# Verifying modeled $SO_2$ in GEOS-5

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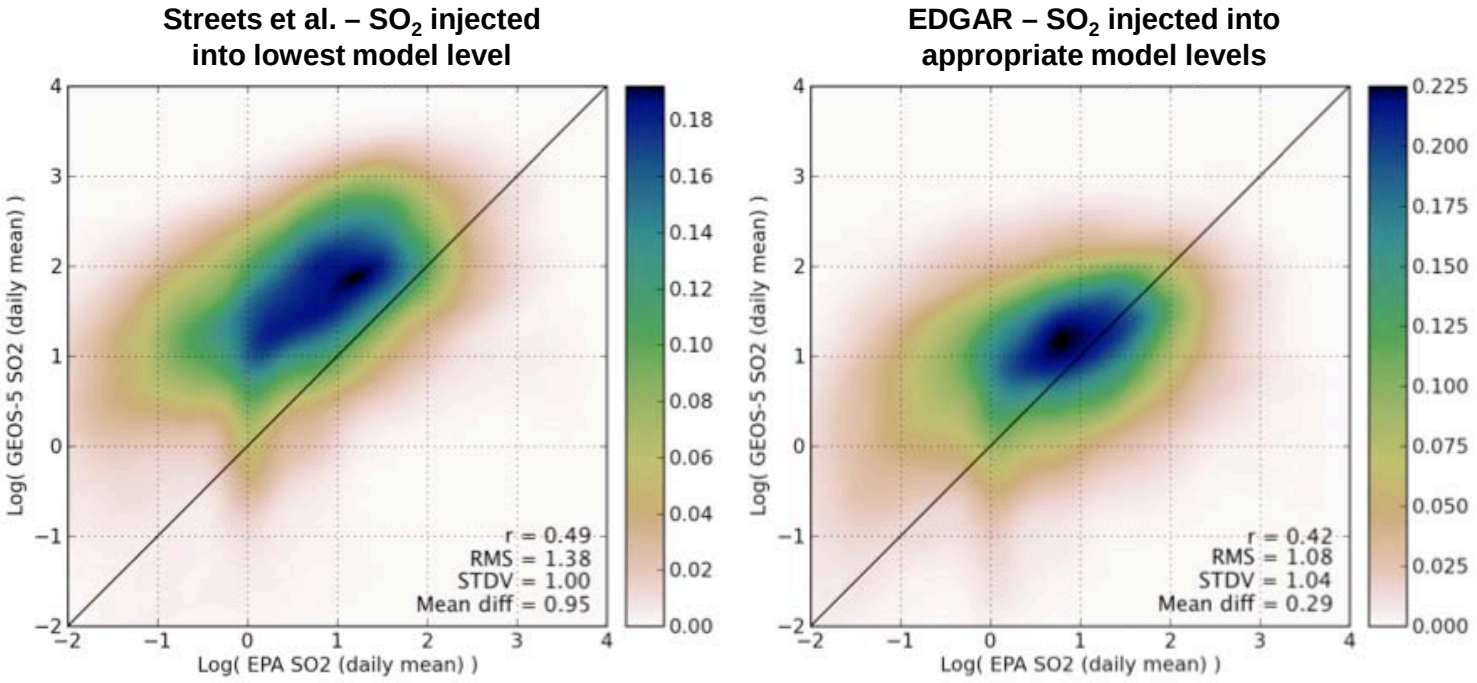
$SO_2$ is harmful to human health near the surface, and is the precursor to acid rain and sulfate aerosols, which impact cloud physics and radiative forcing. GEOS-5 simulations of $SO_2$ were compared with observations from EPA Air Quality System (AQS) sites and a November 2010 field campaign in Frostburg, MD:

- Daily mean surface $SO_2$ values in GEOS-5 were biased high when compared to observations from 102 EPA AQS sites during 2010 (Figure 1). This bias was partially mitigated when $SO_2$ was injected into the model at appropriately varying vertical levels.
- Daily mean values for sulfate aerosols were also biased high in the model, suggesting GEOS-5 may be underestimating the loss of sulfate aerosols.
- GEOS-5 reproduced many key features of vertical profiles of $SO_2$ observed during the Frostburg campaign.




Comparisons of modeled and observed daily mean surface $SO_2$ from 102 EPA AQS sites in 2010 from a control experiment (left), and a revised experiment where $SO_2$ was injected into the model at varying vertical levels (right). Figure from Buchard et al. (2013).

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A series of simulations was run in GEOS-5 using an aerosol transport module based on the Goddard Chemistry Aerosol Radiation and Transport (GOCART) model, which simulates several major tropospheric aerosol types, such as sulfates, dust, organic and black carbon, and sea salt. Sulfur chemistry is included in the module, as are naturally occurring sources of $SO_2$ emissions. Anthropogenic emissions of $SO_2$ are taken from prescribed observational datasets.

**Methods:**

Two simulations were conducted in GEOS-5 and compared with observations: a control run that injected sulfur emissions from Streets et al. (2009, *JGR*) directly into the lowest model layer, and a revised run that allowed emissions from a new Emission Database for Global Atmospheric Research (EDGAR, European Commission, 2010) to be injected into appropriate model levels, depending on the emission source. Each run was performed at a 25km horizontal resolution with 72 vertical levels from the surface up to about 80 km in altitude. Model results were compared against data from observations taken at EPA AQS sites at various locations across the U.S. Additional verification of model output was performed using observations from a field campaign in November 2010 that took place in Frostburg, MD.

**Results:**

Results comparing daily mean surface $SO_2$ in 2010 in GEOS-5 simulations and observations at 102 EPA AQS sites are summarized in Figure 1:

- Daily mean surface $SO_2$ was biased high in both GEOS-5 simulations, but much more so in the control run, when emissions were injected directly into the lowest model level. Injecting emissions into model levels at varying heights significantly decreased model bias in the revised run.
- The remaining high bias in modeled surface $SO_2$ is likely due to the fact that the EDGAR dataset used by GOCART was created from 2005 observations, when anthropogenic $SO_2$ emissions were substantially higher than they were in 2010.

Additional results from simulations reveal that:

- GEOS-5 was able to represent many features of vertical profiles of $SO_2$ taken on two days during the Frostburg campaign. The model performed best on the day with high winds, when the atmosphere was well mixed. The model still performed well on a day with lighter winds, but it missed isolated high concentrations of $SO_2$. This is likely due to the spatial resolution of the model being too coarse to resolve a point source of $SO_2$ emissions.
- Sulfate aerosols were high biased in GEOS-5 simulations, and correlations between model results and observations did not significantly differ between model runs. This high bias, and the fact that the mean lifetime of $SO_2$ in GEOS-5 has been found to be longer than observed, suggest that the model is underestimating the loss of sulfate aerosols.

*More information can be found at [http://gmao.gsfc.nasa.gov/research/aerosol/modeling/SO2](http://gmao.gsfc.nasa.gov/research/aerosol/modeling/SO2)*

**References:**

Buchard-Marchant, V., A. M. daSilva, P. Colarco, N. A. Krotkov, R. R. Dickerson, J. W. Stehr, G. Mount, E. Spinei, H. L. Arkinson, and H. He, 2013: Evaluation of GEOS-5 sulfur dioxide simulations during the Frostburg, MD 2010 field campaign. *Atmos. Chem. Phys. (Submitted)*