CINDI-2

Second Cabauw Intercomparison of Nitrogen Dioxide measuring Instruments

Cabauw, The Netherlands

25 August – 7 October 2016

Semi-blind Intercomparison Protocol

Version 1.2.2

Date 13/09/2016

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Document change record

issue	date	item	comments
0.1.0	2016-07-11	–	Initial version, based on CINDI-2 planning document
1.0.0	2016-07-15	–	Updated
1.1.0	2016-07-20	–	Formatting issues and prepared for release.
1.2.0	2016-07-23	–	-Add horizon scan around noon and Almucantar scan -Use of Serdyuchenko O_3 cross sections for all CINDI-2 products
1.2.1	2016-09-07	–	-Remove the zenith measurement between 11:40:00 and 11:41:00 to allow the horizon scan for all the selected elevation angles -Use of Thalman and Volkamer (2013) O_4 cross sections for all CINDI-2 products including O_3 in the Chappuis bands -Serdyuchenko O_3 cross-sections have been updated in order to have 5 digits after the decimal. -Azimuth directions have been made consistent between Table 4 and the text (page 15, line 3) and Figure 7.

1.2.2	2016-09-13	–	-The numbering of the MAX-DOAS instruments in Tables 1-3 is now consistent with the instrument numbering in Tables 1-2 of the Planning Document. -145° azimuth direction is replaced by 135° (for 2D-MAX-DOAS): Figure 7, text, and Table 4 have been updated accordingly. -Tables with the DOAS settings and example files have been updated according to the remarks made at the Daily Briefings. Main changes are: • The cross sections file names have been added. • The fitting window for HCHO is fixed to 336.5-359nm and noon zenith spectrum should be used as reference. • The fitting window for O_3 in the Chappuis bands is now 450-520nm. The reason is that some groups cannot cover the full 450-550 nm spectral range with their instrument. • NO_2 cross-sections for O_3 in the Chappuis bands: the one at 298K should be used as baseline instead of 220K (see Table 11). • Orthogonalized cross sections generated by Michel have been included in the Tables and headers.

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1 Introduction

Passive UV-visible spectrometry using scattered sunlight as a source provides one of the simplest methods for routine remote sensing of atmospheric trace gases from the ground. While zenith-sky measurements have been used for decades to monitor stratospheric gases such NO_2, O_3, BrO and OClO, observations of the sky at several elevations between horizon and zenith using the so-called Multiple Axis or MAXDOAS method allow to derive vertically resolved information on tropospheric species and aerosols (e.g. Hönninger and Platt, 2002; Wagner et al., 2004; Friess et al., 2006). The number of MAXDOAS-type instruments deployed world-wide has grown considerably in recent years. This increasing use of MAXDOAS instruments for tropospheric observations, together with the diversity of their designs and operation protocols, has created the need for formal intercomparisons including as many different instruments as possible. The first CINDI intercomparison campaign was organised in 2009 under the auspices of ESA, NDACC and the EU GEOMON project to provide an assessment of the status of the capabilities for NO_2 monitoring. This resulted in the first successful large scale intercomparison of both MAXDOAS and zenith-sky ground-based remote sensors of NO_2 (Roscoe et al., 2010).

Seven years after CINDI, the CINDI-2 campaign has the target to intercompare a new and extended generation of ground-based remote-sensing and in-situ air quality instruments. The interest of ESA for such Intercalibration activities is stimulated by the ongoing development of several UV-Visible space missions targeting air quality monitoring such as the Copernicus Sentinel 5 Precursor instrument to be launched in late 2016 and the future ESA Copernicus Sentinel 4 and 5 at the horizon 2020. The validation of measurements from such space missions is essential and requires appropriate dedicated ground-truth measurement systems. Because tropospheric measurements from space-borne nadir UV-visible sensors show little or no vertical discrimination and inherently provide measurements of the total tropospheric amount, surface in-situ measurements are generally unsuitable for validation. Instead, validation demands a technique that can deliver column-integrated information on the key tropospheric species measured by satellite instruments such as NO_2, HCHO, O_3 and SO_2 with a horizontal representativeness compatible with the resolution of space measurements (typically 8x8 km^2 for the Sentinels).

The aim of the CINDI-2 semi-blind intercomparison is to characterise the differences between a large number of measurement systems and approaches and to contribute to a harmonisation of the measurement settings and retrieval methods for similar systems of the MAXDOAS type. Following the precedent set by Roscoe et al. (1999), Vandaele et al. (2005) and Roscoe et al. (2010), the adopted intercomparison protocol is semi-blind, i.e.:

a) Measurement and analysis results from the previous day have to be provided to the campaign referee in early morning. At a daily meeting in the early afternoon, slant columns measured during the previous day are displayed without assignment to the different instruments.
b) The referee notifies instrument representatives if there is an obvious error so that this can be corrected for the rest of the campaign.
c) At the end of the formal campaign, plots have instrument names attached, and plots of mean differences from one selected reference instrument or an average of several selected reference instruments are discussed.

d) After the end of the formal campaign time, revisions are only accepted where full details of the reasons for changes are supplied.

2 Calendar

The CINDI-2 semi-blind intercomparison exercise has been scheduled on weeks 37 and 38, i.e. starting on 12 September and ending on 25 September (inclusive). It will be preceded by one full week of warm-up operation during which hardware and software adjustments will be possible as well as various instrumental tests and calibrations.

Upon necessity (e.g. in case of persisting bad weather conditions during the nominal intensive measurement phase), the possibility of extending the semi-blind intercomparison by up to one full week will be investigated. If not required, this additional week will be used for extra measurements addressing science topics to be agreed during the campaign.

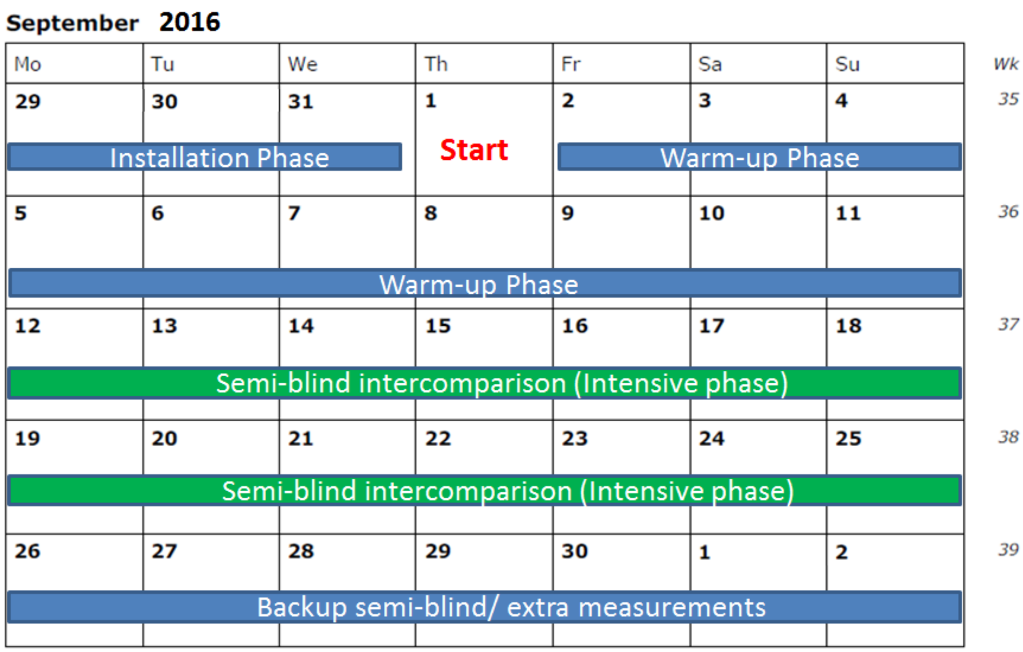


Figure 1: CINDI-2 campaign calendar. Two weeks of intensive measurements are reserved for the semi-blind intercomparison, with an optional extra week in case of bad weather conditions.

3 Participating instruments

The groups and instruments which have been registered for participation in the semi-blind intercomparison exercise are listed in Tables 1 to 3. In total 36 instruments from 26 different organisations will be accommodated on the site. Among these instruments, 19 will be two-dimensional MAXDOAS systems allowing for scans in both elevation and azimuth, 15 will be one-dimensional MAXDOAS systems performing elevation scans in one fixed azimuthal direction, and the last 2 instruments will be simple zenith-sky DOAS systems.

To allow for optimal synchronisation of the measurements all the systems participating to the semi-blind intercomparison exercise will be installed on the Remote Sensing Site (RSS). The complete

technical specifications of each instrument can be found in Appendix A of the Campaign Planning Document.

Table 1: 2D-MAXDOAS spectrometers participating to the semi-blind intercomparison exercise. Columns denote: Institute, instrument type, instrument number, direct-sun capability, field of view, spectral range and resolution, coupling between telescope and spectrometer (F: fibre bundle, D: direct coupling), type of detector, detector temperature, power consumption.

Institute	Instrument	Nr	DS Cap.	FOV (°)	Spectral Range	Resol. (nm)	Light Coupl.	Det. type	T (°C)	Power (W)
AIOFM	2D-MAXDOAS	2.01	N	0.2	290-380	0.35	F (10 m)	CCD	-30	300 (220 V)
AUTH	PHAETHON	2.03	Y	1	297-452	0.34- 0.42	F (10 m)	CCD	5	50 (100- 240V)
BIRA-IASB	2D-MAXDOAS	2.04	Y	<1	300-400 400-560	0.6 1.0	F (10m)	CCD CCD	-50 -50	<1000 (220 V)
BOKU	2D-MAXDOAS	2.06	N	1	Approx. 406-579	0.85	F (25 m)	CCD	-30	500- 1000 (220 V)
CU-Boulder	2D-MAXDOAS	2.11	Y	0.7	327-470 432-678	0.7 1.2	F (25 m)	CCD CCD	-30 -30	380- 785 (220 V)
DLR+USTC	1D-EnviMeS (X2)	2.13- 2.14	N	0.4	300-460 450-600	0.6 0.6	F (10 m)	CCD CCD	20 20	<120 (220 V)
~~**DWD**~~	~~MAXDOAS~~	~~2.15~~	~~N~~	~~<1~~	~~307-436~~	~~0.6/0.7~~	~~F~~	~~CCD~~	~~-7~~	~~450 (220 V)~~
INTA	RASAS-III MAXDOAS	2.17	N	1	325-445 or 400- 550	0.55	F (8 m)	CCD	~17 if room t° is 22- 23	2350- 3450 (220 V)
IUP-Bremen	2D-MAXDOAS	2.18	N	1	305-390 406-579	0.5 0.85	F (22m)	CCD CCD	-35 -30	500- 1000 (220 V)
	Imaging-DOAS	2.37	N	50 (vert.) 1.2 (hori.)	To be decided	~0.5	F (15 m)	CCD	-30	350- 700 (220 V)
IUP-Heidelberg	2D-EnviMeS	2.19	Y	<0.5	296-459 439-583	0.6 0.5	F (10 m)	CCD CCD	0-40 0-40	20-120 (220 V)
KNMI	PANDORA*	2.23	Y	1.5-2	290-530	0.6	F (10 m)	CCD	+20	220 (220 V)
LuftBlick	PANDORA-2S (x2)	2.26- 2.27	Y	1.5 (sky) 2.8 (sun)	280-540 400-900 400-900 400-460	0.6 1.1 1.1 0.6	F (10m)	CCD CCD CCD CCD	15 -20	220 (220 V)
NASA	PANDORA (x2)	2.31- 2.32	Y	1.5	285-530	0.6	F (10 m)	CCD	+20	220 (220 V)
U. Munich	2D-EnviMeS	2.35	N	0.4	300-460 450-600	0.6 0.6	F (10m)	CCD CCD	20 20	<120 (220 V)
U. Toronto	PEARL-GBS	2.36	Y	0.62	300-500	0.4-0.5	F (6 m)	CCD	-70	2200 (120V)

~~VTT-FMI~~	~~Imaging spectrometer~~	~~2.38~~	~~Y~~	~~7~~	~~UV, Vis, Nir~~	~~TBD~~	~~D~~	~~CCD, CMOS, InGaAs~~	~~n/a~~	~~100 W 230 V~~

***Permanently operated by KNMI at the wind profiler cabin.**

Table 2: 1D-MAXDOAS spectrometers participating to the semi-blind intercomparison exercise.

