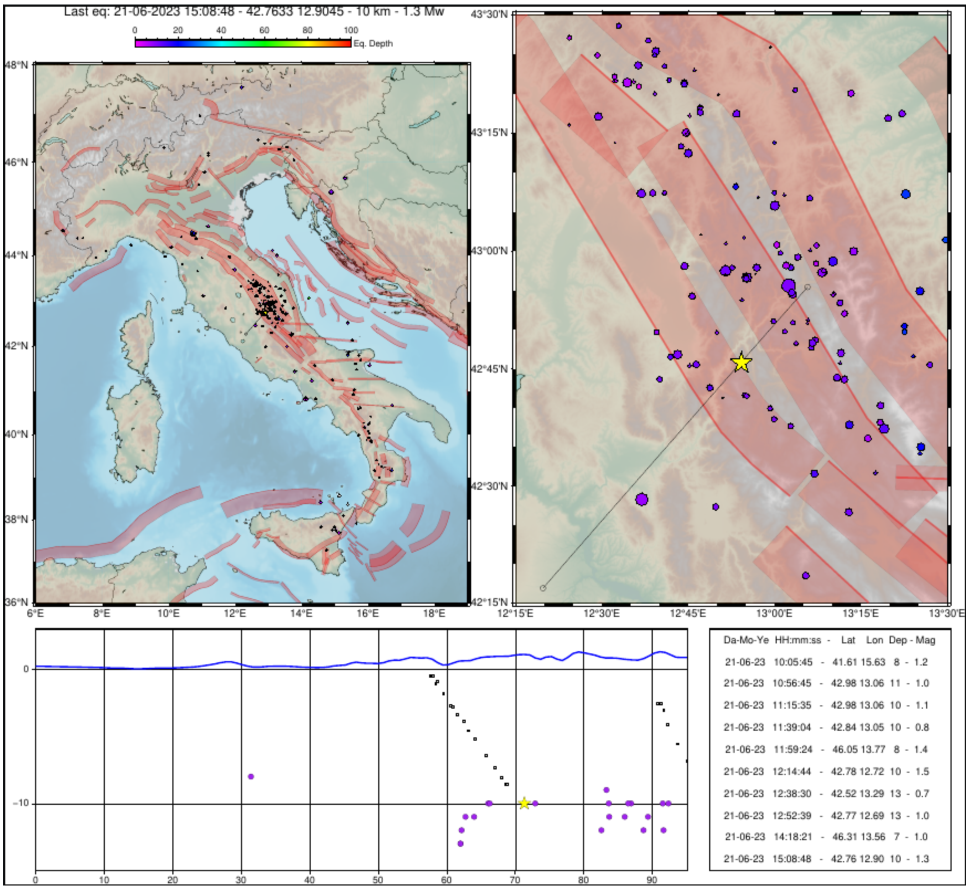
SATA - Seismicity Automatic Tool Analysis

SATA is a Python and GMT tool designed to automatically retrieve data from the INGV (http://terremoti.ingv.it/) online earthquakes database. It captures earthquake information and generates real-time plots. This *Documentation.pdf* file provides a comprehensive overview of the tool in its current release. Furthermore, quick commands and relevant information are also available within each window of the SATA GUI (Graphical User Interface).



Da-Mo-Ye	HH:mm:ss	-	Lat	Lon	Dep	-	Mag
21-06-23	10:05:45	-	41.61	15.63	8	-	1.2
21-06-23	10:56:45	-	42.98	13.06	11	-	1.0
21-06-23	11:15:35	-	42.98	13.06	10	-	1.1
21-06-23	11:39:04	-	42.84	13.05	10	-	0.8
21-06-23	11:59:24	-	46.05	13.77	8	-	1.4
21-06-23	12:14:44	-	42.78	12.72	10	-	1.5
21-06-23	12:38:30	-	42.52	13.29	13	-	0.7
21-06-23	12:52:39	-	42.77	12.69	13	-	1.0
21-06-23	14:18:21	-	46.31	13.56	7	-	1.0
21-06-23	15:08:48	-	42.76	12.90	10	-	1.3

Hardware and software specification

SATA works on both Linux (tested on Manjaro 22.1.2 and Ubuntu 22.04.02 LTS) and Windows (tested on Windows 11) operative systems. You can find both versions in the *main* branch or download the one you need from the available branches (*Linux* or *Windows*).

