Committee on Earth Observation Satellites
Working Group on Calibration & Validation

31th CEOS WGCV Plenary
Hosted by NIST
Potomac, MD, USA
2-5 March 2010

Country/Agency report from the

BELGIAN INSTITUTE FOR SPACE AERONOMY

under mandate of the

BELGIAN FEDERAL SCIENCE POLICY (BelSPO)

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Federaal Wetenschapsbeleid
Politique scientifique fédérale
Föderalen Wissenschaftspolitik
Belgian Science Policy

ORB/KSB IRM/KMI IASB/BIRA PLANETARIUM

Agency report from BELSPO/BIRA-IASB

1. Solar missions
2. Atmospheric composition missions
3. NDACC in support of satellite EO
4. Observation operators
5. Atmospheric services validation protocol

1. Solar Missions

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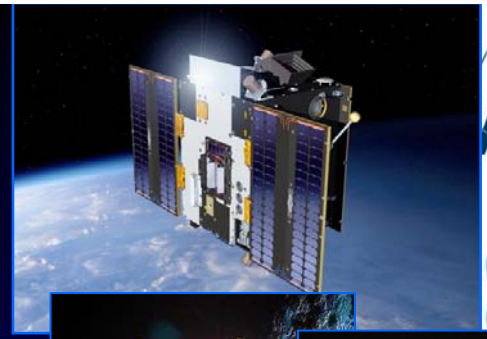
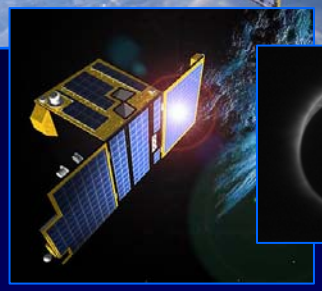
PROBA Series

EO and Solar





- PROBA = ESA's 'Project for Onboard Autonomy'
- Small satellites for technology demonstrations; prime contractor Vehaert 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-3**: double spacecraft to study solar corona while testing precise formation-flying techniques
- **PROBA-V**: miniaturised version of the SPOT-5 VEGETATION
- **Altius**: atmospheric limb mission for atmospheric composition

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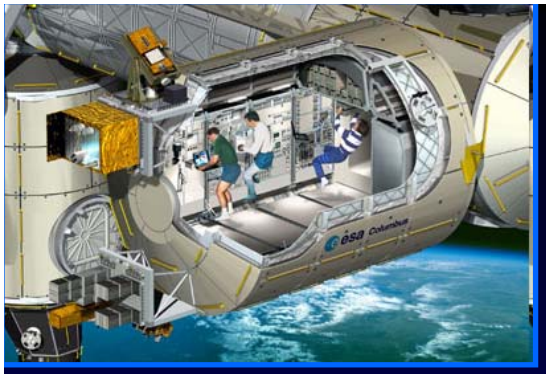
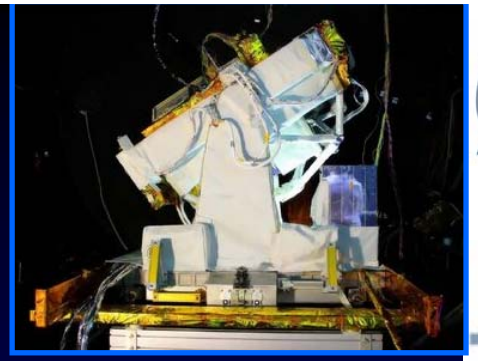


ISS / COLUMBUS

SOLAR



REMINDER

- Three instruments covering solar spectral irradiance from 17 nm to 100 µm (99% of solar energy)
  - **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)
  - **SOLSPEC (SOLar SPECtral Irradiance measurements)**: 180 nm – 3 000 nm; developed by CNRS (France) in partnership with BIRA-IASB (Belgium) and LSW (Germany)
  - **SOL-ACES (SOLar Auto-Calibrating Extreme UV/UV Spectrophotometers)**: EUV/UV; developed by IPM (Germany)
- Facility Support Centre: Belgian USOC at BIRA-IASB

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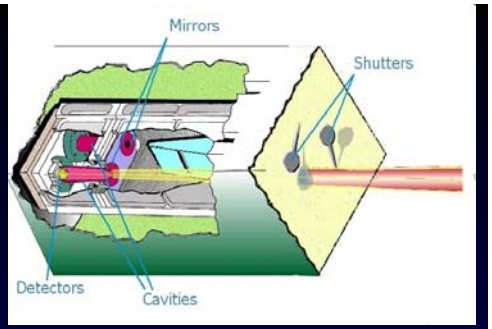
MYRIADE

PICARD



REMINDER

- CNES Myriade microsatellite that will precisely measure the Sun's diameter and its variations, as well as solar irradiance, with the twofold aim of learning more about how the Sun affects Earth's climate and studying its physics and inner structure
  - **SODISM**: an imaging telescope (developed in France by SA/CNRS) capable of measuring the Sun's shape and diameter to within a few milliarcseconds
  - **SOVAP**: a differential radiometer (developed in Belgium by **IRM-KMI**) to measure total solar irradiance
  - **PREMOS 2**: a suite of three photometers and radiometers (Swiss instrument) to study ozone and solar oscillations
- PICARD Mission Centre: Belgian USOC at BIRA-IASB

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2. Atmospheric Composition Missions

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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 GOME-2 and IASI** (SAG, retrieval, Cal/Val)
- **GOSAT** (TCCON, Cal/Val)
- **Development of Altius** (PI)
- **Definition of future missions** (MAG…)

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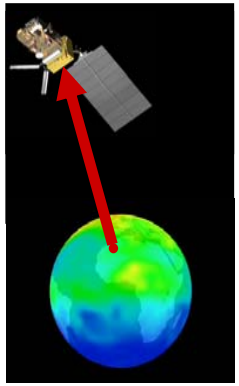
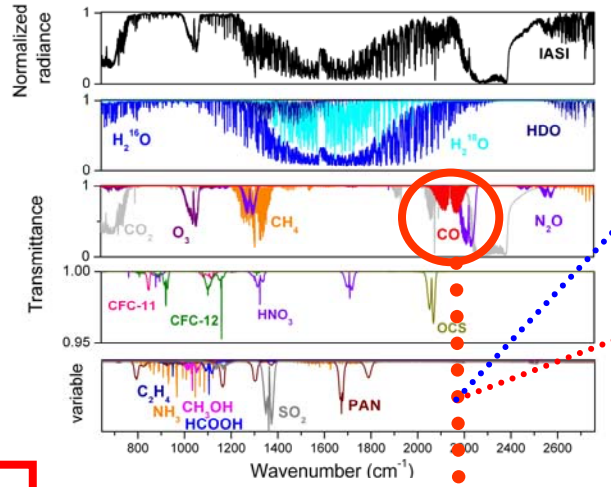
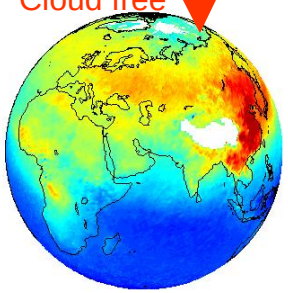
MetOp-A IASI

IASI processing







Trace gas retrievals = lot of IASI Channels! And all FOV (or ½)

