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Simulation database of planetary environments and interoperability with VO visualization tools”

R. MODOLO, S. HESS, V. GÉNOT, AND COLLEAGUES

LATMOS, ONERA, IRAP / CDPP

Simulation data sharing and analysis : Towards a Findable Accessible Interoperable Reusable approach

Goals :



- **Findable** : Describe and archive 3D simulation of planetary environments
- **Accessible** : Make available/access simulation results.
- **Interoperable** : Connect the visualization tools and the simulation database.
- **Reusable** : Use of a simulation set for different studies and by different teams.



Metadata and data model

Space Physics Archive Search and Extract (SPASE) data model consists of an exclusive set of resource types which can be used to describe data along with its scientific context, source, provenance, content and location.

Use of SPASE data model along with the simulation extensions proposed by IMPEx, and now fully included in the current SPASE data model, are a COSPAR recommendation (COSPAR panel, 2021).

Major metadata for simulations : SimulationModel, SimulationRun, NumericalOutput, Granule,...



Context and models:

Modelisation and simulation of planetary neutral and ionized environments

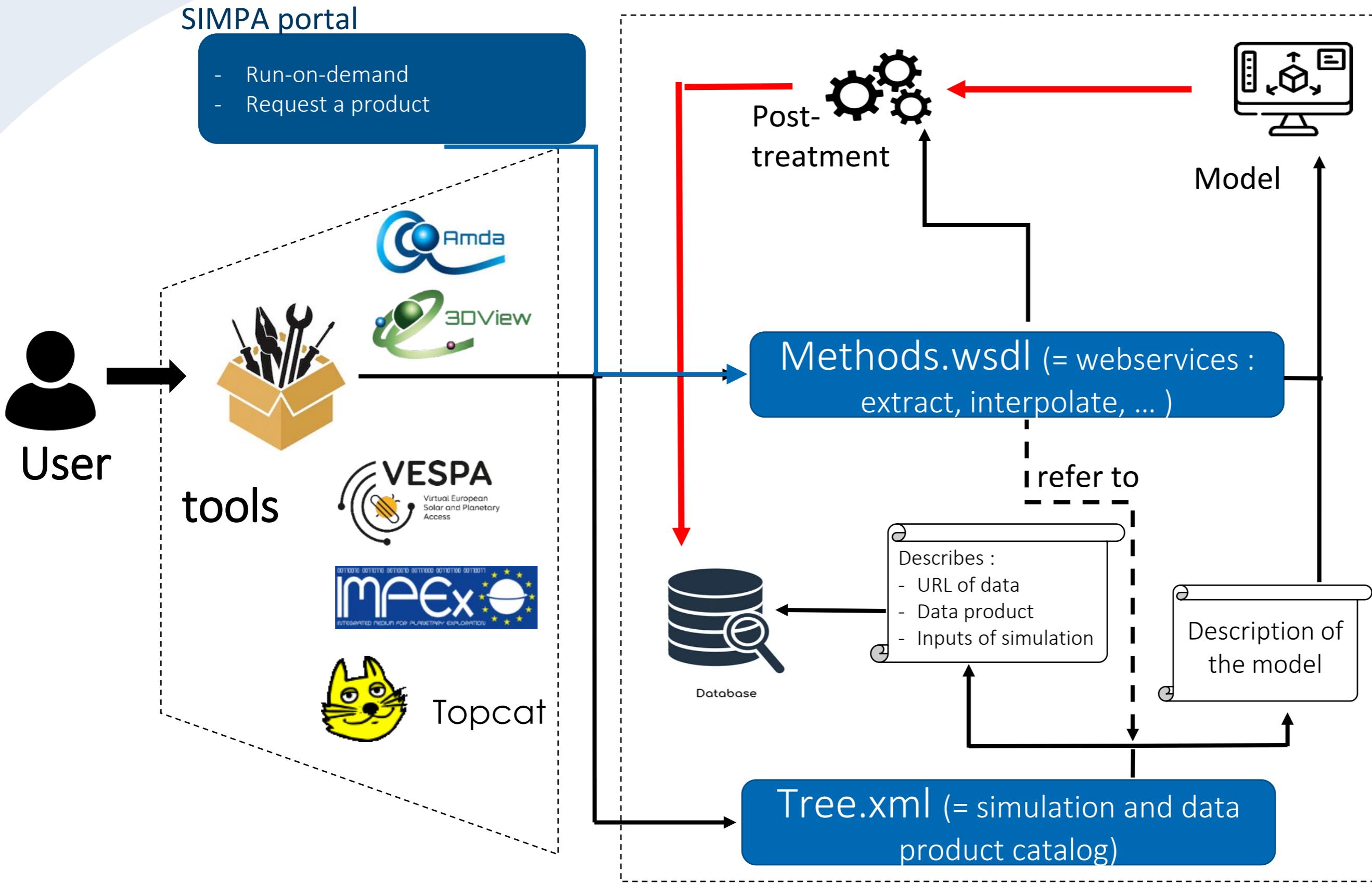
Magnetosphere – LatHyS Modolo et al, 2016
Exosphere – EGM Leblanc et al, 2017

