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Lunar scientific database of Chinese Chang'e missions

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Abstract

This paper describes a lunar scientific facility constructed under the Chang'e-1, Chang'e-2 and Chang'e-3 lunar exploration missions, which acting as an import supplement to the world lunar exploration data source. The dataflow, data types and data retrieve of the database are also introduced.

1. Introduction

Scientific exploration data is the critical footstone of planetary science research. Since its launch of Chinese Lunar Exploration Program (CLEP) in 2007, China successfully carried out the Chang'e-1, Chang'e-2 and Chang'e-3 missions to the Moon, and acquired abundant lunar exploration data. By constructing the lunar scientific database infrastructure (http://moon.bao.ac.cn), the Ground Research and Application System (GRAS) of CLEP made a progressive provision of its lunar exploration data to planetary science community, being an import supplement to the world lunar exploration data source.

2. Data flow of the database

Unlike the geographically distributed nature of the NASA's planetary data system, all procedures of data processing, archiving, management and distribution are proceeded in the headquarter of GRAS in a centralized manner. As seen in Figure 1, the RAW data transferred by Operation Management Subsystem (OMS) and all PDS-compliant Level 0 to Level 2 data products generated by data preprocessing subsystem (DPS) are all forwarded to Data Management Subsystem (DMS) for centralized archiving and management in a scheduled task. After a strict validation for PDS compliance and quality inspection, the qualified lunar scientific data will be pushed to the lunar scientific database to public.

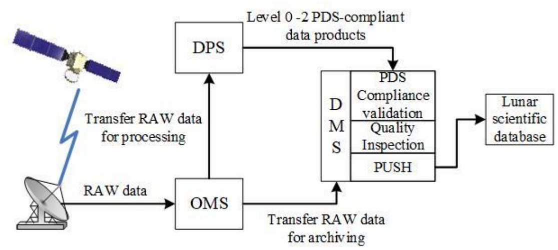

Figure 1: The data flow of lunar scientific database.

3. Data types

The lunar scientific database host main scientific data products from CE-1, CE-2 and CE-3, the data volume from each mission can be seen in Table 1.

Table 1: Data volume of each mission

Mission	Volume (GB)
CE-1	1009.63
CE-2	4352.34
CE-3	2004.12

In terms of data type, the image data, element abundant data, multispectral image data, microwave radiation brightness temperature data, and lunar space environment data of CE-1 and CE-2 can be retrieved from the database [1]. As to CE-3 mission, data products derived from all the 8 payloads [2] are included, as seen in Table 2.

Table 2: Data type and its volume of CE-3

Payload	Data Level	Volume (GB)
PCAM	2A, 2B, 2C	10.03
PIXS	2A, 2B	0.09
VNIS	2A, 2B	0.34
LPR	2A, 2B, 2C	1.81
LCAM	2A, 2B	9.57
TCAM	2A, 2B, 2C	13.28

EUVC	2A, 2B	0.036
MUVT	2A, 2B	1968.96

4. Data retrieve

We provide three granularity of data retrieve:

(1) For specific data files. users can search by mission, payload, data level/type and date range to retrieve specific data files and download them directly; (2) For plenty of data files within specific range, considering the inconvenience of http-based download of multi-files, the database will generate a text file include all data files' download links to be used in some download tools. (3) For the complete dataset, the database provides the corresponding dataset volume to get in bulk. Also, a WebGIS-based interactive interface is provided for browsing the lunar map, mineral spectral data, localized gazetteer, and navigation points of Yutu rover.

5. Future works

Future works of lunar scientific database is concentrated on 3 aspects: 1) progressively incorporate data products from the upcoming CE-4 and CE-5, and the planned Mars Exploration mission of China; 2) Improve the map-based data retrieve function; 3) Adopt the Planetary Data Access Protocol for inter-institute data exchange and interoperability.

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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 provided 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].

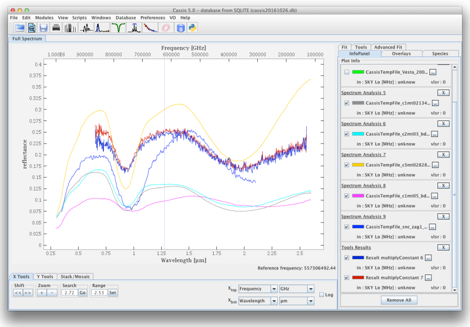

Fig. 1: NIR telescopic spectra of 4 Vesta compared to basaltic meteorites from the PDS spectral library in CASSIS.

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.

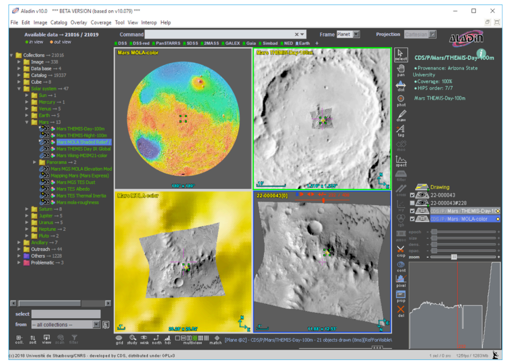

Fig. 2: CRISM spectral cube (georeferenced version converted to geofits) overplotted on MOLA and THEMIS multiresolution maps in Aladin.

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.

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PlanetServer – A web GIS and Python API for planetary hyperspectral images analysis

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1. Introduction

PlanetServer [1] is a web-accessible data visualisation and analysis system comprising different tools: a web Geographic Information System (GIS) and a Python Application Programming Interface (API) capable of visualizing and analyzing a wide variety of hyperspectral data from different planetary bodies.

2. System description

The service comprises a server and a client side. In the server side data are stored using the Array DataBase Management System (DBMS) Raster Data Manager (Rasdaman) [2]. Rasdaman offers features such as query languages, query optimization and parallelization on n-D arrays. Open Geospatial Consortium (OGC) standards such as the Web Coverage Processing Service (WCPS) [3], are implemented in the PetaScope component [4], a set of geospatial and geometry libraries, data access libraries and relational database access components. The web client is based on the JavaScript version of NASA's World Wind [5] a general-purpose 3D/4D client used as a virtual globe to interactively analyze and visualize data. The Python client API [6] provides the user the possibility to create RGB combinations within Python and embed the results in existing data analysis pipelines.

