CASTIA

A Source Visibility Tool for the Italian Radio Telescopes

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CASTIA v3.0

Source Visibility Tool for the Italian Radio Telescopes

1 Introduction

CASTIA is a software package able to check radio source visibilities at a given date from any of the three Italian radio telescopes. The tool produces a plot containing the visibilities of radio-sources versus time with a special mark for the transit time. Visual warnings are provided when the azimuth rate is beyond the recommended limit or superposition with the Sun and/or Moon occurs.

The code has been originally tested in the context of the project *A Mini Survey at 5–8 GHz of Gamma-Ray Selected Supernova Remnants* (PI: A. Pellizzoni) performed at the Medicina radio telescope, INAF - IRA.

2 Using CASTIA

CASTIA has been developed under Python 2.4.3 and Scientific Linux 5.3 operating system and is available at the web page[1] `http://www.ira.inaf.it/Observing/castia/site/index.php`. Using CASTIA requires the user to enter the following information in the home page:

Source file
The user has to upload a file of sources through the drop-down menu. This file has to be written as in Table 1. The maximum character number of the name of the sources has to be 11 and no space has to be included. RA and DEC are in J2000. CASTIA alerts you if the source is never visible from the site. An example of the file is shown in Fig. 1. The user can practice the software with the files example1.dat and example2.dat available through the drop-down menu.

3C286	13	31	08.3	+30	30	33
NGC7027	21	07	01.5	+42	14	12

Table 1: Format for the file of sources. Col. 1: Source name; Col. 2, 3, 4: Right ascension of the source in J2000 (hh mm ss); Col. 5, 6, 7: Declination of the source in J2000 (±dd mm ss). Note that one has to specify the sign of declination even if positive.

Date
The required date format is strictly: YYYY/MM/DD

Site name
CASTIA is conceived to produce the visibility time for all the three radio telescopes of the Italian network: Sardinia Radio Telescope, and Medicina and Noto stations (see Fig. 2). The available options can be selected by the user through a drop-down menu.

Lower elevation and **Upper elevation** (not mandatory)
The user can enter an elevation range (in degrees) that will be characterized by a different color code in the final plot. This option can be useful when the observer is interested in investigating radio sources in a specific elevation interval.

If all the mandatory arguments are not given in input, you will get a warning.

A quick description about these fields is given by the **Quick help** button, while a more exhaustive explanation can be downloaded through the **Manual** button. By pressing **Reset** all the fields will be empty. The default values

[1]The web interface has been designed in collaboration with the Mathematics and Informatics Department of the University of Cagliari represented by S. A. Iacolina.

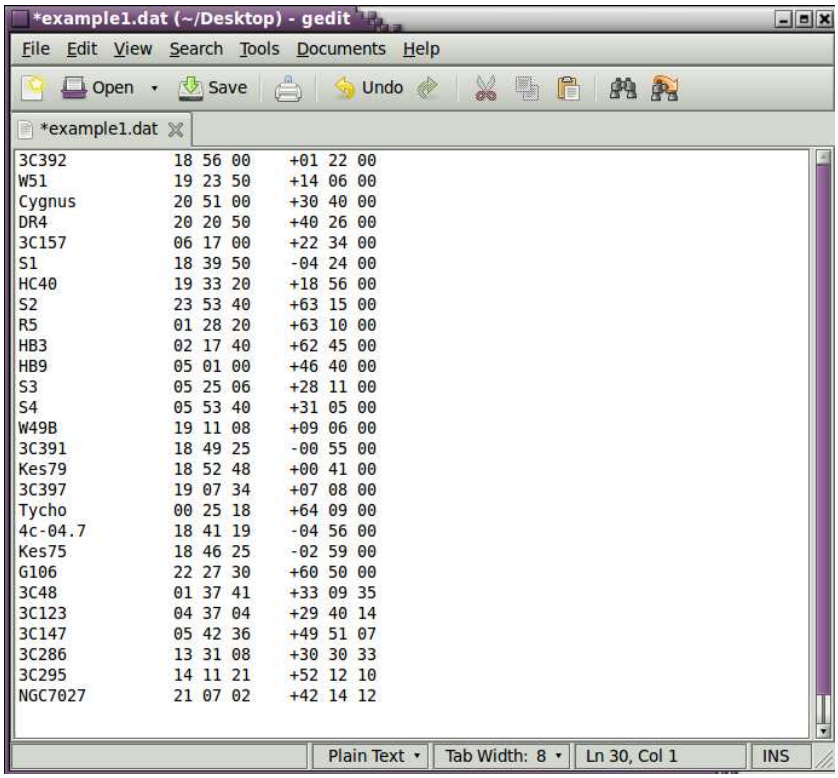

Figure 1: Example of a file containing the information about the radio sources to be given in input to CASTIA.

