

Nationwide impacts by fire emissions in the United States in summer 2002

Tao Zeng^{1,2} and Yuhang Wang²

¹ Georgia Environmental Protection Division

² Georgia Institute of Technology

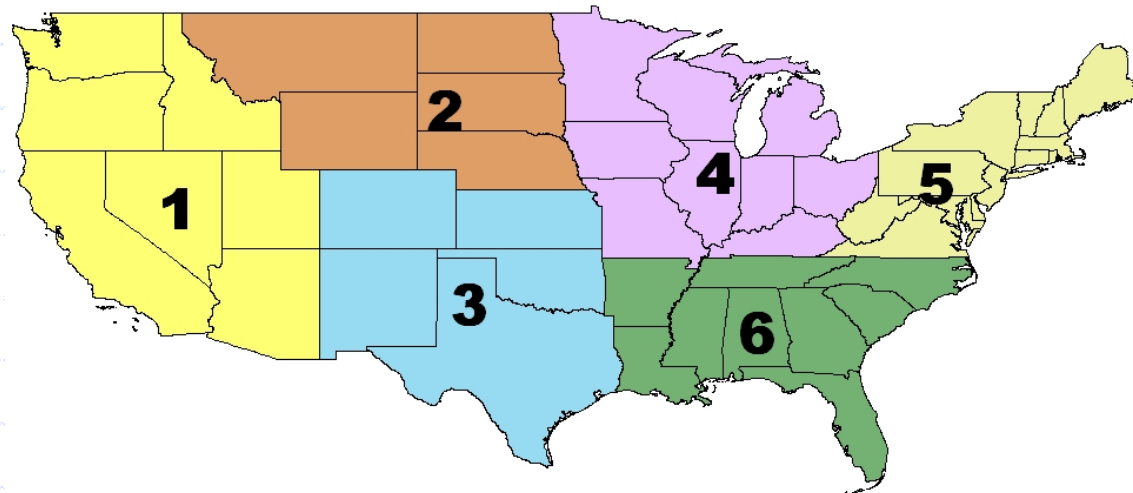
GEOS-Chem 4th Users' Meeting
April 7, 2009

