Committee on Earth Observation Satellites
Working Group on Calibration & Validation

37th CEOS WGCV Plenary
Hosted by ESA/ESRIN
Frascati, Italy
17-20 February 2014

Agency report

BELGIAN INSTITUTE FOR SPACE AERONOMY (BIRA-IASB)

A Federal Scientific Institute under the Authority of the

BELGIAN FEDERAL SCIENCE POLICY OFFICE (BelSPO)

Jean-Christopher LAMBERT

With contributions from

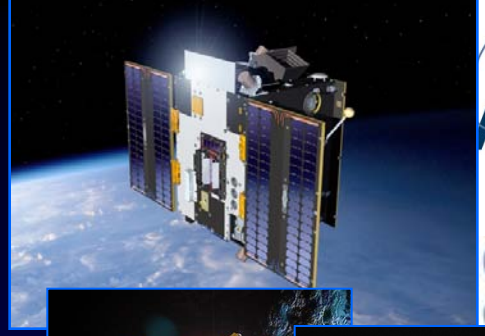
ROYAL METEOROLOGICAL INSTITUTE OF BELGIUM (RMIB)
ROYAL OBSERVATORY OF BELGIUM (ROB)
UNIVERSITY OF LIEGE (ULg)
FREE UNIVERSITY OF BRUSSELS (ULB)

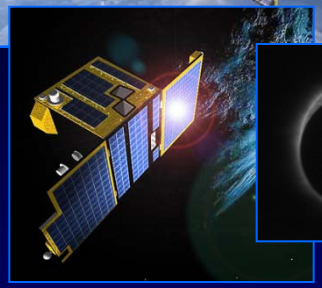
1. Solar and Atmospheric Composition Missions

ISS / COLUMBUS
SOLAR

- Three instruments covering solar spectral irradiance from 17 nm to 100 µm (99% of solar energy)
  - **SOLSPEC (SOLar SPECtral Irradiance measurements)**: 180 nm – 3 000 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)
- Facility Support Centre: Belgian USOC at BIRA-IASB

PROBA Series
EO and Solar





- PROBA = ESA's 'PROject for OnBoard Autonomy'
- Small satellites for technology demonstrations; prime contractor Qinetic Space, Belgium
- **PROBA-1**: launched October 2001; EO sensors still operating; transferred to ESA's Earth Observation Directorate
- **PROBA-2**: 1st ESA space weather mission dedicated to Sun observation, launched Nov. 2, 2009; 4 Belgian and CZ sensors
- **PROBA-V**: miniaturised version of the SPOT-5 VEGETATION, launched 7 May 2013 from Kourou
- **PROBA-3**: double spacecraft to study solar corona while testing precise formation-flying techniques; launch 2016
- **Altius**: atmospheric limb mission for atmospheric composition

ALTIUS – Mission concept

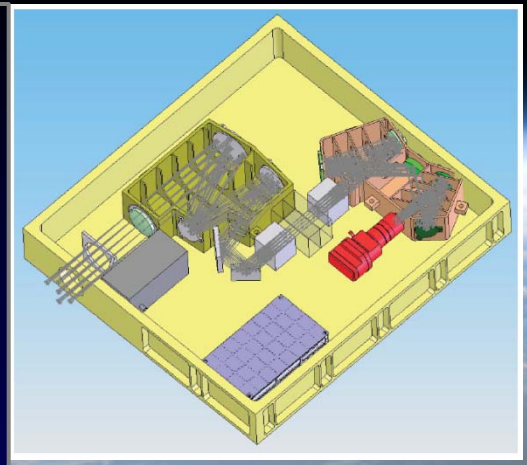
-UV-Vis-NIR spectral imager on-board a PROBA platform on Sun-synchronous LEO.
-3 modes : limb scattering + solar occultation + stellar occultation.
-3 independant spectral channels with AOTF (TeO_2 and KDP).
-Target species : O_3, NO_2, CH_4, H_2O, BrO, PSC, aerosols,...

ALTIUS – Current status

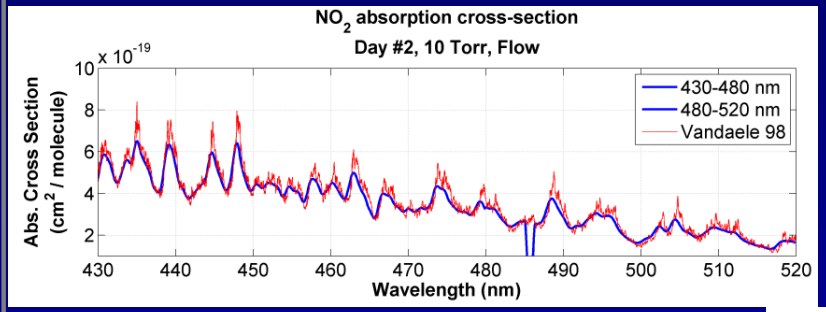
Now in Phase B1 towards PDR.

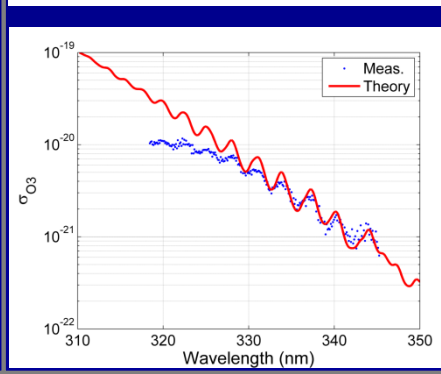
ALTIUS – Breadboarding

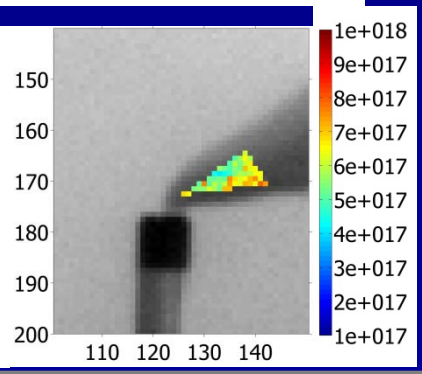
- Demonstration of spectral performance with NO_2 (VIS) and O_3 (UV).
- Spectral imaging.
- Instrument characterisation.
- Test case: Remote sensing of NO_2 emissions from incinerator

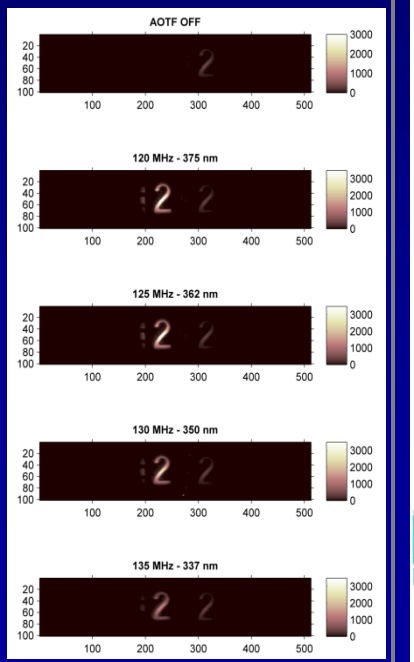


Dekemper et al., Applied Optics 2012









ATMOSPHERIC COMPOSITION MISSIONS

Belgian involvement in:

