

Publishing planetary data in the Virtual Observatory: **VESPA** (Virtual European Solar & Planetary Access)

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UCL, London



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VESPA Europlanet-2024 / Participants



VESPA includes 19 contributing participants (labs) in 14 institutes:

Observatoire de Paris
(IMCCE, LESIA, PADC)



CBK-PAN Warsaw



Jacobs Univ. Bremen



CNRS
(CDS IPSL IPAG
IRAP)



IWF Graz



IASB-BIRA
Brussels



SpaceFrog Toulouse



OATS/INAF Trieste



DLR Berlin



+ Contributions from
the community

UPV/EHU Bilbao



Univ. Bristol



UCL London



SINP-MSU Moscow



Univ. Heidelberg



Science users, but also education / outreach

=> FAIR access

Scope:

Planetary Science

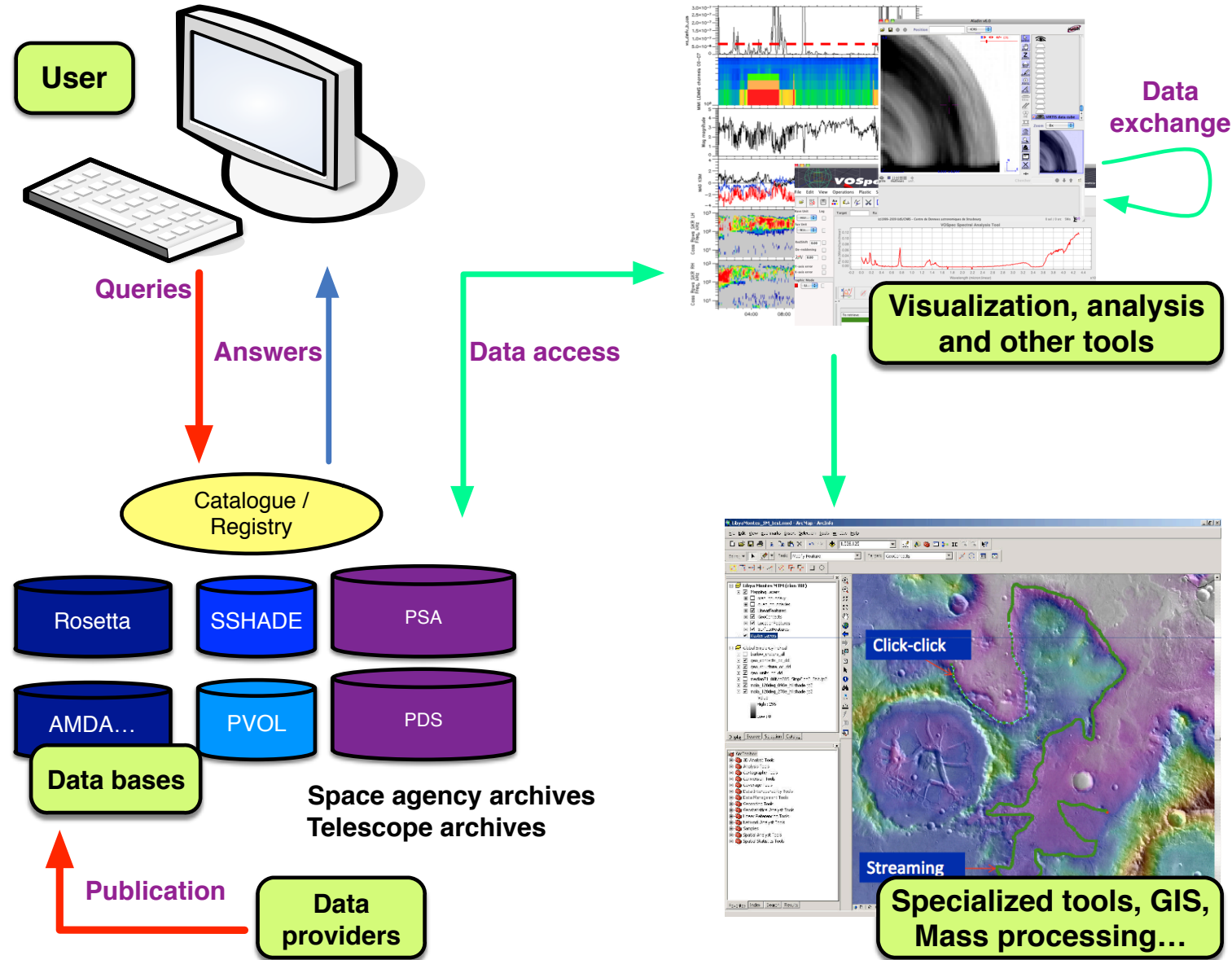
Heliophysics

Exoplanets

Research teams, institutes

EU projects

=> Open Science



What VESPA provides to the community

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

EPNCore metadata - standard in the Virtual Observatory (VO)

