[Venus Express]-[SPICAV/SOIR]

To Planetary Science Archive Interface Control Document

VEX_BIRA_AR_02

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Change Log

Date	Sections Changed	Reasons for Change
20/09/2006	All	Creation of document from template
2/12/2006	All	Corrections applied by M. Barthelemy Addition of reference spectra, BROWSE directory, …
15/12/2006	2.4.5 – 3.1.1.2 2.4.4	Addition BROWSE directory on PSA level 1B Extended description DOCUMENT directory
17/08/2007	All	Updating for delivery to ESA
12/10/2007	2.3.2.1 – 2.3.2.4 2.4.3.2 – 2.4.3.3 2.4.5 – 3.1.1.1	Modify some mistakes previously not corrected
21/01/2008	2.3.2.2, 2.3.2.3, 2.3.2.4, 2.4.5, 2.4.6, 3.1.3, 3.1.4 Appendix: Content of the directories Appendix: Data product design	Regression files description added, new naming of occultations description, additional wavenumber column
21/04/2008	All	Reply to peer review RIDs
21/09/2009	All	Adaptation to new dataset structure (V2.0)
04/05/2011	2.3.2.2, 2.3.2.4	AOTF and Blaze function files
18/04/2013	All	New format for PSA level 3 files Calibration files updated
17/12/2015	All	Measurement types miniscans, nadirs, fullscans, pointings, straylight added to PSA level 3. Calibration files updated

07/03/2016		Adding description of files containing the parameters used for the linear regression.

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1. Introduction

1.1. Purpose and Scope

This EAICD (Experimenter to (Science) Archive Interface Control Document) is exclusively dedicated to the SOIR channel of the SPICAV/SOIR instrument on board Venus Express. The purpose of this EAICD is twofold. First it provides users of the SOIR instrument with detailed description of the product and a description of how it was generated, including data sources and destinations. Secondly, it is the official interface between the SOIR instrument team and the archiving authority.

1.2. Archiving Authorities

The Planetary Data System Standard is used as archiving standard by

- NASA for U.S. planetary missions, implemented by PDS
- ESA for European planetary missions, implemented by the Research and Scientific Support Department (RSSD) of ESA

ESA implements an online science archive, the ESA's Planetary Science Archive (PSA),

- to support and ease data ingestion
- to offer additional services to the scientific user community and science operations teams as e.g.:
  - search queries that allow searches across instruments, missions and scientific disciplines
  - several data delivery options as
    - direct download of data products, linked files and data sets
    - ftp download of data products, linked files and data sets

The PSA aims for online ingestion of logical archive volumes and will offer the creation of physical archive volumes on request.

1.3. Contents

This document describes the data flow of the SOIR instrument on VENUS EXPRESS from the S/C until the insertion into the PSA. It includes information on how data were processed, formatted, labeled and uniquely identified. The document discusses general naming schemes for data volumes, data sets, data and label files. Standards used to generate the product are explained. Software that may be used to access the product is explained.

The design of the data set structure and the data product is given, with examples in appendix.

1.4. Intended Readership

Any potential user of the SOIR data, and the staff of the archiving authority (Planetary Science Archive, ESA, RSSD, design team).

1.5. Applicable Documents

AD1	VENUX EXPRESS - SPICAV - EAICD (Experiment to (Science) Archive Interface Control Document), Feb 14 2006, issue 00, Maud Barthelemy	SA_VEX_ARCH_001
AD2	Planetary Data System (PDS) Preparation Workbook Feb 17 1995, version 3, JPL, D-7669, Part 1	
AD3	Planetary Data System (PDS) Standards Reference, August 1 2003, version 3.6, JPL, D-7669, Part 2	
AD4	Planetary Science Archive, Experiment Data Release Concept, Technical Proposal	SOP-RSSD-TN015
AD5	Venus Express - SPICAV (SPICAM-Light + SOIR) - TC & TM parameters and formats related to SOIR	SPV-BIRA-SP-06
AD6	ROSETTA/MEX/VEX Mission Control System Data Delivery Interface Document (DDID), issue C1	VEX-ESC-IF-5003
AD7	VEX BE Soft Reference and User Manual	VEXBErefxxx.doc
AD8	VEX SPICAV Flight User/Operations Manual	SPV-DES-032

1.6. Relationships to Other Interfaces

Changes in the standard SOIR data products would require changes to this document.

1.7. Acronyms and Abbreviations

BIRA	Koninklijk Belgische Instituut voor Ruimte Aeronomie
DDS	Data Disposition System
DPU	Dedicated Processor Unit
EAICD	Experimenter to (Science) Archive Interface Control Document
IASB	Institut royal d'Aéronomie Spatiale de Belgique
IKI	Institute Kosmitcheski Isledovanie
IR	Infra Red
MPS	Mission Planning System
N/A	Not Applicable
PDS	Planetary Data System
PSA	Planetary Science Archive
SA	Service d'Aéronomie, CNRS
SPICAV	Spectroscopy for the Investigation of Characteristics of the Atmosphere of VENUS
SIR	SPICAV Sensor IR
SU	Sensor Unit

SUV	SPICAV Sensor UV
SOIR	Solar Occultation IR sensor
TC	Telecommand
TM	Telemetry
UV	Ultra Violet

1.8. Contact Names and Addresses

Data preparation and final products delivery into the PSA are provided by the SOIR staff at the BIRA-IASB, Brussels, Belgium.

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2. Overview of Instrument Design, Data Handling Process and Data Product

2.1. Instrument Design

2.1.1. Instrument description

SOIR is a new compact space borne high resolution spectrometer developed for the ESA Venus Express spacecraft. It operates in the IR wavelength range of 2.325 to 4.25 μm and measures absorption spectra of minor constituents in Venus' atmosphere. It uses a novel echelle grating with groove density of 4 lines per mm in a Littrow configuration, in combination with an IR Acousto-Optic Tunable Filter for order sorting and an actively cooled HgCdTe Focal Plane Array of 256 by 320 pixels. It is designed to obtain an Instrument Line Profile, full width at half maximum (FWHM), of 0.2 cm^{-1} and a Sampling Interval of 0.1 cm^{-1} per pixel over the whole spectral range

The FOV in the spatial direction is limited to 30', in order to avoid solar limb darkening effects (apparent solar diameter at Venus is 44'). For the spectral direction, perpendicular to the spatial direction, the FOV is 2' (good height resolution during the inversion process of the Venus occultation data). Hence, a rectangular field of view of 2' by 30' is defined. The attitude of the VEX spacecraft during an occultation observation is controlled such that the boresight of the SOIR instrument is pointing the Sun and that the long side of the rectangular FOV remains parallel to the planet's limb when altitude of measurement equals 65km.

The mass of SOIR is 6.5 kg and its volume to 414 by 254 by 210 mm^3. A periscope-like device is added to the side wall of the instrument, since the VEX solar viewing boresight is at an angle of 60° with respect to the SOIR optical axis. SOIR is thermally qualified for an operational temperature range between -20 °C and +40 °C and a non-operational between -30 °C and +50 °C.

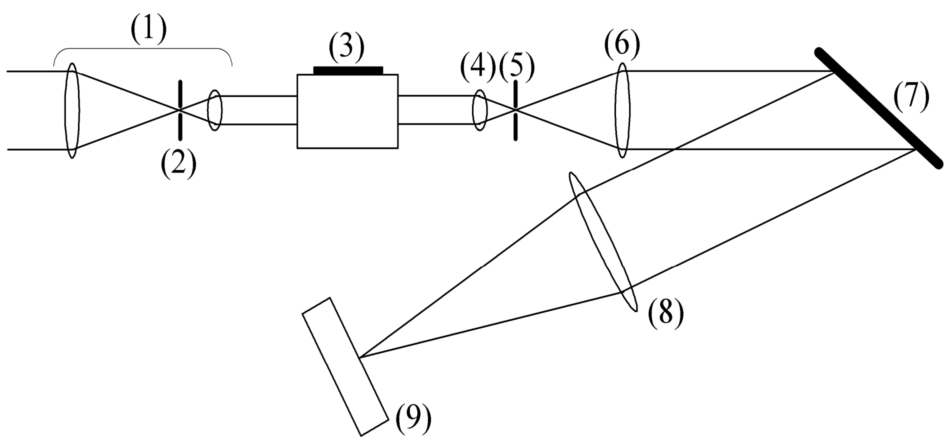

Figure 1: Optical layout of SOIR spectrometer

SOIR uses an echelle grating as a diffracting device; this grating type is known to yield high reciprocal dispersion and high throughput in a compact design. Since an echelle, like all gratings, is generating overlapping orders, an order sorting filtering was required, in this case a tunable bandpass filter. Compared to orthogonal cross-dispersion solutions using prisms or low dispersion gratings, this technique allows the imaging of longer spectral lines on the detector and hence a larger binning factor along the lines, which results in higher signal-to-noise ratios. In SOIR the bandpass filter is an Acousto Optical Tunable Filter (AOTF). It has both the advantage of avoiding mechanical moving mechanisms and of a quick random access to any grating order by electronic control. Moreover, by deactivating the AOTF, one can stop all solar input to the spectrometer; this allows measuring a thermal background spectrum that can be subtracted from the observed spectrum.

The spectrometer is composed of three main parts: (a) the front-end part which collects the solar light, defines the FOV and restricts the observed wavelength domain; (b) the spectrometer itself which realizes the free spectral range and the ILP and finally (c) the detector system that records the spectra according to a spectral sampling interval.

Figure 1 shows the lay-out of the SOIR spectrometer. The front-end starts at the AOTF entrance optics (1) that reduce the diameter of the incoming light beam so that it becomes compatible with the AOTF acceptance aperture. In the intermediate image plane of the entrance optics a first diaphragm (2) is placed that limits the FOV to slightly larger than the desired FOV. Then the beam enters the AOTF (3) to filter out unwanted orders. When activated with an RF signal, the AOTF directs the small fraction of the beam that corresponds to the wavelength domain to be analyzed along its optical axis. The AOTF exit optics (4) images the beam on the spectrometer entrance slit (5), which is the entrance aperture for the spectrometer part of the instrument. A collimating lens (6) captures the light passing through the spectrometer entrance slit, collimates and transports it as a parallel beam to the dispersing element (7), the echelle grating located between collimator lens and imaging lens. Finally, the light diffracted by the grating is imaged via a camera lens (8) on the detector (9).

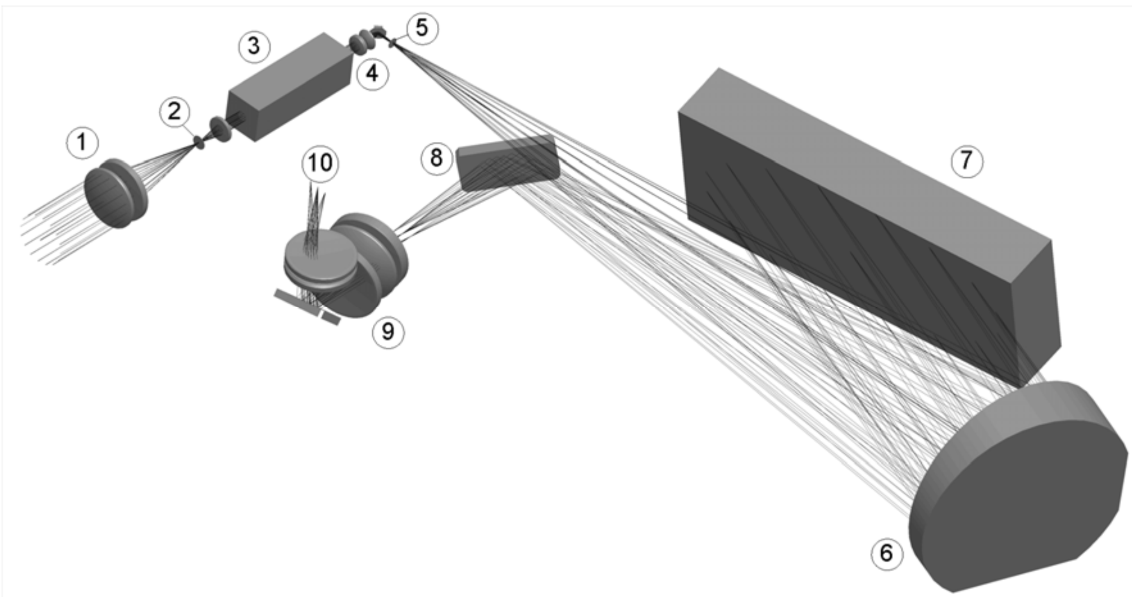

Figure 2: Realistic layout of SOIR optics

In order to obtain a compacted optical scheme for the high-resolution spectrometer part, a quasi-Littrow configuration was selected, in which the function of the collimation lens and of the imaging lens are merged into a single off-axis parabolic mirror. An additional benefit is that no co-alignment of two separate lenses is needed. In the detailed optical scheme and the associated ray tracing scheme, see Figure 2, the main recognizable optical units are: the entrance optics (1), the diaphragm (2), the AOTF (3), the AOTF exit optics (4), the spectrometer slit (5), the off-axis parabolic mirror (6), the echelle grating (7), the folding mirror (8), the detector optics (9) and finally the detector (10).

Table 1 gives an overview of the main characteristics of the SOIR instrument.

	Value or range	**Units**
Wavelength range	2.32 to 4.25	µm
Wavenumber range	2353 to 4310	cm^{-1}
Spectral sampling interval	0.1	cm^{-1}/pixel
Instrument Line Profile	2 (FWHM)	pixels
Resolving power	23200 to 43100	$\lambda/\Delta\lambda=\upsilon/\Delta\upsilon$
Spectral field of view	2	arc minutes
Spatial field of view	30	arc minutes
Entrance aperture diameter	20	mm
Mass	6.5	kg
Dimensions (w/o periscope)	414 x 254 x 210	mm^3

Table 1: Main characteristics of the SOIR instrument

2.1.2. Operational aspects

The SOIR instrument executes two operational phases in sequence: pre-cooling phase with duration T1 and observation phase with duration T2 (divided in a series of time equidistant 1 second observations, each composed of a number of spectral recordings packed into a single TM packet, together with housekeeping information related to the observation).

After power-up, 2 types of TC packets are sent to SOIR by the SPICAV DPU: the first type contains all parameters related to the pre-cooling phase of the SOIR detector system and the second type contains all the parameters to define the operation of SOIR observation phase, see Figure 3.

Upon reception of the first TC packet of type 1 the precooling phase is started. During this phase a TC packet of type 1 is sent every second. These packets are invitations to SOIR to send TM packets. Note that in the precooling phase the TM packets do not contain scientific data. Only housekeeping is sent, see Figure 4.

Upon reception of the first TC packet of type 2 the observation phase starts during which every second a TC packet of type 2 is sent to invite SOIR to send TM packets that do contain scientific and housekeeping, see Figure 4.

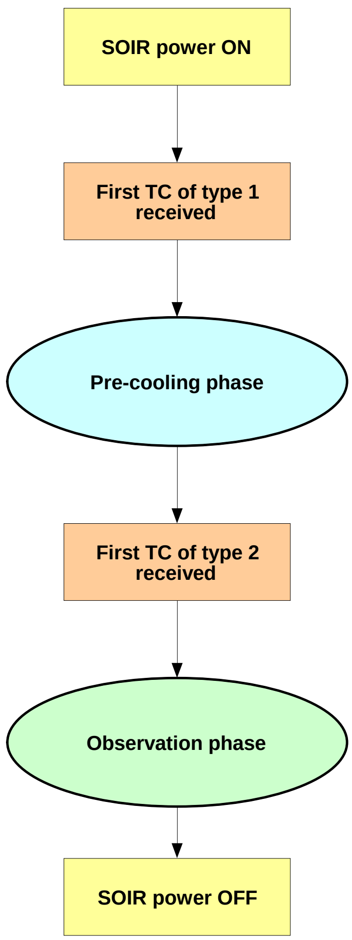

Figure 3: Flow diagram of SOIR operation

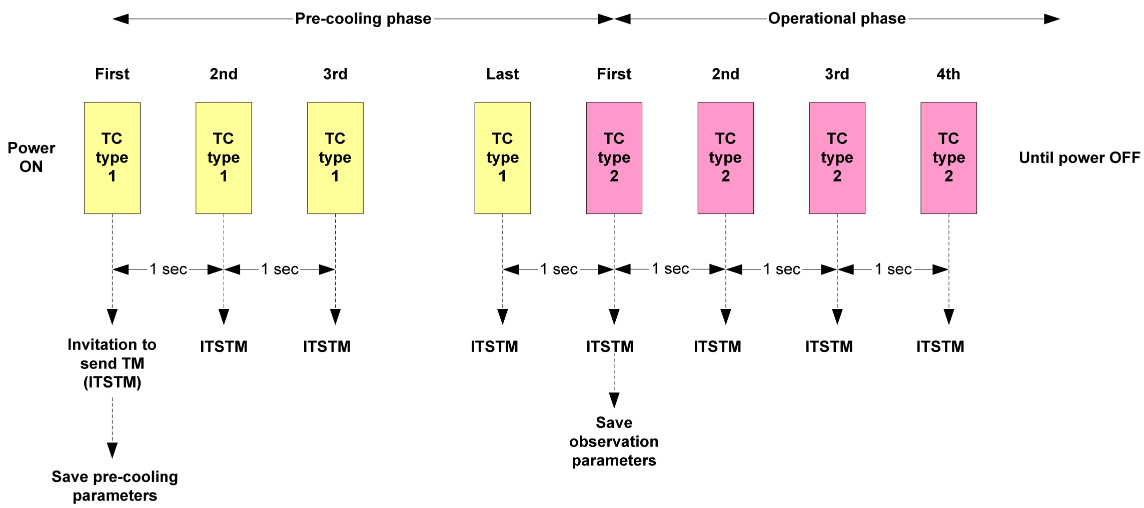

Figure 4: Telecommand and telemetry scheme

Spectra recordings contained within one observation may be taken in either of 3 ways:

- **AOTF frequency hopping**:

During each observation up to 4 random AOTF frequencies (hopping) and hence non-contiguous small wavelength domains are recorded (Figure 5).

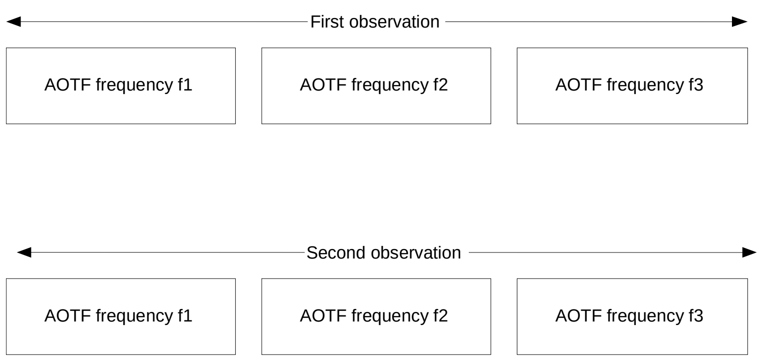

Figure 5: Frequency hopping

- **Single parameter stepping**:

During each observation a series of up to 4 wavelength domains is recorded. The parameters defining each of the domains are identical, except one which is incremented by a fixed amount from domain to domain. Single parameter stepping can be executed either continuous from one observation to the next or with a reset to a value specified by TC at each observation.

A special case of single parameter stepping is **AOTF frequency stepping** (Figure 6): the AOTF frequency is incremented by a fixed frequency step for each sequential spectral domain, while all other parameters remain unchanged.

