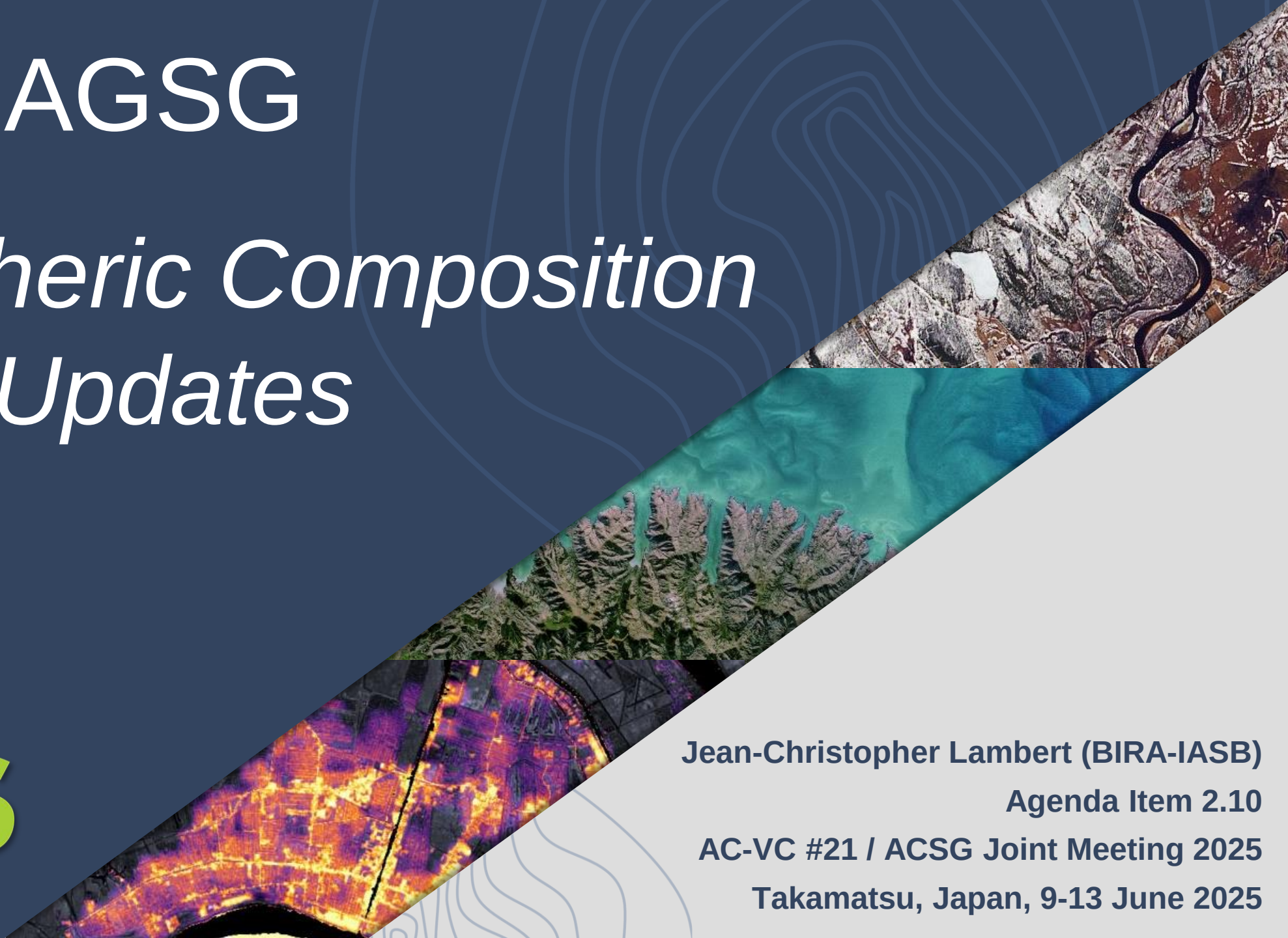
WGCV AGSG

Atmospheric Composition Cal/Val Updates



Committee on Earth Observation Satellites

Jean-Christopher Lambert (BIRA-IASB)

Agenda Item 2.10

AC-VC #21 / ACSG Joint Meeting 2025

Takamatsu, Japan, 9-13 June 2025

WGCV and Atmospheric Composition

Working Group on Calibration and Validation (WGCV) *(talk 2.09 by M. Thankappan)*

Several AO domains, Atmospheric Composition SG since 2001 *(this talk)*

WGCV activities relevant to atmospheric composition

- Pre-flight/in-flight calibration, SI-Traceable Satellites *(6.08 Shiomi, 2.11 Fox, 5.03 August)*
- Cal/Val best practices and protocols *(2.06 Keppens, 2.13 Koopman)*
- Support to Cal/Val networks: RadCalNet, HYPERNETS, TIRCALNET, FRM programmes, infrastructures… *(many updates in AC-VC thematic sessions)*
- CEOS-FRM Maturity Assessment Framework *(2.12 Castracane)*
- Interoperability framework: vocabulary, architecture, interfacing, quality, policy
- Collaboration with WMO, CGMS-GSICS, ISO/OGC, IMEO
- CEOS-ARD certification, VH-RODA, New Space engagement
- CEOS Cal/Val Portal