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

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

Currently 63 data services published, many more in development

Includes ESA's PSA (25+ million files!) + NASA PDS PPI datasets (80+)

Will include data produced during Europlanet-2024 (experimental & field studies)

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

VESPA portal (other access modes are available)

4- Connection with powerful display and analysis tools:

Tools from astronomy (VO, with planetary science updates) + GIS and various environments

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

This data system is available for science teams to access and *to distribute* data

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

Open
Open in test | upgrade required
Drafted
Scheduled 2024 (selection)
• New or upgraded in 2021/22
• New content in 2021/22

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)
 - All MEx derived atmospheric products (via MEx IDS)
 - Venus cloud products (LATMOS)
 - ExoMars/NOMAD (BIRA-IASB)

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)
- VizieR asteroid spectra (CDS / LESIA)

Solid spectroscopy

- SSHADE ices & minerals spectro (IPAG & network)
 - Planetary Spectral Library (DLR)
 - PDS 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 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)
 - 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 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 (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)

Generic / interdisciplinary

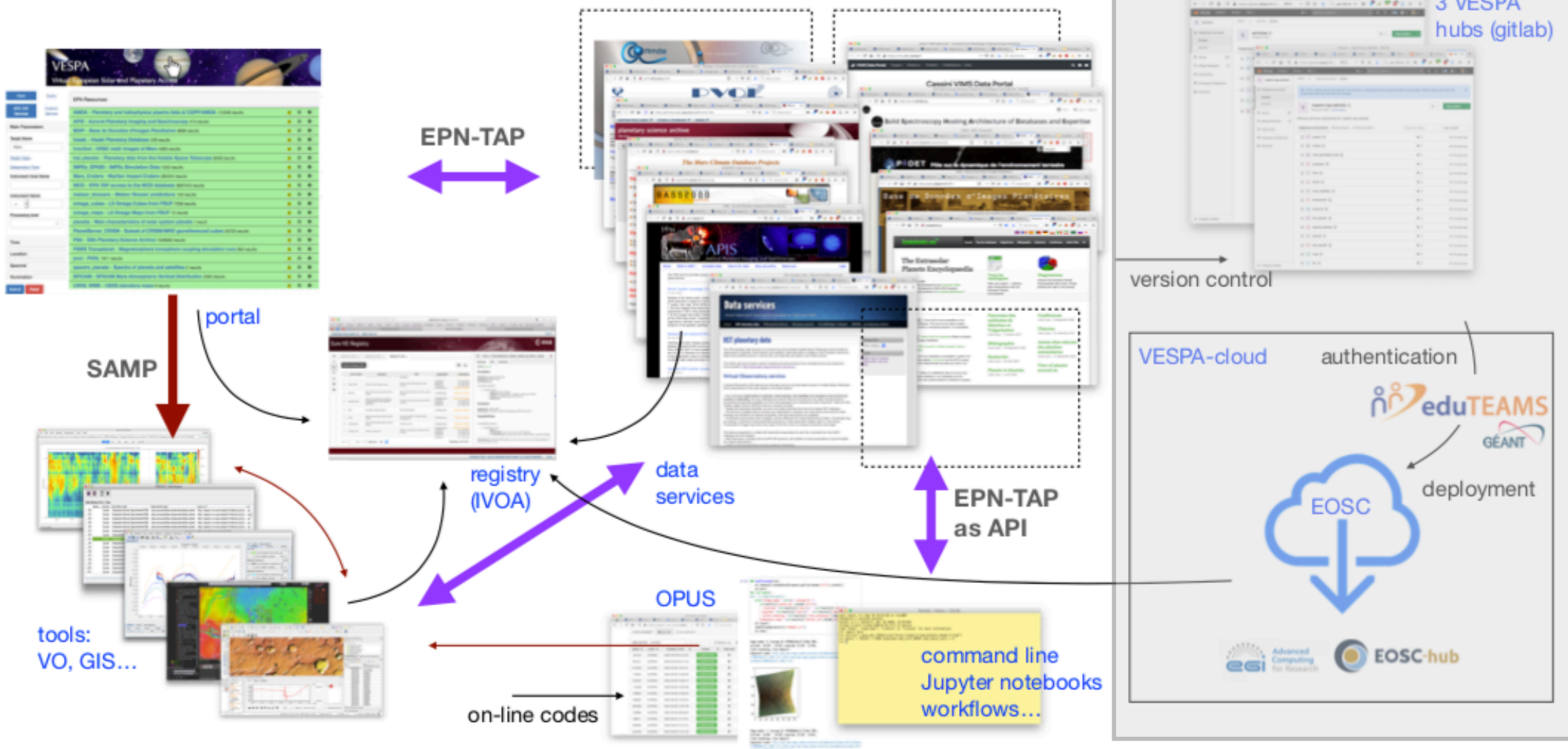
- BDIP (LESIA)
- PVOL (UPV/EHU & amateur network)
 - Telescopic planetary spectra collection (LESIA)
- PSA complete archive (ESA)
- HST planetary data (LESIA, to CADC archive)
 - Catalogues of planetary maps (Budapest)
- VizieR_planets: Planetary Science catalogues (CDS)
 - Gas absorption cross-sections (Granada)
 - Planets then satellites 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: infrastructure

