Progress at Cornell

1. Development Applications
2. Other Science
O₃ Effects on Plants

Danica Lombardozzi

- Ozone decreases primary productivity and alters carbon cycling [Sitch et al., 2007: radiative impacts comparable to direct forcing from ozone]

- Ozone may modify transpiration of plants and alter the hydrological cycle

- Ozone part of the coupling between nitrogen cycle and climate
Field Experiments Showing Plant Response to Fumigation

Transpiration and Photosynthesis are Changing Independently
A: Modifications to *only* photosynthesis, similar to Sitch et al. 2007

B: Independent modifications to *photosynthesis* and *transpiration*

C: Net difference between *photosynthesis-only* and *photosynthesis + transpiration* modifications

Simulated 3-year average photosynthesis and transpiration rates after continuous daytime exposure to 60 ppb O₃. Results on left panel include only photosynthesis modifications (similar to Sitch et al. 2007) while the right panel includes modifications made to photosynthesis and transpiration independently.
Fire dynamics during the 20th century simulated by the Community Land Model

• Silvia Kloster1, Natalie M. Mahowald1, James T. Randerson2, Peter E. Thornton3, Forrest M. Hoffman3, Samuel Levis4, Peter J. Lawrence4, Johannes J. Feddema5, Keith W. Oleson4, and David M. Lawrence4
  • Submitted to Biogeosciences (in discussion)
  • Available at Biogeosciences or http://www.geo.cornell.edu/eas/PeoplePlaces/Faculty/mahowald/

• Improve prognostic fire algorithm in CLM-CN to better match observations (mostly from satellite)
• Include moisture, fuel load, human and natural ignition, wind strength, fire suppression, land use/deforestation
• Goal: capture satellite era observations of fire, so we need humans.
Fig. 1. Simulated annual total (wildfire plus deforestation) area burned [percentage of grid box] compared to satellite based fire products: GFEDv2 (van der Werf et al., 2006) and L3JRC (Tansey et al., 2008). The model simulations are averaged over the corresponding observational periods (GFEDv2: 1997-2004; L3JRC: 2001-2004). Regional values for all simulations performed are given in Fig 2.

T-Full: Thonicke, AB-HI-FS Arora and Boer w/ human ignition, fire suppression
New algorithm (AB-HI-FS) better matches observational based estimates
Improves boreal region.
(also compare to other data/estimates: see paper for details)
Fig. 10. Upper panels: Trend in decadal total (wildfire and deforestation) fire carbon emissions compared to decadal mean GICChist estimates (Mieville et al., 2009) for different regions from 1900 to 2000 normalized with the mean value for 1900-2000. Solid lines represent model simulations: black: T-FULL, red: AB-FULL, green: AB-HI; blue: AB-HI-FS. Dashed orange line with symbols are observations (GICChist). Lower panels: decadal mean change in total carbon loss in [%] with respect to the respective control simulation caused by red: land use change and wood harvest, green: human ignition, blue: human ignition and fire suppression, black: climate. Note here, that the fire carbon-system is highly non-linear and therefore the individual responses are not additive.
Next steps

• Future fires
• Coupling with climate/carbon/chemistry system
Simulating methane emissions from wetlands in CLM3.6

Cornell: Lei Meng, Peter Hess, Natalie Mahowald, and Joseph Yavitt

In collaboration with Zack Subin and Bill Riley at Lawrence Berkeley National Lab
pH dependence of CH4 production

\[ P_{\text{ch4}} = \text{somhr}^1 f(pH) * f(T_{\text{soil}}) * f(WTL) \]

(Data from Dunfield et al. 1993, Soil Biol. Biochem)
Source: ISRIC's Soil Information System (ISIS) and the soil CD-ROM of the Natural Resources Conservation Service (USDA-NRCS)
Global and Tropical methane flux estimates

<table>
<thead>
<tr>
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<th>Tropical (20N-30S)</th>
<th>Global</th>
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</thead>
<tbody>
<tr>
<td>Our model (without pH)</td>
<td>120</td>
<td>178.44</td>
</tr>
<tr>
<td>Our model (with pH)</td>
<td>56.4</td>
<td>116.8</td>
</tr>
<tr>
<td>Other models*</td>
<td>32-80</td>
<td>80-115</td>
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At this site, pH does not have significant impacts on methane production since pH value is close to the optimal pH for methanogenesis.
Single-point simulation

CH4 emission at Kalimantan, Indonesia

CH4 emission (mgCH4/m2/d) vs. Year-Month

- Observed
- FCH4_sat
- FCH4_sat_no_ph

CH4 emission (mgCH4/m2/d)
CH4 emission at Kalimantan, Indonesia

CH4 emission (mgCH4/m2/d)

Year-Month

1981.0  1981.2  1981.4  1981.6  1981.8  1982.0

Observed

FCH4_sat
Indonesia CH4/CO ratio

Data source: Jauhiainen et al. 2005
Asian Influence on US Surface O$_3$

Ben Brown-Steiner

• Tagged NO$_x$ emissions over Asia are modeled as they transport over the Pacific and into the US
• Ozone produced from Asian NO$_x$ tagged as O3A
• Study is Looking at Mechanisms of Asian Ozone import to the U.S. including: Seasonality, Distribution, and Variability
Effect of Specific Ozone Pollution Plumes on the US Atmosphere

Individual Asian Plumes ~ 10 ppbv
Asian Ozone Background

- Increases $O_3$ levels around 5 ppbv in the west US, and 1 ppbv in the east US

(Monthly Average)
P. Hess
Ozone Trends and STE, Peter Hess

1998-1999 Ozone Anomaly
Europe, Eastern U.S., Iceland

Percent Ozone Anomaly, 1992-2004
Macehead, Jungfraujoch

V. Thouret et al., 2006
Increased stratospheric ozone drives large-scale long-term variability since 1990
(Increase ~ 0.2 ppbv/year since 1990)

- CAM-CHEM Simulation
- NCEP Reanalysis
- Tagged NO\textsubscript{x} to calculate ozone produced from NO\textsubscript{x} reactions
- Stratospheric ozone calculated as a residual
Simulated and Measured Ozone at Macehead

CAM-chem simulation
12 month running mean from monthly averages
Crudely Filtered for Clean Sector
-5° off coast
-Filtered for CO < 1σ

Adapted from Derwent et al, 2007 Filtered for clean sector