GEOS-Chem modeling study of smoke transport from Southeast Asia to Yungui Plateau in Southwest China

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Biomass burning in South and Southeast Asia

Southeast Asia is largest of biomass burned in Asia [Streets et al., 2003]

Influence:
- Atmospheric Brown Cloud [Ramanathan et al., 2007; Stone et al., 2007]
- Form a regional-scale haze [Engling and Gelencser, 2010]
- Smoke transport to the northwestern Pacific [Jacob et al., 2003]
- Smoke aerosol transport to South China (Hong Kong) [Chan et al., 2003]
Yungui Plateau in Southwest China

Low AOD in Yungui Plateau

The research of smoke transport from Southeast Asia to this region is limited
Objectives:

1. Evaluate the model AOD in Southeast Asia and south of China

2. Quantify the smoke transport from different region of Southeast Asia to southwest China
Study region and sites:

YGP: Yungui Plateau
SC: South China
EICP: East of ICP
WICP: West of ICP

ICP: Indo-China Peninsular

<table>
<thead>
<tr>
<th>Region</th>
<th>Site name</th>
<th>Site location</th>
<th>Lon(ºE)</th>
<th>Lat(ºN)</th>
<th>Height(m)</th>
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<tbody>
<tr>
<td>YGP</td>
<td>KM</td>
<td>Kunming, Southwest China</td>
<td>102.65</td>
<td>25.01</td>
<td>1889</td>
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<td>SC</td>
<td>HK</td>
<td>Hong_Kong_Sheung, South China</td>
<td>114.117</td>
<td>22.483</td>
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<td></td>
<td>ZU</td>
<td>Zhongshan_Univ, South China</td>
<td>113.390</td>
<td>23.060</td>
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<tr>
<td>EICP</td>
<td>VT</td>
<td>Vientiane, Thailand, near Vientiane (Laos)</td>
<td>102.570</td>
<td>17.992</td>
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<td>LN</td>
<td>Luang_Namtha, Laos</td>
<td>101.416</td>
<td>20.931</td>
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<td>ND</td>
<td>NGHIA_DO, Vietnam</td>
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<td>21.048</td>
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<td>WICP</td>
<td>CM</td>
<td>Chiang_Mai_Met_Sta, Thailand</td>
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<td>18.771</td>
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<td></td>
<td>DU</td>
<td>Dhaka_University, Bangladesh</td>
<td>90.398</td>
<td>23.728</td>
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</tr>
</tbody>
</table>
Data:

**CE318 sunphotometer:** AOD and Angstrom Exponent

**MODIS:** AOD 550nm and fire location products

**CALIPSO:**
- Level 1: attenuated backscattering coefficient profiles at 532 nm
- Level 2: particulate extinction coefficient profiles at 532nm vertical feature mask data products of aerosol subtype

**NCEP/NCAR reanalysis daily data:**
- surface wind and 500mb geopotential height
Descriptions

• GEOS-Chem model v10-1
• GEOS5 meteorological fields on 47 layers.
• NOx-Ox-hydrocarbon-aerosol chemistry
• 0.5x0.667 nest model in East Asia
• BC boundary conditions from 2x2.5 Global model
• Emissions: Fire inventory from NCAR (FINN)
Configurations

Time period:
• Jan 2012-May 2013 & March-April 2013

Sensitivity experiments:
• Experiment-1 (Exp1): turn on global fire emission;
• Experiment-2 (Exp2): turn off global fire emission;
• Experiment-3 (Exp3): turn off fire emission in YGP region;
• Experiment-4 (Exp4): turn off fire emission in SC region;
• Experiment-5 (Exp5): turn off fire emission in EICP region;
• Experiment-6 (Exp6): turn off fire emission in WICP region.
I. Evaluation of model AOD

<table>
<thead>
<tr>
<th>1.KM</th>
<th>2.HK</th>
<th>3.ZU</th>
<th>4.VT</th>
<th>5.LN</th>
<th>6.ND</th>
<th>7.CM</th>
<th>8.DU</th>
</tr>
</thead>
</table>

- **Y = 0.07 + 0.21X**
- **MB = -0.22**
- **RMSE=0.43**
- **R=0.40**
- **N=3226**

- **Y = 0.02 + 0.71X**
- **MB = -0.04**
- **RMSE=0.62**
- **R=0.55**
- **N=1347**

- **non biomass burning period**
- **biomass burning period (Mar-Apr)**

- the model perform better in biomass burning period (Mar-Apr).
II. Regional contribution of biomass burning transport to Southwest China

WICP region is the largest contributor of smoke aerosol in Kunming site.

The contribution of BB in WICP to BB_AOD is 88% and to total_AOD is 57% at KM site.
III. A case of smoke transport from west to Kunming

The model simulation (Exp1) has well caught the trends of AOD in the three days.
MODIS true-color images, Fire locations, CALIPSO_track

MODIS AOD 550 nm and back trajectory

Model simulated AOD 550nm

500hpa hgt and surface wind
CALIOP total attenuated backscatter at 532nm

CALIOP vertical feature mask of aerosol

CALIOP AOD at 532nm (extinction coefficient × level depth)

Model simulated vertical AOD at 550nm
- GEOS-Chem model simulation underestimates the AOD value of 0.16 during Jan 2012-May 2013 but performs better in biomass burning months March –April with a bias only of -0.04. And in biomass burning season, the model AOD often captures the trends of AOD observed by CE318 with a correlation coefficient of 0.55.

- The regional sensitivity experiments reveal that the biomass burning in WICP region (mainly Northeast India and Burma) is the largest contributor of BB_AOD (~88%) and total_AOD (~57%) to Southwest China site Kunming.

- A case study of smoke transport on 21-23 March 2013 shows that the model simulated spatial distribution of AOD and vertical distribution of aerosols are consistent with their respective counterparts retrieved from MODIS and CALIPSO. The smoke in Burma can be lifted to 4km and then transported to YGP by prevailing west wind.
Thank You!