EPSC Abstracts
Vol. 12, EPSC2018-348, 2018
European Planetary Science Congress 2018

Virtual European Solar & Planetary Access (VESPA): Year 3. S. Erard[1], B. Cecconi[1], P. Le Sidaner[2], A. P. Rossi[3], T. Capria[4], B. Schmitt[5], V. Génot[6], N. André[6], J.-M. Glorian[6], A. C. Vandaele[7], M. Scherf[8], R. Hueso[9], A. Määttänen[10], B. Carry[11], N. Achilleos[12], C. Marmo[13], O. Santolik[14], J. Soucek[14], K. Benson[12], P. Fernique[15], [1]LESIA, Observatoire de Paris, Université PSL, CNRS, Sorbonne Université, Univ. Paris Diderot, Sorbonne Paris Cité, 5 place Jules Janssen, 92195 Meudon, France [2]DIO-VO/UMS2201 Observatoire de Paris/CNRS, Fr, [3]Jacobs University, Bremen, Ge [4]INAF/IAPS, Rome, It [5]IPAG UGA/CNRS, Grenoble, Fr [6]IRAP/CNRS, Toulouse, Fr [7]IASB/BIRA, Brussels, Be [8]OeAW, Graz, Aut [9]UPV/EHU, Bilbao, Sp [10]LATMOS/CNRS, Guyancourt, Fr [11]OCA, Nice & IMCCE/Obs. Paris/CNRS, Fr [12]University College London, UK [13]GEOPS/CNRS/U. Paris-Sud, Fr [14]IAP, Prague, Cz R. [15]Observatoire de Strasbourg/UMR 7550, Fr

Introduction: The large datasets produced by modern instruments call for new ways to handle the data, not only to perform mass processing, but also more basically to access them easily and efficiently. Virtual Observatory (VO) techniques developed during the past 15 years can be adapted to address this problem, provided they are enlarged to handle specificities of Solar System studies. The VESPA data access system focuses on applying VO techniques and tools to Planetary Science data, in all aspects of Solar System science [1]. VESPA (Virtual European Solar and Planetary Access) is developed in the framework of the EU-funded Europlanet-2020 program started Sept 1st, 2015 for 4 years. The objective of this activity is to facilitate searches in big archives as well as in sparse databases, to provide simple data access and on-line visualization tools, and to allow small data providers to make their data available in an interoperable environment with minimum effort. This system makes intensive use of studies and developments led in Astronomy (International Virtual Observatory Alliance, IVOA), Solar Physics (HELIO), and space data archive (International Planetary Data Alliance, IPDA).

Data services: the VESPA architecture [1] is based on a new data access protocol, a specific user interface to query the available services, and intensive usage of tools and standards developed for the Astronomy VO. The Europlanet data access protocol, EPN-TAP, relies on the general TAP (Table Access Protocol) mechanism associated to a set of parameters that describe the content of a data service [2]. EPN-TAP parameters introduce both observational and instrumental conditions and are defined to handle the specific diversity and complexity of Planetary Science: ranges on several axes (spatial, temporal, spectral, photometric), measurement type, origin of data, and various references. Location is provided in the most appropriate coordinate system (e.g., sky or planetary coordinates); target-related time (local time and season, through Ls) can be provided when relevant. Specific parameters may also be used to describe individual services in more details.

Data services are installed at their respective provider institutes and are declared in the standard IVOA registries. At the time of writting, 39 data services are publicly open, and about 15 more are being finalized. They encompass a wide scope, including surfaces, atmospheres, magnetospheres and planetary plasmas, small bodies, spectroscopy in solid phase, heliophysics, and exoplanets. To favor the emergence of this kind of material, VESPA organizes a yearly call to select projects of interest; 4 or 5 selected teams are invited to a 1 week workshop to design and install the service in their institute. Some large data archives are also targeted: ESA's Planetary Science Archive (PSA) will get an EPN-TAP interface in 2018, and bridges with PDS4 are being studied. Several amateur data services were selected for implementation in research institutes, including PVOL in Bilbao and RadioJove at Paris Observatory. A special type of services will gather tables of VOevents produced by alert systems in various fields [3].

Data access: EPN-TAP data services are best queried from an optimized user interface, the VESPA portal. It uses the mandatory parameters to search for individual granules in all data services at once, allowing for discovery of data content unknown to the user. Since EPN-TAP relies on the TAP mechanism, individual EPN-TAP data services can also be accessed via standard TAP clients; these include general query interfaces (e.g., TAPhandle, TAPsh) as well as standard tools (e.g., TOPCAT, Aladin, etc).

Tools: Metadata are transferred from the VESPA portal to VO tools according to the IVOA SAMP protocol. The data themselves can be transferred in a similar way for display and standard analyses, e.g. TOPCAT handles all types of tabular data, Aladin most images and spectral cubes, CASSIS and SPLAT-VO spectra in general, 3Dview can plot measurements along a spacecraft trajectory, Autoplot is dedicated to extracting data from long time series, etc.