L1B Calibration and Validation

- Best practices: vicarious calibration, DCC, ISO 19159, PICS, Rayleigh Scattering, SNO/SONO, GEO/LEO…
- SWIR Cal/Val for GOSAT-1/2, OCO-2/3 & TROPOMI *(talk 6.08 by Kei Shiomi)*
  - Regular OCO-GOSAT-TROPOMI Calibration Meetings
  - Vicarious calibration & campaigns website at JAXA https://www.eorc.jaxa.jp/GOSAT/GHGs_Vical/index.html
  - Match-up database for SWIR and TIR sounders *(talk 1.02 by Hiroshi Suto)*
- SI-Traceable Satellites (SITSat) Task Team *(talk 2.11 by Nigel Fox)*
- Collaboration with CGMS-GSICS
  - WGCV participation in GSICS annual meetings
  - Pre-flight Optical Sensors Calibration Workshop, ESA/ESTEC, 2024/11

L2 Validation

- Community practices
  - Peer-reviewed articles, ISO 19124-1 ⇨ Cal/Val Resources document
  - Aerosol, Cloud & Precipitation Profile Validation (ACPPV)

CV-22-01
Talk 2.13 Koopman

- Tropospheric ozone datasets harmonization and validation

VC-20-01
Talk 2.06 Keppens

- Support to validation of constellations

GHG-TT, VC-20-02/03/04

- CEOS-FRM – Atmospheric composition engagement

CV-23-01
Talk 2.12 Castracane

- CINDI-3 intercomparison campaign

CV-24-01
Talk 3.22 Van Roozendael

- Tracking evolving needs, gaps and issues

General discussion Thursday 5pm

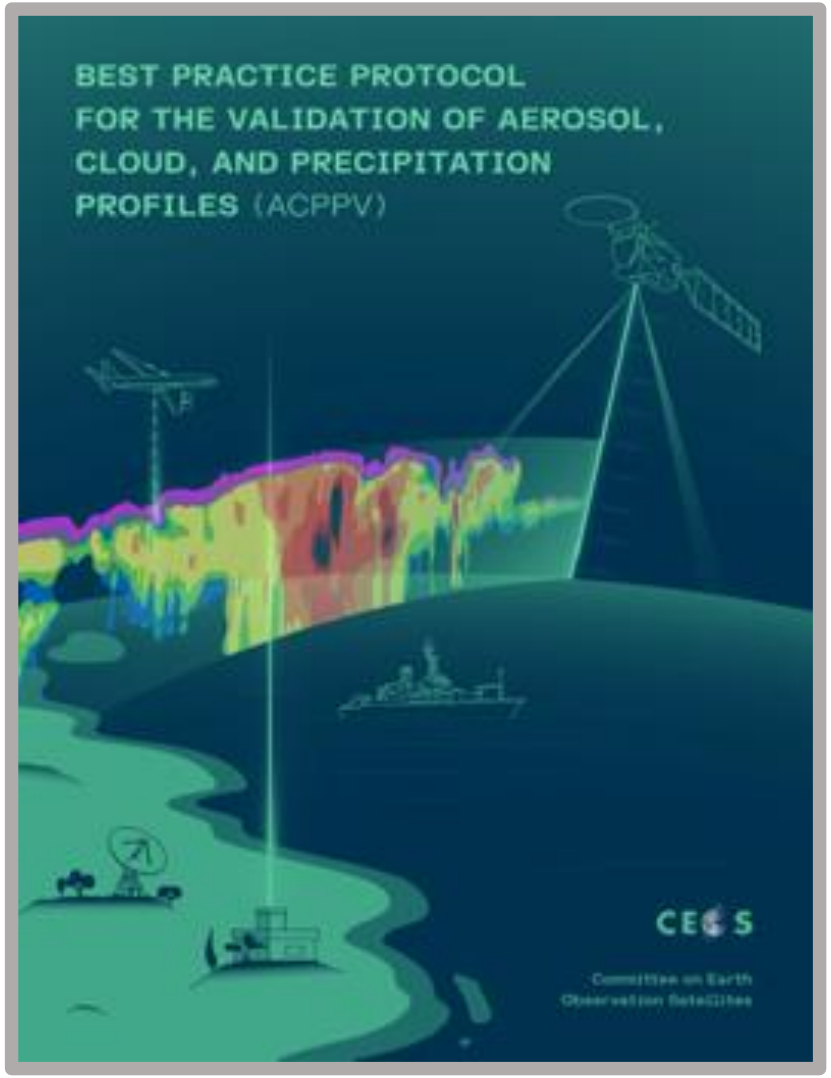
Validation Protocol for Aerosols and Cloud Profiles

See presentation 2.13 by Rob Koopman

- Community effort: NOA, NASA, ESA, DLR, JAXA, NILU, many universities (FI, US, DE, GR…), 51 affiliations
- 16 lead authors, 70+ co-authors
- Reviewed by WGCV and endorsed in Oct. 2024

Content

Validation needs for space profilers
Survey of validation measurements
Correlative metadata and data format
Guidance for the validation of lidar and aerosol products
Guidance for the validation of Radar, cloud and precipitation products
Statistical validation
Near-real-time validation through monitoring in NWP data assimilation
Gaps and challenges



