DIVA2

Demonstration of an Integrated approach for the Validation and exploitation of Atmospheric missions

---

D5 Calibration and data file format for Pandora (Technical Note)

Issue 1, revision 02

October 15th, 2020

Project no.:	4000121773/17/I-EF
Project coordinator:	Doina Nicolae National Institute of R&D for Optoelectronics INOE nnicol@inoe.ro
Technical officer:	Jonas von Bismarck ESA/ESRIN
	Jonas.Von.Bismarck@esa.int

Document Change Record

Document, version	Date	Changes	Originator
DOC, v01	30/09/2020	Original version	Axel Kreuter, LuftBlick
DOC, v02	15/10/2020	Update after PM3	Axel Kreuter, LuftBlick

Table of contents

1 Introduction

1.1 Purpose

The purpose of this document is to describe the new almucantar measurement routines and the first Pandora test data set, prepared for the use within the GRASP aerosol retrieval framework [Dubovik, 2011 and Dubovik, 2014].

The data set is the basis for the development of new aerosol data products from Pandora on the DIVA platform. Also, combined with synergistic input from AERONET data, existing standard data products can potentially be improved.

1.2 Definitions, acronyms and abbreviations

AERONET – Aerosol Robotic Network

AOD – Aerosol optical depth

EVDC – ESA Atmospheric Validation Data Centre

FOV – Field of view

GEOMS – Generic Earth Observation Metadata Standard

GRASP – Generalized Retrieval of Aerosol and Surface Properties

L1/2 – Pandora data level1/2

PGN – Pandonia Global Network

Rome-SAP – Sapienza University of Rome

1.3 Applicable Documents

Contract number: 4000121773/17/I-EF

Project proposal: Demonstration of an Integrated approach for the Validation and exploitation of Atmospheric missions – DIVA2

DIVA_TD_D2_v02, D2 Standard DIVA data formats descriptions, Issue 1, revision 01, June 28, 2018

DIVA_TN_D4_v02, Pandora products optimised for DIVA, Issue 1, revision 02, March 15, 2020

1.4 Reference Documents

Dubovik, O., T. Lapyonok, P. Litvinov, M. Herman, D. Fuertes, F. Ducos, A. Lopatin, A. Chaikovsky, B. Torres, Y. Derimian, X. Huang, M. Aspetsberger, and C. Federspiel: *GRASP: a versatile algorithm for characterizing the atmosphere*, SPIE: Newsroom, Published Online: September 19, 2014. doi:10.1117/2.1201408.005558

Dubovik, O., Herman, M., Holdak, A., Lapyonok, T., Tanré, D., Deuzé, J. L., Ducos, F., Sinyuk, A., and Lopatin, A.: *Statistically optimized inversion algorithm for enhanced retrieval of aerosol properties from spectral multi-angle polarimetric satellite observations*, Atmos. Meas. Tech., 4, 975-1018, 2011. doi:10.5194/amt-4-975-2011

2 New Pandora measurement routine for GRASP

2.1 Almucantar routine

In routine PGN measurement mode, the Pandora spectrometer system measures spectral direct sun irradiance and sky radiance at a fixed azimuth and a selection of elevation angles ("sun-moon-sky" schedule). This schedule is optimized to retrieve trace gas total and tropospheric columns (and a new profile data product) for satellite validation.

Within the DIVA project, a new measurement routine has been developed, tested and implemented, which includes the almucantar (variable viewing azimuth angles at constant viewing elevation of the SZA) and the principal plane geometries (variable elevation angle at constant azimuth). These geometries are the basis for the retrieval of aerosol microphysical properties such as size distribution and refractive index and are routinely measured by the Cimel filter radiometers operated within AERONET.

The almucantar scan in the schedule includes a total of 56 azimuth angles, the following 28 angles in each hemisphere, which correspond to the ones implemented for the almucantar measurements within AERONET:

[3, 3.5, 4, 5, 6, 7, 8, 10, 12, 14, 16, 18, 20, 25, 30, 35, 40, 45, 50, 60, 70, 80, 90, 100, 120, 140, 160, 180]

It should be noted that measurements at small relative viewing angles can be affected by the direct solar beam due to possible imperfections of the Pandora FOV (about 2.5°).

