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RE	Restricted to a group specified by the consortium (including the Commission Services)	
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Abstract: The goal of the VESPA activity in Europlanet2020 is to adapt the Virtual Observatory (VO) standards to Planetary Science to make access to archived and derived data easier, and to develop a community of both data providers and users. The present report summarises at the end of the project available data services, use cases, training and dissemination activities in the VESPA-VA WP, in particular during the last year of the Europlanet 2020 contract, with the newly added data services, including those from ESA mission experiment teams. Information on the workshops organised and co-organised within VA activities are provided.

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Acronym list

Acronym	Description
ATM	Atmosphere
EXO	EXOplanets
IMCCE	Institut de mécanique céleste et de calcul des Ephémérides
INTER	INTERdisciplinary
LATMOS	Laboratoire Atmosphères Milieux Observations Spatiales
LMD	Laboratoire de météorologie dynamique
MAG	Magnetospheres
PADC	Paris Astronomical Data Center
SB	Small Bodies
SP	Solar Physics
SOS	SOlid Spectroscopy
SUR	(Planetary) Surfaces

1 Introduction

The final status of VESPA data services and associated workshop efforts are provided. Reference tasks of WP6 (see D6.8, Erard et al., 2019) include:

- Task 6.1- Coordination (led by OBSPARIS and Jacobs University with all members of WP attending)
- Task 6.2- Internal services (IWF, OBSPARIS)
- Task 6.3- Enlarging VO contents (OBSPARIS, Jacobs University)
- Task 6.4- Involving the Amateur community (OEAW, UVP/EHU)
- Task 6.5- Training (CNRS/IRAP, Jacobs University)
- Task 6.6- Dissemination & sustainability (OBSPARIS, IWF)

External data services have been added via annual calls and respective service implementation workshops (Erard et al., 2018 and refs. therein, 2019).

2 Overview of VESPA data services at project end

VESPA in the 4-year period of the Research Infrastructure engaged a variety of data providers, both institutional, such as ESA and academic, for the provision of VO-compliant data via its data portal.

The state of end-of-project online data services is listed and distinguished by domain in Table 1 (see Acronym list for keys), see also Figure 1.

Additional services in development and test are indicated in Table 2

Table 1: Table 1: list of available VESPA services at project end. See also Erard et al. (2019). Additional draft services are available, see Table 2.

Short name	Name	Description	Location	Domain
Titan	Vertical Profiles in Titan Middle Atmosphere	Atmospheric profiles of Titan (Cassini/CIRS)	PADC	ATM
VVEx	VIRTIS on Venus-Express: standard dataset	Access to spectral cubes. Venus-Express legacy	PADC	ATM
abs_cs	Absorption cross sections	Absorption cross sections for gaseous species of atmospheric interest	IACC-CSIC	ATM
SOIR	SOIR/SPICAV/VEx	UV / IR observations of Venus - vertical profiles	Royal Belgian Institute for Space Aeronomy /	ATM

Short name	Name	Description	Location	Domain
			Planetary Aeronomy	
SPICAM	SPICAM / MEx	Vertical profiles of Mars	LATMOS	ATM
MCD	Mars Climate Database	Sampled version through EPN-TAP	PADC, LMD	ATM
BaseCom	The Nançay Cometary Database	Radio observation of comets from Nançay	PADC	SB
M4ast	Modeling for Asteroids	Asteroid spectroscopy	PADC	SB
NASA dust catalog	INAF-IAPS RDB NASA dust catalogue TAP service	NASA's Cosmic dust catalogs 15 and 18	IAPS, Roma	SB
IKS	IR spectroscopy of comet Halley	IR spectroscopy of 1P/Halley (IKS / Vega-1)	PADC	SB
TNOsarec	TNOs are cool	Compilation of TNOs properties + Herschel/Spitzer observations	PADC	SB
DynAstVO	Minor Planet parameters and orbits, with daily computation (NEO only)	Minor Planet parameters and orbits, with daily computation (NEO only)	IMCCE / PADC	SB
MPC	Minor Planets Center	Asteroid orbital and physical parameters	MPC / IAU, Heidelberg,Paris	SB
Mars_craters	Mars craters database	Robbin's crater database	JacobsUni	SUR
USGS_WMS	Planetary maps from USGS	EPN-TAP access to WMS server	JacobsUni	SUR
PlanetServer_CRISM	subset of CRISM/MRO cubes	Imaging spectroscopy of Mars, W*S access	JacobsUni	SUR
hrsc3nd	HRSC/MEx nadir images of Mars	HiRes imaging of Mars, W*S access	FU Berlin	SUR