Frameworks and Protocols

Cross-EO domains validation framework, standardized in ISO/TS 19124-1

Round-robin protocol for nadir profilers incl. AK-based information content analysis and QIs

Vertical state harmonization incl. tropospheric column representativeness and error propagation of data harmonization

Error budget closure of validation incl. 2D/3D representativeness and co-location mismatch errors

AGU PUBLICATIONS

Reviews of Geophysics

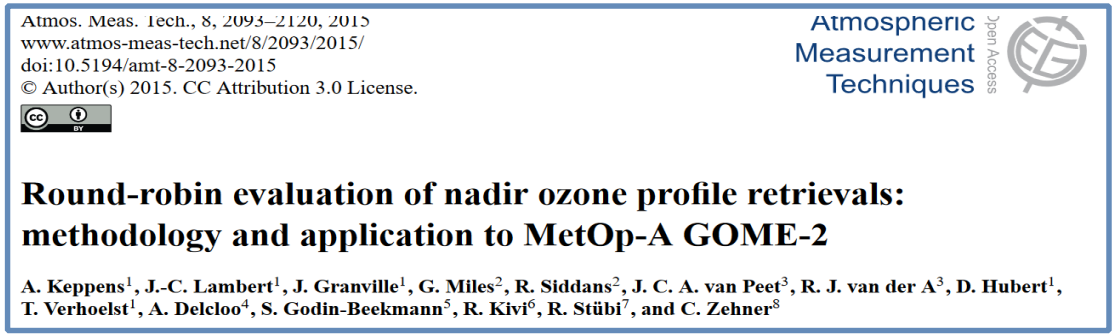
REVIEW ARTICLE

10.1002/2017RG000562

Validation practices for satellite-based Earth observation data across communities

Key Points:
- First review of EO validation approaches across different Geoscience communities
- Validation approaches depend on the intermittency and inhomogeneity

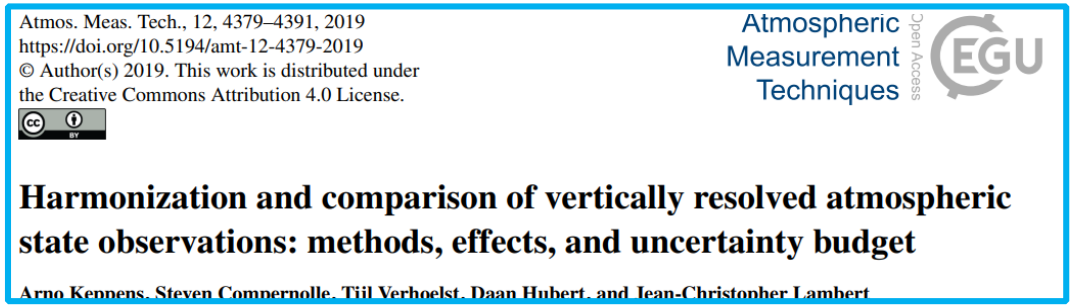
Alexander Loew[1,2], William Bell[3], Luca Brocca[4], Claire E. Bulgin[5], Jörg Burdanowitz[6], Xavier Calbet[7], Reik V. Donner[8], Darren Ghent[9], Alexander Gruber[10], Thomas Kaminski[11], Julian Kinzel[12], Christian Klepp[13], Jean-Christopher Lambert[14], Gabriela Schaepman-Strub[15], Marc Schröder[12], and Tijl Verhoelst[14]


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

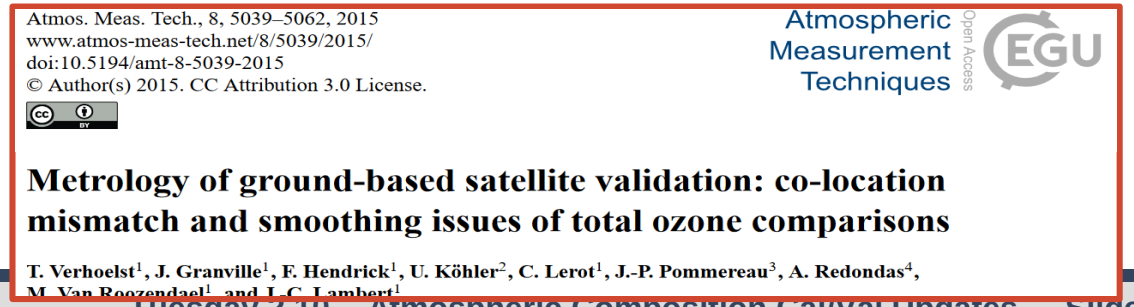
A. Keppens[1], J.-C. Lambert[1], J. Granville[1], G. Miles[2], R. Siddans[2], J. C. A. van Peet[3], R. J. van der A[3], D. Hubert[1], T. Verhoelst[1], A. Delcloo[4], S. Godin-Beekmann[5], R. Kivi[6], R. Stübi[7], and C. Zehner[8]


Atmos. Meas. Tech., 12, 4379–4391, 2019
https://doi.org/10.5194/amt-12-4379-2019
© Author(s) 2019. This work is distributed under the Creative Commons Attribution 4.0 License.

