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Development and Evaluation of a Reactive-Dispersive Plume Model: TexAQS II 2006 Case Study

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We describe the development and evaluation of a reactive-dispersive plume model (RDPM) that combines a photo-chemistry model with a plume dilution driven by turbulent dispersion of a power-plant plume. The plume transport and turbulent dispersion are derived from a Gaussian plume model and the plume chemistry model uses 71 H_xO_y-N_xO_y-CH_4 chemistry-related reactions and 184 NMHC-related reactions. Emissions from large-scale point sources have continuously increased due to the rapid industrial growth. To extensively understand and assess atmospheric impacts of the power-plant emissions, a general RDPM was applied to simultaneously simulate the dynamics and photo-chemistry of the Texas power-plant plumes. During the second Texas Air Quality Study 2006 (TexAQS II 2006) on 16 September 2006, pollutant concentrations were measured by NOAA WP-3D aircraft with successive transects across power-plant plumes in Texas, USA. The simulation performances of the RDPM were evaluated by a comparison study, using the observation data obtained from the measurements of a NOAA WP-3D flight during TexAQS II 2006 airborne field campaign. On 16 September, the WP-3D aircraft observed mainly meteorological parameters and particulate species concentrations, traversing the Monticello and Welsh power-plant plumes four times from transects A to D. In addition, some meteorological variables in an initial condition for model simulation were obtained from the Weather Research and Forecasting (WRF) model output for the specific objects. These power-plant plume cases were selected in this study, because a large number of nitrogen oxides and sulfur dioxide concentrations inside the power-plant plumes were measured without any interruption of other emission sources. For the Monticello and Welsh power-plant plumes, the model-predicted concentrations showed good agreements with the observed concentrations of ambient species (e.g., nitrogen oxides, ozone, sulfur dioxide, etc.) at the four transects. Based on these RDPM results, the power-plant plume chemistry and its possible impacts on atmospheric environments were also analyzed.