TotalPower 7.0.0

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ChatGPT-3 viewpoint ....

- **"TotalPower" is a software program used in the field of radio astronomy for data analysis and calibration. It was developed by *Richard Perley*, an astrophysicist specializing in radio astronomy, at *the National Radio Astronomy Observatory* (NRAO) in the 1990s ...**

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ChatGPT-3 viewpoint ....

- **The program TotalPower, used for measuring radio frequency noise, was written by *Joe Taylor* , a *professor emeritus* at *Princeton University* *and a Nobel laureate in Physics* ...**

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ChatGPT-3 viewpoint ....

- ***Thank you for the additional information.***
  "TotalPower" is a free program created by Mario Armando Natali (callsign I0NAA) **at the University of Bologna (UNIBO). It is used to measure the total power of signals using RTL-SDR (Software-Defined Radio) ...**

..... Ooooh well I am in VERY good company ☺

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Little bit of history

- **TotalPower was started as an exercise to improve my ability to develop programs with C++ and the initial goal was just to measure the RF noise with the low-cost SDR known as RTL-SDR.**

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Little bit of history

- **The program is Windows based and has been developed with *Embarcadero® C++ Builder 10.2 (starter edition)* using the *SDL Delphi Component Suite* from EPINA Softwares Lab and the “classic” *FFTW* libraries for Fourier transformations.**

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Little bit of history

- **TotalPower has been downloaded more than 3000 times to date, is in use in many parts of the world and has been featured both on «Radio Rivista» and on «Dubus».**

TotalPower is distributed for free through my website:

https://i0naa.altervista.org

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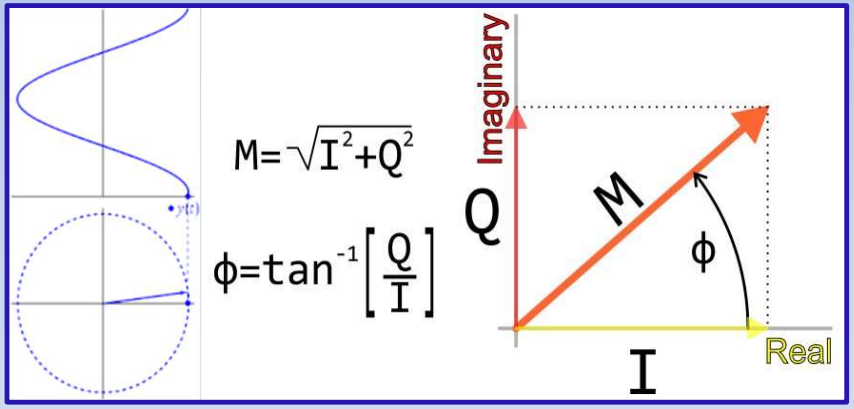
Little bit of theory

We can describe the instantaneous state of a signal with complex numbers, called phasors, which can be represented on the complex plane by vectors containing amplitude and phase information.



The I and Q values represent the peak value of the in-phase and quadrature components of the RF signal vector. With I and Q we can describe the amplitude and phase of the signal and the associated power.

Basic equations :

$$V_{Peak} = \sqrt{I^2 + Q^2} \Rightarrow V_{RMS} = \frac{V_{peak}}{\sqrt{2}} \Rightarrow V_{RMS} = \sqrt{\frac{I^2 + Q^2}{2}}$$

50Ω system $\Rightarrow$ $P_{RMS} = \frac{\frac{I^2 + Q^2}{2}}{50} = \frac{I^2 + Q^2}{100}$

For relative calculations : $P = I^2 + Q^2 \Rightarrow P = 10 \log_{10}(I^2 + Q^2)$

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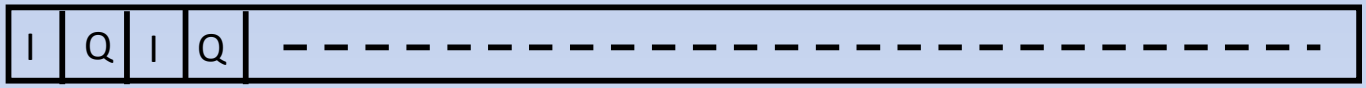
How to implement the measure with RTL-SDR

The RTL-SDR is a low-cost SDR that samples incoming analog signals and digitizes them making them available in a 65536 bytes long buffer that contains a sequence of I and Q values.

RTL-SDR data Buffer 65536 BYTES



The I and Q data acquired are in the form of 8-bit unsigned data. Each I and Q value then ranges from 0 to 255 (00000000 to 11111111). To get signed values, we must subtract 127.5 from each value of I and Q, thus obtaining the correct range from -127.5 to +127.5.

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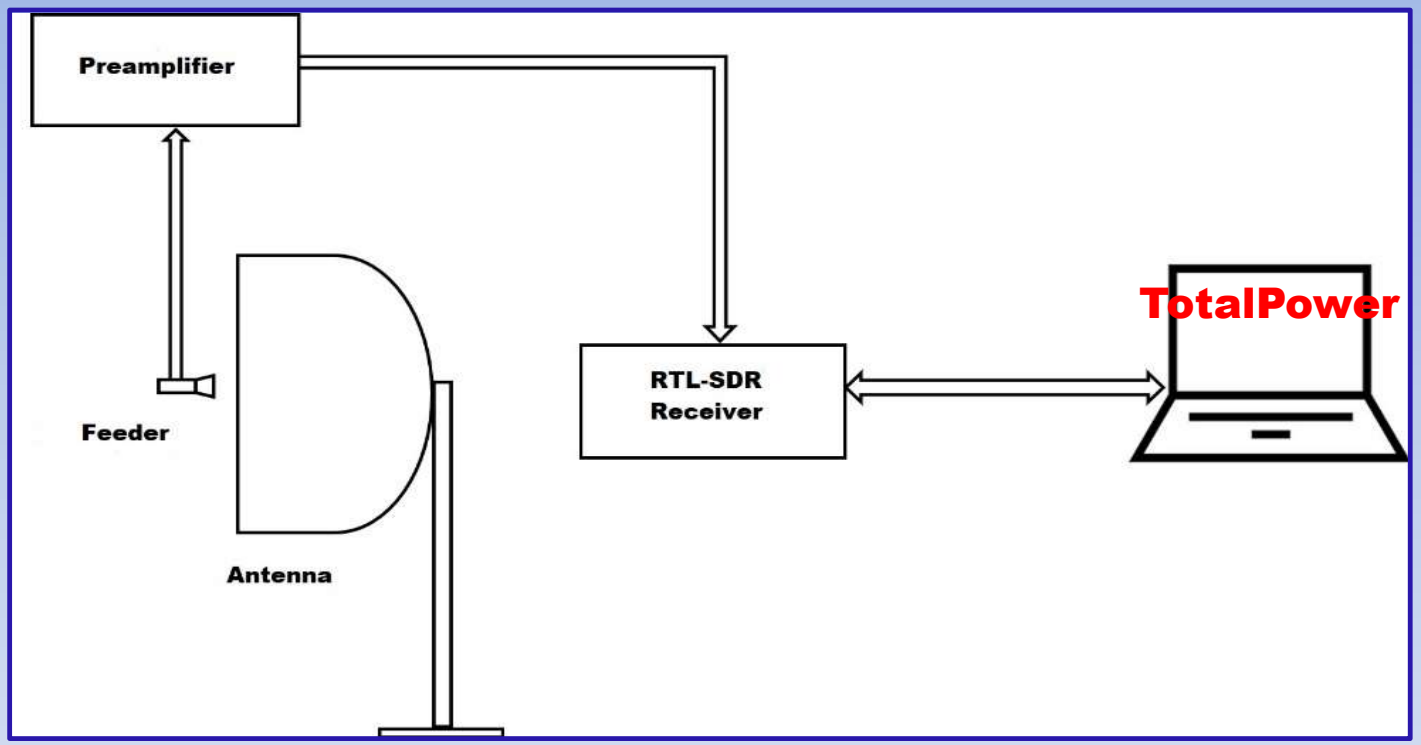
The set-up



The main advantages of this configuration are the very low cost of hardware and the possibility of data processing thanks to DSP algorithms.

