

# VESPA: Virtual European Solar & Planetary Access



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VESPA portal	<a href="https://vespa.obspm.fr">https://vespa.obspm.fr</a>
web site (outreach)	<a href="http://www.europlanet-vespa.eu">http://www.europlanet-vespa.eu</a>
wiki (organisation)	<a href="https://voparis-wiki.obspm.fr/">https://voparis-wiki.obspm.fr/</a>
github (tuto, codes...)	<a href="https://github.com/epn-vespa">https://github.com/epn-vespa</a>
publication list	<a href="https://voparis-wiki.obspm.fr/display/VES/Publications">https://voparis-wiki.obspm.fr/display/VES/Publications</a>



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Support by PADC is acknowledged

Pôle Surfaces  
CNES-INSU  
17 may 2023

## VESPA Europlanet-2024 / Participants

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

eur<sup>o</sup>PLANET 2024  
Research Infrastructure  
**2020-24**

Observatoire de Paris  
(IMCCE, LESIA, PADC)



Jacobs Univ. Bremen

CNRS  
(CDS IPSL IPAG  
IRAP)



IWF Graz



IASB-BIRA  
Brussels



SpaceFrog Toulouse  
**SPACEFROG.**

OATS/INAF Trieste



DLR Berlin



UPV/EHU Bilbao



Univ. Bristol



UCL London



SINP-MSU Moscow



Univ. Heidelberg



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+ Contributions from  
the community

## VESPA: Status

- VESPA : an action in Europlanet 2020-RI (2015-2020)
  - + Follow-up in Europlanet 2024, started Feb 2020 (4 years)

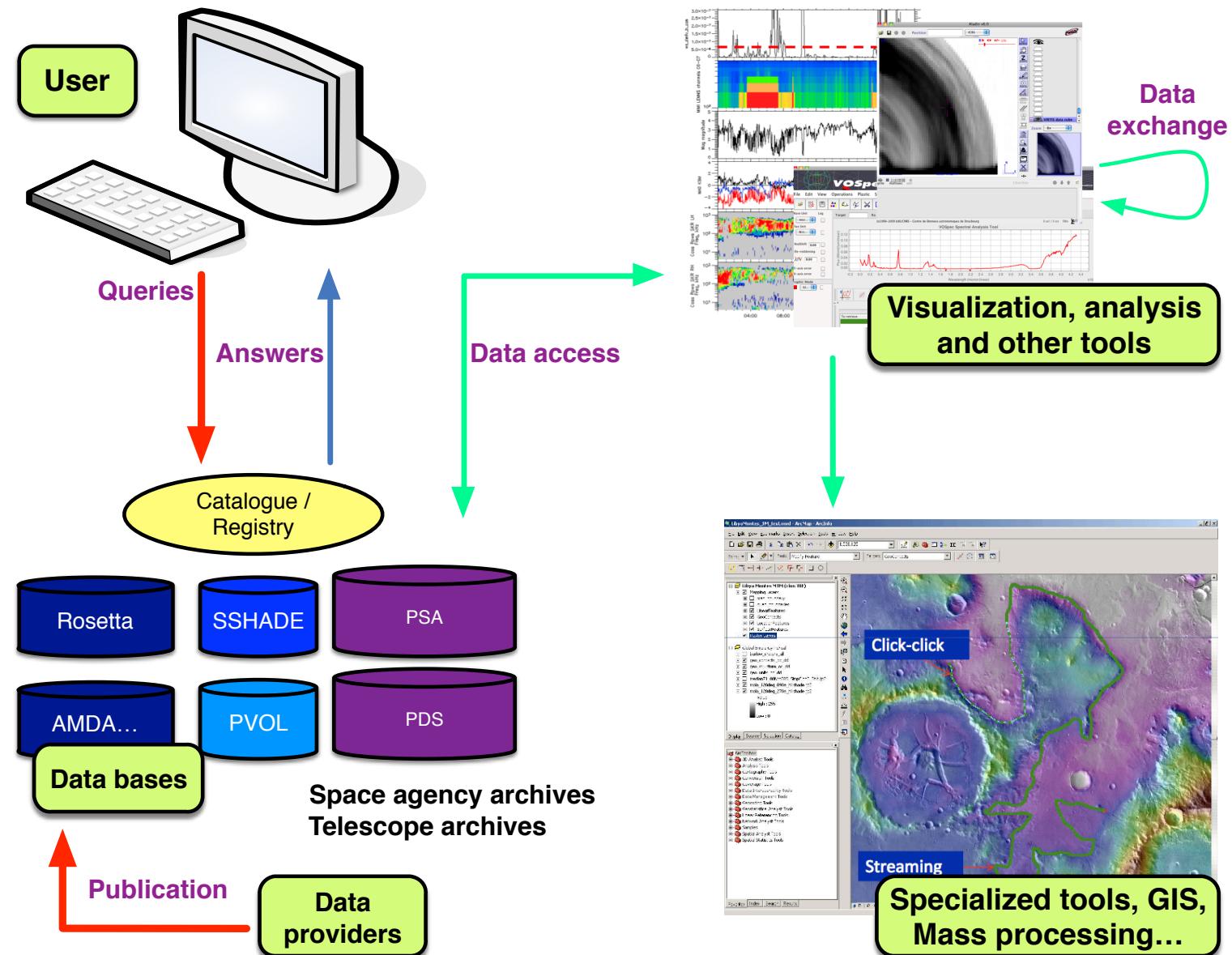
### Research Infrastructure programmes

- Europlanet 2024:
  - Coupled with other actions, in particular planetary cartography WP (GMAP)
  - Big effort integrated at EU level, with many external collaborations  
(ESA, NASA, JAXA, IAU, RDA, EOSC, DACE...)
  - VESPA is also active in 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
  - VESPA portal <https://vespa.obspm.fr>

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](#)

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

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

[VESPA portal](#) (other access modes are available)

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

[Currently 62 data services open](#) (7 new ones this year)

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

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

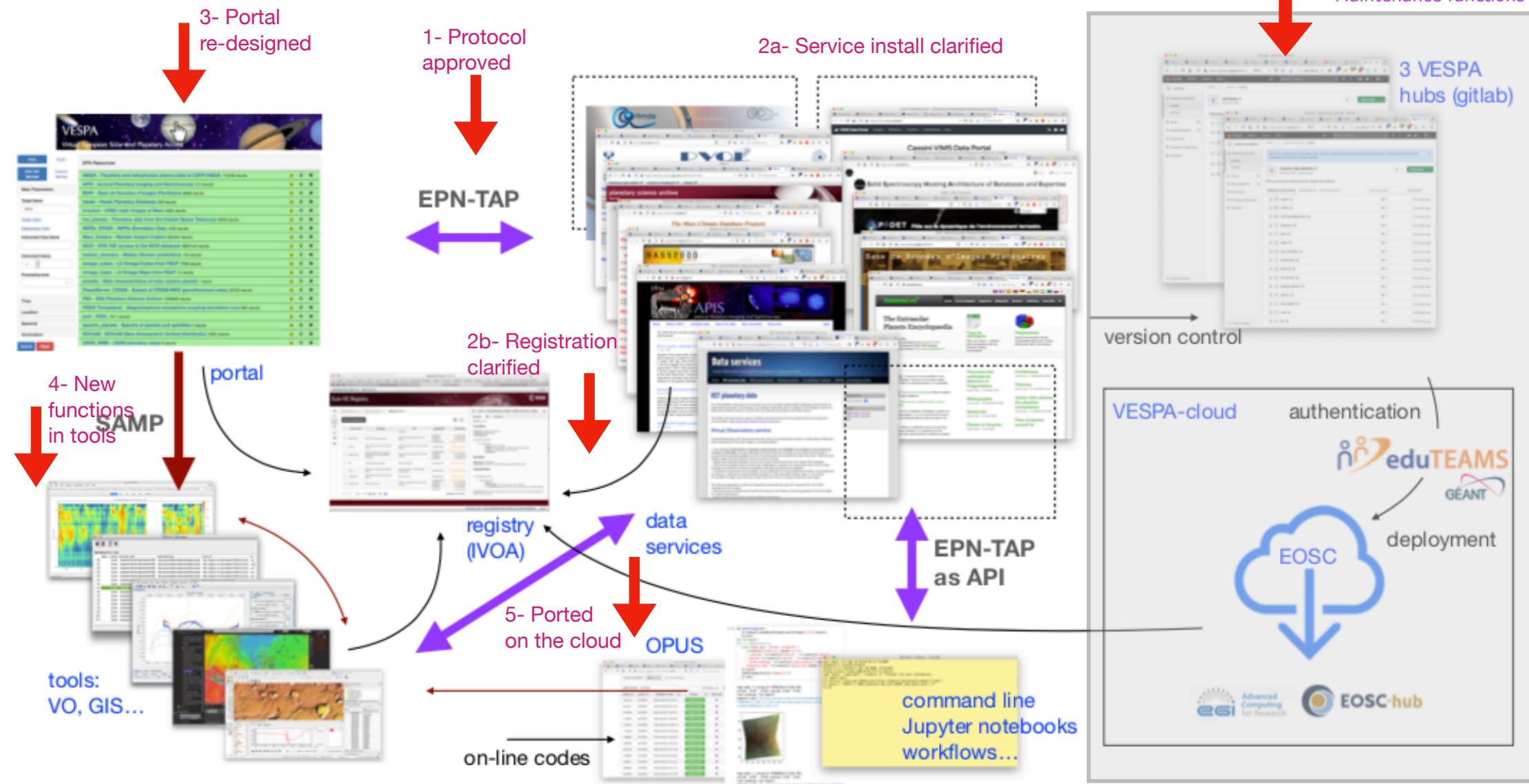
[Tools from astronomy](#) (VO, with planetary science updates) + [GIS](#) and others + Jupyter notebooks

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

This data system is available for - users *to access data*

- science teams *to distribute data*

# VESPA: infrastructure



## VESPA in RP2: consolidation and sustainability

### 1- EPN-TAP

EPN-TAP validated by IVOA, now an international standard — <https://ivoa.net/documents/EPNTAP/>  
Flexible - new extensions can be included in intermediate versions  
Service validator available (taplint in TOPCAT from v4.8.2, Bristol U)

### 2- Service installation procedures

DaCHS server (Heidelberg U) includes extensive EPN-TAP support from v2.6  
Docker version available for tests and deployment (including on cloud / EOSC, validated)  
Registration procedure clarified (in the IVOA registry)  
Service definition files stored on a common **gitlab** at Paris Obs => all services being fixed / updated  
**DMP**, DOI on datasets (assessment), licences...