Atmospheric Measurement Techniques

Harmonization and comparison of vertically resolved atmospheric state observations: methods, effects, and uncertainty budget

Arno Keppens, Steven Compernolle, Tijl Verhoelst, Daan Hubert, and Jean-Christopher Lambert


Atmos. Meas. Tech., 8, 5039–5062, 2015
www.atmos-meas-tech.net/8/5039/2015/
doi:10.5194/amt-8-5039-2015
© Author(s) 2015. CC Attribution 3.0 License.

Atmospheric Measurement Techniques

Metrology of ground-based satellite validation: co-location mismatch and smoothing issues of total ozone comparisons

T. Verhoelst[1], J. Granville[1], F. Hendrick[1], U. Köhler[2], C. Lerot[1], J.-P. Pommereau[3], A. Redondas[4], M. Van Roozendael[1], and J.-C. Lambert[1]

CCVS Requirements and Gap Analysis

Copernicus Cal/Val Solution (EU H2020 CCVS) – With WGCV ACSG, IVOS and SAR participation

CCVS

Ground-based networks design

There is a need for R&D on *network design*, in particular for emerging measurement networks, but also for FRM-tailoring and sustainability of the existing networks.

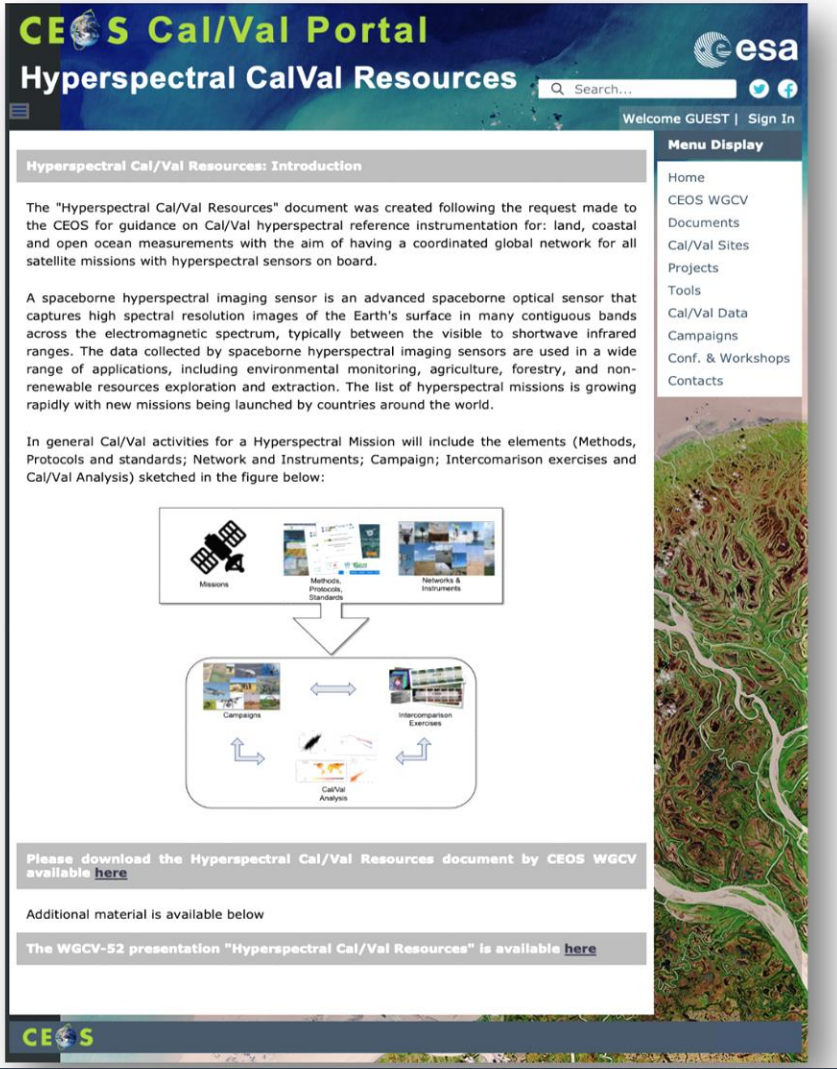
Cal/Val requirements => objective gap analysis criteria for Cal/Val infrastructures

- Range of measurand
- Geographical coverage, types of atmospheric states (or regimes)
- Range and sampling of main influence quantities (SZA, T profile, surface albedo, aerosols, clouds…)
- Assessment of the spatio-temporal representativeness of measurements at a given location – requiring also assessment of spatio-temporal variability at that location => complementarity of airborne campaigns and modelling
- Co-location of instruments at 'supersites', e.g., SWIR with UVVIS, atmospheric composition and ancillary data (incl. surf. albedo) for in-depth validation of retrieval algorithms, validation of attribution proxies (simultaneous measurements of CO_2, NO_2, HCHO, SIF, smoke AOD)…

http://ccvs.eu

Cal/Val Resources Document

https://calvalportal.ceos.org/web/guest/hyperspectral-calval-resources



Plan for an Atmospheric Composition Cal/Val Resources document

- Frameworks, protocols, guidelines
  - ✓ Generic validation process, terminology
  - ✓ Metrics, data comparison error budget
- End-to-end validation from L1B and L2 to L3
- FRMs and other validation measurements
  - ✓ Monitoring networks
  - ✓ Campaigns
  - ✓ Supersite concepts
  - ✓ CEOS-FRM maturity
- Cross-satellite validation
- Alternative retrievals
- Tools, databases and services
- Mission-specific resources