Projects :

ANR HELIOSARES (2009-2014)
FP7 IMPEx (2011-2015)
ANR MARMITE (2014-2019)
ANR TEMPETE (2018-2022)
IPI SU METEO (2022-2024)
SIMPA LATMOS (2022-2023)



Infrastructure



Catalog of simulation results, their descriptions with metadata, the different set of data products with the URL to the (pre-computed and archived) data

« tree.xml »

Ex :

<http://impex.latmos.ipsl.fr/tree.xml>

Webservices : additional service to fetch, extract, interpolate data along S/C trajectory, construct high level data (field/flow lines,...)

« webservices.wsdl »

Ex :

http://impex.latmos.ipsl.fr/Methods_LATMOS.wsdl

GetFileURL

GetDataPointValue

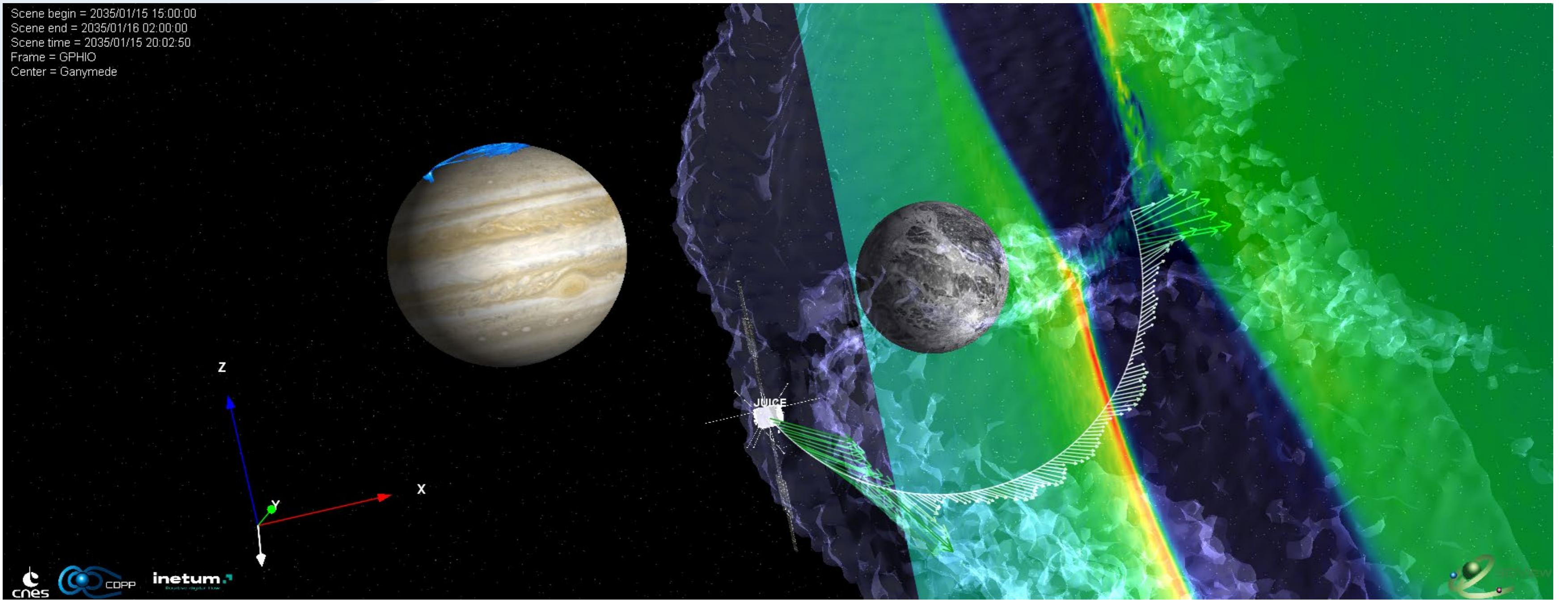
GetFieldLines

GetdataPointSpectra

GetColumnDensity,...



Scene begin = 2035/01/15 15:00:00
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Scene time = 2035/01/15 20:02:50
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Center = Ganymede