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Known problem

The main problem is related to the limits of RTL-SDR :

- ✓ **Frequency stability**
- ✓ **Gain stability**
- ✓ **Performance drifts due to warm-up**
- ✓ **Birdies**
- ✓ **Intermodulation**
- ✓ **Aliasing**
- ✓ **Limited bandwidth**
- ✓ **Overload**

Possible solutions :

- ➢ **Use higher class SDR.**
- ➢ **Introduce Dicke-switch technique to eliminate the problem of gain stability.**

T_{sys} = total noise contribution from hardware
T_{ground} = noise contribuion due to ground radiation (spillover and scattering)
T_{sky} = noise contribution from sky background and atmospheric
T_{source} = noise form source under analysis
Γ = global system parameters (targeted system gain-bandwidth)

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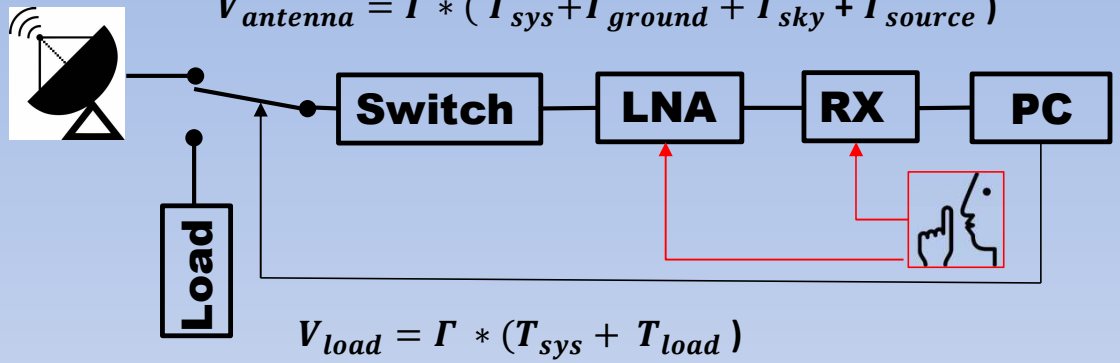
Dicke-switch technique

$$V_{antenna} = \Gamma * (T_{sys} + T_{ground} + T_{sky} + T_{source})$$



$$V_{load} = \Gamma * (T_{sys} + T_{load})$$

A dish radio telescope, connected to a square-law detector (TotalPower) provides an output voltage proportional to the signal power detected.

The Dicke-switch technique alternatively connects the RX chain to the antenna and to a matched load allowing fluctuations in the RX chain to be minimized.

$$\Delta_v = V_{antenna} - V_{load} = \Gamma * (T_{sys} + T_{ground} + T_{sky} + T_{source} - T_{sys} - T_{load})$$

… Very good solution, but a dedicated hardware is required …

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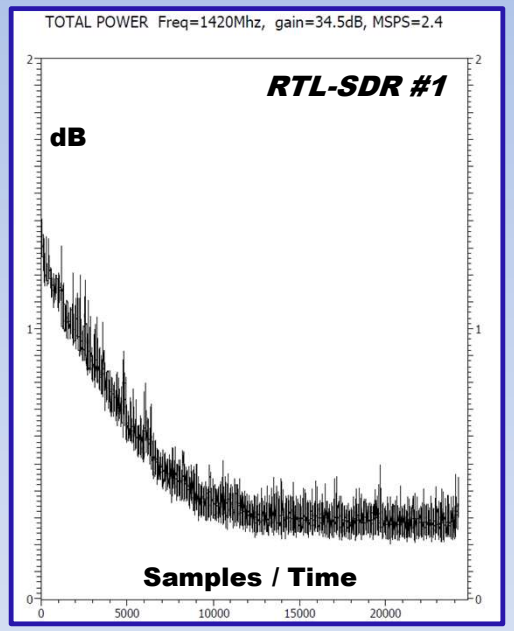
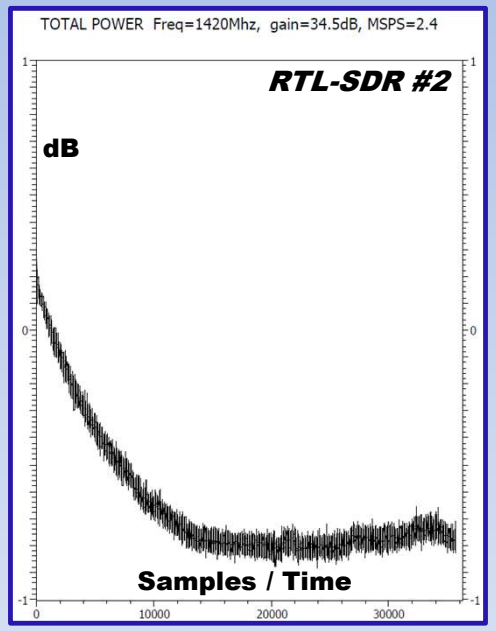
… But the RTL-SDR it is not so bad …

Plot of a two-and-a-half-hour recording made by connecting two different RTL-SDRs to a (stabilized) noise generator.





Deltas are less than 1dB and the stability after warm-up is not so bad for amateur radio applications.

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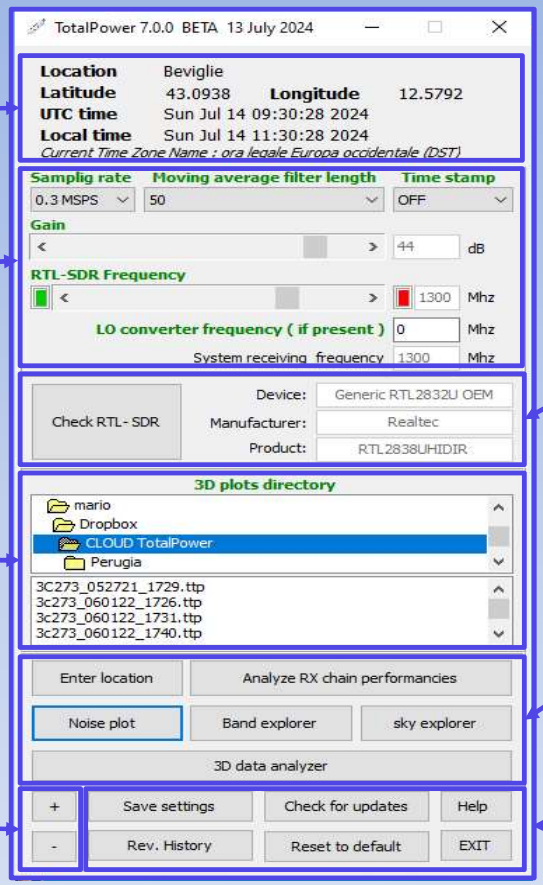
Main screen

Observation site

Main settings

3D Plots repository

User interface zoom



RTL-SDR parameters *should not contain wild characters*

Operating modes

Support functions

- **The proper installation of the RTL-SDR is a prerequisite before starting the program.**
- **RTL-SDR MUST be installed as interface 0 .**

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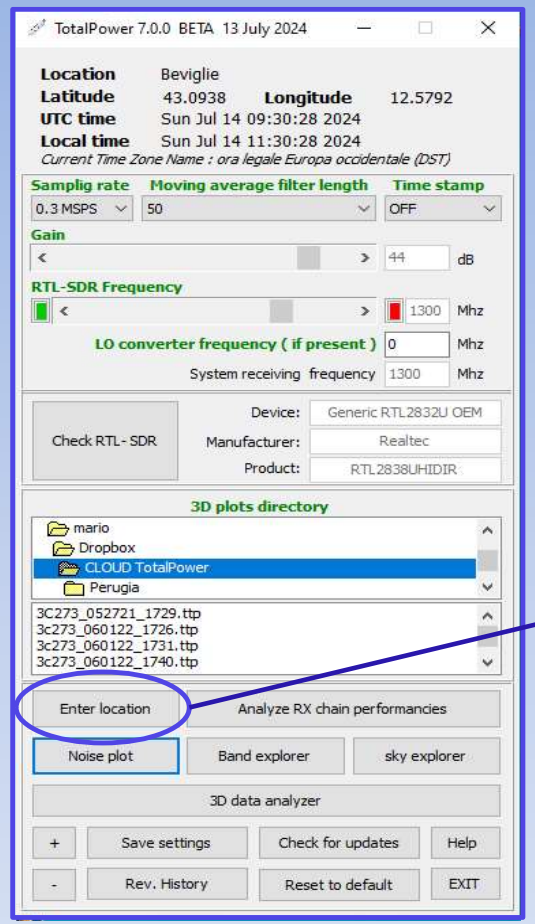
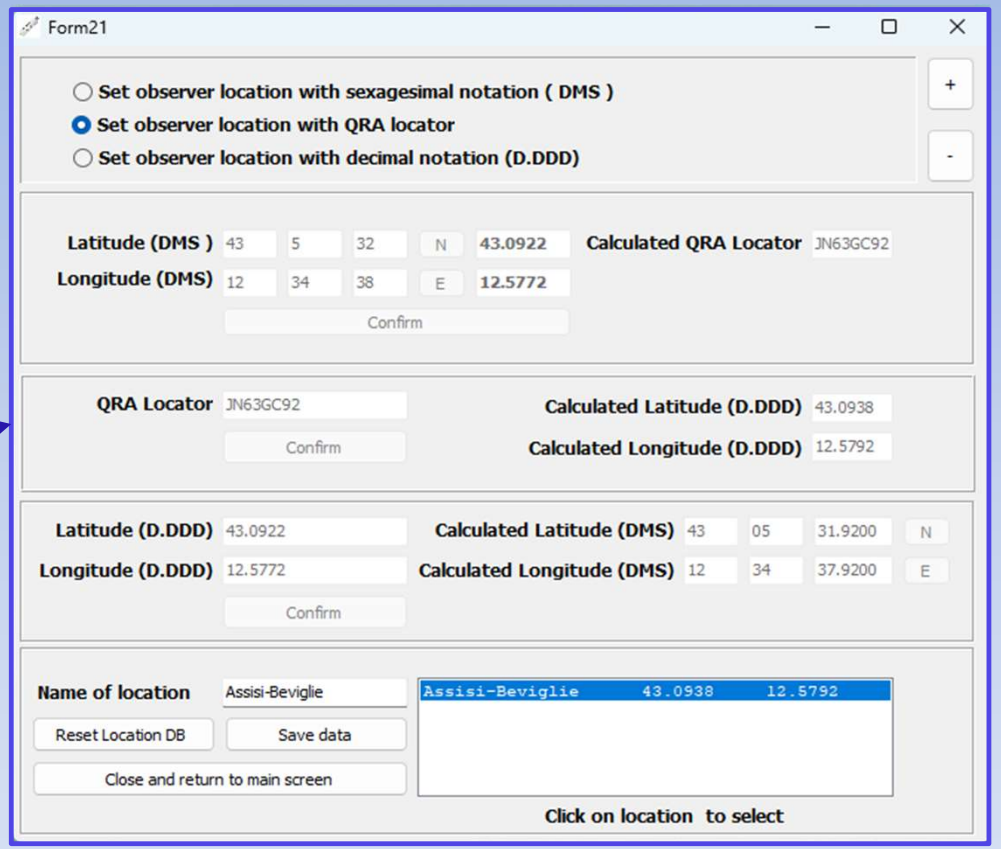
Main functions : Set location





