Opportunities and Barriers to Linking Satellites with Weather, Pollen, and Health

HAQAST 5
Phoenix, Arizona

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Overview

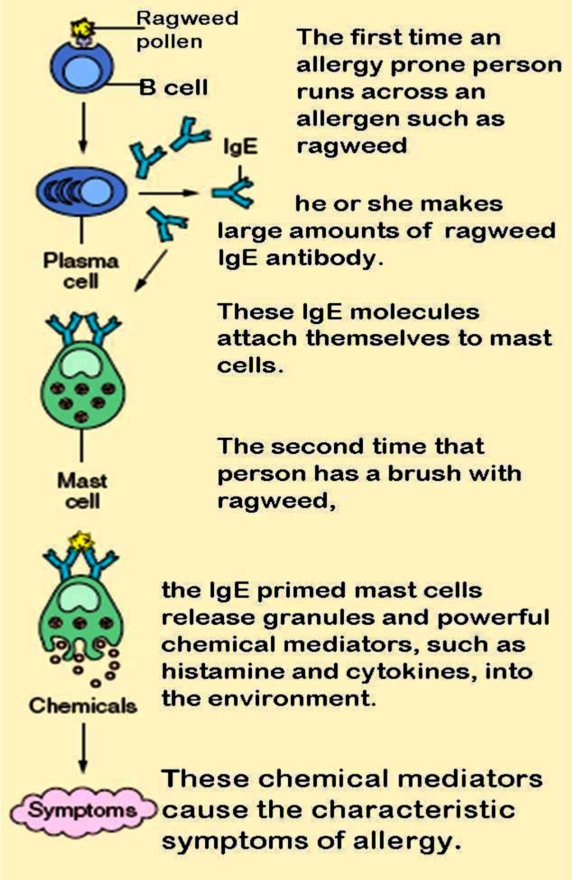
- Brief primer on allergic disease
- Overview of main project themes
- Summary of progress in each domain
- Next steps

The Widespread Burden of Allergic Disease

- Substantial health burden globally
  - Allergic rhinitis (AR) prevalence estimated 10-30%
  - Allergic asthma estimated at 5-10%
- In US, prevalence estimated at 13% in children and 14% in adults (Meltzer, 2009)
  - AR responsible for 3.5m lost work days and 2m lost schooldays per year (Nathan 2007)
  - reduces health-related quality of life by 25% (Avarro et al. 2007)
  - Estimated $2-5b costs in US in 2003 (Reed et al. 2004); inflation adjusted $4-7b in $US2018

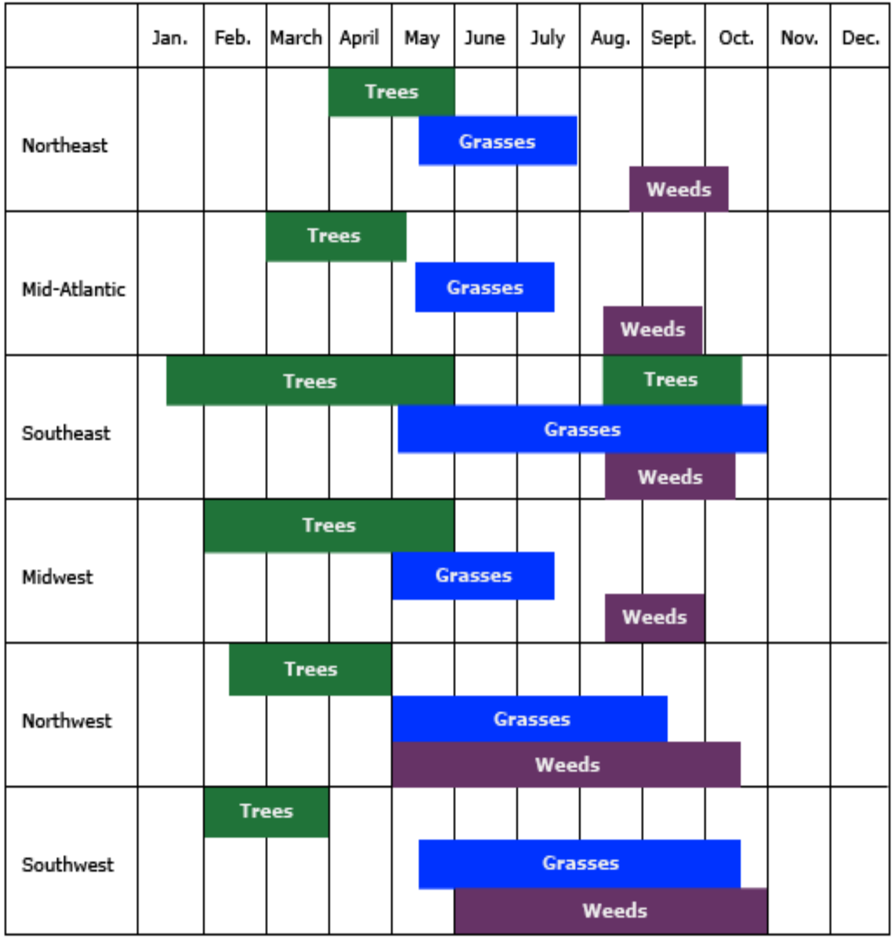
Pollen and allergic disease

- Allergies are immune mediated and driven by immune memory (IgE antibodies)
- Symptoms driven by balance of factors
- Disease is generally not life threatening but makes people miserable
- Range of therapies, from exposure avoidance to symptom reduction to immune modulation