Short name	Name	Description	Location	Domain
PlanetServer_M3	subset of M3 / CHANDRAYAAN-1 cubes	Imaging spectroscopy of the Moon, W*S access	JacobsUni	SUR
omega_cubes	Imaging spectroscopy of Mars	OMEGA/MEx spectral cubes in calibrated format. Non-PDS files (IDL binaries)	IAS/PSup	SUR
omega_maps	Mineralogy spectroscopy of Mars	Mineralogical maps from OMEGA analysis, fits format	IAS/PSup	SUR
PDSspectrallib	Laboratory spectroscopy of mineral samples	Library in support of CRISM/MRO, on PDS Geosciences node	PADC / LESIA, Erard	SOS
SSHADE	Spectroscopy of ices and minerals. A set of ~ 20 evolving databases (including GhoSST).	Alternative access to SSHADE service from VESPA interface. Focus first on reflectance spectra	Grenoble, IPAG	SOS
AMDA	CDPP AMDA Database	AMDA Planetary Plasma database	CDPP, Toulouse	MAG
APIS	Auroral Planetary Imaging and Spectroscopy	Aurorae images/spectra data base (HST)	PADC, Paris	MAG
NDA	Nancay Decameter Array observation database	Jupiter decametric radio observations from Nançay. Part of JUNO-Ground-Radio Observation Support.	Nançay	MAG
RadioJove	Amateur radio observations of Jupiter	Amateur radio observations of Jupiter	PADC	MAG
MDISC	Access to UCL Magnetodisc model output.	Access to UCL Magnetodisc model output.	UCL, London	MAG

Short name	Name	Description	Location	Domain
IMPEx_EPN20	Database from IMPEX simulation tree	Database from IMPEX simulation tree	Graz, IWF	MAG
VExMAG_EPN20	Dataset from MAG/Venus-Express	Venus-Express legacy	Graz, IWF	MAG
IitateHF	Iitate Radio Telescope HF data of Jupiter	Part of JUNO-Ground-Radio Observation Support	Iitate / Tohoku Univ, Japan	MAG
Hisaki	Hisaki E-UV observations of Jupiter, Venus and more	From Hisaki JAXA mission, Exceed instrument	Tohoku Univ, Japan	MAG
PSWS_Transplanet	Transplanet	A Transplanet model of magnetosphere-ionosphere coupling at Earth, Mars, and Jupiter (simulation runs)	IRAP, Toulouse	MAG
cpstasm	cpstasm	.Earth magnetosphere measurements by CLUSTER, correlation matrix.	IAP, Prague	MAG
THMSM	thmsm	Spectral matrix data from the Earth magnetosphere obtained by the THEMIS satellites. Same interface as cpstasm	IAP, Prague	MAG
LOFAR_Jupiter	LOFAR observations of Jupiter,	Measurements under 2 different polarization directions	CBK-PAN, Poland	MAG
MASER	Set of services and tools for radio astronomy/planetary	Initial data services: voyager_pra: ExPRES: simulations Cassini-Jupiter: Cassini/RP	ObsParis, LESIA,	MAG

Short name	Name	Description	Location	Domain
		WS data products on Jupiter		
Encyclopedia of Extra-Solar Planets	Encyclopedia of Extra-Solar Planets	Compilation of published data	PADC	EXO
HFC1T3	Heliophysics Feature Catalog type 3 radio bursts	Solar feature catalogues (from HELIO program)	PADC	SP
HFC1AR	Heliophysics Feature Catalog active regions	Solar feature catalogues (from HELIO program)	PADC	SP
PRSC	IPRT/AMATERAS Iitate Planetary Radio Telescope Solar Data	Solar radio observations	Iitate / Tohoku Univ, Japan	SP
CLIMSO	Images of the photosphere and low corona with two coronagraphs (on H-α, He I, Fe XIII) and two telescopes (on H-α, Ca II)	Images of the photosphere and low corona with two coronagraphs (on H-α, He I, Fe XIII) and two telescopes (on H-α, Ca II)	IRAP, Toulouse	SP
BASS2000	BASS2000 (Paris)	BASS2000 (Paris)	PADC	SP
BDIP	Base de Données d'Images Planétaires	Historical planetary images in Meudon (ground-based)	PADC/Lesia	INTER
Planets	Main characteristics of planets	From IAU / Allen reference data	PADC	INTER
PVOL	Amateur imaging of giant planets + Mars/Venus	Amateur imaging of giant planets + Mars/Venus	Planetary Sciences Group, UPV/EHU, Bilbao	INTER
Planetary spectra	Planetary spectra	Low res, global spectra of planets and satellites. References for ground	LESIA	INTER