The SET LOCATION function allows to store the coordinates of the observation sites in different formats.

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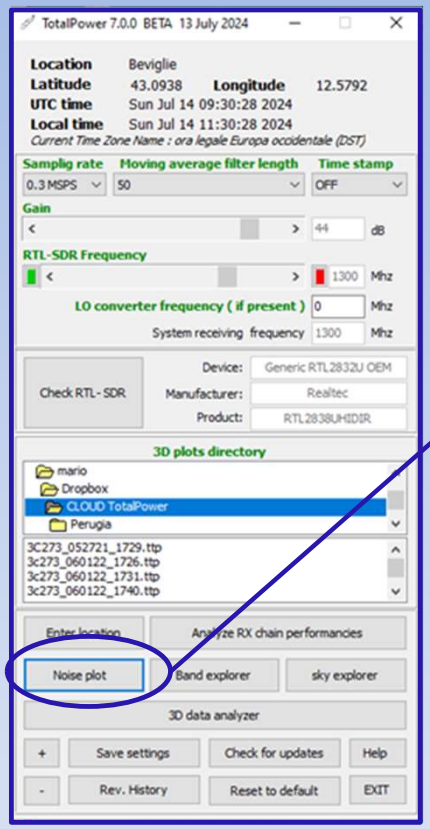
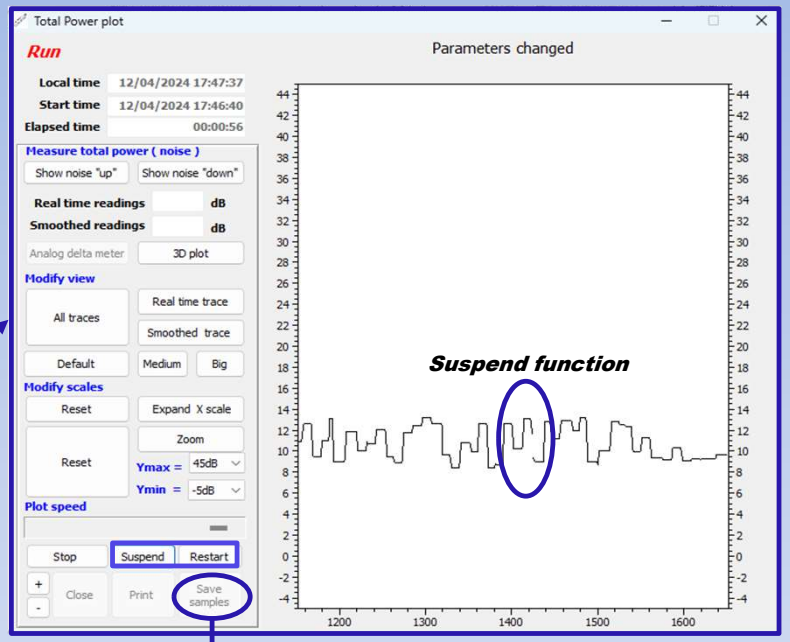
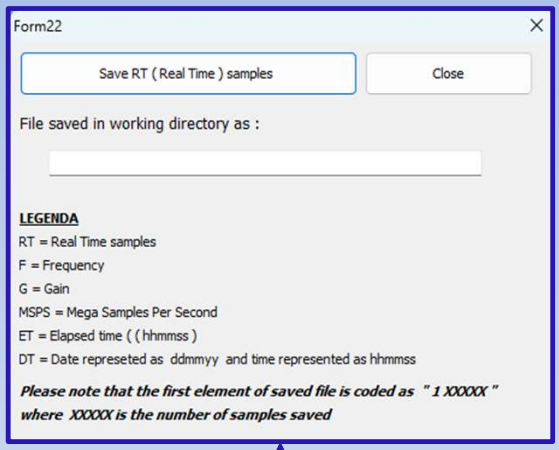
Main functions : Band Monitor in the time domain







The SAVE SAMPLES function allows to save all the samples acquired during the observation session in .csv format so that more in-depth off-line analyses can be carried out.

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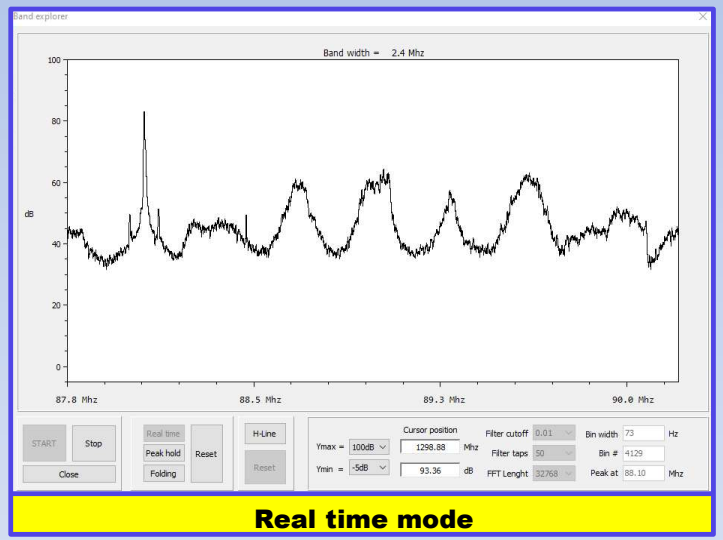
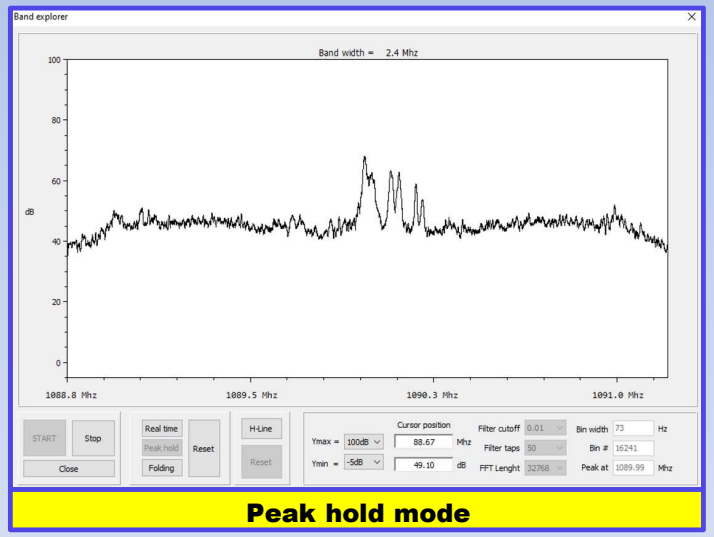
Main functions : Band explorer in the frequency domain

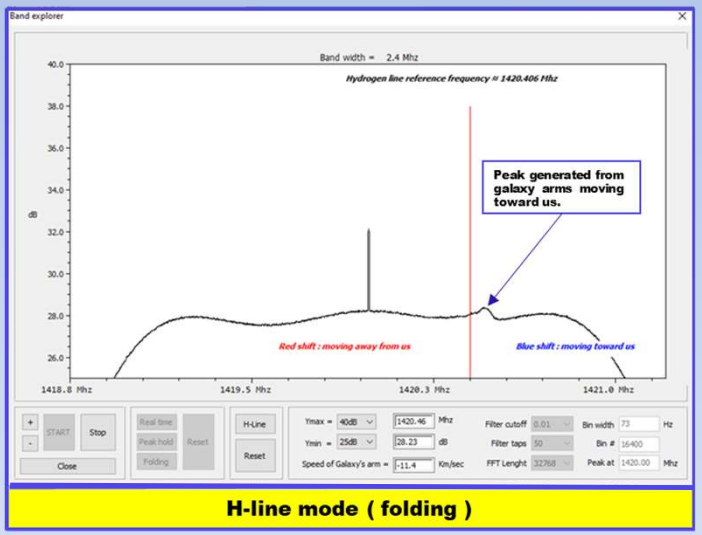
The “BAND EXPLORER" mode works in the frequency domain (using FFTW) and offers three different operating options :



