A Virtual Observatory approach to planetary data for Vesta and Ceres. M. Giardino[1] , S. Fonte[2], R. Politi[2], S. Ivanovski[2], A. Longobardo[2], M. T. Capria[2], S. Erard[3] and M. C. De Sanctis[2]
[1]ASI, Rome, Italy (marco.giardino@asi.it - Via del Politecnico, snc - 00133 - Rome, Italy), [2]INAF-IAPS, Rome, Italy, [3]LESIA, Observatoire de Paris, PSL Research University, CNRS, Sorbonne Universités, UPMC Univ. Paris 06, Univ. Paris Diderot, Sorbonne Paris Cité

Introduction: We present a data access service in the frame of emerging techniques for virtual observatories.
This service is based upon the IVOA (International Virtual Observatory Alliance) standards widely used among the astronomical community, adapted to the planetary field as defined by the VESPA (Virtual European Solar and Planetary Access) activity in the frame of the European Union-founded Europlanet2020 program [1].
We will discuss the general advantages of such an approach, especially concerning the interoperability and availability of this service.
Some use cases will also be presented to address typical analysis performed by planetary scientists, exploiting the service functionalities and demonstrating the improvement obtained with respect to a more classic approach.

VIR instrument and data format: Data considered here consists of spectral cubes produced by the VIR instrument [2], a visible and infrared spectrometer on board the NASA Dawn mission. The published spectra covers various mission phases targeted to Vesta and Ceres observation in the time frame starting from May 2011 till April 2017: some of these data products are still under revision and will be available for the community at the NASA PDS Small Bodies Node.
The Dawn Mission is a NASA project aiming to identify the mineralogy and the surface composition of the asteroids Vesta and Ceres. The mission payload includes a Visible and InfraRed (VIR) mapping spectrometer combining two data channels in one instrument: the visible and the infrared sensors are housed in the same optical head.
The instantaneous field of view of VIR is represented by a slit of 64 milliradians per 250 microradians, the radiation from the slit is split by the optics to hit both sensors. The products corresponding to a single acquisition are two bi-dimensional frames: for each frame the first axis represents wavelength of the radiation (i.e. the spectral information) while in the other axis signal intensities sampled by the sensor at different locations are stored (i.e. spatial information). The instrument, set to implement a repetition time of acquisition (i.e. temporal information), produces several data frames stored in a 3D structure called cube.
The three dimensions of the cube are referred to as bands, samples and lines, respectively. The bands represent the wavelength of the radiations, the samples are the position on the slit while the lines are the number of acquisitions. A cut along the bands produces a bi-dimensional image of the target observed at the chosen wavelength, while the uni-dimensional array obtained by fixing both sample and line is the spectrum observed in that given point of the target.

Service description: The service is implemented according to the EPN-TAP [4] protocol, which is a restriction of the IVOA's TAP (Table Access Protocol) adapted to Planetary Science. Starting from the original PDS3 dataset of VIR data, we translated this file-based archive structure into a relational database schema representing the same information model, then we ingested each cube metadata into its representation in the relational schema. The used target database schema was derived from a similar data model already defined and used for the VIRTIS instrument on board the Venus Express mission [5]. Then, from the tables obtained in the previous step, the final database view was derived, grouping and formatting the information to match the target schema as defined by the EPN-TAP service specification. Finally, the new service is published on our dedicated TAP server and is declared in the IVOA registry system.

Data Access

Once published in the registry system, this service is easily accessible from any EPN-TAP client, such as the VESPA portal located at http://vespa.obspm.fr, or clients embedded in more general Virtual Observatory applications. The VESPA portal will query simultaneously all EPN-TAP services, favoring cross-examination of data from different services.

In addition, the service can equally be queried by any client supporting the TAP protocol, although with lesser user support level. In this case, the query must be provided in the client interface using the Astronomical Data Query Language, a language based on SQL92. Such clients include TOPCAT, a tool specifically developed for table based data manipulation or Aladin which can plot images and cubes.
In both cases, the resulting data products can be directly displayed in any SAMP (Simple Application

Messaging Protocol)-enabled client. For VIR cubes, a suitable choice is the MATISSE [3] tool, which is web based and can be found at https://tools.asdc.asi.it/matisse.jsp .

Conclusions: The availability of our service will foster the scientific return of the Dawn mission, fulfilling two different achievements: firstly improving the accessibility, usability and interoperability of the data set, secondly promoting the emerging tools and technologies in the virtual observatory domain.

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