



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

I. Update on Cal/Val Activities

Jean-Christopher Lambert

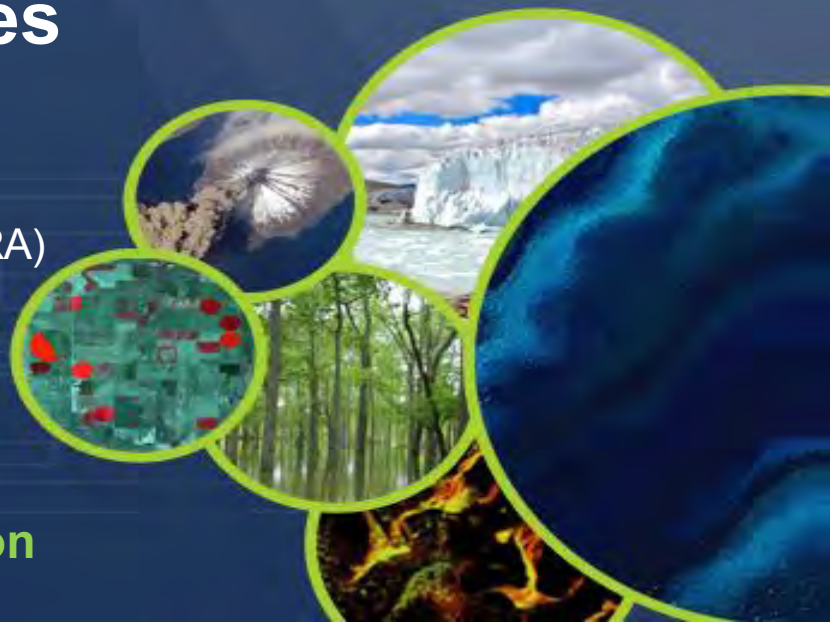
Royal Belgian Institute for Space Aeronomy (IASB-BIRA)

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





Updates on:

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



BELSPO / FSI's

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

In brief...

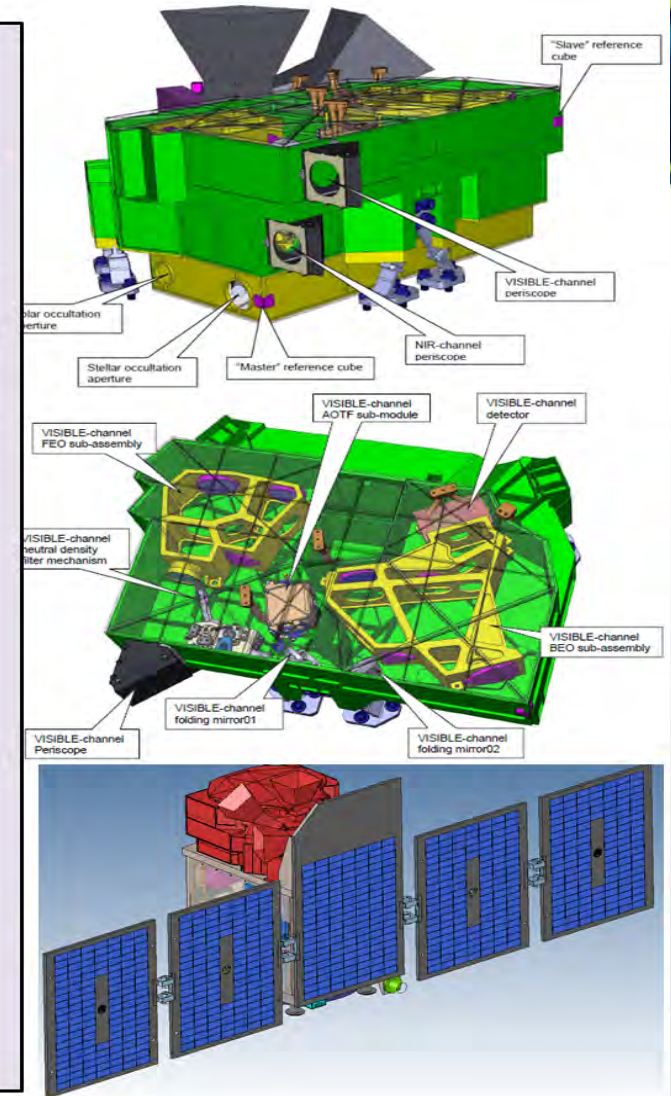
- Atmospheric limb sounder ($z=0-100$ km, $dz \leq 1$ km) for O_3 , NO_2 , aerosols, PSC, PMC, CH_4 , H_2O , $OCIO$, BrO , NO_3 , temperature
- 3 tunable **spectral imagers** (Fabry-Pérot in UV, AOTF in VIS, NIR) ($\lambda=250-1800$ nm, $d\lambda=1-10$ nm)
- Observations in **multi-mode geometries**: limb-scattering, solar, stellar, lunar, planetary occultations
- LEO sunsynchronous 10:30 LTDN, PROBA class (≤ 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

