

Using TOPCAT with sparse measurements on planetary surfaces

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Abstract

Remote sensing instruments produce tens of gigabytes of data. Taking full advantage of such complex datasets is a hard and time-consuming task and the risk exists to miss important information. TOPCAT [1] is a free community software with fast, strong and various functionalities, designed to manage large tables. It allows deep investigations of datasets without large computation capacities and with a smooth learning curve. Here we share an example of workflow based on imaging spectrometry, and present some capabilities of TOPCAT of interest for planetary surfaces, with a stress on the mapping functionalities.

1. TOPCAT

TOPCAT (Tool for OPERations on Catalogues And Tables) is a free interactive software to handle data tables (see section 2 for examples). It is one of the major tools of the Virtual Observatory (VO), with constantly enlarging abilities. It has been developed at University of Bristol [1] in JAVA and is consequently available on Windows, Mac, Linux and Solaris. TOPCAT reads (and can write out) tables in many different formats (FITS, VOTable, CDF, ASCII, CSV...) and is at ease with files made of several millions rows and tens of columns even on relatively modest computer configurations. It can also be scripted for use in a processing pipeline.

2. Use case: TOPCAT and imaging spectrometry data

2.1. Table creation/access

TOPCAT (Figure 1) was initially designed as an astronomy Virtual Observatory tool, and implements the main VO protocols. This provides it with the capacity to send queries to distant databases and catalogues, and also to exchange data with other VO tools such as Aladin and CASSIS through the SAMP protocol. As a TAP client, TOPCAT also supports the more restrained EPN-TAP protocol developed for

Solar System data in the frame of VESPA/Europlanet2020 [2], and currently implemented on ~ 50 data services worldwide.

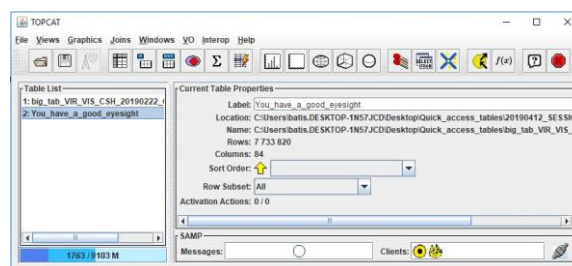


Figure 1 – Main window of TOPCAT.

When working with non-published data, the user can also produce a data table using his favorite programming language: IDL/GDL, Python... With the sparse spatial measurements typical of imaging spectroscopy, the logical organization of the table is to have rows representing a spatial location (a pixel) while each column is assigned to parameters either included in the dataset (coordinates, time, altitude, file name, instrumental mode...) or computed by the user, which can be mapped or not (e.g., spectral parameters). FITS or VOTable are basic VO-ready formats which are particularly convenient since they are self-described and do not require a large amount of disk space.

2.2. Edit, browse, search, concatenate... do whatever you want with your table.

The main window of TOPCAT (Figure 1) displays basic information of the table(s) loaded in memory while icons give direct access to general tools: table browser, table header (editable), column parameters and subset view (editable), column statistic view... New columns or row subsets can be added based on algebraic expressions in a convenient way. Concatenation of tables as well as internal, pair or multiple matches between tables are possible.

2.3. Graphical possibilities

Graphic representations are diverse and fast. Histograms with various statistic tools, 2D plots and 3D plots (based on cartesian, polar or spherical coordinates) are interactive and rich of numerous functionalities (see Figure 2). Are you wondering if a correlation exists between X and Y? What is the evolution of such quantity? An entire dataset is ready for use in the table and plotting million points takes only few seconds, just do it!

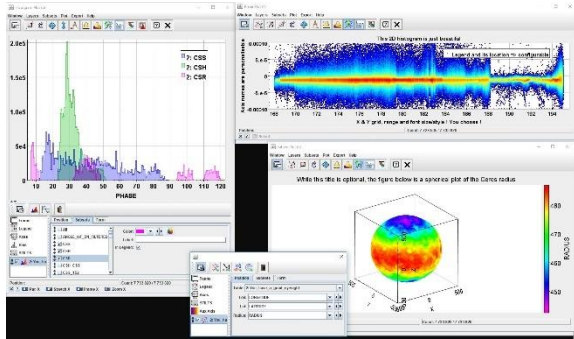


Figure 2 – Three independent windows of TOPCAT. Left: histogram of three subsets defined in a table. Top right: Density plot. Bottom right: Spherical plot based on longitude/latitude/radius coordinates.

2.4. Mapping capacities

The “Sky plot” window supports body-related longitude/latitude systems (either east-handed or west-handed) and allows various type of projection (sinusoidal, Aitoff, plate carrée/equirectangular). If the resolution and the redundancy of the data do not require to account for the pixel footprint, a simple “one point-one pixel” representation can be used. This can be sufficient to build a dense global map as in Figure 3. A HEALPix layer can also be used and tuned to give control over the cell size, which readily provides data integration at the chosen scale.

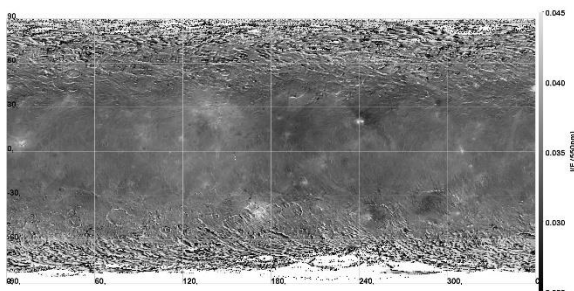


Figure 3 – Global Ceres reflectance map (550 nm) from VIR/Dawn photometrically corrected data [3].

In some cases (high resolution and close view or low resolution and global view) it is necessary to take into account the real projected size of a pixel. To address this, the last TOPCAT version implement the “quadrilateral plot” function (available both in the 2D/3D and Sky plot windows) which can be feed with the pixel corner coordinates to represent the footprints projected on the surface or the atmosphere (Figure 4).

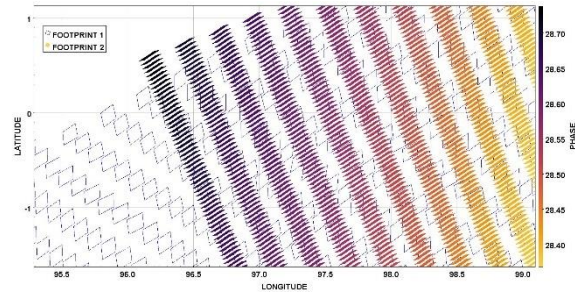


Figure 4 – Mapping of two hyperspectral cubes with different visualizations. The quadrilateral function handles the projection of actual footprints.

3. Conclusion

As a table manager, TOPCAT provides a rich way to explore a dataset, to target more precise subsets of data and to extract and map the information. Its recent developments address the classic issue of mapping extended pixels in imaging spectroscopy on planetary surfaces. Its links with the Virtual Observatory and the SAMP protocol makes it flexible for a use in combination with distant databases and other VO tools (e.g. Aladin, Cassis).

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References

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