ESA FRM$_4$DOAS project

BELGISCH INSTITUUT VOOR RUIMTE-AERONOMIE INSTITUT D'AERONOMIE SPATIALE DE BELGIQUE BELGIAN INSTITUTE OF SPACE AERONOMY BELGISCH INSTITUUT VOOR RUIMTE-AERONOMIE INSTITUT D'AERONOMIE SPATIALE DE BELGIQUE BELGIAN INSTITUTE OF SPACE AERONOMY BELGISCH INSTITUUT VOOR RUIMTE-AERONOMIE INSTITUT D'AERO

esa

BIRA-IASB

iup

MAX-PLANCK-INSTITUT FÜR CHEMIE

Royal Netherlands Meteorological Institute
Ministry of Infrastructure and the Environment

BK Scientific

NDACC

BIRA-IASB

ESA FRM Program

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Fiducial Reference Measurements (FRM):

- Suite of independent, fully characterized, and traceable ground measurements that follow the guidelines outlined by the GEO/CEOS Quality Assurance framework for Earth Observation (QA4EO)

- Objective: Validation of ESA altimetry, atmosphere, land, and ocean products

FRM4SOC: Fiducial Reference Measurements for Satellite Ocean Colour
FRM4ALT: Fiducial Reference Measurements for altimetry
FRM4ALT-coastal: Fiducial Reference Measurements for coastal altimetry
FRM-BOUSSOLE: Buoy for the acquisition of long-term optical time series
FRM4DOAS: Fiducial Reference Measurements for Ground-Based DOAS Air-Quality Observations
FRM4GHG: Reference Measurements for Ground-Based FTIR Greenhouse Gas Observations
FRM4STS: Fiducial Reference Measurements for validation of Surface Temperatures from Satellites
Pandonia FRM: Fiducial Reference Measurements for Ground-Based Direct-Sun Air-Quality Observations

- More details at https://earth.esa.int/web/sppa/activities

ESA FRM Program

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FRM$_4$DOAS

Fiducial Reference Measurements for Ground-Based DOAS Air-Quality Observations

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- 2-year ESA project started in July 2016
- **Coordination:** BIRA-IASB
- **Partners:** IUP-Bremen, IUP-Heidelberg, MPIC, KNMI, BKScientific
- **Objectives:**
  - ✓ Further harmonising MAX-DOAS systems and data sets through:
    1. Specification of best practices for instrument operation
    2. Development and demonstration of a first near-real-time centralised processing system for MAX-DOAS measurements to be operated within NDACC
    3. Establishment of links with other UV-visible networks, e.g. Pandora
  - ✓ Support to the preparation of the CINDI-2 campaign
- Processing system will play a crucial role in the operational validation of atmospheric composition satellite missions (Sentinels S-5P, S-4&5)

