

# Virtual European Solar & Planetary Access (VESPA)

## Providing access to Solar System & heliophysics data

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OeAW/IWF, Graz  
IASB-BIRA, Brussels  
  
DLR, Berlin  
UCL, London  
Spacefrog, Toulouse  
SINP/MSU, Moscow

**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  
**SPACEFROG.**

OATS/INAF Trieste



DLR Berlin



+ Contributions from  
the community

UPV/EHU Bilbao



Univ. Bristol



UCL London



SINP-MSU Moscow



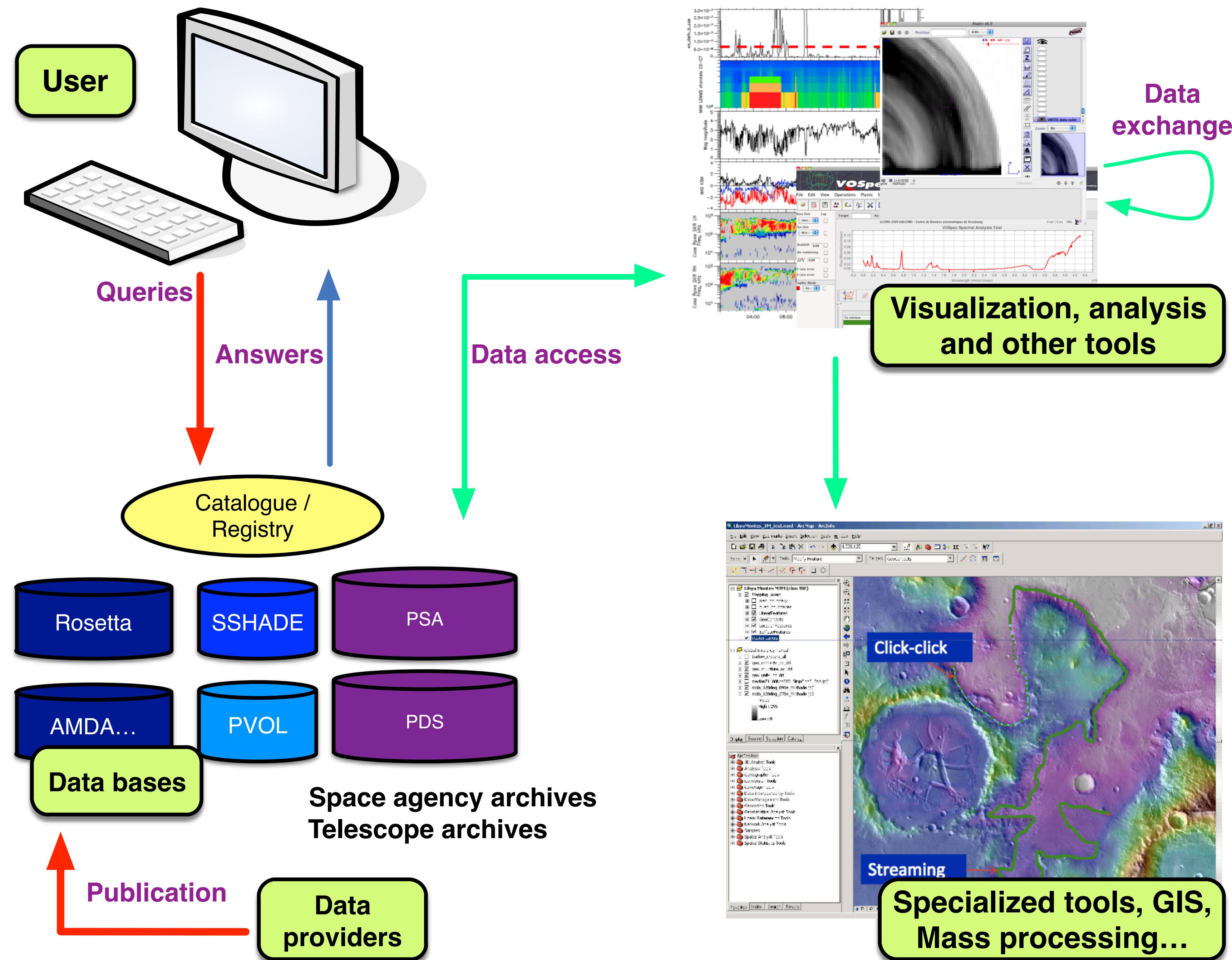
Univ. Heidelberg



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

Scope:  
Planetary Science  
Heliophysics  
Exoplanets

Research teams, institutes  
EU projects  
=> Open Science



# VESPA

## History:

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

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

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

## Overall architecture:

**Virtual Observatory (VO), to be adapted to Planetary Science** - and consistent with main contributors in the field: space agencies, other consortia (IPDA, SPASE...), large institutes, etc

## Develop whatever required:

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

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

**Visu and analysis tools:** handling by VO tools (and possibly other ones)

**Data publication tools and procedures**

=> **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

## What VESPA provides to the community

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

**EPN-TAP:** relies on TAP + adds specific vocabulary:

Not only (reflected) light, but also particles, e-m fields + laboratory samples => new UCDs

+ funny coverages: time scales/location, coord systems on many bodies, etc

=> **EPNCore metadata** - standard in the Virtual Observatory (VO); open to user feedback

