Modeling, Analysis and Simulations of the Emissions in the Radio range. MASER Tool Suite User Guide

S. L. G. Hess

sebastien.hess@onera.fr

Summary

1.Introduction

Up do day, the MASER tool suite is composed of two online tools :

ExPRES (Exoplanetary and Planetary Radio Emission Simulator) simulatea the planetary radio emissions related to auroral processes. It generates mainly synthetic dynamic spectra of planetary radio emissions. Its use and part of its code are described in section XX.

SILFE (Spectral Information from Low Frequency Emissions) displays the dynamic spectra from several sources, either observational (CASSINI, Nançay,...) or numerical (ExPRES). Its allows a simpler analysis and co mparison of all these sources. It is based on the IVAO VOTABLE standard for the data and on the IMPEx (SPASE extension) standard for the metadata.

2. ExPRES

Connecting to ExPRES

The ExPRES online tool address is (as of Sept. 2014) : http://typhon.obspm.fr/maser/serpe

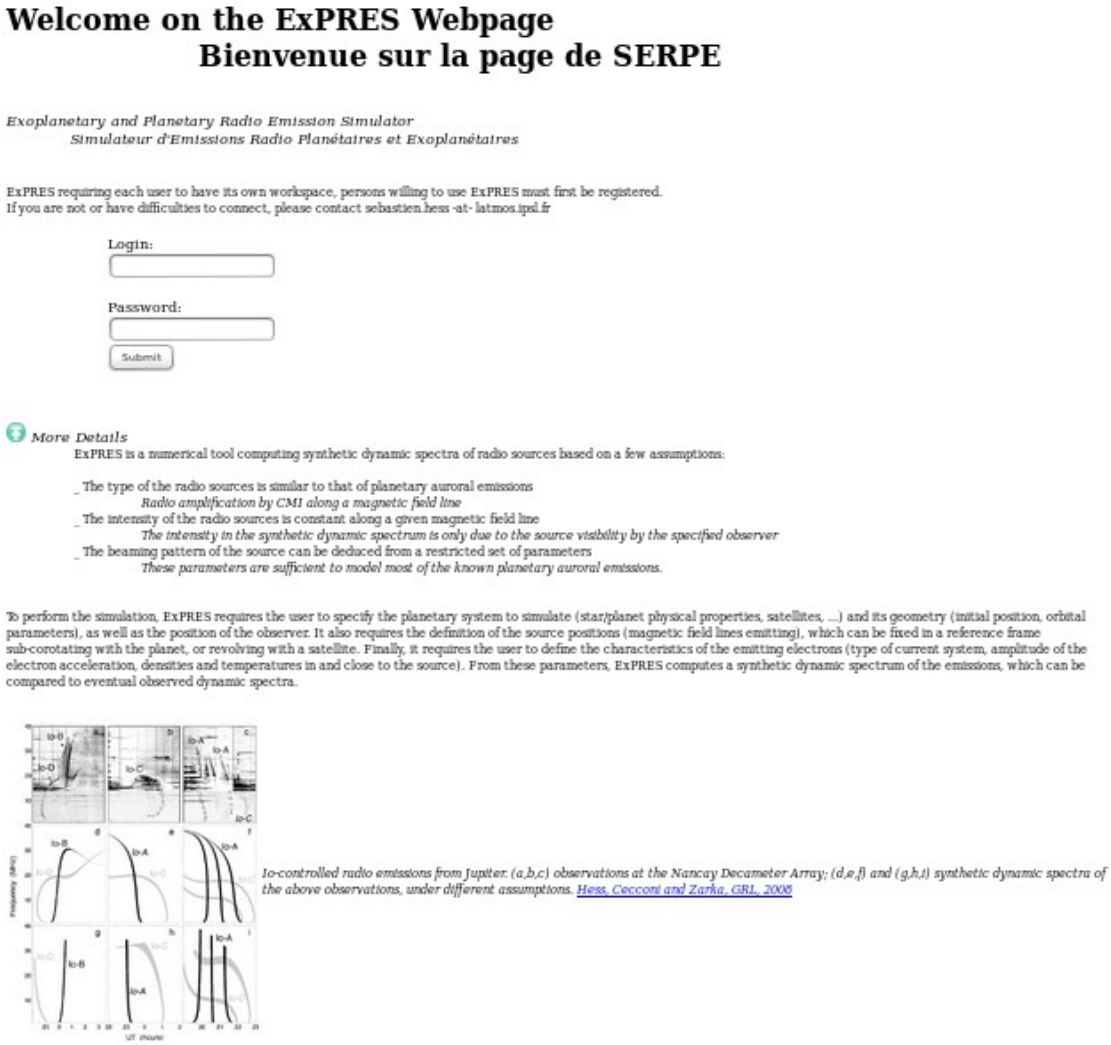


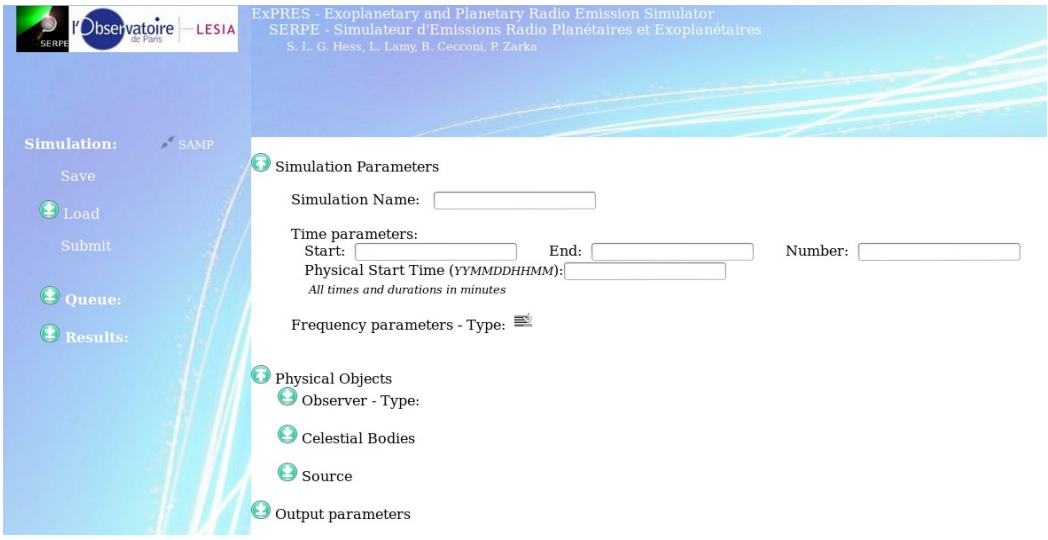
Figure 1: Font page of the ExPRES website

The front page gives a short description of the tool capabilities and invites the user to connect.
The connection necessitates a registration. The ExPRES tool is intended to be freely accessible to all users. However, as the actual software is run on the server and stores data on the server disk, an account needs to be created.

