Testing the SI²N Ozonesonde Data Quality Assessment for the nearby stations Uccle (BE) and De Bilt (NL)

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JÜLICH FORSCHUNGSZENTRUM

1. Introduction and Motivation

Uccle & De Bilt

	Uccle (BE)	De Bilt (NL)
location	50°48' N, 4°21' E, 100 m a.s.l	52°10' N, 5°18' E, 4 m a.s.l.
first launch	Jan 1969	Nov 1992
frequency	3/week	1/week
ozonesondes types	1969-1996: Brewer-Mast from 1997: ENSCI* ECC	SPC ECC* (5A & 6A)
radiosonde types	1990-mid 2007: RS80 from mid 2007: RS92	Nov 1992-Nov 2005: RS80 from Nov 2005: RS92
sensing solution strength	0.5%	1.0%
background current	consistent before O_3 exposure	changed during period after O_3 exposure

* ECC = electrochemical concentration cell, SPC & ENSCI are two different manufacturers.
[+] SST = sensing solution strength

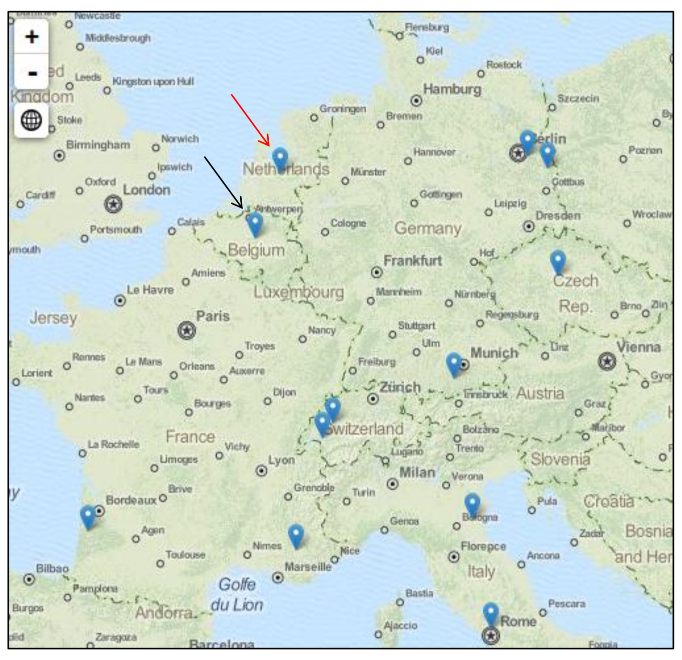

*Fig. 1: Location of **Uccle** (black arrow) and **De Bilt** (red arrow) on a map, showing other European ozonesonde stations (from WOUDC).*

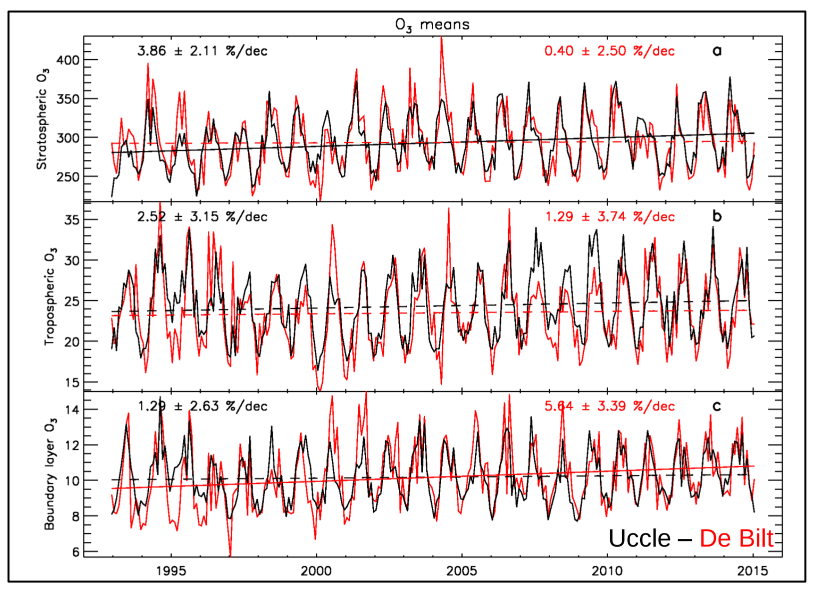

*Fig. 2: Time series of monthly means of integrated ozone amounts in Dobson units (DU) above **Uccle** and **De Bilt** for different parts in the atmosphere: (a) stratosphere (h > tropopause height), (b) free troposphere (3 km< h < tropopause height), and (c) boundary layer (0–3 km).*