Short name	Name	Description	Location	Domain
		observations, provide only 1 or 2 typical spectra/object (from selected archives). Includes historical data of interest		
PSA	ESA's Planetary Science Archive	Complete archive published early 2018.	ESA ESAC	INTER
HST_planeto	HST planetary data	Data of planets, dwarf planets and satellites (no asteroids) from HST. Calibrated & derived products. Data and thumbnails at CADC	PADC & CADC	INTER
meteor_showers	Predictions, on planets	Server of VOevents from PSWS. From simulations of ejection of cometary material + propagation in Solar System	ObsParis, Vaubaillon	INTER

Table 2: Table 2: List of in-development and in-test VESPA services at project end, See also Erard et al. (2029).

Short name	Name	Description	Location	Status	Domain
VVEx+	Enhanced VIRTIS dataset on Venus-Express	It will provide access to individual spectra. Venus-Express legacy (after discussion: same service as above, not a separated one)	PADC	PLANNED	ATM
VIMS data portal		VIMS/Cassini calibrated cubes Catalogue of cubes with description, several thumbnails,	LPG/GeoPlanet + PADC	DRAFT	ATM

Short name	Name	Description	Location	Status	Doma in
		links to PDS raw and ISIS3 calibrated cubes + possibly GeoTiff format			
CEMLS	Cometary emission line catalogue	Comet line catalogue, from observations	IAPS/INAF	DRAFT	SB
SBNAF	Small Bodies Near and Far	Catalogue of asteroids &TNOs properties, from observations. Currently ~ 60,000 obs (several/target)	Max Planck Institute	DRAFT	SB
Pangaea -X	Pangaea-X 2017 data	Various measurements on planetary analogue environment	JacobsUni	DRAFT	SUR
Dawn VIR	Imaging spectroscopy of Vesta and Ceres	Dawn/VIR spectral cubes of Vesta and Ceres (data only, no geometry available)	IAPS/INAF	DRAFT	SUR
Catalogue of planetary maps	Historical maps of all kinds	Historical Planetary maps	Eötvös Loránd University	DRAFT	SUR
BRSL	Berlin Reflectance Spectral Library	Laboratory spectroscopy of mineral samples in support of VIRTIS/Rosetta	DLR	DRAFT	SOS
PSL	Planetary Spectroscopy Laboratory	Laboratory spectroscopy of mineral samples in support of MERTIS/BepiColombo, and more (in emission)	DLR	DRAFT	SOS
HOSER Lab	HOSERLab / Planetary Spectrophotomet er Facility	Large spectral library (in XLS files)	University of Winnipeg	DRAFT	SOS
Kronos	Cassini radio data	Cassini radio data	PADC	PLANN ED	MAG

Short name	Name	Description	Location	Status	Domain
KHTM	MHD instabilities at 67P/C-G	MHD instabilities at 67P/C-G	IAPS/INAF	DRAFT	MAG
Marsis	MarsExpress / MARSIS	MARSIS radar measurements, atmosphere only	U. of Iowa, SwRI	DRAFT	MAG
RWCalerts	Space weather test service	Forecast of Solar-geophysical activity and propagation conditions to Earth	CBK-PAN, Poland	DRAFT	MAG
kharkov	UTR-2-JUNO-ground	Coordinated Decametric observations from Ukraine T-shaped Radiotelescope-2. Part of JUNO-Ground-Radio Observation Support	Institute of radio astronomy NASU / RINANU. Kharkov, Ukraine	DRAFT	MAG
coronasf	Coronas-F satellite measurements (time series in cdf) - charged particle fluxes in the Earth's magnetosphere from orbit.	Coronas-F satellite measurements (time series in cdf) - charged particle fluxes in the Earth's magnetosphere from orbit.	LMSU/SINP Moscow	DRAFT	MAG
Mag models	Magnetosphere models of Mercury and Saturn, using IMPEx architecture	Magnetosphere models of Mercury and Saturn, using IMPEx architecture	LMSU/SINP Moscow	DRAFT	MAG
LWA1	Coordinated Decametric observations from Long Wavelength Array 1	Part of JUNO-Ground-Radio Observation Support	Owens Valley, New Mexico, USA	PLANNED	MAG
GAIA-DEM	Solar Fits images (compressed internally, won't load in SAOimage/ds9) - maps	Solar Fits images (compressed internally, won't load in SAOimage/ds9) - maps with a funny projection?a	IAS/Psup	DRAFT	MAG