SATA does not consume many resources: its reactivity depends on hardware specifications but, especially, depends on the internet connection and the velocity of download.

The tool requires:

- Python (version >= 3) and the modules above (to be manually installed; you can install modules using pip/pipx or directly searching *python3-modulename*)

    - tkinter module
    - bs4 module
    - plyer module
    - geopy module
    - requests module
    - numpy module
    - pillow module
    - matplotlib module
- GMT (version > 6)

We provide an installer that can do it for you. In the folder *installer*, the user can find two bash scripts *install_SATA_on_arch.sh* and *intall_SATA_on_debian.sh* for the Linux version, and *install_SATA_on_windows.bat* in the other version of the tool. Use *install_SATA_on_arch.sh* in case of Arch-based distros (Manjaro, Endeavour,...) and the *install_SATA_on_debian.sh* in case of Debian-based distros (Ubuntu, Linux Mint,...). Both scripts simply provide each required step to install the previously described tool required by SATA. The user can run the installer script or copy each line and run it in a terminal. For the Windows version, the *install_SATA_on_windows.bat* do the same but executable installers for GMT and Python are necessary. The script automatically downloads both from the GitHub page and the Python3 so that the user can simply run the batch by double-clicking on it. In case of errors please check if the URLs are not been changed.

Note: hereinafter we refer only to bash language and .sh scripts but on the Windows version of the code the user can find the correspondent file .bat in batch language having the same names. For running a batch file simply double-click on it.

For Windows users: You must change the first line of *combined_plot.bat* in the *SATA_bin* folder by replacing 'PDFelement.exe' with your default pdf reader...unfortunately, it cannot read it automatically.

How it works

SATA tool is composed of a 'main' script (the be run in a terminal) called *SATA_tool.sh*. It is a bash script which runs a sequence of scripts as described inside it. These Python and bash scripts are stored in the *SATA_bin* folder and they are (in order of execution):

- SATA_execute_tool.py - it launches the starting GUI of SATA. Here you can choose the store folder and the frequency for splitting the earthquake list (for more information see ***Usage: input-output*** chapter). When the tool starts, it downloads the last week's seismic events from the INGV online database; these require some minutes depending on the number of earthquakes and the internet velocity. A notification will advise the user about the start of the first download phase. This script also creates the storage folder *SATA_tool_files* in the directory set by the user and a *temp* folder inside *SATA_bin*.

- SATA_coord_zoom.py - it reads the coordinates of the last earthquake to calculate the boundary of the second plot (see after).

- SATA_coord_sections.py - it calculates the coordinates of a vertical cross-section crossing the last earthquake. The script compares the coordinates of the last seismic event with a file (*Strike_sex.txt* in the *DISS_gmt* folder) containing coordinates of the midpoint of main seismogenic faults reported in the DISS database (DISS - Mapper). Section strike is estimated as the strike of the nearest fault -90°. Along this perpendicular direction, the script estimate the coordinates of starting and ending points as a distance of 0.75° from the earthquake going far from the fault trace and 0.25° on the other side, respectively.

- SATA_last_ten_eqs.py - it extracts the last ten seismic events and saves the table in the corrected format to be inserted in the plot (see after).

- combined_plots.sh - this bash script runs GMT to create and show a plot of downloaded earthquakes; each plot contains the main DISS seismogenic sources. The plot is composed of four panels:

    - Top left - it is an 'Italy plot' representing the last 300 earthquakes of the INGV database. Different points dimensions are related to different magnitudes. The last seismic event is plotted as a star. On the top, there is the colour bar used to classify events by depth, and a summary of the last earthquake. In the background, a coloured DEM of the entire area is shown.

    - Top right - a 'Detailed plot' which is a zoom of 1.25°x1.25° on the last available earthquake. Depth and magnitude follow the same scales as the other plot. In the background, a coluored DEM of the area is shown.

