Virtual Observatory and Planetary Science

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journées ASOV
18 Mars 2024

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euro PLANET 2024
Research Infrastructure
2020-24

VESPA includes 18 contributing participants (labs) in 13 institutes:

Observatoire de Paris
(IMCCE, LESIA, PADC)

l'Observatoire de Paris

PADC
Paris Astronomical Data Centre

CBK-PAN Warsaw

CBK PAN

Constructor Univ.
Bremen

C>ONSTRUCTOR
UNIVERSITY

CNRS
(CDS IPSL IPAG
IRAP)

cnrs

IWF Graz

ÖAW IWF

IASB-BIRA
Brussels

BIRA·IASB

SpaceFrog Toulouse

SPACEFROG.

OATS/INAF Trieste

DLR Berlin

DLR

+ Contributions from
the community

UPV/EHU Bilbao

Universidad
del País Vasco
Euskal Herriko
Unibertsitatea

Univ. Bristol

University of
BRISTOL

UCL London

UCL

Univ. Heidelberg

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VESPA

- **Objective:**

    Accommodate Planetary Science in the Virtual Observatory (VO)

  + consistency with main contributors in the field and similar consortia (IPDA, SPASE…)

   VESPA is active in the IVOA (VO)**, IPDA** (with space agencies)**, IHDEA** (heliophysics)

- **History:**

    A series of Europlanet RI programmes (from 2009 - today)   **ends July 2024 ;(**

   Big effort integrated at EU level, with many external collaborations

   (ESA, NASA, JAXA, IAU, RDA, EOSC, DACE…)

- **VESPA-F in French context:**

  Europlanet / VESPA => 3 ANO5 INSU-certified services: VESPA-F, MASER, SSHADE

  VESPA-F: portal & local data services

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

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

What VESPA provides to the community

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

    EPNCore metadata (https://www.ivoa.net/documents/EPNTAP/)

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

2- User interfaces to search data based on science-relevant parameters:

    VESPA portal (other TAP clients / Jupyter notebook exist)

    No-SQL discovery portal and Geospatial portal (in dev)

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

    Currently 68 data services open & validated (249 in the registry, others in progress)