**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 57 data services open, ~ 15 more in development**

**Includes ESA's PSA (20+ million files!) + New or updated infrastructures: SSHADE, PVOL, AMDA**

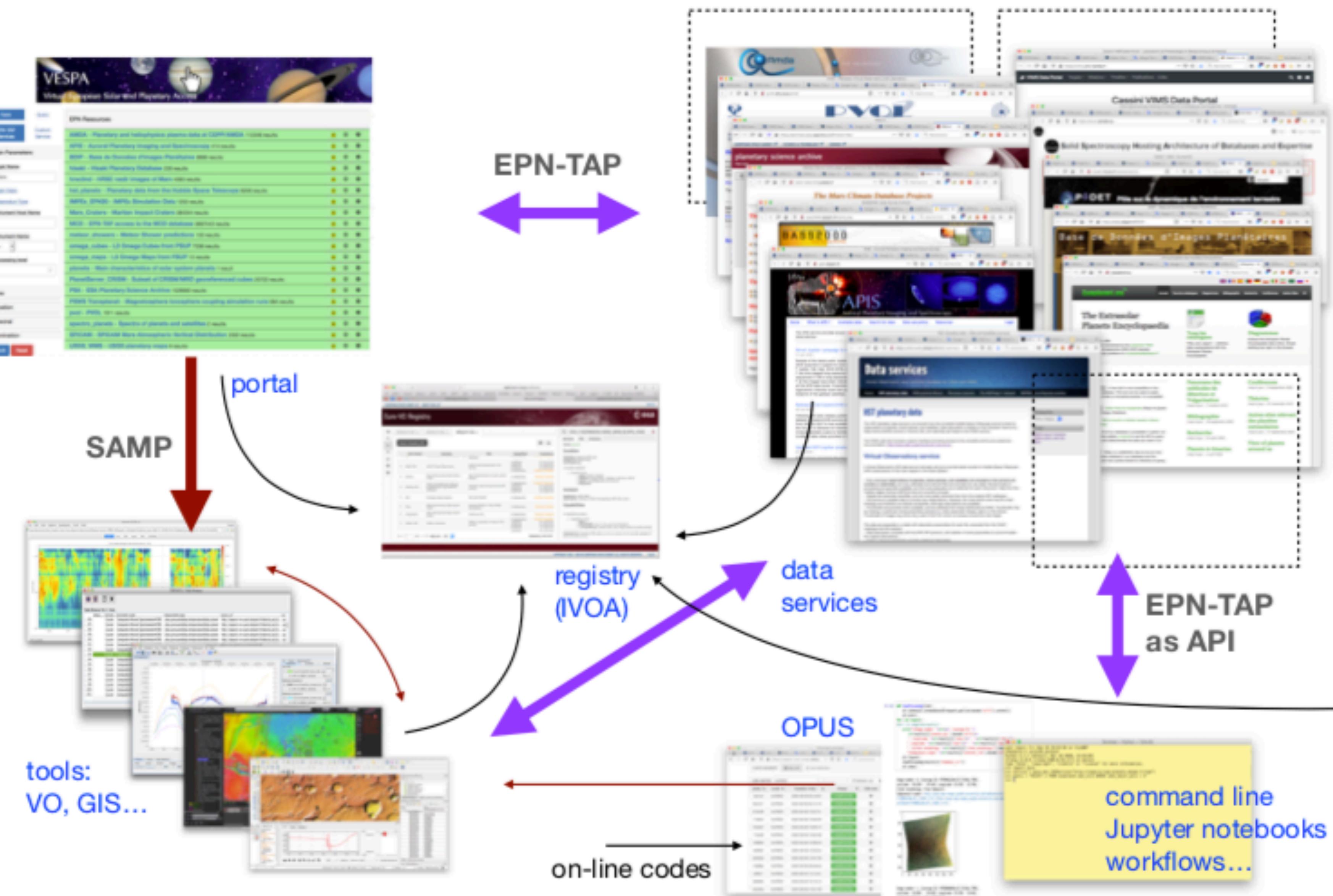
**Will include data produced during Europlanet 2024 RI (experimental & field studies)**

### 4- Connection with powerful display and analysis tools:

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

# VESPA: infrastructure

## Maintenance functions



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

- Open
- Open in test / upgrade required
- Drafted
- Scheduled 2024 (selection)
- New or upgraded in 2020/21
- New content in 2020/21

## Atmospheres

- - Titan profiles - CIRS ([Cassini, LESIA](#))
- - *Venus spectroscopy* - *VIRTIS* ([VEx, LESIA](#))
- - Mars Climate Database (modeling, LMD)
- - 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)
  - *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 (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 ([LESIA / CDS](#))

## 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

- CRISM WCS service ([MRO, Jacobs U](#))
- - Mars craters ([Jacobs U, + update by GEOPS](#))
  - USGS planetary maps WMS ([Jacobs U](#))
- - PlanMap: geol maps ([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](#))
  - *MarsSI GIS* ([Lyon](#))
  - *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* ([LESIA & US amateur network](#))
  - Ilitate 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* (from 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 characteristics ([LESIA/IMCCE](#))
  - *Nasa dust catalogue* ([IAPS](#))
  - Stellar spectra, support for observations & expl. ([LESIA](#))
  - DARTS (JAXA - currently via PDAP)
  - *ESAsky planetary data* ([ESA](#))
  - Interface with VAMDC (TBD)

## Exoplanets

- - Encyclopedia of exoplanets (compilation, 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: Recent developments

## 1- EPN-TAP protocol

**Currently an IVOA Proposed Recommendation:** <https://github.com/ivoa-std/EPNTAP>

Being updated / corrected according to RFC

## 2- Dedicated client

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

Can query all EPN-TAP services together; uses SAMP, datalink, STC-S and MOC, etc

Layout being improved; alternative facets-based search being implemented (ElasticSearch)