Institute	Instrument	Nr	DS Cap.	FOV (°)	Spectral Range	Resol. (nm)	Light Coupl.	Det. type	T (°C)	Power (W)
AMOIAP/IAPh	2-port DOAS	2.02	N	0.3	420-490	0.5	F	CCD	-40	1000
BLS	Catadioptric telescope-MARSB	2.05	N	0.2-1	300-500 (80 nm width)	0.4	D	CCD	-40	300 (220 V)
CAMS	Mini-DOAS Hoffmann UV+Vis	2.07	N	0.8	292-447	0.6-0.8	D	LinArr		200 (220 V)
		2.08	N	0.8	399-712	0.6-0.8	D	LinArr		200 (220 V)
CHIBA-U	SKYNET	2.09	N	<1	310-515	0.4	F (10 m)	CCD	40	<500 (220 V)
CSIC	MAXDOAS	2.10	N	1	300-500	0.5	F (10 m)	CCD	20-25	550 (220 V)
CU-Boulder	1D-MAXDOAS	2.12	N	0.7	300-466	0.77	F (25 m)	CCD	-30	400-800 (220 V)
			N		379-493	0.5		CCD	0	
IISER	Mini-DOAS Hoffmann	2.16	N	0.7	317-466	1.0	D	CCD	<0 (if room t is ~20)	<100 (220V)
KNMI	Mini-DOAS Hoffmann* UV+Vis	2.21	N	0.45	290-433	0.6	n/a	LinArr		5 (220 V)
		2.22	N	0.4	400-600	0.5	n/a	LinArr		5 (220 V)
MPIC	Tube-MAXDOAS	2.28	N	1	316-474	0.6	F (5m)	CCD	10	100 (220 V)
NIWA	EnviMeS	2.29	N	<0.5	305-457	0.7	F (10m)	CCD	20	120 (220 V)
					410-550	0.7		CCD	20	
	ACTON275 MAXDOAS	2.30	N	0.5	290-363	0.6	F (12m)	CCD	-20	100 (220 V)
					400-460	0.6		CCD	-20	
NUST	Mini-DOAS	2.33	N	1.2	320-465	0.7	D	CCD		400 (220V)
~~**TU-Delft**~~	~~Mini-DOAS Hoffmann~~	~~2.34~~	~~N~~	~~0.4~~	~~300-515~~	~~0.67~~	~~n/a~~	~~LinArr~~		~~5 (220 V)~~

***Permanently operated by KNMI at the tower.**

Table 3: ZS-DOAS spectrometers participating to the semi-blind intercomparison exercise.

Institute	Instrument	Nr	DS Cap.	FOV (°)	Spectral Range	Resol. (nm)	Light Coupl.	Det. type	T (°C)	Power (W)
LATMOS	SAOZ	2.24	N	10	270-640	1.3	D	LinArr	n/a	500 (220 V)
	Mini-SAOZ	2.25	N	8	270-820	0.7	F (10m)	CCD	18-20 AirCo room	300 (220 V)

4 Intercomparison setup

Because the tropospheric species under focus for this intercomparison (in particular NO_2, but also aerosols and HCHO) can feature fast changing concentrations in both space and time, it is essential to setup the measurements systems in such a way that they all sample the same air masses at the same time. For this reason, all the instruments participating in the intercomparison will be installed on the CESAR remote-sensing platform (see Figure 2) making use of containers which will be organised in the most compact way. Considering the large number of systems that need to be accommodated, we plan to deploy two rows of containers. The first row will be similar to the one deployed during CINDI-1 (see Figure 2) and will be used to host the 1D-MAXDOAS and the zenith-sky systems. The second row will be deployed on the other side of the platform and will consist of stacked double-containers high enough to exceed the height of the grove of trees visible on the left side of Figure 2. The 2D-MAXDOAS systems will be installed on the top of these containers allowing for more flexibility on the azimuth scan settings and avoiding any risk of interference with the 1D systems.

All the 1D-MAXDOAS instruments will use the same azimuth viewing direction of 287° (i.e. WNW, N=0), which was already used during CINDI-1. This direction will also be one of the azimuth directions used by the 2D MAXDOAS systems. More details on the synchronisation of the instruments are given below in section 7).

Figure 2: Aerial picture of the CESAR remote-sensing site, as configured during the CINDI-1 campaign in 2009. DOAS and MAXDOAS systems were installed on the roof or in front of the 5 white containers.

5 Intercomparison Campaign Referee

The formal intercomparison exercise will be coordinated by Karin Kreher (BK Scientific) assisted by Ermioni Dimitropoulou (BIRA-IASB/AUTH). Karin Kreher has more than 20 years of research experience working with UV-Visible remote-sensing of the atmospheric composition. She has been acting as co-chair of the NDACC UV-Vis working group for about 10 years and was involved as participant in all the recent NDACC Intercomparison exercises. In particular she was part of the CINDI-1 campaign in 2009. Therefore she has the adequate experience and knowledge to coordinate the CINDI-2 semi-blind intercomparison.

Her role as referee will be to interface with the different participating groups, to organise the daily data collection, to manage and chair the daily intercomparison campaign workshops with the support of her assistant for assembling and plotting the measurement data, to provide daily summaries of the campaign progress and, after the campaign, to coordinate the writing of a peer-review publication on the intercomparison results.

6 Instrumental characterisation

Before starting the formal intercomparison campaign, all the participating teams will be asked to perform specific tests and to provide complete information on the specifications of their instrument(s). Most of the required calibrations and instrument tests will be possible on site during the installation and warm-up phases. This information will be collected by the campaign referee and used in support of the interpretation of the measurement results. The calibration procedures described below are, for most them, based on the 'DOAS Best Practice for Instrument Characterization and Operation' document edited by A. Richter (IUP-Bremen) as part of the EC FP7 QA4ECV project.

6.1 Time reference

All computer clocks will be synchronised on the universal UTC reference time. To this aim, a common time server will be used by all groups. Guidelines on this will be provided by the referee and the local organisation.

6.2 Solar angles calculation

For consistency checks, all groups will be asked to provide the campaign referee with a set of solar zenith and azimuth angles calculated using the software routines implemented in their acquisition or data processing code.

6.3 Spectral stray-light test

The best way to characterize spectral stray-light in a grating spectrometer is to use a tunable laser or other monochromatic light source (e.g. double monochromator fed by white light source) to measure spectral response functions on a series of wavelengths. This approach can of course only be applied in the lab. Its main limitation is that it only accounts for stray-light being generated in the spectral interval covered by the instrument. The possible contribution from out-of-band stray-light has to be estimated in a different way.

For on-site characterization, we propose to use a combination of band-pass filters having different cut-off wavelengths (e.g. every 50 nm). This approach has been successfully applied in previous intercomparison campaigns and provides a qualitative estimate of the stray-light level in working conditions (see e.g. Vandaele et al., 2005).

6.4 Polarisation sensitivity test

Most of the MAXDOAS instruments involved in the campaign are using 5-20m long quartz optical fibers, which are strongly depolarizing. As result, residual polarisation should not be an issue for these instruments.

Since the campaign involves a large number of instruments of varying designs, we propose to systematically test the polarisation sensitivity of each of them on-site by using a halogen lamp and placing a polariser in front of the telescope or fiber. Spectra will be measured for different polarizer orientations allowing to identify possible spectral features in the presence of residual polarization.

6.5 Instrumental slit function characterization

Instrumental slit functions (also known as Instrumental Spectral Response Function – ISRF) are generally characterized in the lab using a spectral line lamp (e.g. HgCd). Temporal changes of the slit function should be monitored during the campaign when the instrument is stabilized by taking regular measurements with such lamp placed in front of the telescope or fibers. For a good representation of the slit function, a full and homogenous illumination of the instrument needs to be ensured (e.g. by using a diffusor).

To minimize spectrometer non-linearity effects on the ISRF spectra, the emission peaks which shall be used later for the analysis should be recorded at a similar saturation as the MAX-DOAS measurement spectra itself. This is especially important for weaker emissions like at 334nm.

6.6 Signal-to-noise ratio (SNR) determination

We propose to measure the signal-to-noise ratio of the different systems following the simple approach adopted for the QA4ECV intercomparison. The average S/N ratio in a given fitting interval can be estimated from the inverse of the DOAS fit RMS, for a zenith spectrum analyzed with respect to another zenith spectrum close in time on a clear-sky day. We recommend to select zenith spectra close in time to the noon reference. A common accumulation time should be used to allow for S/N comparison on a fair ground. We propose to adopt a common accumulation time of 1 min.

6.7 Detector linearity test

Detector linearity should be determined in the lab by taking measurements of a broadband light source using a range of exposure times resulting in coverage of the full dynamic range. After dark signal correction, ratios of measurements taken at different exposure time should equal the ratio of the exposure times. Deviations from this value indicate non-linearities. As light sources might be changing in intensity over time, care must be taken to keep the time between measurements short. In principle, a different linearity curve can be derived for each detector pixel. However, in many cases it is sufficient to determine a mean dependency for all pixels.

For the campaign, we propose to test the linearity of the different systems in a simple way by performing successive measurements with different integration times using a stabilized halogen lamp

as light source. The option of using sky measurements on a clear-sky day under stable illumination conditions will be also investigated.

6.8 Dark signal and offset

Dark signal measurements can be performed automatically either by using a shutter if the instrument is such equipped or alternatively at night and pointing the instrument to a dark surface. In the second case, caution should be taken regarding possible contamination by residual light (e.g. street light reflected by low clouds). Each group will provide estimates of the dark signal level at prescribed integration times.

6.9 Calibration of elevation viewing angle

The accuracy of the elevation viewing angle is one amongst the most critical parameters for MAXDOAS measurements. Experience from past campaigns in particular CINDI-1 and the more recent MADCAT campaign in Mainz (Wagner et al., 2015) has shown that pointing inaccuracies are often the source of systematic biases between instruments. Therefore this parameter will receive particular attention.

We plan to use one or several among the 4 different approaches described below to verify the accuracy and stability in time of the zero-elevation angle reference of each instrument.

Approach 1: laser level and fluorescent lamp

This approach has been developed by the University of Heidelberg (U. Friess) during the MADCAT campaign.

