Geophysical Validation Goals and Plans

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Assessment of tropospheric ozone from satellites
Multi-satellite assessments

Typical findings

- Satellites capture well major features and trends.
- Biases between satellites change with time.
- Differences in sensitivity and sampling matter.
- Vertical sensitivity differences not straightforward to assess and handle.
- Data harmonisation improves mutual consistency.
Assessment of tropospheric ozone from satellites

Data assimilation - Reanalyses

- Performance of reanalyses depends on assimilated satellite data.
- Temporal (in)consistency affects trends and interannual variability assessments.
Assessment of tropospheric ozone from satellites
IGAC Tropospheric Ozone Assessment Report (TOAR)

Lessons from TOAR-I (Gaudel et al., 2018)

• Satellites report a wide variety of trends (2008-2016) and variations in tropospheric ozone.
• Differences in vertical sensitivity and sampling
• Differences in tropopause column definition
• Biases change over time.
• (In)consistencies with TOST (ozonesonde trajectories)

TOAR-II Satellite Ozone Working Group goals
https://igacproject.org/satellite-ozone-working-group

• Address above issues
• Global chemistry transport models as transfer standard
• Reconcile satellite-, ground- and aircraft-based data
• Provide common methodology for validation of trends
Assessment of tropospheric ozone from satellites

Validation practices for: sensitivity, bias, drift, precision, sampling errors, geophysical features

Information content, validation metrics...
Discussed at ACC-10/11

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

Biases, drifts and their uncertainties

Ground-based assessment of the bias and long-term stability of 14 limb and occultation ozone profile data records

Representativeness, vertical sampling

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

Validation, sampling errors, geophysical variability and patterns

TROPOMI tropospheric ozone column data: Geophysical assessment and comparison to ozone sondes, GOME-2B and OMI

Atmos. Meas. Tech., 12, 4579–4591, 2019
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Quality Indicators for tropospheric ozone column

**Bias**
- Vs. ozonesondes:
- Dependences SAT-to-SAT:
  - meridian:
  - zonal:
  - seasonal:
- Consistent with ex-ante systematic error?
- Consistent with tropopause definition/sensitivity effects?

**Dispersion**
- From pairwise:
- From triplets:
- Dependences SAT-to-SAT:
  - meridian:
  - seasonal:
- Sampling errors:
- Consistent with ex-ante uncertainty estimate?

**Geophysical patterns & signals**
- Annual + semi-annual cycles?
- ENSO, MJO, QBO?
- Zonal wave one?
- Biomass burning season?
- Other known features?
Lack of harmonisation between the different satellite records, e.g., regarding terms and definitions of the tropopause and the tropospheric content.

Use high-resolution T and O₃ profiles and averaging kernels (or weighting functions) to explore effects of:
- difference in top level tropospheric column,
- difference in tropopause definition,
- difference in auxiliary data to define tropopause.

Correlative T and O₃ profile data:
- ozonesonde network (GAW, NDACC, SHADOZ)
- IAGOS aircrafts
- (NDACC and TOLNet tropospheric lidars)
- (NDACC FTIR)
Sensitivity and Tropospheric Burden

GOME-2A (RAL v2.1) vs. IASI (FORLI v2014)

Adapted from Keppens et al., 2018
O3S-DQA Improving Ozoneonde Network Homogeneity

WMO/GAW O3S-DQA evaluation/improvement of ozonesonde network(s) homogeneity

- Satellite ensemble based evaluation approach
- 2000-2013; 60 WOUDC sites, 28 NDACC sites, SHADOZ
- Network inhomogeneities caused by ozonesonde type, manufacturer, solution strength
- By-product: mutual consistency of data archives (WOUDC, NDACC, SHADOZ, ESRL...)

Courtesy D. Hubert, BIRA-IASB
Assessment of tropospheric ozone from satellites

Ongoing activities

**NASA** (G. Labow et al.)
- The Great Tropospheric Ozone Cook-Off @CEOS AC-VC-15
- Intercomparison of monthly/daily gridded satellite data records
  - Spatial structure of the bias

**BIRA-IASB** (D. Hubert, A. Keppens, J.-C. Lambert, C. Vigouroux)
- National project CASTOAR with ULB (P.F. Coheur, C. Wespes) and RMIB (R. Van Malderen)
- Characterise & understand differences between satellite tropospheric O₃ using ground-based comparisons (ozonesondes, NDACC FTIR)
  - Tropospheric content
  - Vertical sensitivity & smoothing
  - Long-term stability
  - Trends
- Assessment of known geophysical signatures

**DLR** (K.-P. Heue, M. Coldewey-Egbers, D. Loyola et al.)
- Harmonisation, multi-satellite trends
- Intercomparison CCD S5P, GOME-2, OMI and S5P/BASCOE
  - Spatial & temporal structure of the bias
  - Trends
  - Validation with RMIB (A. Delcloo)

**Other activities/groups welcome**
- IAGOS aircraft data?
- ...?
Identification via GoogleDoc registration sheet

Example: S5P TROPOMI tropical tropospheric ozone

- Convective Cloud Differential (CCD) technique using
  - TROPOMI Level-2 total ozone column data (GODFIT v4)
  - TROPOMI Level-2 cloud data (OCRA + ROCINN_CRB)

- Represents
  - \( O_3 \) column between surface and 270 hPa
  - daily Level-3 product, 0.5° lat. x 1° long., latitude range 20°S-20°N
  - 3-day moving average of cloud-free data
  - Associated vertical sensitivity/smoothing estimate: ...
  - Associated uncertainty estimates: ...

- Processed at DLR with L2_O3_TCL OFFL processor v01.01.05-08
- Available operationally since 30 Apr 2018 on the Copernicus data hub: [https://scihub.copernicus.eu](https://scihub.copernicus.eu)
Geophysical Validation Goals and Plans

• VC-20-01: 'Tropospheric O3 dataset validation and harmonization' due by end of 2022
• Initial results to be presented next year in AC-VC-17
• Agreed two reference years for global and regional distributions: 2017-2018
• Agree on ground-based stations & regions for trend & drift studies
• Register and give access to satellite data with requested identification and guidelines (QA filters etc.) ⇒ Request GoogleDocs link to Arno.Keppens and Daan.Hubert both at @aeronomie.be
• Coordination with TOAR-II plans and needs