

VESPA: Virtual European Solar & Planetary Access — a life beyond Europlanet



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Journées ASOV 2025, Paris
24 mars 2025

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VESPA: status

- **History:**

- **Europlanet-RI** (FP7, 2009-2012) — Feasibility study (ISIS WP)

- **Europlanet 2020 RI** (H2020, 2015-2019) — Basic set up

- **Europlanet 2024 RI** (H2020, 2020-2024) — Consolidation, sustainability **ended July 2024**

- Big effort integrated at EU level, with many external collaborations

- **VESPA is also active in international consortia:**

- **IVOA** (VO), **IPDA** (with space agencies), **IHDEA** (heliophysics)

- **VESPA-F in French context:** **certified INSU service, ANO5 (portal & local data services)**

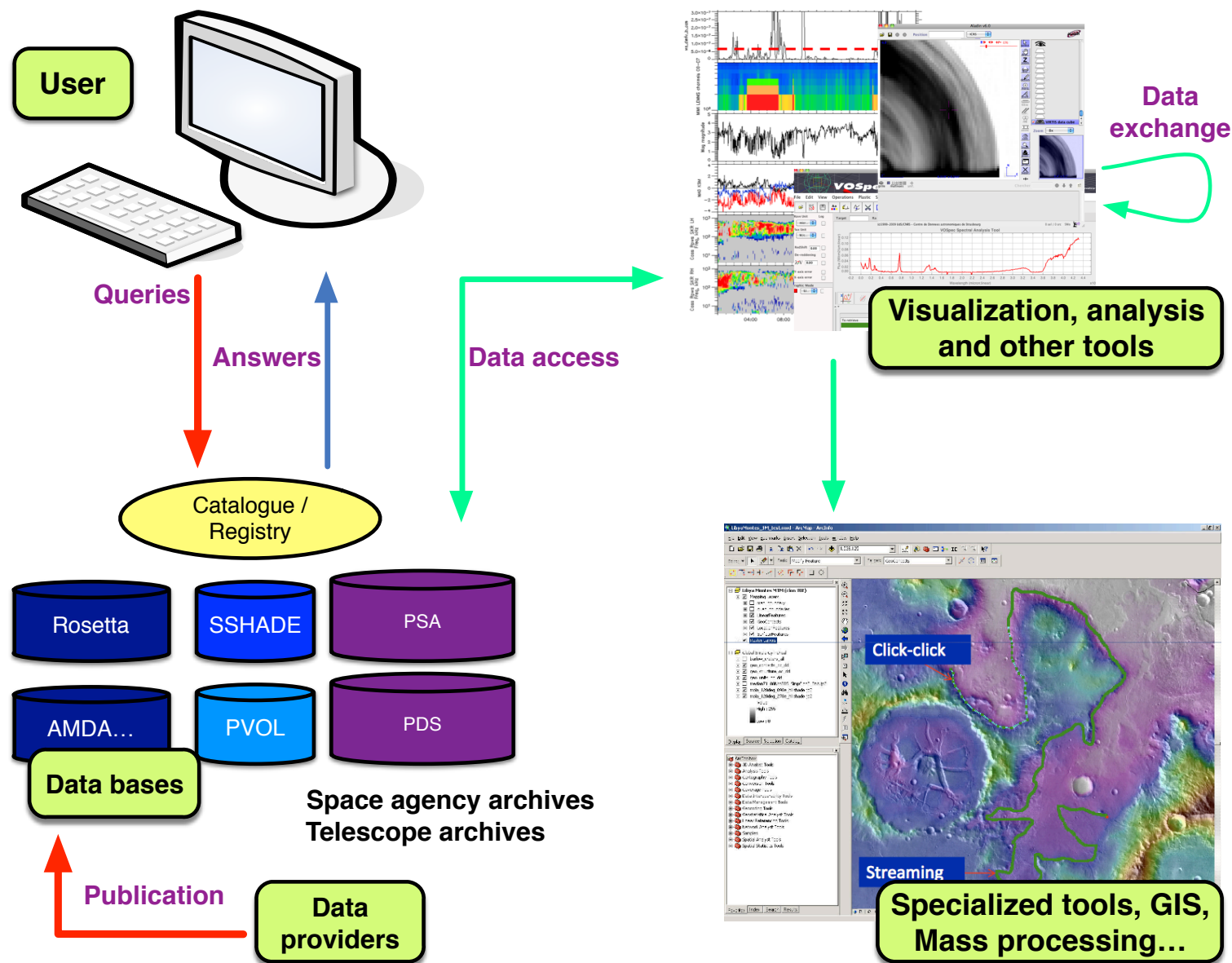
- Coord: ObsParis (PADC support) with OMP + OSUPS + OSUNA

- Involved in the 2 CNES/INSU data nodes (surfaces, small bodies) + CDP

Science users, but also
education / outreach
=> FAIR access

Scope:
Planetary Science
Heliophysics
Exoplanets

Research teams, institutes
EU projects
=> Open Science



VESPA

Overall framework:

Virtual Observatory (VO) - mature data access system, managed by the IVOA

Adapted to Planetary Science & Heliophysics:

Includes elements from IPDA (PDS) / SPASE / IHDEA / OGC (GIS)

- using standards from / contributing to international consortia

Enhance or develop whatever required:

Access protocol, including description of data in this field + enlarge existing standards

+ connect standards from other communities (Solar/IHDEA, terrestrial/OGC)

Search tools: VESPA portal (dedicated) + existing VO tools + other access modes (notebooks...)

