated high-level science products**

Databases/archive in the near future

- Will take part to the life cycle of the data *from the* definition phase of the mission

- Will uniquely reference their datasets for use in papers, catalogue of events

- Will propose online data analysis environments with
  - Upload of the user code instead of downloading data
  - Artificial intelligence for classification and event detection
  - Integration of simulations/models + user-produced data