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Revision History

Version	Date	Released by	Detail
1.0	January 20th 2020	Joëlle Durand	Initial version
1.1	February 5th 2020	Joëlle Durand	Minor improvements and fixes (§3.1, §3.4.1.3.1, § 4)
1.2	June 20th 2020	Joëlle Durand	3DView V2.4 improvements on: - "Add data from user orbit" function (§0) - "View ground stations" function (§3.4.4.8) - the small bodies access (Annex A.6) planned in V2.5

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1 INTRODUCTION

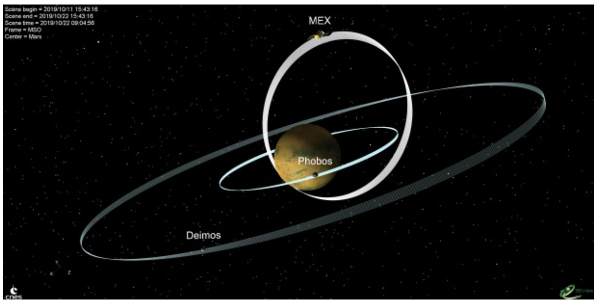
3DView is a science tool that offers immediate 3D visualization of spacecraft position and attitude, planetary ephemerides, as well as scientific data (observations, simulations and models) representation. It covers about 80 scientific missions and is regularly updated.

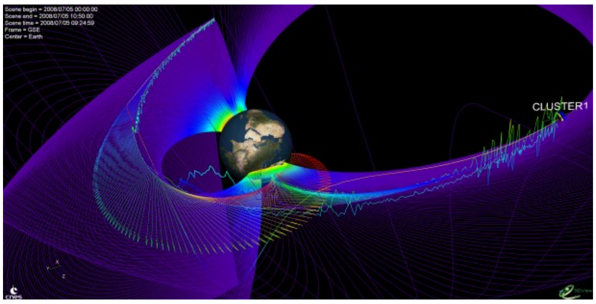
Orbits and attitudes are handled through SPICE kernels and related files from ESA or NASA repositories, as well as through a user upload.

Data from external databases are accessible through web services.

3DView is a Java application available at the following address: http://mm3dview.cnes.fr

3DView allows a user to rapidly obtain simple views (such as spacecraft orbiting around a planet with their orientation) or more complex views with simulated physical models and observational data on the trajectory.





2 PREREQUISITES

2.1 Launch Application Requirements

Java Runtime Environment version 1.8 or later, available at https://www.java.com
The following URLs must be added to the list of sites with exception in the Security panel of the Java Configuration window:

- http://mm3dview.cnes.fr
- http://jogamp.org

This means that the execution of 3DView will be authorized after several security warnings, as depicted in §3.1.

3DView is provided as a **Java Web Start** application. Java Web Start is a framework provided by Oracle that allows users to start application software for the Java Platform directly from the Internet using a web browser.

2.2 Java3D Requirements

The 1.6 version of the Java 3D API has been released for Linux (both x86 and amd64), Windows (both x86 and amd64), and Mac OS X (both PPC and x86). It requires at least the JRE (Java Runtime environment) 1.7u80.
See the specificities for Linux, Windows and Mac OS X on the link Java3D Requirements of the server home page.

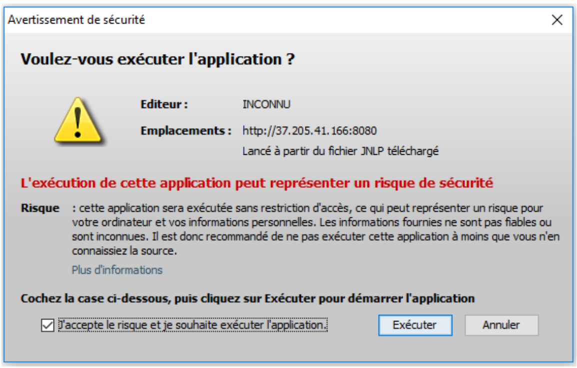
3 USE 3DVIEW

3DView is available at the following address: http://mm3dview.cnes.fr

Click the **Launch 3DView** button to start. A Java application is started using "Java Web Start" technology. This means that a file named launch3dview.jnlp is downloaded. You must execute this file to start 3Dview.

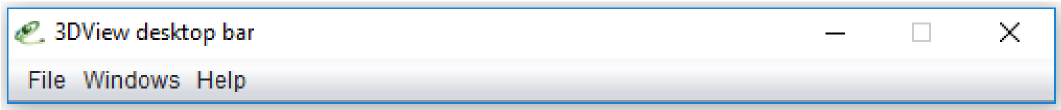
3.1 LAUNCH

At launch, security alert windows will appear. It is due to the signing of java packages as 3Dview requires access to hard disk and therefore special rights. The certificate allowed to sign the main package has been generated to freely use the application without the certificate of a recognized authority. Therefore, windows appear at launch to indicate that an official organization has not recognized the signature:



You have to accept to make it continue.

At the next step, the desktop bar is displayed.



From that moment, the icon  is created for all the 3DView windows.

3.2 Desktop Bar menu

3.2.1 File menu

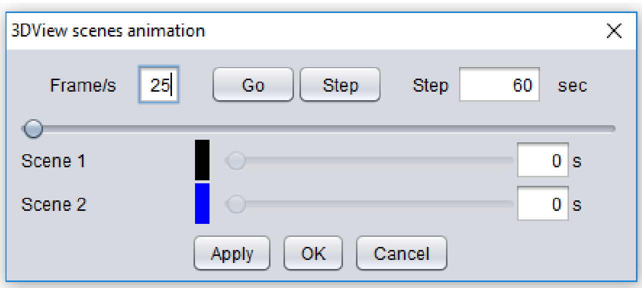
Select:

- **New scene** to open a new 3D window
- **Open all** to open a set of 3D scenes previously saved in a local file
- **Save all** to save the current scenes in a local file
- **Exit** to stop 3DView

3.2.2 Windows menu (active only if a graphic scene exists)

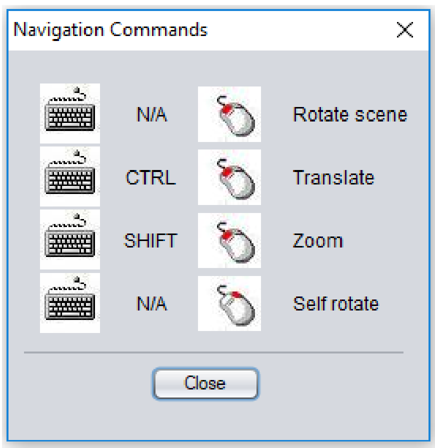
Properties is used to change the colour of scenes contour.

Animation is used to animate several scenes at the same time.



3.2.3 Help menu

The **About** tab displays the current version details.
The **Commands** tab displays the list of navigation commands, using the mouse and the keyboard.

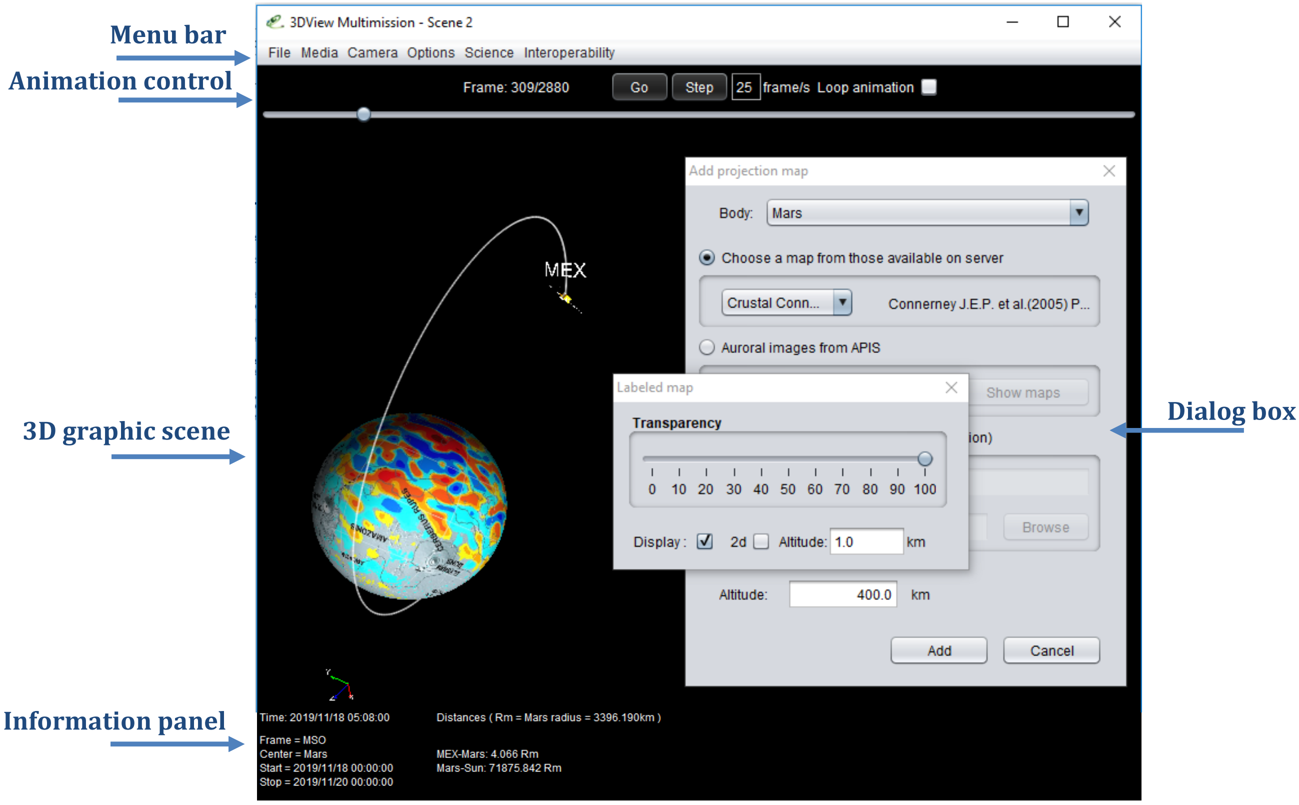


3.3 3D WINDOW

3.3.1 Main view

The 3DView window is composed of 5 parts:

- Menu bar,
- Animation control
- 3D graphic scene,
- Information panel
- Dialog box



3.3.2 3D scene

The 3D scene is the main view of the application. It shows bodies selected in the selection page (Manage scene) and all other items added from menus (instrument views, models, data...).
You can navigate through the 3D scene using mouse and keyboard.
To **rotate the 3D scene** around its center, click with the left mouse button and drag.
To **zoom in and zoom out** (or forward and backward), use the left button and the Shift key on the keyboard. The mouse wheel can also be used for this purpose.
To **move** left or right, use the left button and the Ctrl key.

3.3.3 Information panel

The information panel displays two kinds of information:

- Static information reminding the current selection (coordinate systems, time range...)
- Real-time information: UT Time of the animated scene, distances and time shifts.

3.3.4 Animation control

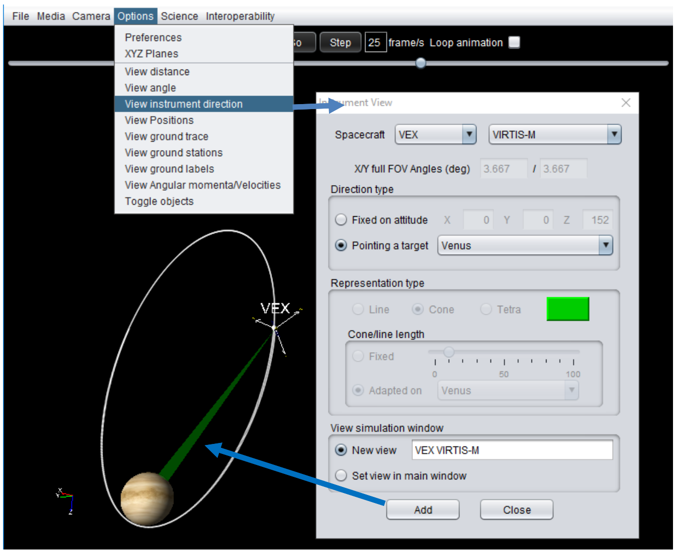
You can **start or stop the animation** via the button Go / Stop.
The 2 **Step** buttons allows to move back or forward step by step.
The number of frames defines the animation speed (it can be modified to change the speed).
It is also possible to play the animation by moving the cursor directly with the mouse.
Loop animation allows to automatically and indefinitely restart the animation.

3.3.5 Menu bar

The Menu bar provides access to advanced features: manage scene, change display settings, display models, access and display data, save images...
Each function and sub functions are detailed below.

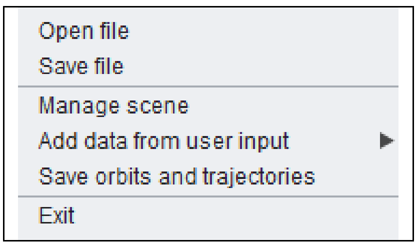
3.3.6 Dialog box

Each sub function activates a dialog box allowing the user to define the display settings.
Example: View instrument direction



3.4 Menu Bar

3.4.1 File



3.4.1.1 Open file

This function opens a scene that was previously saved.

3.4.1.2 Save file

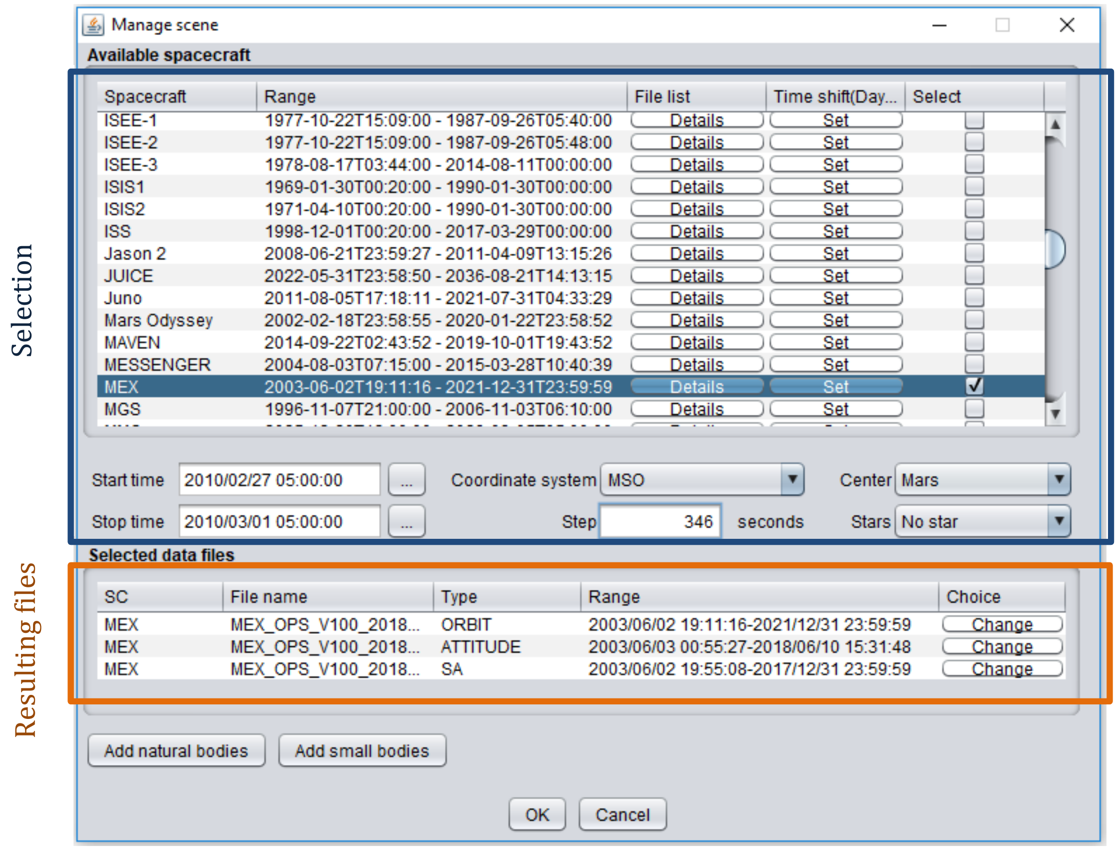
This function saves the current scene.

3.4.1.3 *Manage scene*

This function is used to prepare (and modify) the 3D scene

It opens a dialog box which allows the selection of the attributes of the 3D scene to be displayed, composed of three parts:

- The selection part:
  - Spacecraft
  - Time interval (Start time/Stop time)
  - Time step
  - Center body
  - Coordinate System
- The display of the corresponding kernels files
- The selection of additional bodies
  - Stars
  - Natural bodies
  - Small bodies



3.4.1.3.1 Selection

Spacecraft
A spacecraft is listed with the associated kernel files attributes:

- The *Range* of a spacecraft is determined from the beginning and the end of all the available associated orbit files.
  For a given mission, there can be several kernels. The range represents all the coverage = minimum of start dates and maximum of end dates of the different existing orbit files. The end date of the range is considered by the tool as the end of the mission.
- *Details* gives the available segments of orbit and attitude files.
- *Time shift* function is detailed below.

If no spacecraft is selected, (no box checked) the 3D scene will contain only the **Center body** (Sun by default).

When a spacecraft is selected, the **Center** and the **Coordinate system** are automatically filled as well as the Start and the Stop time (**Time interval**).

Time interval
The Time interval is of **one week** by default, calculated as following:

- For a completed mission, the last week of the mission,
- For a mission in progress, the week whose Stop time is the current time,
- For a future mission, the last week of the predicted mission,
- For several missions, the last week of the common range.

Center, Coordinate system can be changed by the user through the list of the other proposed bodies, for example to change an heliospheric view to a flyby over a planet or a small body.
The **Time interval** can also be changed.
A warning message informs the user when the time interval he has defined for a spacecraft is out of its range, or when several spacecraft are selected and they have no common time range.

Step.
The accuracy of the resulting scene depends on the step (with a step = 60 the results accuracy will be the minute, with a step = 1 the results accuracy will be the second). The Time step depends on the Time range. By default, the step value is computed to plot 500 steps.
It can be changed. The smaller the step, the more accurate the displayed orbit and the numeric results will be.

Inappropriate step

Good step

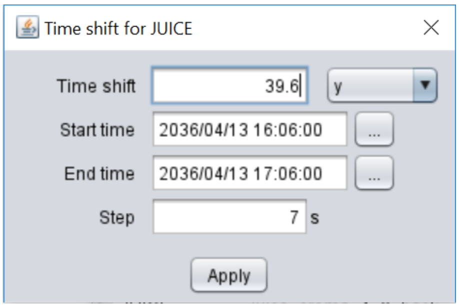
A step of **60 seconds** max
is needed for the low orbits

→ But a too small step could decrease performance or prevent the tool to run properly.

The ***Time shift function***, used only when there are several spacecraft on the scene, allows translating the scene time interval for a spacecraft whose range doesn't match with it.
It may be useful to compare the simulated orbit of a future mission to the one of an old mission.

The time shift may be in seconds, minutes, hours, days or years. It can be positive or negative.

Example: To merge Galileo mission (Ganymede flyby in September 1996) and Juice mission (Ganymede flyby planned in 2036) on the same scene, for comparison purposes, you have to apply for Juice a shift of 40 years. Trajectory of Juice is then drawn in green.



The corresponding image is shown at § 3.4.5.1.3.

3.4.1.3.2 Selected data files

This part of the box lists the available orbit file(s) corresponding to the selection made, as well as attitude file(s) and solar array file(s) if they exist.

The first file found covering the selected time interval is chosen for each type (Orbit, Attitude, Solar Array).

Warning: sometimes, the attitude kernel stops few minutes before the orbit kernel ends and so it is not selected. For that, the Stop time must be adjusted with the end of the attitude file (see Details in the File list).

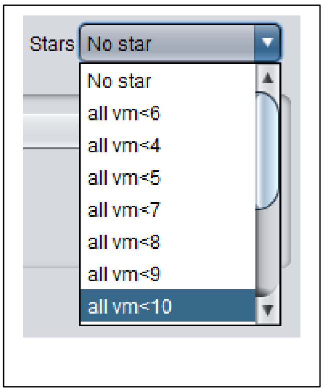
The files selection can still be changed by choosing another kernel from the proposed list (*Change* button).

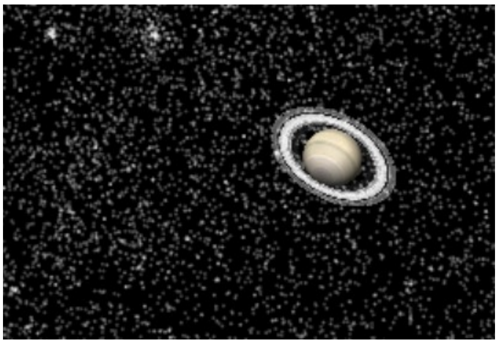
Some missions use meta-kernels instead of classical orbit or attitude kernels files. Meta-kernels are text files combining multiple classical kernels usualy ending with ".tm".
If meta-kernel is combining orbit and attitude kernels files, you should use the same meta-kernel for orbit and attitude selection.

3.4.1.3.3 Additional bodies

Once the 3D scene is defined it is possible to add:

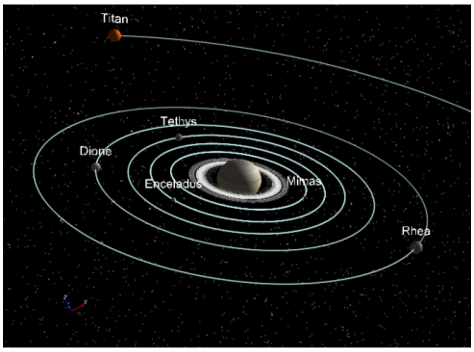
- Stars (from Tycho-2 catalog and a specific catalog for Corot) choosing the magnitude
- Natural bodies (planets and moons of the Solar system)
- Small bodies (asteroids and comets from JPL catalogues, combined or not with a distance from the central body)



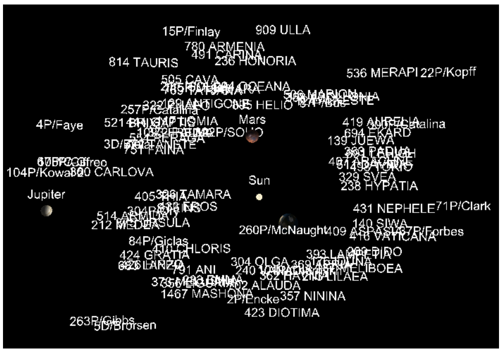


Saturn with stars (all vm < 10)

(Detailed description in Appendix A6)



Moons of Saturn



Asteroïds inside Jupiter orbit

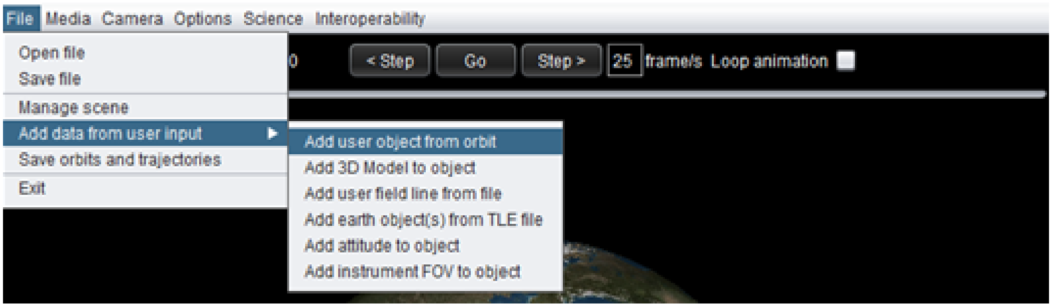
Once the scene completely defined, clicking on the OK button will create the 3D scene in the main window.