Operational L2 products from Eumetsat processing

T and humidity profiles, cloud information

CO_2, CH_4, N_2O columns

O_3 total and partial columns

CO columns

Science L2 products from various processing chains

-LMD-ANN (4A)

-CO_2, CH_4 UT columns

-LISA KOPRAFIT

-O_3 profiles

-LA SOFRID

-O_3 CO profiles

- BIRA AZIMUT

-CH_4

- ULB-LATMOS FORLI

-CO,O_3,HNO_3,NH_3

- ULB-Atmosphit

-Local fire, volcanic plumes, HDO, CH_4, CH_3OH, HCOOH

- RAL-RTTOV

-O_3

- ULeicester-ULIRS

-CO

- SRON-

-O_3

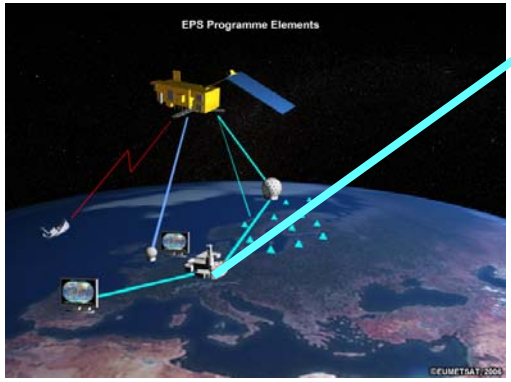
+others

Courtesy P.-F. Coheur, ULB

MetOp-A IASI

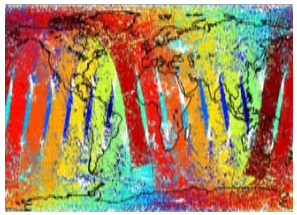
IASI processing

EuroBird-9



ULB receiving station

1.3 10^6 spectra
Global coverage 2 x day



IASI Level1C (BUFR format)
L2 for clouds, T, Q

NRT processing

Pre-filtering (clouds, inhomogeneous radiances)

BTDs masks (K)

NRT processing

FORLI **RTM**
Fast Operational/Optimal Retrievals on Layers for IASI

SA-NN

O_3 total column
O_3 0-6 km column

CO vertical profiles (1/2h)
HNO_3 columns/profiles (3h)
O3 profiles (4-5 h)
NH_3
H2O isot. profiles

→ **MACC + open access through Ether**

Atmosphit/ADA RTM

Research processing

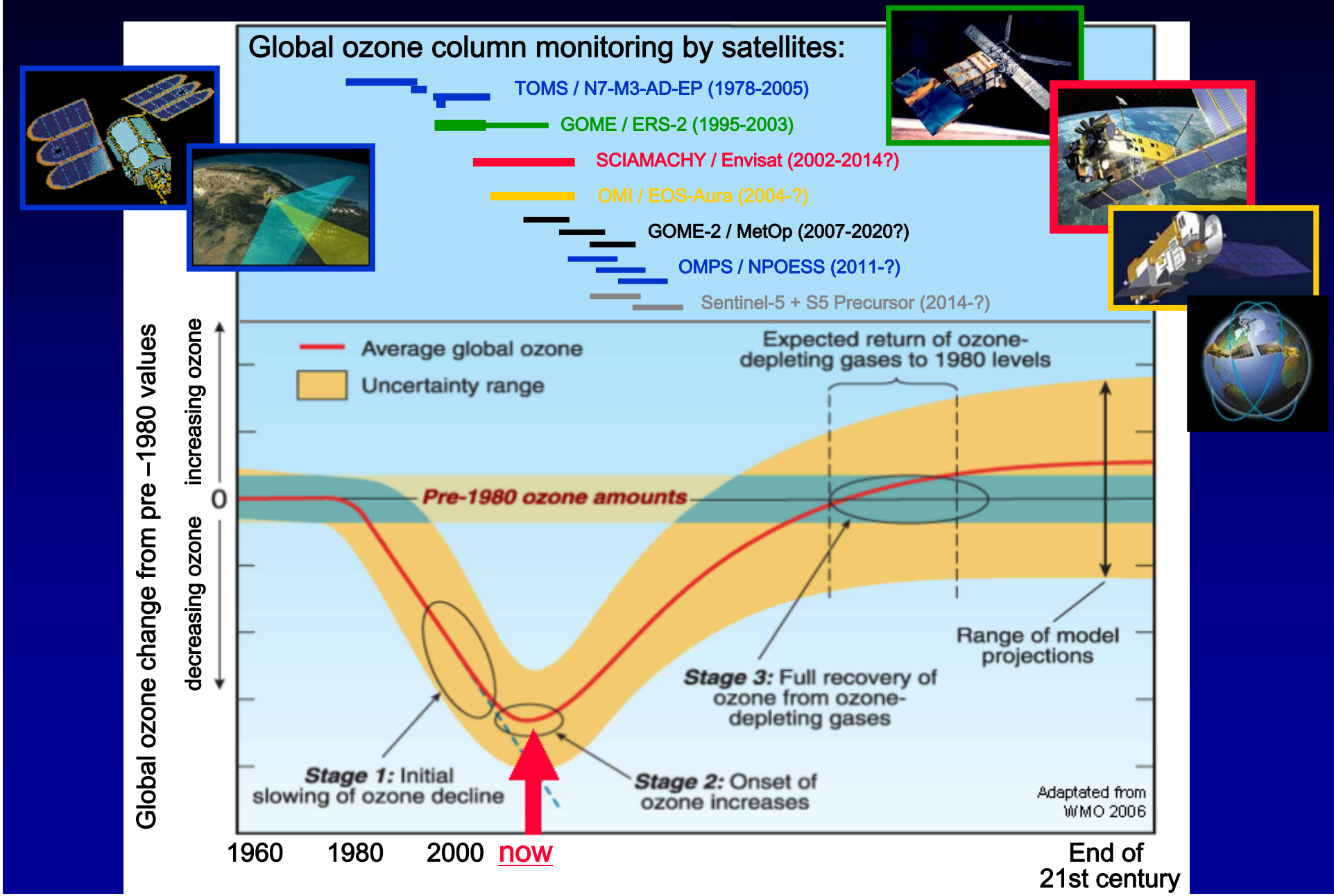
•Profiles/columns of any detected species
•Aerosols (type, size, load)

SO_2, NH_3, OVOcs
Dust, cirrus

Operational alert system for high altitude volcanic clouds → **Users (e.g. VAAC) ESA**