Outline

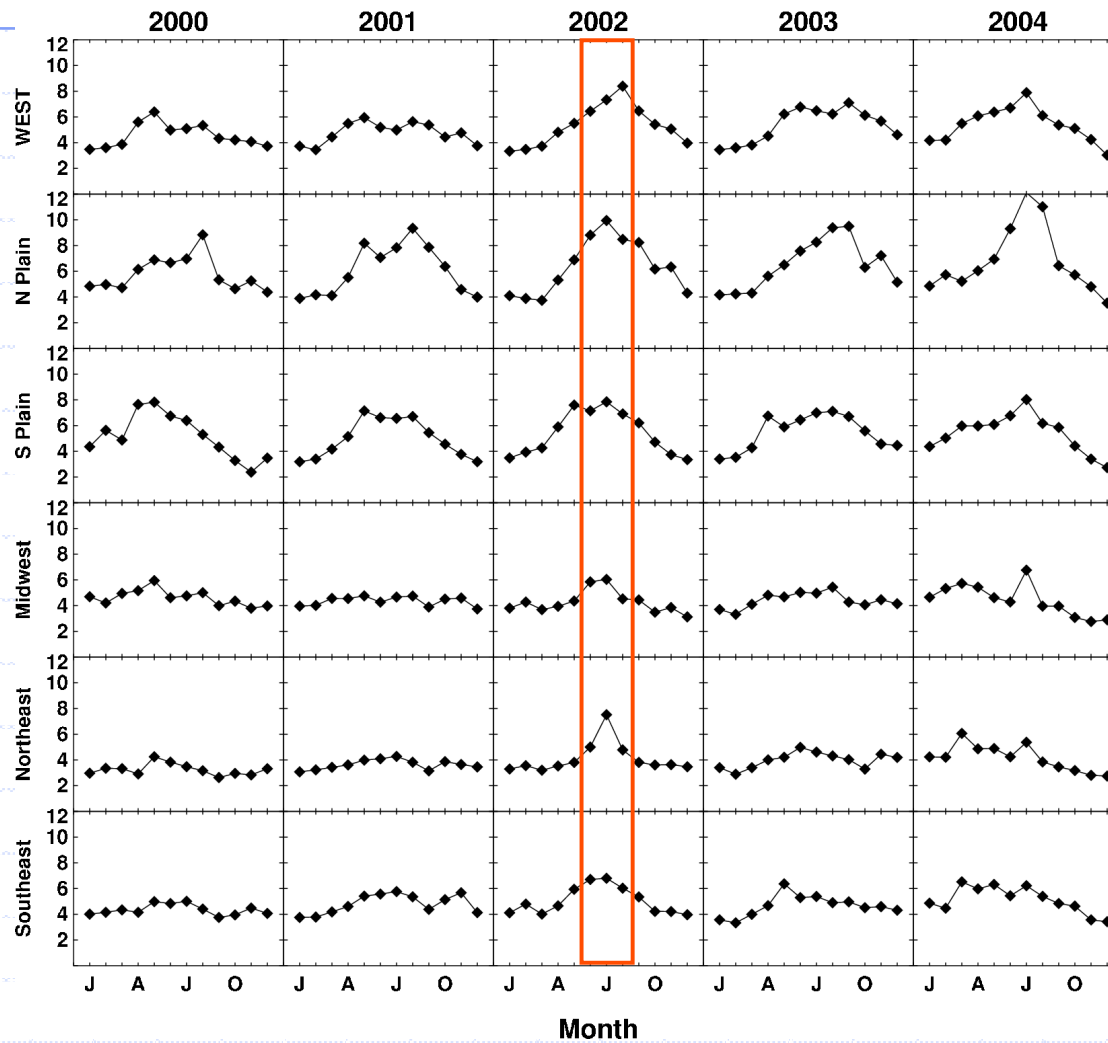
- ◆ Measured OC/EC ratios from 2000-2004 in contiguous US
- ◆ Possible reasons for nationwide OC/EC peaks in 2002
 - ❖ Biomass burning emissions
 - ❖ Secondary organic carbon (SOA) formation
 - ❖ Inter-continental transport from Asia
- ◆ Summary

OC & EC data in the continental United States

- ◆ OC and EC observations from **IMPROVE** network (~170 sites) from 2000-2004
- ◆ Continental US is examined by dividing into 6 regions, 1. West, 2. Northern Plain, 3. Southern Plain, 4. Midwest, 5. Northeast, and 6. Southeast.



Monthly OC/EC ratios from 2000 to 2004

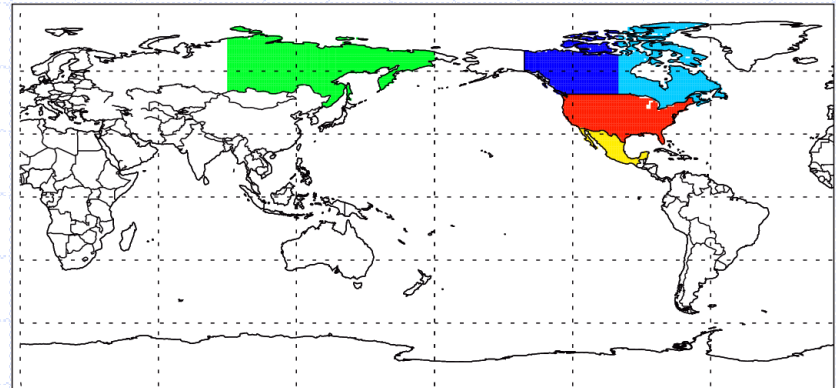


Three potential reasons

1. Large-scale biomass burning
2. Secondary organic aerosol
 - Biogenic SOA formation
 - In-cloud SOA production
3. Transpacific transport

