



# Belgian Science Policy Office (BELSPO) / Federal Scientific Institutes (FSIs)

## I. Update on Cal/Val Activities

Jean-Christopher Lambert

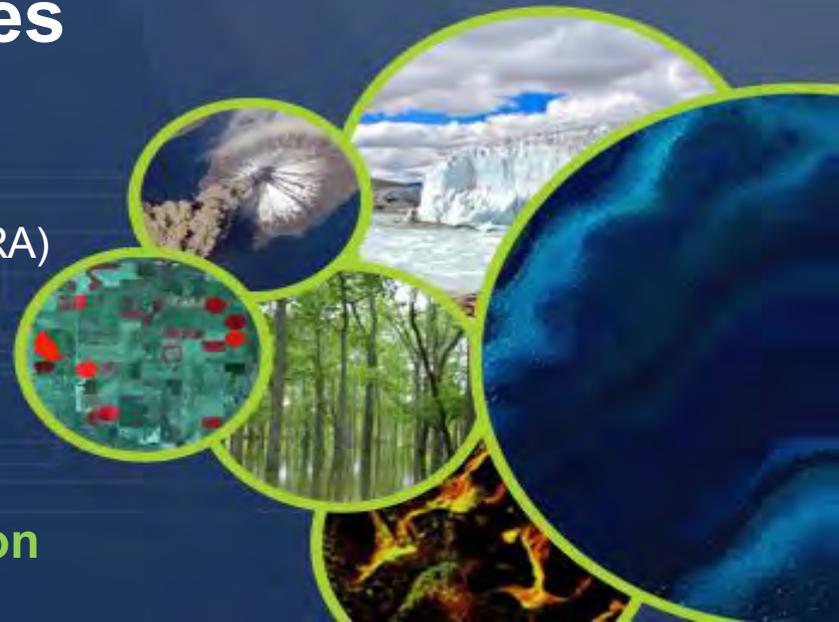
Royal Belgian Institute for Space Aeronomy (IASB-BIRA)

Agency Reports II

WGCV Plenary # 40

Canberra, March 14-18, 2016

**Working Group on Calibration and Validation**



# Agency Reports II

## BELSPO / FSIs



### Contributing institutes

#### Federal Scientific Institutes (FSIs) under BELSPO authority

- Royal Belgian Institute for Space Aeronomy, BIRA-IASB
- Belgian User Support and Operation Centre, B-USOC
- Royal Institute of Natural Sciences of Belgium, IRSN
- Royal Meteorological Institute of Belgium, RMIB
- Royal Observatory of Belgium, ROB

#### Regional partners

- Centre spatial de Liège, CSL
- Université libre de Bruxelles, ULB
- Université de Liège, ULg
- Vlaamse Instelling voor Technologisch Onderzoek, VITO



# Agency Reports II BELSPO / FSIs



## Updates on:

- EO missions
- Validation data
- Validation methods
- Validation systems
  
- Background information (not presented at meeting)



# BELSPO / FSIs

## Update on EO missions



### Atmosphere:

- Phase F: ESA GOME, GOMOS, MIPAS, SCIAMACHY
- Phase E: EUMETSAT MetOp and MSG GOME-2 and IASI (CM-SAF, O3M-SAF); CSA ACE-FTS; NASA/KNMI Aura OMI
- Two days ago: ESA-Roscosmos mission ExoMars with BIRA-IASB's NOMAD/TGO
- This year: Sentinel-5 precursor TROPOMI (see ARS session), PICASSO/CubeSat
- Upcoming: EU Sentinel-4 UVN and 3MI, EU Sentinel-5 UVN and IASI-NG
- Approved: Altius/PROBA, Phase B2 imminent

### Land, Oceans and Snow/Ice:

- PROBA-1 (L 2001/10) transferred to ESA
- PROBA V (L 2013/05)
- EU Sentinel-3 (S-3A L 2016)
- CONAE-CSL cooperation on SAOCOM-1A/1B (L 2016/2017): polarimetric SAR/ScanSAR + InSAR/DInSAR processor

# ALTIUS

(Atmospheric Limb Tracker for the Investigation of the Upcoming Stratosphere)  
Royal Belgian Institute for Space Aeronomy / contact: [Didier.Fussen@oma.be](mailto:Didier.Fussen@oma.be)

## In brief...

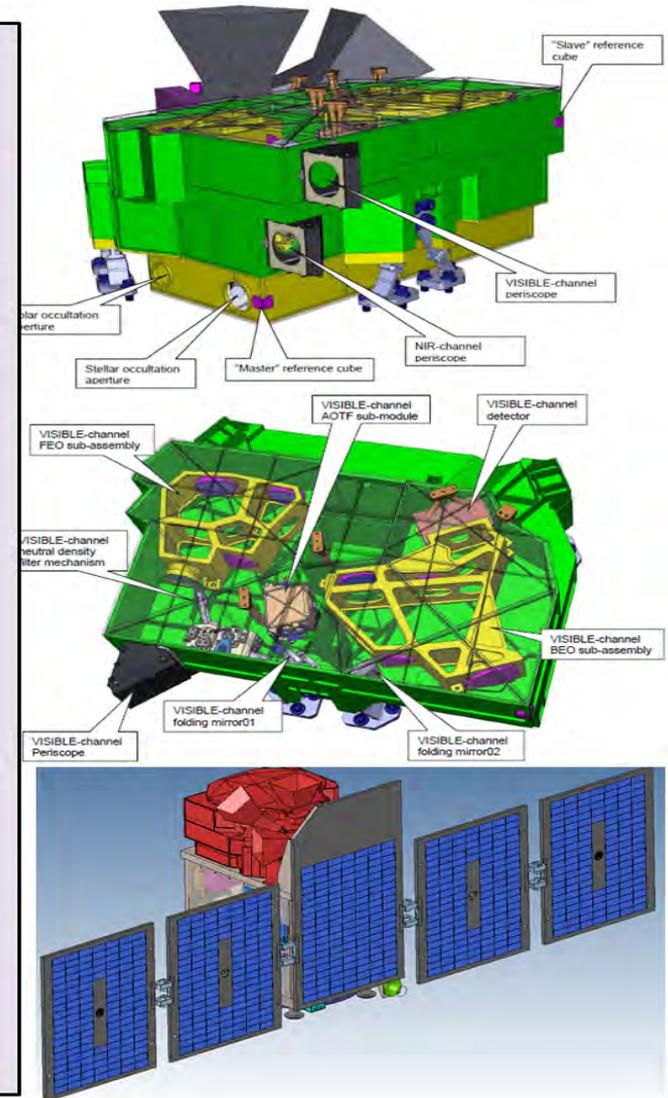
- Atmospheric limb sounder ( $z=0-100$  km,  $dz \leq 1$  km) for  $O_3$ ,  $NO_2$ , aerosols, PSC, PMC,  $CH_4$ ,  $H_2O$ , OClO, BrO,  $NO_3$ , temperature
- 3 tunable **spectral imagers** (Fabry-Pérot in UV, AOTF in VIS, NIR) ( $\lambda=250-1800$  nm,  $d\lambda=1-10$  nm)
- Observations in **multi-mode geometries**: limb-scattering, solar, stellar, lunar, planetary occultations
- LEO sunsynchronous 10:30 LTDN, PROBA class ( $\leq 200$  kg) with high inertial pointing stability and  $1^\circ/s$  agility.

