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Geo-AQ Constellation Geophysical Validation Needs

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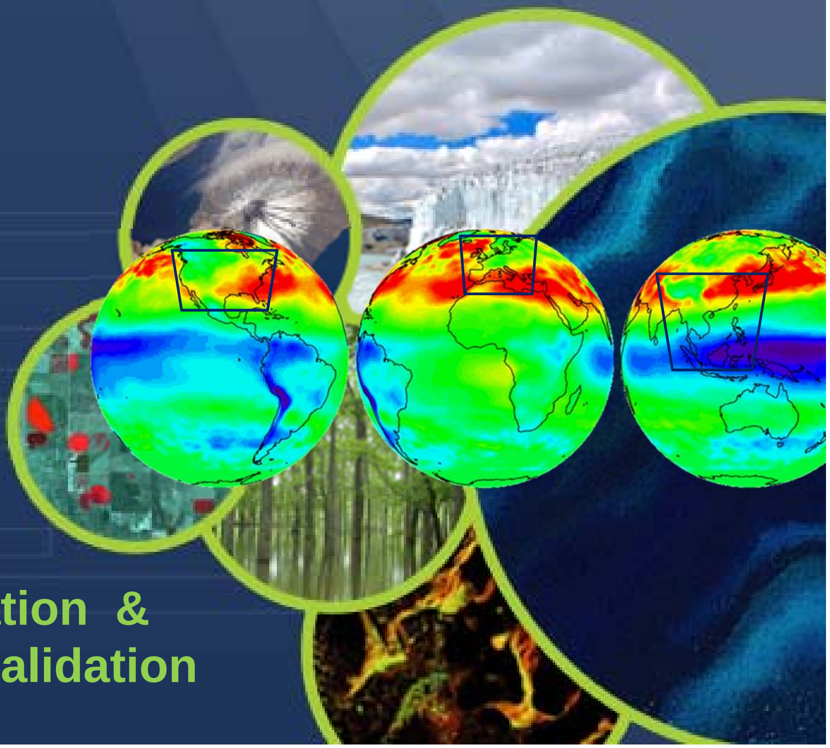
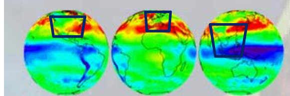
CEOS Atmospheric Composition Constellation & CEOS Working Group on Calibration and Validation



Geo-AQ Constellation Geophysical Validation Needs

1. Lessons learnt from heritage missions
2. Geo-AQ challenges
3. Geo-AQ validation needs
4. Constellation specifics



Lessons learnt
from heritage missions

- Need for common objectives of geophysical validation, which implies identification of users of validation results and sustained interaction with them: operational monitoring, level-1 teams, level-2 teams, provision of quality indicators for generic/identified data users, feedback to agencies…
- Need for common set of quality indicators (bias, stability, SZA/VZA dependences, thermal contrast dependence…) and the way to quantify and report them
- Need for exhaustive validation over at least one complete annual cycle of important parameters: SZA, atmospheric temperature, snow/ice cover, surface BRDF…
- Need for common Terms and Definitions (CEOS endorsed Terminology and Definitions, BIPM/ISO metrology standards like GUM and VIM; avoid giving a numerical value to "accuracy"…)

Lessons learnt
from heritage missions

- Careful identification of reference measurements: traceable measurement procedure, documented data quality including uncertainty estimates and information content, availability of metadata
- Need for harmonization of validation measurements => common measurement protocols, common QA protocols, common data format etc.
- Need to adopt harmonized data formats, for harmonized and shared data handling tools
- Need for harmonized data policy and access to satellite databases and validation databases

Lessons learnt
from heritage missions

- Need for cal/val best practices, including end-to-end traceability of the cal/val process; and need to apply those best practices
- Need for common guidelines regarding data manipulations: filtering, conversion of units and of coordinate system, smoothing manipulations, binning…
- Need for appropriate handling of data representativeness: differences in horizontal resolution, differences in geographical/temporal sampling, point-to-area and area-to-volume conversions…
- Value of child products to facilitate validation work and encourage spontaneous validation studies

