Validation of the long term ESA Ozone-CCI GODFIT_v3 Total Ozone Record Using Three Differe Ground-Based Instruments at a Northern Mid-latitude Station

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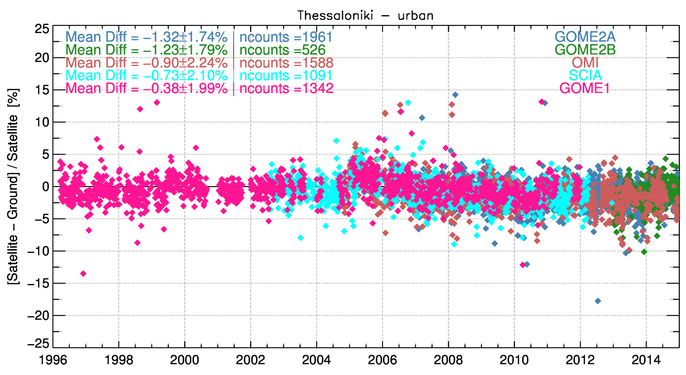
ABSTRACT

For the validation of new, as well as existing, total ozone columns [TOCs] sensed by satellite instruments, daily total ozone columns reported by Brewer and Dobson spectrophotometers are usually employed. As a result, it is not possible to accurately determine the daily variability of the column. In the Laboratory of Atmospheric Physics of the Aristotle University of Thessaloniki, Greece (40.63°E, 22.96°N), three different instruments and algorithms are currently providing instantaneous TOC measurements throughout the day. A **single monochromator Brewer spectrophotometer** performs direct Sun observation of the UV radiation at five selected wavelengths, nominally 306.3, 310, 315.5, 316.8 and 320nm, and is providing TOCs operationally since 1982. In addition, **NILU-UV irradiances** at central wavelengths of 302, 312, 320, 340 and 380 nm have been used as inputs to a neural network model and have been used to extract 1-minute TOCs from 2005 onwards. And thirdly, direct Sun spectrally resolved measurements in the UV-visible region between 300 and 450nm, performed by **a miniature CCD spectrometer** system, have been analyzed with the DOAS technique to deliver TOCs since late 2013. Each of the three instruments has its own strengths and restrictions, however put together they are providing a unique opportunity to assess the satellite TOCs using a full statistical consideration of the comparisons, focusing on the inter-consistency of the different instrumentations and methodologies.

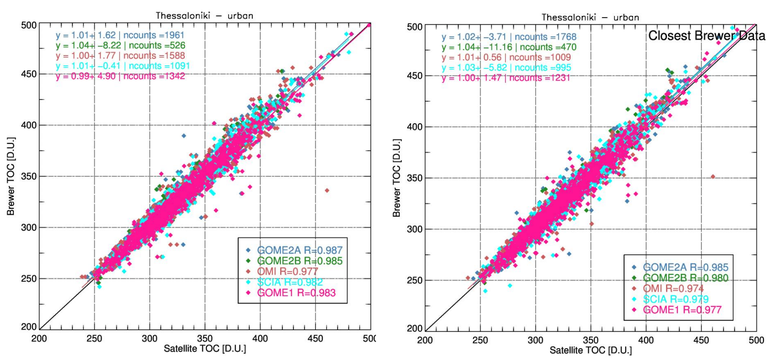
In this work, satellite total ozone from the **GOME/ERS-2, SCIAMACHY/Envisat, OMI/Aura, and GOME2/Metop-A & GOME2/Metop-B** at each overpass time are compared against the Brewer, the NILU-UV and the CCD-extracted TOCs over Thessaloniki. The satellite TOCs have been retrieved using the **ESA Ozone-cci baseline algorithm GODFIT_v3 at BIRA/IASB**. Time series, correlation statistics and investigations of possible systematic dependencies will characterize the strengths and weaknesses of the different instruments and algorithms. Atmospheric, algorithm-related as well as technical factors responsible for sources of discrepancy among the TOC retrievals will be investigated.