Maintenance functions



VESPA: Recent developments

1- EPN-TAP protocol

Currently an IVOA Proposed Recommendation: <https://github.com/ivoa-std/EPNTAP>
Being finalized - hopefully validated next summer

2- Dedicated client (VESPA portal: <http://vespa.obspm.fr>)

New layout released July 2022; alternative facets-based search being implemented (ElasticSearch)
Any TAP client can access the services (does not depend on the VESPA portal)

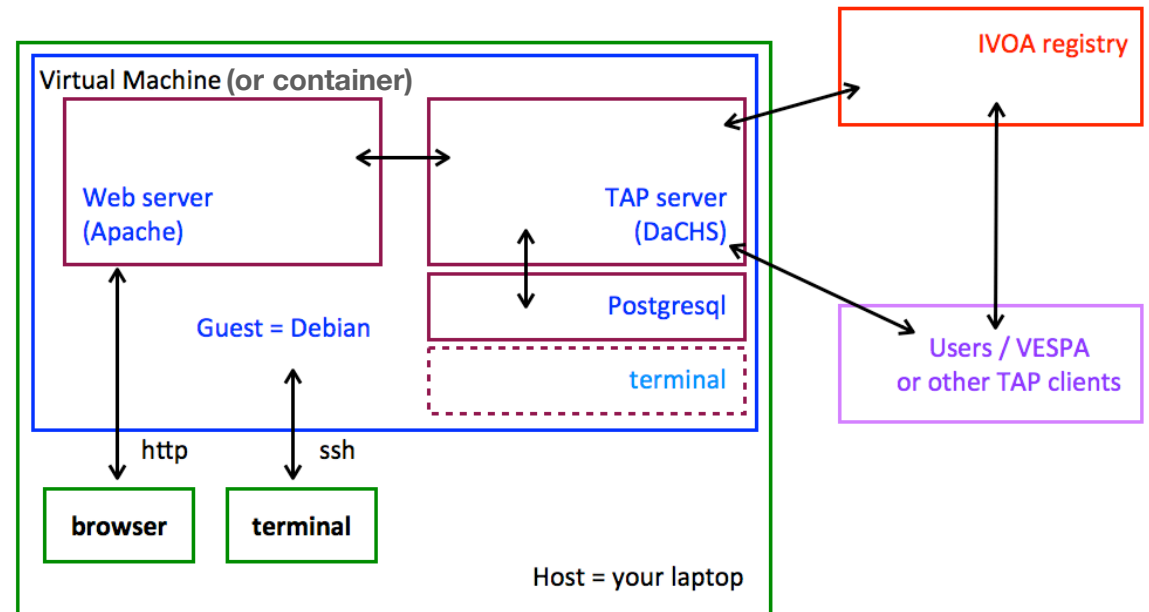
3- Recommended, mature installation procedure