Lessons learnt
from heritage missions

- Need for exhaustive Cal/Val during one year, complemented by monitoring over lifetime
- Value of 1 year tandem operation of a satellite and its successor
- Need for recalibration and reprocessing of satellite datasets over lifetime and beyond, with subsequent (delta-)validations of algorithm and data improvements
- Need for sustainable Cal/Val infrastructure, difficulty to fund campaigns on the long term
- Need for structural funding of validation/monitoring activities (best effort basis works only during CP when scientific motivation of external partners is high)
- Issue of Cal/Val funding by national agencies and institutions, who often regard validation as a subaltern activity; better chance to get funding if part of a geophysical investigation/campaign

Planned Geo-AQ missions (+1 LEO)

	Korea GEMS	Europe Sentinel-4	USA TEMPO	Europe Sentinel-5 Precursor TROPOMI
Orbit	Geostationary	Geostationary	Geostationary	Low-Earth
Domain	Asia-Pacific	Europe and surrounding	North America	Global
Revisit	1 hour	1 hour	1 hour	1 day
Status	Instrument PDR complete	Detailed Design, Phase C	Instrument PDR July 2014	Instrument delivery 2015
Launch	March 2019	2021 (Flight Acceptance Review first instrument)	No earlier than 11/2018	Early 2016
Payload	UV-Vis 300-500 nm	UV-Vis-NIR 305-500, 750-775 nm	UV-Vis 290-490, 540-740 nm	UV-Vis-NIR-SWIR 270-500, 675-775, 2305-2385 nm
Products	O_3, NO_2, SO_2, HCHO, AOD	O_3, NO_2, SO_2, HCHO, AAI, AOD, height-resolved aerosol	O_3, trop. O_3, 0-2km O_3, NO_2, HCHO, SO_2, CHOCHO, AOD, AAI	O_3, NO_2, SO_2, HCHO, AAI, AOD, height-resolved aerosol, CO, CH_4
Spatial Sampling	3.5 km N/S x 8 km E/W @38N	8 km x 8 km at 45N	2.1 km N/S x 4.7 km E/W @35N	7 km x 7 km nadir
Nominal product resolution	7 km N/S x 8 km E/W @38N (gas), 3.5 km N/S x 8 km E/W @38N (aerosol)	8.9 km N/S x 11.7 km E/W @40N	8.4 km N/S x 4.7 km E/W or better @35N (with 100W orbit)	7 km x 7 km nadir
Notes	Synergy with AMI and GOCI-2 instruments w.r.t. aerosol and clouds.	Two instruments in sequence on MTG-S; use TIR sounder on MTG-S (expected sensitivity to O3 and CO). Synergy with imager on MTG-I w.r.t. aerosol and clouds.	GEO-CAPE precursor or initial component of GEO-CAPE. Synergy with GOES-R/S ABI w.r.t. aerosol and clouds.	In formation with S-NPP for synergy w.r.t. clouds and O_3.

Geo-AQ Challenges

Troposphere specifics

- Significant gradients and temporal variability of tropospheric composition, horizontally and vertically
- Diurnal cycles: photochemistry, dynamics etc.
- Influence of local emission sources as well as longer-range transport

Remote sensing specifics

- Sensitivity to tropospheric targets can be poor due to low concentration, low T contrasts, masks/filters (stratospheric layer, clouds, Rayleigh…)
- Variety of retrieval approaches: DOAS, TOR, CCD, OE, PTR, DA…
- Complex retrieval chains with dependence on a-priori assumptions, measurement parameters (clouds, albedo…), use of external data
- Variety of data products: VMR, trop. C, 6km PC, 1DoF PC, trop. excess…

Geo-AQ Challenges

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Geo-AQ specifics

- Discussion of this morning led by Chance, Kim and Veihelmann about GEO-specific retrieval challenges
- Unprecedented horizontal resolution
- Hourly sampling of atmospheric changes and measurement parameters changes over the day
- Moderate to large SZAs and VZAs
- LEO bias of data retrieval and validation experience

Geo-AQ Validation Needs

Traditional validation needs

- See lessons learnt from heritage missions
- In-depth validation of L2 data, intermediate quantities and ancillary parameters during CP and through at least one complete annual cycle
- Long-term validation programme, addressing also operational and service aspects
- Validation database enabling delta validation after each significant algorithm improvement, even decades after satellite lifetime