Brewer Spectrophotometer

- First commercial Brewer installed at LAP/Auth in 1982
- Single monochromator, type MKII
- Wavelength range, 290 – 325 nm
- Step of 0.5 nm and resolution of ~0.55 nm
- Direct irradiances at 303.2, 306.3, 310.1, 313.5, 316.8 and 320.1 nm
- Products: TOC and SO_2 since 1982 ; global UV irradiance since 1989 ; AOD since 1984.



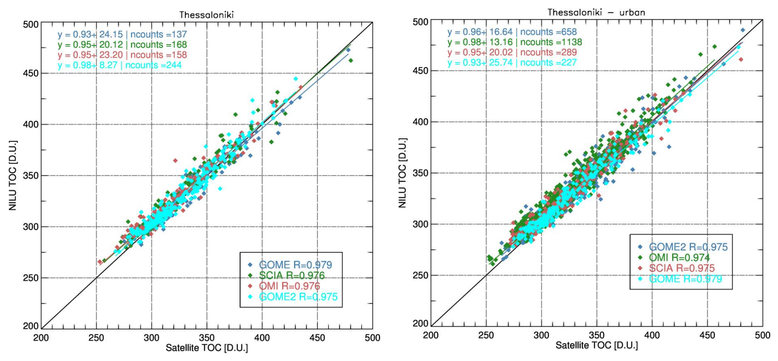
Percentage differences between the Brewer TOC observations and GOME2A [blue], GOME2B [green], OMI [orange], SCIAMACHY [cyan] and GOME1 [fuchsia] GODFIT_v3 TOCs. The inter-sensor stability is verified easily in this long term comparisons starting in 1996 and ending in 2015, **with an average mean of ~-0.90±2%.**



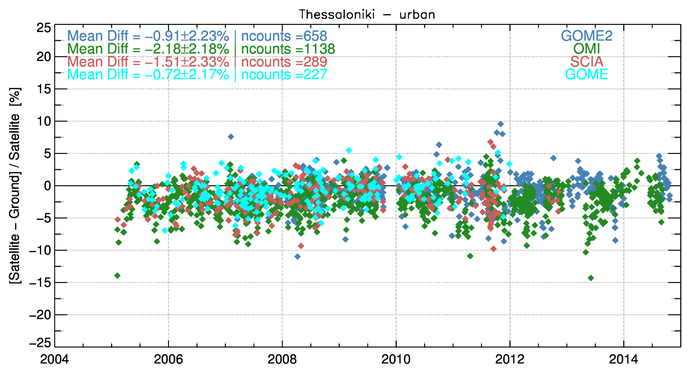
Scatter plot between Brewer TOCs [y-axis] and satellite GODFIT_v3 TOCs [x-axis] for the daily mean Brewer observation **[left]** and the closest Brewer observation **[right]** for GOME2A [blue], GOME2B [green], OMI [orange], SCIAMACHY [cyan] and GOME1 [fuchsia] GODFIT_v3 TOCs. It is well demonstrated that both choices of ground-based Brewer datasets will lead to a viable and informative validation for the satellite products.

NILU-UV multi-filter radiometer

- Operating since 2004
- One-minute irradiance measurements
- 5 UV spectral bands
- Central wavelengths at 302, 312, 320, 340 and 380 nm
- FWHM of ~ 10 nm
- Photosynthetically Active Radiation (PAR) channel
- Products:
  - Total Ozone Column
  - CIE
  - UV index
  - DNA damage
  - Cloudiness estimate