3. Data

PlanetServer contains three different types of data: Base maps and DTMs (for the webGIS) and hyperspectral images (for the Python API and WebGIS).

On Mars we have global Viking and colored Mars Orbiter Laser Altimeter (MOLA) as base maps, a MOLA DTM and Compact Reconaissance Imaging Spectrometer for Mars (CRISM) as hyperspectral images. For CRISM we serve Targeted Reduced Data Record (TRDR) and Multispectral Reduced Data Record (MRDR).

On the Moon we have Lunar Reconaissance Orbiter (LRO) Wide Angle Camera (WAC) mosaic and a colored Lunar Orbiter Laser Altimeter (LOLA) shaded relief as base maps, a LOLA DTM and Moon Mineralogical Mapper (M3) hyperspectral images.

4. Web GIS & Python API

PlanetServer's web client provides an easy and intuitive way to visualize and analyse hyperspectral images. It is composed by a 2D/3D globe where all data cubes are deployed and two main panels where different tools are available. The left panel contains the projections, base map selector, navigator and the RGB combinatory (pre-populated with CRISM products [7] translated into WCPS). In the right menu, the plot docks for single spectra retrieval, spectral ratio calculations and histogram stretching are located. Both plot docks can load the splib06a spectral library in order to pursue a first study of the CRISM spectra vs. laboratory spectra [8]. Results can be downloaded in different formats to be further analysed.

PlanetServer's Python API, integrates all the CRISM products mentioned in [7] and performs different RGB band math combinations. The API has three main parts: the band name and wavelength lookup table, the implementation of the CRISM summary products and the user input and output.

In order to make the API transferable, we created a lookup table linking the band names to their associated wavelengths. This allows us to use the API among different sensors. The main core of the API is the definition and translation of the CRISM summary products. We created a dictionary of summary products that the user can easily call in their RGB combinations. As the API is highly modular [12] this allows the user to define own summary products just by following the structure. Finally, the user can load one image and perform any RGB combination available in the API. Once the output image is shown, the user can collect spectra just by clicking on the desired location.

Planetserver is also exposed via the EuroPlanet Virtual Observatory System of VESPA [10, 11]

5. Summary and Conclusions

Results obtained using PlanetServer demonstrate that it is a reliable tool for the visualization, analysis of hyperspectral data, retrieval of spectra and band math combinations [7, 9].

As PlanetServer is highly modular, it can be easily integrated in existing pipelines in order to get access to science ready hyperspectral images. The combination of OGC standards, open-source server and client tools as well as openly available algorithms together with WCPS versions of hyperspectral formulas allows reproducibility of scientific observations and surface mapping.

Acknowledgements

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SSHADE: the European solid spectroscopy database infrastructure

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Abstract

SSHADE (http://www.sshade.eu) is a database infrastructure containing spectral data of many different types of solids: ices, snows, minerals, carbonaceous matters, meteorites, IDPs and other cosmo-materials,… It cover a wide range of wavelengths: from X-rays, through UV, visible, infrared to millimeter wavelengths. Its Search / Visualization / Export interface is now open to the community.

1. Introduction

Spectroscopy and spectro-imagery are increasingly used in space missions towards planets and small bodies (e.g. OMEGA/Mars Express, VIRTIS/Rosetta, RALPH/New Horizons, MAJIS/JUICE, …) to study the solid phases at their surface. Infrared, Raman, fluorescence and X-rays micro-spectroscopies are also used to study meteorites and cometary dusts in the laboratory and onboard some space missions for in situ measurements. A major contribution to the analysis of these observations is the measurement in the laboratory of spectra of a variety of materials (ices, minerals, organics, …) expected to be present at the surface of the bodies of the solar system or in their ejected grains.

A large number of laboratories in Europe study the spectroscopic properties of a variety of solid materials of astrophysical interest, either natural (terrestrial or extra-terrestrial) or synthetics, as a function of various compositional, structural, textural or environmental parameters. Many of these laboratories boast leading-edge expertise in some solid spectroscopy fields. However most of the published are very difficult to access in a usable form to compare with observations.

1. What is SSHADE?

SSHADE ("Solid Spectroscopy Hosting Architecture of Databases and Expertise") is a project of a set of databases on solid spectroscopy that started its development in September 2015 and is now open to the community since 5th February 2018 (http://www.sshade.eu).

The SSHADE databases cover laboratory, field, airborne as well as simulated spectral data including various levels of products for many different types of solids: ices, snows and molecular solids, minerals, rocks, inorganic solids, natural and synthetics organic and carbonaceous matters, meteorites, IDPs and other cosmo-materials,… They come from a wide range of measurement technics over a wide range of wavelengths: from X-rays, through UV, visible, infrared to millimeter wavelengths

The SSHADE consortium has currently 23 partner groups in 21 laboratories from 8 different European countries plus India and Taiwan. Information about this project can be found in the SSHADE wiki (http://wiki.sshade.eu)

2. SSHADE interface

A user can currently search either spectral data or publications through two distinct forms using a simple 'Google-style' search tool that he can complement with a number of specialized filters to refine the search. For the spectral data he can filter his search according to a series of topics: by experiment, by instrument parameters, by environment, by extra-terrestrial object, by sample, by composition and/or by publication. Both tools can be combined.

The user can select and visualise a spectrum, he will then get a page with the collapsible structure of the experiment/spectra, and of the sample/layer(s) /material(s)/constituent(s). The page display a preview of the spectrum together with the main information on the spectrum and on measured sample.

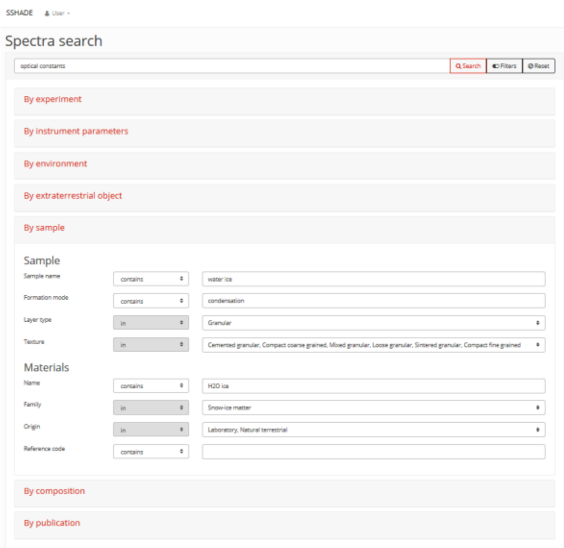

Figure 1: User search page for 'Spectra' showing the different filters for the sample search option.