CEOS-FRM Maturity Assessment Framework

See 2.12 talk by Paolo Castracane

https://calvalportal.ceos.org/web/guest/frms-assessment-framework

CEOS-FRM Maturity Assessment Framework version 1 (2023)

Self-assessment					Independent assessor
Nature of FRM	FRM Instrumentation	Operations/ sampling	Data	Metrology	Verification
Descriptor	Instrument Documentation	Automation level	Data completeness	Uncertainty Characterisation	Guidelines adherence
Location/ availability of FRM	Evidence of traceable calibration	Measurand sampling	Availability and Usability	Traceability Documentation	Utilisation/Feedback
Range of sensors	Maintenance plan	ATBDs on processing/software	Data Format	Comparison/calibration of FRM	Metrology verification
Complementary observations	Operator expertise	Guidelines on transformation to satellite Pixel	Ancillary Data	Adequacy for intended class of sensors	Independent Verificaton
				FRM CLASSIFICATION	**A B C D** (to be selected)

CEOS Working Group on Calibration and Validation

Self-assessment pilots

FRM4DOAS · Fiducial Reference Measurements for Greenhouse Gases · PGN · BREWER NO_2

Self-assessments published in *Remote Sensing* Special Issue

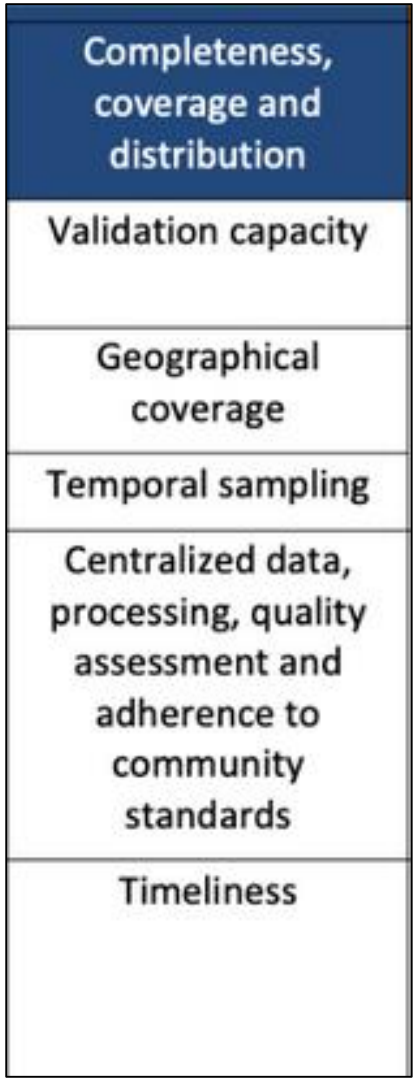
FRM4DOAS · TCCON · CO_2 CCOM

CEOS-FRM Maturity Assessment Framework

See 2.12 talk by Paolo Castracane

CEOS-FRM Version 2

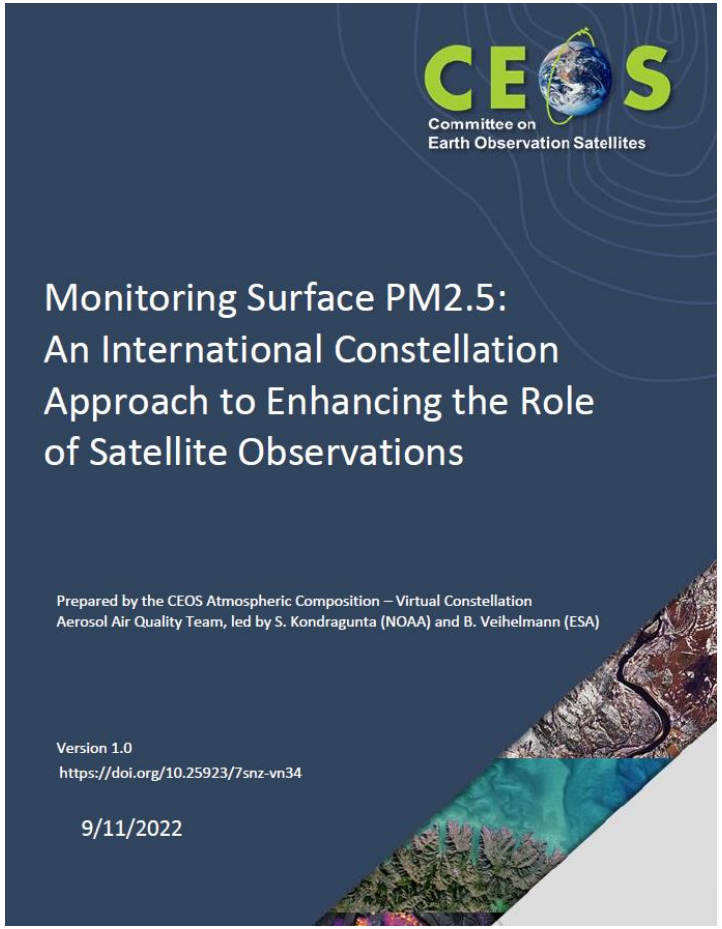
- V1 applicable to a measurement ⇨ classification
- V2: additional column characterizing 'completeness of validation capacity' achieved by network deployment of the same instrumentation, centralized processing, and timeliness; not a classification criteria
- Not meant to be applicable to multi-species/multi-instruments/GHG-AQ-synergy supersite concepts
- Intended to be applied systematically



