

Planetary Science & Provenance

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(and the VESPA team)

LESIA / Observatoire de Paris-PSL

Workshop Provenance in practice

14-15 dec 2021

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Planetary Science data use cases

Two examples of common situations

- • **Space borne observations:**
examples of VIRTIS on Venus-Express and Rosetta
- **Data services:**
VO services on small bodies

Focus here on VESPA — EPN-TAP data services

Space-borne observations

- **During acquisition/processing phase:**

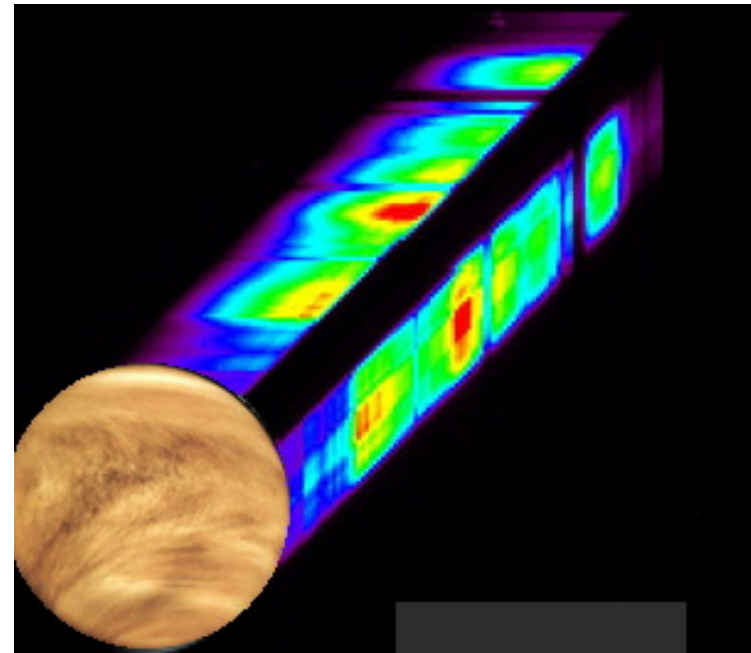
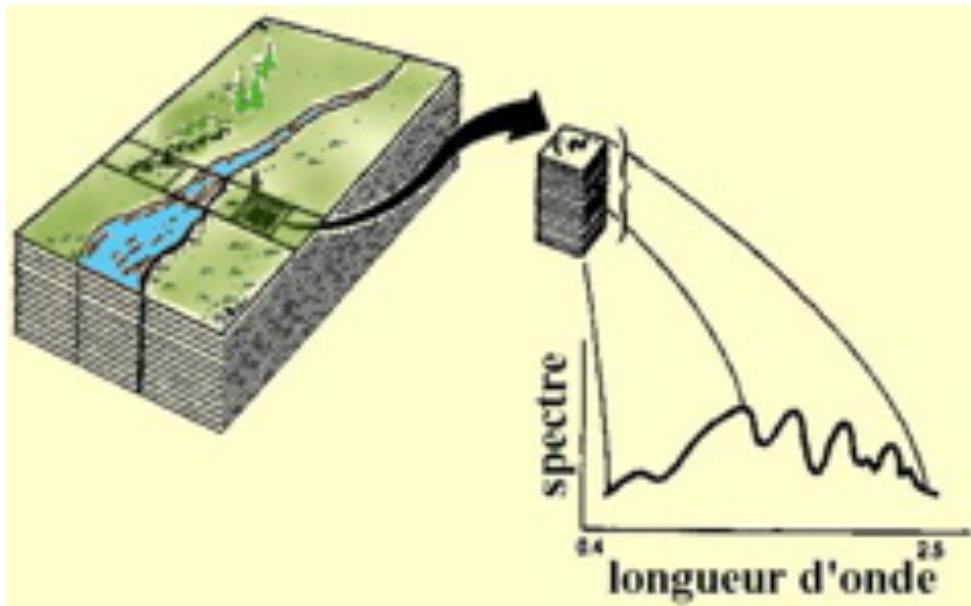
- Raw data retrieved in instrument team, validated by agency
- Calibration performed locally, often many successive versions
- Alternative pipelines to test further techniques
- Calibrated products eventually provided to space agency (PSA or PDS), available there
- Ancillary data computed in PI team (coordinates, illumination angles, etc) => in PSA / PDS

- **Derived products:**

- can be composited from many calibrated products

VIRTIS / Rosetta

- **Imaging spectrometers**
including VIRTIS-M (Venus-Express, Rosetta)