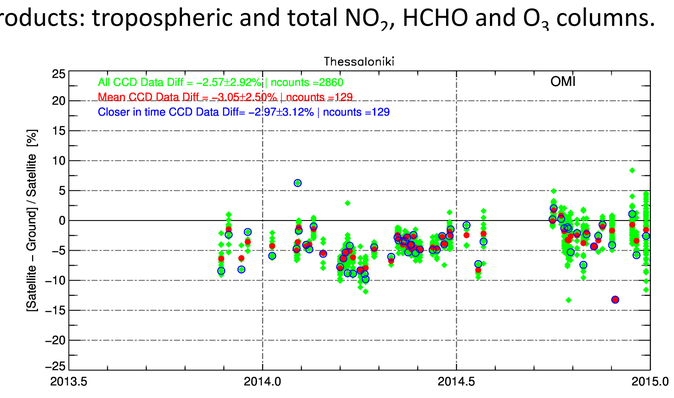
Scatter plot between NILU clear sky TOCs [y-axis] and satellite GODFIT_v3 TOCs [x-axis] for the 1-minute NILU coincidences **[left]** and the 1-hour average NILU coincidences **[right]** for GOME [blue], SCIAMACHY [green], OMI [orange] and GOME2 [cyan] GODFIT_v3 TOCs. A slight over-estimation for low total ozone columns from the ground-based dataset is revealed, constant for all four satellite sensors and irrespective of the temporal scale, with correlations of around **~0.975 – 0.980.**



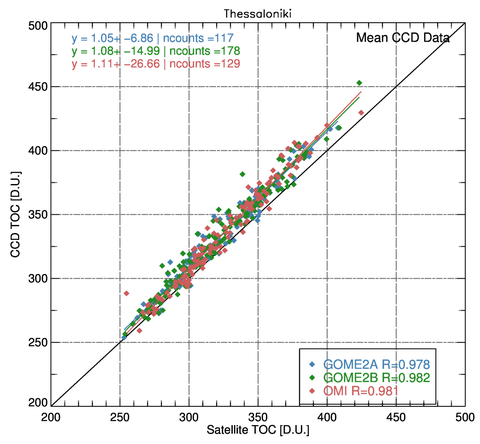
Percentage differences between the NILU TOC clear skies 1-hour average observations and GOME2A [blue], OMI [green], [SCIAMACHY [orange] and GOME [cyan] GODFIT_v3 TOCs. The inter-sensor stability is verified easily in this long term comparisons starting in 2004 and ending in 2015, **with an average mean ~ -1.5±2.2%.**

Mini CCD spectrometer

- Three mini MaxDOAS systems
- Cooled miniature CCD spectrograph (AvaSpec-ULS2048LTEC)
- Operating since late 2013 in different locations
- Range: 300 nm to 452 nm
- Resolution: 0.34-0.42 nm
- Direct solar irradiance and sky radiance measurements (zenith and off-axis)
- Products: tropospheric and total NO_2, HCHO and O_3 columns.



Investigating the effect on the percentage comparisons when comparing the OMI/Aura GODFIT_v3 TOCs against the closest in time CCD observation [blue], the daily mean CCD TOC [red] and all CCD observations irrespective of a temporal restriction [green]. The average comparison remains **quite stable at -3±3%,** irrespective of the temporal choices, pointing to a slight over-estimation by the ground-based instrument.



Comparisons between the daily mean CCD TOCs [y-axis] and GOME2A [blue], GOME2B [green] and OMI [red] GODFIT_v3 TOCs [x-axis] where the slight ground-based over-estimation in TOC is evident for the high TOC loads. Even so, the inter-sensor stability is revealed by the high correlation coefficient of **~0.98** for all three sensors.

See also in QOS:

NILU TOC:

- **Poster 208, QOS2016-140,** by M. M. Zempila and colleagues
  High frequency retrieval of total ozone from a ground-based NILU-UV radiometer using a neural network model: validation of the model and evaluation of satellite observations.

CCD TOC:

- **Poster 230, QOS2016-207**, by A. F. Bais and colleagues
  Retrieval of total ozone with Phaethon DOAS system

Brewer TOC:

- **Poster 209: QOS2016-143,** by I. Fountoulakis and colleagues
  Temperature dependence of the Brewer spectral UV and total ozone column measurements
- **Poster 210, QOS2016-144,** by I. Fountoulakis and colleagues
  Dead time effect on the Brewer measurements of spectral UV irradiance and TOC: correction and estimated uncertainties
- **Poster 221, QOS2016-194,** by K. Fragkos and colleagues
  Umkehr ozone profiles in Thessaloniki and comparison with MLS overpasses.

FUTHER INFORMATION ON THE THREE GROUND-BASED INSTRUMENTS OPERATING AT LAP/AUTH

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