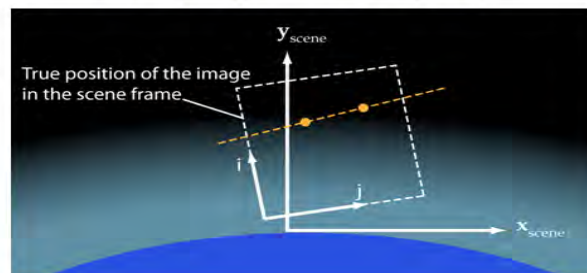
Priority	Observable	Vertical range	Vertical res. [km]	Horizontal res. along parallels [km]	Horizontal res. along meridians [km]	Total error [%]	Coverage	Photo-chemistry [day/night]
A	O ₃	UT-LS	1	10	500	5	global	d/n
A	O ₃	US	1	10	500	5	global	d/n
A	O ₃	MS	1	50	500	20	polar	n
B	NO ₂	LS-US	2	50	500	30	global	d/n
B	H ₂ O	UT-LS	2	50	500	20	global	d/n
B	CH ₄	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 ₃	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)

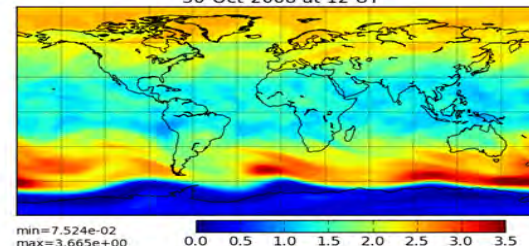


Pointing registration with stars
in FOV (target: <150m, 1σ)

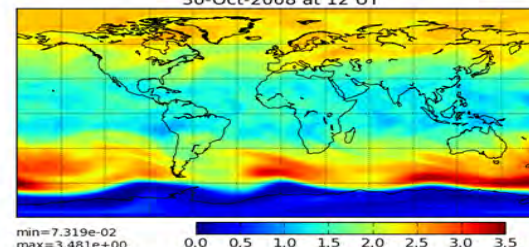


O3 Level-3 product performance

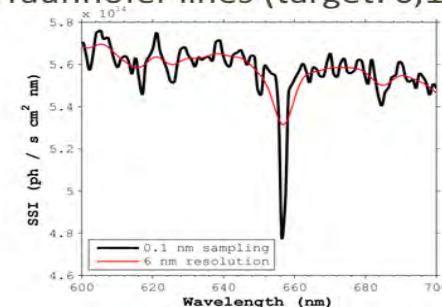
BASCOE ALTIUS Assimilation
30-Oct-2008 at 12 UT



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

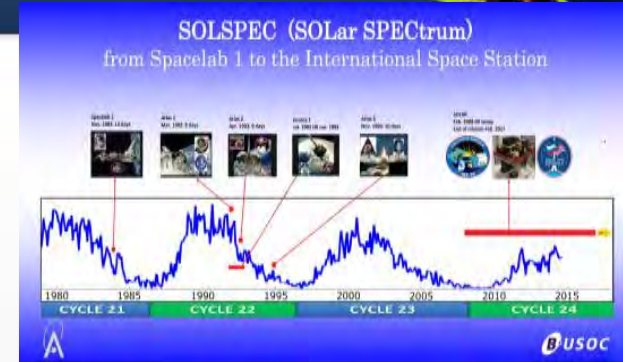


SOLAR on ISS/Columbus (L2008)

