Background Sulfur Source Gas Sensitivities with GEOS-Chem: Preliminary Results and 2-D Model Comparisons

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Abstract

Harvard's GEOS-Chem is a well-validated 3-D model of atmospheric composition using analyzed wind fields from the Goddard Earth Observing System. While this model has traditionally been used for studies of tropospheric chemistry, a recent extension of chemistry to the stratosphere (Eastham et al., 2014) makes it a good choice for sensitivity studies of sulfur budgets under background conditions. This study is a contribution to the SSiRC Background (BG) experiment. Because GEOS-Chem contains only a bulk aerosol representation in the stratosphere at presentr, we focus on the relative contributions of source gases SO_2 and OCS and the role of convective transport in moving these gases from the boundary layer into the stratosphere. We present sensitivity calculation with OCS surface concentrations increased by 20%, with anthropogenic SO_2 emissions eliminated, and with convective fluxes scaled by 2.0 globally and scaled only over the Asian monsoon region. Comparisons with the AER 2-D model (Weisenstein et al., 1997, 2007) are also shown.

Impact of a 20% increase in OCS surface concentration

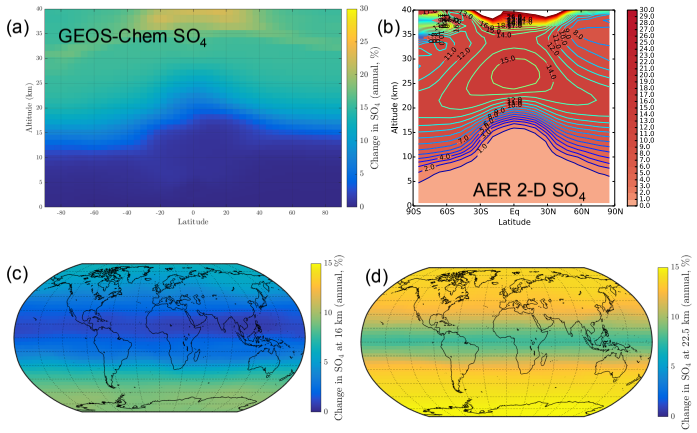

Figure 1: Impact of a 20% increase in OCS surface concentration on aerosol sulfate. Panel (a) shows the zonal mean annual average sulfate change (in percent) in the GEOS-Chem model, and panel (b) the same for the AER 2-D model. Panel (c) shows the percentage change in annual average sulfate at 16 km, and panel (d) the change at 22.5 km.

Table 1: Change in stratospheric sulfate aerosol burden due to modeled variations in source gases

Emission Variation	GEOS-Chem UCX	AER 2-D
+20% OCS	+15%	+11%
SO_2 No Anthropogenic	-16%	-9%
No DMS, anthropogenic SO_2		-28%
No DMS, CS_2, H_2S, anthrop SO_2		-37%

Impact of removing anthropogenic SO_2 emissions

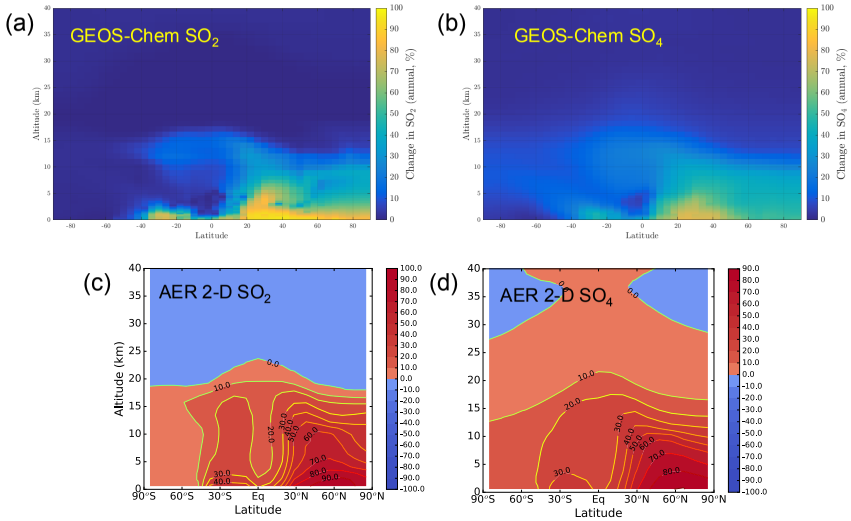

Figure 2: Fraction of total SO_2 or aerosol sulfate due to anthropogenic SO_2 emissions. Panel (a) shows the zonal mean annual average SO_2 change (in percent) and panel (b) the change in aerosol sulfate (in percent) in the GEOS-Chem model. Panel (c) and (d) the same for the AER 2-D model.

Model Details for GEOS-Chem UCX

- Resolution 4°x5°, 72 vertical levels to 0.01 hPa
- Non-interactive dynamics from GEOS-5 for 2006-2010
- Trop + Strat chemistry
- Bulk sulfate aerosol with assumed size distribution
- Run for years 5 years, final year plotted
- Sulfur source gases include: OCS, DMS, SO_2
- Volcanic emissions from Sarychev Peak eruption in 2009 repeated in 2010
- Aircraft emission of SO_2 included

Model Details for AER 2-D

- Resolution 9.5° x 1.2 km to 60 km
- Wind fields, T from Fleming et al. (1999), Year 1992 repeated
- Sulfur sources: SO_2, OCS, DMS, CS_2 H_2S
- Sectional microphysics in 40 bins by volume doubling
- No volcanic or aircraft emissions

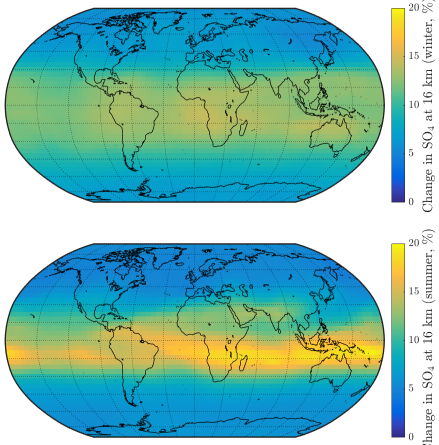

Figure 3: Fraction of aerosol sulfate at 16 km due to anthropogenic SO_2 emissions in winter (DJF) (panel a) and summer (JJA) (panel b).

Future work with GEOS-Chem UCX for SSiRC BG Experiment:

- Repeat for clean background years without volcanic and aircraft sources
- Sensitivity to convection and scavenging
  - scale convective fluxes by 2.0 everywhere
  - scale convective fluxes over Asian monsoon region only
  - scale the scavenging rate
- Longer-term to include microphysics for sulfate aerosols

References:

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