Once the login and password entered and submitted, you should be redirected to the ExPRES main page.

ExPRES UI

Main page layout



The ExPRES main page is composed of two parts the command panel (left) and the simulation setup panel (right).

Command panel

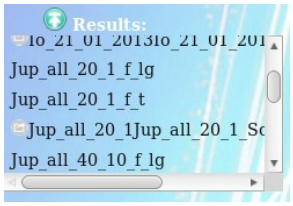
Its main purpose is to permits the user to manage simulation files (Load, save, delete,...) and the simulation runs (submit, follow, get results).

The simulation whose parameters are currently on the right simulation panel can be saved by clicking on “Save” and the simulation can be run by clicking on “Submit”.

The saved simulations can be displayed by clicking on the expand button *Load*. Then, a simulation can be loaded by clicking on the simulation name.

The queue can be viewed by clicking on the expand button *Queue.* Simulations can be either *Running* or *Waiting*.

The results can be accessed by clicking on the expand button *Results*. Then the data can be viewed by clicking on their name. The XML outputs, which follow, the IVOA VOTable standard can be shared with third-party VO applications though the SAMP protocol by clicking on the icon. This can be used to display the results in SILFE.



To use the SAMP capabilities, it is necessary to connect to a SAMP hub by clicking on the SAMP icon . It can be disconnected by clicking at the same location on the icon. If no SAMP hub is running, you will be asked whether you want to run one from the astrojs@github repository.