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

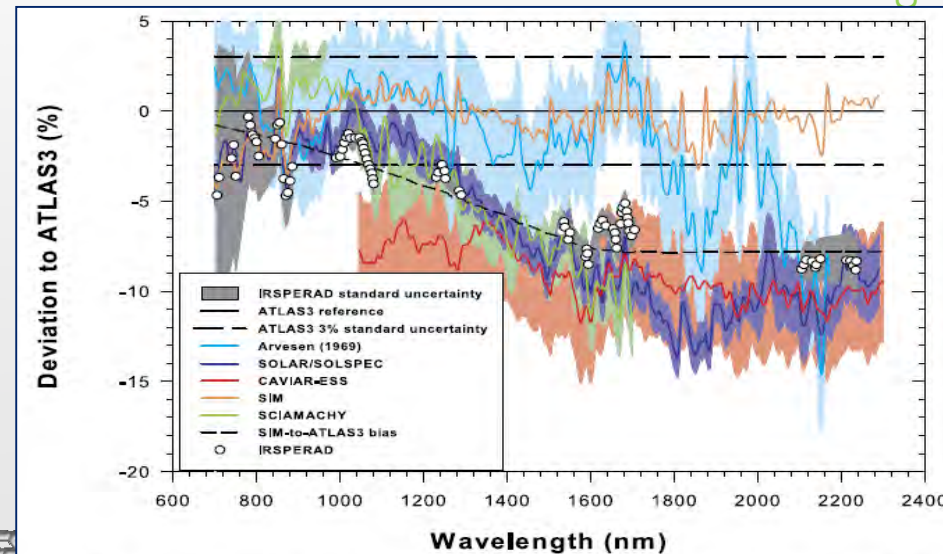
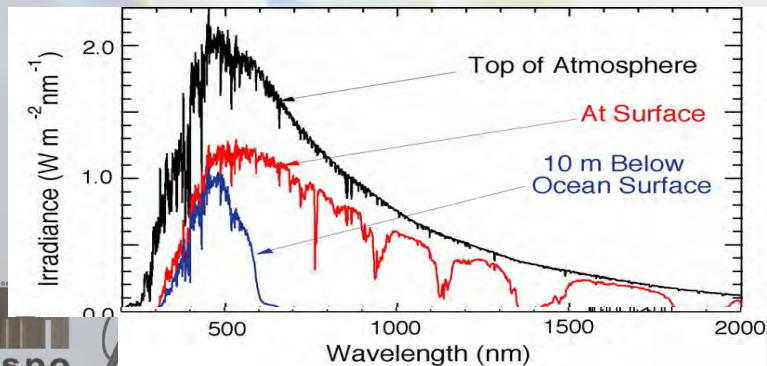
PROBA-3 (L2018) Formation flying for solar corona observations





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



Courtesy D. Gillotay and D. Bolsée⁸



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)

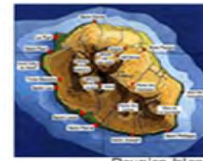
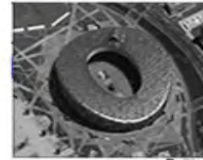
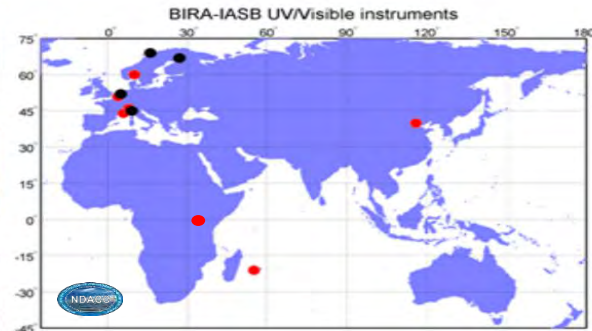
Marine: <http://www.mumm.ac.be/datacentre>

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

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

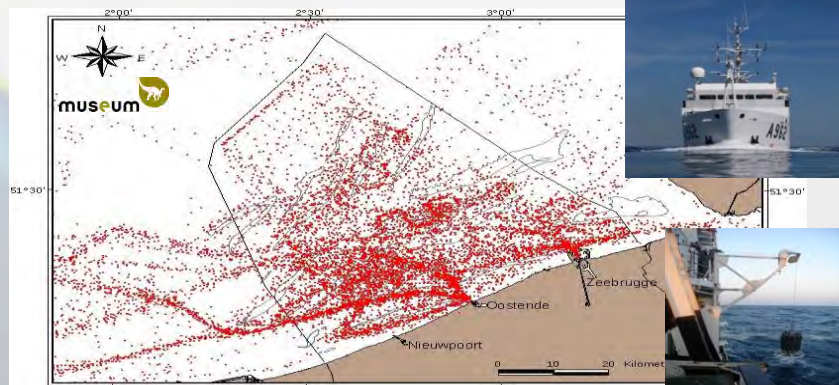
- Solar UV-Visible Irradiance Monitoring Network (7 RT stations in Belgium + Belgian Antarctic Base), with centralised calibration centre in Uccle
- Spectral irradiance 280-600 nm, broadband, clouds, sunshine duration...