- **VIRTIS-H: Echelle spectrometer**
2 spectral dimensions

VIRTIS / Rosetta & VEx

- Raw and calibrated data + geometry typically distributed by Space agencies

planetary science archive

PSA 6.1.1

esa

TABLE VIEW

Number of selected items: 0

Filter by string in the current page

	Postcard	Product Identifier	Start Time	Stop Time	Target	Mission	Instrument	Processing Level	Release Date
<input type="checkbox"/>	N/A	V1_00433747527.QUB	2016-09-29 05:26:57.196	2016-09-29 05:48:56.640	67P/C-G	Rosetta	VIRTIS (Rosetta)	2	2018-08-28
<input type="checkbox"/>	N/A	V1_00433747527.CAL	2016-09-29 05:26:57.196	2016-09-29 05:48:56.640	67P/C-G	Rosetta	VIRTIS (Rosetta)	3	2018-06-07
<input type="checkbox"/>	N/A	V1_00433747527.GEO	2016-09-29 05:26:57.196	2016-09-29 05:48:56.640	67P/C-G	Rosetta	VIRTIS (Rosetta)	2	2018-06-07
<input type="checkbox"/>	N/A	V1_00433745547.QUB	2016-09-29 04:53:57.100	2016-09-29 05:24:56.524	67P/C-G	Rosetta	VIRTIS (Rosetta)	2	2018-08-28
<input type="checkbox"/>	N/A	V1_00433745547.CAL	2016-09-29 04:53:57.100	2016-09-29 05:24:56.524	67P/C-G	Rosetta	VIRTIS (Rosetta)	3	2018-06-07
<input type="checkbox"/>	N/A	V1_00433745547.GEO	2016-09-29 04:53:57.100	2016-09-29 05:24:56.524	67P/C-G	Rosetta	VIRTIS (Rosetta)	2	2018-06-07
<input type="checkbox"/>	N/A	V1_00433743567.QUB	2016-09-29 04:20:57.142	2016-09-29 04:51:56.579	67P/C-G	Rosetta	VIRTIS (Rosetta)	2	2018-08-28
<input type="checkbox"/>	N/A	V1_00433743567.CAL	2016-09-29 04:20:57.142	2016-09-29 04:51:56.579	67P/C-G	Rosetta	VIRTIS (Rosetta)	3	2018-06-07
<input type="checkbox"/>	N/A	V1_00433743567.GEO	2016-09-29 04:20:57.142	2016-09-29 04:51:56.579	67P/C-G	Rosetta	VIRTIS (Rosetta)	2	2018-06-07
<input type="checkbox"/>	N/A	V1_00433741587.QUB	2016-09-29 03:47:57.248	2016-09-29 04:18:56.685	67P/C-G	Rosetta	VIRTIS (Rosetta)	2	2018-08-28
<input type="checkbox"/>	N/A	V1_00433741587.CAL	2016-09-29 03:47:57.248	2016-09-29 04:18:56.685	67P/C-G	Rosetta	VIRTIS (Rosetta)	3	2018-06-07

Items/page: 100 Displaying 1 - 100 of 3543

PSA search interface

- Derived products, available in teams and (sometimes) data access systems such as VESPA

Results in service WEx

Show 10 entries

Column visibility Show all Hide all

Select All in current page Reset Selection

granule_uid	dataprodukt_type	target_name	time_min (d)	time_max (d)
VI0026_07G	spectral_cube	Venus	2006-05-16T17:12:20.414	2006-05-16T17:23:00.457
VI0026_07C	spectral_cube	Venus	2006-05-16T17:12:20.414	2006-05-16T17:23:00.457
VI0026_07G	spectral_cube	Venus	2006-05-16T17:12:20.424	2006-05-16T17:23:00.466
VI0026_07C	spectral_cube	Venus	2006-05-16T17:12:20.424	2006-05-16T17:23:00.466
VI0026_08C	spectral_cube	Venus	2006-05-16T17:27:48.478	2006-05-16T17:38:31.261
VI0026_08G	spectral_cube	Venus	2006-05-16T17:27:48.478	2006-05-16T17:38:31.261
VI0026_08G	spectral_cube	Venus	2006-05-16T17:27:48.672	2006-05-16T17:38:31.453
VI0026_08C	spectral_cube	Venus	2006-05-16T17:27:48.672	2006-05-16T17:38:31.453
VT0027_00C	spectral_cube	Venus	2006-05-18T01:25:15.669	2006-05-18T02:01:54.510
VT0027_00G	spectral_cube	Venus	2006-05-18T01:25:15.669	2006-05-18T02:01:54.510

