Integrated environment for simulation access and visualization : an extension of SPASE proposed by the TEMPETE project

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Starting point

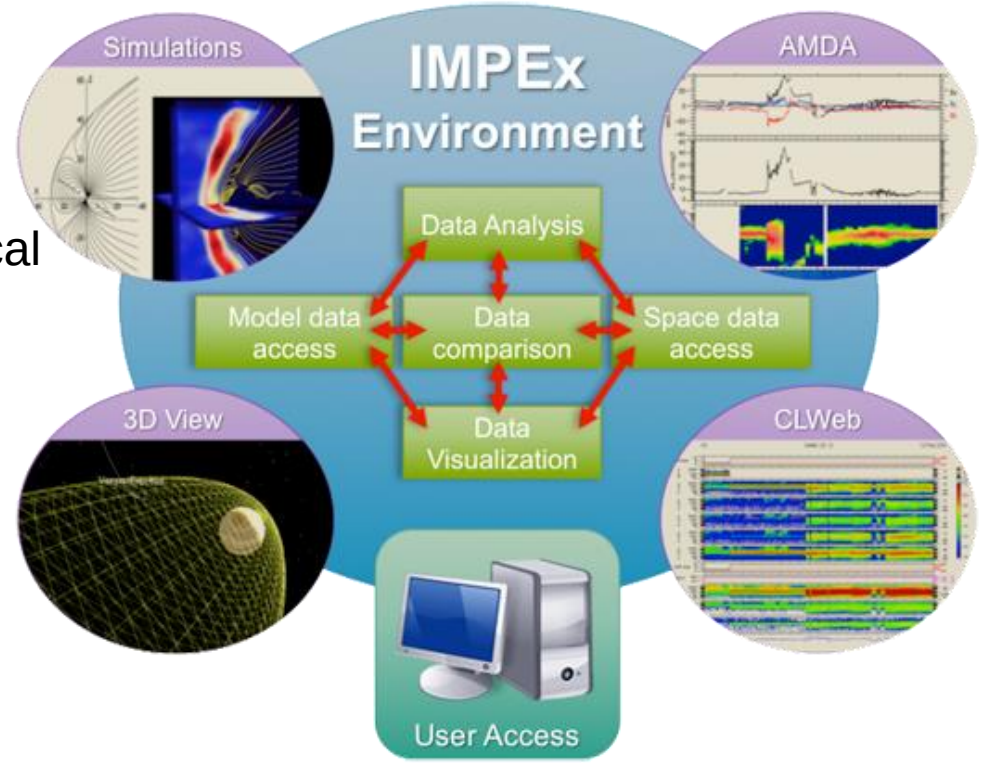
http://impex-fp7.oeaw.ac.at/

Ideas

Analyse observations and models in the same tools

Keep expertise local

Hybrid
MHD
Analytical



- 4 year FP7 project (2011-2015)
- 4 partners project :
  - LATMOS, CDPP (France)
  - FMI (Finland)
  - SINP (Russia)
  - IWF (Austria, *coordinator*)

