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 – QA4ECV community effort retrieval algorithm

4. CONCLUSIONS

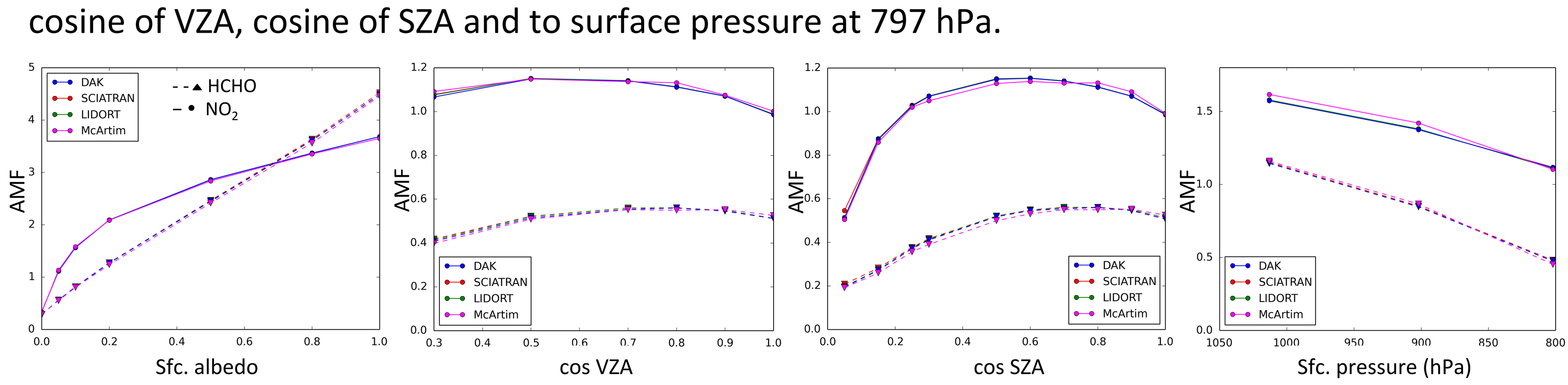
- Uncertainty introduced by the choice of RTM (physical processes, calculation approach and discretization) propagates throughout the AMF calculation process (2-3%).
- There are interpolation errors that are intrinsic to the calculation method and cannot be avoided (6%).
- Choices and assumptions made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

1. Altitude dependent (box-) air mass factor

Box – AMFs (m_l) characterize measurement sensitivity to an absorber at a particular atmospheric layer.
Calculated with radiative transfer models (RTM), they depend on forward model parameters [(**b**): altitude, sfc. albedo, sfc. pressure, solar and viewing geometry].

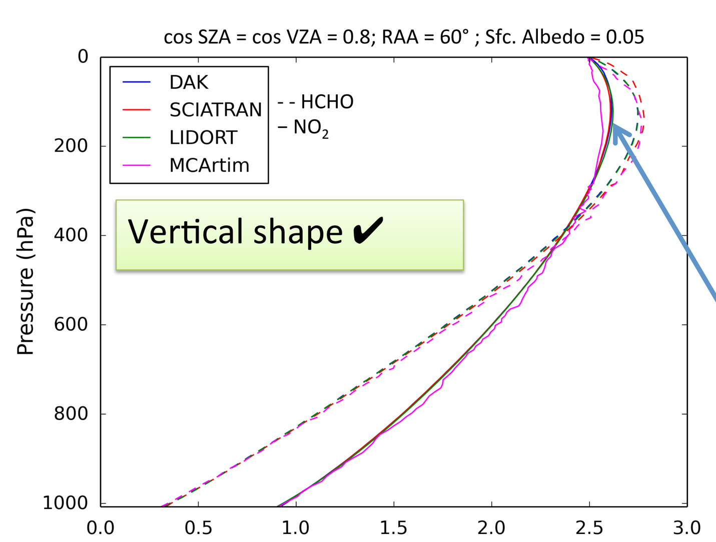
Model	DAK	LIDORT	McArtim	SCIATRAN
Institute	**KNMI, WUR**	**IASB-BIRA**	**MPIC**	**IUP-UB**
Solving the Radiative Transfer Equation	Doubling-Adding Method	Linearized discrete ordinate solution	Monte Carlo methods to solve integral form of RTE	Source function integration and discrete – ordinates method
Sphericity Correction	Pseudo spherical – direct solar beam	Pseudo spherical – solar and scattered beam	Full 3D spherical model	Spherical mode- solar & scattered beam
Multiple scattering	Plane Parallel	Plane Parallel	Spherical mode	Plane Parallel