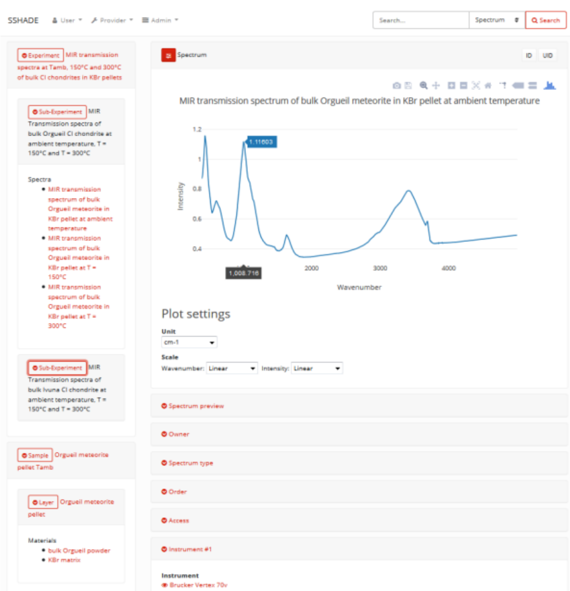

Figure 2: Display of a meteorite spectrum (dynamic), with the different categories of spectrum metadata below (left: experiment and sample structures).

The user can then decide either to visualize the spectrum interactively together with all its associated information, or to look at the detailed information of the experiment or of any part of the sample structure.

The detailed page of each level of the experiment or sample structure contains all the relevant parameters values with different types of links either to another level of the structure, to other information stored in SSHADE (such as publications) or to external pages (such as Wikipedia, WebMineral, …). The users can download a spectrum or an experiment from the export page for immediate and individual download. The users may also add a spectrum or an experiment in the 'basket' for future ex-port.

3. Databases implementation

We are progressively implementing in the SSHADE infrastructure the databases of each of the 20 partners of the SSHADE consortium. 12 databases are already active in SSHADE with over 1400 spectra online covering a wide range of samples, spectroscopic techniques and spectral ranges. Tutorials on the use of the SSHADE database infrastructure will be organized during the conference.

4. SSHADE in Virtual Observatory

SSHADE will be soon a service for Virtual Observatories (VESPA, VAMDC, ...). In particular part of the SSHADE databases will be accessible via the EPN-TAP protocol [1], which will allow comparison with observational data and mass processing in the VESPA environment through a series of dedicated spectroscopy plotting and analysing tools [2].

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Mapping bibliometrics for Planetary Science

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1. Introduction

Digital access to scientific publications is largely performed via web-connected databases nowadays. Several are only subscription-based (e.g. Scopus), some are freely accessible, such as Google Scholar, although retrieved records might be not. Initiatives to extend the open access to citation data are ongoing [1]. The astronomy and planetary communities have substantial advantage over other disciplines in access to scholarly resources, mainly abstracts and papers via the SAO/NASA Astrophysics Data system (ADS) [2]. Most planetary-relevant conferences are indexed and accessible, with time series of decades. Some journals provide access to full-text after embargo of one year, via ADS. Linking publications to underlying data is desirable, and at least the location of study objects or areas in the scientific literature is very valuable. In the case of some astronomical data archives this is already a reality: the integration of the geometric and spatial dimension with bibliographic databases is implemented in astronomical web services such as ESA Sky [3]. Most objects are point-like at such scale. Planetary surface mapping generates data and requires access to a richer topology, including points, lines and polygons [e.g. 4, 5]. As a first approximation the centroid of features and their size can be used, but most features and landforms on Solar System bodies are better represented by polygons or lines.

2. OP Geometrics

Integration of base mapping data (raster) [6], vector nomenclature of Mars and other planetary bodies (Figure 1) from the updated USGS gazetteer [7] and pre-retrieved bibliographic searches of relevant toponyms have been performed in order to build a prototype, navigable bibliographic and bibliometric web mapping service (Figure 2). The system in development has been named OP Geometrics, i.e. OpenPlanetary [8] Geometrics (OPG).

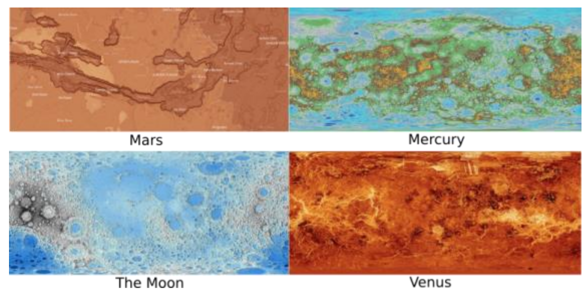

Figure 1: Global Base maps used within OP Geometrics (OpenPlanetaryMap and USGS Astrogelogy).

OpenPlanearyMap basemaps [6] offer high-quality surface feature visualization with labeling. In addition, the vector data retrieved from USGS Astrogeology REST interface [7] are served from a local PostGIS database and accessible and queried via simple forms within the web-based map interface. For the time being, toponym-based queries to the ADS have been cached and have been loaded onto the map interface. Exemplary metrics for each feature have been collected and can be visualized (Figure 2).

3. Discussion and future steps

The implications of such integration for past, ongoing and future mapping and planetary data analysis efforts [e.g. 9] are substantial: timely access to scientific literature for study areas is needed. The same approach is used for integrating bibliographic data and metadata with planetary surface geological units.

Moreover, the use of individual authors as well as teams, particularly experiment teams in combination with mapping data could be extremely valuable. One obvious application would be in obtaining geographically-linked metrics of scientific production (Figure 3) from both within and outside teams.

Figure 2: Early prototype of geo-bibliometrics integration on a web mapping platform (Mars).