    Currently 69 planetary HiPS

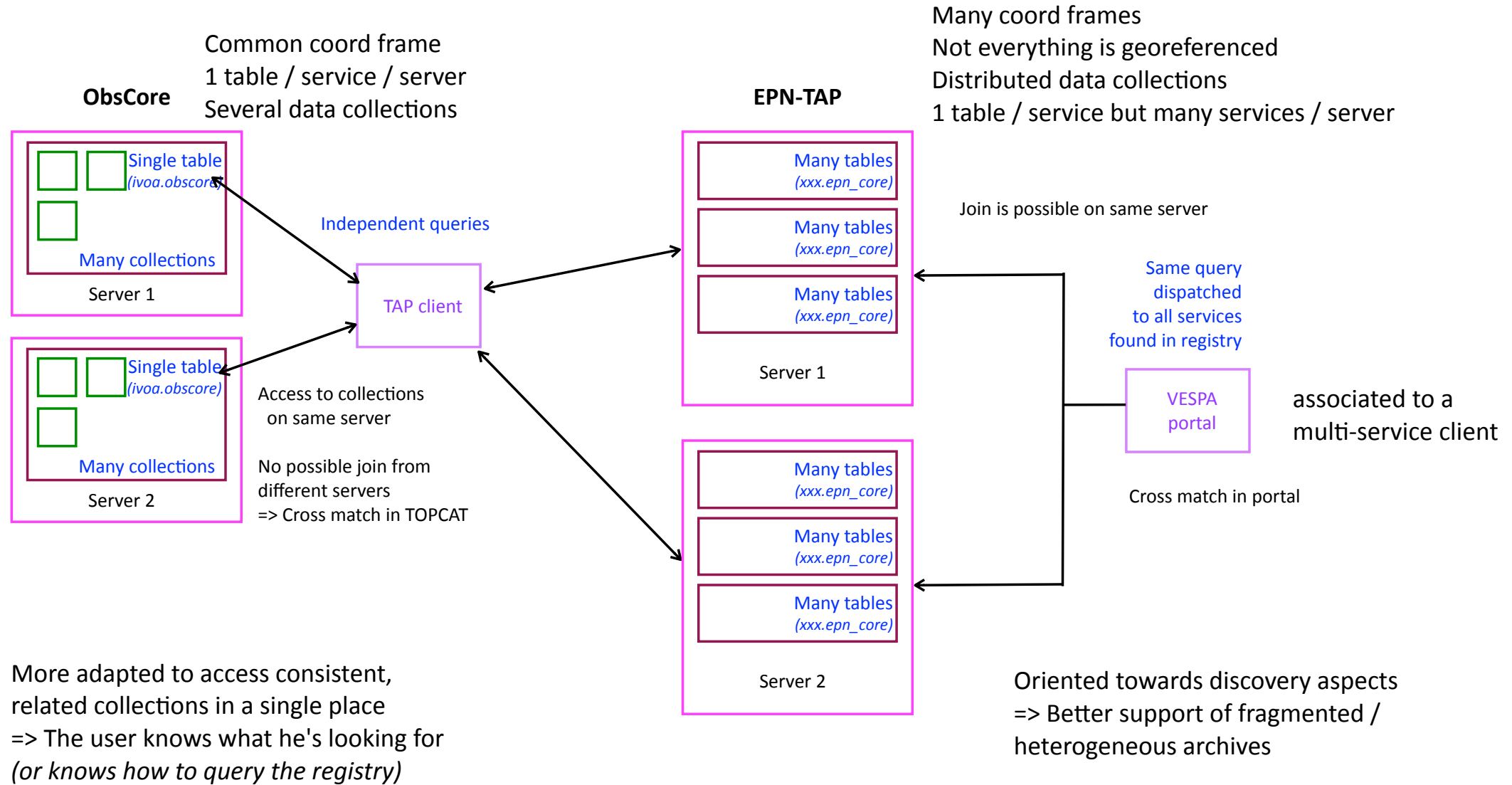   + New or updated data infrastructures: SSHADE, PVOL, AMDA, MASER

4- Connection / adaptation of powerful display and analysis tools:

    Tools from astronomy (VO, with planetary science updates) **+ GIS** and others + Jupyter notebooks

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

    Allows development of services on data

ObsCore vs EPN-TAP

ObsCore

Common coord frame
1 table / service / server
Several data collections

Single table
(ivoa.obscore)

Many collections

Server 1

Single table
(ivoa.obscore)

Many collections

Server 2

Independent queries

TAP client

Access to collections
on same server

No possible join from
different servers
=> Cross match in TOPCAT

More adapted to access consistent,
related collections in a single place
=> The user knows what he's looking for
(or knows how to query the registry)

EPN-TAP

Many coord frames
Not everything is georeferenced
Distributed data collections
1 table / service but many services / server

Many tables
(xxx.epn_core)

Many tables
(xxx.epn_core)

Many tables
(xxx.epn_core)

Server 1

Many tables
(xxx.epn_core)

Many tables
(xxx.epn_core)

Many tables
(xxx.epn_core)

Server 2

Join is possible on same server

Same query
dispatched
to all services
found in registry

VESPA
portal

associated to a
multi-service client

Cross match in portal

Oriented towards discovery aspects
=> Better support of fragmented /
heterogeneous archives