Real time mode



Peak hold mode



H-line mode (folding)

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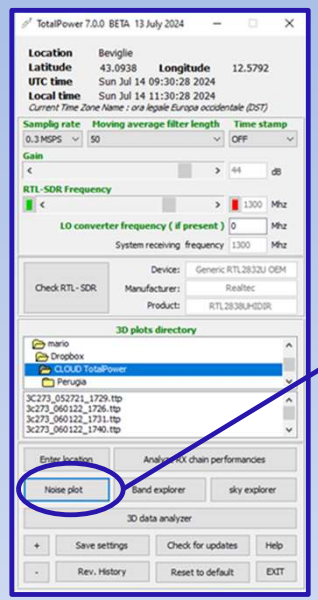
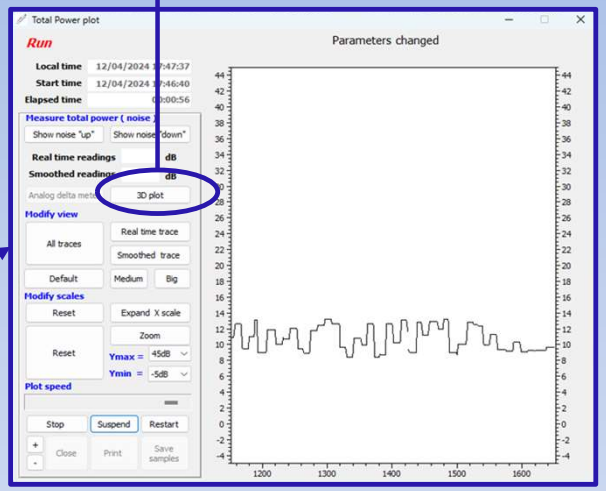
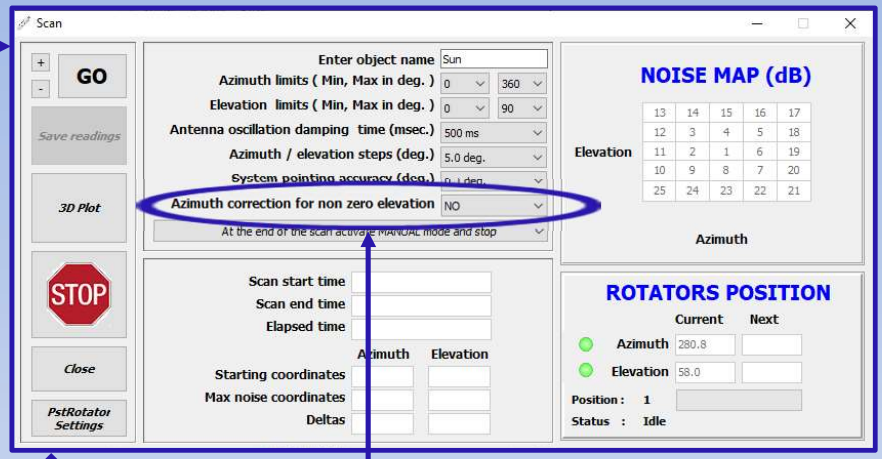
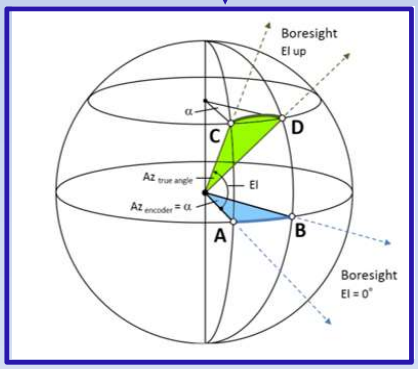
Main functions : Automatic 3D sky noise map









Azimuth correction allows spherical arc length of the travelled azimuth to be independent from elevation.

TotalPower, working together with the program PstRotator, measures and records automatically the noise of an area of the sky.

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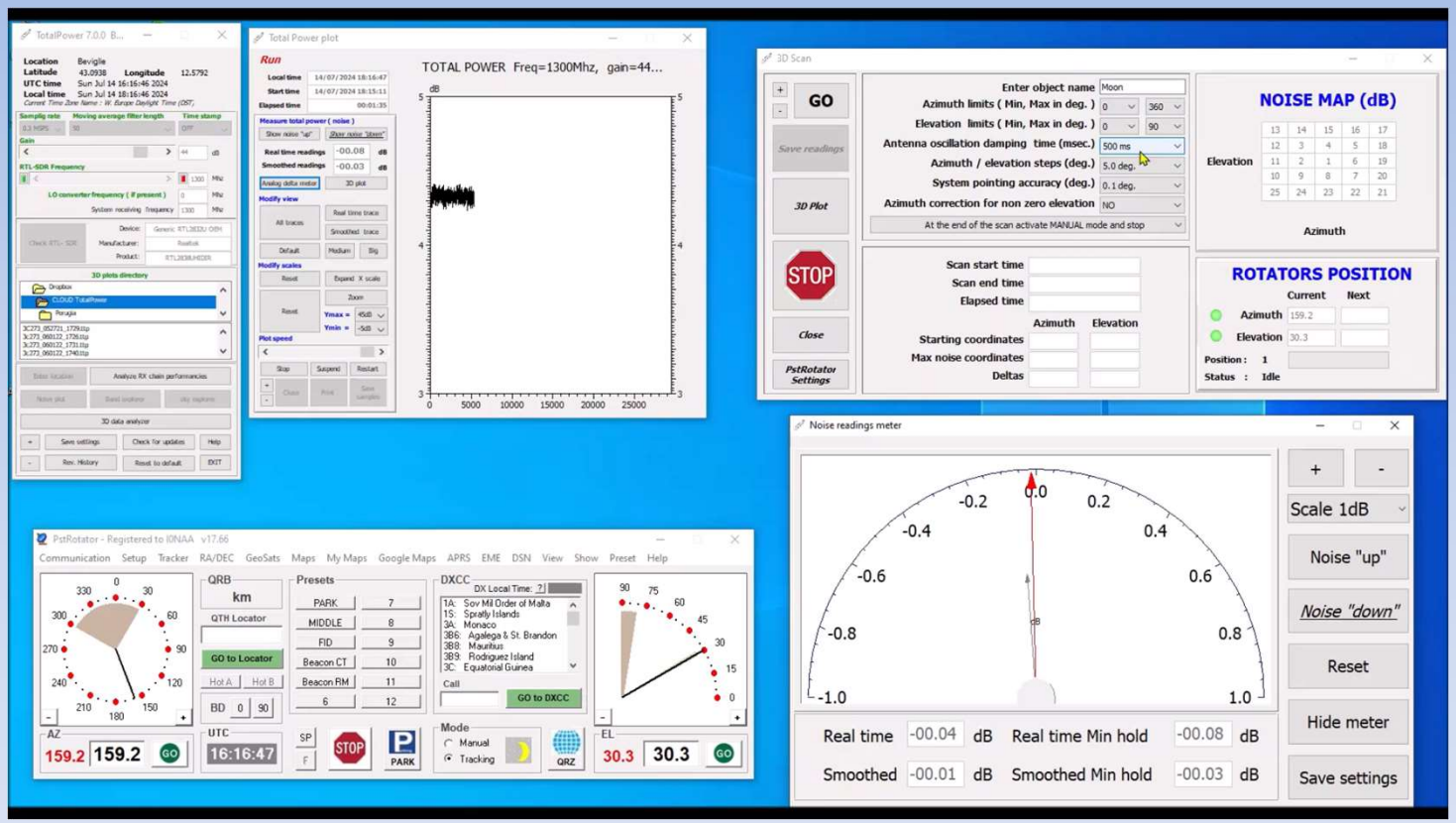
Main functions : Automatic 3D sky noise map