↳ To **modify** the initial scene (ex: the period of time or the step value) and /or complete it (ex: add a new S/C), or completely change it, reuse the **File/Manage scene.**

↳ To **open a new 3D window** reuse the **Desktop New file** menu.

3.4.1.4 *Add data from user input*

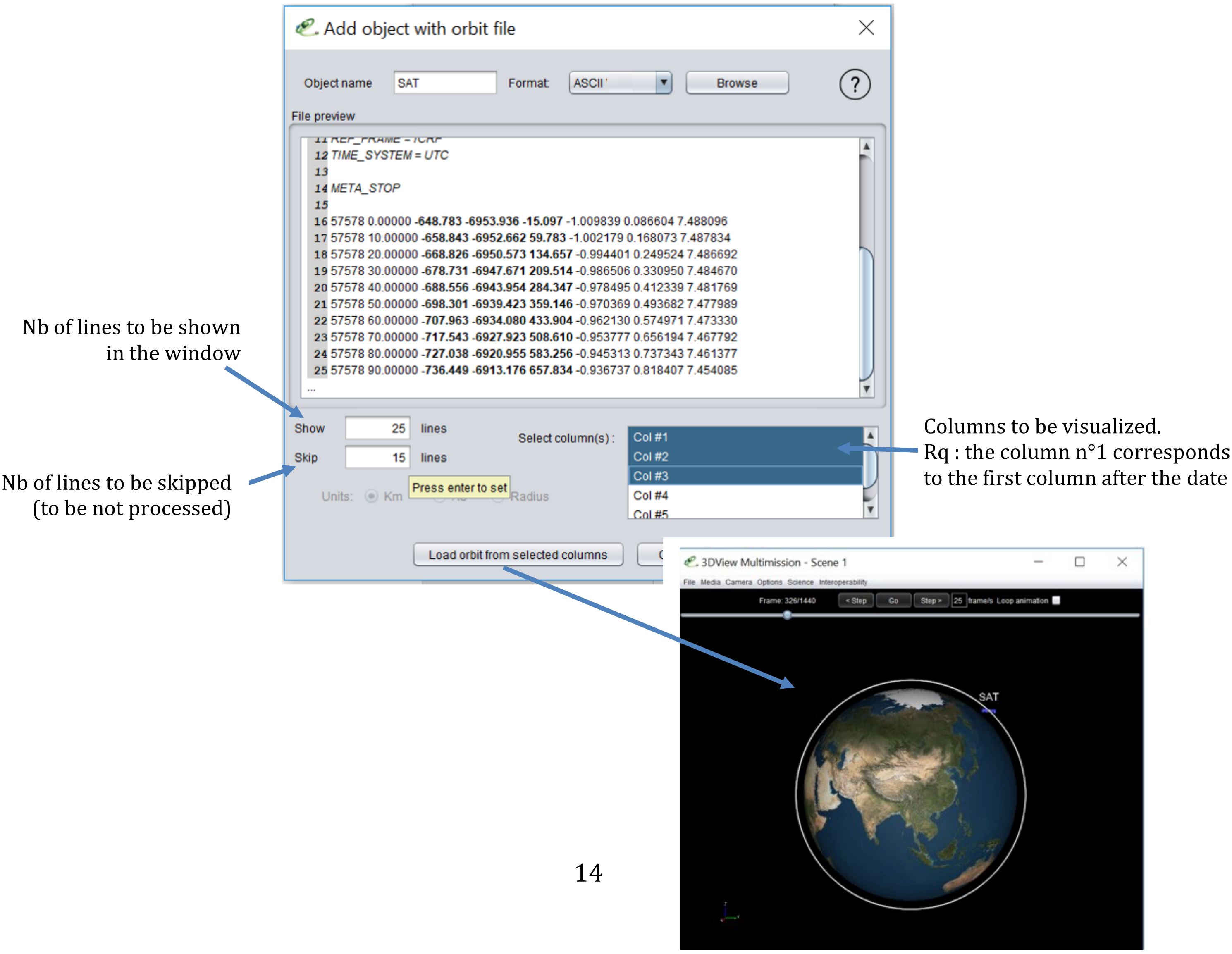
This function allows the user to upload its own files to the 3D scene.



3.4.1.4.1 Add user object from orbit

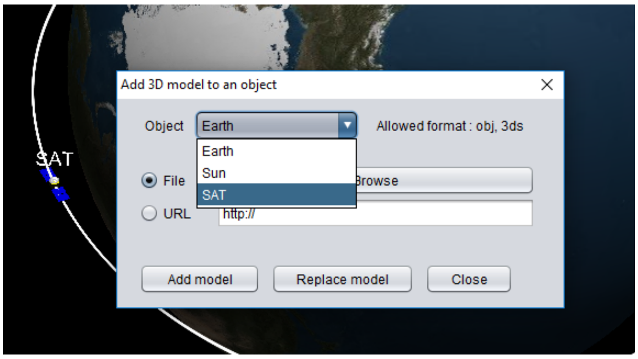
This function is used to upload to the scene, around the central body, the trajectory of an object (s/c or body) defined in a file whose authorized formats are: VOTABLE, ASCII, CIC-CCSDS, CSV and CDF.
The new object must be named (SAT in the example below).
The file must be on a local disk directory. Once loaded, the file content appears in the "File preview" window (the number of **shown** lines, 25 by default, can be changed).
The bottom of the interface allows to choose the part of the file to be displayed:

- the number of **lines to be skipped** (lines to be not processed, ex.: the header)
- the **columns** to be displayed (that go bold)

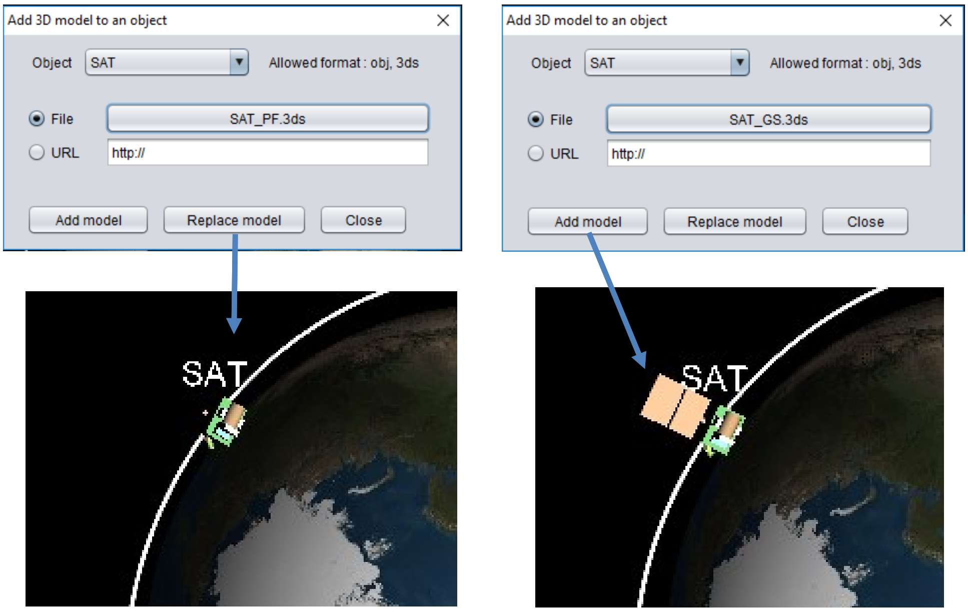


3.4.1.4.2 Add 3D Model to object

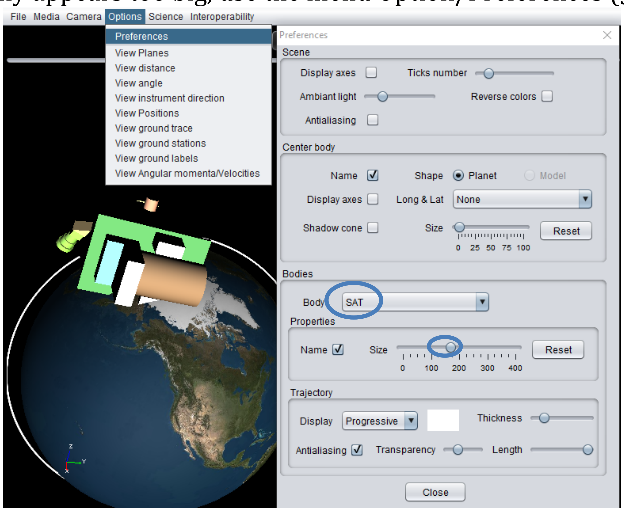
This function is used to associate a 3D Model to an object already displayed on the graphic scene. In the example above, the proposed objects will be the Earth, the Sun and SAT.
To replace the s/c SAT model (here the 3D model by default), select the SAT object and get the desired model file (.obj or .3ds), either browsing disk directories or through an URL.



Using the same interface the 3D model can be built in several times loading several files.



Note: if the model initially appears too big, use the menu Option/Preferences (§ 3.4.4.1) to resize it.



3.4.1.4.3 Add user field line from file

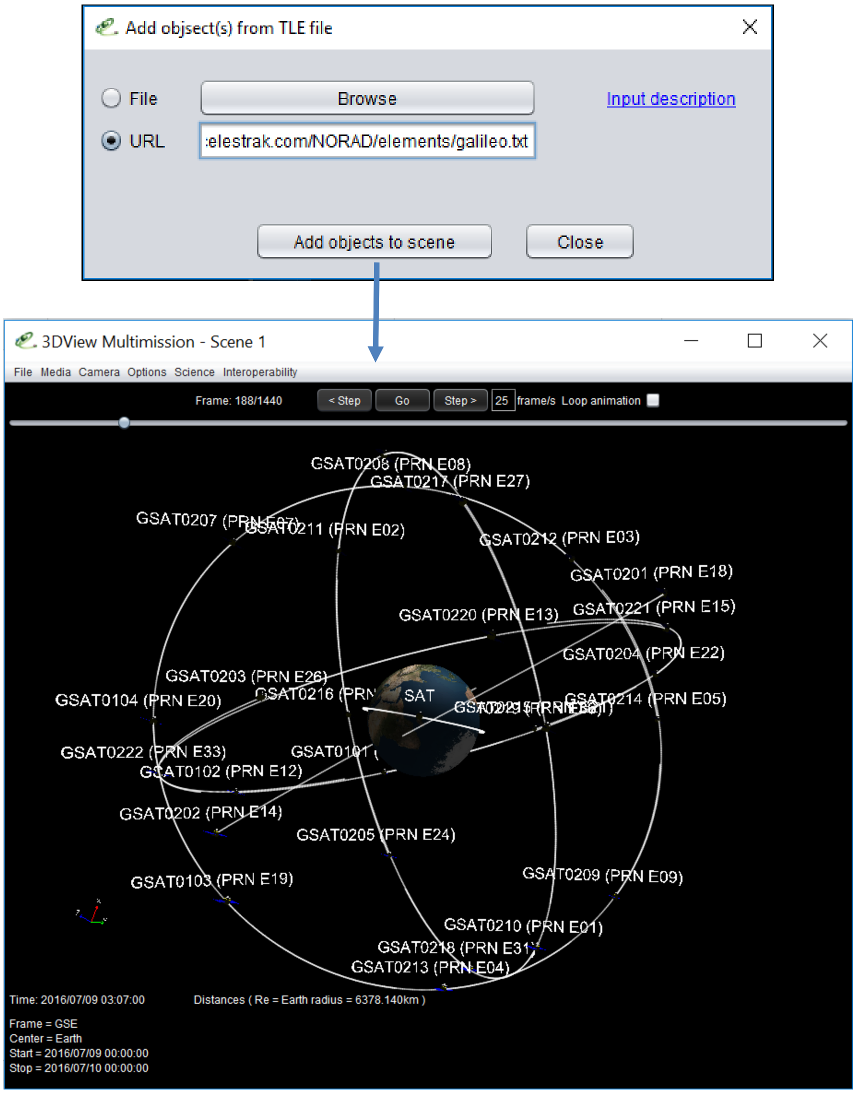
This function is used to add outputs from a field lines generator contained in a local file. Each file contains only one field line with point position, field value, and optional parameters. The format is described below:
R(R_SUN) Theta(rad) Phi(rad) Br(G) Btheta(G) Bphi(G)
It is possible to plot a quantity along this line, typically the velocity.

3.4.1.4.4 Add earth object(s) from TLE file

This option is used to add one or several objects, from a local file, to the scene where the Earth is the central body. The file must be in ASCII and compatible with the TLE format. See below an example:

```
NOAA 14
1 23455U 94089A   97320.90946019  .00000140  00000-0  10191-3 0  2621
2 23455  99.0090 272.6745 0008546 223.1686 136.8816 14.11711747148495
```

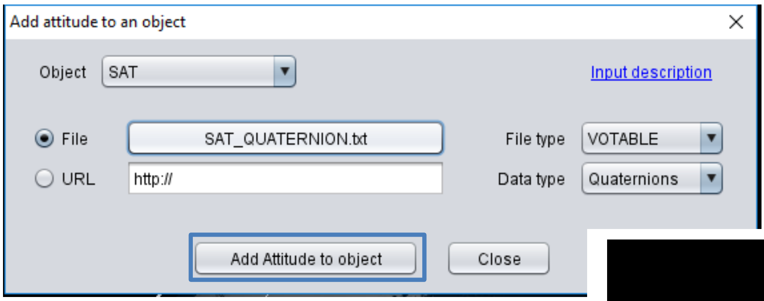
Example with the Galileo constellation from the Celestrak server and NORAD data:
https://www.celestrak.com/NORAD/elements/galileo.txt



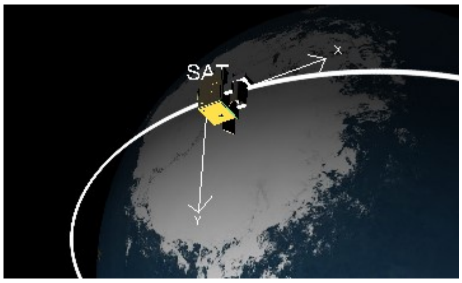
3.4.1.4.5 Add attitude to object from file

This function is used to add attitude data from a local file to a spacecraft of the scene. The format may be VOTable or ASCII. The file may contain:

- matrices (Time,xx,xy,xz,yx,yy,yz,zx,zy,zz) or
- quaternions (Time,x,y,z,w).

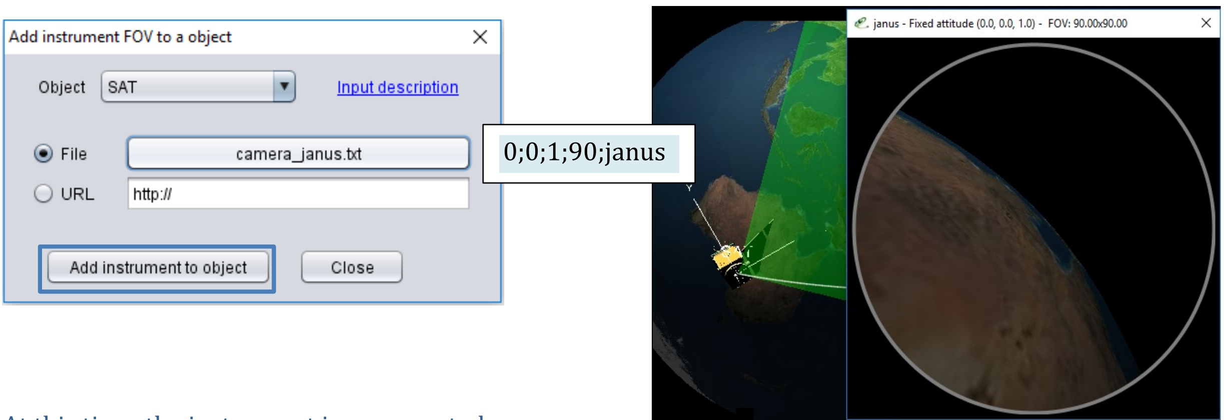


At this time, the spacecraft axes are displayed



3.4.1.4.5.1 *Add instrument FOV to object from file*

This function is used to add instruments with data related to the Field of View from a local file. The file is a csv text file with semi-colon separator and lines containing the boresight vector, full angle FOV in degrees and name of the instrument, as in the example below:
Vx;Vy;Vz; full angle; name (or comment)
Example of line: 1 ;0 ;0 ;90 ;X axis 90°



At this time, the instrument is represented
by a cone with the angle and the boresight indicated in the file. The FOV is displayed in a separated window.

3.4.1.5 ***Save orbits and trajectories***

This function saves orbit and attitude of spacecraft and planets in an ASCII file.

3.4.1.6 ***Exit***

This function closes the 3D scene.

3.4.2 Media

This menu is dedicated to the generation of images and movies.

3.4.2.1 Save image

Save image takes a snapshot of displayed 3D scene as an image in PNG format. The image is saved as displayed on the screen.

3.4.2.2 Save High Res image

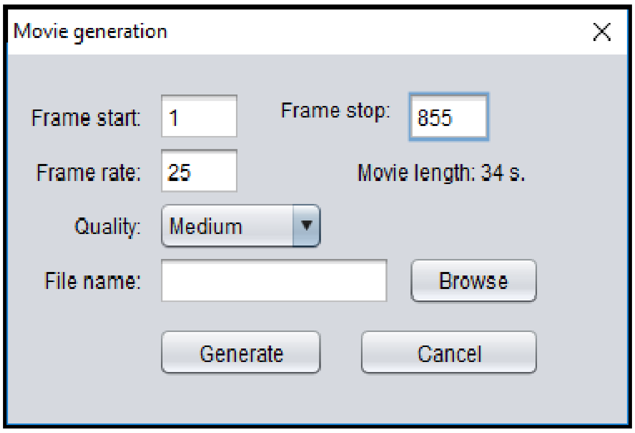
Save high res image takes a snapshot of displayed 3D scene as an image in PNG format. This option generates an image three times bigger or three times more accurate.

NB: Different graphics cards have different maximum size limit:
- Intel: 1024x1024
- ATI: 2048x2048
- NVidia: 4096x4096

If none of these manufacturers is detected, the limit of 1024 is used.
This limit also applies to movies.
If the limit is reached, the application will reduce the size factor to reach the largest possible picture on the basis of capacity of the card.

3.4.2.3 Generate Movie

Generate movie is used to record all or part of the animation.



Frame start and **Frame stop** define the range of the animation to be generated.
Frame rate is the number of image per second during the movie (one image = one frame). The lower the frame rate, the longer the movie, but below 10 fps, the film will look jerky. Going beyond 25 fps is unnecessary because the eye does not see the difference.
Movie length is the length of the generated movie, depending on frame start / stop / rate. "**Quality**" is used to adjust the movie size:

- *Good*: 2 times the screen size
- *Medium*: screen size
- *Poor*: 0.5 times the screen size

Click on **Browse** to select the file in which the movie will be saved, then start the recording with **Generate**.

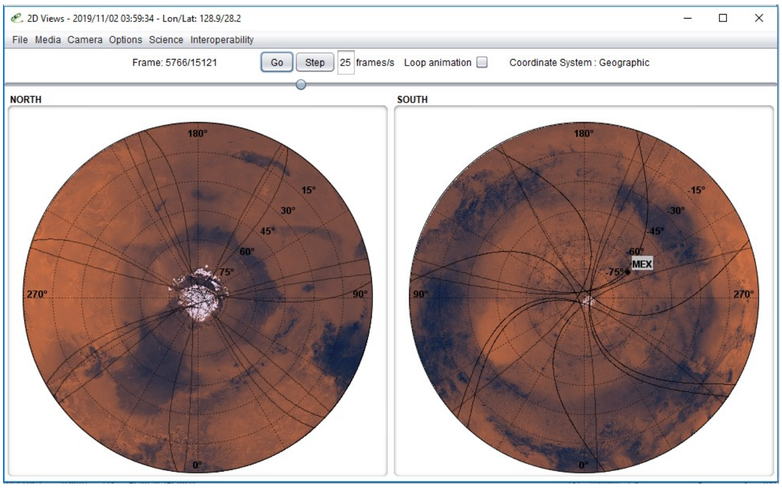
Warning: the generation of a movie may take some time and a lot of memory if a large time range and good image quality are selected.
The lower the step of the scene, the larger the film size. Don't slow down the step unnecessarily.

3.4.3 Camera

This menu allows changing the view of the 3D scene. Two options allow viewing the planes for the selected coordinates system:

- View the planes: sets the camera in front of the chosen plane (XY or ZY or ZX)
- Chase camera: sets a camera which follows an object

2DView menu opens a 2DView window.



The 2D window and the 3D scene are correlated in time.
Menu is similar, but with some differences in camera and Science.

3.4.3.1 Camera

In this menu, users can choose the Projection Type, Coordinate System, and Limits.

According to the source of the data and regions of interest, cylindrical or pseudo-cylindrical **projections** are proposed (for a global 2D view of the planet and visualization of data at middle and low latitudes). Polar projections are proposed for high latitudes. The following projections are proposed:

- Cylindrical (Mercator)
- Pseudo cylindrical(Mollweide)
- Azimuthal Polar North
- Azimuthal Polar South
- Azimuthal Polar South and North

Four **coordinate systems** are available: Geographic, Quasi-dipole, APEX, AACGM

Limits allows the selection of a region (latitude, longitude) on a planet.