Most of these tools have been updated to support Planetary Science, e.g., measurements in reflected light (Fig. 1), coordinate systems on surfaces and in magnetospheres, etc. Other, non-VO tools have been pro-

vided with a SAMP interface so that they can be included in workflows (e.g., ImageJ which now provides image processing functions to the VO). Specific web tools developed in support of larger data services are made accessible for use with external data, e.g. AMDA for planetary plasmas at CDDP, or the new SSHADE service for lab spectroscopy in IRAP [4].

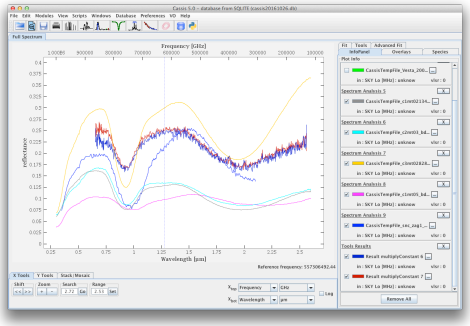

Fig. 1: NIR telescopic spectra of 4 Vesta compared to basaltic meteorites from the PDS spectral library in CASSIS.

Aladin can produce multiresolution maps (HiPS) which allow for very fast change of scale in the client. Currently, 45 planetary maps from USGS have been converted to HiPS and are available from the Aladin data tree.

An on-going activity is the development of a connection between the VO world and Geographic Information Systems (GIS). In a first step, EPN-TAP services are used to provide queries to WMS or similar services, i.e. using non-VO access protocols. The VO layer then allows for powerful search functions in the data, but cross-examinations with other datasets is difficult because of the variety of query systems and image formats. In a second step, the goal is therefore to provide bridges between these two worlds, so that VO (e.g., fits) and GIS (e.g., geotiff) images can be displayed in all applications (Fig. 2). This is done by providing improved georeferentiation support in fits headers and conversion routines in GDAL [5], and with new plug-ins in the QGIS application [6].

A similar situation applies to time series. A protocol of choice in this case is das2server that allows the distribution of data with adjustable temporal resolution. Data services are responsive to EPN-TAP but provide requests to such servers, the results of which can be fetched to the Autoplot tool for display [7].

As far as spatial data are concerned, VESPA makes use of two IVOA protocols to handle footprints. The first one is the pgsphere s_region standard (used in particular in ObsTAP services) which provides oriented contours; the second one is the Multi-Order Coverage (MOC, healpix based) used e.g. in Aladin, TOPCAT, and Mizar. Both standards can be used to issue powerful searches on intersections or inclusions, and to select objects within arbitrary footprints.

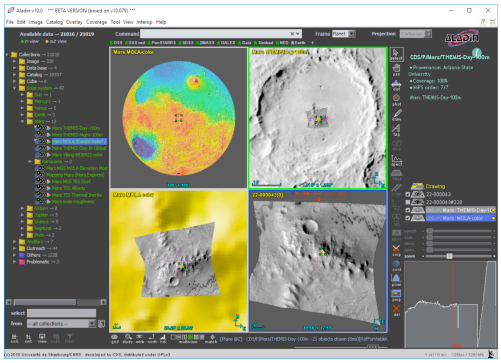

Fig. 2: CRISM spectral cube (georeferenced version converted to geofits) overplotted on MOLA and THEMIS multiresolution maps in Aladin.

Simulation services: another important goal is to connect on-line computation services with interface similar to that of data services, so as to compare observations and simulations more routinely. This activity has obvious applications, e. g., for radiative transfer in planetary atmospheres or for magnetospheres, but also to connect ephemeris systems (e.g. Miriade) with data services.

Building a community: Hands-on sessions are organized twice a year at EGU and EPSC conferences to support new users (see VESPA web site). In complement, regular discussions are held with big data providers, starting with space agencies in the frame of the IPDA. In parallel, a Solar System Interest Group has been started in the IVOA in 2017.

Acknowledgements: The Europlanet 2020 Research Infrastructure project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 654208.
Support from Paris Astronomical Data Centre (PADC) is acknowledged.

References: [1] Erard S. et al 2018 *PSS* 150, 65-85 ArXiv 1705.09727 [2] Erard, S. et al *A&C* **7-8**, 52-61 ArXiv 1407.5738 [3] Gangloff M. et al 2018. *PSIDA conference* [4] Schmitt B et al. 2015. *EPSC* 2015, 628 [5] Marmo C et al. 2016. *LPSC* 47, 1870 [6] Rossi A. P. et al 2016. *LPSC* 47 1422 [7] Cecconi B. et al 2018. *PSIDA conference.*