High ground-level ozone event in Eastern U.S. during June 2007: meteorology and source attribution

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Ground-level ozone (O_3) is a public health concern because it causes respiratory and cardiovascular diseases (National Research Council, 1991). As a result, periods of high ozone pollution could cause severe health effects. For example, Filleul et al. (2006) found that for an increase of 10 μg/m^3 in O_3 level, the excessive risk of death is significant (1.01%; 95% confidence interval, 0.58–1.44). Ground-level ozone is produced from chemical reactions between emissions of nitrogen oxides ($NO_x \equiv NO + NO_2$), volatile organic compounds, and carbon monoxide (CO) in the presence of sunlight. Knowledge of the availability of these O_3 precursors is thus important. Over the past two decades, NO_2 levels present in the lower troposphere have been derived from space-based measurements. Previous studies have shown that ozone is not isolated in urban areas but extends regionally, including over rural regions (Logan, 1989). Meteorological conditions most favorable to the build-up of pollution episodes over the Eastern United States (U.S.) are air stagnation events generally associated with slow-moving high pressure systems and their accompanying warm temperatures and clear, sunny skies [e.g., Vukovich, 1995; Eder et al., 1993]. We analyze an extreme ozone event over Wisconsin (WI) during June 10-18, 2007 as a prototype for Eastern U.S. ozone events. This specific episode was chosen because air quality managers at the WI Department of Natural Resources identified this 9-day high-ozone event as “high priority” and requested NASA’s Air Quality Applied Sciences Team to help them understand it. To explore the meteorological processes and precursor emission sources contributing to this episode, we split our analyses into two parts: (1) We examine day-by-day maps of weather, observed ozone, and NO_2 satellite data to delineate the spatial extent of the pollution episode and to identify the meteorology influencing the regional transport of NO_2 and ozone during the event. (2) We use chemistry-transport model (GEOS-Chem) simulations to estimate contributions from both natural and anthropogenic sources to the ozone pollution episode. Since we utilize GEOS-Chem at 2º latitude x 2.5º longitude horizontal resolution, state boundaries and the U.S./Canada border are not as well resolved as they would be with finer-scale regional models typically used for designing emission control strategies. Because GEOS-Chem is more computationally efficient than these finer-scaled models, it provides relatively quick, initial estimates of source attributions. These ‘first-look’ analyses can inform us about which additional model simulations with finer-scale models would be most helpful. From our analyses of weather maps and ozone and NO_2 data, we find that a high pressure system helps transport NO_2 and ozone regionally from other parts of the Eastern U.S. into Wisconsin. The model simulations show that while the total observed O_3 over Wisconsin during the episode approximately ranges between 60 and 85 ppb, Wisconsin only contributes ~4-10 ppb (less than ~15%). The model attributes more than 50% of the anthropogenic ozone over the Eastern U.S. during the episode to anthropogenic sources from other U.S. states (~32-50 ppb) and Canada (~10-20 ppb).