The impact of neglected sub-grid processes on aerosols and their direct radiative forcing for a representative GCM grid spacing

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Global climate models use coarse grids and do not account for the impact of most sub-grid processes on aerosols. For example, point source emissions, such as those from power plants and industrial sources, are instantly diluted to fill the volume of the grid cell residing over the emission location. In reality, a narrow plume is emitted that becomes wider and more diluted as winds transport pollutants away from the emission location. Concentration dependent nonlinearities in the chemical reactions within the plume can lead to differing aerosol fields downwind of the emission location based on these two scenarios. Additionally, sub-grid variability in wind, clouds, boundary layer mixing, and relative humidity can also lead to different aerosol characteristics depending on the resolution of the model. This presentation presents recently published results demonstrating the impact of neglecting sub-grid processes for aerosols via the resulting error introduced in the aerosol fields and the top-of-atmosphere shortwave direct aerosol radiative forcing. This modeling study was conducted for the MILAGRO field campaign over Mexico during March 2006 using the chemistry version of the Weather Research and Forecasting model (WRF-Chem). The MILAGRO dataset provided extensive data to verify model accuracy and for evaluating the representativeness of the spatial and temporal variability of a high-resolution WRF-Chem simulation performed with 3-km grid spacing. This was then compared with a coarser simulation using 75-km grid spacing, which was representative of grid spacing in a modern global climate model. This research lays the groundwork for understanding the importance of sub-grid spatial variability for aerosol modeling. Through quantification of the potential error due to the neglected processes, one can then target the development of parameterizations to represent these processes and improve the simulation accuracy.