Amazonian GPP Estimated from Satellite-Observed Carbonyl Sulfide Mixing Ratios

Jim Stinecipher – Elliott Campbell – Le Kuai
(et al.)
Background

- GPP estimates are highly variable in the tropics.
- 2.5x difference between low and high members of TRENDY project in tropics

**Approach:**
1. Using TRENDY as a guideline, scale COS plant fluxes in SiB up/down.
2. Compare GEOS-Chem output to satellite COS observations (MIPAS).
COS vs. CO$_2$

- **GOSAT CO$_2$ at 250hPa**
  - ±1% from global mean
  - Competing signals from photosynthesis and respiration over land.

- **MIPAS COS at 250hPa**
  - ±10% from global mean
  - No competing respiration signal over land!
MIPAS

- Michelson Interferometer for Passive Atmospheric Sounding onboard ENVISAT (now inactive)
- COS retrievals 2002-12.
- Approximately 250hPa
- See Glatthor et al., 2015 (GRL) for details. 10.1002/2015GL066293
GEOS-Chem Model Output

(A) MIPAS Annual mean deviation from global mean (ppt COS)
(B) GEOS-Low model output
(C) GEOS-Med model output
(D) GEOS-High model output

→ GEOS-Med and GEOS-High seem to be in the appropriate range.
(A) GEOS-Med model output  
(B) PCTM model output (using GEOS-Med fluxes)  
(C) GEOS-Med with increased anthropogenic, decreased ocean  
(D) GEOS-Low model output  

(A)-(C) relatively similar, even with large changes. Low is significantly lower.  

→ Changes to plant fluxes have strong effect, relative to changes to other fluxes or choice of transport model
Amazon Flux Uncertainty

Average annual COS flux in box 5N-15S, 75W-50W

Plant: SiB Low, Med, High (this paper)

Soil: Kettle 2002, SiB

Anthropogenic: Zumkehr 2016, Kettle 2002

Biomass Burning: GFED spatial scaling to total from Berry; high and low based on range in Campbell 2015.
Amazon Depression, 250hPa

Average annual concentration difference in box 5N-15S, 75W-50W

GEOS TES is a run optimized using TES retrievals over ocean.
Implications for GPP

Average annual GPP in box 5N-15S, 75W-50W

Put differently...

Crude optimization still yields a constraint close to other metrics!
Conclusions

Remote-sensed COS concentrations are a promising tracer for terrestrial gross primary production.

Using MIPAS COS observations yields Amazonian GPP estimate close to other independent metrics, and near the median of the TRENDY model ensemble.

Future work:
- Investigating convective transport scenarios
- Magnitude and timing of seasonal cycles
- Collection and assimilation of airborne and flux-tower data
- 4D variational inverse modeling

Many thanks to Ian Baker (SiB data), Christian Beer (FLUXNET GPP data), Norbert Glatthor/Michael Höpfner/KIT (MIPAS data), Scot Miller (PCTM runs), Nick Parazoo (SIF GPP data), Stephen Sitch (TRENDY data), John Worden/JPL (TES data), Andrew Zumkehr (anthropogenic fluxes). Funded in part by UC Lab Fees Fellowship LGF-17-476795.
Stomatal Conductance and GPP

[Map showing global distribution of GPP, stomatal conductance, and OCS canopy uptake with color gradients and scale bars.]
# GEOS-Chem Setup

<table>
<thead>
<tr>
<th>Flux (GgS COS)</th>
<th>Berry 2013</th>
<th>This Study</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ocean COS</td>
<td>39</td>
<td>43.5</td>
<td>Kettle</td>
</tr>
<tr>
<td>Ocean DMS</td>
<td>81</td>
<td>90</td>
<td>Kettle</td>
</tr>
<tr>
<td>Ocean CS2</td>
<td>156</td>
<td>156</td>
<td>Kettle</td>
</tr>
<tr>
<td>Anthropogenic</td>
<td>180.5</td>
<td>180.5</td>
<td>Kettle</td>
</tr>
<tr>
<td>Biomass Burning</td>
<td>136</td>
<td>136</td>
<td>GFED, scaled to 136 GgS/yr</td>
</tr>
<tr>
<td>Addl Ocean Source</td>
<td>600</td>
<td>269 to 619</td>
<td>Same approach and scaling factors as in Berry</td>
</tr>
<tr>
<td>OH Radical</td>
<td>-101</td>
<td>-111</td>
<td>GEOS-Chem OH</td>
</tr>
<tr>
<td>Canopy Uptake</td>
<td>-738</td>
<td>-793 to -948</td>
<td>SiB, adjusted</td>
</tr>
<tr>
<td>Soil Uptake</td>
<td>-355</td>
<td>-166</td>
<td>SiB</td>
</tr>
</tbody>
</table>
Amazon COS Depression

![Graph showing the average deviation from the global mean (ppt COS) for different models over months from January to December. The models include MIPAS, PCTM Berry, PCTM Miller, Berry Hi, Berry Med, Berry Low, New Anthro, and TES Opt.](image)
Comparison of monthly concentration difference from global mean between all models compared to MIPAS observations.

TES-optimized is best, but GEOS-Med and GEOS-High are close seconds.