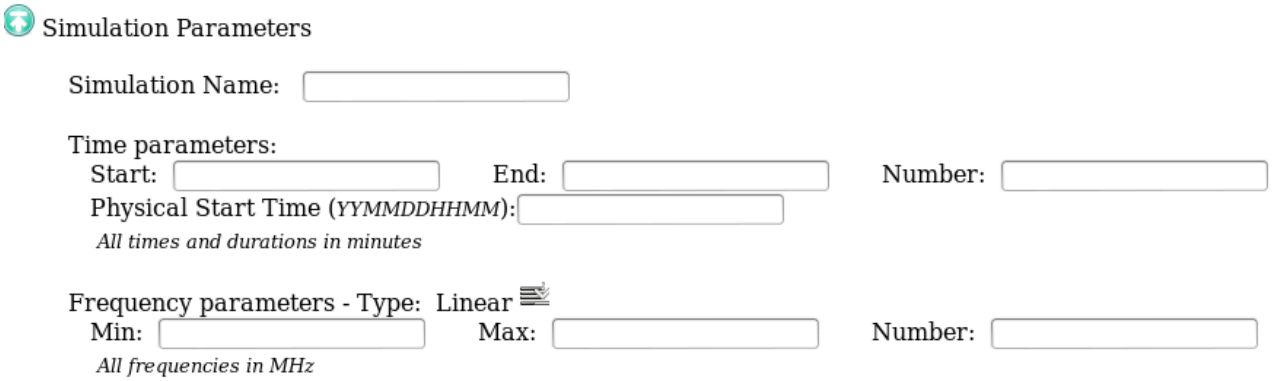
Simulation Setup panel

General parameters

The general parameters cover the time and frequency domain covered by the simulation and allow to give a name to it.

The time settings are limited to the times at which the simulation starts and ends (in minutes, like all times and durations in ExPRES) and the number of time steps.

It is also possible to define a physical “zero” time by providing a date. This date is particularly used for the generation of the VOTable outputs, but are also used for ephemeris.



Frequency parameters are of three types that can be selected in a list (click on Type:). The linear and logarithmic scales are defined by minimum and maximum frequencies and the number of frequencies to simulate. Predefined frequencies also exist that corresponds to known instruments they can be selected by .

Observer

There are three types of observers : fixed ones whose position in the simulation reference frame does not vary ; orbiters which moves in the simulation reference frame, orbiting around a celestial body ; predefined observers which represent known mission around celestial bodies. To select the type of observer, select it in the Type list (click o n Type:).

In any cases, it is necessary to define the celestial body which serves as reference for the position of the observer. Open the parent list (click on Parent:) and select the reference celestial body.

(**Notes** : 1- The selection is not updated, so if the celestial body is deleted or its name changed, the parent must be manually updated or the simulation will not run. 2- Obviously, at least one celestial body must be created before associating the observer to a body.).

Fixed observer are parametrized by their distance to the reference body, their sublongitude and their declination (in the reference body reference frame and at initialization time).

Orbiter orbits are defined by their semi-major and semi-minor axis, the apoapsis sublongitude and declination (in the reference body reference frame and at initialization time) and the inclination of the orbit plane around the semi-major axis.) Finally, the orbiter position requires the definition of its initial phase on the orbit (0deg. is at the apoapsis position).
(**Tips** : The trajectories of all objects can be checked by using the 3D movie output).

Predefined types corresponds to the orbits of some missions whose ephemerisis are provided by the AMDA tool of the French Plasma Physics Center (CDPP -).

Celestial bodies

Two types of celestial bodies can be included in the simulations, fixed bodies (at least one needed) and orbiting bodies (which can orbit both fixed and orbiting bodies).

Bodies can be created using the icon in the celestial bodies section (expend by clicking on).

They can be deleted by clicking on the icon in front of their name.

The parameters of the celestial body can be set/modified by expending the section (click on).