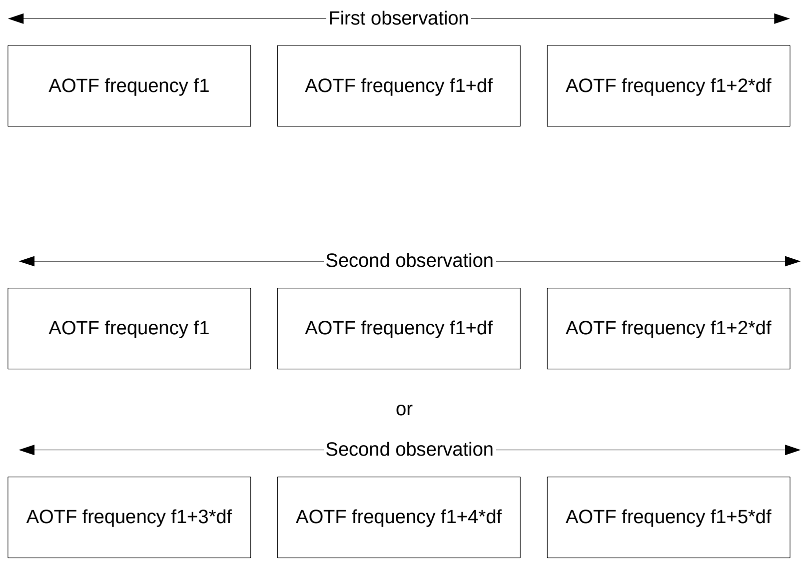

Figure 6: General scheme for frequency stepping

- **Automatic window stepping:**

The detector is read-out completely by reading sequentially windows of 8 lines. Observations start with the detector window positioned at line 1 and for subsequent observations the window is shifted by 8 lines. In total 32 observations are required to read out the complete detector array (Figure 7).

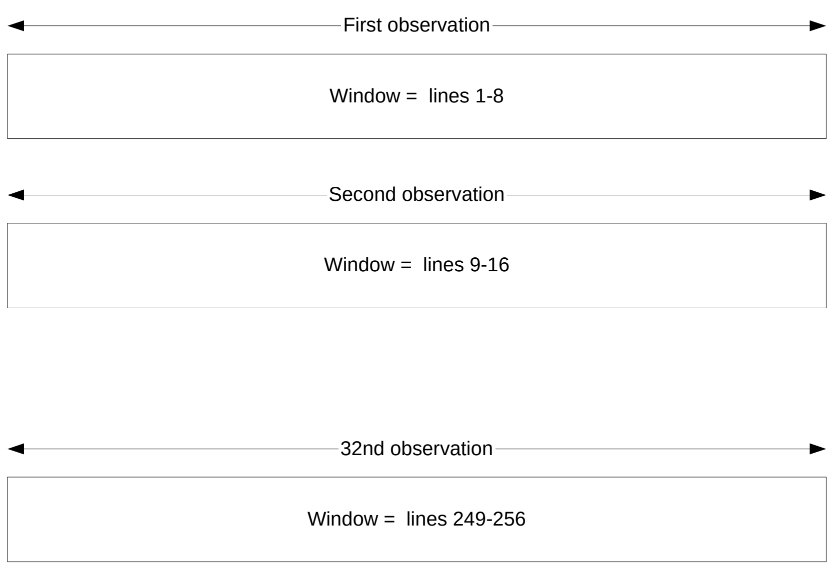

Figure 7: Automatic window stepping

2.2. Scientific Objectives

The general SPICAV/SOIR scientific objectives are:

Chemistry: Simultaneous measurements of O_3 and H_2O will allow validating and/or modifying chemistry models, from which will be derived an assessment of the oxidation environment (effect of solar UV, O_3, H_2O_2, O, on minerals and oxidation molecules).

Structure/Dynamics/Meteorology: Vertical profiles of density / temperature (60-160 km) will provide unique information about the global structure and dynamics of the atmosphere, in particular in the altitude region crucial for aerocapture and aerobraking, and a better understanding of meteorological systems.

Clouds/dust/aerosols: Occultation measurements will allow the detection, measurement and characterization of the physical nature of aerosols, dust particles, and their vertical distribution.

Ionosphere/escape rate: Vertical profiling of daylight aeronomic emissions (H, C, O, CO, CO_2^+) will allow to adjust a comprehensive model of the ionosphere, from which an estimate of escape processes may be derived (evolution of the atmosphere), and to study the interaction with the solar wind.

The main SOIR target components are listed in Table 2.

Species	**Spectral range (µm)**	**Altitude**
CO_2	2.7, 4.3	60-180km
H_2O	2.56	60-105 km
HDO	2.56, 3.7	60-90 km
CO	2.35	60-150 km
OCS	3.44	60-80 km
H_2S	2.63, 3.7	60-80km
HCl	3.6	60-100 km
HF	2	60-100 km
SO_2	4.0	60-70 km

Table 2: Main SOIR target components

2.3. Data Handling Process: SPICAV data processing, retrieval algorithms, and definitions of data levels

2.3.1. SOIR data processing, retrieval algorithms

The data collected between each switch ON and switch OFF of SOIR is downlinked from the S/C to ESOC and stored on the Data Disposition System (DDS). From there it will be retrieved via ftp and stored at BIRA-IASB.

Data from the DDS-files will be treated and processed at different levels, internal to the BIRA-IASB data collection structure (SOIR internal data levels). Some of these levels will be converted into deliverable PDS format levels.

Retrieval algorithms and software which will be used throughout the processing steps, starting at download from DDS and stepping up from low to high archiving levels are developed at BIRA-IASB in python programming language.

2.3.2. Definitions of data levels

2.3.2.1. SOIR internal data levels

Level 0.0: dds-file

Level 0.1a: SOIR raw data

- source dds file
- product 1 raw bin files (pure telemetry)
- product 2 raw csv files with updated time tag information, housekeeping values, TC copy (standard format)
- structure one file per second throughout complete precooling and observation phase
- data contents ADC code afo pixel number

Level 0.1B: SOIR raw data in PDS format (see below)

Level 0.2: SOIR data after correction step 1

- source level 0.1 csv files
- action correct for non-linear detector behaviour
- product csv files (standard format)
- structure one file per second throughout complete precooling and observation phase
- data contents arbitrary signal units afo pixel number

Level 0.3: SOIR data after correction step 2

- source level 0.2 csv files
- action
  1. selection of useful observation period: tangent altitude between 60 and220 km
  2. division full sun reference spectrum corrected for linear time dependency of sun intensity due to spacecraft drift (linear regression of reference solar spectrum)
  3. faulty pixels treatment
  4. pixel-to-wavenumber conversion
  5. split each selected file into 4 files (one per order)
  6. separate combined sunset + sunrise observations into one sunrise and one sunset
- product 1 csv files (standard format)
  - structure up to 4 files per second for the selected period (up to 4 orders observed per second)
  - data contents transmission ($0 \leq T \leq 1$) afo wavenumber
- product 2 file lin_regr_param (csv-format)
  - data contents : the linear regression parameters used for the linear regression for every bin
- calib 1 resolution calibration; one file per binning type
  - structure 1 value per order per bin
  - data contents single value
- calib 2 AOTF transfer function; one file per binning type

  - structure 1 calibration per order per bin
  - data contents AOTF transfer function value given afo centered wavenumber, in the range -100 to +100 cm^{-1} around the maximum of the function (values between 0 and 1)
- calib 3 AOTF tuning function
  - structure 1 calibration per bin
  - data contents AOTF tuning function values to relate the AOTF frequency to a wavenumber
- calib 4 Blaze function
  - structure 1 calibration per order per bin
  - data contents Blaze function value given afo center of the order wavenumber, in the -100 to +100 cm^{-1} around the maximum of the function (values between 0 and 1)

2.3.2.2. Data levels deliverable to PSA

The internal SOIR levels that are converted into PDS format and deliverable to PSA, are shown in Table 3.

SOIR LEVEL	CONTENTS	PSA LEVEL	CODMAC	PRODUCT TYPE
0.2	edited data	2	2	RDR – Reduced Data Record
0.3	calibrated data	3	3	RDR – Reduced Data Record

Table 3: Conversion between internal SOIR levels and deliverable PSA levels.

Level 1.0: SOIR raw data in PDS format

- product .TAB files and associated .LBL files
- structure 1 table with science contents + 1 table with additional data (telecommand TC 2)
- science data contents ADC code afo pixel number
- additional data contents telecommand of type 2 (observation phase)

Level 2.0: SOIR calibrated data in PDS format

- product .TAB files and associated .LBL files
- structure up to 4 tables with science contents (1 table per order, containing the transmittance of each order) + 1 tables with additional data (telecommand TC 2, treatment)
- science data contents time, transmission and noise, housekeeping, attitude, the parameters used and other parameters obtained during the linear regression of the full sun spectrum
- calibration data contents AOTF frequency to wavenumber calibration per bin, AOTF transfer function per bin per order afo wavenumber, Blaze transfer function per bin per order afo wavenumber, instrument resolution
- additional data contents telecommand of type 2 (observation phase)

A description of the data files will be given (per level) in the SOIR_DATAFILE_DESC.TXT file in the DOCUMENT directory.

2.3.2.3. PSA data level 2 construction philosophy

All the data of the observation phase (answers to TC2 type commands) are considered, regardless their scientific usefulness.

Assume the observation phase N_{obs} seconds. Each second an observation is made.

Source files used for PSA level 2 construction are the N_{obs} csv-files at internal SOIR level 0.2

Directory naming is based on the date of the observation `YYYYMMDD`, while the filenames contain both date `YYYYMMDD` and time `hhmmss` of the observation.

```
../Venus_Express/DATA/L2/YYYYMMDD_TCC/tmYYYYMMDDhhmmss.csv
```

with *YYYY*=year, *MM*=month, *DD*=day, *hh*=hours, *mm*=minutes, *ss*=seconds, *T*=measurement type, *CC*= chronological measurement number of the day (starting at 1).

T (measurement type) can have the following values:

* I = Ingress (occultation)

* E = Egress (occultation)

* M = Miniscan

* F = Fullscan (outside atmosphere)

* A = Fullscan (inside atmosphere)

* N = Nadir

* C = Pointing calibration

Example: Sept 12th 2006, MTP 05, Occultation 13

Observation phase: N_{obs} = 593 - start 3h04'21" – end 3h14'13":

```
../Venus_Express/DATA/L2/20060912_I01/tm20060912030421.csv
...
../Venus_Express/DATA/L2/20060912_I01/tm20060912031413.csv
```

From these (N_{obs}) source files the PSA data level 2 is constructed resulting in 1 science data table and 1 additional data tables (each table with its associated PDS label). All tables are in ASCII-format. The directory structure and file naming convention and the file contents are discussed in detail further on. Hence the PDS data set for one occultation consists of:

1 science data table and 1 associated label containing time, spectra and housekeeping data:

```
./VEX-Y_V-SPICAV-2-SOIR-V2.0/DATA/YYYYMMDD_TCC/YYYYMMDD_TCC_OBS.TAB
./VEX-Y_V-SPICAV-2-SOIR-V2.0/DATA/YYYYMMDD_TCC/YYYYMMDD_TCC_OBS.LBL
```

1 additional data table for "telecommand 2" (TC2 suffix) and its associated label:

```
./VEX-Y_V-SPICAV-2-SOIR-V2.0/DATA/YYYYMMDD_TCC/YYYYMMDD_TCC_TC2.TAB
./VEX-Y_V-SPICAV-2-SOIR-V2.0/DATA/YYYYMMDD_TCC/YYYYMMDD_TCC_TC2.LBL
```

with *YYYY*=year, *MM*=month, *DD*=day, *T*=measurement type, *CC*= chronological measurement number of the day (starting at 1).

Example: Sept 12th 2006, MTP 05, Occultation 13

```
../VEX-Y_V-SPICAV-2-SOIR-V2.0/DATA/20060912_I01/20060912_I01_OBS.TAB
../VEX-Y_V-SPICAV-2-SOIR-V2.0/DATA/20060912_I01/20060912_I01_OBS.LBL

../VEX-Y_V-SPICAV-2-SOIR-V2.0/DATA/20060912_I01/20060912_I01_TC2.TAB
../VEX-Y_V-SPICAV-2-SOIR-V2.0/DATA/20060912_I01/20060912_I01_TC2.LBL
```

The science data tables contain all information that can be catalogued per second: time, spectrum, housekeeping. One column is added to distinguish precooling from observation phase data. Its format is shown in Table 4.

C_1 time			C_2 bin_0			…	C_9 bin_7			C_{10} housekeeping		
T_1	…	T_4	I_1	…	I_{320}		I_1	…	I_{320}	H_1	…	H_{16}

Table 4: PSA level 2 science data table – TAB-file format

C_i (i=1 to 11) are 11 columns

- C_1 = 4 time items T_s (s=1 to 4) corresponding to the time stamps within 1 second observation (format `"2006-08-09T01:30:53.000"`) (4 x 23 bytes, type *character*)
- C_3 to C_{10} = 8 spectrum bins (bin_0 through bin_7) each bin consisting of 320 items I_j (j=1 to 320) corresponding to $pixel_j$ (8 x 320 x 10 bytes, type *ASCII_integer*)
- C_{11} = 16 housekeeping items H_k (k=1 to 16) (16 x 11 bytes, type *ASCII_real*)

The tables contain Npre + Nobs rows. See appendix 2 for column contents details.

The additional data tables for the SOIR telecommand of type 2 (issued to start the observation phase) has the format shown in Table 5.

C_1 telecommand parameter name	C_2 telecommand parameter value

Table 5: PSA level 1B additional data table for TC2 – TAB-file format

- C_1 = name of the telecommand parameter (e.g. *dpss, aofs1, deit3*, …) (8 bytes, type *character*)
- C_2 = value of the telecommand (8 bytes, type *ASCII_integer*)

The TC2 table contains 31 rows.

2.3.2.4. PSA data level 3 construction philosophy

The description hereafter is dedicated to the occultation type of measurement but the same holds for all other types of measurement. A transmittance is computed only for occultation measurements, i.e. egress, ingress and atmospheric fullscans. The files produced for the other types of measurement contain the measured radiance (in ADU), and are thus not calibrated in intensity. More information can be found in APPENDIX 4.

Assume a certain occultation containing N observations (= N seconds) at the internal SOIR level 0.3.

Assume that in each observation (each second) spectra from P orders are registered. N is typically around 120, P can vary from 1 to 4.

Directory naming is based on the date of the observation *`YYYYMMDD`*, while the filenames contain both date *`YYYYMMDD`* and time *`hhmmss`* of the observation.

Source files used for PSA level 3 construction are the N x P SOIR internal level 0.3 science csv-files that can be as

`../Venus_Express/DATA/L0.3/YYYYMMDD_TCC/tmYYYYMMDDhhmmss_orderxxx.csv`

`or`

`../Venus_Express/DATA/L0.3/YYYYMMDD_TCC/tmYYYYMMDDhhmmss_orderxxxE.csv`

Or

`../Venus_Express/DATA/L0.3/`*`YYYYMMDD_TCC`*`/tm`*`YYYYMMDDhhmmss`*`_order`*`xxxEE`*`.csv`

and the corresponding attitude csv-file

`../Venus_Express/DATA/ATT/`*`YYYYMMDD_TCC`*`/`*`YYYYMMDD_TCC_qqqq`*`.csv`

with *YYYY*=year, *MM*=month, *DD*=day, *hh*=hours, *mm*=minutes, *ss*=seconds, *T*=measurement type, *CC*=chronological measurement number of the day (starting at 1), *xxx*=order number, *E* a letter (from a to z) present in case a given order has been scanned more than once during the occultation (i.e. it is not always present), EE if an order has been scanned more than 26 times (used only for miniscans) and *qqqq*=orbit number.

Example: Sept 12th 2006, MTP 05, Orbit 144, Ingress, Occultation 13, P = 4 (orders per observation)

```
Observation (second) N = 1 (3h07'57")
../Venus_Express/DATA/L0.3/20060912_I01/tm20060912030757_order126.csv
../Venus_Express/DATA/L0.3/20060912_I01/tm20060912030757_order127.csv
../Venus_Express/DATA/L0.3/20060912_I01/tm20060912030757_order128.csv
../Venus_Express/DATA/L0.3/20060912_I01/tm20060912030757_order129.csv
...
Observation (second) N = 110 (3h09'46")
../Venus_Express/DATA/L0.3/20060912_I01/tm20060912030946_order126.csv
../Venus_Express/DATA/L0.3/20060912_I01/tm20060912030946_order127.csv
../Venus_Express/DATA/L0.3/20060912_I01/tm20060912030946_order128.csv
../Venus_Express/DATA/L0.3/20060912_I01/tm20060912030946_order129.csv
```

From these (N x P + 2) source files the PSA data level 3 is constructed resulting in P science data tables and 1 additional data tables (each table with its associated PDS label). All tables are in ASCII-format. The directory structure and file naming convention and the file contents are discussed in detail further on. Hence the PDS data set for one occultation consists of:

P science data tables and P associated labels containing time, spectra, housekeeping and attitude data

`../VEX-Y_V-SPICAV-3-SOIR-V2.0/DATA/`*`YYYYMMDD_TCC`*`/`*`YYYYMMDD_TCC_xxxE`*`.TAB`

`../VEX-Y_V-SPICAV-3-SOIR-V2.0/DATA/`*`YYYYMMDD_TCC`*`/`*`YYYYMMDD_TCC_xxxE`*`.LBL`

with *YYYY*=year, *MM*=month, *DD*=day, *T*=measurement type, *CC*=chronological measurement number of the day (starting at 1), *xxx*=order number and *E* a letter, only present if an order has been scanned more than once during an occultation.

Example: Sept 12th 2006, MTP 05, Orbit 144, Occultation 13, P = 4 (number of orders per observation)

```
../VEX-Y_V-SPICAV-3-SOIR-V2.0/DATA/20060912_I01/20060912_I01_126.TAB
../VEX-Y_V-SPICAV-3-SOIR-V2.0/DATA/20060912_I01/20060912_I01_126.LBL
../VEX-Y_V-SPICAV-3-SOIR-V2.0/DATA/20060912_I01/20060912_I01_127.TAB
../VEX-Y_V-SPICAV-3-SOIR-V2.0/DATA/20060912_I01/20060912_I01_127.LBL
../VEX-Y_V-SPICAV-3-SOIR-V2.0/DATA/20060912_I01/20060912_I01_128.TAB
../VEX-Y_V-SPICAV-3-SOIR-V2.0/DATA/20060912_I01/20060912_I01_128.LBL
../VEX-Y_V-SPICAV-3-SOIR-V2.0/DATA/20060912_I01/20060912_I01_129.TAB
```

../VEX-Y_V-SPICAV-3-SOIR-V2.0/DATA/20060912_I01/20060912_I01_129.LBL

The science data tables contain all information that can be catalogued per second per bin in the observation for one specific order time, spectrum, housekeeping, attitude of the S/C. It has the format shown in Table 6.