Showing 91 to 100 of 15,682 entries

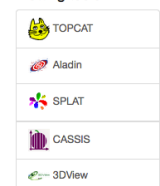
Page 10 of 1569

First Previous Next Last

Earth Footprints

VESPA search interface

Plotting tools



Example queries

Saturn in March 2012

VIRTIS-H / Rosetta

- **Echelle spectrometer**
on Venus-Express
and Rosetta

1) Nominal pipeline

Uses:

Raw data

Averaged dark

Normalized flat field

Spectral map

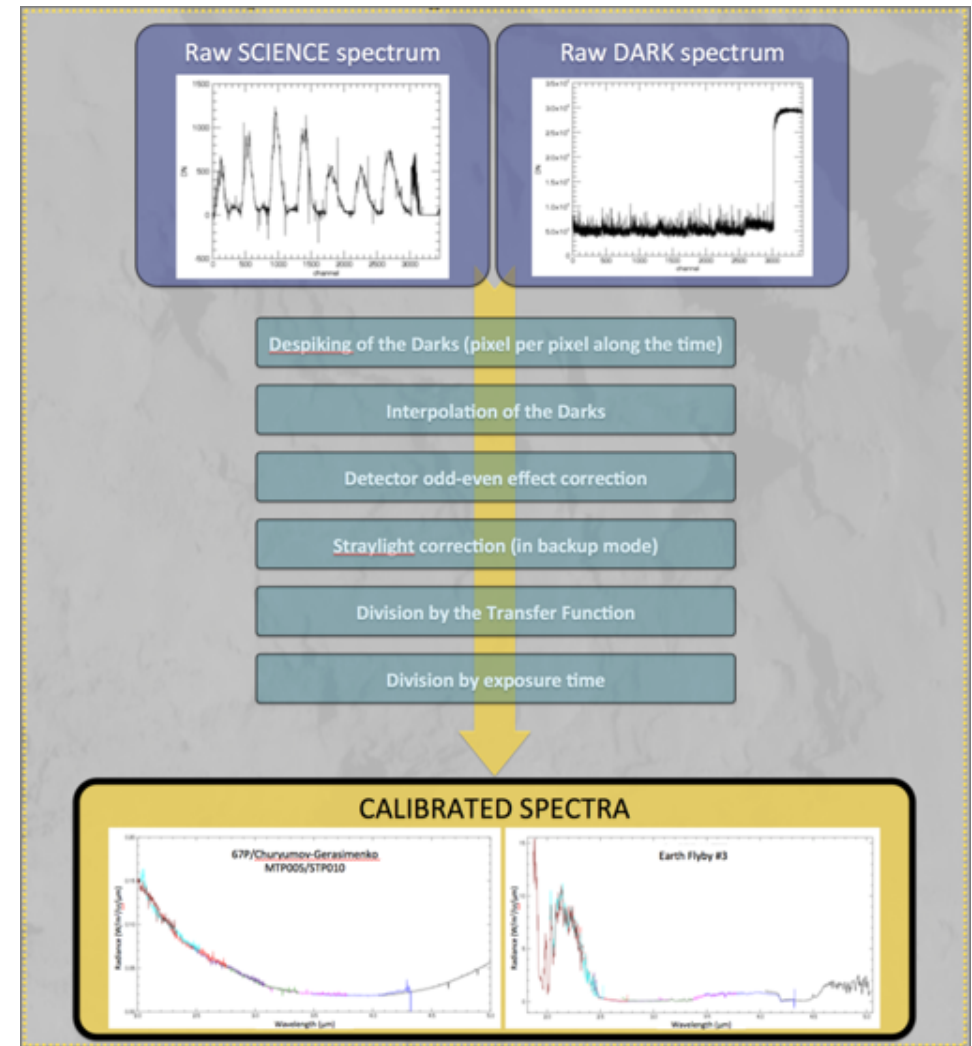
Spectral registration

Spectral transfer function

Despiking method with coef

Division by solar flux / normalization

=>References stored in metadata



PDS(3) labels in data products

Calibrated

```
1 PDS_VERSION_ID = PDS3
2 LABEL_REVISION_NOTE = "SE-MTC, 16/12/2015"
3
4 /* File format and length */
5 PRODUCT_ID = "T1_00426059346.CAL"
6 ORIGINAL_PRODUCT_ID = "PTG72500.QUB"
7 RECORD_TYPE = FIXED_LENGTH
8 RECORD_BYTES = 512
9 FILE_RECORDS = 8757
10 LABEL_RECORDS = 31
11 FILE_STATE = CLEAN
12
13 /* Pointers to data objects */
14 ^HISTORY = 32
15 ^TABLE = 33
16 ^QUBE = 114
17
18 /* Producer information */
19 PRODUCER_ID = ROSETTA_VIRTIS_TEAM
20 PRODUCER_FULL_NAME = "CAPACCIONI"
21 PRODUCER_INSTITUTION_NAME = "OBSERVATOIRE DE PARIS-LESIA"
22 PRODUCT_CREATION_TIME = 2017-06-08T16:23:03.00
23 TELEMETRY_SOURCE_ID = "VIRTIS_EGSE3"
24 SOFTWARE_VERSION_ID = {"VirtisRos SW v.4.10", "EGSE_SOFT_7.4",
25 "PDS_CONVERTER_7.4", "EGSE2PSA_LBL_1.2.2", "GEOROS_7.2", "V_GEOLABEL_6",
26 "GEOROS_7.2", "V_GEOLABEL_6", "CALIBROS_1.2_150126", "V_CONVLABEL_2.3"}
27
28 /* Data description parameters */
29 DATA_SET_NAME = "ROSETTA-ORBITER 67P VIRTIS 3 EXTENDED 3 MTP031 V1.0"
30 DATA_SET_ID = "RO-C-VIRTIS-3-EXT3-MTP031-V1.0"
31 PRODUCT_TYPE = RDR
32 PROCESSING_LEVEL_ID = 3
33 STANDARD_DATA_PRODUCT_ID = "VIRTIS DATA"
34 MISSION_NAME = "INTERNATIONAL ROSETTA MISSION"
35 MISSION_ID = ROSETTA
36 INSTRUMENT_HOST_NAME = "ROSETTA-ORBITER"
37 INSTRUMENT_HOST_ID = RO
38 MISSION_PHASE_NAME = "ROSETTA EXTENDED 3 MTP031"
39 PI_PDS_USER_ID = CAPACCIONI
40 INSTRUMENT_NAME = "VISIBLE AND INFRARED THERMAL IMAGING SPECTROMETER"
41 INSTRUMENT_ID = "VIRTIS"
42 INSTRUMENT_TYPE = "IMAGING SPECTROMETER"
43 ^INSTRUMENT_DESC = "RO_VIRTIS_EAICD.ASC"
44 ROSETTA:CHANNEL_ID = "VIRTIS_H"
45 PHOTOMETRIC_CORRECTION_TYPE = NONE