WPs description

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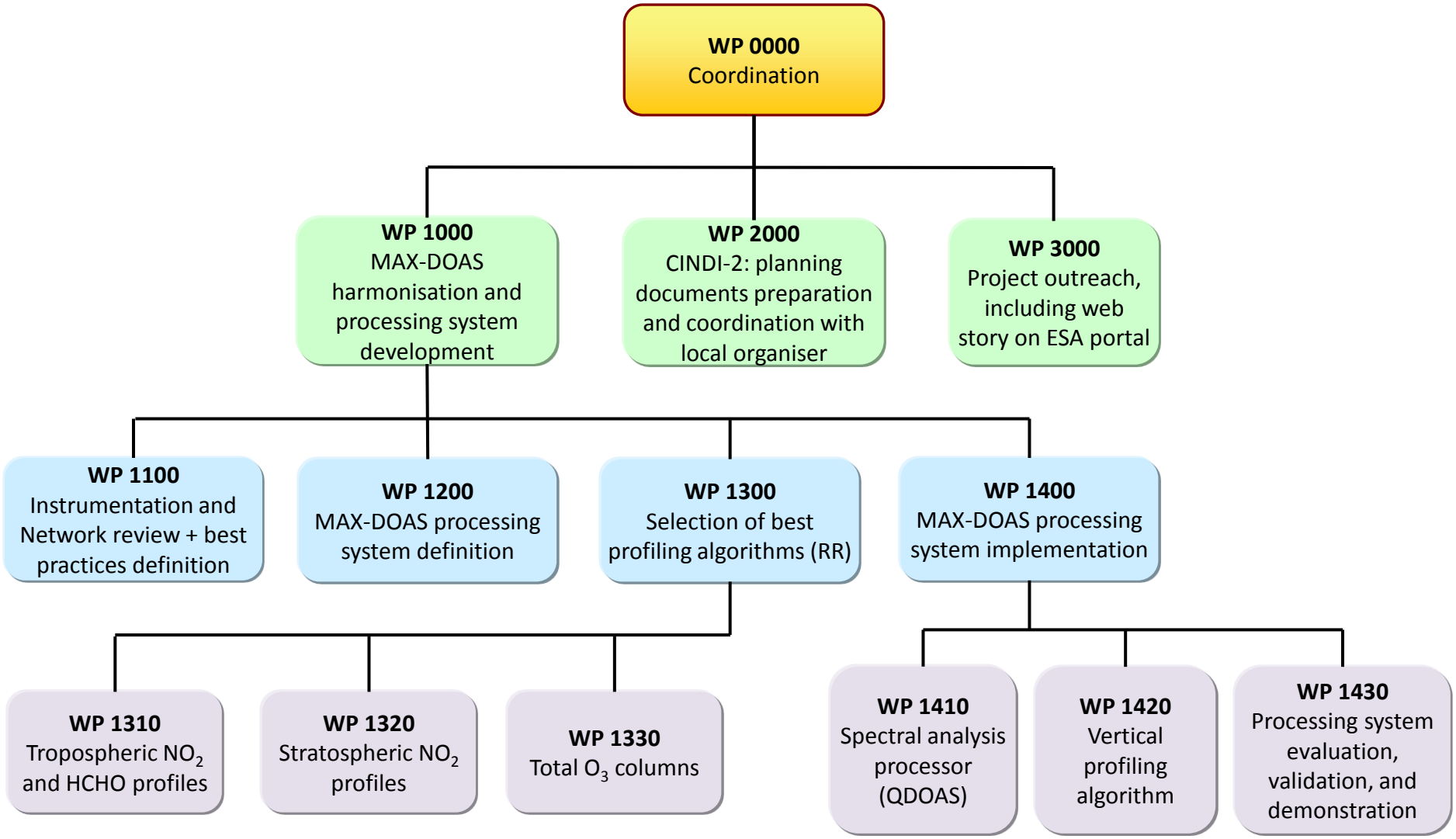