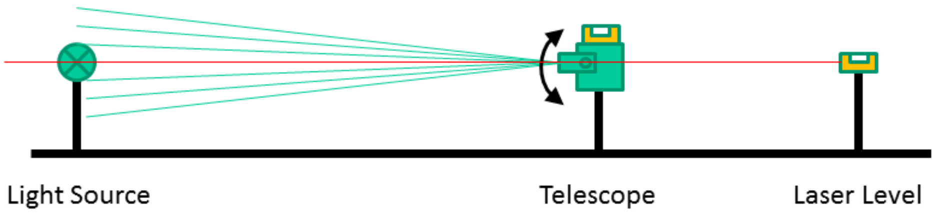


Figure 3: Sketch describing Approach 1 for elevation angle calibration (© U. Friess/IUP-Heidelberg)

It consists in four steps (see Figure 3):

1. Make sure the telescope is at the same height as the light source using a laser level.
2. Level out the telescope housing.
3. Measure intensity as a function of elevation angle.
4. Determine elevation angle offset (= angle between motor end-switch and horizon) by fitting a Gaussian to the observed intensity distribution (see).

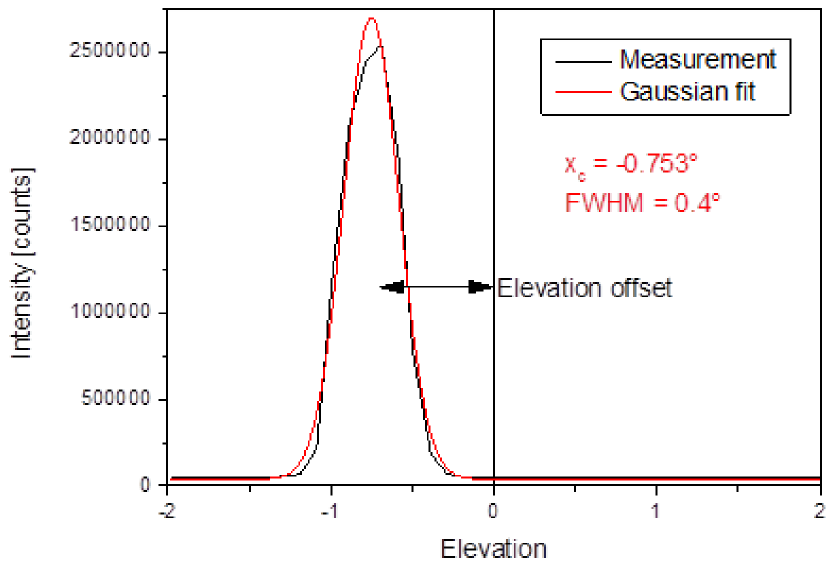


Figure 4: Illustration of the determination of the elevation angle offset using Approach 1.

Approach 2: White stripe on black target

The main drawback of Approach 1 is that such measurements must be performed at night. A variant of this approach which can be applied during daytime is to replace the light source by a black target with a white stripe as proposed by MPIC-Mainz (T. Wagner) also during MADCAT (see Figure 5).

Figure 5: Black target with a white stripe prepared for elevation calibration during the CINDI-2 campaign (© M. Gu and T. Wagner/MPIC-Mainz).

Approach 3: common light source at long distance

An artificial light source (array of LEDs) will be installed at some distance from the remote-sensing site in the pointing direction of the 1D-MAXDOAS systems. This light source will be scanned by all the instruments once a day at night, providing a way to verify the accuracy of the MAXDOAS scanner alignment in both azimuth and elevation axes.

Approach 4: camera image correlation

Jonas Kuhn (University of Heidelberg) will set up a system to measure the MAXDOAS scanner FOV using camera images to invert the actual FOV of the instrument according to an approach introduced by Holger Sihler (MPIC), currently in preparation for submission to AMTD. Proof-of-concepts experiments using digital reflex camera have been recently realised by Johannes Lampel (see https://vimeo.com/162520417).

6.10 Calibration of azimuth viewing angle

The accuracy of the azimuth viewing angle is by far less critical than the elevation angle, however it might be useful to optimise this parameter as well for the purpose of optimising the colocation of the sampled air masses. The approach 2 used for elevation angle calibration, which makes use of a light source installed at a reference azimuth and elevation point can be used to this purpose.

6.11 Field of view characterization

The field of view of each MAXDOAS instrument should be characterised at least along the elevation axis. We encourage the participants to perform such calibrations before the campaign. Additional estimates of the instrument field of view will be possible on-site based on the results of the elevation angle measurements.

7 Data acquisition protocol

It has been recognised in past intercomparison campaigns (e.g. CINDI-1 or MADCAT) that the achievable level of agreement between MAXDOAS sensors is often limited by imperfect co-location and a lack of synchronisation. This problem is especially critical for tropospheric NO_2 comparisons, because of the large variability of this pollutant as very small scales. For this reason, it was been decided to co-locate all the DOAS instruments on the same observation platform (the Cabauw RSS) and additionally to impose a strict protocol on the timing of the spectral acquisition.

The settings recommended for MAXDOAS and zenith-sky DOAS data acquisition are described below. The baseline for all MAXDOAS instruments is to point towards a fixed azimuth direction (287°, i.e. west-north-westerly) throughout the day. In addition, 2D-MAXDOAS instruments will perform azimuthal scans at regular time interval. The convention for the azimuth angle is 0° for North, 90° for East, etc. The scheme described below is designed in order to ensure the maximum of synchronicity between the same type of instruments (e.g. azimuthal scans by 2D-MAXDOAS) but also between the different types of instruments (1D-, 2D-MAXDOAS and zenith-DOAS).

We distinguish between twilight (morning and evening) and daytime conditions, for which separate data acquisition protocols are prescribed. According to the geometry of the solar position during the campaign (see Figure 6), the daytime period is set between 6:00 UTC and 17:00 UTC.

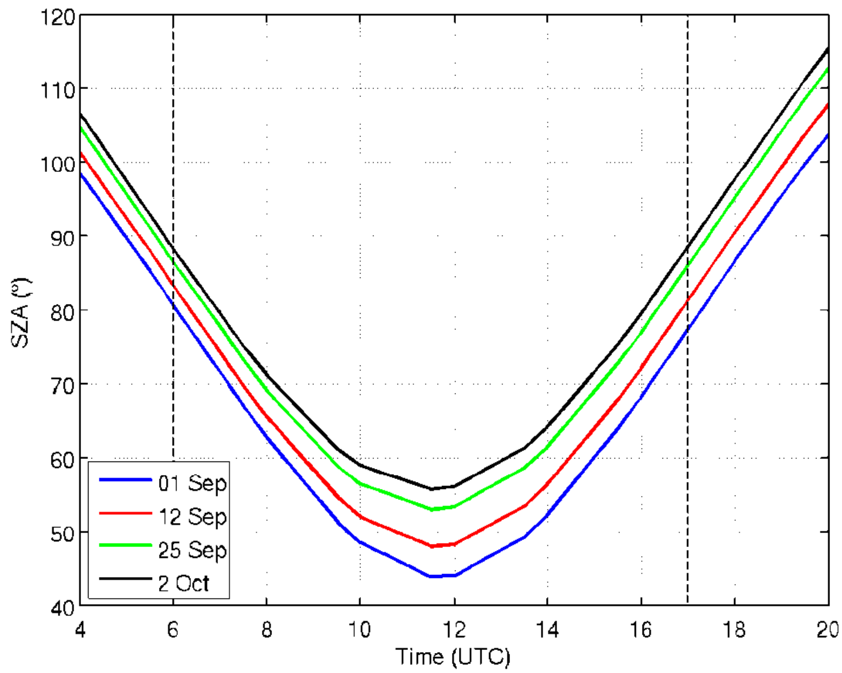


Figure 6: SZA diurnal variation at Cabauw during the CINDI-2 period. The black dashed lines denote the limits between the twilight and daytime observations.

7.1 Zenith-sky twilight observations

This protocol holds for all instruments willing to contribute to the zenith-sky NDACC-type intercomparison of stratospheric measurements at twilight.

For measurements at sunrise, the following acquisition scheme shall be followed:

- 39 measurements with a duration of 180s (integration time: 170s; overhead: 10s) starting at 04:00:00 UTC and ending at 05:57:00 UTC
- This sequence is then followed by a 180s (3 min) interval allowing for a transition to the MAXDOAS mode of which the first scans starts 06:00:00 UTC (see below).

For measurements at sunset, 40 acquisitions shall be recorded with a duration of 180s each (integration time: 170s; overhead: 10s) starting at 16:45:00 UTC and ending at 18:45:00 UTC.

7.2 MAXDOAS and zenith-sky observations during the day

For daytime observations the following baseline shall be followed:

- 4 sequences of 15 minutes starting at 06:00:00 UTC
- Duration of each single acquisition: 1 minute total integration
- For 1D-MAXDOAS systems (pointing azimuth direction: 287°):
  - 1 scan per 15’ sequence (→ 4 scans/hour) at the following elevation angles: 1,2,3,4,5,6,8,15,30,90°

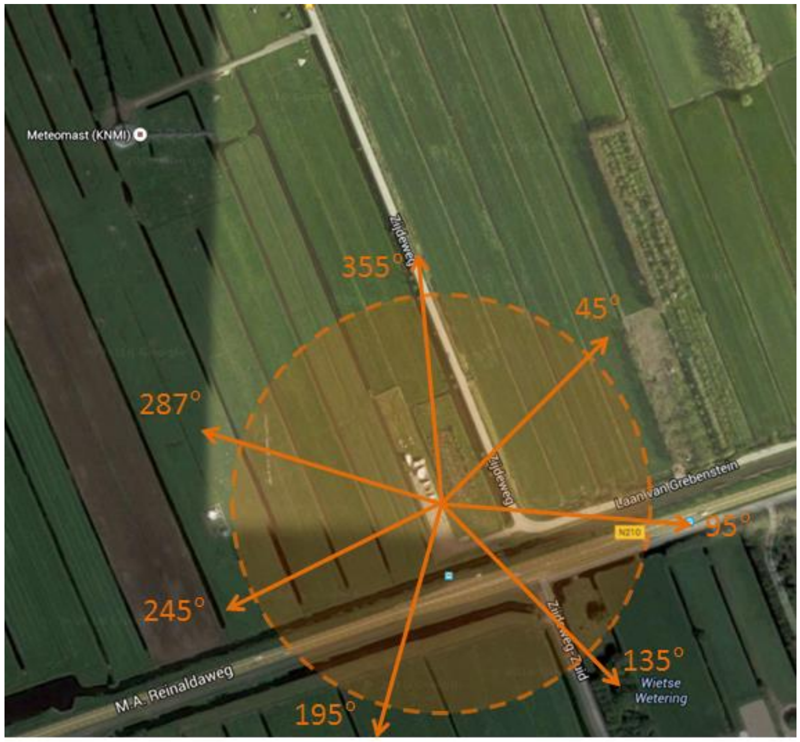


Figure 7: Azimuthal directions for the 2D-MAXDOAS instruments (North is 0°).

- For 2D-MAXDOAS systems:
  - 1 full azimuthal scan per hour at the following azimuth angles (see Figure 7): 355,45,95,135,195,245,287°
  - For each azimuth, 4 elevation angles (1,3,5,15°) will be scanned except for the reference azimuth of 287° where the same elevations as prescribed for the 1D-MAXDOAS systems will be used.
  - 1 zenith reference spectrum shall recorded per 15' sequence
  - For instruments having the appropriate technical capabilities, direct-sun measurements or 1 almucantar scan shall performed between the 10^{th} and 15^{th} minutes of the sequence
- For Zenith-DOAS systems:
  - Zenith measurements of one minute total integration shall be performed during the whole day from 06:00.00 UTC to 16:44:00 UTC

These data acquisition schemes are described in tabular form in Table 4 and Table 5. The corresponding variation of the viewing elevation and relative azimuth angles around noon are represented for the 2D-MAXDOAS and 1D-MAXDOAS systems in Figure 8 and Figure 9, respectively.