Visu and analysis tools: from the VO, GIS, radio, heliophysics, etc

Data publication tools and procedures

=> **Contributive, interoperable, Open Science system, providing FAIR access to the data**

VESPA: current status

- **Europlanet 2024 RI has ended (July 2024)**

The Europlanet Society remains as a permanent consortium

The main VESPA contributors remain active => the infra is self-sustained

VESPA involved in

IVOA (VO) - Solar System Interest Group + inputs in other WG

IPDA (space missions) - Europlanet Society in the SC with space agencies, for VESPA (2021)

IHDEA (heliophysics) - contributor

Europlanet Society (planetary science) - as ObsParis

EOSC-France - at national level

What VESPA provides to the community

1- A vocabulary to describe physical & observational parameters making sense to researchers:

EPNCore metadata

An international standard validated by the IVOA (2022) — <https://ivoa.net/documents/EPNTAP/>

Very broad scope: surfaces, atmospheres, small bodies, magnetospheres, heliophysics

Flexible and evolutive - new extensions can be included in intermediate versions

Service validator available (taplint in TOPCAT $\geq$ v4.8.2, Bristol U)

Next update in progress — 2.1

Intended to be used by the community, beyond Europlanet!

— **Usable in other contexts:** research projects, ground or space experiments...

Other VESPA standards:

TFCAT for dynamical spectra

SSDM for solid spectroscopy and bandlists

Observation facility nomenclature - common with IVOA

What VESPA provides to the community

2- A user interface to search data based on science-relevant parameters:

VESPA main portal: <https://vespa.obspm.fr>

Web form optimized for discovery (cross-searches over all data services) Erard et al ASOV 2024

The screenshot displays the VESPA web interface. At the top, the VESPA logo and the text 'Virtual European Solar and Planetary Access' are visible. A 'Refine your search' section on the left contains input fields for 'Target Name', 'Target Class', 'Dataproduct Type', 'Instrument Host Name', 'Instrument Name', and 'Processing level'. Below these are expandable sections for 'Time' and 'Location'. The main area is titled 'Data Services' and lists various databases with their result counts. A 'Service categories' dropdown menu is open, showing options like 'Surfaces', 'Atmospheres', 'Plasma-Radio', 'Exoplanets', 'Heliophysics', 'Small bodies - Dynamics', 'Laboratory', and 'Other'. The 'Surfaces' category is selected. Each data service row includes a yellow circle icon, a download icon, and a magnifying glass icon.

Data Services	Results	Service categories	Download	Search
BDIP - IAU database of historical planetary images	168	☒ Surfaces	Download	Search
CRISM_speclib - CRISM spectral library	2260	☐ Atmospheres	Download	Search
GMAP - Planetary geological maps	92	☐ Plasma-Radio	Download	Search
hrsc3nd - HRSC nadir images of Mars	4093	☐ Exoplanets	Download	Search
hst_planeto - Planetary data from the Hubble Space Telescope	168	☐ Heliophysics	Download	Search
ILLU67P - Illumination maps of 67P	189000	☐ Small bodies - Dynamics	Download	Search
Lunar craters - Moon Crater Database v1	60645	☐ Laboratory	Download	Search
M4AST - Spectral modeling for Asteroids	6306	☐ Other	Download	Search
Mars_Craters - Martian Impact Craters	384344		Download	Search
Mars_Craters_Lagain - Martian Impact Craters revised	384561		Download	Search
Mercury craters - Mercury craters catalogue	17038		Download	Search
NOMAD - Mars atmospheric profiles from NOMAD/TGO	26165		Download	Search
omega_cubes - Omega/Mars-Express Cubes	7038		Download	Search
omega_maps - Omega/Mars-Express mineralogical maps	10		Download	Search
Parsec - Europlanet Telescope Network database	4457		Download	Search

VESPA

② Help

Similar to new ESA/PSA portal

Gallery view

+NASA kw search

PDAP deprecated

The screenshot displays the VESPA (Virtual European Solar and Planetary Access) web interface. The main search results are for 'Mars_Craters - Martian Impact Craters' with 384,344 results. A red arrow points to the 'Mars_Craters' entry in the 'Data Services' list. Another red arrow points to the 'Instrument Name' field in the 'Main Parameters' search filter. The 'Main Parameters' section includes fields for Target Name, Target Class, Dataproduct Type, Instrument Host Name, Instrument Name, and Processing level. The 'Data Services' list includes various planetary data services like BDIP, CRISM, GMAP, hrsc3nd, hst_planeto, ILLU67P, Lunar craters, M4AST, Mars_Craters, Mars_Crater, Mercury_Crater, NOMAD, omega_cube, omega_map, Parsec, PSA, PVOL, spectro_ast, spectro_m, and spectro_planets. The 'Mars_Craters' entry is highlighted in green. The 'Instrument Name' field is also highlighted in green. The 'Main Parameters' section is on the right, and the 'Data Services' list is on the left. The 'Mars_Craters' entry is the 10th item in the list. The 'Instrument Name' field is the 6th item in the 'Main Parameters' section. The 'Mars_Craters' entry is the 10th item in the list. The 'Instrument Name' field is the 6th item in the 'Main Parameters' section. The 'Mars_Craters' entry is the 10th item in the list. The 'Instrument Name' field is the 6th item in the 'Main Parameters' section.