Geo-AQ Validation Needs

Traditional activities

In-depth, long-term and delta validations by

- Established, QA'd ground-based networks (most under WMO/GAW umbrella): PTU radiosondes, GO_3OS, NDACC (MAX/ZLS-DOAS, FTIR, sondes, lidar, MWR, UV), SHADOZ, TCCON, PANDORA, AGAGE, HATS, AERONET, EARLINET, MPLNET…
- Global (GAW *in situ*) and national/regional AQ and UV monitoring networks
- Inter-comparison with other satellites => role of LEOs as standard transfer and for global perspective on emissions and transport

In-depth campaigns with exhaustive instrumentation

- Ground-based intercomparisons/intercalibrations
- Airborne
- Balloon-borne

Geo-AQ Validation Needs

GEO-specific activities

New/dedicated measurement needs:

- Need for horizontal and vertical details, changing with time
- Need for wide range of atmospheric states and observation conditions
- Need for validation data with enhanced sensitivity to the troposphere: MAX-DOAS, PANDORA, FTIR, NO_2 sonde
- Need for synergistic campaigns joining mapping capabilities to more traditional instrumentation: DISCOVER-AQ (2011-2014), COMEX (2014), AROMAT (2014-2015), KORUS-AQ (2016)…
- Need for mapping instrumentation affordable for frequent/routine operation, enabling long-term 2D monitoring : UAV, multi-instrument supersite, tomography?