1. Source file: example1.dat
2. Date: today
3. Site Name: SRT
4. Lower elevation: NONE
5. Upper elevation: NONE

can be inserted with **Default**. **Plot** starts executing the software.

An example of a plot given in output from CASTIA is shown in Fig. 3. An extensive description of all the outputs is given in § 5.

3 Software performances

Planning an observation of an astronomical radio source requires a precise geographical knowledge of the radio telescope location. Different terrestrial latitudes and longitudes imply that the observation has to be performed during different time intervals. The optical horizon (i.e. the orography of the site, see Fig. 4 for SRT as an example) poses additional limits as well as the terrestrial man-made radio frequency interferences (RFI) coming from the surrounding. The elevation limit imposed by the combination of the two effects is called hereafter *site horizon*. The observing time depends also on the declination of the source since in the Northern hemisphere sources at lower declination are visible for shorter time intervals. In particular, sources with declination higher than the co-latitude of the radio telescope are always visible, while sources with declination lower than minus the co-latitude are never visible. Viceversa for the Southern hemisphere. In addition, during a radio-astronomical observation, the Sun/Moon can cross the line of sight blocking the signal coming from the target or anyway contaminating the data. The software CASTIA takes into account all these aspects as well as the followings.

In astrophysics the time coordinate systems mainly adopted are the local sidereal time (LST) and the coordinated universal time (UTC). LST is the hour angle between the vernal equinox and the local meridian taken counterclockwise. LST corresponds to the right ascension of celestial bodies at the local meridian (see Fig. 5). UTC is the solar time coordinate referred to the prime meridian (Greenwich).

Figure 2: The three antennas of the Italian network: Sardinia Radio Telescope in the South-West, Medicina in the North, and Noto in the South-East. Image taken from `http://www.srt.inaf.it/astro/ivlbi`

In the diurnal motion of a radio source the point of maximum elevation is called *transit*. For a radio telescope with an alt-azimuth mount (as the three Italian antennas), when the radio source is approaching its transit, it may happen that its elevation is such that the antenna azimuth rate is beyond the recommended limit. With CASTIA the user knows when it will happen and can plan the observation carefully avoiding it. Otherwise, it is strongly suggested a consultation of the antenna manual, e.g. *Observing at the SRT with Nuraghe* by S. Righini and A. Orlati, for the antenna control system (Nuraghe) of SRT. This tool is mainly conceived to planning in advance radio-astronomical observations. Nevertheless, during a session at the radio telescope it may happen that the planned schedule has to be changed (e.g. because of technical reasons or scientific opportunities). In this case, a quick new planning is essential to successfully conclude the observation. Therefore, the present time (vertical black line) as a reference in the plot should be helpful for the user.

Moreover, the user could be interested in observing radio sources in a specific elevation range (e.g. to produce good-quality scientific images or, for SRT, during grey zone tests when the active surface is not yet available). To take into account this need, CASTIA is able to take in input a lower and an upper elevation threshold selected by the user.

Overall, on the basis of what above mentioned, the performances of CASTIA take into account:

- geographical coordinates of the radio telescope station;
- site horizon (dependent on RFI and on the optical horizon);
- declination limit of the telescope;
- possible overlapping with the Sun/Moon;
- LST and UTC coordinate systems;
- transit of the target;
- elevation limit of the radio telescope;
- needs for variations in the schedule during the observing session;
- possibility to select an elevation range of interest.

4 Main structure and parameters

CASTIA consists of a main program `castia` and three subroutines `tempus`, `sobi` and `luna`. `castia` takes in input the source coordinates, date, and telescope site and passes them to the subroutines.

`tempus` evaluates the time when the source elevation is higher than the horizon, the site horizon, the lower and the upper elevation thresholds entered by the user, and the antenna elevation limit. The site horizon is set to 6° for SRT (see