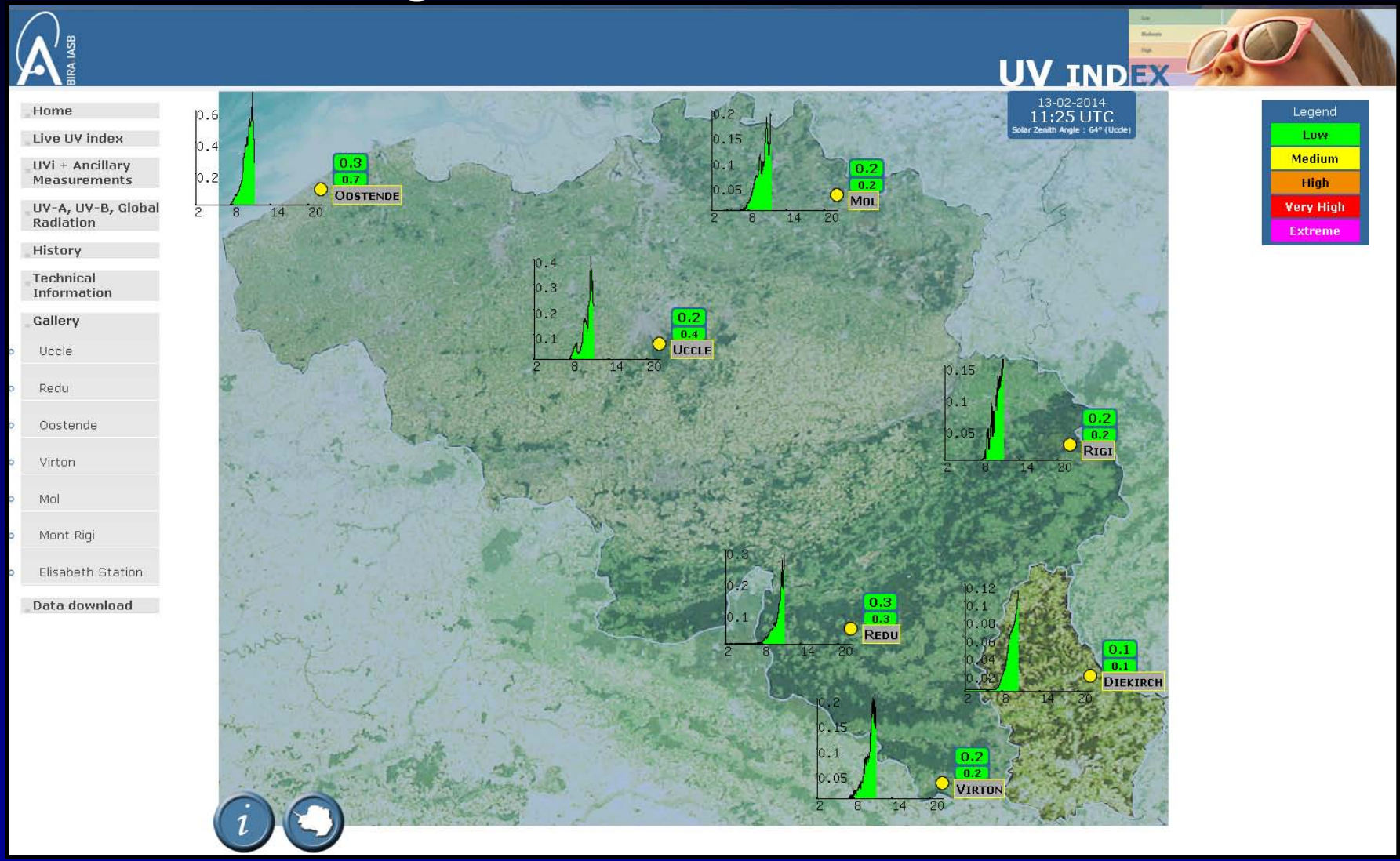
- **ERS-2 GOME** (SAG, retrieval, Cal/Val)
- **Meteor-3M SAGE-III** (ST, retrieval, Cal/Val)
- **SCISAT-1 ACE** (Belgian imagers, SAG, retrieval, Cal/Val)
- **Envisat SCIAMACHY** (Co-PI, Belgian PMDs, SAG, retrieval, Cal/Val)
- **Envisat GOMOS and MIPAS** (SAG, retrieval, Cal/Val)
- **EOS-Terra MOPITT** (ST, retrieval, Cal/Val)
- **EOS-Aura OMI** (ST, retrieval, Cal/Val)
- **MetOp-A/B GOME-2 and IASI** (SAG, SAF, retrieval, Cal/Val)
- **TANSO-GOSAT** (TCCON, Cal/Val)
- **Copernicus Sentinels 4 (GEO) and 5 (LEO), Sentinel 5 Precursor**
- **Definition of future missions** (MAG, ACC, ORM…)
- **Development of Altius** (PI)

+ SPICAV/SOIR on VENUS EPXRESS, SOIR-NOMAD on ExoMars…

2. Reference Measurements for Satellite Validation

UV Monitoring Stations

http://uvindex.aeronomie.be



UV Monitoring Stations

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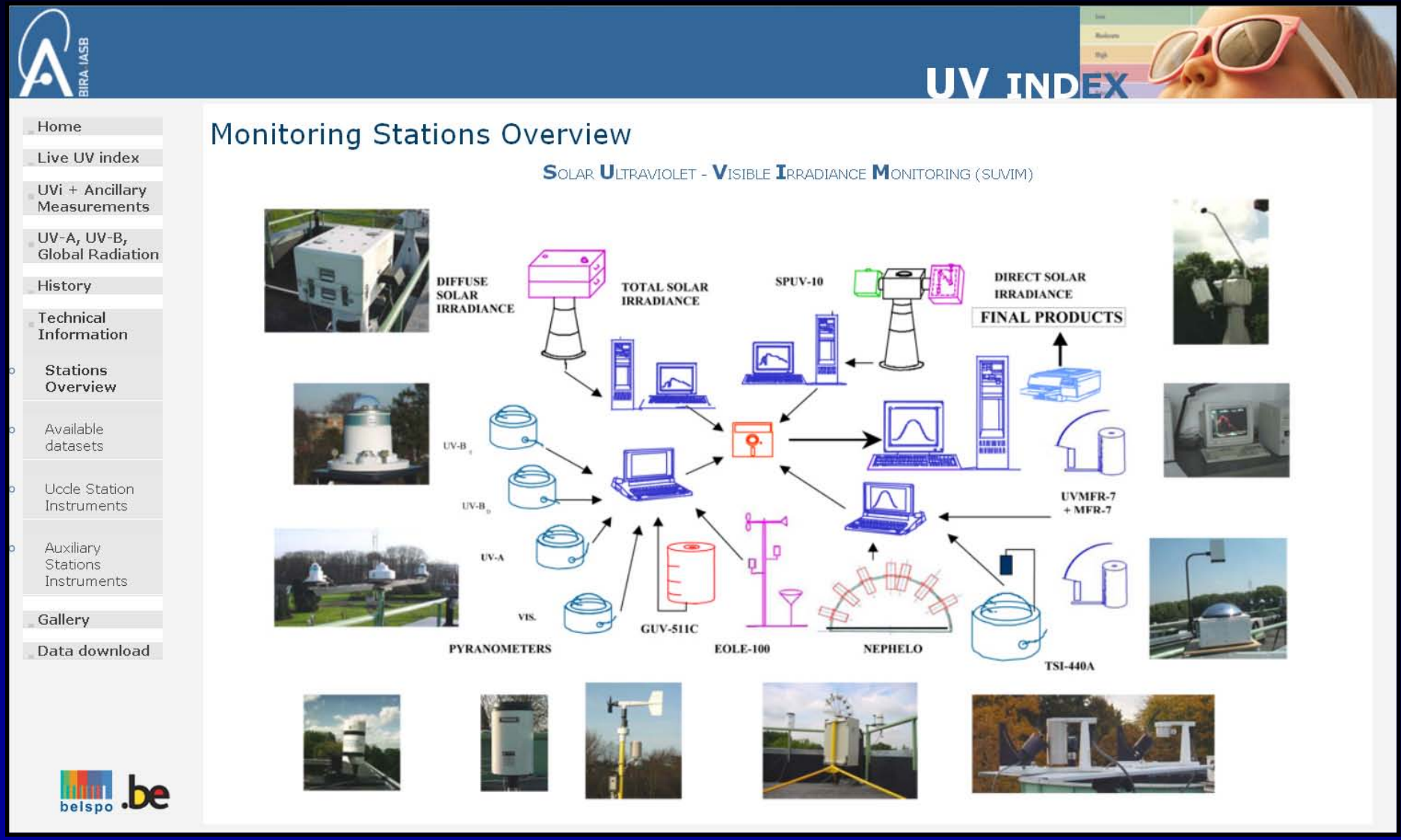
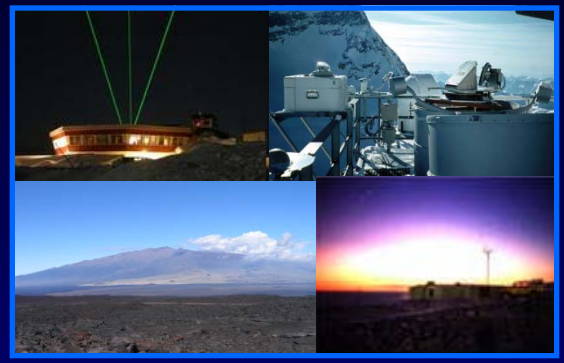
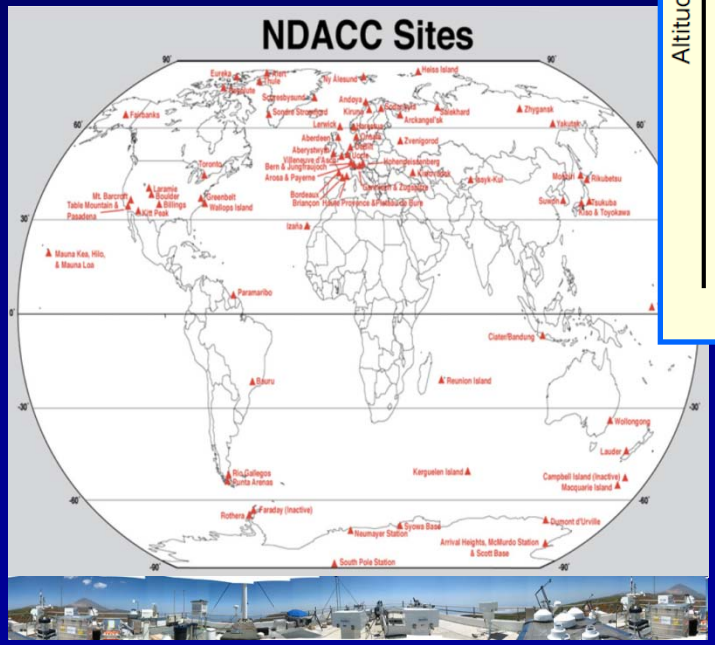
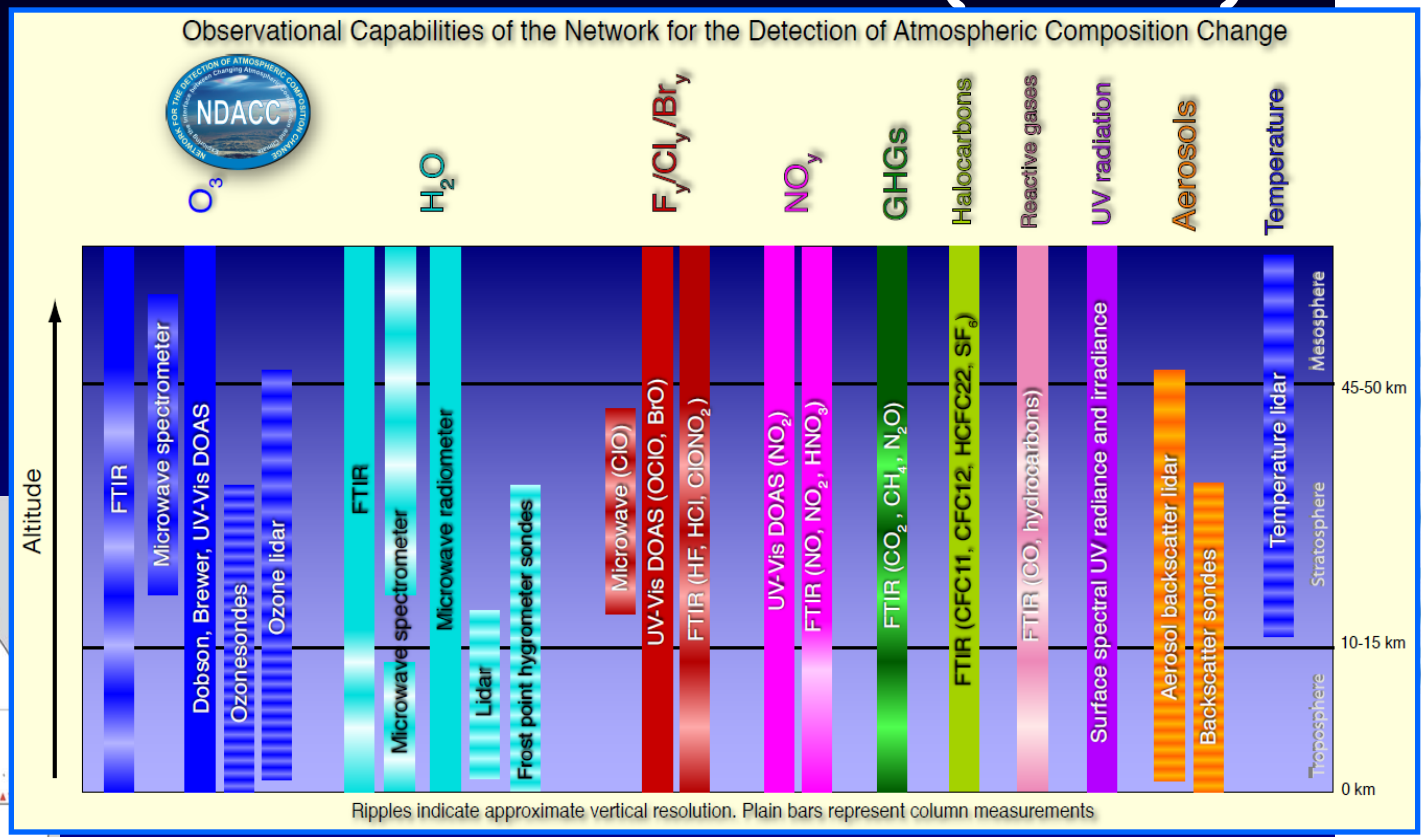