## 3- Servers

**DaCHS 2.5** includes extended support and mixin; some services on **Vollt** (ESA PSA, VizieR\_planets)

**taplint 3.4.2** includes an **EPN-TAP validator**

## 4- Services

**Preserved on a common gitlab. Deployment on EOSC assessed**

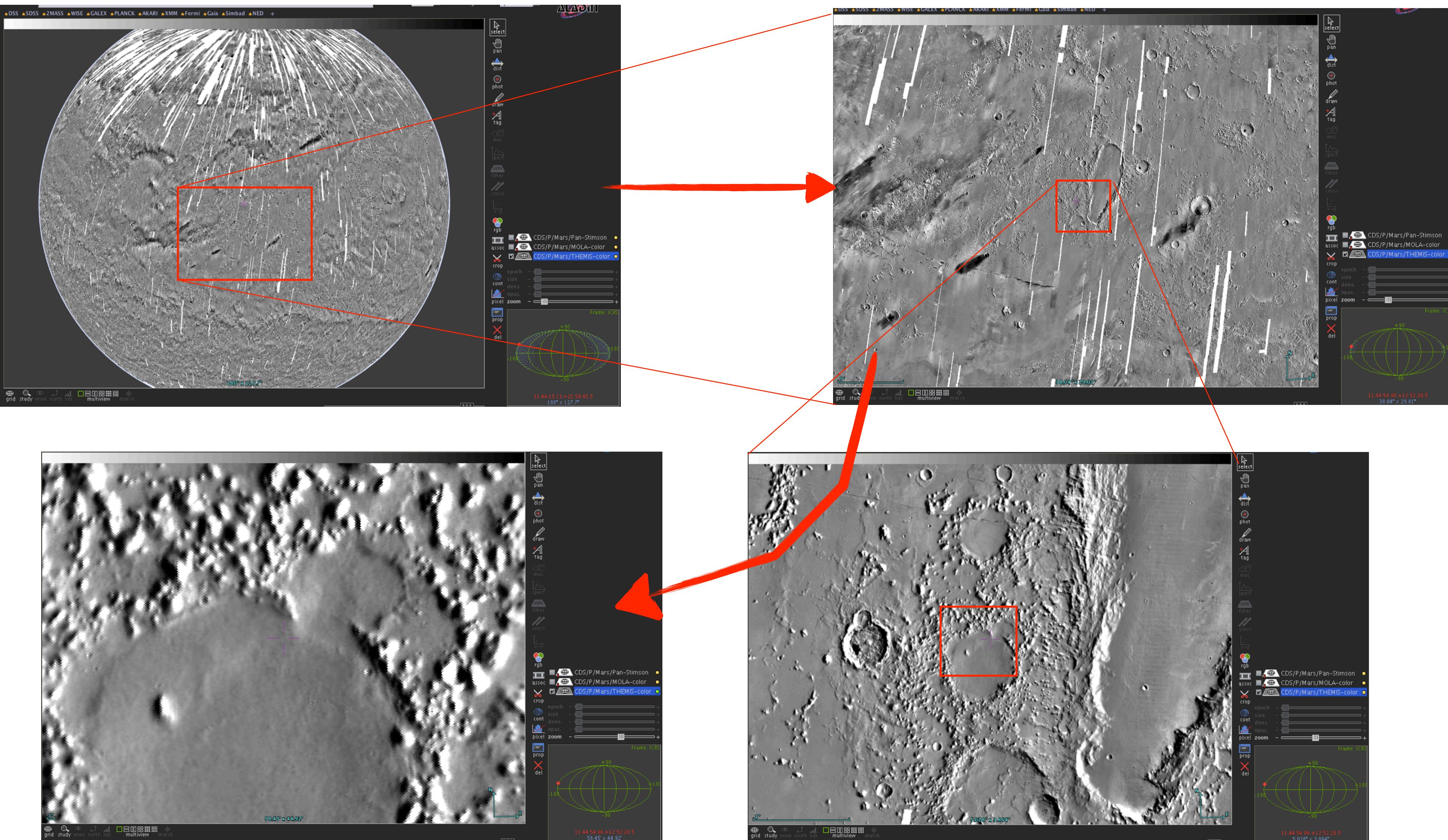
## 5- Workflows

**OPUS platform used in VESPA; ML techniques being assessed**

## **VESPA: Using VO tools in practical Planetary Science situations**

## VESPA and VO tools: images and maps

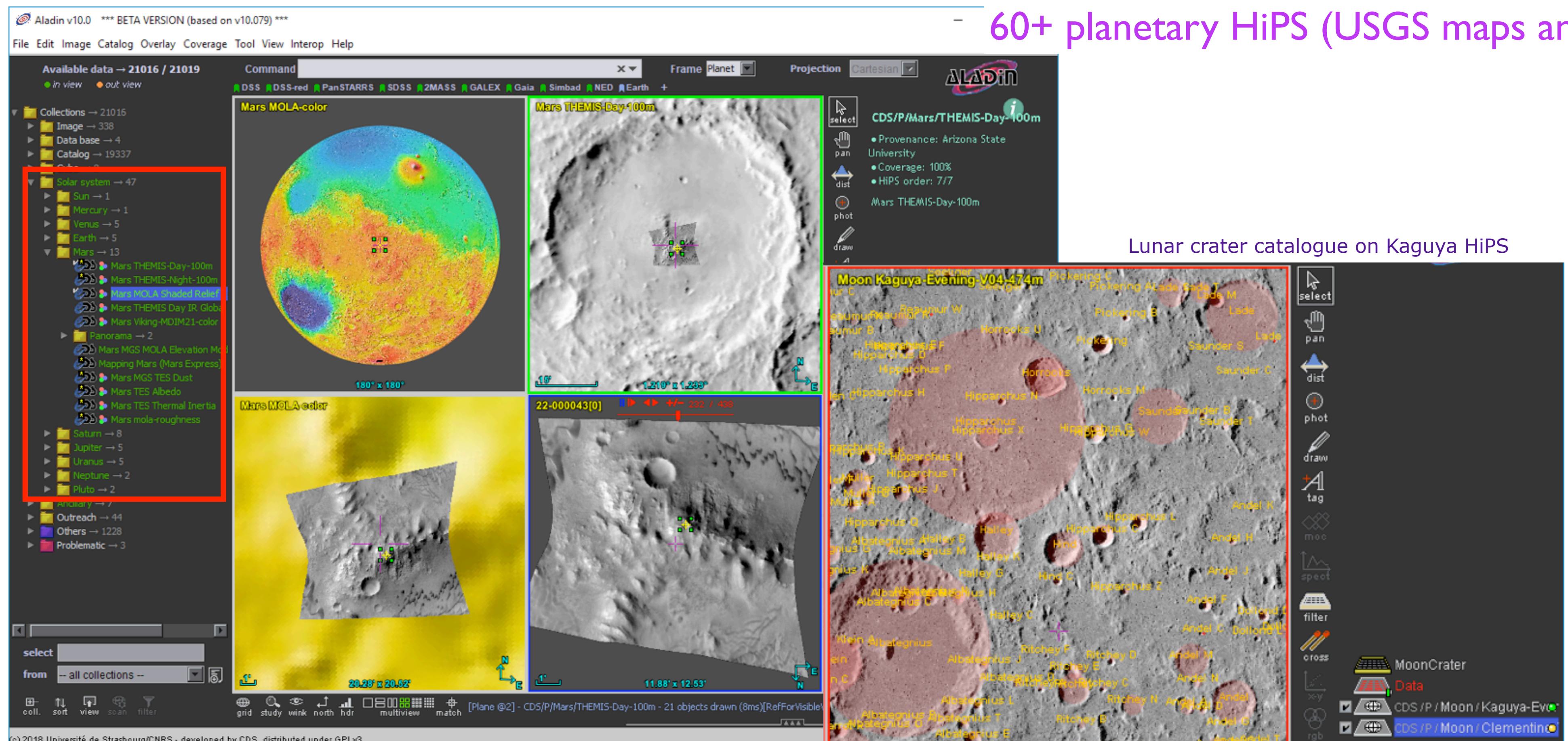
## Multiresolution maps (**HiPS**) in Aladin



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

Currently 60+ planetary HiPS available for use (from USGS maps and more)