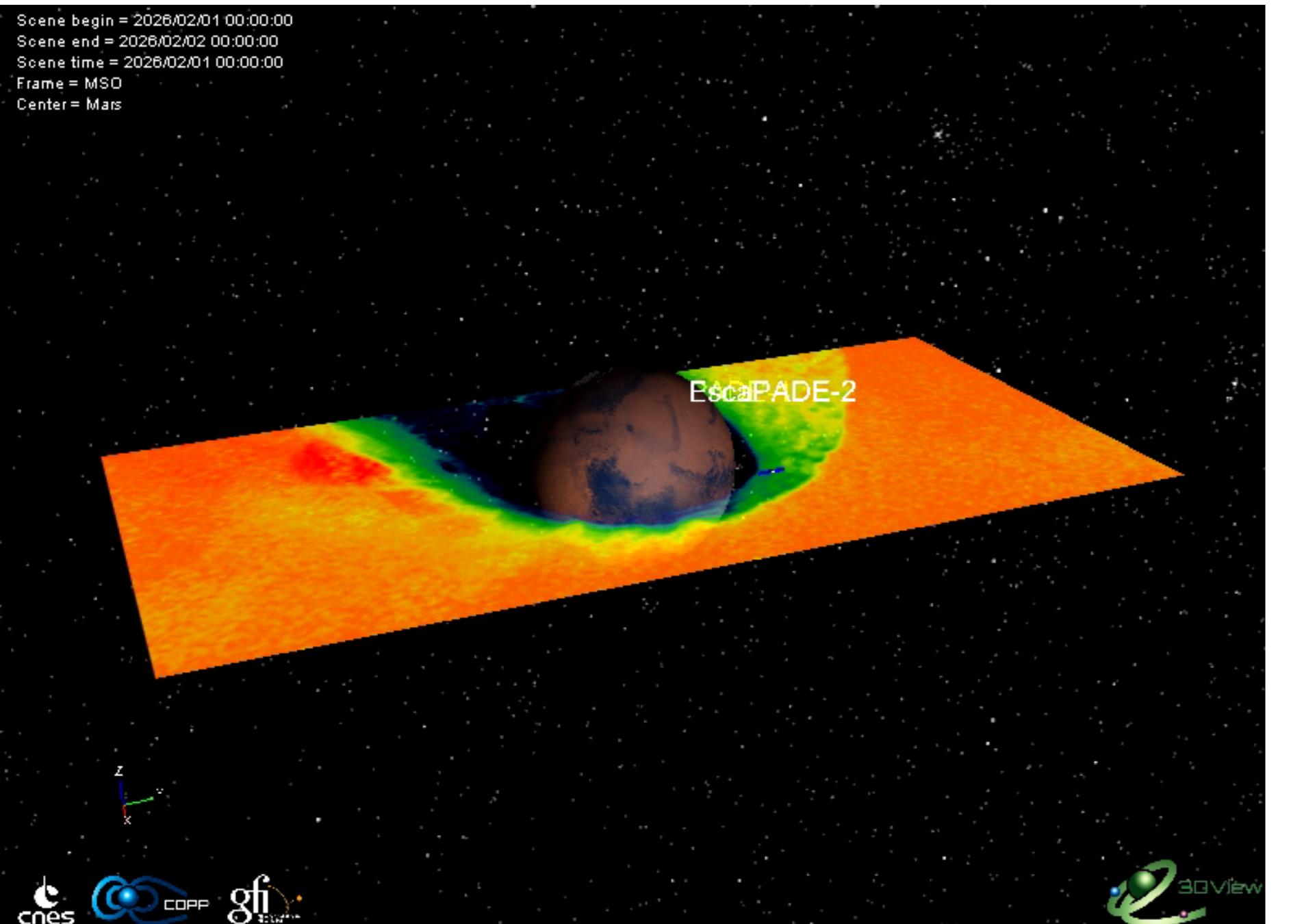


Jupiter- Ganymede interaction, with its Alfvén wings (isosurface shaded blue), Bulk speed along S/C trajectory (colored vectors) and 2D velocity map in the wake of the moon