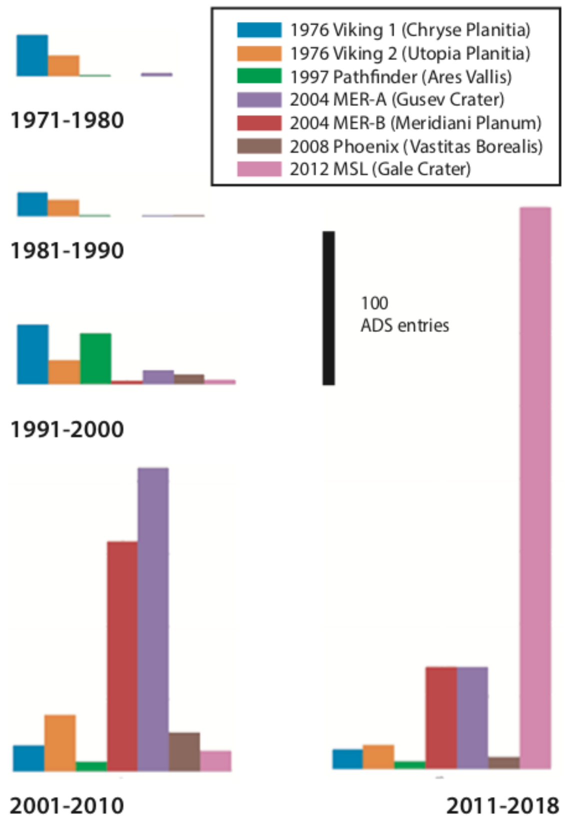

Figure 3: Example of ADS query results per geographic regions through time: Those include both results from lander missions, as well as work performed based on orbital data on the same areas.

The use of mapping bibliometric data could promote more and better data exploitation. Comparing for example the papers produced by a certain experiment team over a certain period of time and, possibly, over various geographic areas on a planet or moon, vs. the outside community, could be a good proxy on how much and how good data are used (or usable). Funding or support could be then adjusted accordingly.

Applications beyond the planetary case, with particular reference to Earth mapping data, not only geological in nature would be a natural extension of the OPG case.

Acknowledgements

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Data exploration in the ESA Planetary Science Archive – current status and future plans

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Abstract

The Planetary Science Archive (PSA – http://psa.esa.int/) is the PDS-compatible long-term archive of planetary mission data within the European Space Agency. As a cross-mission and cross-discipline archive, there are a wealth of possibilities for complex queries, but also a number of difficulties due to the diverse instruments involved. The current status and future plans to address this are discussed here.

1. The PSA

The PSA (1) contains data from a variety of Solar System missions, and supporting ground based observations. The earliest data are from ESA's first deep space mission, Giotto, whilst the archives are already being prepared for upcoming missions such as BepiColombo and JUICE. This includes orbiters, landers, descent probes, flyby spacecraft and, shortly, a rover. Combining the data from multiple missions, targets and instruments is key to truly exploit the data in the archive. However, the variety of instrument and mission types makes it difficult to find a unified way to present and search the catalogue.

1.1 The GUI

In early 2017 ESA released a new version of the PSA offering a flexible user interface for browsing and finding data products by target, instrument type etc. Responding to community and mission input, the user interface has been expanded to include additional functionality including filtering by wavelength range. Since a web interface has to find a balance between usability and flexibility, some advanced search functionality is only available through a query language.

A major recent improvement to the interface is in the display of browse products, essentially thumbnails that allow the user to visually identify interesting data. These can now be viewed in a gallery display. In the longer term, an enhanced geometric search will be available to query the data based on the location of the observations and other geometric parameters.

1.2 Machine interfaces

Whilst the web interface is useful for browsing and finding single products, data exploration requires more complex searches. The PSA currently offers two options for machine access to the meta-data and data themselves [2]. The Planetary Data Access Protocol (PDAP) uses a REST API to discover and retrieve available products and datasets. The query functionalities are, however, rather limited and make the service most suitable for retrieving and mirroring data. More recently an extension to the popular astronomical protocol TAP (Table Access Protocol) was defined for the purposes of planetary science [3]. EPN-TAP is supported by the PSA, although the full range of core data fields have not yet been populated. This offers more complex queries on meta-data and the resulting products can be directly downloaded using the PDAP file access mechanism.

2. Future developments

One of the key features that is missing from the PSA is a geometry-based search function. Currently the PDS labels delivered with each product describe the geometric conditions associated with that measurement, but they are often used in different ways by different instrument teams delivering the data. To address this a new development will generate geometric information for relevant instrument directly using the mission SPICE kernels and instrument descriptions. Eventually this will be used in a map-based interface to allow geospatial searches on relevant products.

New missions (specifically ExoMars, BepiColombo and JUICE) will use the new PDS4 standard [ref] for archiving which also enables better linking of data products within the archive.

The ultimate data exploration system would allow all meta data (coming from all data labels) to be indexed and queried, to allow the user to perform detailed searches and retrieve only those data relevant. Although the PSA is currently far from this goal, steps have been taken in this direction by indexing selected parameters requested by several active missions.

3. Summary and Conclusion

The PSA offers a diverse range of data from in-situ and remote sensing instruments on a range of platforms. Ensuring long-term preservation of the data is the key goal of the PSA, but steps have been taken to enable more efficient data exploration. New functionality will be added in an incremental fashion and feedback from the user community is essential in shaping these developments.

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MASER: A Toolbox for Low Frequency Radio Astronomy

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Abstract

The MASER (Measurements, Analysis, and Simulation of Emission in the Radio range) project provides a comprehensive infrastructure dedicated to low frequency radio emissions (typically < 50 to 100 MHz). The four main radio sources observed in this frequency are the Earth, the Sun, Jupiter and Saturn. They are observed either from ground (down to 10 MHz) or from space. Ground observatories are more sensitive than space observatories and capture high resolution data streams (up to a few TB per day for modern instruments). Conversely, space-borne instruments can observe below the ionospheric cut-off (10 MHz) and can be placed closer to the studied object. Several tools have been developed in the last decade for sharing space physics data. Data visualization tools developed by The CDPP (http://cdpp.eu, Centre de Données de la Physique des Plasmas, in Toulouse, France) and the University of Iowa (Autoplot, http://autoplot.org) are available to display and analyze space physics time series and spectrograms.

Other tools include ExPRES (Exoplanetary and Planetary Radio Emission Simulator) developed at LESIA. The VESPA (Virtual European Solar and Planetary Access) which provides a search interface that allows the discovery of data of interest for scientific users, and is based on IVOA standards (astronomical International Virtual Observatory Alliance). The University of Iowa has developed the Das2 server that allows the distribution of data with adjustable temporal resolution.