Key features

-No centralization

-Comparison Observations / Simulations for planetary plasmas

- Fly virtual S/C in 3D simulation results

- Visualisation 2D/3D

- Data along S/C trajectories, 3D model cuts, boundaries

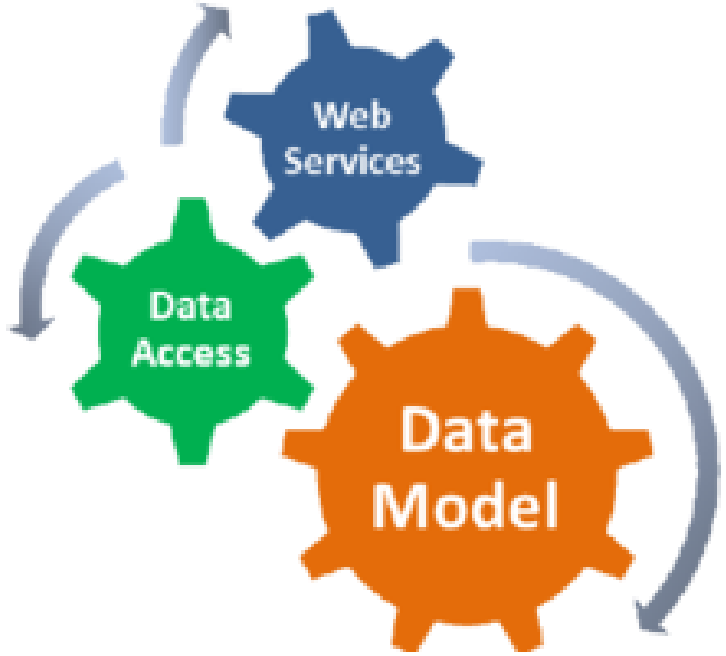
- Event lists

- Method to find most relevant runs for given observations

IMPEx
INTEGRATED MEDIUM FOR PLANETARY EXPLORATION

IMPEx : how to share information ?
The use of a unified protocol

- A standard/unique dictionary for describing observations and simulations
  - Use of an extended version of SPASE
- Standard methods for data analysis and machine to machine exchange
  - REST/SOAP web services definition
  - Implemented in all tools and databases
  - ex. : interpolation, 3D cut, field lines tracing
- Standard formats
  - netCDF, CDF, VOTable



Simulation Database current status

✓Describe simulation/model runs with the data model in a *tree.xml* including the access URL of each file

✓LatHyS simulation results archived

- Model developped at LATMOS and data archive hosted by LATMOS and IPSL

✓WWW LatHyS web-interface implemented (http://impex.latmos.ipsl.fr/LatHyS.htm)

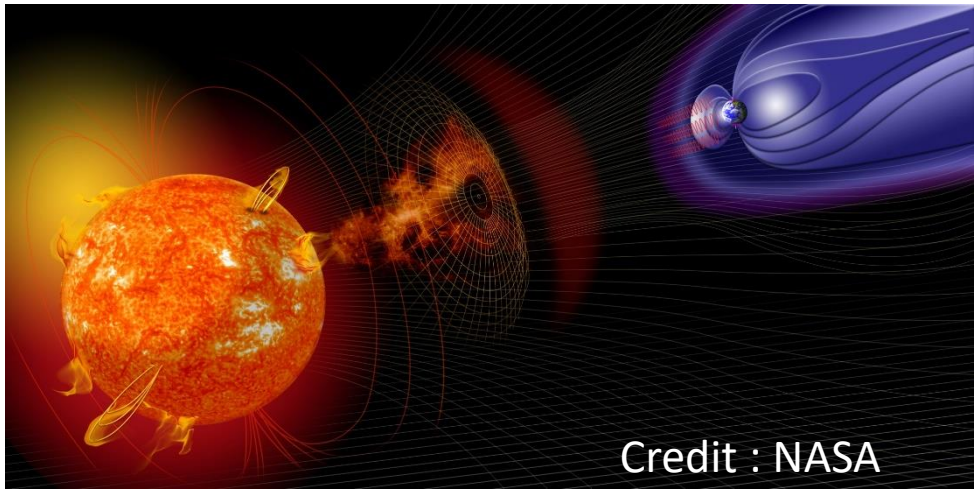
- Complete (3D, 2D, 1D) pre-computed data-product archived and available
- Description of simulation characteristics
- Automatic generation of the catalogue description (*tree.xml)*

✓8 Web-services implemented (*methods.xml*) **<-> interaction with AMDA / 3Dview visualization tools**

- getFileURL
- getDataPointValueSpacecraft
- getDataPointSpectra
- getFileLine
- getDataPointValue
- getSurface
- getDataPointSpectraSpacecraft
- isAlive

✓Catalogue Linked with AMDA and 3Dview

TEMPETE ANR project - objectives



- Investigate the response of **planetary exosphere and magnetosphere** to **solar extreme** events (CME, CIR, Flare, …)
- Mars / Mercury / Earth