Table 4: **Data acquisition scheme for daytime conditions at the following UTC times (hh in the Table): 06, 07, 08, 09, 10, 12, 13, 14, 15, 16h.**

TIME (UTC)	2D-MAXDOAS		1D-MAXDOAS	Zenith
	Azimuth(°) 0° : north ; 90° : east 180° : south ; 270° : west	Elevation (°)	Pointing direction : 287°	
hh:00:00	287	1	1	x
	287	2	2	x
	287	3	3	x
	287	4	4	x
	287	5	5	x
hh:05:00	287	6	6	x
	287	8	8	x
	287	15	15	x
	287	30	30	x
	287	90	90	x
hh:10:00	Direct-sun acquisition, or continued zenith-sky		90	x
			90	x
			90	x
			90	x
			90	x
hh:15:00	355	1	1	x
	355	3	2	x
	355	5	3	x
	355	15	4	x
	move	move	5	x

hh:20:00	45	1	6	x
	45	3	8	x
	45	5	15	x
	45	15	30	x
	45	90	90	x
hh:25:00	Almucantar scan: 15 measurements with a 10s integration time + 5s overhead at solar elevation for the following relative azimuth angles*: -15, -10, -6, -5, 5, 6, 10, 15, 30, 50, 70, 90, 120, 150, and 180°. Or continued zenith-sky.		90	x
			90	x
			90	x
			90	x
			90	x
hh:30:00	95	1	1	x
	95	3	2	x
	95	5	3	x
	95	15	4	x
	move	move	5	x
hh:35:00	135	1	6	x
	135	3	8	x
	135	5	15	x
	135	15	30	x
	135	90	90	x
hh:40:00	Direct-sun acquisition, or continued zenith-sky		90	x
			90	x
			90	x
			90	x
			90	x

hh:45:00	195	1	1	x
	195	3	2	x
	195	5	3	x
	195	15	4	x
	move	move	5	x
hh:50:00	245	1	6	x
	245	3	8	x
	245	5	15	x
	245	15	30	x
	245	90	90	x
hh:55:00	Almucantar scan: 15 measurements with a 10s integration time + 5s overhead at solar elevation for the following relative azimuth angles*: -15, -10, -6, -5, 5, 6, 10, 15, 30, 50, 70, 90, 120, 150, and 180°. Or continued zenith-sky.		90	x
			90	x
			90	x
			90	x
			90	x

***For instruments which need an overhead time longer than 5s, the number of relative azimuth angles (RAA) should be reduced in such a way that the total time of 225s for this Almucantar sequence is kept. The measurements at the selected RAA should also be synchronized with those from the faster instruments. RAA values are given with respect the current position of the sun and not its position at the start of the Almucantar sequence. The sign convention for the relative azimuth angle is + for the hemisphere which is clockwise with respect to the instrument-sun direction and – for the other hemisphere.**

Table 5: Data acquisition scheme for noon conditions between 11:00:00 UTC and 11:59:00 UTC. It includes a zenith-only acquisition sequence between 11:30:00 and 11:41:00 UTC and a horizon scan between 11:41:00 and 11:44:00 UTC.

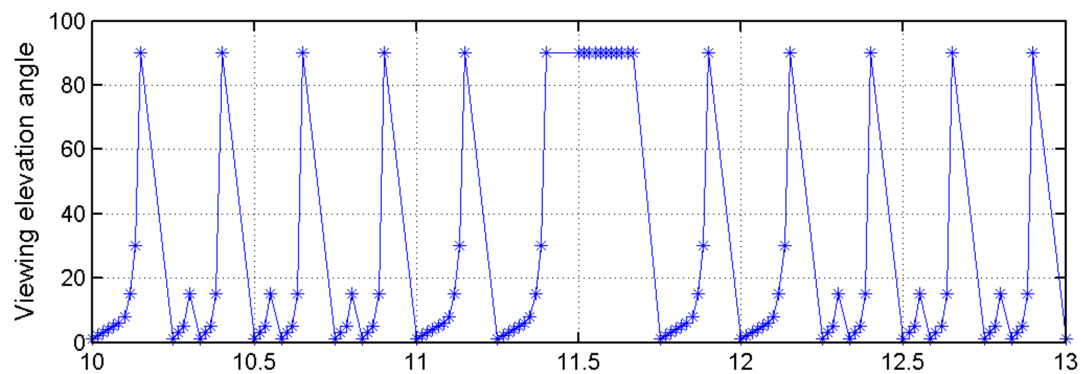
TIME (UTC)	2D-MAXDOAS		1D-MAXDOAS	Zenith
	Azimuth(°) 0° : north ; 90° : east 180° : south ; 270° : west	Elevation (°)	Pointing direction : 287°	
hh:00:00	287	1	1	x
	287	2	2	x

	287	3	3	x
	287	4	4	x
	287	5	5	x
hh:05:00	287	6	6	x
	287	8	8	x
	287	15	15	x
	287	30	30	x
	287	90	90	x
hh:10:00	Direct-sun acquisition, or continued zenith-sky		90	x
			90	x
			90	x
			90	x
			90	x
hh:15:00	287	1	1	x
	287	2	2	x
	287	3	3	x
	287	4	4	x
	287	5	5	x
hh:20:00	287	6	6	x
	287	8	8	x
	287	15	15	x
	287	30	30	x
	287	90	90	x
hh:25:00	Almucantar scan: 15 measurements with a 10s integration time + 5s overhead at solar elevation		90	x
			90	x

	for the following relative azimuth angles*: -15, -10, -6, -5, 5, 6, 10, 15, 30, 50, 70, 90, 120, 150, and 180°. Or continued zenith-sky.		90	x
			90	x
			90	x
hh:30:00	287	90	90	x
	287	90	90	x
	287	90	90	x
	287	90	90	x
	287	90	90	x
hh:35:00	287	90	90	x
	287	90	90	x
	287	90	90	x
	287	90	90	x
	287	90	90	x
hh:40:00	287	Horizon scan between -5° and +5° above the horizon with a step of 0.2° between -2 and +2° and a step of 1° outside this range. 5s integration time + 5s overhead per elevation		x
	287			x
	287			x
	287			x
	287			x
hh:45:00	287	1	1	x
	287	2	2	x
	287	3	3	x
	287	4	4	x
	287	5	5	x
hh:50:00	287	6	6	x
	287	8	8	x

	287	15	15	x
	287	30	30	x
	287	90	90	x
hh:55:00	Direct-sun acquisition, or continued zenith-sky		90	x
			90	x
			90	x
			90	x
			90	x

***For instruments which need an overhead time longer than 5s, the number of relative azimuth angles (RAA) should be reduced in such a way that the total time of 225s for this Almucantar sequence is kept. The measurements at the selected RAA should also be synchronized with those from the faster instruments. RAA values are given with respect the current position of the sun and not its position at the start of the Almucantar sequence. The sign convention for the relative azimuth angle is + for the hemisphere which is clockwise with respect to the instrument-sun direction and – for the other hemisphere.**



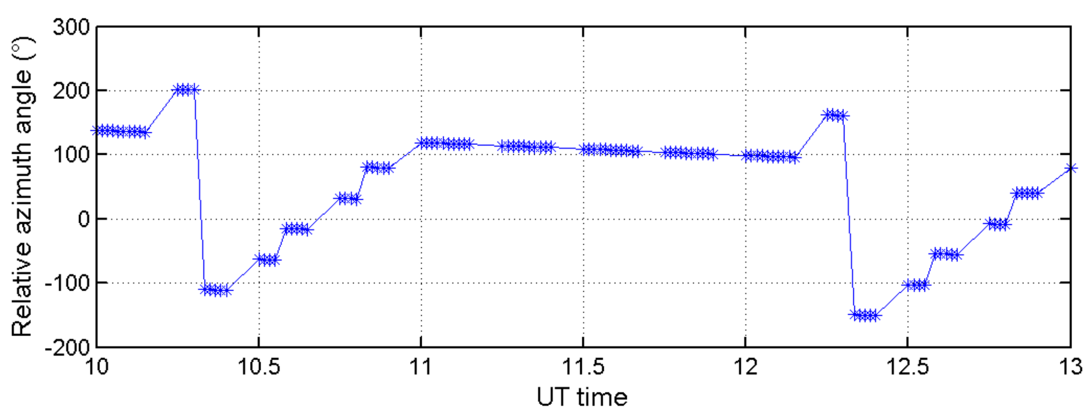


Figure 8: Variation of the viewing elevation and relative azimuth angles around noon for 2D-MAXDOAS systems (calculated for the conditions of 12/09/2016, in Cabauw).

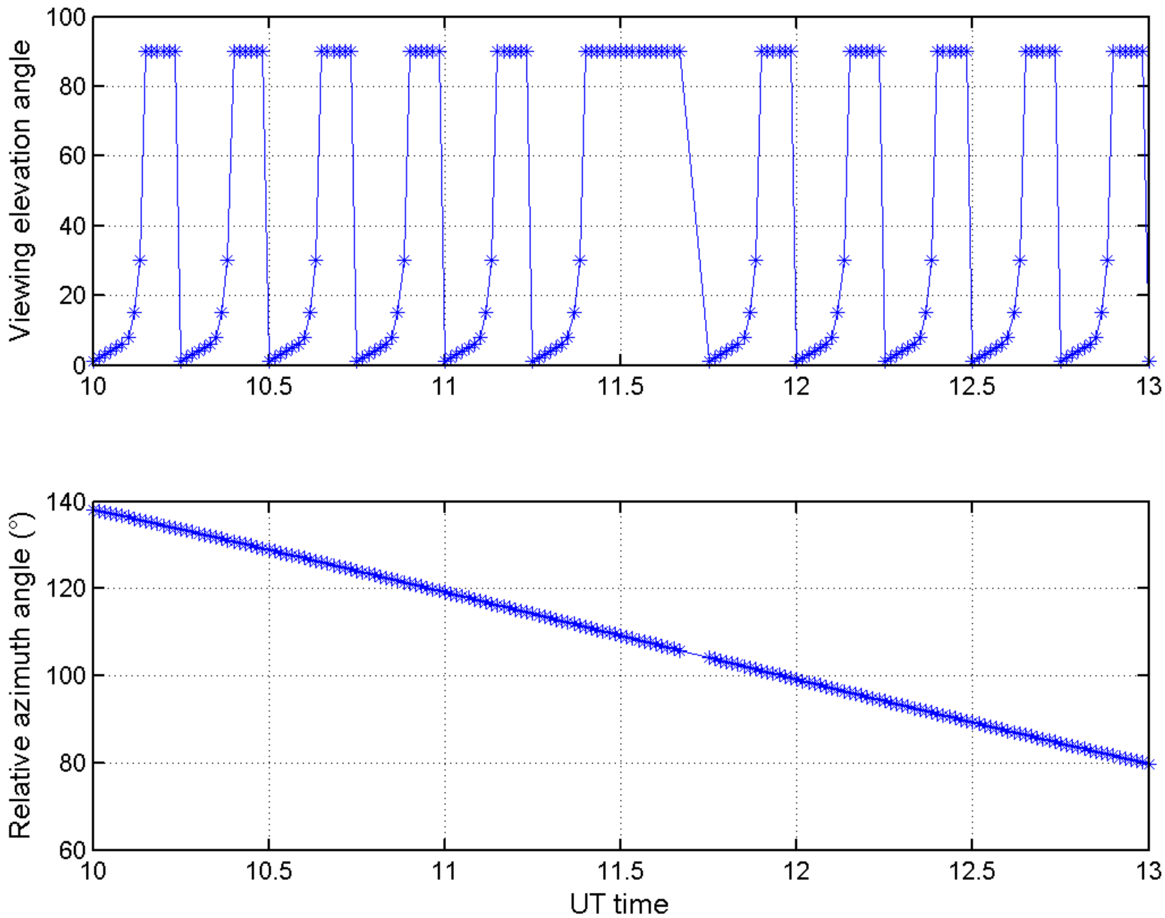


Figure 9: Variation of the viewing elevation and relative azimuth angles around noon for 1D-MAXDOAS systems (calculated for the conditions of 12/09/2016, in Cabauw).

