Geophysical Research Abstracts
Vol. 14, EGU2012-1698, 2012
EGU General Assembly 2012

The effect of coal-fired power plant NOX, SO_2 and particulate control technologies on aerosol nucleation and growth in source plumes

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Nucleation and growth in coal-fired power-plant plumes can greatly contribute to particle number concentrations in plumes near source regions. The changing emissions rates of SO_2, NOX and primary ash particulates due to pollution-control technologies over recent decades may have a significant affect on aerosol formation and growth in the plumes, with ultimate implications for climate and human health. We use the System for Atmospheric Modelling (SAM) Large-Eddy simulation model with the TwO-Moment Aerosol Sectional (TOMAS) microphysics algorithm to model the nucleation and growth in the plume of coal-fired units for a range of test cases with varying emissions to simulate the implementation of clean technologies. These cases include representations of emissions at the W.A. Parish power plant near Houston Texas in 1997, 2000, 2006 and 2010. For Parish during this time period, NOX emissions were reduced by about a factor of 10 due to the addition of Selective Catalytic Reduction (SCR) technology, leading to a predicted increase in OH concentrations by about a factor of 10, while SO_2 emissions have decreased by only 20-30%. Based on and tested against the TexAQS2000 and TexAQS2006 field campaigns, this case study predicted an increase in OH leading to faster production of H2SO4 in the plume, and increased nucleation and growth even though SO_2 emissions had decreased as well. Thus for this case study, controlling NOX more strongly than SO_2 may lead to increased nucleation and growth in power-plant plumes. Finally, we calculated how particle formation and growth may have changed for about 200 power plants in the US and Canada between 1997 and 2010 for the meteorological and chemical background conditions of the Parish cases.