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

Scope:
Planetary Science
Heliophysics
Exoplanets

Research teams, institutes
EU projects
=> Open Science

User

Queries

Answers

Data access

Catalogue / Registry

Rosetta
SSHADE
PSA

AMDA...
PVOL
PDS

Data bases

Space agency archives
Telescope archives

Publication

Data providers
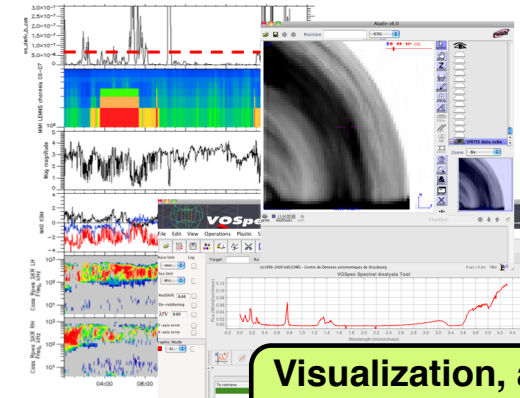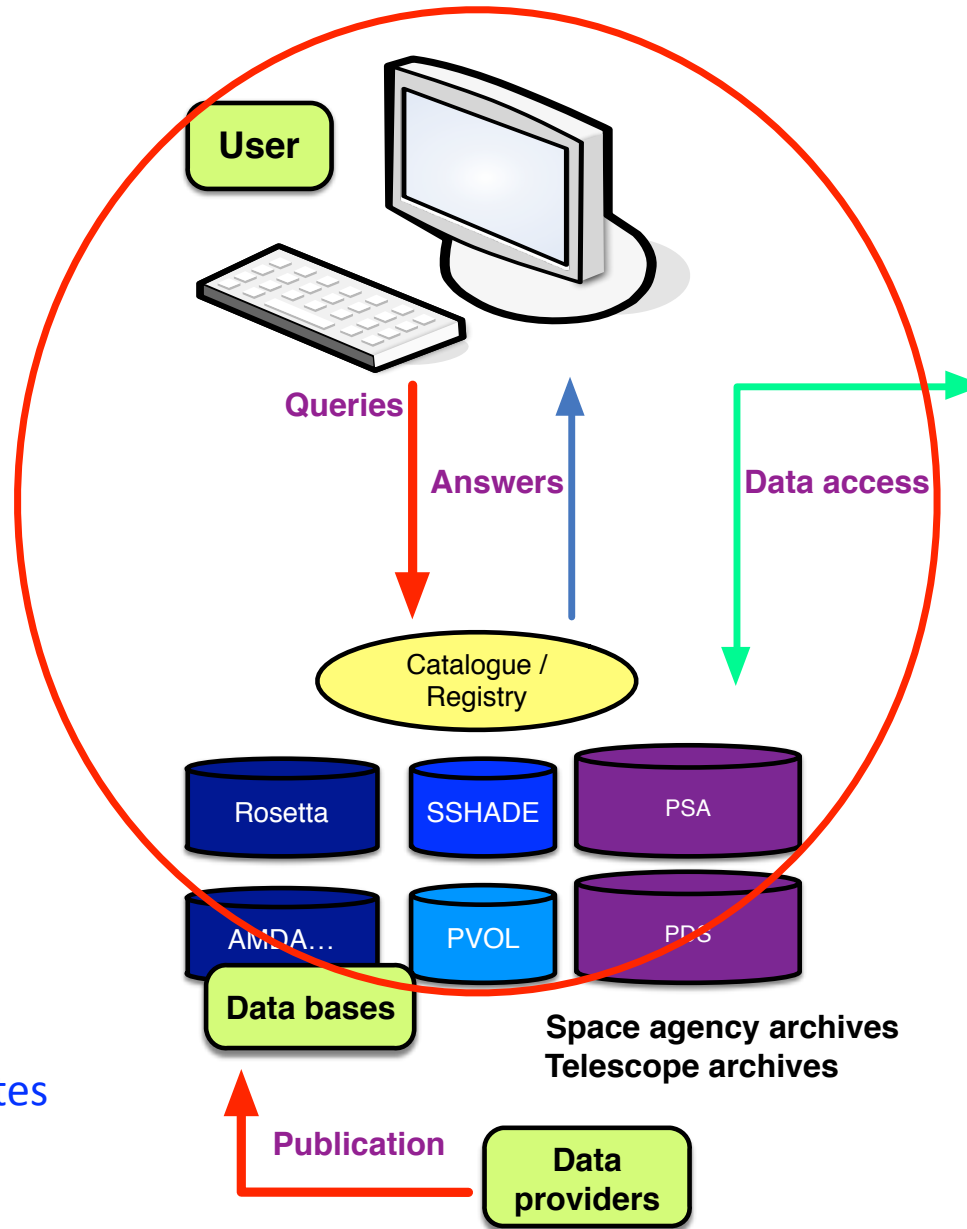
Data exchange