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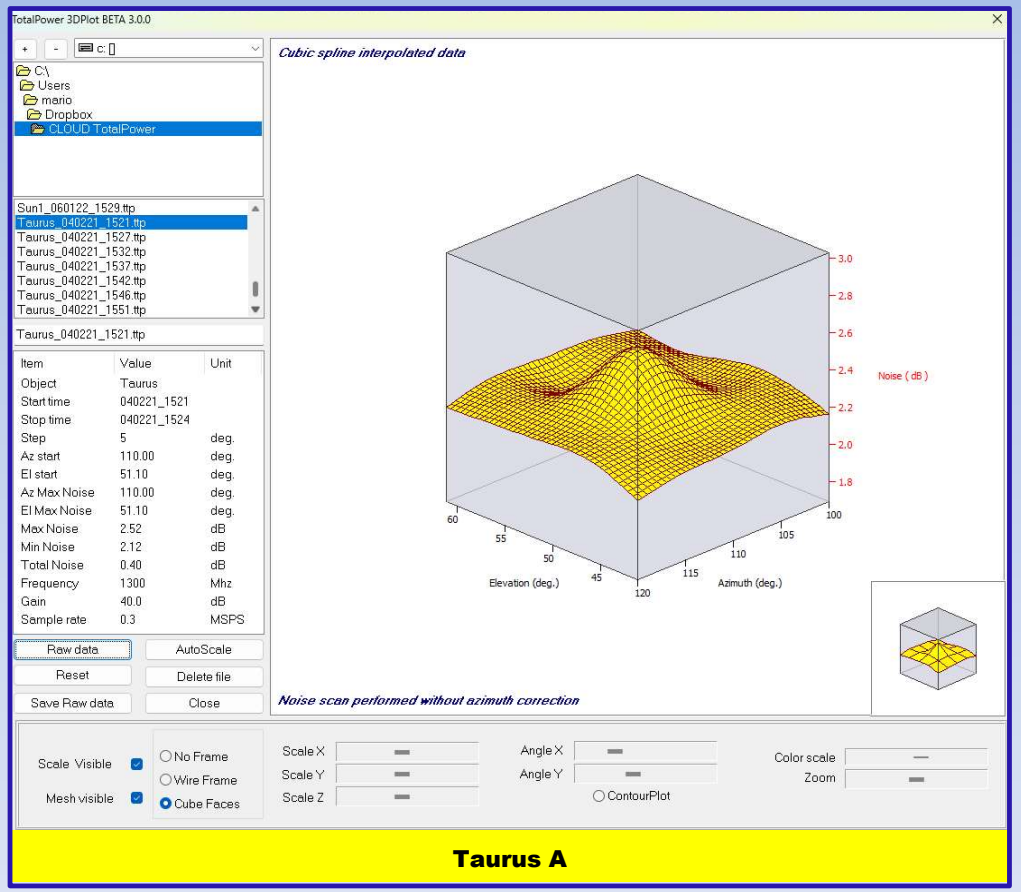
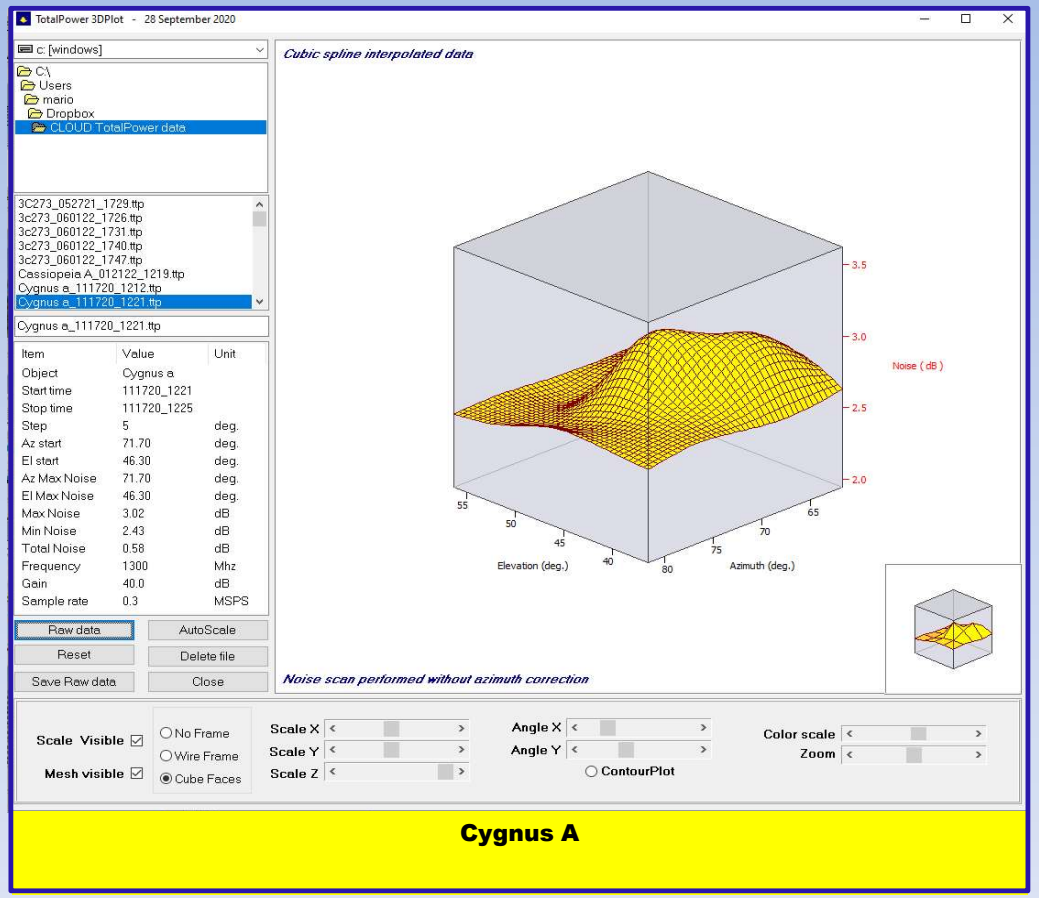
Main functions : Automatic 3D sky noise map





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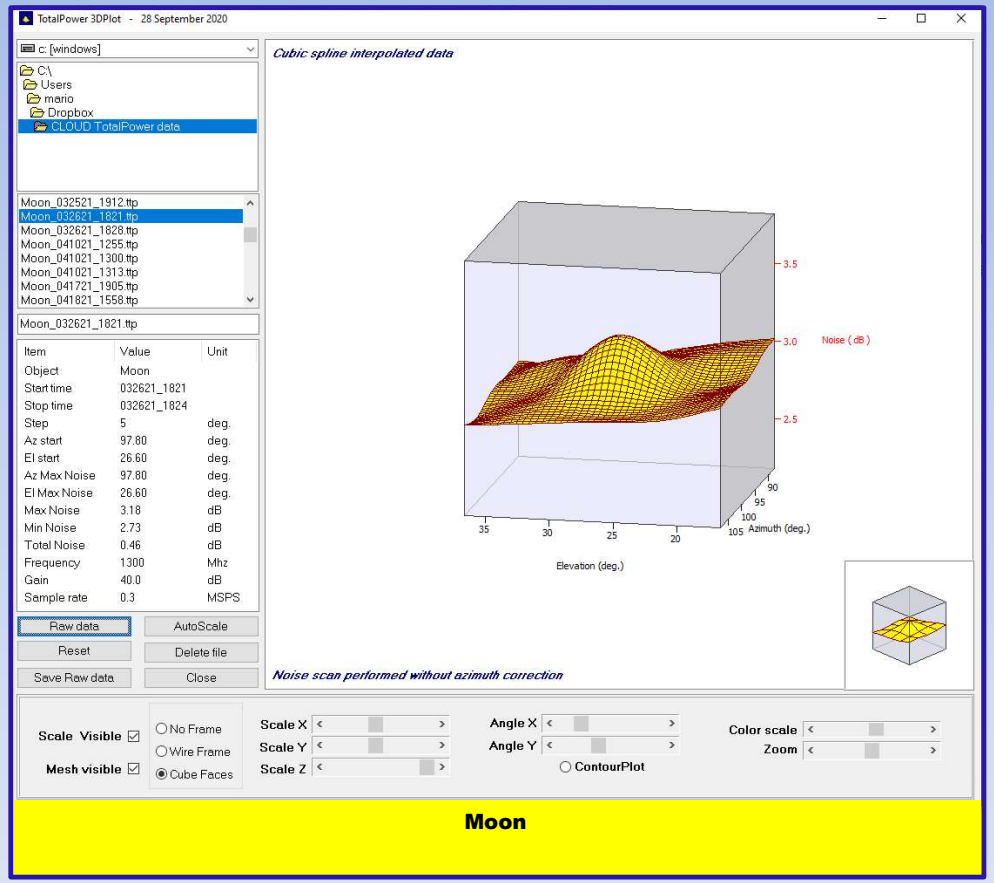
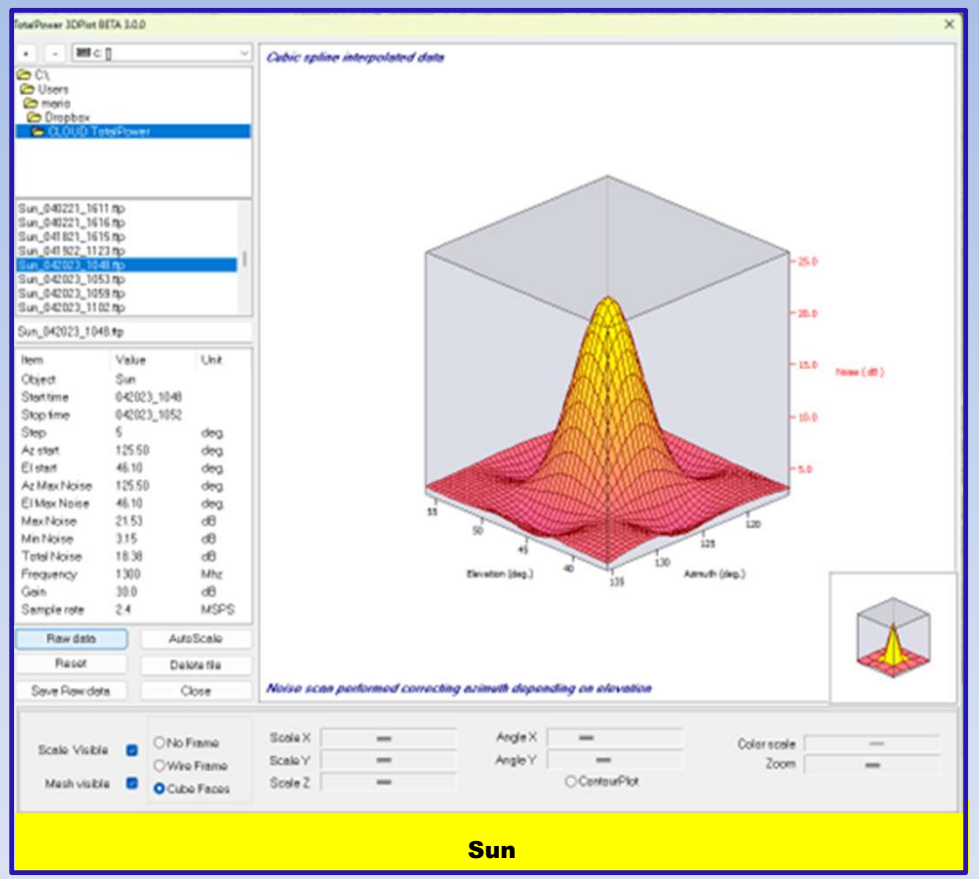
Main functions : Automatic 3D sky noise map