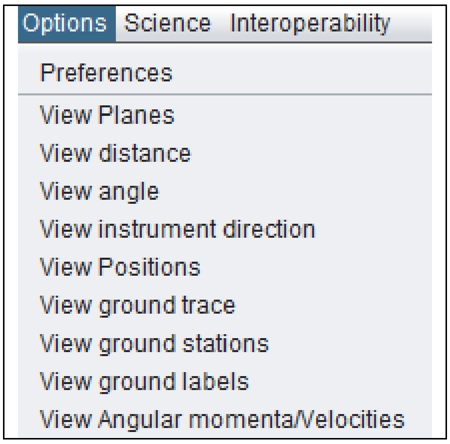
3.4.3.2 Science

The science menu in the 2DView window is similar to the 3D Science Menu (§ 3.4.5) with two additions:

- **Satellite tracks**
  Two ways: *radial* to the center of the Earth or *along the magnetic field lines*, with several magnetic field models (Tsyganenko 96, 02, 05)
- **Interhemispheric mode**
  Find the magnetic conjugate from every position pointed by the mouse

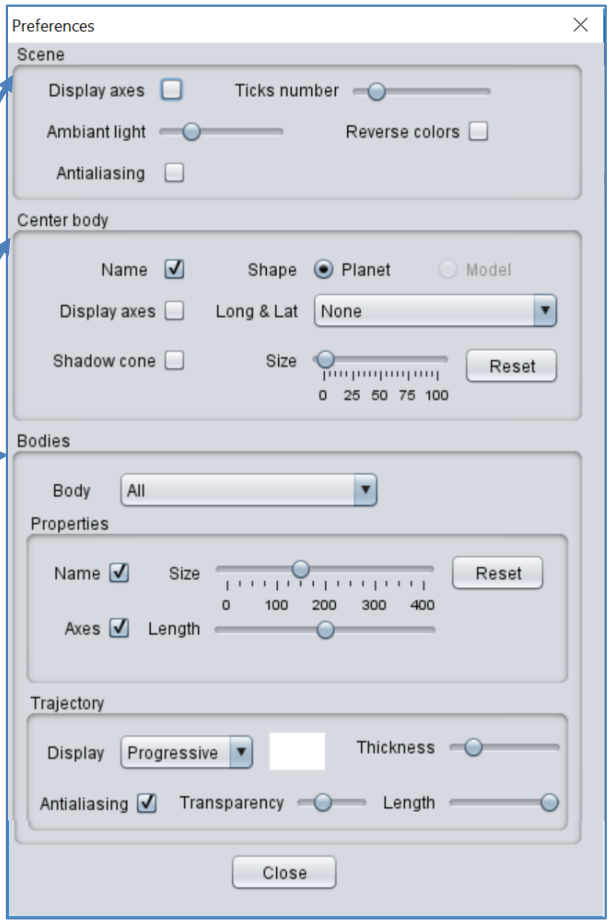
3.4.4 Options

This menu provides a set of functions allowing to add items on the 3D scene (distances, angles, fields of view, ground trace, etc.).



3.4.4.1 Preferences

This menu provides several display options:
- General at the scene: light, antialiasing…
- Related to the Center body: name display or not, shape, size, axes/meridians display, shadow cone…
- Related to the other bodies in the scene (S/C or natural bodies): name display, size, axes display and length (for bodies having an attitude), body trajectory display options.
  The changes can be applied either on all bodies (All) or on each one.

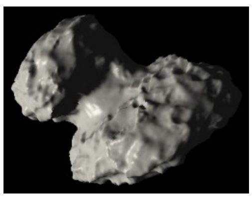


3.4.4.1.1 Center body display

The central body is always a natural body (planet, moon, asteroid...)

Several options are available to change the display of the central body:

Body shape: to choose a sphere (Planet) or a 3D model (Model) to represent the body (only available for small bodies: asteroids and comets). When a 3D model exists for the central body, it is displayed by default.

Ex: 3D Model of the Tchourioumov-Gerasimenko comet 

Body size changes the size of the central body. This is useful when flying over an asteroid, for example, where the difference between asteroid size and the fly-by distance does not allow to clearly distinguishing the two objects in the same scene.
Reset button allows to come back to the initial size.

Display axes: displays the axes X, Y, Z on central body

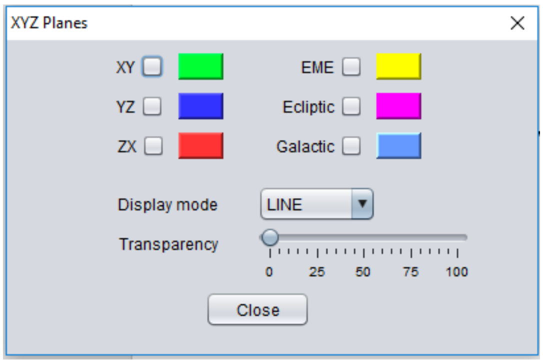
Long & Lat: Displays a grid representing the longitudes and latitudes.

3.4.4.1.2 Bodies display

This part of the interface allows, for each body (except the Center body):
- Displaying or not the name of the body,
- Modifying the size of the body. This is useful for example to adapt the spacecraft size after a zoom. Also to make visible a natural body added in the scene.
Warning: If you change the size of a body, the common scale is no longer respected.
Reset button allows to come back to the initial body size.
- Displaying or not the axes (and modifying their length) of the body for those having an attitude

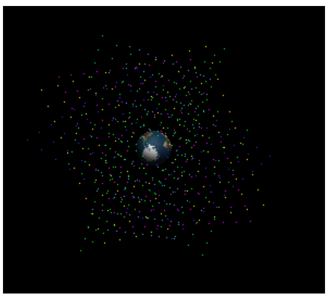
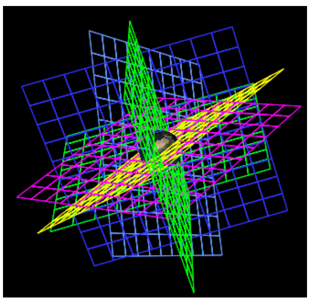
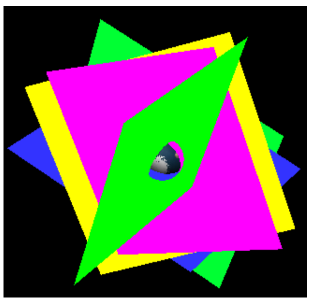
In a second part, the interface allows modifying the trajectory display:
Thickness and display mode of trajectory can be modified. Three display modes are available:
Full: trajectory is shown completely independently of the state of the animation
None: no trajectory is shown.
Progressive: trajectory is shown as the progression of the animation. ***Length*** allows to adjust its visible part. Trajectories of natural bodies (planets and moons) remain fully displayed.

3.4.4.2 View planes



This function allows to display the central body **XYZ planes** as well as **EME, Ecliptic and Galactic planes.**

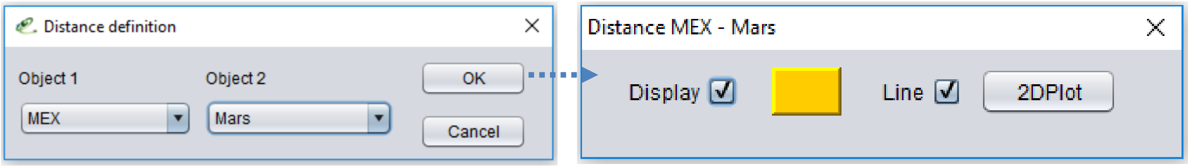
To view planes, tick the associated boxes. The colour by default can be changed.
Planes can be displayed as a shape of points (POINT), grids (LINE) or translucent (FILL) plans:

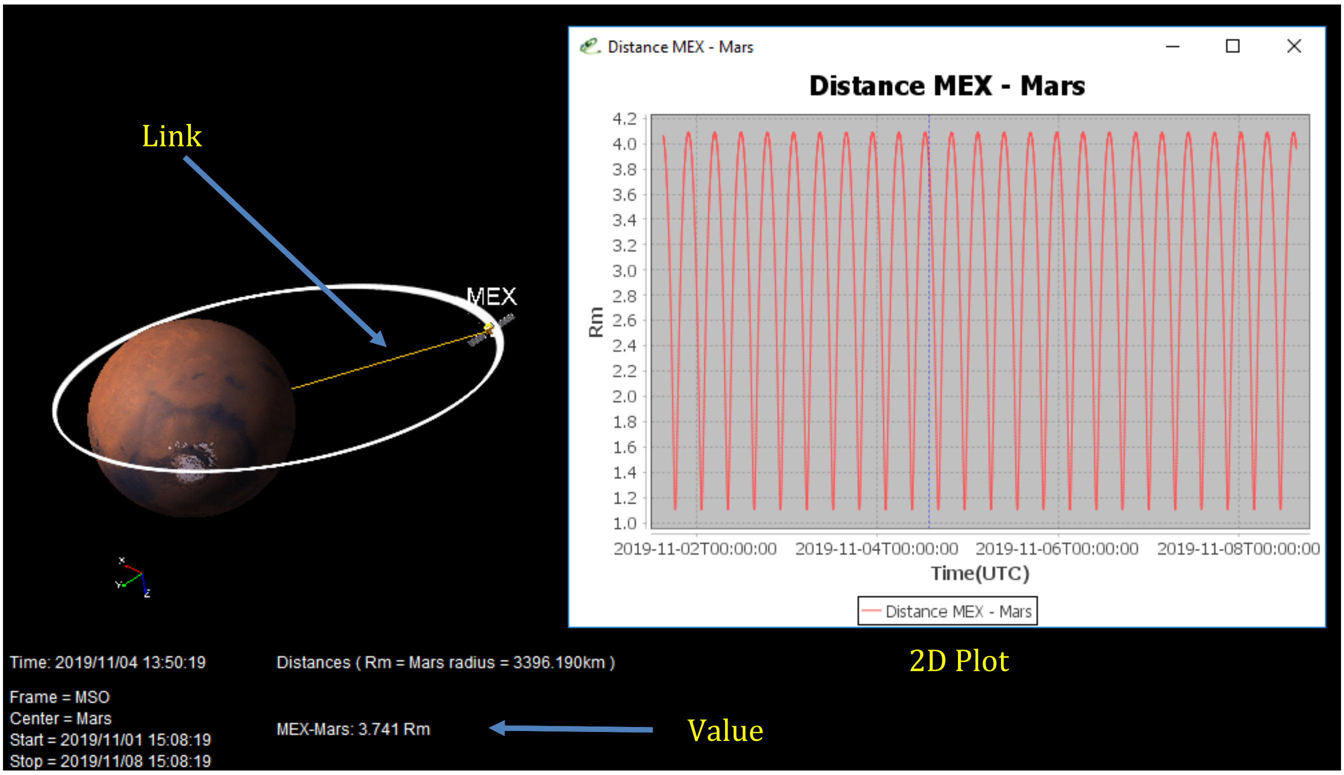




3.4.4.3 *Distance between 2 objects*

This function is used to give a distance between two objects.

A first dialog box allows to select the objects, a second one allows to draw a link between the objects in the 3D scene and to plot the evolution of the distance on the time interval of the scene.



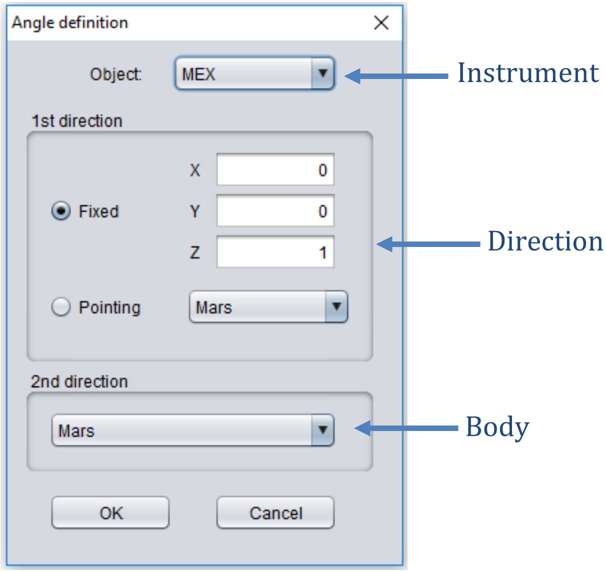


Several distances between objects present on the scene can be displayed.

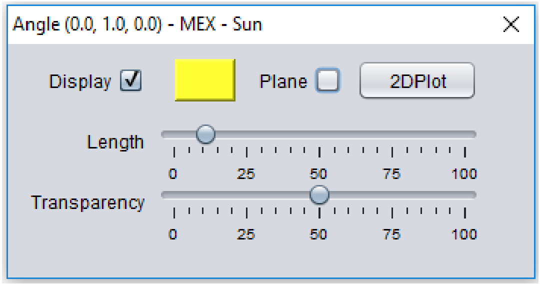
3.4.4.4 *Instrument angle*

This menu allows users to see an angle between one direction (referred to an instrument) and a body. This allows for example to get the angle between the sun and the bore sight of a camera.

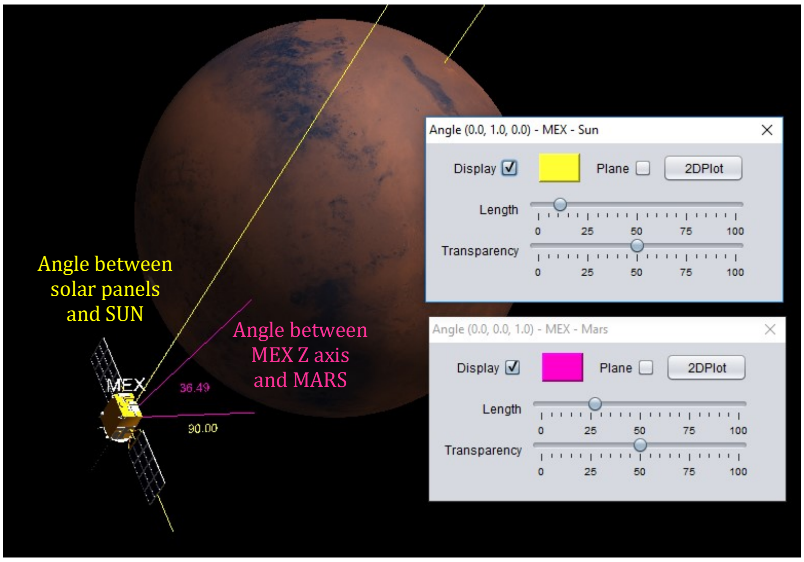
A first dialog box allows to select the angle to be displayed, a second one allows to define the display settings.



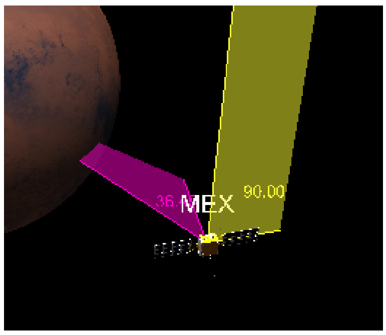
Display settings



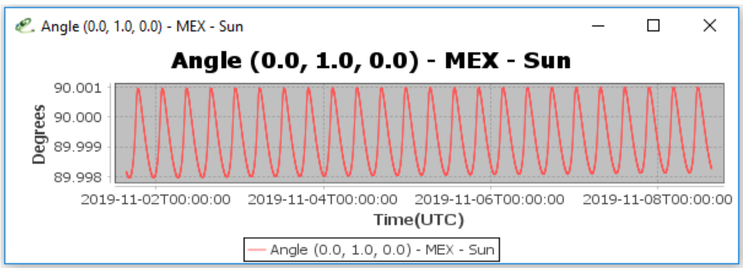
Result in the 3D scene:



Planes



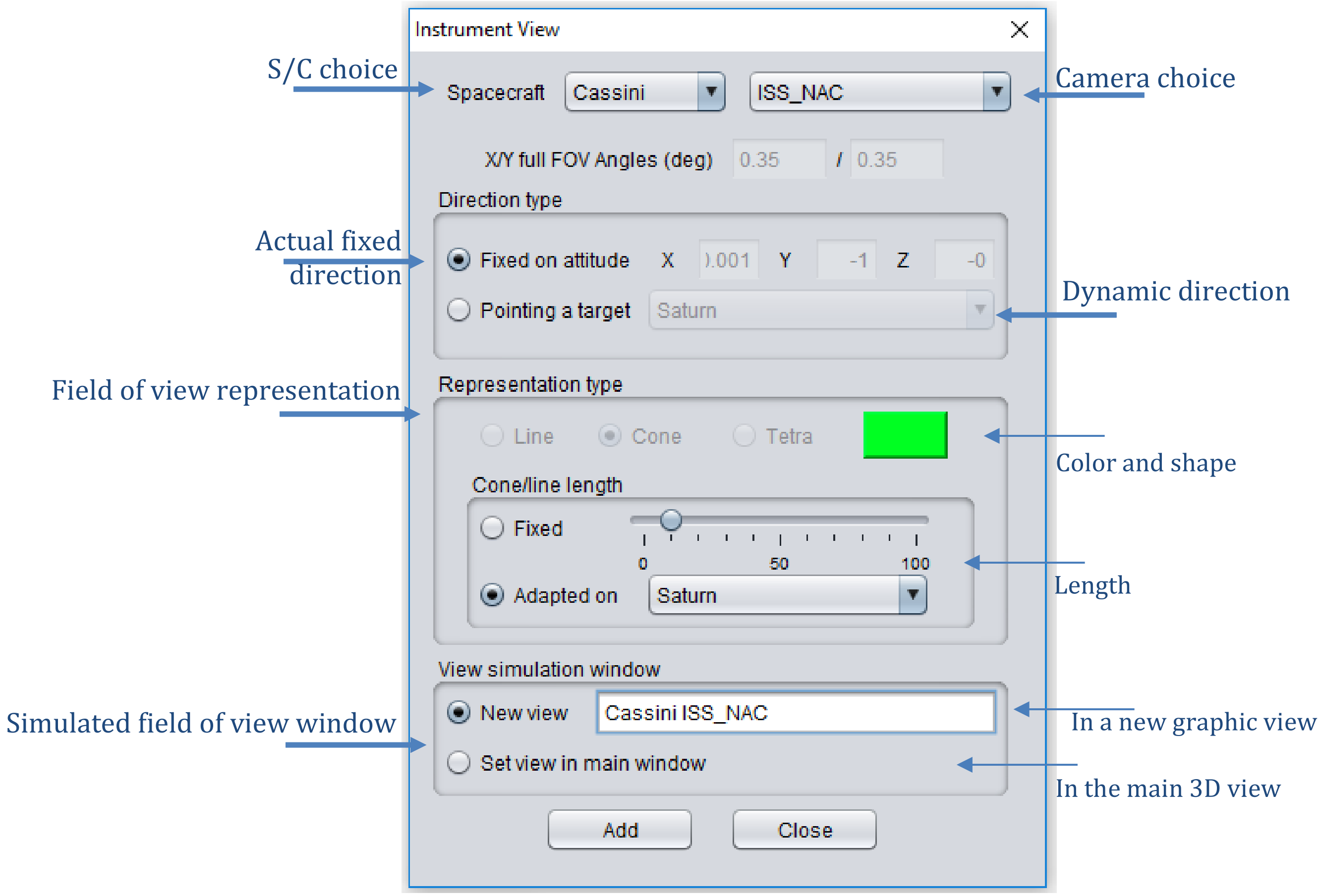
2D Plot



3.4.4.5 *View instrument direction*

This function allows users to display an instrument field of view (camera or detector).
The display is based on the instrument characteristics (FOV angles and direction on the S/C). It is possible to add several FOV to display different instruments simultaneously.

The associated dialog box is the following:



S/C choice: The list allows choosing a spacecraft among those displayed in the 3D scene.

Camera choice: The list allows choosing an instrument among those on board the selected spacecraft or simulating a new one.
When an existing instrument is selected, its FOV settings (angle, direction in the spacecraft coordinate system and shape) are automatically filled and not changeable.
When **New** is chosen, the fields are free in order to simulate the FOV of a new instrument.

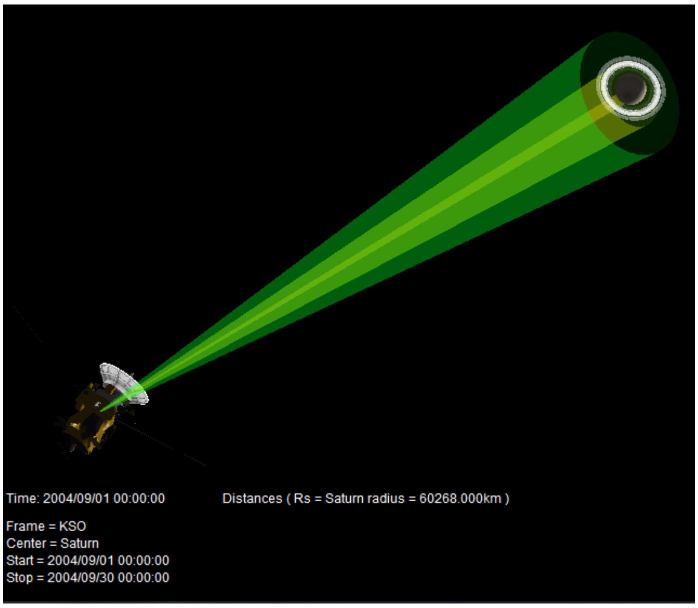
Direction type: The type allows choosing between a fixed direction in the spacecraft coordinate system or a target to point at.
The <u>first option</u> concerns instruments whose attitude is available. You must enter the direction vector relative to spacecraft coordinate system. It is not necessarily normalized.
With the <u>second option</u>, you can choose to point instrument direction to an object in the scene. The right ascension / declination of the direction in EMEJ2000 will be displayed if the simulation is displayed in a separate view (by default).

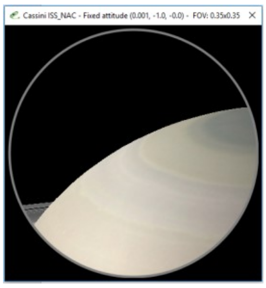
Representation type: Three types of the FOV representation are available: cone, line, tetra
The slider allows changing the length**;** The length can also be adapted to reach the target.
The colour is editable by clicking on the coloured area.

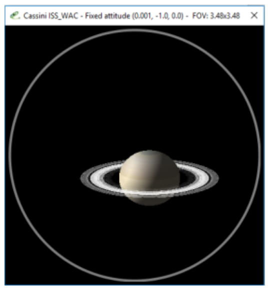
View simulation window
New view: by default, the FOV is displayed in a separate window (in addition to the main view).
A text box allows adding a name to the information already recorded in the title.
Set View in main window: In this case the instrument view is displayed in the **main scene**

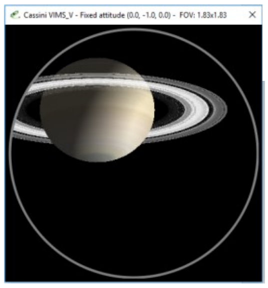
Warning: If the size of at least one object in the scene has been modified (through the menu Option /Preferences (§ 3.4.4.1), the user will be warned to reset it (to do it the Preferences menu is automatically opened).

The example below represents 3 cameras on board Cassini pointing Saturn in September 2004.