Short name	Name	Description	Location	Status	Domain
	with a funny projection?a				
Radio Solar Database	Nançay Radio Solar Database	Nançay Radio Solar Database	PADC	PLANNED	MAG
E-Callisto	E-Callisto	World-wide network of Solar radio spectrographs	Windisch (Switzerland), Csillaghy	DRAFT	MAG
IRTF_Orton	IR telescopic images of Jupiter	Images from IRTF, Hawaii, in support of Juno	PADC/Lesia	DRAFT	INTER
† Cassini rings	Cassini CIRS ring data	Assessment study of EPN-TAP services and VESPA infrastructure for Cassini derived data services to come.	JPL (Connell, Brooks)	DRAFT	INTER
Juno images	From Juno spacecraft camera	From Juno spacecraft camera	U. of Iowa, SwRI	DRAFT	INTER
VizieR planeto	VizieR catalogues	Table linking Solar System-related catalogues in VizieR (query to a web service returning one or more VOtables).	CDS & ObsParis	DRAFT	INTER
CDPP alerts	Solar wind predictions	Server of VOevents from PSWS	IRAP/CDPP, ObsParis	DRAFT	INTER
CDPP alerts - detection	Fireballs, etc	Server of VOevents from PSWS	IRAP/CDPP, ObsParis	DRAFT	INTER

3 Access to VESPA data services

Up-to-date information and data access is available from the VESPA portal service result page (http://vespa.obspm.fr/planetary/data), Figure 1. Additional draft services are expected to be added even beyond project end.

Figure 1: A sample view of the VESPA query interface results (retrieved in August 2019) with all available data services, in Green. The list is longer. Access to the VESPA web-based query interface at http://vespa.obspm.fr/planetary/data/

4 Tutorials

User-oriented tutorials have been produced and refined throughout the VESPA activity. The entry point (see Rossi et al., 2019) is on the GitHub VESPA organisation, in a specific repository: https://github.com/epn-vespa/tutorials.

Access is also provided from the VESPA web page - http://www.europlanet-vespa.eu/tutos.shtml

Data producer-oriented tutorials on implementing vespa services, also used and refined during VESPA implementation workshops are available on the VESPA technical wiki hosted at the Observatory of Paris, at https://voparis-wiki.obspm.fr/display/VES/Implementing+a+VESPA+service

5 Workshops

A number of workshops has been organised through the years, both for users/community and data producers. Data-producers workshop, i.e. VESPA implementation workshops have been held during the entire project (e.g. see Erard et al., 2016. Scherf et al., 2017). The 2016-2018 implementation workshops have been

covered by previous documents (E.g. Erard et al., 2016; Scherf et al, 2017) and reporting periods.

VESPA implementation workshops include:

- **1st VESPA implementation workshop - Toulouse, 2016 (Erard et al., 2016), including selected external teams/services**
  - o Absorption cross sections of relevant species for atmospheric modeling in the UV-vis-NIR range. Compilation of published data selected and resampled properly (IAA-CSIC). - Luisa Lara, Jaime Jimenez
  - o Decametric observations of Jupiter from the ground. Support to the JUNO mission (Institute of radio astronomy NASU / RINANU - Vyacheslav ZakharenkoSerge Yerin
- **2nd VESPA implementation workshop - Graz 2017 (Scherf et al., 2017), including selected external teams/services**
  - o Mapping Mars subsurface using a MARSIS and SHARAD plug-in for QGIS - Roberto Orosei/Anton B. Ivanov, Federico Cantini
  - o Minor Planet Physical Properties Catalogue (mp3c) - Marco Delbo, Benoit Carry:
  - o : Cassini Data Archive - Andrea Connell
  - o Rosetta Spectral Library - Gabriele E. Arnold, Daniela Henckel:
- **3rd VESPA implementation workshop - Prague 2018 (See Erard et al., 2019) inlcuding selected external teams/servivices:**
  - o Planetary Surface Portal & GAIA-DEM (IAS/CNRS): Karin Dassas
  - o Planetary Spectroscopy Laboratory (DLR): Mario D'Amore
  - o Mars Express data (U. of Iowa, SwRI): Andrew Kopf, Chris Piker, Joey Mukherjee
  - o Thermal infrared observations of asteroids and trans-Neptunian objects (Max Planck): Róbert Szakáts
- **4th VESPA implementation workshop - Rome 2019, inlcuding selected external teams/servivices:**
  - o International catalog of planetary maps (Henrik Hargitai, Matyas Gede)
  - o Spectral library of terrestrial and planetary material (Edward Cloutis, Daniel Applin)
  - o e-Callisto Data Access (André Csillaghy, Simon Beck)