### 3- Main user interface (VESPA portal)

Layout updated from User Experience analysis — open to feedback  
Supports other protocols (PDAP to ESA and JAXA, PDS keyword search)  
Facet-based search being assessed — currently as a verification tool

### 4- Tools (from the VO)

Planetary (multiresolution) maps in Aladin (was in beta only)  
Support for spectra in reflected light in CASSIS + spectral cubes in Aladin/CASSIS plugin  
PDS4 tables in TOPCAT

# VESPA practical progress, 1

## Data services:

**7 new ones, some older ones deprecated** (currently 62 published)

**Upgrade existing servers, update existing services** - using new validation tools

**Sustainability:** preservation/curation on a gitlab (VESPA-hub);

data storage on EUDAT B2SHARE for difficult cases (some TA data)

**Rework registration procedure and clean up the registry** (tests...)

**New HiPS, usable in Aladin** (currently 68, some highest resolution)

**Other EPN WP:** VAs, but also TAs and NA2

**Implementation workshop Nov 2021** - 5 services from the community, in final test

**NASA PDS PPI node** - preparing ~ 170 services!

**Upgrade of ESA PSA service** - currently 28 million files!

## VESPA portal:

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

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

**Alternative interface in "natural language"** — currently used to check service content

## VESPA practical progress, 2

### Tools:

**New functions in data infrastructures: SSHADE (bandlists), AMDA (services), PVOL**

**Tests of EOSC infra - VM, AAI, computation**

**New functions for planetary science in astro tools:**

**Aladin:** better access to planetary HiPS and TAP services from v11.122 (was only in beta version)

**CASSIS:** Aladin plugin to display spectral cubes from v6

**TOPCAT:** new graphic functions, refined support for Datalink and MOC, spectra embedded in tables

**DaCHS:** full support of EPN-TAP

**ImageJ:** updated VO / fits interface - provides image processing functions to the VO

### Dissemination:

**Engagement with IVOA (VO), IPDA (space agencies), IHDEA (heliophysics), in touch with OGC**

**Consortia meetings:** usually technical

**Science conferences:** more for users & potential data providers

**National projects:** e.g. CNES/INSU planetary data nodes in France, connecting INSU data services

**Open call and implementation workshops** restarted



Form

Query

EPN-TAP Services

Custom Service

**Main Parameters**

**Target Name**

**Target Class**

**Dataproduct Type**

**Instrument Host Name**

**Instrument Name**

**Processing level**

**Time**

**Location**

**Spectral**

**Illumination**

**EPN Resources**

- [abs\\_cs - Data for numerical modeling of planetary atmospheres](#) 13 results
- [AMDA - Planetary and heliophysics plasma data at CDPP/AMDA](#) 1217441 results
- [APIS - Auroral Planetary Imaging and Spectroscopy](#) 55371 results
- [BASECOM - The Nançay Cometary Database](#) 15611 results
- [bass2000 - Bass2000 solar survey archive](#) 313365 results
- [BDIP - Base de Données d'Images Planétaires](#) 16906 results
- [cassini\\_jupiter - Cassini RPWS/HFR Calibrated Jupiter Flyby Dataset](#) 7 results
- [CLIMSO - CLIMSO coronagraphs at pic du midi de Bigorre](#) 808951 results
- [cpstasm - CLUSTER STAFF-SA Spectral Matrix Data](#) 11688 results
- [DynAstVO - Asteroid orbital database and ephemerides](#) 20659 results
- [ExoPlanet - Extrasolar Planets](#)
- [expres - ExPRES Simulation Data](#)
- [HFC1AR - Heliophysics Features](#)
- [HFC1T3 - Heliophysics Features](#)
- [hisaki - Hisaki Planetary Database](#)
- [hrsc3nd - HRSC nadir images](#)
- [hst\\_planeto - Planetary data from Hubble](#)

**Results in service VVEx**

Show 10 entries	Column visibility	Show all	Hide all		
Select All in current page					
V0026_07G	spectral_cube	Venus	2006-05-16T17:12:20.414	2006-05-16T17:23:00.457	<a href="#">ftp://psa.esac.esa.int/.../V0026_07G.spectral_cube</a>
V0026_07C	spectral_cube	Venus	2006-05-16T17:12:20.414	2006-05-16T17:23:00.457	<a href="#">ftp://psa.esac.esa.int/.../V0026_07C.spectral_cube</a>
V0026_07B	spectral_cube	Venus	2006-05-16T17:12:20.424	2006-05-16T17:23:00.466	<a href="#">ftp://psa.esac.esa.int/.../V0026_07B.spectral_cube</a>
V0026_07C	spectral_cube	Venus	2006-05-16T17:12:20.424	2006-05-16T17:23:00.466	<a href="#">ftp://psa.esac.esa.int/.../V0026_07C.spectral_cube</a>
V0026_08C	spectral_cube	Venus	2006-05-16T17:27:48.478	2006-05-16T17:38:31.261	<a href="#">ftp://psa.esac.esa.int/.../V0026_08C.spectral_cube</a>
V0026_08G	spectral_cube	Venus	2006-05-16T17:27:48.478	2006-05-16T17:38:31.261	<a href="#">ftp://psa.esac.esa.int/.../V0026_08G.spectral_cube</a>
V0026_08B	spectral_cube	Venus	2006-05-16T17:27:48.672	2006-05-16T17:38:31.453	<a href="#">ftp://psa.esac.esa.int/.../V0026_08B.spectral_cube</a>
V0026_08C	spectral_cube	Venus	2006-05-16T17:27:48.672	2006-05-16T17:38:31.453	<a href="#">ftp://psa.esac.esa.int/.../V0026_08C.spectral_cube</a>
VT0027_00C	spectral_cube	Venus	2006-05-18T01:25:15.669	2006-05-18T02:01:54.510	<a href="#">ftp://psa.esac.esa.int/.../VT0027_00C.spectral_cube</a>
VT0027_00G	spectral_cube	Venus	2006-05-18T01:25:15.669	2006-05-18T02:01:54.510	<a href="#">ftp://psa.esac.esa.int/.../VT0027_00G.spectral_cube</a>

Showing 91 to 100 of 15,682 entries

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Earth [Footprints](#)

**VESPA portal**

<https://vespa.obspm.fr>

Paris Observatory 2016 – VESPA Tutorials  
Contact : support.vespa@obspm.fr

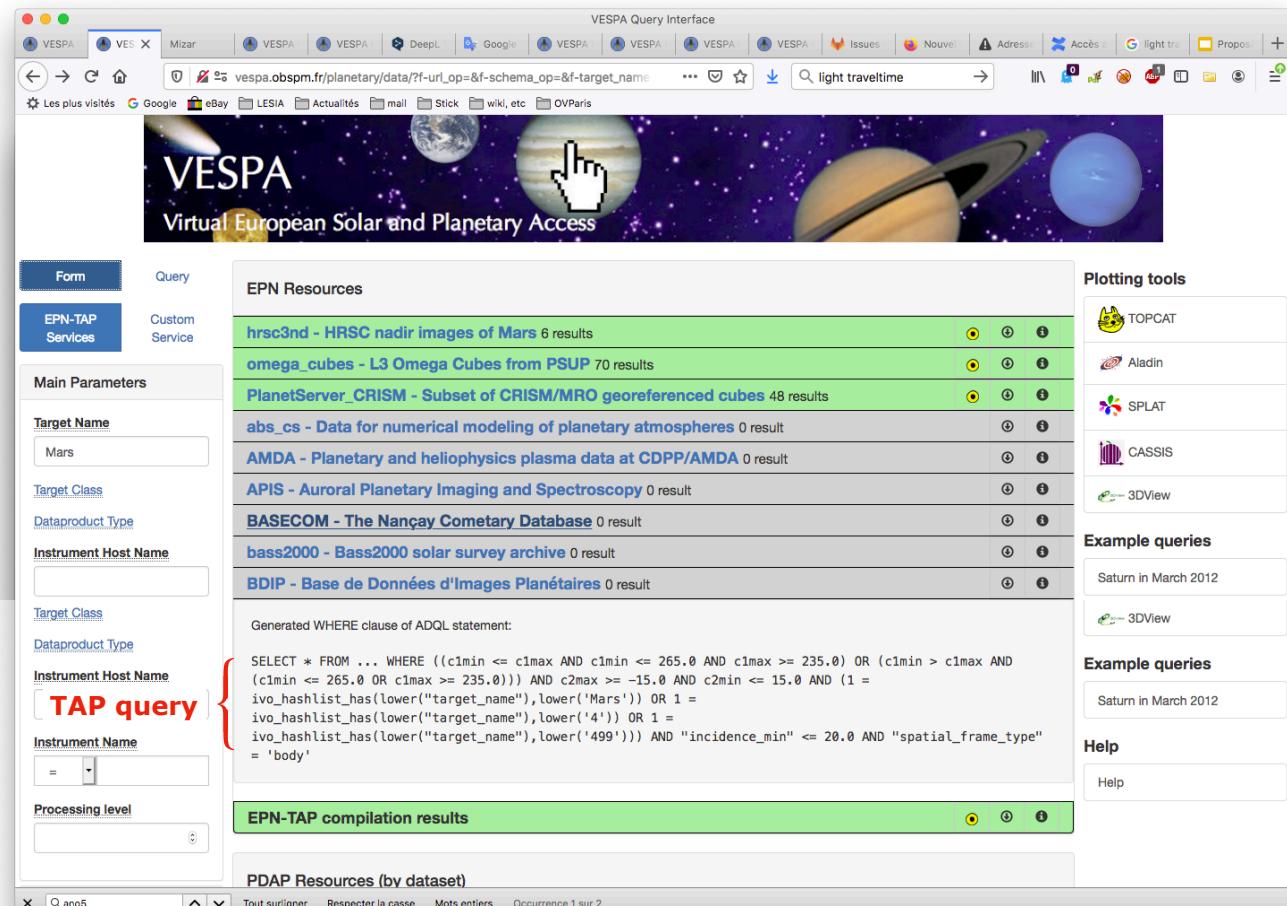
PADC France eurPLANET

## EPN-TAP request:

**Typical for surfaces** (assuming all data correctly described):  
**Mars, a given region (~ Tharsis volcanoes)** (disk images need to be informed)  
**Illumination conditions** ( $i \leq 20^\circ$  / phase: needs to be informed)  
**Local time or season, etc** (need to be informed)