Update on validation data Contribution to networks



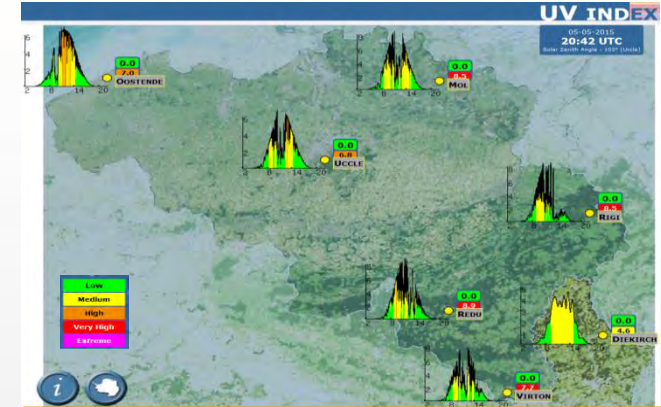
Contact M. Van Roozendaal and F. Hendrick, BIRA-IASB
+ Brewer/O₃sondes in Uccle, H. De Backer, RMIB

IRSN/MUMM North Sea measurements



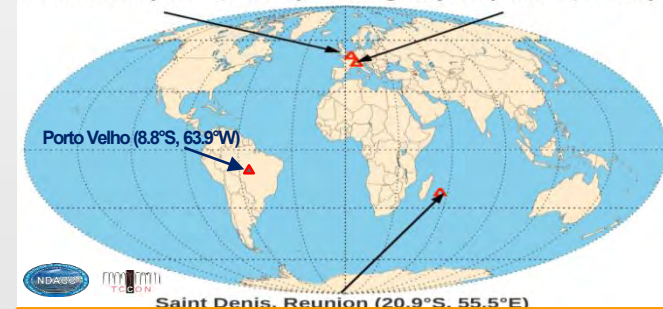
Contact S. Scory, IRSN/MUMM

BIRA-IASB UV radiation measurements



Contact D. Bolsée, BIRA-IASB

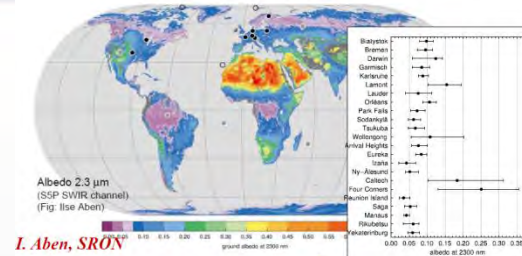
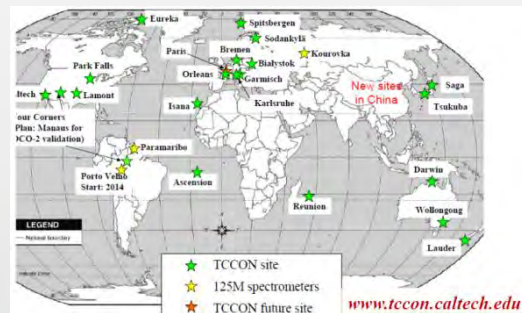
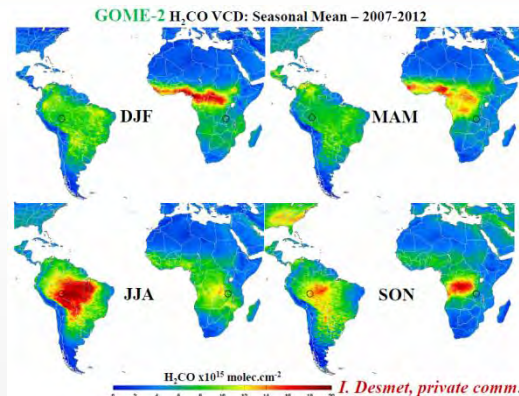
BIRA-IASB and ULg FTIR instruments (NDACC and TCCON)



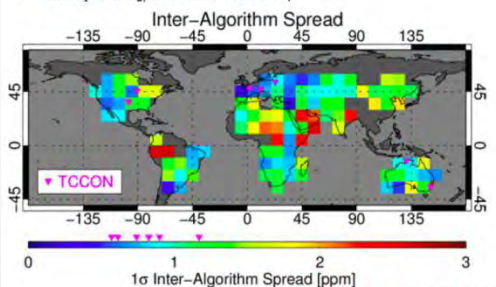
Contact M. De Mazière, BIRA-IASB

Rationale for Porto Velho:

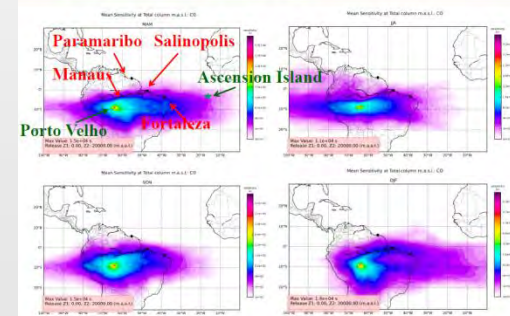
1. Amazon rainforest = important biogenic, biomass burning and greenhouse gas emissions
2. NIR-SWIR satellite observations of GHG have large uncertainties over the Amazon forest due to low albedo
3. Very few ground-based remote sensing (column/profile) observations over Amazon forest
4. Heterogeneity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