8 Target species and retrieval settings

The semi-blind intercomparison exercise will focus on a limited number of key data products of direct relevance for satellite validation and NDACC operation continuity. These products are list in Table 6. Note that it is not mandatory to provide results for all data products. Depending on the specific characteristics of their instrumentation, participants are free to contribute only a subset of the data products. This will be communicated to the campaign referee ahead of the comparison exercise.

Table 6: Data products included in the semi-blind intercomparison exercise.

Data product	Typical wavelengths
NO_2 (VIS range)	425 – 490 nm
NO_2 (UV range)	338 – 370 nm
O_4 (VIS range)	425 – 490 nm
O_4 (UV range)	338 – 370 nm

HCHO	336.5 – 359 nm
O_3 (Chappuis bands)	450 – 520 nm
O_3 (Huggins bands)	320 – 340 nm
Relative intensity	340, 380, 440, 500 nm
Colour Index	To be defined

For each data product, a set of retrieval settings and parameters is prescribed. The use of these settings will be mandatory for participation in the semi-blind exercise. A preliminary version of the CINDI-2 prescribed settings is given in the Tables below. These settings are based on the experience and results from the recent MADCAT (http://joseba.mpch-mainz.mpg.de/mad_analysis.htm) and QA4ECV intercomparison exercises. The corresponding spectral data (absorption cross sections and solar spectra) will be made available for the campaign on the CINDI-2 ftp server. A final baseline will be defined during the warm-up period in the first week of the campaign, and frozen upon consensus for the semi-blind intercomparison period.

Note that the reported intensities should be calculated without normalisation with respect to the noon spectrum, i.e. using the formula: *I=total_counts/total_integration_time* (or equivalent according to individual acquisition schemes). They should be provided in the trace gas data files, if possible at similar wavelengths than AERONET ones: 340, 380, 440, 500, 675, 870, and 1020 nm.

Colour indices CI should be defined as the ratio of the intensity of the lowest over the highest wavelength:

$I_{\lambda,low}/I_{\lambda,high}$.

Table 7: DOAS settings for NO_2 and O_4 (VIS range)

Wavelength range	425-490 nm
Fraunhofer reference spectra	Noon zenith spectra averaged between 11:30:00 and 11:40:00 UT
Cross-sections:	
NO_2 (298 K)	Vandaele et al. (1998) with I_0 correction (SCD of 10^{17} molecules/cm^2) File: no2_298K_vanDaele.xs
NO_2 (220 K)	Pre-orthogonalized Vandaele et al. (1998) with I_0 correction (SCD of 10^{17} molecules/cm^2) File: no2a_220p298K_vanDaele_425-490nm.xs
O_3 (223 K)	Serdyuchenko et al. (2014) with I_0 correction (SCD of 10^{20} molecules/cm^2) File: o3_223K_SDY_air.xs
O_4 (293 K)	Thalman and Volkamer (2013) File: o4_thalman_volkamer_293K_inAir.xs
H_2O	HITEMP (Rothman et al., 2010) File: H2O_HITEMP_2010_390-700_296K_1013mbar_air.xs
Ring	RING_QDOAS_SAO2010 File: Ring_QDOAScalc_HighResSAO2010_Norm.xs
Polynomial degree	Order 5 (6 coefficients)
Intensity off-set	Constant

Table 8: DOAS settings for NO_2 and O_4 (alternative VIS range)

Wavelength range	411-445 nm
Fraunhofer reference spectra	Noon zenith spectra averaged between 11:30:00 and 11:40:00 UT
Cross-sections:	
NO_2 (298 K)	Vandaele et al. (1998) with I_0 correction (SCD of 10^{17} molecules/cm^2)

	File: no2_298K_vanDaele.xs
NO_2 (220 K)	Pre-orthogonalized Vandaele et al. (1998) with I_0 correction (SCD of 10^{17} molecules/cm^2) File: no2a_220p298K_vanDaele_425-490nm
O_3 (223 K)	Serdyuchenko et al. (2014) with I_0 correction (SCD of 10^{20} molecules/cm^2) File: o3_223K_SDY_air.xs
O_4 (293 K)	Thalman and Volkamer (2013) File: o4_thalman_volkamer_293K_inAir.xs
H_2O	HITEMP (Rothman et al., 2010) File: H2O_HITEMP_2010_390-700_296K_1013mbar_air.xs
Ring	RING_QDOAS_SAO2010 File: Ring_QDOAScalc_HighResSAO2010_Norm.xs
Polynomial degree	Order 4 (5 coefficients)
Intensity off-set	Constant

Table 9: DOAS settings for NO_2 and O_4 (UV range)

Wavelength range	338-370 nm
Fraunhofer reference spectra	Noon zenith spectra averaged between 11:30:00 and 11:40:00
Cross-sections:	
NO_2 (298 K)	Vandaele et al. (1998) with I_0 correction (SCD of 10^{17} molecules/cm^2) File: no2_298K_vanDaele.xs
NO_2 (220 K)	Pre-orthogonalized Vandaele et al. (1998) with I_0 correction (SCD of 10^{17} molecules/cm^2) File: no2a_220p298K_vanDaele_338-370nm.xs
O_3 (223 K)	Serdyuchenko et al. (2014) with I_0 correction (SCD of 10^{20} molecules/cm^2) File: o3_223K_SDY_air.xs
O_3 (243 K)	Pre-orthogonalized Serdyuchenko et al. (2014) with I_0 correction (SCD of 10^{20} molecules/cm^2) File: o3a_243p223K_SDY_338-370nm.xs
O_4 (293 K)	Thalman and Volkamer (2013) File: o4_thalman_volkamer_293K_inAir.xs
HCHO (297 K)	Meller and Moortgat (2000) File: hcho_297K_Meller.xs
BrO (223 K)	Fleischmann et al. (2004) File: bro_223K_Fleischmann.xs
Ring	RING_QDOAS_SAO2010 File: Ring_QDOAScalc_HighResSAO2010_Norm.xs
Polynomial degree	Order 5 (6 coefficients)
Intensity off-set	Constant

Table 10: DOAS settings for HCHO

Wavelength range	336.5-359 nm
Fraunhofer reference spectra	Noon zenith spectra averaged between 11:30:00 and 11:40:00 UT
Cross-sections:	
HCHO (297 K)	Meller and Moortgat (2000) File: hcho_297K_Meller.xs
NO_2 (298 K)	Vandaele et al. (1998) with I_0 correction (SCD of 10^{17} molecules/cm^2) File: no2_298K_vanDaele.xs
O_3 (223 K)	Serdyuchenko et al. (2014) with I_0 correction (SCD of 10^{20} molecules/cm^2) File: o3_223K_SDY_air.xs
O_3 (243 K)	Pre-orthogonalized Serdyuchenko et al. (2014) with I_0 correction (SCD of 10^{20} molecules/cm^2) File: o3a_243p223K_SDY_324-359nm.xs
O_4 (293 K)	Thalman and Volkamer (2013)

	File: o4_thalman_volkamer_293K_inAir.xs
BrO (223 K)	Fleischmann et al. (2004) File: bro_223K_Fleischmann.xs
Ring	RING_QDOAS_SAO2010 File: Ring_QDOAScalc_HighResSAO2010_Norm.xs
Polynomial degree	Order 5 (6 coefficients)
Intensity off-set	Order 1

Table 11: DOAS settings ozone in the Chappuis band

Wavelength range	450-520 nm
Fraunhofer reference spectra	Noon zenith spectra averaged between 11:30:00 and 11:40:00 UT
Cross-sections:	
O_3 (223 K)	Serdyuchenko et al. (2014) with I_0 correction (SCD of 10^{20} molecules/cm^2) File: o3_223K_SDY_air.xs
O_3 (293 K)	Pre-orthogonalized Serdyuchenko et al. (2014) with I_0 correction (SCD of 10^{20} molecules/cm^2) File: o3a_293p223K_SDY_450-550nm.xs
NO_2 (298 K)	Vandaele et al. (1998) with I_0 correction (SCD of 10^{17} molecules/cm^2) File: no2_298K_vanDaele.xs
NO_2 (220 K)	Pre-orthogonalized Vandaele et al. (1998) with I_0 correction (SCD of 10^{17} molecules/cm^2) File: no2a_220p298K_vanDaele_450-550nm.xs
O_4 (296 K)	Thalman and Volkamer (2013) File: o4_thalman_volkamer_293K_inAir.xs
H_2O	HITEMP (Rothman et al., 2010) File: H2O_HITEMP_2010_390-700_296K_1013mbar_air.xs
Ring	RING_QDOAS_SAO2010 File: Ring_QDOAScalc_HighResSAO2010_Norm.xs
Polynomial degree	Order 5 (6 coefficients)
Intensity off-set	Order 1

Table 12: DOAS settings ozone in the Huggins band

Wavelength range	320-340 nm
Fraunhofer reference spectra	Noon zenith spectra averaged between 11:30:00 and 11:40:00 UT
Cross-sections:	
O_3 (223 K)	Serdyuchenko et al. (2014) with I_0 correction (SCD of 10^{20} molecules/cm^2) File: o3_223K_SDY_air.xs
O_3 (293 K)	Pre-orthogonalized Serdyuchenko et al. (2014) with I_0 correction (SCD of 10^{20} molecules/cm^2) File: o3a_293p223K_SDY_320-340nm.xs
O_3	Non-linear correction terms (Puķīte et al., 2010) Files: o3_SDY_Pukite1_320-340nm.xs and o3_SDY_Pukite2_320-340nm.xs
NO_2 (298 K)	Vandaele et al. (1998) with I_0 correction (SCD of 10^{17} molecules/cm^2) File: no2_298K_vanDaele.xs
HCHO (297 K)	Meller and Moortgat (2000) File: hcho_297K_Meller.xs
Ring	RING_QDOAS_SAO2010 File: Ring_QDOAScalc_HighResSAO2010_Norm.xs
Polynomial degree	Order 3 (4 coefficients)
Intensity off-set	Order 1

9 Data formatting

The output data file format used for the semi-blind intercomparison will be based on the ascii format adopted for the MADCAT campaign. Example files for all target species and wavelength domains can be found on the ftp server of the campaign. File headers include all necessary information on instrument and data provider, column content, and DOAS settings (see examples in Appendix A of the present document).

For the file naming, we propose the following convention (one file per day and per species/wavelength domain):

Institute_MAXDOAS_ InstrumentNr _species+wavelengthdomain_CINDI2_yyyymmdd_vx.asc

where *Institute* is the Institute acronym, *Nr* is the campaign number of the instrument (see Table 1), *species* is NO2/HCHO/O3, *wavelengthdomain* is the wavelength range (uv, vis, visSmall), *yyyymmdd* is the date, and *x* is the version of the file.

10 Daily workshops

For the whole duration of the semi-blind intercomparison, daily briefings will be organised in a dedicated cabin at around 13:30 local time (TBC). Skype and WebEx accesses for these meetings will be organized for participants who are not on-site. The aim of these daily workshops will be to present an overview on the status of the intercomparison and discuss various scientific, organisational or logistical points.