DaCHS 2.5 includes extended support and mixin; some services on **Vollt** (ESA PSA, VizieR_planets)
EPN-TAP validator included in **taplint 3.4.2**; parameter usage monitored from portal
Service registration is now IVOA compliant
Services preserved on a common gitlab. Allows quick deployment (including on EOSC, validated)

EPN-TAP service installation procedure

1- Install data server

- Preferred solution: DaCHS 2.5 (TAP server) - in a VM or container under Debian
- will handle internal database, registration, and queries



<https://voparis-wiki.obspm.fr/display/VES/Running+dachs+on+docker>

EPN-TAP service installation

2- Data ingestion

Typically from CSV table, fits headers, or existing database

=> provide as many parameters as possible

Flexible (on-the-fly modifications possible with python scripts)

Standards EPN-TAP parameters are predefined in DaCHS

3- Add web services (optional)

Cut-outs, ephemerides, simulations + attached documents, alt formats... => datalink

granule_uid	dataprodukt_type	target_name	time_min (d)	time_max (d)	access_url	datalink
orbit2888A1_temp_SPICAMmeasurements	profile	Mars	2006-04-11T06:09:11.232	2006-04-11T06:09:11.232	http://vo.projet.lat...	<input type="button" value="SEND"/>
orbit2888A1_temp_MCDsimulations	profile	Mars	2006-04-11T06:09:11.232	2006-04-11T06:09:11.232	http://vo.projet.lat...	<input type="button" value="SEND"/>
orbit2888A1_co2dens_SPICAMmeasurements	profile	Mars	2006-04-11T06:09:11.232	2006-04-11T06:09:11.232		
orbit2888A1_co2dens_MCDsimulations	profile	Mars	2006-04-11T06:09:11.232	2006-04-11T06:09:11.232		

SPICAM / Mars-Express atmospheric profiles

Mars Climate Database simulations in the same conditions

Links for orbit2888A1_temp_MCDsimulations

▼ the data itself

the primary (as opposed to related) data of the identified resource

[climavr](#) : Associated MCD simulation results for Climatology scenario, with solar EUV average conditions

[climmin](#) : Associated MCD simulation results for Climatology scenario, with solar EUV minimum conditions

[climax](#) : Associated MCD simulation results for Climatology scenario, with solar EUV maximum conditions

[warmmax](#) : Associated MCD simulation results for Warm scenario, dusty atmosphere, with solar EUV maximum conditions

[coldmin](#) : Associated MCD simulation results for Cold scenario, dusty atmosphere, solar EUV minimum conditions

