Climate change impact on co-occurrences of ragweed pollen and ozone episodes across the contiguous US

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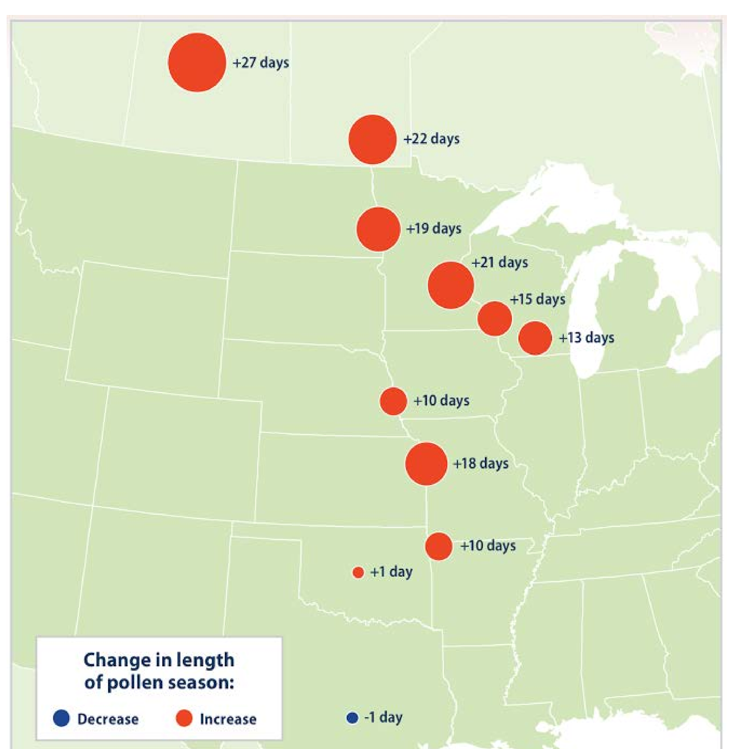
Abstract

The prevalence of Allergic Airway Disease (AAD) is growing globally, resulting in increased numbers of emergency department visits and hospitalizations. Clinical studies show that AAD can be exacerbated by the synergistic action of aeroallergens such as pollen and fungi, and atmospheric pollutants such as ozone. Furthermore, climate change has critically affected atmospheric processes involved in the dynamics of air pollution systems and emissions of natural pollutants such as pollen and spores. Previous studies, involving data from nationwide observations of airborne pollen counts of selected plant species in conjunction with climatic factors, indicated that the start date and length of pollen season, the average peak value and annual total of daily counted airborne pollen have been affected substantially by the changing climate. The present study investigates co-occurrences of ozone exceedance and ragweed pollen across the contiguous United States (ConUS). Analyses of observed ragweed pollen counts and ozone concentrations at 58 pollen monitor stations were conducted. Concentrations of ragweed pollen in base years (2004) and future years (2047) were simulated with a customized version of CMAQ (the Community Multiscale Air Quality model) employing a grid with 50 km by 50km horizontal resolution, while corresponding ozone concentrations at similar resolutions for the above timeframes were conducted by a multi-university/agency consortium including USEPA. The study employed spatiotemporal correlation analysis to examine patterns of co-occurring ozone and ragweed pollen concentrations. The outcomes of this study provide information that can support development of strategies for managing health-impacts of co-occurring photochemical pollutants and aeroallergens.

Background

Climate change is increasingly affecting atmospheric processes involved in the dynamics of air pollution systems, leading to higher levels of ozone and other photochemical pollutants in certain areas. Climate change is also critically affecting emissions of natural pollutants such as pollen and spores as well as of biogenic gases of atmospheric photochemistry reaction systems.



