Changes in Aerosol Optical Depth and $PM_{2.5}$ Concentrations due to Open Domestic Waste Burning

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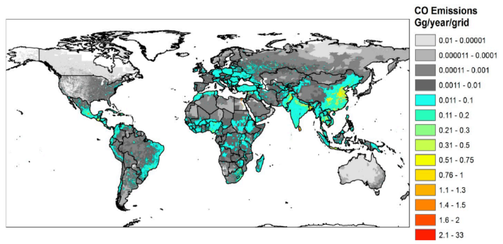
Introduction:

- Domestic waste burning is common in developing countries that lack waste management.
- Open combustion emits black carbon and organic aerosols. These aerosols can have effects on climate and human health.
- Black carbon has different mixing states that can alter the degree of warming and cooling effects it has on the atmosphere.
- We added the trash burning inventory to the GEOS-Chem- TOMAS model and compared Aerosol Optical Depth (AOD) and PM2.5 mass concentrations to AERONET and SPARTAN observations to see if including the trash inventory gave a more accurate representation of the atmosphere.
- Including the trash burning inventory increases slope, percent variance explained and log mean normalized bias when compared to the observations.
- Some *regional* Aerosol Indirect Effects show cooling – 0.50 W/m^2 and a *global mean* cooling effect of -0.002 W/m^2. Some *regional* Direct-Radiative Effects show warming +0.50 W/m^2 and *global mean* effects ranging between -0.008 to+0.006 W/m^2

Background:

Trash Burning:



Estimated annual emissions of carbon monoxide from the open combustion of waste at residences and dumps. Wiedinmyer et al. (2014)

- Greatest emissions come from China, India, Brazil, Mexico, Pakistan and Turkey.
- The emissions were estimated by population density, national income status, urban vs. rural, and waste collection practices.
- Now included in GEOS-Chem –TOMAS model.

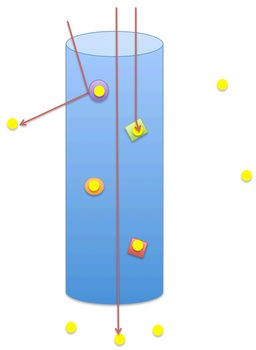
Aerosol Optical Depth :

The intensity of light that makes it to the surface.

$$\tau(s_1, s_2) = \int_{s_1}^{s_2} \beta_e(s) ds$$

$$I = I_o e^{-\tau}$$

- The βe is integrated extinction coefficient that is a measure of total scattering and absorption.
- Tau is dimensionless.
- Indicates the number of aerosols in a column.



Column of atmosphere containing aerosols that scatter or absorb passing photons.

GEOS-Chem-TOMAS:

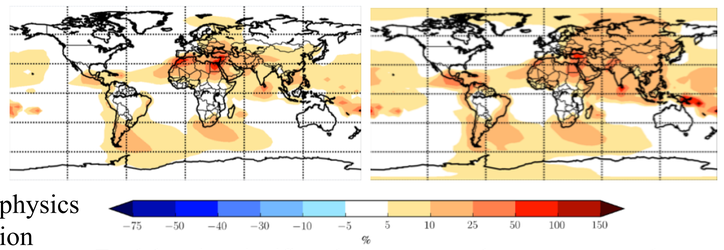
GEOS-Chem

- Global transport model
- 4°x5° horizontal resolution
- 47 vertical layers
- Assimilated meteorology

TOMAS

- Special Addition- online aerosol microphysics
- Condensation, nucleation and coagulation
- Species: sulfate, sea-salt, OA, BC, dust

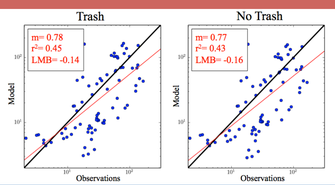
Organic Aerosol **Black Carbon Aerosol**



Trash burning significantly increases carbonaceous aerosol.

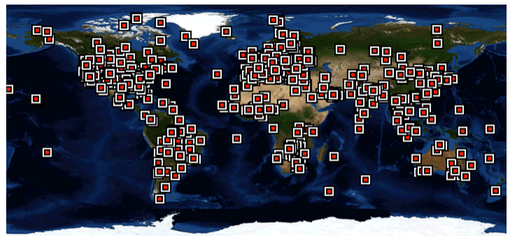
SPARTAN Observations:

- **S**urface **PART**iculate m**A**tter **N**etwork used for PM2.5 observations.
- Small number of sites (only 11)
- The network includes sites in trash burning locations



Increases in the slope, r^2 and log mean bias values show that when the trash inventory is included the model is closer to the observations.

