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SPICAM
Virtual Observatory service in VESPA

User Manual

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This document aims to explain quickly how the service SPICAM on VESPA is build and how to interrogate it on VESPA query interface. The first part will detail the most useful query criteria of the service, the second will provide queries examples and plots on Topcat tool.



Chapter 1

Service Content

The SPICAM service¹ on VESPA aims to give access to some profiles of temperature and densities measured by SPICAM[1] spectrometer on board of Mars Express. These profiles are given as VOTable/XML files² which allows the use of VO tools³. The Table 1.1 summarizes the content of the profiles for the different types of granules. Additionally, this service give access to MCD[2] simulated profiles of these parameters on the same conditions. If you want to obtain the MCD profiles for the same coordinates and an other sceanrio, you can select it into the datalink scrolling menu and obtain the corresponding VOTable.

1.1 SPICAM measurements

SPICAM (Spectroscopy for Investigation of Characteristics of the Atmosphere of Mars) is an ultraviolet [118-300]nm and infrared [1.0-1.7] μ m spectrometer on board Mars Express. It has been observing the Martian atmosphere from January 2004 (Mars Year 27) onwards with nadir, limb and stellar/solar occultation measurements. The UV channel ceased operations in 2014, but the IR channel is still currently collecting data. Four types of data profiles derived from occultations in the UV channel are provided in the VO service SPICAM : aerosol extinction [3] derived from solar occultations, temperature, and densities of CO₂ [4] and O₃ [5] from stellar occultations. On the VO service, each SPICAM profile is associated with an Mars Climate Database (MCD) [2] profile at the same coordinates for the corresponding Mars Year scenario on the service. These profiles are provided in VOTable format (An XML table that contains also metadata).

1.2 Parameter description

The research criteria of the service allows to retrieve exactly the data subset wanted. The more useful criteria of the services are detailed below and summarized in table 1.2 with its range of values.

¹http://vespa.obspm.fr/planetary/data/display/?&service_id=ivo://latmos.ipsl/spicam/q/epn_core&service_type=epn

²VOTable Standard Format Definition : <https://www.ivoa.net/documents/VOTable/>

³<http://www.europlanet-vespa.eu/tools.shtml>

data_category	data_type	content
All	All	Altitude above Mars Zero Datum (km) Altitude above the local surface (km) Radial Distance from center of the planet (km)
SPICAMmeasurements	temp	Temperature assuming Ttop= 100 K (K) Temperature assuming Ttop= 175 K (K) Temperature assuming Ttop= 250 K (K) Temperature error bar(K) see Forget at al.(2009) (K)
	co2dens	CO2 density assuming Ttop= 100 K (kg.m-3) CO2 density assuming Ttop= 175 K (kg.m-3) CO2 density assuming Ttop= 250 K (kg.m-3) Instrument error + bias due to spectroscopy (kg.m-3) Instrument error (kg.m-3)
	o3dens	Ozone density (cm-3) Instrument error (cm-3)
	aerosol	Aerosol extinction (m-1) Instrument error (m-1)
MCDsimulations	temp	Temperature (K)
	co2dens	CO2 density (kg.m-3)
	o3dens	Ozone density (cm-3)
	aerosol	Dust column visible optical depth Water Ice column (kg.m-2)

Table 1.1: Content of the profiles provided in SPICAM VO service

instrument_name Indicates if the profile provided comes from a measurement from SPICAM instrument or if it is a MCD-simulated profile.

mars_year Mars year of the observation.

orbit_id Identifier of the orbit of the observation

ndata Indicates the number of points contained in the profile. It is variable (from 1 to 330) for SPICAM measurements, and it is fixed at 51 for MCD simulations .

solar_longitude_min, solar_longitude_max The solar longitude LS in degrees during the observation. Same value for solar_longitude_min and solar_longitude_max .

local_time_min, local_time_max The local time in hours, same value for local_time_min and local_time_max.

Parameter name	Content	Range of values
instrument_name	Name of the instrument or simulation used to retrieve the profile	MCD SPICAM
mars_year	Mars year of the measurement	From 26 to 31
ndata	Number of altitude points of the profile	
solar_longitude_{min max}	Solar longitude in degrees	From 0 to 360
local_time_{min max}	Local time in hours	From 0 to 24
c1_{min max}	Longitude in degrees	From 0 to 360
c2_{min max}	Latitude in degrees	From -90 to 90
c3_{min max}	{min max} altitude above areoid in the profile (km)	Always 0 to 249.5 for MCD, variable for SPICAM measurements (between 0 and 141.5 km)
time_{min max}	Earth date YYYY-MM-DDThh-mm-sss	From 2004-01-13 to 2011-09-21
obs_id	{Orbit_id}	8 characters
granule_gid	Type of data contained in the profile	temp co2dens o3dens aerosols
granule_uid	orbit{orbit_id}_{Profile_type}_{MCDsimulation SPICAMmeasurement}	

