

# VESPA

(Virtual European Solar & Planetary Access)

## involvement with planetary surfaces

---

Stéphane Erard  
Chiara Marmo  
Angelo Pio Rossi  
Mikhail Minin  
Pierre Fernique  
Batiste Rousseau  
Baptiste Cecconi  
Pierre Le Sidaner



Journées ASOV  
Paris, IAP, 10/3/2020

[stephane.erard@obspm.fr](mailto:stephane.erard@obspm.fr)

## VESPA: Status

- **VESPA : an action in Europlanet 2020-RI (2015-2020)**  
**Research Infrastructure programme**  
big effort integrated at EU level, with many external collaborations  
(ESA, NASA, JAXA, IPDA, IVOA, IAU)
- **Europlanet 2020 ended Aug 2019**
- **Follow-on in Europlanet 2024, started Feb 2020 (4 years)**  
Coupled with other actions, in particular planetary cartography WP
- **VESPA portal in French context: certified INSU service, ANO5**  
**VESPA portal**     <http://vespa.obspm.fr>

## VESPA: What has been provided to the community?

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

**VESPA portal** <http://vespa.obspm.fr>

2- A set of data services provided by VESPA participants and other teams:

**55 data services open, 15 more in development**

**Includes ESA's PSA (10 million files!)**

**New or updated infrastructures: SSHADE, PVOL, AMDA**

3- Connection with powerful display and analysis tools:

**Tools from astronomy (VO, with planetary science updates)**

**+ Earth observation (GIS) + space archives (PDS)**

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

**This data system is available for science teams to access and *to distribute* data, as per the Virtual Observatory paradigm**

## VESPA: objectives

### Make research data easily accessible:

- **search Planetary Science databases based on physical / observational parameters (making sense for researchers)**

New DM : EPNCore, used with TAP protocol

- **search many databases at once**

All services queried together in default mode => data discovery

- **straightforward interface to access VO tools for Planetary Science**

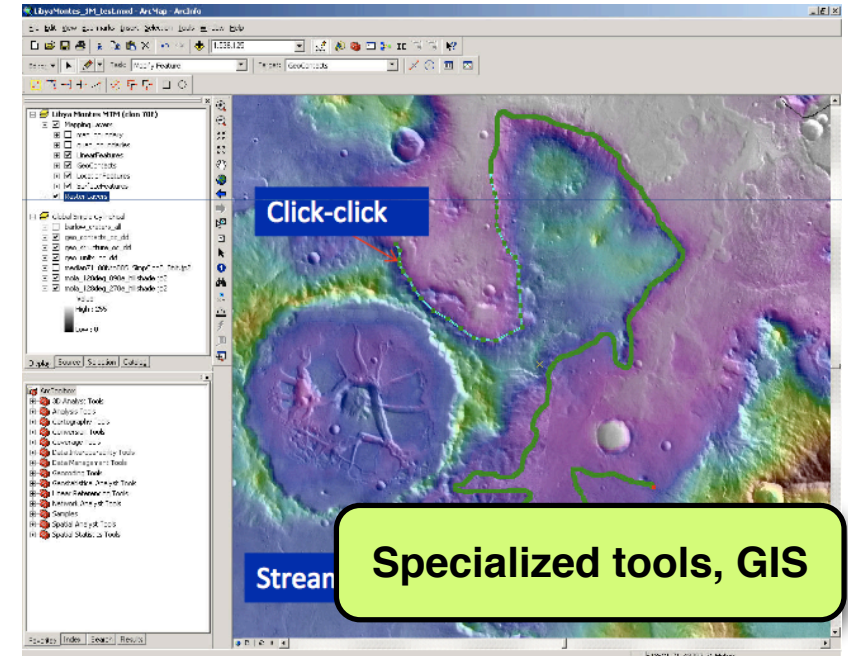
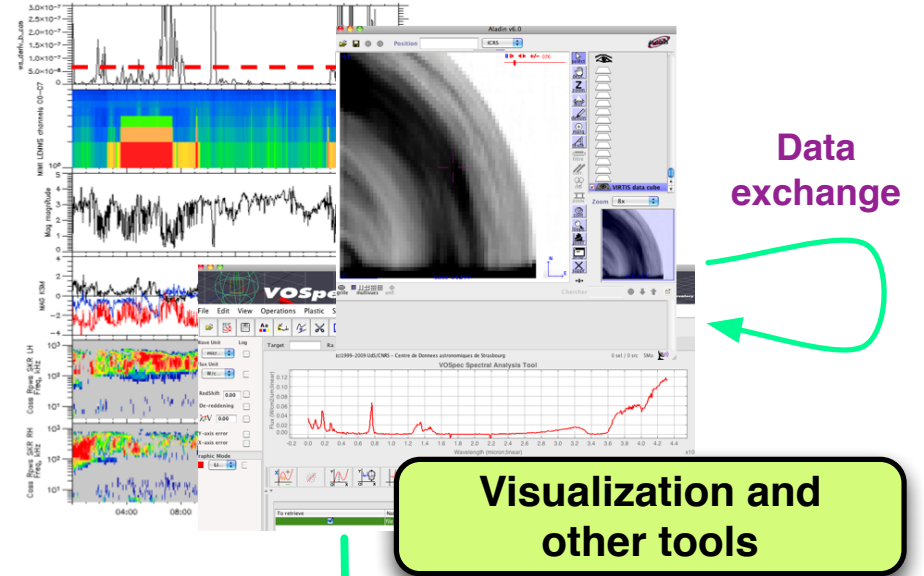
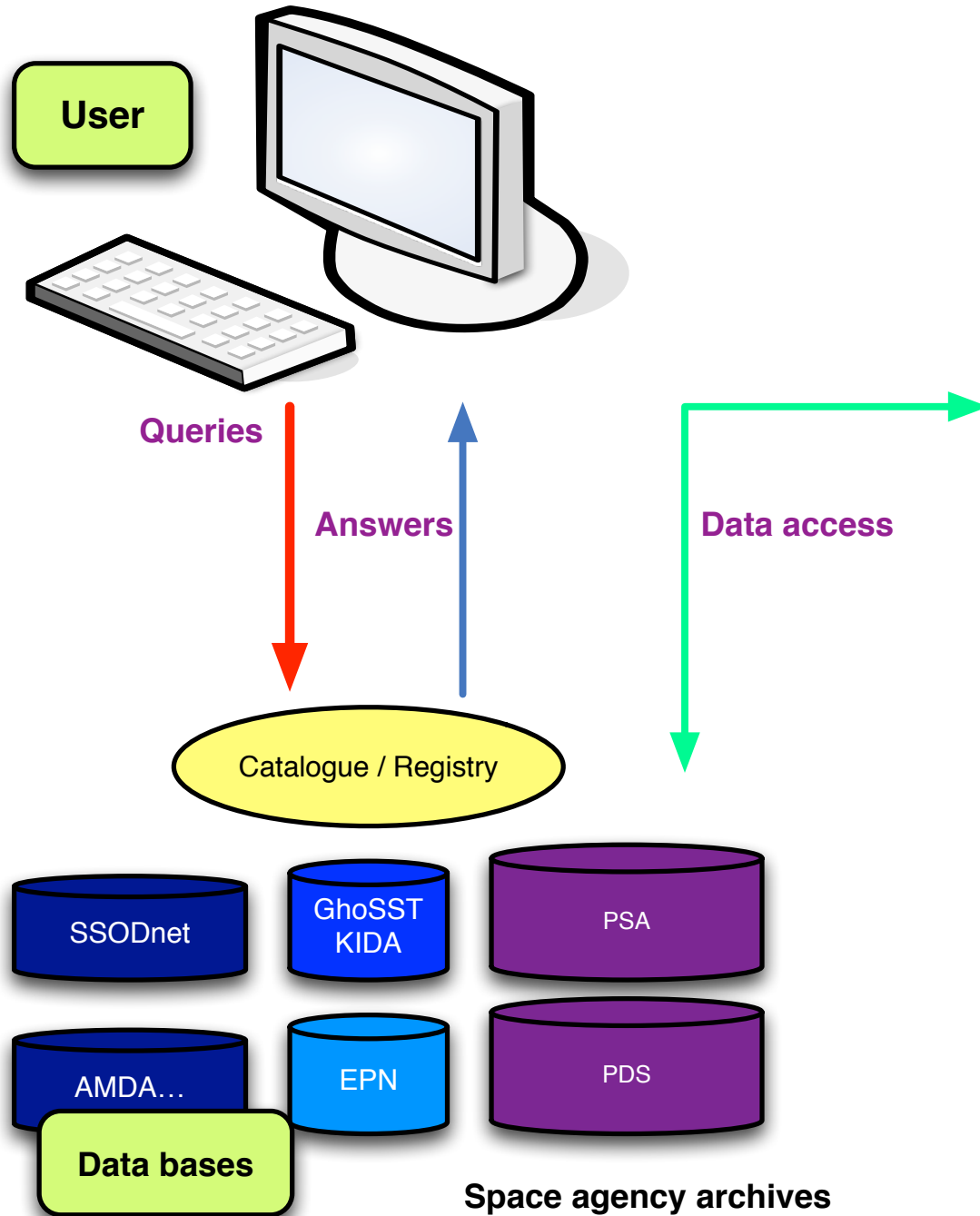
SAMP on portal & new tools; OK as long as format permits

- **contributive system open to additions**

Stress on derived data, related to publications

=> publication of EPN-TAP standard and docs, tutorials

# User's experience



## VESPA: scope

VESPA encompasses many aspects of Solar System studies:

- surfaces
- atmospheres
- magnetospheres / radio observations
- small bodies / satellites / rings / dynamics
- solar physics / planetary plasmas
- exoplanets
- solid spectroscopy / experimental reference data

- **Today: discussion restrained to surfaces only**

VO context is handled in IVOA (IG for Solar System, 2017+),  
& IPDA for space data

Main contributors in IVOA include VESPA / Europlanet

## Contexte de la discussion

- Actions CNES sur surfaces / petits corps / atmosphères / accès OV en soutien à la communauté

- Today: discussion restrained to surfaces only

=> commencé comme une confrontation entre solutions OV et GIS

- *pas pertinent, ce sont des solutions complémentaires*

- Rapport INSU 2019:

... jusqu'à l'arrivée de JUICE dans le système jovien (2030). La poursuite du développement de l'observatoire virtuel de planétologie VESPA est nécessaire.

[A propos de JUNO] Un soutien au SNO5 « VESPA » et à la proposition de labellisation du SNO5 « MASER » est souhaité.

- Rapport PNP 2018:

[A propos des surfaces planétaires] La prochaine décennie verra un plus faible nombre de missions spatiales européennes être lancées ou en opération que durant les deux dernières décennies. Il en résultera une *baisse significative du volume de nouvelles données qui devra être compensé par un investissement plus fort dans les demandes d'observation sol et dans les outils d'Observatoire Virtuel* pour augmenter le retour scientifiques des missions précédentes.

## Planetary surfaces

- **Encompass all solid surfaces (planets, satellites, asteroids, comets) as long as they are resolved**
- **This community is (roughly) split in two parts for historical reasons:**
  - physicists / astronomers - including spectroscopy (& space operations?)
  - geologists / geomorphologists - plus possibly geochemistry, etc
- **These 2 communities use different tools / formats & have different needs**

More astro than geol in France? - No reason to favor one against the other

Conversely, need to make all results accessible to all researchers
- **In addition, space data are available in a different, funny format — PDS**

+ in situ (landers /rover) data to be handled



## Planetary surfaces - needs

### • physicists / astronomers

#### Needs:

- powerful search functions in datasets (to find obs configs of interest)
- including own dataset (to manage an experiment in operation)
- quick visu in context (on maps / images)
- other dim are important: time, spectral (incl. lab data), alti (surf-atm interactions)

#### Formats:

- PDS (mostly PDS3) for space data; fits for ground-based/orbital ones; others
- VO context is recent: fits, VOTable, HiPS, MOC, STC-S, VOevents... + TAP, CS, SIA... queries

### • geologists / geomorphologists

#### Needs:

- powerful and accurate 2D visu, mapping, many layers (including vectors)

#### Formats:

- GDAL lib available. geotiff, geojson, WMS / WCS / WMTS queries (OGC world)

## Planetary surfaces - needs

### • physicists / astronomers

#### **Objectives:**

- Adapt existing VO standards and tools for Planetary Science (2D and spectral)
- support funny formats (PDS, possibly netcdf...)

#### **Difficulties:**

- Coordinate systems (here limited body-fixed ones => IAU, but not only)
- New data descriptors, often with no counterpart in astro (reflected light, illumination angles, local time, light travel time...) => UCDs

### • geologists / geomorphologists

#### **Objectives:**

- Take advantage of (huge) dev for Earth observation, adapt to Planetary Science

#### **Difficulties:**

- Coordinate systems (body-fixed ones)
- Tiling schemes adapted to planets?



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 CDP/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

Results in service VEx

Show 10 entries

Column visibility Show all Hide all

Select All in current page Reset Selection

id	dataprodct_type	target_name	time_min (d)	time_max (d)	access_url
VI0026_07G	spectral_cube	Venus	2006-05-16T17:12:20.414	2006-05-16T17:23:00.457	ftp://psa.esac.esa.i...
VI0026_07C	spectral_cube	Venus	2006-05-16T17:12:20.414	2006-05-16T17:23:00.457	ftp://psa.esac.esa.i...
VV0026_07G	spectral_cube	Venus	2006-05-16T17:12:20.424	2006-05-16T17:23:00.466	ftp://psa.esac.esa.i...
VV0026_07C	spectral_cube	Venus	2006-05-16T17:12:20.424	2006-05-16T17:23:00.466	ftp://psa.esac.esa.i...
VI0026_08C	spectral_cube	Venus	2006-05-16T17:27:48.478	2006-05-16T17:38:31.261	ftp://psa.esac.esa.i...
VI0026_08G	spectral_cube	Venus	2006-05-16T17:27:48.478	2006-05-16T17:38:31.261	ftp://psa.esac.esa.i...
VV0026_08G	spectral_cube	Venus	2006-05-16T17:27:48.672	2006-05-16T17:38:31.453	ftp://psa.esac.esa.i...
VV0026_08C	spectral_cube	Venus	2006-05-16T17:27:48.672	2006-05-16T17:38:31.453	ftp://psa.esac.esa.i...
VT0027_00C	spectral_cube	Venus	2006-05-18T01:25:15.669	2006-05-18T02:01:54.510	ftp://psa.esac.esa.i...
VT0027_00G	spectral_cube	Venus	2006-05-18T01:25:15.669	2006-05-18T02:01:54.510	ftp://psa.esac.esa.i...

Showing 91 to 100 of 15,682 entries

Data Selection - Metadata Selection - All Data - All Metadata -

Plotting tools

- TOPCAT
- Aladin
- SPLAT
- CASSIS
- 3DView

Example queries

Saturn in March 2012

VESPA portal

http://vespa.obspm.fr

# Data services connected via EPN-TAP / field

Open  
Open in test  
In development  
Being studied

## Atmospheres

- Titan profiles - CIRS (Cassini, LESIA)
- Venus spectroscopy - VIRTIS (VEx, LESIA)
- Mars Climate Database (modeling, LMD-LESIA)
- Venus profiles - SPICAV/SOIR (VEx, IASB-BIRA)
- Mars profiles - SPICAM (MEx, LATMOS)
- 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 - (outcome of the H2020 prog, Konkoly Obs)
- Cometary lines catalogue (IAPS)
- Vesta & Ceres spectroscopy - VIR/DAWN (IAPS)
- \*- DynAstVO: NEO refined parameters (IMCCE)
- MPCorb: Small bodies orbital cat (MPC/Heidelberg)
- Rosetta ground-based support (via C. Snodgrass)
- 67P illumination config (IRAP)
- \*- Meteor\_showers predictions (IMCCE)

## Surfaces

- CRISM WCS service (MRO, Jacobs U)
- Mars craters (Jacobs U, + update by GEOPS)
- \*- USGS planetary maps, WMS (Jacobs U)
- M3 WMS service (Chandrayaan-1, Jacobs U)
- \*- HRSC data, WMS (MEx, Frei Univ)
- OMEGA cubes and maps (MEx, IAS)
- \*- VIMS calibrated/geometry cubes (Cassini, LPG)
- MarsSI GIS (Lyon)

## Solid spectroscopy

- \*- SSHADE: ices & minerals (IPAG & network)
- Planetary Spectral Library (DLR)
- \*- PDS spectral library (LESIA)
- Berlin Reflectance Spectral Lib (DLR)

## Magnetospheres / radio

- \* - APIS (HST/Cassini, LESIA)
- NDA (Jupiter radio Nançay, LESIA)
- AMDA (CDPP / IRAP)
- MAG data (VEx, IWF Graz)
- \* - MASER & Juno support (LESIA) + associated services
- RadioJove (LESIA & US amateur network)
- \* - Iitate HF data of Jupiter (Tohoku Univ, Jap)
- UTR-2 Juno ground support (Kharkiv)
- MDISC (modeling, UCL)
- \* - Cluster & Themis data (IAP, Prague)
- Interface with IMPEx models (IWF Graz)
- Hisaki (Tohoku Univ., Jap)
- \* - Transplanet (CDPP / IRAP)
- \* - LOFAR Jupiter (SRC/PAS, Varsovie)

\* New/updated in 2019

## Exoplanets

- Encyclopedia of exoplanets (compilation, LUTH/LESIA)
- Transit observations (Bern)
- Interface with DACE (Geneva)

## Solar

- HELIO AR & 1T3 solar features catalogues (LESIA)
- \*- Bass2000 (LESIA)
- Radio Solar db (Nançay, LESIA)
- \*- CLIMSO (Pic du Midi, IRAP)
- \*- Iitate AMATERAS (Tohoku Univ, Jap)