WPs description

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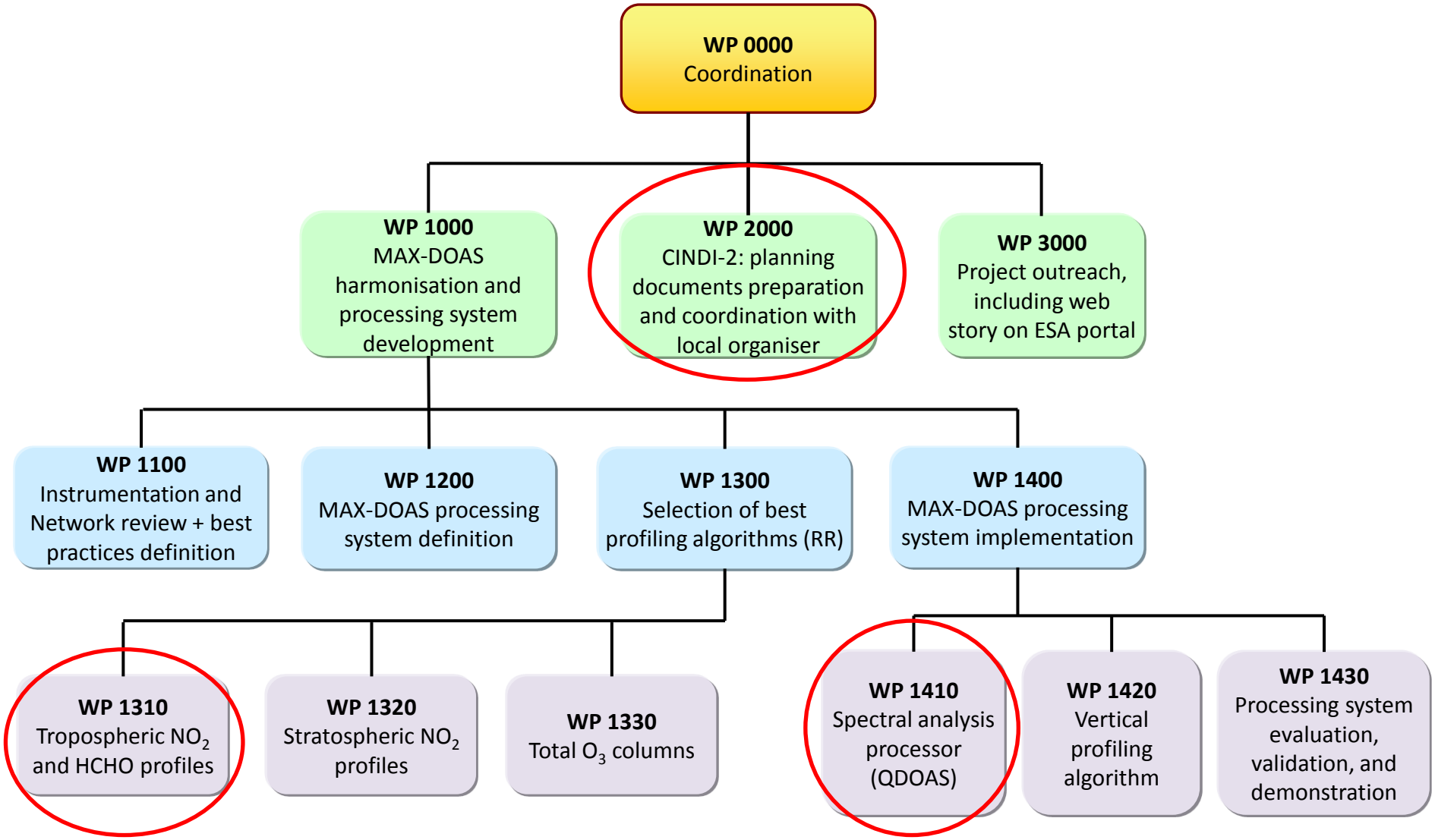

Links between FRM_4DOAS and CINDI-2

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- FRM_4DOAS contributed to the planning and preparation of the CINDI-2 campaign through the following Deliverables:
  - ✓ D11: 'Intercomparison campaign requirements document'
  - ✓ D12: 'Intercomparison campaign technical requirements document'
  - ✓ D13: 'Intercomparison campaign planning document'
  - ✓ D14: 'Intercomparison campaign data protocol'

Links between FRM$_4$DOAS and CINDI-2

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- Centralised processing of CINDI-2 spectra using QDOAS:
  - ✓ Will contribute to determine the origin of the remaining discrepancies in the semi-blind exercise
  - ✓ Will contribute to the development and testing of the FRM4DOAS spectral processor
  - ✓ Common spectra file ascii format:

```
# Station = Cabauw (51.97 N,4.93 E)
# Institute = IUPB
# PI name = Andreas Richter (richter@iup.physik.uni-bremen.de)
# Instrument = UV
# Size of the detector = 1340
# Total number of records = 551
Date (DD/MM/YYYY) = 24/09/2016
UTC Time (hh:mm:ss) = 04:08:06.340
UTC Start Time (hh:mm:ss) = 04:07:01.600
UTC End Time (hh:mm:ss) = 04:09:11.080
Viewing Elevation Angle (deg) = 90.000
Viewing Azimuth Angle (deg) =  0.000
Measurement Type (OFFAXIS/DIRECT SUN/ALMUCANTAR/ZENITH/HORIZON) = ZENITH
Total Measurement Time (sec) = 129.479
Total Acquisition Time (sec) = 128.000
Exposure time (sec) =  12.800
Solar Zenith Angle (deg) = 103.283
Solar Azimuth Angle (deg) =  73.512 (North=0, East=90)
305.508000  2.048671246E-01
305.571844  2.048671246E-01
```