Moon



Sun

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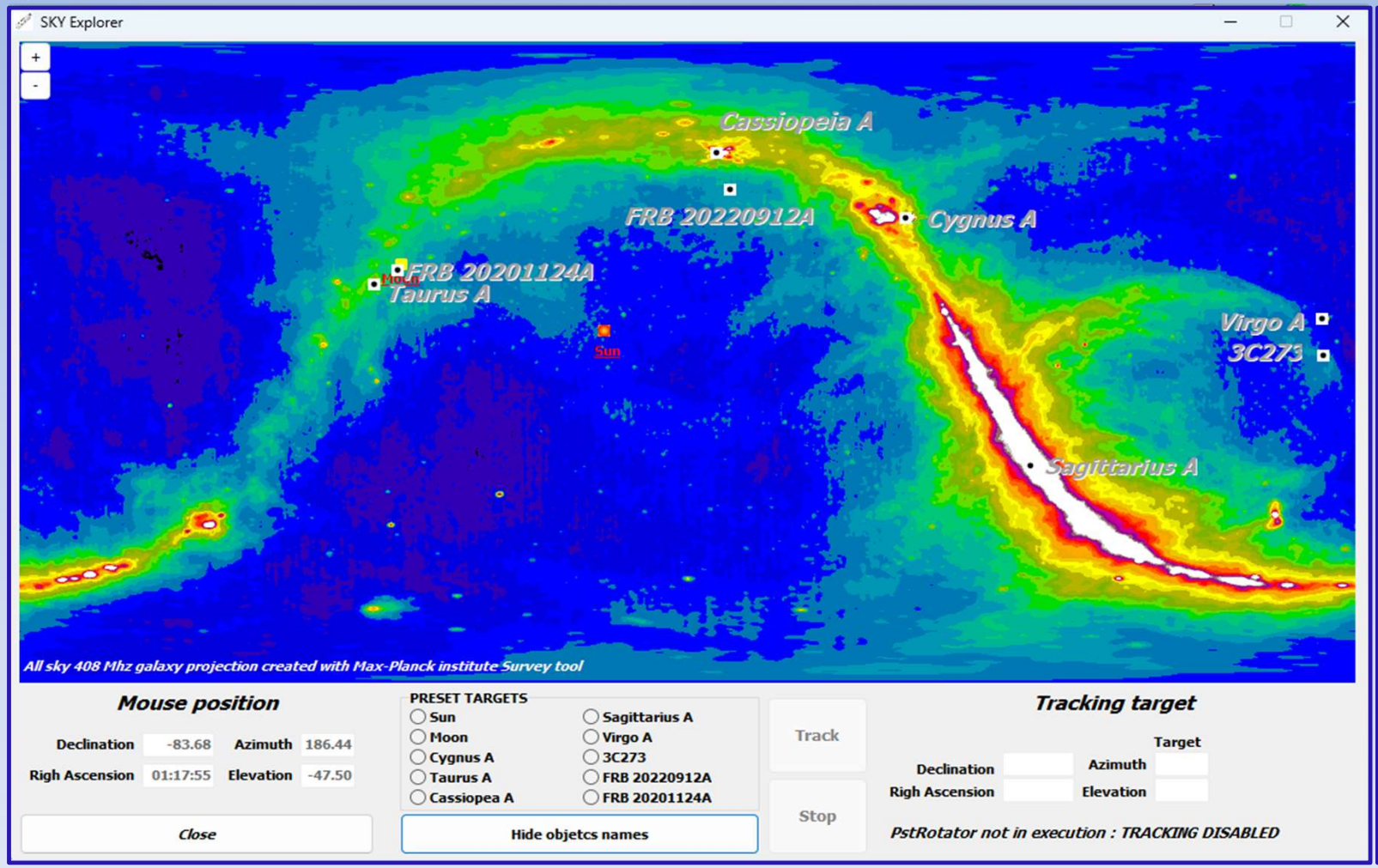
Main functions : Sky Explorer

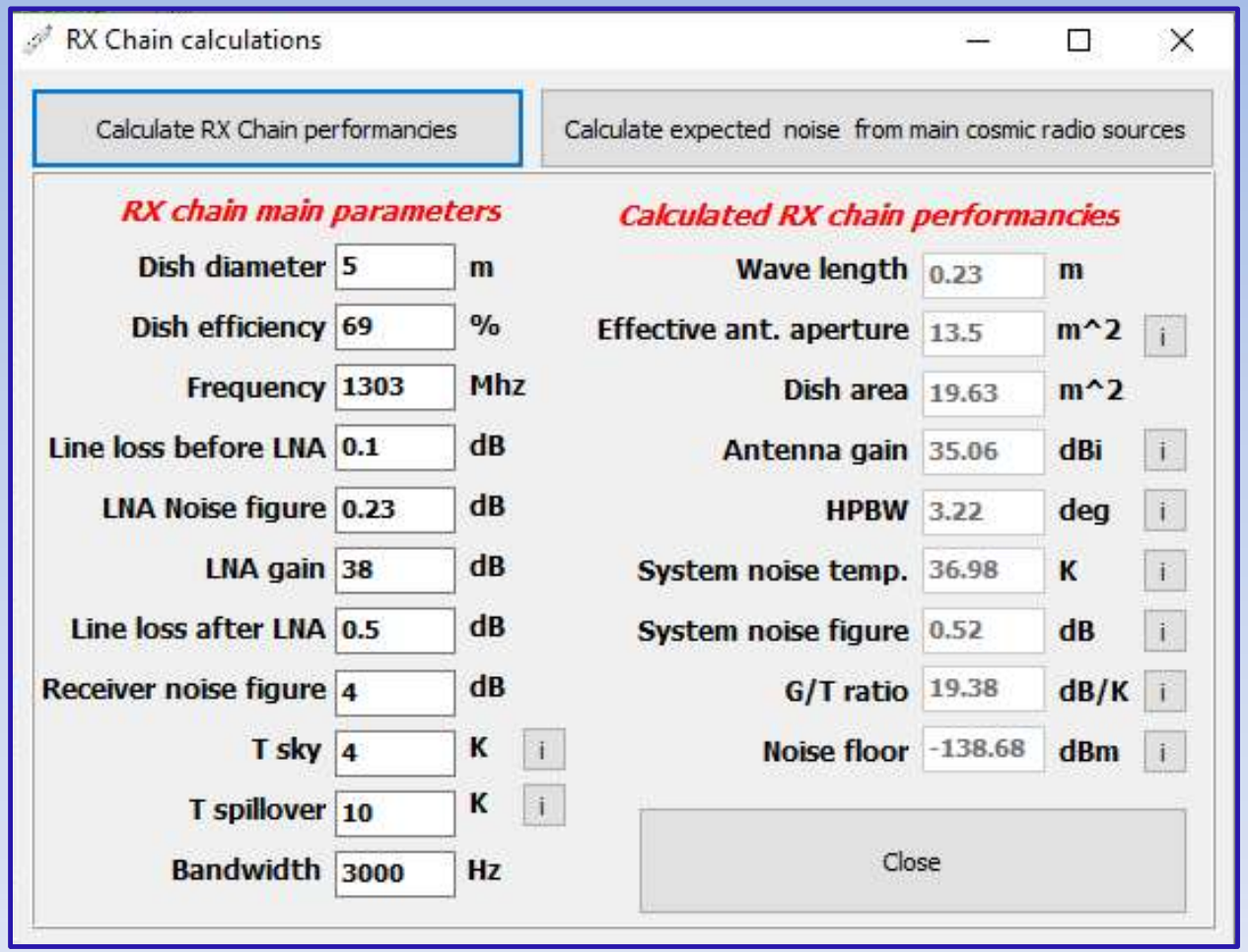


The SKY EXPLORER function uses a 408 Mhz noise-based galaxy map generated with a tool of the Max-Planck Institute and, in addition of automatic tracking of preset objects, offers the Click-And-Point (CAP) function.

