Planetary Science & Provenance

S. Erard (and the VESPA team)

LESIA / Observatoire de Paris-PSL

Workshop Provenance in practice

14-15 dec 2021

The Europlanet-2024 Research Infrastructure project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 871149.



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

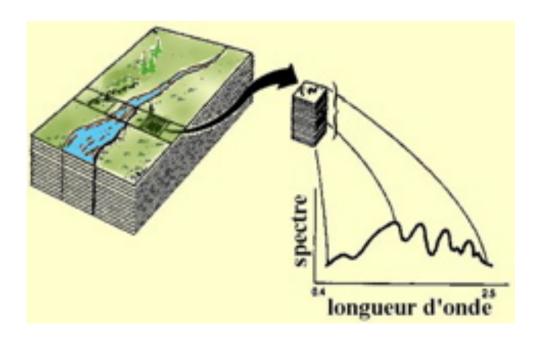
Space-borne observations

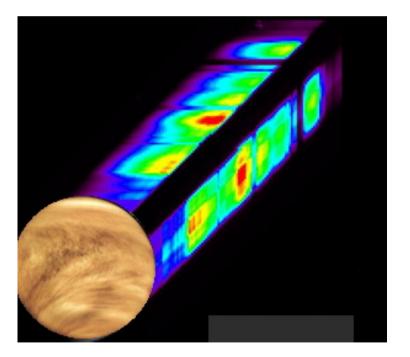
- During acquisition/processing phase:
- Raw data retrieved in instrument team, validated by agency
- Calibration performed locally, often many successive versions
- Alternative pipelines to test further techniques
- Calibrated products eventually provided to space agency (PSA or PDS), available there
- 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

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PSA search interface

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

Results in se	rvice WEx				Plotting tools
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VV0026_08G	spectral_cube	Venus	2006-05-16T17:27:48.672	2006-05-16T17:38:31.453	
VV0026_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	
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© Paris	Observatory 2016 - VESPA Tutorials				A State of the sta