  - ✓ So far, 13 groups (on a total of 24) have sent their example files

Links between FRM$_4$DOAS and CINDI-2

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WP1300:

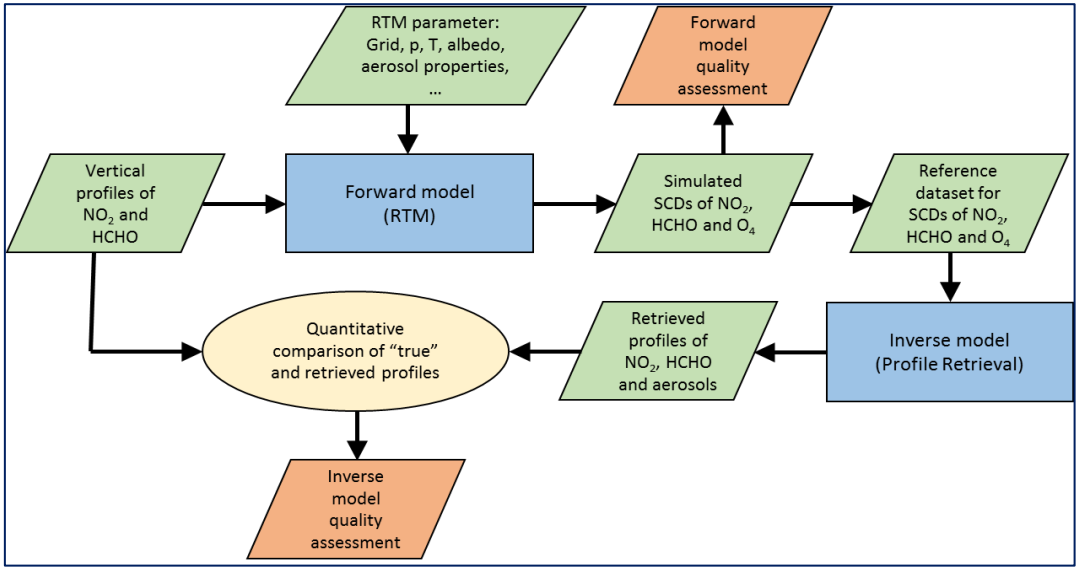
Round-Robin profiling algorithm selection (lead: U. Friess/IUP-Heidelberg)

Objectives:

Conduction of a round-robin exercise with the aim to:

1. Review the strengths and weaknesses of the MAXDOAS profile retrieval algorithms available in the scientific community
2. Jointly define a community algorithm that will be implemented as baseline in the centralized processing system

- Target species: Aerosols @ 360 and 477 nm, HCHO, NO_2
- Creation of a synthetic dSCD reference dataset based on the output of 5 different RTMs
- 9 trace gas profiles and 11 aerosol profiles
- > 20 000 simulated SCDs for different atmospheric scenarios and viewing geometries
- 3 960 retrieved profiles