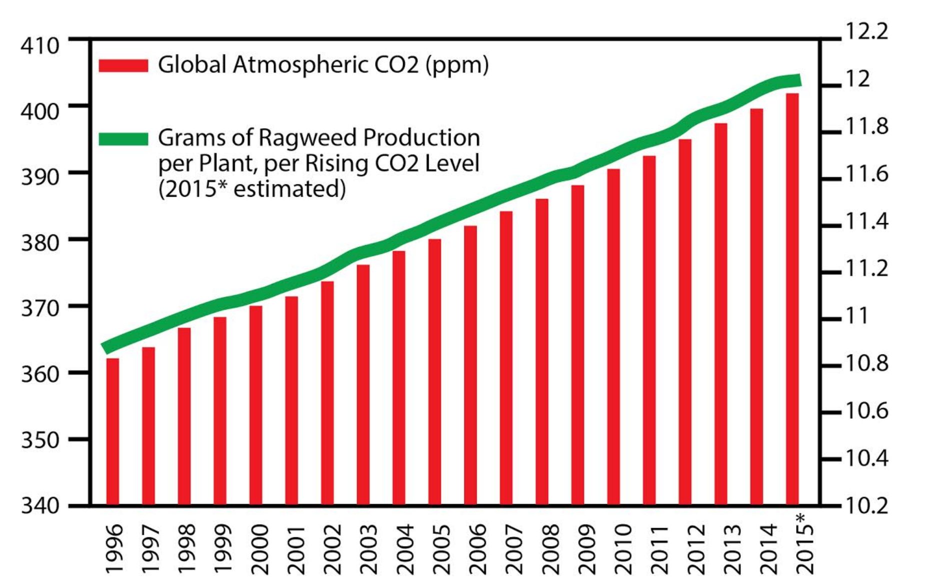
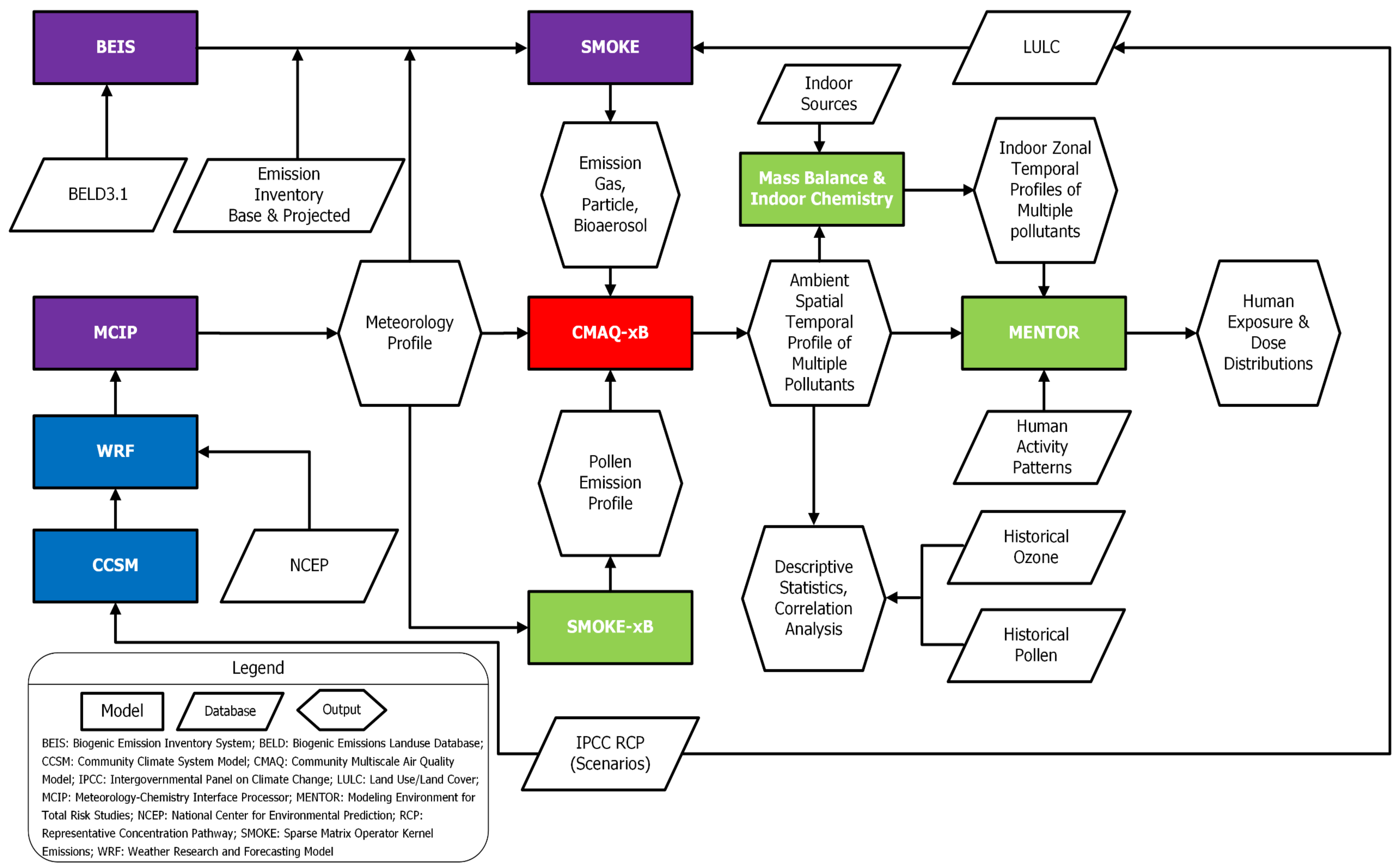


Fig. 1. Change in ragweed pollen season length (1995-2013) at 11 locations in the US (Ziska et al., 2016) (left); and observation of increased ragweed pollen production with rising CO2 level (source: Asthma and Allergy Foundation of America) (right).