Courtesy P.-F. Coheur, ULB

MULTI-MISSION OZONE MONITORING



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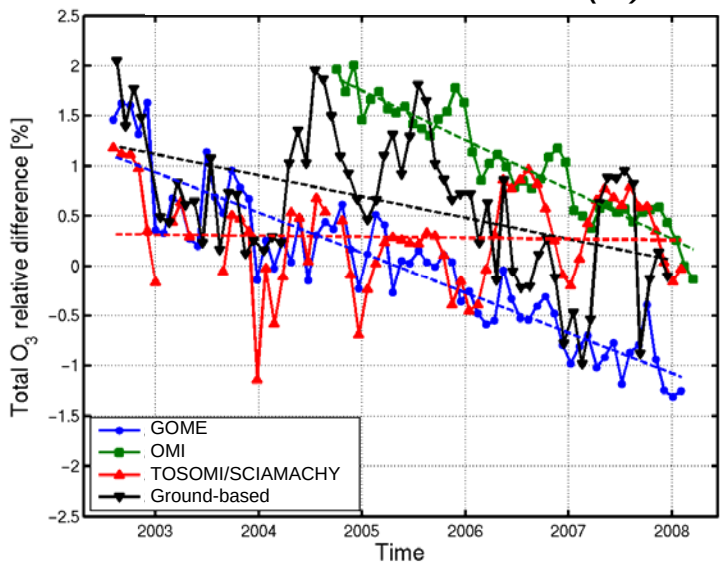
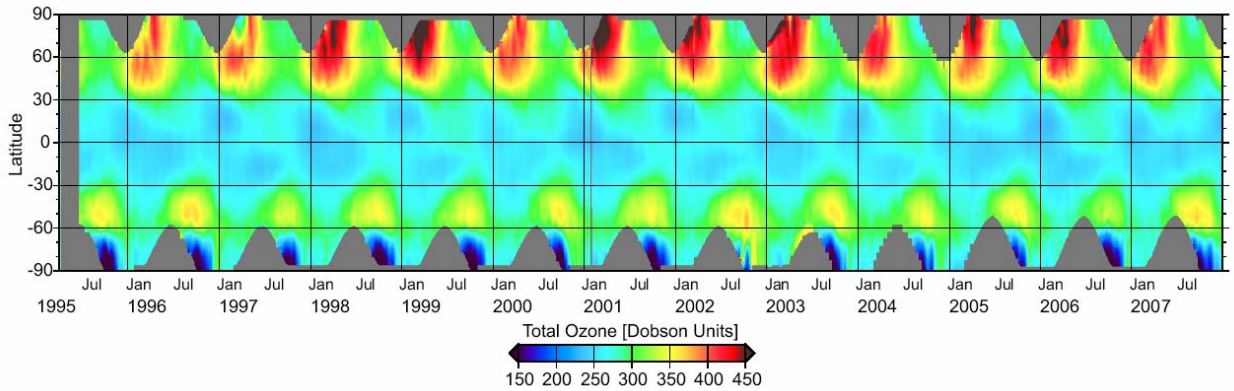
ATMOSPHERIC COMPOSITION MISSIONS
Multi-mission consistency (1): ALGORITHMS

- **The GOME series (GOME/SCIAMACHY/GOME-2)**
  - Contributions to prototype and operational trace gas retrieval; multi-mission, multi-parameter validation
  - Merged ozone data record => need for algorithm upgrades
  - Upgrade and reprocessing undertaken for the three sensors

SCIAMACHY - reference (%)





Zonal mean record of total ozone obtained from merged GOME, SCIAMACHY and GOME-2 data from April 1995 to December 2007

D. Loyola et al., IJRS 2009

C. Lerot et al, AMT, 2009

3. NDACC Support to Satellite Validation

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NETWORK FOR THE DETECTION OF ATMOSPHERIC COMPOSITION CHANGE

- **Sustained Belgian support since commissioning (1980s)**
- **Member of SC, of Strategy WG; Co-chair of 3 WGs**
- **Operation of NDACC instruments (BIRA, KMI and ULg)**
  [CL-06-01, CL-09-01/02/03, DA-09-01]
  - FTIR in Switzerland since 1950s + Reunion Isl. + mobile FTIR
  - Uccle (Brussels): ozonesondes and Brewer since 1970s, CIMEL
  - UV-visible DOAS in Norway, Haute Provence and Reunion Isl.
- **Support to satellite missions**
  - Close link between NDACC Satellite WG and WGCV ACSG
  - Coordination of NDACC-based validation for GOME, SCIAMACHY, GOMOS, MIPAS, OMI, GOME-2…
  - Various types of support to many other missions
  - GOSAT: CO_2 FTIR (TCCON) in Reunion Island [CL-09-03]

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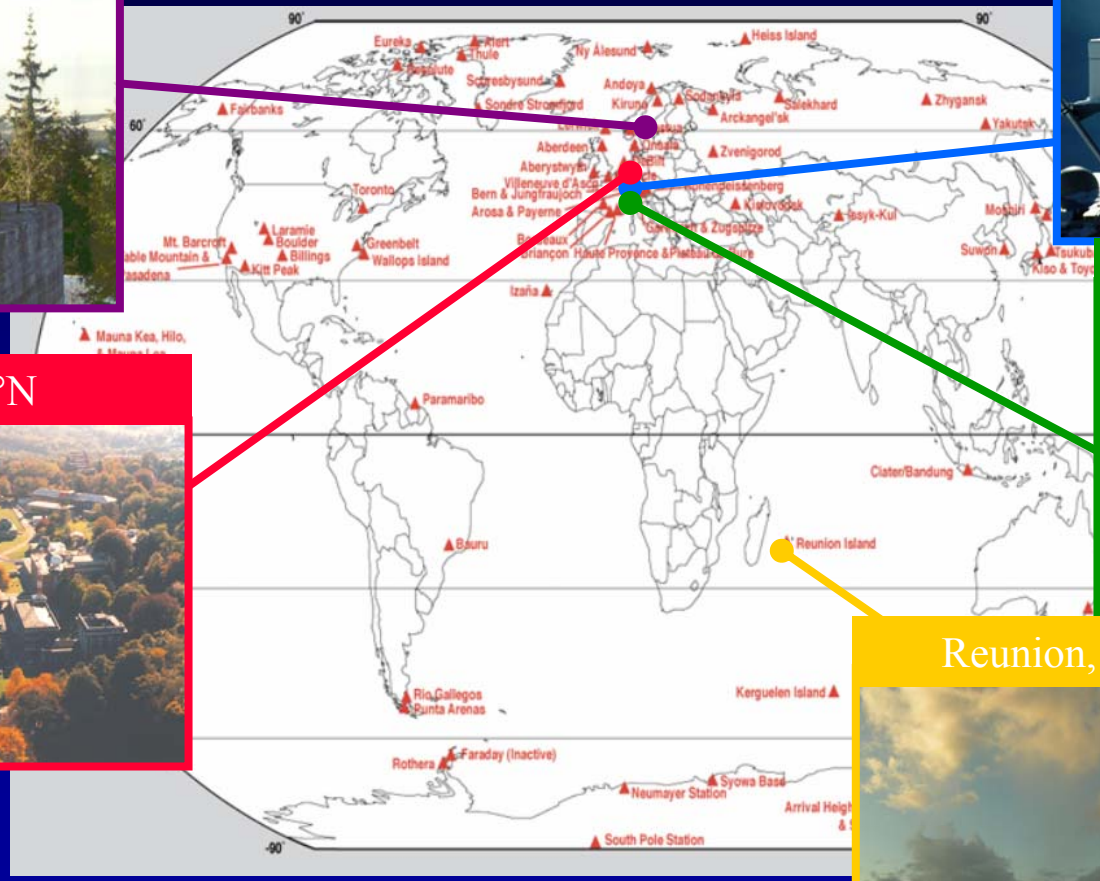
NETWORK FOR THE DETECTION OF ATMOSPHERIC COMPOSITION CHANGE