In order to be included in the daily overview plots, data shall be turned in for analysis on the dedicated FTP-site before 10:00 LT (i.e. 8:00 UTC). In case data cannot be submitted in time for a given day, this data set will not be part of the comparison for that day. Later the complete data sets will of course be intercompared.

Standard figures to be plotted every day will be defined ahead of the campaign.

11 Semi-blind Intercomparison Data Protocol

All participants are requested to read and sign the CINDI-2 Semi-blind Intercomparison Data Protocol annexed to this document (see Annex B). An electronic version of this signed protocol will be send to Francois Hendrick (BIRA-IASB) ahead of the campaign.

Appendix A: Output file format description

We provide 5 examples of output format for HCHO, NO_2 in the UV range, NO_2 in the visible range, NO_2 in the specific mini-DOAS interval and O_3 in the visible Chappuis bands.

The corresponding output files will use the following naming convention:

Institute_MAXDOAS_InstrumentNr_species+wavelengthdomain_CINDI2_yyyymmdd_vx.asc

Example: assuming data produced with the BIRA instrument, the following files will be generated:

- BIRA_MAXDOAS_5_HCHO_CINDI2_20160913_v1.asc (HCHO in the 336.5-359 nm range)
- BIRA_MAXDOAS_5_NO2uv_CINDI2_20160913_v1.asc (NO_2 in the 338-370 nm range)
- BIRA_MAXDOAS_5_NO2vis_CINDI2_20160913_v1.asc (NO_2 in the 425-490 nm range)
- BIRA_MAXDOAS_5_NO2visSmall_CINDI2_20160913_v1.asc (NO_2 in the 411-445 nm range)
- BIRA_MAXDOAS_5_O3vis_CINDI2_20160913_v1.asc (O_3 in the 450-520 nm range)
- BIRA_MAXDOAS_5_O3uv_CINDI2_20160913_v1.asc (O_3 in the 320-340 nm range)

```
* NofHeaderlines: 48
* NofColumns: 27 (if any info missing, put -999, even if it's the whole column)
* Instrument identifier: BIRA_MAXDOAS
* Retrieval code: QDOAS (v2.110, June 2015)
* Created by: Gaia Pinardi
* Version: HCHO_v1
*  X-Axis (Col  1) = Day of year (DOY) 2016   (please start with 0.0 for January 1st, 0:00 UTC)
* Y1-Axis (Col  2) = Time of day in hours (UTC)
* Y2-Axis (Col  3) = Total Integration Time(s)
* Y3-Axis (Col  4) = Solar Zenith Angle (°)
* Y4-Axis (Col  5) = Solar Azimuth Angle (°) North=0, East=90
* Y5-Axis (Col  6) = Elevation Angle (°)
* Y6-Axis (Col  7) = Viewing Angle (°) North=0, East=90
* Y7-Axis (Col  8) = HCHO_DSCD (1*10^15 molec/cm2)
* Y8-Axis (Col  9) = HCHO_DSCD_Error (1*10^15 molec/cm2)
* Y9-Axis (Col 10) = O4_DSCD (1*10^40 molec2/cm5)
* Y10-Axis (Col 11) = O4_DSCD_Error (1*10^40 molec2/cm5)
* Y11-Axis (Col 12) = NO2_DSCD_298  (1*10^15 molec/cm2)
* Y12-Axis (Col 13) = NO2_DSCD_298_Error  (1*10^15 molec/cm2)
* Y13-Axis (Col 14) = O3_DSCD_223 (1*10^20 molecules/cm2)
* Y14-Axis (Col 15) = O3_DSCD_223_Error (1*10^20 molecules/cm2)
* Y15-Axis (Col 16) = O3a_DSCD_243 (1*10^20 molecules/cm2)
* Y16-Axis (Col 17) = O3a_DSCD_243_Error (1*10^20 molecules/cm2)
* Y17-Axis (Col 18) = BrO_DSCD (1*10^15 molec/cm2)
* Y18-Axis (Col 19) = BrO_DSCD_Error (1*10^15 molec/cm2)
* Y19-Axis (Col 20) = Ring
* Y20-Axis (Col 21) = Ring_Error
* Y21-Axis (Col 22) = Fit RMS (in OD)
* Y22-Axis (Col 23) = Spectrum shift (nm, against FRS reference)
* Y23-Axis (Col 24) = Relative Intensity (counts/integration time @ 340nm)
* Y24-Axis (Col 25) = Colour index: (340 nm / 359 nm)
* Y25-Axis (Col 26) = intensity offset with normalisation by I, I is the mean intensity in the
spectral analysis windows, constant term
* Y26-Axis (Col 27) = intensity offset, linear term
* Fit settings: 1
* Fitting Window: 336.5-359 nm
* Polynomial: 5 (6 coefficients)
* Offset: 1st order
*  Calibration: Based on reference SAO solar spectra (Chance and Kurucz, 2010) -->
sao2010_solref_air.dat
* Wavelength adjustment: all spectra shifted and stretched against reference spectrum
* Reference: noon zenith spectra averaged between 11:30:00 and 11:40:00
*    HCHO  : Meller and Moortgat (2000), 297 K --> file: hcho_297K_Meller.xs
*     O4   : Thalman_volkamer, 293 K  --> file: o4_thalman_volkamer_293K_inAir.xs
*     NO2   : Vandaele et al. (1998), 298 K with I0 correction (1*10^17 molecules/cm2) --> file:
no2_298K_vanDaele.xs
*     O3   : Serdyuchenko  et al., (2014), 223 K with I0 correction (1*10^20 molecules/cm2) --> file:
o3_223K_SDY_air.xs
*     O3a    : Serdyuchenko  et al., (2014), 243 K with I0 correction (1*10^20 molecules/cm2) pre-
orthogonalized --> file: o3a_243p223K_SDY_324-359nm.xs
*    BrO   : Fleischmann et al. (2004), 223 K --> file: bro_223K_Fleischmann.xs
*     RING     : High Resolution calculation with QDOAS according to Chance and Spurr (1997) and
normalized as in Wagner et al. (2009) --> file: Ring_QDOAScalc_HighResSAO2010_Norm.xs
*DOY    UTC     Tint    SZA     SAA     Elev    Viewing_angle  HCHO_DSCD      HCHO_DSCD_error
        O4_DSCD O4_DSCD_error  NO2_DSCD_298    NO2_DSCD_298_Error    O3_DSCD_223    O3_DSCD_223_Error
        O3a_DSCD_243   O3a_DSCD_243_Error     BrO_DSCD       BrO_DSCD_Error Ring    Ring_Error     RMS
        Spectrum_shift Intens(340)    CI(340/359)    offset_cst     offset_lin
```

Frame 1: Header of the file for reporting HCHO analysed in the 336.5-359 nm wavelength range. Each line starts with a *. Lines not starting with * are due to a carriage return for presentation purpose here.

```
* NofHeaderlines: 50
* NofColumns: 28 (if any info missing, put -999, even if it's the whole column)
* Instrument identifier: BIRA_MAXDOAS
* Retrieval code: QDOAS (v2.110, June 2015)
* Created by: Gaia Pinardi
* Version: NO2uv_v1
*  X-Axis (Col  1) = Day of year (DOY) 2016   (please start with 0.0 for January 1st, 0:00 UTC)
* Y1-Axis (Col  2) = Time of day in hours (UTC)
* Y2-Axis (Col  3) = Total Integration Time(s)
* Y3-Axis (Col  4) = Solar Zenith Angle (°)
* Y4-Axis (Col  5) = Solar Azimuth Angle (°) North=0, East=90
* Y5-Axis (Col  6) = Elevation Angle (°)
* Y6-Axis (Col  7) = Viewing Angle (°) North=0, East=90
* Y7-Axis (Col  8) = NO2_DSCD_298 (1*10^15 molec/cm2)
* Y8-Axis (Col  9) = NO2_DSCD_298_Error (1*10^15 molec/cm2)
* Y9-Axis (Col 10) = O4_DSCD (1*10^40 molec2/cm5)
* Y10-Axis (Col 11) = O4_DSCD_Error (1*10^40 molec2/cm5)
* Y11-Axis (Col 12) = NO2a_DSCD_220  (1*10^15 molec/cm2)  (Fit results for the "cold NO2 residue")
* Y12-Axis (Col 13) = NO2a_DSCD_220_Error  (1*10^15 molec/cm2)
* Y13-Axis (Col 14) = O3_DSCD_223 (1*10^20 molecules/cm2)
* Y14-Axis (Col 15) = O3_DSCD_223_Error (1*10^20 molecules/cm2)
* Y15-Axis (Col 16) = O3a_DSCD (1*10^20 molecules/cm2)
* Y16-Axis (Col 17) = O3a_DSCD_Error (1*10^20 molecules/cm2)
* Y17-Axis (Col 18) = BrO_DSCD (1*10^15 molec/cm2)
* Y18-Axis (Col 19) = BrO_DSCD_Error (1*10^15 molec/cm2)
* Y19-Axis (Col 20) = HCHO_DSCD (1*10^15 molec/cm2)
* Y20-Axis (Col 21) = HCHO_DSCD_Error (1*10^15 molec/cm2)
* Y21-Axis (Col 22) = Ring
* Y22-Axis (Col 23) = Ring_Error
* Y23-Axis (Col 24) = Fit RMS (in OD)
* Y24-Axis (Col 25) = Spectrum shift (nm, against FRS reference)
* Y25-Axis (Col 26) = Relative Intensity (counts/integration time @ 340nm)
* Y26-Axis (Col 27) = Colour index: (340 / 370 nm)
* Y27-Axis (Col 28) = intensity offset with normalisation by I, I is the mean intensity in the
spectral analysis windows, constant term
* Fit settings: 1
* Fitting Window: 338-370 nm
* Polynomial: 5 (6 coefficients)
* Offset: 1st order
* Calibration: Based on reference SAO solar spectra (Chance and Kurucz, 2010) -->
sao2010_solref_air.dat
* Wavelength adjustment: all spectra shifted and stretched against reference spectrum
* Reference: noon zenith spectra averaged between 11:30:00 and 11:40:00
* NO2_298   : Vandaele et al. (1998), 298 K with I0 correction (1*10^17 molecules/cm2)  --> file:
no2_298K_vanDaele.xs
* NO2a_220   : Vandaele et al. (1998), 220 K with I0 correction (1*10^17 molecules/cm2) pre-
orthogonalized --> file: no2a_220p298K_vanDaele_338-370nm.xs
*   O3     : Serdyuchenko  et al., (2014), 223 K with I0 correction (1*10^20 molecules/cm2) --> file:
o3_223K_SDY_air.xs
*    O3a     : Serdyuchenko  et al., (2014), 243 K with I0 correction (1*10^20 molecules/cm2) pre-
orthogonalized --> file: o3a_243p223K_SDY_338-370nm.xs
*   O4     : Thalman and Volkamer 2013, 293 K  --> file: o4_thalman_volkamer_293K_inAir.xs
*   HCHO   : Meller and Moortgat (2000), 297 K --> file: hcho_297K_Meller.xs
*   BrO    : Fleischmann et al. (2004), 223 K  --> file: bro_223K_Fleischmann.xs
*     RING     : High Resolution calculation with QDOAS according to Chance and Spurr (1997) and
normalized as in Wagner et al. (2009) --> file: Ring_QDOAScalc_HighResSAO2010_Norm.xs
*DOY    UTC             Tint    SZA             SAA             Elev    Viewing_angle  NO2_DSCD_298
        NO2_DSCD_298_error     O4_DSCD O4_DSCD_error  NO2a_DSCD_220  NO2a_DSCD_220_Error    O3_DSCD_223
        O3_DSCD_223_Error      O3a_DSCD        O3a_DSCD_Error BrO_DSCD       BrO_DSCD_Error HCHO_DSCD
        HCHO_DSCD_Error        Ring    Ring_Error     RMS     Spectrum_shift Intens(340)    CI(340/370)
        offset_cst     offset_lin
```