## Recent milestones

- **Aug 2005 (!)**: first ideas ...
- **Jun 2015**: Intermediate payload Design Review by ESA (phase B1)
- **Dec 2015**:
  - technical and performance compliance reviews wrt OPEROZ study (User-driven  $O_3$  requirements study) by ESA
  - scientific review by international panel
- **Feb 2016**: BELSPO approves the full mission and mandate ESA/EO to take actions for implementation

## Future actions

- start Phase B2 asap towards PDR



# ALTIUS

## Scientific objectives

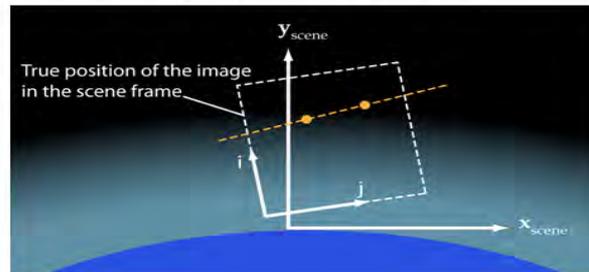
Priority	Observable	Vertical range	Vertical res. [km]	Horizontal res. along parallels [km]	Horizontal res. along meridians [km]	Total error [%]	Coverage	Photo-chemistry [day/night]
A	O <sub>3</sub>	UT-LS	1	10	500	5	global	d/n
A	O <sub>3</sub>	US	1	10	500	5	global	d/n
A	O <sub>3</sub>	MS	1	50	500	20	polar	n
B	NO <sub>2</sub>	LS-US	2	50	500	30	global	d/n
B	H <sub>2</sub> O	UT-LS	2	50	500	20	global	d/n
B	CH <sub>4</sub>	UT-LS	2	50	500	20	global	d/n
B	aerosol	UT-LS	1	20	500	25	global	d/n
B	PSC	UT-LS	1	20	500	25	polar	d/n
C	PMC	MS	1	20	500	50	polar	d/n
C	OCIO	LS-US	1	50	500	25	global	n
C	BrO	UT-LS	1	50	500	20	global	d
C	NO <sub>3</sub>	LS-US	1	50	500	25	global	n
C	T°	LS-MS	2			2		
C	gradients	LS-US	1	10	10	30	global	d/n

## In-flight calibration strategies

Flatfielding with clouds  
(target: 3% RMS PRNU)

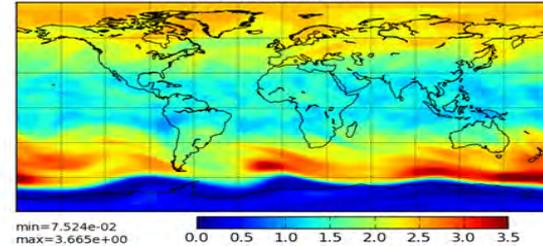


Pointing registration with stars  
in FOV (target: <150m, 1σ)

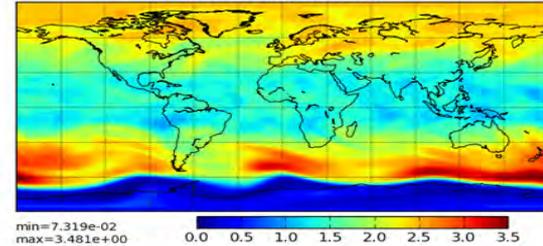


## O3 Level-3 product performance

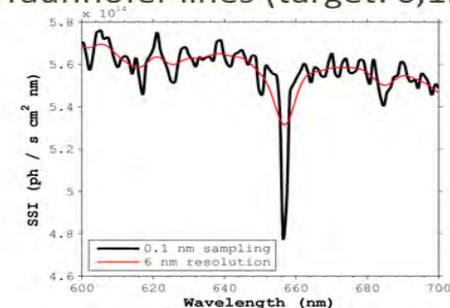
BASCOE ALTIUS Assimilation  
30-Oct-2008 at 12 UT



BASCOE Aura MLS v3.3 Assimilation  
30-Oct-2008 at 12 UT



Wavelength registration with Fraunhofer lines (target: 0,1nm, 1σ)





# Update on EO missions Solar irradiance spectrum

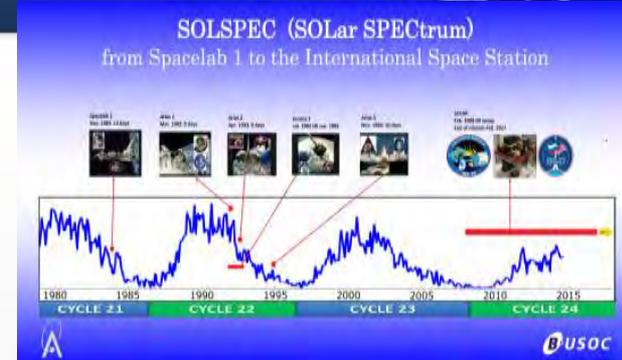


## SOLAR on ISS/Columbus (L2008)

Facility Support Centre: Belgian USOC hosted by BIRA-IASB

Measurement of solar spectral irradiance from 17 nm to 100 μm (99% of solar energy)