Harestua, 60°N

Jungfraujoch, 47°N



O.H.P., 44°N

Uccle, 50°N

Reunion, 21°S

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NDACC SATELLITE WORKING GROUP

Network for the Detection of Atmospheric Composition Change (NDACC)
Satellite Working Group

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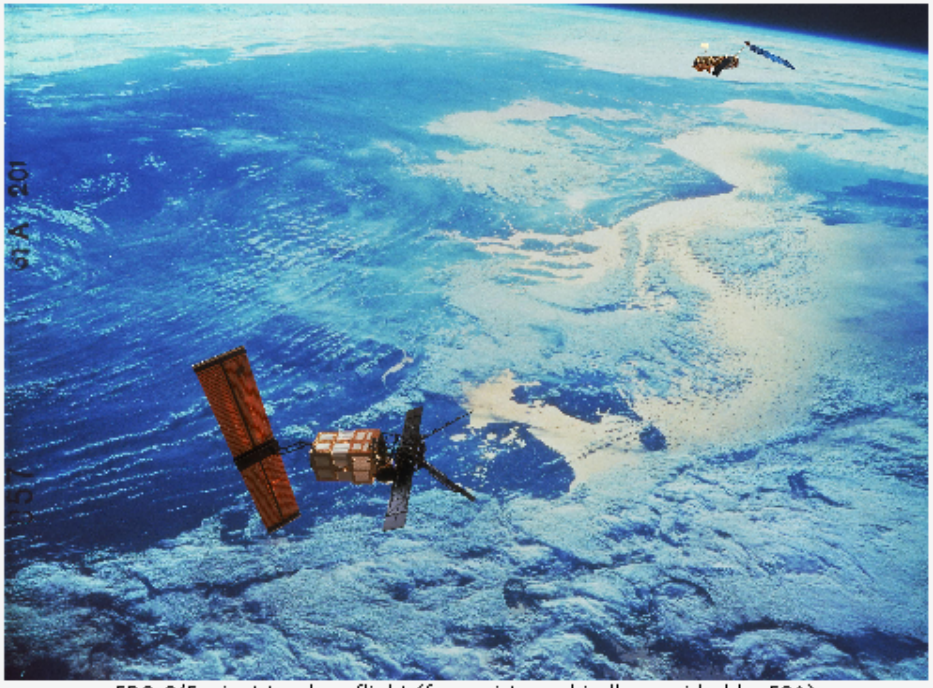
- Satellite Missions
- Members
- Publications &
- References
- Links



ERS-2/Envisat tandem flight (from pictures kindly provided by ESA)

Welcome to the NDACC Satellite Working Group Homepage!

The objective of the Satellite Working Group is to foster collaboration among atmospheric scientists involved in the NDACC and in satellite missions. This website is a guide to ground-based researchers, space agencies and other interested parties to practical information on atmospheric chemistry satellite missions.

Enjoy your visit!

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CONTACTS

http://accsatellites.aeronomie.be
or via http://www.ndacc.org

Satellite Missions

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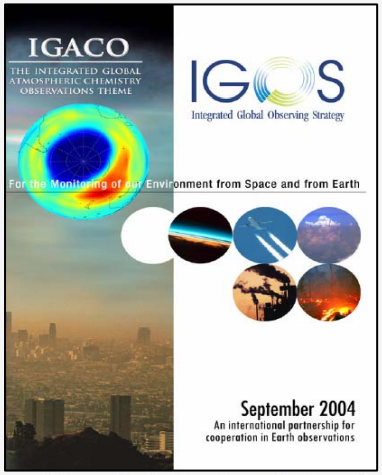
Trace gases measured by atmospheric sensors



Back to the satellite missions page

- Oxygen compounds
- Nitrogen compounds
- Surfur compounds
- Hydrogen compounds
- Water vapour
- Carbon and hydrocarbon
- Halogen compounds
- Tropospheric clouds
- Aerosols
- Temperature
- Compounds recommended by international strategies, but not measured

	Trace Gases	Sensors
Oxygen compounds	Ozone column (O_3)	AIRS, GOME-1, GOME-2, IASI, OMI, OMPS, SBUV, SBUV/2, SCIAMACHY, SSBUV, TOMS, TOVS
	Ozone profile (O_3)	ACE-FTS, ATMOS, CRISTA, CLAES, GOME-1, GOME-2, GOMOS, GRILLE, HALOE, HIRDLS, HIRS-2, IASI, ILAS, ILAS-II, IMG, ISAMS, LIMS, MAESTRO, MAS, MIPAS, MLS/EOS Aura, MLS/UARS, OMI, OMPS, OSIRIS, ORA, OZONE/ISTOK, POAM II, POAM III, SABER, SAGE I, SAGE II, SAGE III, SBUV, SBUV/2, SCIAMACHY, SME, SMR, SOFIE, SOLSE/LORE, SSBUV, STEAM, TES, UVISI

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Contact: Webmaster
Last update: Oct. 2007

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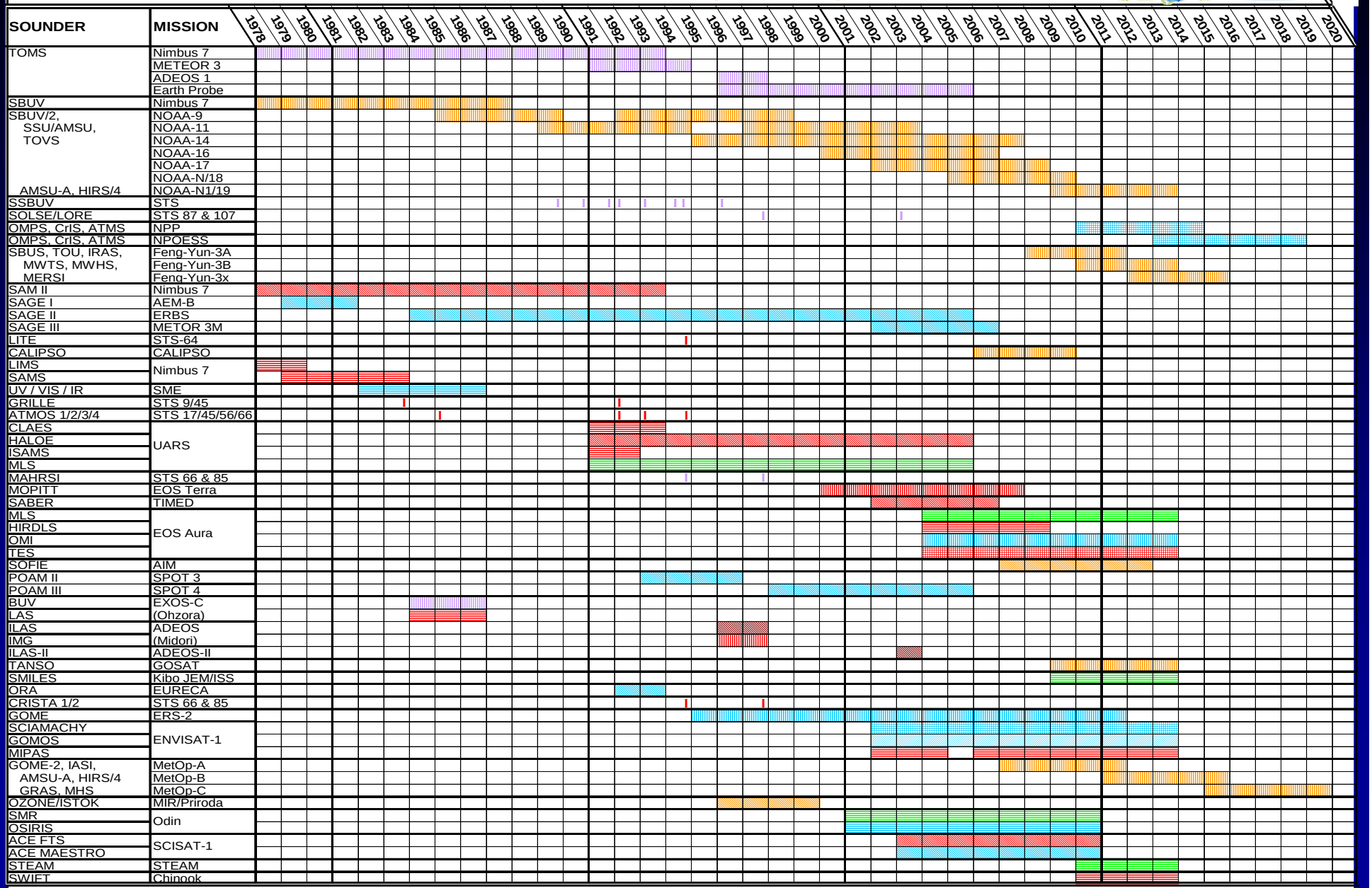
SATELLITE MISSIONS FOR ATMOSPHERIC COMPOSITION (1978-2020)