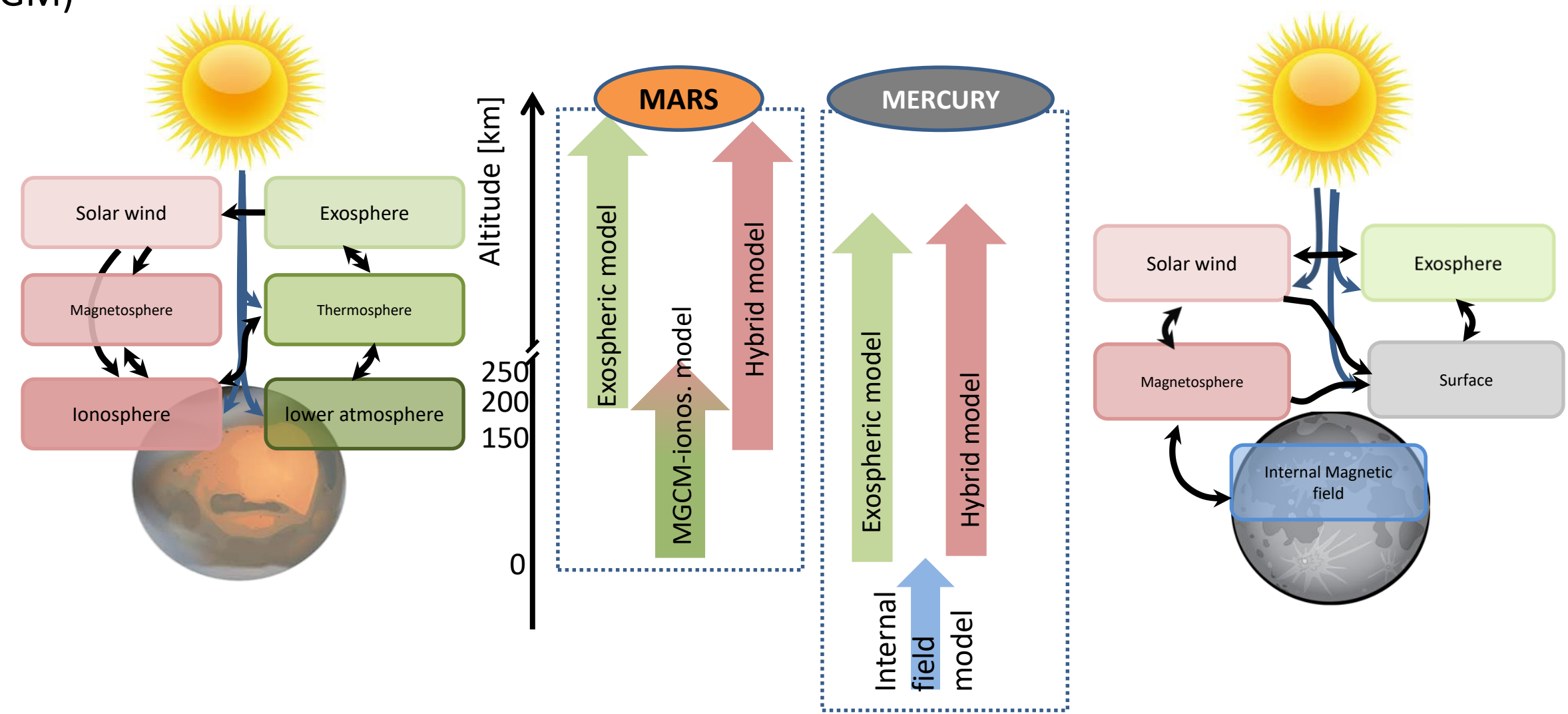
- Characterization of the boundaries' and magnetosphere's response to different drivers and extreme events
- Assessment of the impacts of extreme events on the upper atmosphere/exosphere (Mars/Mercury)
- Determination of the reconfiguration time scales of weakly-magnetized objects (Mars) as compared to small or large scale magnetosphere

Numerical approach (coupling **codes** EGM & LatHyS) + *visualisation tools* (CDPP) + space data analysis

exosphere **Plasma/magnetosphere**

Plasma – neutral interaction in planetary environment

Coupling plasma/magnetospheric model (LatHyS) with upper atmosphere/exophere model (EGM)



Evolution of the SPASE/IMPEX data model for TEMPETE – a few examples

- Accounting for specificities linked to the EGM exospheric model

New type of inputs: neutral quantities
New geometry: spherical coordinates

Element SimulationType

Namespace	http://impex.latmos.ipsl.fr
Annotations	A characterization of the numerical scheme used in the simulation
Diagram	SimulationType — Type: enumSimulationType — enumSimulationType A characterization of the numerical scheme used in the simulation Identifiers for the characterization of the numerical scheme used in the simulation.
Type	enumSimulationType
Properties	Content: simple
Facets	