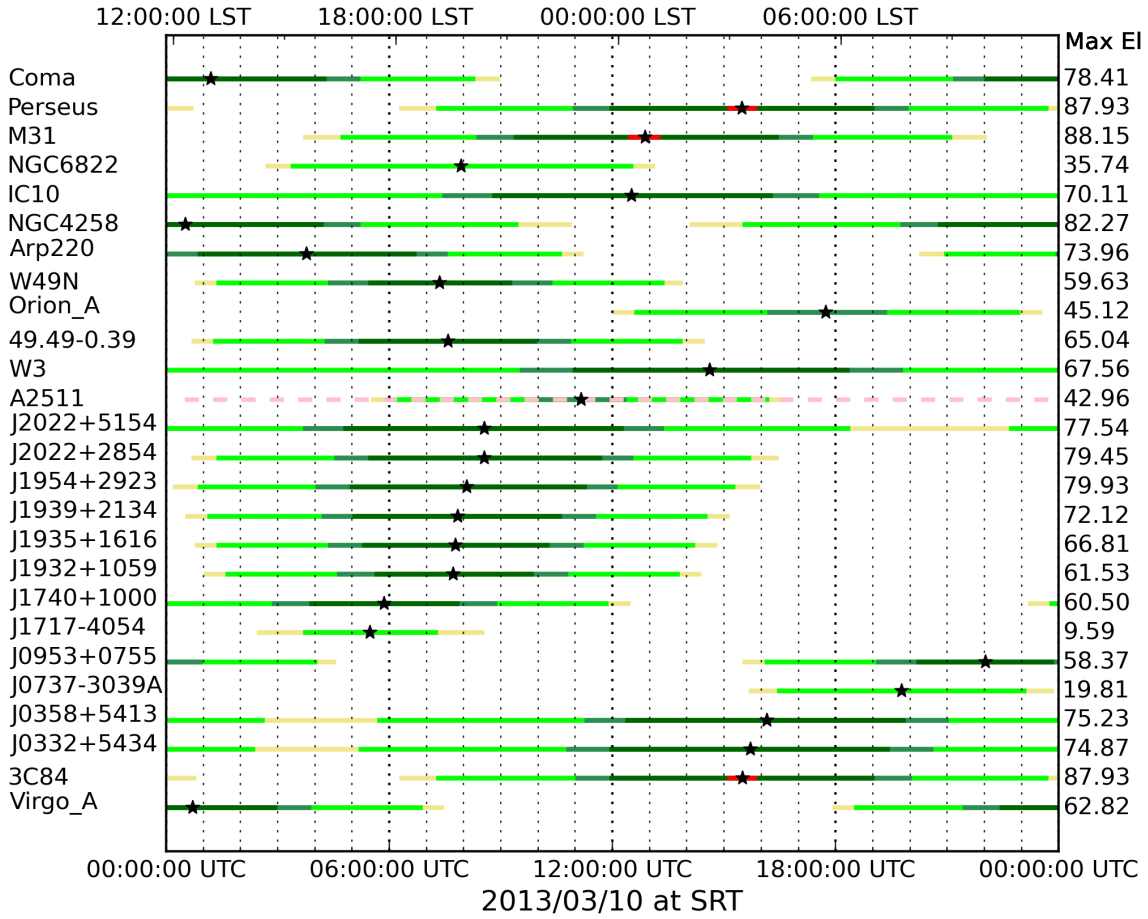

Figure 3: Example of the plot in output from CASTIA. The target visibilities are shown versus coordinated universal time (UTC, bottom axis) and local sidereal time (LST, top axis). Yellow lines refer to sources with elevation between the horizon and the site horizon. Different green-tone lines indicate radio sources with elevation between the site horizon and the antenna elevation limit: light-green between the site horizon and the lower elevation threshold entered by the user (in this example 40°), medium-green between the lower and upper (50°) selected threshold, and dark-green between the upper threshold and the antenna elevation limit. Red lines denote elevations higher than the antenna limit. Stars mark the transit. A pink dashed-line is overlaid for targets nearby the Sun. Vertical continuous line shows the present time. On the left the names of sources and on the right their maximum elevation are given.

Fig. 4) and Noto, and to 20° for Medicina, the horizon and the elevation limit to 0° and 85°, respectively, for all the three antennas. Continuous colored lines are drawn between the different thresholds.

`sobi` and `luna` check the time when the distance between each target and the Sun and/or the Moon is smaller than the Sun avoidance radius (set to 10°) and/or the Moon avoidance radius (set to 5°). If at least one of these conditions is verified a dashed-line is plotted to warn the user.

5 Software output

CASTIA produces in output a plot, a data file and a log section.