The actual Pandora almucantar routine specification (*.rout file), as needed for the Blick operation software, is shown on the next page. The almucantar and principal plane routine has been inserted into the regular PGN measurement schedule four times a day, approximately at 70° and 50° SZA, in the morning and afternoon. Due to the priority of PGN satellite validation, no measurements at smaller SZA (closer to local noon) have been scheduled.

```
DESCRIPTION -> Almucantar plane routine with open hole in filterwheel #1
DESCRIPTION -> measures at selected azimuth angles in clockwise(here solar side) and
counterclockwise direction (here antisolar side) without polarization

PROCESSINFO -> TYPE=PROFILE

DURATION -> LENGTH=20;TIMEMODE=ADDED

SET FILTERWHEELS -> FUNCFILT=OPEN

Solar side
If you do not want to scan at the solar side, remove all '>'
in between the two ----- lines and put a # before STOP LOOP
-------------------------------------------------------------------
START LOOP ->
XIJ=0,3,3.5,4,5,6,7,8,10,12,14,16,18,20,25,30,35,40,45,50,60,70,80,90,100,120,140,160,180

Set azimuth relative to sun
SET POINTING -> DELTA=CONT;AZI=XIJ;ZEN=0;AZIMODE=RELSUN;ZENMODE=RELSUN

Open hole measurement
SET FILTERWHEELS -> FUNCFILT=OPEN
CHECK INTENSITY -> ADJUSTIT=FROMMIN;ADJUSTND=FROMCURRENT
SET SPECTROMETER -> NREPETITIONS=1;DURATION=5;DARKRATIO=OPTIMIZED
MEASURE -> SAVE=STDERRTOLINE

STOP LOOP
-------------------------------------------------------------------
Antisolar side
If you do not want to scan at the antisolar side, remove all '>'
in between the two ----- lines
-------------------------------------------------------------------
START LOOP ->
XI-
J=360,357,356.5,356,355,354,353,352,350,348,346,344,342,340,335,330,325,320,315,310,30
0,290,280,270,260,240,220,200,180

Set azimuth relative to sun
SET POINTING -> DELTA=CONT;AZI=XIJ;ZEN=0;AZIMODE=RELSUN;ZENMODE=RELSUN

Open hole measurement
SET FILTERWHEELS -> FUNCFILT=OPEN
CHECK INTENSITY -> ADJUSTIT=FROMMIN;ADJUSTND=FROMCURRENT
SET SPECTROMETER -> NREPETITIONS=1;DURATION=5;DARKRATIO=OPTIMIZED
MEASURE -> SAVE=STDERRTOLINE

STOP LOOP
-------------------------------------------------------------------
```

2.2 Implemented test schedule

The aim is to prepare a Pandora data set for use within the highly versatile GRASP retrieval algorithm [Dubovik, 2011 and Dubovik, 2014] which then also allows synergetic use with Cimel radiometer data.

The new almucantar and principal plane measurement routine has been running on the following PGN Pandora instruments:

Pandora ID	Location	Date range
110	Innsbruck	28.7.2020 - 28.9.2020
117	Rome-SAP	28.7.2020 - 8.9.2020
138	Rome-SAP	5.8.2020 - 8.9.2020

The L1 radiance data sets for both Pandora instruments at Rome-SAP have been converted to the GEOMS format described in TN4 and transferred to the DIVA server. For these data sets for proof-of-principle studies, data from spectrometer 1 (spectral range 300 nm - 540 nm) have been included. Since, in particular Pandora 117 and 138 are 2S instruments, the second spectrometer (spectral range 400 nm - 950 nm) can in principle also be included.

For the location of Rome-SAP, the measured radiances can be compared to the ones of the collocated AERONET Cimel photometers at the filter wavelengths of 340 nm, 380 nm, 440 nm and 500 nm.

3 Pandora example data for Rome-SAP

Two examples of Pandora almucantar data are shown below in Fig. 1. In the left panels, the normalized radiances at four selected (AERONET) wavelengths are shown against the relative azimuth angle. As discussed already in TN4, since the Pandora instrument cannot yet be calibrated in absolute radiometric radiance units, the radiance for the GRASP input is normalized to the sum of all radiances (another possible normalization for GRASP is to the measurement at a specific angle).

In the right panels, the relative differences between the right and the left hemisphere (positive versus negative relative angles) of the almucantar are shown. In the standard AERONET processing, this symmetry parameter is the criterion for cloud screening and should be <20% (AERONET's Version 2.0 quality assurance criteria). This threshold is exceeded e.g. in the almucantar measurement at 50.6 SZA between 20° and 70° azimuth angle.