Enumeration	Analytic	
Enumeration	Hybrid	A numerical scheme simulating ions as particles and electrons as a fluid.
Enumeration	MHD	A numerical scheme simulating the plasma as a fluid.
Enumeration	PIC	A numerical scheme simulating ions and electrons as macroparticles.
Enumeration	Test_Particle	A numerical scheme simulating the motion of charged particles in a prescribed field.
Enumeration	Paraboloid	
Enumeration	Monte_Carlo	A numerical scheme simulating the motion of particles in order to reconstruct macroscopic parameters.
Enumeration	Paraboloid	
Complex Type	SimulationModel	

```
<xsd:element name="SimulationType" type="enumSimulationType">
  <xsd:annotation>
    <xsd:documentation xml:lang="en">A characterization of the numerical scheme used in the simulation</xsd:documentation>
```

Simple Type enumProduct

Namespace	http://impex.latmos.ipsl.fr
Annotations	Product type of the simulation results
Diagram	enumProduct — xsd:string Product type of the simulation results Built-in primitive type. The string datatype represents character strings in XML.
Type	restriction of xsd:string
Facets	

Enumeration	~~3DCubes~~
Enumeration	3DSpheres
Enumeration	~~2DCuts~~
Enumeration	2DShells
Enumeration	~~TimeSeries~~
Enumeration	SpatialSeries
Enumeration	Lines
Enumeration	Spectra
Used by	Element SimulationProduct