Alternative access, 1:

VO tools (internal clients)

Other TAP web clients (taphandle, etc)

Specialized web services

Jupyter notebook

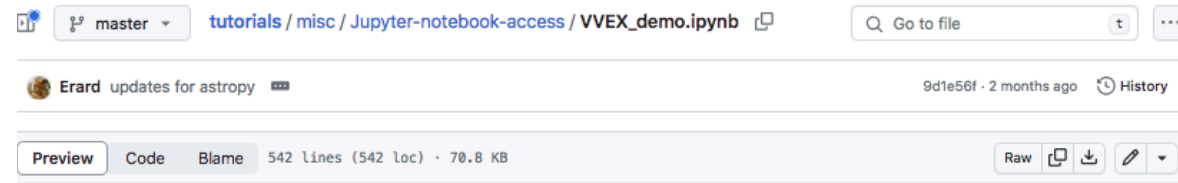
Astropy and VO python libraries

In development:
discovery portal

geoportal

see tutorials:

<https://github.com/epn-vespa/tutorials/tree/master>



Access to public EPN-TAP data services through Jupyter notebook

```
In [1]: import pyvo as vo
from matplotlib import pyplot as plt
from astropy.table import Table
import urllib
# beware that this is incompatible with IDLpy
from astroquery.utils.tap.core import TapPlus
import astropy.io.votable as vot
```

1- Search an EPN-TAP data service

Example from VIRTIS / Venus-Express

Here we search a service in the registry from keywords.

```
In [2]: # Search the VO registry for TAP services about the VIRTIS instrument

In [3]: tap_services = vo.registry.search(servicetype='tap',keywords=['VIRTIS'], includeaux=True)
print(tap_services.to_table)

print('pyvo version: '+vo.__version__)
# will work in pyvo 1.5:
#r2 = vo.registry.search(datamodel="epntap")
#r2
```

```
<bound method DALResults.to_table of <Table length=3>
      ivoid      res_type      ... intf_roles
      ...
      object      object      ... object
-----
      ivo://cds.vizier/j/a+a/585/a53 vs:catalogservice ... std
      ivo://cds.vizier/j/a+a/647/a119 vs:catalogservice ... std
      ivo://padc.obspm.planeto/vvex/q/epn_core vs:catalogresource ... std>
pyvo version: 1.4.1
```

We manually choose a service that uses the epn-tap data model (can be automatized in pyvo 1.5)

```
In [4]: tap_services = vo.registry.search(servicetype='tap',keywords=['VIRTIS'], ivoid='ivo://padc.obspm.planeto/vvex/q/epn_core')
resource = tap_services[0]
mytable = list(resource.get_tables().keys())[0]
print('schema and table to query:',mytable)
myurl = resource.access_url
print('url of the TAP service:',myurl)
query = 'SELECT top 100 * FROM ' + mytable
```

schema and table to query: vvex.epn_core

VESPA alternative access, 2

VESPA portal:

New layout (main user interface), based on UX analysis, **Gallery view**

Design upgrade to support many more services (200+ expected), **Thematic grouping**

Enlarged multiservice answers

VESPA discovery portal (dev):

Alternative Elasticsearch interface — currently used to check service content

Workaround the complexity of metadata / SQL-like access

VESPA geoportal (dev):

Focus on data georeferenced on planetary surfaces

GIS-like interface, centered on IVOA footprints (MOC, HiPS, but also ArcGIS shape files...)

Command line / Jupyter nb:

Single or multiple service access via astropy; possibly in private context

What VESPA provides to the community

3- Data services provided by VESPA participants and other teams:

Currently 94 data services validated in 20+ institutes

41 new ones since Jan 2023: 28 from beneficiaries; 13 from workshops & collaborations

290 declared in the IVOA registry, pending validation — at least ~ 25 advanced drafts

All services updated/regularized/enlarged recently, obsolete ones have been removed

NASA PDS PPI node preparing ~180 data services (all their collections)

Largest one = ESA / PSA (35 millions files)

Some services from the Europlanet WP: VAs, Telescope Network

69 multiple resolution maps of planets (HiPS)

Large data infra (with EPN-TAP interface):

AMDA - with new tools and datasets

PVOL - 60,000 amateur images; 15,000 maps from projected images

SSHADE - 30 datasets from 16 countries; solid spectroscopy + bandlists

Europlanet VESPA: Data services connected via EPN-TAP / field

Open
Open in test | upgrade required
Drafted
Scheduled in 2024 (selection)
• New or upgraded in 2023/24
• New content in 2023/24

Atmospheres

- Titan profiles - CIRS (Cassini, LESIA)
- - Venus spectroscopy - VIRTIS (VEx, LESIA)
- - Mars & Venus Climate Databases (modeling, LMD)
 - GEM_Mars (modeling, IASB-BIRA)
- - Venus profiles - SPICAV/SOIR (VEx, IASB-BIRA)
- - Mars profiles - SPICAM (MEx, LATMOS)
- - Mars profiles - NOMAD (TGO, BIRA-IASB)
 - Venus cloud products (LATMOS)