# VESPA and VO tools: overplotting elements



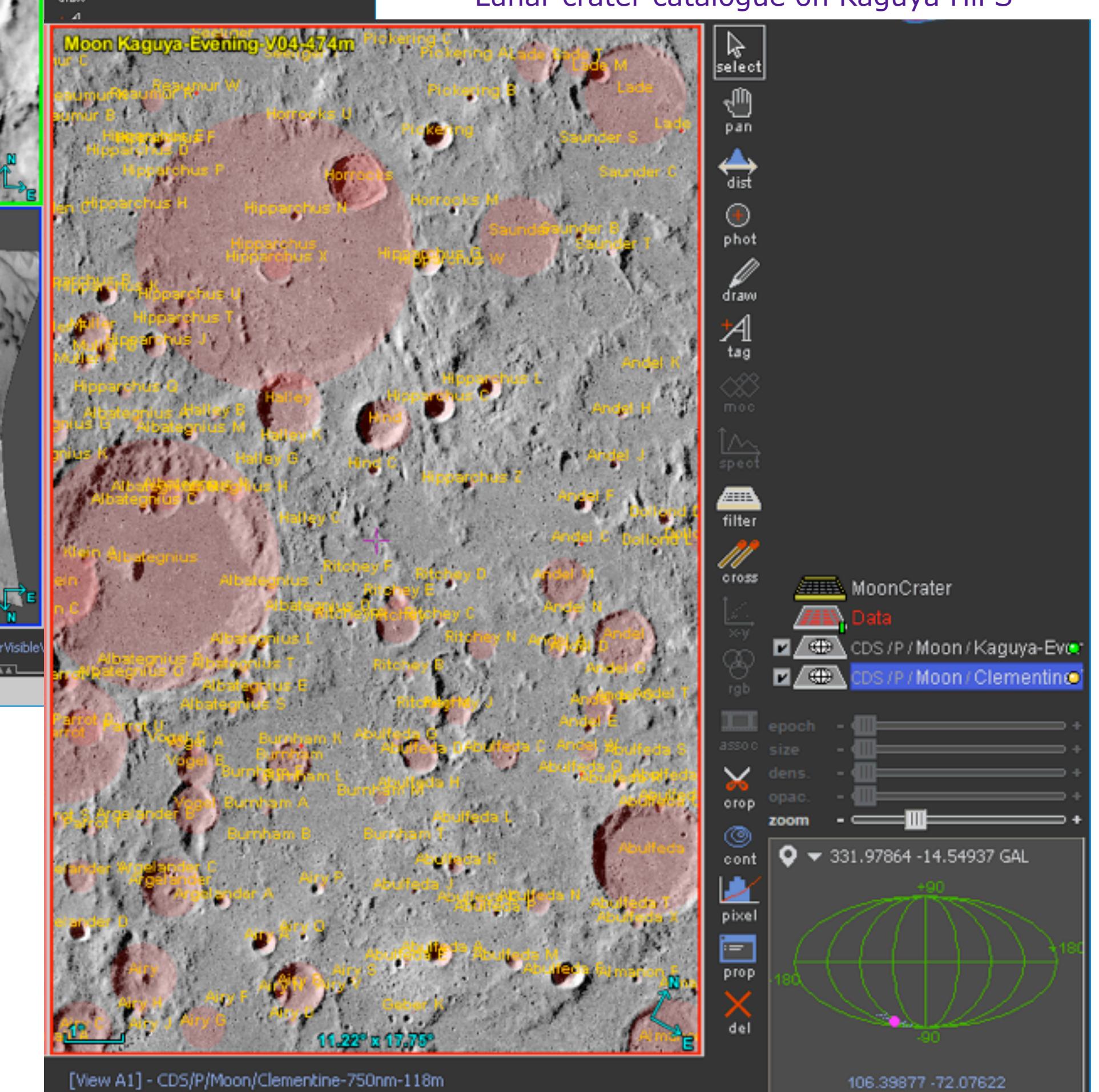
CRISM cubes on MOLA HiPS

Relies on IAU planetary coordinate frames (fits' WCS)

Aladin (CDS/CNRS):

Georeferenced images + objects superpositions

60+ planetary HiPS (USGS maps and more)



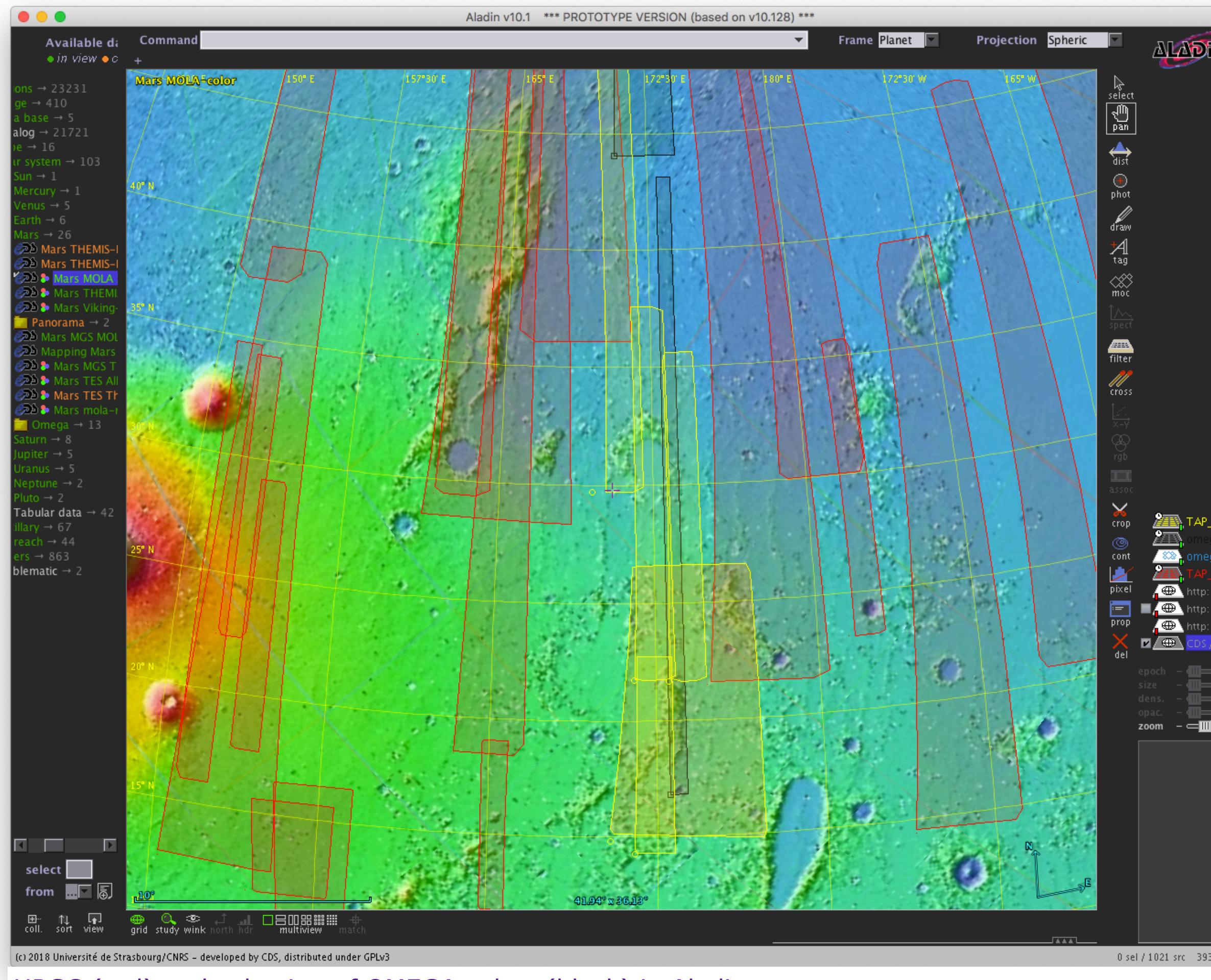
# Footprint-based searches (STC-S strings)

2D overlaps based on actual footprints, in TAP

Typical request:

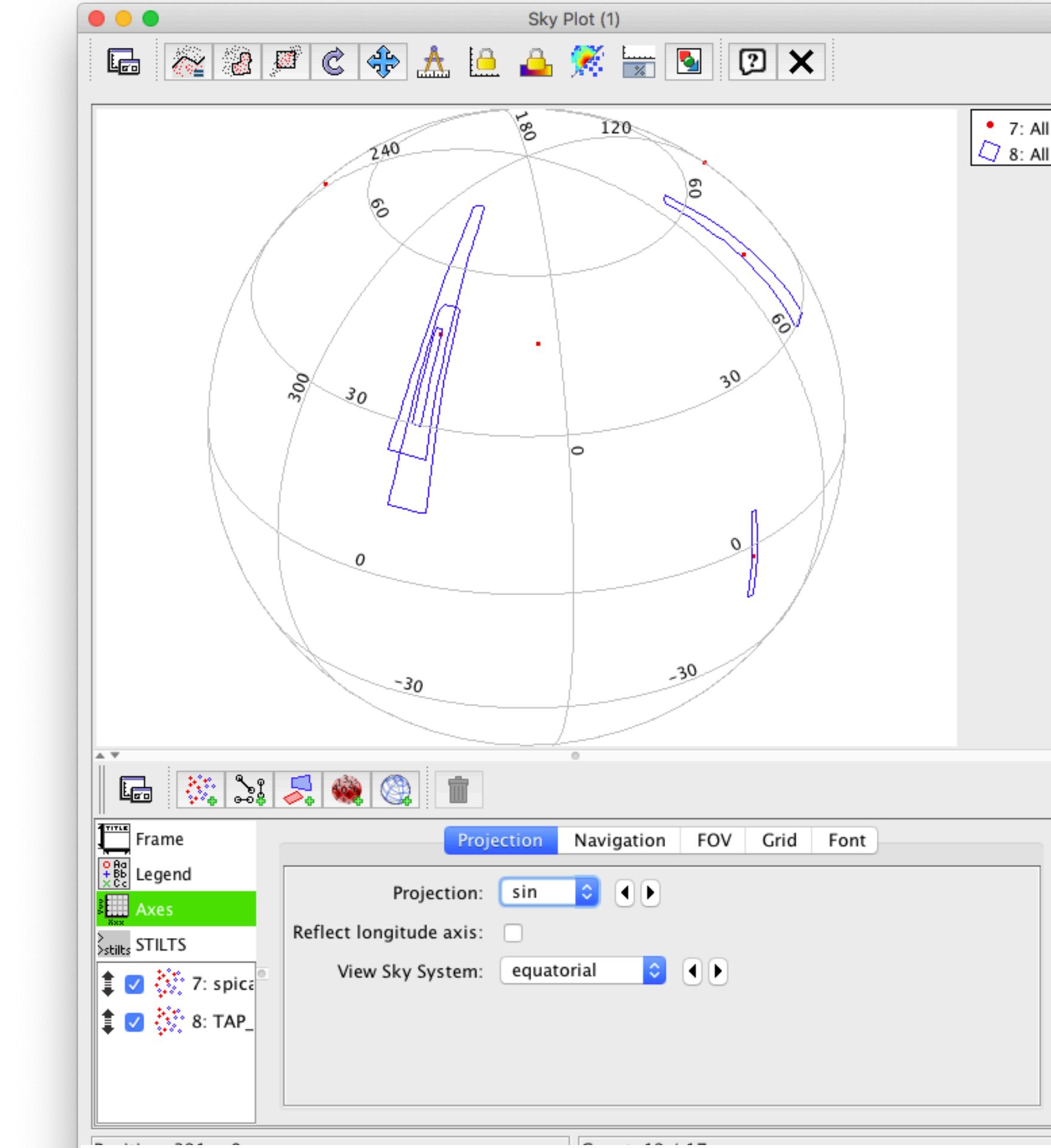
identify overlapping images / spectral cubes from different datasets based on footprints (also works with point features)

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)

(MOCs to come, with additional temporal/spectral coverages)