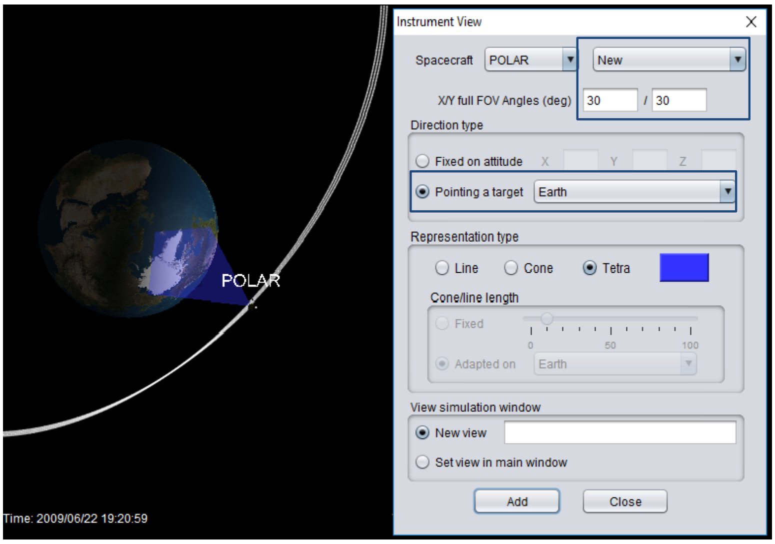


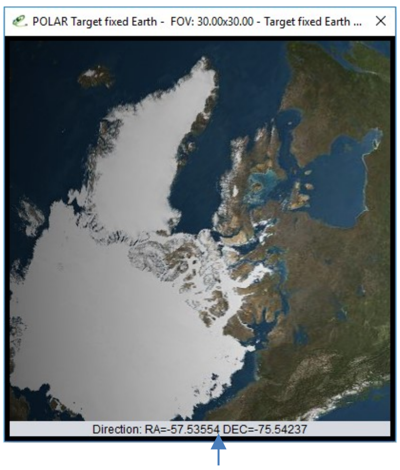




The 3 fields of view
are displayed
on separated windows

The example below represents a simulated camera (30°x30°) on board POLAR pointing the Earth.





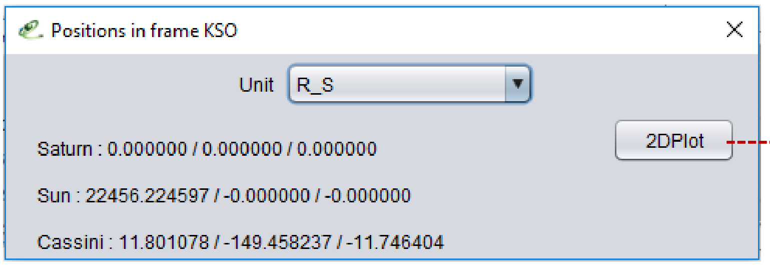
Display of the Right ascension
and Declination
of the simulated direction

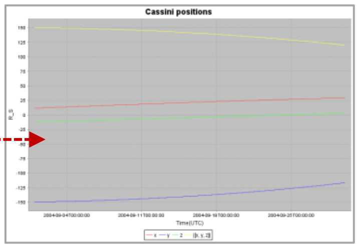
↳ Closing the window automatically removes the FOV representation in the main view.

↳ To return to the initial view, select the menu **Camera/ZY view**.

3.4.4.6 *View Positions*

Used to display the position of the different bodies of the scene in the time of the animated scene. They are expressed in the frame of the scene:

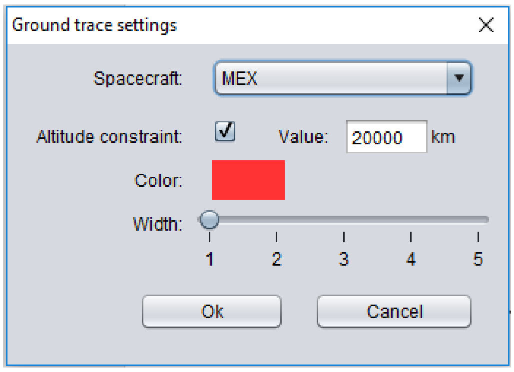




2DPlot function gives a 2D plot (X, Y, Z, |X, Y, Z|) of the different bodies position on the time interval of the scene with the possibility to save UTC stamped time values in a file.

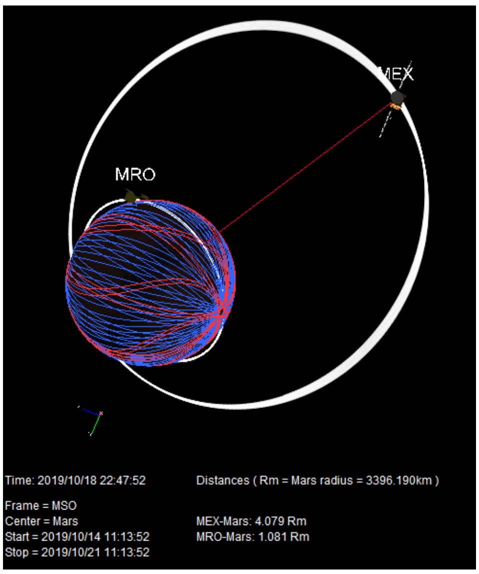
3.4.4.7 *View ground trace*

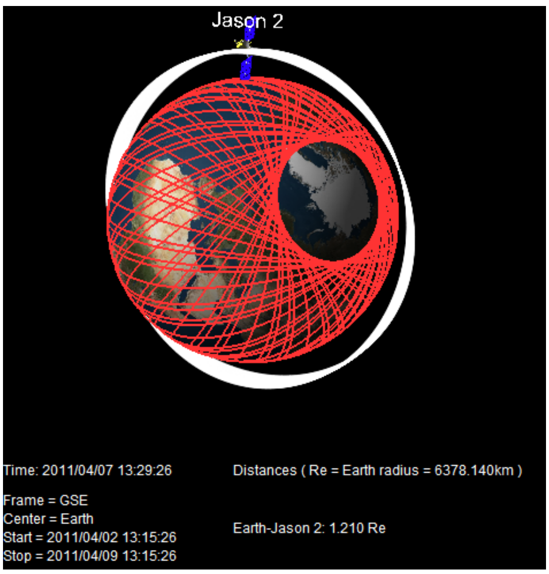
Used to display the ground trace of a spacecraft on the central body.



The maximum generation altitude of the ground trace allows generating the ground trace only once the distance between the spacecraft and central body surface is below this limit.

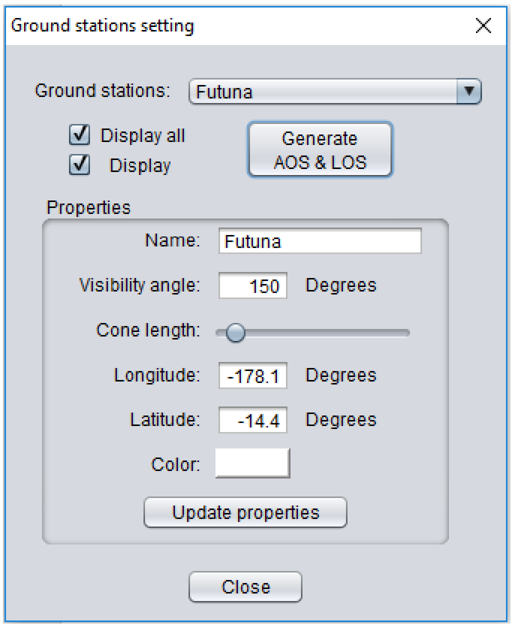
Examples:



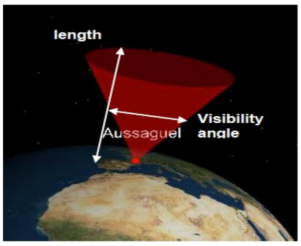


3.4.4.8 *View ground stations*

When the central body is the Earth, this menu allows visualizing the location of ground stations and their zone of influence.



This dialog box allows to choose the ground stations to be displayed among those proposed, in two different ways: All or One by one .
The Properties (visibility angle, long/lat) of the ground stations associated to a mission are recorded and filled by default.

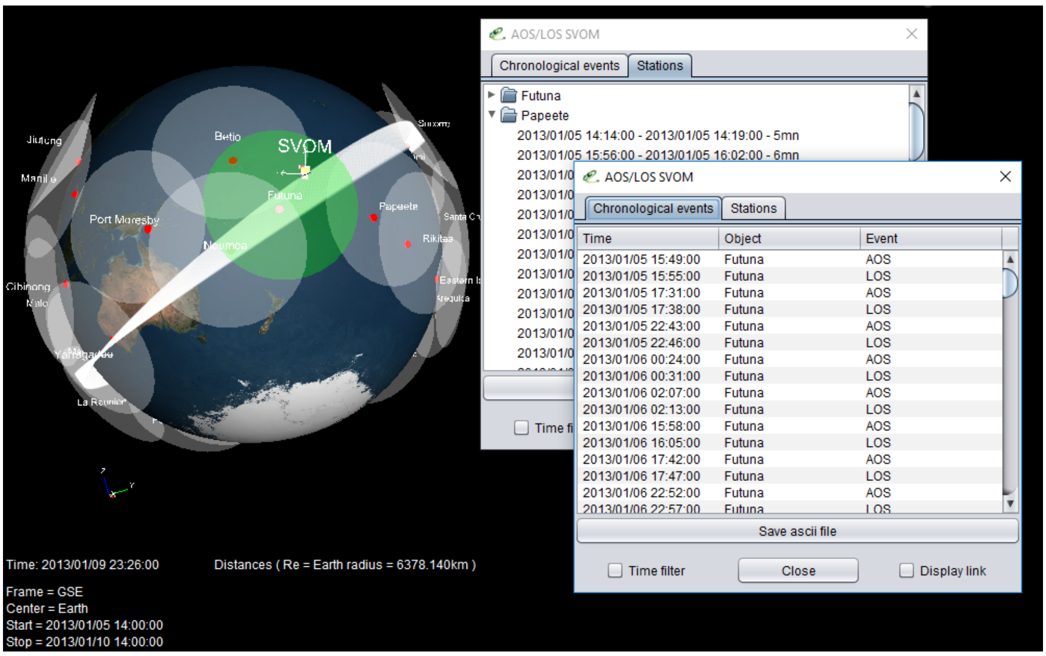


Only the cone length and te color can be changed
Changes are not retained after a restart of the application

The function **Generate AOS & LOS** allows to compute and display in separated windows the timestamped AOS and LOS, in the chronological order (all stations combined or station by station).
(The computation may take time)

When the spacecraft is flying over a ground station, the cone turns green.

Here is the example of SVOM satellite (on a simulated orbit):



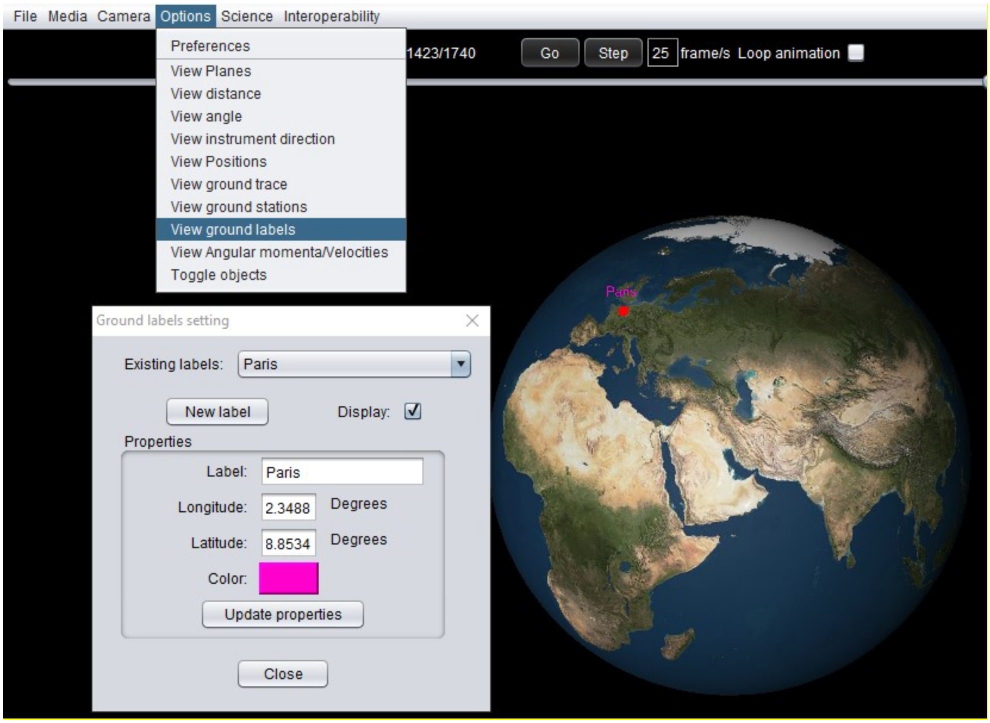
Warning: to benefit from this fucntion, the ground stations have to be associated to the spacecraft by the server administrator. Only SVOM and JASON-2 are updated for the moment.

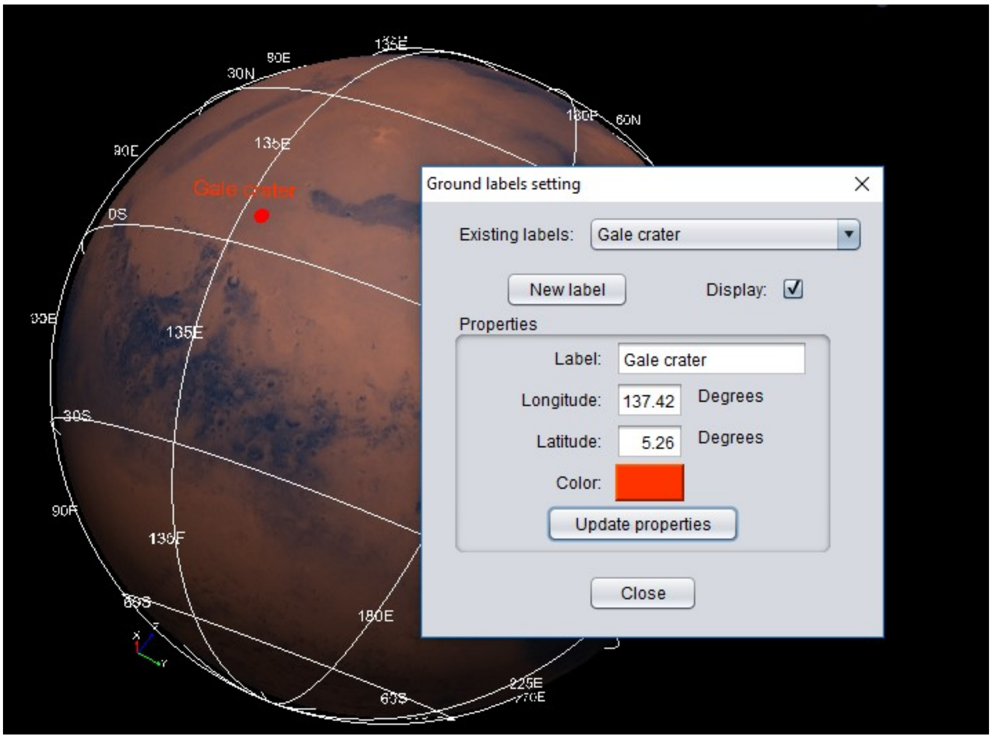
In any case, selecting "New" allows to add one or several stations (either existing or simulated) entering their parameters.

3.4.4.9 *View ground labels*

This menu allows setting labels on the central body. The dialog box allows either to choose an existing label (previously saved) or fill the text boxes for defining a new label (name, longitude, latitude, color) and update properties.

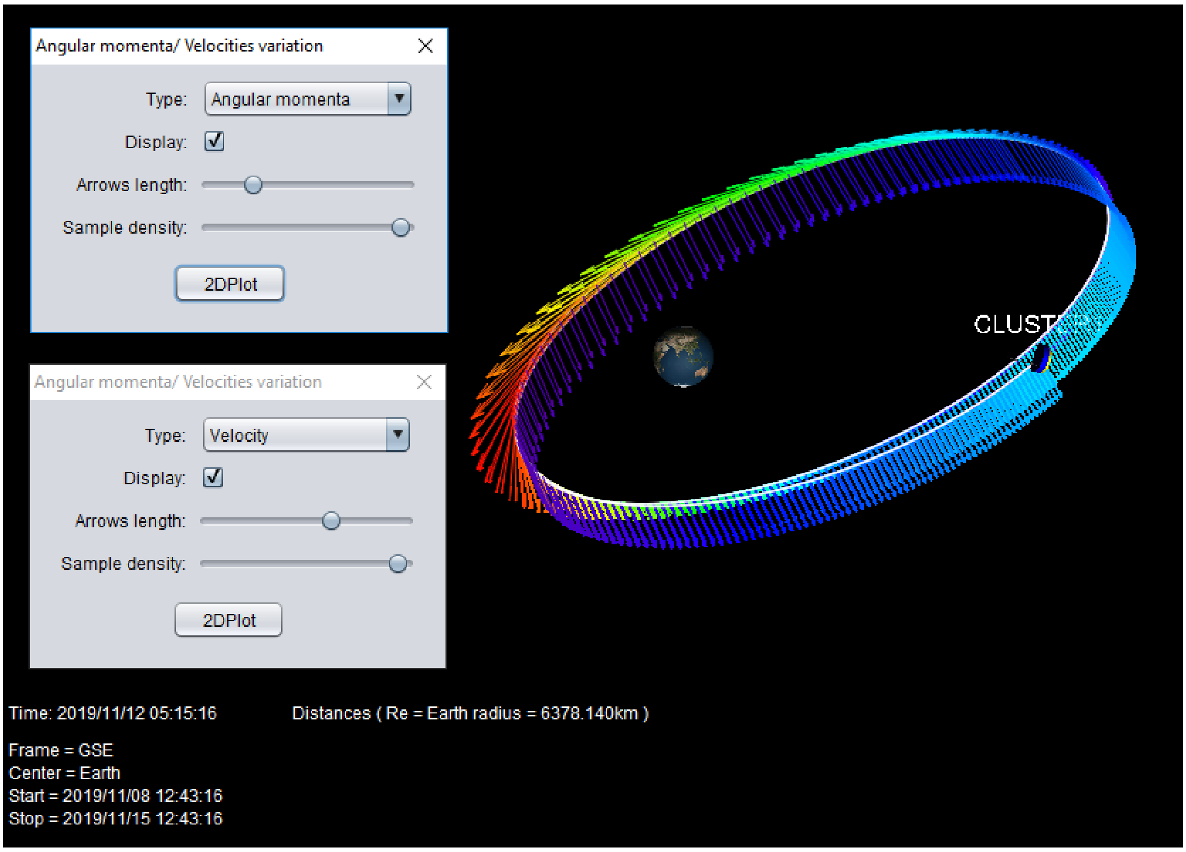
Examples:



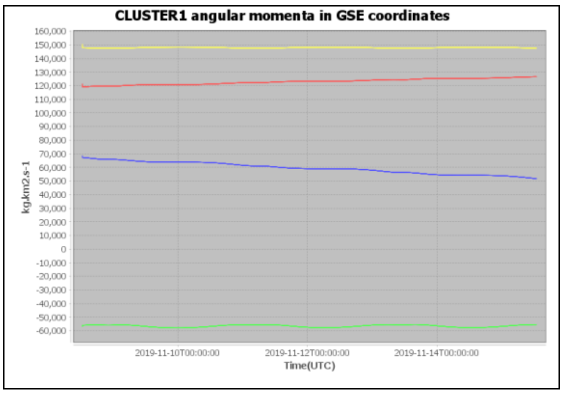


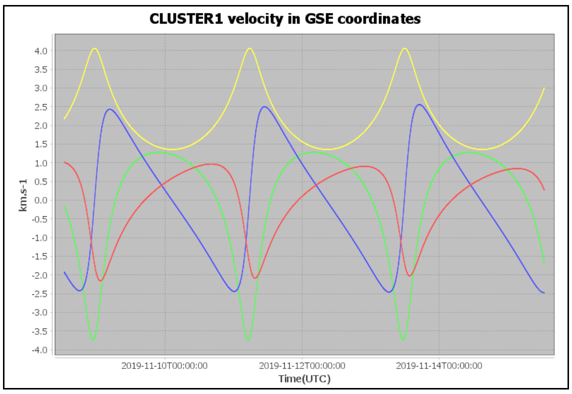
3.4.4.10 *View Angular momenta/Velocities*

This menu allows displaying Angular momenta and/or velocities of a spacecraft on its trajectory. Select Options>View Angular momenta/Velocities



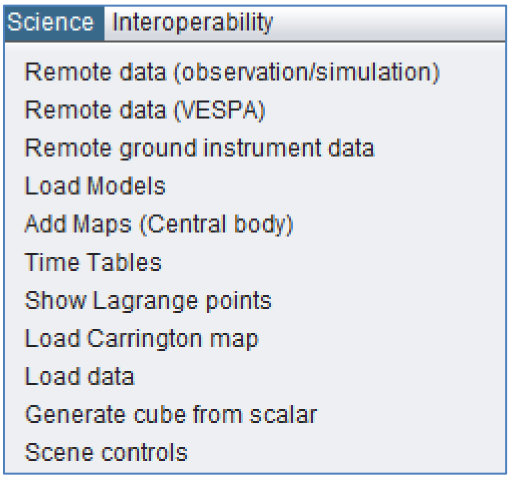
2DPlot function gives a 2D time series plot (X, Y, Z, |X, Y, Z|) of the angular momenta and velocity variation on the time interval of the scene:





3.4.5 Science

This menu provides a set of functions allowing to add on the 3D scene scientific observation data, maps and models coming from remote servers, 3DView server or user local disk.



3.4.5.1 Remote data (simulations/observations)

This function allows to add data (simulations and observations) in the graphic scene coming from external databases. Data are accessible via web services through a data tree interface, using the IMPEx [1] protocol.