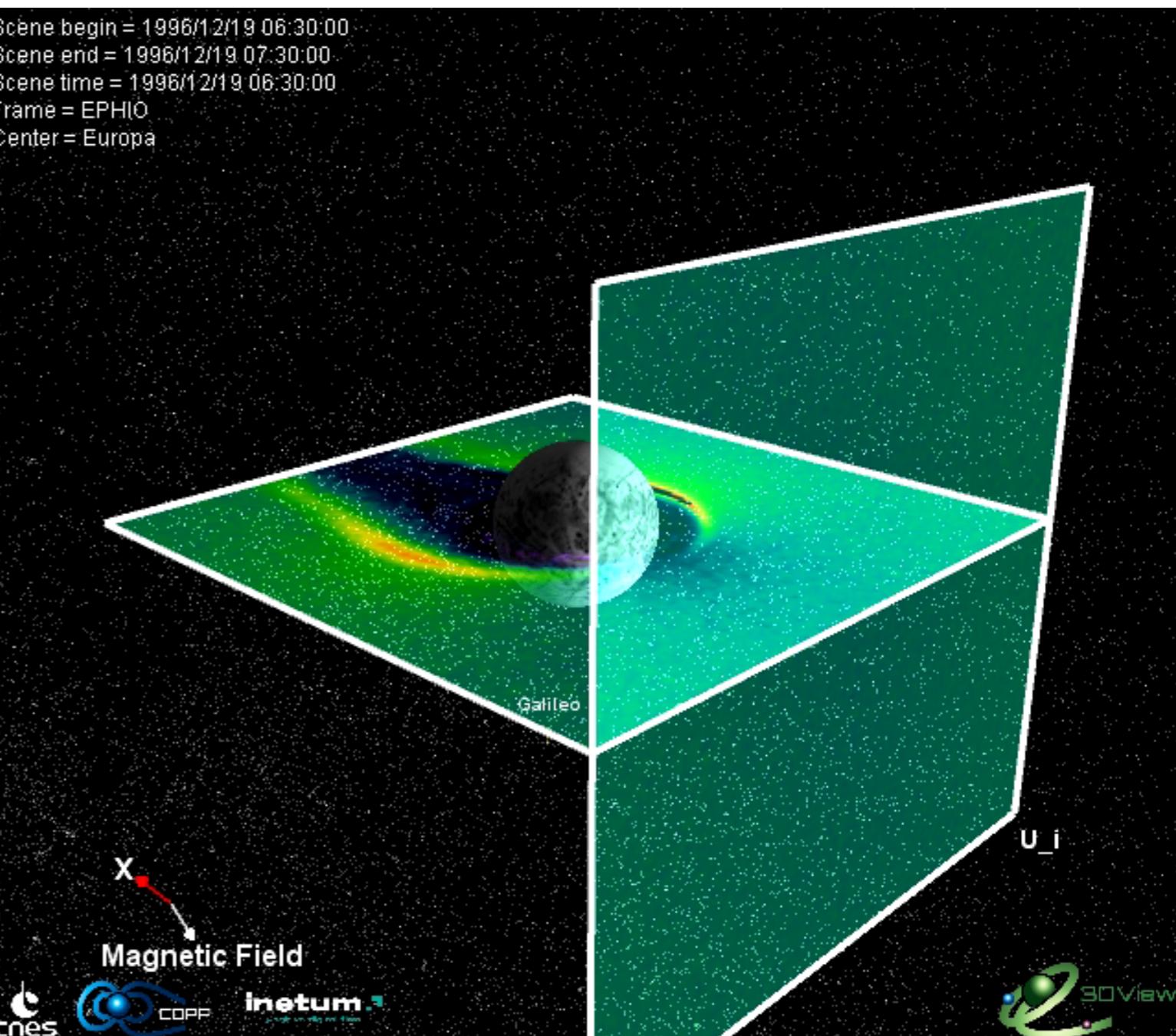
Crédit : CNES / CDPP / Inetum/ LATMOS



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Scene time = 2026/02/01 00:00:00