Table 1.2: Principal research parameters on SPICAM service

c1_min, c1_max Longitude of the observation in degrees from 0(West) to 360(East), growing eastward. The value is the same for c1_min and c1_max.

c2_min, c2_max Longitude of the observation in degrees from -90(South) to +90(North), growing Northward. The value is the same for c2_min and c2_max.

c3_min, c3_max Altitude above areoid of the profile in meters c3_min: minimum altitude point contained in the profile ; c3_max: maximum altitude point contained in the profile.

time_min, time_max Earth date of the observation, in YYYY-MM-DDThh-mm-sss format. From 2004-01-13T13:41:09.599 to 2011-09-21T11:31:03.360

obs_id Is an identifier that refers to the observation, here it refers to the orbit id (8 characters).

granule_gid Gives what is contained in the profile : if the profile provided contains temperature, aerosols extinction, density of ozone or density of dioxygen. For aerosols extinction, as the MCD output has no aerosols extinction, the associated MCD VOTable provides dust column visible optical depth and water ice column.

granule_uid Is an unique identifier, different for every profile of the service. It compiles the orbit, data category and profile type.

Chapter 2

Examples

2.1 Example 1

For this example, we want to select all SPICAM measurements recorded between 2004 and 2006 that have at least 50 points of measurements. We first select 'instrument_name' in the 'Main Parameters' section on bottom LEFT of the interface, then type "SPICAM". Then in the "time" section, set time_min and time_max to the wanted values, it will select every profile in the interval. And in the "other" category, add a criteria and select 'ndata' category, change the = sign into a \geq and type the value 50. See Figure 2.1.

2.2 Example 2

We want to obtain all data corresponding to the orbit '1226A1', we can search the orbit identifier in the Obs_ID parameter into the 'Data Reference' category. We will obtain temperature, ozone and carbon dioxide results for SPICAM measurements and MCD simulations. We can, for example compare the MCD temperature profile and the SPICAM measured temperature profile and the MCD simulated one using the SAMP (Simple Access Messaging Protocol) interface and the TopCAT tool. First, we have to open TopCAT. Then go on the VESPA query results, select the two profiles and click 'Data Selection' → 'Send Tables'. You will receive a confirmation dialog box, click "OK" and you data selection profiles will be sent on TopCAT. You can then plot the profiles easily.

If we want to obtain the corresponding CO₂ density MCD profile with a dust storm scenario with maximum EUV. we can click on "send" on datalink column, select the scenario in the scrolling menu and submit. We obtain a VOTable containing the wanted MCD profile.

VESPA
Virtual European Solar and Planetary Access

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Results in service SPICAM

SPICAM - SPICAM Mars Atmospheric Vertical Distribution
SPICAM Mars Express - Vertical profiles of aerosols extinction [1], temperature and density of CO₂ [2], density of O₃ [3] derived from UV occultations. An user manual for the service is available here: http://vo.projekt.lamda.pt/3000/vo/SPICAM_VESPA_service_user_manual.pdf (1) Malinowski et al. (2015). A complete climatology of the seasonal vertical distribution on Mars from MCD-SPICAM UV solar occultations. Icarus, 233, 480-501 (doi:10.1016/j.icarus.2012.12.001) (2) Forget et al. (2008). Density and temperature of the upper Martian atmosphere measured by stellar occultations with Mars Express SPICAM. J. Geophys. Res., 114, E01504, doi:10.1029/2008JE013088 (3) Labeyrie et al. (2006). Vertical distribution of ozone on Mars as measured by SPICAM Mars Express using stellar occultations. J. Geophys. Res., 111, E06805, doi:10.1029/2005JE002452

Onfile:
Geophys: Chik Azhiz, Alexander Rozovang, Zi Yin
Contributing: Ann Malinowski, François Forget, Sébastien Labeyrie
Publisher: IAGLR

granule_id	desigproduct_type	target_name	time_min (d)	time_max (d)	access_url	download
orbit1226A1_temp_SPICAMmeasurements	profile	Mars	2004-12-31T21:18:28.511	2004-12-31T21:18:28.511	http://vo.projekt.lamda.pt/	Download
orbit1226A1_temp_MCDsimulations	profile	Mars	2004-12-31T21:18:28.511	2004-12-31T21:18:28.511	http://vo.projekt.lamda.pt/	Download
orbit1226A1_cobdens_SPICAMmeasurements	profile	Mars	2004-12-31T23:38:56.831	2004-12-31T23:38:56.831	http://vo.projekt.lamda.pt/	Download
orbit1226A1_cobdens_MCDsimulations	profile	Mars	2004-12-31T23:38:56.831	2004-12-31T23:38:56.831	http://vo.projekt.lamda.pt/	Download
orbit1226A1_cobdens_SPICAMmeasurements	profile	Mars	2004-12-31T21:18:28.511	2004-12-31T21:18:28.511	http://vo.projekt.lamda.pt/	Download
orbit1226A1_cobdens_MCDsimulations	profile	Mars	2004-12-31T21:18:28.511	2004-12-31T21:18:28.511	http://vo.projekt.lamda.pt/	Download