3.4.5.1.1 Selection

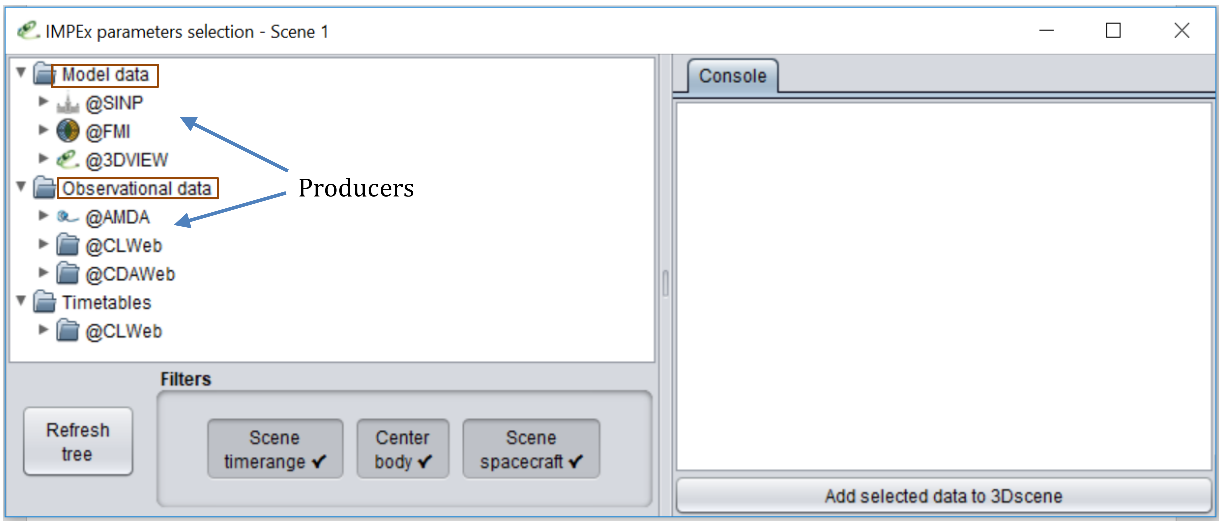
Two types of data are available:

- **Model data**, as Tsyganenko96, from labs producers' servers, available for natural bodies.
- **Observational data**, as magnetic/electric fields, particles density, temperature, pressure… from NASA/CDAWeb, CLWeb and AMDA servers (for the moment). They are displayed along the trajectories as scalar, vector or spectrogram.

The interface of the selection and preparation of data to be displayed is divided into 2 parts:

- the left part gives the list of available external data
- the right part displays, always the Console, and, if needed, other tabs when additional information must be given about selected data.

[1]IMPEX (Integrated Medium for Planetary Exploration) protocol builds bridges between scientific databases and online tools. Publication: European Planetary Science Congress 2014, EPSC Abstracts, Vol. 9, id. EPSC2014-159



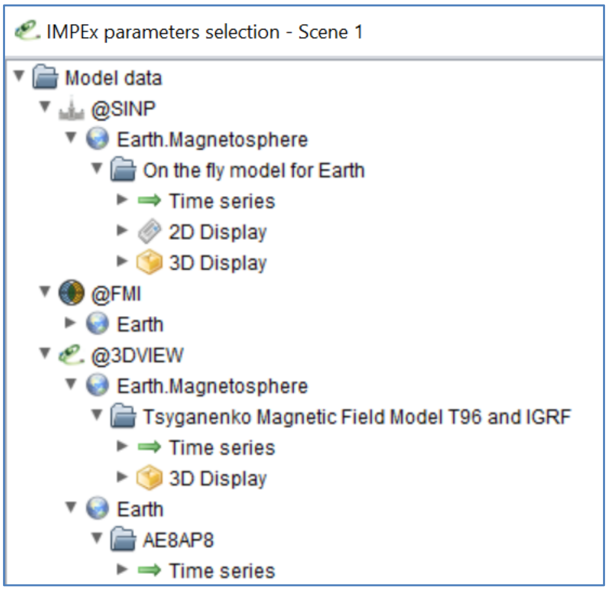
By default, the proposed data are filtered according to the **Central Body** and the **Time interval** of the **scene.**

The three filters may be desactivated to modify the proposed data:

- Scene timerange to extend the selection outside the scene time range. The data tree is then updated.
- Center body to extend the selection to all bodies. The data tree is then updated.
- Scene spacecraft to extend the selection to all spacecraft. A link to a new database is displayed.

Data is organized under 3 display types:

- Time series will contain scalar and vector parameters displayable along trajectory
- 2D Display contains 2D cuts and 3D Cubes (displayed as 2D slices)
- 3D Display show field/flow lines and spectrograms.

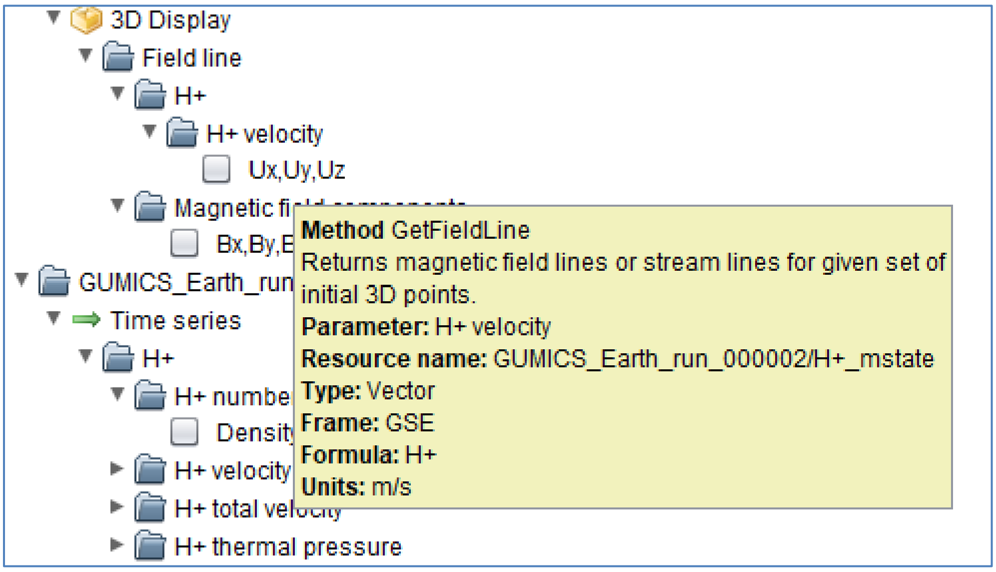


Hierarchy of available external data

Clicking on the left arrows expands the directories up to see the available data.

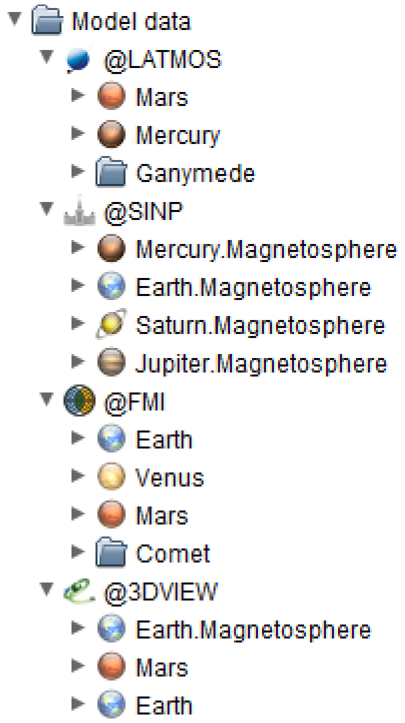
Passing the mouse on the wording data opens a tooltip giving detailed information about data.

Data appear with a box to be ticked to put them in the selection:



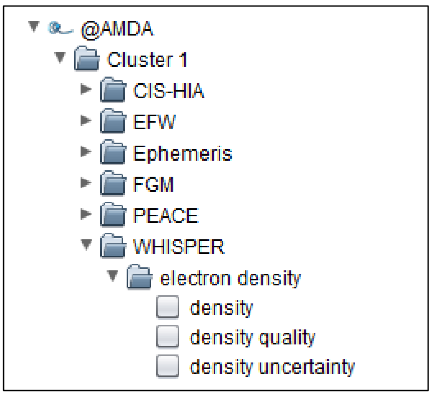
3.4.5.1.1.1 Models

List of planets and moons having models proposed by different providers (LATMOS, SINP, FMI…):



3.4.5.1.1.2 Observational data

They are proposed for the spacecraft available in the scene (CLUSTER1 at AMDA server in the example below) and the period of time of the scene.



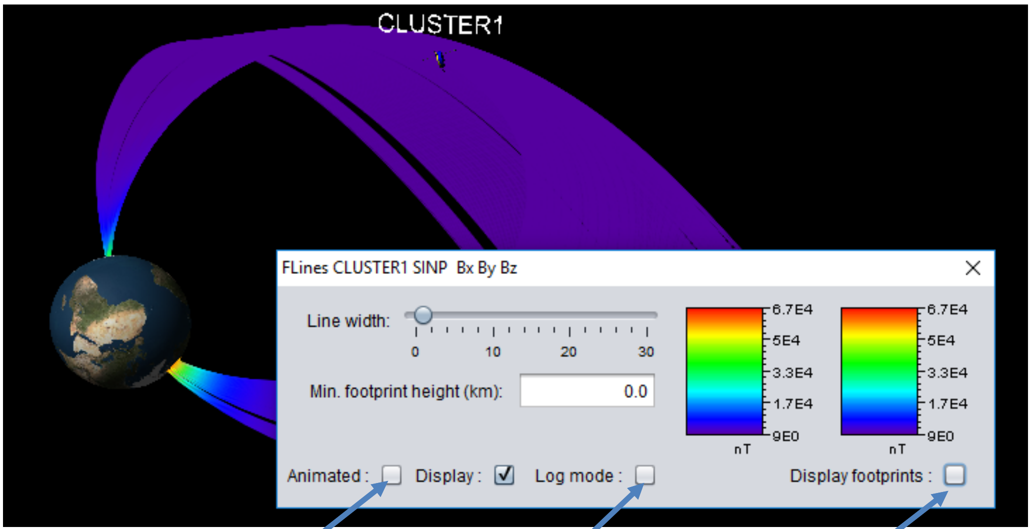
3.4.5.1.2 Launch

Once the data selected and prepared, clicking on the ***Add selected data to the 3D scene*** button to begin retrieving data from server.
If data on server has to be computed it can take a few minutes to obtain data.
You can play with the step in "Manage scene" to get less points and reduce the computing time.
If the model coordinate system is different from the scene one, 3DView will propose to convert data. The process can take some additional delay, especially for field lines.
At the end of the waiting dialog, data and its control window should appear.

3.4.5.1.3 Display

Each data type displayed in the 3D scene is associated to a specific control box allowing to change the data representation.

Example with the Earth Magnetic field lines model T96 passing through CLUSTER1 trajectory:

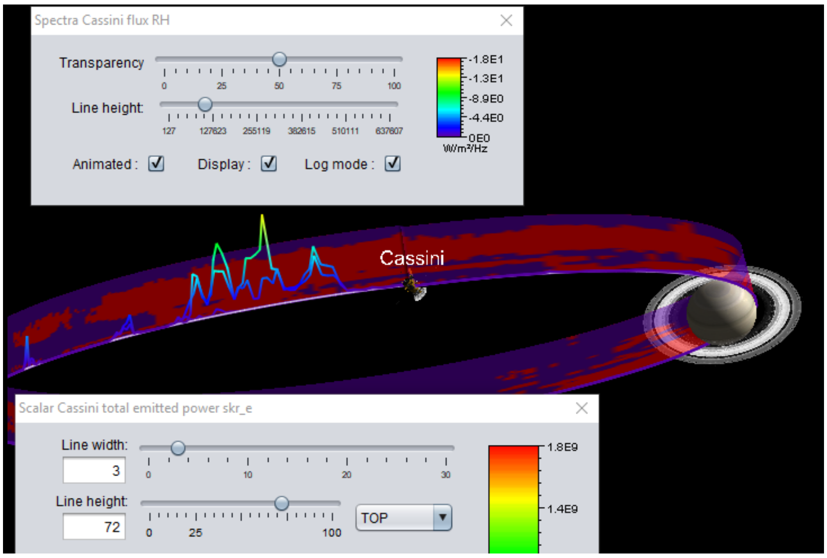


Display of only the line passing through the S/C (by default)

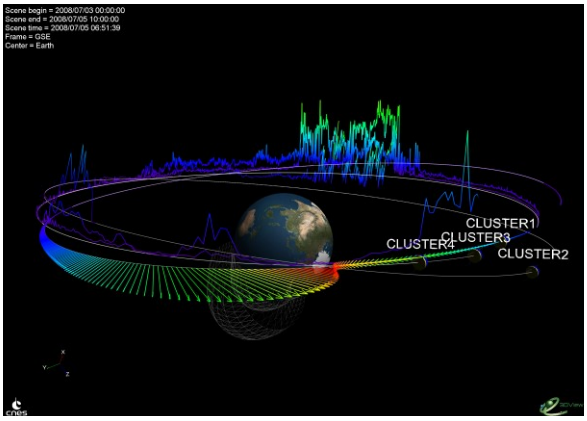
Display in Log mode

Display of lines footprints

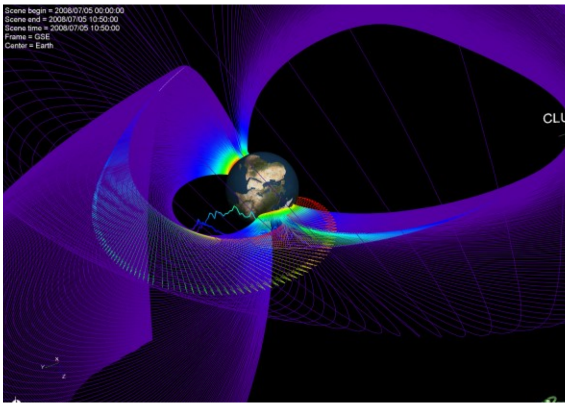
Example with the SKR total power and energy flux displayed along the CASSINI trajectory:



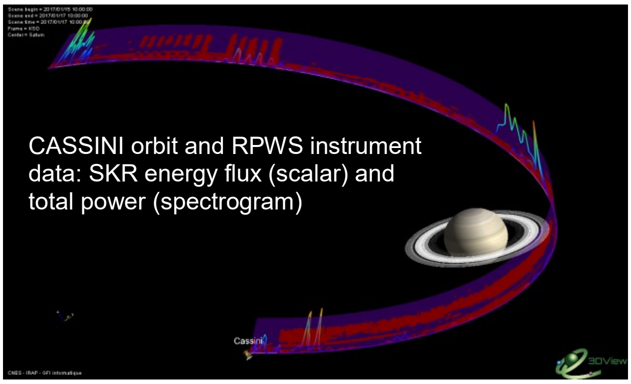
Examples of scientific data displays



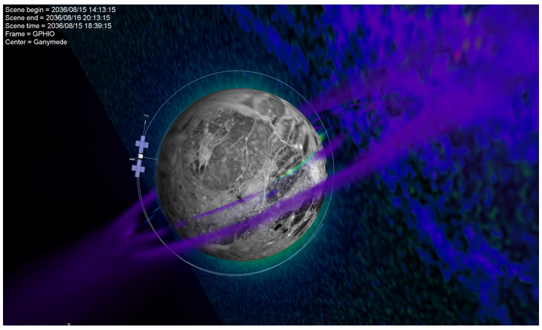
Scientific observational data displayed as scalars and vectors along the 4 CLUSTER spacecraft trajectories



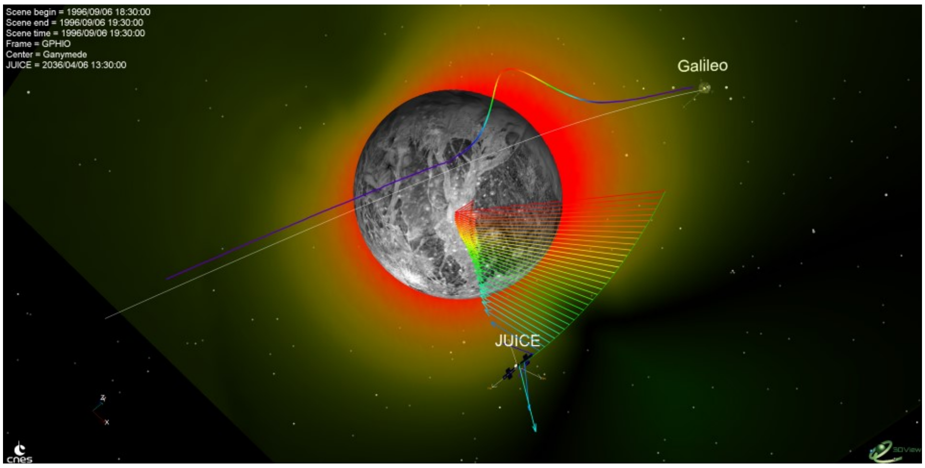
Magnetic field from CLUSTER1 along the orbit in the Earth environment (T96 model)



CASSINI orbit and RPWS instrument data: SKR energy flux (scalar) and total power (spectrogram)



Simulated JUICE orbit around Ganymede in 2036 with magnetic, electric and temperature fields models

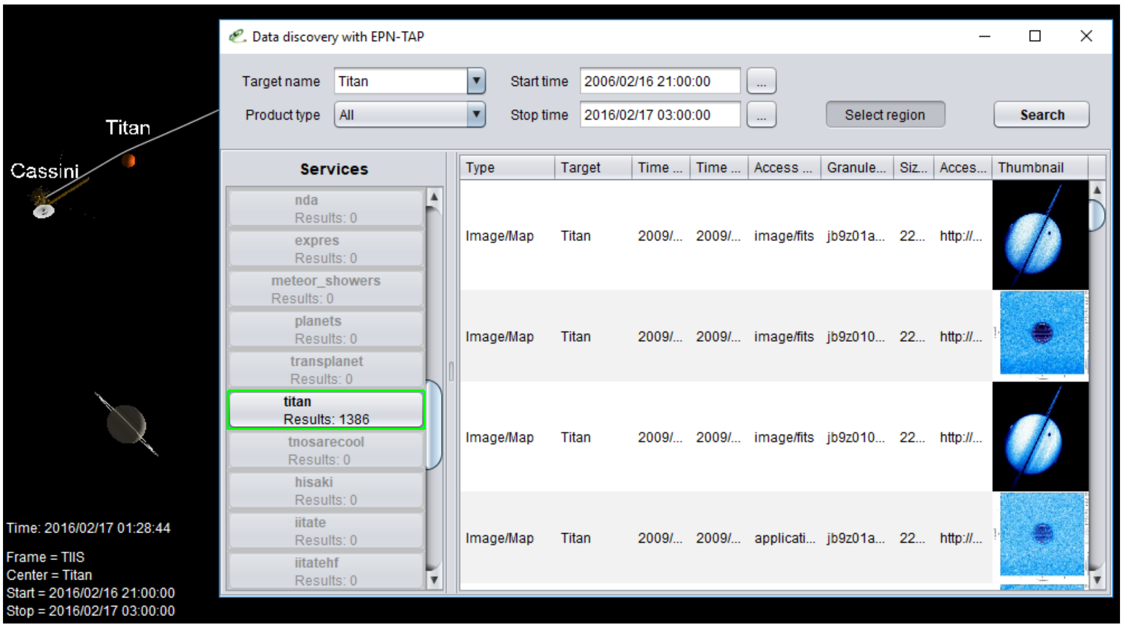


Flybys of Juice and Galileo over Ganymede
in the same scene by shifting the Juice orbit of 40 years.
The Ganymede environment model comes from LATMOS server

↳ How to display some scenes is described in Appendix A.

3.4.5.2 *Remote data (VESPA)*

This option is used to search for data provided through VESPA[2] with EPN-TAP protocol.



Depending on the file type, a right click on a line allows to download or view the corresponding product.

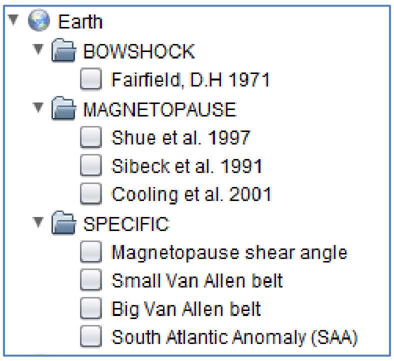
3.4.5.3 *Remote ground instrument data*

This menu is similar to the Remote Data menu, for Ground instruments data.

3.4.5.4 *Load Models*

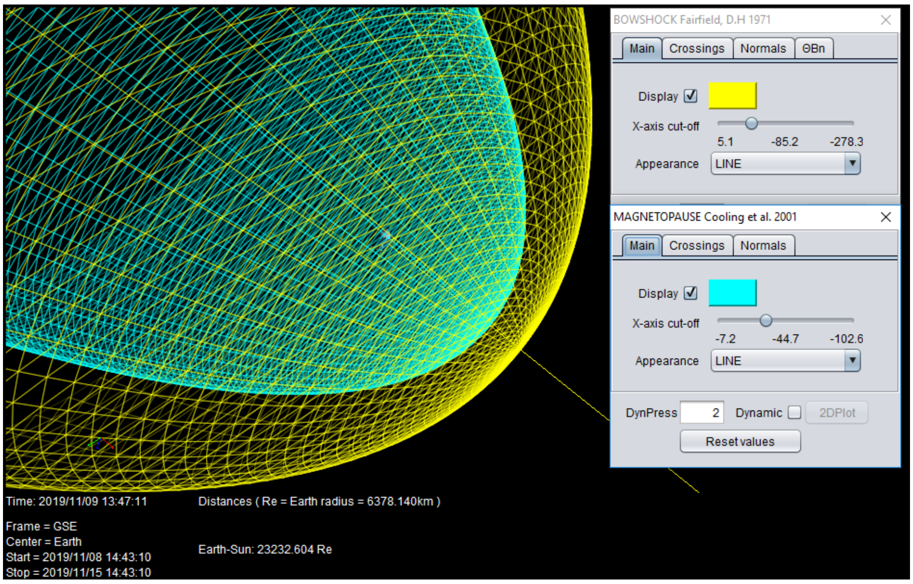
This function allows to display analytical models (Magnetopause, Bow shock, Parker spiral, ...) for central bodies (Earth, Mars, Venus and Sun for the moment).

