Modeling Climate Change Effects on Spatiotemporal Distributions of Allergenic Pollen of Trees, Weeds and Grasses

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Abstract: Many diseases are linked with climate trends and variations. In particular, climate change is expected to alter the spatiotemporal dynamics of airborne allergenic pollen and potentially increase occurrence of allergic airway disease. A comprehensive prognostic modeling system, combining climate models and anthropogenic and biogenic emission models with an expanded version of the Community Multiscale Air Quality (CMAQ) Model has been developed to support integrated studies of the impact of climate change on Airway Allergic Disease (AAD). The present work focuses on the mechanistic pollen emission module and the transport module, and their application to model the spatiotemporal distributions of allergenic pollen from representative trees, weeds and grasses. The model system was used to simulate the allergenic pollen season timing and airborne levels of representative trees, weeds and grasses for multiple historical and future years.

The predicted mean start dates and season lengths for birch, oak, ragweed, mugwort and grass pollen season in 1994-2010 are mostly within 0 to 6 days of the corresponding observations for the majority of the National Allergy Bureau (NAB) monitoring stations across the contiguous United States (CONUS). Simulated airborne pollen levels are consistent with the observations for oak and ragweed, but do not match observations well for birch, mugwort and grass at some locations. Simulated vertical profiles of pollen concentrations can match well with the observed qualitative profiles reported in the literature. Process analysis indicates that emissions, dry deposition and vertical diffusion dominate the processes determining airborne pollen concentrations most, and that wet removal (cloud process) plays an important role during rain events. The spatially resolved maps for simulated onset, duration and airborne levels of allergenic pollen seasons in the CONUS are consistent with the long term observations. Changes of pollen season timing and airborne levels depend on latitude, and vary in different climate regions.

Keywords: Climate change, Allergenic pollen, CMAQ, Allergic airway disease, Emission model