C_1 time	C_2 bin	C_3 binning	C_4 attitude			C_5 instrumental			C_6 wavenumber calib.			C_7 transmittance & noise			C_8 housekeeping		
			A_1	…	A_{12}	I_1	…	I_3	W_1	…	W_5	I_1	…	I_{640}	H_1	…	H_{16}

Table 6: PSA level 3 science data table – TAB-file format

C_i (i=1 to 8) are 8 sets of columns

- C_1 = time stamp corresponding to the order in the filename (format "2006-08-09T01:30:53.000") (23 bytes, type *character*)
- C_2 = bin number (type *ASCII_INTEGER*)
- C_3 = number of detector binned (type *ASCII_INTEGER*)
- C_4 = 12 attitude data A_m (m=1 to 12) (22 x 14 bytes, type *ASCII_REAL*)
- C_5 = 3 instrumental data I_m (m=1 to 3) (22 x 14 bytes, type *ASCII_INTEGER*)
- C_6 = 5 wavenumber calibration coefficients for the 4th order polynomials, with W_j (j=1 to 10) corresponding to polynomial coefficients (5 x 14 bytes, type *ASCII_REAL*)
- C_7 = spectrum and noise, consisting of 2 x 320 items I_j (j=1 to 620) (320 x 10 bytes, type *ASCII_real*)
- C_8 = 16 housekeeping items H_k (k=1 to 16) (16 x 11 bytes, type *ASCII_real*)

See appendix 2 for column contents details.

For some miniscans, during which the same order is scanned more than 26 times, 2 letters are used in the filename is:

../Venus_Express/DATA/L0.3/*YYYYMMDD_TCC*/tm*YYYYMMDDhhmmss*_order*xxxEE*.csv

The first 26 same scanned order have names with only one letter. At the 27th order, the second letter is added in this way:

For instance, for the miniscan measurement made at orbit 374.2 (30/04/2007), the following files have been created:

tm20070430064806_order110a.csv

…

tm20070430064831_order110z.csv

tm20070430064832_order110aa.csv

…

tm20070430064857_order110az.csv

tm20070430064858_order110ba.csv

For all other kind of observation than occultation (miniscans, fullscans, nadirs, calibration), not available data have been set to 999.999 or -999.999 in the LBL file.

To ensure good quality of all data at each level of the pipeline, few occultation couldn't be produced at the internal SOIR level 0.3. These occultation are thus not present in PSA level 3.

The additional data table contains information over the linear regression used to calibrate the occultation observations. It has the format shown in Table 7.

C_1 bin number	C_2 Indexes of the different regions			C_3 Parameters used to find the regression region			C_4 Validation of the criteria			C_5 Bad pixels		
	a1	…	a11	b_1	…	b6	c_1	…	c1600	d1		d320

Table 7 : PSA level 2 data table containing the regression of the full sun spectrum – TAB-file format

- C_1 = bin number (2 bytes, type *ASCII_integer*)
- C_2 = 11 indexes corresponding to times of measurement a_j (j=1 to11) (10 x 35 bytes + 1 x 17 bytes, type *CHARACTER*)
- C_3 = 6 parameters used for the algorithm (5 x 13 bytes + 1 x 14 bytes, type *ASCII_real*)
- C_4 = 5 x 320 items c_j (j=1 tot 1600) corresponding to validation of the 5 criteria defined in APPENDIX 4 for each pixel (1600 x 4160 bytes, type *ASCII_real*)
- C5 = 320 items d_j (j=1 tot 320) for the 320 pixels telling if they are "bad pixels" as defined in APPENDIX 4 (320 x 4147 bytes, type BOOLEAN)

The additional data table has the following file name:

P science data tables and P associated labels:

`../VEX-Y_V-SPICAV-3-SOIR-V2.0/DATA/`*`YYYYMMDD_TCC/YYYYMMDD_TCC`*`_R`*`xxxE`*`.TAB`

`../VEX-Y_V-SPICAV-3-SOIR-V2.0/DATA/`*`YYYYMMDD_TCC/YYYYMMDD_TCC`*`_R`*`xxxE`*`.LBL`

with *YYYY*=year, *MM*=month, *DD*=day, *T*=measurement type, *CC*=chronological measurement number of the day (starting at 1), *xxx*=order number and *E* a letter, only present if an order has been scanned more than once during an occultation.

Example: Sept 12th 2006, MTP 05, Orbit 144, Occultation 13, P = 4 (number of orders per observation)

```
../VEX-Y_V-SPICAV-3-SOIR-V2.0/DATA/20060912_I01/20060912_I01_R126.TAB
../VEX-Y_V-SPICAV-3-SOIR-V2.0/DATA/20060912_I01/20060912_I01_R126.LBL
../VEX-Y_V-SPICAV-3-SOIR-V2.0/DATA/20060912_I01/20060912_I01_R127.TAB
../VEX-Y_V-SPICAV-3-SOIR-V2.0/DATA/20060912_I01/20060912_I01_R127.LBL
../VEX-Y_V-SPICAV-3-SOIR-V2.0/DATA/20060912_I01/20060912_I01_R128.TAB
../VEX-Y_V-SPICAV-3-SOIR-V2.0/DATA/20060912_I01/20060912_I01_R128.LBL
../VEX-Y_V-SPICAV-3-SOIR-V2.0/DATA/20060912_I01/20060912_I01_R129.TAB
../VEX-Y_V-SPICAV-3-SOIR-V2.0/DATA/20060912_I01/20060912_I01_R129.LBL
```

2.3.2.5. PSA data level 5 construction philosophy

Not used for SOIR.

2.4. Overview of Data Products

2.4.1. Instrument Calibrations

All information about calibration is related to the flight model. Information needed to calibrate the SOIR data will be given in the SOIR_CALIBRATION_DESC.DOC file in the DOCUMENT directory. It also describes the contents of the CALIB directory. These documents explain how the in-flight calibration is done for the observations with the SOIR sensors. The software used to apply these calibrations is described in the SOIR_CALIBRATION_SOFTWARE.TXT document in the DOCUMENT directory. An article on SOIR calibration (published in Applied Optics) is also part of the DOCUMENT directory.

2.4.2. In-Flight Data Products

During the active mission SOIR data from the CRUISE and NOMINAL phases will be collected. A SOIR data set will be defined for each data product level.

2.4.3. Software

The SOIR data pass through a number of different software filters, written in the *python* and *Matlab* programming languages.

2.4.3.1. Extraction from DDS – level 0.1 creation

After extraction from the VEX DDS the SOIR data file is loaded into a software tool with several functions

- graphical presentation of scientific data contents, second per second
- graphical presentation of intensity profile throughout complete observation
- graphical presentation of housekeeping values
- conversion of raw DDS data to internal SOIR level 0.1 data (csv-files). Also .bin- and/or .png-files can be created upon demand

2.4.3.2. Level 0.2 and 0.3 creation

The level 0.1 .csv-files are used to produce level 0.2 csv-files which contain data that are corrected for the non-linearity of the detector response. No input parameters are needed. The file conversion is strictly one to one (same number of files on level 0.2 as on level 0.1). This production is done from a *python* code.

The level 0.2 .csv-files are used to produce level 0.3 csv-files which contain data that are wavenumber calibrated (pixel number converted to wavenumber) and that have been scaled with respect to the intensity level of the full solar spectrum (reference). This production is done from a *MATLAB* code.

2.4.3.3. PDS file creation

The internal SOIR level 0.1 .csv-files are transformed (without modification to the scientific contents) into PDS format files corresponding to the PSA level 2.

The internal SOIR level 0.3 .csv-files are transformed into PDS format files corresponding to the PSA level 2.

Geometric attitude files (one file per observation) are generated with dedicated software using SPICE routines and SPICE kernels. These files are used to extract the relevant attitude parameters (corresponding to the zone of interest of the observation), which are then inserted in the PSA level 3 data files.

Relevant calibration software will be archived in the DOCUMENT directory (since the software modules are not compliant with the PSA prescription rules, hence cannot be placed in the SOFTWARE directory).

Information needed to read the data files will be given in the SOIR_DATAFILE_DESC.TXT file in the DOCUMENT directory.

The SOIR data can be read using the new version SBN (Small Bodies Node) software written in IDL as available for download in April 2005 from http://pdssbn.astro.umd.edu/nodehtml/software.shtml.

2.4.4. Documentation

This document (EAICD) will be provided in the DOCUMENT directory in PDF, Microsoft Word and ASCII format.

The SPICAV Flight User Manual (FUM) and other technical document which could be helpful to use data will be provided in the DOCUMENT directory in PDF or Microsoft Word format.

The following SPICAV documents will be present in the DOCUMENT directory of each archive volume

- INSTRUMENT_DESC.TXT: this document contains a description of the SOIR instrument.
- SOIR_DATAFILE_DESC.TXT: this document contains a description of the SOIR data files of all PSA levels.
- SOIR_CALIBRATION_DESC.DOC: this document describes the calibration of the SOIR data on the 1.0 level (PSA level 2).
- INSTRUMENT_MODE_DESC.TXT: this document describes the different operating mode of the SOIR spectrometer.
- SOIR_DATA_QUALITY_DESC.TXT: this document gives for each product an overview of the quality checks and parameters.
- SOIR_CALIBRATION_SOFTWARE.TXT: this document describes the software used to calibrate the SOIR data (go from raw PSA level 1B to calibrated PSA level 2 data)

The following RSSD documents will be present in the DOCUMENT directory of each archive volume

- OBSERVATION_TYPE_DESC.TXT: this document gives the definition of the OBSERVATION_TYPE keyword values.
- VEX_ORIENTATION_DESC.TXT: this document describes the convention used to describe the VEX orientation
- VEX_POINTING_MODE_DESC.TXT: this document describes the values for the SPACECRAFT_POINTING_MODE keyword
- VEX_SCIENCE_CASE_ID_DESC.TXT: this file describes 10 typical VEX modes of observations, called “science cases”.

2.4.5. Quick look products (BROWSE-directory)

Users of the SOIR archive can make use of the BROWSE directory to have a quick look into the available data products. The structure and naming conventions for the BROWSE directory are completely identical to that of the DATA directory.

<u>PSA LEVEL 2</u>

For each observation the following product is available in the BROWSE directory

1 jpeg file (.JPG) and its associated label containing an intensity plot of the observation

`../VEX-Y_V-SPICAV-2-SOIR-V2.0/BROWSE/`*`YYYYMMDD_TCC/YYYYMMDD_TCC`*`_OBS.JPG`

`../VEX-Y_V-SPICAV-2-SOIR-V2.0/BROWSE/`*`YYYYMMDD_TCC/YYYYMMDD_TCC`*`_OBS.LBL`

Example Sept 12th 2006, MTP 05, Orbit 144, Occultation 13, P = 4 (orders per observation)

`../VEX-Y_V-SPICAV-2-SOIR-V2.0/BROWSE/20060912_I01/20060912_I01_INT.JPG`

`../VEX-Y_V-SPICAV-2-SOIR-V2.0/BROWSE/20060912_I01/20060912_I01_INT.LBL`

PSA LEVEL 3

For each observation the following products are available in the BROWSE directory (assuming P is the number of orders measured in that observation).

P jpeg files (.JPG) and P associated labels containing an overview picture of all spectra taken in a given order during the observation plus 1 jpeg file (.JPG) containing the overall intensity plot of the observation (intensity in each bin afo time).

../VEX-Y_V-SPICAV-3-SOIR-V2.0/BROWSE/*YYYYMMDD_TCC*/*YYYYMMDD_TCC_xxx*.JPG

../VEX-Y_V-SPICAV-3-SOIR-V2.0/BROWSE/*YYYYMMDD_TCC*/*YYYYMMDD_TCC_xxx*.LBL

../VEX-Y_V-SPICAV-3-SOIR-V2.0/BROWSE/*YYYYMMDD_TCC*/*YYYYMMDD_TCC*_INT.JPG

../VEX-Y_V-SPICAV-3-SOIR-V2.0/BROWSE/*YYYYMMDD_TCC*/*YYYYMMDD_TCC*_INT.LBL

with *YYYY*=year, *MM*=month, *DD*=day, *T*=measurement type, *CC*=chronological mesurement number of the day (starting at 1), *xxx*=order number.

Example Sept 12th 2006, MTP 05, Orbit 144, Occultation 13, P = 4 (orders per observation)

```
../VEX-Y_V-SPICAV-3-SOIR-V2.0/BROWSE/20060912_I01/20060912_I01_126.JPG
../VEX-Y_V-SPICAV-3-SOIR-V2.0/BROWSE/20060912_I01/20060912_I01_126.LBL
../VEX-Y_V-SPICAV-3-SOIR-V2.0/BROWSE/20060912_I01/20060912_I01_127.JPG
../VEX-Y_V-SPICAV-3-SOIR-V2.0/BROWSE/20060912_I01/20060912_I01_127.LBL
../VEX-Y_V-SPICAV-3-SOIR-V2.0/BROWSE/20060912_I01/20060912_I01_128.JPG
../VEX-Y_V-SPICAV-3-SOIR-V2.0/BROWSE/20060912_I01/20060912_I01_128.LBL
../VEX-Y_V-SPICAV-3-SOIR-V2.0/BROWSE/20060912_I01/20060912_I01_129.JPG
../VEX-Y_V-SPICAV-3-SOIR-V2.0/BROWSE/20060912_I01/20060912_I01_129.LBL

../VEX-Y_V-SPICAV-3-SOIR-V2.0/BROWSE/20060912_I01/20060912_I01_INT.JPG
../VEX-Y_V-SPICAV-3-SOIR-V2.0/BROWSE/20060912_I01/20060912_I01_INT.LBL
```

In the INDEX directory a BROWSE_INDEX .TAB-file and associated .LBL-file describe the contents of the BROWSE directory. Note that the last column of the BROWSE_INDEX refers to the fact whether a file in the BROWSE directory has a PRIMARY or SECONDARY status. Distinction is needed since the BROWSE directory contains 2 types of files each pointing to the same data source.

2.4.7. Derived and other Data Products

Delivery of any other derived data or data products resulting from cooperation with other instrument teams is not foreseen.

2.4.8. Ancillary Data Usage

SPICE files produced by PST/ESTEC in collaboration with NAIF/JPL from the VENUS Express orbit files generated by ESOC will be used in our data processing chain, in particular to generate geometry and attitude files. SPICE files are available from the following file servers:

At ESTEC FTP Server ftp://gorilla.estec.esa.int/pub/projects/VenusExpress/data/spice/

At NAIF FTP Server: ftp://naif.jpl.nasa.gov/pub/naif/VEX

Available SPICE files are:

1. SPK spacecraft/planet/satellites/asteroids ephemeris data kernel files
2. EK event kernel – no EK available for VENUS EXPRESS
3. CK C-matrix instrument attitude kernel files
4. LSK leap second kernel files
5. FK frame kernel files
6. IK instrument kernel files
7. PCK planetary constant kernel files
8. SCLK spacecraft clock kernel files

Orbit numbering files, which are derived data product from the VEX kernel data set, are also available at ESTEC or NAIF FTP Servers (in the ORBNUM directory).

SPICE subroutines are also available at ftp://naif.jpl.nasa.gov/pub/naif/toolkit/ to help the use of these kernels and tutorials and documentation can be retrieved from http://naif.jpl.nasa.gov/naif/tutorials.html and http://naif.jpl.nasa.gov/naif/documentation.html.

2.4.9. Geo index files

One geometry index .TAB-file with its associated .LBL-file is generated for the whole data set :

```
../VEX-Y_V-SPICAV-3-SOIR-V2.0/INDEX/GEO_VENUS.LBL
../VEX-Y_V-SPICAV-3-SOIR-V2.0/INDEX/GEO_VENUS.TAB
```

The .TAB-file is a list of consecutive footprints, one footprint for every observation in the data set. Each footprint consists of a number of lines in the table, each line corresponding to a measurement, i.e. there are as much lines in the footprint as there are seconds in the observation. The footprint however is limited to measurements that have a tangential height of the SOIR boresight between 220 and 40 km (last column in GEO index table). It is possible that for certain measurements (highest or lowest tangential heights) no measurements were taken. In that case N/A values (999.999 or -999.999) are placed in the table for geometric parameters that cannot be calculated.

Each line in the GEO index table contains a number of geometric parameters describing the exact location of each measurement. The geometric parameters are documented in the corresponding DESCRIPTION fields in the .LBL-file.

The 6 parameters describing the footprint are (START_POINT_LATITUDE, START_POINT_LONGITUDE), (CENTER_LATITUDE, CENTER_LONGITUDE), (END_POINT_LATITUDE, END_POINT_LONGITUDE). The CENTER point is the tangential point itself projected on a 60 km altitude shell around Venus. The START point and END point are points at the left and the right of the CENTER point, so that at each measurement (each second) not one point but one line is defined as footprint of the measurement. The complete footprint of the observation is then a sequence of such traces or the contour described by the extremes of the traces (the START and the END points).

START and END point are situated in a tangential plain to the planet, perpendicular to the boresight, at a distance of 10 km (when the tangential height is between 40 and 100 km) and at variable distance (when the tangential height is between 100 and 220 km). This variable distance is calculated by linear regression between the 2 following (tangential height, distance to center)-points : (100 km, 10 km), (250 km, 500 km).

2.5. Standards

2.5.1. PDS standard

The PDS standard used to describe data products in the SOIR archive is that of PDS version 3.6 [2]. Each PDS archived product is described using label objects that provide information about the data types of stored values.

In order to identify and describe the organization, content, and format of each data product, PDS requires a distinct data product label for each individual data product file. This data product label can be attached or detached from the data. The SOIR PDS data product label is detached from the data and resides in a separate file which contains a pointer to the data product file. There is one detached label file for every data product file. The label file should have the same base name as its associated data file, but the extension is .LBL.

Each PDS label must begin with the PDS_VERSION_ID data element. This element identifies the published version of the standards to which the label adheres. For labels adhering to the standards version 3.6 the appropriate value is “PDS3”:

PDS_VERSION_ID = PDS3

PDS data product labels contain data element informations that describe important attributes of the physical structure of a data product file. The PDS file characteristic data elements are:

RECORD_TYPE , RECORD_BYTES , FILE_RECORDS.

The RECORD_TYPE data element identifies the record characteristics of the data product file. The RECORD_BYTES data element identifies the number of bytes in each physical record in the data product file. The FILE_RECORDS data element identifies the number of physical records in the file.

The following data identification elements must be included in product labels for all spacecraft science data products:

DATA_SET_ID , PRODUCT_ID , INSTRUMENT_HOST_NAME ,
INSTRUMENT_NAME , TARGET_NAME , START_TIME , STOP_TIME ,
SPACECRAFT_CLOCK_START_COUNT ,
SPACECRAFT_CLOCK_STOP_COUNT , PRODUCT_CREATION_TIME.

The PDS requires a separate data object definition within the product label for each object in the product, to describe the structure and associated attributes of each constituent object.

Object definitions are of the form:

OBJECT = *aaa* where *aaa* is the name of the data object
...
END_OBJECT = *aaa*

The PDS uses a pointer within the product labels to identify the file location for all objects which are described in the label file. For example

```
^SOIR_TABLE = "20060809_M04_120.TAB"
```

2.5.2. Time Standards

The PDS formation rule for dates and time in UTC is:

*YYYY-MM-DD*T*hh:mm:ss.fff* or *YYYY-DDD*T*hh:mm:ss.fff*

With *YYYY* = year (0000-9999), *MM* = month (01-12), *DD* = day of month (01-31), *DDD* = day of year (001-366), T = date/time separator, *hh* = hour (00-23), *mm* = minute (00-59), *ss* = second (00-59), *fff* = fractions of second (000-999) (restricted to 3 digits)

The START_TIME and STOP_TIME data elements required in data product labels and catalog templates use the UTC format. Times in any format other than the ISO/DIS 8601 format described above are considered to be in a format native to the data set, and thus “native times”.

The spacecraft clock reading often provides the essential timing information for a space-based observation. Therefore, the elements SPACECRAFT_CLOCK_START_COUNT and SPACECRAFT_CLOCK_STOP_COUNT are required in labels describing space-based data. This value is formatted as a string to preserve precision.