3.4.5.4.1 Earth models



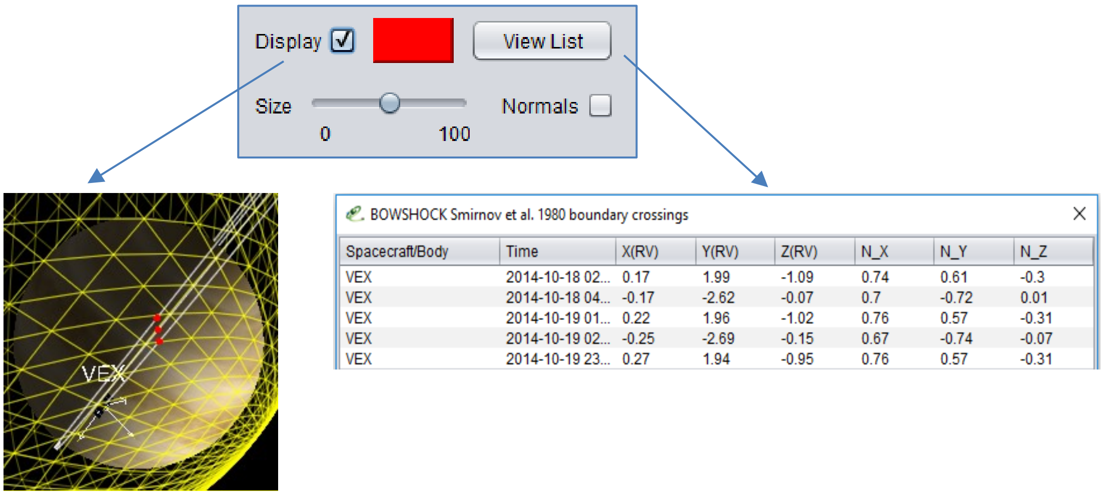
[2] VESPA (Virtual European Solar and Planetary Access): http://www.europlanet-vespa.eu/

3.4.5.4.1.1 *Bow shock and Magnetopause boundaries*



The control box associated to the model allows:

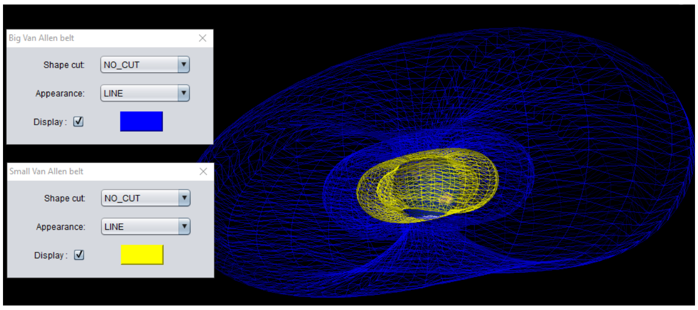
- [Main tab] to change its appearance: length, colour, display mode (line, fill, points)
- [Crossing tab] to add the display crossings of the model's boundary by the spacecraft (as little red dots whose colour and size can be adjusted, and list can be displayed)

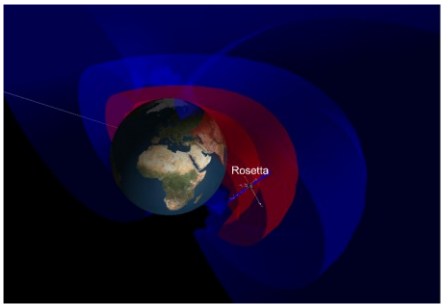


Spacecraft/Body	Time	X(RV)	Y(RV)	Z(RV)	N_X	N_Y	N_Z
VEX	2014-10-18 02...	0.17	1.99	-1.09	0.74	0.61	-0.3
VEX	2014-10-18 04...	-0.17	-2.62	-0.07	0.7	-0.72	0.01
VEX	2014-10-19 01...	0.22	1.96	-1.02	0.76	0.57	-0.31
VEX	2014-10-19 02...	-0.25	-2.69	-0.15	0.67	-0.74	-0.07
VEX	2014-10-19 23...	0.27	1.94	-0.95	0.76	0.57	-0.31

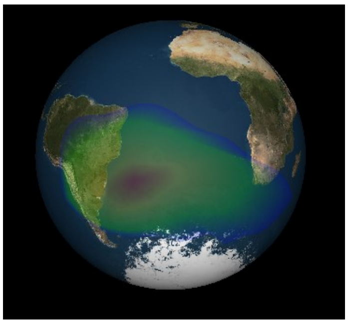
3.4.5.4.1.2 *Van Allen belt*

For each radiation belt, it is possible to select different display modes (point (POINT), wired (LINE) and full (FILL)) and cutting (no cutting, ½, ¼, ¾). Examples:





3.4.5.4.1.3 South Atlantic Anomaly



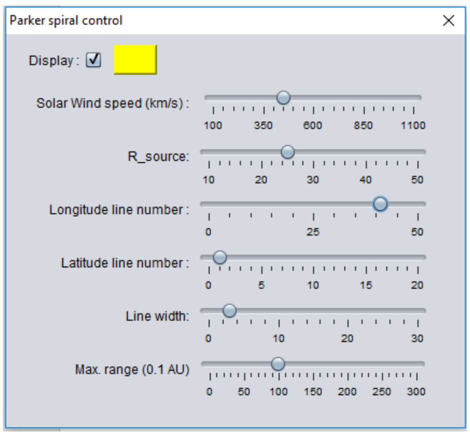
3.4.5.4.2 Sun models

3.4.5.4.2.1 Solar Parker spiral

Three options are provided to display the Parker Spiral

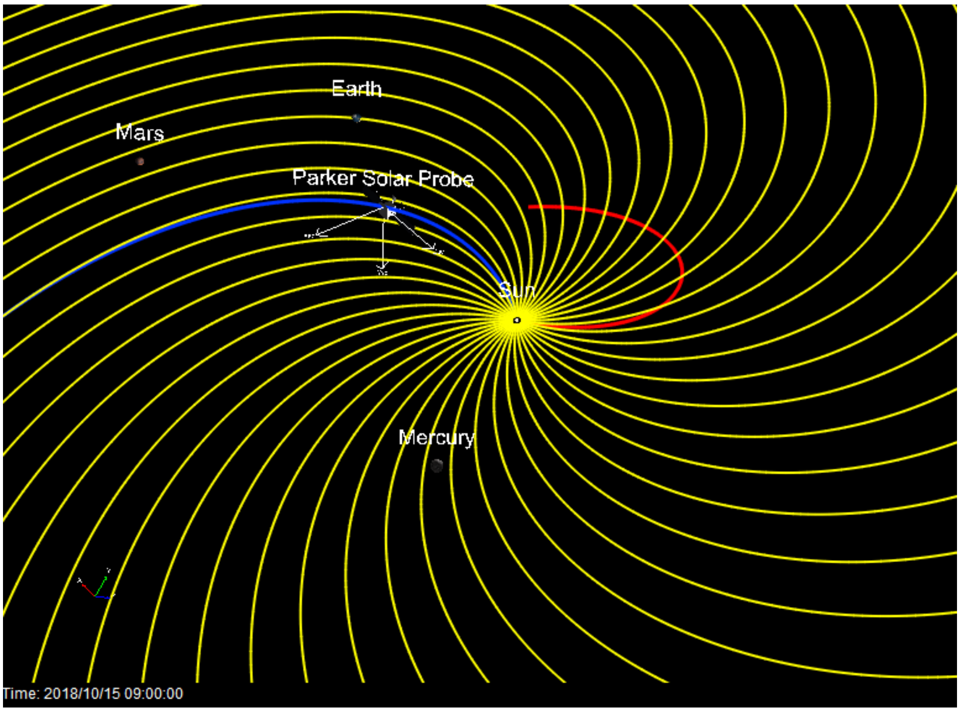
- Free (Yellow on the scene hereafter): displays a set of lines
- Fixed point (Red on the example hereafter): displays one line depending on one point defined by the user
- Follow scene object (Blue line on the example hereafter going through PSP spacecraft): displays one line depending on the trajectory of a spacecraft

The representation of the spiral can be defined through a control box, as the following:



Control box allowing to adjust the parameters of the free spiral

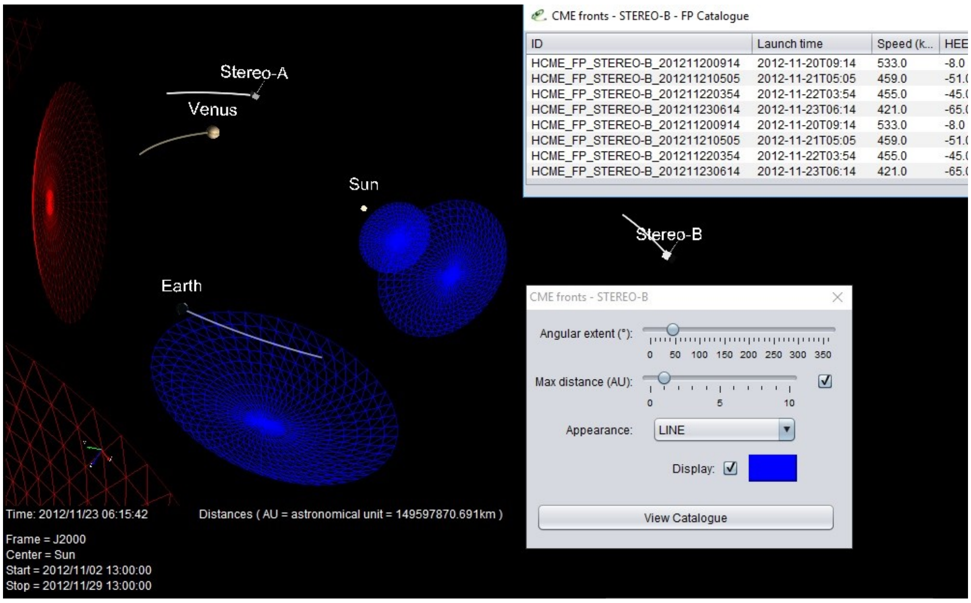
Example of Parker spiral displayed on a scene with Parker Solar Probe:



3.4.5.4.2.2 CME fronts

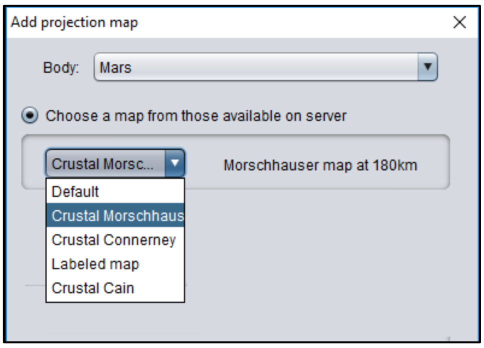
Use this option to display CME frontiers observed by STEREO-A or STEREO-B.

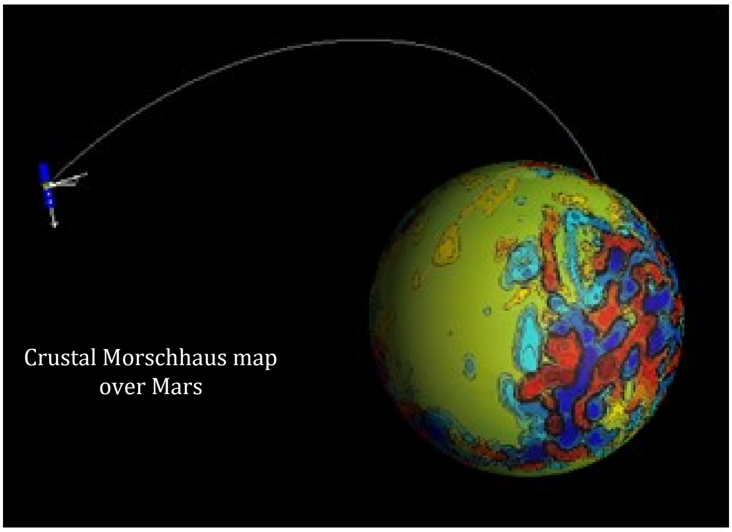
Example of CME fronts displayed on a scene with Stereo-A and Stereo-B:



3.4.5.5 Add Maps

This option allows projecting a map on a body from a list on the 3DView server.

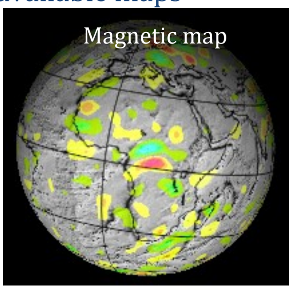


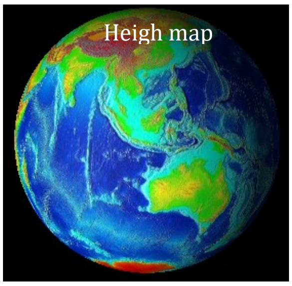


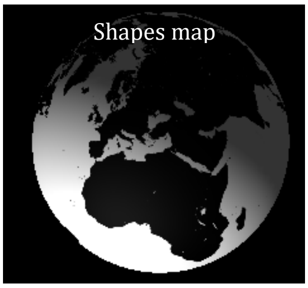
The altitude of the projection can be chosen

Some other available maps

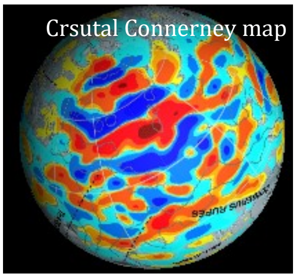
Earth maps:

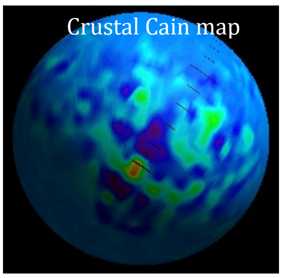


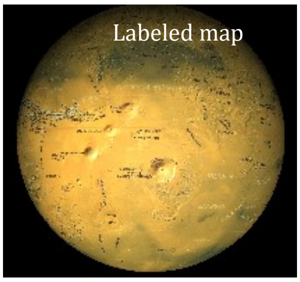




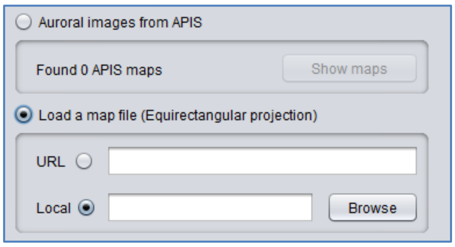
Mars maps:







Maps can also come from APIS[3] service, local disk or a user URL.



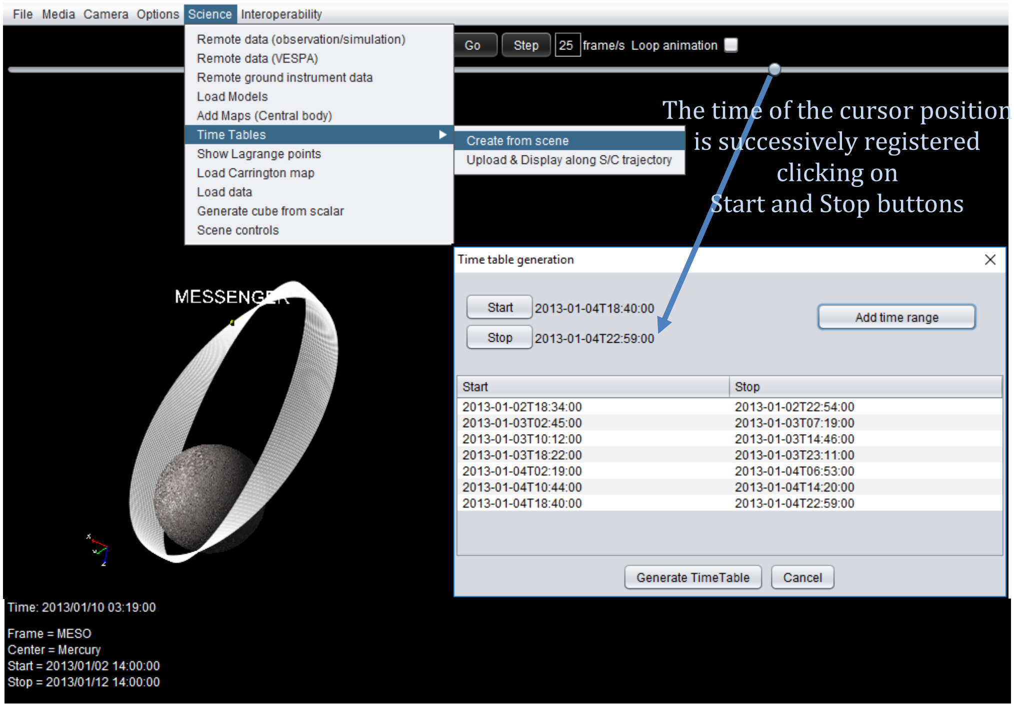
[3] APIS : Auroral Planetary Imaging and Spectroscopy

3.4.5.6 *Time Tables*

A Timetable is a series of intervals of time (as characterization of particular events).
3DView allows the creation of Timetables from the orbit display on the scene, as well as the visualization of Timetables uploaded from local or remote servers.

3.4.5.6.1 Create from scene

The generation of Time Tables from a 3DView scene is made by selecting time intervals from the animation bar.
After positioning the animation cursor at START and STOP times, the user clicks on the *Add time range* button to save the corresponding time period. This operation is repeated as many times as periods to create.



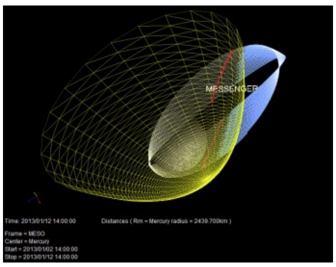
At the end of this iterative process, clicking on the *Generate Time Table* button saves the set of time intervals on a local disk with an ".xml" extension.

3.4.5.6.2 Upload and display along S/C trajectory

A Time Table can be uploaded either from an URL address or from a local disk

The corresponding periods are displayed along the S/C trajectory. Every portion of the trajectory corresponding to a time interval belonging to the Time is highlighted/colored.

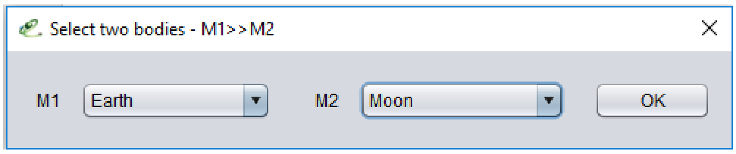
Example of Solar wind intervals observed by MESSENGER on 10 days.

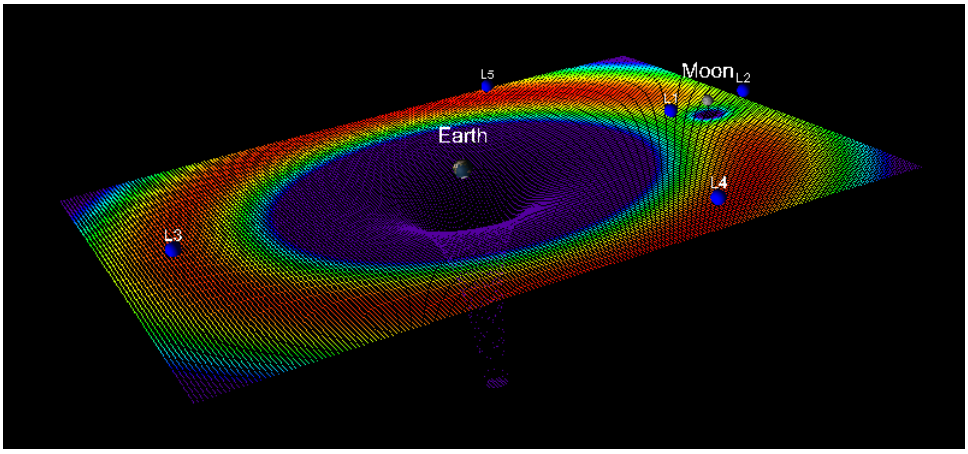


The time tables may come from an ".xml" file previously saved or from search tools, data mining on mathematical criteria applied on the content of databases, or on machine learning algorithms.

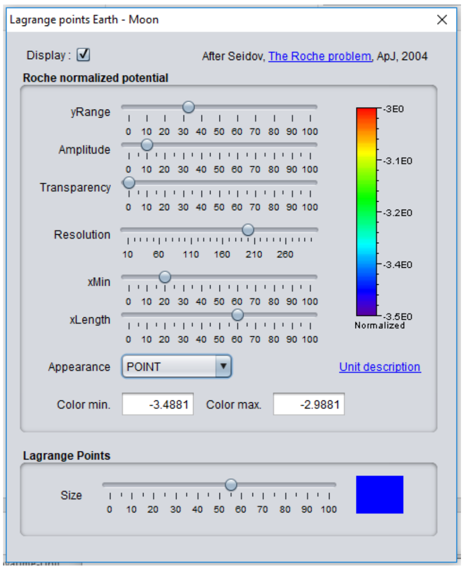
3.4.5.7 *Show Lagrange points/Roche normalized potential*

This function displays the Lagrange points and the normalized potential on any two-body system.
You have to first select two bodies already in the scene (body 1 mass >> body 2 mass), then click ok to display normalized potential and Lagrange points in the scene.



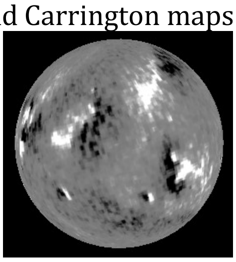


Example on the Earth-moon system



The associated control box allows to change appearance of normalized potential sheet.
yRange, xMin and xLength are used to change the plane size.
To change color range, modify min or max value and hit Enter key on the corresponding input.
If Lagrange points are not visible or too big, use the bottom size control to adjust it.

3.4.5.8 *Load Carrington map*

This option is used to add Carrington maps from STEREO or SDO to the Sun as central body.MONG/MAG map : 

3.4.5.9 Load data

This option is used to upload a data file related to a spacecraft. Data will be displayed along the spacecraft trajectory.

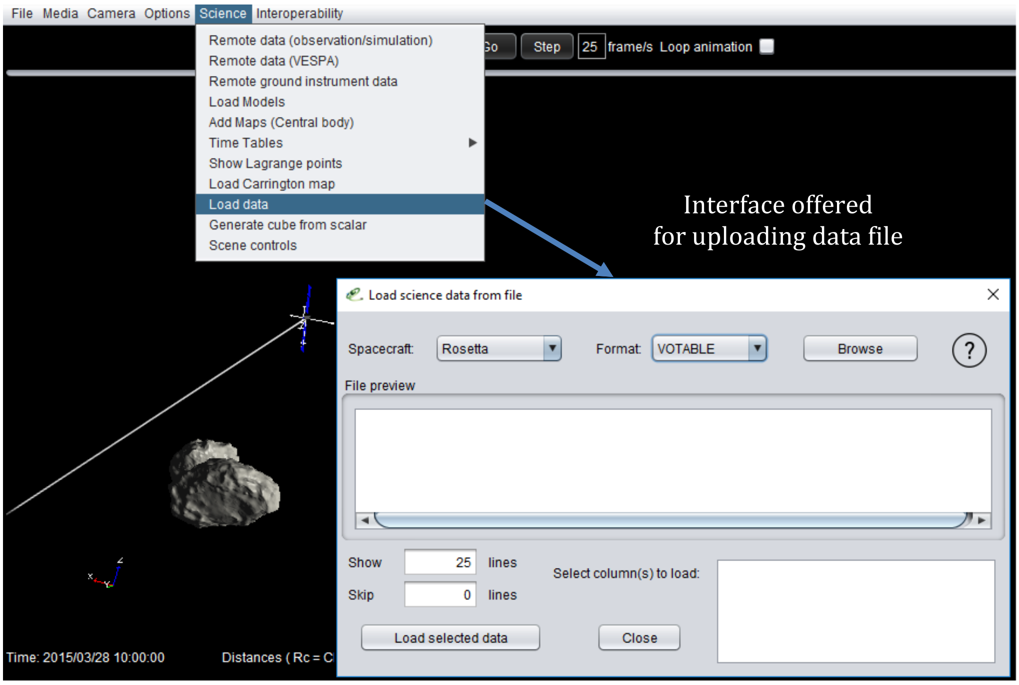
Only timeseries can be uploaded and only scalars and vectors can be selected for scene display.

The authorized formats are the following: VOTABLE, ASCII, CSV, CDF, NetCDF.
The Help explains the specificities of each format.