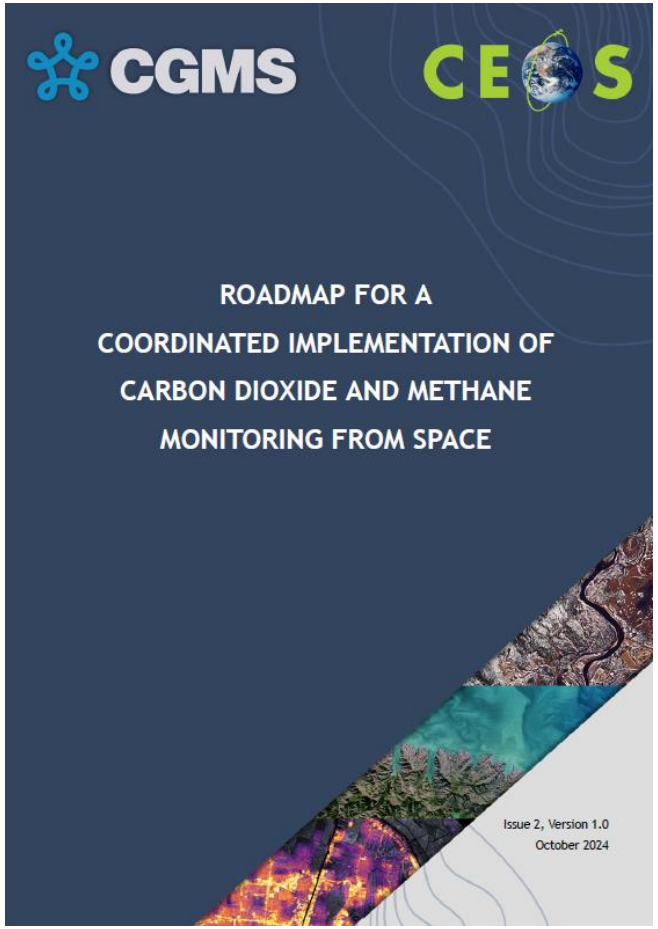
Cal/Val Needs for the Constellations

Air Quality

PM 2.5



GHG



Tracking Gaps in Validation Capabilities

GHG Constellation Roadmap V2 – Annex C – L2VAL-03

- To track L2 validation Capabilities, Evolving Needs and Gaps in the ground-based L2 validation system
- To explore a more operational framework for delivering its products to support evolving GHG mission needs

Extension to other thematic domains

- Ozone: ongoing collaboration with WMO GAW
- Air Quality: CCVS gap analysis; AGU 2024 update talk, ESA LPS25 session

➢ AC-VC / ACSG General Discussion Th 17:00-17:30

- 5.01 – Tracking need, gaps and issues'
- 5.02 – 'WMO ET on Network Design and Evolution'

CEOS Cal/Val Portal

https://calvalportal.ceos.org

Atmospheric updates in development

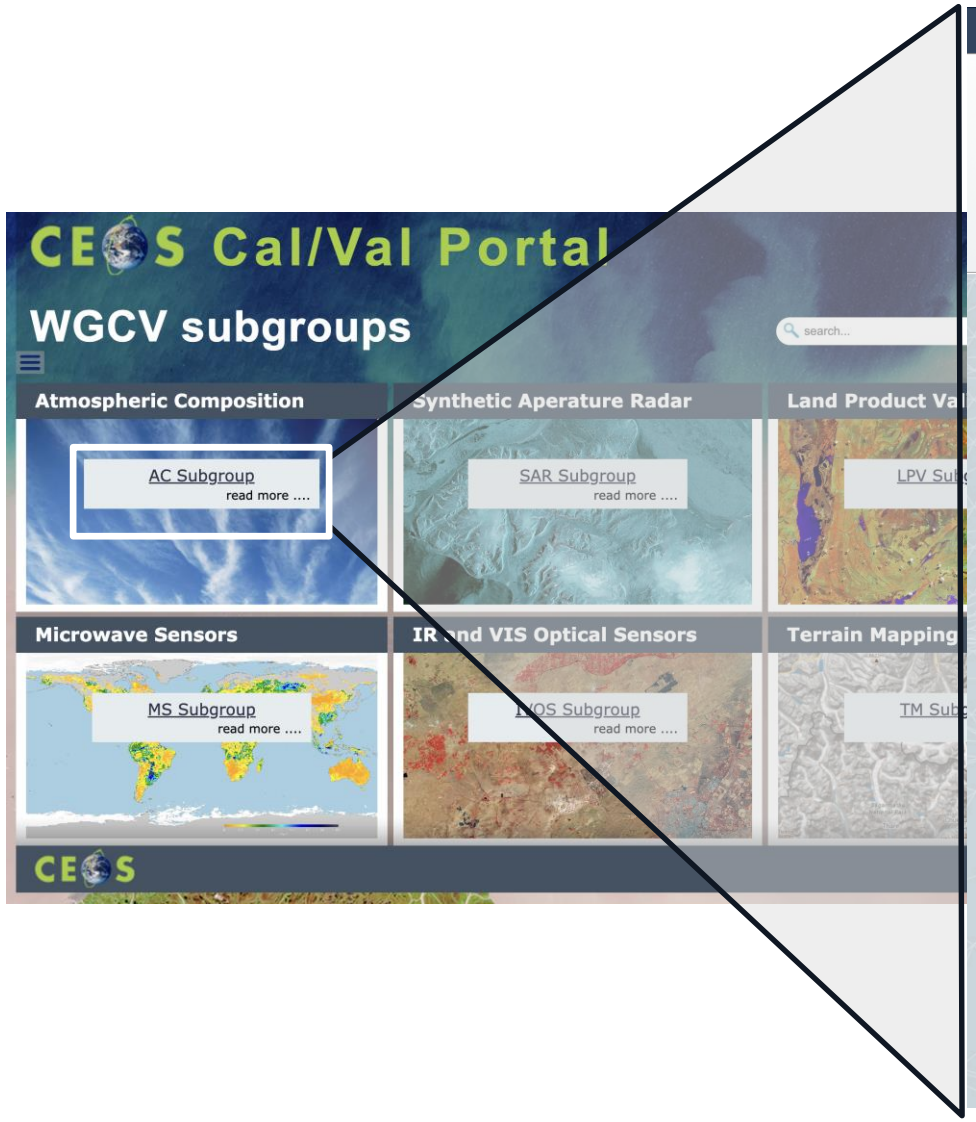
- Registry of Cal/Val practices
- Registry of Cal/Val networks
- Registry of Cal/Val resources
- Advertisement of campaigns