- SOLSPEC (SOLar SPECtral Irradiance measurements): 180 nm – 3000 nm; developed by CNRS (France) in partnership with BIRA-IASB (Belgium) and LSW (Germany)
- SOVIM (Solar Variable and Irradiance Monitor): near-UV, visible and thermal (200 nm – 100 μm); developed by PMOD/WRC (Davos, Switzerland) with one instrument's radiometers provided by IRM-KMI (Belgium)
- SOL-ACES (SOLar Auto-Calibrating Extreme UV/UV Spectrophotometers): EUV/UV; developed by IPM (Germany)



**PROBA-2 (L2009)** Space weather mission with Sun observations

**PROBA-3 (L2018)** Formation flying for solar corona observations

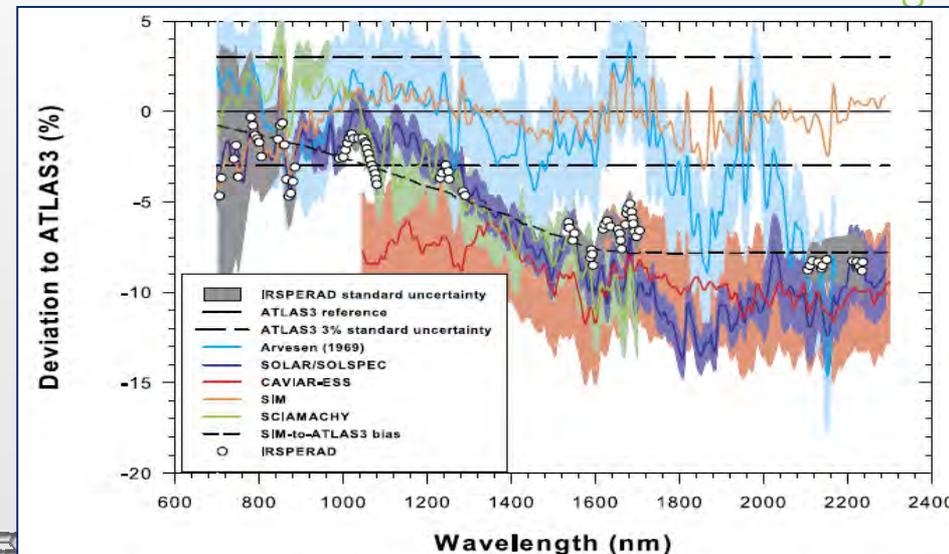
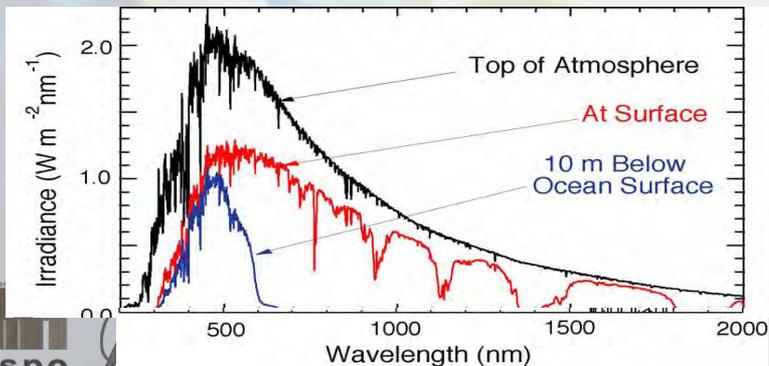


up on Calibre



### ISS Columbus SOLAR/SOLSPEC Workshop, Uccle, March 2015

- 30 participants from Belgium, France, NL, UK and USA: BELSPO, ESA, B-USOC, IASB-BIRA, RMIB, ROB, LASP, LATMOS, PMOD/WRC
- Highlights:
  - 166 nm to 2900 nm since 2008, degradation controlled
  - Usefulness in ozone, sea and climate research, WRC
  - Legacy instruments back to 1980s
  - IRSPERAD campaign, Izaña, 2011
  - NIR under discussion
  - Data preservation and distribution





# BELSPO / FSIs

## Update on validation data



### Atmosphere: [\[various websites\]](#)

- AERONET, EEA/EMEP, NDACC, TCCON, WMO/GAW stations
- International effort on harmonization, reprocessing, error characterization: FTIR & MAXDOAS bilateral cooperation with China, GAIA-CLIM WP2, QA4ECV WP4
- FRM4DOAS, CINDI-2 campaign (Cabauw, see also S-5p talk)
- FRM4GHG, AirCore+FTIRs campaign for TCCON/OCO-2 calibration (Sodankylä, S-5p talk)
- UAV- and car-based DOAS instruments in AROMAT campaigns (Romania, S-5p talk)

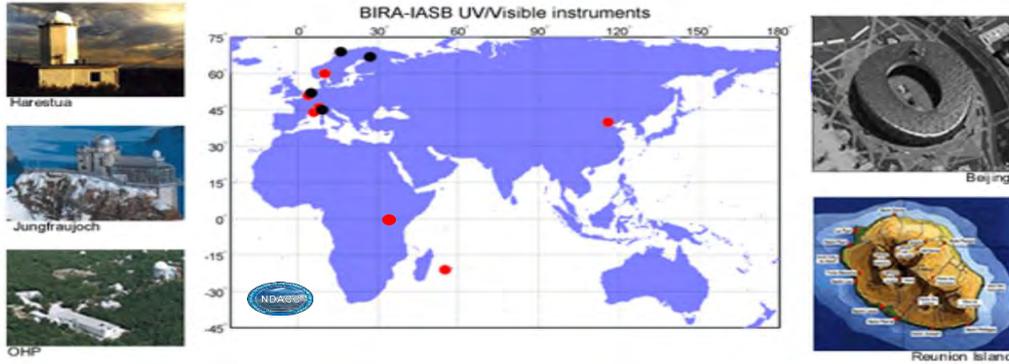
### Marine: <http://www.mumm.ac.be/datacentre>