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Center = Mars

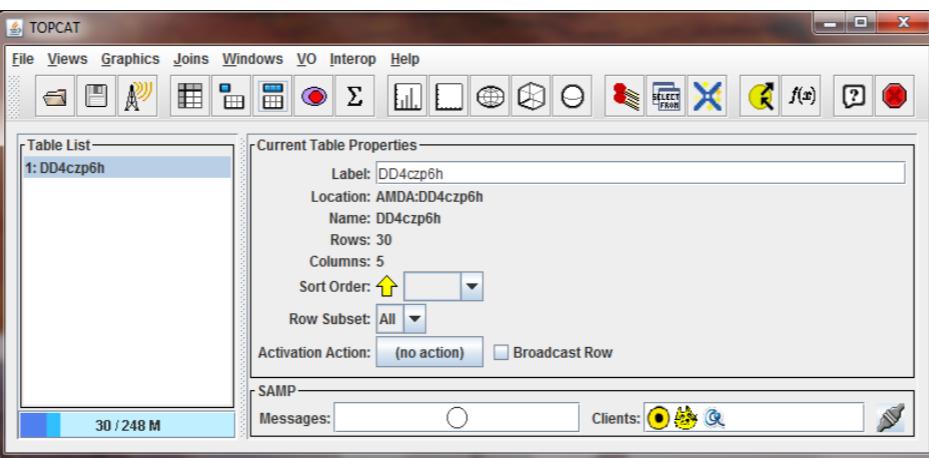
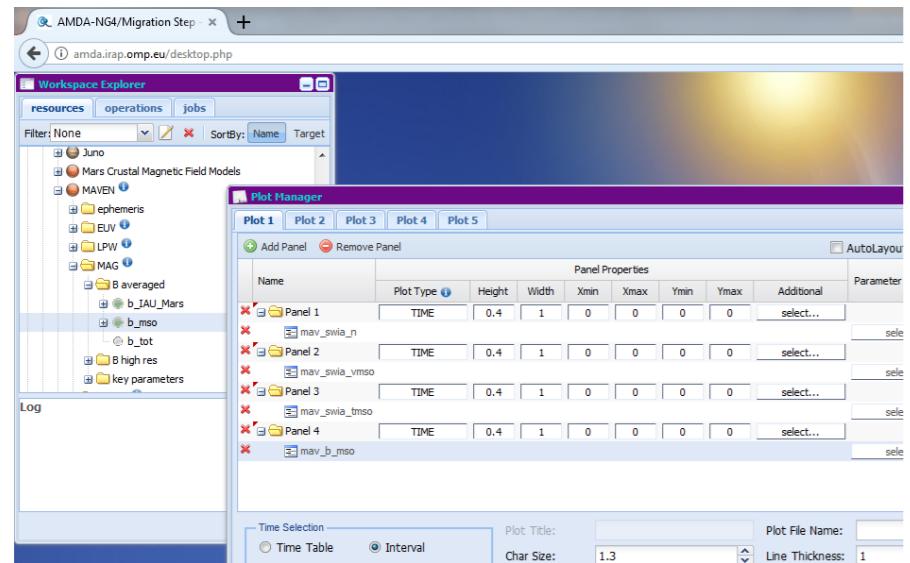