Fig. 1: NO_2 (@440nm) 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.



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

Fig. 2: Vertical profile of NO_2 (@440nm) 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 RMTs.
  McArtim box-AMFs are 2% lower
- Higher differences for extreme geometry where sphericity treatment is relevant

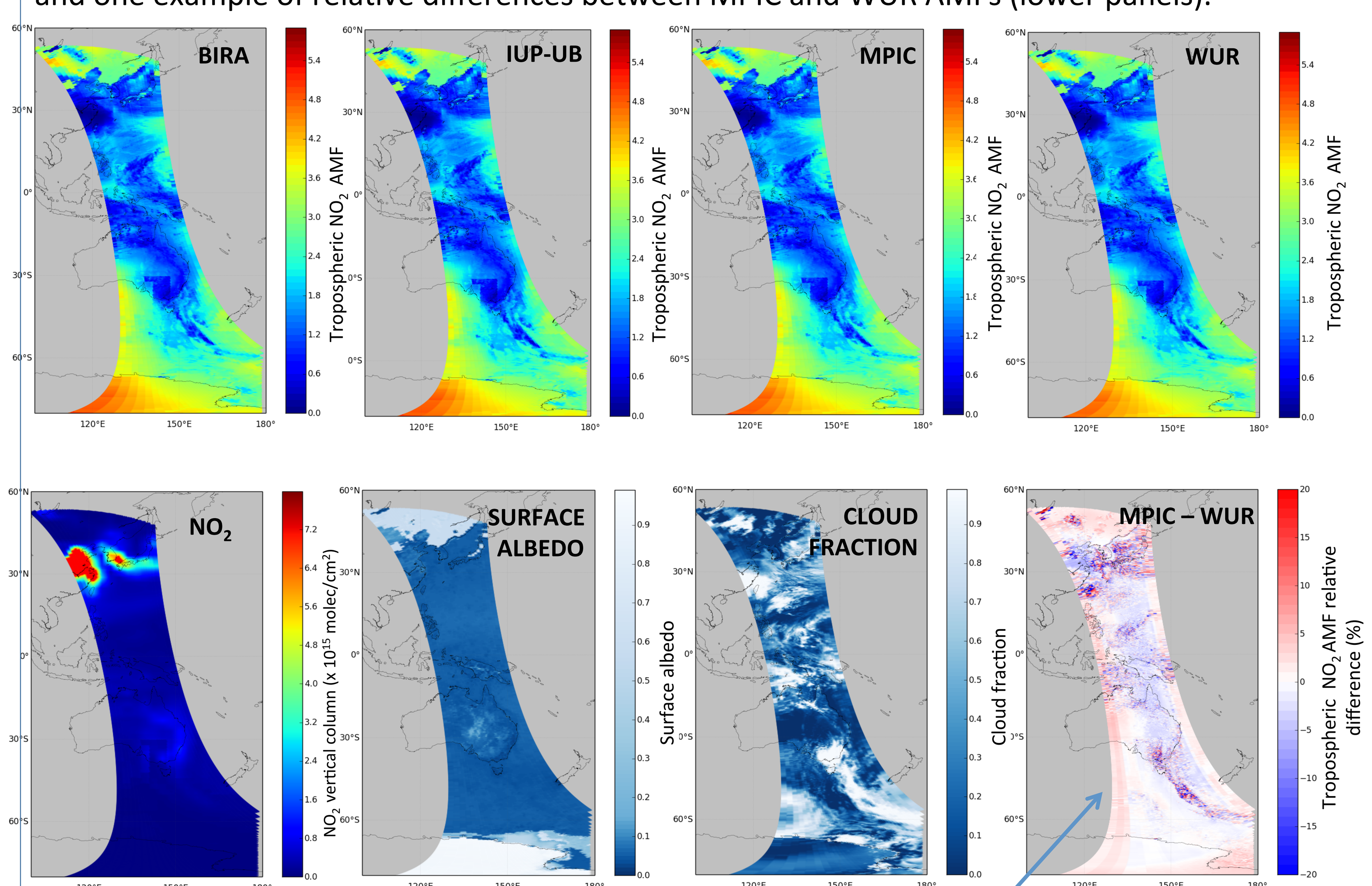
2. Tropospheric AMF – common settings

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*.

$$M = \frac{\sum_l m_l(\hat{b})\, x_{a,l}}{\sum_l x_{a,l}}$$

AMF (M) = 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).

