Study of Globalizing Air Pollution: Recent Progress

Jintai Lin 林金泰
Atmospheric Chemistry & Modeling Group
Peking University
linjt@pku.edu.cn
http://www.phy.pku.edu.cn/~acm/
Globalizing Air Pollution

Lin JT et al., ACP 2014; ACP 2015
Liu MY et al., ACP 2018; AMT 2019
Kong H et al., ACPD 2019
Cui YZ et al., ACP 2016

Yan YY et al., ACP 2014;
ACP 2016; GMD 2019
Ni RJ et al., ACP 2018
Weng HJ, in prep

Mengyao Liu
Chunjin Li
Hao Kong
Yuanzheng Cui
Yingying Yan
Hongjian Weng
Mingxi Du
Lulu Chen
Da Pan
Jingxu Wang

Integrated Trade-Emission-Pollution Modeling

Lin JT et al., PNAS 2014
Lin JT et al., Nature Geoscience 2016
Zhang Q et al., Nature 2017
Wang JX et al., AE 2018
Du MX et al., Nature Comm., in review
POMINO – Peking University OMI NO$_2$ Product

http://www.phy.pku.edu.cn/~acm/acmProduct.php#POMINO

All Level-2 and Level-3 data are freely available (2004-2018)

POMINO algorithm features:
- Explicit aerosol optical effects
- Coherent cloud retrieval
- Anisotropic surface reflectance
- High-res NO$_2$ profiles
- Pixel-specific radiative transfer calculation

Users: 4 continents, 10 regions, 50+ institutes

Lin et al., 2014 ACP; Lin et al., 2015 ACP; Liu et al., 2019 AMT
Initial Result for TROPOMI NO₂ Retrieval: July 2018

PKU NO₂ Product vs. KMNI Official NO₂ Product

- PKU NO₂ Product
  - 55°N to 15°N
  - 80°E to 140°E
  - Color scale: 0 to > × 10^{15} molec/cm²

- KMNI Official NO₂ Product
  - 55°N to 15°N
  - 80°E to 140°E
  - Color scale: 0 to > × 10^{15} molec/cm²

Comparison charts for Fukue, Nanjing, and Xuzhou:

- Number: 63
- Intercept: 1.63
- Slope: 0.70
- R²: 0.75
- NMB: 0.8%

- Number: 63
- Intercept: 0.31
- Slope: 0.42
- R²: 0.68
- NMB: -41.9%

Liu et al., in prep
Satellite+Model Derived High-res (5 km) NOx Emissions (Shanghai Area, 2012-2016 JJA)

POMINO NO$_2$ VCD

P

MEIC (bottom-up)

Routes Density in 2016

PHLET: 2-D Peking University High-resolution Lifetime-Emission-Transport Model

Kong et al., 2019 ACPD
Global-multi-regional Two-way Coupled Modeling Based on GEOS-Chem

- Same chemistry in all models; same meteorology except resolution
- High-res regional nested simulations ‘correct’ global model
- Global and multiple regional models interact simultaneously
- High computation efficiency and low model complexity

Two-way coupling framework

Reduced tropospheric oxidative capacity Closer to observations

<table>
<thead>
<tr>
<th></th>
<th>Global Model</th>
<th>Two-way Model</th>
<th>‘Observation’</th>
</tr>
</thead>
<tbody>
<tr>
<td>OH (10^5 \text{ cm}^{-3})</td>
<td>11.8</td>
<td>11.2 ((-5% *))</td>
<td>10.4 – 10.9</td>
</tr>
<tr>
<td>(\text{O}_3) (DU)</td>
<td>34.5</td>
<td>31.5 ((-8.7%))</td>
<td>31.1 ± 3 (OMI/MLS)</td>
</tr>
<tr>
<td>(\text{O}_3) (Tg)</td>
<td>384</td>
<td>348 ((-9.5%))</td>
<td></td>
</tr>
<tr>
<td>MCF lifetime (yr)</td>
<td>5.58</td>
<td>5.87 (+5.2%)</td>
<td>6.0 – 6.3</td>
</tr>
<tr>
<td>(\text{CH}_4) lifetime (yr)</td>
<td>9.63</td>
<td>10.12 (+5.1%)</td>
<td>10.2 – 11.2</td>
</tr>
<tr>
<td>NOx (TgN)</td>
<td>0.169</td>
<td>0.176 (+4.1%)</td>
<td></td>
</tr>
<tr>
<td>CO (Tg)</td>
<td>359</td>
<td>398 (+10.8%)</td>
<td></td>
</tr>
</tbody>
</table>

* Two times the [OH] interannual variability (2.3%)
# Greater than the change from 2000 to 2100 under RCP6.0
& Equivalent to a 25% increase in global CO emissions

Yan Y.-Y. et al., ACP, 2014, 2016
Adding SPARC-11 Aromatics Chemistry in GEOS-Chem: Effects on Surface OH and Ozone in 2005

Yan et al., 2019, GMD
2–11 ppb of near-surface anthropogenic O$_3$ over China are foreign

Foreign contribution: 40–50% below 2 km, 50–85% above 2 km

% of anthropogenic O$_3$ contributed by a region

Anthropogenic O$_3$ near the surface

Ni et al., ACP, 2018
Spatiotemporal Analysis & Visualization with EOF-EEMD

This package is available on a collaborative basis

EOF-EEMD framework

Applied to East China in Fall-Winter 2013

Liu et al., 2018 ACP
• Thank you very much for your attention!

• Peking University hires faculty members
  https://atmos.pku.edu.cn/rczp/87145.htm

• We hire postdocs
  – Bo Xin Postdoc 博新计划 $39K+$14K
  – Bo Ya Postdoc 博雅计划 $37K+$14K
  – Regular Postdoc 科研博士后 $27K+$10K

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http://www.phy.pku.edu.cn/~acm/
Satellite+Model Derived High-res (5 km) NOx Emissions Reveal Biases in Bottom-up Inventories (Shanghai Area, 2012-2016 JJA)

POMINO NO$_2$ VCD

$10^{15}$ molec./cm$^2$

POMINO + PHLET (top-down)

Kong et al., 2019 ACPD
Spatiotemporal Analysis & Visualization with EOF-EEMD

This package is available on a collaborative basis

Liu et al., 2018 ACP