Small bodies

- - MPCorb: Small bodies orbital cat (MPC/Heidelberg)
- - NEOCC: ast properties (ESA/ESRIN)
- - MP3C: Small body properties (OCA)
- - DynAstVO: NEO refined parameters (IMCCE)
- - Asteroid spectra + PDS SBN collections (CDS / LESIA)
- - M4ast (ground based spectroscopy, IMCCE)
- - Spectro_m_ast & Spectro_trojans (converted PDS4)
 - TNOs are cool (Herchel & Spitzer LESIA/LAM/Utinam)
 - SBNaf (from H2020 prog, Konkoly Obs)
 - Vesta & Ceres spectroscopy - VIR/DAWN (IAPS)
 - 1P/Halley spectroscopy (IKS / Vega-1, LESIA)
 - BaseCom (Nançay Obs, LESIA)
- - BAA comet section (UK)
- 67P illumination config (IRAP)
- Meteor_showers predictions (IMCCE)
- - Occultations predictions by sat. (IMCCE)
 - LuckyStar, occultations (ERC prog, LESIA)
- - Natural satellites db (IMCCE)
- - VIRTIS Rosetta at 67P (LESIA/PADC)
- - Recalibrated VIRTIS-M at 67P (LESIA/Munster/PADC)

ANO5 services: LESIA/IMCEE/IRAP/GEOPS/LPG

Surfaces

- - Mars craters (Jacobs U / PADC + GEOPS)
- - Moon, Mercury, Venus, Earth craters (LESIA)
- - USGS planetary maps WMS (Jacobs U)
- - GMap: geol maps (H2020 prog, Jacobs U)
 - CRISM WCS service (MRO, Jacobs U)
 - M3 WMS service (Chandrayaan-1, Jacobs U)
 - HRSC nadir images, WMS (MEx, Frei Univ)
 - OMEGA cubes and maps (MEx, IAS)
- - VIMS satellites, w/geometry (Cassini, LPG)
 - Mars topo preTharsis (GEOPS)
- - MESSENGER MASCS spectra (DLR)

Magnetospheres / radio

- - APIS (HST/Cassini, LESIA)
- - NDA (Jupiter & Sun radio, LESIA/CDN)
- - AMDA (CDPP / IRAP)
- - MASER & related services (LESIA)
 - RadioJove (PDS PPI: US amateur network)
 - Datasets from NASA PDS / PPI (UCLA)
- - Iitate HF data of Jupiter (Tohoku Univ, Jap)
 - UTR-2 Juno ground support (Kharkiv)
- - MDISC & JASMIN (modeling, UCL)
- - Cluster & Themis data (IAP, Prague)
- Transplanet (CDPP / IRAP)
- - LOFAR Jupiter (CBK/PAS, Warsaw)
 - ASPERA & MARSIS atm obs (MEx, Iowa U)

Solid spectroscopy

- - SSHADE solid spectro & bandlists (IPAG & network)
 - Planetary Spectral Library (DLR)
 - CRISM spectral library (LESIA)
 - Berlin Reflectance Spectral Lib (DLR)
 - Hoserlab (Winnipeg U)

Solar

- - HELIO AR & 1T3 solar features (FP7 prog, LESIA)
- - Bass2000 (LESIA)
 - Radio Solar db (Nançay, LESIA)
- - CLIMSO (Pic du Midi, IRAP)
 - Gaia-DEM (SDO, IAS)
- - EIT_syn (SoHO, IAS)
 - e-Callisto (Windisch, Sw)
- - 3 sunspot services (ESCAPE-related, ROB)
- - 3 solar services (ESCAPE-related, KIS, Freiburg)

Generic / interdisciplinary

- - BDIP (LESIA)
- - PVOL (UPV/EHU & amateur network)
- - Europlanet Telescope Network (Adam M Univ)
 - Planetary spectra collection (LESIA)
- - PSA complete archive (ESA)
- - HST planetary data (LESIA, to CADC archive)
 - Catalogues of planetary maps (Budapest)
- - VizieR_planets: Planetary Science catalogues (CDS)
 - Planets properties (LESIA/IMCCE)
 - Nasa dust catalogue (IAPS)
- - Stellar spectra, support for observations (LESIA)
 - DARTS (JAXA - currently via PDAP)
 - ESAsky planetary data (ESA)
 - Interface with VAMDC ?