Flow diagram of the Round Robin exercise for tropospheric retrieval algorithms

Processing system flowchart

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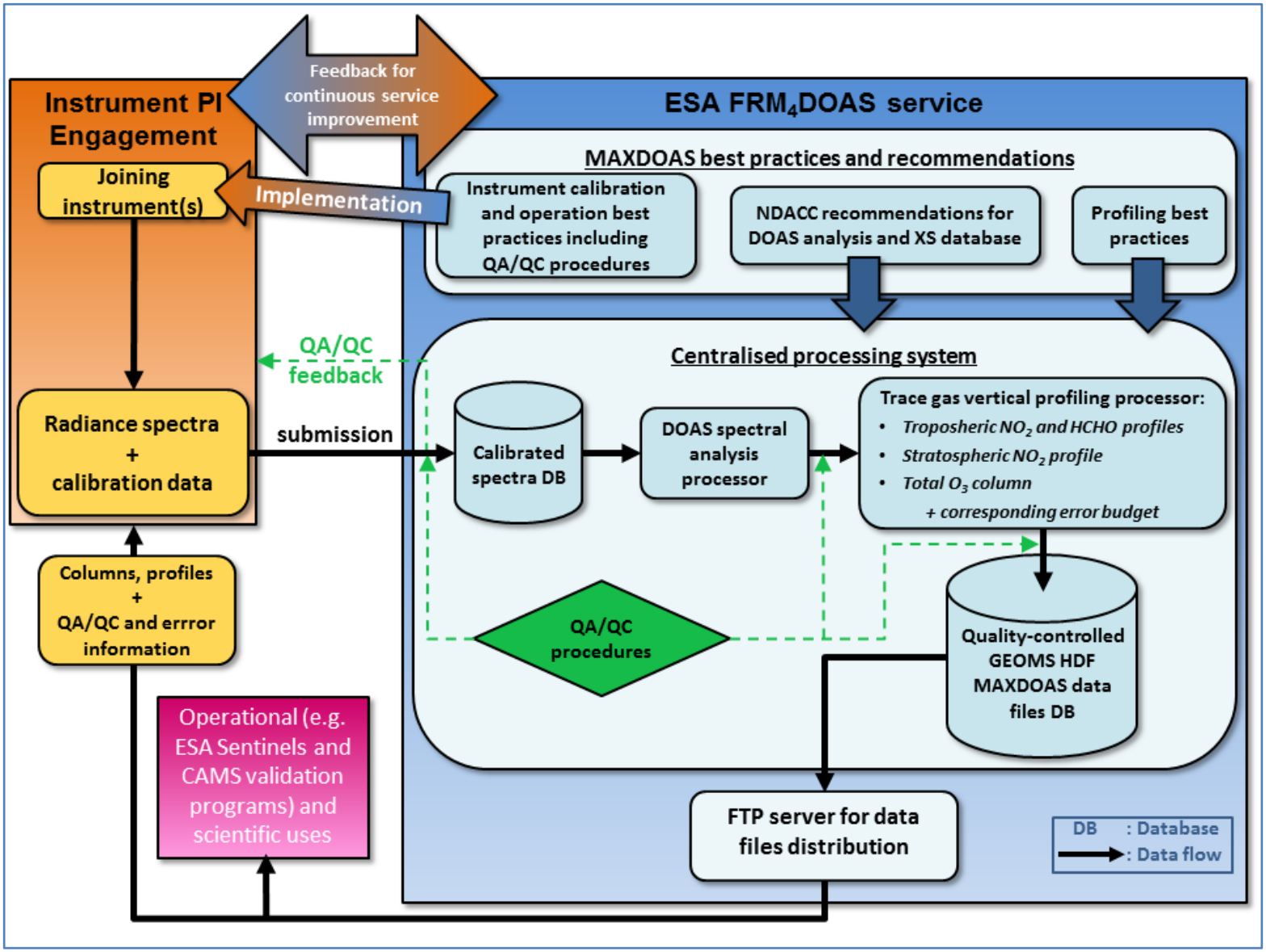

FRM$_4$DOAS service advantages

BELGISCH INSTITUUT VOOR RUIMTE-AERONOMIE INSTITUT D'AERONOMIE SPATIALE DE BELGIQUE BELGIAN INSTITUTE OF SPACE AERONOMY BELGISCH INSTITUUT VOOR RUIMTE-AERONOMIE INSTITUT D'AERONOMIE SPATIALE DE BELGIQUE BELGIAN INSTITUTE OF SPACE AERONOMY BELGISCH INSTITUUT VOOR RUIMTE-AERONOMIE INSTITUT D'AERO

- ✓ Free-of-charge systematic Level 1 (radiance spectra) to Level 2 (vertical columns and profiles) NRT processing service
- ✓ Only 6-24h latency between the submission of the spectra and the availability of final products data files
- ✓ Continuous quality monitoring for both Level 1 and 2 data with automated feedback to instrument PI in case of anomaly
- ✓ Increased data visibility as part of an international network (NDACC)
- ✓ Collaboration to international operational validation projects like Copernicus
- ✓ Processed level-2 data back to instrument PI for scientific use

A strict data policy to avoid external use of the data without consent of all parties (ESA and instrument PI) will be applied.