## Generic / interdisciplinary

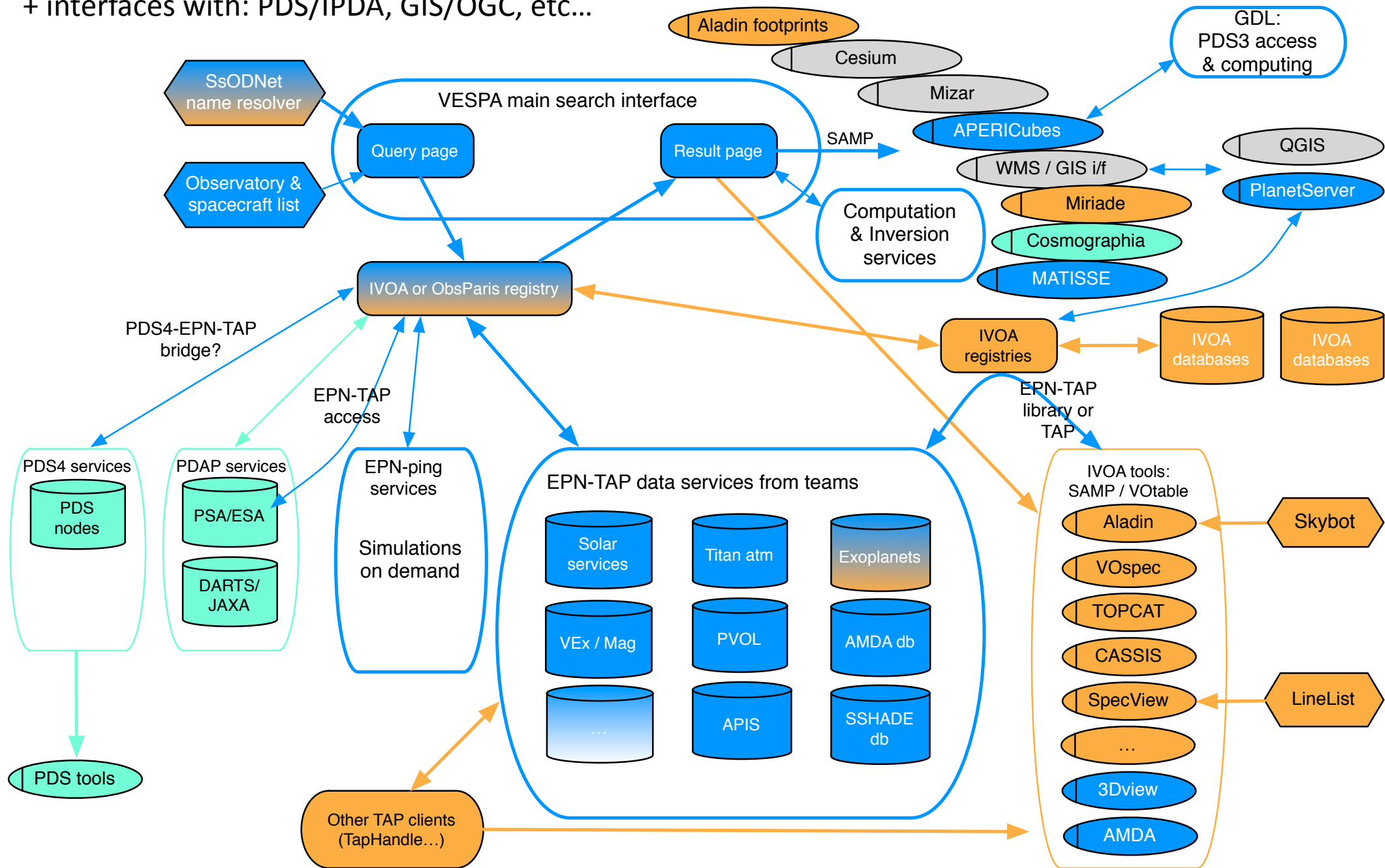
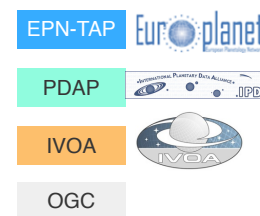
- BDIP (LESIA)
- \*- PVOL (UPV/EHU & amateur network)
- \*- PSA complete archive (ESA)
- \*- HST planetary data (LESIA, to CADC archive)
- Planets/satellites spectra collection (LESIA)
- DARTS (JAXA - currently via PDAP)
- Planets then satellites characteristics (LESIA/IMCCE)
- Gas absorption cross-sections (Granada)
- Nasa dust catalogue (IAPS)
- Stellar spectra, support for observations & exopl. (LESIA)
- Interface with VAMDC (TBD)

# A Virtual Observatory in Planetary Science

Built on astronomical VO developments (IVOA)

+ previous European programs: IMPEX, HELIO, VAMDC...

+ interfaces with: PDS/IPDA, GIS/OGC, etc...



# 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

**VESPA Query Interface**

vespa.obspm.fr/planetary/data/?f-url\_op=&f-schema\_op=&f-target\_name=

light travelttime

**VESPA**  
Virtual European Solar and Planetary Access

**Form** Query  
**EPN-TAP Services** Custom Service

**Main Parameters**

**Target Name**  
Mars

**Target Class**

**Dataproduct Type**

**Instrument Host Name**

**Target Class**

**Dataproduct Type**

**Instrument Host Name**  
**TAP query**

**Instrument Name**  
=

**Processing level**

**EPN Resources**

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 CDP/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	⊕	⊕	ⓘ
BDIP - Base de Données d'Images Planétaires	0 result	⊕	⊕	ⓘ

Generated WHERE clause of ADQL statement:

```
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'
```

**EPN-TAP compilation results**

**Plotting tools**

- TOPCAT
- Aladin
- SPLAT
- CASSIS
- 3DView

**Example queries**

- Saturn in March 2012
- 3DView

**Example queries**

- Saturn in March 2012

**Help**

- Help

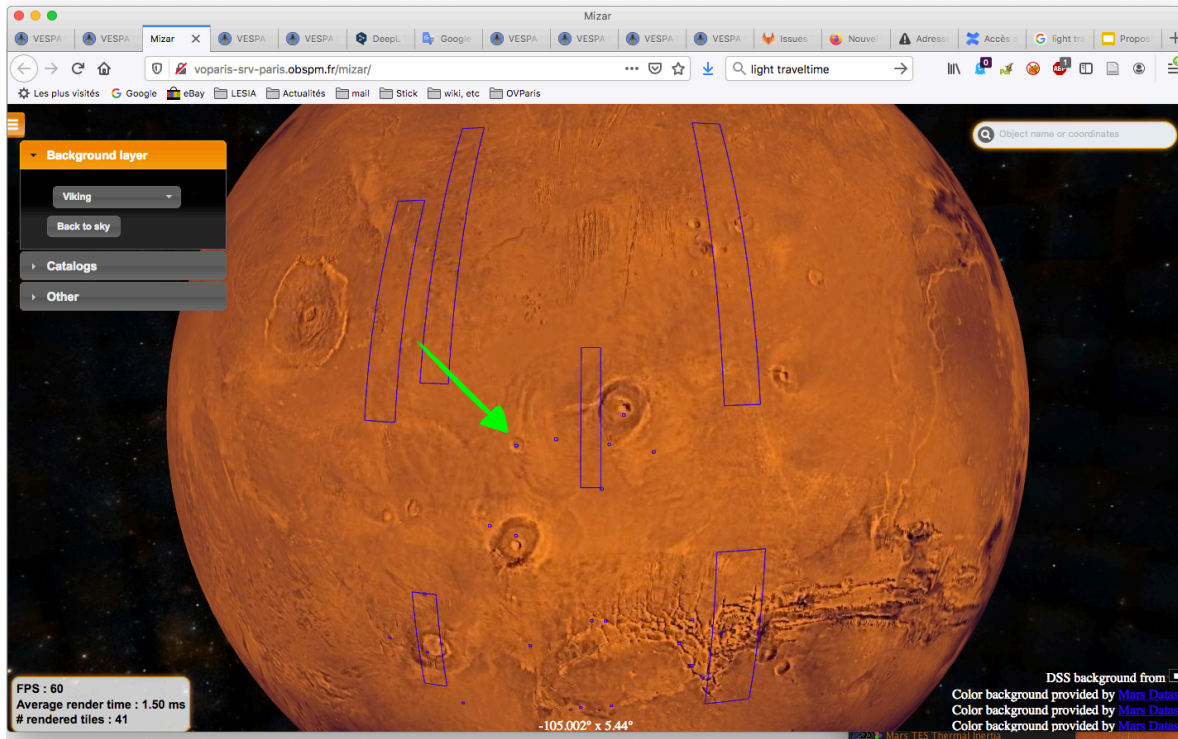
Tout surligner Respecter la casse Mots entiers Occurrence 1 sur 2

# EPN-TAP typical request on surfaces:

Mars, a given region ( $\sim$  Tharsis volcanoes  $\Rightarrow$  limits in lon/lat)

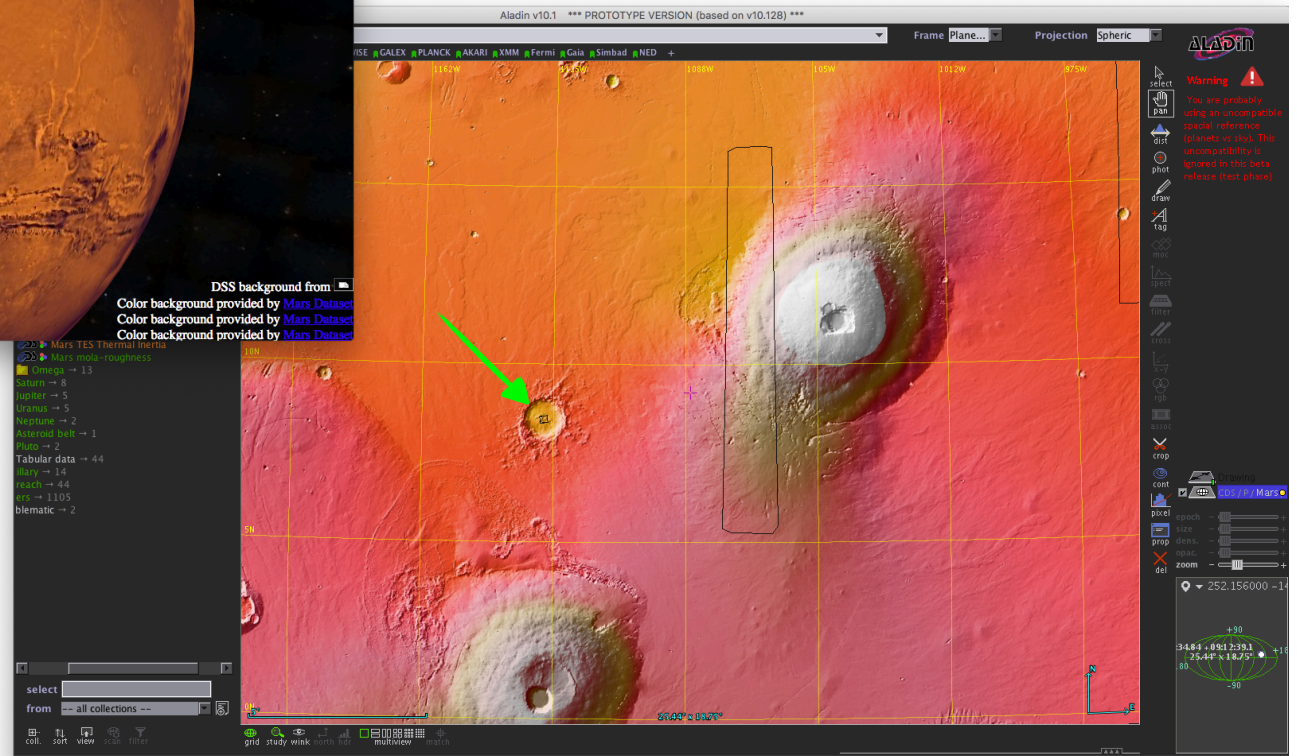
Illumination conditions ( $i \leq 20^\circ$  / phase: needs to be informed)

Local time or season, etc (needs to be informed)



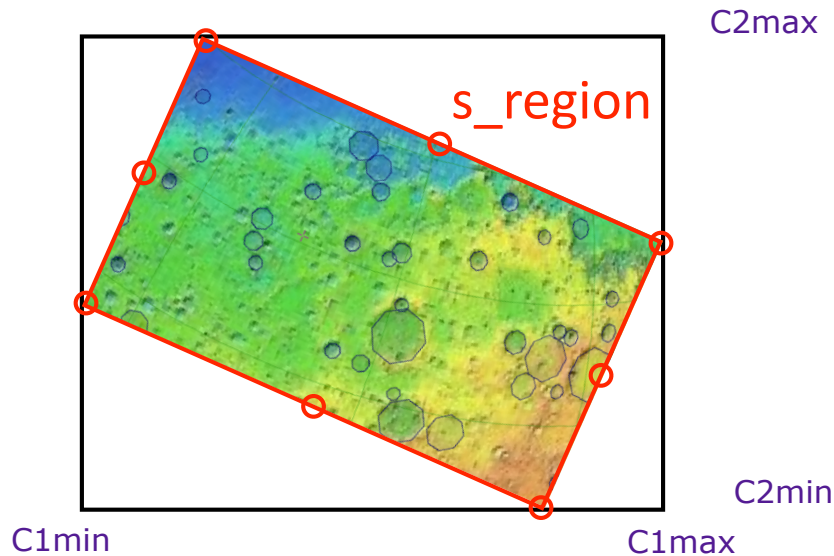
HRSC & CRISM in Mizar (bounding boxes)

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



# Using clever footprints

lon/lat min/max coordinates

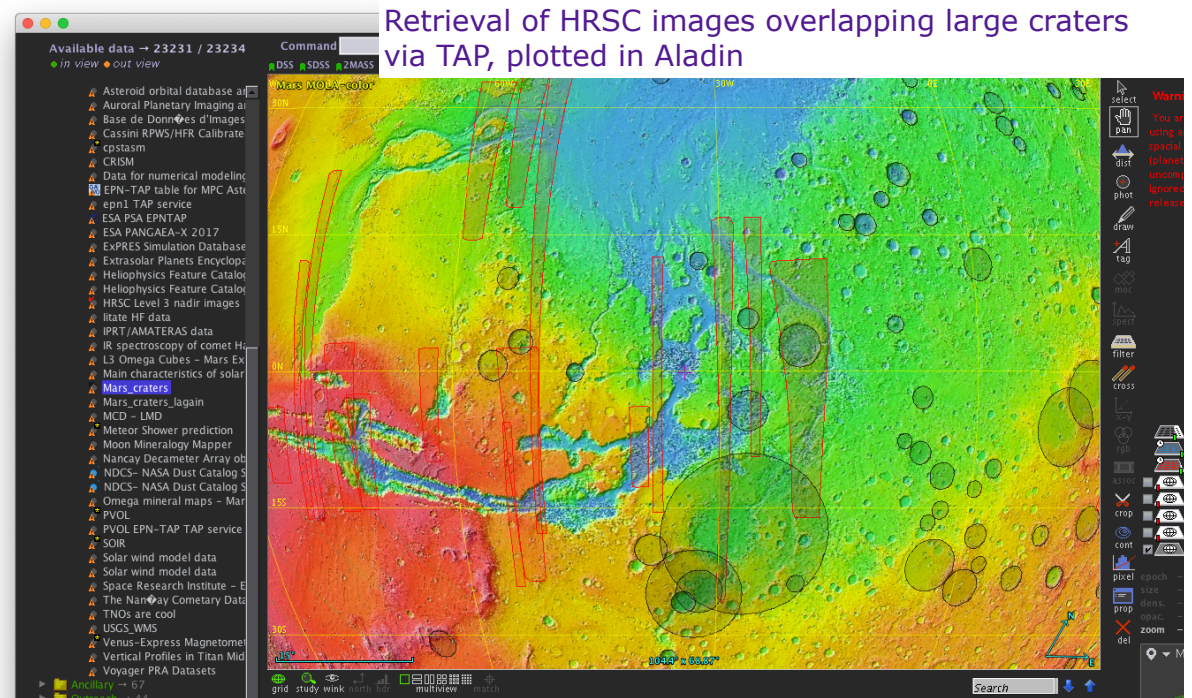


- **PDS3-like limits** (lon/lat bounding box)  
=> provide very rough estimate of footprint and many false alarms

- **STC-S strings, aka s\_region** (sampling the contour)  
=> provide much more accurate footprints with tunable resolution  
Close equivalent in OGC world: geojson

STC-S allow for very powerful searches on intersections / overlaps via TAP, e.g. images overlapping structures

Open issue with coord system IDs though (~same as geojson)