AERONET Observations:



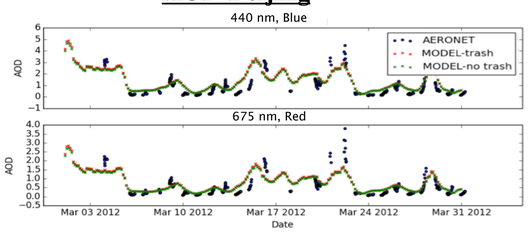
AERONET sites around the world. Network used for Aerosol Optical Depth observations.

Spectral Radiometer- sun photometer at each AERONET location.

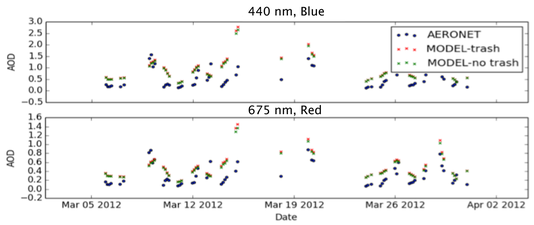
- Filters at 8 different wavelengths (1020-870-675-440-936-500-340-380 nm)
- Measures **Aerosol Optical Depth**
- Scan on ~15 minutes intervals

Time-series:

AOD Beijing



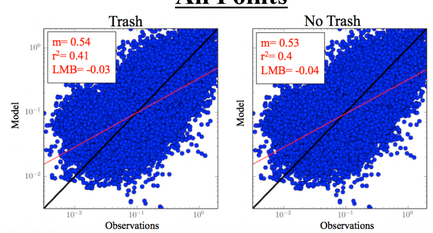
This shows how the model changes with the incoming fluxes of pollutants over time compared to the observations. The model's lag is due to the size of the grid box and the positioning within the box.



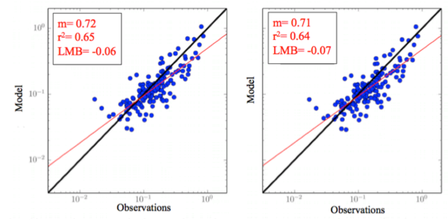
We cosampled the data so the model only outputs if there is observation data point. This was done for every location.

Model vs. Observations:

All Points



Monthly Average



- Including the trash burning inventory consistently improves the slope, percent variance explained and log mean bias.
- Using monthly averages further improves our comparison to the observations.

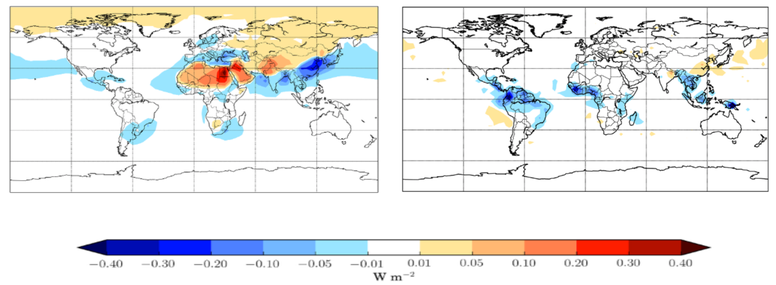
Climate Impacts:

By seeing an increase in agreement between the observations and the model, that includes the trash burning inventory, we can now better estimate climate effects.

Direct Radiative Effect (DRE)
DRE- is when the photon interacts directly with the aerosol.

Cloud Albedo Indirect Effect (AIE)
AIE- aerosols changing cloud properties, like reflectivity and distribution.

DRE **AIE**



The change in [W/m^2] looking solely at the emissions added to the atmosphere from the trash burning.

References:

Wiedinmyer, C., Yokelson, R. J. and Gullett, B. K.: Global emissions of trace gases, particulate matter, and hazardous air pollutants from open burning of domestic waste., Environ. Sci. Technol., 48(16), 9523–30, doi:10.1021/es502250z, 2014.

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