In particular, the 2019 VESPA implementation workshop was built upon the previous ones and it took place at IAPS/INAF in Rome (Erard et al., 2019), enabling new data service additions to the VESPA portal (e.g. MEX HRSC, see Table 1) as well as allowing technical discussion, including:

- [Stéphane Erard](): [VESPA, EPN-TAP and data services]()
- Installation and configuration of DaCHS server, AWStats using Docker
- Inventory EPN-TAP V2 metadata
- Write q.rd file for DaCHS and test the new service with the validator
- how to use grammars and mixins to build VESPA services

Additional community-oriented workshops for data users and providers alike were organised in cooperation and with the support of NA1.

5.1 1st VESPA mapping workshop

The workshop, back in 2017 was supported by EuroPlanet NA and took place in Roscoff (France) between April 19th and 21st 2017(Marmo et al., 2017). The programme included presentations, tutorials, hands-on and hackathons, as well as discussion sessions. 30 people participated on-site.

5.2 2nd VESPA mapping workshop

The 3-days EuroPlanet NA-supported workshop took place in July 2019 near Paris (Marmo et al, 2019).

The workshop aimed at bringing together the geologic, geospatial and VO communities at a European scale for bringing forward knowledge, tools and standards for mapping the Solar System.

The programme included keynotes, lightning presentations (5 minutes) and associated posters, tutorials, hands-on and hackathons, as well as discussion sessions. 40 people participated on-site, a third of which were female. In addition, at least 4 remote participants joined remotely the workshop. The workshop is the first one where multiple projects contributed, including the non-profit association OpenPlanetary (https://www.openplanetary.org/) via its newly release forum (https://forum.openplanetary.org/)

The entire set of presentations is online on the EuroPlanet VESPA wiki, as well as the programme and the list of participants (https://voparis-wiki.obspm.fr/display/VES/Mapping+2019+Programme). Materials from tutorial sessions are available on the OpenPlanetary Repository (https://github.com/openplanetary/vespamap19tutorials). The discussion during tutorials and hackathons are available on the OpenPlanetary forum (https://forum.openplanetary.org/c/events/vespa-mapping-2019).

Also, almost a third of participants were junior scientists (PhD students) and undergraduates.

Programme and participants, including abstracts and presentations are available online:

- Programme: https://voparis-wiki.obspm.fr/display/VES/Mapping+2019+Programme?src=contextnavpagetreemode
- List of presentations: https://voparis-wiki.obspm.fr/display/VES/List+of+Presentations

GitHub repositories used during the workshop"

- https://github.com/epn-vespa/tutorials

- o e.g. Aladin (by Pierre Fernique) - https://aladin.u-strasbg.fr
  - o 1- Various use cases on planetary surfaces with Aladin & TOPCAT
  - o https://github.com/epn-vespa/tutorials/blob/master/surfaces/HRSC_vs_OMEGA/HRSC_vs_OMEGA-tutorial.md
- https://github.com/openplanetary/vespamap19tutorials

Workshop-related Forum page/topics

- https://forum.openplanetary.org/c/events/vespa-mapping-2019

Long-term available live stream record of the workshop

- Youtube OpenPlanetary channel - https://www.youtube.com/channel/UCDU3LPvSZJTdGT2vTkejFMg

References

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Erard et al., (2016) - Report on VESPA first AO for data services, and on the first implementation workshop, held in Toulouse (April 5-8, 2016). available online at MS41 & 45 - First VESPA implementation workshop

Erard et al. (2018) D6.8 - Third VESPA annual report, available online at D6.8 - Third VESPA annual report

Marmo, C., Rossi, A. P., et al., (2017) 1st VESPA mapping workshop, available online at https://epn-vespa.github.io/mapping2017/

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Scherf, M., et al., (2017) , available online at MS42 & 46 - Second VESPA implementation workshop (draft)