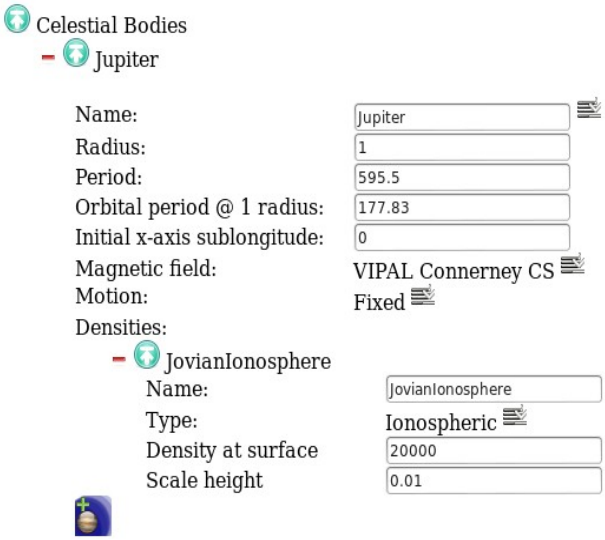
The body must be given a name. Each object must be given a different name as they are internally referred by it in ExPRES.

The body radius must be indicated. Contrary to the other quantities in ExPRES, the unit of the lengths and distances are arbitrary. However, the units must be consistent through a simulation parameter set.

The body's period and the Keplerian period at the body's surface must be defined in minutes.

The orientation of the body relative to the simulation reference frame is given by the sublongitude of the x-axis at the simulation start.

The model of the body's magnetic field can be selected (click on Magnetic field:).



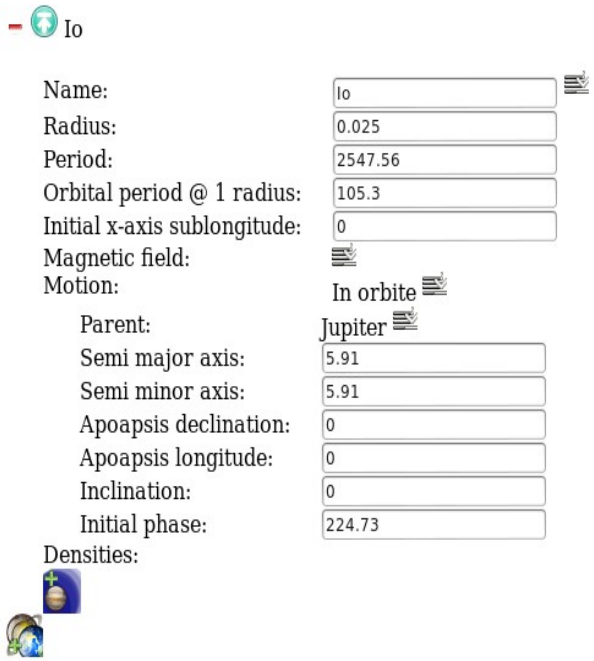
Density profiles

To each celestial body can be associated several (plasma) density profiles. Four types of density models exist : ionospheric (exponential decrease versus distance), stellar (decreases as the distance squared), disk (exponential decrease with altitude relative to equatorial plane and distance), and torus, (exponential decrease from the center of a torus of given radius).

These profiles can be set by clicking on the icon, and deleted by clicking on the icon.

The profiles must be given a unique name and the profile type can be selected in the profile list (click on). The profile parameter will be asked below.

Satellites



All angles in degrees, periods in minutes, sizes in arbitrary units and distances in parent body's radii

The body can be made orbiting another one by changing the Motion selection from “Fixed” to “In orbite”. In this case, the body's parent must be set by selecting a parent body in the list (click on Parent:).

(**Notes** : 1- The selection is not updated, so if the celestial body is deleted or its name changed, the parent must be manually updated or the simulation will not run. 2- Obviously, the parent celestial body must be created before associating the it to a body.).

Satellite orbits are defined by their semi-major and semi-minor axis, the apoapsis sublongitude and declination (in the reference body reference frame and at initialization time) and the inclination of the orbit plane around the semi-major axis.) Finally, the orbiter position requires the definition of its initial phase on the orbit (0deg. is at the apoapsis position).
(**Tips** : The trajectories of all objects can be checked by using the 3D movie output).

Sources

Radio sources can be added by expending the source section (click on the icon in front of the “source” section) and clicking on the icon. Once created, they can be deleted by clicking on the icon.

They must be given a unique name.