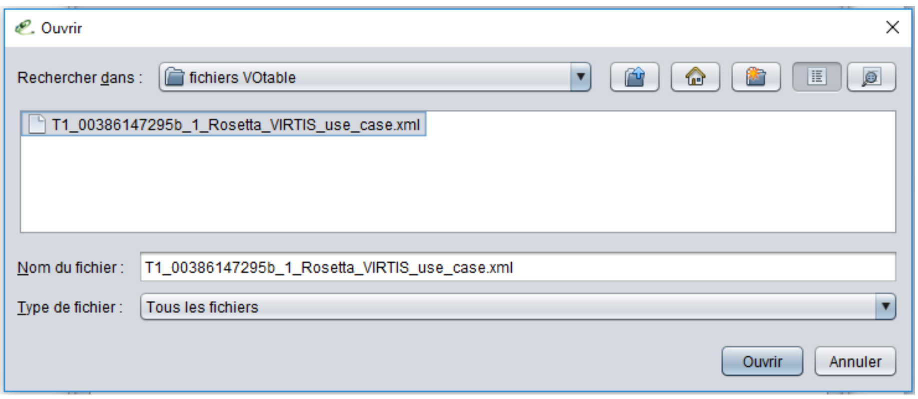
The interface allows to choose the spacecraft, the file format and the data file on local disk to be opened (*Browse* button). The file is then previewed (the number of **shown** lines by default (25) can be changed), and the user has to enter:

- the number of **lines to be skipped** (not to be processed), in general to skip the header
- the **columns** to be displayed (one for a scalar, three for a vector)

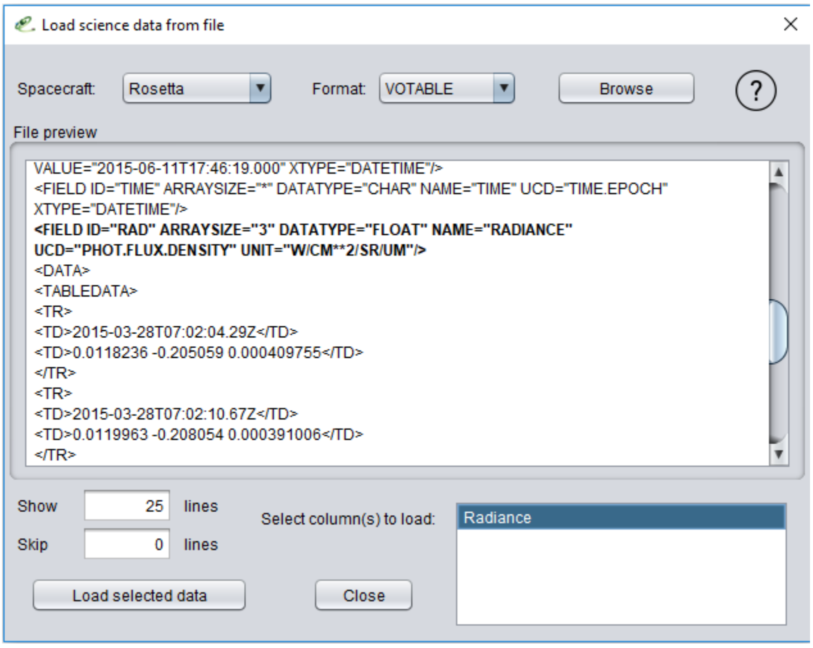
Here is an example of data upload and display along the Rosetta trajectory (VOTABLE format).



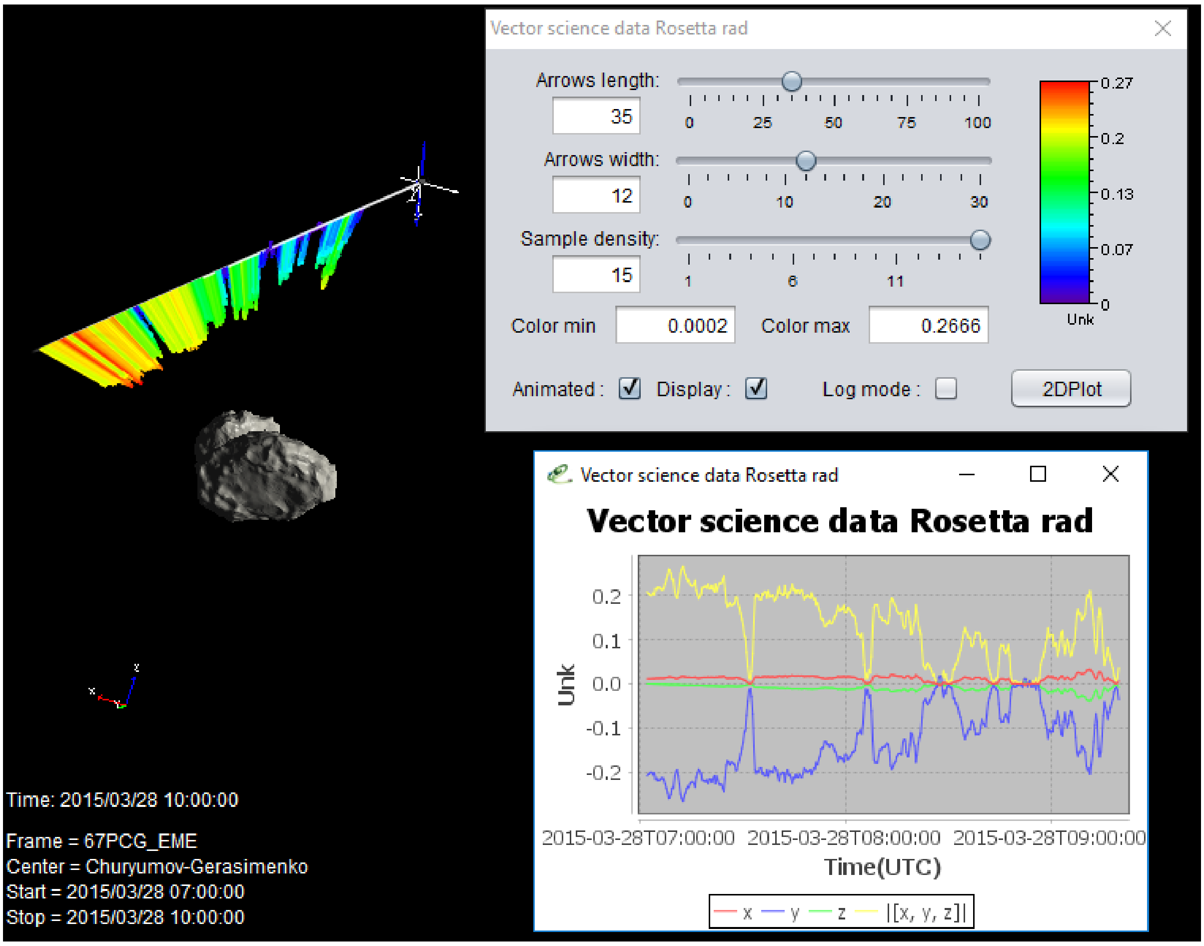
Load of data file:



File Preview:



The *Load selected data* button displays the selected data and opens a dialog box allowing to adjust the settings of the 3D display and plot data in 2D.

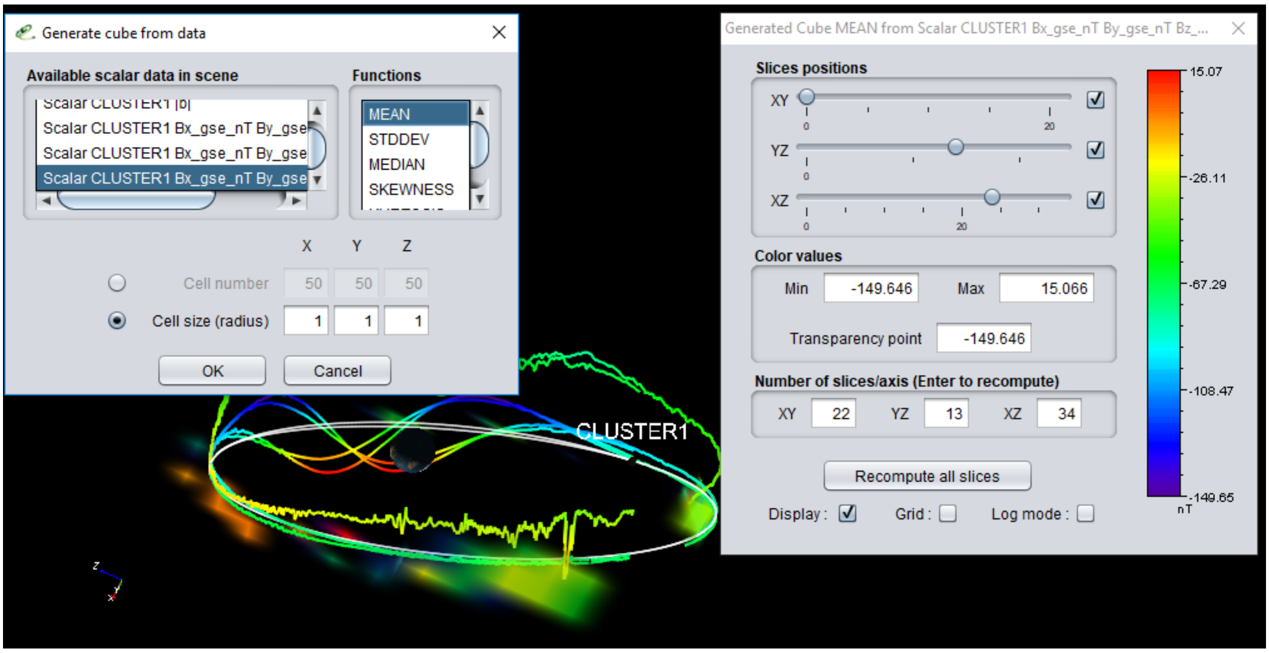


3.4.5.10 *Generate cube from scalar*

This option allows the display of 3D "histograms" along a trajectory.

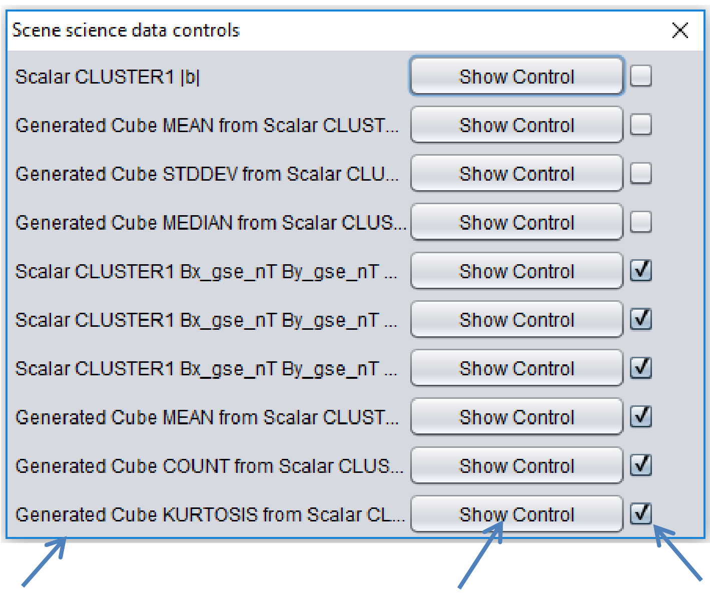
The values of a parameter along the trajectory of a spacecraft are accumulated in a grid of parallelepipeds.

User may set the size of these parallelepipeds through a control box.



3.4.5.11 *Scene controls*

This option is used to control plots in the 3D scene:



Name of all the control boxes associated to the session

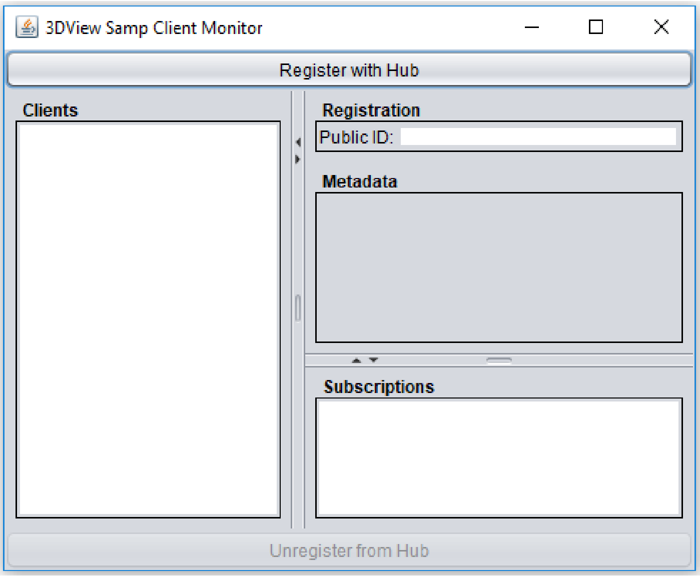
Show/Hide Control box

Show/Hide plot in the 3D scene

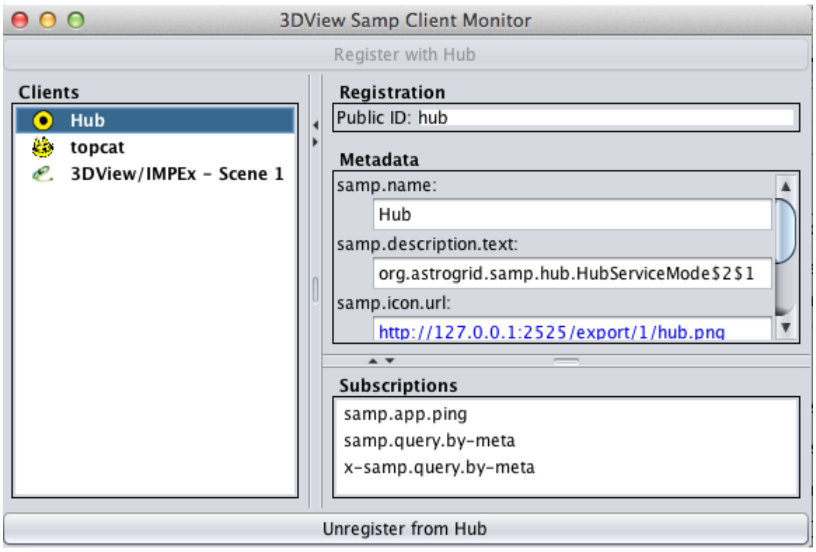
3.4.6 Interoperability

3.4.6.1 SAMP

This option is used to set up a connection between 3DView and a SAMP[4] Hub. A SAMP Hub must be active, via TOPCat or AMDA for example. Data provided to 3DView via SAMP are displayed along the trajectory of a spacecraft.

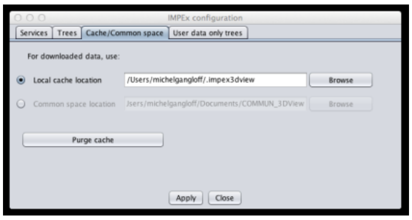


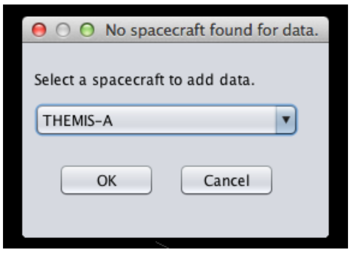
Click on **Register with Hub** to connect 3DView to the Hub. This opens the following window:



As soon as data are available on the SAMP Hub, the following pop-up window is displayed by 3DView. Select the spacecraft name. Data are then displayed along its trajectory.

[4] SAMP (Simple Application Messaging Protocol): https://wiki.ivoa.net/twiki/bin/view/IVOA/SampInfo





3.4.6.2 IMPEX configuration

3.4.6.2.1 Services

This option displays the URL of IMPEx services providing access to observations and simulations.

3.4.6.2.2 Trees

This option displays the URL of IMPEx files providing the description of simulation resources:

3.4.6.2.3 Cache/Common space

This option is used to give the name of a local directory used to store shared information and data.

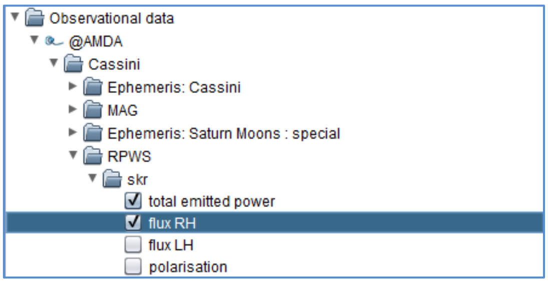
3.4.6.2.4 User data only trees

This option is used to add a new tree of simulation data. This tree of data is made accessible via the Remote data (IMPEx) menu.

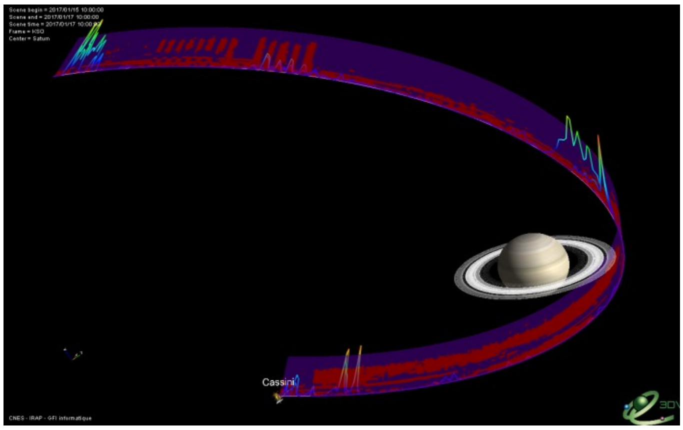
4 APPENDIX A: Tutorial for some 3DView visualizations

A.1: **CASSINI** orbit and **RPWS** instrument **data** (SKR energy flux (spectrogram) and total power (scalar)) visualization

1- Select **CASSINI** and directly click on **OK** button
2- Menu **Science/Remote data**
3- In the data tree select in the **Observational data** the RPWS Saturn kilometric radiation (skr) from AMDA service as below:

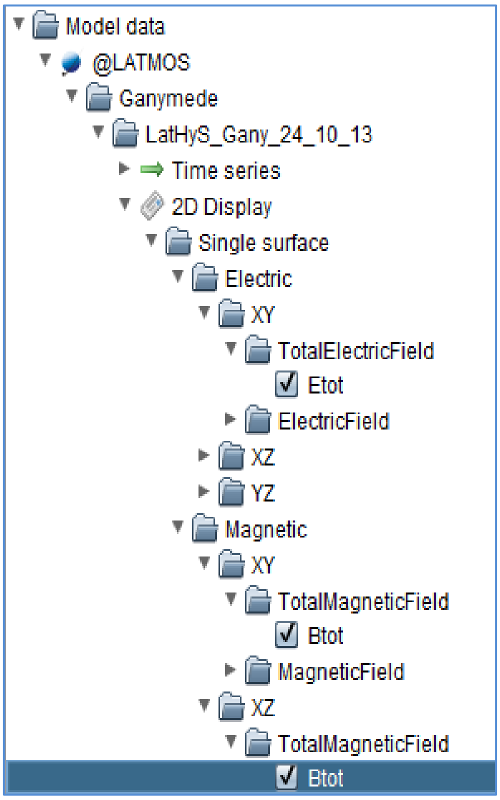


4- Click on **Add selected data to the scene**
5- Move the graphic scene

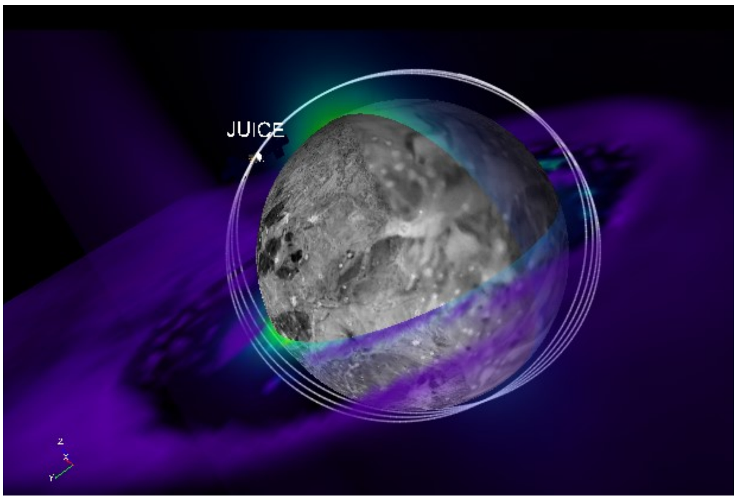


A.2: **Simulated JUICE orbit** around **Ganymede** in **2036** with magnetic, electric and temperature fields models (2D cuts)

1- Select **JUICE**, change the **Body center** for **Ganymede**, and the **Step** to 60 seconds. Click on **OK** button.
2- Menu Options/Preferences: increase the body JUICE a little
3- Menu **Science/Remote data**
4- In the data tree select the in **Model LATMOS data, the electric** and **magnetic 2D cuts** as below:

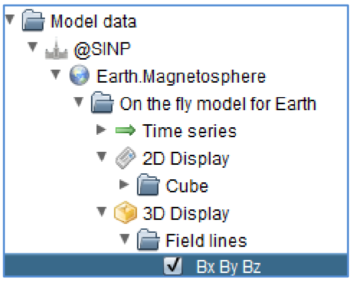


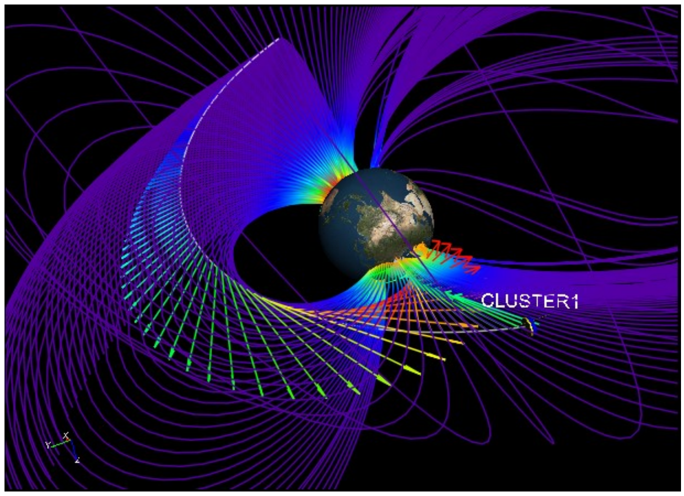
5- Click on **Add selected data to the scene**
6- Move the graphic scene
7- Use the control boxes to change the plots



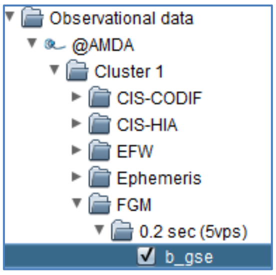
A.3: Visualization of **Magnetic field** from CLUSTER1 along the orbit (vectors) in the Earth magnetic environment (T96 model: field lines)

1- Select **CLUSTER1; Stat Time: 2008/07/05; Stop Time: 2008/07/06;** click on **OK** button
2- Menu **Science/Remote data**
3- In the data tree select in the **SINP model** the 3D magnetic field lines as below:

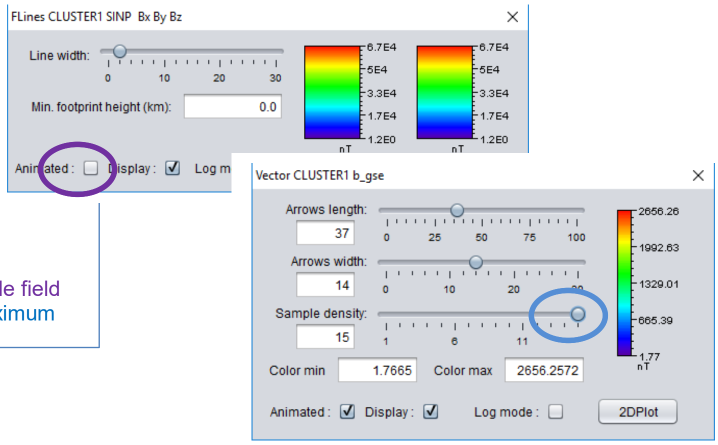




4- In the data tree select in the **Observational data** the FGM data as below:



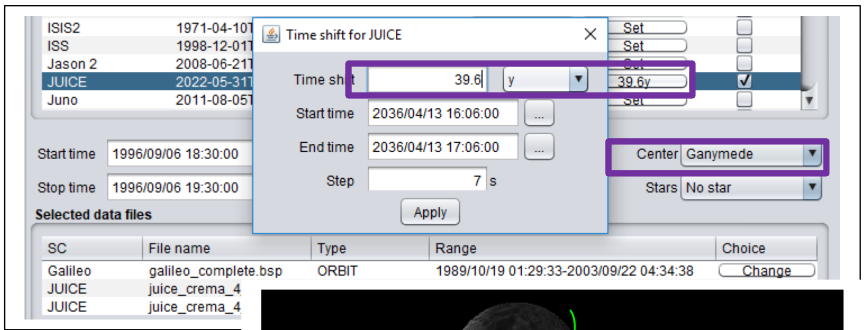
5- Click on **Add selected data to the scene**
6- Move the graphic scene
7- Use the control boxes to change the plots:
a. Unselect the box "Animated" to have the whole field
b. Push the Sample density (vectors) to the maximum

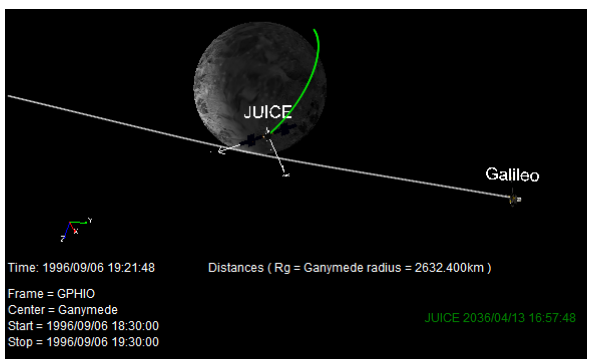


A.4: Plots for preparing the flybys of **Juice** over Ganymede (2036) using the **Galileo** flyby 1996) data shifting the Juice orbit of 40 years.