MASER is making use of all these tools and standards to distribute datasets from space and ground radio instruments available from the Observatoire de Paris, the Station de Radioastronomie de Nancay and the CDPP deep archive. These datasets include Cassini/RPWS, STEREO/Waves, WIND/Waves, Ulysses/URAP, ISEE3/SBH, Voyager/PRA, Nancay Decameter Array (Routine, NewRoutine, JunoN), RadioJove archive, swedish Viking mission, Interball/POLRAD. MASER also includes a Python software library for reading raw data.

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Multi-dimensional analysis and visualization of planetary electromagnetic field fluctuations by the iPECMAN interface

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Abstract

Interface for a sPECtral Matrix ANalyzer (iPECMAN) is a web-based analytical tool that aims at multi-dimensional analysis and visualization of planetary electromagnetic field fluctuations. It calculates characteristics of electromagnetic waves from in-situ spacecraft measurements. These characteristics are the key signatures of fundamental processes in the solar wind and planetary magnetospheres. The interface is developed as a part of VESPA (Virtual European Solar and Planetary Access) work packages in the frame of Europlanet-H2020-RI.

1. Introduction

The iPECMAN is based on the PRASSADCO (PRopagation Analysis of STAFF-SA Data with COherency tests) analysis tool [1], developed originally in the frame of the ESA Cluster Project. PRASSADCO implements various methods used to estimate polarization and propagation parameters, such as the degree of wave polarization, sense of elliptic polarization and axes of polarization ellipse, the wave vector direction, the Poynting vector or the refractive index [2, 3, 4, 5].

The above methods have been previously used for data analysis and validation from the STAFF-SA instruments onboard the four Cluster spacecraft [2], the Cassini RPWS data [6, 7], the IMSC and ICE instruments on the DEMETER spacecraft [8], the Polar PWI-HFWR data [3, 4], and data from the EMFISIS Waves instruments onboard the NASA Van Allen Probes Spacecraft [9].

2 iPECMAN

IPECMAN is a tool designed to provide different outputs of the electromagnetic wave characteristics observed in the solar wind and planetary magnetospheres. It interfaces the VESPA data services or user

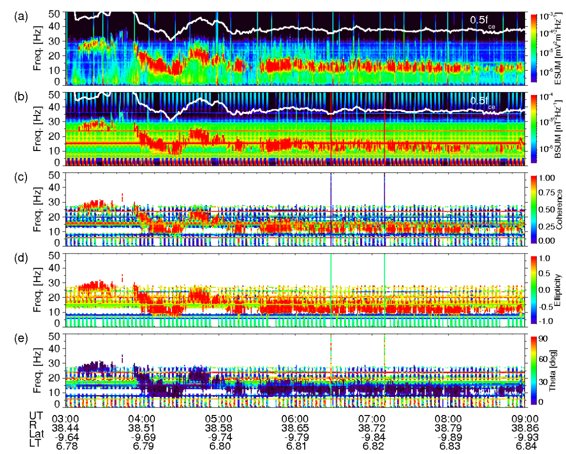

Figure 1: Example of the PRASSADCO output as presented in [4]. Analysis of electric and magnetic field waveforms recorded by the RPWS instrument onboard Cassini on 3 July 2005.

provided data with the PRASSADCO analysis tool. The interface is written in PHP and requires Apache2 web server and PostgreSQL database. This gives sufficient performance and painless portability.

The input data are in CDF (Common Data Format) [10]. The interface implements the existing Cluster STAFF-SA Spectral Matrix data [11] or generic CDF files [12]. The input CDF file must be structured with a header section containing the global attributes, and a data section containing the variables and the associated variable attributes. Metadata compliant with the EPNcore data model, used by the VESPA project for its data distribution protocol EPN-TAP [13], can also be included. The input data can be directly uploaded to the interface through a form or url query.

An uploaded CDF file is converted to the PRASSADCO input format. Then a two-step configuration of an output file format is done. In the first step, common definitions and output formats are set (Fig. 2). Consequently, an output panel setting is made. A user fills a simple form or selects output from several predefined options. Finally, input data are processed by PRASSADCO using an user-defined configuration and visual files are returned. Together with a visual output, i.e. a PNG image, a CDF ouput file [14] is provided. Another way to retrieve data is to use SAMP [15]. SAMP is a messaging protocol that enables various software tools (e.g. TOPCAT) to interoperate and supports communication between applications on the desktop and in web browsers. A user is allowed to edit his options in every step of configuration.

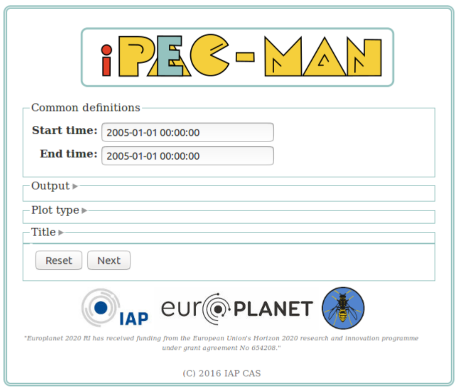

Figure 2: A screenshot of common definition form for the iPECMAN output configuration.

3 Summary

We developed the web-based interface (iPECMAN) dedicated to calculation and visualization of multi-dimensional electromagnetic wave analysis. It can be used to analyze characteristics of electromagnetic waves from in-situ spacecraft measurements that are the key signatures of fundamental processes in the wide range of space plasma environments. The web-based interface implements the existing data or allows to upload user-defined data using a generic CDF data format.

Acknowledgements

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NEODECS – presentation of the new service

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Abstract

During th last EPSC meeting in 2017 we presented a concept of a new web service NEODECS for collecting and sharing data on Near Earth Objects and facilitating collaboration among observers and researchers. During discussions with potential users and data providers we collected suggestions for improvement of the service. In particular, we opened it for other Small Solar System Bodies like MBAs, TNOs, etc. Now NEODECS is running and we encourage you to use it. Below we present a short descripion of the service and its most important functionalities.

1 Introduction

The goal of the NEO Data Exchange and Collaboration Service (NEODECS) is to create an open access central repository of structured meta data on NEOs, as well as a platform for collaboration among NEO researchers, using elements well known in social networking. It collects meta data on NEOs' databases and services as well as announces observing plans, helps to seek collaborators and offers of free telescope time. NEODECS can potentially attract observers from other fields of astronomy and encourage them to spent some of their free telescope time on NEO studies. While the information available at the beginning is gathered by us (to reach a critical mass), the service will then live its own life and its content will rely on the needs of its users.