Exoplanets

- - Encyclopedia of exoplanets (LUTH/LESIA)
 - Catalogue of exo disks (LESIA)
 - Interface with DACE (Geneva)
- - ARTECS climate simulations (AOTS/INAF)
 - Atmospheric studies (UCL)
- - Exotopo: exoplanet surface simulations (GEOPS)

What VESPA provides to the community

4- Visu and processing tools

Connected VO tools

Long standing collaborations with Aladin, AladinLite, TOPCAT, CASSIS

Erard et al ASOV 2022

=> Additional functionalities for Solar System data

=> Very efficient to spot and fix issues in existing collections (including at ESA)

Open Source tools connected via SAMP

Plugins for ImageJ / astrolImageJ, QGIS, Autoplot, etc

Software

EPN-TAP supported by VO libraries: astropy, pyvo, astroquery, etc

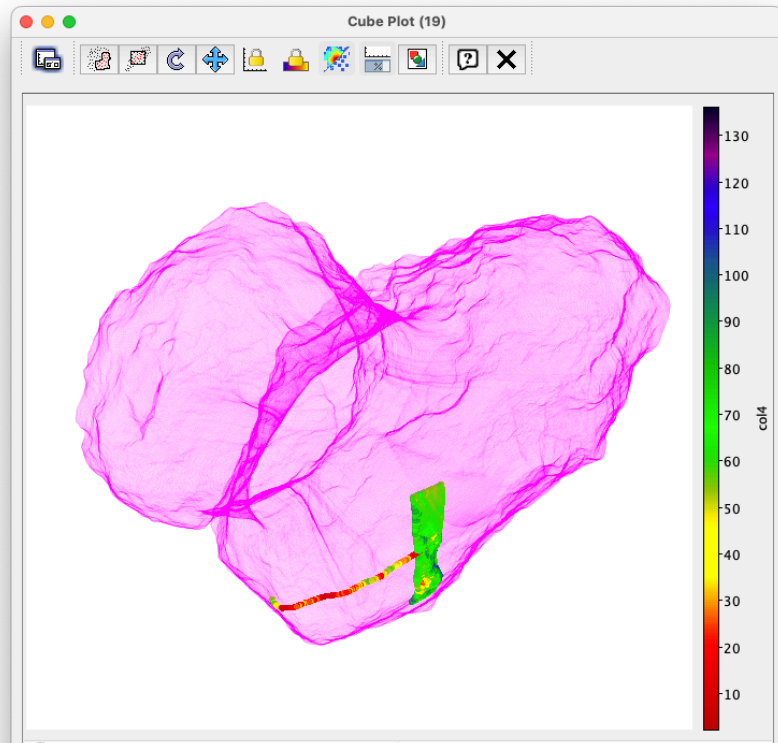
Planetary coordinates implemented in fits WCS and WCSlib (v8.0) + astropy (v6.0)

VESPA: novelties

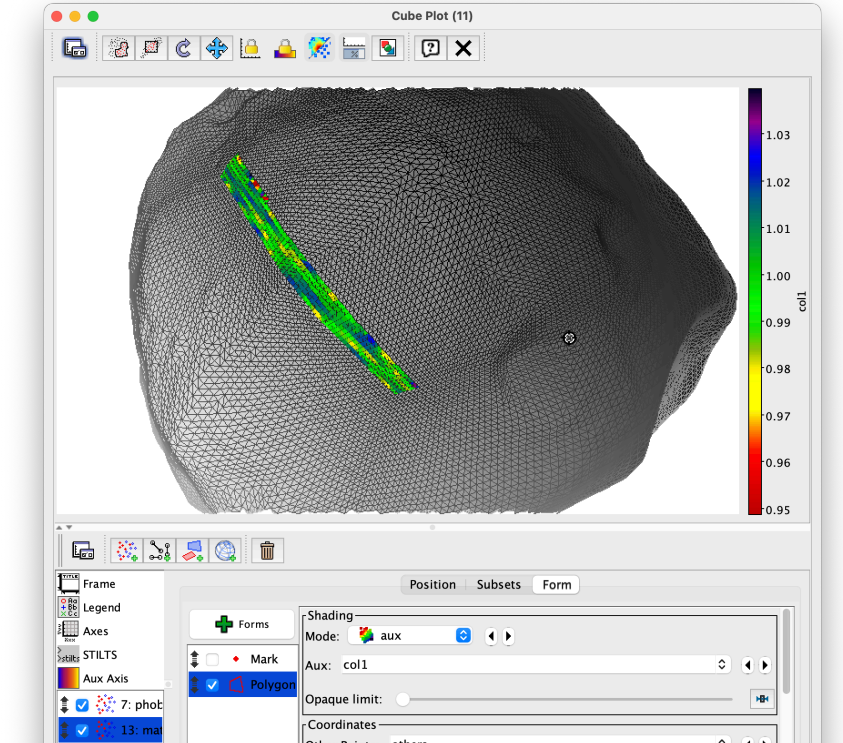
- Automated conversions of PDS4 collections - exploratory
— test presented at IVOA Interop meeting, Nov 2024

- New tool functions

Plotting 3D shape models and overplotting data in TOPCAT ($\geq 4.10-3$)



VIRTIS Rosetta data
on comet 67P



Simulated MMX data on Phobos shape model

VESPA geoportal (in development)