- Example CO₂, same issue for CH₄



Total column sensitivity

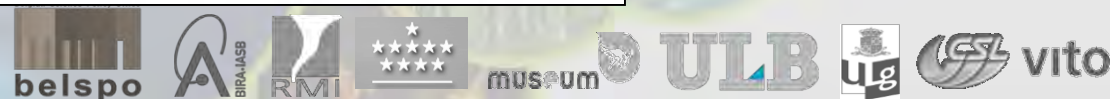
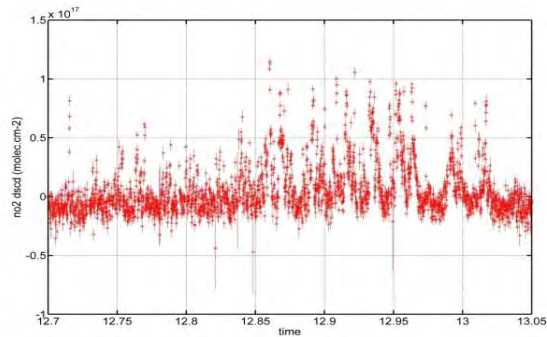
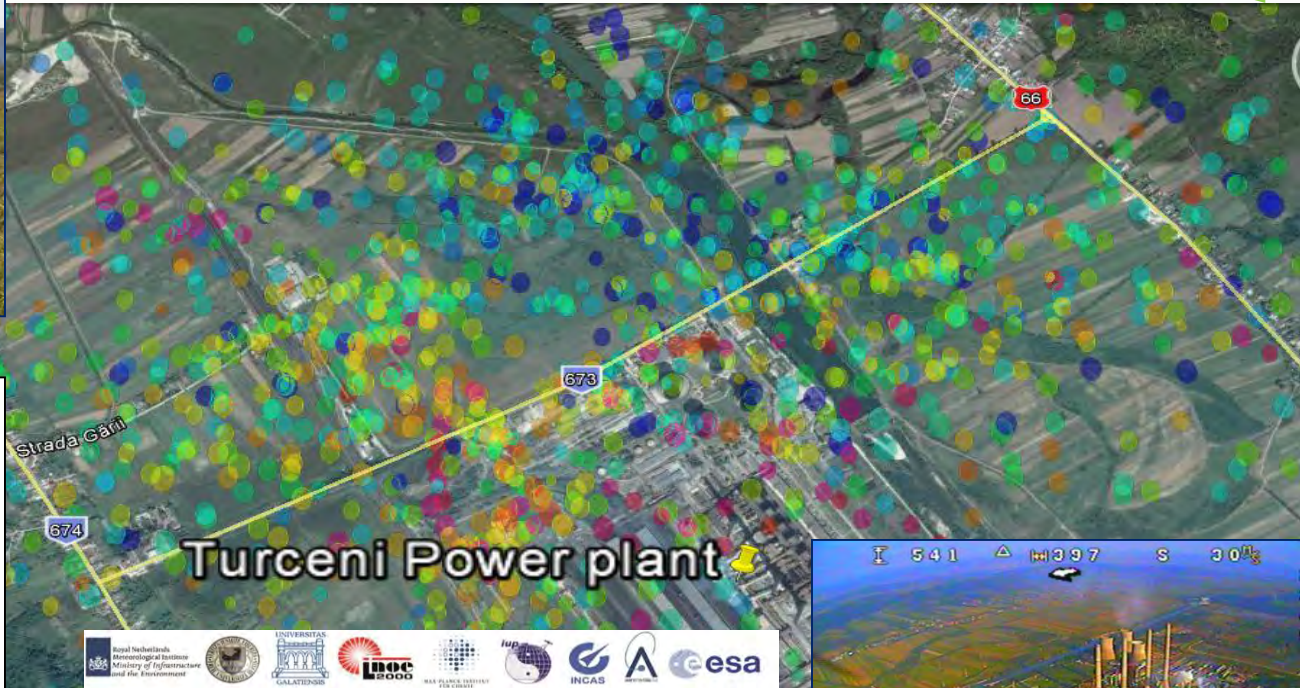


Update on validation data AROMAT Campaigns

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



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

A. Keppens¹, J.-C. Lambert¹, J. Granville¹, G. Miles², R. Siddans², J. C. A. van Peet³, R. J. van der A³, D. Hubert¹, T. Verhoelst¹, A. Delcloo⁴, S. Godin-Beekmann⁵, R. Kivi⁶, R. Stübi⁷, and C. Zehner⁸