Their parent body (body on which field lines the source is located) must be specified by clicking on the Parent:

(**Notes** : 1- The selection is not updated, so if the celestial body is deleted or its name changed, the parent must be manually updated or the simulation will not run. 2- Obviously, the parent celestial body must be created before associating the it to a body.).

The source parameters (type of current, electron energies and temperatures, …), that are defined in a paper (), must be specified. The steady-state current implies an emission by a shell-distribution

obtained by the parallel acceleration (energy increase δε) of a bi-Maxwellian distribution (defined by the core and halo temperatures).

The hemisphere(s) is which the source is located can be selected using the checkboxes.

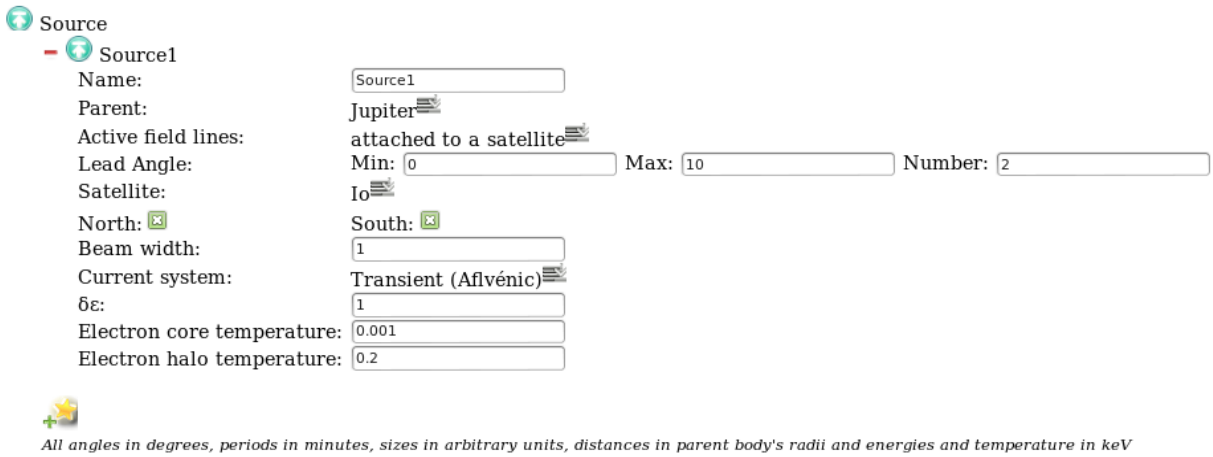
Then, the position and motion of the magnetic field line on which the source is located must be selected.

The emission pattern is a deformed hollow cone (deformation due to refraction). The width of the conical sheet is given by the “Beam width” field.

It can either be attached to a satellite, fixed in equatorial L-Shell or in surface latitude. The selection is made in the “Active field line” list (click on)

(**Notes** :In any cases, the possibilities for magnetic field line positions are limited by the fact that they must be pre-computed – with a precision or step of 1degree in longitude and latitude or distance. If you needs exceed the existing possiblities please contact the maintenance contact person. At this time Dr. B. Cecconi: baptiste.cecconi@obspm.fr).