Status September 2009
Compiled by CEOS ACSG and the NDACC Satellite WG
Details via http://www.ndacc.org ⇨ Satellite WG

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4. Observation Operators

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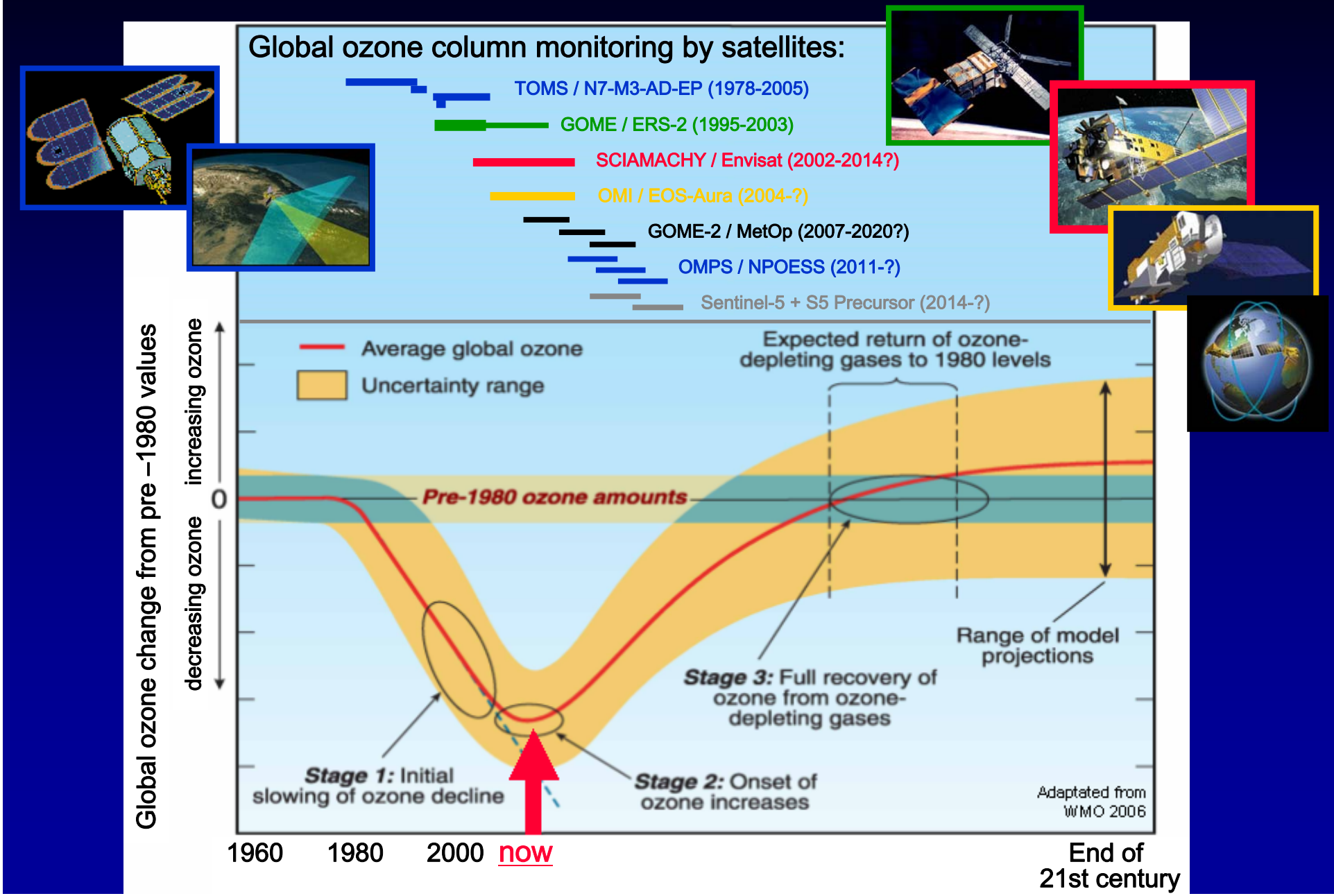
Multi-mission consistency (2): VALIDATION