- **Uccle** and **De Bilt** are **only 175 km from each other**
  - ✓ horizontal O_3 correlation lengths: 500 km (troposphere), 1500 km (stratosphere)
  - ✓ timescales of O_3 autocorrelation: 1.5-3.5 days (troposphere), 2-6 days (stratosphere) *(Liu et al. 2009, 2013)*

→ both stations show **similar profiles** (see e.g. ***Fig 3***) and a **similar time variability** (see ***Fig. 2***), in different atmospheric layers

- each station represents one **O3S-DQA ECC standard**
- differences in operating procedures (e.g. different background current measurement and subtraction)
- both stations apply **operationally different correction strategies** (e.g. at Uccle: pressure and temperature dependent pump efficiency correction combined with a total ozone normalisation)

Ozonesonde Data Quality Assessment (O3S-DQA)

- see talk by Smit et al., on Thursday, 8 Sept, 14h30
- only for **ECC ozonesondes**
- standard operation procedures
- guidelines for metadata collection
- **two standards are set**: ENSCI* 0.5% SST[+] & SPC* 1% SST (ratio is 1.0 with 1%)
- **transfer functions** to those standards, based on double soundings/simulation chamber experiments
- **standard correction algorithms** (based on simulation chamber experiments)
- **uncertainty estimation** for every data point (5-6% for Uccle ECC, see Van Malderen et al., 2016)

➔ **(revised) worldwide, homogenous, consistent dataset to be used for satellite validation and trend analysis**

Motivation & Aim

The ozonesonde stations Uccle and De Bilt are for the period 1997-2014 a unique test bed for the O3S-DQA corrections!

- impact of operating procedures and corrections (operational vs. O3S-DQA) on the (average) ozone profiles?
- impact of operating procedures and corrections on the vertical ozone trends?

2. Impact on average O_3 profiles

Methodology

1. for both stations: we calculate the **average ozone profiles** of the 1997-2014 datasets, corrected by different strategies (operational & O3S-DQA)
2. The average O_3 profiles are calculated in **altitudes relative to the tropopause**.
3. Then, we calculate **relative differences** between the average profiles and one reference average ozone profile.

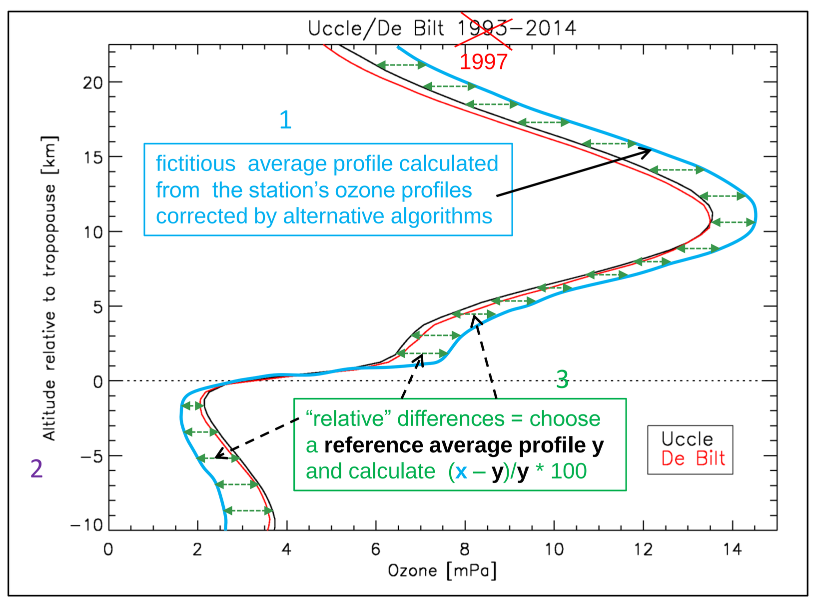

*Fig. 3: Average ozone profiles of **Uccle** and **De Bilt** for the period 1993-2014, from which we illustrate our method of calculating relative differences between average ozone profiles.*