Attached to a satellite

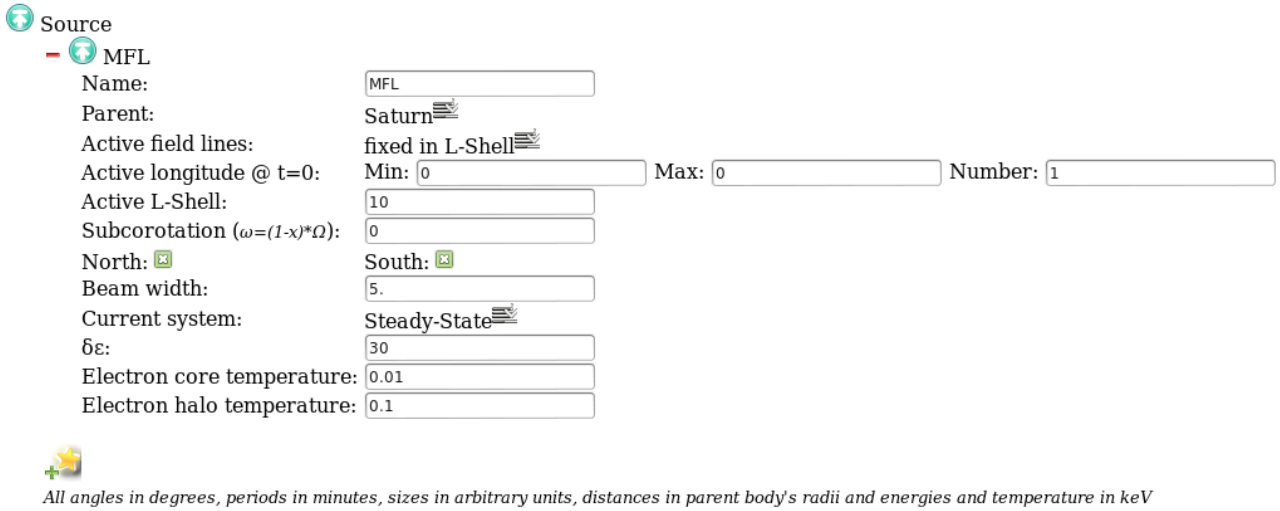


For source attached to a satellite, the satellite must be selected in the Satellite list (click on).

The motion of the field line will be that of the satellite.

A set of lead angles can be defined be giving a minimum and maximum lead angles, and the number of active field lines.

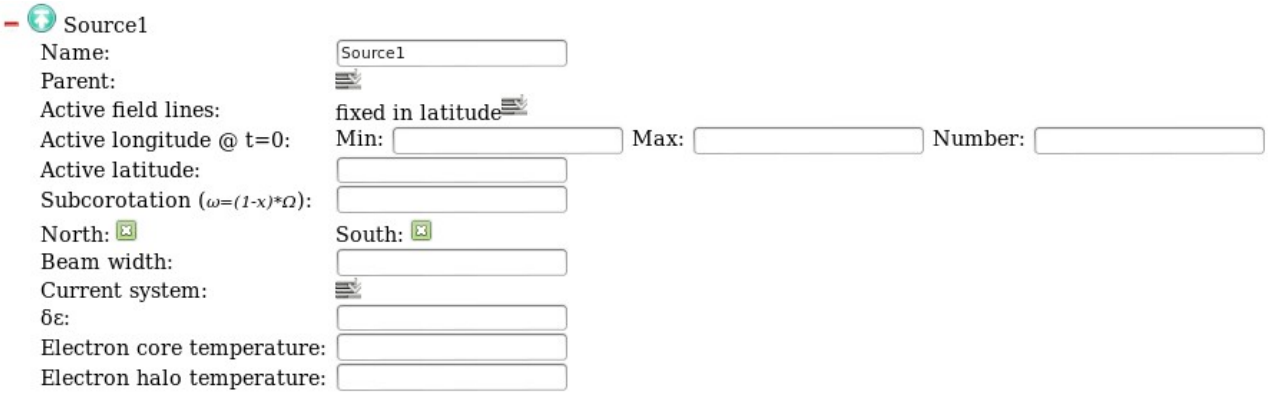
Fixed in L-Shell



For sources fixed in L-Shell, the field line motion is in corotation by default, but a subcorotation rate can be set in the “Subcorotation” field (0 = rigid corotation, 1 = no rotation at all).

The L-Shell of the active field lines can be set in the “Active L-shell” field, and the longitudinal position of the active magnetic field lines can be set by providing the minimum and maximum longitudes of the active field lines and the number of active field lines..