New in TotalPower 7.0.0

TotalPower 7.0.0

Main functions : System evaluation



The SYSTEM EVALUATION function derives the fundamental parameters of RX chain from the input parameters entered by the the user. The small buttons i , when clicked, show the equations and basic information.

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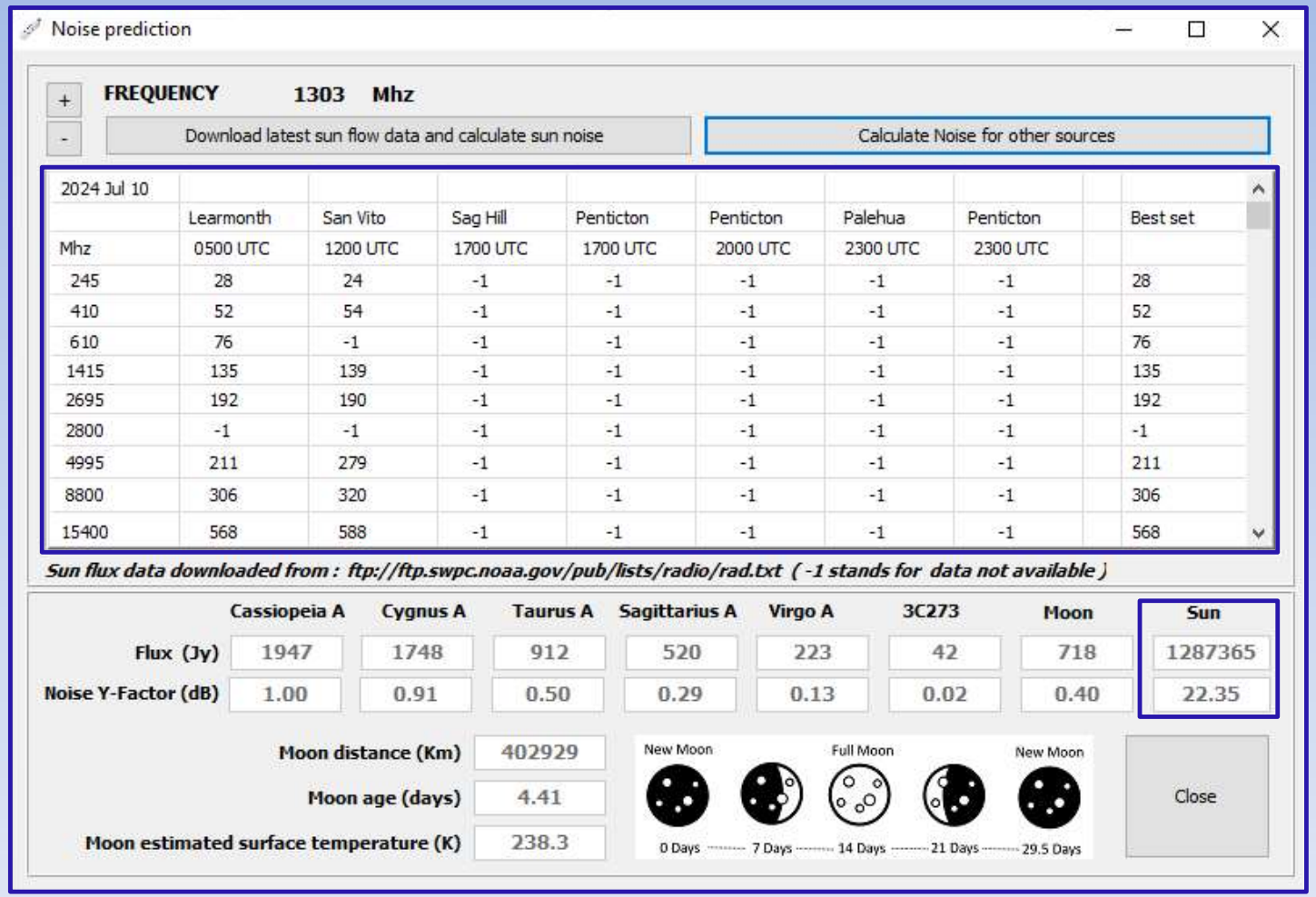
New in TotalPower 7.0.0

Main functions : Noise prediction



The predicted Sun Y-factor noise is calculated with a spline interpolation based on the latest solar flux data downloaded from NOAA sun observatories ftp site.

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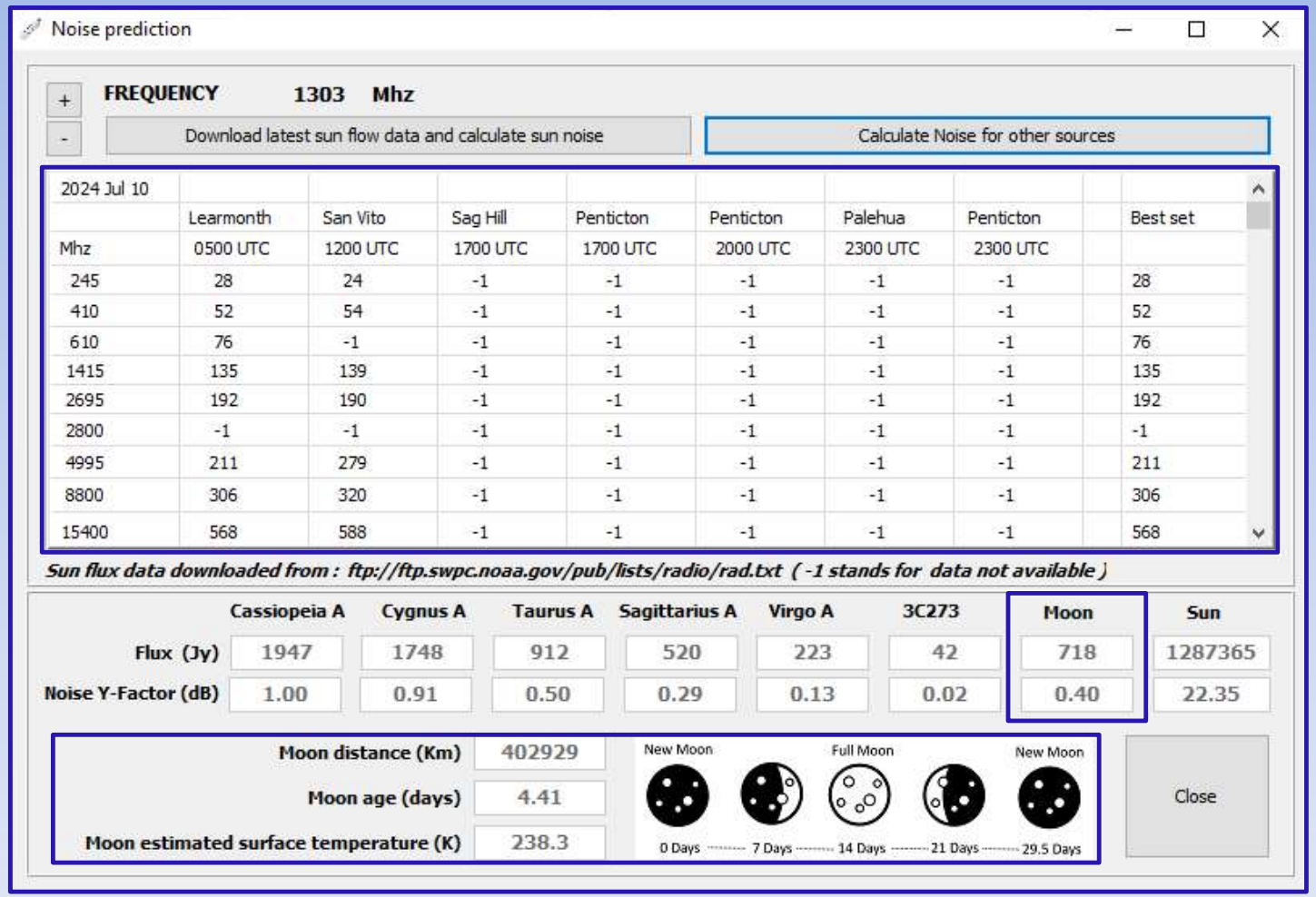
New in TotalPower 7.0.0

Main functions : Noise prediction



The predicted Moon Y-factor noise is calculated with an experimental algorithm that takes into account the estimated temperature of the lunar surface with a 3-day lag factor on the Moon's age .