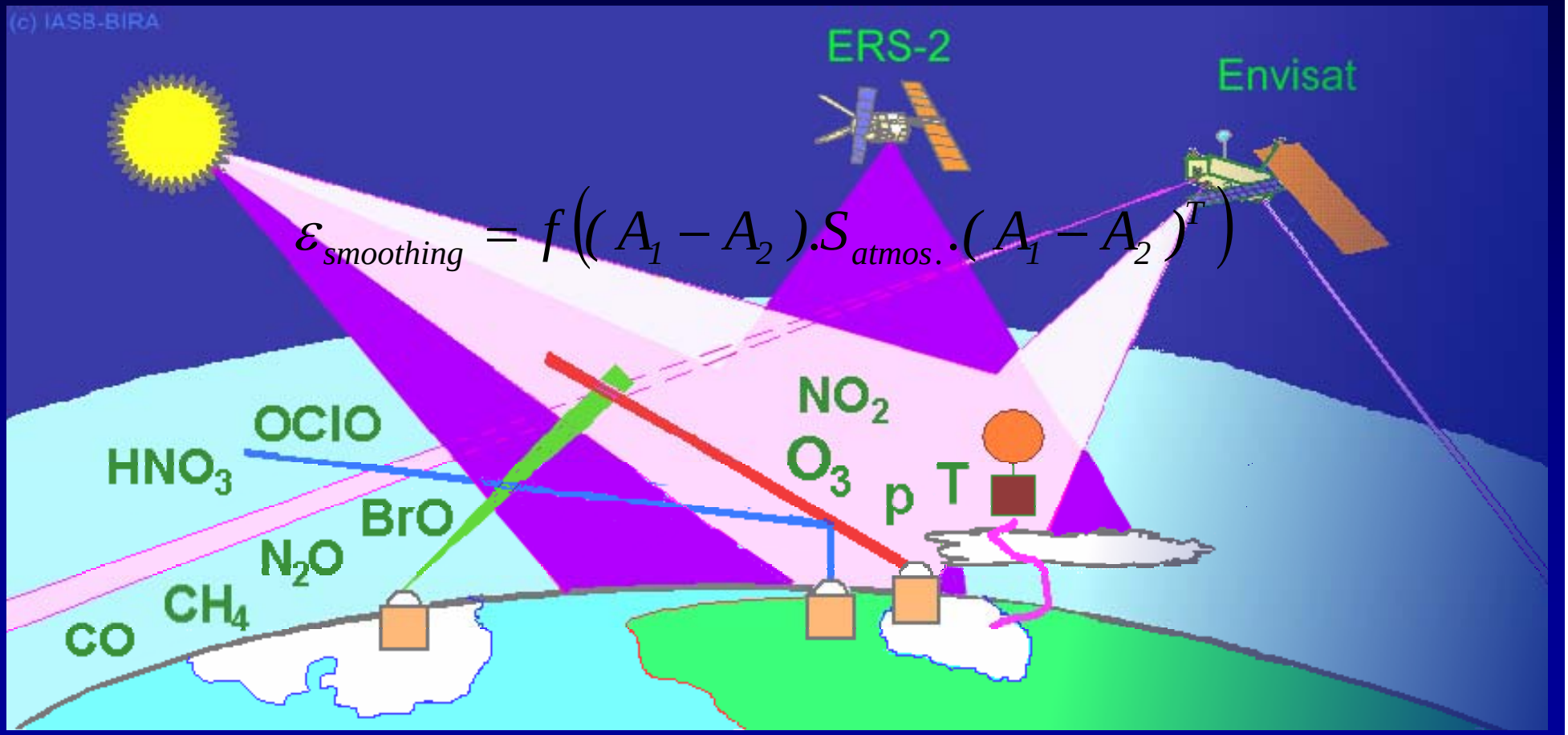


ProDEx SECPEA and EC FP6 GEOmon

Errors inherent to data comparison

[DA-09-02]
[DA-06-02]
[CL-06-01]

Air masses actually probed by Envisat and by NDACC instruments:
FTIR, UVVIS DOAS, balloon-sonde, lidar, MWR

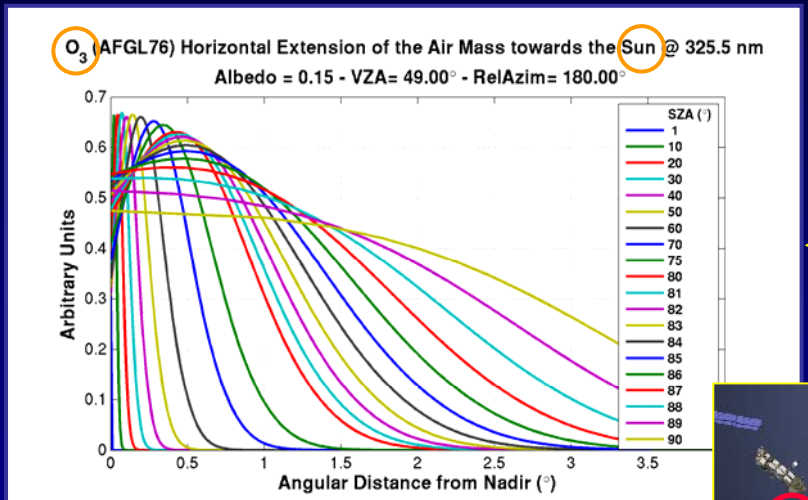


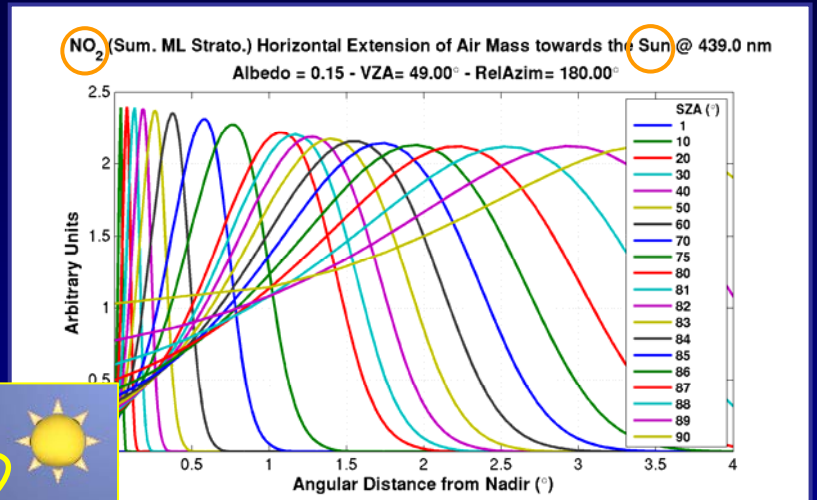
$$\varepsilon_{smoothing} = f\left((A_1 - A_2).S_{atmos.}.(A_1 - A_2)^T\right)$$

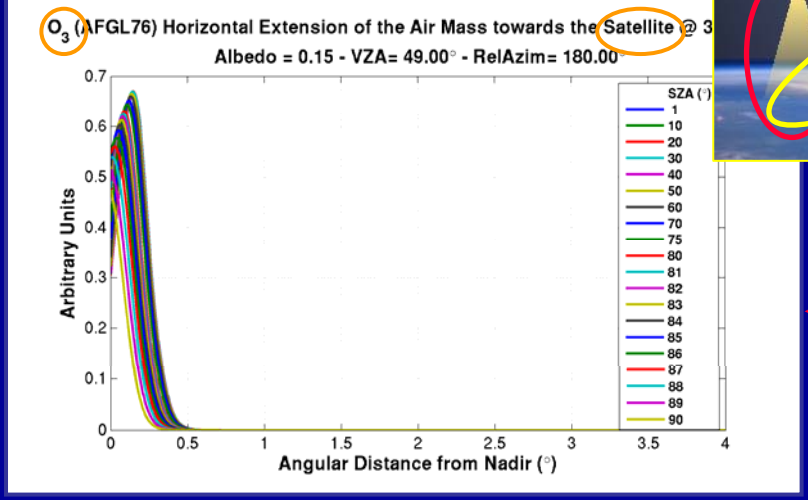
ProDEx SECPEA and EC GEOmon

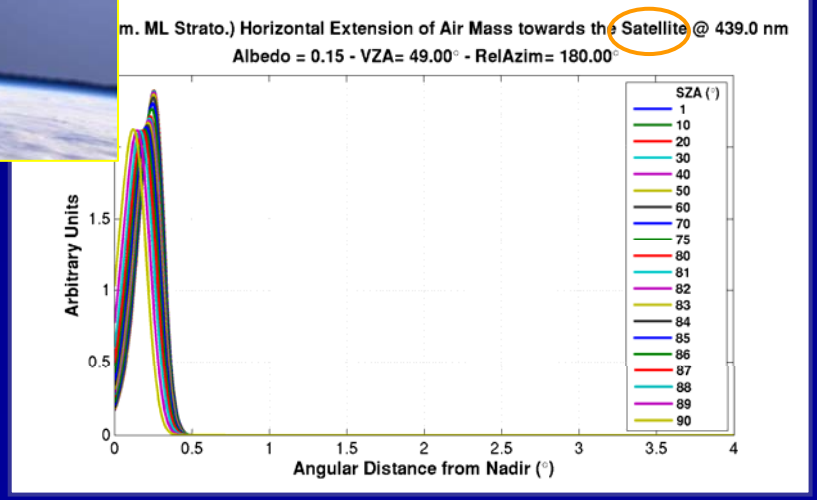
Errors inherent to data comparison

Air mass measured by GOME-2: dilution of information between Sun, scatterer and sensor