46 DATA_QUALITY_ID = 1
47 DATA_QUALITY_DESC = "0:INCOMPLETE ; 1:COMPLETE"
48
49 /* Science operations information */
50 TARGET_TYPE = "COMET"
51 TARGET_NAME = "67P/CHURYUMOV-GERASIMENKO 1 (1969 R1)"
52 START_TIME = 2016-07-02T05:03:15.574
53 STOP_TIME = 2016-07-02T09:17:35.285
```

Raw

```
1 PDS_VERSION_ID = PDS3
2 LABEL_REVISION_NOTE = "SE-MTC, 11/12/2015"
3
4 /* File format and length */
5 PRODUCT_ID = "T1_00426059346.QUB"
6 ORIGINAL_PRODUCT_ID = "PTG72500.QUB"
7 RECORD_TYPE = FIXED_LENGTH
8 RECORD_BYTES = 512
9 FILE_RECORDS = 5076
10 LABEL_RECORDS = 12
11 FILE_STATE = CLEAN
12
13 /* Pointers to data objects */
14 ^HISTORY = 13
15 ^QUBE = 14
16
17 /* Producer information */
18 PRODUCER_ID = ROSETTA_VIRTIS_TEAM
19 PRODUCER_FULL_NAME = "CAPACCIONI"
20 PRODUCER_INSTITUTION_NAME = "ISTITUTO NAZIONALE DI ASTROFISICA"
21 PRODUCT_CREATION_TIME = 2017-06-08T15:35:11.00
22 TELEMETRY_SOURCE_ID = "VIRTIS_EGSE3"
23 SOFTWARE_VERSION_ID = {"VirtisRos SW v.4.10", "EGSE_SOFT_7.4",
24 "PDS_CONVERTER_7.4", "EGSE2PSA_LBL_1.2.2", "GEOROS_7.2", "V_GEOLABEL_6",
25 "GEOROS_7.2", "V_GEOLABEL_6"}
26
27 /* Data description parameters */
28 DATA_SET_NAME = "ROSETTA-ORBITER 67P VIRTIS 2 EXTENDED 3 MTP031 V1.0"
29 DATA_SET_ID = "RO-C-VIRTIS-2-EXT3-MTP031-V1.0"
30 PRODUCT_TYPE = EDR
31 PROCESSING_LEVEL_ID = 2
32 STANDARD_DATA_PRODUCT_ID = "VIRTIS DATA"
33 MISSION_NAME = "INTERNATIONAL ROSETTA MISSION"
34 MISSION_ID = ROSETTA
35 INSTRUMENT_HOST_NAME = "ROSETTA-ORBITER"
36 INSTRUMENT_HOST_ID = RO
37 MISSION_PHASE_NAME = "ROSETTA EXTENDED 3 MTP031"
38 PI_PDS_USER_ID = CAPACCIONI
39 INSTRUMENT_NAME = "VISIBLE AND INFRARED THERMAL IMAGING SPECTROMETER"
40 INSTRUMENT_ID = "VIRTIS"
41 INSTRUMENT_TYPE = "IMAGING SPECTROMETER"
42 ^INSTRUMENT_DESC = "RO_VIRTIS_EAICD.ASC"
43 ROSETTA:CHANNEL_ID = "VIRTIS_H"
44 DATA_QUALITY_ID = 1
45 DATA_QUALITY_DESC = "0:INCOMPLETE ; 1:COMPLETE"
46
47 /* Science operations information */
48 TARGET_TYPE = "COMET"
49 TARGET_NAME = "67P/CHURYUMOV-GERASIMENKO 1 (1969 R1)"
50 START_TIME = 2016-07-02T05:03:15.574
51 STOP_TIME = 2016-07-02T09:17:35.285
52 SPACECRAFT_CLOCK_START_COUNT = "1/0426056508.37679"
53 SPACECRAFT_CLOCK_STOP_COUNT = "1/0426071768.18408"
```