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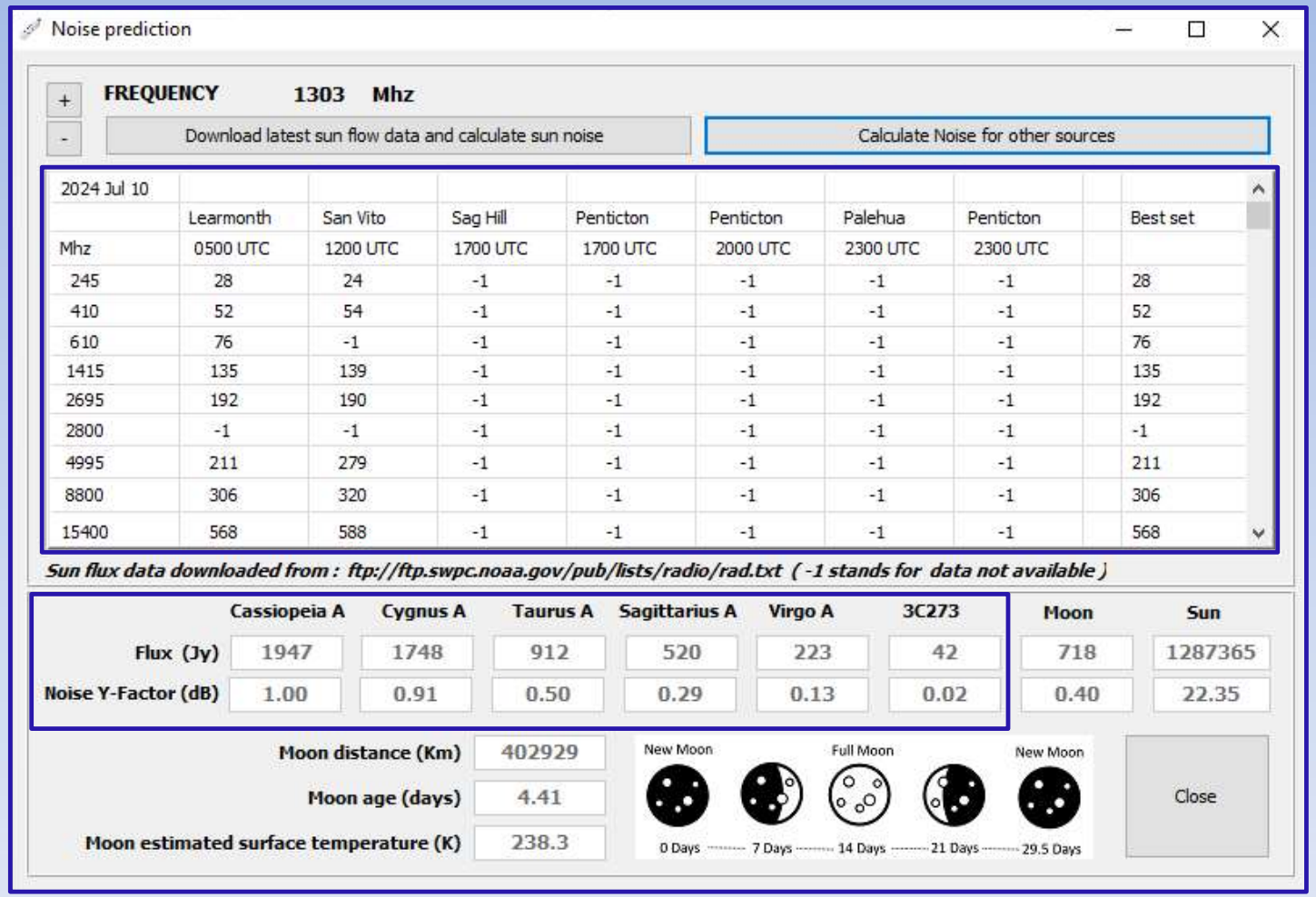
New in TotalPower 7.0.0

Main functions : Noise prediction



The predicted Noise Y-factor for the other objects is derived from the interpolation of the data published in the papers reported in the visual manual.

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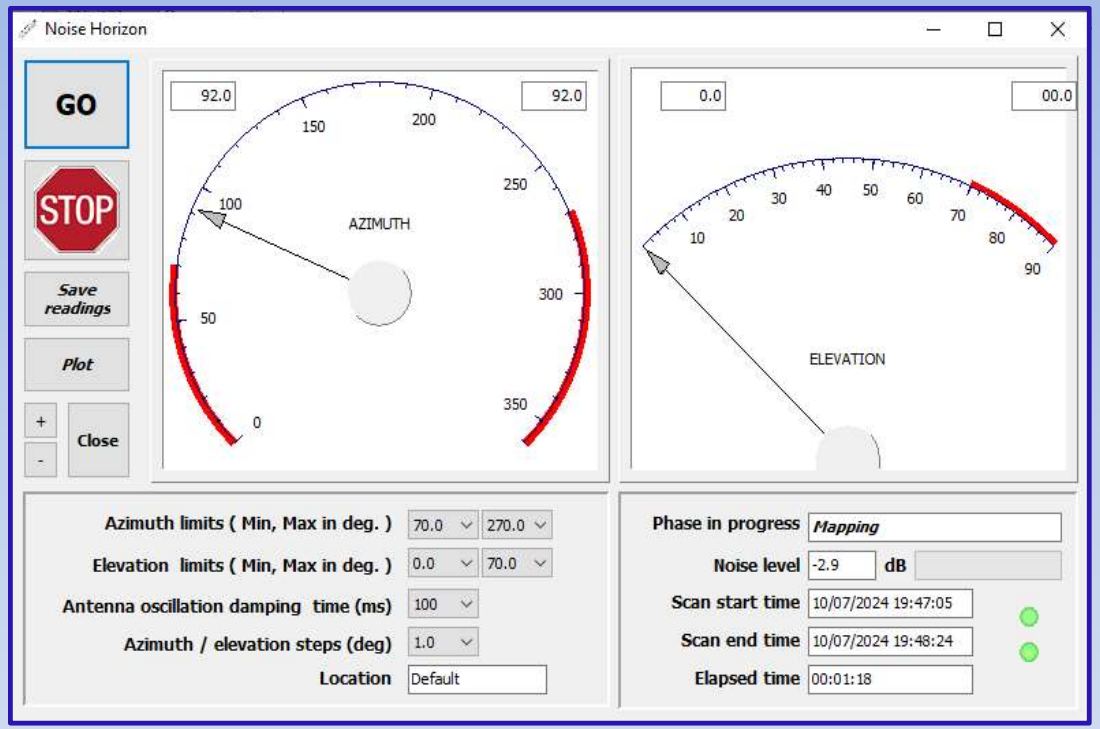
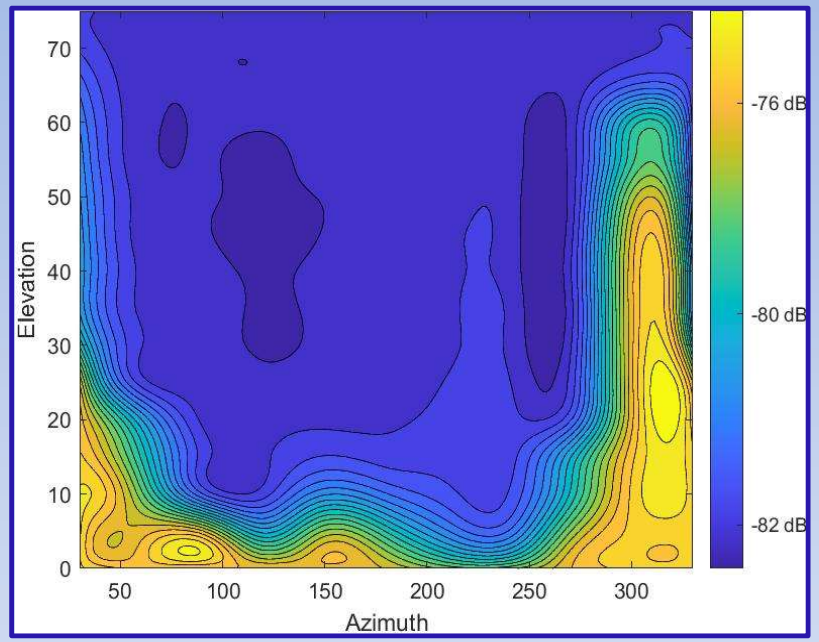
Future function : Noise Horizon

Future function





Noise Horizon at my site @ 1300 Mhz

The NOISE HORIZON function, working together with PstRotator, generates a "contour plot" that can be archived and then executed regularly to monitor changes at the observation site.

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What's next

Few more functions / improvements are in plan :

- ✓**NOISE HORIZON with his own 3D analysis tool.**
- ✓**Linearization of frequency domain plots.**
- ✓**Visibility improvements to operate under the sun.**
- ✓**Introduce a new SDR : Air spy … Adalm Pluto… B200…. need to define.**

… any input and request will be much appreciated !

Grazie !

Thank you !