Spacecraft clock counts shall be represented as a right-justified character string field with a maximum length of thirty characters.

The SPACECRAFT_CLOCK_START_COUNT and SPACECRAFT_CLOCK_STOP_COUNT represent the on-board time counters (OBT) of the spacecraft and instrument computers. This OBT counter is given in the headers of the experiment telemetry source packets. It contains the data acquisition start time as 32 bit of unit seconds followed by 16 bit of fractional seconds. The time resolution of the fractional part is 2^-16 = 1.52×10^-5 seconds. Thus the OBT is represented as a decimal real number in floating-point notation with 5 digits after the decimal point.

A reset of the spacecraft clock is represented by an integer number followed by a slash, e.g. “1/” or “2/”.

Examples

```
SPACECRAFT_CLOCK_START_COUNT = "1/21983325.39258"
SPACECRAFT_CLOCK_START_COUNT = "21983325.39258"
SPACECRAFT_CLOCK_START_COUNT = "2/0000325.39008"
```

2.5.3. Reference Systems

The SOIR data products are not projected into any coordinate system, however some basic geometric parameters are provided in the data files (described in the associated detached labels) and in the GEO_VENUS index tables.

3. Archive Format and Content

This section describes the format of SOIR Archive Volumes. Data in the archive will be formatted in accordance with Planetary Data System specifications [2].

3.1. Format and Conventions

3.1.1. Deliveries and Archive Volume Format

3.1.1.1. SOIR Deliveries

At the end of the priority phase the data will be delivered to PSA at ESTEC. BIRA-IASB is the single point of contact for the PSA archive team and for data distribution (during priority phase).

Deliveries to the PSA will be made by the SOIR archive team. Target date for delivery of SOIR data (both PSA level 1b and 2) to PSA is 4 months after the end of a specific VEX mission phase.

3.1.1.2. Archive Volume Format and Concept of Deliveries

The SOIR_ARCHIVE volume set contains 2 archive volumes, each corresponding to a specific data level (Figure 8)

- VEXSPI_2003_2 SOIR data level 0.1 = PSA data level 2
- VEXSPI_3003_3 SOIR data level 0.3 = PSA data level 3

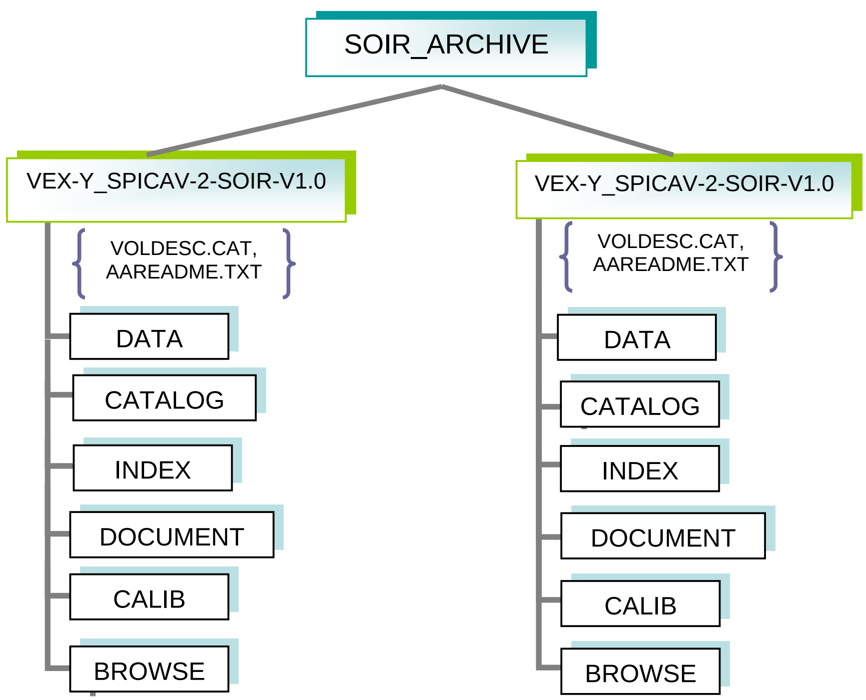

Figure 8 SOIR archive directory structure

Each SPICAV archive volume has the name of the VOLUME_ID.

In each archive volume, the following standard directories are included:

- DATA — contains one or more subdirectories of data products with data files (.TAB) and detached label files (.LBL)
- CATALOG — PDS catalogue files
- INDEX — indices to assist in locating data of interest + GEO_VENUS index (footprints)
- DOCUMENT — documentation, supplementary and ancillary information to assist in understanding and using the data products. + calibration software
- CALIB — calibration files to process the data
- SOFTWARE — not used
- GEOMETRY: — not used
- BROWSE — At PSA level 2 intensity plot.

  At PSA level 3 P intensity plots, P order overview plots,
- EXTRAS — not used

In the ROOT directory of each archive volume, 2 files give an overview of the archive volume in ASCII format (AAREADME.TXT file) and a description of the volume in PDS format (VOLDESC.CAT file).

Within the Planetary Science Archive (PSA) the archive volume represents an online delivery. Deliveries are based on the concept of a release and a revision of a well-defined period of time. This concept [4] allows the delivery of experiment data without the delivery of all supplementary information, that has already been delivered at the first initial delivery of a fully PDS compatible archive volume, containing the VOLDESC.CAT file and all necessary CATALOG, DOCUMENT, INDEX, DATA,… directories and their content. The usage of the release object is not fully compliant with the PDS standard 3.6, however the full data set itself is PDS compatible. This concept should be transparent to the end user.

3.1.1.3. VOLDESC.CAT file

The VOLDESC.CAT file gives a description of the archive volume in a PDS format.

Example PSA level 2 SOIR data volume, release 0001, revision 0000

```
PDS_VERSION_ID                  = PDS3
RELEASE_ID                      = 0001
REVISION_ID                     = 0000

OBJECT                          = VOLUME
  DATA_SET_ID                   = "VEX-Y/V-SPICAV-2-SOIR-V1.0"
  DESCRIPTION                   = "This volume contains the PSA level 2 SOIR data"
  MEDIUM_TYPE                   = "ONLINE"
  PUBLICATION_DATE              = 2006-10-05
  VOLUME_FORMAT                 = "ISO-9660"
  VOLUME_ID                     = VEXSPI_2003
  VOLUME_NAME                   = "VOLUME 3: SPICAV SOIR VENUS EXPRESS DATA"
  VOLUME_SERIES_NAME            = "MISSION TO VENUS"
  VOLUME_SET_NAME               = "VENUS EXPRESS SPICAV DATA PRODUCTS"
```

```
    VOLUME_SET_ID                  = BE_BIRA_IASB_VEXSPI_2000
    VOLUME_VERSION_ID              = "VERSION 1"
    VOLUMES                        = 1

    OBJECT                         = CATALOG
      ^DATA_SET_CATALOG            = "DATASET.CAT"
      ^INSTRUMENT_CATALOG          = "INST.CAT"
      ^INSTRUMENT_HOST_CATALOG     = "INSTHOST.CAT"
      ^MISSION_CATALOG             = "MISSION.CAT"
      ^REFERENCE_CATALOG           = "REFERENCE.CAT"
      ^DATA_SET_RELEASE_CATALOG    = "RELEASE.CAT"
      ^SOFTWARE_CATALOG            = "SOFTWARE.CAT"
    END_OBJECT                     = CATALOG

    OBJECT                         = DATA_PRODUCER
      INSTITUTION_NAME             = "BELGIAN INSTITUTE FOR SPACE AERONOMY"
      FACILITY_NAME                = "N/A"
      FULL_NAME                    = "EDDY NEEFS"
      ADDRESS_TEXT                 = "RINGLAAN 3 1180 BRUSSELS"
    END_OBJECT                     = DATA_PRODUCER


  END_OBJECT                       = VOLUME
  END
```

3.1.1.3.1. VOLUME_ID

The VOLUME_ID of a SOIR archive volume is composed by combining the following fields

- the mission identifier VEX
- the instrument identifier SPI
- an underscore
- a 4 digit sequence number dedicated to the SOIR data: 2003 (L2), 3003 (L3)

Hence the VOLUME_ ID for SOIR is VEXSPI_2003 (L2), VEXSPI_3003 (L3).

If a volume is refurbished because of errors in the initial production, the VOLUME_ID remains the same while the VOLUME_VERSION_ID is incremented.

3.1.1.3.2. VOLUME_SET_ID

Each SOIR archive volume is also identified by a VOLUME_SET_ID composed by combining the following fields

- the country abbreviation BE
- the government branch BIRA
- the discipline IASB
- the mission identifier VEX
- the instrument identifier SPI
- a 4 digit sequence number

The VOLUME_SET_ID for SOIR is BE_BIRA-IASB_VEXSPI_2000 (L2) , BE_BIRA-IASB_VEXSPI_3000 (L3) ,

3.1.1.3.3. RELEASE_ID and REVISION_ID

A data set release (or volume release) contains data from a well-defined period of time and is identified by a RELEASE_ID keyword. The first release (RELEASE_ID = 0001) is a fully validated, complete PSA data set. A volume release is made of at least one revision the initial revision. The initial revision contains the initial data of a data set release and is identified by a REVISION_ID equal to 0000.

All labels within the first release will also contain the keywords

RELEASE_ID = 0001
REVISION_ID = 0000

A following revision of the data set release (updated files, supplementary files, deleted files) would need the value of the REVISION_ID incremented by one (eg. RELEASE_ID = 0001, REVISION_ID = 0001).

Labels of the updated files will have the keywords

RELEASE_ID = 0001
REVISION_ID = 0001

Any further release covering a following period of time would need the value of the RELEASE_ID incremented by one, with an initial revision (eg. RELEASE_ID = 0002, REVISION_ID = 0000).

The new data labels will contain the keywords

RELEASE_ID = 0002
REVISION_ID = 0000

The VOLDESC.CAT file shall contain the keywords RELEASE_ID and REVISION_ID set to the latest RELEASE_ID and within this release to the latest REVISION_ID.

3.1.1.3.4. CATALOG object

The VOLDESC.CAT file contains a CATALOG object with pointers to catalog files stored in the CATALOG directory. Files in the CATALOG directory provide a top-level understanding of the mission, spacecraft, instruments, and data sets.

One of these files, the RELEASE.CAT catalog file, contains a release object, which fully defines the releases and revisions of deliveries.

3.1.1.4. The release object

A release object needs to be included in each archive volume to fully describe each release and revision within this release. This object is not PDS-compliant.

Example PSA level 2 SOIR data volume, release 0001, revision 0000

```
PDS_VERSION_ID = PDS3
LABEL_REVISION_NOTE = "E.NEEFS, 2006-10-06 (original)"
RECORD_TYPE = STREAM
RELEASE_ID = 0001
REVISION_ID = 0000

OBJECT = DATA_SET_RELEASE
 DATA_SET_ID = "VEX-Y/V-SPICAV-2-SOIR-V1.0"
 RELEASE_ID = 0001

 DESCRIPTION = "
 This release contains the PSA level 2 data of the SOIR instrument on
 board of spacecraft Venus Express.
 These data underwent a number of correction and calibration procedures.
 This release contains data measured between May 12th 2006 (orbit 21)
 and August 31st 2006 (orbit 132).
```

```
 Revision 0000 contains the original delivery. "

 OBJECT = REVISION
 REVISION_ID = 0000
 REVISION_DATE = 2006-10-06
 REVISION_MEDIA = "ONLINE"
 DESCRIPTION = "FIRST DELIVERY: RELEASE 0001,REVISION: 0000"
 END_OBJECT = REVISION

END_OBJECT = DATA_SET_RELEASE

END
```

A release will concern a well-defined period of time, based on the nominal science mission timeline, as shown in the SOIR archive volume delivery schedule (section 0). Each release will be described in this file by a DATA_SET_RELEASE object, containing all keyword-value pairs that are necessary to identify the release (DATA_SET_ID, RELEASE_ID, DESCRIPTION, …). The DESCRIPTION part of the DATA_SET_RELEASE object will contain the full history of the release including all previous revisions. Each revision of a release is added in the release catalog object and all necessary information about this revision is given by a REVISION object.

A revision of this release might be added after improvement of the data.

Example PSA level 2 SOIR data volume, release 0001, revision **0000**

```
PDS_VERSION_ID = PDS3
LABEL_REVISION_NOTE = "E.NEEFS, 2006-10-07 (original)"
RECORD_TYPE = STREAM
RELEASE_ID = 0001
REVISION_ID = 0000

OBJECT = DATA_SET_RELEASE
 DATA_SET_ID = "VEX-Y/V-SPICAV-3-SOIR-V1.0"
 RELEASE_ID = 0001

 DESCRIPTION = "
 This release contains the PSA level 2 data of the SOIR instrument on
 board of spacecraft Venus Express.
 These data underwent a number of correction and calibration procedures.
 This release contains data measured between May 12th 2006 (orbit 21)
 and August 31st 2006 (orbit 132).

 Revision 0000 contains the original delivery. "

 OBJECT = REVISION
 REVISION_ID = 0000
 REVISION_DATE = 2006-10-06
 REVISION_MEDIA = "ONLINE"
 DESCRIPTION = "FIRST DELIVERY: RELEASE 0001,REVISION: 0000"
 END_OBJECT = REVISION

 OBJECT = REVISION
 REVISION_ID = 0000
 REVISION_DATE = 2006-10-07
 REVISION_MEDIA = "ONLINE"
 DESCRIPTION = "RELEASE 0001,REVISION: 00001,
                                    Modification of the label files"
 END_OBJECT = REVISION

END_OBJECT = DATA_SET_RELEASE

END
```

A following release of a new well defined period of time in the archive volume will be described by a new DATA_SET_RELEASE object in the same RELEASE.CAT file.

Example PSA level 2 SOIR data volume, release **0002**, revision 0000

```
PDS_VERSION_ID = PDS3
```

```
LABEL_REVISION_NOTE = "E.NEEFS, 2006-10-08 (original)"
RECORD_TYPE = STREAM
RELEASE_ID = 0002
REVISION_ID = 0000

OBJECT = DATA_SET_RELEASE
 DATA_SET_ID = "VEX-Y/V-SPICAV-2-SOIR-V1.0"
 RELEASE_ID = 0002

 DESCRIPTION = "
 This release contains the PSA level 2 data of the SOIR instrument on
 board of spacecraft Venus Express.
 These data underwent a number of correction and calibration procedures.
 This release contains data measured between September 1st 2006 (orbit 133)
 and November 30th 2006 (orbit 223).

 Revision 0000 contains the original delivery. "

 OBJECT = REVISION
 REVISION_ID = 0000
 REVISION_DATE = 2006-10-08
 REVISION_MEDIA = "ONLINE"
 DESCRIPTION = "SECOND DELIVERY: RELEASE 0002,REVISION: 0000"
 END_OBJECT = REVISION

END_OBJECT = DATA_SET_RELEASE

OBJECT = DATA_SET_RELEASE
 DATA_SET_ID = "VEX-Y/V-SPI-1-SOIRSPECTRA-V1.0"
 RELEASE_ID = 0001

 DESCRIPTION = "
 This release contains the PSA level 2 data of the SOIR instrument on
 board of spacecraft Venus Express.
 These data underwent a number of correction and calibration procedures.
 This release contains data measured between May 12th 2006 (orbit 21)
 and August 31st 2006 (orbit 132).

 Revision 0000 contains the original delivery. "

 OBJECT = REVISION
 REVISION_ID = 0000
 REVISION_DATE = 2006-10-06
 REVISION_MEDIA = "ONLINE"
 DESCRIPTION = "FIRST DELIVERY: RELEASE 0001,REVISION: 0000"
 END_OBJECT = REVISION

 OBJECT = REVISION
 REVISION_ID = 0000
 REVISION_DATE = 2006-10-07
 REVISION_MEDIA = "ONLINE"
 DESCRIPTION = "RELEASE 0001,REVISION: 00001,
       Modification of the label files"
 END_OBJECT = REVISION

END_OBJECT = DATA_SET_RELEASE

END
```

3.1.1.5. Index files

The PDS standard defines index files containing information that allows a user to locate data of interest. The index table files below the INDEX directory cover all data set releases and revisions. Therefore the index table files will contain at least two columns named RELEASE_ID and REVISION_ID.

The index label files describing the index table files shall contain the keywords RELEASE_ID and REVISION_ID, set to the latest RELEASE_ID and within this release to the latest REVISION_ID (same as the VOLDESC.CAT file).

The INDEX directory will contain 3 types of index files

INDEX.TAB	: the index into the DATA directory
BROWSE_INDEX.TAB	: the index into the BROWSE directory
GEO_VENUS.TAB	: the footprints of all the observations in the data set

To each .TAB file is associated a detached .LBL label file.

3.1.2. Data Set Name and Data Set ID Formation

Each PDS data set must have a unique name (DATA_SET_NAME) and a unique identifier (DATA_SET_ID). The name and identifier should be composed based on the following elements

- Instrument host name : VENUS EXPRESS
- Target : e.g. VENUS/SKY
- Instrument host ID : VEX
- Target ID : e.g. V (VENUS), Y (SKY/CRUISE)
- Instrument ID : SPICAV
- Data processing level number : see below
- Mission phase abbreviation (optional) : see below
- Description (optional) : see below
- Version number : e.g. V1.0

Within the DATA_SET_NAME, elements are separated by blanks. Within the DATA_SET_ID, elements are separated by hyphens. Multiple instrument hosts, instruments or targets are referenced in the DATA_SET_NAME or DATA_SET_ID by concatenation of the values with a forward slash, "/", which is interpreted as "and."

Data processing level number

The data processing level number is the National Research Council (NRC) Committee on Data Management and Computation (CODMAC) data processing level number

Level	Type	Data Processing Level Description
1	Raw Data	Telemetry data with data embedded
2	Edited Data	Corrected for telemetry errors and split or de-commutated into a data set for a given instrument. Sometimes called Experimental Data Record (EDR).
3	Calibrated Data	Edited data that are still in units produced by instrument, but that have been corrected so that values are expressed in or are proportional to some physical unit such as radiance. No resampling, so edited data can be reconstructed.
4	Resampled Data	Data that have been resampled in the time or space domains in such a way that the original edited data cannot be reconstructed. Could be calibrated in addition to being resampled.
5	Derived Data	Derived results, as maps, reports, graphics, etc.
6	Ancillary Data	Nonscience data needed to generate calibrated or resampled data sets. Consists of instrument gains, offsets, pointing information for scan platforms, etc.
7	Correlative Data	Other science data needed to interpret space-based data sets.
8	User Description	Description of why the data were required, any peculiarities associated with the data sets, and enough documentation to allow secondary user to extract information from the data.

Mission phase abreviation (optional)

Data set type is the concatenation of the data type and of the PRODUCT_TYPE keyword (e.g. EDR, RDR) provided in each PDS data product labels.