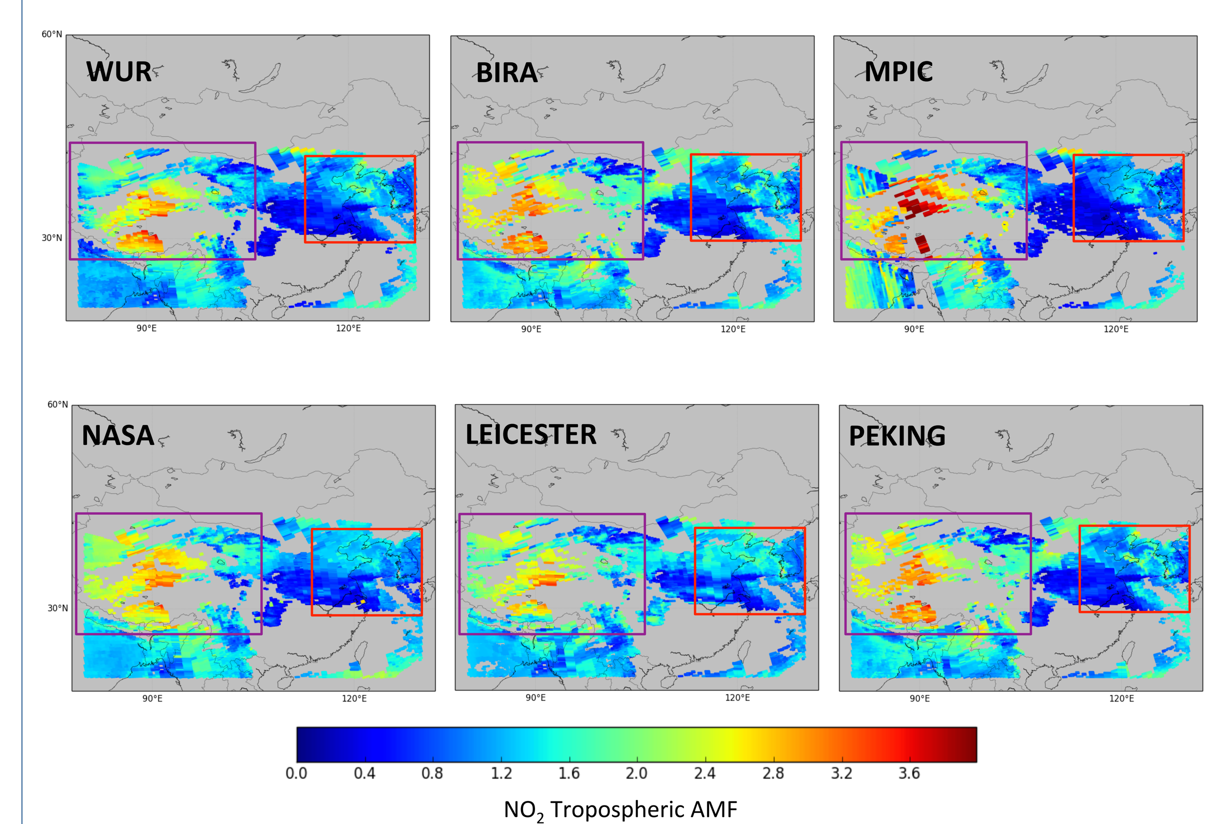


- Specific differences at the edges of the orbit (high VZA) suggest that the uncertainty introduced by the choice of RTM is still visible.
- Agreement: 6.5% in polluted areas & 2.5% in clean remote areas

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*.

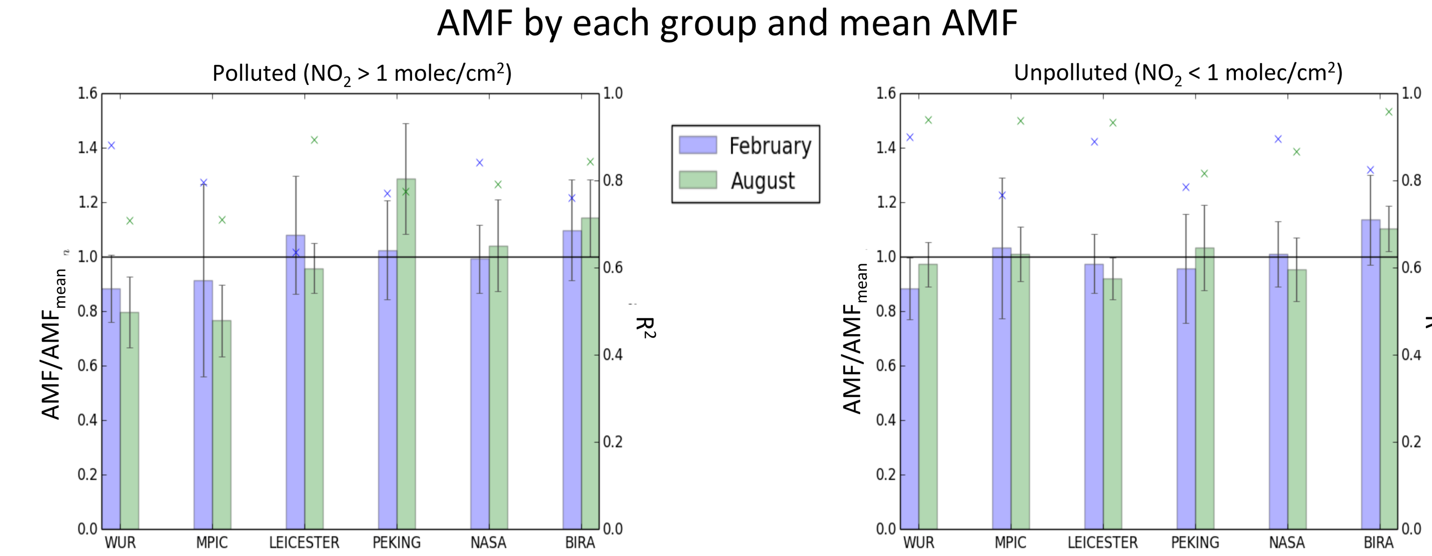
Fig. 4: Tropospheric NO_2 AMFs calculated by each retrieval group (2nd February 2005)(cloud fraction < 0.2, sfc. albedo < 0.3 , SZA < 70°)



Which *parameters* have more *influence* on the *AMF differences*?

- Surface albedo,
- NO_2 a priori profile,
- terrain height and aerosols

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 R^2

RTMs with equal settings → Models reproduce box-AMFs within 2.6% → common settings for the choice of ancillary data and cloud treatment → Tropospheric AMFs agree within 6.5% → preferred settings for the choice of ancillary data and cloud treatment → Structural uncertainty 30%