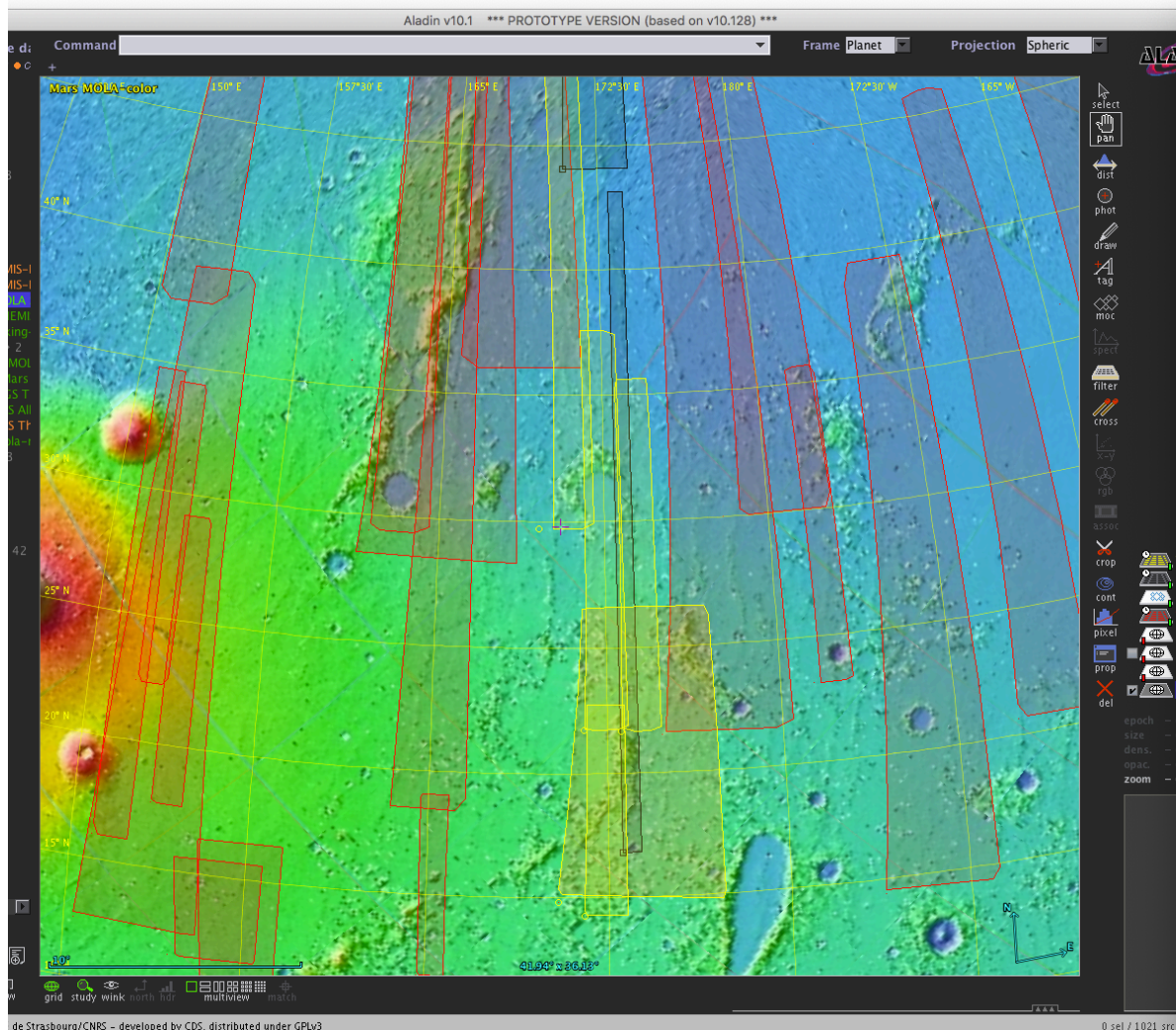
# footprint based searches

2D overlaps based on actual footprints, in TAP

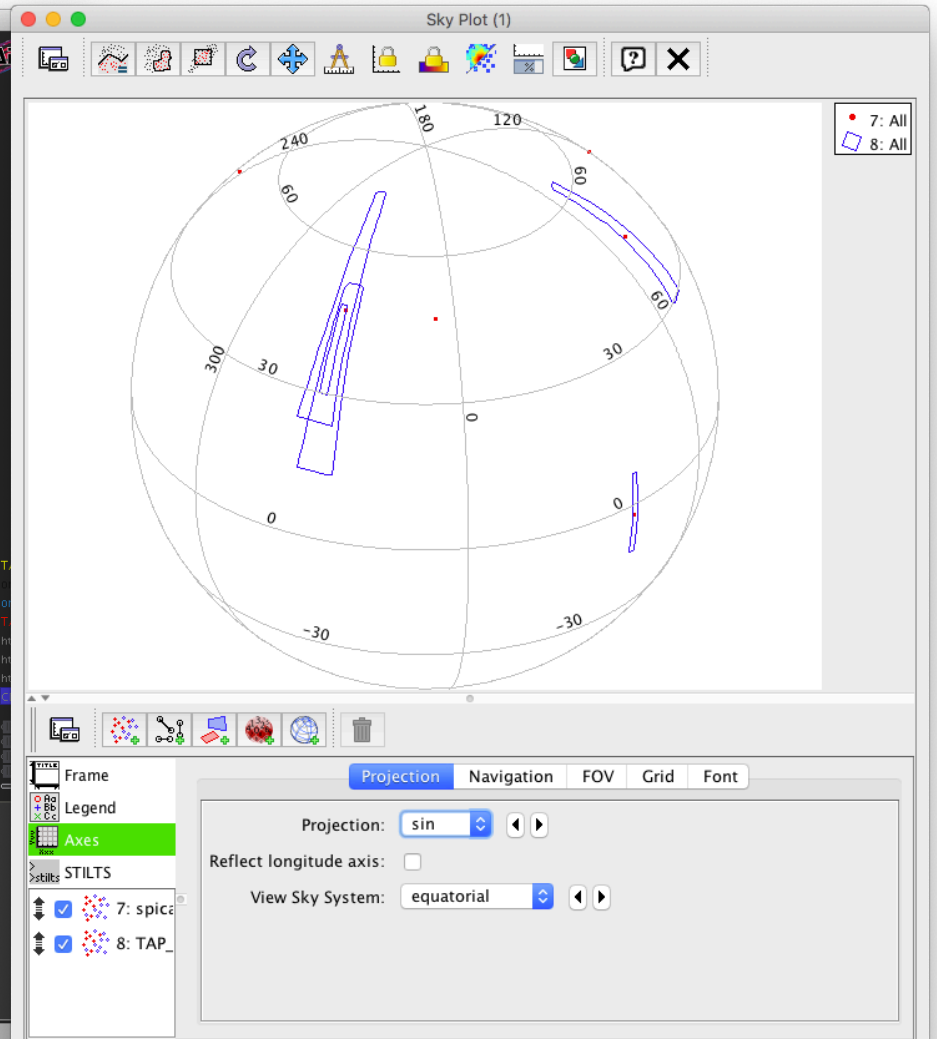
Typical request:

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

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

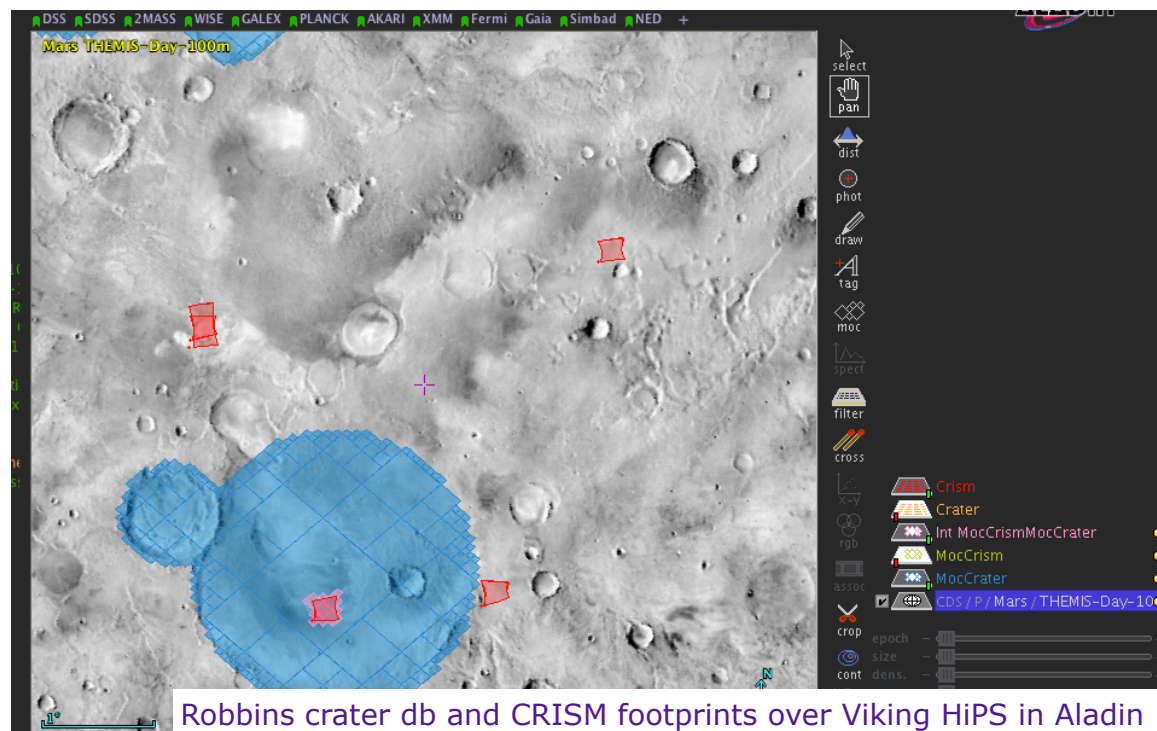


Selected SPICAM profiles (red) and overlapping HRSC images (blue) in TOPCAT (Mars-Express observations)

## Using clever footprints, next step

- **MOC - Multi Order Coverages**  
(healpix-based)

=> Even quicker to compute and use (but difficult to store). Can apply to entire datasets or individual files



- preserves reference to progenitors

- now extended to time coverage

=> potentially extremely powerful to manage an operational dataset & cross-correlate several datasets

See <https://www.youtube.com/watch?v=ggnJ5glhRmA>

Application to Saturn ephemerides: [https://wiki.ivoa.net/internal/IVOA/InterOpMay2019TDIG/Aladin\\_time\\_2019](https://wiki.ivoa.net/internal/IVOA/InterOpMay2019TDIG/Aladin_time_2019) - Fernique.pdf

Application to VIRTIS/VEx dataset in progress

# Coordinate Systems

## Need to tag spatial data correctly

**Body / frame** (IAU2000, etc) / **properties** (-centric / -graphic) / **etc**

**Need for short descriptors / IDs to be used as keyword values**

## Several classifications exist:

**IAU WGCCRE** (mostly body-fixed)

**NAIF / SPICE** (JPL - usual computation system for space missions)

**STC** (IVOA standard for astronomy, with room for planets)

**Reference publications** for heliophysics / magnetospheres

## VESPA action started in EPN-RI & EPN2020

**Body-fixed frames** (Jacobs Uni / GEOPS / USGS / ObsParis)

**Outer solar system** (JPL / PDS PPI / ObsParis)

To be completed and made consistent

— long-term effort, should involve all the community

CNES is certainly involved in this (same issue for OGC standards)

## Tools connected to / used by VESPA

### - Standard/existing tools associated to VESPA/Europlanet:

**Aladin** (CDS/CNRS), **CASSIS** (IRAP/CNRS)

Both include Planetary Science updates from VESPA

**3Dview** (CNES/IRAP/GFI): plot along s/c trajectories

**MATISSE** (ASI/IAPS): 3D visu for *some* PDS3 data, supports shape models

**TOPCAT** (Univ Bristol): tabular data, including metadata

### - New tools developed in VESPA:

**Planetary Cesium Viewer** (GEOPS/CNRS)

**APERICubes** (*some* PDS spectral cubes, ObsParis)

**QGIS SAMP plug-in & improved fits** (VO-GIS bridge, Jacobs Univ/GEOPS)

**ImageJ SAMP plug-in & improved fits support** (ObsParis, in progress)

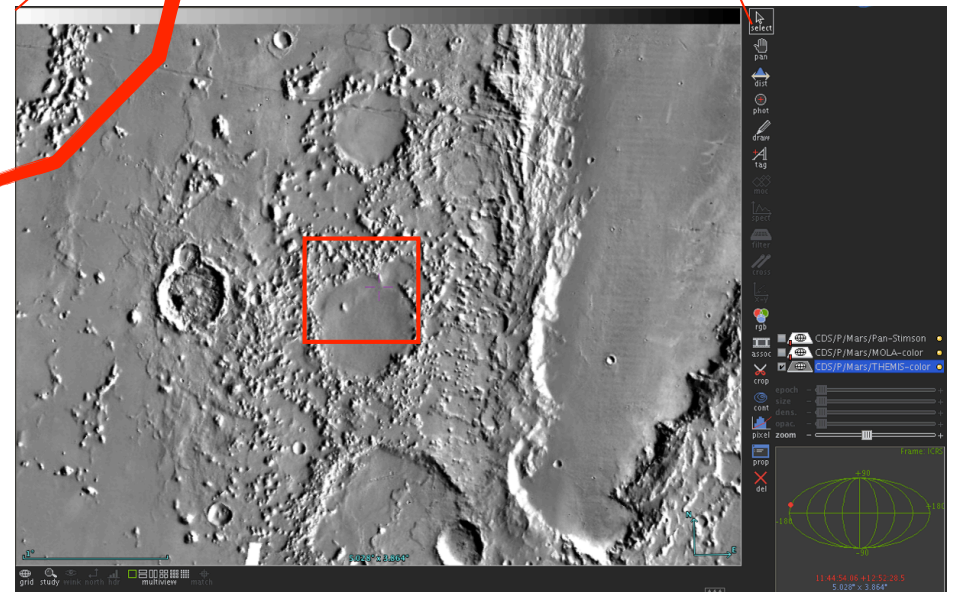
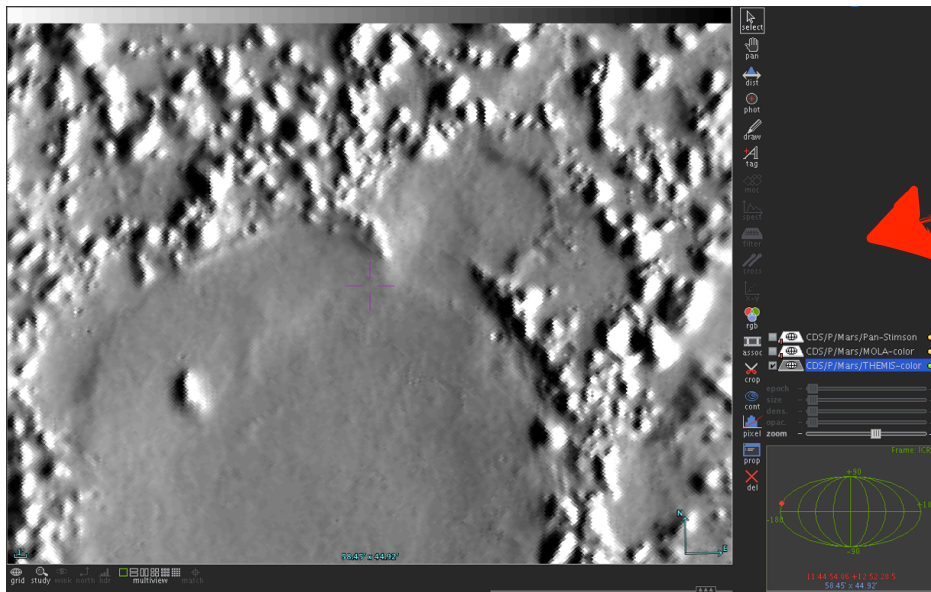
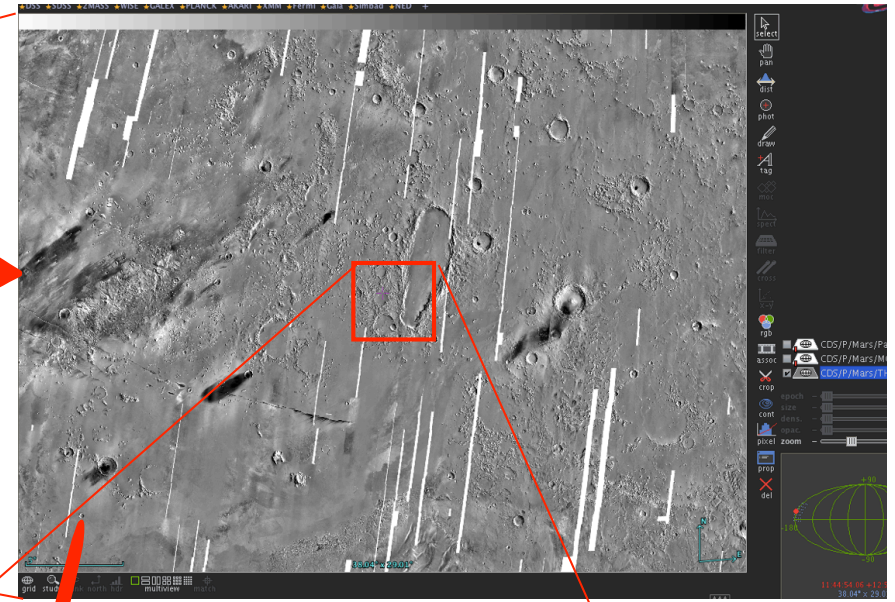
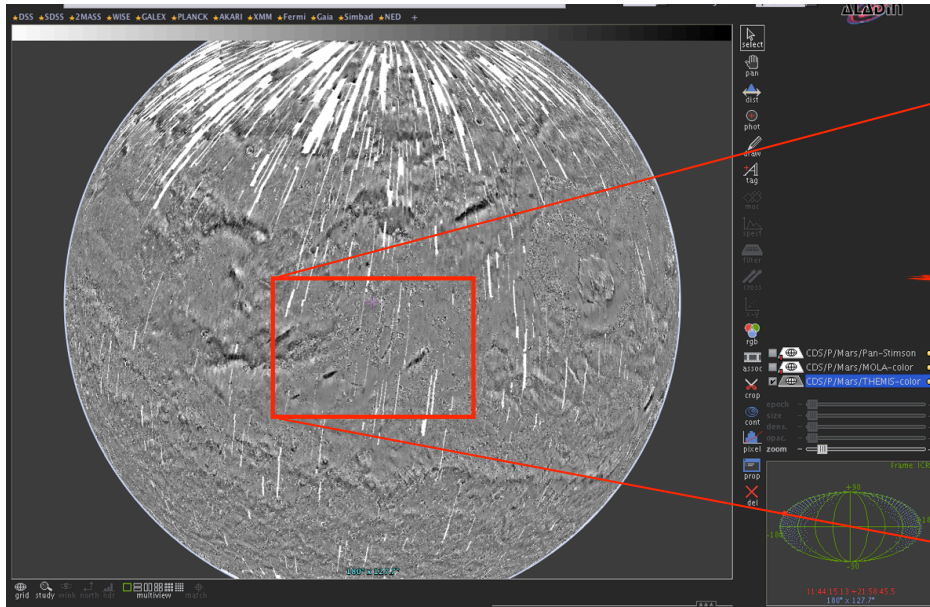
### - Other useful tools in VESPA context:

**SPLAT-VO** (Heidelberg), **Autoplot** (Iowa), **Mizar** (CNES)

+ possibly **DS9** (SAO), **Cosmographia**, **WebGeoCalc** (JPL)

# New VESPA functions

# Multiresolution maps (HiPS) in Aladin (and more)

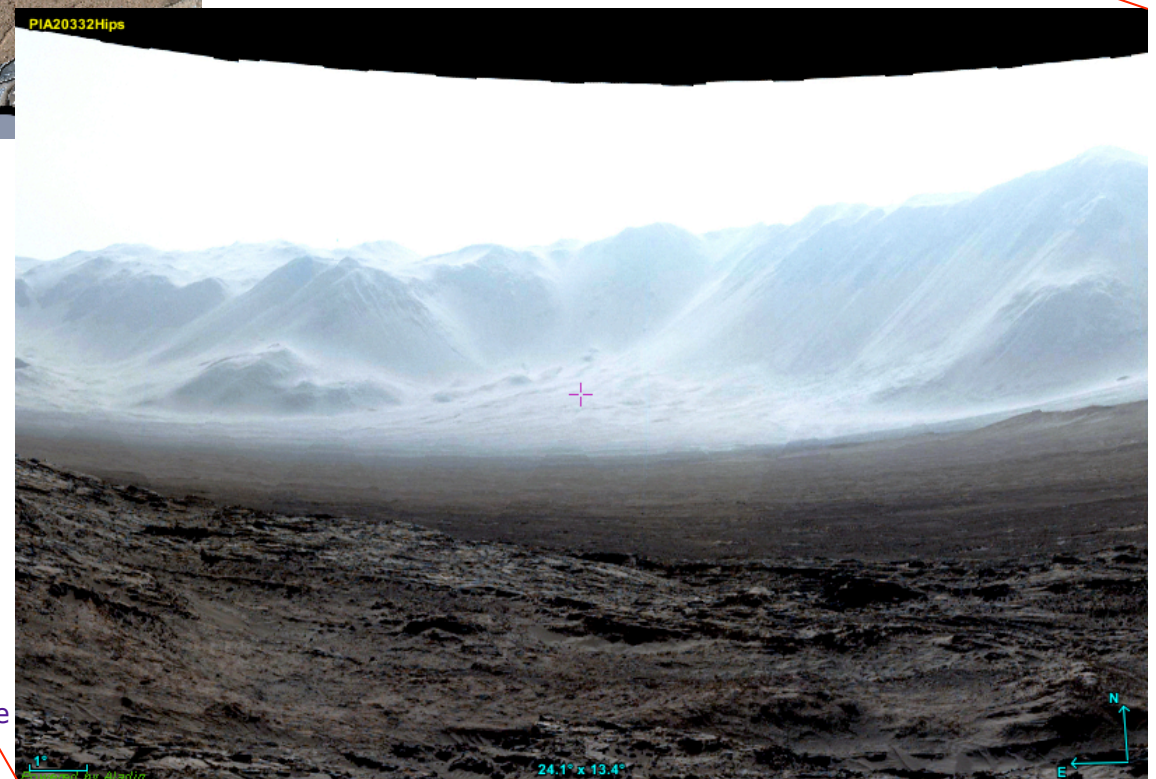
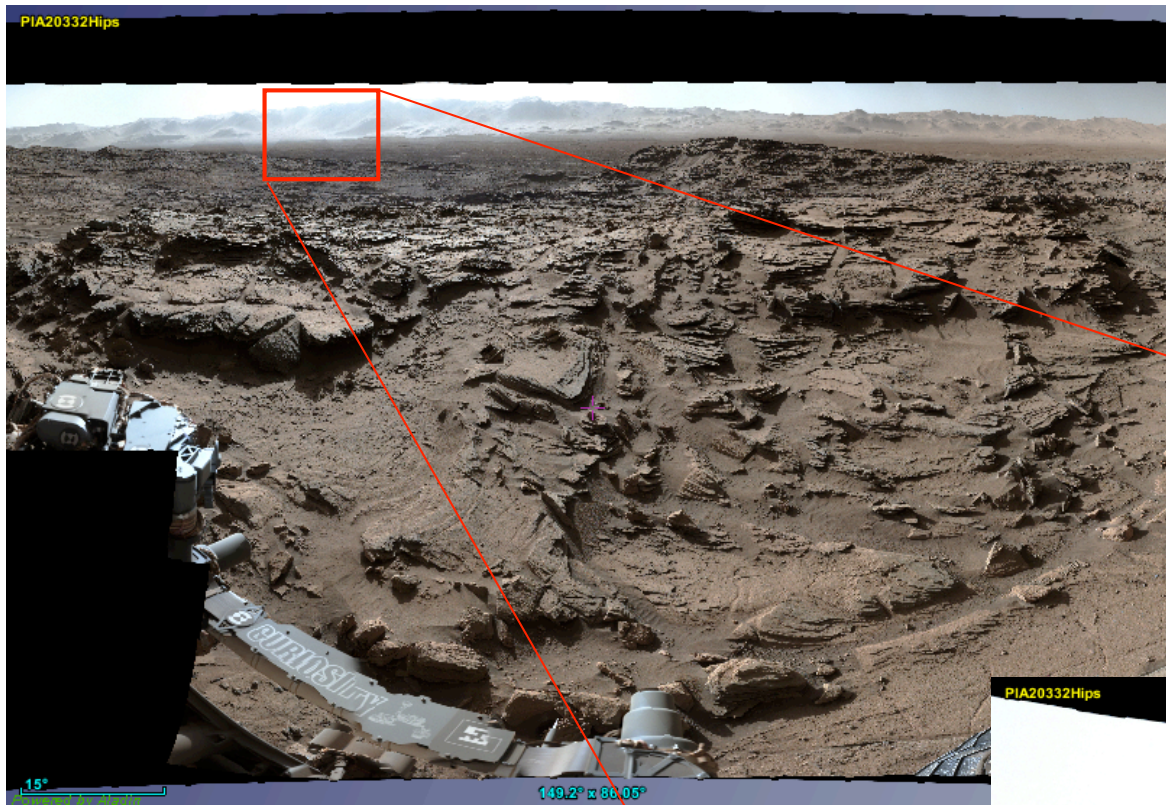


See also <http://aladin.u-strasbg.fr/AladinLite/doc/API/examples/mars-visualisation/>

Currently 61 planetary HiPS available for use (from USGS WMS maps and more)

# New VESPA functions

# Multiresolution in Aladin: panoramic images

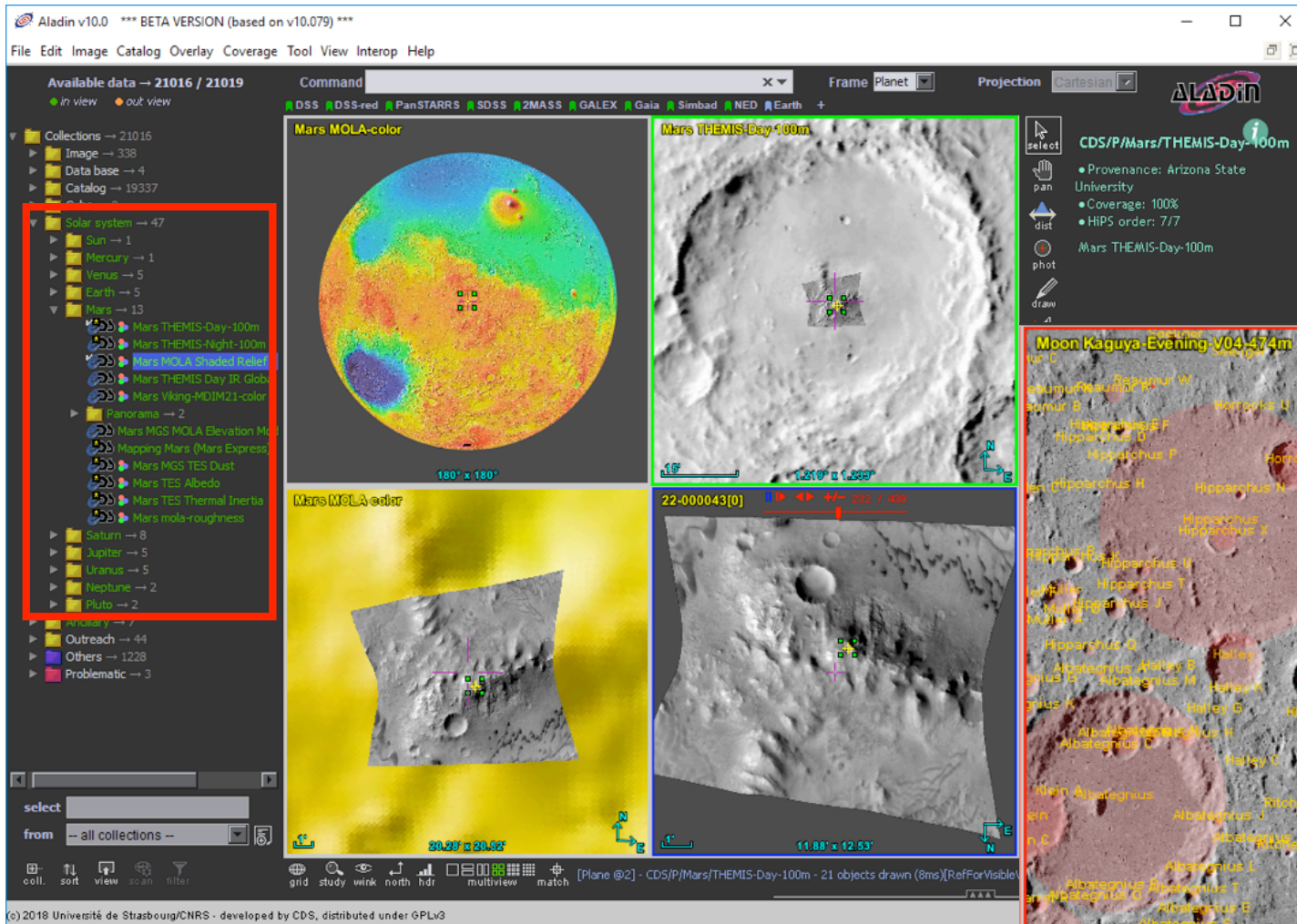


HiPS computed from a Curiosity MASTCAM panorama from JPL web site (available in the Aladin data tree)

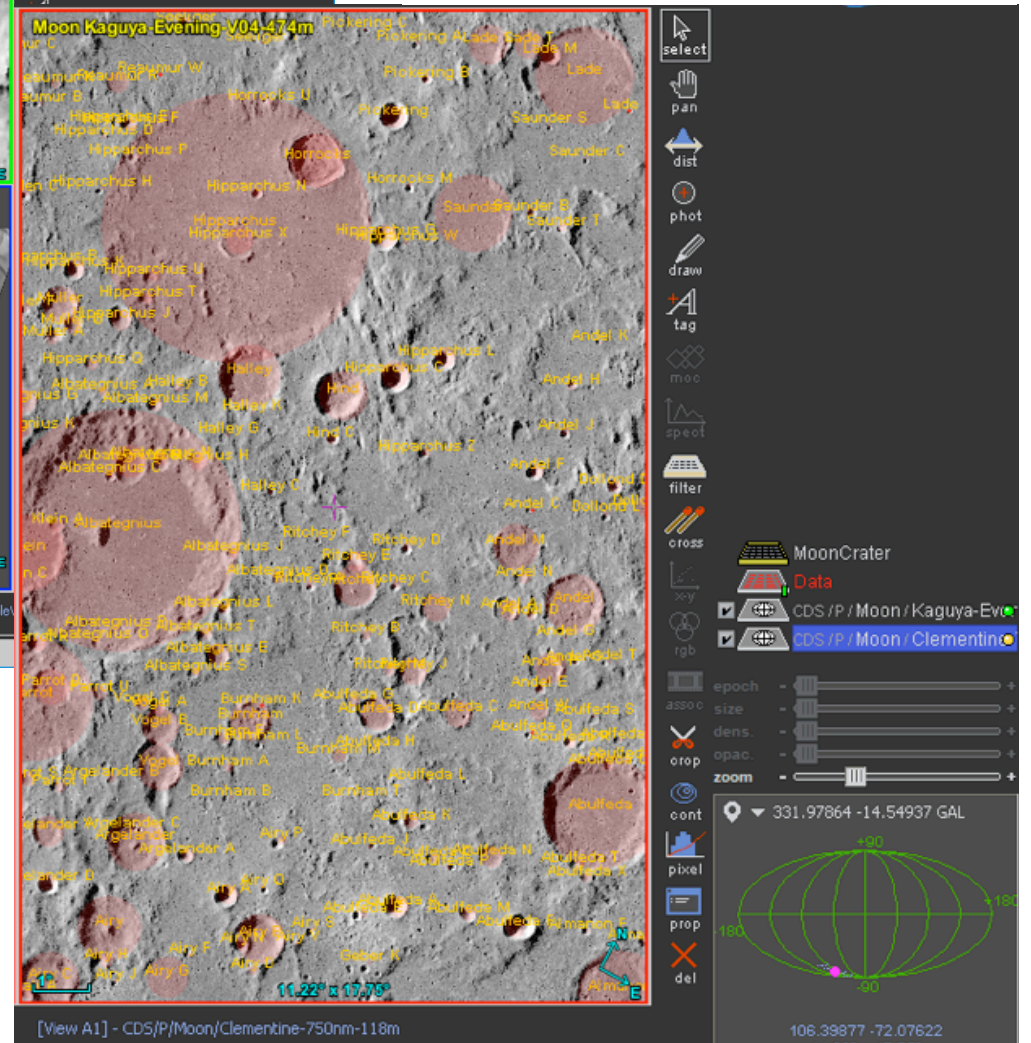
# Favorite VESPA tools

# Aladin (CDS/CNRS):

Georeferenced images + objects superpositions



Lunar crater catalogue over Kaguya HiPS



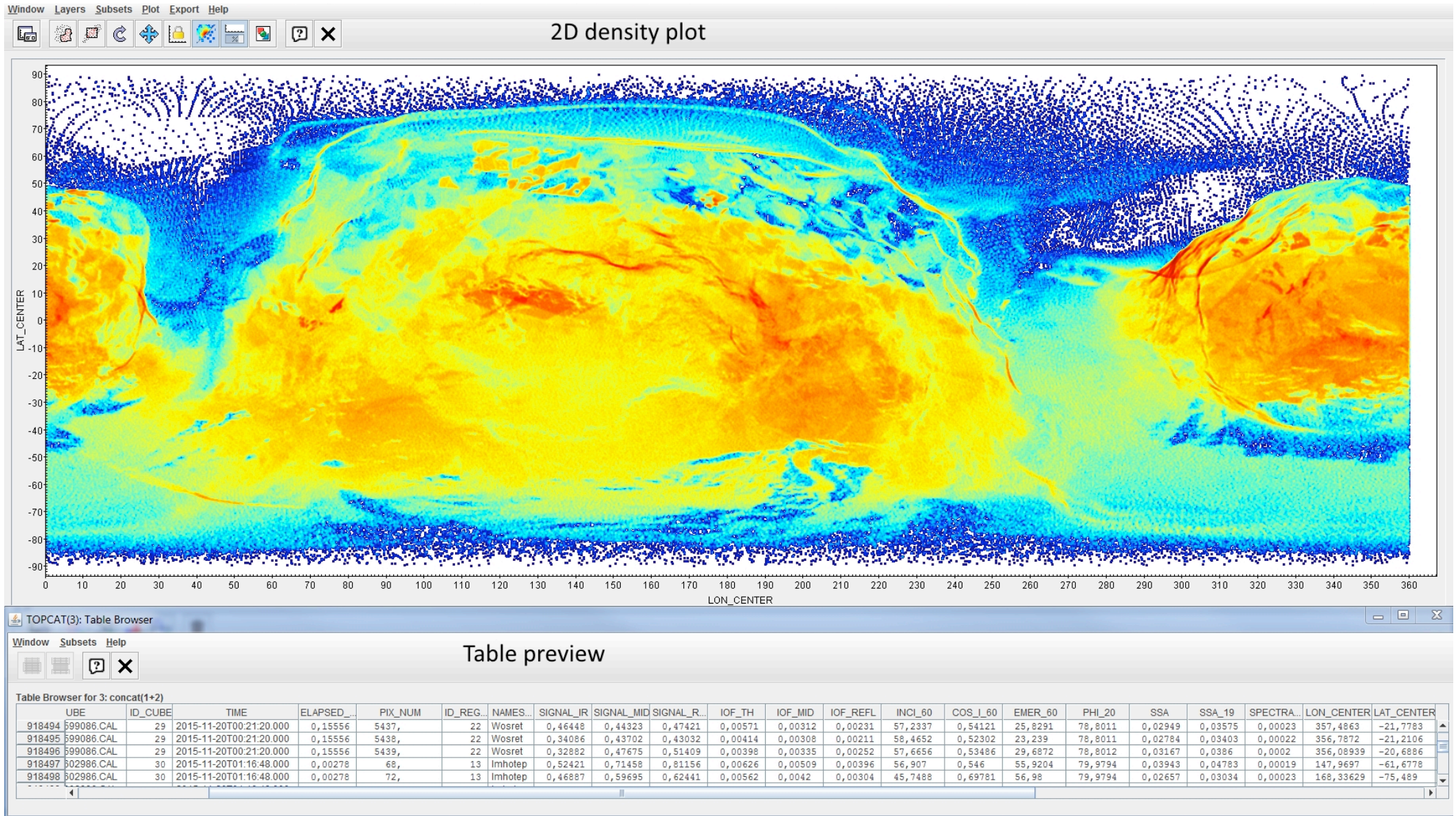
CRISM cubes over MOLA HiPS

Relies on IAU planetary coordinate frames (fits' WCS)