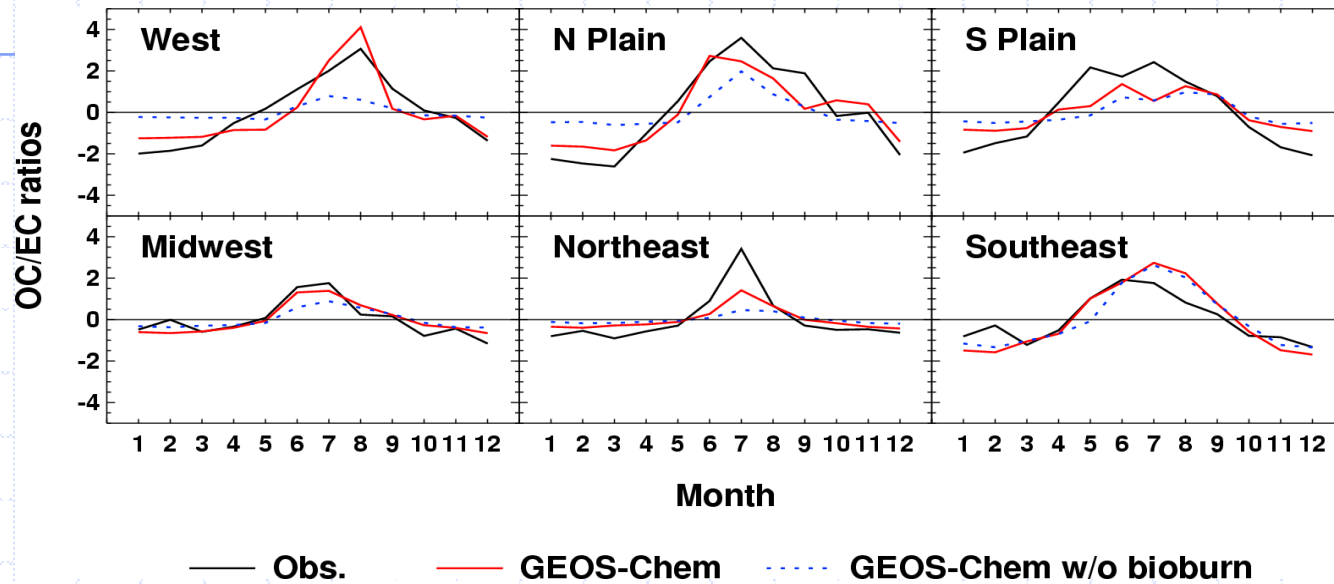
GEOS-Chem simulations

- ◆ GEOS-Chem v7-03-06 [*Bey et al., 2001*]
- ◆ Biomass burning emissions of OC and EC from Global Fire Emissions Database (GFED) version 2 [*van der Werf et al., 2006*].
- ◆ SOA contribution is assumed to be 10% carbon yield of OC from terpenes [*Park, et al., 2003*].
- ◆ 8 runs in 2002
 - One base run with all emission.
 - One sensitivity run without biomass burning emission.
 - Five sensitivity runs with regional biomass burning emission from 5 regions, Eastern Russia (ERUS), Western Canada (west of 110°W, WCAN), Eastern Canada (east of 110°W, ECAN), the United States (USA), and Northern Mexico (north of 20°N, NMEX).
 - One sensitivity run without biogenic SOA

