Assessing the Parameterization of \(\text{NO}_x\) Emissions By Lightning in a Chemical Transport Model with \(\text{HNO}_3\) Columns from IASI

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[Cooper et al., JGR 2014]
IASI Satellite Provides Global HNO\textsubscript{3} Columns.

IASI – A Nadir-viewing FTS

Global coverage 2x daily

Provides total column HNO\textsubscript{3}

Measurements over remote Pacific Ocean used alongside GEOS-Chem CTM to extract tropospheric portion of column

[Cooper et al., JGR 2014]
GEOS-Chem HNO₃ Lower Over Southeast Asia

IASI: Nadir-viewing FTS Satellite instrument

GEOS-Chem: Global chemical transport model

GEOS-Chem too low, or IASI too high?

[Cooper et al., JGR 2014]
Bias Due to Model Underestimating HNO$_3$ in SE Asia

- Bias observed by multiple instruments, across large vertical region

* HIRDLS - Limb-viewing radiometer * ACE-FTS - Solar occultation FTS * Aircraft –PEM West B, PEM Tropics A campaigns *

[Cooper et al., JGR 2014]
Lightning NO\textsubscript{x} is Most Likely Bias Source

- No error in CO gives confidence in anthropogenic and biomass burning emissions
- Deposition processes also ruled out via model studies
- Lightning emits NO\textsubscript{x} but not CO

[Cooper et al., JGR 2014]
Some Regionally Varying Lightning Properties that could Affect SE Asia

- GEOS-Chem lightning scaled by observed flash density
- SE Asia lightning flashes are longer, more radiant than elsewhere in tropics
- Intra-cloud lightning more common in SE Asia


[Cooper et al., JGR 2014]
The GEOS-Chem Lightning Parameterization

Flash rates match satellite observations

Prescribed NO\textsubscript{x}/flash (260 mol/flash)

Emissions added to GEOS-Chem

4°x5° grid boxes

Prescribed vertical profiles

[Cooper et al., JGR 2014]
LNO$_x$ Plumes have Sub-Grid Spatial Scale. LNO$_x$ Chemistry is Non-linear

• Early subgrid plume has high NO$_x$ concentration
• Leads to rapid HNO$_3$ production, lower OPE
• This is not represented in the model

[Cooper et al., JGR 2014]
A Simple LNO$_x$ Plume Pre-processor

Current Mechanism
- Adding 0.5 Tg N to Southeast Asia gives better agreement

With Pre-Processing

92% Bias

HNO$_3$ Tropospheric Column

(IASSI – Standard GEOS-Chem)/IASSI

6% Bias

(IASSI – GC w/ PreProcessor)/IASSI

[Cooper et al., JGR 2014]
Conclusions

• Tropospheric HNO$_3$ from IASI valuable for understanding NO$_x$ sources

• GEOS-Chem underestimates HNO$_3$ in Southeast Asia

• Lightning NO$_x$ is most likely contributor to bias

• Developed representation of early stage of concentrated lightning NO$_x$ plume

• A preprocessor for early stages of plume improves the simulation

[Cooper et al., JGR 2014]
LNO$_x$ Plume Pre-processor VS Prescribed Flash Yield

HNO$_3$ Tropospheric Column
(IASI – Standard GEOS-Chem)/IASI

(IASI – GEOS-Chem w/ Pre-Processor)/IASI