Evolution of the element **RegionParameter**

Evolution of the element **SpatialDescription**

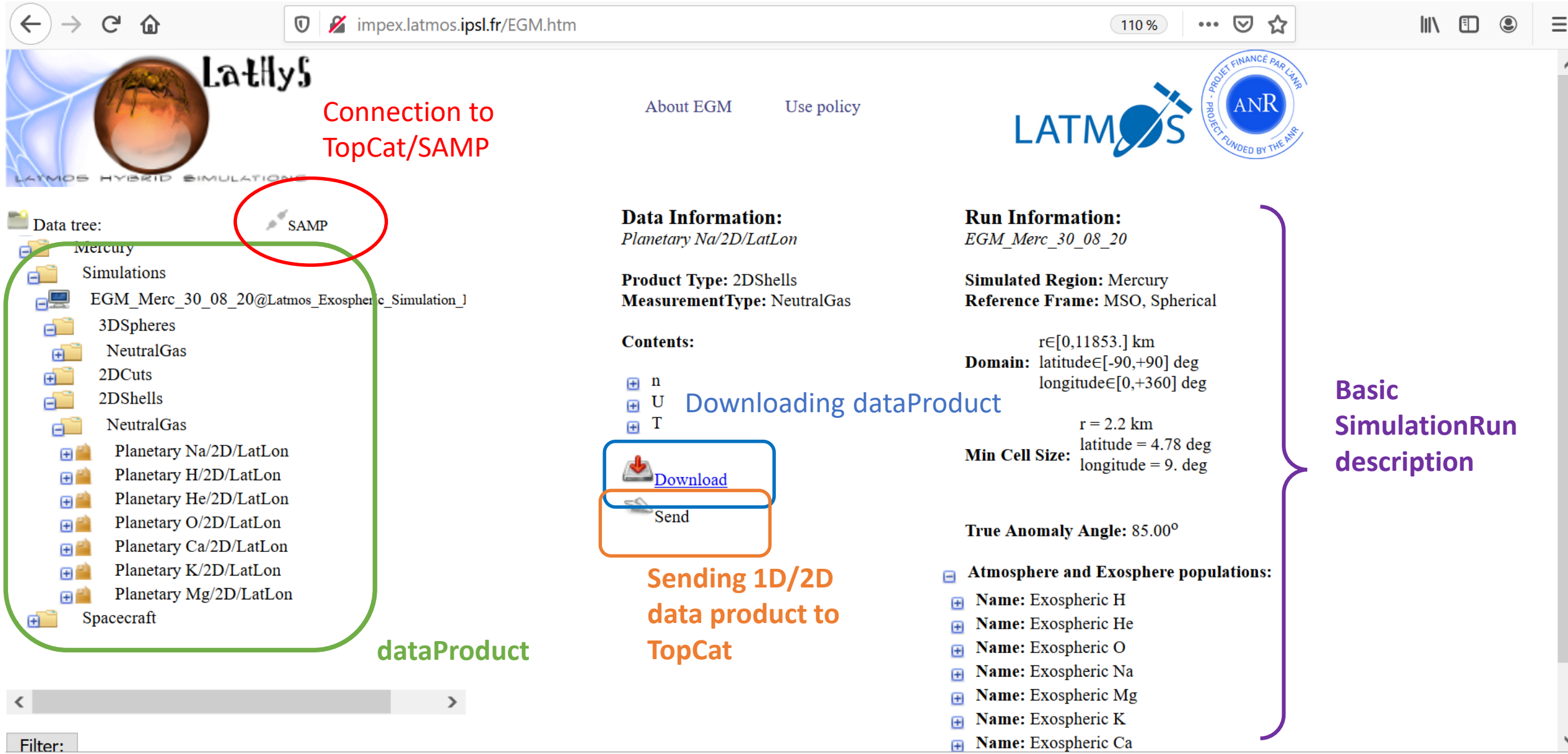
```
<xsd:group name="ShellsDescription">
   <xsd:annotation>
   </xsd:annotation>
   <xsd:sequence>
      <xsd:element ref="DistancePoint"/>
   </xsd:sequence>
 </xsd:group>
```

```
<xsd:element minOccurs="0" ref="TrueAnomalyAngle">
        <xsd:annotation>
          <xsd:documentation>angle between the direction of periapsis and the current position of the body, as seen from the main focus of the ellipse.</xsd:documentation>
        </xsd:annotation>
      </xsd:element>
      <xsd:element minOccurs="0" ref="LocalTime">
        <xsd:annotation>
          <xsd:documentation>  Local Time is UT adjusted for location around the Planet in time zones. The subsolar position is located at noon the dawn/ dusk at 06 :00 and 18 :00 respectively.  .</xsd:documentation>
        </xsd:annotation>
      </xsd:element>

  <xsd:simpleType name="enumTempeteQuantity">
    <xsd:annotation>

    </xsd:annotation <xsd:documentation xml:lang="en">
        Quantities for the description of TEMPETE elements.
      </xsd:documentation>>
    <xsd:restriction base="xsd:string">
      <xsd:enumeration value="NormalizedEnergyThreshold"/>
      <xsd:enumeration value="ModelSurfaceTemperature"/>
      <xsd:enumeration value="ChemistryActivation"/>
      <xsd:enumeration value="CollisionActivation"/>
      <xsd:enumeration value="CollisionScheme"/>
      <xsd:enumeration value="RotationActivation"/>
    </xsd:restriction>
  </xsd:simpleType>
```

Introduction of a new element enumTempeteQuantity in **ParameterQuantity**

- For chained models: add InputResourceID to InputPopulation. This is theGranule ID containing input data and defined in the tree of the preceding model
- Accounting for time dependant simulations
  - TemporalDependance=Yes in Simulation Model
  - Use InputTableURL to refer to the VOTable containing time series of inputs
  - StopDate=StartDate for individual snapshot