¹Belgian Institute for Space Aeronomy (BIRA-IASB), Brussels, Belgium

²Rutherford Appleton Laboratory (RAL), Chilton, Didcot, UK

³Royal Netherlands Meteorological Institute (KNMI), De Bilt, the Netherlands

⁴Royal Meteorological Institute (KMI-IRM), Brussels, Belgium

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

⁶Finnish Meteorological Institute (FMI-ARC), Sodankylä, Finland

⁷Federal Office of Meteorology and Climatology (MeteoSwiss), Payerne, Switzerland

⁸European 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



CCI
ozone

esa



CEOS
ACC



QA4ECV



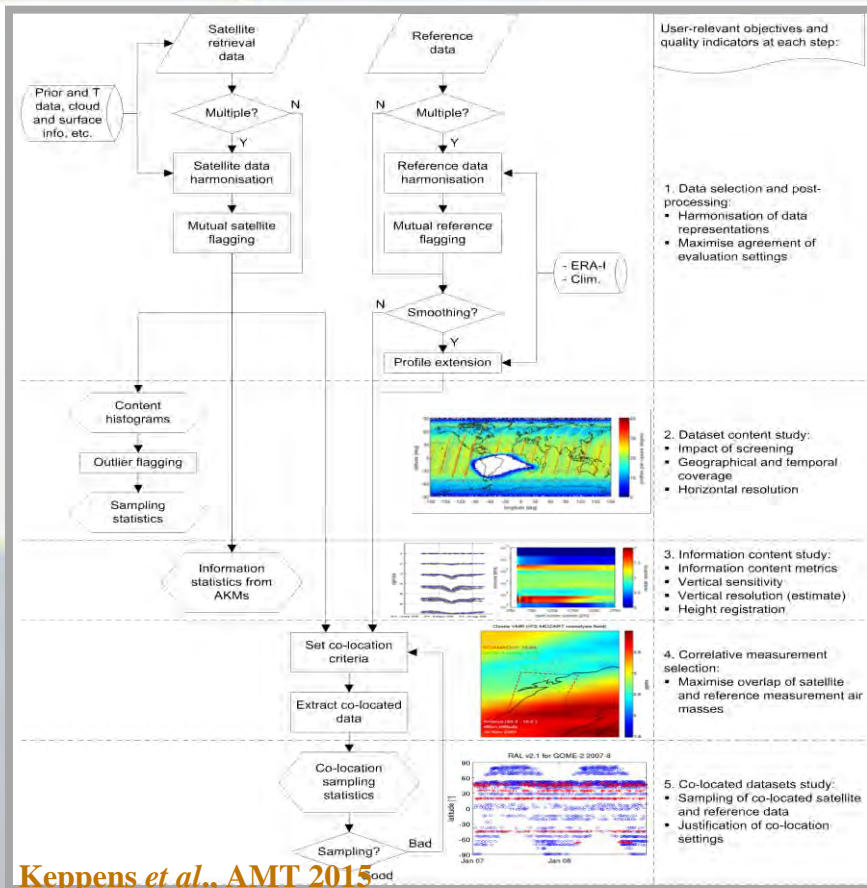
CEOS WGCV
ACSG / ACC
interaction
through ESA
CCI Ozone

Being
implemented
in QA4ECV
Atmosphere
Validation
Server (AVS)

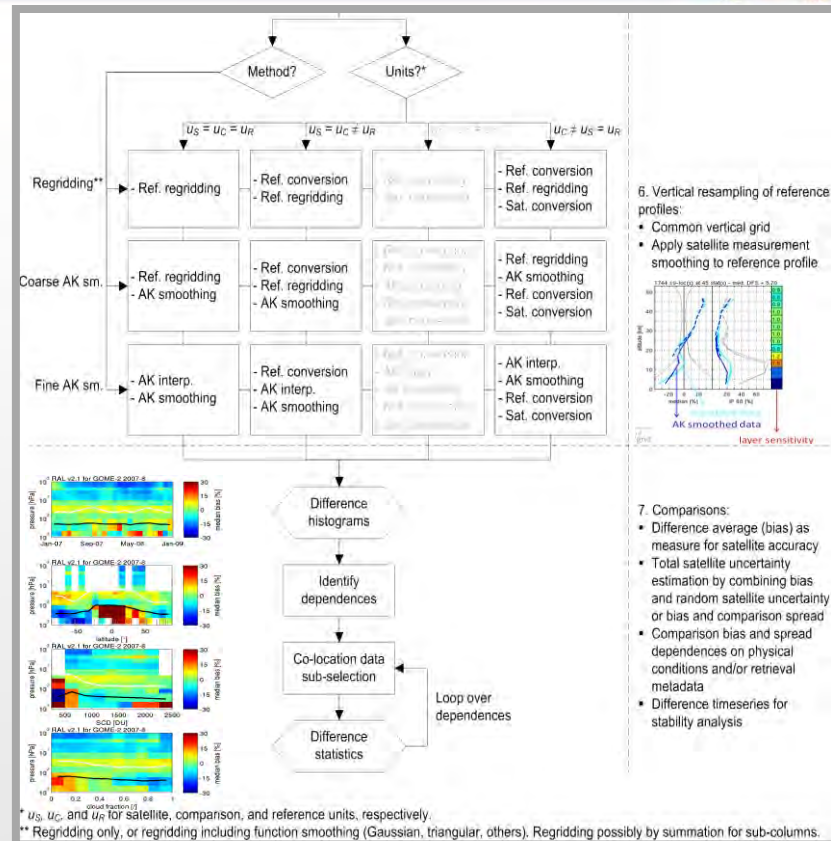
Working Group on Calibration and Validation