Footprint-based searches

<https://padc-findme.obspm.fr/>

MOC-based 2D searches on surfaces

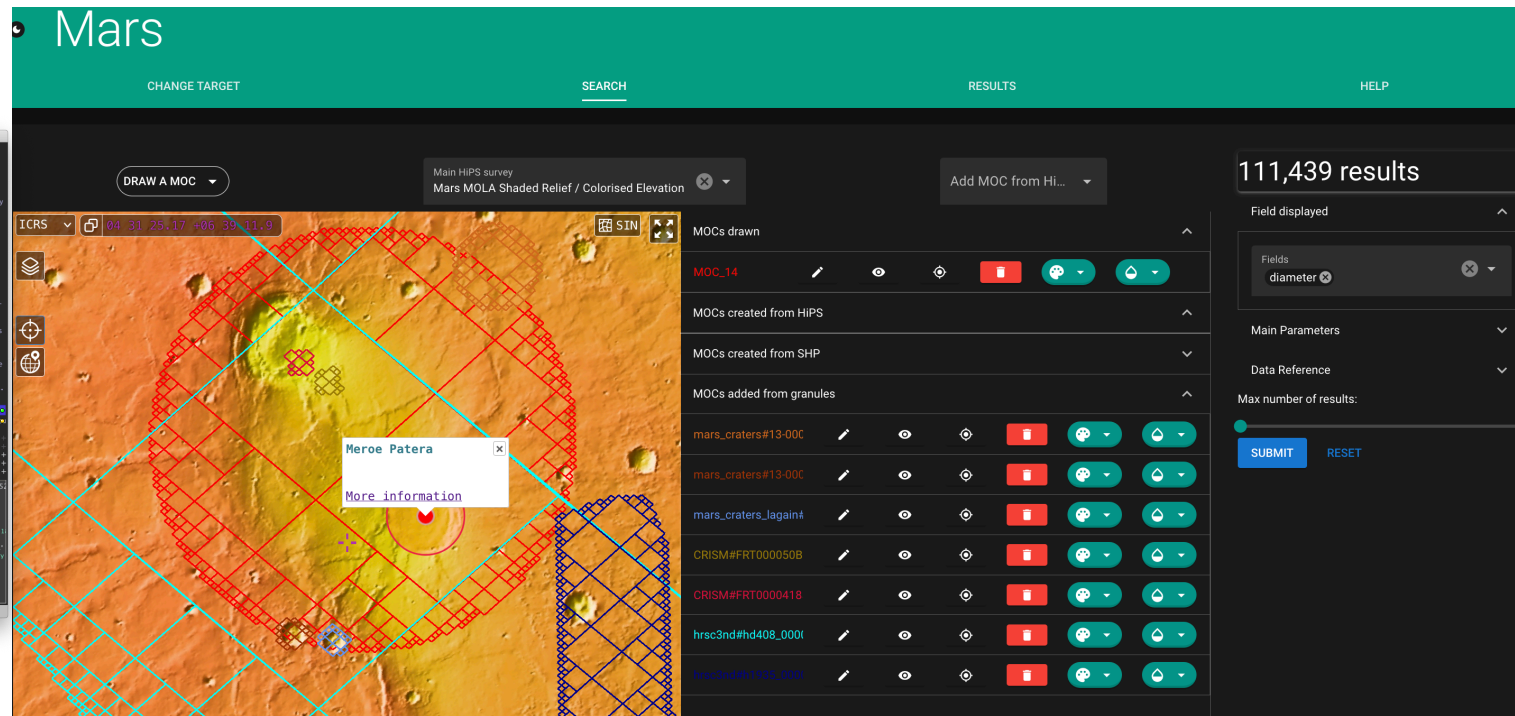
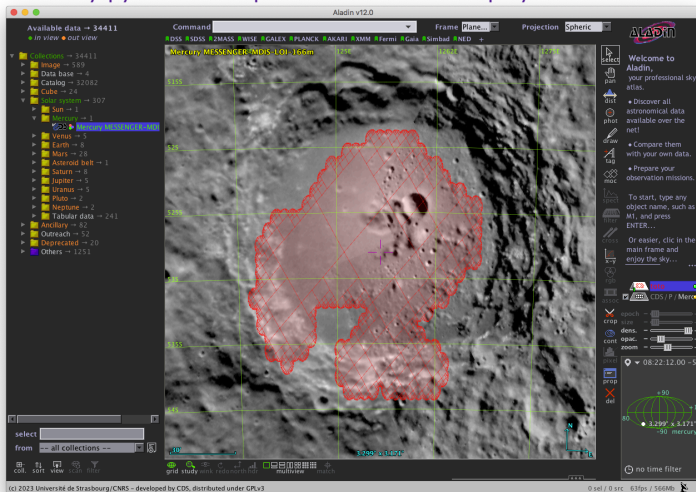
=> MOCs are hand-drawn but also converted from more common GIS formats (shp, geojson, kml...)

Search for interceptions with footprints provided in EPN-TAP services

Collaboration with CDS

CRISM and HRSC footprints + Mars craters
on MOLA topo HiPS, Syrtis Major area

Mercury pyroclastic deposit unit on MDIS displayed in Aladin



VESPA geoportal

HiPS can be used as data sources (not only as basemaps)

=> MOCs from data ranges, for region selection in all services — Relies on mocpy and moc-set