VESPA search interface

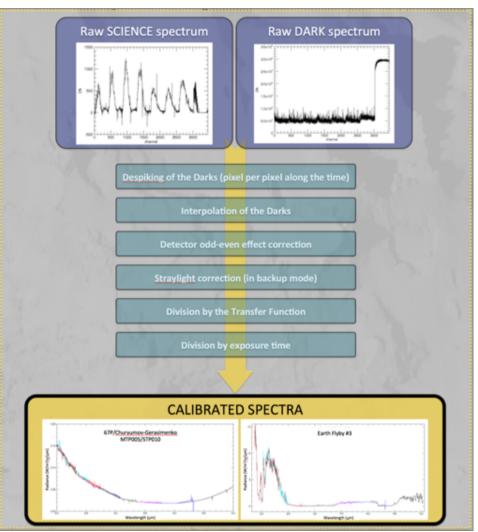
PADC 😡

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

Raw

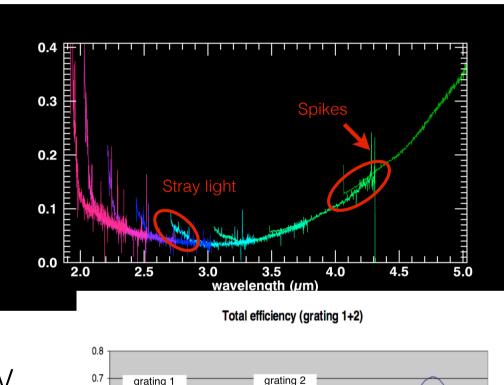
PDS VERSION ID PDS VERSION ID = PDS3 = PDS3 LABEL_REVISION_NOTE = "SE-MTC, 16/12/2015" LABEL REVISION NOTE = "SE-MTC. 11/12/2015" 3 /* File format and length */ /+ File format and length */ PRODUCT_ID = "T1_00426059346.CAL" PRODUCT_ID = "T1_00426059346.QUB" ORIGINAL PRODUCT_ID = "PTG72500.QUB" ORIGINAL PRODUCT_ID = "PTG72500.QUB" RECORD_ITPE = EIXED_LENGTH **RECORD** TYPE = FIXED LENGTH RECORD_BYTES = 512 RECORD BYTES = 512 FILE RECORDS = 8757 FILE RECORDS = 5076LABEL RECORDS = 31 LABEL_RECORDS = 12 = CLEAN FILE_STATE = CLEAN FILE STATE /* Pointers to data objects */ /* Pointers to data objects */ ^HISTORY = 32 $^{HISTORY} = 13$ $^{OUBE} = 14$ **^TABLE** = 33 ^0UBE = 114 /* Producer information */ /* Producer information */ PRODUCER_ID = ROSETTA_VIRTIS_TEAM PRODUCER ID = ROSETTA_VIRTIS_TEAM PRODUCER_FULL_NAME = "CAPACCIONI" 20 PRODUCER FULL NAME = "CAPACCIONI" PRODUCER INSTITUTION NAME = "ISTITUTO NAZIONALE DI ASTROFISICA" 21 PRODUCER_INSTITUTION_NAME = "OBSERVATOIRE DE PARIS-LESIA" PRODUCT_CREATION_TIME = 2017-06-08T15:35:11.00 TELEMETRY_SOURCE_ID = "VIRTIS_EGSE3" PRODUCT_CREATION_TIME = 2017-06-08T16:23:03.00 TELEMETRY_SOURCE_ID = "VIRTIS EGSE3" SOFTWARE VERSION_ID = {"VirtisRos SW v.4.10", "EGSE_SOFT_7.4", 24 SOFTWARE VERSION ID = {"VirtisRos SW v.4.10", "EGSE_SOFT_7.4", "PDS_CONVERTER_7.4","EGSE2PSA_LBL_1.2.2", "GEOROS_7.2", "V_GEOLABEL_6", "PDS_CONVERTER_7.4", "EGSE2PSA_LBL_1.2.2", "GEOROS_7.2", "V_GEOLABEL_6" 25 "GEOROS 7.2", "V GEOLABEL 6"} "GEOROS_7.2", "V_GEOLABEL_6", "CALIBROS_1.2_150126", "V_CONVLABEL_2.3"} 26 /* Data description parameters */ 28 /* Data description parameters */ DATA_SET_NAME = "ROSETTA-ORBITER 67P VIRTIS 2 EXTENDED 3 MTP031 V1.0" 29 