**Introduction**

Lightning produces NO because the extreme temperatures (>20000 K) in lightning channels dissociate stratNO2. Lightning produces NO because the extreme temperatures (>20000 K) in lightning channels dissociate stratNO2. Lightning produces NO because the extreme temperatures (>20000 K) in lightning channels dissociate stratNO2. 

**TROPMI and GLM-based Estimate of NOx Production by Lightning over the U.S.**

The data suite for the Tropospheric Monitoring Instrument (TROPMI) (Veefkind et al., 2012) onboard the Copernicus Sentinel-5 Precursor satellite began operating in its nominal mode in late April 2018. This suite includes products such as the Ozone and Cloud product. The TROPMI NOx processing system is an improved version of the EM-KA DOMINO system that retrieves slant columns from Level 1b radiance using O3DAS). It separates the tropospheric and stratospheric column based on data from the TMS modelled O3DAS. We also like the use of the SNOx PE. The NOx PE is used for non-convective lightning and has been increased from a spatial resolution of 8 km and 14 km and a mean day time detection efficiency that exceeds 90%.

This study uses fluxes from GLM-16. No correction is made for detection efficiency or false alarms.

**Figure 4** shows TROPMI and TROPMI products over deep convection observed on April 15, 2018 (upper left), April 13, 2019 (upper right), May 9, 2018 (center left), July 8, 2018 (center right), July 14, 2019 (bottom left), and August 9, 2019 (bottom right). For each day, the upper left panel shows FLUXG flashes 5-hour period preceding the time of the TROPMI observations. In the upper right panel, the FLUXG data show the cloud pressure and also the mean over pixels satisfying the DCC. The mid-left panels show the FLUXG pressure in the TROPMI window and also the mean over pixels satisfying the DCC. The mid-right panels show the NOx and give the number of DCC pixels for which the NOx is defined. The lower-left panels show the NOx for good quality pixels (quality flag = 40). The lower-right panels show the NOx for which it is available are also shown. The lower-right panels also show the NOx for good and fair-quality pixels (quality flag = 40).

**Table 1.**

<table>
<thead>
<tr>
<th>Region</th>
<th>Area (10^4 km^2)</th>
<th>Mean NOx (10^15 mol)</th>
<th>NOx standard deviation (10^15 mol)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Europe</td>
<td>3591.9</td>
<td>5.6</td>
<td>2.9</td>
</tr>
<tr>
<td>North America</td>
<td>794.9</td>
<td>4.2</td>
<td>2.1</td>
</tr>
<tr>
<td>South America</td>
<td>1457.6</td>
<td>3.8</td>
<td>1.9</td>
</tr>
<tr>
<td>Africa</td>
<td>4603.1</td>
<td>7.1</td>
<td>3.6</td>
</tr>
<tr>
<td>Asia</td>
<td>10728.3</td>
<td>11.0</td>
<td>5.2</td>
</tr>
</tbody>
</table>

**Uncertainties**

- **AMF used to convert FLUXG to TROPMI NOx in Vlue or NOx is assumed to equal 0.66. However, in reality it varies with the surface reflectivity.**
- The NOx profile of the TNOx, and the NOx ratio within a deep convective system (e.g., Nault et al. (2016)).
- The bottom of the NOx in the near field of the convective system varies from 2-12 hours depending on the proximity of the flash to the ground (Allen et al. (2019)).
- **TROPMI NOx is sensitive to the VNOx NOx due to sources other than recent lightning (e.g., Allen et al., 2019).**
- **NOx fluxes are not adjusted for detection efficiency or false alarms.**
- **TROPMI columns are often missing over bright regions where flashes and presumably VNOx are large.**

**Figure 6** shows O3DAS and TROPMI products over deep convection observed on April 15, 2018 (upper left), May 9, 2018 (upper right), August 9, 2019 (bottom left), and August 16, 2019 (bottom right). For each day, the upper left panel shows the O3DAS 5-hour period preceding the time of the TROPMI observations. In the upper right panel, the O3DAS data show the cloud pressure and also the mean over pixels satisfying the DCC. The mid-left panels show the O3DAS pressure in the TROPMI window and also the mean over pixels satisfying the DCC. The mid-right panels show the NOx and give the number of DCC pixels for which the NOx is defined. The lower-left panels show the NOx for good quality pixels (quality flag = 40). The lower-right panels show the NOx for which it is available are also shown. The lower-right panels also show the NOx for good and fair-quality pixels (quality flag = 40).

**Below:**

- **LNOx PE as a function of chemical lifetime of NOx (i.e., 2, 3, or 12 h) for 3 different methods of estimating the tropospheric background (khD, khS, khC), pixel quality check (Quality flag = 1.06 or 2.05), and 2 versions of TROPMI retrievals (TROPMI v1.0 and TROPMI V2.1 test). Colors show the standard deviations for the 32 cases.
- For a 4-hour lifetime, LNOx PE = 390 (350) mol per flash when calculated using v1.5.2 (v1.3, 2 test) TROPMI products with quality flags exceeding 0.16 when the 10% VNOx over non-flashing pixels on the day of interest is used in estimating the tropospheric background.
- For a 3-hour lifetime, LNOx PE = 115 (127) mol per flash when calculated using v1.5.2 (v1.3, 2 test) TROPMI products with quality flags exceeding 0.16 when the 40% VNOx is used in estimating the background.
- For a 3-hour lifetime, LNOx PE = 143 (146) mol per flash when calculated using v1.5.2 (v1.3, 2 test) TROPMI products with quality flags exceeding 0.16 when the climatological background is used for the background.