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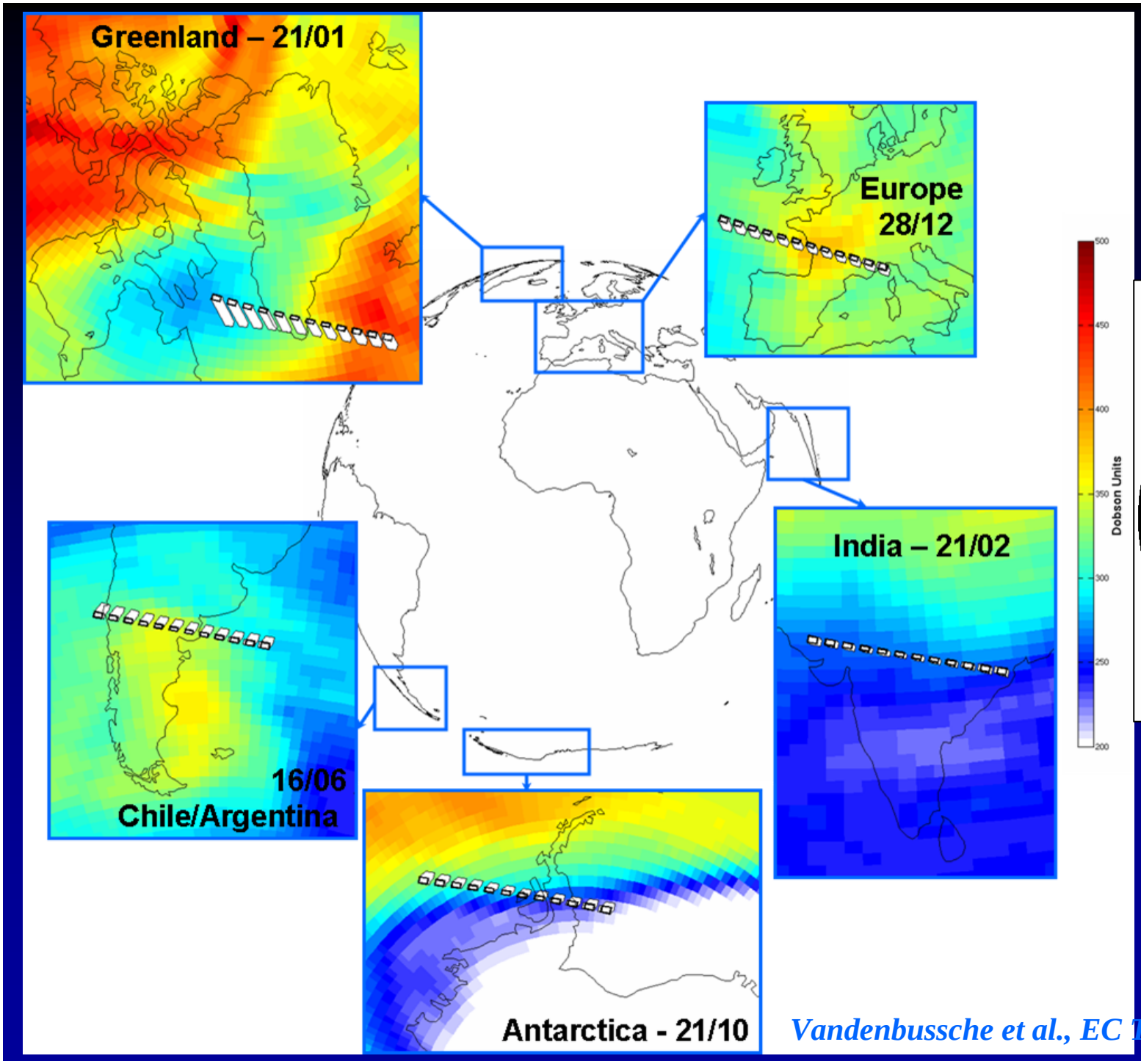