NETWORK FOR THE DETECTION OF ATMOSPHERIC COMPOSITION CHANGE (NDACC)







UNEP

Cooperating Networks

AERONET
AEROSOL ROBOTIC NETWORK

AGAGE

The Micro Pulse Lidar Network
MPLNET

TCCON

SHADOZ

HATS

http://ndacc.org

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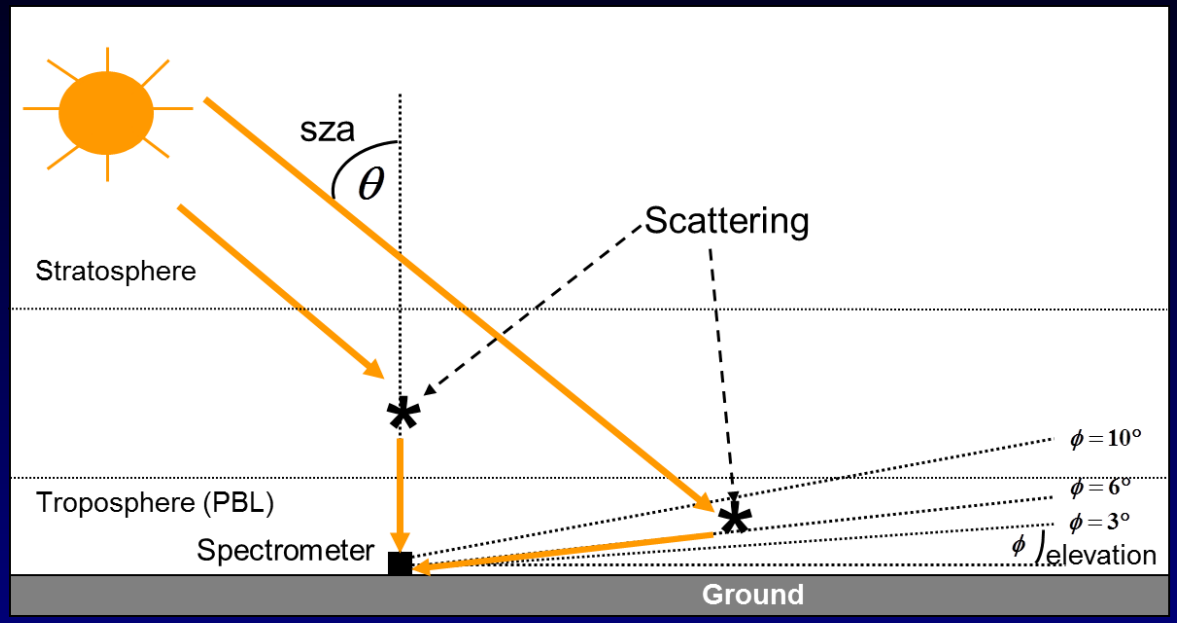
.be

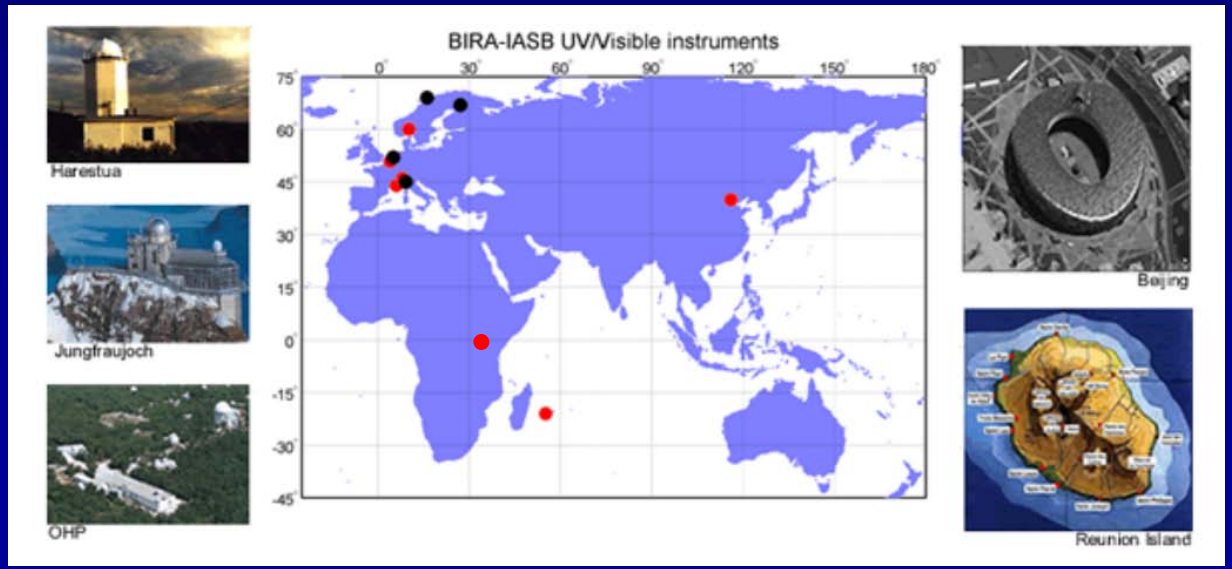
NDACC UV-Visible (MAX-)DOAS Spectrometers



http://uv-vis.aeronomie.be

Retrieved gases

Ozone (O_3)
Nitrogen dioxide (NO_2)
Bromine monoxide (BrO)
Chlorine dioxide (OClO)
Formaldehyde (CH_2O)
Glyoxal (CHOCHO)
Sulfur dioxide (SO_2)