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Frame = EPHIO
Center = Europa

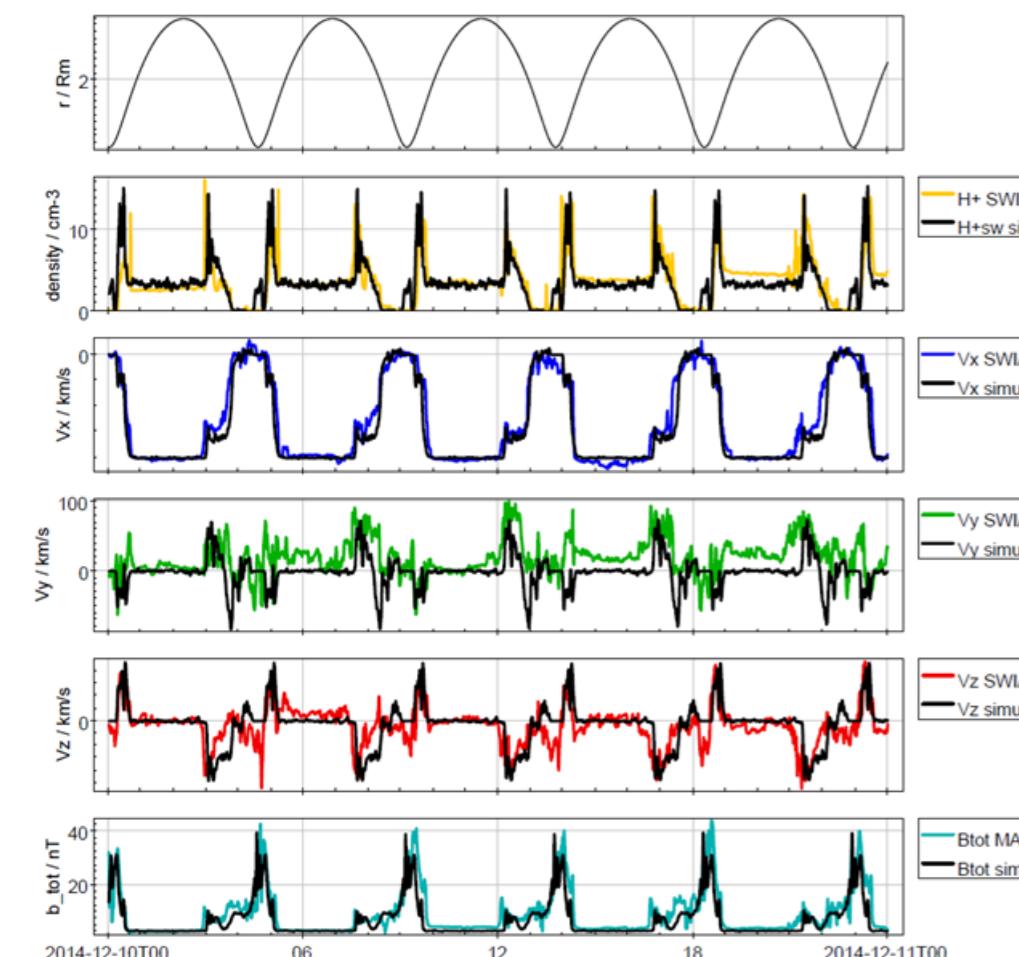


Example of a scientific use case : Comparison of simulation results and MAVEN and MEX observations (Modolo et al, 2018)