Prototype EGM catalog



Implementing the Time Dependent data/simulation model

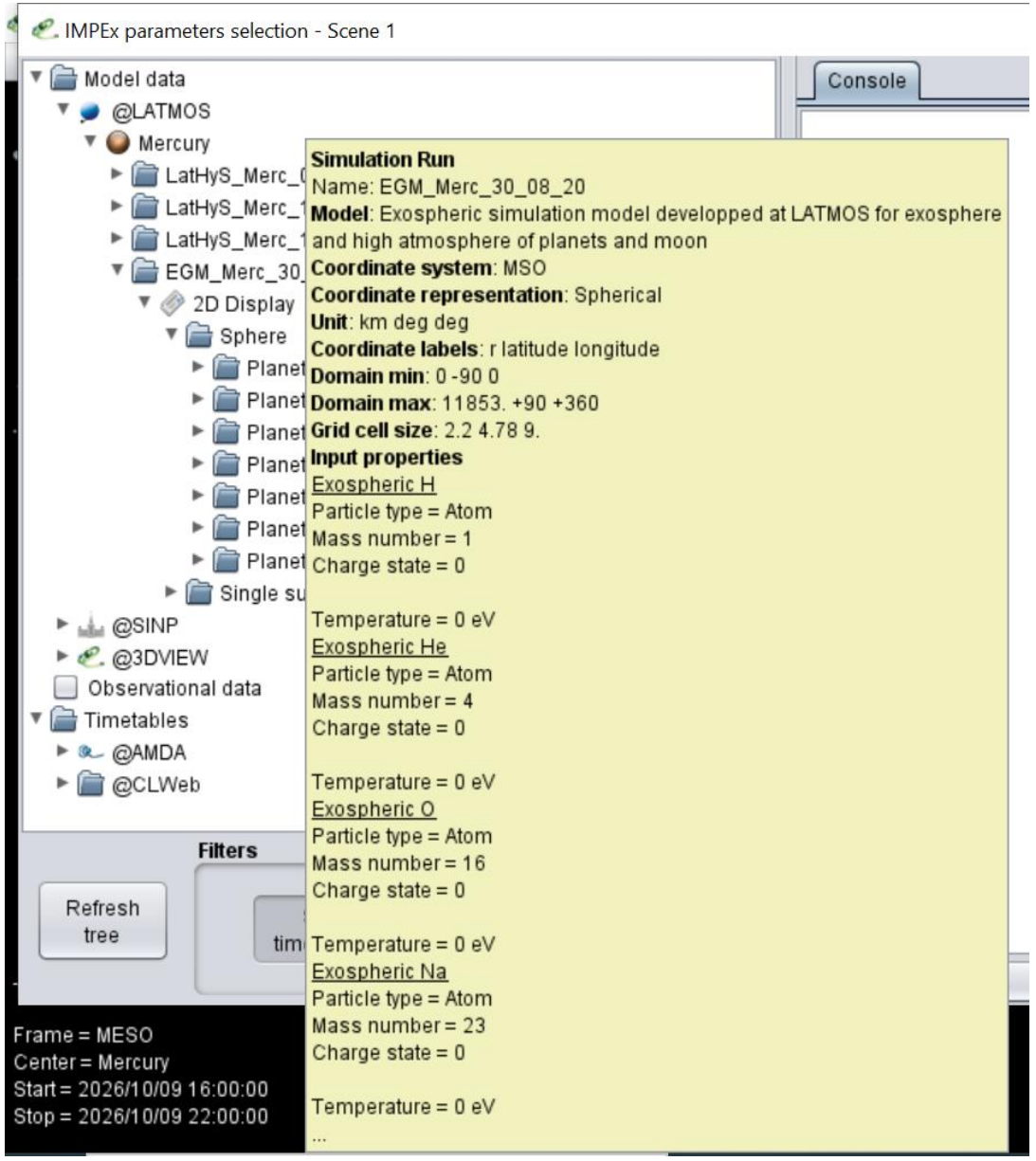
- Exemple of a *tree.xml* file for the description of Time Dependent a run
- Here for an InputTableURL (varying upstream magnetic field)
- Here for a 2D cut of magnetic field (LATMOS hybrid model for Mars)
  - XML code/model descriptions
  - XML parameter descriptions
  - Access URL

```
<InputField>
<Name>IMF</Name>
<Description>Interplanetary Magnetic Field</Description>
<SimulatedRegion>Heliosphere</SimulatedRegion>
<FieldQuantity>Magnetic</FieldQuantity>
<Units>nT</Units>
<UnitsConversion> 1.E-9 &gt; T </UnitsConversion>

<InputTableURL>http://impex.latmos.ipsl.fr/Hybrid/Mars_12_06_17_TD/input_MAVEN_B_MSO.vot</InputTableURL>
</InputField>
```