Instrument PI engagement

To adhere to the FRM_4DOAS guidelines and standards in terms of

- ✓ Best practices, data protocol, and QA/QC for instrument calibration and operation
- ✓ Latency time for the submission of their radiance spectra

- ➢ *Recommendations/guidelines will be described in the Deliverable D4 ('MAX-DOAS calibration and operations best practices')*
- ➢ *This document will be made available on the FRM_4DOAS website and continuously updated with input from the (MAX-)DOAS Community*

Project schedule

- During the first two years, demonstration of the NRT processing system on
  - ✓ CINDI-2 spectra
  - ✓ Measurements at a selection of 11 MAX-DOAS stations:

Location	Lat (°N)	Long (°E)	Alt (m) a.s.l	Owner
Ny-Alesund, Norway	79	12	15	IUPUB
Bremen, Germany	53	9	50	IUPUB
Cabauw, The Netherlands	52	5	0	KNMI
Uccle, Belgium	51	4	104	BIRA
Mainz, Germany	50	8	50	MPIC
Heidelberg, Germany	49	8	115	UHEID
Xianghe, China	40	116	178	BIRA/ IAP-CAS
Athens, Greece	38	24	300	IUPUB
Bujumbura, Burundi	-3	29	820	BIRA
Lauder, New-Zealand	-45	170	370	NIWA
Neumayer	-71	-8	50	UHEID

- Mid-/long-term objective: extension to other MAX-DOAS stations

→ Assessment of the current MAX-DOAS network needed

FRM$_4$DOAS questionnaire

Fiducial Reference Measurements for Ground-Based DOAS Air-Quality Observations

ESA Contract No. 4000118181/16/I-EF

Questionnaire for MAX-DOAS network assessment in view of joining the FRM$_4$DOAS centralised processing system

Date: 31/03/2017

Version: 1.0

1

FRM$_4$DOAS questionnaire

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2. Questionnaire

Personal details:

Name :.....

Position :.....

Institute + address :.....

:.....

:.....

:.....

:.....

E-mail :.....

Q1/ Are you interested in providing radiance spectra (Level 1 data) from your MAXDOAS instrument(s) to a centralised processing system making use of common community algorithms ? If yes, go to Q2; if not, please explain the reason(s) why you are not interested:

y/n

.....

Q2/ What are the locations (site name + coordinates) of the MAXDOAS instruments from your Institute that could provide Level 1 data to the FRM$_4$DOAS processing system? For each site/instrument, please indicate whether it is already part of NDACC, provide a general classification of the instrument type (e.g. "research grade system" , "mini-DOAS", "EnviMes" etc + pointing/imaging CCD/PDA; outdoor/indoor instrument; manufacturer/custom-built; see example below), and provide instrument specifications according to the Table below:

Site 1: site_name, country (lat, long); NDACC-affiliated site ? ; instrument type

Site 2: site_name, country (lat, long); NDACC-affiliated site ? ; instrument type

Site 3: site_name, country (lat, long); NDACC-affiliated site ? ; instrument type

Site 4: site_name, country (lat, long); NDACC-affiliated site ? ; instrument type

.....

Example:

Site 1: Bremen, Germany (53°N, 9°E), NDACC-Yes, research grade, pointing, CCD, indoor, custom-built

Instrument specifications (mark relevant specification with a cross):

	Site 1	Site 2	Site 3	Site 4
UV spectral range (300-400nm)*	*x (310-390)*			
Visible spectral range (400-550nm)*				
Depolarizing fiber(s)				
Fiber light mixing				
Detector(s) cooling				
Instrument thermal stabilization				
Elevation scan capability				
Azimuthal scan capability				
Direct-sun pointing capability				

*Please also mention the spectral range in nm (see example in *italic*).