VIRTIS-H / Rosetta

- **Echelle spectrometer**

on Venus-Express
and Rosetta

2) Complementary steps

May include:

Correction of darks

Odd-even correction

Stray light correction

depend on Sun position wrt FOV

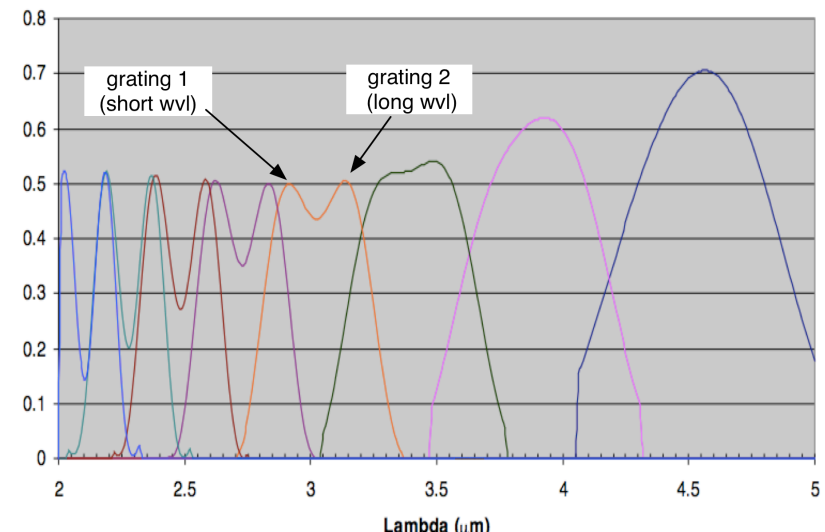
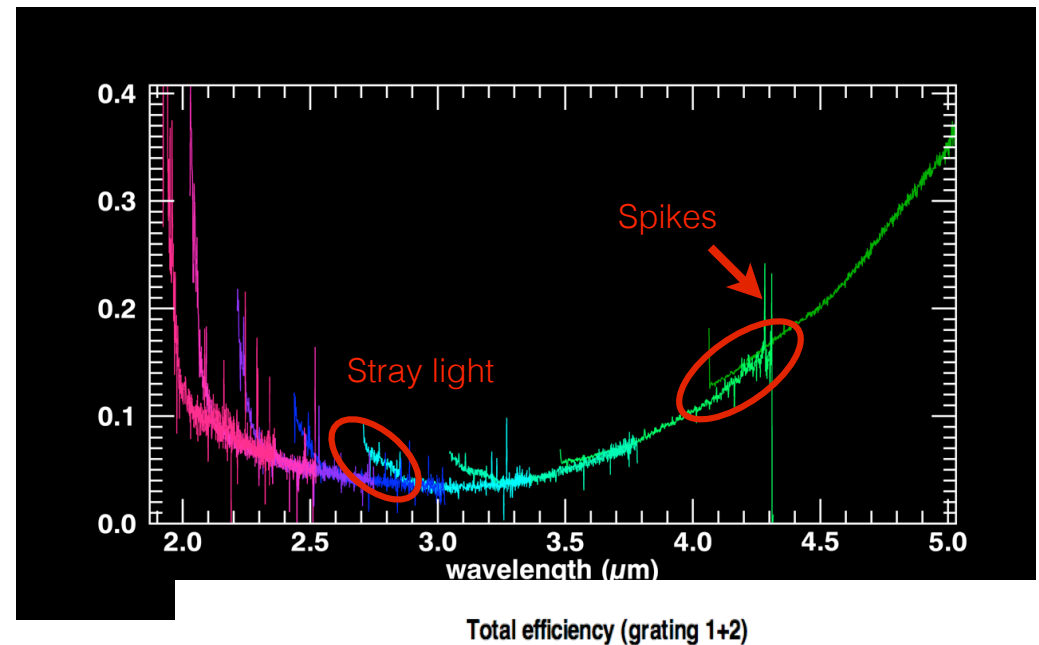
Strabismus correction