2 Basic functionalities

2.1 Search engine

Our service provide a fast access to even little known resources, which are difficult to find through traditional Internet searches. A good example is a list of rotation periods of small NEAs derived by Bill Ryan from the Magdalena Ridge Observatory (Fig. 1). It can be located by searching for the parameters *Absolute magnitude*, *Rotation period* or a substring present in the resource title (*Magdalena Ridge Observatory*).

2.2 Coordination of observations

When a new, interesting NEO is discovered, its observing window is usually only 1–2 weeks long. If a researcher wants to fully characterize it, he or she has to act promptly building up a world-wide network of observers, who can pool together their resources. NEODECS service will help to set up an observing campaign very quickly by filling up a standard web form, with all basic information included. Request for collaboration will then be sent automatically by e-mail to all registered observers, who expressed their interest in joint observations.

2.3 Telescope time sharing

It often happens that observers have free telescope time which cannot be spent on program targets. NEODECS will make it easy to offer their services to all registered users, who expressed interest in such form of collaboration. To make it easier, NEODECS provides a web form including all relevant elements like the specification of the available time at the telescope, observatory location, telescope and detector parameters, ownership of the obtained data etc., (Fig. 2).

3 Summary

We encourage you to try NEODECS at www.neodecs.eu.

Acknowledgements

The NEODECS service is developed under the European Space Agency contract ESA-PLP 028.

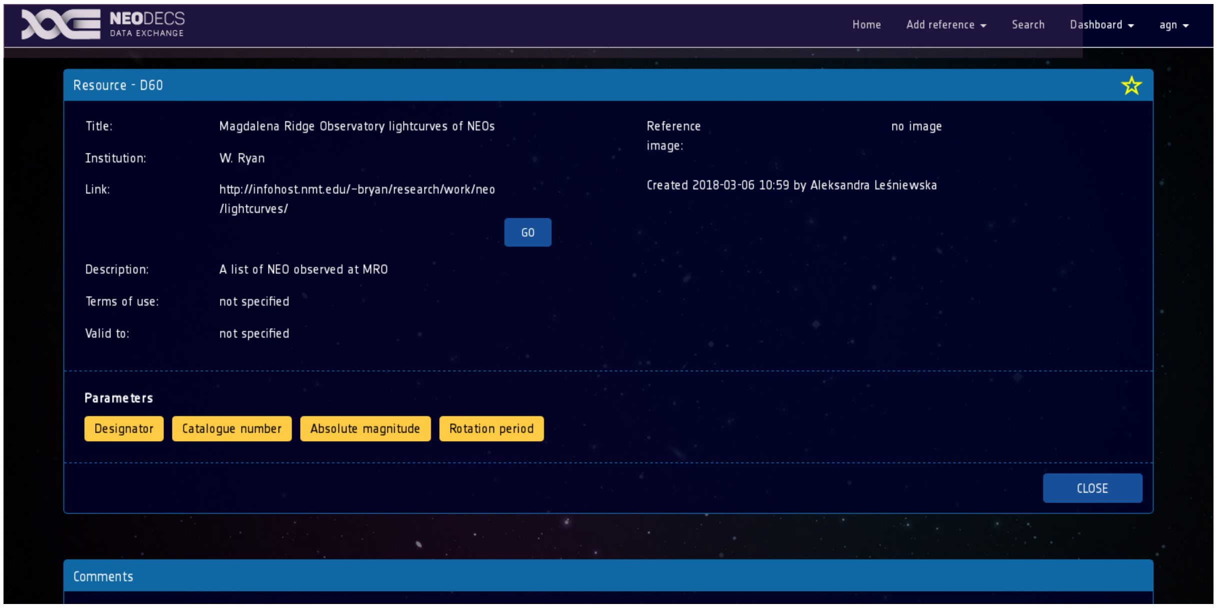

Figure 1: One of the results of a search for the *rotation period* parameter in the NEODECS service. The presented screen shows the meta data with a short description of the Internet resource, a link to its web site, and parameters which are present in the resource.

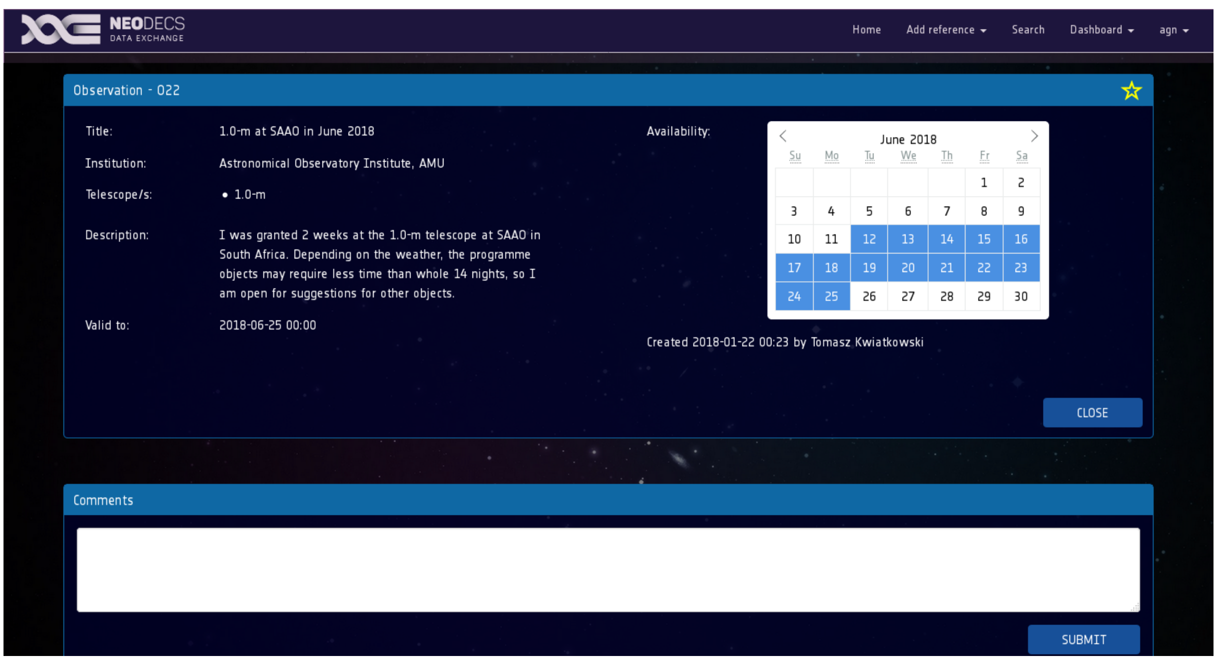

Figure 2: A result of the search for the telescope time offers. The *Telescope/s* field provides a link to additional page with the parameters of the observing system. A calendar shows the time span when the telescope can be used for observations. There is a *Comments* window to provide a feedback from the NEODECS users – it can turn into short discussion on the proposed observing programme.