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

Footprints can be sent to plotting tools from the portal



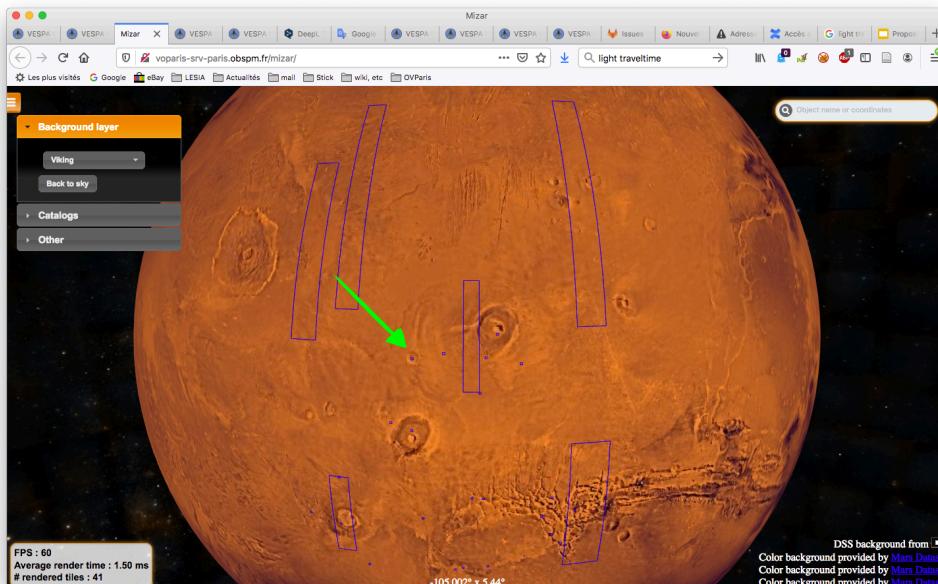
The screenshot shows the VESPA Query Interface. On the left, there's a sidebar with tabs for 'Form' (selected), 'Query', 'EPN-TAP Services', and 'Custom Service'. Under 'Main Parameters', there are fields for 'Target Name' (Mars), 'Target Class', 'Dataproduct Type', 'Instrument Host Name', and 'Instrument Name' (with a dropdown menu). A red bracket highlights the 'TAP query' field, which contains the text: 'SELECT \* FROM ... WHERE ((c1min <= c1max AND c1min <= 265.0 AND c1max >= 235.0) OR (c1min > c1max AND (c1min <= 265.0 OR c1max >= 235.0))) AND c2max >= -15.0 AND c2min <= 15.0 AND (1 = ivo\_hashlist\_has(lower("target\_name"),lower('Mars')) OR 1 = ivo\_hashlist\_has(lower("target\_name"),lower('4')) OR 1 = ivo\_hashlist\_has(lower("target\_name"),lower('499'))) AND "incidence\_min" <= 20.0 AND "spatial\_frame\_type" = 'body'

The main area displays 'EPN Resources' with several entries: 'hrsc3nd - HRSC nadir images of Mars' (6 results), 'omega\_cubes - L3 Omega Cubes from PSUP' (70 results), 'PlanetServer\_CRISM - Subset of CRISM/MRO georeferenced cubes' (48 results), 'abs\_cs - Data for numerical modeling of planetary atmospheres' (0 result), 'AMDA - Planetary and heliophysics plasma data at CDPP/AMDA' (0 result), 'APIS - Auroral Planetary Imaging and Spectroscopy' (0 result), 'BASECOM - The Nançay Cometary Database' (0 result), 'bass2000 - Bass2000 solar survey archive' (0 result), and 'BDIP - Base de Données d'Images Planétaires' (0 result).

On the right, there are sections for 'Plotting tools' (TOPCAT, Aladin, SPLAT, CASSIS, 3DView), 'Example queries' (Saturn in March 2012, 3DView), and 'Help'.

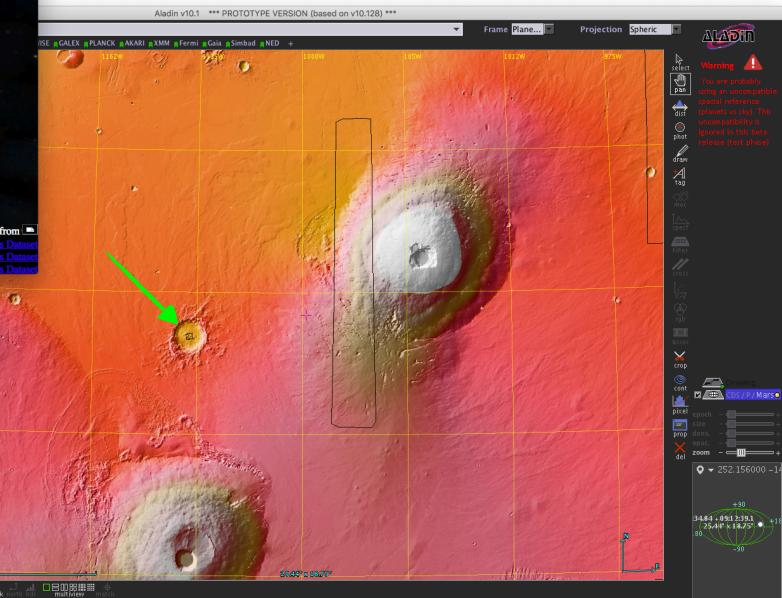
## EPN-TAP typical request on surfaces:

**Mars, a given region** ( $\sim$  Tharsis volcanoes => limits in lon/lat)  
**Illumination conditions** ( $i \leq 20^\circ$  / phase: needs to be informed)  
**Local time or season, etc** (needs to be informed)



Mars TES Tharsis	Mars model - requirements
	Omega → 13
	Saturn → 5
	Uranus → 5
	Vegemine → 2
	Asteroid belt → 1
	Pluto → 2
	Tabular data → 44
	Many → 44
	Masses → 44
	vers = 1105
	blematic → 2

HRSC & CRISM in Aladin (STC-S contours)  
- also implemented in TAPHandle with AladinLite



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

Open

Open in test / upgrade required

Drafted

Scheduled 2024 (selection)

- New or upgraded in 2022/23
- New content in 2022/23

## 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 \(DLR\)](#)
- [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 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 \(UCLA\)](#)
- - [Ilite 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 \(Windisch, Sw\)](#)

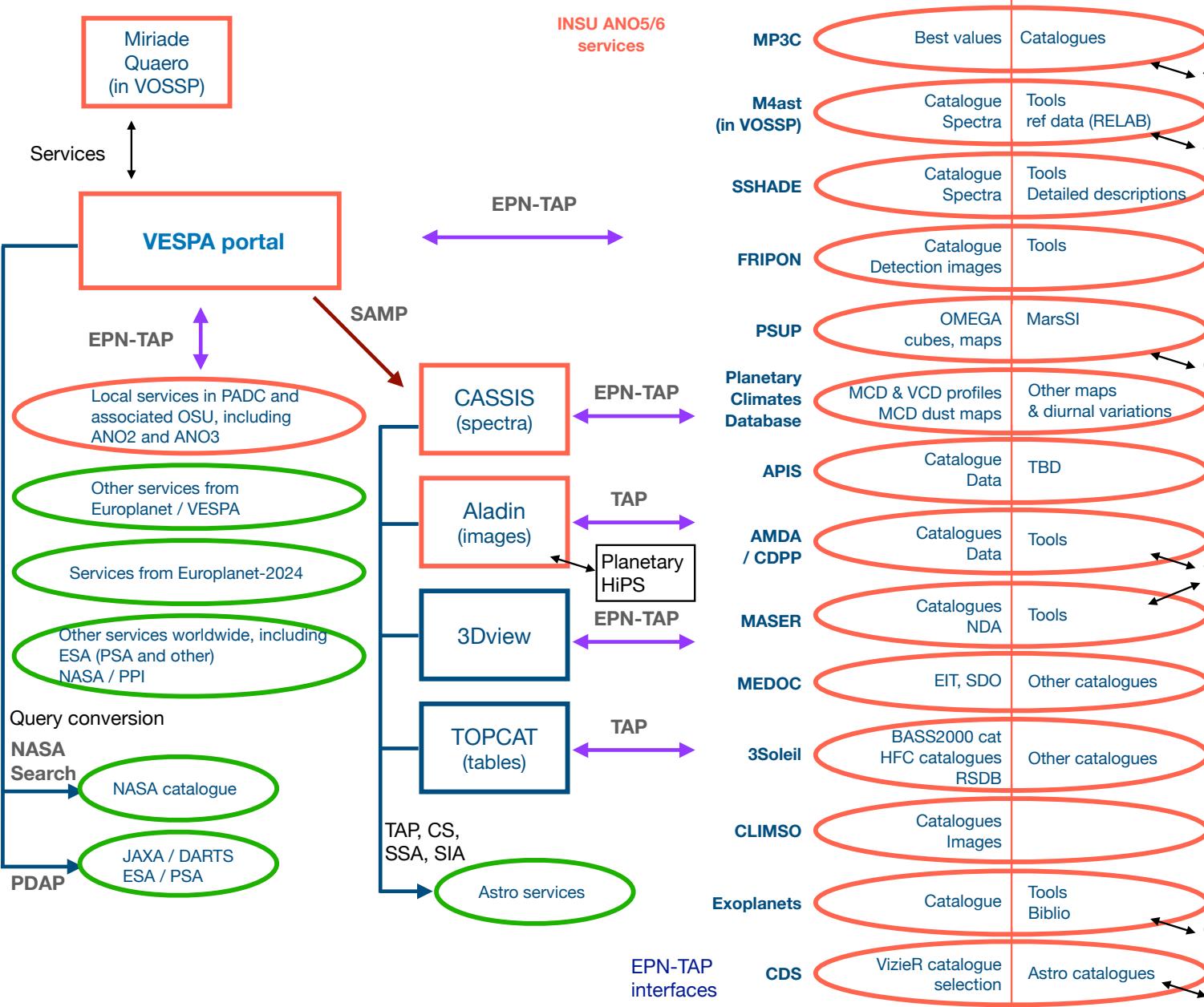
## Generic / interdisciplinary

- - [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 ?

