Inverse modeling for CO emissions and HCHO production by NMVOCs


1 Laboratoire des Sciences du Climat et de l’Environnement, LSCE, Paris
2 Atmospheric Chemistry Division, National Center for Atmospheric Research, Boulder, Colorado, USA
3 UPMC Université Paris 6, Université Versailles St-Quentin, CNRS/INSU, LATMOS-IPSL, Paris, France
4 Atomic and Molecular Physics Division, Harvard-Smithsonian Center for Astrophysics, Cambridge, Massachusetts, USA
5 Jet Propulsion Laboratory, California Institute of Technology, USA
6 Earth Observing Laboratory, National Center for Atmospheric Research, Boulder, Colorado, USA
Inverse approach

Minimization of a cost function

Optimized Fluxes

Uncertainties + Observations

Chemistry Transport Model

Prior Fluxes

Inverse Procedure
Methane (CH\textsubscript{4})

Methylchloroform (CH\textsubscript{3}CCl\textsubscript{3} or MCF)

[OH]

Optimized variables

Surface stations

EDGAR-v3.2 + GFD-v2

Emissions

(Methane)

Resolution: 3.75° x 2.5°

Chemistry transport model: LMDZ-SACS
Methane (CH₄)

Formaldehyde (CH₂O)

Emissions (CH₃CCl₃ or MCF)

Methylchloroform

Optimized variables

Surface stations (Hauglustaine et al., 2004; Folberth et al.; 2006; Pison et al.; 2009)

Resolution: 3.75° x 2.5°

Production by NMVOCs

From a previous simulation of the full model LMDz-INCA

EDGAR-v3.2 + GFED-v2

Resolution transport model: LMDz-SACS

Chemistry transport model: LMDz-SACS
Carbon Monoxide (CO)

Emissions

Methylchloroform (CH$_3$CCl$_3$ or MCF)

Monoxide Carbon

Formaldehyde (CH$_2$O)

Optimized variables

Surface stations

(Edgylustaine et al., 2004; Folberth et al., 2006; Pison et al., 2009)

Resolution: 3.75° x 2.5°

Chemistry transport model: LMDZ-SACSA
CO fluxes Increment (in kg/m²/s)

1.2 × 10⁻⁹

HCHO scale factor increment

1, 2.84 × 10⁻²

CO Concentrations in July 2004, at 700 hPa, in ppm

Increments from the Inversion
The posterior emissions are 37% higher than the prior ones (~1405 TgCO/yr).

Prior anthropogenic sources for year 1995 from inventory EDGAR v3.2 (Olivier et al., 2001).
Prior interannual biomass burning sources from GFEDv2 (van der Werf et al., 2006).
Total prior emissions = 1038 Tg/yr (on the 10-year average).

I. Ten years of CO emissions as seen from MOPITT
South American Temperate region

(from Torres et al., 2010)
Significant seasonal variations found in the Northern Hemisphere (also found by Kopacz et al., 2010).
Year 2000

CO Emissions (Tg CO per month)

not reported by other inventories
I. Multi-satellite constraints

Optimized variables

II. Multi-satellite constraints

Hauglustaine et al., 2004, Foldenth et al., 2006, Pison et al., 2009

Optimized variables

Emissions

MOPITT or IASI

Methytrichlorform (CH₃CCl₃ or MCF)

OMI

Surface stations

Production 3D

Emissions

Dihydrogen (H₂)

Formaldehyde (CH₂O)

Surface stations

Monoxide

Carbon Dioxide (CO₂)

Surface stations

Carbon Monoxide (CO)

Surface stations
<table>
<thead>
<tr>
<th>Region</th>
<th>EDGAR3.2+</th>
<th>GFED2</th>
<th>4.2+GFED3</th>
<th>USA</th>
<th>Canada</th>
<th>Western Europe</th>
<th>Global</th>
</tr>
</thead>
<tbody>
<tr>
<td>Posterior</td>
<td>1284</td>
<td>22</td>
<td>12</td>
<td>96</td>
<td>60</td>
<td>132</td>
<td>112</td>
</tr>
<tr>
<td>Posterior</td>
<td>1401</td>
<td>58</td>
<td>54</td>
<td>151</td>
<td>132</td>
<td>151</td>
<td>54</td>
</tr>
<tr>
<td>Posterior</td>
<td>1467</td>
<td>52</td>
<td>49</td>
<td>213</td>
<td>112</td>
<td>49</td>
<td>112</td>
</tr>
<tr>
<td>Posterior</td>
<td>1066</td>
<td>44</td>
<td>8</td>
<td>108</td>
<td>105</td>
<td>108</td>
<td>105</td>
</tr>
</tbody>
</table>

CO Regional emissions in TgCO/yr: Summary for Year 2005
Discrimination between atmospheric chemistry and emissions at surface

Prior

Emissions

Posterior

Emissions

and emissions at surface

Discrimination between atmospheric chemistry

Prior
Interestingly, seasonal cycle in agreement with isoprene measurements at Tapajos, Brazil [Barkley et al., 2008].

HCHO concentrations

HCHO production by NMVOCs

HCHO production by NMVOCs
Ratio of the posterior to the prior simulation

Improvement relative to the prior simulation

correlations

Value between simulated and observed AMMA

Ratio of the posterior to the prior values of bias (in absolute
Variational system with simplified chemistry

MULTI SPECIES – MULTI CONSTRAINTS inversion

Time series and budget of CO emissions, CH₄ emissions, and HCHO production by

Summary

Our conclusions rely on the quality of HCHO columns retrievals

Uncertainties remain large for OMI data and the scarcity of in situ measurements remains an issue for evaluation.

Through evaluation of our results:

- Time series and budget of CO emissions, CH₄ emissions, and HCHO production by NMVOCs for 2005-2010 [Foretms-Cheiney et al., 2012, ACPD]
- Comparison with recent studies
- CO concentrations at surface stations from NOAA/ESRL
- HCHO concentrations from AMMA INTEX-B;
- Comparison with independent data (HCHO columns retrievals from OMI/UVCDR)
- Update with inventories EDGAR-V4.2, GFED-V3 and MEGAN [Guenther et al., 2006]
- Sensitivity tests
- Comparison with recent studies

Summary

Our conclusions rely on the quality of HCHO columns retrievals

Uncertainties remain large for OMI data and the scarcity of in situ measurements remains an issue for evaluation.
Thank you for your attention.