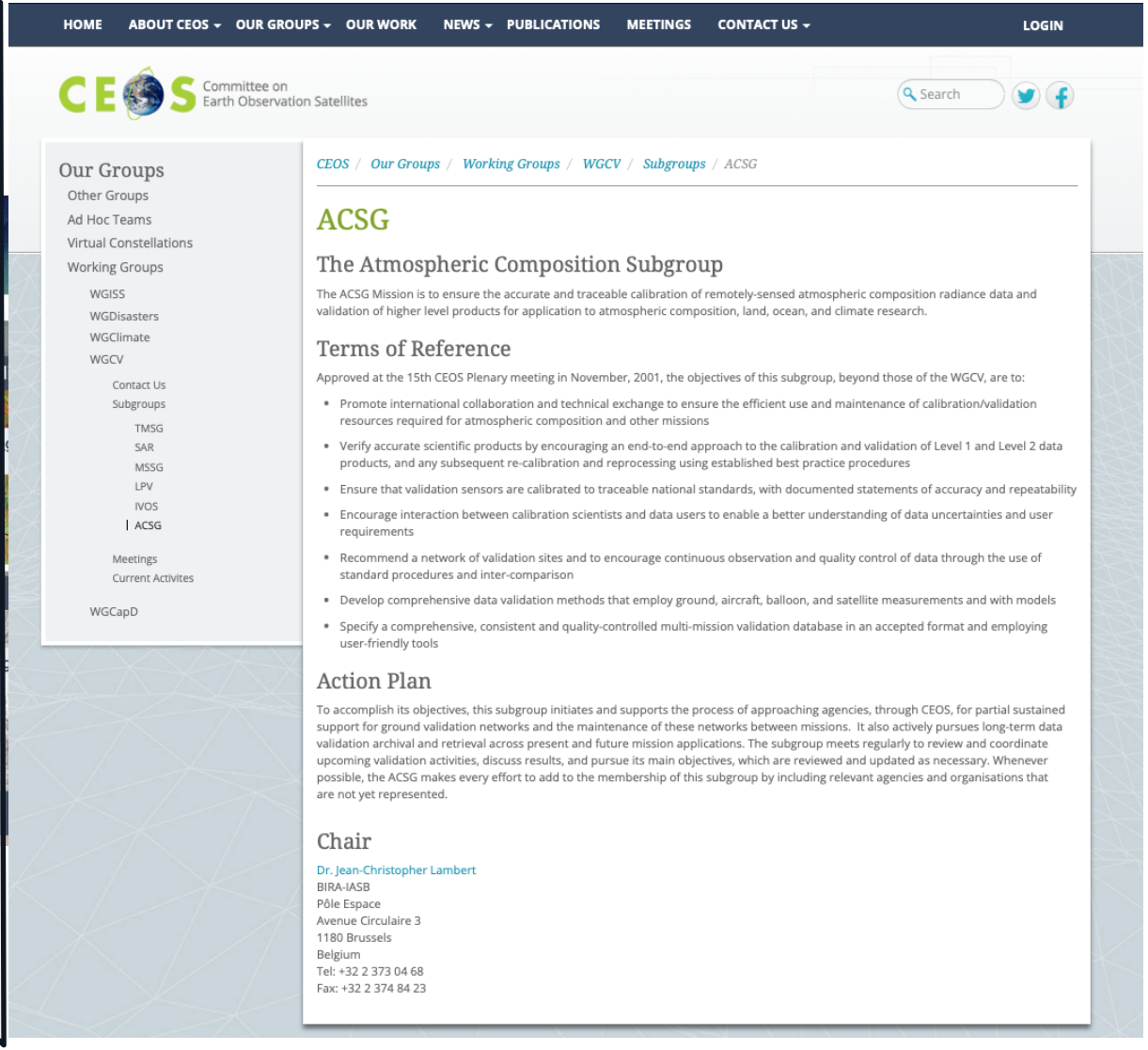
The Third Cabauw INtercomparison of DOAS-like Instruments (CINDI-3)

We are pleased to announce the Third Cabauw INtercomparison of DOAS-like Instruments (CINDI-3), that will take place in Cabauw (The Netherlands) during four weeks from May 21 until June 22, 2024.