Frame 2: Header of the file for reporting NO_2 and O_4 analysed in the 338-370 nm wavelength range. Each line starts with a *. Lines not starting with * are due to a carriage return for presentation purpose here.

```
* NofHeaderlines: 44
* NofColumns: 24 (if any info missing, put -999, even if it's the whole column)
* Instrument identifier: BIRA_MAXDOAS
* Retrieval code: QDOAS (v2.110, June 2015)
* Created by: Gaia Pinardi
* Version: NO2vis_v1
*  X-Axis (Col  1) = Day of year (DOY) 2016   (please start with 0.0 for January 1st, 0:00 UTC)
* Y1-Axis (Col  2) = Time of day in hours (UTC)
* Y2-Axis (Col  3) = Total Integration Time(s)
* Y3-Axis (Col  4) = Solar Zenith Angle (°)
* Y4-Axis (Col  5) = Solar Azimuth Angle (°) North=0, East=90
* Y5-Axis (Col  6) = Elevation Angle (°)
* Y6-Axis (Col  7) = Viewing Angle (°) North=0, East=90
* Y7-Axis (Col  8) = NO2_DSCD_298 (1*10^15 molec/cm2)
* Y8-Axis (Col  9) = NO2_DSCD_298_Error (1*10^15 molec/cm2)
* Y9-Axis (Col 10) = O4_DSCD (1*10^40 molec2/cm5)
* Y10-Axis (Col 11) = O4_DSCD_Error (1*10^40 molec2/cm5)
* Y11-Axis (Col 12) = NO2a_DSCD_220  (1*10^15 molec/cm2)
* Y12-Axis (Col 13) = NO2a_DSCD_220_Error  (1*10^15 molec/cm2)
* Y13-Axis (Col 14) = O3_DSCD_223 (1*10^20 molecules/cm2)
* Y14-Axis (Col 15) = O3_DSCD_223_Error (1*10^20 molecules/cm2)
* Y15-Axis (Col 16) = H2O_DSCD (1*10^23 molec/cm2)
* Y16-Axis (Col 17) = H2O_DSCD_Error (1*10^23 molec/cm2)
* Y17-Axis (Col 18) = Ring
* Y18-Axis (Col 19) = Ring_Error
* Y19-Axis (Col 20) = Fit RMS (in OD)
* Y20-Axis (Col 21) = Spectrum shift (nm, against FRS reference)
* Y21-Axis (Col 22) = Relative Intensity (counts/integration time @ 440nm)
* Y22-Axis (Col 23) = Colour index: (425 / 440 nm)
* Y23-Axis (Col 24) = intensity offset with normalisation by I, I is the mean intensity in the
spectral analysis windows, constant term
* Fit settings: 1
* Fitting Window: 425-490 nm
* Polynomial: 5 (6 coefficients)
* Offset:  zeroth order
* Calibration: Based on reference SAO solar spectra (Chance and Kurucz, 2010) -->
sao2010_solref_air.dat
* Wavelength adjustment: all spectra shifted and stretched against reference spectrum
* Reference: noon zenith spectra averaged between 11:30:00 and 11:40:00
* NO2_298   : Vandaele et al. (1998), 298 K with I0 correction (1*10^17 molecules/cm2) --> file:
no2_298K_vanDaele.xs
* NO2a_220  : Vandaele et al. (1998), 220 K with I0 correction (1*10^17 molecules/cm2) pre-
orthogonalized --> file: no2a_220p298K_vanDaele_425-490nm
*   O3     : Serdyuchenko  et al., (2014), 223 K with I0 correction (1*10^20 molecules/cm2) --> file:
o3_223K_SDY_air.xs
*   O4     : Thalman and Volkamer 2013, 293 K  --> file: o4_thalman_volkamer_293K_inAir.xs
*   H2O    : HITEMP, Rothman et al., 2010 --> file: H2O_HITEMP_2010_390-700_296K_1013mbar_air.xs
*    RING     : High Resolution calculation with QDOAS according to Chance and Spurr (1997) and
normalized as in Wagner et al. (2009) --> file: Ring_QDOAScalc_HighResSAO2010_Norm.xs
*DOY    UTC            Tint    SZA            SAA            Elev    Viewing_angle  NO2_DSCD_298
       NO2_DSCD_298_error     O4_DSCD O4_DSCD_error  NO2a_DSCD_220  NO2a_DSCD_220_Error    O3_DSCD_223
       O3_DSCD_223_Error      H2O_DSCD       H2O_DSCD_Error Ring    Ring_Error     RMS
       Spectrum_shift Intens(440)    CI(425/440)    offset_cst
```

Frame 3: Header of the file for reporting NO_2 and O_4 analysed in the 425-490 nm wavelength range. Each line starts with a *. Lines not starting with * are due to a carriage return for presentation purpose here.

```
* NofHeaderlines: 44
* NofColumns: 24 (if any info missing, put -999, even if it's the whole column)
* Instrument identifier: BIRA_MAXDOAS
* Retrieval code: QDOAS (v2.110, June 2015)
* Created by: Gaia Pinardi
* Version: NO2visSmall_v1
*  X-Axis (Col  1) = Day of year (DOY) 2016   (please start with 0.0 for January 1st, 0:00 UTC)
* Y1-Axis (Col  2) = Time of day in hours (UTC)
* Y2-Axis (Col  3) = Total Integration Time(s)
* Y3-Axis (Col  4) = Solar Zenith Angle (°)
* Y4-Axis (Col  5) = Solar Azimuth Angle (°) North=0, East=90
* Y5-Axis (Col  6) = Elevation Angle (°)
* Y6-Axis (Col  7) = Viewing Angle (°) North=0, East=90
* Y7-Axis (Col  8) = NO2_DSCD_298 (1*10^15 molec/cm2)
* Y8-Axis (Col  9) = NO2_DSCD_298_Error (1*10^15 molec/cm2)
* Y9-Axis (Col 10) = O4_DSCD (1*10^40 molec2/cm5)
* Y10-Axis (Col 11) = O4_DSCD_Error (1*10^40 molec2/cm5)
* Y11-Axis (Col 12) = NO2a_DSCD_220  (1*10^15 molec/cm2)  (Fit results for the "cold NO2 residue")
* Y12-Axis (Col 13) = NO2a_DSCD_220_Error  (1*10^15 molec/cm2)
* Y13-Axis (Col 14) = O3_DSCD_223 (1*10^20 molecules/cm2)
* Y14-Axis (Col 15) = O3_DSCD_223_Error (1*10^20 molecules/cm2)
* Y15-Axis (Col 16) = H2O_DSCD (1*10^23 molec/cm2)
* Y16-Axis (Col 17) = H2O_DSCD_Error (1*10^23 molec/cm2)
* Y17-Axis (Col 18) = Ring
* Y18-Axis (Col 19) = Ring_Error
* Y19-Axis (Col 20) = Fit RMS (in OD)
* Y20-Axis (Col 21) = Spectrum shift (nm, against FRS reference)
* Y21-Axis (Col 22) = Relative Intensity (counts/integration time @ 440nm)
* Y22-Axis (Col 23) = Colour index: (412 / 440 nm)
*  Y23-Axis  (Col  24)  =  intensity  offset  with  normalisation  by  I,  I  is  the  mean  intensity  in  the
spectral analysis windows, constant term
* Fit settings: 1
* Fitting Window: 411-445 nm
* Polynomial: 4 (5 coefficients)
* Offset:  Zeroth order (constant)
*   Calibration:   Based   on   reference   SAO   solar   spectra   (Chance   and   Kurucz,   2010)   -->
sao2010_solref_air.dat
* Wavelength adjustment: all spectra shifted and stretched against reference spectrum
* Reference: noon zenith spectra averaged between 11:30:00 and 11:40:00
* NO2_298   : Vandaele et al. (1998), 298 K with I0 correction (1*10^17 molecules/cm2) --> file:
no2_298K_vanDaele.xs
* NO2a_220  :  Vandaele  et  al.  (1998),  220  K  with  I0  correction  (1*10^17  molecules/cm2)  pre-
orthogonalized --> file: no2a_220p298K_vanDaele_411-445nm.xs
*   O3     : Serdyuchenko  et al., (2014), 223 K with I0 correction (1*10^20 molecules/cm2) --> file:
o3_223K_SDY_air.xs
*   O4     : Thalman and Volkamer 2013, 293 K  --> file: o4_thalman_volkamer_293K_inAir.xs
*   H2O    : HITEMP, Rothman et al., 2010 --> file: H2O_HITEMP_2010_390-700_296K_1013mbar_air.xs
*     RING     : High Resolution calculation with QDOAS according to Chance and Spurr (1997) and
normalized as in Wagner et al. (2009) --> file: Ring_QDOAScalc_HighResSAO2010_Norm.xs
*DOY    UTC             Tint    SZA             SAA             Elev    Viewing_angle  NO2_DSCD_298
       NO2_DSCD_298_error     O4_DSCD O4_DSCD_error  NO2a_DSCD_220  NO2a_DSCD_220_Error    O3_DSCD_223
       O3_DSCD_223_Error      H2O_DSCD        H2O_DSCD_Error Ring    Ring_Error     RMS
       Spectrum_shift Intens(440)    CI(412/440)    offset_cst
```