DATA_SET_NAME = "ROSETTA-ORBITER 67P VIRTIS 3 EXTENDED 3 MTP031 V1.0" DATA SET ID = "RO-C-VIRTIS-2-EXT3-MTP031-V1.0" 30 DATA_SET_ID = "R0-C-VIRTIS-3-EXT3-MTP031-V1.0" 30 PRODUCT_TYPE = EDR PRODUCT_TYPE = RDR PROCESSING_LEVEL_ID = 2 PROCESSING_LEVEL_ID = 3 STANDARD_DATA_PRODUCT_ID = "VIRTIS DATA" STANDARD_DATA_PRODUCT_ID = "VIRTIS DATA" MISSION_NAME = "INTERNATIONAL ROSETTA MISSION" MISSION_NAME = "INTERNATIONAL ROSETTA MISSION" MISSION_ID = ROSETTA MISSION_ID INSTRUMENT_HOST_NAME = "ROSETTA-ORBITER" 35 = ROSETTA INSTRUMENT_HOST_NAME = "ROSETTA-ORBITER" INSTRUMENT_HOST_ID = R0 36 INSTRUMENT_HOST_ID MISSION_PHASE_NAME = "ROSETTA EXTENDED 3 MTP031" = R0 MISSION PHASE NAME = "ROSETTA EXTENDED 3 MTP031" 38 PI_PDS_USER_ID = CAPACCIONI PI_PDS_USER_ID INSTRUMENT_NAME = "VISIBLE AND INFRARED THERMAL IMAGING SPECTROMETER" 39 - CAPACCIONI = "VISIBLE AND INFRARED THERMAL IMAGING SPECTROMETER" INSTRUMENT_ID = "VIRTIS" 40 INSTRUMENT_NAME 40 INSTRUMENT ID = "VIRTIS" INSTRUMENT TYPE = "IMAGING SPECTROMETER" ^INSTRUMENT_DESC = "RO_VIRTIS_EAICD.ASC" INSTRUMENT_TYPE = "IMAGING SPECTROMETER" ROSETTA: CHANNEL_ID = "VIRTIS_H" ^INSTRUMENT_DESC 43 = "RO_VIRTIS_EAICD.ASC" 44 ROSETTA: CHANNEL ID = "VIRTIS H" 44 DATA QUALITY ID = 1DATA_QUALITY_DESC = "0:INCOMPLETE ; 1:COMPLETE" PHOTOMETRIC_CORRECTION_TYPE = NONE 46 DATA_QUALITY_ID = 1 DATA QUALITY DESC = "0:INCOMPLETE ; 1:COMPLETE" /* Science operations information */ TARGET_TYPE = "COMET" 49 /* Science operations information */ TARGET_NAME = "67P/CHURYUMOV-GERASIMENKO 1 (1969 R1)" TARGET TYPE = "COMET" 50 START TIME = 2016-07-02T05:03:15.574 TARGET_NAME = "67P/CHURYUMOV-GERASIMENKO 1 (1969 R1)" STOP_TIME = 2016-07-02T09:17:35.285 START TIME = 2016 - 07 - 02T05:03:15.574SPACECRAFT_CLOCK_START_COUNT = "1/0426056508.37679" SPACECRAFT_CLOCK_STOP_COUNT = "1/0426071768.18408" STOP_TIME = 2016-07-02T09:17:35.285