Update on AC validation methods

Generic L2 data validation protocol



Keppens et al., AMT 2015



* U_S , U_C and U_R for satellite, comparison, and reference units, respectively.

** Regridding only, or regridding including function smoothing (Gaussian, triangular, others). Regridding possibly by summation for sub-columns.

Keppens et al., AMT 2015

QA validation methods Validation protocol



Working Group on Calibration and Validation



MACC-II Deliverable D_153.1

Atmospheric Validation

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

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

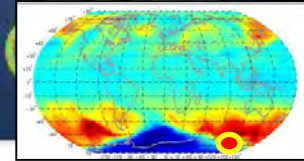
Date: DRAFT June 2015
Lead Beneficiary: IASB-BIRA (#2)
Nature: R
Dissemination level: PU



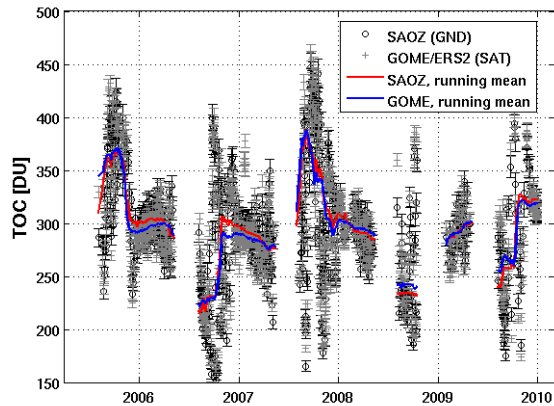
PROJECT:
SUB-PROJECT / CLUSTER:
WORK PACKAGE / TASK:
DELIVERABLE:

D_MAN_34

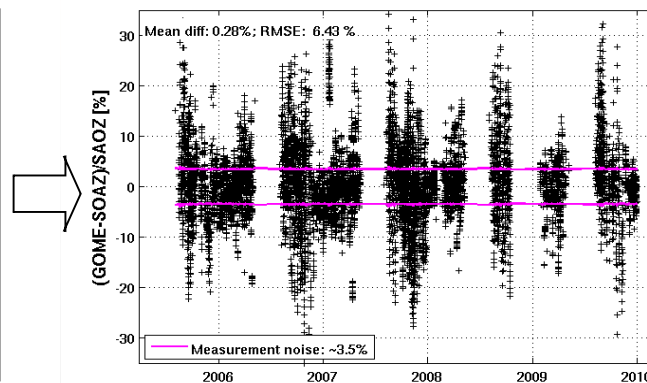
Update on AC validation methods OSSSMOSE Metrology Simulator



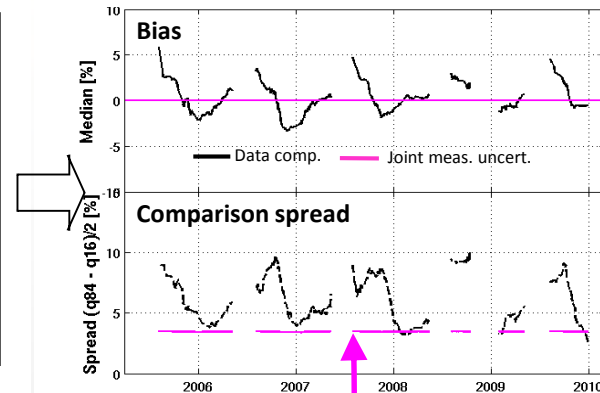
Total ozone data



Relative ozone differences



Statistics on differences



Measurement uncertainties often available and considered

$$S_{diff, f, \text{andom}} = S_{sat, \text{andom}} + S_{gnd, \text{andom}} + S_{smooth, \text{diff, f, andom}} + S_{spat, \text{inils mat } \text{andom}} + S_{tempor, \text{ils mat } \text{andom}}$$

$$S_{diff, f, \text{ys}} = S_{sat, \text{ys}} + S_{gnd, \text{ys}} + S_{smooth, \text{diff, f, ys}} + S_{spat, \text{inils mat } \text{ys}} + S_{tempor, \text{ils mat } \text{ys}}$$