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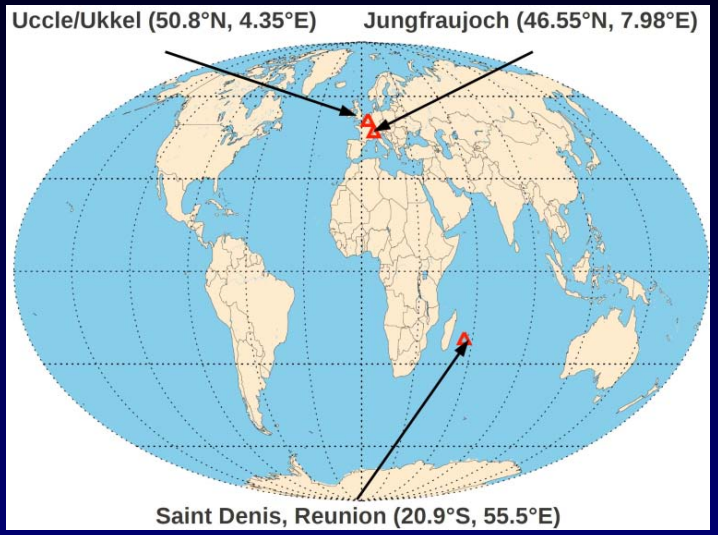
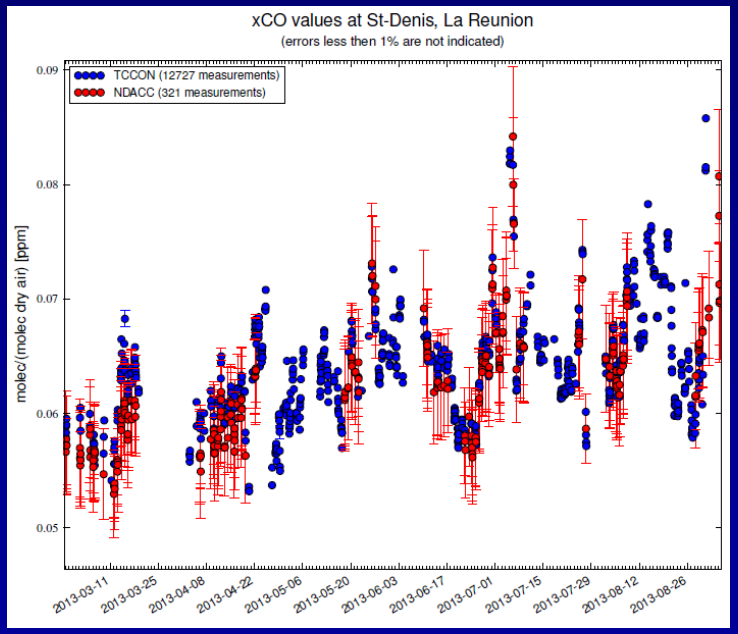
NDACC & TCCON FTIR Spectrometers

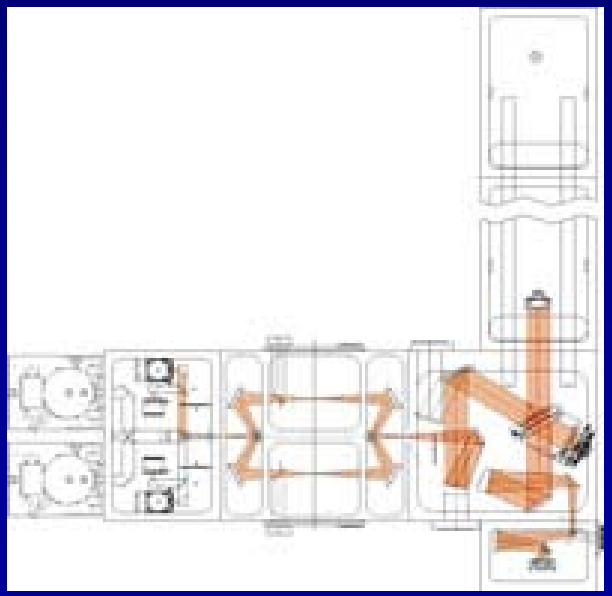
Direct greenhouse gases:
Methane (CH_4)
Nitrous oxide (N_2O)
Ozone (O_3)
Water Vapour (H_2O)
Carbon Dioxide (CO_2)

Other species:
Carbon monoxide (CO)
Ethane (C_2H_6)
Hydrogen cyanide (HCN)
Formaldehyde (CH_2O)
Nitric acid (HNO_3)
Hydrogen chloride (HCl)
Hydrogen fluoride (HF)

http://infrared.aeronomie.be







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ESA CEOS Intercalibration - ICal

Background (CEOS WGCV ACSG)

- Continuity of geophysical parameters to capture global change requires multi mission data sets
- Assessment needs high quality long-term reference data sets

Objectives of ESA CEOS ICal project

- Achieve consistency between global sensor networks contributing to EO atmospheric mission validation →
- Support calibration campaigns (ozone, aerosols, NO_2)
- Improve / demonstrate new retrieval algorithms for ground-based networks

ESA CEOS Intercalibration - ICal

Activities 2009-2013

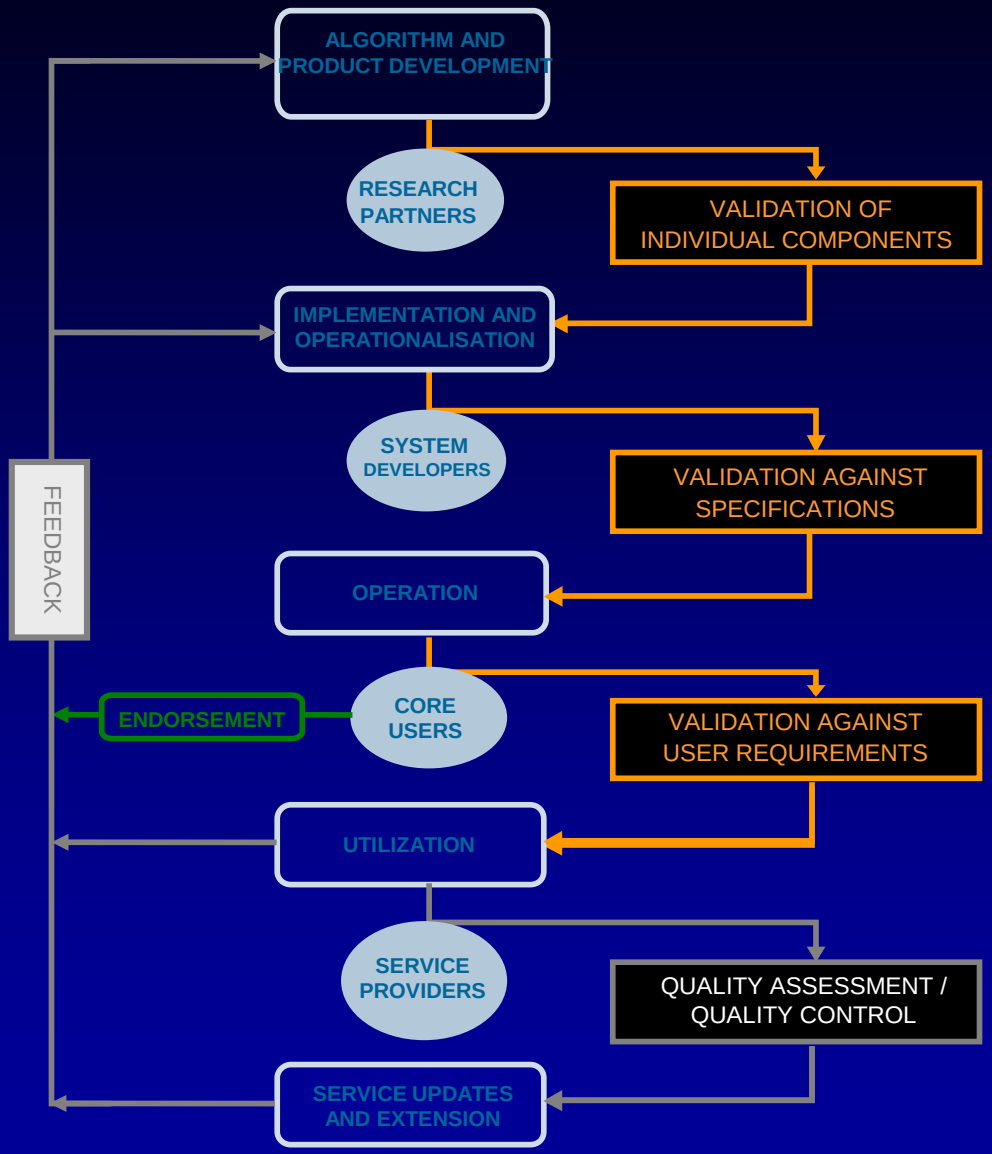
- Support CINDI field campaign and data exploitation
- Support Dobson/Brewer intercalibrations
- Support Earlinet calibrations by traveling standard
- Support mini-Spectrometer intercalibrations

Main results

- Development of MAXDOAS data products
- Operative straylight correction for Brewer instrument
- Assessment of Brewer and Dobson network quality
- Earlinet calibrations in several key sites
- Mini-Spectrometer (Pandora) network capacity building

3. QA / Validation System for Atmospheric Composition

ATMOSPHERIC SERVICE VALIDATION PROTOCOL



- General rules to ensure unbiased, independent and traceable validation => starts with QA4EO
- Definition of terminology and validation levels
- Top-level validation criteria
- Requirements for reference data sources and methods
- Metrology of data comparisons (incl. sampling and smoothing issues)
- Error/uncertainty budget, error propagation
- Validation of services (beyond the classical validation of data)
- Validation metadata and reporting
- Documentation requirements