    - Bottom left - it is a 'Section plot' showing the vertical section that crosses the last event along a direction perpendicular to the nearest fault strike. On the image are projected earthquakes within 10 km from the trace (the last event is represented as a star) and a topographic profile (blue line) calculated from a DEM of 0.1° of resolution. The intersection with fault surfaces is also shown using points: these are the vertex of triangles of a mesh surface representing faults in 3D; the vertex are plotted using a semi-width of 10 m to represent only the faults that are crossed by the vertical section. As a result, in case of section trace crossing a fault parallel to his strike, it will be represented as horizontal alignment. Section trace is reported in both the previous plots.

    - Bottom right - a list of the last ten earthquakes that occurred.

- SATA_close_banner.py - the python script create a banner to advise the user that SATA is running. The banner has two buttons for controlling the SATA actions:

    - *Save plot* button: it saves the plot you are shown on screen in pdf format. The plot is stored together with the input GMT files in a folder (under the '*SATA_tool_files/Plots/*' path) named by the date and time of the button pushing. It also saves the files *coordinates_of_zoom_plot.txt* and *coordinates_of_section.txt* to allow the reproduction of all the plots.

    - *Stop tool* button: SATA checks the existence of a file called *running* stored in the *temp* folder. This button deletes the *running* file to stop the tool at the next check. As a consequence, the GUI window will disappear but SATA will be completely stopped at the next refresh. The refresh time is set at 5 minutes (300 seconds) but it can easily be changed by modifying the main script *SATA_tool.sh* at line 18 (*sleep 300*).

- SATA_refresh.py - it reads the first page of the INGV database (last 30 events) and checks if there are new events to be stored locally and to be plotted. The comparison is made using the events ID. The main bash script runs it each 5 minutes and a notification will be shown on the screen reporting the time of the last refresh. This script also split the earthquake list following the preferences set by the user in the first window of the GUI (see next chapter).

- SATA_m_to_km.py - this is not called directly from *SATA_tool.sh* but from *combined_plots.sh*. It makes a conversion of earthquake depths from km to m for plotting it in the cross-section.

Usage: input - output

SATA requires only the storage path and the preference of storage for the earthquakes list. The directory can be indicated by pasting the complete path in the available space, or by clicking on the *browse* button and navigating to the preferred folder. Once started the tool will create a *SATA_tool_files* folder containing two subdirectories:

- Earthquakes - contain the list of seismic events appended in the last week, the actual list to be refreshed every 5 minutes and all the lists split by the time selected (see below).

- Plots - contains the files of coordinates to plot earthquakes with GMT and a folder for each saved plot: by pushing the *Save plot* button a folder named with the actual time is created; it contains the plot and the input GMT files.

SATA storage in the *Earthquakes* folder lists of seismic events for a precise period of time as reported by the list name. In the first window of the tool the user can decide the length of earthquake lists in terms of consecutive days:

- Daily: it creates a separate list of events for each day.
- Weekly: it creates a separate list of events for each week. SATA considers a week as composed of 7 consecutive days starting from the day it begins the download.
- Monthly: it creates a separate list of events for each week. SATA considers a week as composed of 30 consecutive days starting from the day it begins the download.

Usage: tool

For using SATA, clone the repository or download it as a zip. The files can be stored everywhere on the local PC but you must maintain the relative position of files (do not move *SATA_tool*.sh without moving *SATA_bin* and do not put it inside the latter folder).

To run SATA you should need two steps in a terminal:

1. Make bash scripts executable

   ```
   cd /your-download-directory/
   chmod +x SATA_tool.sh
   cd SATA_bin
   chmod +x combined_plot.sh
   ```

2. Simply run it

   ```
   ./SATA_tool.sh
   ```

The dimension of storage will variate depending on how long you will use the tool (each earthquake is stored in a text file so the dimension should be small). The only space allocated is the one in the folder set by the user: the dimension of the folder containing SATA scripts will not change more than some KiloBytes (the dimension of the *temp* folder).

Bugs and upgrades

One known bug is about the transparency of the GMT plots. The command of transparency works properly only on some PC but it should be a problem with the version of Ghostscript (package for managing ps files) or GMT. It works with version 9 of GS.

We are now working to include also a version for MacOS.

Licence

SATA is released under the MIT license