depend on illumination / pointing

Photometric corrections

model-depend => parameters

=>References difficult to handle



VIRTIS / Rosetta

- **Imaging spectrometer**
on Venus-Express
and Rosetta

3) Geometry data

Computed for each pixel

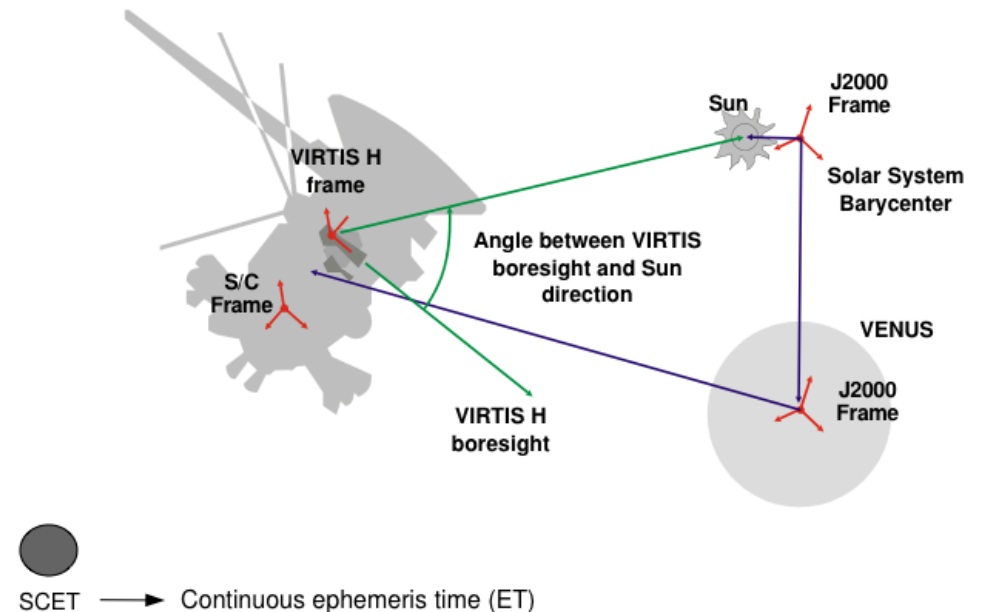
Uses:

On-board time

Spice kernels provided by ESA & JPL

(geometry of instrument, trajectory, orbits, rotation)

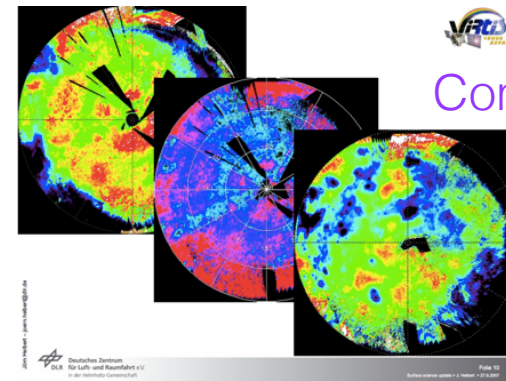
Software library (JPL) + dedicated routines (team)



=>References stored in metadata / labels

VIRTIS / Venus-Express

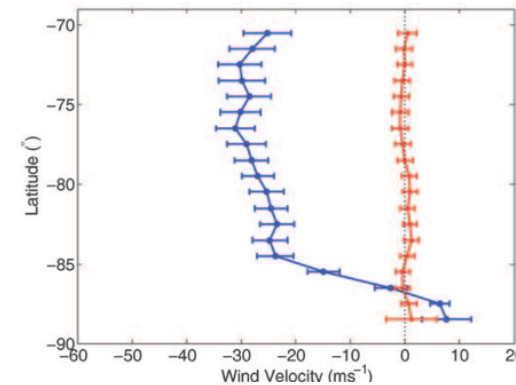
- **Imaging spectrometer**
on Venus-Express
and Rosetta



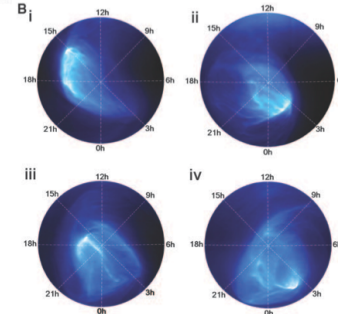
Composite maps

4) Derived products

Many types, but need to track:
Original files used (may be 100s)
Calibration version
Additional steps/algorithm
(mosaicking, composing...)