- Belgian Maritime Data Centre (BMDC), SeaDataNet member
- Physical, chemical and meteorological parameters over North Sea
- Ship- and shore-based

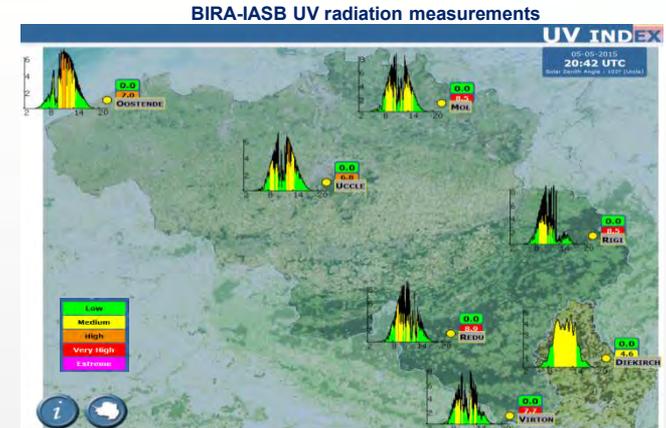
### Solar: <http://uvindex.aeronomie.be>

- Solar UV-Visible Irradiance Monitoring Network (7 RT stations in Belgium + Belgian Antarctic Base), with centralised calibration centre in Uccle
- Spectral irradiance 280-600 nm, broadband, clouds, sunshine duration...

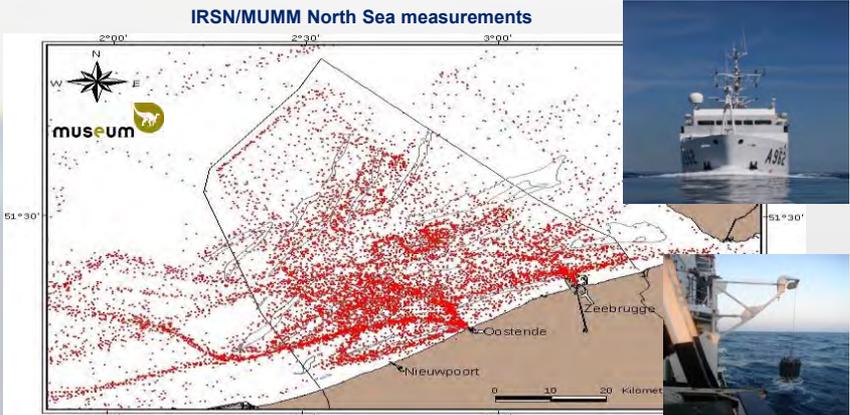
# Update on validation data Contribution to networks



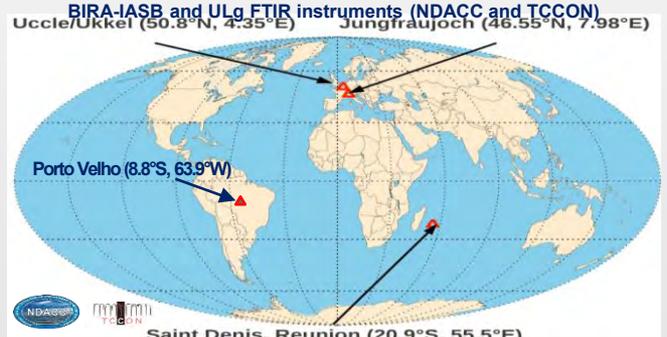
Contact M. Van Roozendael and F. Hendrick, BIRA-IASB  
+ Brewer/O<sub>3</sub>sondes in Uccle, H. De Backer, RMIB



Contact D. Bolsée, BIRA-IASB



Contact S. Scory, IRSN/MUMM



Contact M. De Mazière, BIRA-IASB

Working Group on Calibration and Validation

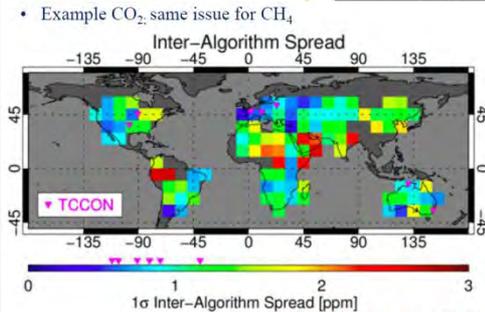
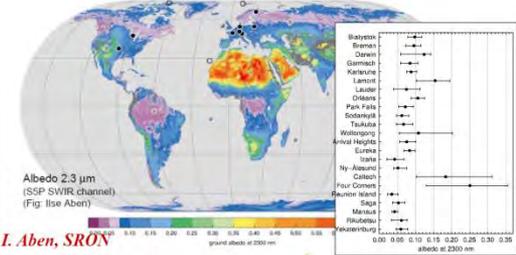
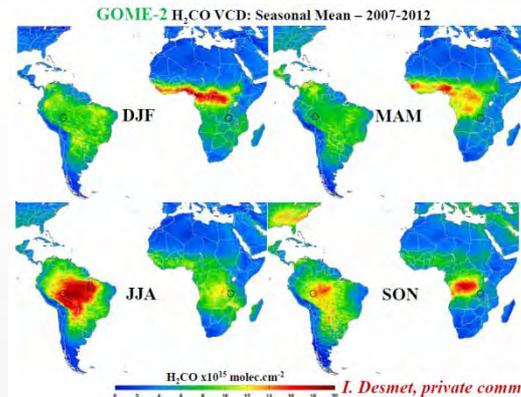


