Ozone Profile Analysis with Umkehr measurements and Satellite Validation for selected Brewer and Dobson spectrophotometers

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1. INTRODUCTION

- **Umkehr technique**: an inexpensive way to retrieve high quality and high vertical resolution ozone profiles that cover both troposphere, UTLS and the stratosphere, from Dobson or Brewer spectrophotometers.
- Within the **European Space Agency IDEAS+ QA4EO** framework, new efforts are currently underway to improve the operational Umkehr analysis algorithm and provide a more robust and unique **validation dataset for ozone profile observations** by space-born sensors, such as S5P/TROPOMI, as well as the GOME2 and IASI instruments on the Metop platforms.
- **Four Dobson and four Brewer stations** have been analyzed for the period 2017 – 2020.
- An **optimization technique** has been developed for the analysis of Dobson Umkehr measurements (Petropavlovskikh et al. 2021), expected to be applied on Brewer measurements in the future.
- **Comparisons with SBUV and GOME2 ozone profiles overpasses are shown**

2. DATA AVAILABILITY

Umkehr measurements:

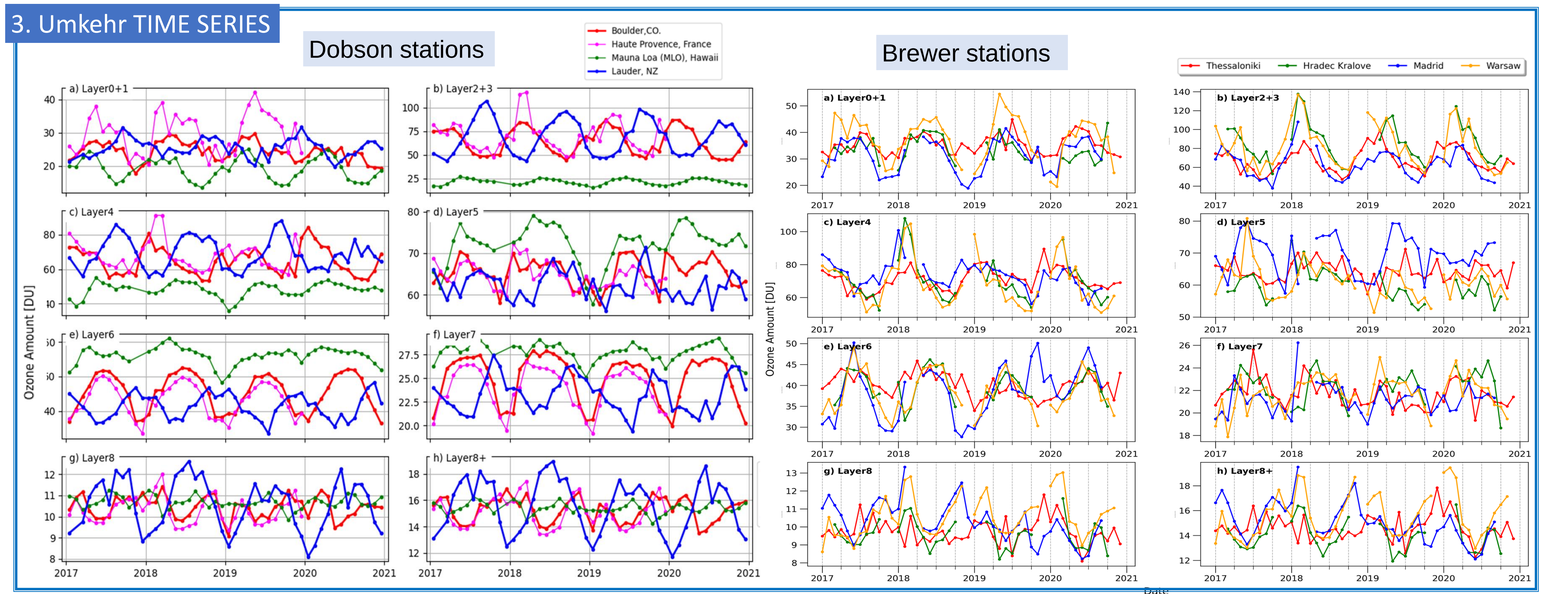
Station	Instrument Type/ Number	Latitude	Longitude
Thessaloniki	Brewer MKII (#005)	40.63 N	22.96 E
Hradec Kralove	Brewer MKIII (#184)	50.18 N	15.84 E
Madrid	Brewer MKIII (#186)	40.45 N	3.72 W
Warsaw	Brewer MKIII (#207)	52.25 N	20.94 E
Boulder	Dobson (#061)	40.02 N	105.25 W
Mauna Loa	Dobson (#076)	19.53 N	155.58 W
Haute Provence	Dobson (#085)	49.93 N	5.71 E
Lauder	Dobson (#256)	45.05 S	169.68 E

Brewer measurements were extracted from the European Brewer Network (http://www.eubrewnet.org/) database.