The plot

The plot contains the visibility time-lines of 50 radio sources at maximum, this limit still allowing an optimal visualization. An example is given in Fig. 3. The visibility of the targets is shown versus time: UTC is indicated in the bottom axis, while LST in the top axis. The plot refers to the whole solar day provided in input by the user, from the midnight UTC to

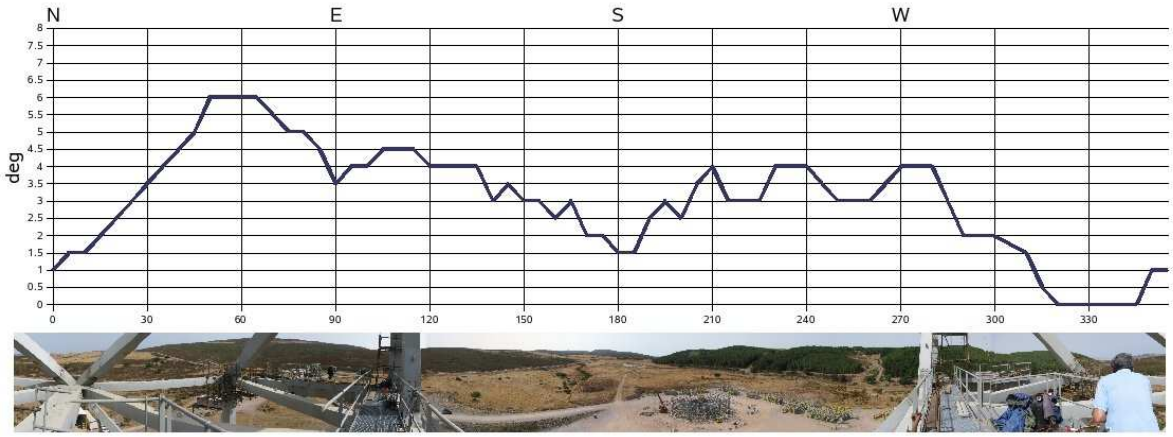

Figure 4: Orography of the SRT site. Courtesy of F. Buffa, G. L. Deiana.

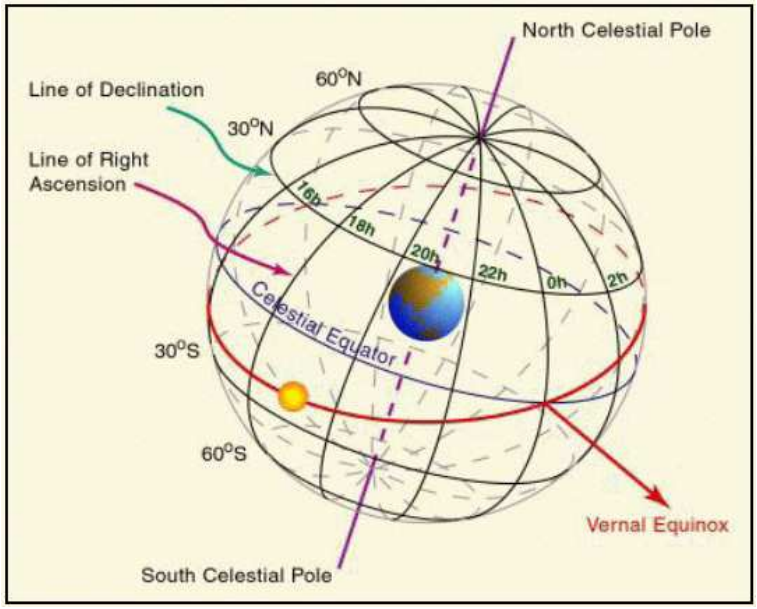

Figure 5: Scheme of the celestial coordinate system. The vernal equinox and the hour angle are indicated.

the midnight UTC of the day after. For each source the user can see: on the left the name, in the middle the plot of the visibility time-line, and on the right the maximum elevation.

In the visibility time-line we can identify the different elevation values of the radio source with different colors. Yellow indicates that the source has an elevation between 0° and the site horizon. Different green-tones indicate radio sources with elevation between the site horizon and the antenna elevation limit, the darker the higher elevation range: light-green between the site horizon and the lower elevation threshold entered by the user, medium-green between the lower and upper selected threshold, and dark-green between the upper threshold and the antenna elevation limit. Red lines denote elevation higher than the limit of the antenna. The visibility time-line is dashed if the target is nearby the Moon. A pink dashed-line is overlaid if the target is nearby the Sun. The star mark represents the source transit time, being the corresponding elevation indicated on the right. Vertical continuous line shows the present time.

In the home page, the button **Plot** allows to visualize the plot, while **Save Plot** to save it as a png image, called *plot_YYYY-MM-DD_SITE.png*.