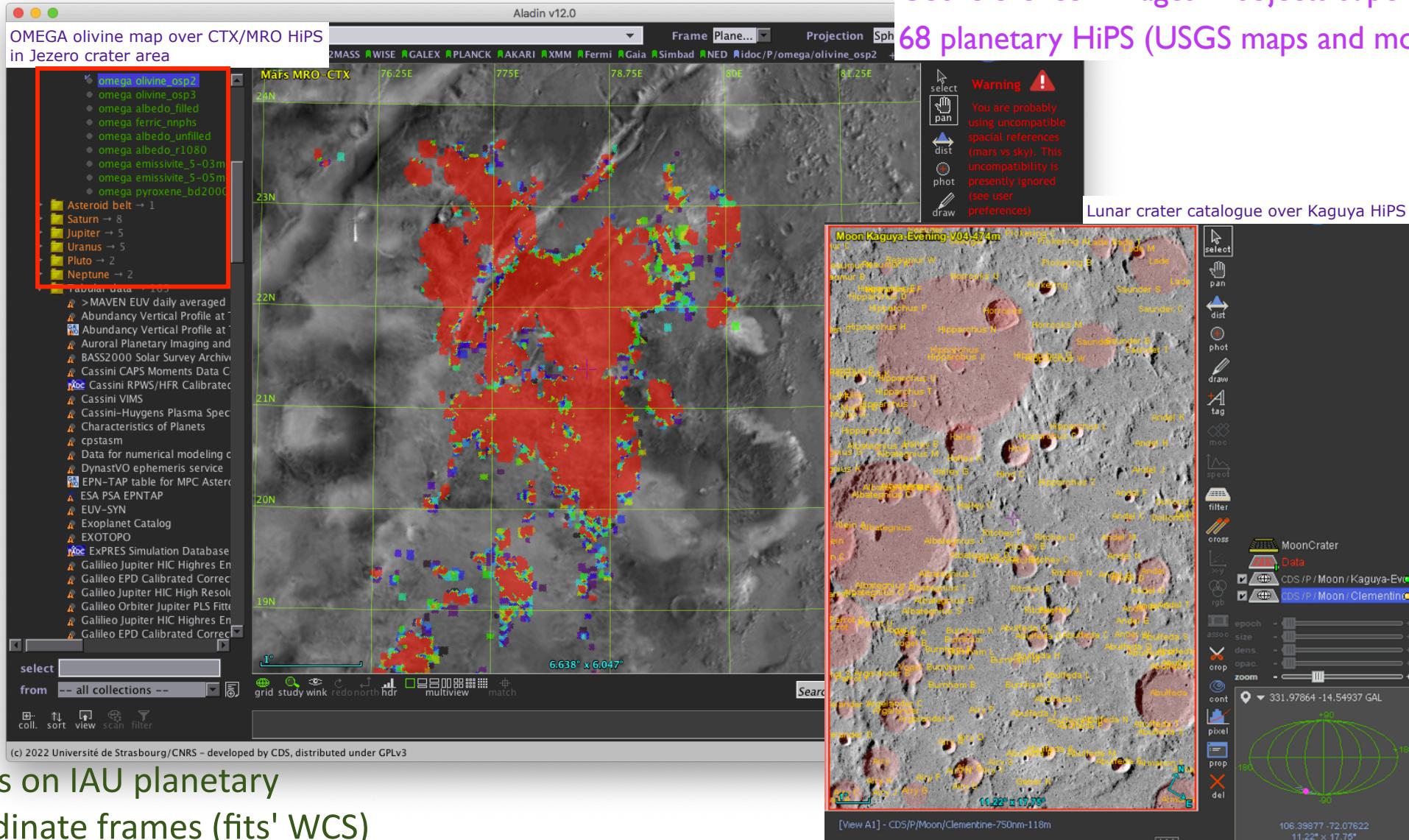
## Exoplanets

- - [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 & INSU services



## VESPA and VO tools: images/vectors



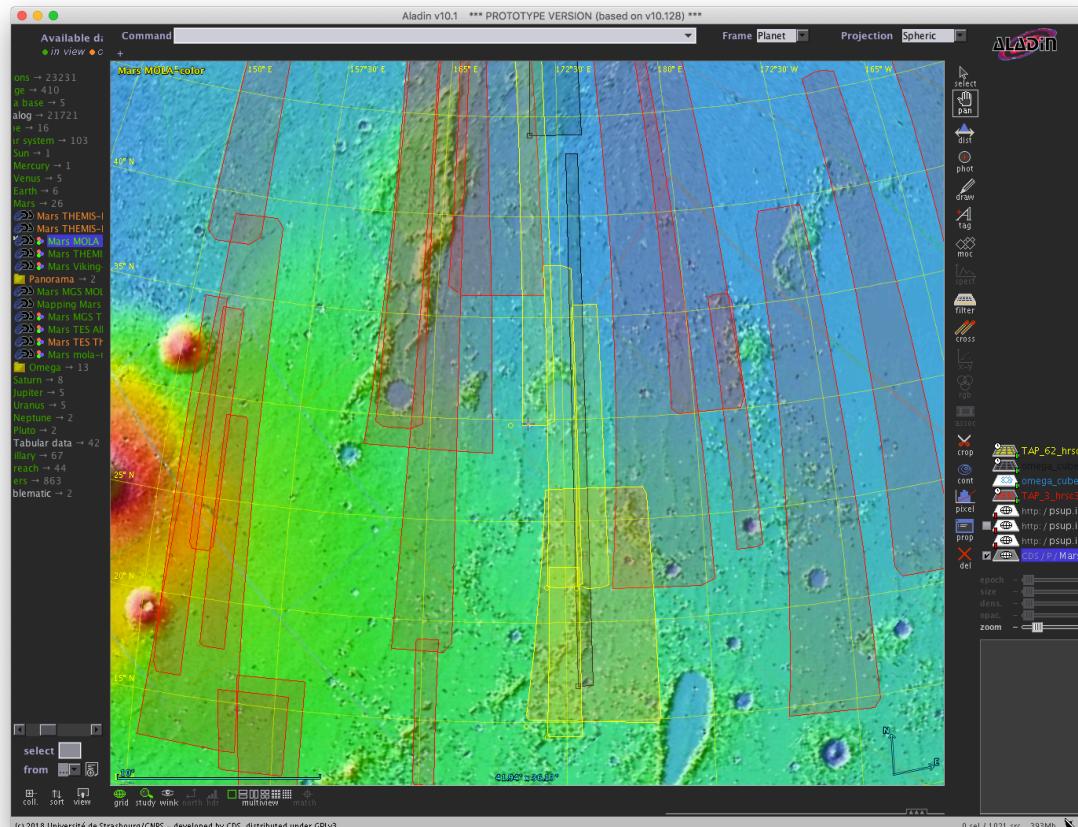
Relyes on IAU planetary  
coordinate frames (fits' WCS)

## Footprint-based searches

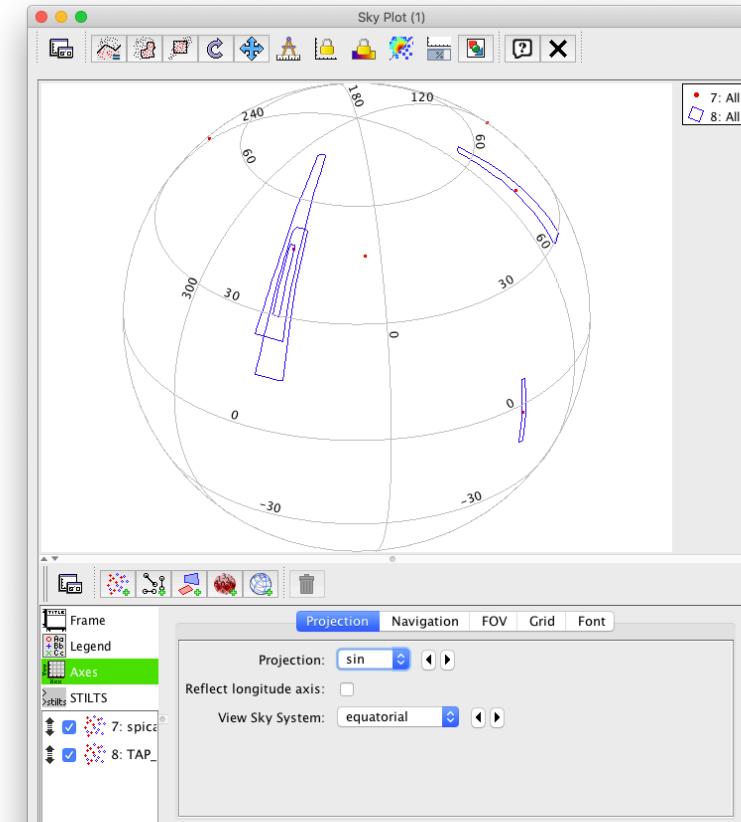
2D overlaps based on actual footprints, in TAP

**Typical request:**  
**identify overlapping images / spectral cubes from different datasets based on footprints (also works with point features)**

Tutorial: [https://github.com/epn-vespa/tutorials/blob/master/surfaces/HRSC\\_vs\\_OMEGA/HRSC\\_vs\\_OMEGA-tutorial.md](https://github.com/epn-vespa/tutorials/blob/master/surfaces/HRSC_vs_OMEGA/HRSC_vs_OMEGA-tutorial.md)



HRSC (red) and selection of OMEGA cubes (black) in Aladin  
Overlapping HRSC images in yellow (Mars-Express observations)