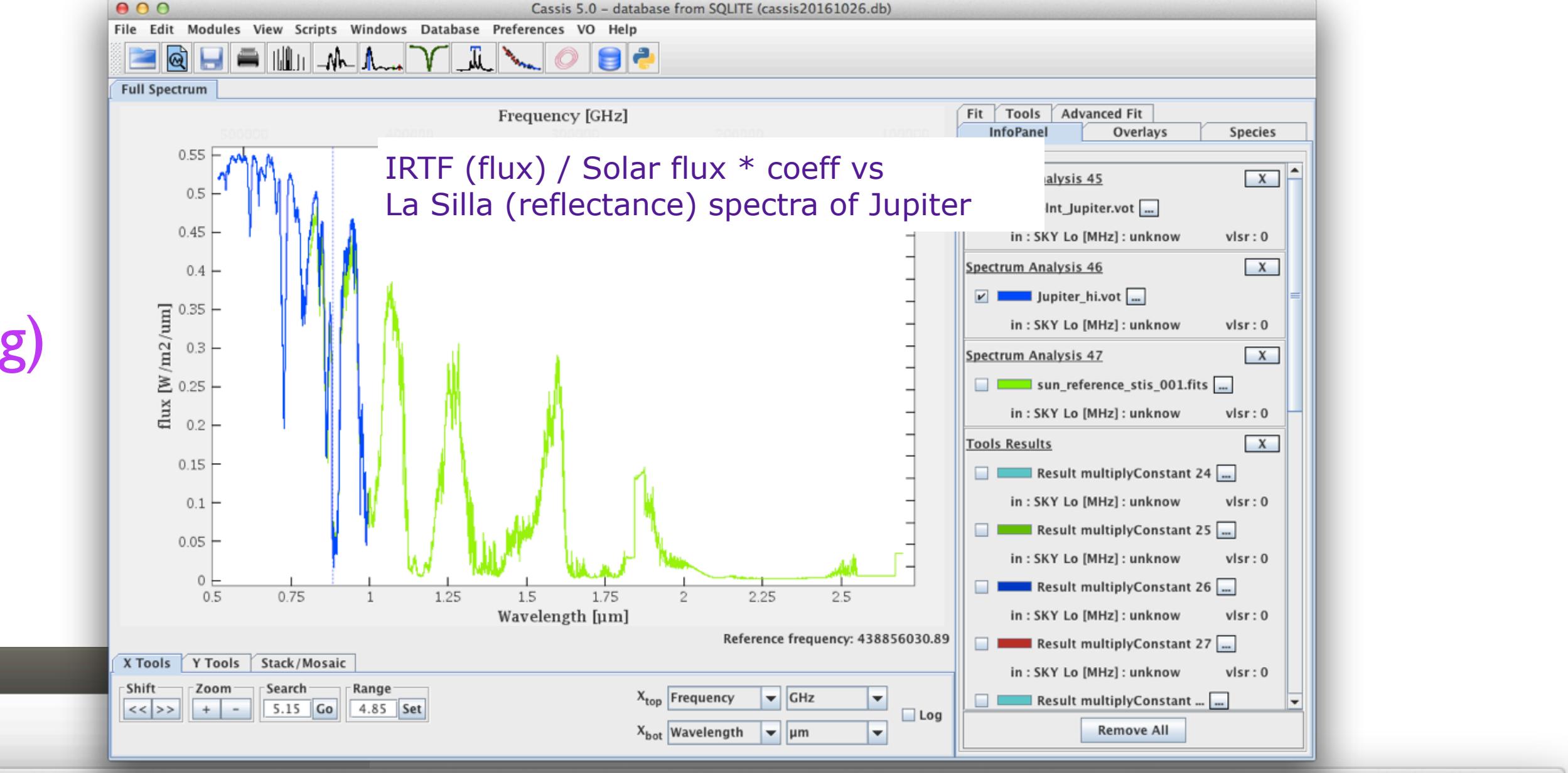
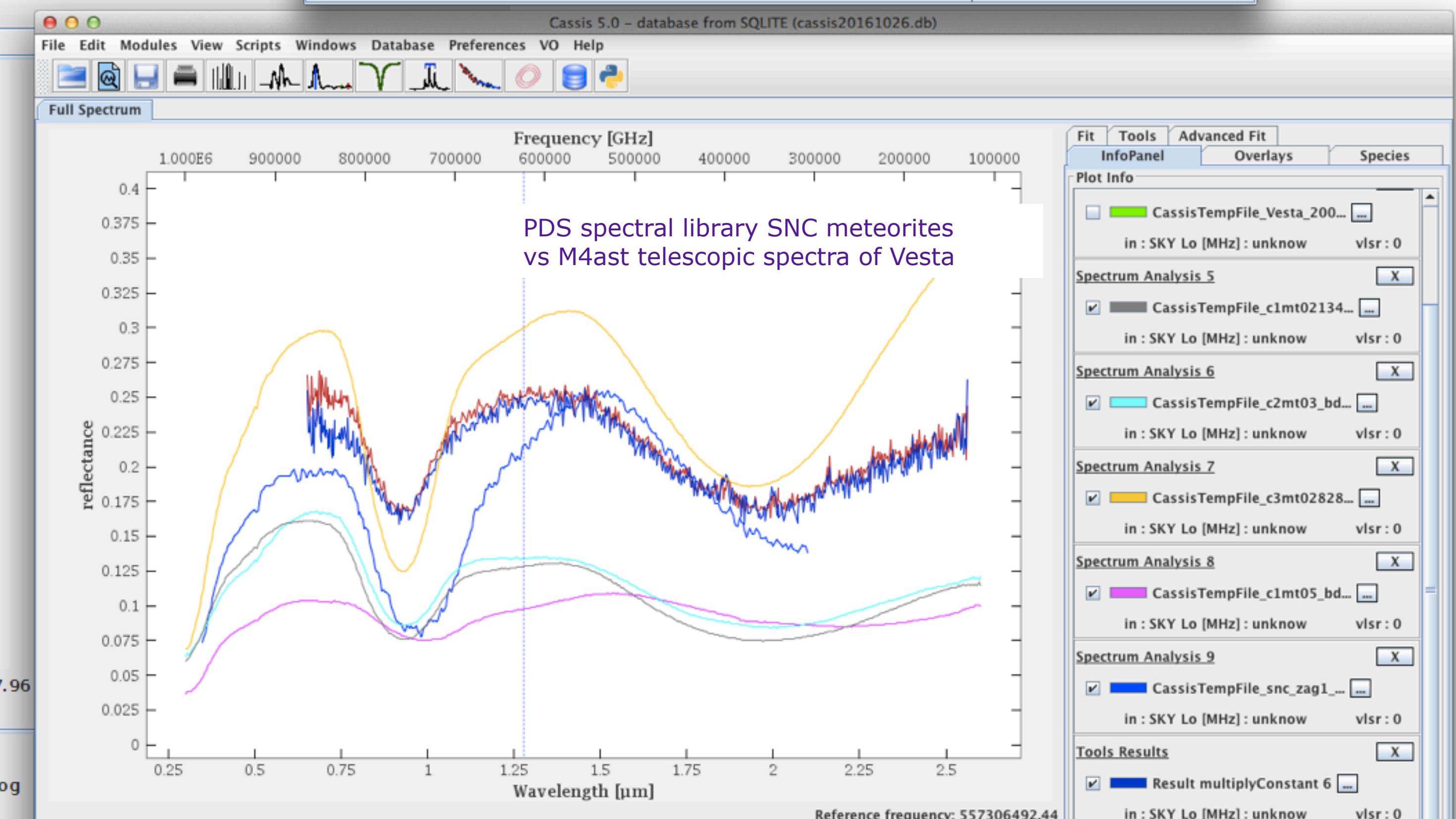
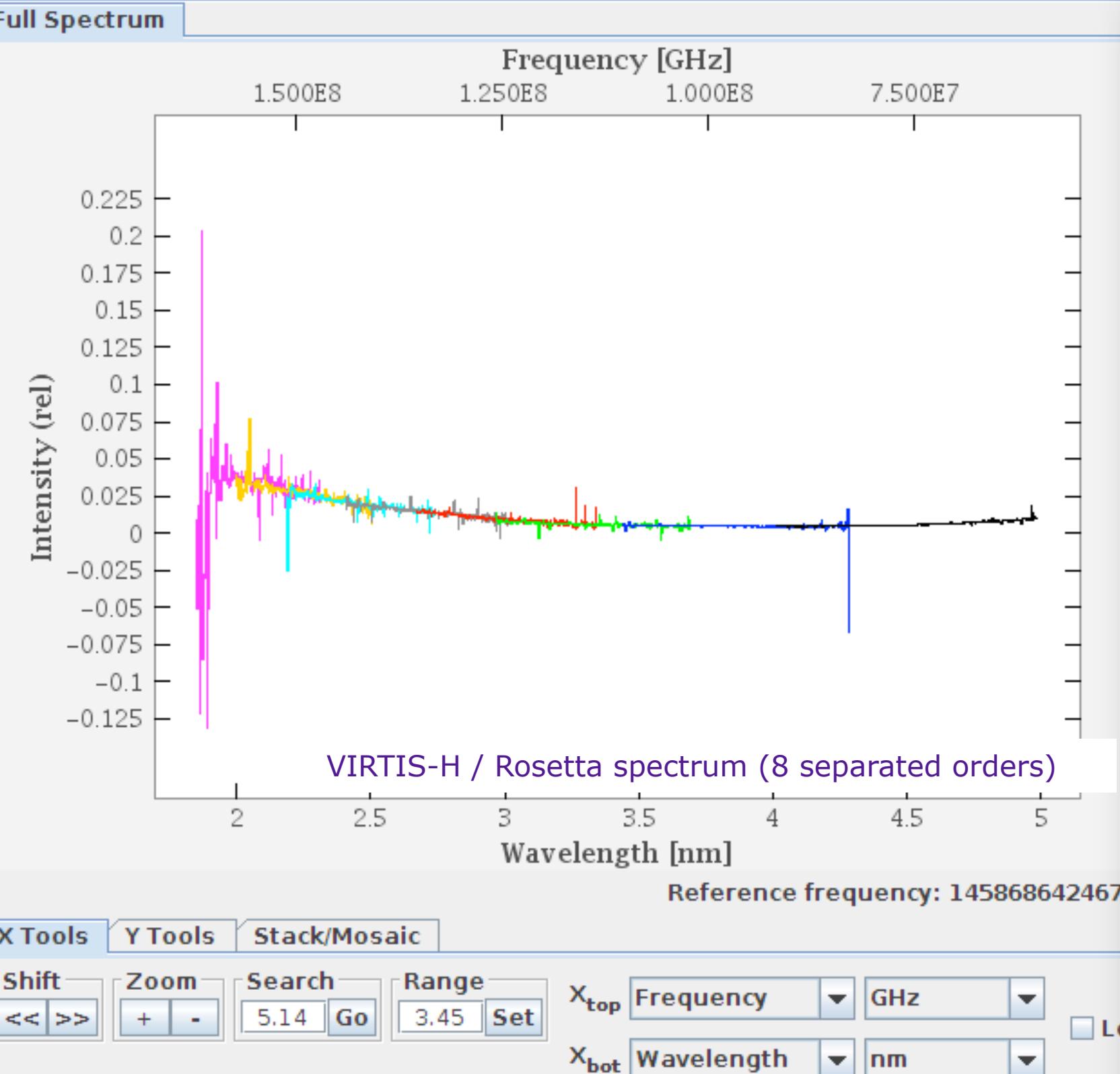
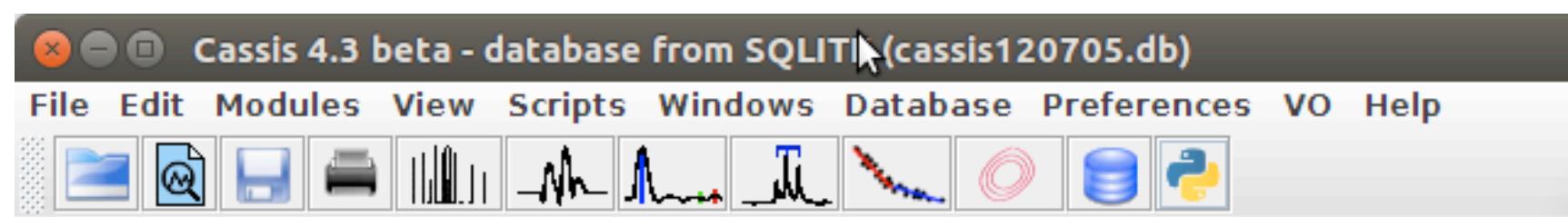