Methods

- This project adapted and expanded standard models for emissions and air quality (SMOKE and CMAQ) as well as developed new modules to account for pollen-relevant processes.
- IPCC scenario A2 was used to drive the General Circulation Model (GCM) and Weather Research and Forecasting (WRF) model .
- SMOKE 3.5.1 (ConUS 50x50 km, 16 layers) and CMAQ 4.7.1 (ConUS 50x50 km, 34 layers) are used to model emission and atmospheric fate/transport.
- Emission: EPA historical NEI and projected emissions under future climate.
- ArcGIS 10.4 is used for data analysis and visualization.
- R3.2.4 is used for data analysis.

Framework of the Study



Analysis of Observed Pollen Counts and Ozone Concentrations

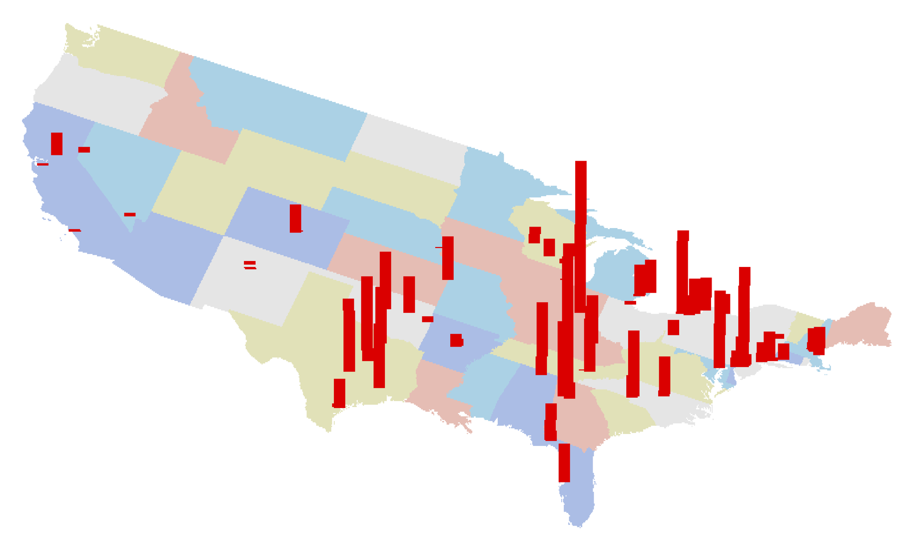
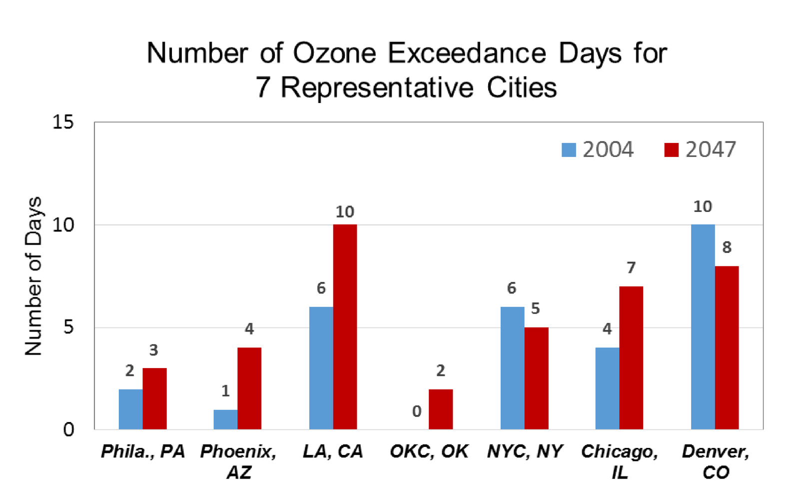