Showing 1 to 6 of 6 entries

QUERY: SELECT * FROM "spicam"."spicam.epn_core" WHERE "obs_id" = "1226A1"

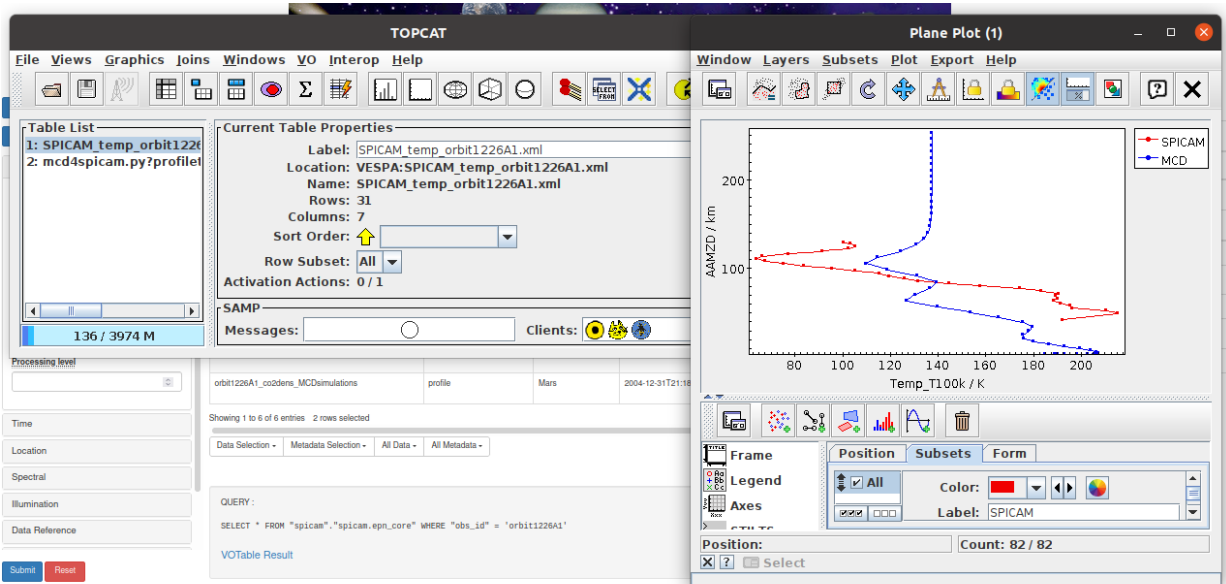


Figure 2.2: Example 2 .a - Plot and Compare SPICAM and MCD profiles

The screenshot shows the SPICAM service interface. A dialog box titled "Datalink" is open, displaying the URL: "http://vo.projet.lammos.ipsl.fr:8080/cgi-bin/mcd4spicam.py?profiletype=co2dens&orbit=1226A1&scenario=7". A red arrow points to the "Submit" button in the dialog. Below the dialog, a table lists simulation results with columns for profile_id, description, type, target, name, time_min (jd), time_max (jd), access_url, and datalink. The datalink column contains "SEND" buttons, one of which is highlighted with a red box. The table shows results for various profiles (temp, MCD, cddens) on Mars at different times and locations.