# Favorite VESPA tools

# Mapping capabilities in TOPCAT

From a list of point measurements  
Convolved with marker symbol/size  
=> powerful to visualize an operation plan

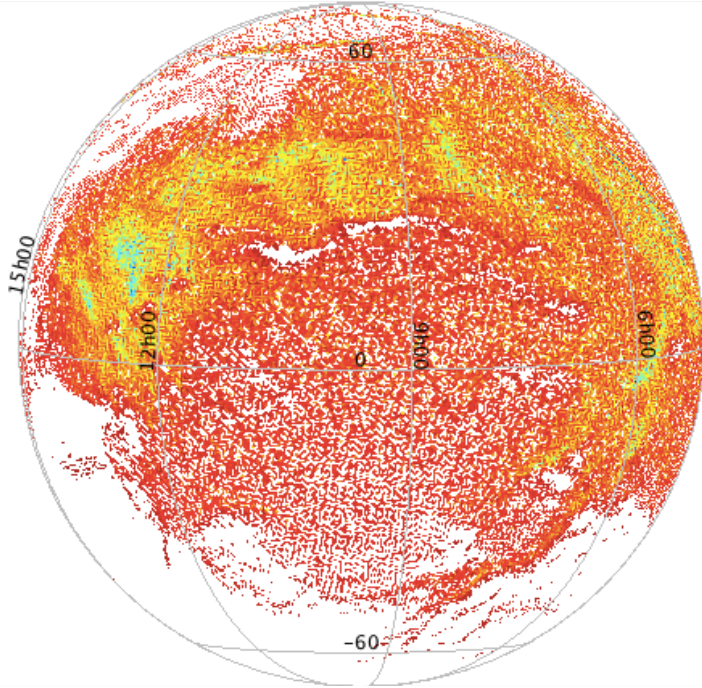


VIRTIS / Rosetta coverage in TOPCAT (4 months of observation)

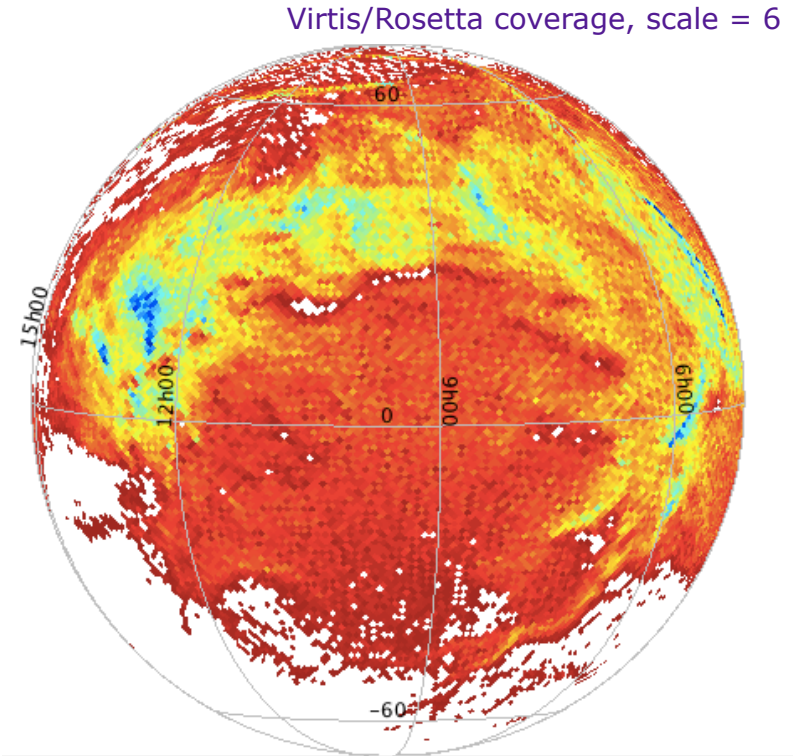


# New functions in VESPA

# Multiresolution maps in TOPCAT (Bristol Univ)



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



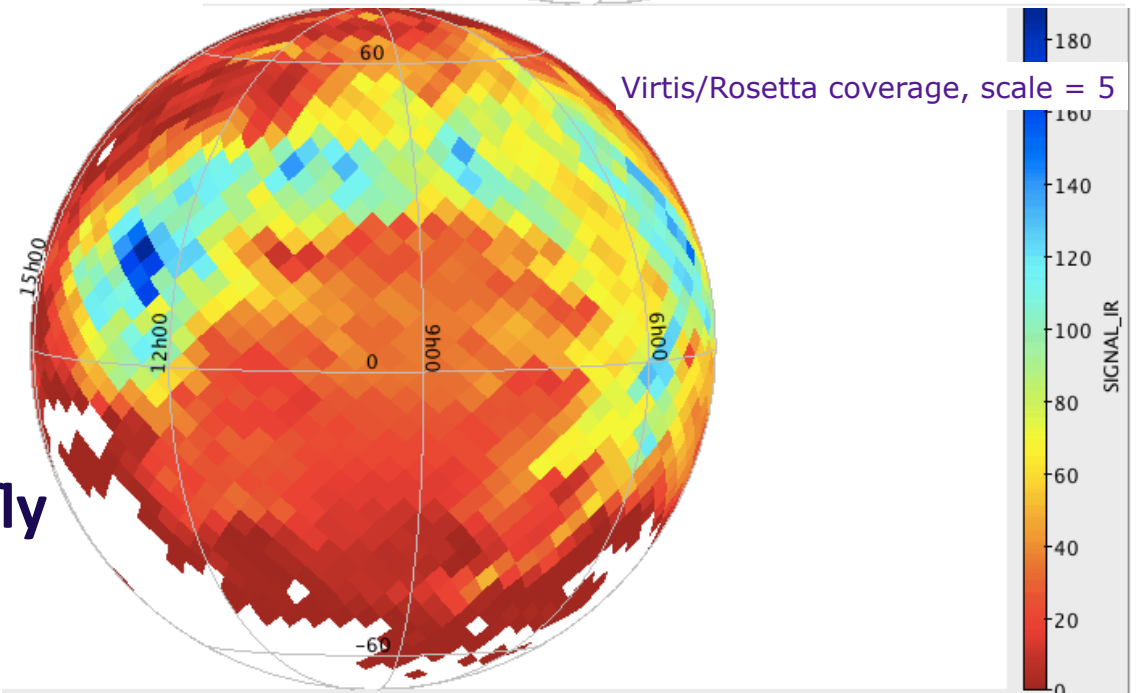
**Start from a table of sparse observations (lon/lat)**

VIRTIS/Rosetta on 67P

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

**Modify resolution / scale on the fly**

Output format now consistent with Aladin



## Typical workflow in imaging spectroscopy from PDS format

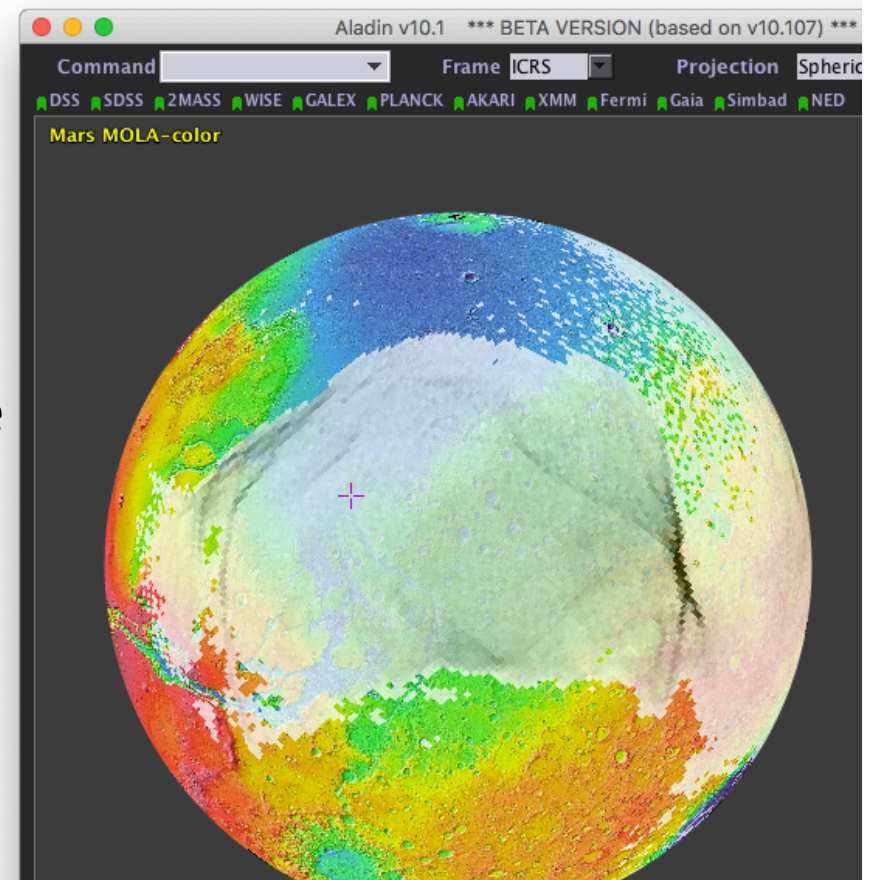
- identify cubes of interest from EPN-TAP query
- read file, select pixels, process under IDL | python (or TOPCAT?)
- write in VOTable, open in TOPCAT for spatial integration in healpix cells
- Plot result in Aladin over HiPS

### Applications:

- VIR/Dawn spectral parameter over Ceres HiPS in Aladin
- OMEGA spectral parameter over Mars HiPS
- any point measurements (altimeter, etc)

=> Alternative:

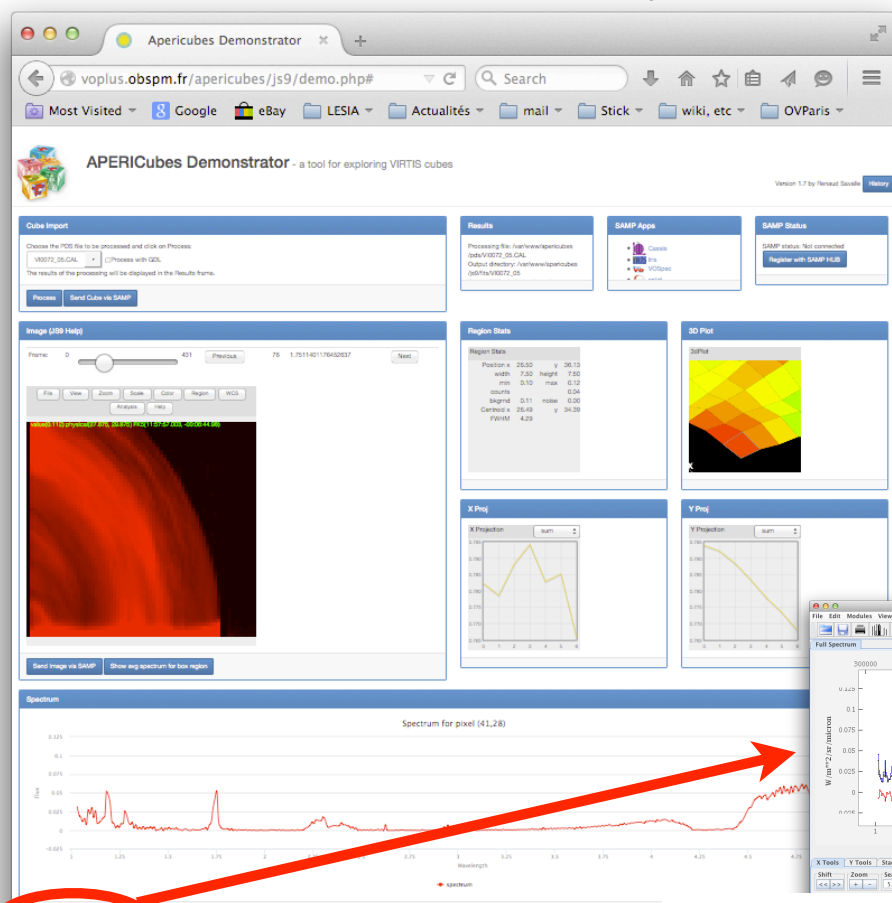
- provide *individual* spectra in EPN-TAP service
- + access tool (being tested on VIRTIS / VEx)



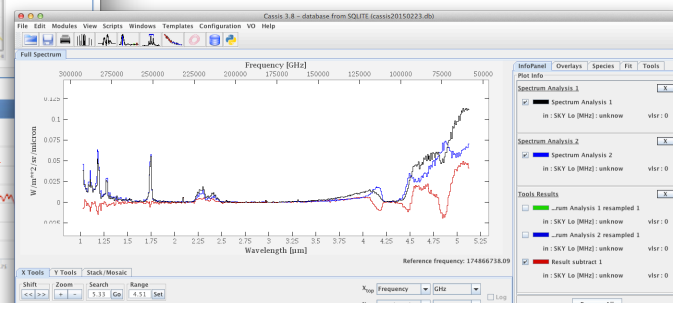
TOPCAT healpix map (scale = 6) over MOLA HiPS in Aladin - dummy example

# Nice solution to browse imaging spectroscopy data

- 1- EPN-TAP service describing *cubes* with geometry range (coord / angles)
  - => retrieve sessions of interest
  - => Aladin, DS9, APERIcubes (which allows extracting spectra)
- 2- add EPN-TAP service describing *pixels* with geometry (coord / angles)
  - => retrieve measurements of interest, comparison with HR imaging
  - => CASSIS, SPLAT-VO (or TOPCAT for 2D aspects)



Open issues with data format (PDS reader?) & representation (no standard cube format) Spatial dimension is neglected