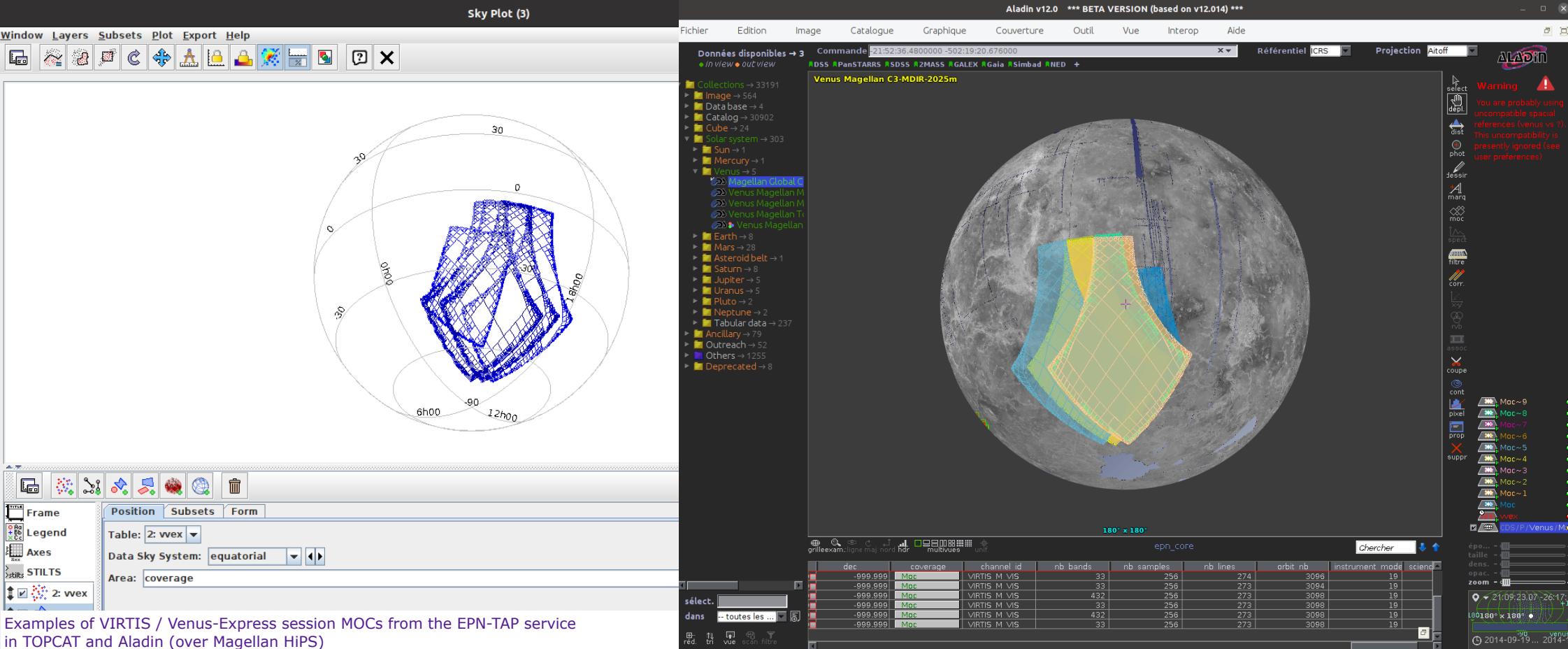


Selected SPICAM profiles (red) and overlapping HRSC images (blue) in TOPCAT (Mars-Express observations)

## Footprint-based searches

2D overlaps based on actual footprints

Now assessing MOC instead of contours: much quicker and robust  
Can be generated from contours by Aladin in real time  
Also support time coverage (and frequency to come)

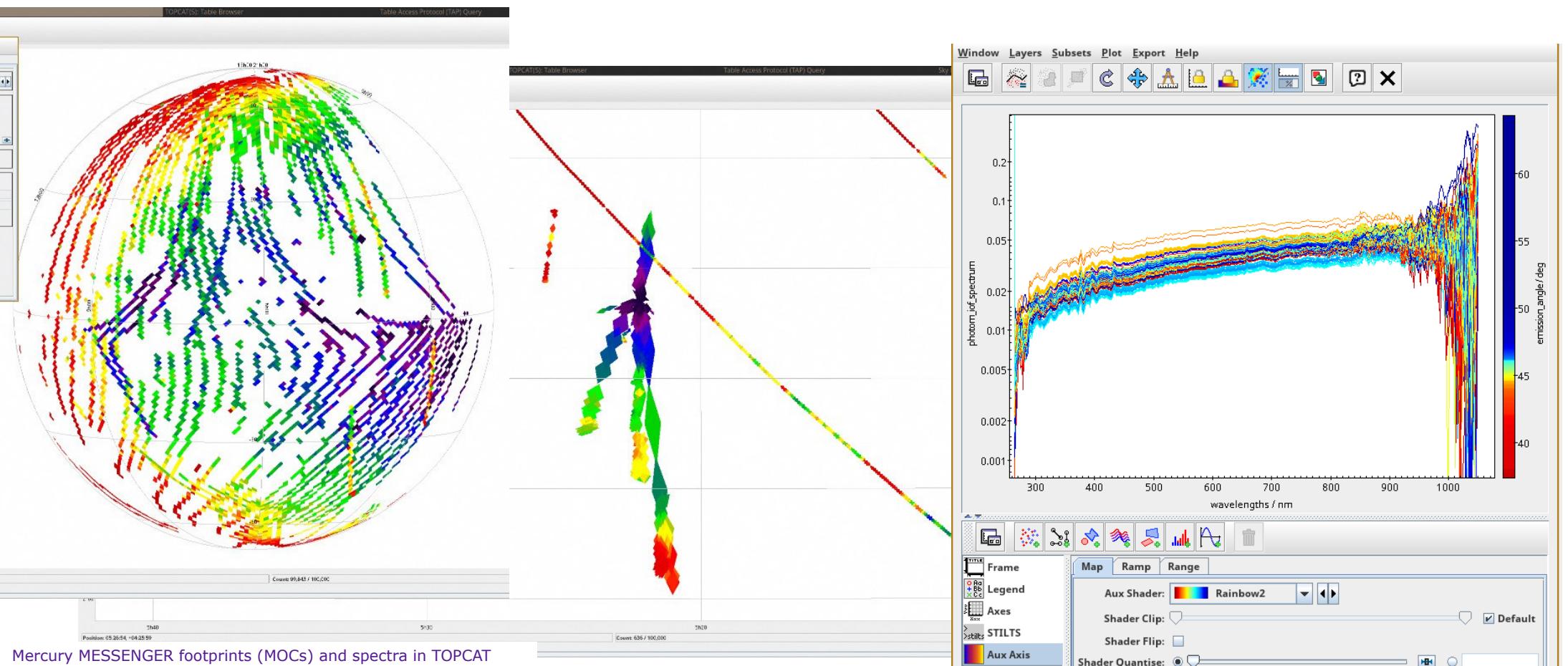


## VESPA and VO tools: spectra support

**TOPCAT** (Bristol Univ):

New graphic functions

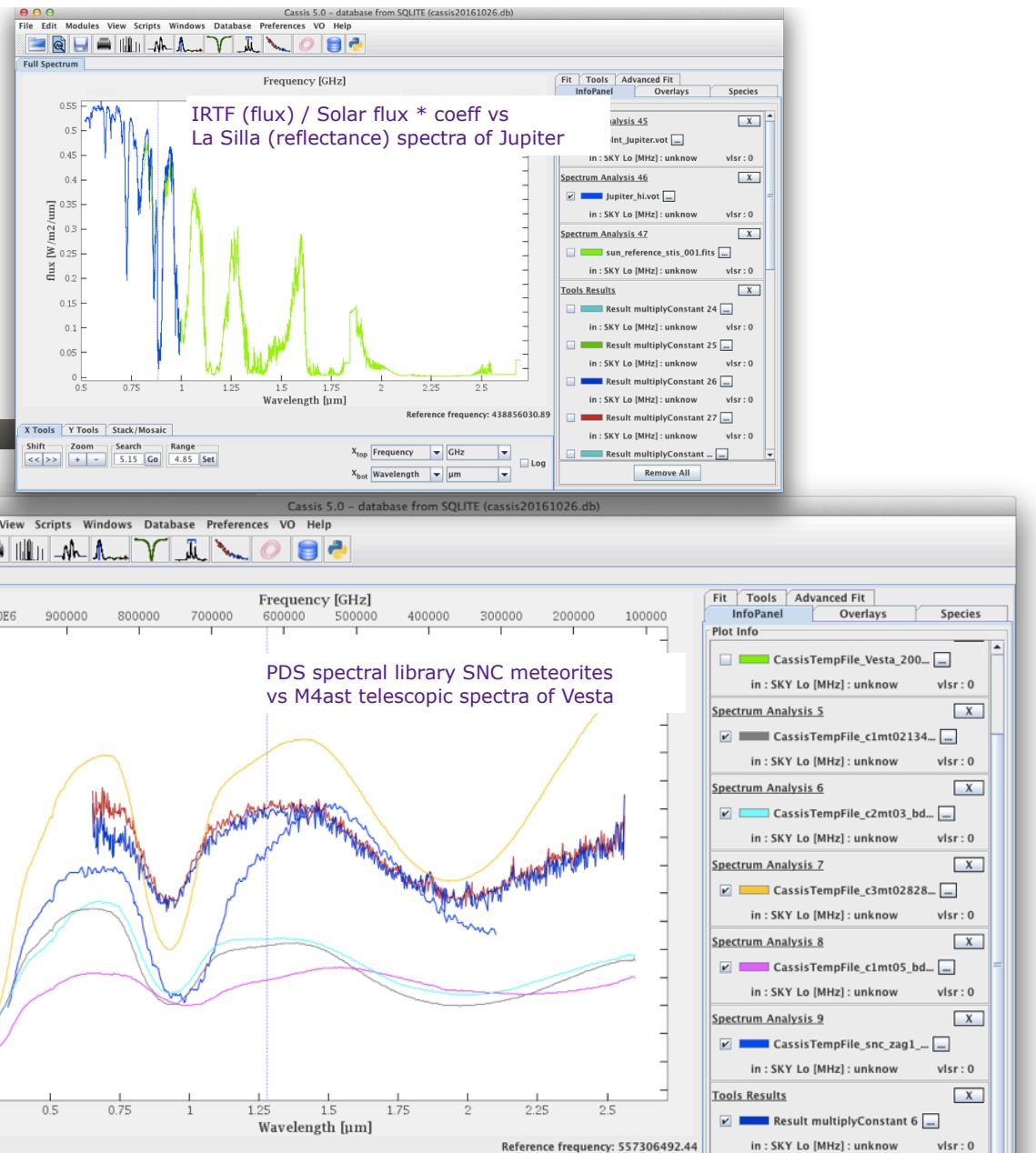
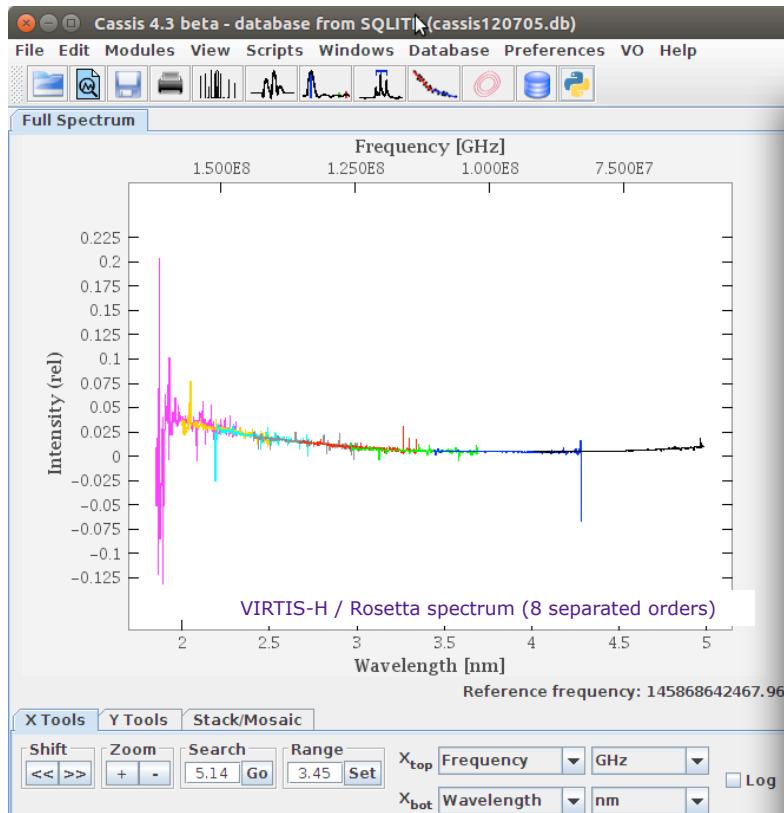
- MOC and datalink support
- Can now include spectra inside tables (powerful, but demanding)