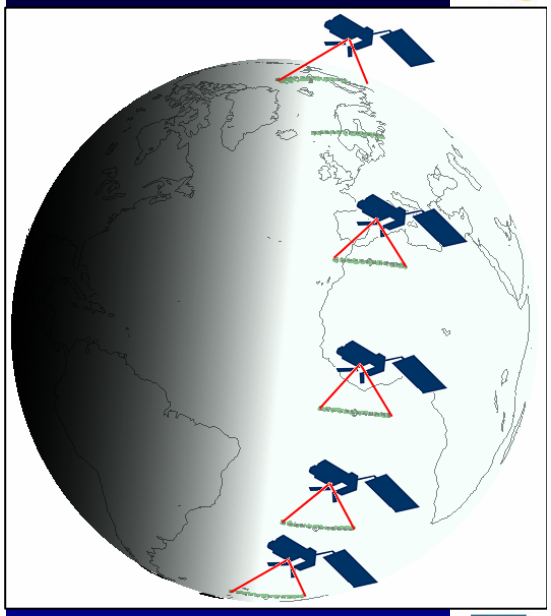

Vandenbussche et al., EC TN 2009

5. Atmospheric Services Validation Protocol

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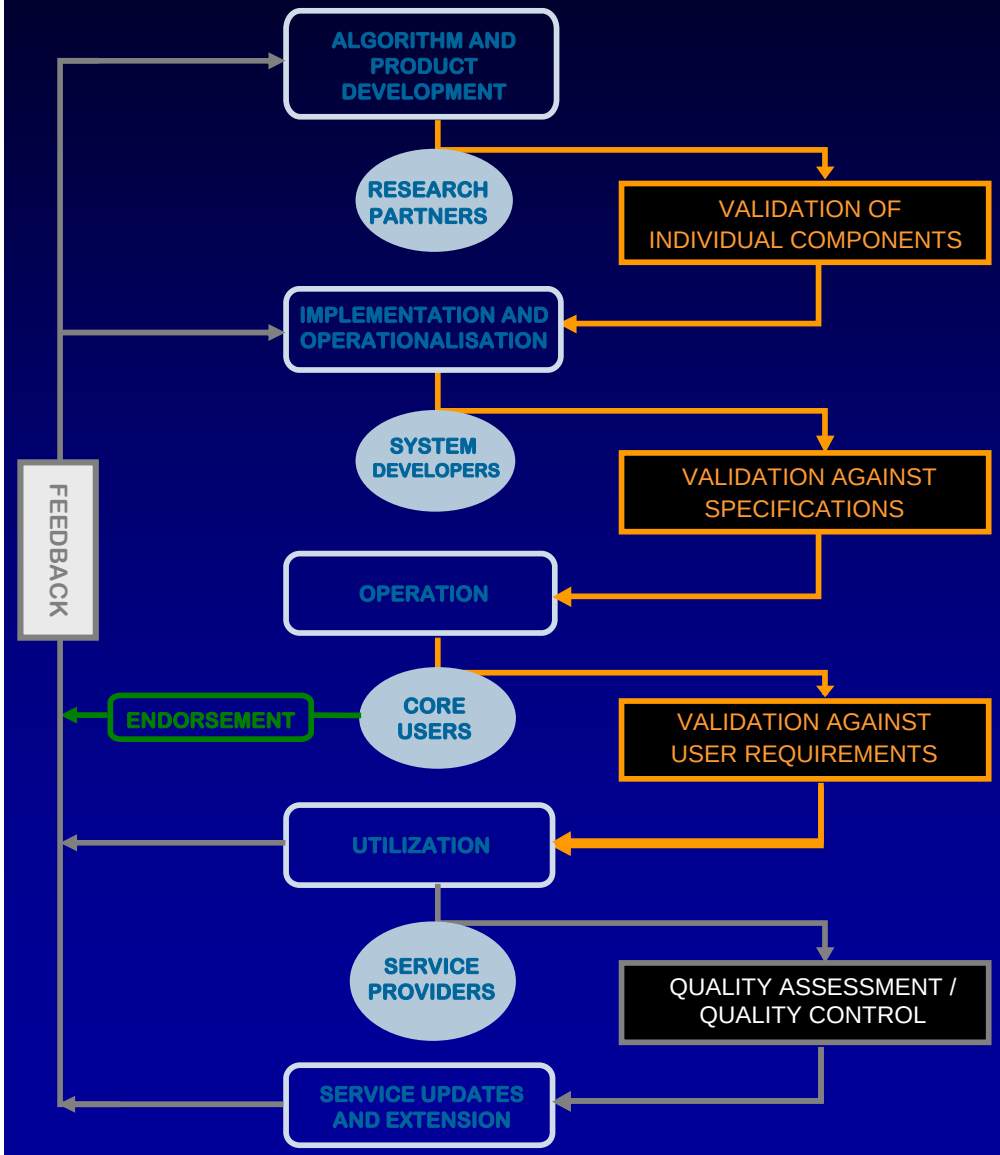
The PROMOTE laboratory

Towards operational atmospheric services



Networks of atmospheric services
[DA-09-01/02/03, CB-06-04, CL-06-01]

SLA-committed users
[US-09-01/03, CL-09-01, ST-09-02, HE-09-02]

Central Office (at BIRA-IASB) coordinating QA/Validation

- Fitness for purpose of validation
- Service Validation Protocol

Protocol being adapted to MACC, will be also for PASODOBLE

DOSSIER: Common TASK: 2

PROMOTE

Atmospheric Monitoring Services

Stage 2 of the Earthwatch GMES Services Element

PROMOTE 2

Atmospheric Services Validation Protocol

C5
Version 3
Issue 1

title / titre	Atmospheric Services Validation Protocol
reference / référence	GSE-PROMOTE-C5
version / version	3
revision / révision	1
status / état	final
date of issue / date d'édition	14.10.2009
document type / type de document	Framework Document

ENDORSEMENT !

AUTHOR	Validation Office	J.-C. Lambert, IASB-BIRA	14.10.2009	
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		M. Van Roozendael, IASB-BIRA	11.01.2010	
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		R. van der A, KNMI	13.01.2010	
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APPROVED BY	Scientific Officer	C. Zehner, ESA		
ISSUED BY	Validation Office	J.-C. Lambert, IASB-BIRA		

Service Validation – C5 Validation Protocol

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International standards, QA4EO, INSPIRE etc.

Best Cal/Val practices, fitness-for-purpose of validation

Best practices of Cal/Val, Cal/Val data updates, harmonisation across services…

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6.2 Terminology

The following terms and definitions have been proposed by standards development organisations of international recognition. They are expected to evolve as these organisations regularly update their standards and as further standardisation and harmonisation occur.

6.2.1 Reference Documents

[RD7] CDRH: Center for Devices and Radiological Health (CDRH), General Principles of Software Validation; Final Guidance for Industry and FDA Staff, CBER CDRH/OC Doc. N. 938, January 11, 2002. Publicly available via http://www.fda.gov/MedicalDevices/DeviceRegulationandGuidance/

[RD8] CEOS: CEOS Terms and Definitions, available via http://calvalportal.ceos.org

[RD11] Larssen, S., Sluyter R. and Helmis C. (1999), Criteria for EUROAIRNET – The EEA Air Quality Monitoring and Information Network.

[RD12] Nappo, C.J., Caneill J.Y., Furman R.W., Gifford F.A., Kaimal J.C., Kramer M.L., Lockhart T.J., Pendergast M.M, Pielke R.A., Randerson D., Shreffler J.H., and Wyngaard J.C. (1982) The Workshop on the Representativeness of Meteorological Observations, June 1981, Boulder, CO, Bull. Am. Meteorol. Soc. 63, 761-764.

[RD13] NIST: Prokhorov, A. V., R. U. Datla, V. P. Zakharenkov, V. Privalsky, T. W. Humpherys, and V. I. Sapritsky, Spaceborne Optoelectronic Sensors and their Radiometric Calibration. Terms and Definitions. Part 1. Calibration Techniques, Ed. by A. C. Parr and L. K. Issaev, NIST Technical Note NISTIR 7203, March 2005.

[RD15] VIM: Joint Committee for Guides in Metrology (JCGM/WG 2) 200:2008 & ISO/IEC Guide 99-12:2007, International Vocabulary of Metrology - Basic and General Concepts and Associated Terms (VIM), http://www.bipm.org/en/publications/guides/vim.html

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6.2.2 Recommended terminology

TERM	DEFINITION	SOURCE
accuracy	closeness of agreement between a quantity value obtained by measurement and the true value of the measurand; note that it is not a quantity and it is not given a numerical quantity value	VIM
area (volume) of representativeness	the area (volume) in which the concentration does not differ from the concentration at the station by more than a specific range	Larssen et al. (1999)
bias	(1) systematic error of indication of a measuring system (2) estimate of a systematic measurement error	VIM
calibration	(1) the process of quantitatively defining the system responses to known, controlled signal inputs (2) operation that, under specified conditions, in a first step, establishes a relation between the quantity values with measurement uncertainties provided by measurement standards and corresponding indications with associated measurement uncertainties and, in a second step, uses this information to establish a relation for obtaining a measurement result from an indication	CEOS VIM
dead band (or neutral zone)	maximum interval through which a value of a quantity being measured can be changed in both directions without producing a detectable change in the corresponding indication	VIM
detection limit	measured quantity value, obtained by a given measurement procedure, for which the probability of falsely claiming the absence of a component, given a probability α of falsely claiming its presence	VIM
error	(1) measured quantity value minus a reference quantity value (2) difference of quantity value obtained by measurement and	VIM

THANK YOU !

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