EPN-TAP service installation

4- Document and validate the service

Ingestion script contains standard keywords describing the contents

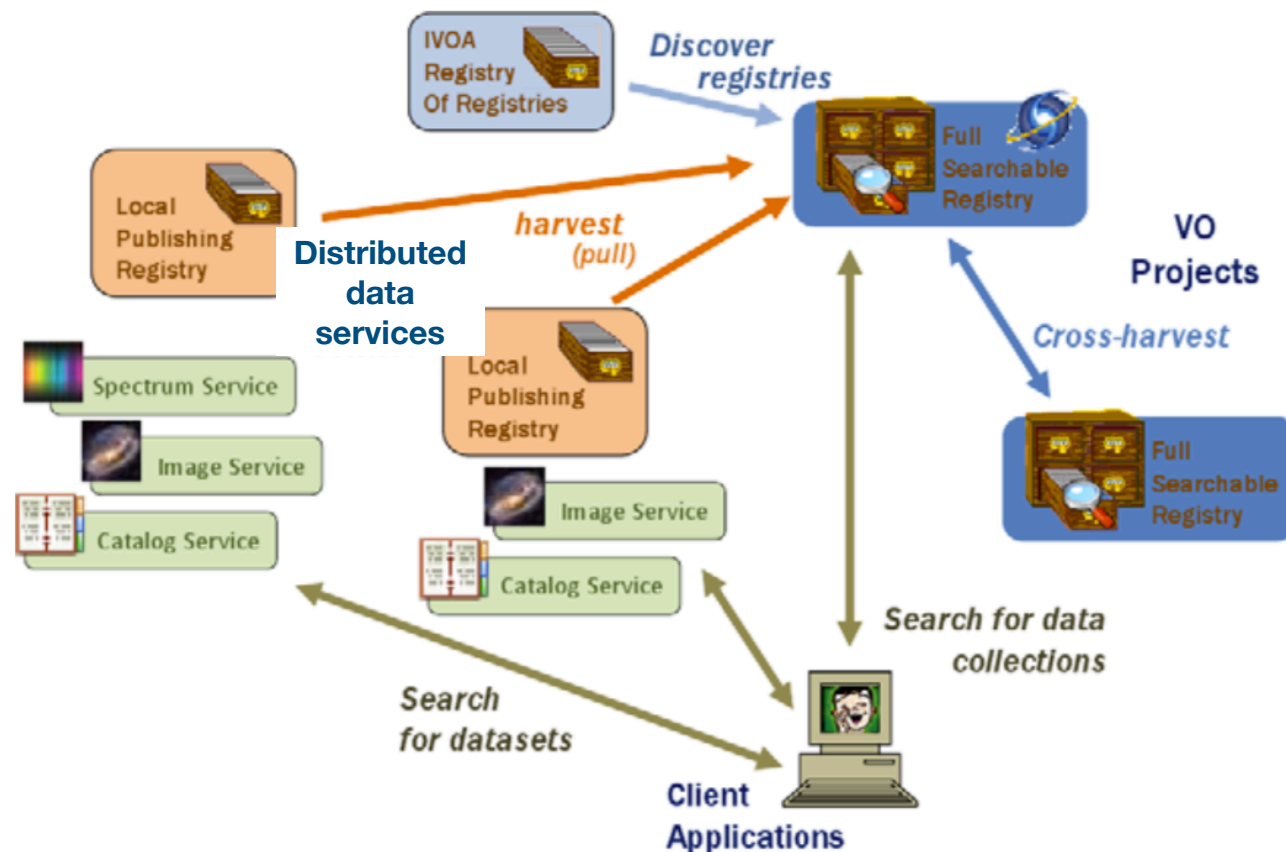
Run service validator (from taplint in TOPCAT)

5- (test and) Publish

Will be stored in the IVOA registry
and accessible by all clients/tools

6- Store metadata on VESPA gitlab

Will enforce sustainability



VESPA: Interfaces

1- New connected tools

Das2 (time series with adaptive resolution) => **Autoplot with SAMP**

WMS/WCS (georeferenced, OGS protocols) => **QGIS with SAMP and fits support** (via GDAL)
=> **HiPS/WMS converter** (from CNES)

Images => **ImageJ with SAMP and extended fits support** (provides processing functions to the VO)

2- Tool capacities

✓ **PDS4** (tables) **support in TOPCAT** (space agency archives)

✓ **Dynamic spectra** (radio): workflows in MASER

✓ **Support for reflected light spectra in CASSIS**

✓ **Spectral cubes: Aladin's CASSIS plugin** (with support for planetary science)

Support for spectral band lists in CASSIS (consistent with SSHADE service)

Spectral analysis (surfaces): workflow project

3- Workflows

OPUS run-on-demand platform used in VESPA (from CTA / ASTERICS)

VESPA: next steps

0- Enforce sustainability

DOI, DMP... on-going

1- Access to PDS data (space mission archives)

Some PDS4 products supported, depending on exact formats (√ tables, √ fits...)

PDS3 still challenging (existing IDL/GDL solutions with Jupyter notebooks)

2- Coordinate systems

Need for a consistent naming scheme

Need to be interoperable with OGC standards / tools

3- Observatories / facilities list

Ongoing in IVOA (using Wikidata)

4- Interoperability with space agencies / observatories:

√ ESA / PSA - include Guest Storage Facility?

NASA, JAXA, ISRO? - discussed in the IPDA

ESO, CADK, Noirlab?

tool examples

search interface <http://vespa.obspm.fr>
web site (with tutos) <http://www.europlanet-vespa.eu>
wiki (EPN activity) <https://voparis-confluence.obspm.fr/>
github <https://github.com/e pn-vespa>
IVOA <https://ivoa.net>
(last Interop meeting) <https://wiki.ivoa.net/twiki/bin/view/IVOA/InterOpApr2022>