## VESPA and VO tools: spectroscopy

### CASSIS v6 (IRAP/CNRS)

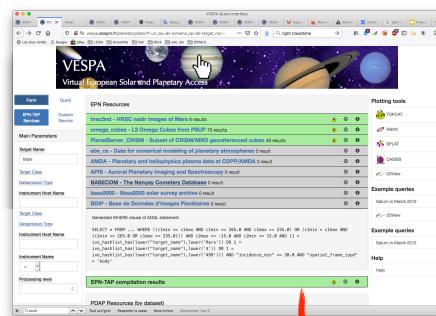
- Supports data in flux & various types of reflectance (scaling)
- Auto converts spectral axis & flux
- Supports échelle spectra



# VESPA VO-GIS bridge

service with fits images & spectra

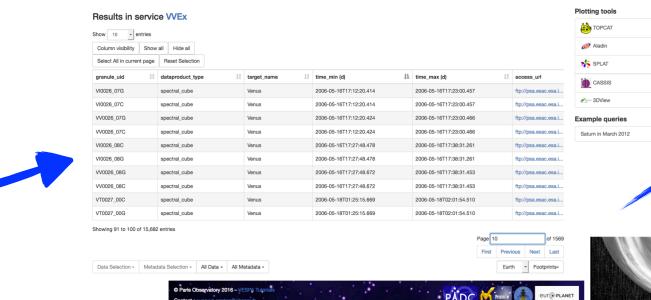
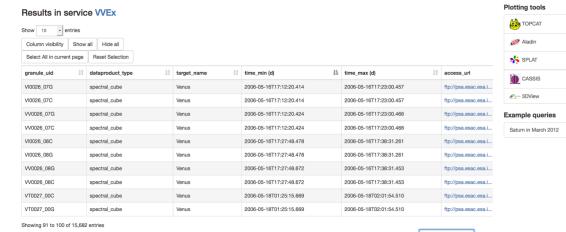
## Portal



EPN-TAP query



TAP  
servers

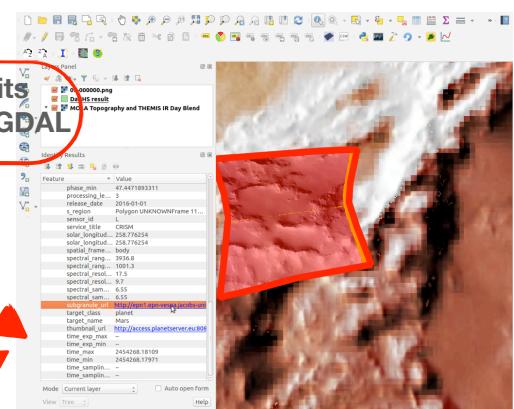


service with OGC-type products

OGC  
servers

link:  
geofits image,  
spectrum

QGIS



Geofits  
driver / GDAL  
SAMP  
interface

link:  
WMS/WCS query

Std OGC query

## VESPA VO-OGC link

### Services:

[HIPS <=> WMS converter \(CNES\)](#)

[Registry of planetary CRS \(CNES\)](#)

[Addition of planetary images in fits headers + support in GDAL \(EPN, body-fixed only\)](#)

[Addition of planetary reference frames in astropy \(EPN, body-fixed only\)](#)

### 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 \(common with CDS, based on WikiData\)](#)

# VESPA - prospects

Future:

EPN2024 ends in July 2024

VESPA (and SSHADE) in Horizon Europe proposal SpaceSci-RI (under review: astro+planeto+astrobio)

Personnel needs:

Hiring a developer required to go further and survive EPN2024 (very good candidate identified!)

=> Will also support other ANO5 services in LESIA / ObsParis

plus connection of other ANO services (including instruments in Nançay)

Involvement of extra CNAP personnel required / welcome

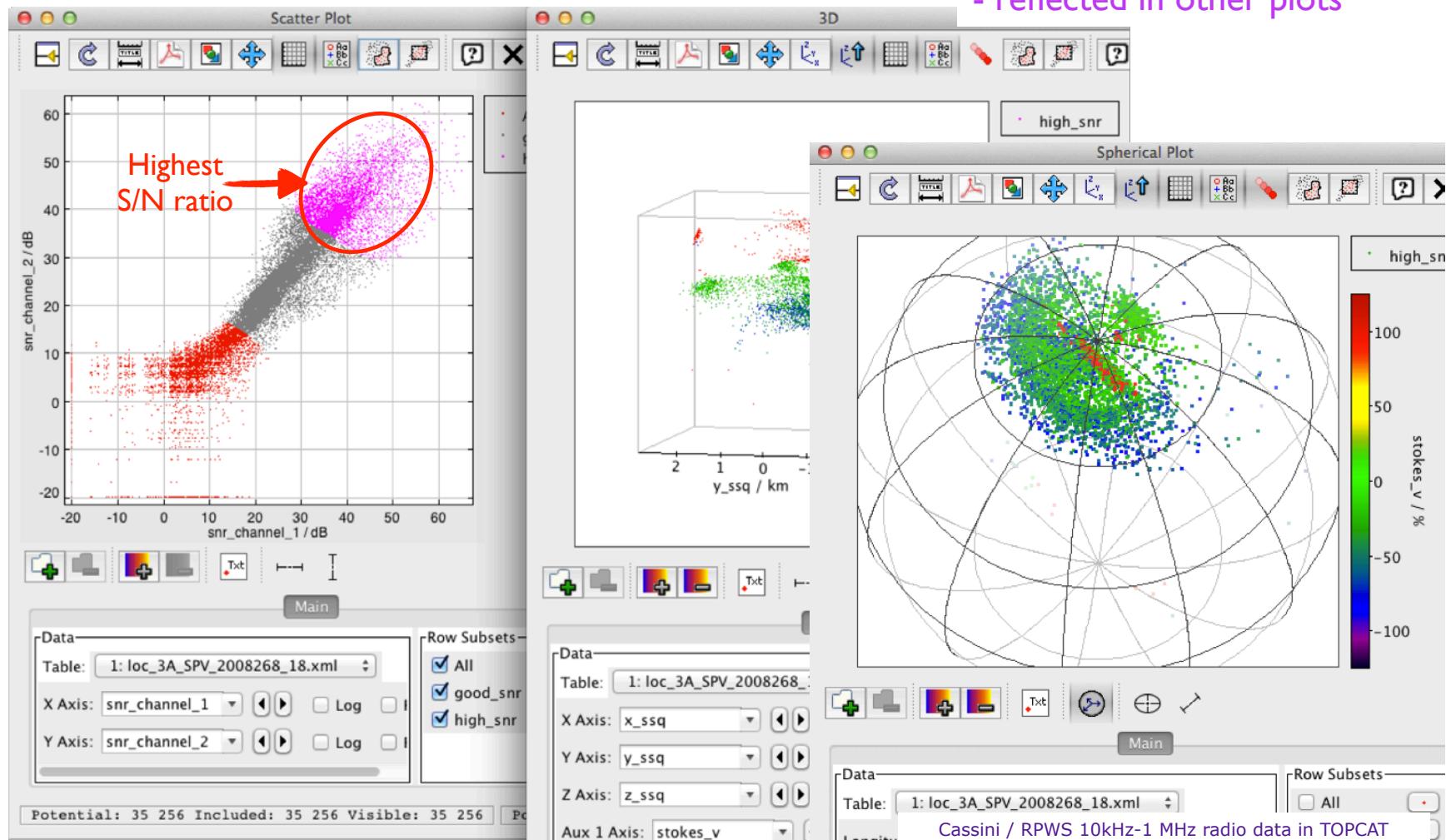
Data analysis project:

Spectral infrastructure in preparation (~ MASER for radio):

- feature extraction from observational spectra (to be published)
- comparison with extraction from experimental spectra and existing bandlists (SSHADE)
- + Spectral classification from cubes (with GEOPS, LPG?)
- + Hapke simulation / inversion workflows (with GEOPS?), etc