Description (optional)

The CODMAC level for some of the datasets is the same, and this means the end user has no way of knowing which dataset he is looking at from the data processing level number alone. Therefore, in order to help the end user, the STANDARD_DATA_PRODUCT_ID keyword has been added to all of SPICAV data product labels and the value of this keyword is given in the Description component of the DATA_SET_ID. The value must be no more that 4 characters long. The STANDARD_DATA_PRODUCT_ID for SOIR is "SOIR"

For the different SOIR levels the corresponding CODMAC level and PRODUCT_TYPE are given in Figure 9

SOIR LEVEL	CONTENTS	PSA LEVEL	CODMAC	PRODUCT TYPE
0.1	calibrated data	2	3	RDR – Reduced Data Record
0.3	science data	3	5	DDR – Derived Data Record

Figure 9 Correspondence between SOIR, PSA and CODMAC levels

For a data set containing the first version of SOIR data collected from the SPICAV instrument on Venus Express during the cruise and Venus nominal phases

The DATA_SET_NAME for SOIR would be

- VENUS EXPRESS SKY/VENUS SPICAV 2 SOIR V1.0 for PSA level 2 data
- VENUS EXPRESS SKY/VENUS SPICAV 3 SOIR V1.0 for PSA level 3 data

The DATA_SET_ID for SOIR would be

- VEX-Y/V-SPICAV-2-SOIR-V1.0 for PSA level 2 data
- VEX-Y/V-SPICAV-3-SOIR-V1.0 for PSA level 3 data

3.1.3. Data Directory Naming Convention

In the DATA directory, data are stored in subdirectories

For PSA level 2

Subdirectories correspond to observation periods during cruise phase (e.g. pointing test) or medium term planning observation phases (MTP).

`../VEX-Y_V-SPICAV-2-SOIR-V2.0/DATA/YYYYMMDD_TCC/(files)`

with *YYYY*=year, *MM*=month, *DD*=day, *hh*=hours, *mm*=minutes, *ss*=seconds, *T*=measurement type, *CC*= chronological measurement number of the day (starting at 1).

T (measurement type) can have the following values :

* I = Ingress (occultation)

* E = Egress (occultation)

* M = Miniscan

* F = Fullscan (outside atmosphere)

* A = Fullscan (inside atmosphere)

* N = Nadir

* C = Pointing calibration

For PSA level 3

Subdirectories correspond to individual observations, i.e. one subdirectory per observation day in orbit around Venus.

`../VEX-Y_V-SPICAV-3-SOIR-V2.0/DATA/`*`YYYYMMDD_TCC/(files)`*

with *YYYY*=year, *MM*=month, *DD*=day, *hh*=hours, *mm*=minutes, *ss*=seconds, *T*=measurement type, *CC*= chronological measurement number of the day (starting at 1).

3.1.4. Filenaming Convention

For PSA level 2

Data product files provided at PSA level 2 are

`../`*`YYYYMMDD_TCC`*`_OBS.TAB (science data)`

`../`*`YYYYMMDD_TCC`*`_TC2.TAB (telecommand type 2)`

For PSA level 3

Data product files provided at PSA level 3 are

`../`*`YYYYMMDD_TCC_xxx`*`.TAB (science data)`

with *YYYY*=year, *MM*=month, *DD*=day, *hh*=hours, *mm*=minutes, *ss*=seconds, *T*=measurement type, *CC*= chronological measurement number of the day (starting at 1) , *xxx*=order number.

Associated detached label files follow the same filenaming convention with the .LBL extension.

APPENDIX 1: Content of directories

Archive Directory

```
../VEX-Y_V-SPICAV-2-SOIR-V1.0
../VEX-Y_V-SPICAV-3-SOIR-V1.0
```

Root Directory

```
../CATALOG
../CALIB
../DATA
../DOCUMENT
../INDEX
../BROWSE
AAREADME.TXT
VOLDESC.CAT
```

Catalog Directory

```
CATINFO.TXT
DATASET.CAT
INST.CAT
INSTHOST.CAT
MISSION.CAT
REFERENCE.CAT or REF.CAT
SOFTWARE.CAT
RELEASE.CAT
TARGET.CAT
```

Index Directory

```
INDXINFO.TXT
INDEX.TAB
INDEX.LBL
BROWSE_INDEX.TAB
BROWSE_INDEX.LBL
GEO_VENUS.TAB
GEO_VENUS.LBL
```

Data Directory

For PSA level 2

```
/20051125_C01
/20051127_C01
/20051128_C01
/20051129_C01
/20051214_C01
/20051214_C02
/20051214_C03
/20051214_C04
/20060116_C01
/20060117_C01
/20060118_C01
/20060221_C01
/20060509_C01
/20060510_C01
/20060512_I01
/20060526_I01
/20060527_I01
/20060530_I01
/20060805_A01
/20060805_A02
/20060807_I01
/20060809_I01            /20060809_I01_OBS.LBL
                         /20060809_I01_OBS.TAB
                         /20060809_I01_TC2.LBL
                         /20060809_I01_TC2.TAB

/20060810_E01
/20060812_I01
/…
```

For PSA level 3

```
/20060512_I01
/20060526_I01
/20060527_I01
/20060530_I01
/20060807_I01
/20060809_I01            /20060809_I01_120.LBL
                         /20060809_I01_120.TAB
                         /20060809_I01_121.LBL
                         /20060809_I01_121.TAB
                         /20060809_I01_122.LBL
                         /20060809_I01_122.TAB
                         /20060809_I01_123.LBL
                         /20060809_I01_123.TAB
/20060810_E01
/20060812_I01
/20060813_E01
/20060815_I01
/20060817_E01
/20060820_E01
/20060823_E01
/20060829_E01
/...
```

Browse Directory

For PSA level 2

```
/20051125_C01
/20051127_C01
/20051128_C01
```

```
/20051129_C01
/20051214_C01
/20051214_C02
/20051214_C03
/20051214_C04
/20060116_C01
/20060117_C01
/20060118_C01
/20060221_C01
/20060509_C01
/20060510_C01
/20060512_I01
/20060526_I01
/20060527_I01
/20060530_I01
/20060805_A01
/20060805_A02
/20060807_I01
/20060809_I01             /20060809_I01_INT.JPG
                          /20060809_I01_INT.LBL
/20060810_E01
/20060812_I01
/…
```

For PSA level 3

```
/20060512_I01
/20060526_I01
/20060527_I01
/20060530_I01
/20060807_I01
/20060809_I01             /20060809_I01_120.LBL
                          /20060809_I01_120.JPG
                          /20060809_I01_121.LBL
                          /20060809_I01_121.JPG
                          /20060809_I01_122.LBL
                          /20060809_I01_122.JPG
                          /20060809_I01_123.LBL
                          /20060809_I01_123.JPG
/20060810_E01
/20060812_I01
/20060813_E01
/20060815_I01
/20060817_E01
/20060820_E01
/20060823_E01
/20060829_E01
/...
```

Geometry Directory

Not used for SOIR

Software Directory

Not used for SOIR

Calib Directory

```
AOTF_F_WN.LBL
AOTF_F_WN.TAB
AOTF_TF_BINNING03.LBL
```

```
AOTF_TF_BINNING03.TAB
AOTF_TF_BINNING04.LBL
AOTF_TF_BINNING04.TAB
AOTF_TF_BINNING12.LBL
AOTF_TF_BINNING12.TAB
AOTF_TF_BINNING16.LBL
AOTF_TF_BINNING16.TAB
BLAZE.LBL
BLAZE.TAB
CALINFO.TXT
RESOL_BINNING03.LBL
RESOL_BINNING03.TAB
RESOL_BINNING04.LBL
RESOL_BINNING04.TAB
RESOL_BINNING12.LBL
RESOL_BINNING12.TAB
RESOL_BINNING16.LBL
RESOL_BINNING16.TAB
```

Label Directory

There is no label directory. All PDS detached label files describing data or document files in a volume are in the corresponding data directory.

Document Directory

```
DOCINFO.TXT
EAICD.DOC
EAICD.TXT
EAICD.PDF
EAICD.LBL
FLIGHT_USER_MANUAL.TXT
FLIGHT_USER_MANUAL.LBL
INSTRUMENT_CALIB_PAPER.DOC
INSTRUMENT_CALIB_PAPER.LBL
INSTRUMENT_DESC.TXT
INSTRUMENT_DESC.LBL
INSTRUMENT_MODE_DESC.LBL
INSTRUMENT_MODE_DESC.TXT
INSTRUMENT_PAPER.DOC
INSTRUMENT_PAPER.LBL
OBSERVATION_TYPE_DESC.LBL
OBSERVATION_TYPE_DESC.TXT
SOIR_CALIBRATION_DESC.DOC
SOIR_CALIBRATION_DESC.LBL
SOIR_CALIBRATION_DESC.PDF
SOIR_CALIBRATION_DESC.TXTSOIR_DATAFILE_DESC.LBL
SOIR_DATAFILE_DESC.TXT
SOIR_DATA_QUALITY_DESC.LBL
SOIR_DATA_QUALITY_DESC.TXT
TMTC.DOC
TMTC.LBL
VEX_MISSION_CALENDAR.ACS
VEX_MISSION_CALENDAR.LBL
VEX_MISSION_CALENDAR.PDF
VEX_ORIENTATION_DESC.LBL
VEX_ORIENTATION_DESC.TXT
VEX_POINTING_MODE_DESC.LBL
VEX_POINTING_MODE_DESC.TXT
SOIR_CALIBRATION_SOFTWARE.LBL
SOIR_CALIBRATION_SOFTWARE.TXT
VEX_RSSD_LI_009.LBL
VEX_RSSD_LI_009.TAB
VEX_SCIENCE_CASE_ID_DESC.LBL
VEX_ SCIENCE_CASE_ID_DESC.TXT
```

APPENDIX 2: Data Product Design

This appendix contains example labels for each of the SOIR data product, both for PSA level 2 and level 3.

Data product design - PSA level 2

Data file

A SOIR data product file at PSA level 2 contains the data of one observation, i.e. the data gathered between a switch ON and a switch OFF of the instrument. This can be an occultation (standard case) but also a calibration or other technological measurement. It covers both the precooling and the effective observation phase.

Each file is an ASCII table, containing 11 thematic columns C and 2581 basic columns c and a variable number of rows, equal to the number of seconds in the observation (precooling + effective observation). For a 10 minutes precooling + a 15 minutes observation period there will be 1500 seconds, hence 1500 rows in the file. Each row contains 28462 bytes. Hence, for a 1500 seconds observation the file size will be approximately 43 Mbytes (42.693.000 bytes)

C_1 time			C_2 bin_0			…	C_9 bin_7			C_{10} housekeeping		
T_1	…	T_4	I_1	…	I_{320}		I_1	…	I_{320}	H_1	…	H_{16}
c_1		c_4	c_6		c_{325}		c_{2246}		c_{2565}	c_{2566}		c_{2581}

C_i (i=1 to 11) are 11 columns

- C_1 $= c_1 \dots c_4$: 4 x 23 bytes, type *character*
- C_2 to C_9 $= c_6 \dots c_{2565}$: 8 x 320 x 10 bytes, type *ASCII_integer*
- C_{10} $= c_{2566} \dots c_{2581}$: 16 x 11 bytes, type *ASCII_real*

The data table (OBJECT=SOIR_TABLE) is composed of a set of 11 COLUMN objects (TIME, PHASE, BIN_0, BIN_1, BIN_2, BIN_3, BIN_4, BIN_5, BIN_6, BIN_7, HOUSEKEEPING). Each column consists of a certain number of ITEMS (sub-columns of the main column). The sub-columns are separated by comma’s and each line is terminated by a <line feed> <carriage return> combination. The object SOIR_TABLE is described in a detached label in the following way

```
OBJECT = SOIR_TABLE
 COLUMNS = 2581
 INTERCHANGE_FORMAT = ASCII
 ROW_BYTES = 28462
 ROWS = 1191

/* column contents : time of measurement */

 OBJECT = COLUMN
 NAME = TIME
 BYTES = 103
 DATA_TYPE = CHARACTER
 START_BYTE = 2
 ITEMS = 4
 ITEM_OFFSET = 26
 ITEM_BYTES = 23
 END_OBJECT = COLUMN

/* column contents : precooling or observation phase */


/* column contents : first bin of the observation – nr of rows in bin depends on
              configuration in telecommand */
```

```
 OBJECT = COLUMN
 NAME = BIN_1
 BYTES = 3519
 DATA_TYPE = ASCII_INTEGER
 START_BYTE = 110
 UNIT = “N/A”
 ITEMS = 320
 ITEM_OFFSET = 11
 ITEM_BYTES = 10
 END_OBJECT = COLUMN

/* column contents : second bin of the observation – nr of rows in bin depends on
             configuration in telecommand */

 OBJECT = COLUMN
 NAME = BIN_2
 BYTES = 3519
 DATA_TYPE = ASCII_INTEGER
 START_BYTE = 3630
 UNIT = “N/A”
 ITEMS = 320
 ITEM_OFFSET = 11
 ITEM_BYTES = 10
 END_OBJECT = COLUMN

/* column contents : third bin of the observation – nr of rows in bin depends on
             configuration in telecommand */

 OBJECT = COLUMN
 NAME = BIN_3
 BYTES = 3519
 DATA_TYPE = ASCII_INTEGER
 START_BYTE = 7150
 UNIT = “N/A”
 ITEMS = 320
 ITEM_OFFSET = 11
 ITEM_BYTES = 10
 END_OBJECT = COLUMN

/* column contents : fourth bin of the observation – nr of rows in bin depends on
             configuration in telecommand */

 OBJECT = COLUMN
 NAME = BIN_4
 BYTES = 3519
 DATA_TYPE = ASCII_INTEGER
 START_BYTE = 10670
 UNIT = “N/A”
 ITEMS = 320
 ITEM_OFFSET = 11
 ITEM_BYTES = 10
 END_OBJECT = COLUMN

/* column contents : fifth bin of the observation – nr of rows in bin depends on
             configuration in telecommand */

OBJECT = COLUMN
 NAME = BIN_5
 BYTES = 3519
 DATA_TYPE = ASCII_INTEGER
 START_BYTE = 14190
 UNIT = “N/A”
 ITEMS = 320
 ITEM_OFFSET = 11
 ITEM_BYTES = 10
 END_OBJECT = COLUMN

/* column contents : sixth bin of the observation – nr of rows in bin depends on
             configuration in telecommand */

 OBJECT = COLUMN
 NAME = BIN_6
```

```
 BYTES = 3519
 DATA_TYPE = ASCII_INTEGER
 START_BYTE = 17710
 UNIT = "N/A"
 ITEMS = 320
 ITEM_OFFSET = 11
 ITEM_BYTES = 10
 END_OBJECT = COLUMN

/* column contents : seventh bin of the observation – nr of rows in bin depends on
             configuration in telecommand */

 OBJECT = COLUMN
 NAME = BIN_7
 BYTES = 3519
 DATA_TYPE = ASCII_INTEGER
 START_BYTE = 21230
 UNIT = "N/A"
 ITEMS = 320
 ITEM_OFFSET = 11
 ITEM_BYTES = 10
 END_OBJECT = COLUMN

/* column contents : eighth bin of the observation – nr of rows in bin depends on
             configuration in telecommand */

 OBJECT = COLUMN
 NAME = BIN_8
 BYTES = 3519
 DATA_TYPE = ASCII_INTEGER
 START_BYTE = 24750
 UNIT = "N/A"
 ITEMS = 320
 ITEM_OFFSET = 11
 ITEM_BYTES = 10
 END_OBJECT = COLUMN

/* following 16 columns are housekeeping values */

/* FPAT 2 : temperature measurement on focal plane array in detector */

 OBJECT                       = COLUMN
 NAME                         = "FPAT_2"
 BYTES                        = 11
 DATA_TYPE                    = ASCII_REAL
 START_BYTE                   = 28270
 UNIT                         = "N/A"
 END_OBJECT                   = COLUMN

/* SOFC : temperature measurement at socket of AOTF */

 OBJECT                       = COLUMN
 NAME                         = "SOFC"
 BYTES                        = 11
 DATA_TYPE                    = ASCII_REAL
 START_BYTE                   = 28282
 UNIT                         = DEGREE
 END_OBJECT                   = COLUMN

/* BPL_1 : first temperature measurement at baseplate */

 OBJECT                       = COLUMN
 NAME                         = "BPL_1"
 BYTES                        = 11
 DATA_TYPE                    = ASCII_REAL
 START_BYTE                   = 28294
 UNIT                         = DEGREE
 END_OBJECT                   = COLUMN

/* BPL_2 : second temperature measurement at baseplate */

 OBJECT                       = COLUMN
 NAME                         = "BPL_2"
```

```
 BYTES                         = 11
 DATA_TYPE                     = ASCII_REAL
 START_BYTE                    = 28306
 UNIT                          = DEGREE
 END_OBJECT                    = COLUMN

/* AOTF_T : temperature measurement inside AOTF box */

 OBJECT                        = COLUMN
 NAME                          = "AOTF_T"
 BYTES                         = 11
 DATA_TYPE                     = ASCII_REAL
 START_BYTE                    = 28318
 UNIT                          = DEGREE
 END_OBJECT                    = COLUMN

/* RF_AMP : amplitude of RF signal that drives AOTF */

 OBJECT                        = COLUMN
 NAME                          = "RF_AMP"
 BYTES                         = 11
 DATA_TYPE                     = ASCII_REAL
 START_BYTE                    = 28330
 UNIT                          = "N/A"
 END_OBJECT                    = COLUMN

/* MOT_C : DAC value used for the control of the cooler motor */

 OBJECT                        = COLUMN
 NAME                          = "MOT_CT"
 BYTES                         = 11
 DATA_TYPE                     = ASCII_REAL
 START_BYTE                    = 28342
 UNIT                          = "N/A"
 END_OBJECT                    = COLUMN

/* +12_V : measurement of +12 V power supply */

 OBJECT                        = COLUMN
 NAME                          = "+12_V"
 BYTES                         = 11
 DATA_TYPE                     = ASCII_REAL
 START_BYTE                    = 28354
 UNIT                          = VOLT
 END_OBJECT                    = COLUMN

/* -12_V : measurement of -12 V power supply */

 OBJECT                        = COLUMN
 NAME                          = "-12_V"
 BYTES                         = 11
 DATA_TYPE                     = ASCII_REAL
 START_BYTE                    = 28366
 UNIT                          = VOLT
 END_OBJECT                    = COLUMN

/* +8.5_V : measurement of +8.5 V power supply */

 OBJECT                        = COLUMN
 NAME                          = "+8.5_V"
 BYTES                         = 11
 DATA_TYPE                     = ASCII_REAL
 START_BYTE                    = 28378
 UNIT                          = VOLT
 END_OBJECT                    = COLUMN

/* -8.5_V : measurement of -8.5 V power supply */

 OBJECT                        = COLUMN
 NAME                          = "-8.5_V"
 BYTES                         = 11
 DATA_TYPE                     = ASCII_REAL
 START_BYTE                    = 28390
```

```
 UNIT                            = VOLT
 END_OBJECT                          = COLUMN

/* +3.3_V : measurement of +3.3 V power supply */

 OBJECT                          = COLUMN
 NAME                            = "+3.3_V"
 BYTES                           = 11
 DATA_TYPE                       = ASCII_REAL
 START_BYTE                      = 28402
 UNIT                            = VOLT
 END_OBJECT                      = COLUMN

/* +2.5_V : measurement of +2.5 V power supply */

 OBJECT                          = COLUMN
 NAME                            = "+2.5_V"
 BYTES                           = 11
 DATA_TYPE                       = ASCII_REAL
 START_BYTE                      = 28414
 UNIT                            = VOLT
 END_OBJECT                      = COLUMN

/* +5_V : measurement of +5 V power supply */

 OBJECT                          = COLUMN
 NAME                            = "+5_V"
 BYTES                           = 11
 DATA_TYPE                       = ASCII_REAL
 START_BYTE                      = 28426
 UNIT                            = VOLT
 END_OBJECT                      = COLUMN

/* -5_V : measurement of -5 V power supply */

 OBJECT                          = COLUMN
 NAME                            = "-5_V"
 BYTES                           = 11
 DATA_TYPE                       = ASCII_REAL
 START_BYTE                      = 28438
 UNIT                            = VOLT
 END_OBJECT                      = COLUMN

/* FPAT : temperature measurement on focal plane array in detector used for closed loop
             feedback */

 OBJECT                          = COLUMN
 NAME                            = "FPAT"
 BYTES                           = 11
 DATA_TYPE                       = ASCII_REAL
 START_BYTE                      = 28450
 UNIT                            = KELVIN
 END_OBJECT                      = COLUMN

END_OBJECT = SOIR_TABLE
```

Associated files

At the PSA level 2 each data set contains, besides the main data table file, an associated table file for the telecommands of type 2 issued during this observation. The table for TC2 contains 31 rows. Each row is 19 bytes long, hence a TC2 table file is 589 bytes long.

