NO₂ AND SO₂ DRY DEPOSITION INFERRED FROM SATELLITE MEASUREMENTS

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ABSTRACT

We develop a method to estimate global NO₂ and SO₂ dry deposition fluxes at high spatial resolution (0.1°×0.1°) using OMI satellite measurements in combination with GEOS-Chem simulations. GEOS-Chem is used to infer surface concentrations from OMI retrievals of column densities, and 2) to calculate deposition velocities. These global maps provide a dataset for use in examining regional budgets of deposition and deposition near urban areas. NO₂ dry deposition from OMI is typically found to be larger than GEOS-Chem deposition, reflecting larger observed NO₂ column densities, while the reverse is true for SO₂. Preliminary results from OMI-derived fluxes indicate NO₂ contributed 1.6 Tg N and SO₂ contributed 10.0 Tg S globally through dry deposition to land in 2005 at latitudes observed by OMI. (GEOS-Chem simulated global dry deposition to similar regions is 1.1 Tg N and 17.5 Tg S, for NO₂ and SO₂, respectively.)

DRIY DEPOSITION

Atmospheric nitrogen and sulfur can be deposited to ecosystems and water bodies by wet and dry deposition. Enhanced nitrogen deposition may lead to eutrophication, where too much nutrient input causes changes in ecosystem health. Both sulfur and nitrogen deposition have the potential to cause acidification of soil and water, and may influence climate by perturbing carbon sequestration [Vite et al., 2003; Reay et al., 2008].

Dry deposition in GEOS-Chem is calculated for each trace gas using a big-leaf model formulation [Vile et al., 2003; Reay et al., 2008]. In this study, we use measurements from the Ozone Monitoring Instrument (OMI) in combination with deposition velocities calculated from GEOS-Chem to estimate OMI dry deposition.

GLOBAL DEPOSITION FLUX

OMI measurements of NO₂ are from the NASA standard product 0MNO2 v003. SO₂ is from the NASA OMSO2 product. Tropospheric vertical columns are determined for each ground pixel using a scene-specific air mass factor calculation. A surface concentration is inferred by application of the GEOS-Chem profile shape to the measured column [Lamsal et al., 2008]. These surface concentrations are combined with deposition velocities from GEOS-Chem to create global maps of deposition flux.

The footprint of OMI allows deposition to be determined at a similar resolution of 0.1°×0.1°. In order to fully exploit the spatial resolution of OMI, the deposition calculation can be performed offline using high-resolution land type and leaf area index maps at a resolution of 0.1°×0.1° (to be implemented soon).

REFERENCES


ACKNOWLEDGEMENTS

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REGIONAL DEPOSITION BUDGETS

The derived global high-resolution maps of NO₂ and SO₂ deposition flux can be used to calculate regional and country-specific flux budgets.

NO₂ is a small contributor to total global nitrogen deposition (~1-2%), while SO₂ plays a larger role in sulfur deposition (~35%). However, in urban regions with significant NO₂, dry deposition can be significant. These high-resolution deposition estimates can also be used to examine NO₂ deposition in regions near urban areas.

Direct measurements of NO₂ flux (i.e., from eddy covariance towers) are rare and difficult to interpret. The table below shows comparisons with other published regional flux budgets derived from in situ and satellite concentration data. The large differences highlight the significant uncertainties in NO₂ deposition flux estimates; even models applied for calculations of deposition at identical sites may have NO₂ deposition velocities that vary by as much as a factor of four [Flechard et al., 2011].

<table>
<thead>
<tr>
<th>Reference</th>
<th>Source</th>
<th>Time</th>
<th>NO₂ USA</th>
<th>NO₂ Europe</th>
</tr>
</thead>
<tbody>
<tr>
<td>This work</td>
<td>OMI</td>
<td>2005</td>
<td>0.24 Tg N yr⁻¹</td>
<td>0.29 Tg N yr⁻¹</td>
</tr>
<tr>
<td>Zang et al., 2002</td>
<td>GEOS-Chem v8-02-03</td>
<td>2005-2008</td>
<td>0.19 Tg N yr⁻¹</td>
<td>0.19 Tg N yr⁻¹</td>
</tr>
<tr>
<td>Holland et al., 2005</td>
<td>EMEP model + in situ observations</td>
<td>1997-1998</td>
<td>0.64 Tg N yr⁻¹</td>
<td>3.24 Tg N yr⁻¹</td>
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UCS

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