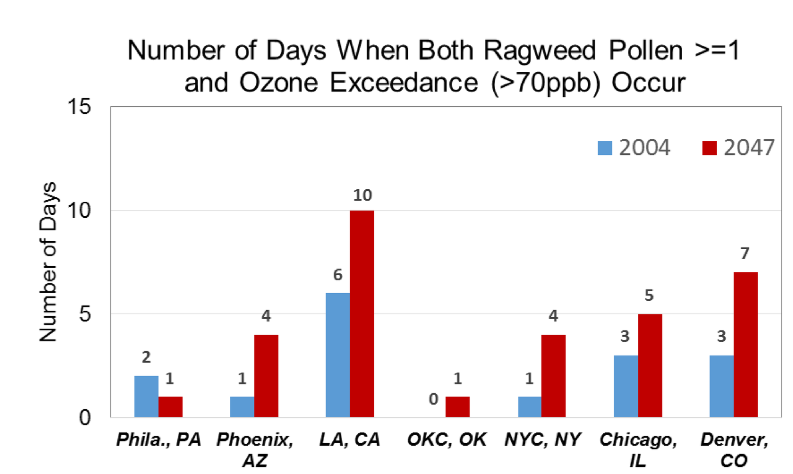
Fig. 2. Number of days when both ragweed pollen >=1 and ozone exceedances (*DMA8[O_3]>70ppb) occur for 58 pollen stations during 1994-2010 (except 2001,2002,2009)
*DMA8[O_3] is daily maximum 8 h average O_3 concentration

Table 1. List of top 10 cities with highest number of days when both ragweed pollen >=1 and ozone exceedances (*DMA8[O_3]>70ppb) occur (see left figure)

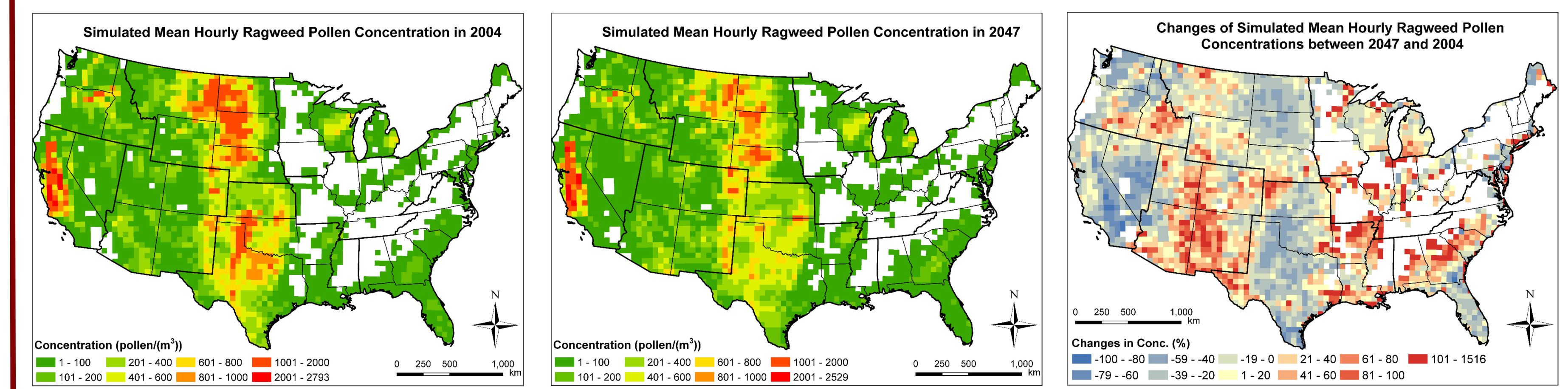
Station Location	Lat(°N)	Lon(°W)	Number of days
Indianapolis, IN	39.91	86.20	83
Marietta, GA	33.97	84.55	81
Cherry Hill, NJ	39.94	74.91	54
Erie, PA	42.10	80.13	46
Baltimore, MD	39.37	76.47	42
Douglasville, GA	33.74	84.78	41
Georgetown, TX	30.64	97.76	40
Waco, TX	31.51	97.20	40
Huntsville, AL	34.73	86.59	40
Manitou Springs, CO	38.85	104.90	36

Ozone Exceedance and Ragweed Pollen Co-occurrences from Modeled Results for 7 Representative Cities





