

Interactive Visualization of Modeled Atmospheric Trace Constituents

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Extended Abstract

This presentation describes the development of visualization techniques for 3-dimensional study of the results of the Brookhaven National Laboratory Chemical Transport Model (CTM) of sulfate in the atmosphere. The visualization techniques described here can be applied to any atmospheric trace constituents – aerosols (such as dust, anthrax spores, etc), gases (such as sulfur dioxide or sarin, etc) and liquids (such as cloud droplets, etc).

Aerosols are microscopic particles suspended in the gaseous atmosphere which can be liquid (ex: water droplets) or solid (ex: soot) particles. Aerosols can influence climate, depending on their size and composition. Aerosol diameters (in μm , 10^{-6} m) pertinent to their influence on climate include: a) nuclei mode: 0.005 to 0.1, b) accumulation mode: 0.1 to 2.5 (these particles become cloud condensation nuclei, CCN), and c) coarse: > 2.5 . In contrast, the diameter of cloud droplets (CD) is $> 10 \mu\text{m}$. The climate influences of tropospheric aerosols are exerted in two ways: a) Direct Radiative Forcing: scattering and absorption of shortwave radiation by aerosols, and b) Indirect Radiative Forcing: changes in cloud microphysical properties influencing their radiative properties. Both these influences have a cooling effect on climate.

Anthropogenic activities affect the aerosol content of the atmosphere. Anthropogenic emissions \Rightarrow increase CCN \Rightarrow increase CD \Rightarrow increased cloud albedo \Rightarrow cooling effect on climate. Aerosols can be emitted directly as particles, for example from industrial activities, biomass burning, mineral dust sources (deserts, tilled fields, etc.), sea salt or as gaseous sulfur precursors which are converted to sulfate particles in the atmosphere, for example SO_2 from industrial activities, dimethyl sulfide (DMS) from biogenic ocean and land processes, SO_2 from volcanoes (degassing and erupting), SO_2 from biomass burning.

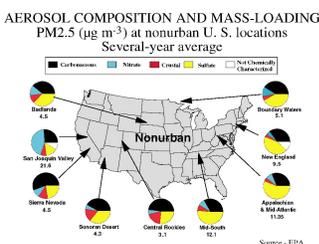


Figure 1

What do we need to study the aerosol influence on climate?

Observations of the mixing ratios of atmospheric aerosols are sparse in time and space. Therefore, regional to global CTMs are needed to study the distribution of aerosols and their effects on climate. The amount of data resulting from a CTM simulation is very large; we need new and exciting techniques to study results.

Why did we start by modeling sulfate? Figure 1, taken from an EPA report, shows that sulfate is the most important component of

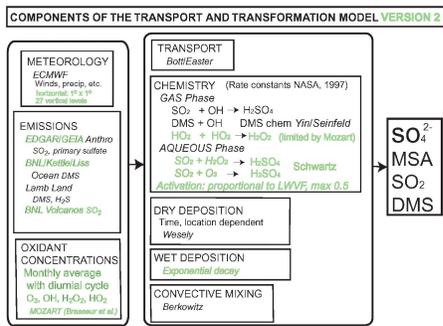


Figure 2

aerosols in the eastern part of the US; it is also the most important anthropogenic component.

Figure 2 presents a schematic of the components of the BNL CTM for sulfate. The results to be presented were taken from a simulation of the Aerosol Characterization Experiment (ACE-2) with the following characteristics: domain included the Northern Hemisphere to 81N, $360 \times 81 \times 27$ grid cells (787,320), 25 species: 6 SO₂ (by source region), 16 sulfate (by source region & conversion pathway), MSA, DMS, H₂O₂. Time period: simulation from June 1 to July 25, 1997, analyses start June 17, 1997.

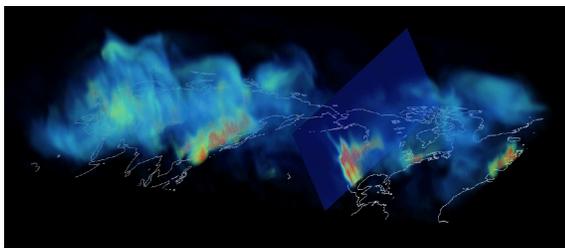


Figure 3

Figure 3 presents our first attempt at a 3-dimensional display of the model-calculated sulfate mixing ratios (MRs, parts sulfur/part air) for June 22, 1997. The figure is a volume rendering; blue -> red is lower -> higher MRs. Rectangle over western Mexico shows the effects of the emissions of Popocatepetl volcano, located near Mexico City. The effects of stronger emissions in Europe and Asia are prominent on this date. The software used needs additional development; for example, our vertical grid is

unevenly spaced whereas here it is represented as evenly spaced, values of the MRs span several orders of magnitude so in place of the adjusted linear scale used here a logarithmic scale would allow greater range of display.

Figure 4 presents the sulfate column burden (vertical integral of the sulfate MR) for June 22, 1997 at 18 UT; these plots can be considered a “satellite” view of the MRs. Each panel represents the contribution of the sulfur sources from a particular source region; total burden is on lower right panel. Note how all source regions influence the burden in all others, in particular west to east (prevailing wind direction in midlatitudes): North America to Europe, Europe to Asia, Asia to North America.

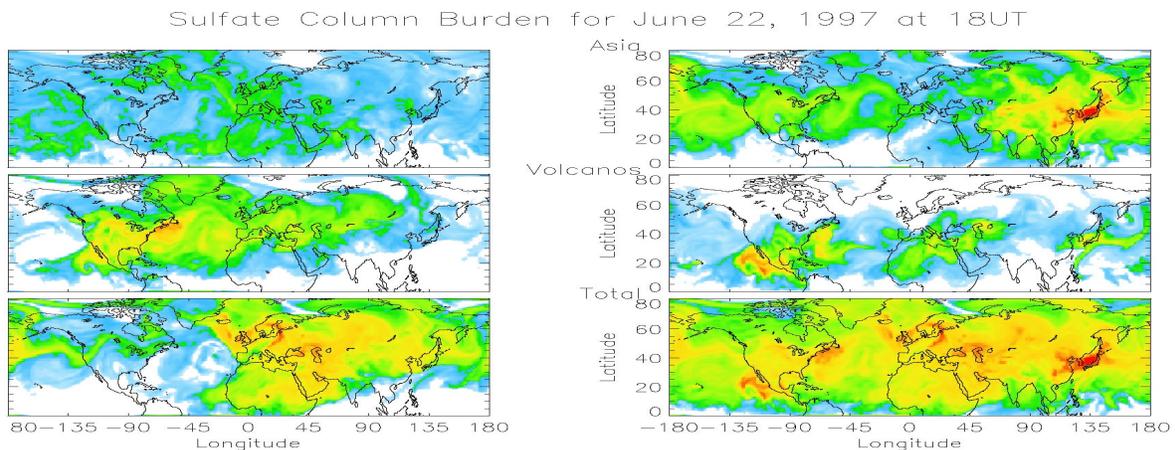


Figure 4