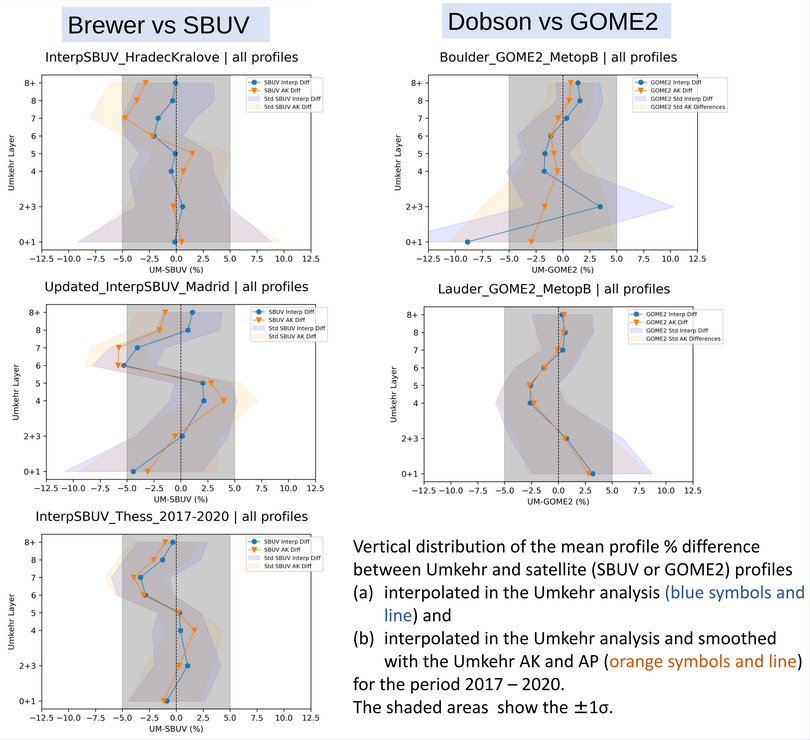
Satellite ozone profile measurements

- SBUV Version 8.7 MOD v2 Release 1: the same core algorithm as Version 8.6 (Firth et al., 2020), but includes new inter-instrument calibration adjustments for instrument records since 2000 (NOAA-16 SBUV/2 though OMPS NP)
- GOME2 on board MetopA, -B and –C: retrieved by the Ozone ProfilE Retrieval Algorithm (OPERA), within the EUMETSAT Atmospheric Composition Monitoring Project, ACSAF (Tuinder et al., 2019).

3. Umkehr TIME SERIES



4. SATELLITE COMPARISONS



Vertical distribution of the mean profile % difference between Umkehr and satellite (SBUV or GOME2) profiles
(a) interpolated in the Umkehr analysis (blue symbols and line) and
(b) interpolated in the Umkehr analysis and smoothed with the Umkehr AK and AP (orange symbols and line)
for the period 2017 – 2020.
The shaded areas show the ±1σ.

5. DISCUSSION - RESULTS

Umkehr time series

- **Brewer profiles** have the same temporal variability, while the small changes in the magnitude is due to the different geographic location of each station and the different sampling rates.
- **Dobson profiles** have different vertical and temporal distribution due to the different geographical location (e.g., Lauder in Southern Hemisphere shows an opposite annual cycle).

Satellite comparisons

- The **agreement between the Umkehr profile measurements and the satellite ozone profile products is always within ± 5%,** for all layers of observation. In the lower stratosphere, some biases remain, possibly due to wide AKs of the Umkehr retrieval.
- **Best agreement** (~±1%) occurs for layers 2+3, 4 and 5, i.e., **for the tropopause and the lower half of the stratosphere**, where the bulk of the ozone amount is located.
- **Higher discrepancies appear at layers 6 and 7 for the Brewer stations**. The original Dobson Umkehr profiles (before the optimization) compared to satellite records had also larger biases in the upper layers, which are eliminated in the optimized Dobson versions. Therefore, **it is expected that the application of the same optimization process in Brewer profiles will also significantly reduce the observed biases**.
- **Highest variability** (expressed by the standard deviation) is seen in the troposphere (Layer 0+1).
- Application of the AK smoothing, does not improve the comparison, possibly because the vertical resolution of Umkehr and SBUV is comparable.
- No particular discontinuities were seen in the **time series of the comparisons** for any of the layers. On the contrary, they were all very stable temporally, with no abrupt changes present for the time span of 2017 to 2020

There are several more Dobson and Brewer Umkehr records that can be homogenized and used for satellite validations. Although Umkehr profiles are not highly resolved profiles like ozonesondes or lidar observations, they are performed more frequently than the once-a-week ozonesonde launches and they are scheduled to be measured during the day, when most of the satellite observations take place.

The optimized, quality controlled and fully characterized Umkehr dataset is anticipated to be an added value for the validation of the expected TROPOMI/S5P ozone profile product.

References:

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