# Update on validation data New NDACC/TCCON FTIR in Brazil

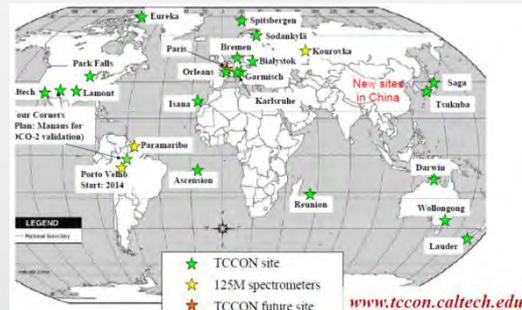
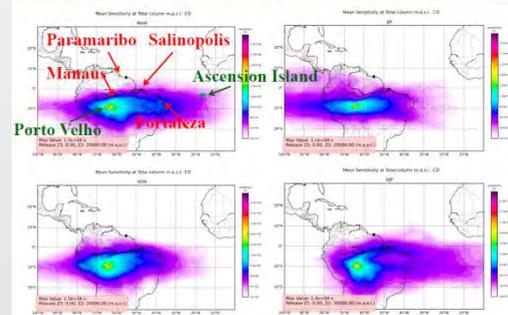


## Rationale for Porto Velho:

1. Amazon rainforest = important biogenic, biomass burning and greenhouse gas emissions
2. NIR-SWIR satellite observations of GHG have large uncertainties over the Amazon forest due to low albedo
3. Very few ground-based remote sensing (column/profile) observations over Amazon forest
4. Heterogeneity of Amazon forest => complementarity with Paramaribo FTIR
5. Area investigated by aircraft campaigns for atmospheric composition measurements



Total column sensitivity





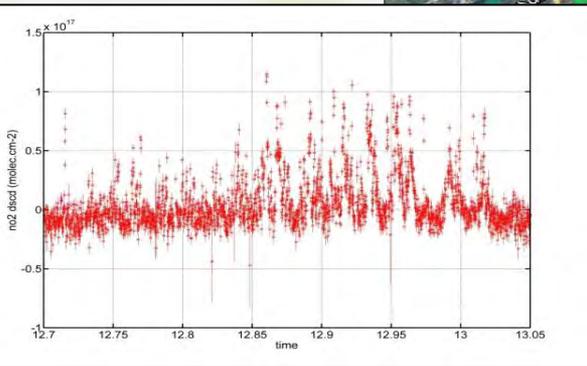
# Update on validation data AROMAT Campaigns



IASB-BIRA\_SWING/UAV Ref: Merlaud et al., 2013



ESA sponsored campaigns in 2014/09, 2015/08, 2017





# Update on AC validation methods Generic L2 data validation protocol



Atmos. Meas. Tech., 8, 2093–2120, 2015  
www.atmos-meas-tech.net/8/2093/2015/  
doi:10.5194/amt-8-2093-2015  
© Author(s) 2015. CC Attribution 3.0 License.



Atmospheric  
Measurement  
Techniques  
Open Access



## Round-robin evaluation of nadir ozone profile retrievals: methodology and application to MetOp-A GOME-2

A. Keppens<sup>1</sup>, J.-C. Lambert<sup>1</sup>, J. Granville<sup>1</sup>, G. Miles<sup>2</sup>, R. Siddans<sup>2</sup>, J. C. A. van Peet<sup>3</sup>, R. J. van der A<sup>3</sup>, D. Hubert<sup>1</sup>, T. Verhoelst<sup>1</sup>, A. Delcloo<sup>4</sup>, S. Godin-Beekmann<sup>5</sup>, R. Kivi<sup>6</sup>, R. Stübi<sup>7</sup>, and C. Zehner<sup>8</sup>

<sup>1</sup>Belgian Institute for Space Aeronomy (BIRA-IASB), Brussels, Belgium

<sup>2</sup>Rutherford Appleton Laboratory (RAL), Chilton, Didcot, UK

<sup>3</sup>Royal Netherlands Meteorological Institute (KNMI), De Bilt, the Netherlands

<sup>4</sup>Royal Meteorological Institute (KMI-IRM), Brussels, Belgium

<sup>5</sup>Laboratoire Atmosphère, Milieux, Observations Spatiales (LATMOS), Université Pierre et Marie Curie, Université Versailles St-Quentin-en-Yvelines, Centre National de la Recherche Scientifique, Paris, France

<sup>6</sup>Finnish Meteorological Institute (FMI-ARC), Sodankylä, Finland

<sup>7</sup>Federal Office of Meteorology and Climatology (MeteoSwiss), Payerne, Switzerland

<sup>8</sup>European Space Agency (ESA/ESRIN), Frascati, Italy

Correspondence to: A. Keppens (arno.keppens@aeronomie.be)

Received: 16 September 2014 – Published in Atmos. Meas. Tech. Discuss.: 21 November 2014

Revised: 17 April 2015 – Accepted: 24 April 2015 – Published: 20 May 2015

**Abstract.** A methodology for the round-robin evaluation and the geophysical validation of ozone profile data retrieved from nadir UV backscatter satellite measurements is de-

ferent recipes are investigated and discussed. Several approaches for information content quantification, vertical resolution estimation, and reference profile resampling are com-