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The Use of Git in Planetary Science Research

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Abstract

The accessiblity to planetary data is increasing with the development of new technologies and strategies for data distribution across the network.

This forces the remote sensing data analyst and planetary science researcher to update its own digital working environment towards flexible solutions.

The management of changes to documents, computer programs, and other collections of information is critical to keep track of developments and refinement within a research project.

A family of softwares generically called Version Control Systems are focused on supporting this task. Initially common among the software developers, in the last decade these system are becoming popular across the scientific community.

Among the different Version Control System, Git is gaining popularity as it adapts particularly well to a wide of different use cases from software developments, numerical experiment setup and scientific production [1].

The flexibility of Git comes at the price of a quite steep learning curve due to the absence of a standard git workflow, which has to be decided on the base of the specific project's needs. Here we explore some use cases which can turn useful in the field of Planetary Science.

1 Introduction

Git was created in 2005 by Linus Torvalds, the main developer of the Linux kernel. As the main pupil of its creator, Git is distributed as free open source software [2].

Being a Version Control System, Git shares the basic concepts of this software family: it manages *changes*, which are called *revisions* to any kind of digital information, where the *changes* are associated to the *time* and a *person*. Simple version control systems ranges from file naming convention to the Dropbox or Google Drive services.

Git is part of a group of more advanced softwares, where the process of tracking changes allows to precisely overview which changes have been applied, when, where and by whom. A Git tracked project can be run off line, for example for a own project, or on line where collaborator can contribute asynchronously.

2 The Git workflow

There is no standardized process on how to interact with Git, and this is probably the main reason this system is extremely flexible. Anyway, a workflow necessary. It is commonly created and shared with the working team in case of collaborative projects, or simply self-decided for own projects.

A common workflow, which is similar to older concurrent versioning systems, is the *Centralized Workflow*, where all the updates are committed to a central codebase.

Another workflow is the *Feature Branch Workflow* where different features are developed individually in different branches, leaving the master branch untouched. This is extremely useful for continuous integration, as the master branch contains a codebase which is never broken.

3 Git in planetary science

GitHub is the online platform which allows to create Git repositories online. Several institutions involved in planetary research have chosen GitHub as versioning platform for some projects. ESA and NASA have their own github accounts and numerous projects are developed on this platform. The OpenPlanetary initiative[3] is using GitHub for the document tracking and collaborative developments.

The main field of application of GitHub Among the current GitHub repositories devoted to planetary science are software and document development and numerical experiments setup.

4. Conclusions

Git represents an efficient way to track versions of a wide range of digital information. The absence of a standardized approach means that a workflow must be developed form time to time in function of the specific idea or project we want to keep under version control. This hides the most appreciated characteristic of Git: the extreme flexibility of the system which can be used both for small own, offline projects, or for very large collaborative projects where online platform like GitHub enable different subjects to asynchronously work at the same project.

Building experience and use cases on the use of Git will facilitate collaboration among researchers which is important in science in general and critical in planetary science.

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Applications of Jupyter Notebook to VO-GIS interoperability

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1. Introduction

Jupyter Notebook [1] is an interactive environment inside a web browser capable of running a variety of scripting languages, primarily python. The notebook allows annotating code with markdown text and multimedia, thus allowing presenting reproducible workflows accompanied by a rich narrative.

Jupyter Notebook can be connected to Virtual Observatory (VO) tools [2], VO registries (GAVO DaCHS servers) [3], QGIS [2], as well as geospatial web servers such as PlanetServer [4, 5] by implementing appropriate protocols (Figure 1).

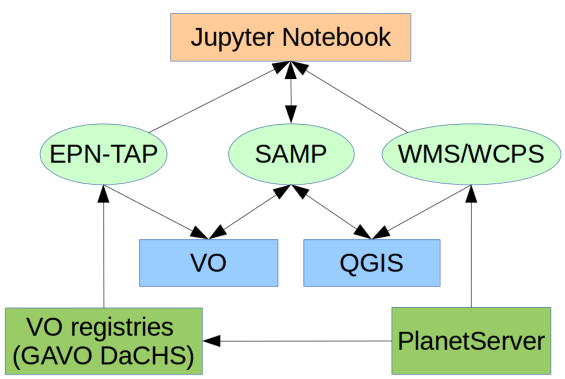

Figure 1: Enabling VO/GIS interoperability in Jupter Notebook with EPN-TAP, SAMP, and WMS / WCPS protocol interfaces.

2. VO Registries

Access to Planetary Science data in Virtual Observatory is provided by VO Registries (GAVO DaCHS servers) through EPN-TAP data access protocol [1]. The requests to the Table Access Protocol (TAP) endpoint are formatted in Astronomical Data Query Language (ADQL). Astropy affiliated package Pyvo can be used to interface with TAP Service from Jupyter Notebook, thus removing a need to use intermediate data mining software, while at the same time making it easy to share TAP queries.

Functionality similar to TOPCAT/STILTS [6] is available through STILTS python wrapper, allowing complex workflows involving tables from different sources, and data visualization. Furthermore, capabilities are extended through data analysis libraries available for Python and R in Jupyter.

3. SAMP interface

The communication between different VO tools is done by RPC/XML messages sent through Simple Application Messaging Protocol (SAMP) interfaces [2]. SAMP clients connect to a SAMP hub, which routes the messages between the clients. Files are shared between SAMP clients by sending an access link. A SAMP interface for QGIS exists [2], and can be easily added to Jupyter Notebook by instantiating it from Astropy library [7].

The default standard for tabular data in VO is VOTable, support for which in python is provided in Astropy library. Geospatial datasets can be converted to VOTable in Jupyter and forwarded via SAMP to other VO tools. Alternatively, Jupyter Notebook can be used to simplify the process of Resource Descriptor creation for ingesting new data into GAVO DaCHS. This has the potential to streamline the process of data publication to VO registries.