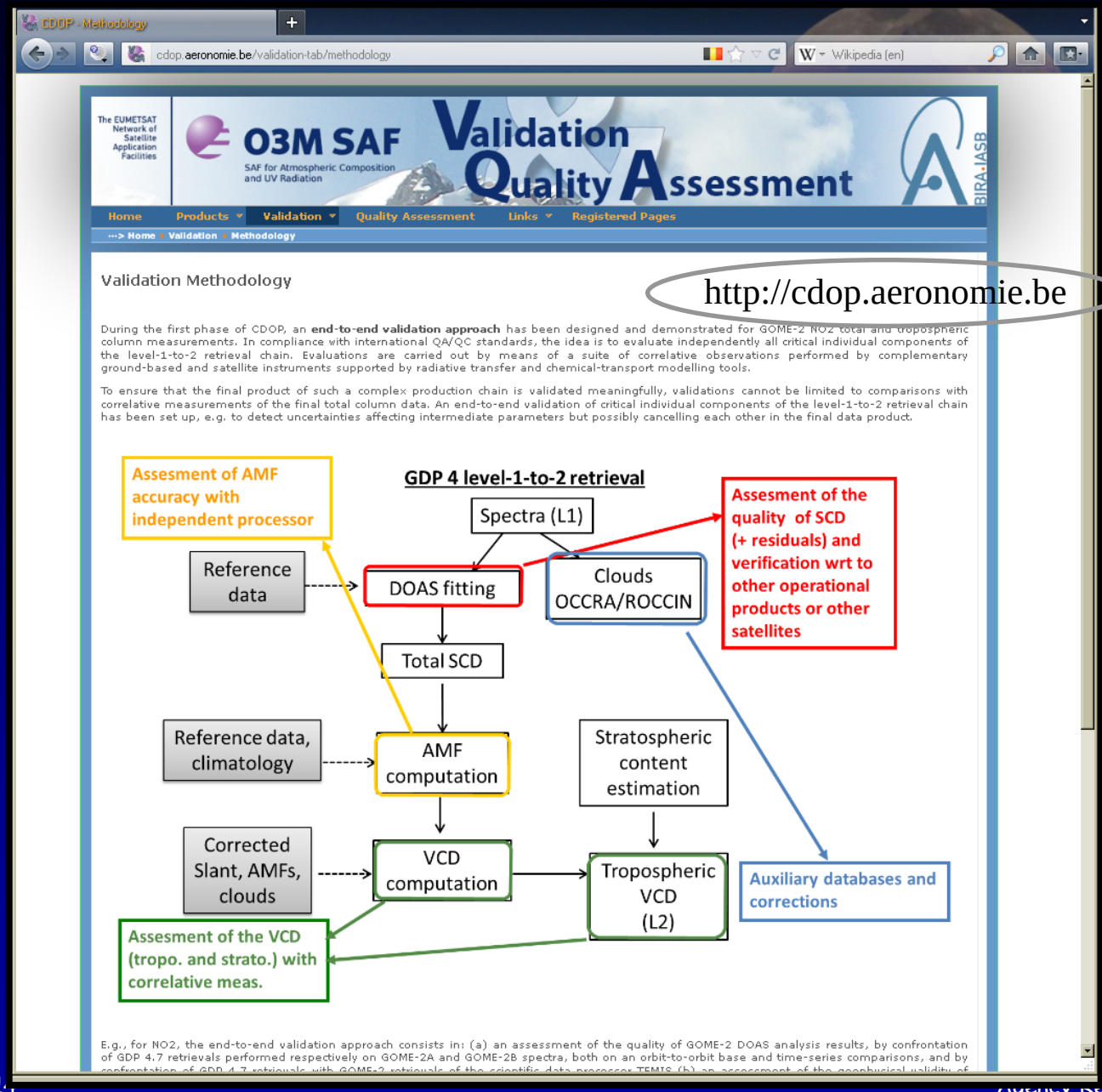

MACC-II Deliverable D_153.1
Atmospheric Service Validation Protocol
Date: May 2013
Lead Beneficiary: BIRA-IASB (#6)
Nature: R
Dissemination level: PU
macc
Monitoring atmospheric composition & climate – II
Grant agreement n°283576
Written by:
Date: 03/01/2012
Version: 1.0
Phase 1, Task 1
Deliverable D2.1 – WP1221
esa
esa

ESA CCI Ozone: QI and User Requirements

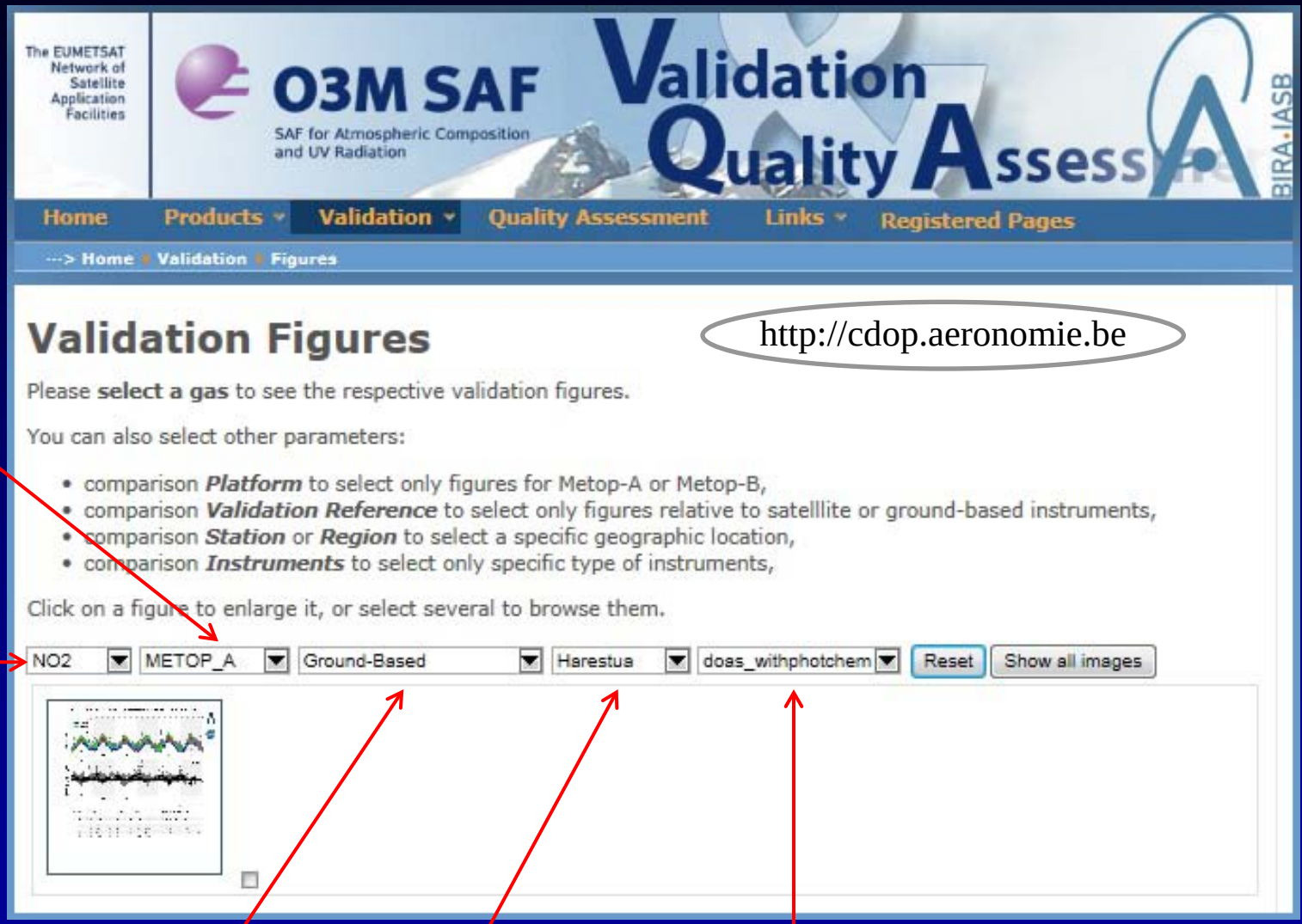
NADIR L2	Part atmos.	URD / PVP	GOME (1997)	GOME-2 (2007-2008)
Filtering			~ 3 %	~ 10 %
Geographical sampling			SAA and mid-Asia missing	SAA missing
DFS			5 to 5.5	5 to 6
Vertical resolution (resolving length estimate)	TS	6 km to TS-col.	> 50 km	> 50 km
	UT/LS	3 to 6 km	10 to 20 km	10 to 20 km
	MA	3 to 10 km	> 50 km	> 50 km
Height registration offset	TS	/	5 to 20 km (SZA dep.)	5 to 20 km (SZA dep.)
	UT/LS		negligible	negligible
	MA		-10 to -30 km	-10 to -30 km
Accuracy (bias)	TS	/	-10 to -30 % (-5 DU)	7 to 8 % (1 DU)
	UT/LS		-5 to 15 % (-2 to 5 DU)	1 to 4 % (1 DU)
	MA		-15 to 0 % (-3 to 0 DU)	-15 to 0 % (-3 to 0 DU)
Temporal dependence		/	Hardly any	Increased bias around and below TP for northern hemisphere winter
Meridian dependence	60-90	/	Negative bias around and below TP, small positive around ozone maximum	Negative bias around and below TP, positive around ozone maximum
	30-60		Negative bias below TP	Negative bias below TP
	0-30		Increased bias below TP	Increased bias below TP, related to bias for small SCD values
SCD dependence			Relation with meridian dependence less clear	Clearly related to meridian dependence
CF dependence			Slightly decreasing (more negative) bias with CF	Slightly decreasing (more negative) bias with CF
Comparison spread	TS	/	10 to 15 % (2 to 5 DU)	30 to 35 % (4 to 5 DU)
	UT/LS		5 % (3 DU)	5 % (3 DU)
	MA		5 to 10 % (0 to 3 DU)	5 to 10 % (0 to 3 DU)
Satellite random uncertainty	TS	/	10 to 40 %	10 to 30 %
	UT/LS		~5%	~5%
	MA		3 to 5 %	3 to 5 %
Total uncertainty	TS	10%	14 to 50 %	12 to 36 %
	UT/LS	8%	7 to 16 %	5 to 7 %
	MA	8%	3 to 18 %	3 to 18 %