Visualization, analysis and other tools

Click-click

Streaming
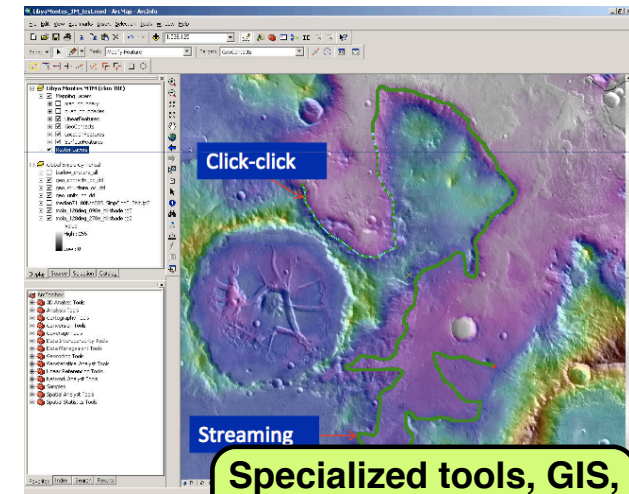
Specialized tools, GIS, Mass processing...

EPN-TAP / EPNCore — metadata status

v2.0: IVOA Recommendation, Aug 2022

~ 180 parameters, some with list of values (vocabularies)
Including coordinate frames, derived time scales (local time, season…), illumination coverages, etc

v2.1: on-going update

Started Nov 2023 in IVOA Solar System IG (last Interop meeting)
Revisions: clarifications; minor changes (name of some parameters)
Extensions:
  - new parameters e.g. for small bodies (rotation, dynamics, families…) and spectroscopy (bandlists)
  - better support for coordinate systems (nomenclature of body-fixed frames)
  - vocabularies to be handled with new IVOA system

Contributions / user feedback welcome!

EPNCore: non-VO / non-TAP usage

EPNCore can be used to describe data in various contexts

- Research work with private datasets — involving many files / looking for configurations
- Data management for lab experiments
- Ground segment of space experiments: provides access to VO tools — being assessed

Application to no-SQL context

• VESPA discovery portal (in dev):
relies on ElasticSearch db
- Very demanding: all metadata mirrored
   in a single place + MOC computation
- Perform multi-service cross searches easily
- Very efficient to validate service content

Search	Results (47571674)

Keyword search ?
Enter query

Instrument host name		Instrument name	
ExoMars 2016	20183704	CaSSIS	11632882
Simulation	8355694	ACS	8271363
Rosetta	7276371	Mars Climate Database V5.3	5992272
Mars Express	1283643	ROSINA	4654847
SDO	1148791	GEM-Mars_V652	1399680
SOHO	850591	OSIRIS	1363906
2010-005A	787932	AIA	1148791
Mars Odyssey	768905	Venus Climate Database V1.1	961440
Venus Express	619698	Atmospheric Imaging Assembly	787932