Jupyter Notebook connection to SAMP allows for rapid prototyping of work-flows to geospatial problems. SAMP interface between QGIS and Jupyter Notebook would allow seamless interoperability and data sharing.

4. PlanetServer

PlanetServer is a web GIS providing access to hyperspectral raster data cubes for Moon and Mars served by Rasdaman Array DBMS [4, 5]. Hyperspectral coverages stored on PlanetServer can be accessed via HTTP using Web Coverage Processing Service

(WCPS), additionally a python API exists for generating common derived data products [8].

5. Summary and Conclusions

Smoother interoperability between geospatial and astronomical software is an ongoing effort. Jupyter Notebook is a platform which can accommodate WCPS, SAMP and TAP interfaces, while presenting reproducible workflows with rich annotations. Capacity to interface simultaneously with different systems enables development of high degree of automation, assisting machine learning. For instance, a workflow may involve discovering hyperspectral data with EPN-TAP, accessing data with WCPS, analyzing it with numpy library, then forwarding the results via SAMP interface to QGIS or Aladin for plotting. Within a Jupyter Notebook such a workflow could be fully automated, easily modifiable, shareable and reproducible. Derived data can even be published back to the Virtual Observatory.

An example of using VO interfaces in Jupyter Notebook can be found at [9].

Acknowledgements

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MATISSE web-tool functions integration into VESPA-Europlanet 2020 infrastructure: real-time computation and visualization of aerodynamic coefficients for convex objects moving in a rarefied gas field

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Abstract

The large amount of planetary data acquired by planetary space missions opened room for developing processing platforms able to provide easily and efficient data access and visualization as also to enable delivery and analysis of high-level scientific data products.

We propose the implementation of a new VESPA (Virtual European Solar and Planetary Access) application using the MATISSE (Multi-purpose Advanced Tool for the Instruments of the Solar System Exploration) web-tool, to handle the computation of aerodynamic coefficients of non-spherical convex objects.

The coefficients describe the motion of these objects in rarefied gas field present in various astrophysical environments as for example protoplanetary disks and cometary coma. Most of the state-of-the-art cometary gas-dust dynamical models use spherical particles. The new application will provide the aerodynamic coefficients for convex objects and "averaged" ones ready as inputs to the spherical dust codes approximating realistic convex object shapes.

Introduction

In contrast to a spherical grain, an aspherical grain experiences not only drag but lift and torque as well. It is usual to represent the aerodynamic force F_{aas} the sum of its components parallel to the gas velocity relative to the grain, i.e. the drag force D and of its component transverse to it –the lift force L. Then it is common to introduce dimensionless aerodynamic coefficients – the drag C_D and lift C_L:

$$C_D = \frac{D}{1/2\rho V_r^2 S} \quad ; \quad C_L = \frac{L}{1/2\rho V_r^2 S}$$

where $Vr = Vg - Vd$ is the gas-grain (center of mass) relative velociity vector, ρ is the gas mass density, $\rho V_r^2/2$ is the dynamic pressure, and S is a shape-dependent characteristic cross-section. The calculation of these coefficients in rarefied gas field is necessary to compute the motion of dust in different astrophysical physical conditions (e.g. protoplanetary disks of cometary environment). The detailed description of the approach we take for computation of the aerodynamic coefficients is described in [1].

1. VESPA and MATISSE tool

VESPA, within the H2020 Europlanet project, developed such an infrastructure and deals with implementation of new data services [2]. Although VESPA activity is focused on derived archives of calibrated data from ground-based observations and space missions, the VESPA interface (http://vespa.obspm.fr) demonstrates capability of comparing observations and simulations entirely in a Virtual Observatory (VO) environment. For simulations that generate moderate data volume, such approach is feasible, and can even accommodate simulation results of different scenarios or inputs.

MATISSE (Multi-purpose Advanced Tool for the Instruments of the Solar System Exploration) is a web-tool developed for the 3D visualization of small bodies shape models, single observations or real-time computed high-order products [3]. Here, we discuss a new functionality integrated in MATISSE that can provide computed aerodynamic parameters and their visualization using an input data from a dedicated future VESPA service. MATISSE connects with VESPA through a Simple Application Messaging Protocol (SAMP).

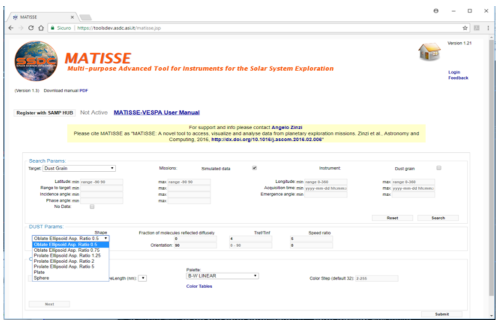

Figure 1. MATISSE view of the interface with the input dust parameters which the user chooses to call real time computation of the aerodynamic coefficients.

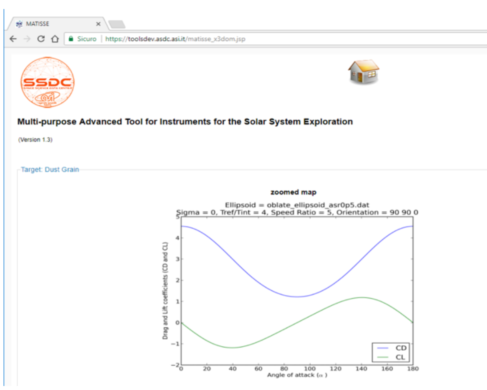

Figure 2. MATISSE view of the plot of the aerodynamic coefficients versus the angle of attack, i.e. the angle between the gas flow direction and the axis perpendicular to the axis of rotation of the dust grain.

2. Real-time computation and visualization of aerodynamic coefficients

The implementation of the aerodynamic application is based on the approach by [2] and provide the following functionality: 1) choice and visualization of the irregular object shape (Figure 1); 2) choice and visualization of the Euler solution of ideal gas flow; 3) real-time computation (if not available as precomputed) of the aerodynamic coefficients; 4) plots of the aerodynamic coefficients vs convex objects dynamical parameters (Figure 2).

3. Conclusions

We present the design and implementation of a new scientific real-time application open to the astrophysical community that computes the aerodynamical coefficients of irregular objects in a rarefied gas flow.

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