Frame 4: Header of the file for reporting NO_2 analysed in the 411-445 nm wavelength range. Each line starts with a *. Lines not starting with * are due to a carriage return for presentation purpose here.

```
* NofHeaderlines: 48
* NofColumns: 27 (if any info missing, put -999, even if it's the whole column)
* Instrument identifier: BIRA_MAXDOAS
* Retrieval code: QDOAS (v2.110, June 2015)
* Created by: Gaia Pinardi
* Version: O3vis_v1
*  X-Axis (Col  1) = Day of year (DOY) 2016   (please start with 0.0 for January 1st, 0:00 UTC)
* Y1-Axis (Col  2) = Time of day in hours (UTC)
* Y2-Axis (Col  3) = Total Integration Time(s)
* Y3-Axis (Col  4) = Solar Zenith Angle (°)
* Y4-Axis (Col  5) = Solar Azimuth Angle (°) North=0, East=90
* Y5-Axis (Col  6) = Elevation Angle (°)
* Y6-Axis (Col  7) = Viewing Angle (°) North=0, East=90
* Y7-Axis (Col  8) = O3_DSCD_223 (1*10^20 molecules/cm2)
* Y8-Axis (Col  9) = O3_DSCD_223_Error (1*10^20 molecules/cm2)
* Y9-Axis (Col  10) = O3a_DSCD_293 (1*10^20 molecules/cm2)
* Y10-Axis (Col 11) = O3a_DSCD_293_Error (1*10^20 molecules/cm2)
* Y11-Axis (Col 12) = O4_DSCD (1*10^40 molec2/cm5)
* Y12-Axis (Col 13) = O4_DSCD_Error (1*10^40 molec2/cm5)
* Y13-Axis (Col 14) = NO2_DSCD_298 (1*10^15 molec/cm2)
* Y14-Axis (Col 15) = NO2_DSCD_298_Error (1*10^15 molec/cm2)
* Y15-Axis (Col 16) = NO2a_DSCD_220  (1*10^15 molec/cm2)
* Y16-Axis (Col 17) = NO2a_DSCD_220_Error  (1*10^15 molec/cm2)
* Y17-Axis (Col 18) = H2O_DSCD (1*10^23 molec/cm2)
* Y18-Axis (Col 19) = H2O_DSCD_Error (1*10^23 molec/cm2)
* Y19-Axis (Col 20) = Ring
* Y20-Axis (Col 21) = Ring_Error
* Y21-Axis (Col 22) = Fit RMS (in OD)
* Y22-Axis (Col 23) = Spectrum shift (nm, against FRS reference)
* Y23-Axis (Col 24) = Relative Intensity (counts/integration time @ 500nm)
* Y24-Axis (Col 25) = Colour index: (440 / 500 nm)
* Y25-Axis (Col 26) = intensity offset with normalisation by I, I is the mean intensity in the
spectral analysis windows, constant term
* Y26-Axis (Col 27) = intensity offset, linear term
* Fit settings: 1
* Fitting Window: 450-520 nm
* Polynomial: 3 (4 coefficients)
* Offset:  1st order
*  Calibration: Based on reference SAO solar spectra (Chance and Kurucz, 2010) -->
sao2010_solref_air.dat
* Wavelength adjustment: all spectra shifted and stretched against reference spectrum
* Reference: noon zenith spectra averaged between 11:30:00 and 11:40:00
* O3_223   : Serdyuchenko  et al., (2014), 223 K with I0 correction (1*10^20 molecules/cm2) --> file:
o3_223K_SDY_air.xs
* O3a_293   : Serdyuchenko  et al., (2014), 293 K with I0 correction (1*10^20 molecules/cm2) Pre-
orthogonalized --> file: o3a_293p223K_SDY_450-550nm
* NO2_298   : Vandaele et al. (1998), 298 K with I0 correction (1*10^17 molecules/cm2) --> file:
no2_298K_vanDaele.xs
* NO2a_220  : Vandaele et al. (1998), 220 K with I0 correction (1*10^17 molecules/cm2) Pre-
orthogonalized --> file: no2a_220p298K_vanDaele_450-550nm
* O4       : Thalman and Volkamer 2013, 293 K  --> file: o4_thalman_volkamer_293K_inAir.xs
* H2O      : HITEMP, Rothman et al. (2010) --> file: H2O_HITEMP_2010_390-700_296K_1013mbar_air.xs
*  RING       : High Resolution calculation with QDOAS according to Chance and Spurr (1997) and
normalized as in Wagner et al. (2009) --> file: Ring_QDOAScalc_HighResSAO2010_Norm.xs
*DOY    UTC            Tint    SZA            SAA            Elev    Viewing_angle  O3_DSCD_223
       O3_DSCD_223_Error      O3a_DSCD_293   O3a_DSCD_293_Error     O4_DSCD O4_DSCD_error  NO2_DSCD_298
       NO2_DSCD_298_error     NO2a_DSCD_220  NO2a_DSCD_220_Error    H2O_DSCD       H2O_DSCD_Error Ring
       Ring_Error     RMS     Spectrum_shift Intens(500)    CI(440/500)    offset_cst     offset_lin
```

Frame 5: Header of the file for reporting O_3 analysed in the Chappuis bands (450-520 nm wavelength range). Each line starts with a *. Lines not starting with * are due to a carriage return for presentation purpose here.

```
* NofHeaderlines: 43
* NofColumns: 21 (if any info missing, put -999, even if it's the whole column)
* Instrument identifier: BIRA_MAXDOAS
* Retrieval code: QDOAS (v2.110, June 2015)
* Created by: Gaia Pinardi
* Version: O3uv_v1
*  X-Axis (Col  1) = Day of year (DOY) 2016   (please start with 0.0 for January 1st, 0:00 UTC)
* Y1-Axis (Col  2) = Time of day in hours (UTC)
* Y2-Axis (Col  3) = Total Integration Time(s)
* Y3-Axis (Col  4) = Solar Zenith Angle (°)
* Y4-Axis (Col  5) = Solar Azimuth Angle (°) North=0, East=90
* Y5-Axis (Col  6) = Elevation Angle (°)
* Y6-Axis (Col  7) = Viewing Angle (°) North=0, East=90
* Y7-Axis (Col  8) = O3_DSCD_223 (1*10^20 molecules/cm2)
* Y8-Axis (Col  9) = O3_DSCD_223_Error (1*10^20 molecules/cm2)
* Y9-Axis (Col  10) = O3a_DSCD_293 (1*10^20 molecules/cm2)
* Y10-Axis (Col 11) = O3a_DSCD_293_Error (1*10^20 molecules/cm2)
* Y11-Axis (Col 12) = NO2_DSCD_298  (1*10^15 molec/cm2)
* Y12-Axis (Col 13) = NO2_DSCD_298_Error  (1*10^15 molec/cm2)
* Y13-Axis (Col 14) = HCHO_DSCD (1*10^15 molec/cm2)
* Y14-Axis (Col 15) = HCHO_DSCD_Error (1*10^15 molec/cm2)
* Y15-Axis (Col 16) = Ring
* Y16-Axis (Col 17) = Ring_Error
* Y17-Axis (Col 18) = Fit RMS (in OD)
* Y18-Axis (Col 19) = Spectrum shift (nm, against FRS reference)
* Y19-Axis (Col 20) = Relative Intensity (counts*n_scans/integration time @ 340nm)
* Y20-Axis (Col 21) = Colour index: (320 / 340 nm)
*  Y21-Axis  (Col  22)  =  intensity  offset  with  normalisation  by  I,  I  is  the  mean  intensity  in  the
spectral analysis windows, constant term
* Y22-Axis (Col 23) = intensity offset, linear term
* Fit settings: 1
* Fitting Window: 320-340 nm
* Polynomial: 3 (4 coefficients)
* Offset:  1st order
*   Calibration:   Based   on   reference   SAO   solar   spectra   (Chance   and   Kurucz,   2010)   -->
sao2010_solref_air.dat
* Wavelength adjustment: all spectra shifted and stretched against reference spectrum
* Reference: noon zenith spectra averaged between 11:30:00 and 11:40:00
* O3_223   : Serdyuchenko  et al., (2014), 223 K with I0 correction (1*10^20 molecules/cm2) --> file:
o3_223K_SDY_air.xs
* O3a_293   : Serdyuchenko   et al.,  (2014),  293  K  with  I0  correction  (1*10^20  molecules/cm2)  pre-
orthogonalized --> file: o3a_293p223K_SDY_320-340nm.xs
* O3 non-linear correction terms (Pukite et al., 2010) at 223K --> files: o3_SDY_Pukite1_320-340nm.xs
and o3_SDY_Pukite2_320-340nm.xs
* NO2_298   : Vandaele  et  al.  (1998),  298  K  with  I0  correction  (1*10^17  molecules/cm2)  -->  file:
no2_298K_vanDaele.xs
* HCHO     : Meller and Moortgat (2000), 297 K --> file: hcho_297K_Meller.xs
*  RING       :  High  Resolution  calculation  with  QDOAS  according  to  Chance  and  Spurr  (1997)  and
normalized as in Wagner et al. (2009) --> file: Ring_QDOAScalc_HighResSAO2010_Norm.xs
*DOY    UTC            Tint    SZA            SAA            Elev    Viewing_angle  O3_DSCD_223
       O3_DSCD_223_Error      O3a_DSCD_293   O3a_DSCD_293_Error     NO2_DSCD_298   NO2_DSCD_298_Error
       HCHO_DSCD      HCHO_DSCD_error        Ring    Ring_Error     RMS    Spectrum_shift Intens(340)
       CI(320/340)    offset_cst     offset_lin
```

Frame 6: Header of the file for reporting O_3 analysed in the Huggins bands (320-340 nm wavelength range). Each line starts with a *. Lines not starting with * are due to a carriage return for presentation purpose here.

Appendix B: Semi-blind Intercomparison Data Protocol

Second Cabauw Intercomparison of Nitrogen Dioxide measuring Instruments

Cabauw, The Netherlands 25 August – 7 October 2016

SEMI-BLIND INTERCOMPARISON DATA PROTOCOL

The CINDI-2 semi-blind intercomparison exercise will be held from 12 to 25 September 2016, with a possible 1-one week extension (26 September-3 October 2016). The aims of this data protocol are: a) to encourage rapid dissemination of the measurement data collected during this exercise; b) to uphold the rights of the participating scientists; and c) to have all involved researchers/groups treated equitably. The rules and guidelines with respect to the production and use of measurement data are the following:

1. For their analyses, each group will apply the DOAS settings defined in the Semi-blind Intercomparison Protocol which is available on the CINDI-2 website (http://www.tropomi.eu/science/cindi-2). The measurement files will be formatted according to the prescribed ascii text format.
2. Each group engage to follow the recommendations formulated in the Semi-blind Intercomparison Protocol, in particular to adopt the measurement sequences and to perform the required calibrations to the best of their possibilities.
3. Each group engage to submit their daily data files to the CINDI-2 ftp server by 10am local time at the latest. Data will be collected by the Campaign Referee and semi-blind comparison results will be presented at the daily briefings which will start at 1pm local time. The ftp server will be hosted by KNMI at an address to be communicated ahead of the campaign. KNMI will take the responsibility of the server management.
4. Each participating group engage to have at least one representative attending the daily briefings. The possibility to attend via a teleconferencing system (Skype or Webex) will be offered. Daily briefings will address the discussion of fresh semi-blind comparison results. Upon relevance they will also cover relevant science or logistical topics in relation with the overall campaign organisation.
5. After completion of the formal two weeks intercomparison exercise, all scientists involved in CINDI-2 will have equal and complete access to all semi-blind intercomparison measurement data.
6. Data submitted to the CINDI-2 ftp server are and remain the exclusive property of the respective group.
7. Data will not be distributed outside the CINDI-2 consortium without prior permission of the corresponding instrument PI(s). The CINDI-2 consortium is defined as being all scientists/groups participating to the campaign.

8. Persons interested in using measurement data from others in scientific papers or presentations should offer the data owner(s) participation and co-authorship. If the data owner(s) refrain(s) from co-authorship, a second option is to mention the data owner(s) in the acknowledgements.
9. In agreement with the ESA CINDI-2 contract supporting the campaign, each group funded by ESA for its participation to the semi-blind intercomparison engage submitting its measurement data to the ESA Validation Data Center (EVDC) hosted at NILU within 3 months after the end of the semi-blind intercomparison exercise, i.e. by 31 December 2016 at the latest. They should also sign the EVDC/NILU data Protocol. The other participants are encouraged to submit their data according to the same protocol.
10. In agreement with the ESA FRM_4DOAS contract supporting the preparation of the campaign and the development of a prototype centralised MAXDOAS processing system, the campaign data submitted to EVDC will be used for testing and validating the profiling algorithms implemented in the FRM_4DOAS processor. All participating CINDI-2 data providers will be associated to this activity.
11. The ownership of data submitted to EVDC remains with the instrument PI.
12. EVDC will provide ECMWF meteorological fields (analysis and forecast) for the campaign area and period. Participants to the campaign are asked to not distribute these data outside the CINDI-2 consortium, neither to make commercial use of them.

The undersigned agrees to the conditions of this data protocol.

Signature : ....
Date : ....

Name : ....

Position (PI, Post-doc, student…) : ……………………………..

Address : ....

....

....

E-mail : ....

Please return to:
BIRA-IASB
3, Avenue Circulaire
B-1180 Brussels
Belgium
Attn: Dr François Hendrick francois.hendrick@aeronomie.be