Spatially and temporally constraining the lightning parameterization in GEOS-Chem and its impact on tropospheric ozone variability

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Lightning NO\textsubscript{x} in GEOS-Chem

**v7-04-12:** Substantial updates to standard model

Cloud Top Height

[Price and Rind, 1992]

Flash Rate Parameterization

Flash-to-NO\textsubscript{x} Conversion

Vertical Distribution

LNO\textsubscript{x}(x,y,z,t)

6.2 TgN a\textsuperscript{-1}

All arbitrary top-down scaling factors eradicated

Instead scale flash rate to observed annual average 46 fl s\textsuperscript{-1} from OTD/LIS

[Christian et al., 2003] and use NO\textsubscript{x} per flash values from the literature

Average NO\textsubscript{x} yields per flash introduced

Differential yields applied in extratropics

[ Hudman et al., 2007]

An updated to the local redistribution technique by Sauvage et al., [2007] using the LIS/OTD HRMC v2.2 product, with higher temporal resolution, and less spatiotemporal smoothing

LIS/OTD

C TH


fl km\textsuperscript{2} a\textsuperscript{-1}

>50

0

500 mol fl\textsuperscript{-1}

260 mol fl\textsuperscript{-1}

[Martin et al., 2006]
Impact on tropospheric composition

Note: Lightning in GEOS-Chem is NOT a climatology - it is still driven locally by the physics of the Cloud Top Height scheme during deep convective events; however, the modeled 11-year climatology matches that of the observations.

- LNO$_x$ shifted from tropics to N Midlats in all redistributions
- Decreases tropical and increases N Midlats UT O$_3$
- Total column O$_3$ differences greatest over Amazon and Middle East
Meanwhile, in progress...

Developing large continental-scale regions via clustering algorithms to redistribute lightning and still match the LIS/OTD climatology

See Poster

This gives us regions large enough for robust statistics to constrain inter-annual temporal variability of lightning in the tropics to LIS

[Graph showing time series and map with scale factors]
Large inter-annual variability observed in long-term satellite tropical tropospheric ozone columns

Tropospheric O3 Column Monthly Anomaly SD (1998-2005)

EPTOMS

GEOS-Chem with LIS Temporal Variability

[Ziemke et al., 2006]
Constraining the temporal variability of LNO\textsubscript{x} emissions in GEOS-Chem increases O\textsubscript{3} variability.
Lightning is one of the most important factors driving interannual variability in tropical tropospheric ozone.

Contribution of different sources to Tropospheric O3 Column Monthly Anomaly SD

Biomass Burning

LNOx with LIS-induced Variability

Relative Contribution

Biomass Burning

LNOx + LIS var

% total variability

Dobson Units

0 1 2 3
Lightning is one of the most important factors driving interannual variability in tropical tropospheric ozone.
Inclusion of temporal constraint into standard model

Development of new physically-based lightning flash rate parameterization for GEOS-Chem

Perform a full-chemistry inversion with the improved a priori flash rate parameterization to better constrain spatiotemporal variability in NO\textsubscript{x} yields

Couple GEOS-Chem with past and future climates to quantify the natural chemistry-climate feedbacks of LNO\textsubscript{x}