The data file

The data file contains the rising and setting LST at different elevations (site horizon, lower elevation threshold, upper elevation threshold) and the LST at the transit of the sources in the format hh:mm:ss.ss for the site and the date selected by the user. An example is given in the following

```
#-------------------------------------------------------------------------------------------------------
#                            ELEVATION LSTs (hh:mm:ss.ss) IN DATE 2013/05/01 at SRT
#
# SOURCE NAME       SH-RISE      LE-RISE      UE-RISE      TRANSIT       UE-SET       LE-SET       SH-SET
#
#                       6.0         30.0         50.0                      50.0         30.0          6.0
#                       deg          deg          deg                       deg          deg          deg
#-------------------------------------------------------------------------------------------------------
#
  3C392           13:25:45.17  15:33:20.16  18:03:34.78  18:56:41.90  19:53:48.84  22:24:03.45   0:34:16.78
  W51             13:10:42.71  15:15:54.22  17:03:26.92  19:24:27.97  21:49:00.71  15:20:55.04   1:44:20.26
  Cygnus          13:35:46.81  15:53:22.44  17:38:30.67  20:51:33.96   0:09:12.68   1:54:20.90   4:14:39.89
  DR4             12:15:33.67  14:55:50.93  16:53:27.29  20:21:19.49  23:54:10.21   1:49:21.08   4:29:41.35
  3C157           23:34:06.93   1:44:20.26   3:29:32.50   6:17:48.35   9:10:11.30  10:55:25.54  13:05:41.89
```

The acronyms used in the data file are:

SH - site horizon

LE - lower elevation

UE - upper elevation

The tag `ABOVE` indicates that the source is always above that elevation, while the tag `NONE` that the source never reaches that threshold.

In the home page, the button **Contu** allows to visualize a section containing all these times, while **Save Contu** to save it as a data file, named *contu_YYYY-MM-DD_SITE.dat*.

The log section

The log section contains all the information concerning the execution of the software including possible errors and the header:

```
CASTIA - A SOURCE VISIBILITY FOR THE ITALIAN NETWORK

Iacolina M. N. - Vacca V.
Pellizzoni A. - Iacolina S. A. - Trois A.
and the SRT Astrophysical Validation Team

Release 3.0 - April 2013

contact: castia@oa-cagliari.inaf.it
```

Afterwards an identification number and the name of each source are provided.

The visualization of the log section is possible pressing the button **Log**.

6 Software requirements and testing

The code requires the following Python modules:

- Pyephem 3.7.2
- Numpy 1.2.1
- Matplotlib 0.99
- Scipy packages 0.6

and has been tested with:

- Python 2.4.3 on **`nuraghe-obs1`** - Scientific Linux 5.3 – i386
- Python 2.6.6 on **`storage`** - Scientific Linux 6.3 – x86_64

where nuraghe-obs1 and storage are two of the machines available at present at SRT site.

Compatible browsers are:

- Mozilla Firefox 20.0
- Google Chrome 26.0
- Internet Explorer 9.0
- Safari 6.04
- Opera 12.15
- Android 2.2
- iPhone/iPad

They are also listed by the button in the right of the home page.

7 Releases

First release: CASTIA_0.1 developed under Python 2.6.5 on Ubuntu 10.04 (September 2012).

Second release: CASTIA_1.1 developed under Python 2.4.3 on Scientific Linux 5.3 (October 2012).

Third release: CASTIA_2.1 developed under Python 2.4.3 on Scientific Linux 5.3 (February 2013).

Fourth release (with graphic web interface): CASTIA_3.0 developed under Python 2.4.3 on Scientific Linux 5.3 (April 2013).

Future developments

In the next release we will consider the azimuth limit due to cable wrapping. Azimuth unwrapping requires some minutes. Therefore, while planning observation of a specific target it is better to know in advance if the whole azimuth range includes this limit. In this case, through CASTIA, you will be aware of the situation and you can unwrap the cables before starting the observation. An additional text output for the initial and final azimuth of the source will be given thus the user can plan the observations in such a way that the slew time is minimized.

A new module will allow to visualize the radio-source visibility time-lines for all the three Italian antennas simultaneously. This feature will be useful for observations with the Italian VLBI network.

8 Remarks

The CASTIA user has to take into account the following:

- CASTIA usage is intended in the context of observations with the antennas in the Italian network. The use and redistribution of the software outside this framework is not allowed without explicit permission of the authors;
- for all the questions related to using CASTIA please contact the developers at the e-mail address: `castia@oa-cagliari.inaf.it`

9 Curiosities

The names of the CASTIA components have been taken from the Sardinian language. `castia` means *look at*, `tempus` *time*, `sobi` *Sun*, and `luna` *Moon*.

The `Show Hide` button in the top right of the home page allows to entirely visualize the picture in the background. It includes the promontory Sella del Diavolo raising in the Cagliari seaside (Sardinia), an Hubble image of the sky, and a VLA antenna.

10 Acknowledgments

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