Additional errors due to mismatches usually missing, hence neglected

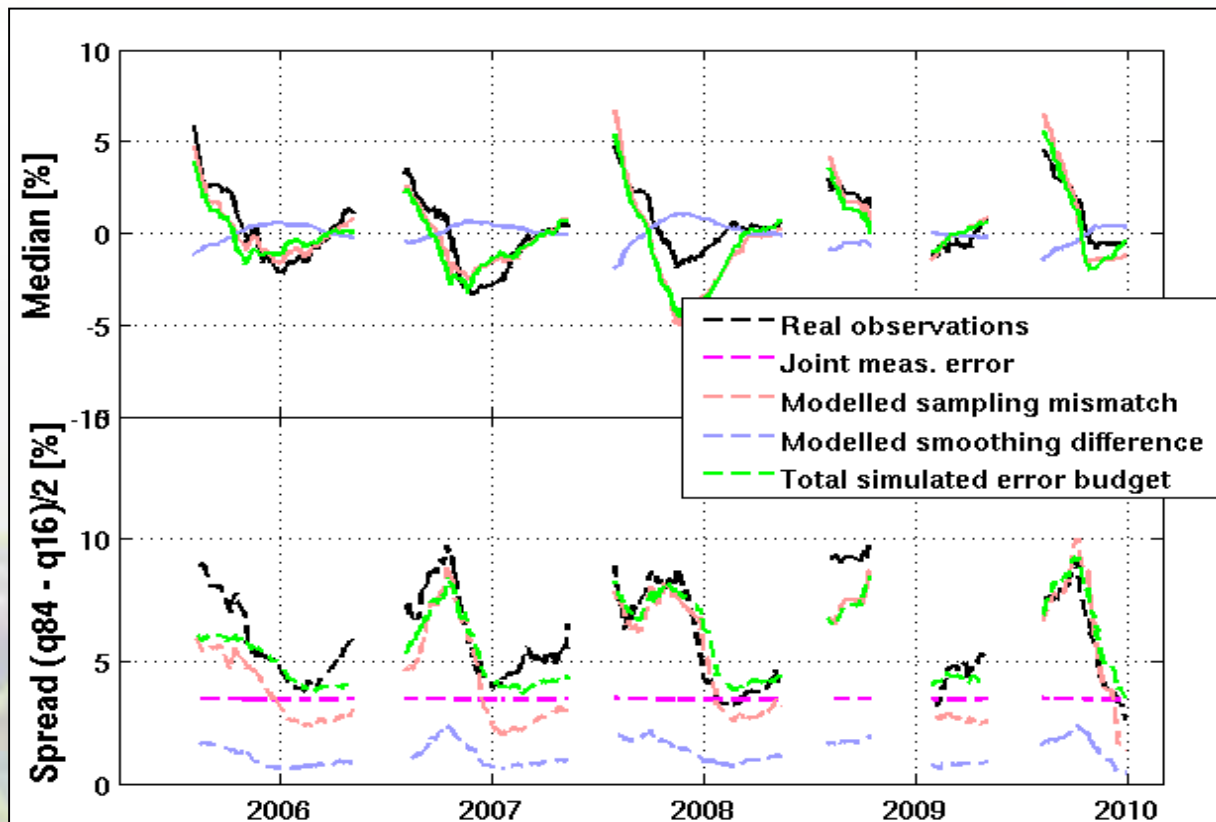
calibration and validation



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) !

Update on AC validation systems

CAMS NDACC Validation Server

<http://atmosphere.copernicus.eu>



CAMS NDACC Validation Server

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[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 [sl<](#), The Netherlands.

ECMWF COPERNICUS | REPORT



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



Update on AC validation systems

CAMS NDACC Validation Server





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CAMS NDACC Validation Server [Browse reports](#)
[Help](#) [Sign in](#)

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](#)

O3 total column values per location
 (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
BERN	40
BREMEN	30
BUJUMBURA	35
EUREKA	28
HARESTUA	39
HAUTE.PROVENCE	69
IZANA	68
JUNGFRAUJOCH	113
KIRUNA	7
LA.REUNION.MAIDO	61
LA.REUNION.STDENIS	29
LAUDER	18
MAUNA.LOA.HI	23
NY.ALESUND	56
RIO.GALLEGOS	17
THULE	14
TORONTO	48
UCCLE	27
WOLLONGONG	11
XIANGHE	65
ZUGSPITZE	28

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

Consortium partners



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

Working Group on Calibration and Validation



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

II. Background information

Jean-Christopher Lambert

Royal Belgian Institute for Space Aeronomy (IASB-BIRA)

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