Selected SPICAM profiles (red) and overlapping HRSC images (blue) in TOPCAT (Mars-Express observations)

# VESPA and VO tools: spectroscopy

## CASSIS from v5 (IRAP/CNRS)

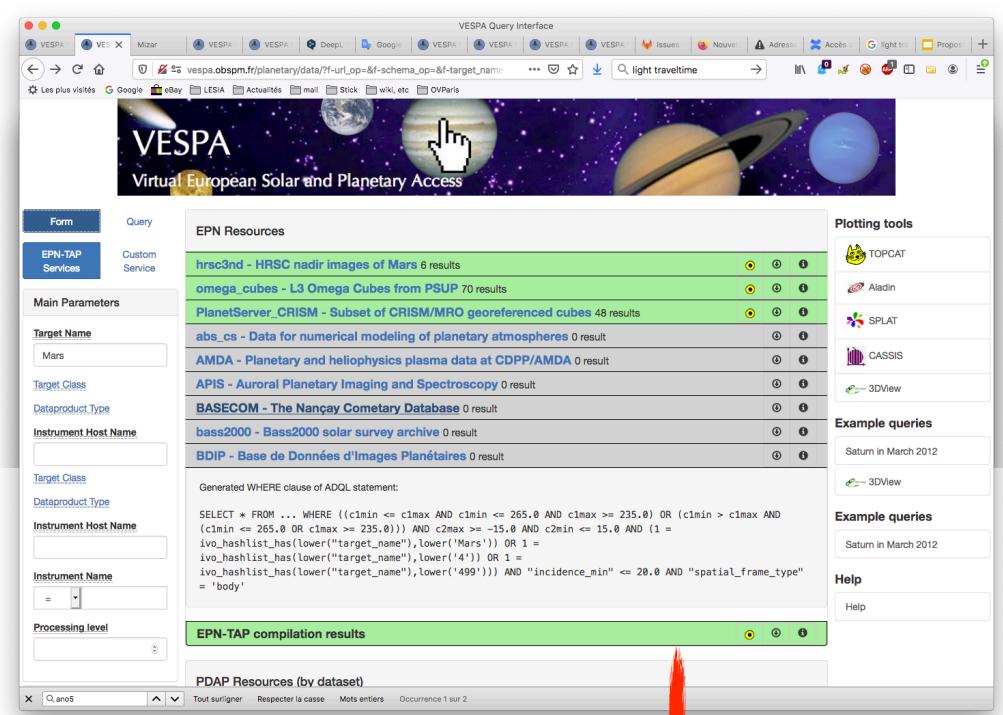
- Supports data in flux & various types of reflectance (scaling)
- Auto converts spectral axis & flux
- Supports échelle spectra



