City-scale top-down verification of NO\textsubscript{x} emissions in South Korea using satellite observations

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1. Introduction
Anthropogenic NO\textsubscript{x} (=NO+NO\textsubscript{2}) emissions play an important role as a precursor of forming atmospheric ozone (O\textsubscript{3}) and inorganic particulate matters (PMs). In South Korea, the emissions are attributed to both local anthropogenic sources and the remote sources from adjacent countries of China and Japan. In this study, national NO\textsubscript{x} emissions in South Korea of 2010 are top-down verified using satellite-derived NO\textsubscript{2} column measurements and the modelled atmospheric concentrations at a city scale.

2. Method and data
2.1 WRF-Chem model
- Configuration of WRF-Chem (Grell et al., 2005)
- Nested domains: 32.4/10.8/3.6 km
- Meteorological forcing: NCEP FNL reanalysis data (FDDA grid nudging)
- RACM (gas) MADE/SORGAM (aerosol)
- MOZART-4 chemical IC/BCs
- Anthropogenic emissions: MICS-Asia 2010
- Biogenic emissions: MEGAN V2
- Simulation: April-September 2010 (6 months)

2.2 NO\textsubscript{x} emissions
- 10 urbanized areas (rectangles) are defined based on the NO\textsubscript{x} emission intensity (R1-R10).
- Total emission amount of the urbanized areas accounts for 68% of the South Korea emissions.
- Each box has at least 50×43 km².

2.3 Aura/OMI column NO\textsubscript{2} measurements
- UV/Vis nadir spectrometer onboard NASA EOS-Aura satellite
- KNMI DOMINO v2.0 data

<table>
<thead>
<tr>
<th>KNMI/DOMINO v2.0 (Level 2)</th>
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<tbody>
<tr>
<td>Information</td>
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<tr>
<td>2004/07-present</td>
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<tr>
<td>Condition</td>
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<td>&lt; 0.4</td>
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- KNMI OMI NO\textsubscript{2} vertical column data (NO\textsubscript{2} VCD) are processed following
- Retrieval uncertainties of OMI NO\textsubscript{2} (Boersma et al., 2011)
- AMF (Air Mass Factor) calc.: \(-1.0\times10^{15}\) molec. cm\textsuperscript{-2}
- Spectral fitting: \(-0.7\times10^{15}\) molec. cm\textsuperscript{-2}
- Stratospheric slant columns: \(-0.25\times10^{15}\) molec. cm\textsuperscript{-2}

3. Results

3.1 Modelled and observed NO\textsubscript{2} columns over South Korea
- High NO\textsubscript{2} VCD values are apparent in major urbanized areas (rectangles) over South Korea
- The WRF-Chem model and NO\textsubscript{2} columns are higher at all the urbanized area with a range of 13-69% (40% in the whole South Korea) than those in the observations, indicating that the national emission inventory may slightly overestimates the city-scale NO\textsubscript{x} emissions.
- Downscaled NO\textsubscript{2} columns reduce the model-observation differences from 4% at region R4 to 14% at region R7, but the overestimation of the modelled emissions remains.

3.2 City-scale comparison of modelled and observed NO\textsubscript{2} VCD
- The national anthropogenic NO\textsubscript{x} emissions over South Korea in 2010 (MICS-Asia 2010) are top-down verified using OMI NO\textsubscript{2} column measurements and the WRF-Chem simulated concentrations at 10 urbanized areas.
- The modelled NO\textsubscript{2} columns with MICS-Asia 2010 emissions overestimated the observed atmospheric concentrations by 13-69% at the urbanized area (40% in South Korea), which is also valid at different seasons.
- The downsampling approach has a little difference of 4-14% in the interpretation of the results due to increased uncertainties.

4. Summary and conclusions
- The national anthropogenic NO\textsubscript{x} emissions over South Korea of 2010 (MICS-Asia 2010) are top-down verified using OMI NO\textsubscript{2} column measurements and the WRF-Chem simulated concentrations at 10 urbanized areas.
- The modelled NO\textsubscript{2} columns with MICS-Asia 2010 emissions overestimated the observed atmospheric concentrations by 13-69% at the urbanized area (40% in South Korea), which is also valid at different seasons.
- The downsampling approach has a little difference of 4-14% in the interpretation of the results due to increased uncertainties.

References

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