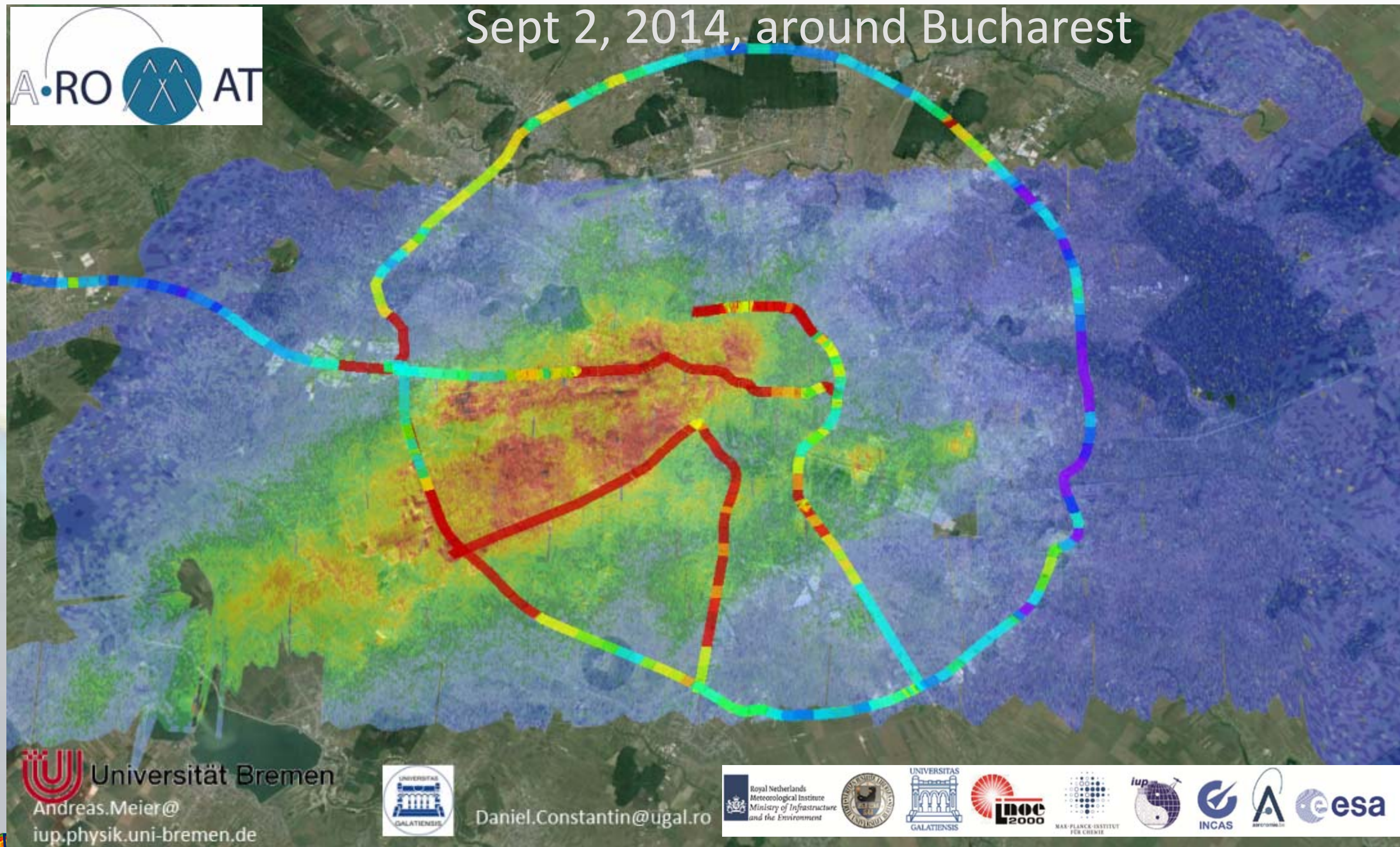
AROMAT Campaign 2014

(more in presentation by Van Roozendael)

AirMAP: IUP-Bremen pushbroom imager, resolution <u>100m</u>, from the Uni. Berlin Cessna
Ref: Schönhardt et al., 2014

Mobile DOAS systems: compact uv-vis spectrometers on cars (MPIC, IASB-BIRA, Uni. Galati) *Ref: Wagner et al., 2010; Merlaud, 2013; Constantin et al., 2013*

+ KNMI **NO_2 sonde** + **SWING/UAV** + on site instrumentation



Geo-AQ Validation Needs
Specific needs

Need for approaches to handling:

- Mismatches of spatial representativeness between satellite and validation measurements, in the vertical as well as the horizontal
- Accuracy of geo-location of satellite data => use of fiducial markers?
- Variety of products (and conversions?): VMR, 6km PV, trop. excess…
- Complexity and variety of retrieval methods and systems
- Significant dependence of vertical sensitivity of tropospheric retrievals on SZA, ground albedo, clouds, a priori assumptions…
- Effects of clouds and of orography (shadow) in neighbouring pixels
- Variation of solar illumination and viewing geometries during the course of a day, and the corresponding sensitivity to directional characteristics of clouds, aerosols, surface reflectance and orography

Next step: Constellation-specific validation needs

Value added by a constellation?

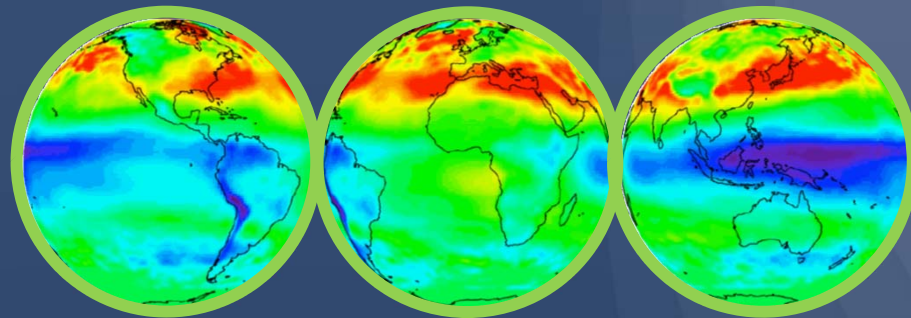
Mutual consistency of L2 data across the AQ constellation (Geo-AQ + LEOs) critical for:

- long-range transboundary air pollution transport monitoring (CLRTAP)
- geographically unbiased climate change assessments (IPCC)
- accurate alert of volcanic hazards to aviation control
- use in global data assimilation systems
- Impact studies of environmental regulations…

Inter-mission validation strategy

Mutual consistency of L1 data addressed by GSICS

=> Some harmonization needed at Level-1-to-2 stage to ensure consistency of L2 data, including harmonization in validation measurements, validation procedures, expression of QIs and uncertainties



Thank you !

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