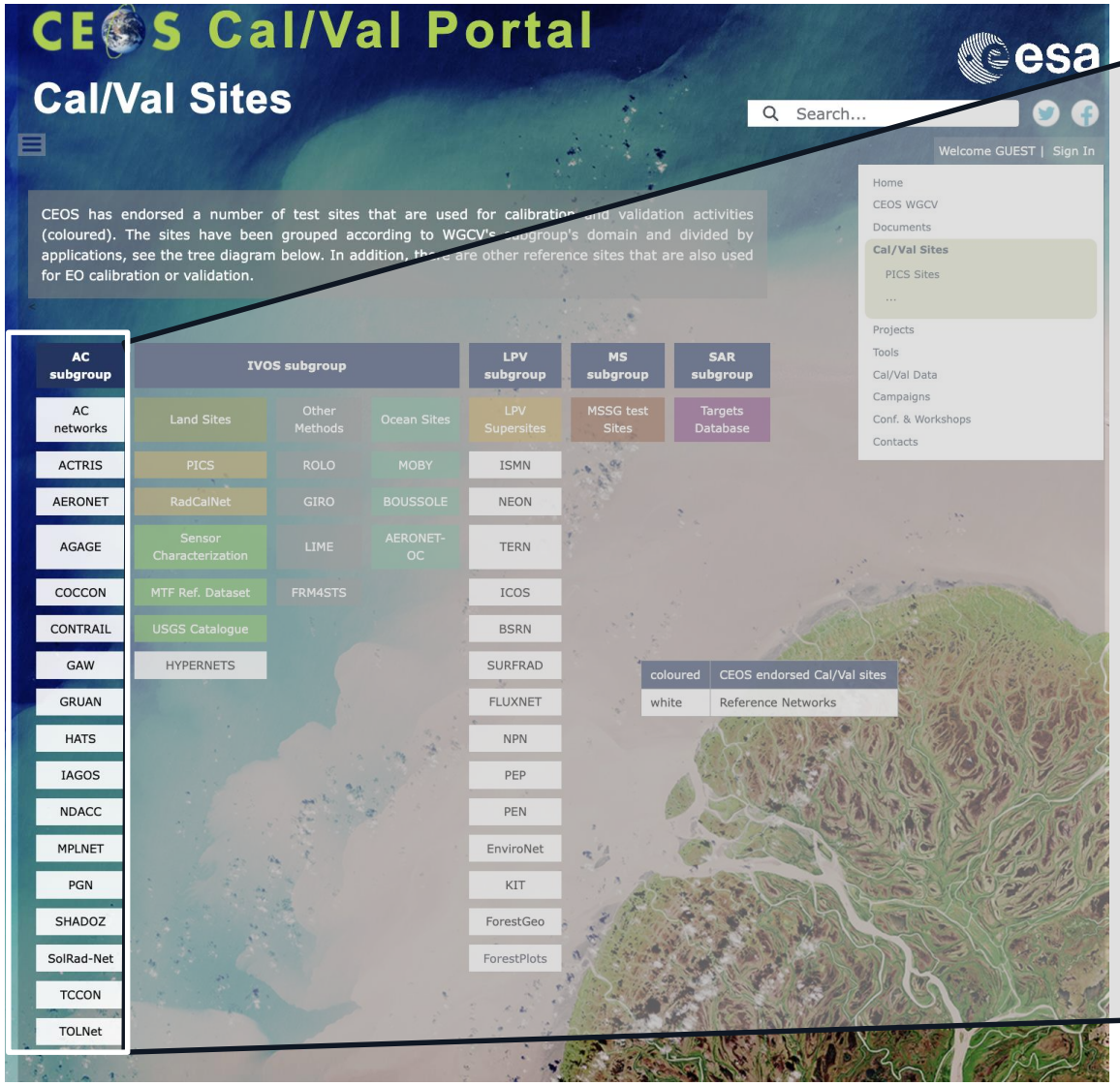
CINDI-3 is a community-wide intercalibration campaign of ground-based UV-Visible DOAS instruments measuring the atmospheric column and profile of NO2 and O3, complemented by mobile-DOAS observations and an exhaustive range of measurements of aerosols, NO2, O3 and other UV-Visible trace gases of interest like HCHO, CHOCHO, HONO, BrO and H2O. The campaign also includes an airborne component for the characterization of the

CEOS Cal/Val Portal – ACSG





CEOS Cal/Val Portal – ACSG



Cal/Val Discussion Topics for This Week

General discussion on requirements and practices

later this morning

- WGCV-ACSG and AC-VC collaboration
- Systematic application of CEOS-FRM V2
- Input to Cal/Val Portal update
- Atmospheric Composition Cal/Val Resources document

Gaps, evolving needs, and issues

- Operational validation capacity — today 15:10 - 2.24
- Tracking gaps for validation systems and networks — Thursday 17:00 - 5.01