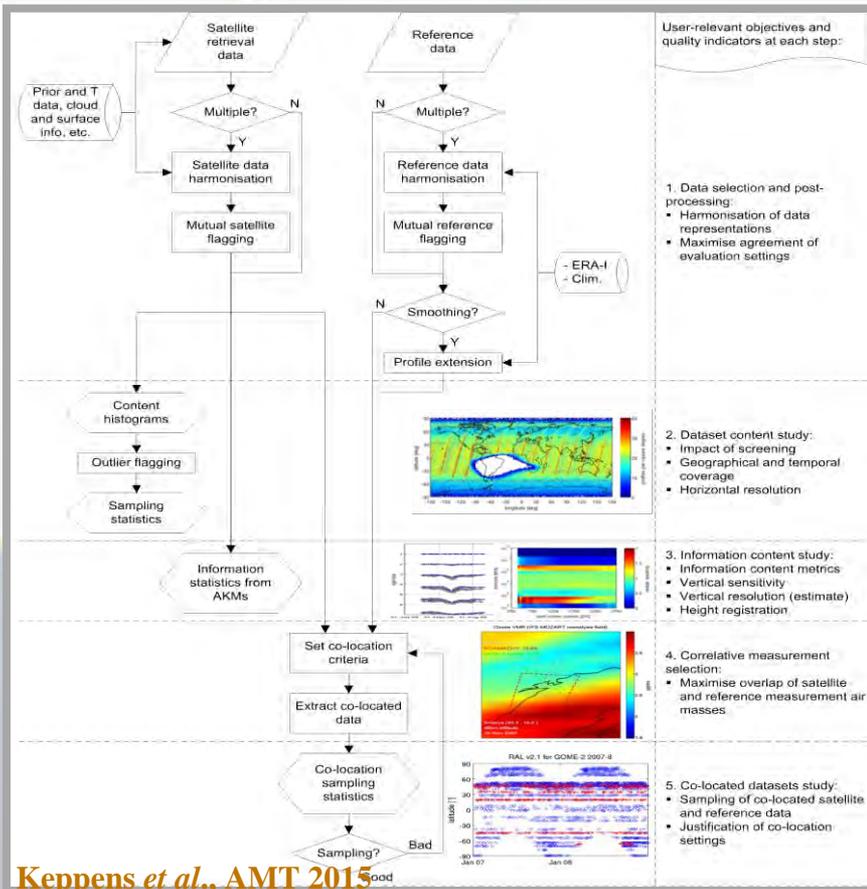
CEOS WGCV  
ACSG / ACC  
interaction  
through ESA  
CCI Ozone

Being  
implemented  
in QA4ECV  
Atmosphere  
Validation  
Server (AVS)

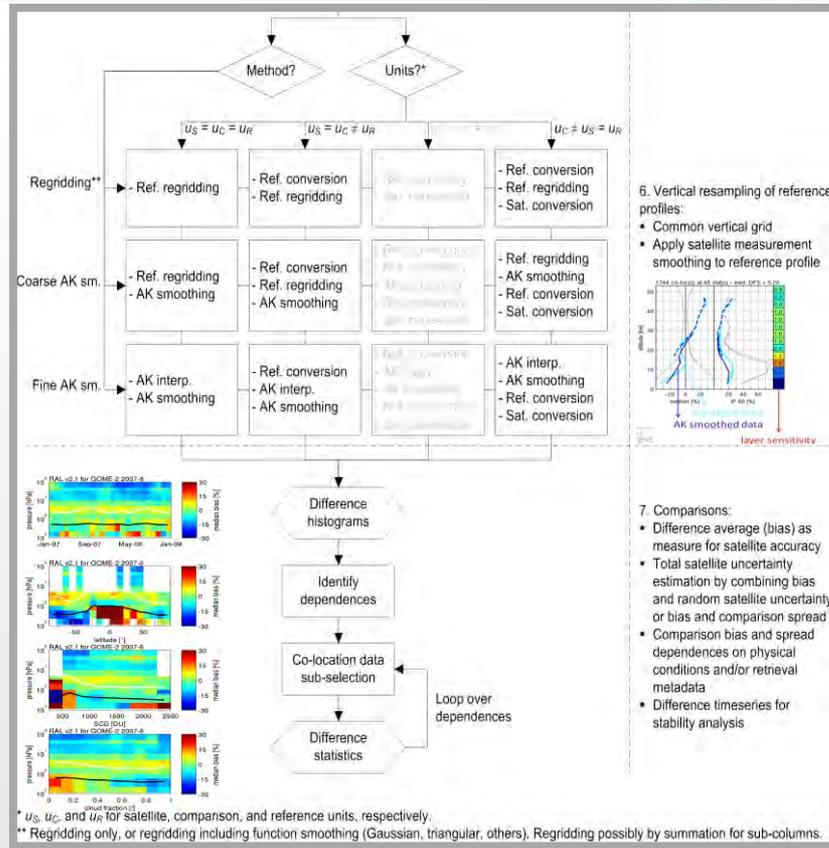
Working Group on Calibration and Validation

# Update on AC validation methods

## Generic L2 data validation protocol



Keppens et al., AMT 2015<sup>pod</sup>



Keppens et al., AMT 2015

# QA validation methods Validation protocol



Working Group on Calibration and Validation



Valid  
GME  
on A

PROJECT:  
SUB-PROJECT / CLUSTER:  
WORK PACKAGE / TASK:  
DELIVERABLE:

DATE: 03/01/2012  
VERSION: 1.0  
PHASE 1, TASK 1  
DELIVERABLE D2.1

WP Manager: J  
WP Manager O  
Other partners:  
VALT: A  
EOST: D  
CRG: D

PROJECT: M  
SUB-PROJECT / CLUSTER: M  
WORK PACKAGE / TASK: M  
DELIVERABLE: D\_MAN\_34

MACC-II Deliverable D\_153.1

## Atmospheric Validation

Date: May 2013  
Lead Beneficiary: BIRA-IASB (#6)  
Nature: R  
Dissemination level: PU



QA4ECV Report / Deliverable D2.4

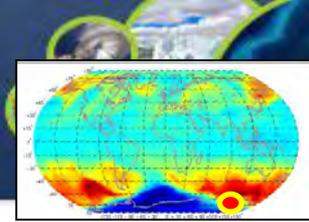
## Prototype QA/Validation Service for Atmospheric ECV Precursors: Detailed Processing Model Version 1

Date: DRAFT June 2015  
Lead Beneficiary: IASB-BIRA (#2)  
Nature: R  
Dissemination level: PU