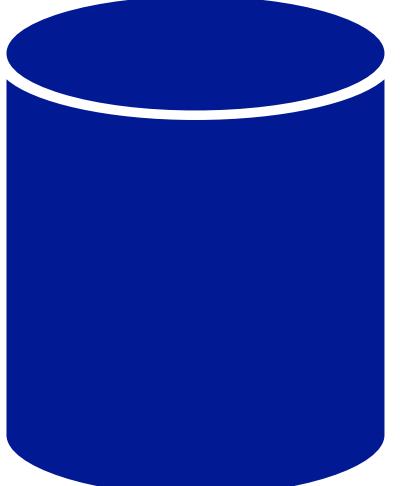
# VESPA VO-GIS bridge

service with fits images & spectra

## Portal



EPN-TAP query



TAP  
servers

service with OGC-type products

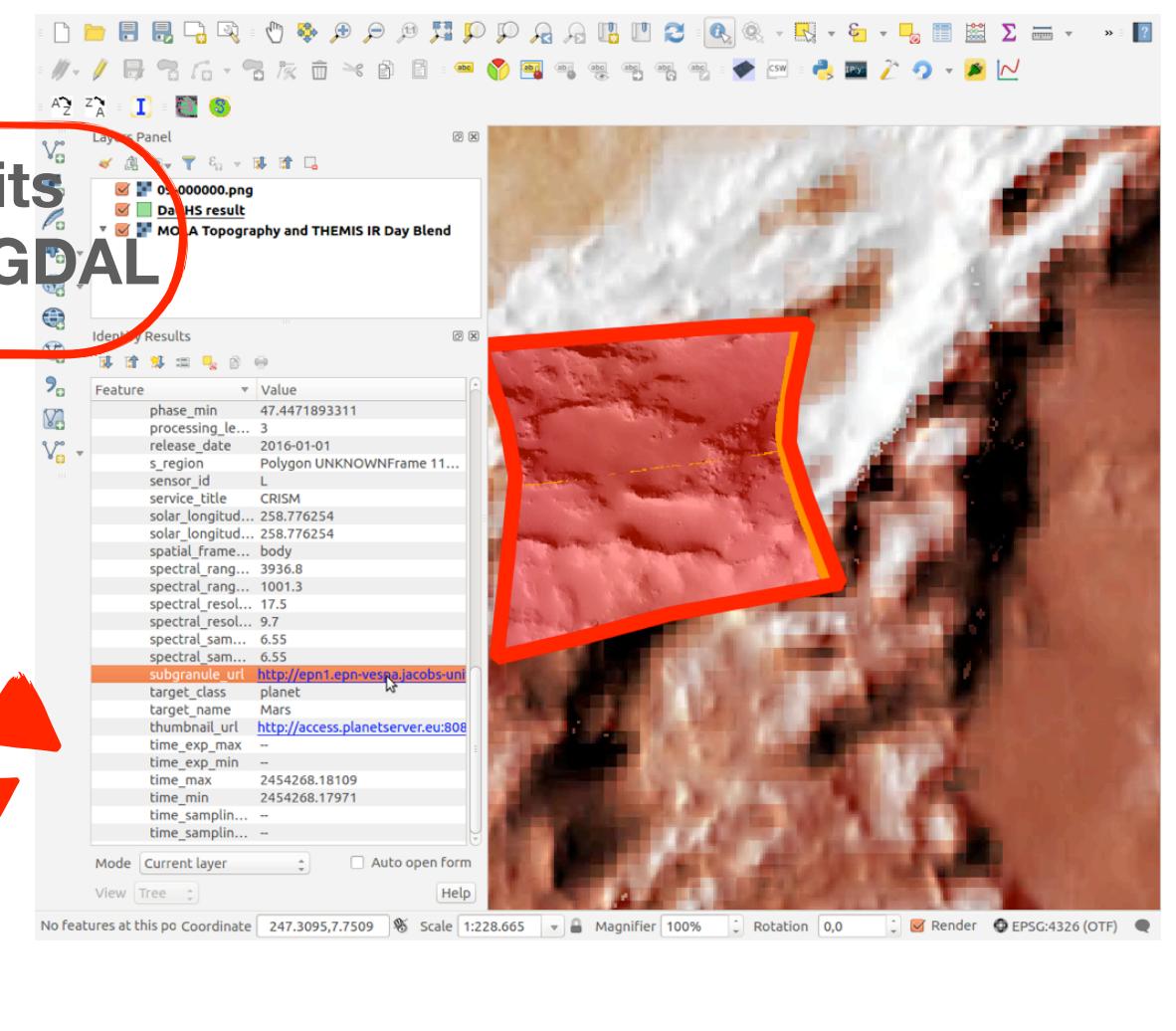
OGC  
servers

link:  
geofits image,  
spectrum

SAMP  
interface

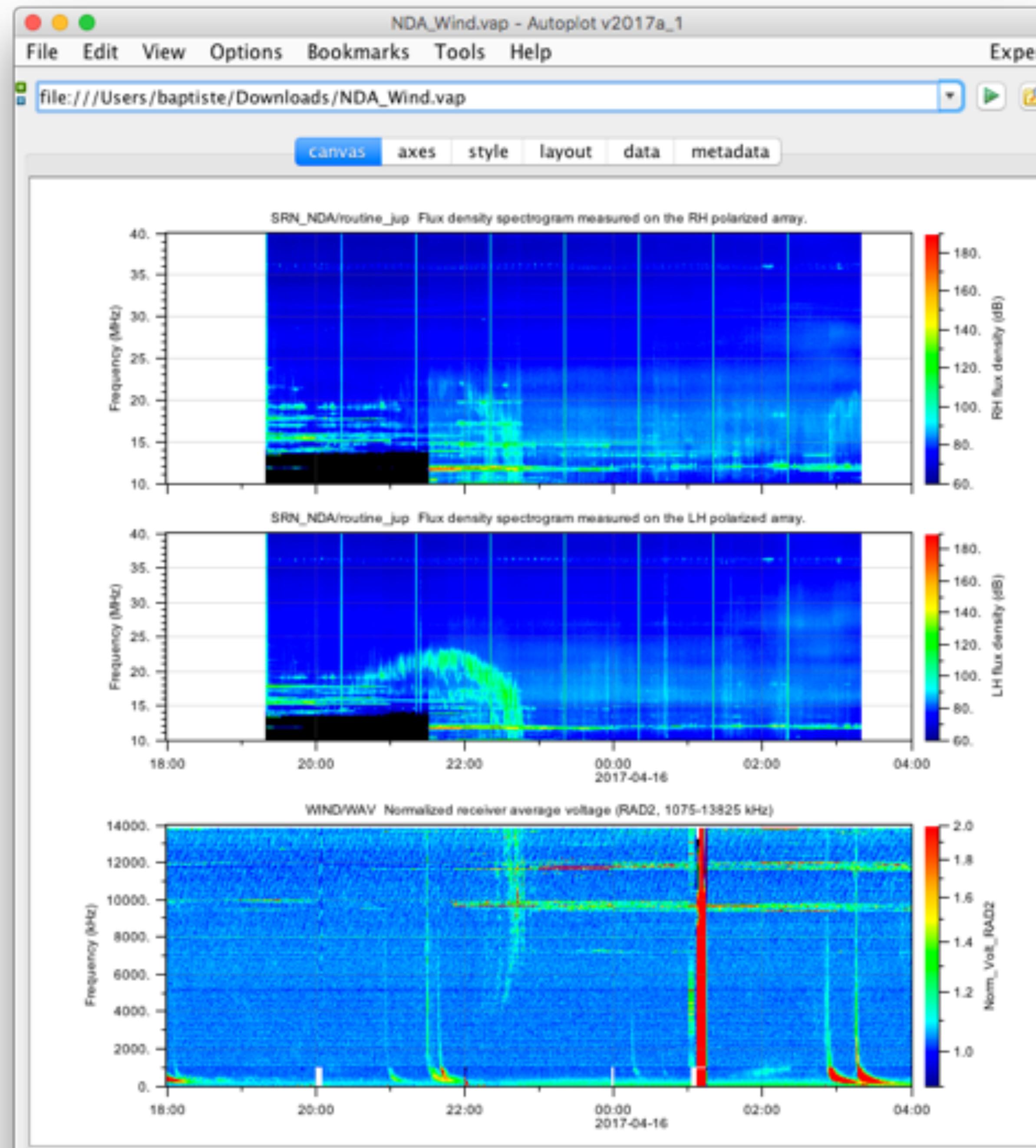
link:  
WMS/WCS query

QGIS



Std OGC query

## 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

## VESPA: Other usages

### 1- EPNCore is convenient for your own private work

**Design your personal data tables / organisation in advance — will save time eventually**

**Any data table can use EPNCore consistent vocabulary**

**Will benefit from powerful visu/analysis VO tools: Aladin, TOPCAT, CASSIS, etc**

**Powerful data handling functions in private context (experiments)**

### 2- Any institute/team can publish in the VO

**Off-the-self solution to distribute results, high visibility**

**Light system, docs and tutos available + Support from VESPA team**

**Infrastructure is maintained by the VO community**

### 3- VESPA is designed to support projects from calls

**Open Science policy:**

**National and EU-funded projects (ERC, H2020...) require the data to be made available**

### 4- Guidelines:

**Provide metadata, as complete as possible; Think about convenient formats**

**Larger projects may require a Data Management Plan (DPM)**