Services		Dataproduct type		Target region	
psa	30091541	catalogue_item	33706282	atmosphere	8380169
mcd	5992272	profile	8426791		2552097
AMDADB	2527004	time_series	2695272	crater	384344
gem_mars	1399680	image	1841411	chromosphere	132178
mpc	1311496	dynamic_spectrum	1222548	Magnetosphere	69562
hfc1ar	1211449	spectral_cube	355448	corona	52863
vcd	961440	map	58191	Aurora	44313

VESPA main portal — example EPN-TAP request:

Typical for surfaces (assuming all data are correctly described)**:**

Mars, a given region (~ Tharsis volcanoes) (footprint need to be provided)

Illumination conditions (i ≤ 20° / phase: needs to be provided)

Local time or season, etc (need to be provided)

Results from all services
=> need to be described at similar level

Footprints can be sent to plotting tools from the portal

https://vespa.obspm.fr

VESPA portal updates

Redesigned from UX analysis

Similar to new ESA/PSA portal

(Gallery view in dev)

Focuses on data georeferenced on planetary surfaces (relies on the ElasticSearch db)
GIS-like interface, centered on footprints (MOC, HiPS, but also ArcGIS shape files...)
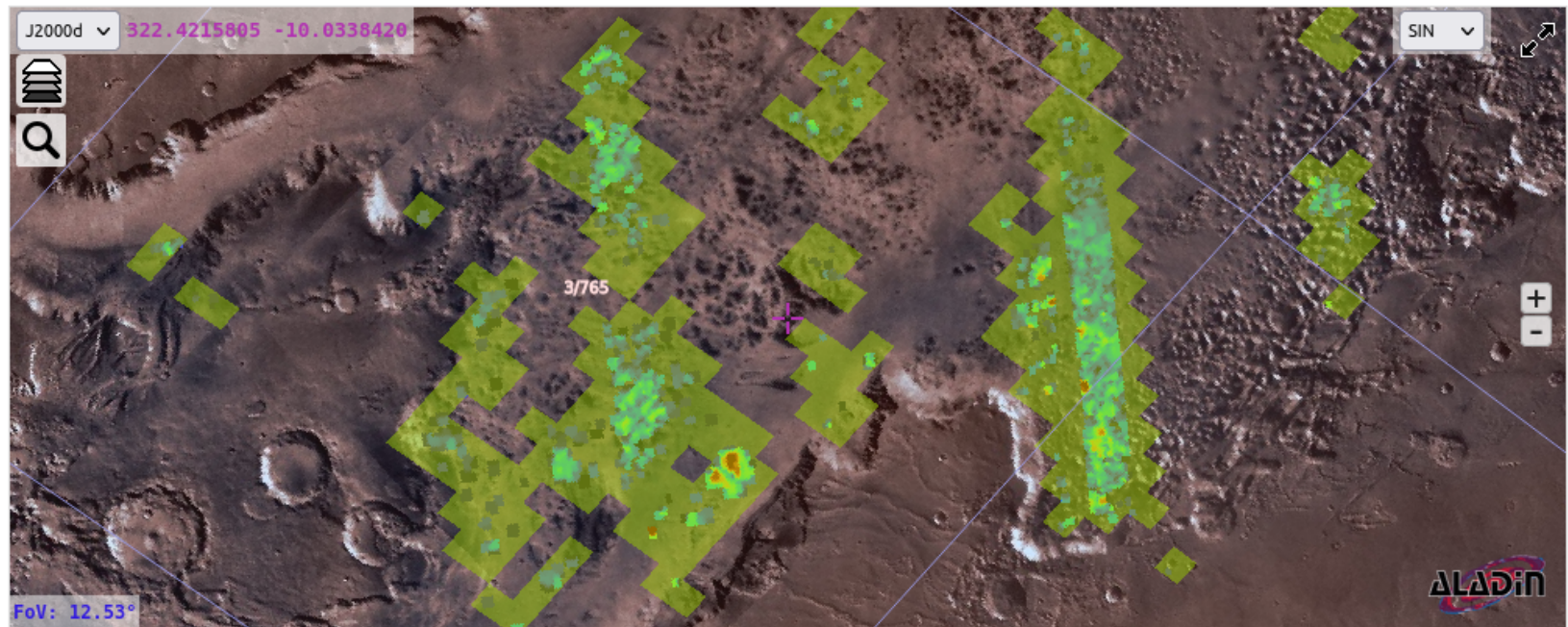
Main HiPS survey:

Mars Viking-MDIM21-color

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

Add additional HiPS surveys:

omega olivine_osp1   Add

Enable HiPS to MOC conversion
Use Allsky FITS
Pixel range:

VESPA geoportal (dev)

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

Uses AladinLite in planetary mode

Calls IAU nomenclatures at USGS instead of SIMBAD

(still to be implemented here)

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

Python access

Command line or Jupyter notebook

=> **Single or multiple service access via astropy; possible access to private services**

python / IDL mixed processing in Jupyter nb

Addition of IAU planetary reference frames in astropy (body-fixed only; in v6)

Community developments:

Support of EPN-TAP in pyvo (in v1.5)

Addition of VESPA planetary kw in WCSlib (in v8.1)

see tutorials:

https://github.com/epn-vespa/tutorials/
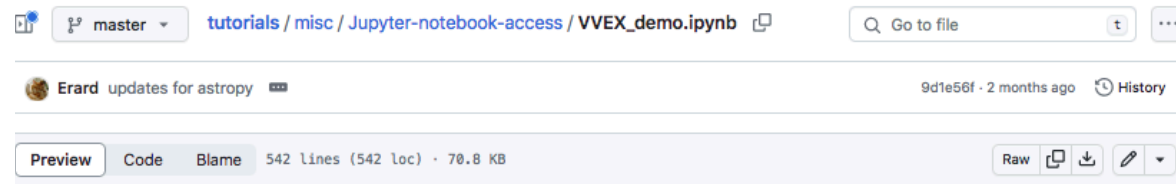
Access to public EPN-TAP data services through Jupyter notebook

```
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/e
         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 VO-OGC link (CNES/INSU planetary surface node)

Services:

    HiPS <=> WMS converter (CNES)

    Registry of planetary CRS (CNES)

    Addition of planetary images in fits headers / WCS + support in GDAL (EPN, body-fixed only)

    Addition of planetary reference frames in astropy (EPN, body-fixed only; in v6)

      + Support of EPN-TAP in pyvo (in v1.5)

On-going actions:

    Assessment of STAC on local data

    List / nomenclature of reference frames in the Solar System (not only body-fixed)

    List and resolver of space missions / observatories / facilities, plus instruments

      (common with CDS, based on WikiData)

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

Open
Open in test | upgrade required
Drafted
Scheduled 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)
- *All MEx derived atmospheric products (via MEx IDS)*
- *Venus cloud products (LATMOS)*

Small bodies
- *M4ast* (ground based spectroscopy, **IMCCE**)
- 1P/Halley spectroscopy **(IKS / Vega-1, LESIA)**
- BaseCom **(Nançay Obs, LESIA)**
- TNOs are cool **(Herchel & Spitzer** + compilation**, LESIA & LAM & Utinam)**
- SBNAF **(from H2020 prog, Konkoly Obs)**
● - MP3C: Small body properties **(OCA)**
- *Vesta & Ceres spectroscopy - VIR/DAWN (IAPS)*
● - DynAstVO: NEO refined parameters **(IMCCE)**
● - MPCorb: Small bodies orbital cat **(MPC/Heidelberg)**
- *Rosetta ground-based support (Edinburgh)*
● - 67P illumination config **(IRAP)**
- Meteor_showers predictions **(IMCCE)**
● - *Occultations predictions, ast & sat (IMCCE)*
- *LuckyStar, occultations (ERC prog, LESIA)*
● - Natural satellites db **(IMCCE)**
●● - Asteroid spectra (from archives, **CDS / LESIA**)

Solid spectroscopy
●● - SSHADE ices & minerals spectro **(IPAG & network)**
- *Planetary Spectral Library (DLR)*
- CRISM spectral library **(LESIA)**
- *Berlin Reflectance Spectral Lib (DLR)*
