Intercomparison of OMI NO$_2$ and HCHO air mass factor calculations
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0. MOTIVATION
Air mass factor (AMF) calculation is the largest source of uncertainty in trace gas retrievals. We have compared the AMF calculation process by KNMI/WUR, IASB-BIRA, IUP-UB, MPIC, NASA GSFC, Leicester Uni. and Peking Uni. Main goals are:
- Understand and estimate the structural uncertainty in every step of the AMF calculation
- Best practices and recommendations for UV/Vis trace gas retrievals – QAAECV community effort retrieval algorithm

1. Altitude dependent (box-) air mass factor
Box – AMFs ($m_i$) characterize measurement sensitivity to an absorber at a particular atmospheric layer. Calculated with radiative transfer models (RTM), they depend on forward model parameters ($h_i$: altitude, sf. albedo, sf. pressure, solar and viewing geometry).

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- Sensitivity to different parameters well captured by all RTMs
- Strong increase of 950 hPa box-AMF for low albedo and high SZA

Fig. 1: NO$_2$ (4140nm) and HCHO (338nm) box-AMFs dependency at 950 hPa to surface albedo, cosine of VZA, cosine of SZA and to surface pressure at 797 hPa.

Fig. 2: Vertical profile of NO$_2$ (4140nm) and HCHO (338nm) box-AMFs calculated by each RTM.
- Specific differences in mid-upper troposphere and stratosphere due to different treatment of sphericity and multiple scattering in the RTMs.
- McArtin box-AMFs are 2% lower
- Higher differences for extreme geometry where sphericity treatment is relevant
- Specific differences at the edges of the orbit (high VZA) suggest that the uncertainty introduced by the choice of RTM is still visible.
- Agreement: 6.5% in polluted areas & 2.5% in clean remote areas

2. Tropospheric AMF – common settings
Comparison of tropospheric AMFs calculated by IASB-BIRA, IUP-UB, MPIC and WUR using the same settings (ancillary data, cloud treatment) gives an estimation of the uncertainty introduced by the vertical discretization and the interpolation scheme.

$$M = \sum_i m_i(h_i) x_{a,i} / \sum_i x_{a,i}$$

AMF ($M_i$) = sum of the box – AMFs of each layer weighted by the partial (a priori) vertical column

Fig. 3: Tropospheric NO$_2$ AMFs calculated by each retrieval group (upper panels). Ancillary data and one example of relative differences between MPIC and WUR AMFs (lower panels).

- Tropospheric AMFs agree within 6.5%
- Comparison of ancillary data and cloud treatment

3. Tropospheric AMF – Round Robin
Comparison of tropospheric AMFs calculated by 6 international groups using their preferred settings gives an estimation of the uncertainty introduced by the choice of ancillary data.

Which parameters have more influence on the AMF differences?
- Surface albedo, NO$_2$ a priori profile, terrain height and aerosols

Fig. 4: Tropospheric NO$_2$ AMFs calculated by each retrieval group (29th February 2003) (cloud fraction < 0.2, sf. albedo < 0.3, SZA < 70°)

Fig. 5: Ratio (bars, left axis) and correlation (crosses, right axis) of NO$_2$ tropospheric AMF by each group and mean AMF.
- WUR, MPIC: below average
- Peking Uni., BIRA: above average
- Ratio closest to 1 in Feb. (83%)
- Differences between seasons higher
- WUR, Leicester: below average
- MPIC, BIRA: above average
- Ratio closest to 1 in August (66%) and higher

4. CONCLUSIONS
- Uncertainty introduced by the choice of RTM (physical processes, calculation approach and discretization) propagates throughout the AMF calculation process (2-3%).
- There are interpolation errors that are intrinsic to the calculation method and cannot be avoided (6%).
- Choices and assumptions made to represent the state of the atmosphere introduce the highest uncertainty (30%)