Vertical profiles



Movies

=>Difficult to document in final products

Planetary Science data use cases

Two examples of common situations

- **Space borne observations:**
examples of VIRTIS on Venus-Express and Rosetta
- • **Data services:**
VO services on small bodies

Small body services

Many services in VESPA

- Observations
- Derived quantities / classifications / compilations / computed
- Difficulty to provide bib references for all parameters / all versions



Form

Query

EPN-TAP Services

Custom Service

Main Parameters

Target Name

Target Class

☒ Asteroid

☐ Calibration

☐ Comet

☐ Dwarf Planet

☐ Exoplanet

☐ Intplanet. Medium

☐ Planet

EPN Services

DynAstVO - Asteroid orbital database and ephemerides	26761 results	↔	↕	ⓘ
hst_planeto - Planetary data from the Hubble Space Telescope	208 results	↔	↕	ⓘ
M4AST - M4AST - Modeling for Asteroids	6298 results	↔	↕	ⓘ
mpc - Minor Planet Center - Asteroid Orbital Data	1152519 results	↔	↕	ⓘ
PSA - ESA Planetary Science Archive	52009 results	↔	↕	ⓘ
SBNaf - Small Bodies Near and Far	170445 results	↔	↕	ⓘ
spectro_asteroids - Spectra of asteroids	451 results	↔	↕	ⓘ
tnosarecool - TNOs are Cool	630 results	↔	↕	ⓘ
USGS_WMS - USGS planetary maps	1 result	↔	↕	ⓘ
VizieR_planets - VizieR Solar system catalogues (B/planets)	180 results	↔	↕	ⓘ
abs_cs - Data for numerical modeling of planetary atmospheres	0 results	↔	↕	ⓘ

Plotting tools

TOPCAT

Aladin

SPLAT

CASSIS

3DView

Example queries

Saturn in March 2

Help

orbital param

observations

properties

Small body services

Services complement each other

- Minor Planet Centre and MP3C (to come) provide global properties, families, taxonomical classes...
- Big issue with names / ID => name resolver required (Quaero at IMCCE)



Form

Query

EPN-TAP Services

Custom Service

Main Parameters

Target Name

Target Class

☒ Asteroid

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☐ Intplanet. Medium

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EPN Services

DynAstVO - Asteroid orbital database and ephemerides	26761 results	↻	⬇	ⓘ
hst_planeto - Planetary data from the Hubble Space Telescope	208 results	↻	⬇	ⓘ
M4AST - M4AST - Modeling for Asteroids	6298 results	↻	⬇	ⓘ
mpc - Minor Planet Center - Asteroid Orbital Data	1152519 results	↻	⬇	ⓘ
PSA - ESA Planetary Science Archive	52009 results	↻	⬇	ⓘ
SBNaf - Small Bodies Near and Far	170445 results	↻	⬇	ⓘ
spectro_asteroids - Spectra of asteroids	451 results	↻	⬇	ⓘ
tnosarecool - TNOs are Cool	630 results	↻	⬇	ⓘ
USGS_WMS - USGS planetary maps	1 result	↻	⬇	ⓘ
VizieR_planets - VizieR Solar system catalogues (B/planets)	180 results	↻	⬇	ⓘ
abs_cs - Data for numerical modeling of planetary atmospheres	0 results	↻	⬇	ⓘ

Plotting tools

TOPCAT

Aladin

SPLAT

CASSIS

3DView

Example queries

Saturn in March 2

Help

orbital param

observations

properties

Small body services

Several general EPNCore keywords:

- *instrument_name* / *instrument_host_name*, etc
- *service_title* / *granule_uid* => call-back mechanism
- *bib_reference* => to papers

Services with history of values

- Especially orbital parameters, change over time
 - Some services have very complete web sites field with information on individual targets
- Ex: MP3C, spectro_asteroids, VizieR_planets
(but also Exoplanets, vims_satellites in other fields)
=> referred to through *external_link* parameter