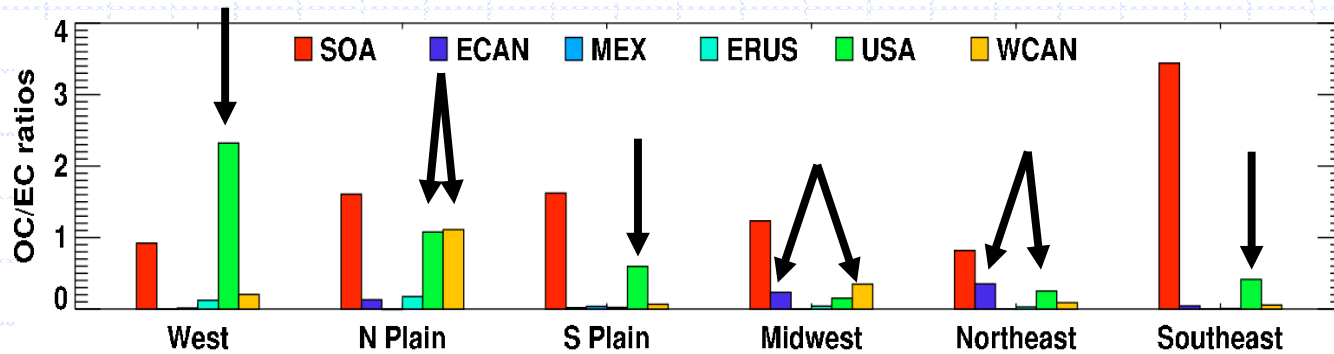


5 regions with biomass burning emission

GEOS-Chem simulated OC/EC ratios



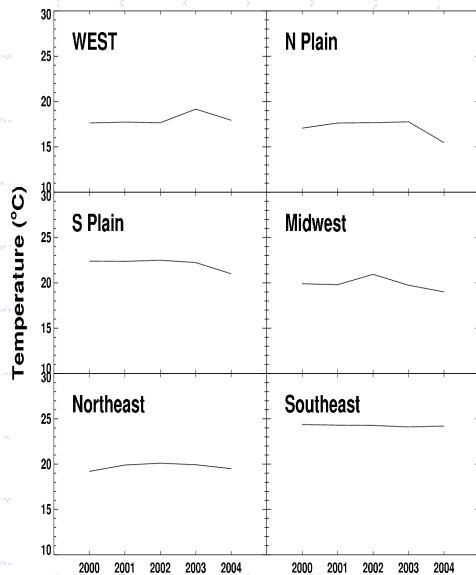
BSOA and biomass burning emissions contributions in the 6 regions in summer 2002.



Biogenic SOA contributions

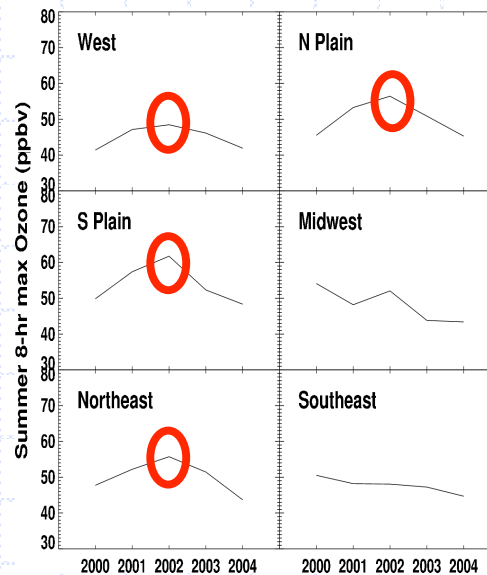
Assumption: The inter-annual variations come from biogenic VOCs emissions by neglecting the inter-annual variations of anthropogenic VOCs emissions. Without clear understanding of SOA formation mechanism, we are trying to tackle the inter-annual variations (anomalies) of biogenic SOA contributions in 3 aspects:

- The **emission** of biogenic VOCs [Guenther et al., 1995] (**Temperature**)
- The **oxidation** of VOCS (**Ozone**)
- The **removal** of SOA (applied to all fine PM) (**Precipitation**)



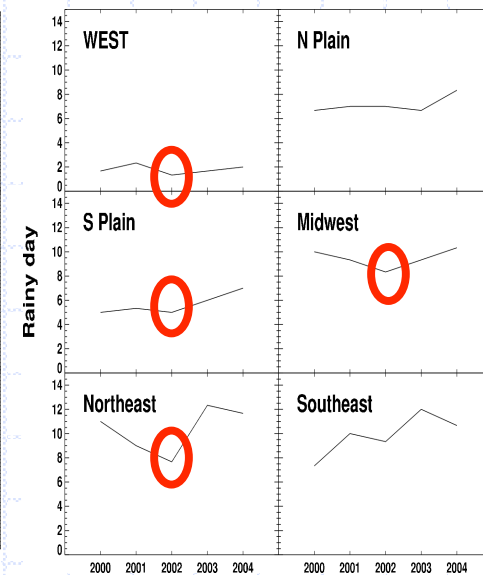
Surface Temperature
(NCEP ADP datasets)