C_1 telecommand parameter name	C_2 telecommand parameter value

- C_1 = 1 x 8 bytes, type *character*
- C_2 = 1 x 8 bytes, type *ASCII_integer*

The file contains a small table object, namely OBJECT=TC2_TABLE, both consisting of two COLUMN objects (TC_NAMES and TC_VALUES).

```
OBJECT                              = TC2_TABLE
    INTERCHANGE_FORMAT              = ASCII
    ROWS                            = 10
    ROW_BYTES                       = 19
    COLUMNS                         = 2

    OBJECT                          = COLUMN
        NAME                        = TC_NAMES
        DATA_TYPE                   = CHARACTER
        START_BYTE                  = 1
        BYTES                       = 8
        END_OBJECT                  = COLUMN

    OBJECT                          = COLUMN
        NAME                        = TC_VALUES
        DATA_TYPE                   = ASCII_INTEGER
        START_BYTE                  = 10
        BYTES                       = 8
    END_OBJECT                      = COLUMN

END_OBJECT                          = TC2_TABLE
```

Besides the object definition of the respective tables the label files contain headers that describe a number of supplementary parameters documenting the observation. Below an example.

```
PDS_VERSION_ID = PDS3

/* DESIGN */
/* per observation 1 data file + 1 telecommand file type_1 + 1 telecommand file type_2 */
/* 3 label files to accompany the 3 data files */

/* FILE RELATED INFORMATION*/
PRODUCT_ID = "20060828_M05_001_OBS.TAB"
FILE_NAME = "20060828_M05_001_OBS.TAB"
^SOIR_TABLE = "20060828_M05_001_OBS.TAB"
RECORD_TYPE = FIXED_LENGTH
RECORD_BYTES = 33898242
FILE_RECORDS = 1

/* PRODUCER IDENTIFICATION */
PRODUCER_ID = VEX_SPICAV_SOIR
PRODUCER_FULL_NAME = «VANDAELE/NEEFS/MAHIEUX/TROMPET»
PRODUCER_INSTITUTION_NAME = "SERVICE D'AERONOMIE/BELGIAN INSTITUTE FOR SPACE AERONOMY"
PRODUCT_CREATION_TIME = 2008-04-28T08:45:09

/* DATA DESCRIPTION AND IDENTIFICATION */
DATA_SET_ID = "VEX-Y/V-SPICAV-2-SOIR-V1.0"
DATA_SET_NAME = "VENUS EXPRESS SKY/VENUS SPICAV 2 SOIR V1.0"
RELEASE_ID = 0001
```

```
REVISION_ID = 0000
PRODUCT_TYPE = EDR
PROCESSING_LEVEL_ID = 2
MISSION_NAME = "VENUS EXPRESS"
MISSION_ID = VEX
INSTRUMENT_HOST_NAME = "VENUS EXPRESS"
INSTRUMENT_HOST_ID = VEX
MISSION_PHASE_NAME = "PHASE 0"
INSTRUMENT_NAME = "SPICAV SOLAR OCCULTATION IN THE INFRARED"
INSTRUMENT_ID = SPICAV
INSTRUMENT_TYPE = SPECTROMETER
^INSTRUMENT_DESC = "INSTRUMENT_DESC.TXT"

/* TARGET IDENTIFICATION */
TARGET_TYPE = SUN
TARGET_NAME = SUN
RIGHT_ASCENSION = “N/A”
DECLINATION = “N/A”

/* SCIENCE OPERATIONS INFORMATION */
VEX:SCIENCE_CASE_ID = 6
VEX:SCIENCE_CASE_ID_DESC = "See document VEX_SCIENCE_CASE_ID_DESC.TXT in DOCUMENT
       directory"
OBSERVATION_TYPE = AC001A
^OBSERVATION_TYPE_DESC = "OBSERVATION_TYPE_DESC.TXT"

/* TIME RELATED INFORMATION */
START_TIME = 2006-08-28T02:37:33
STOP_TIME = 2006-08-28T02:57:26
SPACECRAFT_CLOCK_START_COUNT = "1/0047097453.57585"
SPACECRAFT_CLOCK_STOP_COUNT = "1/0047098646.50066"

/* ORBITAL INFORMATION */
ORBIT_NUMBER = 129
ORBITAL_ECCENTRICITY = “N/A”
ORBITAL_INCLINATION = “N/A”
ORBITAL_SEMIMAJOR_AXIS = “N/A”
PERIAPSIS_ALTITUDE = “N/A”
PERIAPSIS_ARGUMENT_ANGLE = “N/A”
PERIAPSIS_TIME = “N/A”
SPACECRAFT_ORIENTATION = “N/A”
^SPACECRAFT_ORIENTATION_DESC = "VEX_ORIENTATION_DESC.TXT"
SPACECRAFT_POINTING_MODE = INERT
SPACECRAFT_POINTING_MODE_DESC = "See document  VEX_POINTING_MODE_DESC.TXT in DOCUMENT
       directory"

/* GEOMETRICAL INFORMATION */
SPACECRAFT_ALTITUDE = “N/A”
SPACECRAFT_SOLAR_DISTANCE = “N/A”
SUB_SPACECRAFT_LATITUDE = “N/A”
SUB_SPACECRAFT_LONGITUDE = “N/A”
SLANT_DISTANCE = “N/A”

VEX: OCCULTATION_ENTRY_TIME = 2006-08-28T02:05:50
VEX: OCCULTATION_EXIT_TIME = 2006-08-28T02:52:29

/* QUALITY IDENTIFICATION */
DATA_QUALITY_ID = 0001111
DATA_QUALITY_DESC = "See document SOIR_DATA_QUALITY_DESC.TXT in DOCUMENT directory"

/* INSTRUMENT RELATED INFORMATION */
INSTRUMENT_MODE_ID = HOPPING
^INSTRUMENT_MODE_DESC = "INSTRUMENT_MODE_DESC.TXT"
DETECTOR_ID = SOIR
```

For other types of measurement than occultation (M, F, N, C), the table for TC2 contains 19 rows. Each row is 19 bytes long, hence a TC2 table file is 324 bytes long.

Data product design - PSA level 3

<u>Data file</u>

A SOIR data product file at PSA level 3 contains the data of one order throughout a selected reduced part of the observation, containing the scientifically interesting part of the measurement, i.e. the zone around "the occultation", the sunset or sunrise.

Each file is an ASCII table, containing 8 thematic columns C and 680 basic columns c and a variable number of rows, equal to the number of detector binned lined by the number of seconds selected as scientifically interesting occultation data. For a 1 minute occultation period there will be 120 rows in the file if the detector lines are binned in 2 bins. Each row contains 8848 bytes. Hence, for a 60 seconds occultation the file size will be approximately 1.36 Mbytes (1061760 bytes).

C_1 time	C_2 bin	C_3 binning	C_4 attitude			C_5 instrumental			C_6 wavenumber calib.			C_7 transmittance & noise			C_8 housekeeping		
			A_1	…	A_{12}	I_1	…	I_3	W_1	…	W_{10}	I_1	…	I_{640}	H_1	…	H_{16}

Table 8: PSA level 2 science data table – TAB-file format

C_i (i=1 to 8) are sets of 8 columns

- C_1 $= c_1$: 1 x 23 bytes, type *character*
- C_2 $= c_2$: 1 x 12 bytes, type *ASCII_integer*
- C_3 $= c_3$: 1 x 12 bytes, type *ASCII_integer*
- C_4 $= c_4 \ldots c_{15}$: 12 x 13 bytes, type *ASCII_real*
- C_5 $= c_{16} \ldots c_{18}$: 3 x 12 bytes, type *ASCII_integer*
- C_6 $= c_{19} \ldots c_{28}$: 5 x 13 bytes, type *ASCII_real*
- C_7 $= c_{29} \ldots c_{668}$: 640 x 13 bytes, type *ASCII_real*
- C_8 $= c_{669} \ldots c_{684}$: 16 x 13 bytes, type *ASCII_real*

The data table (OBJECT=SOIR_TABLE) is composed of a set of 7 COLUMN objects (TIME, WAVENUMBER BIN 1, WAVENUMBER BIN 2, TRANSMITTANCE BIN 1, TRANSMITTANCE BIN 2, HOUSEKEEPING, ATTITUDE). Each column consists of a certain number of ITEMS (sub-columns of the main column). The sub-columns are separated by comma's and each line is terminated by a <line feed> <carriage return> combination. The object SOIR_TABLE is described in a detached label in the following way

```
OBJECT                              = SOIR_TABLE

    OBJECT                          = COLUMN
        NAME                        = "TIME"
        BYTES                       = 25
        DATA_TYPE                   = CHARACTER
        UNIT                        = "N/A"
        ITEMS                       = 1
        DESCRIPTION                 = "Time of measurement"
    END_OBJECT                      = COLUMN

    OBJECT                          = COLUMN
        NAME                        = "BIN"
        BYTES                       = 12
        DATA_TYPE                   = ASCII_INTEGER
        UNIT                        = "N/A"
        ITEMS                       = 1
```

```
    DESCRIPTION                = "Detector bin number"
END_OBJECT                     = COLUMN

OBJECT                         = COLUMN
    NAME                       = "BINNING"
    BYTES                      = 12
    DATA_TYPE                  = ASCII_INTEGER
    UNIT                       = "N/A"
    ITEMS                      = 1
    DESCRIPTION                = "Number of detector lines in each bin"
END_OBJECT                     = COLUMN

OBJECT                         = COLUMN
    NAME                       = "ALT"
    BYTES                      = 13
    DATA_TYPE                  = ASCII_REAL
    UNIT                       = "KM"
    ITEMS                      = 1
    DESCRIPTION                = "Measurement tangent altitude"
END_OBJECT                     = COLUMN

OBJECT                         = COLUMN
    NAME                       = "POINTING_ANGLE"
    BYTES                      = 13
    DATA_TYPE                  = ASCII_REAL
    UNIT                       = "DEGREE"
    ITEMS                      = 1
    DESCRIPTION                = "Measurement complementary pointing angle"
END_OBJECT                     = COLUMN

OBJECT                         = COLUMN
    NAME                       = "DIST2VENUS"
    BYTES                      = 13
    DATA_TYPE                  = ASCII_REAL
    UNIT                       = "KM"
    ITEMS                      = 1
    DESCRIPTION                = "Distance between VEX and Venus"
END_OBJECT                     = COLUMN

OBJECT                         = COLUMN
    NAME                       = "SLIT_TILT_ANGLE"
    BYTES                      = 13
    DATA_TYPE                  = ASCII_REAL
    UNIT                       = "DEGREE"
    ITEMS                      = 1
    DESCRIPTION                = "Slit tilting angle wrt the limbs"
END_OBJECT                     = COLUMN

OBJECT                         = COLUMN
    NAME                       = "SLIT_HEIGHT"
    BYTES                      = 13
    DATA_TYPE                  = ASCII_REAL
    UNIT                       = "KM"
    ITEMS                      = 1
    DESCRIPTION                = "Slit height projection at the tangent point"
END_OBJECT                     = COLUMN

OBJECT                         = COLUMN
    NAME                       = "LATITUDE"
    BYTES                      = 13
    DATA_TYPE                  = ASCII_REAL
    UNIT                       = "DEGREE"
    ITEMS                      = 1
    DESCRIPTION                = "Measurement latitude"
END_OBJECT                     = COLUMN

OBJECT                         = COLUMN
    NAME                       = "LONGITUDE"
    BYTES                      = 13
    DATA_TYPE                  = ASCII_REAL
    UNIT                       = "DEGREE"
    ITEMS                      = 1
    DESCRIPTION                = "Measurement longitude"
```

```
END_OBJECT                      = COLUMN

OBJECT                          = COLUMN
    NAME                        = "LST"
    BYTES                       = 13
    DATA_TYPE                   = ASCII_REAL
    UNIT                        = "HOUR"
    ITEMS                       = 1
    DESCRIPTION                 = "Measurement local solar time"
END_OBJECT                      = COLUMN

OBJECT                          = COLUMN
    NAME                        = "SPDVEXSUN"
    BYTES                       = 13
    DATA_TYPE                   = ASCII_REAL
    UNIT                        = "KM/S"
    ITEMS                       = 1
    DESCRIPTION                 = "Relative speed of VEX wrt Sun in SOIR reference frame projected
                                   on disp vector"
END_OBJECT                      = COLUMN

OBJECT                          = COLUMN
    NAME                        = "SPDVENSUN"
    BYTES                       = 13
    DATA_TYPE                   = ASCII_REAL
    UNIT                        = "KM/S"
    ITEMS                       = 1
    DESCRIPTION                 = "Relative speed of Venus wrt Sun in SOIR reference frame projected
                                   on disp vector"
END_OBJECT                      = COLUMN

OBJECT                          = COLUMN
    NAME                        = "SPDVEXVEN"
    BYTES                       = 13
    DATA_TYPE                   = ASCII_REAL
    UNIT                        = "KM/S"
    ITEMS                       = 1
    DESCRIPTION                 = "Relative speed of VEX wrt Venus in SOIR reference frame projected
                                   on disp vector"
END_OBJECT                      = COLUMN

OBJECT                          = COLUMN
    NAME                        = "ERROR_ALT"
    BYTES                       = 13
    DATA_TYPE                   = ASCII_REAL
    UNIT                        = "KM"
    ITEMS                       = 1
    DESCRIPTION                 = "Error on tangent altitude"
END_OBJECT                      = COLUMN

OBJECT                          = COLUMN
    NAME                        = "AOTF_F"
    BYTES                       = 12
    DATA_TYPE                   = ASCII_INTEGER
    UNIT                        = "KHZ"
    ITEMS                       = 1
    DESCRIPTION                 = "AOTF frequency"
END_OBJECT                      = COLUMN

OBJECT                          = COLUMN
    NAME                        = "INTEGRATION_TIME"
    BYTES                       = 12
    DATA_TYPE                   = ASCII_INTEGER
    UNIT                        = "MS"
    ITEMS                       = 1
    DESCRIPTION                 = "Detector integration time"
END_OBJECT                      = COLUMN

OBJECT                          = COLUMN
    NAME                        = "NB_ACC"
    BYTES                       = 12
    DATA_TYPE                   = ASCII_INTEGER
    UNIT                        = "N/A"
```

```
        ITEMS                           = 1
        DESCRIPTION                     = "Number of accumulations on the detector"
    END_OBJECT                          = COLUMN

    OBJECT                              = COLUMN
        NAME                            = "PIXWN"
        BYTES                           = 65
        DATA_TYPE                       = ASCII_REAL
        UNIT                            = "N/A"
        ITEMS                           = 5
        DESCRIPTION                     = "Pixel to wavenumber polynomial relation"
    END_OBJECT                          = COLUMN

    OBJECT                              = COLUMN
        NAME                            = "T"
        BYTES                           = 4160
        DATA_TYPE                       = ASCII_REAL
        UNIT                            = "1"
        ITEMS                           = 320
        DESCRIPTION                     = "Transmittance"
    END_OBJECT                          = COLUMN

    OBJECT                              = COLUMN
        NAME                            = "DT"
        BYTES                           = 4160
        DATA_TYPE                       = ASCII_REAL
        UNIT                            = "1"
        ITEMS                           = 320
        DESCRIPTION                     = "Noise"
    END_OBJECT                          = COLUMN

    OBJECT                              = COLUMN
        NAME                            = "FPAT_2"
        BYTES                           = 13
        DATA_TYPE                       = ASCII_REAL
        UNIT                            = "DEGREE"
        ITEMS                           = 1
        DESCRIPTION                     = "Temperature measurement on focal plane array in detector"
    END_OBJECT                          = COLUMN

    OBJECT                              = COLUMN
        NAME                            = "SOFC"
        BYTES                           = 13
        DATA_TYPE                       = ASCII_REAL
        UNIT                            = "DEGREE"
        ITEMS                           = 1
        DESCRIPTION                     = "Temperature measurement at socket of AOTF"
    END_OBJECT                          = COLUMN

    OBJECT                              = COLUMN
        NAME                            = "BPL_1"
        BYTES                           = 13
        DATA_TYPE                       = ASCII_REAL
        UNIT                            = "DEGREE"
        ITEMS                           = 1
        DESCRIPTION                     = "First temperature measurement at baseplate"
    END_OBJECT                          = COLUMN

    OBJECT                              = COLUMN
        NAME                            = "BPL_2"
        BYTES                           = 13
        DATA_TYPE                       = ASCII_REAL
        UNIT                            = "DEGREE"
        ITEMS                           = 1
        DESCRIPTION                     = "Second temperature measurement at baseplate"
    END_OBJECT                          = COLUMN

    OBJECT                              = COLUMN
        NAME                            = "AOTF_T"
        BYTES                           = 13
        DATA_TYPE                       = ASCII_REAL
        UNIT                            = "DEGREE"
        ITEMS                           = 1
```

```
    DESCRIPTION                 = "Temperature measurement inside AOTF box"
END_OBJECT                      = COLUMN

OBJECT                          = COLUMN
    NAME                        = "RF_AMP"
    BYTES                       = 13
    DATA_TYPE                   = ASCII_REAL
    UNIT                        = "N/A"
    ITEMS                       = 1
    DESCRIPTION                 = "Amplitude of RF signal that drives AOTF"
END_OBJECT                      = COLUMN

OBJECT                          = COLUMN
    NAME                        = "MOT_CT"
    BYTES                       = 13
    DATA_TYPE                   = ASCII_REAL
    UNIT                        = "N/A"
    ITEMS                       = 1
    DESCRIPTION                 = "DAC value used for the control of the cooler motor"
END_OBJECT                      = COLUMN

OBJECT                          = COLUMN
    NAME                        = "+12_V"
    BYTES                       = 13
    DATA_TYPE                   = ASCII_REAL
    UNIT                        = "VOLT"
    ITEMS                       = 1
    DESCRIPTION                 = "Measurement of +12 V power supply"
END_OBJECT                      = COLUMN

OBJECT                          = COLUMN
    NAME                        = "-12_V"
    BYTES                       = 13
    DATA_TYPE                   = ASCII_REAL
    UNIT                        = "VOLT"
    ITEMS                       = 1
    DESCRIPTION                 = "Measurement of -12 V power supply"
END_OBJECT                      = COLUMN

OBJECT                          = COLUMN
    NAME                        = "+8.5_V"
    BYTES                       = 13
    DATA_TYPE                   = ASCII_REAL
    UNIT                        = "VOLT"
    ITEMS                       = 1
    DESCRIPTION                 = "Measurement of +8.5 V power supply"
END_OBJECT                      = COLUMN

OBJECT                          = COLUMN
    NAME                        = "-8.5_V"
    BYTES                       = 13
    DATA_TYPE                   = ASCII_REAL
    UNIT                        = "VOLT"
    ITEMS                       = 1
    DESCRIPTION                 = "Measurement of -8.5 V power supply"
END_OBJECT                      = COLUMN

OBJECT                          = COLUMN
    NAME                        = "+3.3_VT"
    BYTES                       = 13
    DATA_TYPE                   = ASCII_REAL
    UNIT                        = "VOLT"
    ITEMS                       = 1
    DESCRIPTION                 = "Measurement of +3.3 V power supply"
END_OBJECT                      = COLUMN

OBJECT                          = COLUMN
    NAME                        = "+2.5_V"
    BYTES                       = 13
    DATA_TYPE                   = ASCII_REAL
    UNIT                        = "VOLT"
    ITEMS                       = 1
    DESCRIPTION                 = "Measurement of +2.5 V power supply"
```

```
    END_OBJECT                      = COLUMN

    OBJECT                          = COLUMN
        NAME                        = "+5_V"
        BYTES                       = 13
        DATA_TYPE                   = ASCII_REAL
        UNIT                        = "VOLT"
        ITEMS                       = 1
        DESCRIPTION                 = "Measurement of +5 V power supply"
    END_OBJECT                      = COLUMN

    OBJECT                          = COLUMN
        NAME                        = "-5_V"
        BYTES                       = 13
        DATA_TYPE                   = ASCII_REAL
        UNIT                        = "VOLT"
        ITEMS                       = 1
        DESCRIPTION                 = "Measurement of -5 V power supply"
    END_OBJECT                      = COLUMN

    OBJECT                          = COLUMN
        NAME                        = "FPAT"
        BYTES                       = 13
        DATA_TYPE                   = ASCII_REAL
        UNIT                        = "KELVIN"
        ITEMS                       = 1
        DESCRIPTION                 = "Temperature measurement on focal plane array in detector used for
                                       closed loop feedback"
    END_OBJECT                      = COLUMN
```

Associated files

The additional data table contains information over the linear regression used to calibrate the occultation observations. It has 1938 columns with a total of 25KB per line.