Small body (and other) services

	thumbnail_url	publisher	bib_reference	file_name	external_link	magnitude	sun_dist
06	http://voparis-srv-p...	LESIA	2008AJ....135...55B	Varuna_hk.vot	https://cdsarc.unist...		
0	http://voparis-srv-p...	LESIA	2008AJ....135...55B	Quaoar_hk.vot	https://cdsarc.unist...		
	http://voparis-srv-p...	LESIA	2008AJ....135...55B	Pholus_hk.vot	https://cdsarc.unist...		
5	http://voparis-srv-p...	LESIA	2008AJ....135...55B	Okurbaa_hk.vot	https://cdsarc.unist...		

product list in VESPA portal

Portal Simbad VizieR Aladin X-Match Other Help

NIR spectra of Centaurs and Kuiper Belt objects : J/AJ/135/55

Access to [VizieR](#) [FTP](#) [ReadMe](#) [TAP](#)

Authors : Barkume K.M., Brown M.E., Schaller E.L.

VizieR DOI : 10.26093/cds/vizieR.51350055 [Cite](#)
Bibcode : 2008AJ....135...55B (ADS)

UAT : Infrared astronomy, Solar system, Asteroids, Spectroscopy

Observation (OC)
Inserted into VizieR : 21-Mar-2011
Last modification : 04-Apr-2011

Article Origin Description See also Prov FTP **VizieR**

Near-infrared spectra of Centaurs and Kuiper Belt objects. (2008)
Go to the original article (10.1088/0004-6256/135/1/55)

Keywords : Infrared solar system - Kuiper belt - minor planets, asteroids

Abstract: We present here an extensive survey of near-infrared (NIR) spectra of Kuiper belt objects (KBOs) and Centaurs taken with the Keck I Telescope. We find that most spectra in our sample are well characterized by a combination of water ice and a featureless continuum. A comparative analysis reveals that the NIR spectral properties have little correlation to the visible colors or albedo, with the exception of the fragment KBOs produced from the giant impact on 2003 E

Exoplanet.eu Accueil Tous les catalogues Diagrammes Bibliographie Recherche Conférences Autres Sites

Planet 11 Oph b

Name	11 Oph b
Planet Status	Confirmed
Discovered in	2007
Mass	21.0 (-3.0 +3.0) M _J
Mass*sin(i)	—
Semi-Major Axis	243.0 (± 55.0) AU
Orbital Period	730000.0 (± 365000.0) day
Eccentricity	—
ω	—
T _{peri}	—
Radius	—
Inclination	—
Update	2018-06-18
Detection Method	Imaging
Mass Detection Method	—
Radius Detection Method	—
Primary transit	—
Secondary transit	—
λ	—
Impact Parameter b	—
Time V _r =0	—

Star

11 Oph

Nom 11 Oph

Distance 145.0 (± 20.0) pc

Spectral type M9

Apparent magnitude V —

Mass 0.0162 (-0.005 +0.005) M_{Sun}

Age 0.011 (± 0.002) Gyr

Effective temperature 2375.0 (± 175.0) K

Radius —

Metallicity [Fe/H] —

Detected Disc —

Magnetic Field —

RA₂₀₀₀ 16:22:25.0

Dec₂₀₀₀ -24:05:14

Alternate Names Oph 1622-2405, Oph 11A

Planetary system 1 planet

More data

- Simbad
- Most recent references (ADS)

- *Datalink* can also be used to associate documentation, large metadata sets (labels), a related space archive, etc

Example with Voyager/PRA collection

Table links

Where?	Description	What?
Link	Data Product	#this VG2-U-PRA-3-RDR-LOWBAND-6SEC-V1.0:
Link	Label File	#documentation VG2-U-PRA-3-RDR-LOWBAND-6SEC-V1.0:VG2_URN_PRA_6SEC.TAB
Link	Data Collection repository	#parent VG2-U-PRA-3-RDR-LOWBAND-6SEC-V1.0:V

Index of /data/voyager/pr/PDS/VG2-U-PRA-3

Name	Last modified	Size	Description
Parent Directory		-	
AAREADME.TXT	2013-02-06 10:40	15K	
CATALOG/	2013-02-06 11:12	-	
CHECKSUMS.TXT	2020-04-19 18:15	2.5K	
DATA/	2013-02-06 11:12	-	
DOCUMENT/	2013-02-06 11:12	-	
ERRATA.TXT	2012-02-03 09:51	6.0K	

Summary

- Space experiments:
Need to keep track of detailed processing
- calibration, but also further processing
- EPN-TAP:
Focus on search metadata associated to data products
Little room for extensive Provenance info
- Datalink and references to detailed web sites provide a solution