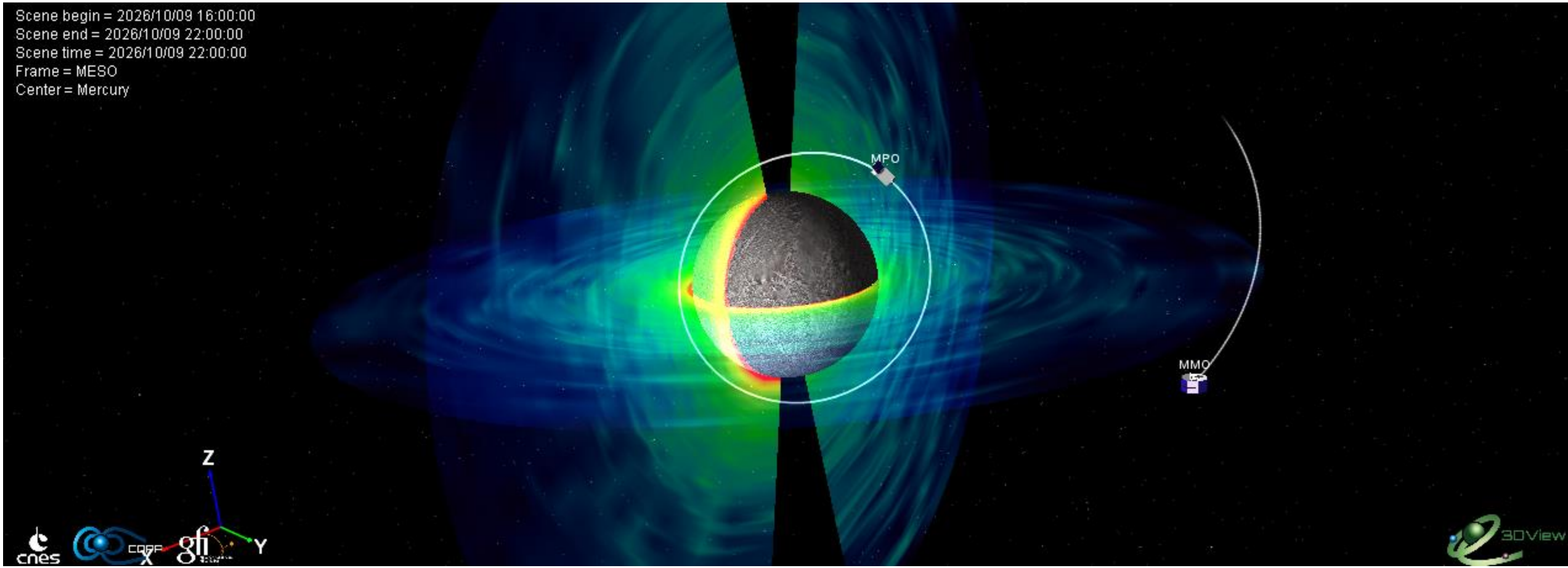
```
<Granule>
    <ResourceID>spase://IMPEX/Granule/LATMOS/Hybrid/Mars_12_06_17_TD/Mag/2D/XY/Bfield_XY_12_06_17_t08622</ResourceID>
    <ReleaseDate>2020-07-02T00:00:00.000</ReleaseDate>
    <ParentID>spase://IMPEX/NumericalOutput/LATMOS/Hybrid/Mars_12_06_17_TD/Mag/2D/XY</ParentID>
    <StartDate>2014-12-23T10:42:00</StartDate>
    <StopDate>2014-12-23T10:42:00</StopDate>
    <Source>
      <SourceType>Data</SourceType>
      <URL>http://impex.latmos.ipsl.fr/Hybrid/Mars_12_06_17_TD/Bfield_XY_12_06_17_t08622.xml</URL>
    </Source>
  </Granule>
```

In 3DView

- Tooltips give information on simulation inputs
- Several levels of products are proposed (see next slide)
- Once the product is chosen the web-service of the related (simulation) database is called to retrieve the full cube, planar/shell cuts, interpolation for time series, …



Example of visualization of EGM dataProduct (2DCuts in XY and XZ planes of Na) for the Hermean environment



Implementation of 2 EGM webservices in progress :

- getColumnDensity
- getShellCut

Conclusions

- IMPEx project initiated the effort of describing simulations runs and models
- It is now included in SPASE
- TEMPETE project expends the data model to new set of simulation (upper atmosphere/exosphere) and time dependant simulation runs