Courtesy A. Keppens, ESA Ozone_cci Final Review

O3M-SAF: End-to-end QA/validation of retrieval



EUMETSAT O3M-SAF: Trace Gas Validation Server



Platform: MetOp-A

Gas: NO_2

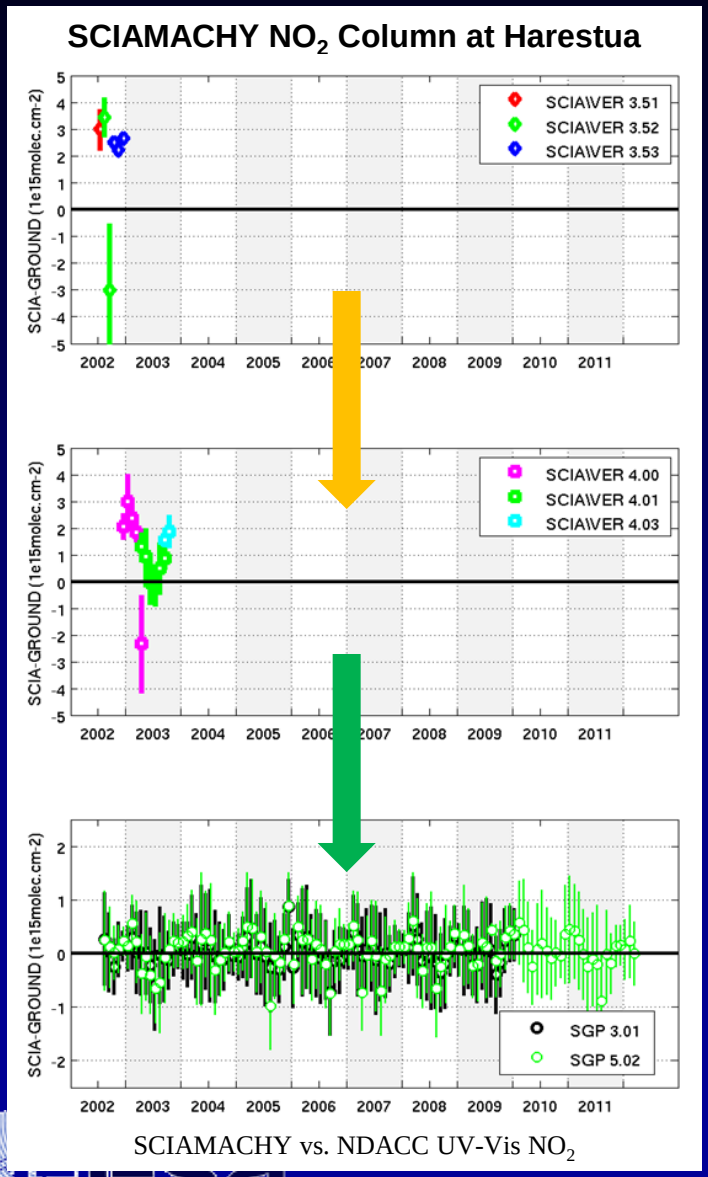
Validation reference: ground-based

Station: Harestua

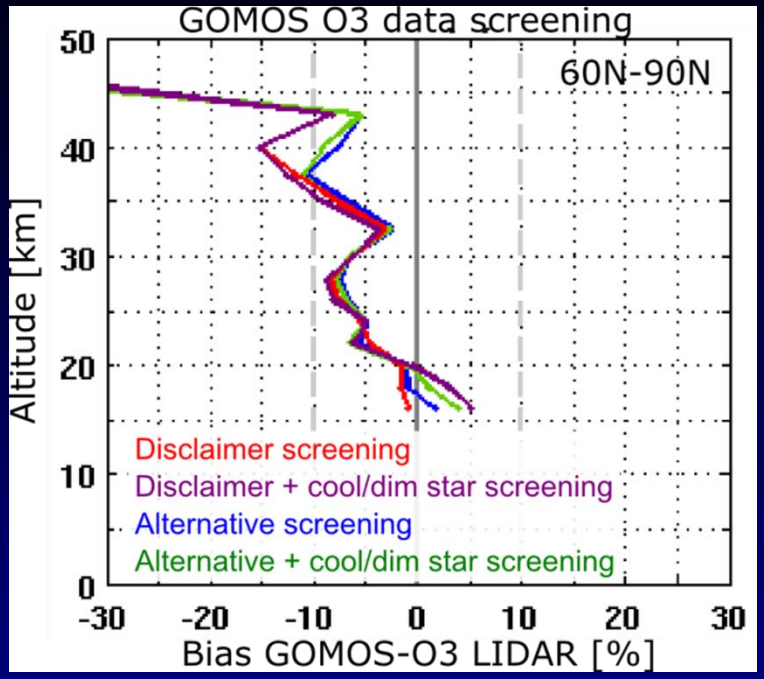
Instrument: DOAS with photochemistry

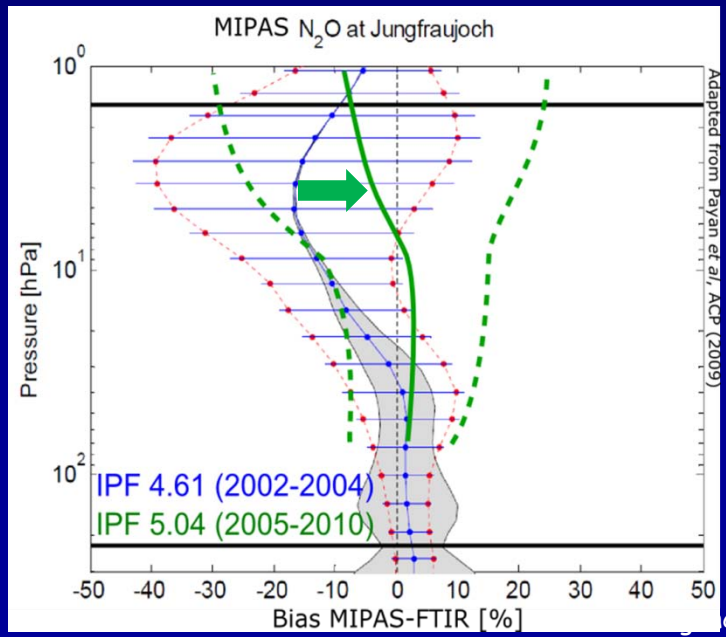
ESA Multi-TASTE Phase F:

Validation of Envisat Product Evolution



SCIAMACHY vs. NDACC UV-Vis NO_2





NORS Validation Server for Copernicus Atmosphere

n Server | Browse reports | Special functions | Product files | Help | Martine De

Intercomparison Selection

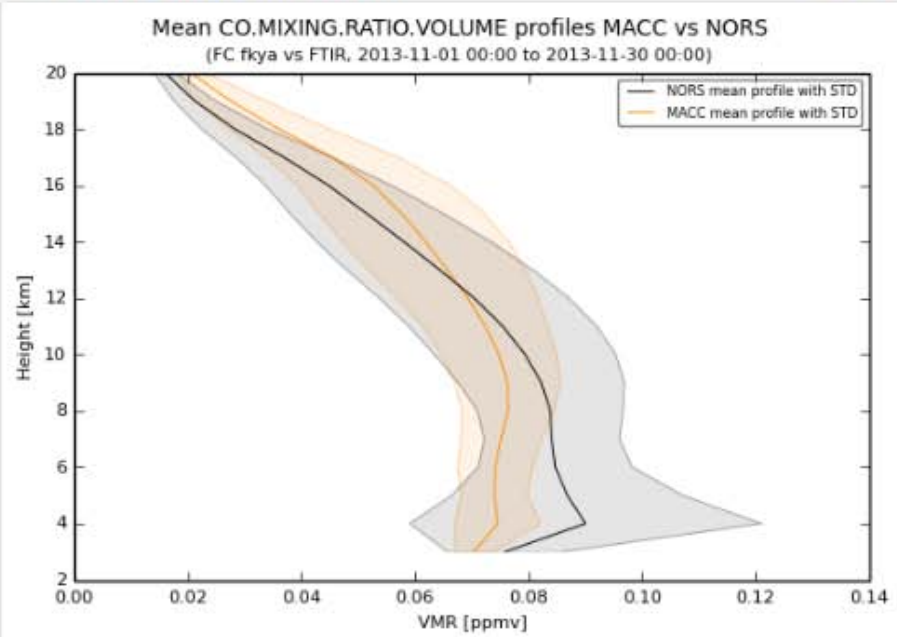
PARAMETER	
AEROSOL	2
CH2O	3
CH4	1
CO	3
NO2	3
O3	13