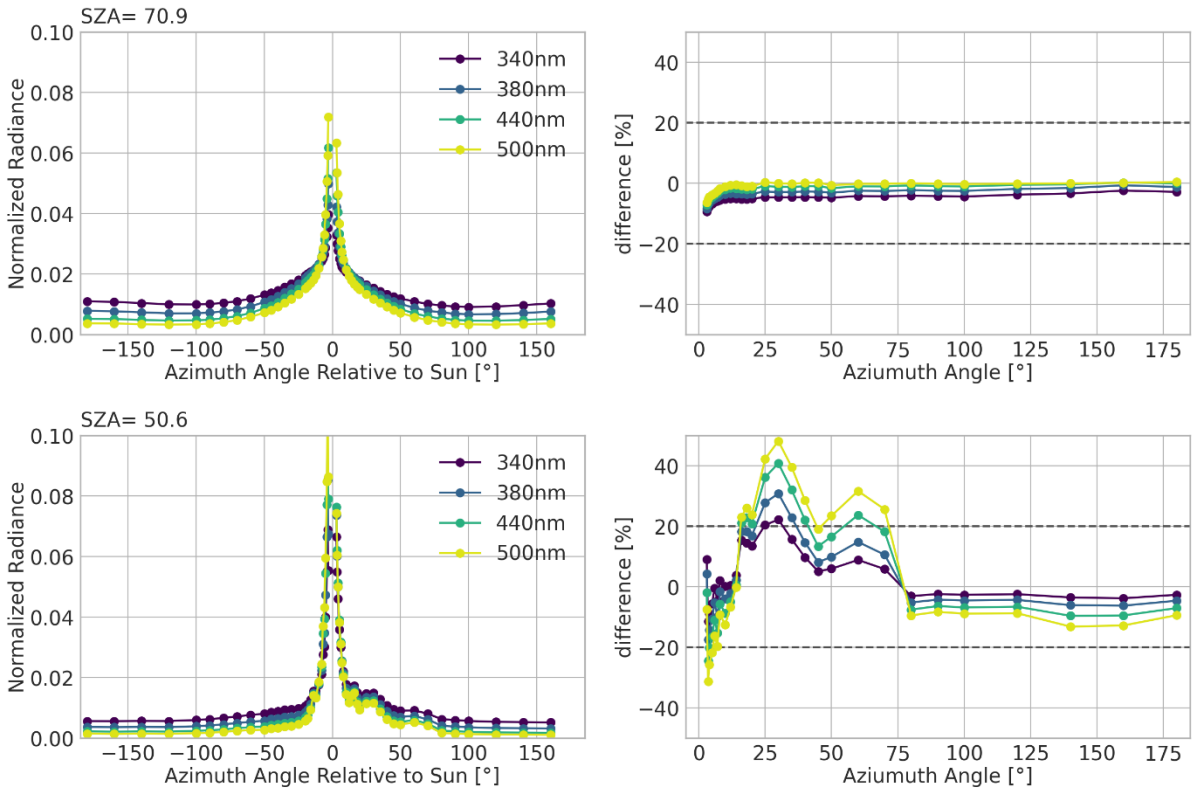

Figure 1 Two examples of almucantar radiances and corresponding symmetries (between left and right hemisphere) of Pandora 117, measured in Rome-SAP on 3.8.2020, between 5:58-6:10 and 14:40-14:52 UTC, respectively.

4 Outlook

Within this TN we have described the new almucantar routine designed for the input data of the GRASP algorithm. The routine has been implemented for three PGN Pandora instruments, two of which are located in Rome-SAP close to an AERONET Cimel photometer. As a first use case of the DIVA platform, the radiances of these instruments can be compared (note that the AERONET radiances are not an official data product) as well as the retrieved aerosol properties.

Furthermore, this data set of more than a month of almucantar data, available in GEOMS format on the DIVA server, together with the data conversion tools and the GRASP modules are the ideal basis and playground for scientific investigations regarding the potential of aerosol property retrieval using Pandora data and the GRASP algorithm.

As another use case of the DIVA platform, a sensitivity study is currently being prepared on the DIVA GRASP Jupyter hub to evaluate the retrieval accuracy of aerosol parameters depending on the number and range of wavelengths used as well as other input variables such as viewing geometry. Also, the synergy between Pandora and Cimel and its corresponding effect on the quality of the aerosol data products can now fully be explored.

5 Requirements Traceability Matrix

ID	Requirement according to SOW	
R-8	The Contractor shall assess if an update of the calibration procedure is necessary to adapt product to the simultaneous usage with the AERONET DIVA products in the DIVA GRASP algorithm described in Task 2 and provide a description of the new product format (DIVA/EVDC conform).	In section 2, the new DIVA data product (L1 almucantar radiances) is described, with an example given in section 3. The data format was described in TN D5.