- Determination of the solar wind conditions using **AMDA** and **TOPCAT** and the SAMP application (Génot et al, 2014)



5 orbits comparison of MAVEN observations in black (n , V_x, V_y, V_z , $|B|$) and simulation (colors) using TOPCAT (also possible with AMDA)



Visualization of simulation results and observations in a 3D interactive scene

- Finding the most relevant simulation the in the LatHyS database
- Using the LatHyS webservices through the AMDA interface
- Visualisation on AMDA and/or TOPCAT

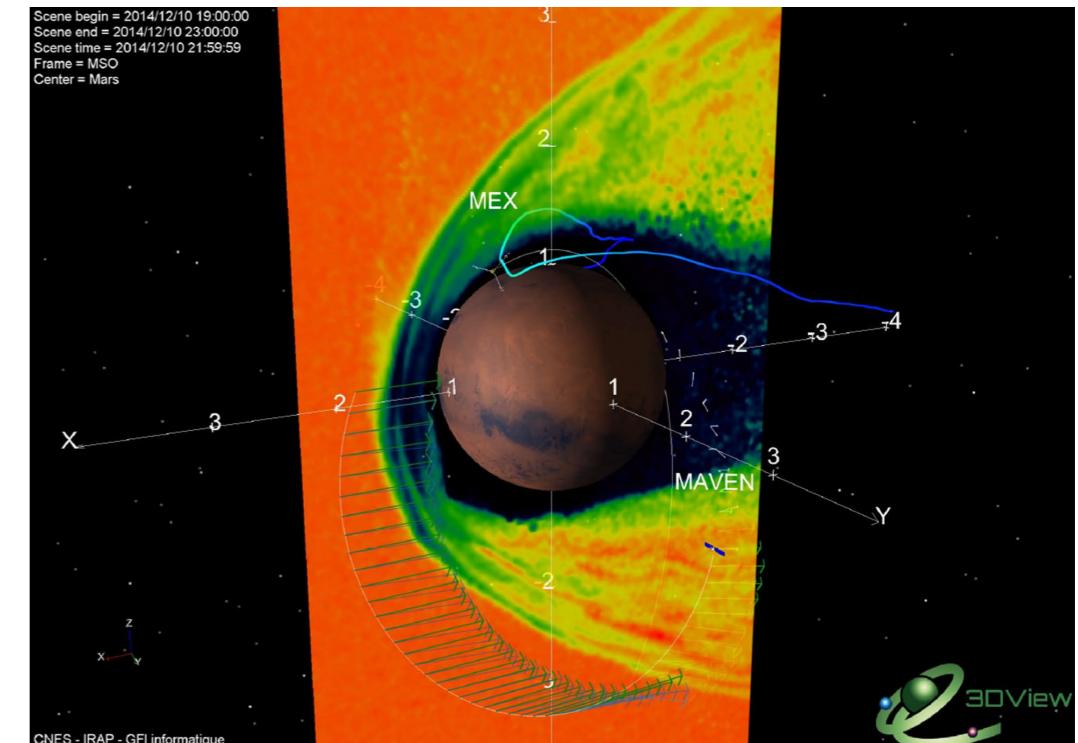
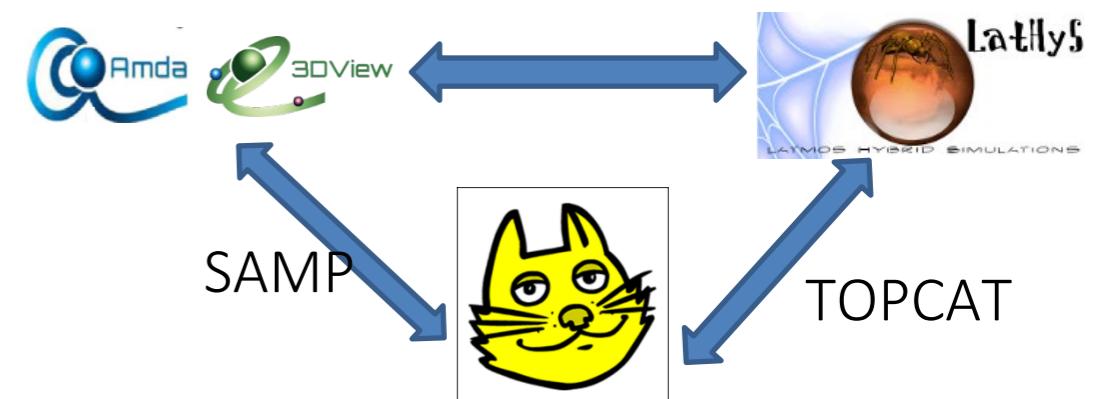