MODEL TYPE	
fkya	6
fnyp	9
fsd7	10

INSTRUMENT TYPE	
FTIR	10
LIDAR	3
MWR	3
UVVIS.DOAS	5
UVVIS.DOAS.OFFAXIS	2
UVVIS.DOAS.ZENITH	2

Reports

CO-fkya-FTIR, [ALL]@[ALL]: 2013-11 zip pdf



CO-fkya-FTIR, KIT@IZANA: 2013-11 zip pdf

Filter Options

LOCATION	
[ALL]	38
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LA.REUNION.MAIDO	9
LAUDER	25
MAUNA.LOA.HI	22
NY.ALESUND	31
XIANGHE	12
ZUGSPITZE	30

AFFILIATION	
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BIRA.IASB	31
CNRS.LATMOS	6
IUP	31
KIT	64

NORS
Network of Remote Sensing Ground-Based Observations in support of the Copernicus Atmospheric Service

http://nors-server.aeronomie.be
See also presentation by M. De Mazière

SEVENTH FRAMEWORK PROGRAMME

aeronomie.be

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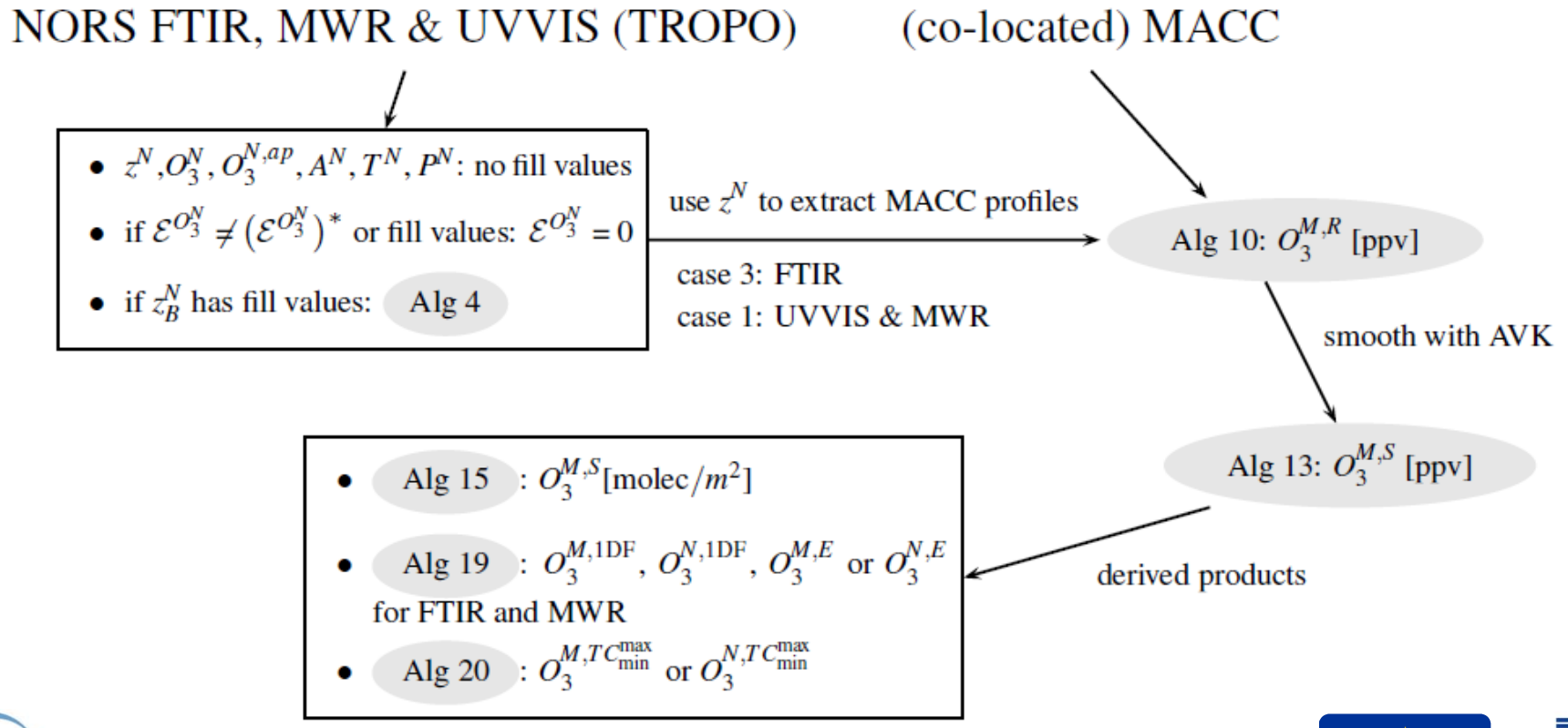
NORS Validation Scheme for Copernicus Atmosphere



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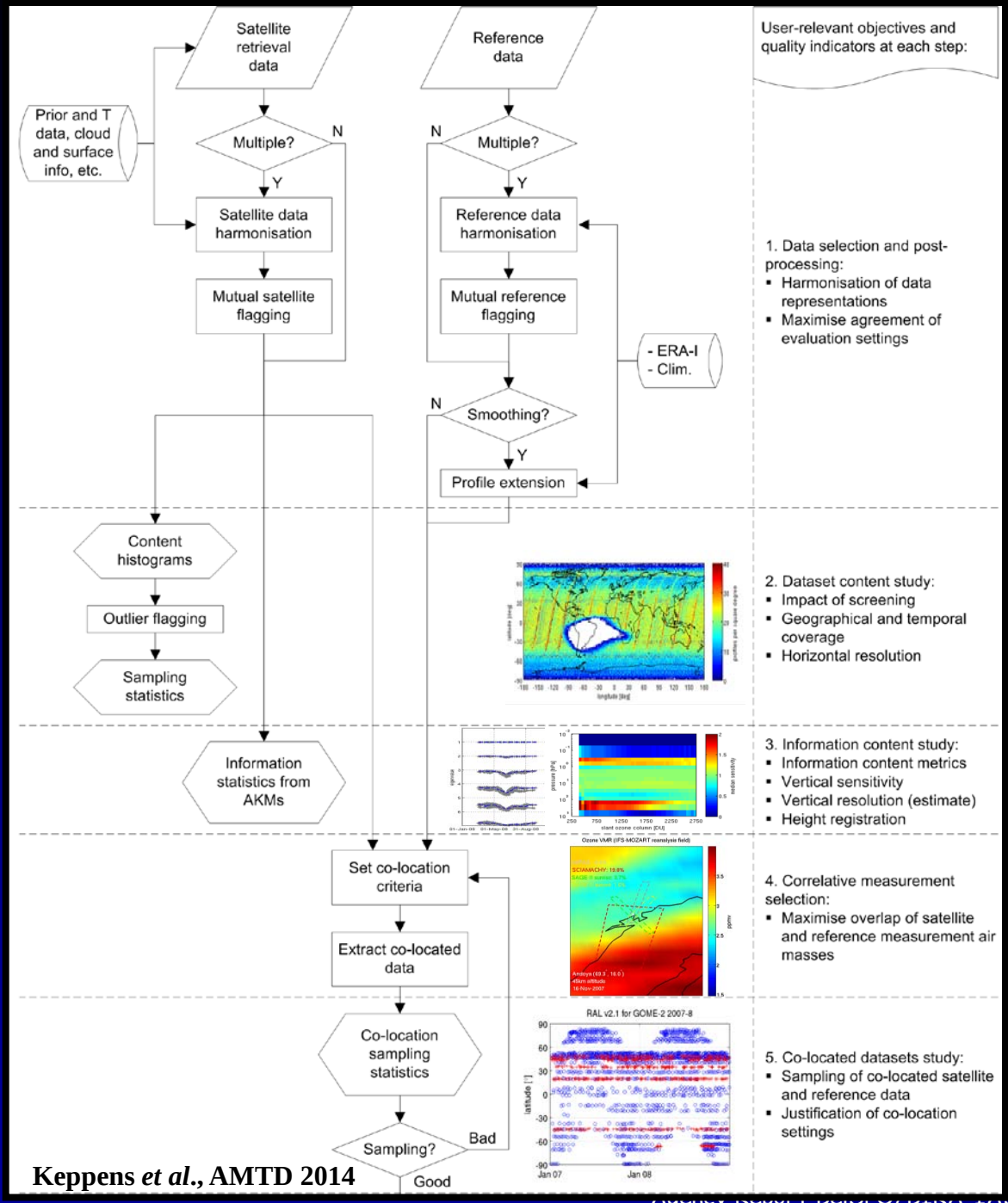
Traceability of Validation Processing Chain