\propto
Biogenic VOC emission



Surface O₃
(EPA AQS datasets)

\propto
VOCs oxidation and
SOA formation

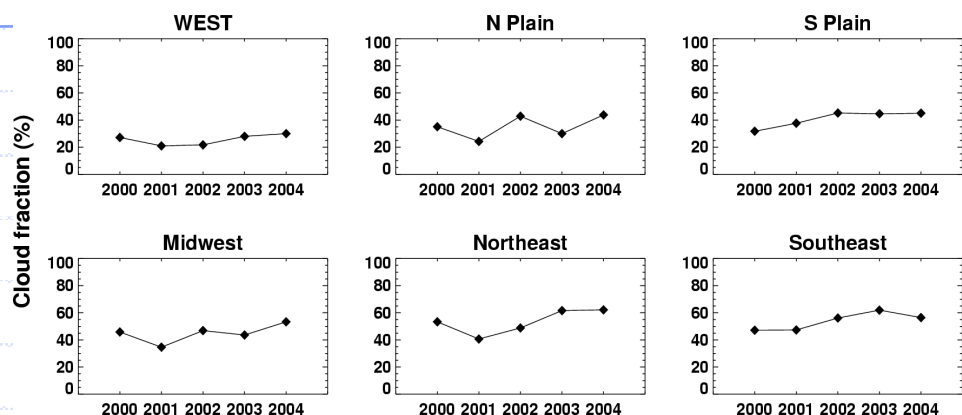


Rainy Days
(NCEP ADP datasets)

\propto
Aerosol removal

In-cloud SOA formation

Assumption: no variations in VOCs emissions, cloud coverage is positively associated with SOA formation in cloud. We checked MODIS cloud fraction products ($1^{\circ} \times 1^{\circ}$).



Transpacific transport

Facts: Reports of Asian outflow impact in the West, stronger in spring, weaker in summer.

Data: NNRP U wind (west-east) at 300mb over northern Pacific (150°E - 140°W and 30 - 50°N) in summer (JJA) 2002.

Year	2000	2001	2002	2003	2004
U wind (m/s)	11.7	12.0	15.7	13.2	13.7

Lim et al. 2003 (ES&T): “The OC/EC ratio decreased with increasing time since the air mass encountered the source regions of China, Japan, and Korea. This suggests a longer atmospheric residence time for EC than for OC.”

Heald et al. 2006 (JGR): “No such Asian enhancements are observed for nitrate or for organic carbon (OC) aerosol.”

Conclusions

- ◆ With the updated biomass burning emissions in 2002, the GEOS-Chem model is able to reproduce a general OC/EC patterns. It shows the major role of biomass burning to explain the OC/EC anomalies in summer 2002.
- ◆ The biomass burning emissions from different regions show varying impacts on each individual regions, depending on the transport distances.
- ◆ Our qualitative analysis on the air temperature, ozone concentrations, and precipitation shows that summertime biogenic SOA production is favored in 2002 in some regions, such as West, Southern Plain and Northeast.
- ◆ Less aerosol removal associated with less rain can be part of explanation as well.
- ◆ Other mechanisms such as in-cloud SOA production and transpacific transport do not appear to have major contribution.
- ◆ Since only the anomalies are discussed, the major source contributions to OC can be different from the aforementioned factors, especially in other seasons with less burning and SOA productions.

Acknowledgement

- ◆ This work was funded by the US EPA 2004-STAR-L1 Program (grant RD-83227601) and USDA Air Quality Program (grant 2007-55112-17855).