- *Hoserlab (Winnipeg U)*

Surfaces
●● - Mars craters **(Jacobs U,** + update by GEOPS**)**
- USGS planetary maps WMS **(Jacobs U)**
● - PlanMap: geol maps (H2020 prg, **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)**
- *Global spectral param of Mercury (DLR)*

Magnetospheres / radio
● - APIS **(HST/Cassini, LESIA)**
●● - NDA **(Jupiter & Sun radio, LESIA/CDN)**
●● - AMDA **(CDPP / IRAP)**
- *MAG data (VEx, IWF Graz)*
●● - 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)**
- *IMPEx models (from FP7 prog, IWF Graz)*
● - *Hisaki & IPRT (Tohoku Univ., Jap)*
- Transplanet **(CDPP / IRAP)**
● - LOFAR Jupiter **(CBK/PAS, Warsaw)**
- *Magnetic field simus (LMSU)*
- *ASPERA & MARSIS atm obs (MEx, Iowa U)*

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

Generic / interdisciplinary
● - BDIP **(LESIA)**
●● - PVOL **(UPV/EHU & amateur network)**
● - Europlanet Telescope Network **(Adam M Univ)**
- Telescopic 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)**
- *Gas absorption cross-sections (Granada)*
- 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)**

VESPA & INSU services

Miriade Quaero (in VOSSP)

Services

VESPA portal

EPN-TAP

EPN-TAP

SAMP

Local services in PADC and associated OSU, including ANO2 and ANO3

Other services from Europlanet / VESPA

Services from Europlanet-2024

Other services worldwide, including ESA (PSA and other) NASA / PPI

Query conversion

NASA Search

NASA catalogue

PDAP

JAXA / DARTS ESA / PSA

CASSIS (spectra)

EPN-TAP

Aladin (images)

TAP

Planetary HiPS

3Dview

EPN-TAP

TOPCAT (tables)

TAP

TAP, CS, SSA, SIA

Astro services

Service		
MP3C	Best values	Catalogues → TAP
M4ast (in VOSSP)	Catalogue Spectra	Tools ref data (RELAB) → SSA
SSHADE	Catalogue Spectra	Tools Detailed descriptions
FRIPON	Catalogue Detection images	Tools
PSUP	OMEGA cubes, maps	MarsSI → OGC
Planetary Climates Database	MCD & VCD profiles MCD dust maps	Other maps & diurnal variations
APIS	Catalogue Data	TBD
AMDA / CDPP	Catalogues Data	Tools → SPASE → Das2
MASER	Catalogues NDA	Tools
MEDOC	EIT, SDO	Other catalogues
3Soleil	BASS2000 cat HFC catalogues RSDB	Other catalogues
CLIMSO	Catalogues Images	
Exoplanets	Catalogue	Tools Biblio → CS
CDS	VizieR catalogue selection	Astro catalogues → TAP

EPN-TAP

EPN-TAP interfaces

Other interfaces on complete service

Prospects

Contribution to CNES/INSU data nodes on planetary surfaces & small bodies

   => provide interoperability between elements

   Reinforce consistency of the planetary data VO ecosystem

Services on data

   2 on-going projects with SSHADE:

   fitting observed spectra with lab spectra/optical constants (GEOPS)

   fitting observed spectral features with bandlists (LESIA)

Interoperability with neighboring fields

   Space agency archives (PDS), Heliophysics (SPASE, etc)

   Planetary surfaces from geology point of view (GIS)

   Laboratory samples / meteorites

End of Europlanet funding in July 2024 ;(

   But the Europlanet Society carries on