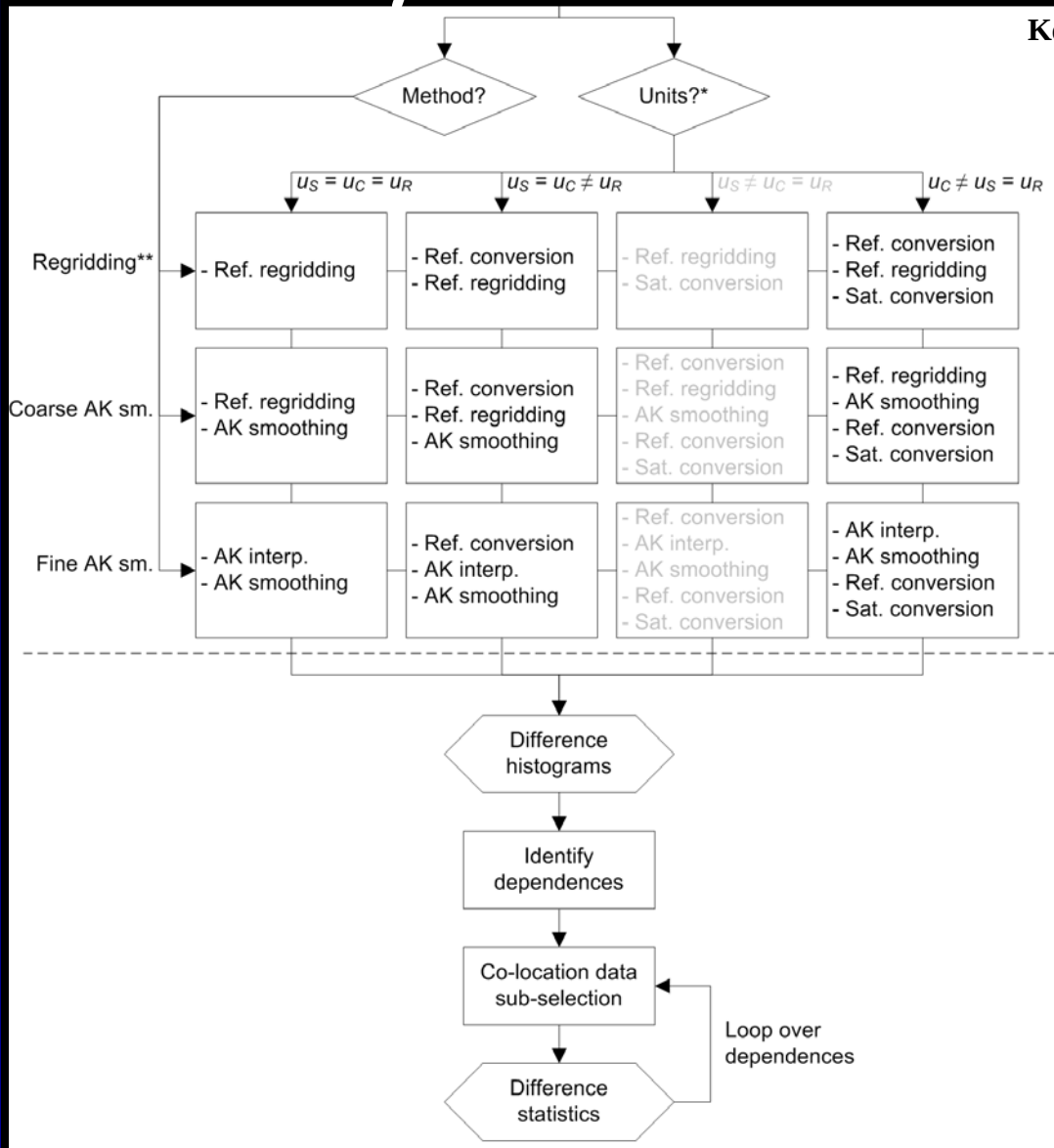
Illustration: validation process for nadir backscatter UV ozone profiles (from MetOp-A GOME-2)



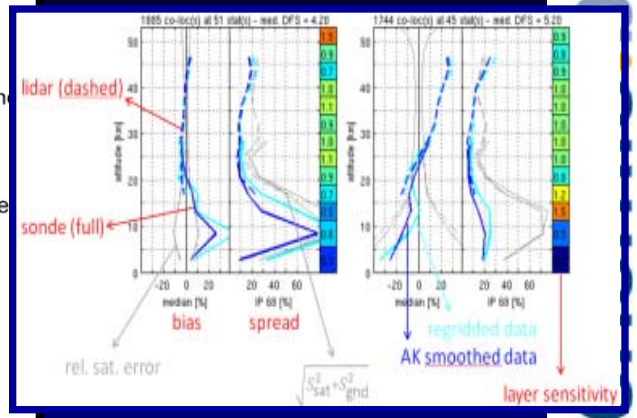
Keppens *et al.*, AMTD 2014

Traceability of Validation Processing Chain

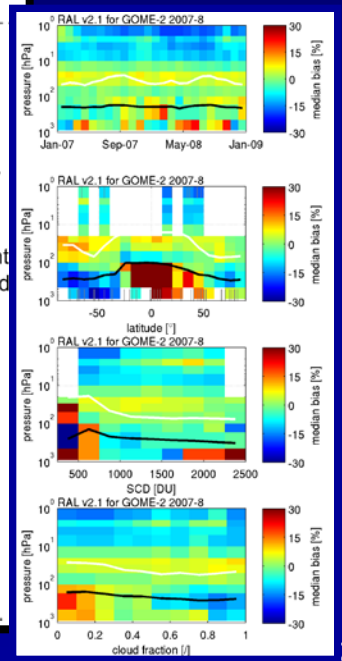
Keppens *et al.*, AMTD 2014



6. Vertical resampling of reference profiles:
- Common vertical grid
- Apply satellite measurement smoothing to reference profile

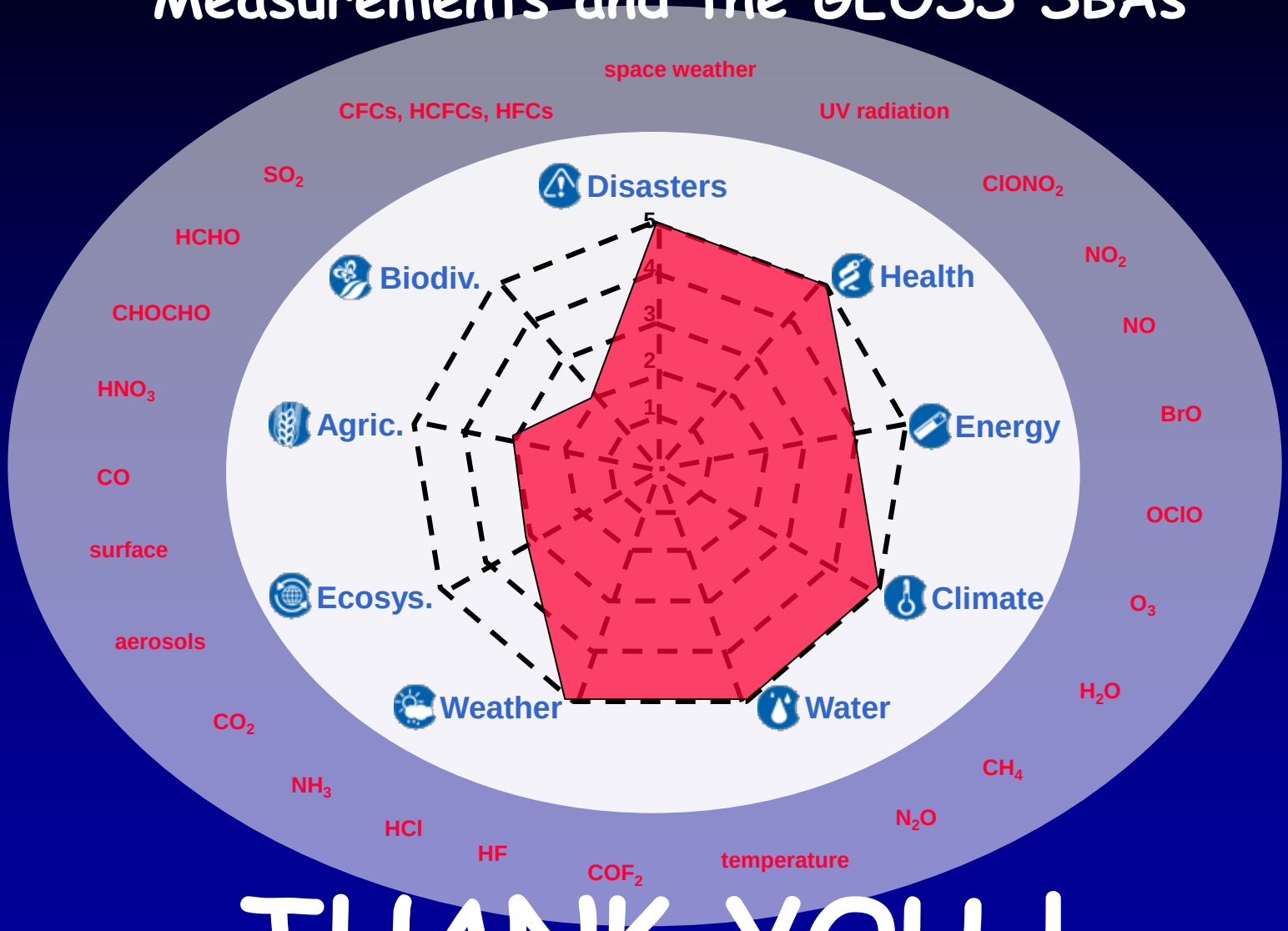


7. Comparisons:
- Difference average (bias) as measure for satellite accuracy
- Total satellite uncertainty estimation by combining bias and random satellite uncertainty or bias and comparison spread
- Comparison bias and spread dependences on physical conditions and/or retrieval metadata
- Difference timeseries for stability analysis



* 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.

Belgian Atmospheric Composition and Solar Radiation Measurements and the GEOSS SBAs



THANK YOU !