Results

Uccle

- relative differences between operational (reference) and O3S-DQA correction (grey) are **within ± 2%**
  - ✓ **closest to 0 at O_3 max** (10 km relative to tropopause)
  - ✓ largest at lower troposphere and upper stratosphere

De Bilt

- relative differences between operational (gold dotted) and O3S-DQA correction (magenta) **between 2 to 4%**
  - ✓ **largest deviation at UTLS**
  - ✓ due to differences in background current subtraction
  - ✓ O3S-DQA average profile has lower ozone concentrations at all altitudes

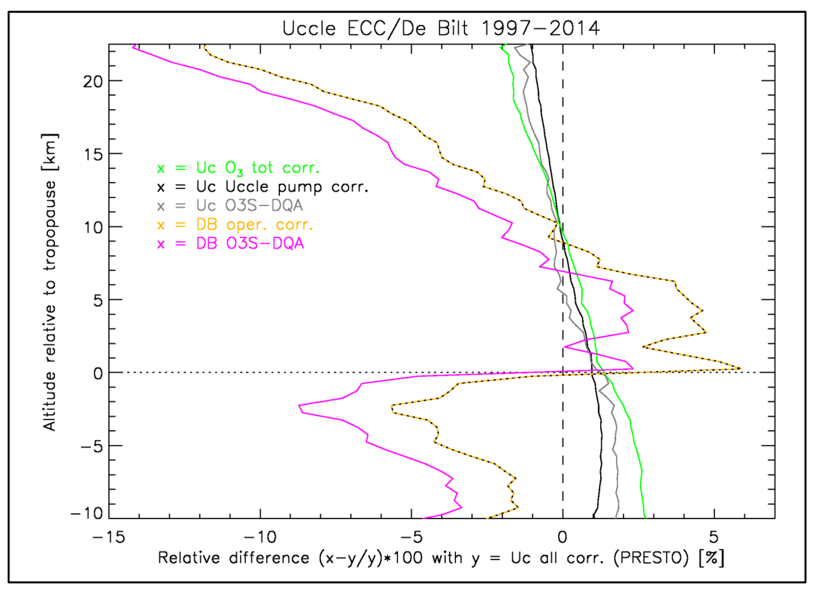

Fig. 4: Relative differences of the average Uccle and De Bilt ozone profiles calculated for different correction strategies with respect to the average Uccle ozone profile obtained by applying the operational PRESTO correction. The average ozone profiles are calculated in layers of 0.5 km height, relative to the tropopause height.

Uccle vs. De Bilt

- relative differences seem **dependent on the measured O_3 concentrations**: closest to 0 at the O_3 max and most distinct from 0 at upper troposphere (between -5 to -9%) and at upper range of the stratosphere (> 10%)
  - ✓ pressure offset? ➔ found for RS80-RS80, RS80-RS92 & RS92-RS92 Uccle-De Bilt comparison periods
  - ✓ differences in procedures/corrections? ➔ for tropospheric O_3: differences in background current measurement/subtraction
  - ✓ ascent rate differences? ➔ Uccle: 7.5 m/s, De Bilt 5.6 m/s → O_3 max higher at Uccle than at De Bilt
  - ✓ natural differences? → seasonality in the differences, also present in Aura MLS climatology, different temperature distribution at both sites
- **only in the lower stratosphere** (layers below O_3 max), the **O3S-DQA** corrections (grey and magenta) effectively **reduce the relative differences** between the Uccle and De Bilt ozone partial pressures

