Evaluating tropospheric CH4 concentration hotspot in Himalaya region with GEOS-Chem and AIRS satellite retrievals

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Research motivation

AIRS CH₄ (150–250 hPa)  
250–350 hPa

Difference between September and May 2004, Xiong et al. (2008)

4/14/09
Research motivation

(upper) 850 Mean Omega field: 2004 May to Sep.

(right) Mean wind field: 2004 May to Sep.
**Research questions**

- Is the hotspot (260–359 hPa) over Himalaya region mostly due to long range transport or local transport (rice paddy emissions)?
- If dominated by local transport, which source is more important: China/India rice paddy?
- What are the relative contributions of the long range transport and local transport to the hotspot over Himalaya region?
Region of interest
## GEOS–Chem simulation

<table>
<thead>
<tr>
<th>Source</th>
<th>Tg/year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Animal</td>
<td>80.0</td>
</tr>
<tr>
<td>Coal mining</td>
<td>34.0</td>
</tr>
<tr>
<td>Gas production</td>
<td>48.5</td>
</tr>
<tr>
<td>Landfill+waste</td>
<td>66.2</td>
</tr>
<tr>
<td>Other anthro.</td>
<td>29.3</td>
</tr>
<tr>
<td>Termite</td>
<td>20.0</td>
</tr>
<tr>
<td>Hydrate</td>
<td>20.0</td>
</tr>
<tr>
<td>Biomass burning</td>
<td>~40.0 (multi–year mean)</td>
</tr>
<tr>
<td>Wet tundra</td>
<td>10.0</td>
</tr>
<tr>
<td>5–c wetland</td>
<td>197.5</td>
</tr>
<tr>
<td>Rice paddy</td>
<td>60.0 [india(15)/china(20)]</td>
</tr>
<tr>
<td>Total</td>
<td>605.5</td>
</tr>
</tbody>
</table>


7 sets of simulations are conducted based on keep(1)/half(1/2)/turn off (0) the rice paddies in India & China.
The OH field is tested by MCF (CH₃CCl₃) transport with a total lifetime 5.51 years, subject to a stratospheric loss 46.0 years and ocean uptake 77.0 years. The overall lifetime of CH₄ is 8.1~8.2 years.

To compare with AIRS retrieval, model simulation is convolved using the equation

\[ y = Ax + (I - A) x_a \]

y is the convolved data, x is GEOS–Chem output, \( x_a \) is the first guess profile and A is averaging kernel.
Result: general comparison

AIRS Sep minus May 2004 160–260 hPa

Model Sep minus May 2004 160–260 hPa

AIRS Sep minus May 2004 260–359 hPa

Model Sep minus May 2004 260–359 hPa
Result: general comparison
Result: general comparison
Result: general comparison

2004–2005 AIRS longitudinal average 359–460 hPa

2004–2005 AIRS longitudinal average 460–590 hPa

2004–2005 model longitudinal average 359–460 hPa

2004–2005 model longitudinal average 460–590 hPa
Result: regional comparision

Himalaya

India

China

Africa

260-359 hpa

Dec 2004 - Dec 2005

Dec 2004 - Dec 2005

Dec 2004 - Dec 2005

Dec 2004 - Dec 2005

AIRS
Exp(0,1)
Exp(1,0)
Exp(0,0)
Exp(1/2,0)
Exp(0,1/2)
Exp(1/2,1/2)
Exp(1,1)
Contribution analysis

\[ F(x,y) = F(x_0, y_0) + a \Delta x + b \Delta y + c \Delta x \Delta y \]

x China, y India, \( F(x,y) \) the hotspot strength defined by Sep. CH\(_4\) minus May CH\(_4\) on 160hPa~206hPa

<table>
<thead>
<tr>
<th>( (x_0, y_0) )</th>
<th>a</th>
<th>b</th>
<th>c</th>
</tr>
</thead>
<tbody>
<tr>
<td>(0,0)</td>
<td>0.57</td>
<td>1.05</td>
<td>-0.56</td>
</tr>
<tr>
<td>(1/2,1/2)</td>
<td>0.14</td>
<td>0.46</td>
<td>-0.33</td>
</tr>
<tr>
<td>(1,1)</td>
<td>0.03</td>
<td>0.25</td>
<td>-0.23</td>
</tr>
</tbody>
</table>
Conclusion

- A significant part (almost half) of the hotspot is due to long range transport.
- The India rice paddy emission contributes more to the hotspot, because of the strong convection and the upper level westerlies.
Further work

- An inverse modeling will be undertaken to optimize the various sources subject to the constraint provided by GLOBALVIEW-CH4, 2008 observations.
- A new quantification of CH4 emissions from the natural ecosystems will be conducted with a newly developed version of process-based model TEM.
- Better answers to the research questions would be provided based on the optimized simulation.
Acknowledgement

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