Confirm selected area

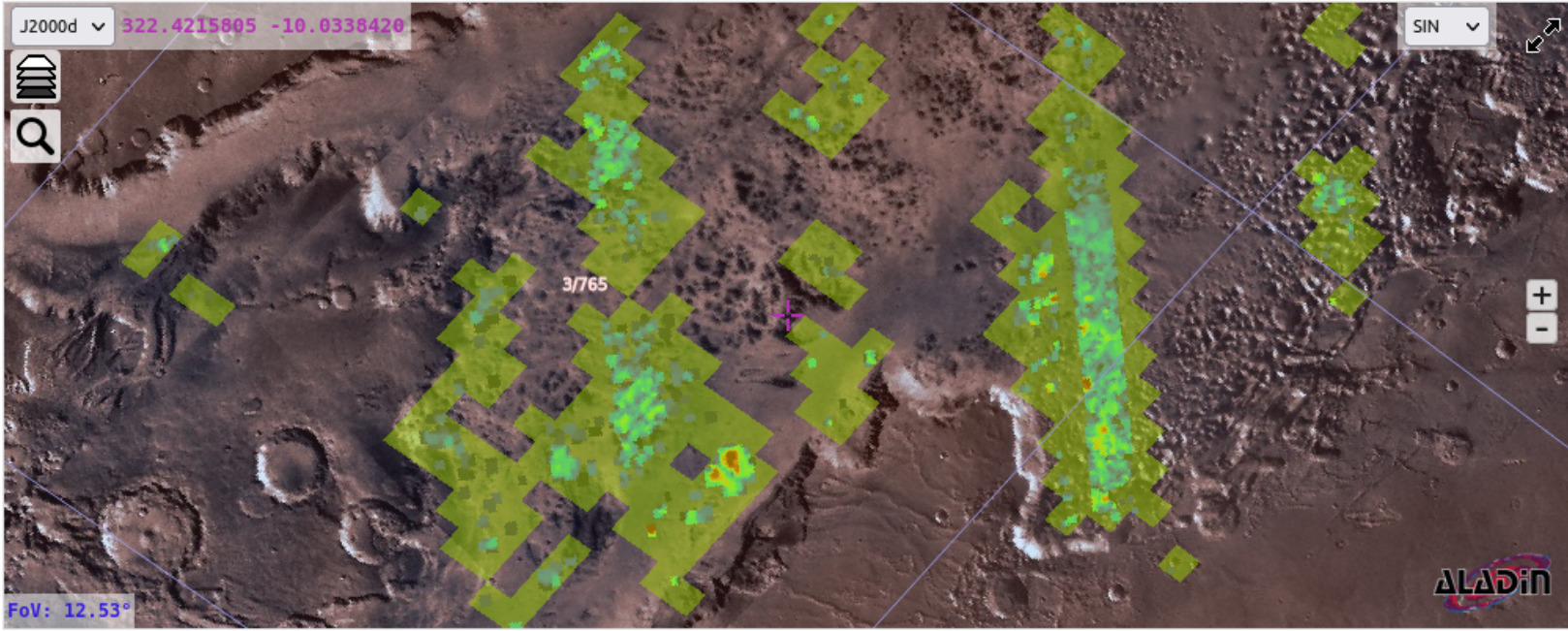
Reset drawn area

Reset MOCs of additional layers

Toggle draw mode

Center the view

J2000d 322.4215805 -10.0338420



Main HiPS survey:

OMEGA olivine map (higher abundances)
over Viking MDIM HiPS in Aurorae Chaos / Valles Marineris

-MDIM21-color

Add additional HiPS surveys:

omega olivine_osp1

Add

VESPA geoportal

Uses AladinLite in planetary mode (CDS)

Calls IAU nomenclatures at USGS to identify planetary features - instead of SIMBAD on the sky

AladinLite planets explorer
<https://aladin.cds.unistra.fr/AladinLite/planets-explorer>

The image displays the Vespa geoportal interface, which integrates the AladinLite planets explorer and the USGS Gazetteer of Planetary Nomenclature.

Top Panel (AladinLite planets explorer): Shows a 3D view of Mars with a blue color scale. The top left panel displays "Planets surveys:" with a dropdown menu set to "J2000d" and coordinates "286.3192183 -3.2474975". Below this, a "7m" resolution thumbnail and "Mars Viking MDIM21" data are shown. The top right panel includes a "SIN" dropdown and zoom controls (+, -).

Bottom Panel (USGS Gazetteer of Planetary Nomenclature): The left sidebar shows the "Gazetteer of Planetary Nomenclature" logo and a navigation menu with links to Home, About, Nomenclature, Mercury, Venus, The Moon, Mars System, Mars, Phobos, Deimos, Asteroids, and Jupiter System. The main content area is titled "MARS - Ceti Mensa" and features a 3D topographic map of the Ceti Mensa region. A red circle highlights a specific feature, and a red arrow points from this feature to a detailed view of Ceti Mensa.

Right Panel (Detailed View): A close-up view of Ceti Mensa, showing its topographic details. A red circle highlights the feature, and a red arrow points from this feature to a detailed view of Ceti Mensa. The detailed view includes a pop-up window with the following information:

- Ceti Mensa**
- Type: Mensa, mensae
- [More information](#)

The bottom of the detailed view shows a table with the following columns: Feature Name, Ceti Mensa, Approval, and Status. The table is currently empty.