Comments (optional):

.....

FRM$_4$DOAS questionnaire

Q3/ What are your usual procedures for instrument characterization/calibration ?

Instrument characterization and calibration (mark relevant specification with a cross):

	Site 1	Site 2	Site 3	Site 4
Slit function (ISRF)				
Wavelength registration				
Dark signal				
Spectral stray-light				
Detector non-linearity				
Detector interpixel variability				
Field of view				
Elevation angle				
Radiometric calibration				

Comments (optional):

.....

Q4/ How do you operate your instrument(s) ?

Instrument operation (mark relevant specification with a cross):

	Site 1	Site 2	Site 3	Site 4
Automatic operation				
Automatic calibration				
Automatic QA/QC of instrument parameters				
Documentation (e.g. data acquisition protocol, calibration report, etc)				

Comments (optional):

.....

Q5/ What are the procedure in place for data transfer ?

Station->institute data transfer (mark relevant specification with a cross):

	Site 1	Site 2	Site 3	Site 4
Manual				
Automatic with a latency >24h				
Automatic with a latency <24h				

Comments (optional):

.....

Q6/ What is the current latency for spectral data accessibility ?

Calibrated radiance spectra ready for DOAS processing (mark relevant specification with a cross):

	Site 1	Site 2	Site 3	Site 4
Manual				
Automatic with a latency >24h				
Automatic with a latency <24h				
Final QA/QC check on calibrated radiance spectra implemented				

Comments (optional):

.....

Q7/ Please list below your relevant publications (i.e. where your instrument(s) and data are described and/or used):

.....

Q8/ Please list below your relevant past and current international research projects (i.e. projects in relation to your MAXDOAS measurements):

.....

Q9/ In case you would join the FRM$_4$DOAS centralized processing system, would you be willing to be involved in future community efforts for improving standards ?

y/n

Q10/ If not yet the case, would you be willing to affiliate to NDACC ? If not, could you explain why ?

y/n

.....

FRM$_4$DOAS questionnaire

Q11/ General comments and constraints

Comments/remarks/questions are welcome, e.g. about your financial and manpower constraints/efforts to reach FRM$_4$DOAS standards.

Please return to:
Dr François Hendrick, BIRA-IASB (francois.hendrick@aeronomie.be)

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- ✓ Official release by ESA through an e-mail sent to the DOAS community by mid-April 2017
- ✓ Questionnaire will be also made available on the FRM$_4$DOAS project website
- ✓ Filled questionnaire should be returned to F. Hendrick by e-mail *(francois.hendrick@aeronomie.be)*

FRM$_4$DOAS website

Fiducial Reference Measurements for Ground-Based DOAS Air-Quality Observations

Home | Project overview | Partners | Links | Documents | Contact us

Welcome to the FRM$_4$DOAS website

The Fiducial Reference Measurements for Ground-Based DOAS Air-Quality Observations (FRM$_4$DOAS) is a 2-year ESA project which started in July 2016 and is aiming at further harmonization of MAXDOAS systems and data sets, through the specification of best practices for instrument operation, the demonstration of a first centralised NRT processing system for MAXDOAS instruments to be operated with a latency between 6h and 24h within the international NDACC network, and the establishment of links with other UV-Visible instrument networks, e.g. Pandonia. The target species for the first phase of the project are tropospheric and stratospheric NO_2 vertical profiles, total O_3 columns, and tropospheric HCHO profiles. These activities will help and guarantee that homogenous ground-based reference datasets are produced from reference ground-based UV-Vis instruments. Such systems are used both during campaigns and for the long-term monitoring of space-borne instrumentation, and will play a crucial role in the validation of future atmospheric composition satellite missions, especially the ESA Sentinel missions S-5P, S-4, and S-5 that will be carried out in support to the EU Copernicus Atmospheric Monitoring Service (CAMS).

Image courtesy of A. Piters (KNMI)

More information available at:

http://frm4doas.aeronomie.be