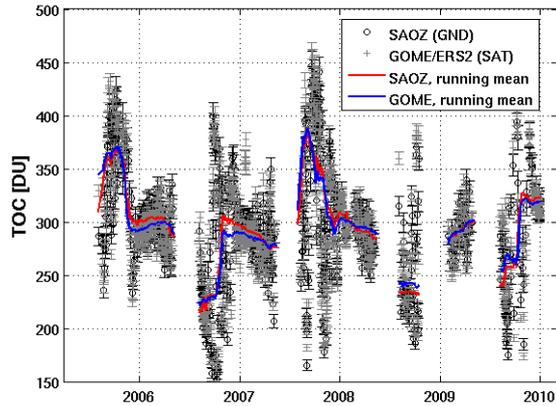




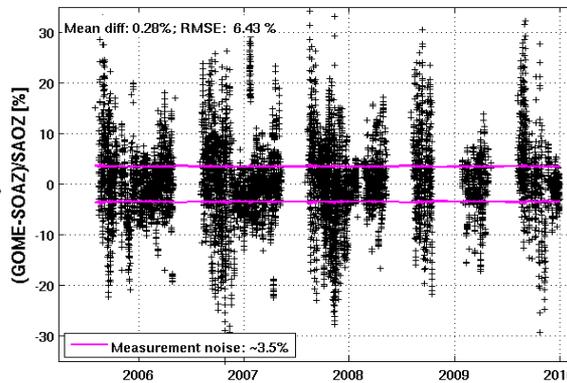
# Update on AC validation methods OSSSMOSE Metrology Simulator



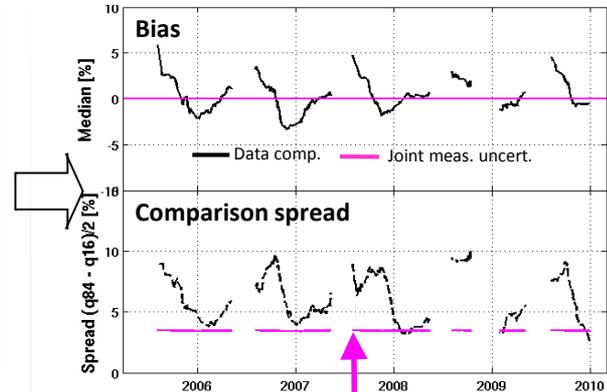
Total ozone data



Relative ozone differences



Statistics on differences



Measurement uncertainties often available and considered

$$S_{diff, f, \text{andom}} = S_{sat, \text{random}} + S_{gnd, \text{random}} + S_{smooth, \text{diff, f, \text{andom}}} + S_{spat, \text{inval, mat, r, \text{andom}}} + S_{temp, \text{or, inval, mat, r, \text{andom}}}$$

$$S_{diff, f, \text{ys}} = S_{sat, \text{sys}} + S_{gnd, \text{sys}} + S_{smooth, \text{diff, f, \text{ys}}} + S_{spat, \text{inval, mat, s, \text{ys}}} + S_{temp, \text{or, inval, mat, s, \text{ys}}}$$

Additional errors due to mismatches usually missing, hence neglected

calibration and validation



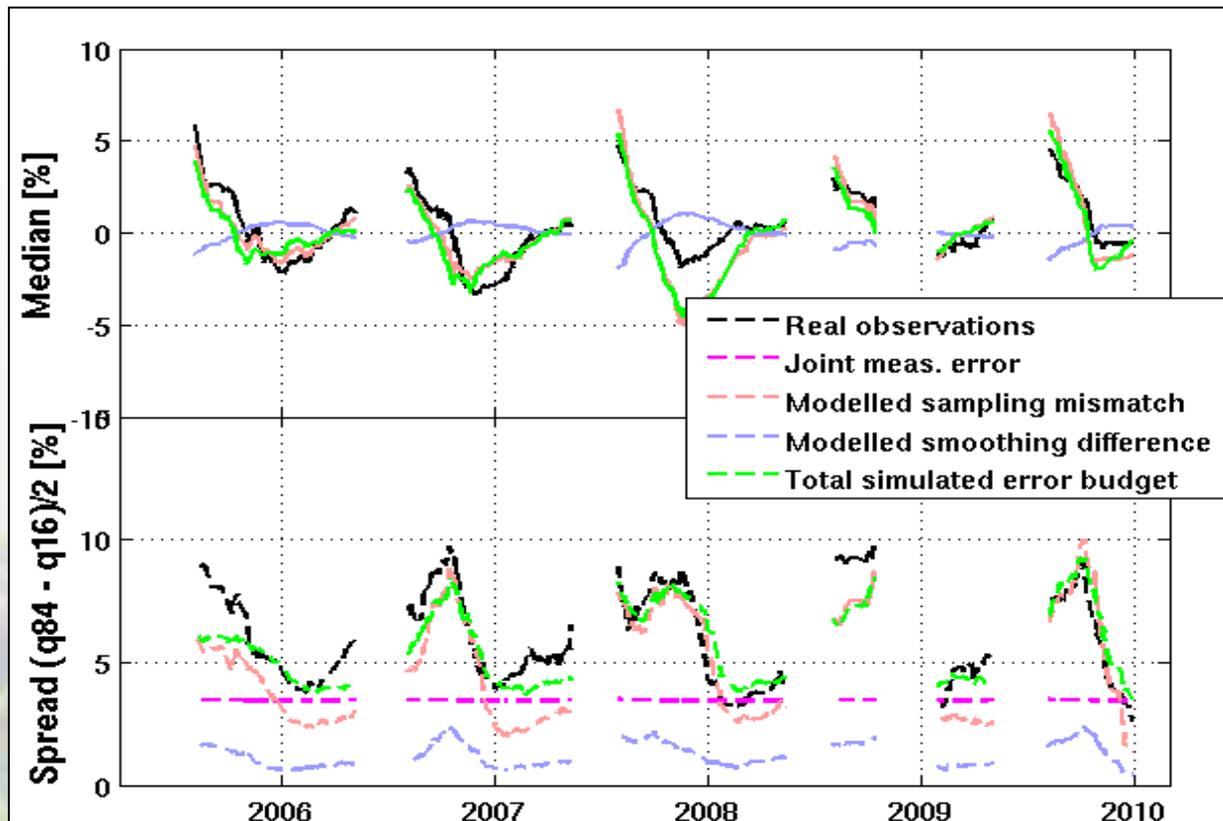
# Update on AC validation methods OSSSMOSE Metrology Simulator



## Error budget closure for ozone column validation

Pioneering in  
BELSPO/PRODEX A3C:  
OSSSMOSE application to  
GOME GODFIT v3 vs.  
CNRS SAOZ v3 in Dumont  
d'Urville (ANT)