VESPA-F ANO5: Prospects

- **Pôle données et services Surfaces CNES/INSU**

 - Mapping STACplanet / EPNCore - CNES or ObsParis

 - Finalisation of geoportal & shape model support

 - Retrieve Rosetta anaglyphs db at CNES? (proto ready, just needs a dump)

- **Pôle données et services Petits Corps CNES/INSU**

 - Mapping Common vocabulary / EPNCore => access to SSODnet, JPL, possibly PDS4, etc

 - Spectral workflow: analysis of spectral bands, comparison with SSHADE bd

 - Infra to collect amateur data? (for occultations & other possible applications)

- **Provide new data content in both cases**

- **Prepare for interactions with PNP** (from INSU evaluation, 2024)

 - Wait for INSU signal

VESPA-F ANO5: Prospects, 2

- Resources

Europlanet over => no extra manpower in ObsParis for workshops, large data collections, etc
Still enough manpower available to maintain and grow in the 4 associated OSU

- Next programmes?

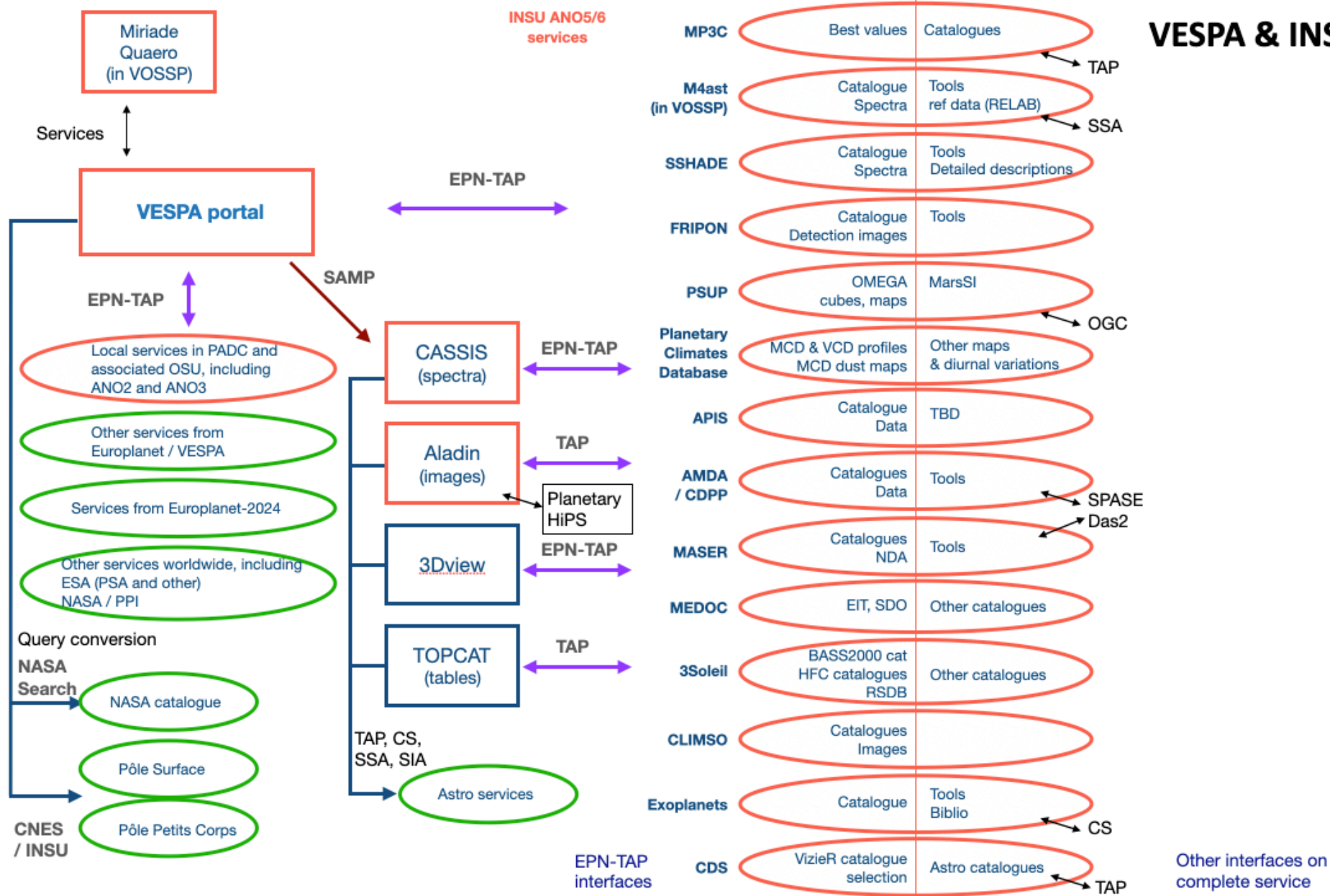
Europlanet in standby, will react to opportunities (Horizon Europe) - eg, SpaceSci-RI bid in 2023
Astro-CC in OSCARS?

- Collaborations

VESPA community still alive, in and beyond Europlanet
Contributions to IVOA, IPDA, etc on-going

- French ANO5

Grouping?



VESPA & INSU services

VESPA portal	<u>https://vespa.obspm.fr</u>
web site (outreach)	<u>http://www.europlanet-vespa.eu</u>
github (tuto, codes...)	<u>https://github.com/e pn-vespa</u>
Wiki (docs, use cases)	<u>https://voparis-wiki.atlassian.net/wiki/spaces/VES</u>
GitLab (preservation)	<u>https://voparis-gitlab.obspm.fr/vespa</u>

GitLab and Confluence wiki access on demand