Illustration of the catalog : <http://impex.latmos.ipsl.fr/LatHyS.htm>

Filtering capabilities

LatHyS
LATMOS HYBRID SIMULATIONS

Connect to SAMP (/TopCat)

Data tree:

- + LatHyS_Mars_20_01_12@Latmos_Hybrid_Simulation
- + LatHyS_Mars_18_11_13@Latmos_Hybrid_Simulation
- + LatHyS_Mars_26_11_13@Latmos_Hybrid_Simulation
- + LatHyS_Mars_18_06_14@Latmos_Hybrid_Simulation
- + LatHyS_Mars_22_11_16@Latmos_Hybrid_Simulation
- + LatHyS_Mars_01_12_16@Latmos_Hybrid_Simulation
- + LatHyS_Mars_11_11_18@Latmos_Hybrid_Simulation
- + LatHyS_Mars_23_11_18@Latmos_Hybrid_Simulation
- + LatHyS_Mars_05_02_19@Latmos_Hybrid_Simulation
- + LatHyS_Mars_02_12_18@Latmos_Hybrid_Simulation
- + LatHyS_Mars_08_12_18@Latmos_Hybrid_Simulation

3DCubes

2DCuts

IonComposition

ElectricField

MagneticField

Mag_XY

Mag_XZ

Mag_YZ

ThermalPlasma

Filter:
Region:
Upstream Bmag,min: nT max: nT
Flow Velocity,min: km.s⁻¹ max: km.s⁻¹
Flow Density,min: cm⁻³ max: cm⁻³

SAMP

Sending 1D/2D data to Topcat

Data product

About LatHyS Use policy



Run Information:

LatHyS_Mars_08_12_18

Simulated Region: Mars

Reference Frame: MSO, Cartesian

x ∈ [-7639.8, 7639.8] km

Domain: y ∈ [-14651.7, 14685.2] km

z ∈ [-14651.7, 14685.2] km

Cell size: 76.5 76.5 76.5 km

Sub Solar Longitude: 0.00°

Solar wind properties:

IMF value: 3.2 nT

IMF cone angle: 90°

IMF: (0.00,-3.20,0.00) nT

Density: 2.32E+00 cm⁻³

Velocity: 425.00 km/s

Solar UV Flux @ 10.7: 120.00

Solar wind populations:

Name: Solar Wind electrons

Name: Solar Wind H

Charge: 1 e Mass: 1 amu

Density: 2.20E+00 cm⁻³

Temperature: 17.83 eV

FlowSpeed: 425.00 km/s

Name: Solar Wind He

Ionosphere populations:

Atmosphere and Exosphere populations:

Downloading data

Download
Send

Basic SimulationRun description