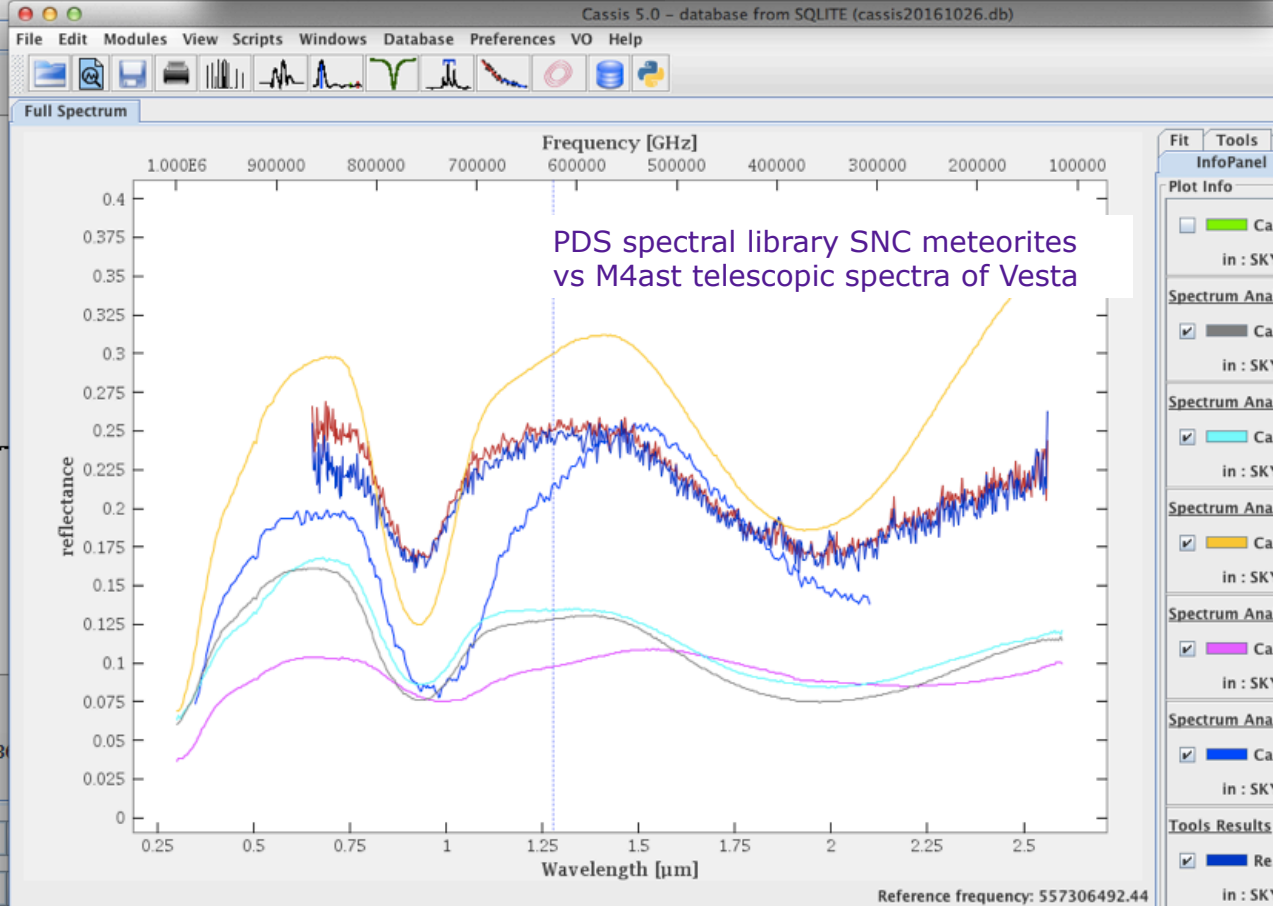
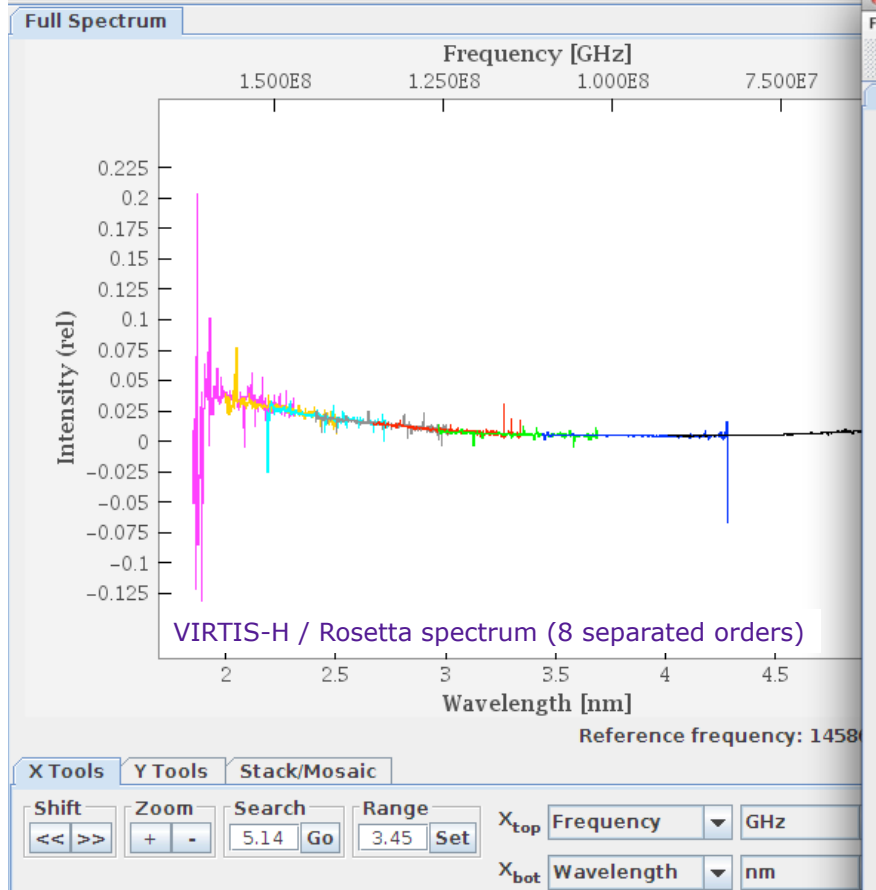
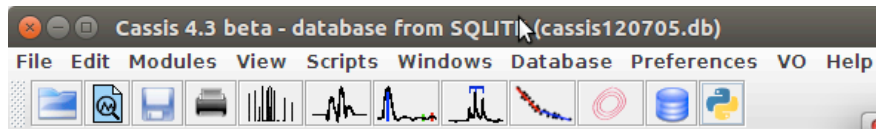
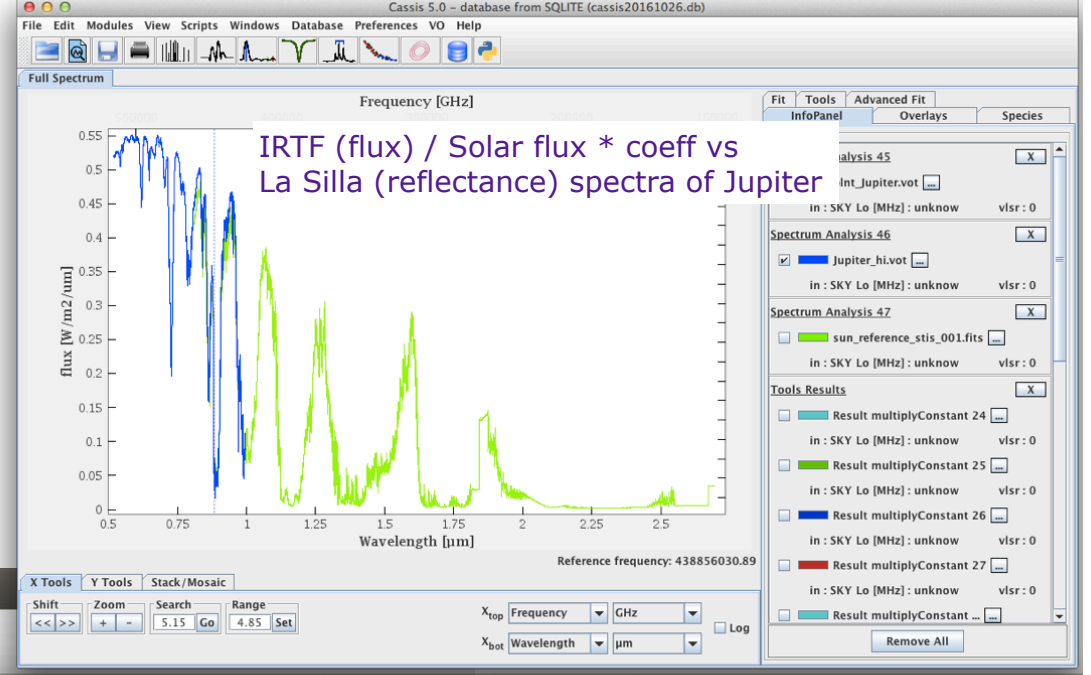


Similar extraction function is provided by VESPA GIS interface for CRISM service

# Favorite VESPA tools

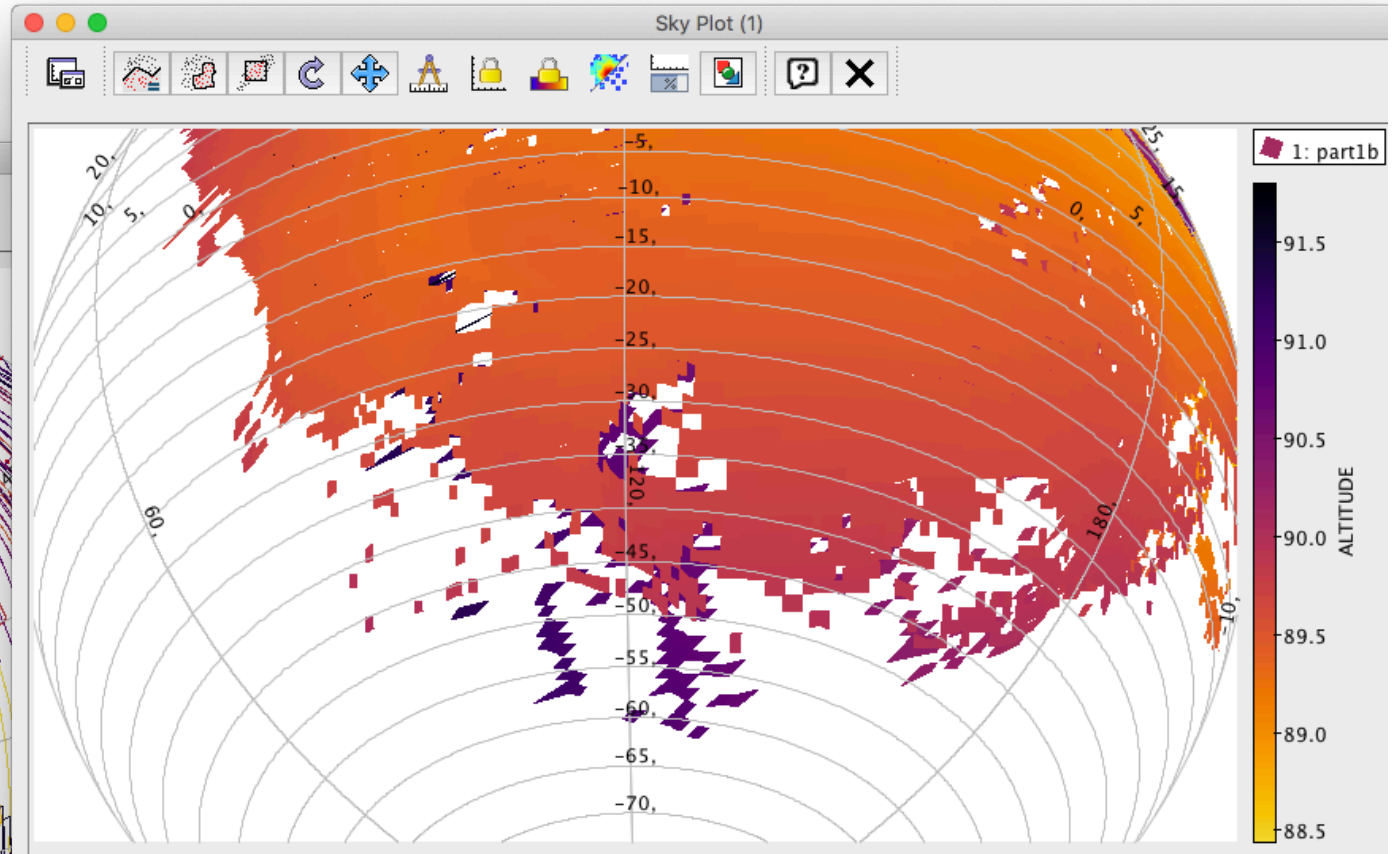
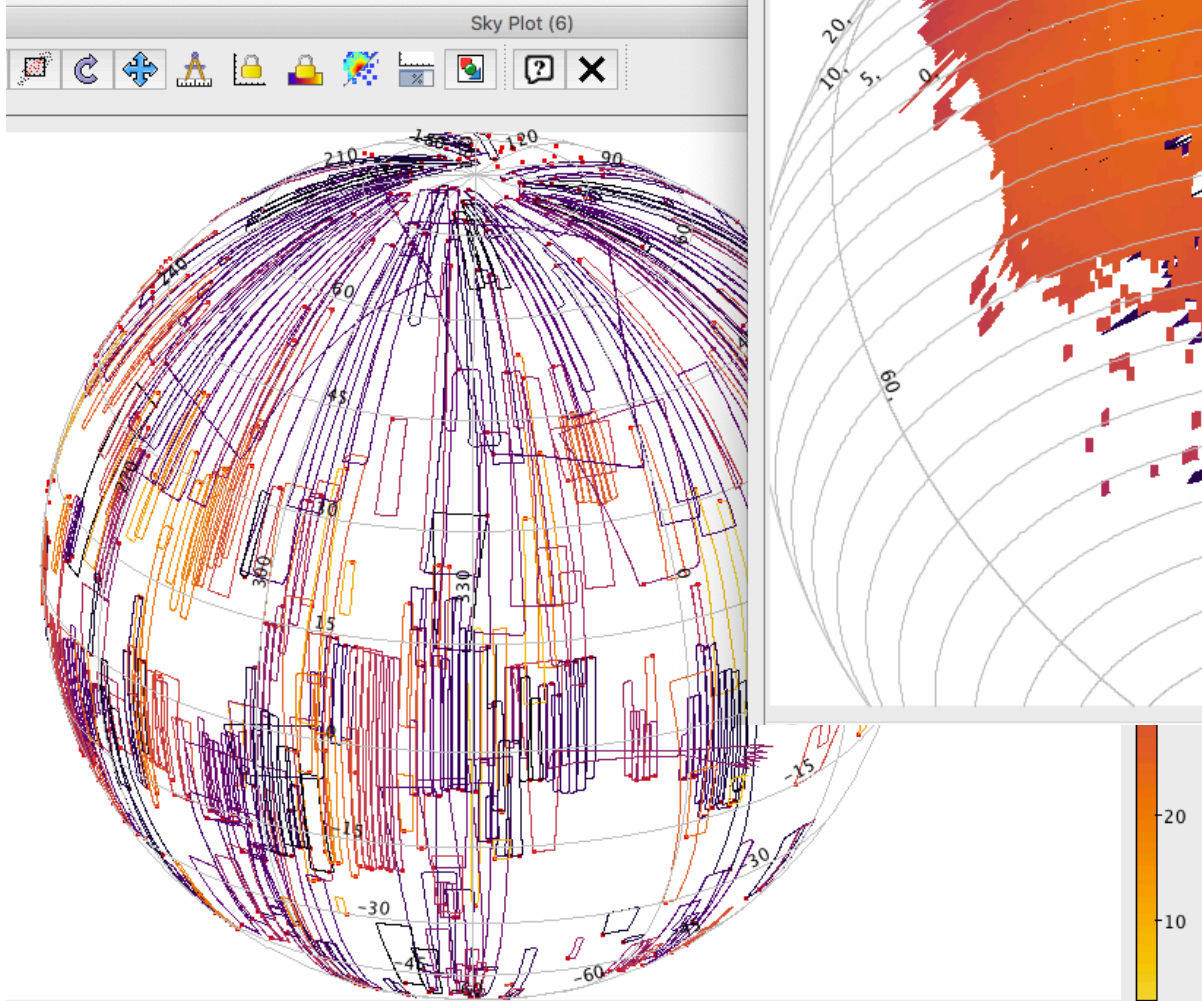
## CASSIS v5 (IRAP/CNRS)

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



# New functions in VESPA

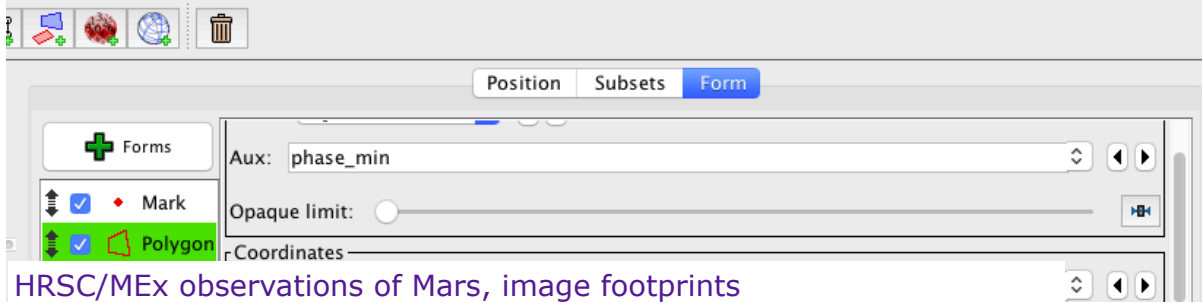
# Support for extended pixels in TOPCAT



VIRTIS/Rosetta observations of 67P, individual pixels

Position is defined by a quadrilateral instead of a point

**Particularly useful for imaging spectroscopy and to display image footprints**



# Fits extensions & GIS interface

## geofits

- **fits/WCS extension for planetary surfaces**

Extends the WCS standard for planetary coordinates, including description of projection in use — handled by fits software (ds9, Aladin...)

*Marmo et al 2018, Earth & Space Sc*

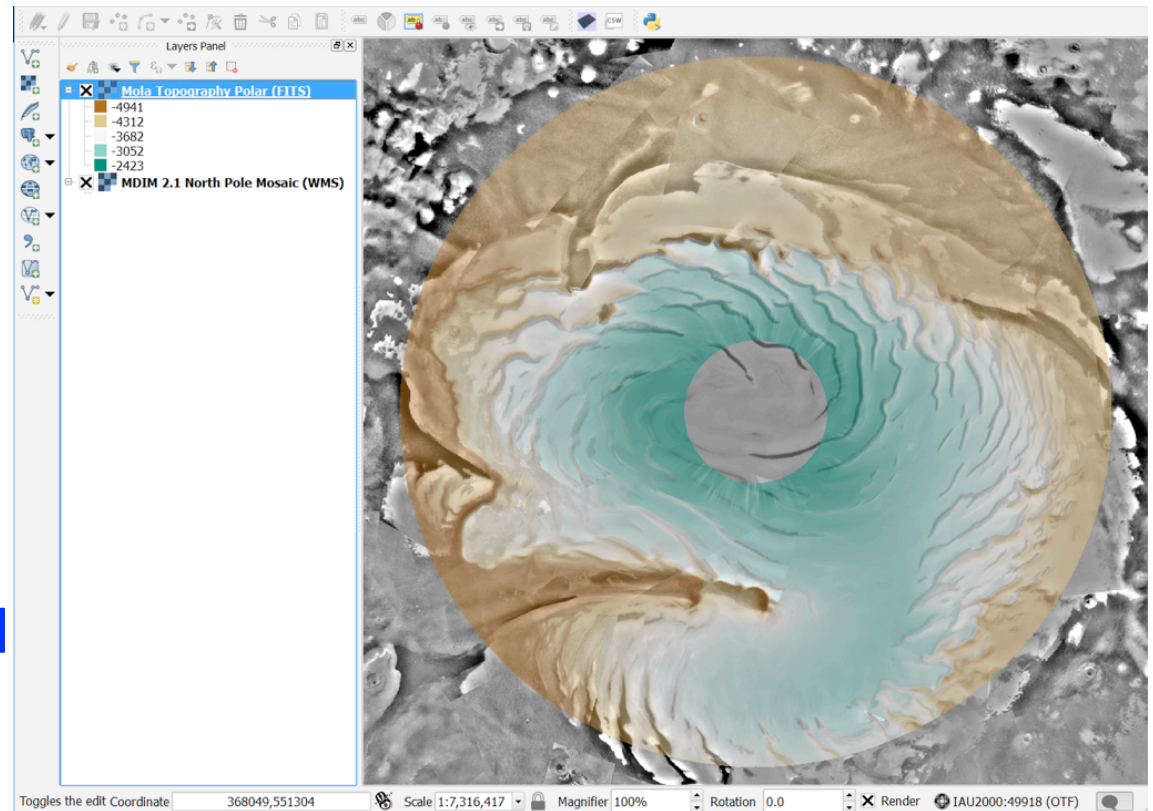
Driver included in GDAL from v3.0:

- georeferenced fits files can be converted & projected in QGIS
- *geoTIFF* files can be converted to *geofits* for use in VO tools

Associated to QGIS SAMP plug-in:

=> QGIS can receive fits from portal

Mars polar fits image (MOLA altimetry) on Viking MDIM2.1 basemap, in QGIS



## Fits extensions

### Fits cubes

- **(spectral cubes + coordinates + viewing geometry) in a multi-extension fits file**

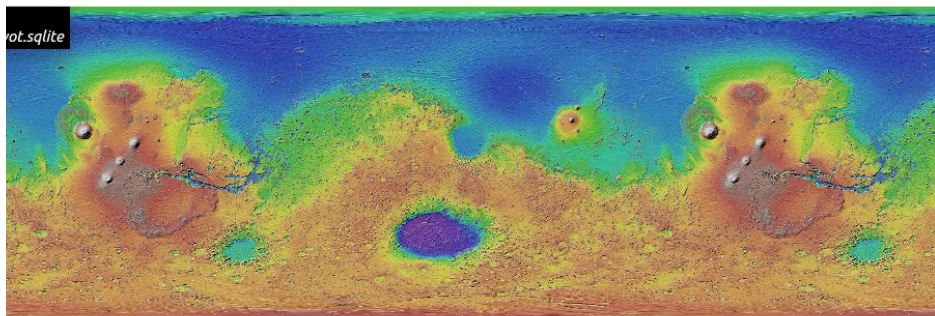
Assessment based on VIRTIS / VEx experiment

=> demo that imaging spectroscopy data, with ancillary information, can be provided in fits & embedded in PDS4

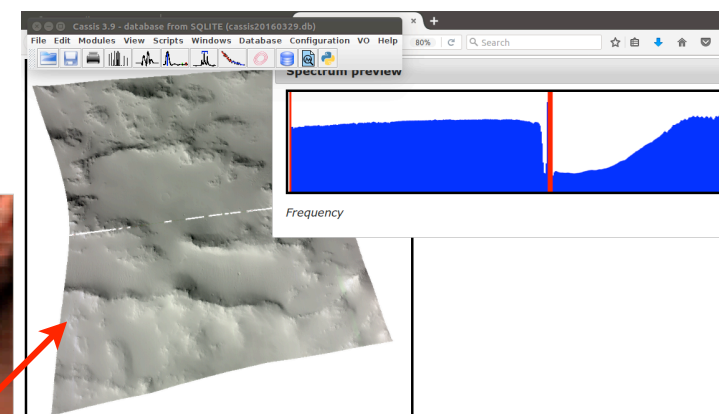
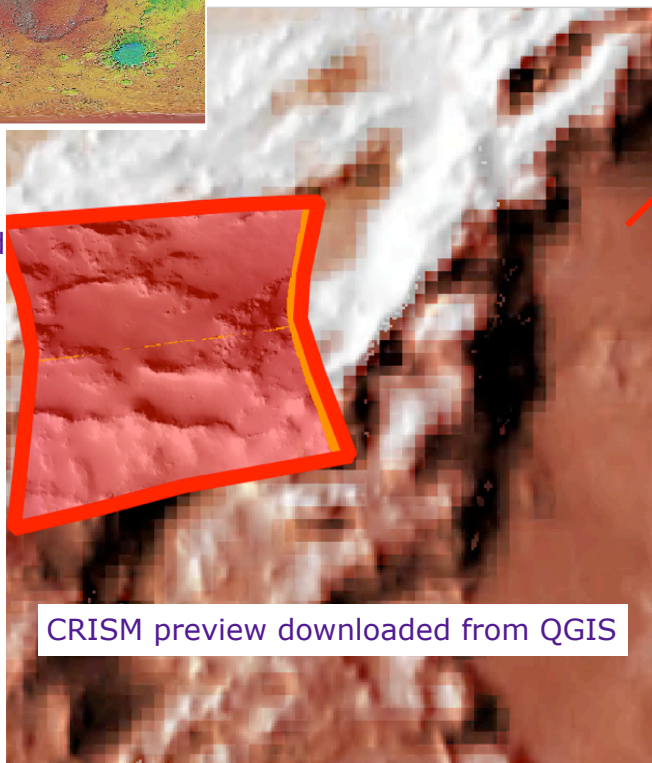
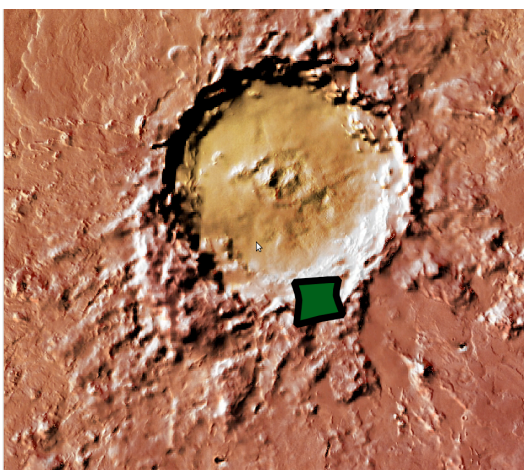
# Typical workflow in imaging spectroscopy involving GIS queries

- identify CRISM granules (cubes) of interest from EPN-TAP query
- passes WMS queries to QGIS (via new SAMP plug-in), plot maps
- passes WCS footprints to QGIS, forward to Aladin
- New Image plug-in downloads the preview
- subgranule module browses spectra, forward to CASSIS

USCS\_WMS map SAMPed to QGIS from VESPA portal

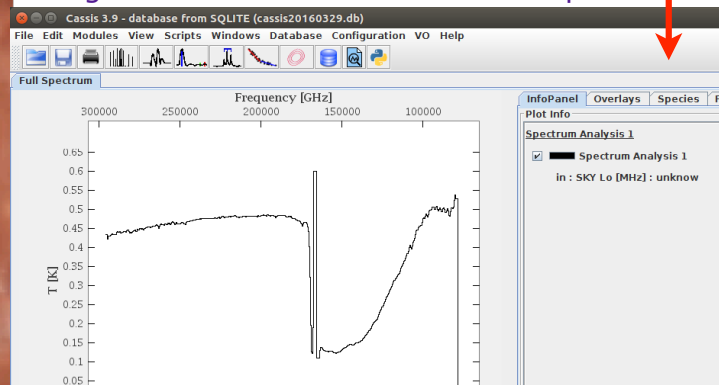


CRISM footprint SAMPed from portal & overplotted



Click on the image, spectrum for that location will appear on the box below:  
Copy and paste it in a text editor and save as .fus, open with CASSIS.

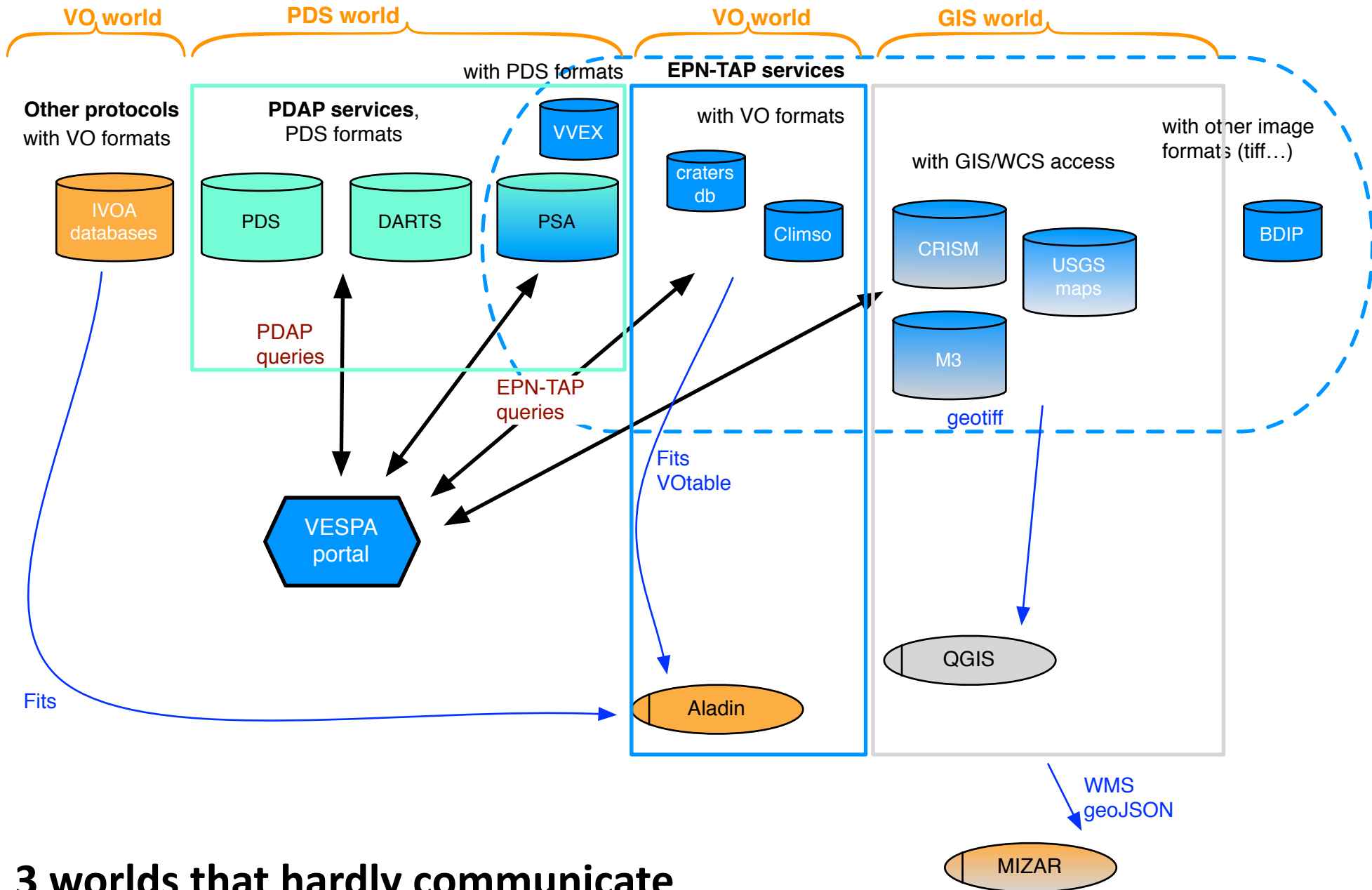
Subgranule module browses cube in portal