**Now: Wider application  
to several CDRs in  
EU GAIA-CLIM  
Virtual Observatory  
developed at  
EUMETSAT**



Verhoelst et al., AMT 2015



# BELSPO / FSIs

## Update on AC validation systems



### **Multi-TASTE: Unification of satellite validation systems:**

- CP => Phase E => Phase F: ESA Multi-TASTE, EUMETSAT O3M-SAF
- Long-term/Climate Data Records: SI2N, ESA CCI
- Generic framework, specific methods and tools, linkage with Copernicus Climate Change Service: QA4EO, EU FP7 QA4ECV
- Versatile validation system for atmospheric composition satellites
- Baseline for QA4ECV AVS Detailed Processing Model

### **NORS: NDACC-based validation server for Copernicus Atmosphere**

- FP7 project ended; MACC-III funding for implementation of routine activity
- NORS transfer to CAMS NDACC operational validation line
- On-line operational validation + contributor to 3-monthly reports

**No funding for data acquisition and analysis (“in situ“ component) !**



<http://atmosphere.copernicus.eu>

**Opennicus**  
Europe's eyes on Earth

**Atmosphere Monitoring Service**

MENU

CAMS NDACC Validation Server Browse reports Help Sign in

### The CAMS NDACC Validation Server

On this validation website you can browse and view intercomparison reports that use remote sensing data from NDACC network stations to validate models produced by the CAMS project.

[Browse the Validation Server intercomparison reports](#)

[Learn about the Models, Instruments, and Parameters used in the validation](#)

[Download CAMS validation reports](#)

This validation server was initially developed within the context of NORS (*Demonstration Network Of ground-based Remote Sensing Observations in support of the Copernicus Atmospheric Service*), an FP7 R&D project.

[Visit the NORS project home page](#)

The CAMS NDACC Validation Server is copyright © 2013-16 by s&lt, The Netherlands.

ECMWF COPERNICUS | REPORT

**Opennicus**  
Europe's eyes on Earth

**Copernicus Atmosphere Monitoring Service**

## Validation report of the CAMS near-real time global atmospheric composition service

### System evolution and performance statistics

### Status up to 1 December 2015

Issued by: KNMI  
Date: 29/02/2016  
REF.: CAMS84\_2015SC1\_D.84.1.2-2016Q1\_201602

EUROPEAN UNION Copernicus ECMWF



[Contact us](#)

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EVENTS
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RESOURCES
TENDERS
USER SUPPORT

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CAMS NDACC Validation Server
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Help ▾
Sign in

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### Intercomparison Selection

**PARAMETER**

AEROSOL (4)

CH2O (8)

CH4 (3)

CO (4)

NO2 (9)

O3 (20)

**MODEL TYPE**

o-suite (13)

control (13)

fnyp (9)

g4e2 (13)

**INSTRUMENT TYPE**

FTIR (18)

LIDAR (4)

MWR (4)

UVVIS.DOAS.DIRECTSUN (4)

UVVIS.DOAS.OFFAXIS (11)

UVVIS.DOAS.ZENITH (7)

### 1000 Reports

1 2 3 4 5 6 7 8 9 10

O3-o-suite-UVVIS.DOAS.ZENITH, BIRA.IASB@JUNGFRAUJOCH: 2016-02 [zip](#) [pdf](#)

(AN o-suite vs UVVIS.DOAS.ZENITH@JUNGFRAUJOCH, 2016-02-01 00:00 to 2016-02-29 00:00)

O3-o-suite-MWR, UBERN@BERN: 2016-02 [zip](#) [pdf](#)

Mean O3.MIXING.RATIO.VOLUME profiles CAMS vs NDACC  
(AN o-suite vs MWR@BERN, 2016-02-01 00:00 to 2016-02-29 00:00)

### Filter Options

**LOCATION**

[ALL]	158
ALTZOMONI	13
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## Mission Exploration Platform (MEP) PROBA-V

- ESA pathfinder project
- Operational platform hosted by VITO; big data and standards TRASYS, SPACEBEL
- Engaged third-party projects and users
- Data: SPOT-VEGETATION (1998) till present PROBA-V
- Also MERIS and AVHRR
- Also correlative data needed for Cal/Val and derived products
- Tools/libraries/applications
- Pre-release 2016, iterations 2016-2018

<http://proba-v-mep.esa.int>



esa Mission Exploitation Platform PROBA-V

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About MEP PROBA-V Applications Documents Blog Software & tools Contact

You are here: Home Applications Time Series Viewer

### Time Series Viewer

This application allows you to explore and view PROBA-V time series and in the future as well derived indicators for vegetation and environmental monitoring.

In the pre-release (Jan 2016) the application is available on the PROBA-V S10 TOC NDVI and rainfall data from CHIRPS. Soon derived parameters from the Copernicus Global Land Service (<http://land.copernicus.eu/global>) will be added.

In future releases, more data collections will be added, e.g. all radiometric bands from PROBA-V S10. The functionality of the application will be extended allowing a user to draw a polygon as AOI for which the time series will be calculated on-the-fly. Furthermore Web services can be developed to integrate this service as a data feed into a user application.

Applications

- Geo Viewer
  - Launch Geo Viewer
- Time Series Viewer
  - Launch Time Series Viewer
- N-daily Compositor
  - Launch N-Daily Compositor
- Cloud Toolbox

Spotlight

ESA PROBA-V app for Android

GET IT ON Google Play

Recent blog posts

- 10/03/2016 - ESA Proba-V app for Android
- 13/01/2016 - iPython notebooks preview
- 30/11/2015 - MEP PROBA-V release on January 26

MEP Stakeholders

Launch application

User guide

Consortium partners





# Belgian Science Policy Office (BELSPO) / Federal Scientific Institutes (FSIs)

## II. Background information

Jean-Christopher Lambert

Royal Belgian Institute for Space Aeronomy (IASB-BIRA)

Agency Reports II

WGCV Plenary # 40

Canberra, March 14-18, 2016

**Working Group on Calibration and Validation**