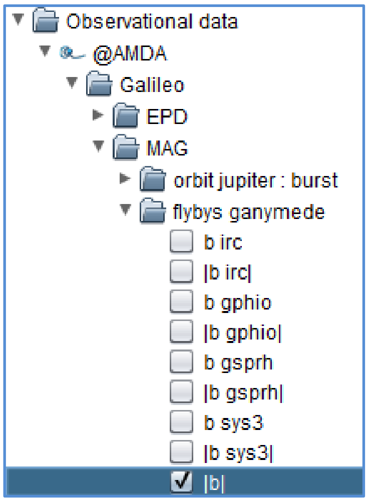
1- Select **Galileo**. **C**hange the **Body center** for **Ganymede**, and the **period of time by 1996/09/06 18:30:00 - 1996/09/06 19:30:00**

2- Select **JUICE**. Change the **Body center** for **Ganymede**. Use the Time shift function to shift **of 39.6 years** (Enter) the period of time (1996/09/06) for JUICE to correspond to its own flyby in 2036. In the scene, the shifted JUICE orbit is displayed in green.

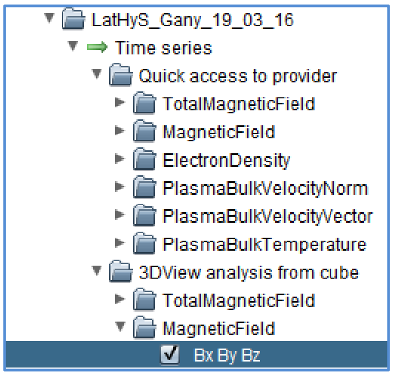




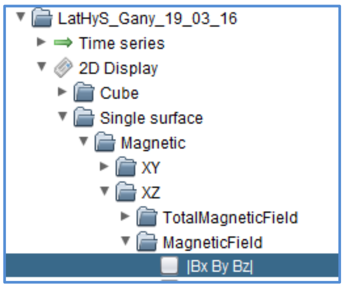
3- Menu **Science/Remote data**
4- In the data tree first deselect the Center body filter (the tree is then reconstructed adding the Ganymede models)
5- Select in the AMDA data the **MAG** magnetic field amplitude (**|b|**) to be plotted on the Galileo trajectory (by default) and add to the scene.



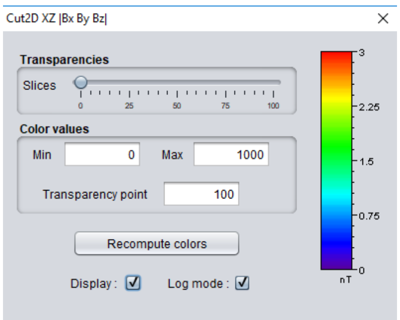
6- **In the LATMOS Ganymede Model data/ LatHyS_Gany_19-03-16, select the Magnetic field (Bx, By, Bz) in 3DView analysis (Time series) to be plotted on the JUICE trajectory!**

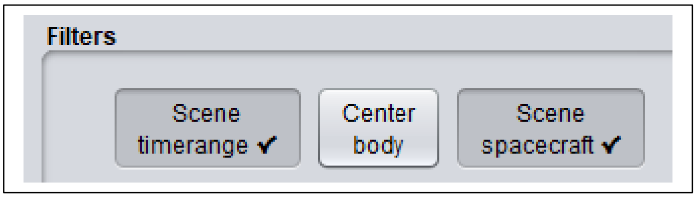


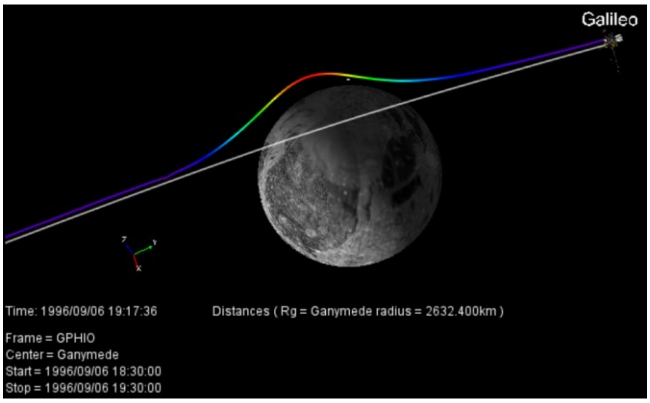
7- **Select now in the 2D Display the Magnetic field |Bx, By, Bz| to be plotted on the XZ plane.**

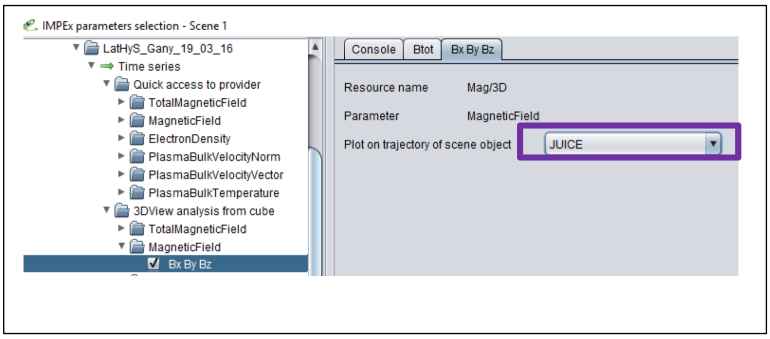


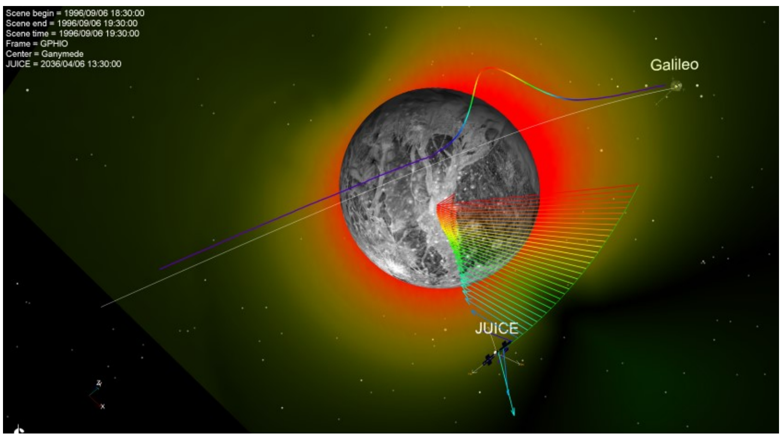
8- Use the associated control box to change the 2D Cut plot as below:
Color max= 1000, Log Mode **and Recompute colors**





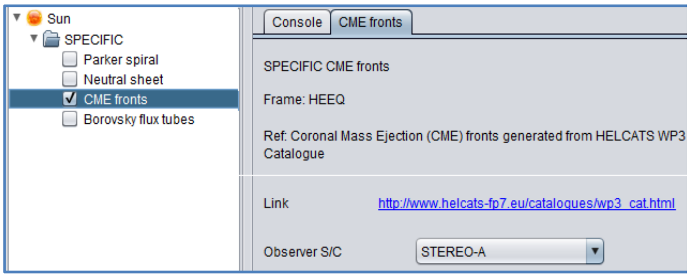




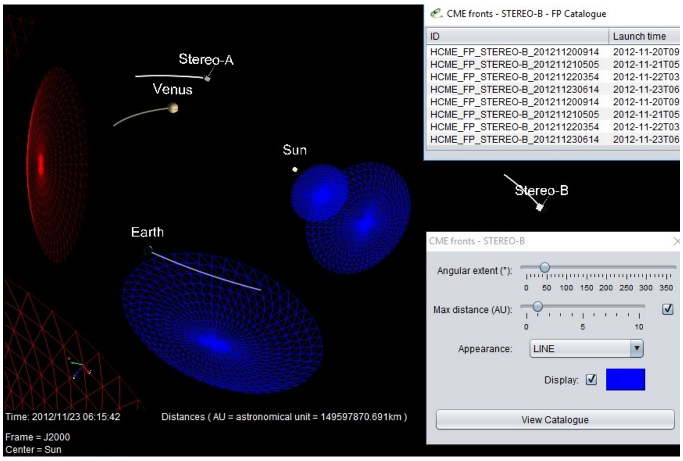


A.5 : Visualization of **Coronal Mass Ejections** (CME) fronts expanding in the heliosphere (HELCAT catalog)

1- Select **STEREO-A and STEREO-B S/C on the period of time: 2012/11/02 13:00:00 - 2012/11/29 13:00:00.**
2- Add Natural bodies: Earth and Venus
3- Move the graphic scene (heliocentric view)
4- **Science/Load models**
5- Select CME, once with STEREO-A as observer, again for STEREO-B.



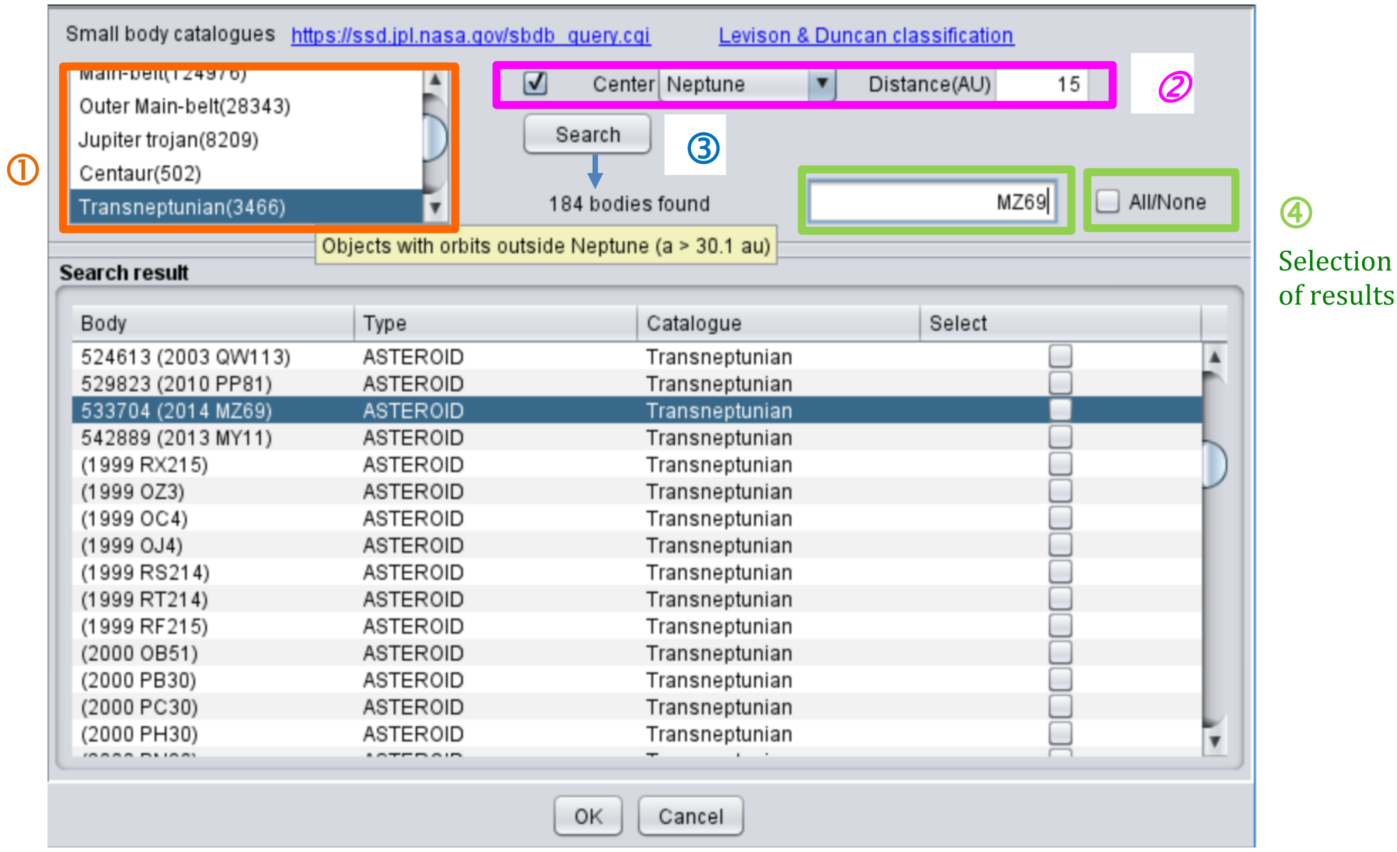
6- Add on the scene
7- Move the scene



A.6 : Small Bodies Visualization (from JPL catalogs) planned in the next version (V2.5)

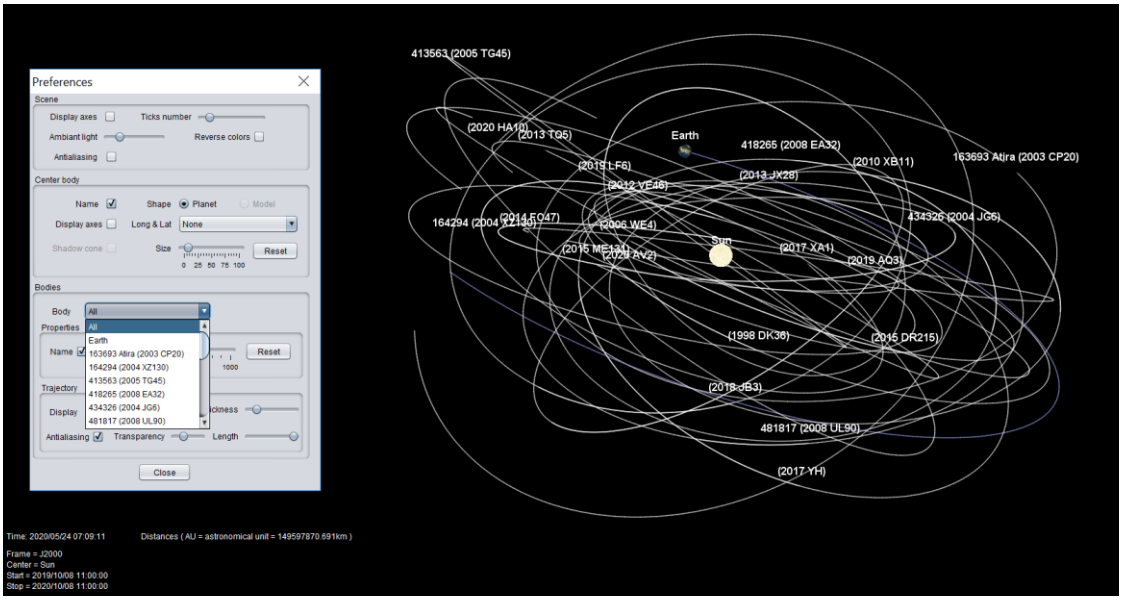
The interface below allows to select one or several catalogs (their content appears in a bubble when passing the mouse on the catalog name). This selection can be combined with the distance of bodies from a selected object.

Ex: How to get the asteroids outside Neptune but no further from the planet than 15 AU

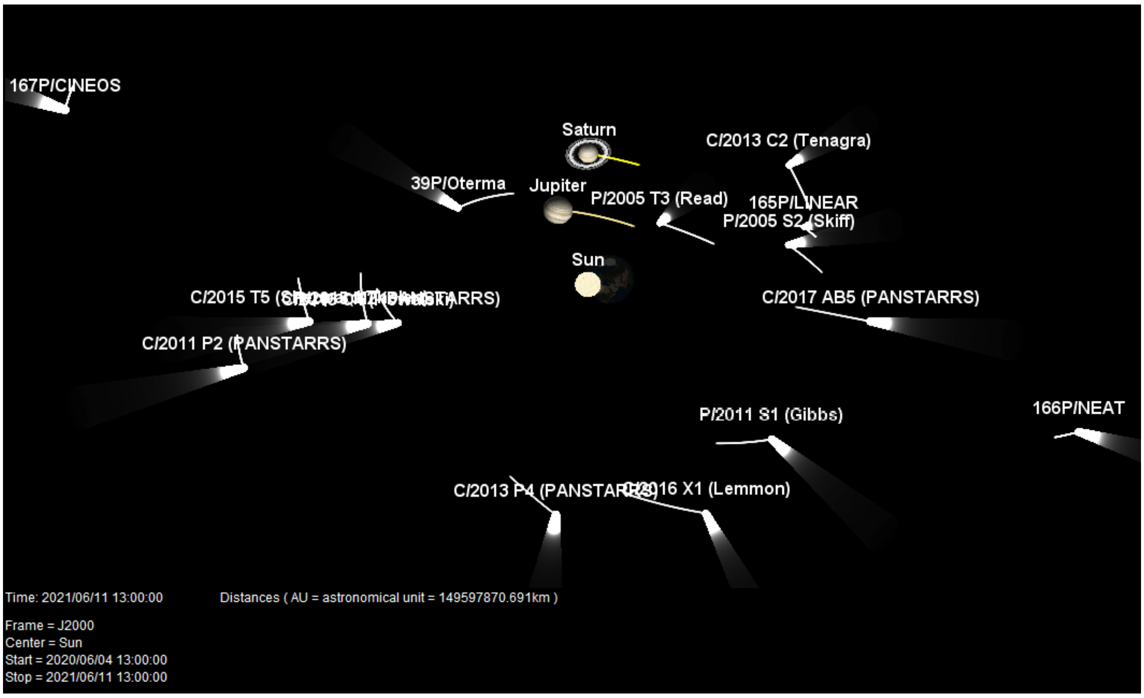


Small bodies visualization examples:

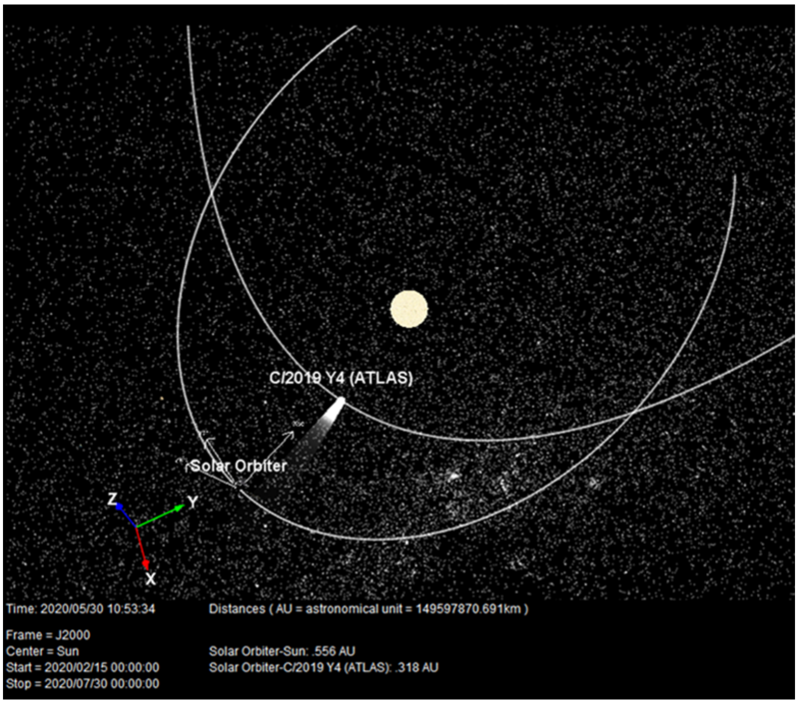
- 1 year of Atira asteroids (Select All) and Earth orbits



- 1 year of Chiron-type comets (Select All) orbits plus Jupiter and Saturn



- May 2020: Solar Orbiter crossing the tail of Y4 ATLAS comet (Other comet catalog, selected by Text filter: Y4)



- May 2020 6th : Y4 ATLAS comet in the STEREO-A field of view