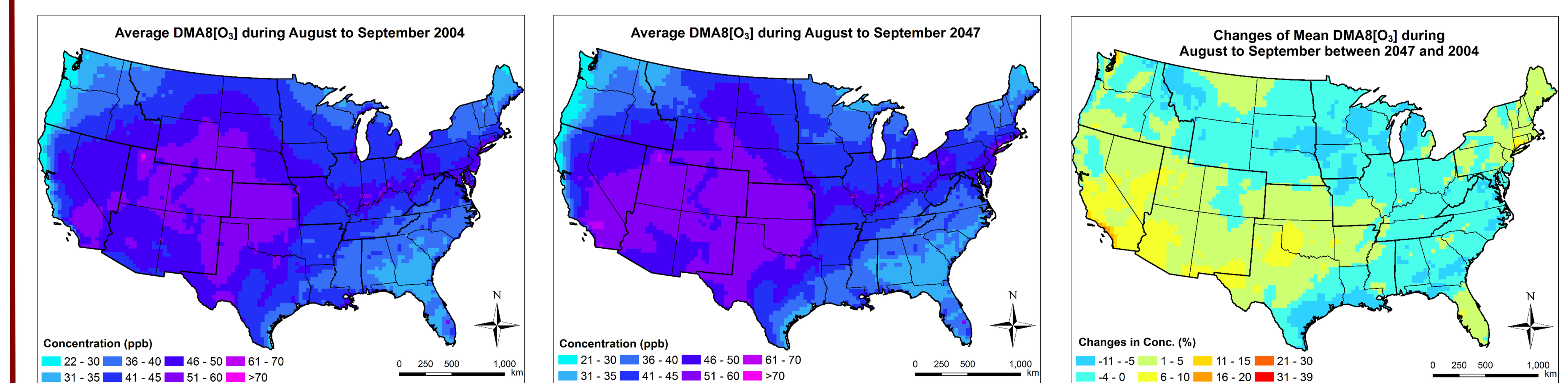
Simulated Mean Hourly Ragweed Pollen Concentrations for August & September in 2004 and 2047 at 50kmx50km Horizontal Grid Resolution



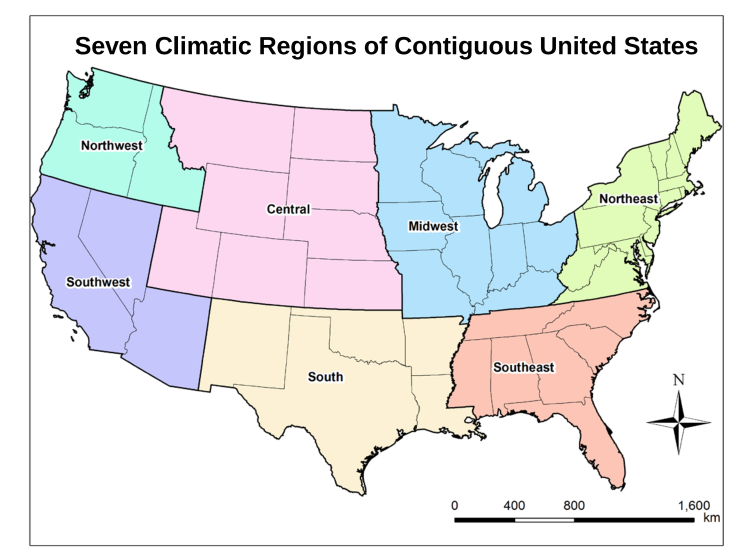
*36kmx36km simulations of pollen emissions and transport/fate are currently in progress.

Simulated Mean DMA8[O_3] for August & September in 2004 and 2047 at 36kmx36km Horizontal Grid Resolution under RCP 8.5

(Collaborative efforts with Dr. C. Nolte, USEPA)



Average Percent Change (%) in DMA8[O_3] and Mean Ragweed Pollen Concentrations between 2047 and 2004 by 7 Climate Regions



Climatic Region	Percent Change (%)	
	*DMA8[O_3]	Ragweed Pollen
Central	-1.0	4.3
Midwest	-2.9	60.7
Northeast	-0.2	24.6
Northwest	-0.6	-3.8
South	1.2	28.2
Southeast	-2.0	55.4
Southwest	4.4	-6.5

*Modeled estimates from collaborator from EPA

Conclusions

- Simulation results of ambient distributions of ragweed pollen for 2004 and 2047 showed that responses of pollen timing and quantity to future climatic conditions will be different for different regions.
- The number of hours during which pollen concentrations would exceed threshold values for triggering allergies are expected to increase in the majority of climate regions of the ConUS.
- Ozone concentrations around 2050 are estimated to increase compared to historical years around 2000 for most parts of the ConUS under the impacts of changing climate.

References

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