Spectrum forwarded to CASSIS

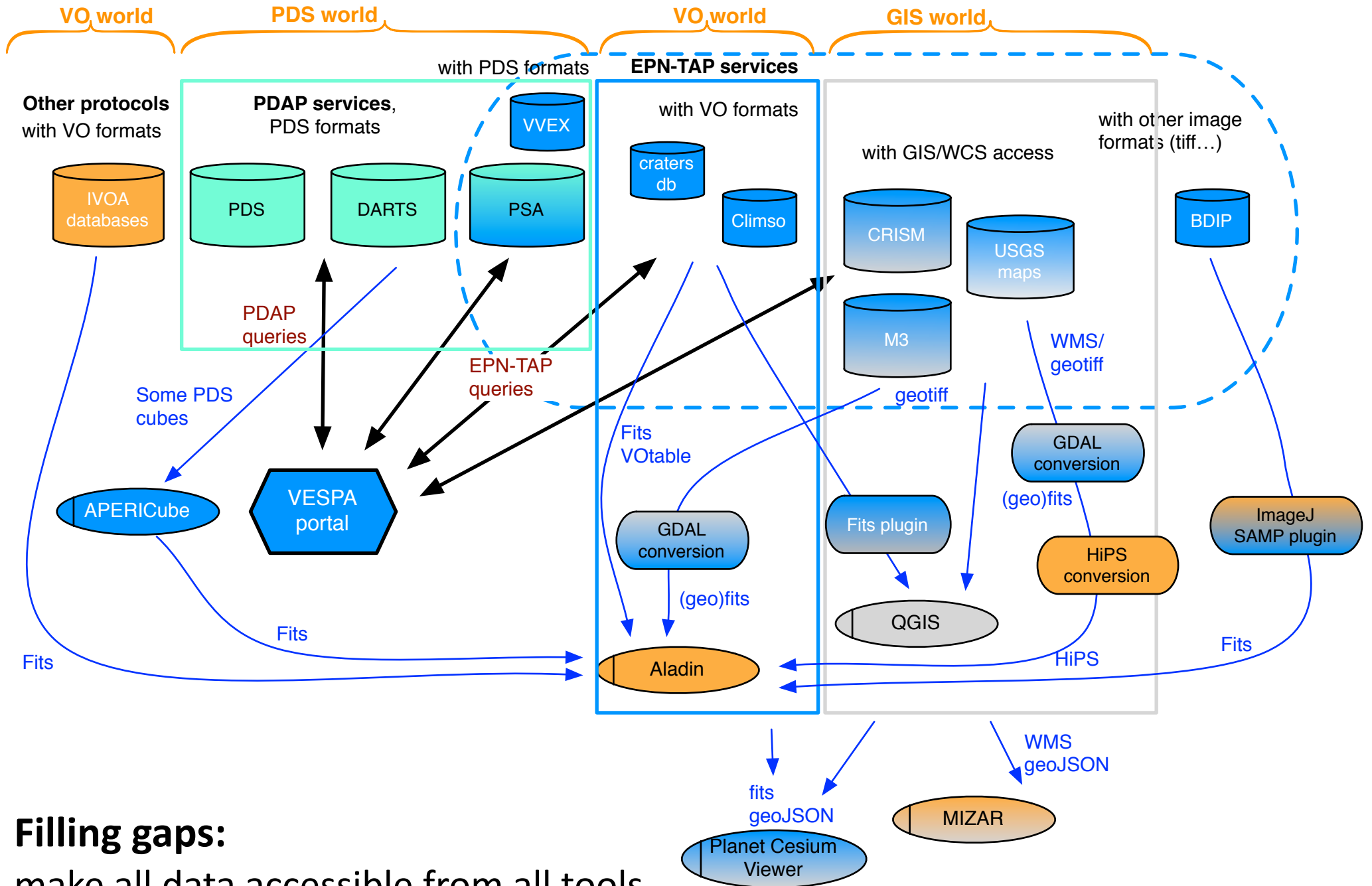


# Planetary images: data and tools



**3 worlds that hardly communicate**  
but EPN-TAP allows for searches in data services

# Planetary images: data and tools



**Filling gaps:**  
make all data accessible from all tools

## VESPA VO-GIS bridge, summary

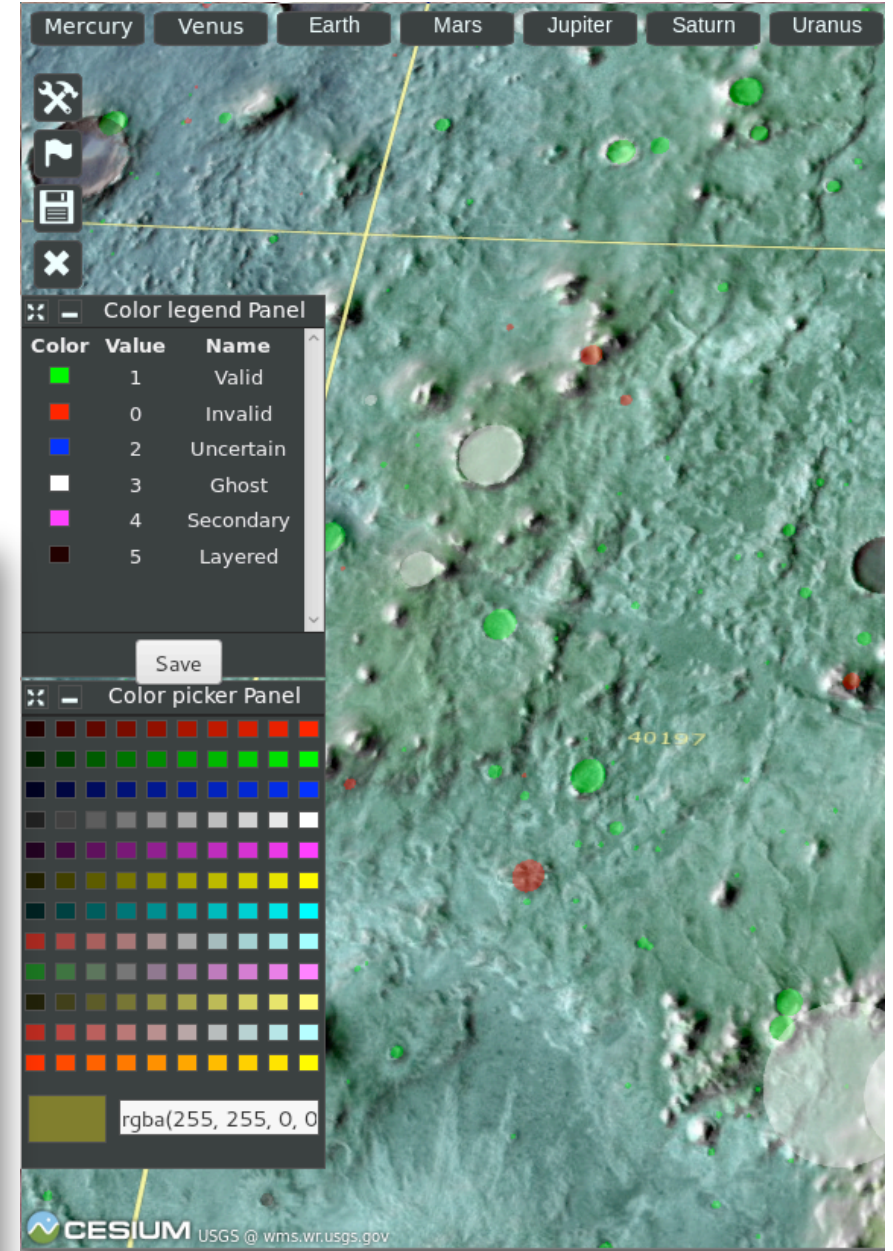
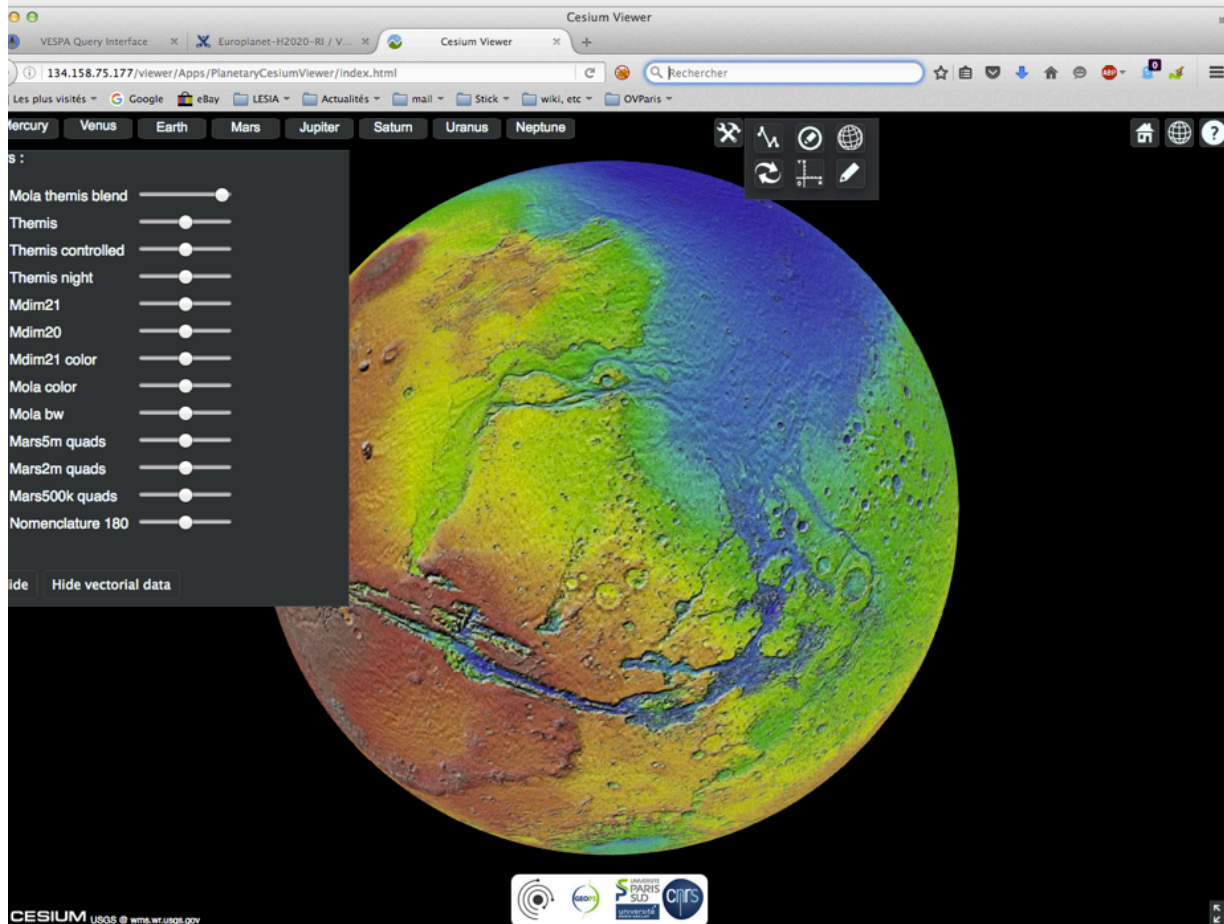
- EPN-TAP services can provide WMS or WCS requests instead of file URL (currently CRISM, M3, USGS\_maps, HRSC) - add service for MarsSI outputs?
- These data can be sent to QGIS (open source, terrestrial)  
Planetary GIS such as JMars are closed and can't be used as viewers
- Format conversion relies on GDAL library (extended fits  $\Leftrightarrow$  geotiff)  
Can be included in workflows (fits handled in QGIS)
- Tools connection relies on SAMP
- USGS reference maps (WMS/geotiff) are converted to HiPS for use in Aladin and other clients (other HiPS generated from different formats)
- Contours can be converted STC-S  $\Leftrightarrow$  geojson (coord syst ID required)  
DaCHS provides conversion to geojson (in progress)
- Contours can be sent from QGIS to Aladin (as STC-S)
- geojson bounding boxes are produced by VESPA portal for quick display

# New VESPA tool

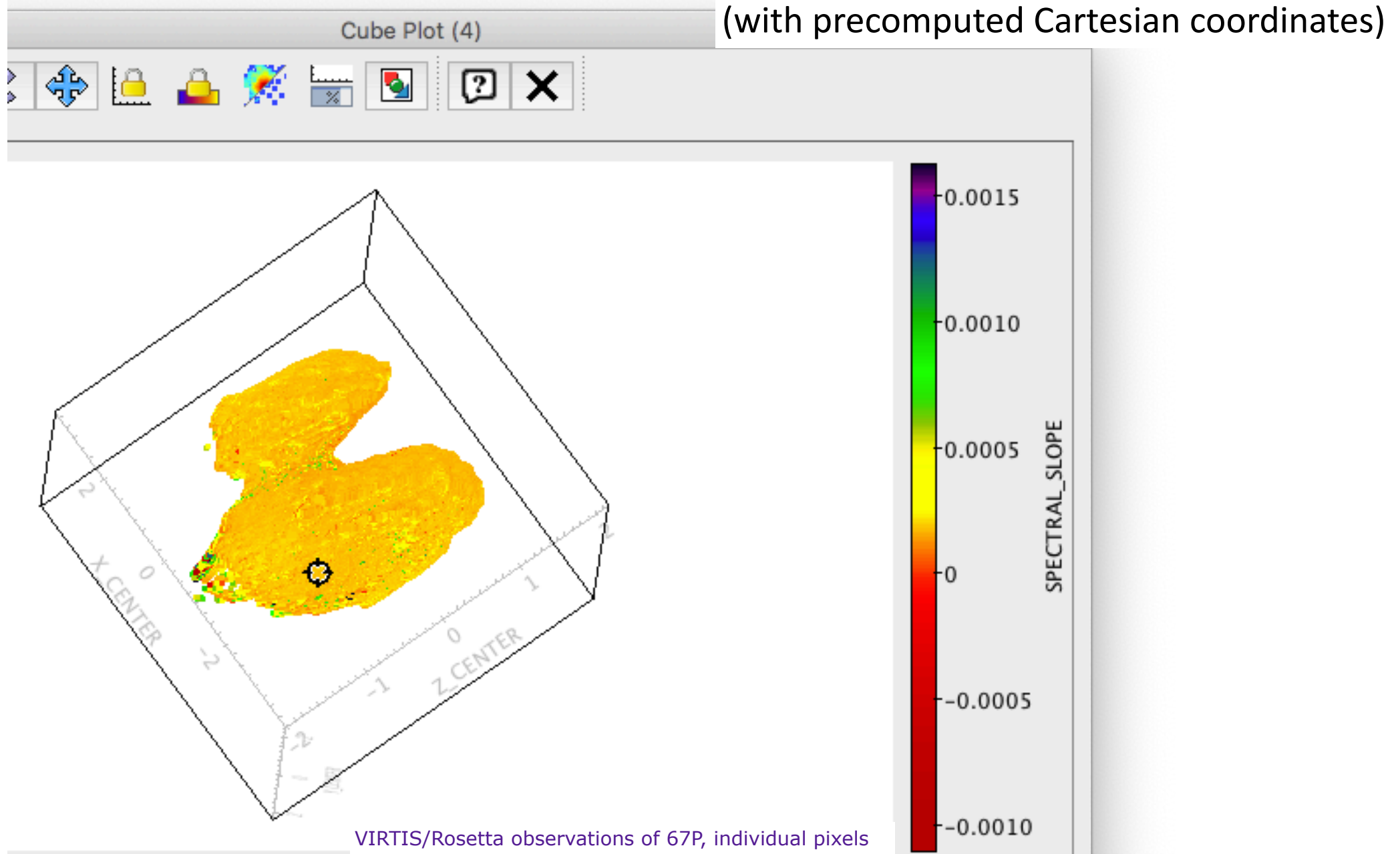
## Planetary Cesium Viewer (GEOPS/CNRS)

- Quick multiresolution 3D visu
- Supports ellipsoids
- Annotation/validation tool
- SAMP implementation to come

<http://134.158.75.177/viewer/Apps/PlanetaryCesiumViewer/index.html>



Robbins Mars craters database in PCV



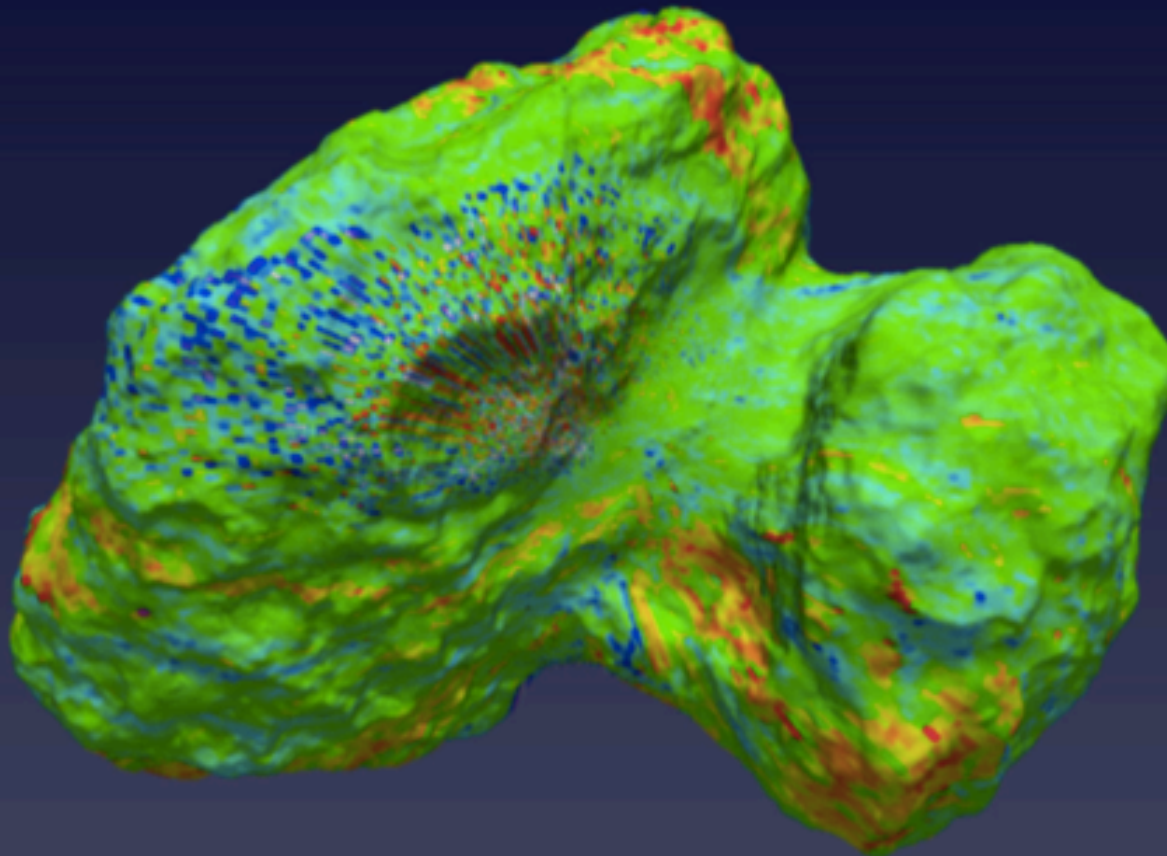
## Updated tools in VESPA

## MATISSE (ASI):

mapping on 3D shape models

SAMP connection added

<https://tools.ssd.cnr.it/matisse.jsp>



Reflectance @ 1.2 micron (corrected)

0.040      0.048      0.055      0.063      0.070



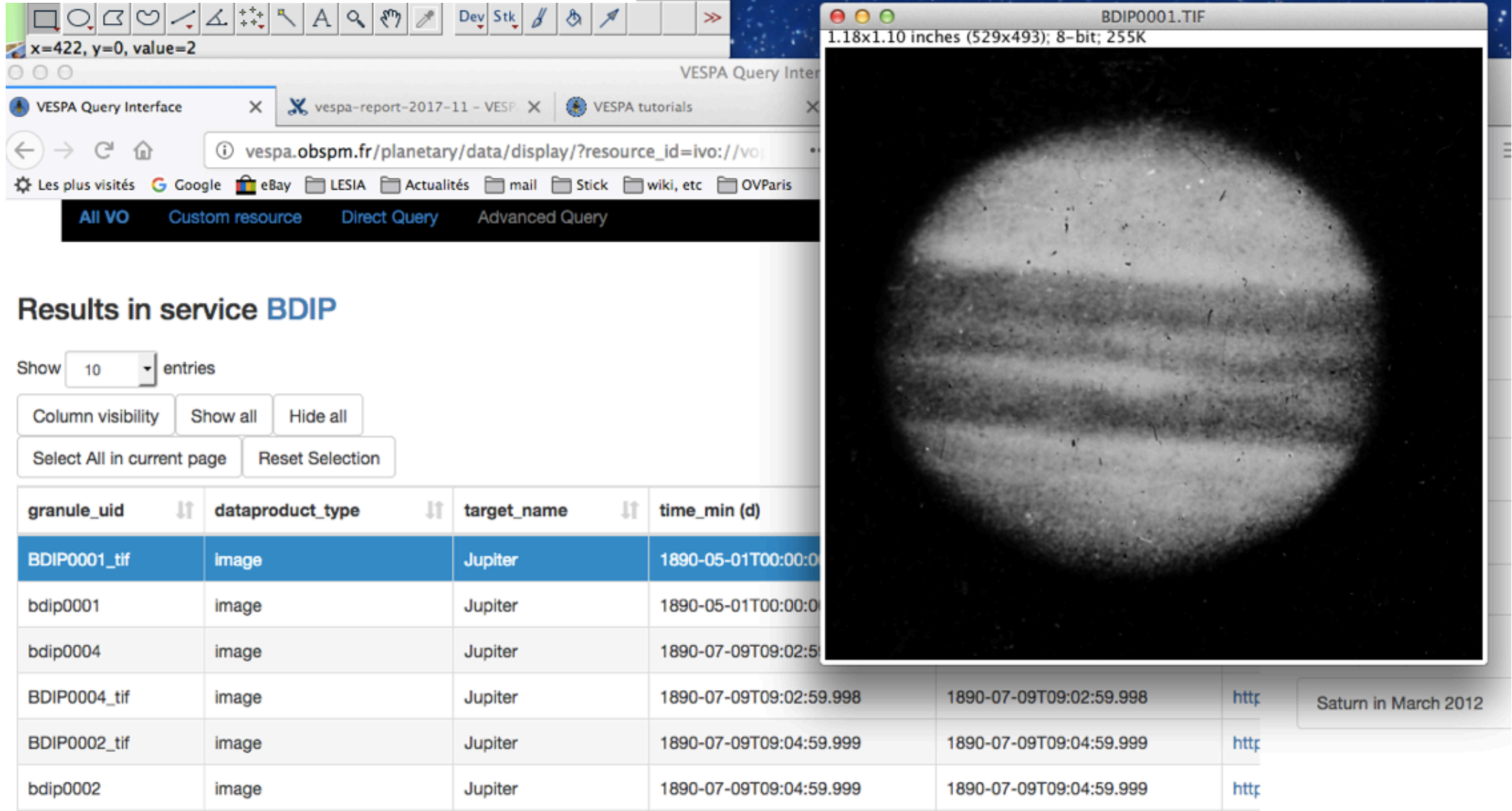
VIRTIS/Rosetta observations of 67P on OSIRIS 3D shape model

# New tools in VESPA

## ImageJ (open source):

- SAMP connection installed (input only)
- Provides support for unusual data types (TIFF...) & format conversion
- Provides image processing functions in the VO

Historical image of Jupiter from BDIP (tiff format) in ImageJ



The screenshot shows a web browser window with the VESPA Query Interface. The address bar displays the URL: `vespa.obspm.fr/planetary/data/display/?resource_id=ivo://vo`. Below the browser, a table titled "Results in service BDIP" is visible. The table has columns for `granule_uid`, `dataprod`, `target_name`, and `time_min (d)`. The first row is highlighted in blue and corresponds to the image shown in the overlaid window.

granule_uid	dataprod	target_name	time_min (d)
BDIP0001_tif	image	Jupiter	1890-05-01T00:00:00
bdip0001	image	Jupiter	1890-05-01T00:00:00
bdip0004	image	Jupiter	1890-07-09T09:02:59.998
BDIP0004_tif	image	Jupiter	1890-07-09T09:02:59.998
BDIP0002_tif	image	Jupiter	1890-07-09T09:04:59.999
bdip0002	image	Jupiter	1890-07-09T09:04:59.999

The overlaid window titled "BDIP0001.TIF" shows a grayscale image of Jupiter with a resolution of 529x493 pixels. The image displays the characteristic bands of Jupiter's atmosphere.

## Conclusion (surfaces)

- VESPA mature, proposes standard VO-based solutions to handle surface data
  - Will be supported in Europlanet-2024 for 4 years*
  - Main focus remain data search & visu + further processing*
  - Need to add new dedicated functions in VO tools*
- Open issues
  - Coord syst need std description and IDs (hopefully common with planetary GIS)*
  - Extend both geojson & s\_region standards to support planetary context*
  - Refine access to PDS data*
  - No standard for spectral cubes - cruelly missing*
  - Refine existing VO-GIS bridge, starting with refined fits support in GDAL (TBC)*

search interface

<http://vespa.obspm.fr>

web site (with tutos)

<http://www.europlanet-vespa.eu>

wiki

<https://voparis-confluence.obspm.fr/>

github

<https://github.com/e pn-vespa>