profile_id	description	type	target	name	time_min (jd)	time_max (jd)	access_url	datalink
orb1226A1_temp_SPICAMmeasurements	temp	profile	Mars		2004-12-31T21:18:28.511	2004-12-31T21:18:28.511	http://vo.projet.lammos.ipsl.fr:8080/cgi-bin/mcd4spicam.py?profiletype=temp&orbit=1226A1&scenario=7	SEND
orb1226A1_temp_MCDsimulations	temp	profile	Mars		2004-12-31T21:18:28.511	2004-12-31T21:18:28.511	http://vo.projet.lammos.ipsl.fr:8080/cgi-bin/mcd4spicam.py?profiletype=temp_mcd&orbit=1226A1&scenario=7	SEND
orb1226A1_cddens_SPICAMmeasurements	cddens	profile	Mars		2004-12-31T23:38:56.831	2004-12-31T23:38:56.831	http://vo.projet.lammos.ipsl.fr:8080/cgi-bin/mcd4spicam.py?profiletype=cddens&orbit=1226A1&scenario=7	SEND
orb1226A1_cddens_MCDsimulations	cddens	profile	Mars		2004-12-31T23:38:56.831	2004-12-31T23:38:56.831	http://vo.projet.lammos.ipsl.fr:8080/cgi-bin/mcd4spicam.py?profiletype=cddens_mcd&orbit=1226A1&scenario=7	SEND
orb1226A1_cddens_SPICAMmeasurements	cddens	profile	Mars		2004-12-31T21:18:28.511	2004-12-31T21:18:28.511	http://vo.projet.lammos.ipsl.fr:8080/cgi-bin/mcd4spicam.py?profiletype=cddens&orbit=1226A1&scenario=7	SEND
orb1226A1_cddens_MCDsimulations	cddens	profile	Mars		2004-12-31T21:18:28.511	2004-12-31T21:18:28.511	http://vo.projet.lammos.ipsl.fr:8080/cgi-bin/mcd4spicam.py?profiletype=cddens_mcd&orbit=1226A1&scenario=7	SEND

```

<!--
Produced with astrocy.io:restable version 4.2.1
http://www.astrocy.org
-->
<VOTABLE version="1.4" xmlns:namespaceSchemaLocation="http://www.ivoa.net/xml/VOTable/v1.4">
  <RESOURCE type="results">
    <DESCRIPTION> Table from Mars Climatic Database </DESCRIPTION>
    <TABLE>
      <FIELD ID="Radial_Distance" datatype="double" name="Radial_Distance" ucd="pos.bodyrc.alt" unit="km">
        <DESCRIPTION>
          Radial Distance from center of the planet
        </DESCRIPTION>
      </FIELD>
      <FIELD ID="AAMZD" datatype="double" name="AAMZD" ucd="pos.bodyrc.alt" unit="km">
        <DESCRIPTION> Altitude above Mars Zero Datum </DESCRIPTION>
      </FIELD>
      <FIELD ID="AASFC" datatype="double" name="AASFC" ucd="pos.bodyrc.alt" unit="km">
        <DESCRIPTION> Altitude above the local surface </DESCRIPTION>
      </FIELD>
      <FIELD ID="CO2_Abundance" datatype="double" name="CO2_Abundance" ucd="phys.abund" unit="kg.m-3">
        <DESCRIPTION> Carbon Dioxide Abundance </DESCRIPTION>
      </FIELD>
      <PARAM ID="Dust_scenario" arraysize="*" datatype="char" name="Dust_scenario" ucd="meta.version,obs.atmos" value="Warm">
        <DESCRIPTION>
          Warm scenario, dusty atmosphere, solar EUV maximum conditions
        </DESCRIPTION>
      </PARAM>
      <PARAM ID="Latitude" datatype="double" name="Latitude" ucd="pos.bodyrc.lat" unit="deg" value="15.7">
        <DESCRIPTION>
          Latitude, positive in North hemisphere, negative in South
        </DESCRIPTION>
      </PARAM>
      <PARAM ID="Longitude" datatype="double" name="Longitude" ucd="pos.bodyrc.lon" unit="deg" value="276">
        <DESCRIPTION>
          Longitude, positive in East, negative in West
        </DESCRIPTION>
      </PARAM>
      <PARAM ID="Solar_Longitude" datatype="double" name="Solar_Longitude" ucd="pos.posAng.pos.heliocentric" unit="deg" value="137.4">
        <DESCRIPTION>
          The Sun-Planet vector angle counted from the planet position at N hemisphere spring equinox
        </DESCRIPTION>
      </PARAM>
      <PARAM ID="Local_Time" datatype="double" name="Local_Time" ucd="time.period.rotation,time.phase" unit="h" value="1">
        <DESCRIPTION>
          Local True Solar Time at longitude (in martian hours)
    </TABLE>
  </RESOURCE>
</VOTABLE>

```

Figure 2.3: Example 2 .b - Obtain an alternative MCD profile using datalinks

Bibliography

- [1] SPICAM instrument <https://mars-express.cnes.fr/fr/MEX/Fr/spicam.htm>;
- [2] Mars Climate Database : Forget et al. 1999, Improved general circulation models of the Martian atmosphere from the surface to above 80 km ; Millour et al. 2018, The Mars Climate Database (Version 5.3) ;
- [3] Määttä et al. (2013), A complete climatology of the aerosol vertical distribution on Mars from MEx/SPICAM UV solar occultations, *Icarus*, 223, doi:10.1016/j.icarus.2012.12.001;
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