C_1 bin number	C_2 Indexes of the different regions			C_3 Parameters used to find the regression region			C_4 Validation of the criteria			C_5 Bad pixels		
	a1	…	a11	b_1	…	b6	c_1	…	c1600	d1		d320

Table 9 : PSA level 2 data table containing the regression of the full sun spectrum – TAB-file format

- C_1 $= c_1$: 2 bytes, type *ASCII_integer*
- C_2 $= c_2 \dots c_{12}$: 10 x 35 bytes + 1 x 17 bytes, type *CHARACTER*
- C_3 $= c_{13} \dots c_{18}$: 5 x 13 bytes + 1 x 14 bytes, type *ASCII_real*
- C_4 $= c_{19} \dots c_{1618}$: 1600 x 4160 bytes, type *ASCII_real*
- C_5 $= c_{1619} \dots c_{1938}$: 320 x 4147 bytes, type BOOLEAN

The columns of this table are described here after:

```
OBJECT                              = REF_TABLE
    COLUMNS                         = 1938
    INTERCHANGE_FORMAT              = ASCII
    ROW_BYTES                       = 25233
    ROWS                            = 2
```

```
OBJECT                          = COLUMN
    NAME                        = "BIN"
    UNIT                        = "N/A"
    BYTES                       = 2
    DATA_TYPE                   = ASCII_REAL
    START_BYTE                  = 1
    ITEMS                       = 1
    ITEM_OFFSET                 = 18
    ITEM_BYTES                  = 17
    DESCRIPTION                 = "Detector bin number"
END_OBJECT                      = COLUMN

OBJECT                          = COLUMN
    NAME                        = "SUN INDEXES"
    UNIT                        = "N/A"
    BYTES                       = 19
    DATA_TYPE                   = ASCII_REAL
    START_BYTE                  = 1
    ITEMS                       = 2
    ITEM_OFFSET                 = 18
    ITEM_BYTES                  = 17
    DESCRIPTION                 = "First and last indexes of
                                   the defined SUN region"
END_OBJECT                      = COLUMN

OBJECT                          = COLUMN
    NAME                        = "T INDEXES"
    UNIT                        = "N/A"
    BYTES                       = 35
    DATA_TYPE                   = ASCII_REAL
    START_BYTE                  = 38
    ITEMS                       = 2
    ITEM_OFFSET                 = 17
    ITEM_BYTES                  = 16
    DESCRIPTION                 = "First and last indexes of the defined
                                   Transmittance region"
END_OBJECT                      = COLUMN

OBJECT                          = COLUMN
    NAME                        = "W INDEXES"
    UNIT                        = "N/A"
    BYTES                       = 35
    DATA_TYPE                   = ASCII_REAL
    START_BYTE                  = 73
    ITEMS                       = 2
    ITEM_OFFSET                 = 17
    ITEM_BYTES                  = 16
    DESCRIPTION                 = "First and last indexes of the defined
                                   reference (W) region"
END_OBJECT                      = COLUMN

OBJECT                          = COLUMN
    NAME                        = "R INDEX"
    UNIT                        = "N/A"
    BYTES                       = 17
    DATA_TYPE                   = ASCII_REAL
    START_BYTE                  = 108
    ITEMS                       = 1
    ITEM_OFFSET                 = 17
    ITEM_BYTES                  = 16
    DESCRIPTION                 = "Index of the altitude unity (R)"
END_OBJECT                      = COLUMN

OBJECT                          = COLUMN
    NAME                        = "V INDEXES"
    UNIT                        = "N/A"
    BYTES                       = 35
    DATA_TYPE                   = ASCII_REAL
    START_BYTE                  = 125
    ITEMS                       = 2
    ITEM_OFFSET                 = 17
    ITEM_BYTES                  = 16
```

```
    DESCRIPTION                 = "First and last indexes of the defined
                                   effective (V) region"
  END_OBJECT                    = COLUMN

  OBJECT                        = COLUMN
    NAME                        = "U INDEXES"
    UNIT                        = "N/A"
    BYTES                       = 35
    DATA_TYPE                   = ASCII_REAL
    START_BYTE                  = 160
    ITEMS                       = 2
    ITEM_OFFSET                 = 17
    ITEM_BYTES                  = 16
    DESCRIPTION                 = "First and last indexes of the defined
                                   Umbra (U) region"
  END_OBJECT                    = COLUMN

  OBJECT                        = COLUMN
    NAME                        = "MINPOINTS"
    UNIT                        = "N/A"
    BYTES                       = 13
    DATA_TYPE                   = ASCII_REAL
    START_BYTE                  = 195
    ITEMS                       = 1
    ITEM_OFFSET                 = 13
    ITEM_BYTES                  = 12
    DESCRIPTION                 = "Parameter used to define the minimum
                                   number of indexes for the S region"
  END_OBJECT                    = COLUMN

  OBJECT                        = COLUMN
    NAME                        = "SNRMIN"
    UNIT                        = "1"
    BYTES                       = 13
    DATA_TYPE                   = ASCII_REAL
    START_BYTE                  = 208
    ITEMS                       = 1
    ITEM_OFFSET                 = 13
    ITEM_BYTES                  = 12
    DESCRIPTION                 = "Parameter used to define a minimum
                                   SNR for the second criterion
                                   of validation of the S region
                                   (see report)"
  END_OBJECT                    = COLUMN

  OBJECT                        = COLUMN
    NAME                        = "THRESHOLD"
    UNIT                        = "1"
    BYTES                       = 14
    DATA_TYPE                   = ASCII_REAL
    START_BYTE                  = 221
    ITEMS                       = 1
    ITEM_OFFSET                 = 14
    ITEM_BYTES                  = 13
    DESCRIPTION                 = "Parameter used to define a minimum
                                   threshold for the validation
                                   of the S region (see report)"
  END_OBJECT                    = COLUMN

  OBJECT                        = COLUMN
    NAME                        = "FACTORDT"
    UNIT                        = "N/A"
    BYTES                       = 13
    DATA_TYPE                   = ASCII_REAL
    START_BYTE                  = 235
    ITEMS                       = 1
    ITEM_OFFSET                 = 13
    ITEM_BYTES                  = 12
    DESCRIPTION                 = "Parameter used for the criterions
                                   (see report)"
  END_OBJECT                    = COLUMN

  OBJECT                        = COLUMN
```

```
        NAME                        = "ALTSTEP"
        UNIT                        = "N/A"
        BYTES                       = 13
        DATA_TYPE                   = ASCII_REAL
        START_BYTE                  = 248
        ITEMS                       = 1
        ITEM_OFFSET                 = 13
        ITEM_BYTES                  = 12
        DESCRIPTION                 = "Step used over the maximum altitude
                                       of the S region (see report)"
    END_OBJECT                      = COLUMN

    OBJECT                          = COLUMN
        NAME                        = "STEP"
        UNIT                        = "N/A"
        BYTES                       = 13
        DATA_TYPE                   = ASCII_REAL
        START_BYTE                  = 261
        ITEMS                       = 1
        ITEM_OFFSET                 = 13
        ITEM_BYTES                  = 12
        DESCRIPTION                 = "Altitude difference between
                                       the global maximum altitude and
                                       the regression maximum altitude."
    END_OBJECT                      = COLUMN

    OBJECT                          = COLUMN
        NAME                        = "CRITERION1"
        UNIT                        = "N/A"
        BYTES                       = 4160
        DATA_TYPE                   = ASCII_REAL
        START_BYTE                  = 274
        ITEMS                       = 320
        ITEM_OFFSET                 = 13
        ITEM_BYTES                  = 12
        DESCRIPTION                 = "Fullfilment of the first criterion
                                       for each pixel over the W region"
    END_OBJECT                      = COLUMN

    OBJECT                          = COLUMN
        NAME                        = "CRITERION2"
        UNIT                        = "N/A"
        BYTES                       = 4160
        DATA_TYPE                   = ASCII_REAL
        START_BYTE                  = 4434
        ITEMS                       = 320
        ITEM_OFFSET                 = 13
        ITEM_BYTES                  = 12
        DESCRIPTION                 = "Fullfilment of the second criterion
                                       for each pixel over the W region"
    END_OBJECT                      = COLUMN

    OBJECT                          = COLUMN
        NAME                        = "CRITERION3"
        UNIT                        = "N/A"
        BYTES                       = 4160
        DATA_TYPE                   = ASCII_REAL
        START_BYTE                  = 8594
        ITEMS                       = 320
        ITEM_OFFSET                 = 13
        ITEM_BYTES                  = 12
        DESCRIPTION                 = "Fullfilment of the third criterion
                                       for each pixel over the W region"
    END_OBJECT                      = COLUMN

    OBJECT                          = COLUMN
        NAME                        = "CRITERION4"
        UNIT                        = "N/A"
        BYTES                       = 4160
        DATA_TYPE                   = ASCII_REAL
        START_BYTE                  = 12754
        ITEMS                       = 320
        ITEM_OFFSET                 = 13
```

```
        ITEM_BYTES                  = 12
        DESCRIPTION                 = "Fullfilment of the fourth criterion
                                       for each pixel over the V region"
    END_OBJECT                      = COLUMN

    OBJECT                          = COLUMN
        NAME                        = "CRITERION5"
        UNIT                        = "N/A"
        BYTES                       = 4160
        DATA_TYPE                   = ASCII_REAL
        START_BYTE                  = 16914
        ITEMS                       = 320
        ITEM_OFFSET                 = 13
        ITEM_BYTES                  = 12
        DESCRIPTION                 = "Fullfilment of the fifth criterion
                                       for each pixel on the unity altitude"
    END_OBJECT                      = COLUMN

    OBJECT                          = COLUMN
        NAME                        = "BADPIXELS"
        UNIT                        = "BOOLEAN"
        BYTES                       = 4147
        DATA_TYPE                   = ASCII_REAL
        START_BYTE                  = 21074
        ITEMS                       = 320
        ITEM_OFFSET                 = 13
        ITEM_BYTES                  = 12
        DESCRIPTION                 = "List of the bad pixels (see report)"
    END_OBJECT                      = COLUMN

END_OBJECT                          = REF_TABLE
```

APPENDIX 3: Label keywords descriptions

PDS version information

PDS_VERSION_ID: version number of the PDS standards document that is valid when a data product label is created. For labels adhering to the PDS Standards Reference, Version 3.6, the appropriate value is [PDS3].

File related information

PRODUCT_ID: unique identifier assigned to a data product. Data file name is used
Example PSA level 2 ["20060812_M04_OBS.TAB"]
Example PSA level 3 ["20060809_M04_120.TAB"]

FILE_NAME: name of the data file. E.g. [“20060809_M04_OBS.TAB”] for PSA level 2, [“20060526_M01_165.TAB”] for PSA level 3.

SOIR_TABLE: pointer to the table file containing the SPICAV data and described in the label file
Example ["20060809_M04_120.TAB"]

RECORD_TYPE: record format of a file. For the SOIR ASCII data files the RECORD_TYPE is [FIXED_LENGTH].

RECORD_BYTES: number of bytes in a record = “number of rows in the record” times “row length”. For PSA level 2 observation files the number of rows equals the number of seconds in the observation (order of magnitude 1500), the row length is 28.462 bytes. For PSA level 3 observation files the number of rows equals the number of interesting observations (seconds) in the occultation (order of magnitude 60), the row length is 10.119 bytes.

FILE_RECORDS: Number of records in a file. Always [1] for SOIR.

Producer identification

PRODUCER_ID: identity of the producer of this dataset [VEX_SPICAV_SOIR]

PRODUCER_FULL_NAME: full name of the person responsible for the production of a data [“VANDAELE/NEEFS/MAHIEUX/TROMPET”]

PRODUCER_INSTITUTION_NAME: institution associated with the production of a data set ["PLANETARY AERONOMY/BELGIAN INSTITUTE FOR SPACE AERONOMY"]

PRODUCT_CREATION_TIME: time of creation of this data file on the ground (in UTC).
Example for SOIR [2006-10-23T10:06:03]

Data description and identification

DATA_SET_ID: unique alphanumeric identifier of this dataset. For SOIR PSA level 2 [“VEX-Y_V-SPICAV -2-SOIR-V1.0“]. For SOIR PSA level 3 [“VEX-Y_V-SPICAV-3-SOIR-V1.0“]. The DATA_SET_ID is an abbreviation of the DATA_SET_NAME.

DATA_SET_NAME: full name given to a data set or a data product. The data_set_name typically identifies the instrument that acquired the data, the target of that instrument, and the processing level of the data. For SOIR PSA level 2 “VENUS EXPRESS SKY/VENUS SPICAV 3 SOIR V1.0“]. For SOIR PSA level 2 [“VENUS EXPRESS SKY/VENUS SPICAV 3 SOIR V1.0“]

RELEASE_ID: number of the release of this data set. E.g. 0001

REVISION_ID: number of the revision of this data set. E.g. 0000

PRODUCT_TYPE: type or category of a data product within a data set [EDR for PSA level 2, RDR for PSA level 3]

PROCESSING_LEVEL_ID: CODMAC level [2 for PSA level 2, 3 for PSA level 3]

MISSION_NAME: Name of the mission including the SPICAV instrument [“VENUS EXPRESS”]

MISSION_ID: [VEX]

INSTRUMENT_HOST_NAME: name of the host spacecraft for the SPICAV instrument [“VENUS EXPRESS”]

INSTRUMENT_HOST_ID: abbreviated name of the host spacecraft [VEX]

MISSION_PHASE_NAME: mission subphases during which the data were collected [“CRUISE”, “VOI”, “PHASE 0”, “PHASE 1”, …]

INSTRUMENT_NAME: name of the instrument ["SPICAV SOLAR OCCULTATION IN THE INFRARED"]

INSTRUMENT_ID: acronym which identifies the instrument [SPICAV-SOIR]

INSTRUMENT_TYPE: type of the instrument [SPECTROMETER]

INSTRUMENT_DESC: pointer to the instrument description text file [“INSTRUMENT_DESC.TXT”]

Target identification

TARGET_TYPE: observed target [SUN]

TARGET_NAME: the name of the target observed in the data [SUN]

RIGHT_ASCENSION: not used for SOIR

DECLINATION: not used for SOIR

Science operations information

VEX: SCIENCE_CASE_ID: case number as used during operations planning. Solar occultations using SOIR [6]

VEX: SCIENCE_CASE_ID_DESC: science case description text file [“See document SCIENCE_CASE_DESC.TXT in DOCUMENT directory”]

OBSERVATION_TYPE: observation type number as used during science definition. For SOIR [AC001A]

OBSERVATION_TYPE_DESC: pointer to the observation type description text file [“OBSERVATION_TYPE_DESC.TXT”]

Time related information

START_TIME: the time of data acquisition of the first record (in UTC)
e.g. [2006-08-09T01:30:53]

STOP_TIME: the time of data acquisition of the last record (in UTC)
e.g. [2006-08-09T01:31:42]

SPACECRAFT_CLOCK_START_COUNT: the value of the spacecraft clock at the beginning of data acquisition of the first record
e.g. ["1/0045451851.49184"]

SPACECRAFT_CLOCK_STOP_COUNT: the time on the spacecraft clock at the end of data acquisition of the last record
e.g. ["1/0045451900.49183"]

Orbital information

ORBIT_NUMBER: spacecraft orbit during which this data were collected. Valid values are [“N/A”] during the CRUISE phase or the value of the orbit (e.g.[“103”]) during the VENUS phase.

ORBITAL_ECCENTRICITY: not used for SOIR

ORBITAL_INCLINATION: not used for SOIR

ORBITAL_SEMIMAJOR_AXIS: not used for SOIR

PERIAPSIS_ALTITUDE: not used for SOIR

PERIAPSIS_ARGUMENT_ANGLE: not used for SOIR

PERIAPSIS_TIME: not used for SOIR

SPACECRAFT_ORIENTATION: orientation vector of the spacecraft. The definition of the vector and the standard values are given via the SPACECRAFT_ORIENTATION_DESC pointer

SPACECRAFT_ORIENTATION_DESC: pointer to a file containing information about the spacecraft orientation ["VEX_ORIENTATION_DESC.TXT"]

SPACECRAFT_POINTING_MODE: pointing mode of the spacecraft. The definition of the modes and the standard values are given via the SPACECRAFT_POINTING_MODE_DESC pointer [INERT]

SPACECRAFT_POINTING_MODE_DESC: definition file of the different pointing modes of the spacecraft ["see document VEX_POINTING_MODE_DESC.TXT in DOCUMENT directory"]

Geometrical information

SPACECRAFT_ALTITUDE: **Example [271.6]**

SPACECRAFT_SOLAR_DISTANCE: not used for SOIR

SUB_SPACECRAFT_LATITUDE: Example [76.0]

SUB_SPACECRAFT_LONGITUDE: Example [202.1]

SLANT_DISTANCE: not used for SOIR

VEX: OCCULTATION_ENTRY_TIME (PENS): not used for SOIR **VEX: OCCULTATION_EXIT_TIME (PENE):** not used for SOIR

Quality identification

DATA_QUALITY_ID: binary code describing in 7 bits the quality of the data. Example [1110101]

DATA_QUALITY_DESC: description file of the data quality of the SOIR instrument ["SOIR_DATA_QUALITY_DESC.TXT in DOCUMENT directory"]

Instrument related information

INSTRUMENT_MODE_ID: observation mode of the SOIR instrument (taken from telemetry).
Examples [HOPPING], [PARAMETER_STEPPING], [WINDOW_STEPPING]

INSTRUMENT_MODE_DESC: pointer to the instrument mode description file ["INSTRUMENT_MODE_DESC.TXT"]

DETECTOR_ID: name of the instrument [SOIR]

APPENDIX 4: Calculation of the transmittances (PSA level 3 data)

All routines producing the PSA level 3 files have been developed in MATLAB.