Backup

## VESPA and VO tools: tabular data

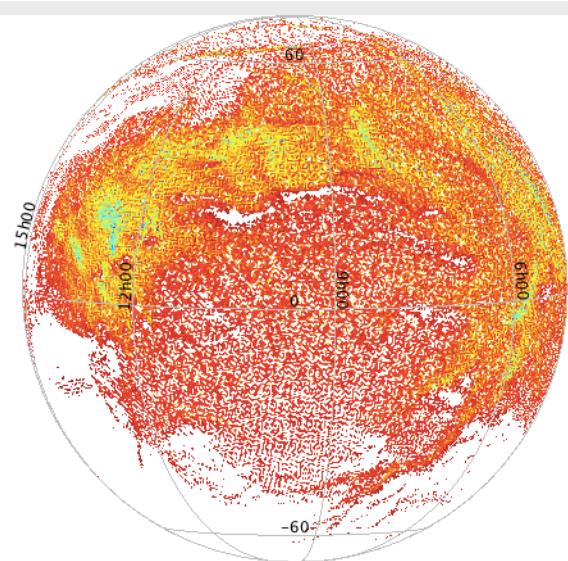


## TOPCAT (Bristol Univ):

Allows data selection

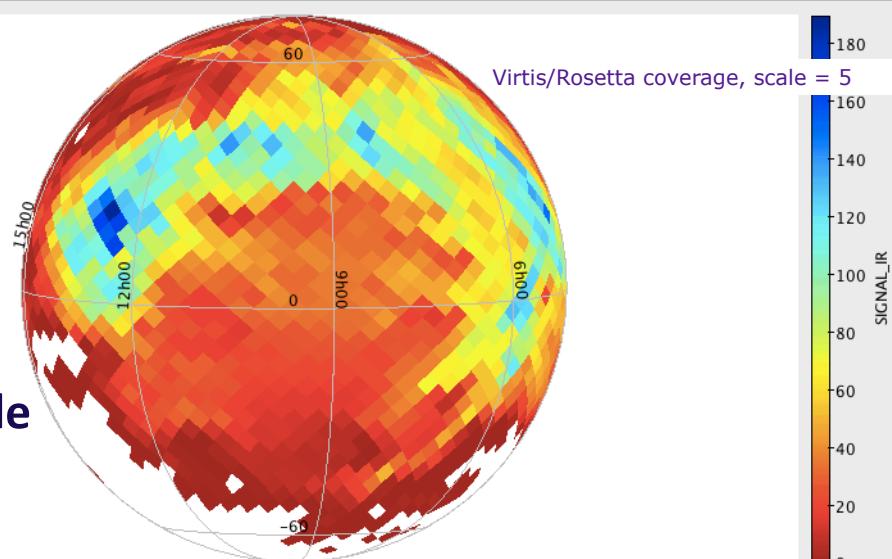
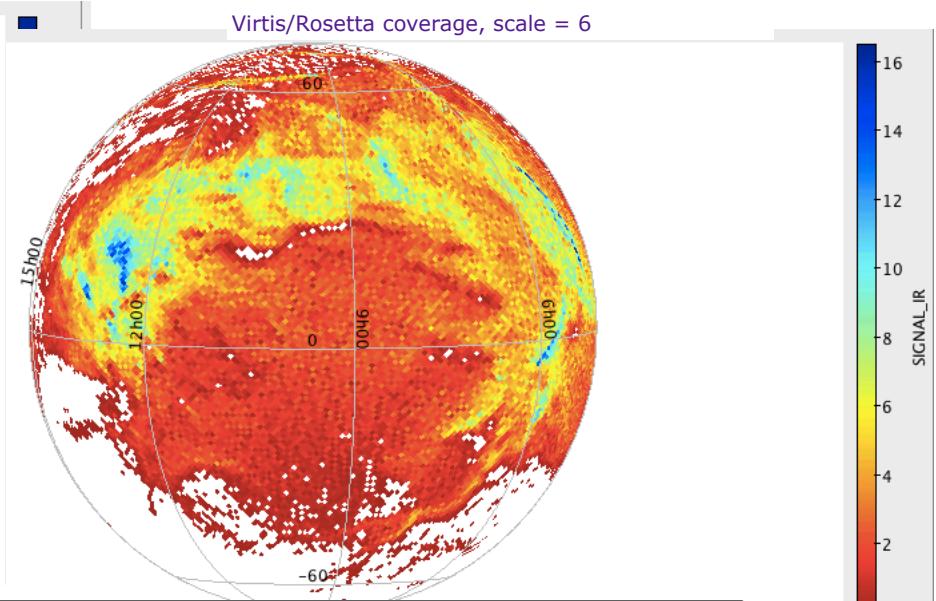
- by formula or graphically
- reflected in other plots