3. Impact on the vertical O_3 trends

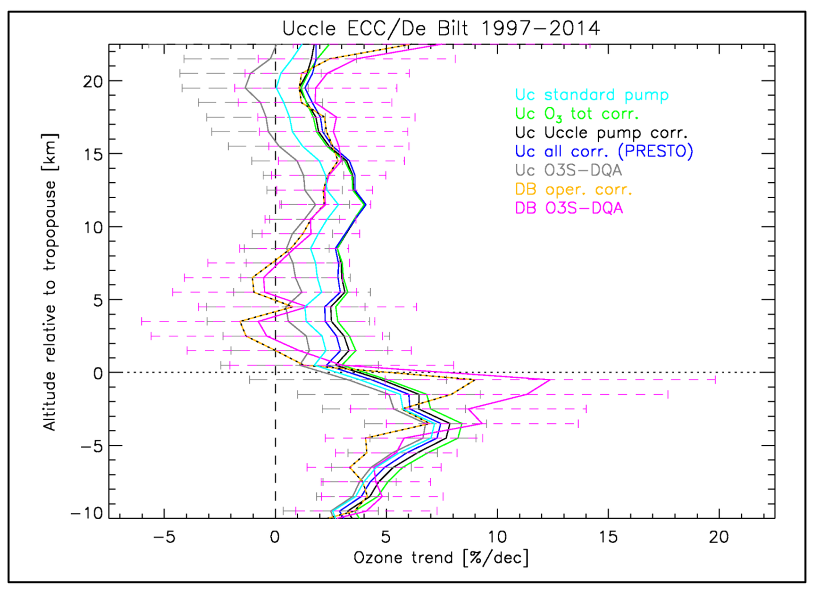

Fig. 5: Vertical distribution of the linear relative trends for different correction strategies applied to the Uccle and De Bilt ozone data for the 1997–2014 time period. The trends are estimated for layers of 1 km height, relative to the tropopause height. The error bars denote the 2σ standard errors of the linear regression slope determination after applying all profile corrections and can be considered as a rough estimate of the trend uncertainty.

Results

Uccle

- trend differences between operational (blue) and O3S-DQA correction (grey) are **< 3 %/dec**
  - ✓ **largest in the (upper) stratosphere**
  - ✓ lower trends, at all altitudes, for the O3S-DQA correction

De Bilt

- trend differences between operational (gold dotted) and O3S-DQA correction (magenta) are **< 4%**
  - ✓ **largest deviation at upper troposphere**, especially due to differences in background current subtraction before Nov 1998
  - ✓ higher trends, at all altitudes, for the O3S-DQA correction

Uccle vs. De Bilt

- **only in the lower stratosphere and in the lower part of the free troposphere**, the O3SDQA corrections bring the Uccle and De Bilt trend estimates **closer to one another** (compare the grey and magenta lines)
- The trends at both stations are **not significantly different from each other**, independently of the used correction strategy.

Ozone recovery?

- This 1997-2014 period starts with the maximum peak value in the EESC.
- Only in **the troposphere** are the ozone **trends significantly different from 0**.
- The sign of the O_3 trend in the stratosphere depends on the station and on the applied data processing!
- ➔ **caution is needed when using terminology like "the onset of ozone recovery!"**

4. Conclusions

- The close ozonesonde stations Uccle and De Bilt provide a **unique test bed for the homogenisation activity** O3S-DQA.
- Still, **natural differences** in the vertical distribution of ozone between Uccle and De Bilt cannot completely cancelled out.
- Despite their **large impact on the average ozone profiles**, the different correction strategies do not change the ozone **trends** significantly, usually only **within their statistical uncertainty** due to atmospheric noise.
- The O3S-DQA corrections do **not** give an **overall better agreement** of the average profiles and trends between both stations.
- Results for the same analysis for the periods 1969-1996 & 1969-2014 at Uccle: Van Malderen et al. (2016)

Acknowledgements and References

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More information: Van Malderen, R., Allaart, M. A. F., De Backer, H., Smit, H. G. J., and De Muer, D.: On instrumental errors and related correction strategies of ozonesondes: possible effect on calculated ozone trends for the nearby sites Uccle and De Bilt, *Atmos. Meas. Tech.*, 9, 3793-3816, doi:10.5194/amt-9-3793-2016, 2016