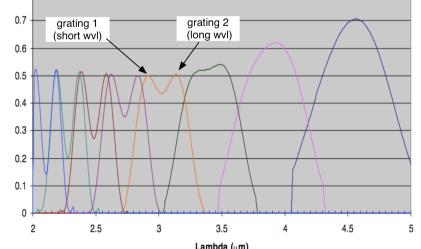
VIRTIS-H / Rosetta

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

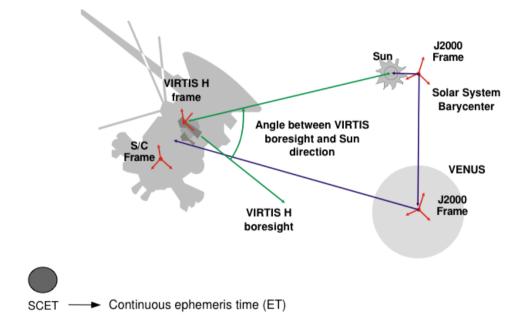




VIRTIS / Rosetta

- 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



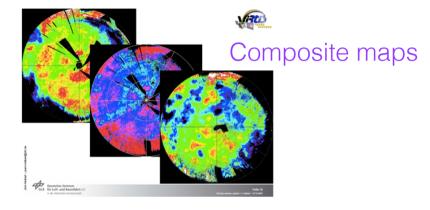
VIRTIS / Venus-Express

 Imaging spectrometer on Venus-Express and Rosetta

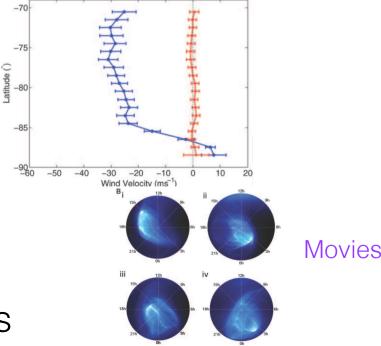
4) Derived products

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

=>Difficult to document in final products



Vertical profiles



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 Services				Plotting tools
EPN-TAP	Custom Service	DynAstVO - Asteroid orbital database and ephemerides 26761 results	•	æ	0	
Services		hst_planeto - Planetary data from the Hubble Space Telescope 208 met ODSErvations	•	•	0	🧭 Aladin
Main Parameter	rs	M4AST - M4AST - Modeling for Asteroids 6298 results	۲	٩	0	* SPLAT
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		PSA - ESA Planetary Science Archive 52009 results	۲	٩	0	CASSIS
Target Class		SBNAF - Small Bodies Near and Far 170445 results	۲	٩	0	@ 3DView
Asteroid Calibration		spectro_asteroids - Spectra of asteroids 451 results	۲	٩	0	
□ Comet		tnosarecool - TNOs are Cool 630 results	۲	⊕ D	Cownload V	CTable
Dwarf Planet		USGS_WMS - USGS planetary maps 1 result	۲	٢	0	Saturn in March 2
Exoplanet	ium	VizieR_planets - VizieR Solar system catalogues (B/planets) 180 results	۲	٩	0	Help
Dianat		abs. cs. Data for numerical modeling of planetary atmospheres 0 moult		A	A	

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 Services				Plotting tools
EPN-TAP	Custom Service	DynAstVO - Asteroid orbital database and ephemerides 26761 results	•	æ	0	
Services		hst_planeto - Planetary data from the Hubble Space Telescope 208 read and Observations	•	•	0	🧭 Aladin
Main Paramete	rs	M4AST - M4AST - Modeling for Asteroids 6298 results	۲	۲	0	N SPLAT
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		PSA - ESA Planetary Science Archive 52009 results	۲	٩	0	CASSIS
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Dwarf Planet		USGS_WMS - USGS planetary maps 1 result	۲		0	Saturn in March 2
Exoplanet	lium	VizieR_planets - VizieR Solar system catalogues (B/planets) 180 results	۲	٩	0	Help
Dianet		abs. cs. Data for numerical modeling of planetany atmospheres 0 moult		A	8	

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

11	thumbnail_url 1	publisher 💵	bib_reference	file_name	lt	external_link 1	magnitude 💵	sun_dist				
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	Authors : Barkume K.M. , Brown M.E., Scha	A	rticle Origin Description See also Prov	FTP VizieR			Update	2018-06-18		Metallicity [Fe/H]	_	
	VizieR DOI : 10.26093/cds/vizier.51350055 Bibcode : 2008AJ13555B (ADS)	Nea	ar-infrared spectra of Centaurs and Kuiper Belt obj to the original article (10.1088/0004-6256/135/1/55)	ects. (2008)			Detection Method	Imaging			-	
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Simbad
 Most recent references (ADS)

Planetary system 1 planet

More data

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

	Example with Voyager/PRA	CONNECTION
WESPA v forums v Missi	ion 🛩 IPDA 🗸 JUICE 🗸 CDPP 🖌 radio 🗸 bib-cnrs Adress'RLR OnlineOCR Cassini 🖍 STEREO 🗸 Revues 🗸 Webmail 🗸 Banques 🗸 bibli 🛩 English '	
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Form Query	Back To Services Results	Plotting tools
EPN-TAP Services Custom Service	Results in service voyager_pra	🐣 TOPCAT
Main Parameters	voyager_pra - Voyager PRA Datasets	20 Aladin
Target Name	Voyager PRA (Planetary Radio Astronomy) Datasets catalog. The dataset are originally published by several data centers: NASA/PDS, NASA/NSSDC, NASA/GSFC, Univ. Iowa and CNES/SERAD. Credits:	👫 SPLAT
layer Halle	Creators: Baptiste Cecconi	D CASSIS
Target Class	Publisher: Paris Astronomical Data Centre	e- 3DView
Dataproduct Type	Show 10 \$ entries Column visibility Show all Hide all	
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Summary

- Space experiments: Need to keep track of detailed processing
 - calibration, but also further processing
 - canoration, bat aloc rantinor pro
- 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