Fixed in latitude

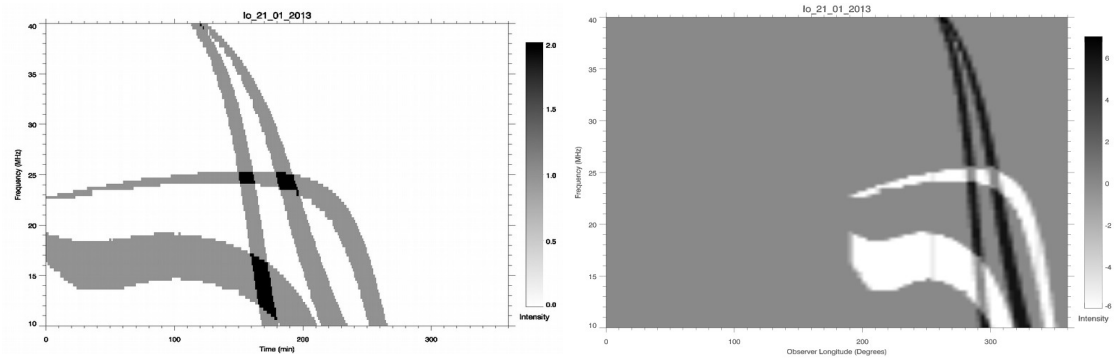


For sources fixed in magnetic latitude, the field line motion is in corotation by default, but a subcorotation rate can be set in the “Subcorotation” field (0 = rigid corotation, 1 = no rotation at all).

The latitude of the active field lines can be set in the “Active latitude” field, and the longitudinal position of the active magnetic field lines can be set by providing the minimum and maximum longitudes of the active field lines and the number of active field lines..

Outputs

Dynamic spectra



ExPRES standard outputs are dynamic spectra (intensity in the time-frequency domain). But ExPRES can also display the intensity as a function of observer or source longitude, source latitude, or local time or observer distance. This can be managed by selecting the corresponding checkboxes in the type section. The longitude/latitude/local time/distance ranges to be display must be specified in the corresponding fields.

ExPRES can also display the polarization (positive for northern sources, negative for southern ones) in the same manner. This can be done be selecting the polarization checkbox.

The frequency axis unit, the output format, and the frequency scale can be chosen using the "Options" checkboxes.

Dynamic spectrum

Type: Intensity ☒ Polarization ☐

Source/Observer	Time	Distance	Longitude	Latitude	Local time
Frequency	✓	☐	☐	☐	☐
Longitude	☐	☐	☐	☐	☐
Latitude	☐	☐	☐	☐	☐

Domains:

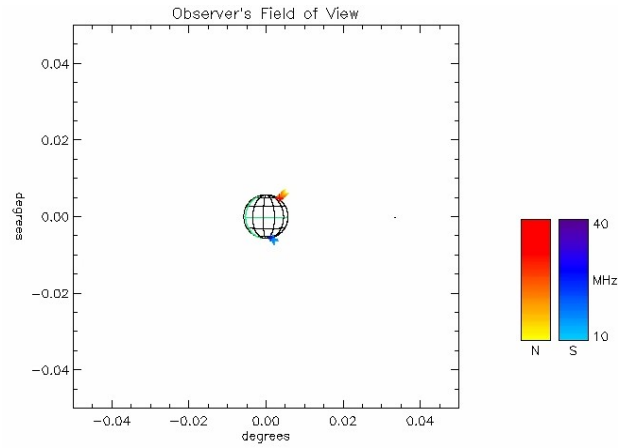
Distance, min [ ] max [ ]
Longitude, min [ ] max [ ]
Latitude, min [ ] max [ ]
Local time, min [ ] max [ ]

Options:

Frequency unit: kHz: ○ MHz: ◉
Frequency scale: Log: ○ Linear: ◉
Format: PDF: ○ PostScript: ◉

All distances in arbitrary unit and angles in degree

2D movies



ExPRES can also display the position of the observed sources in the "field of view" of the instrument. This is done by adding a "2D movie" in the simulation (click on *2D movie*).

Then, it is needed to specify the Field of view opening in degrees, that is the extent of the part of the sky to be displayed. It is also needed to specify the subcycling for the movie, that is the number of simulation time steps between to successive pictures.

2D Movie
Subcycling: 4
Field of view openning: 0.05
All angles in degrees

3D Movie
Subcycling: 10
Show observer:
Show trajectories:
X range, min: -10 max: 10
Y range, min: -10 max: 10
Z range, min: -10 max: 10
All distances in arbitrary units

3D movies

ExPRES can also display the celestial bodies and sources position in 3D. This is done by adding a "3D movie" in the simulation (click on *3D movie*).
The trajectories of the satellites and observers can be displayed by checking the corresponding checkboxes.
Then, it is needed to specify the spatial domain to be displayed. It is also needed to specify the subcycling for the movie, that is the number of simulation time steps between to successive pictures.