## VESPA and VO tools



Virtis/Rosetta coverage of 67P for a selected mission phase, scale = 7

## Multiresolution maps in TOPCAT (Bristol Univ)



**Start from a table of sparse observations (lon/lat)**

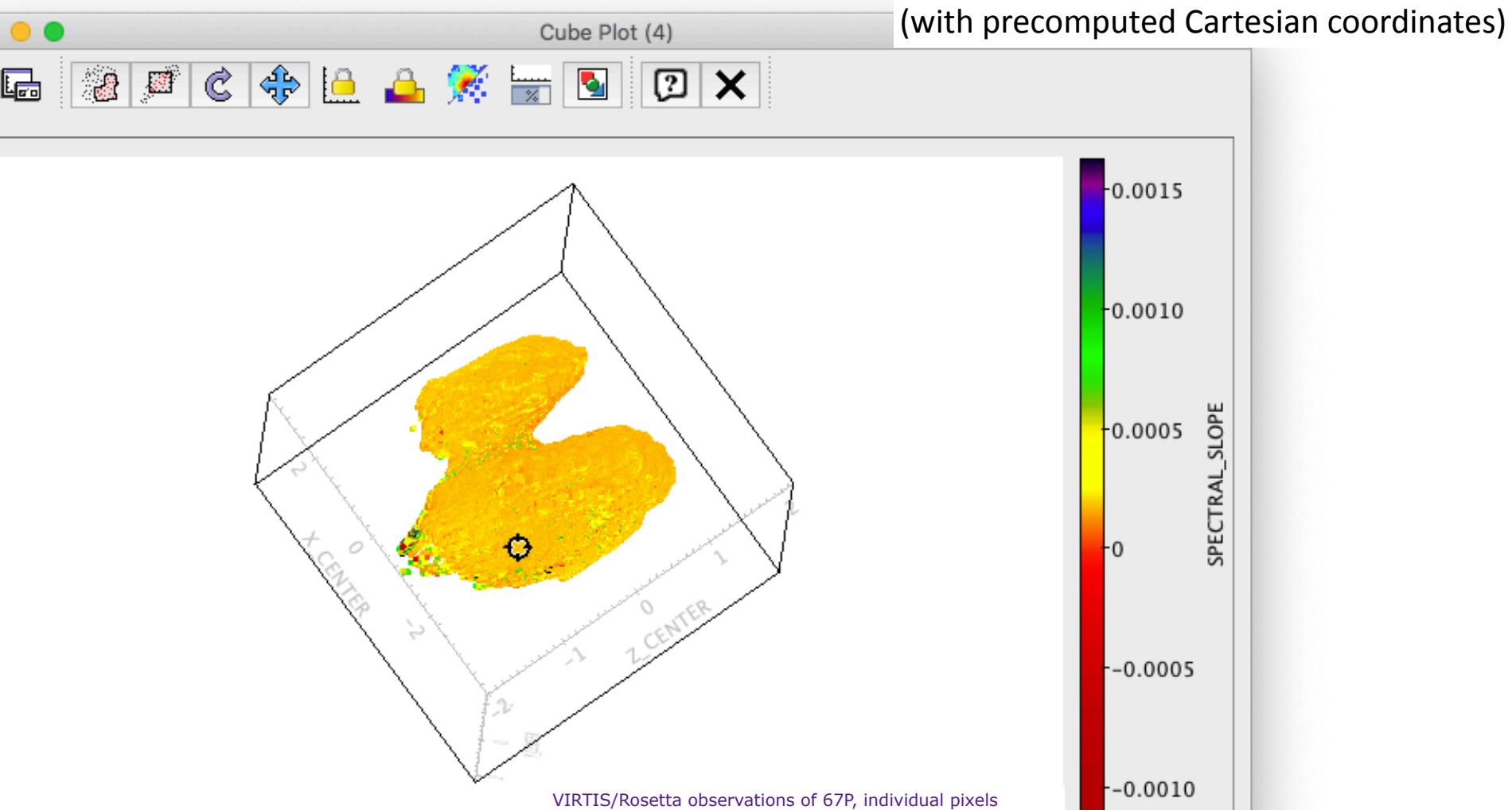
VIRTIS/Rosetta on 67P

**Integrate / average on healpix cells** (including overlaps)

**Modify resolution / scale on the fly**

## VESPA and VO tools

## Support for shape models in TOPCAT

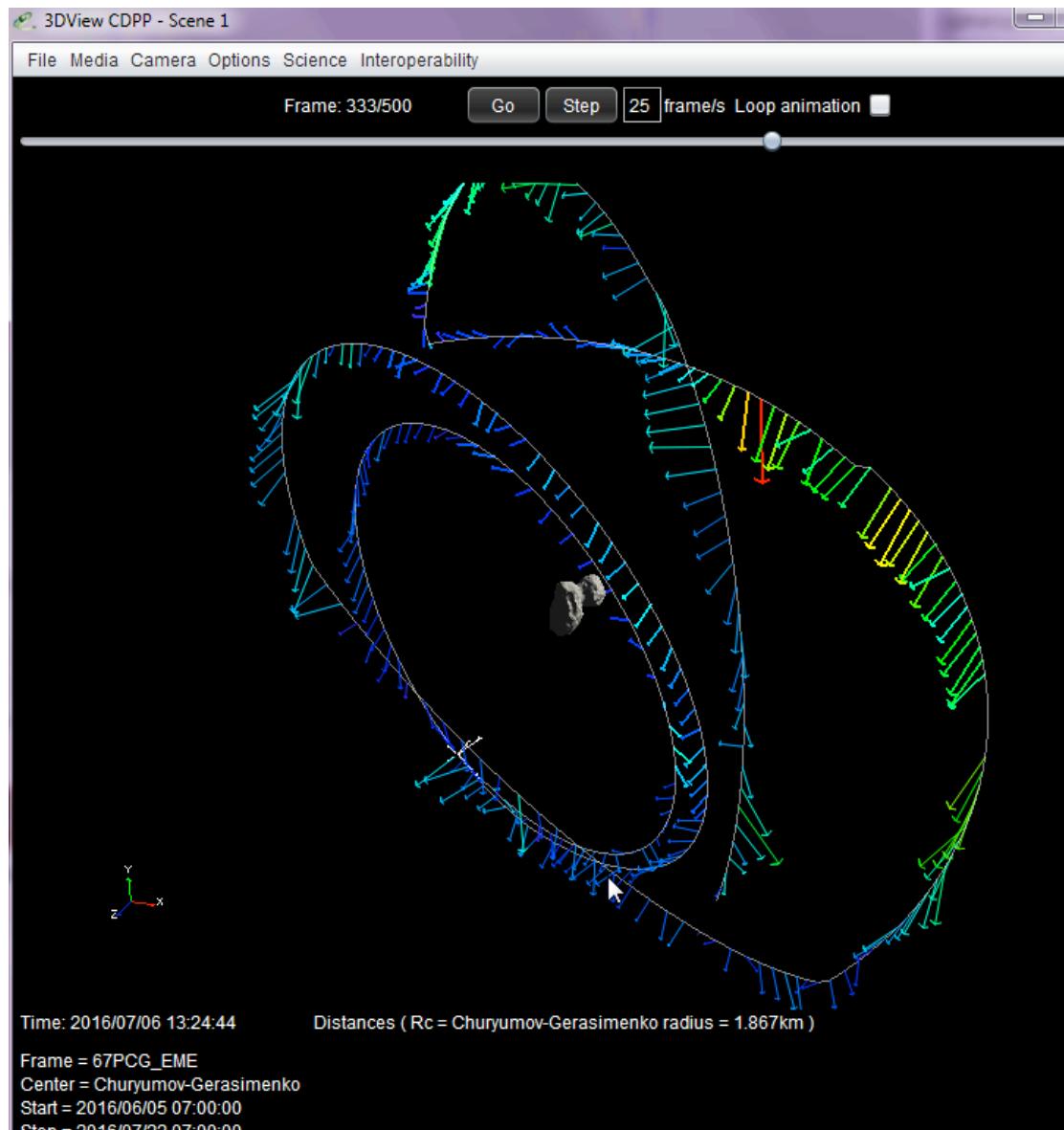


## VESPA and VO tools: space borne data

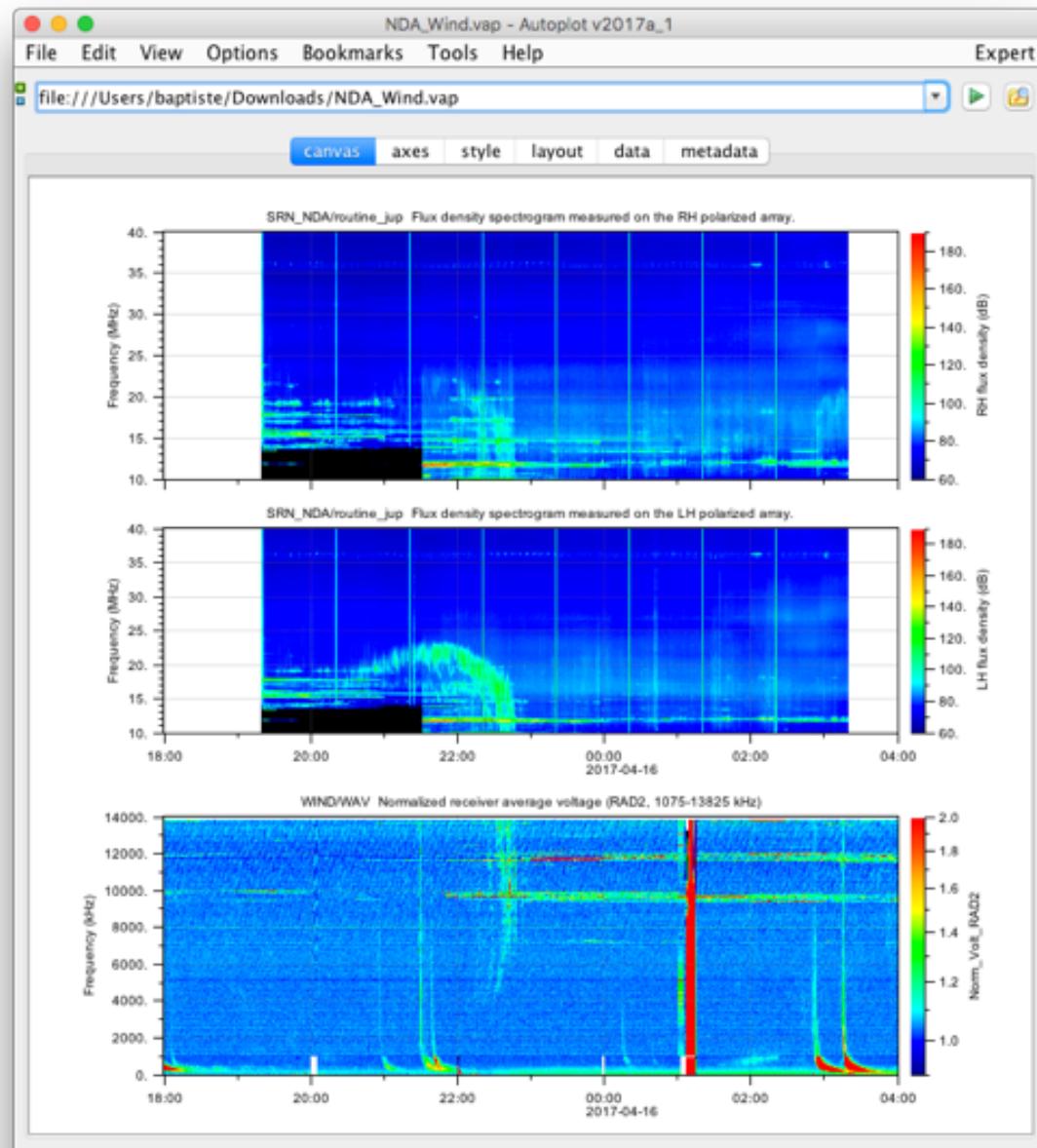
### 3Dview (CNES/IRAP):

- Spice kernels from all space missions
- image projection capacities
- Better Spice support from collaboration with ESA

(using M. Costa's metakernels)



## VESPA and VO tools: time series

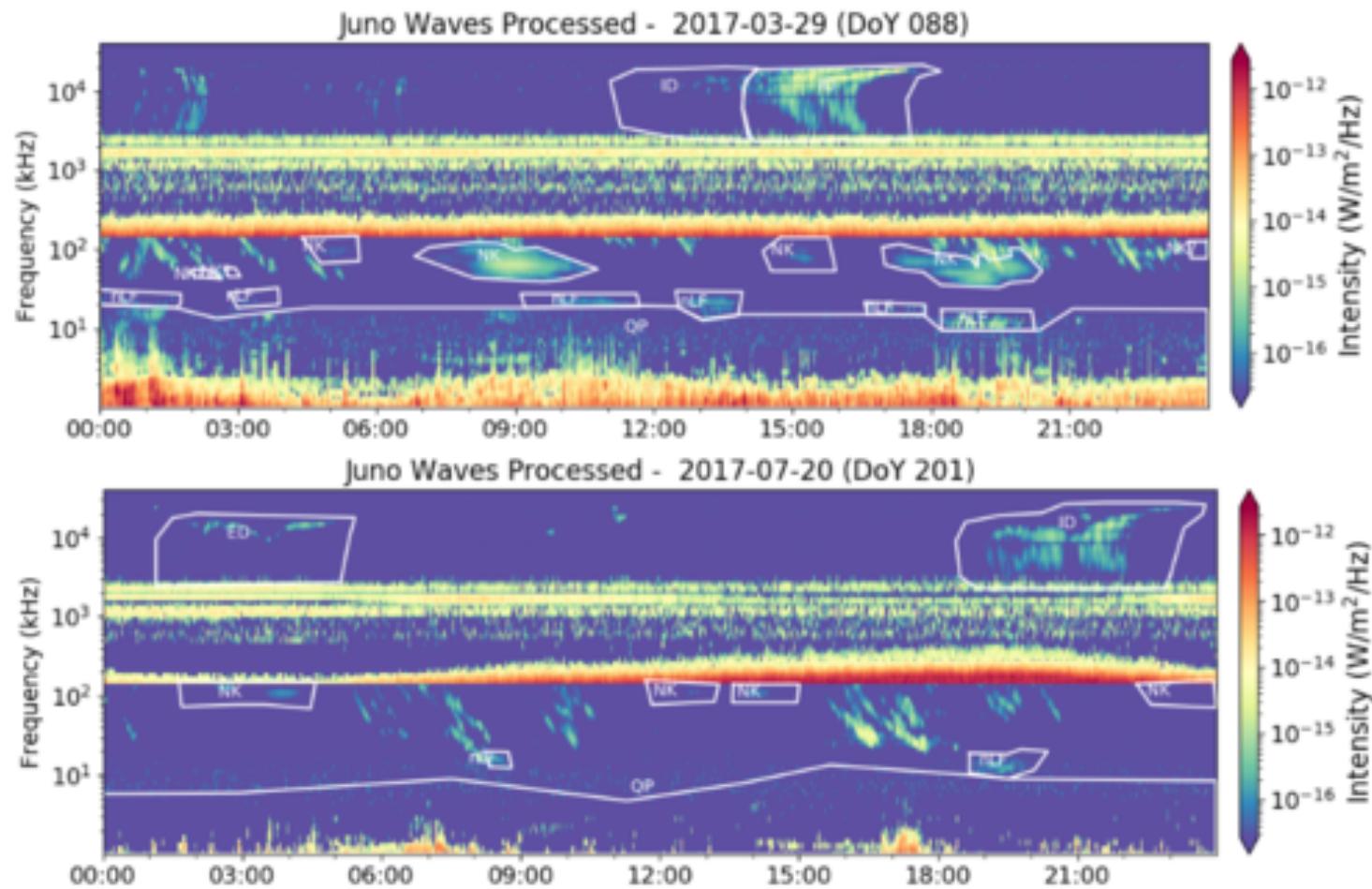


**Autoplot (Iowa Univ):**  
time series / dynamic spectra  
Support for das2 protocol  
with adaptive resolution  
SAMP connection added

Nançay Decameter Array

Wind/Waves

## Locating features in dynamical spectra: TFCat



Jupiter radio emissions identified in Juno/Waves data  
(dynamical spectra), in Autoplot