Description of the algorithm producing the transmittances

Figure 10shows an example of the signal measured on the detector pixel during a solar occultation in an ingress. This signal can be separated in three parts:

- A, the 'Sun region': the SOIR line-of-sight is does not cross the atmosphere. This region extends above 220 km of altitude.
- B, the 'Penumbra region': the SOIR line-of-sight crosses the Venus atmosphere and the light is not totally absorbed by the atmosphere compounds. This region has been defined to extend from 60 to 220 km of altitude and it is over this region that we can calculate transmittances.
- U, the 'Umbra region' the SOIR line of sight crosses the atmosphere but the Sun light is totally absorbed by it. This regions extends for altitudes lower than 60 km.

The transmittances are obtained by dividing the signal in the Penumbra region by the extrapolation of the signal of the Sun region in the Penumbra region. In any case, transmittances computed for tangent altitudes close to the Sun region must have values close to 1. For the extrapolation, a simple linear regression is calculated in the Sun region. Indeed regression using fits of higher orders might introduce unwanted behavior of the 'reference' level.

In SOIR solar occultation observations, the whole Sun region can extend from dozens to thousands of kilometers. When transmittances are calculated using a linear regression over such a region, the ones computed for tangent altitudes close to the Sun region can have values taken away from 1. This is a problem if these values are greater than 1 plus the calculated noise over the transmittances ($1+\delta T$). To avoid that, the regression is calculated over a subregion of the Sun region.

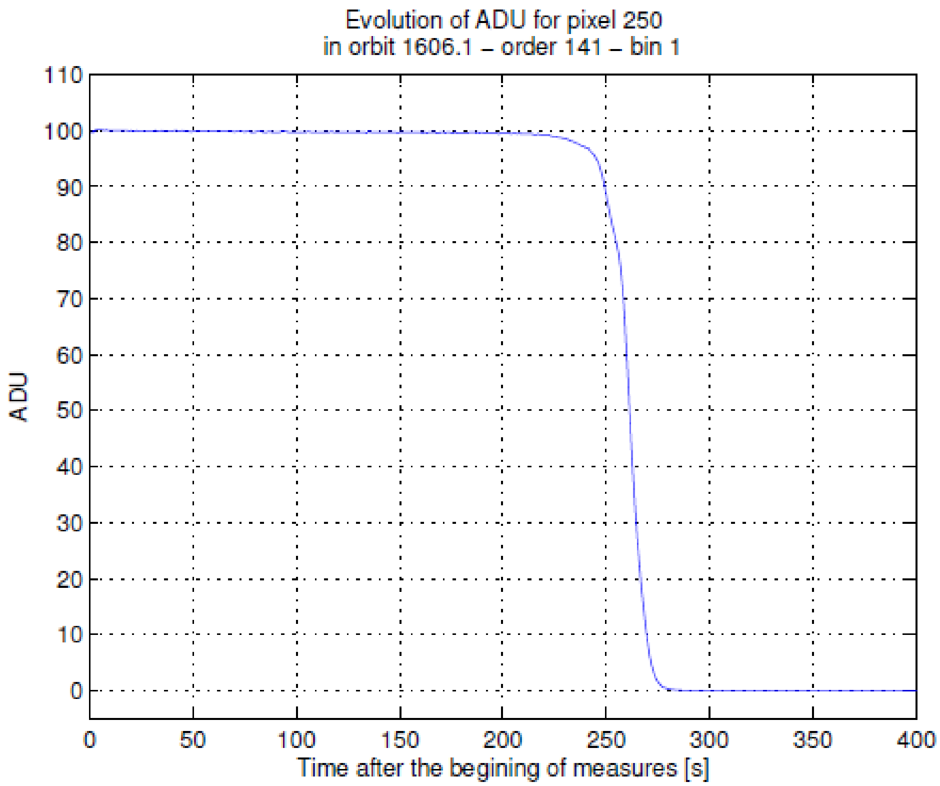

Figure 10: Example of signal obtained for one pixel during a solar occultation observation in an ingress. A is the Sun part: the line of sight does not cross the atmosphere. B is the Penumbra region: the line of sight crosses the atmosphere and the signal is non zero. U is the Umbra region: the line of sight crosses the atmosphere and the light is totally absorbed.

To be sure to obtain transmittances with values that do not exceeds 1+δT, 5 criteria have been introduced requiring the definition of several subregions within the Sun and Penumbra region as shown in Figure 11. When a measurement is made, spectra are recorded by step of time called here *indexes*. For clarity, we have plotted the data for only 5 pixels on this figure. The black lines are the measured signal for these five pixels. Thereafter, all these subregions will be called in this way:

- S is the region in the Sun region that is used to calculate the linear regression. The linear regression is plotted in green in Figure 11.

- T is the whole subregion on which the transmittances are computed, i.e. the region between the last index of the S subregion the *unity altitude* and 60 km of tangent altitude.

- W is the subregion of T containing the indexes corresponding to tangent altitudes above the *unity altitude*. The extrapolated S subregion in W is depicted in red in Figure 11. This subregion will be called the *reference* subregion.

- V is the subregion of T containing the indexes corresponding to tangent altitudes under the *unity altitude.* The extrapolated S subregion in V is depicted in purple in Figure 11. This subregion will be called the *effective* subregion as absorption occurs at the corresponding tangent altitudes.

- R is a single index corresponding to the closet tangent altitude to the *unity altitude*(*altUnity*), i.e. the altitude from which molecular and aerosols absorption are occurring; this altitude is wavenumber dependent. In Figure 11, this point is represented by a cross.

- U is the umbra region defined above. It extends between 60 km of tangent altitude and the lowest tangent altitude were a measurement has been done.

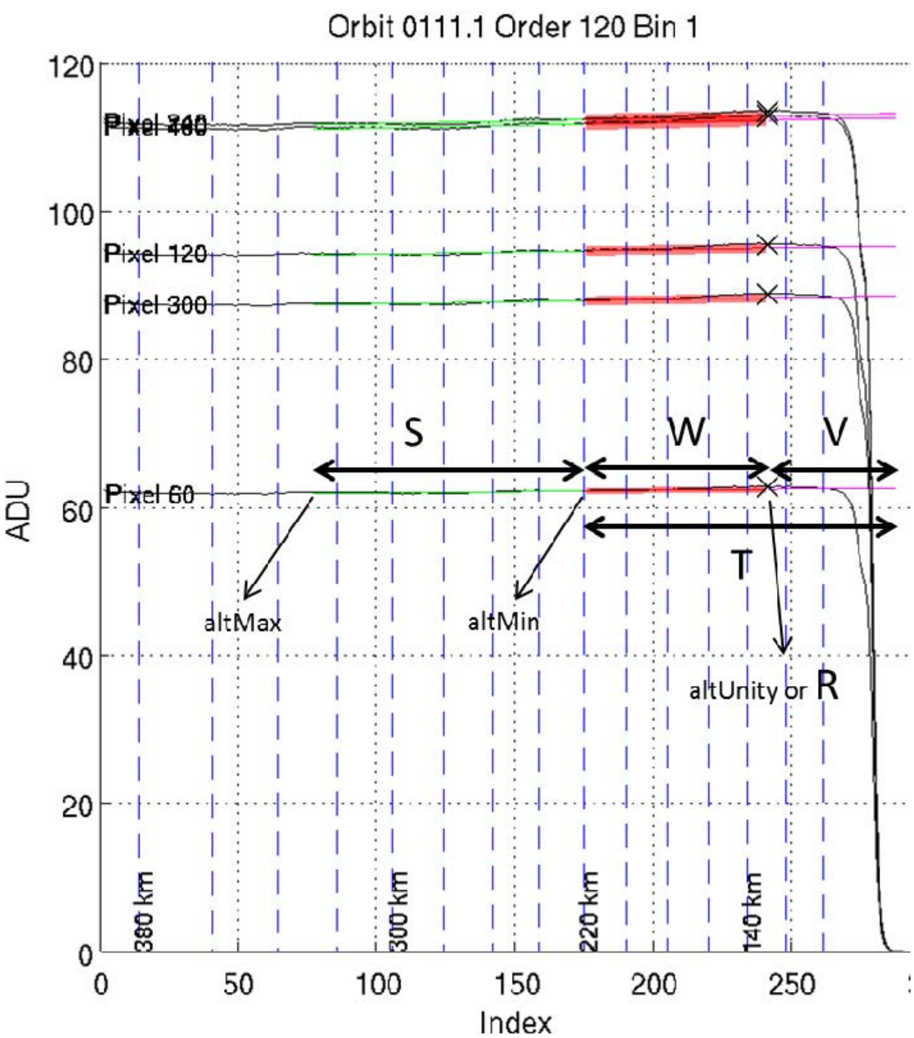

Figure 11 Separation of the Sun region in different zones for 5 pixels of the detector: the black line is the measured signal, the green line is the linear regression applied on S. The red and purple lines are the extrapolation of the linear regression over S. The cross is the "unity altitude.

Working principle of the algorithm producing the transmittances

As first step, we take all the information from the 0.2 level: data from the different bins and the useful data from the telecommand. Then, with the known measurements times (from the name of 0.2 level files), we call a routine that calculate the corresponding tangent altitudes for each measurement index using NAIF SPICE routines and kernels.

The maximum tangent altitude used for the regression is first set as the highest tangent altitude and the minimum tangent altitude is set to 220 km. Tangent altitude beneath 60 km are belonging to the umbra part of the spectra.

We perform a loop till an acceptable regression zone is found. This loop is controlled with two variables: *again* telling if no acceptable regression zone has been found yet and the *stop* variable telling if we have reached the last possible iteration. Figure 12 is a flowchart of the different tests and computations done inside this loop. In this flowchart, boxes in solid lines are assignments or computations and boxes in dotted lines are tests. The different variables are defined hereunder.

During the first iteration in this loop, we calculate the different subregions:

- *indsS* containing the indexes of S used for the linear regression. The upper bound of this region is called *altMax* and the lowest bound of this region is called *altMin*.
- *indsT* contains the indexes of T (the penumbra region - indexes corresponding to altitudes between the altitude just under *altMin*, the lower one used for regression and 60km).
- *indsU* contains the indexes of the umbra region (indexes corresponding to altitudes lower than 60km).
- *indsW* contains the indexes of W (indexes of *indsT* that correspond to altitudes between *altMin* and the *unity altitude*).
- *indsV* contains the index of V (*indesT\indsW*).
- *indsR* is the closest spectrum to the unity altitude (it is the same than R).

Then we verify that the number of indexes contained in the *S* subregion is not too small (for instance at least 20 indexes, this number can be changed). If it is the case and if the minimum altitude *altMin* is above altUnity, we decrease *altMin* and we restart the loop. If *altMin* is equal or smaller than altUnity the loop stops (*stop*=true) and we make a last check on the calculated transmittance

If the *S* subregions is sufficiently large, the same procedure is applied on *W* which has to contain at least 5 indexes).

If *S* and *W* regions contain enough indexes, we then calculate the transmittance and noise using the method described in [Vandaele, A.C., et al., *Improved Calibration of SOIR/Venus Express Spectra.* Optics Express, 2013. **21**(18): p. 21148.]:

The transmittance *T(t)* is calculated for each pixel and index of the defined penumbra region by dividing the values in the penumbra region by *S(t)*, the extrapolation of the linear regression performed over the values of the indexes of the Sun region:

$$T(t) = \frac{P(t)}{S(t)} \qquad (1)$$

The noises in the Sun and Umbra regions (δS and δU) are calculated as the standard deviation of the signal with time and the noise in the Penumbra (dP) regions is obtained as

$$\delta P(t) = \delta U + \sqrt{T(t)}(\delta S - \delta U) \qquad (2)$$

The noise $\delta T(t)$ on the transmittance spectrum *T(t)* can then be compute as

$$\delta T(t) = \frac{[illegible]}{S(t)} \qquad (3)$$

In Equation 3, we used the time *t* as variable but speaking of time, tangent altitude or indexes of measurement is equivalent. If δS is too small (lower than 10^{-14}ADU) - for example, by using points with very close values - , the SNR will have values artificially high for some pixels, which might be flagged then as *bad pixels*. To avoid that, all δS less than 10^{-14} are tagged and the corresponding values of these pixels will not be considered in the criteria described hereafter. The transmittances and noises of the *bad pixels* are calculated at the end of the procedure using the values of their nearest neighbors.

The criteria used to determine if the regression zone is valid are:

$$(|1 - T(i)|) < f \bullet \delta T(i), \quad i \in indsW \qquad (4)$$

$$\delta T(i) < \frac{1}{snrmin}, \quad i \in indsW \qquad (5)$$

$$\delta T(i) < f \bullet std(T(indsW)), \quad i \in indsW \qquad (6)$$

$$T(i) - 1 < f \bullet \delta T(i), \quad i \in indsV \qquad (7)$$

$$(|1 - T(R)|) < f \bullet \delta T(R), \qquad (8)$$

where *snrmin* is the minimum signal-to-noise ratio (default value is set to 200) and f is a factor (default value is 2).

Hereafter, it will be easier to speak about *set of spectra*: one set of spectra gather spectra of only one bin of one scanned order all along an observation. As one set of spectra is obtained for each bin for each **order** for each observation, SOIR has provided 6212 sets of spectra.
To accept the calculated data as a valid set of spectra, each criterion has to be satisfied for more than a defined ratio called *threshold* (default value is set to 0.8) over the whole set of pixels and indexes of the *I* zone:

$$\sum_{pixels}\sum_{zone}\frac{(criterion)}{320 \times l_{zone}} > threshold \qquad (9)$$

where l_{zone} is the number of points contained in the corresponding defined.

For Equation (6), some precautions have to be taken because if *indsW* contains only few indexes, the right hand side of this equation will be very small and this criterion will never be satisfied in spite of an acceptable transmittance found. To avoid this case, the standard deviation of the transmittance over the region *indsW* $(1 \times std(T(indsW)))$ for equation (6) is lowered to 0.001. if *indsW* is really too small (smaller than 10 indexes) this criterion is not used.

If each of these criteria is matched for more than 80% (value defined by *threshold*) of the pixels, the regression zone and the calculated values of *T* and δT are validated.

If it is not the case, the maximum tangent altitude *altMax* is iteratively reduced by steps of 10 km if *altMax* was higher than 220 km, and by steps of 1 km if it was under 220 km. If the number of remaining index in the Sun region are smaller than 20, the minimum altitude *altMin* is reduced by 10 km.

For each order, a minimum tangent altitude *altUnity* is defined for the linear regression calculation. This limit has to be set since absorption lines might be present at lower altitudes. They are defined inTable 10.

Tangent altitudes (km)	120	130	140	150	160	170
orders	108, 109, 110, 134, 135, 136, 137, 138, 139, 140, 176, 177, 178, 179, 180, 181, 182, 183, 184, 185, 186	114, 115, 116, 117, 118, 119, 120, 121, 122, 123, 124, 125, 126, 127, 141, 142, 143, 144, 145, 146, 147, 152, 153, 154, 170, 171, 172, 173, 174, 175, 187, 188	111, 112, 113, 128, 129, 130, 131, 132, 133, 148, 149, 150, 151, 155, 168, 169, 189, 192, 193, 194.	190, 191	156, 157, 158	101, 102, 103, 104, 105, 106, 107, 159, 160, 161, 162, 163, 164, 165, 166, 167.

Table 10: Minimum tangent altitudes (unity altitude or altUnity) for the Sun part above which we are sure that no absorption can be present on spectra.

If the algorithm stopped without finding any zone that matches the criteria, then the measurement for this particular bin is rejected and no 0.3 files are created.

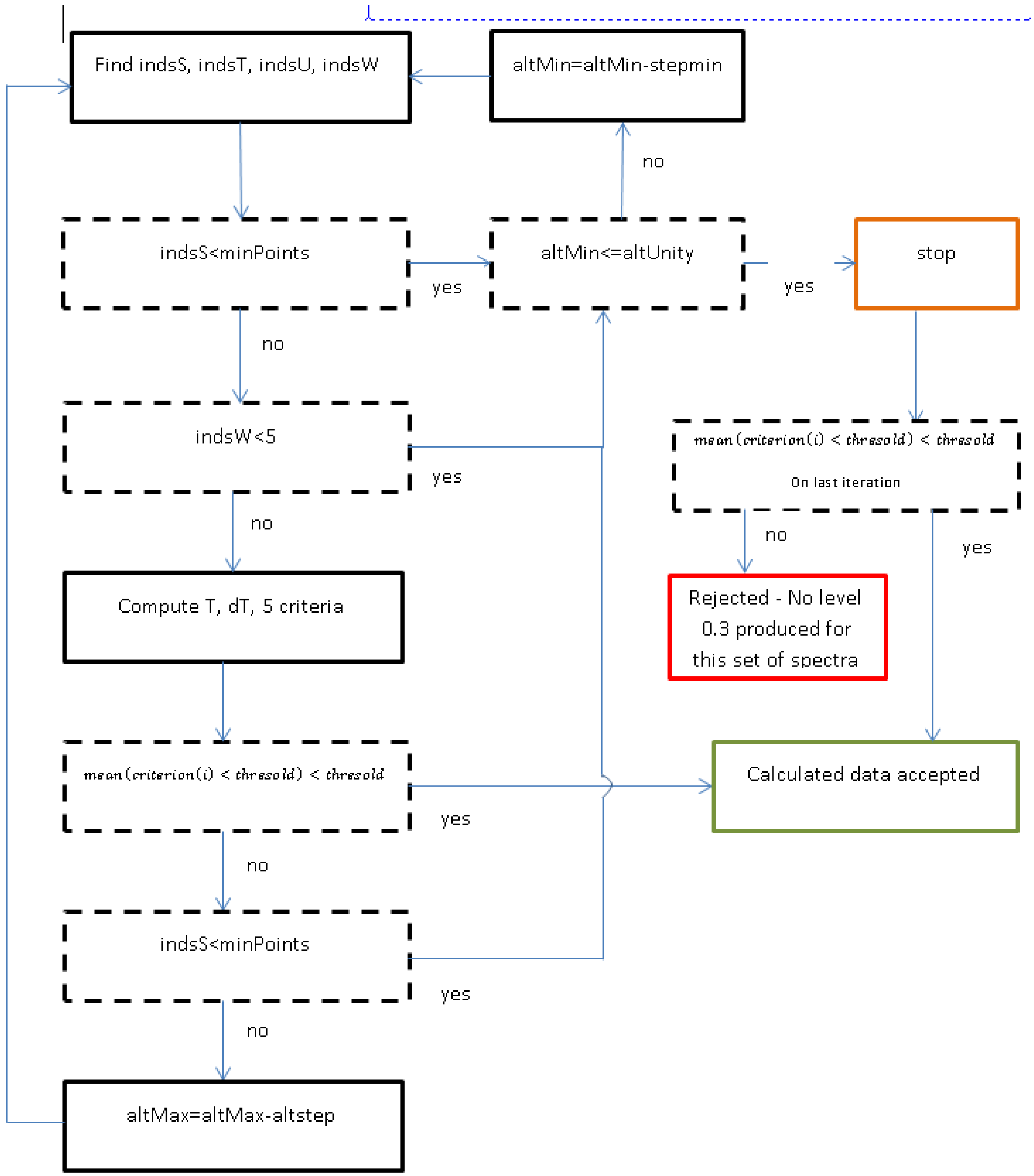

Figure 12: Flowchart of the working principle of the algorithm producing the transmittances. Boxes with straight lines are computation and dotted lines are tests.