Pollen seasonality

- Different for three major groups of pollens
- Tree season starts later in northern latitudes
- Seasons in lower latitudes are longer and overlap more

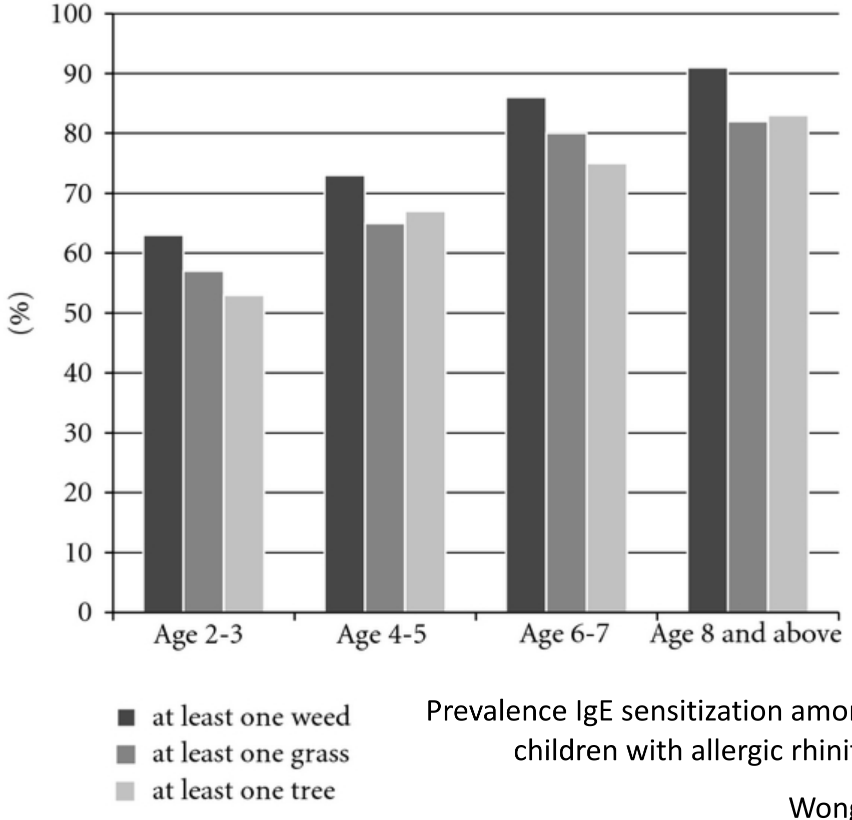


Nowak-Wegrzyn A. Up To Date, 2017.

Allergic disease attributable to pollen

- Population attributable fraction (PAF) of allergen sensitivity (exposure) for respiratory disease peaks in late childhood
- For adults 21-40, PAF sensitization for any allergen 79% for rhinitis and 49% for asthma (Simons et al. 2011)
- PAF for pollen sensitization likely slightly lower
- 3.7m DALYs among adults 21-39 due to asthma and 22.8m in all ages in 2017, a quarter of PM2.5 burden (GBD 2017)
- Just under half of asthma burden likely attributable to pollen

Pollen sensitization by age, related to local flora



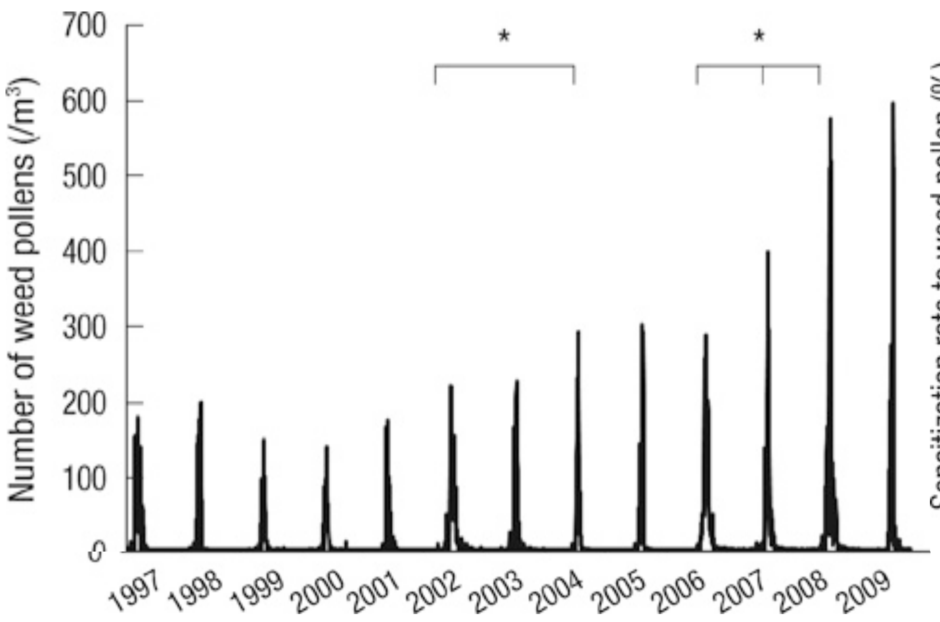
Prevalence IgE sensitization among children with allergic rhinitis

6-7-year-old children	Pollen	Positive percent of 56 children
Most common weeds	Russian thistle	68%
	Pigweed	61%
	Sagebrush	49%
Most common grasses	Saltgrass	58%
	Timothy	48%
	Bermuda	45%
	Johnson	45%
Most common trees	Willow	39%
	Sweet gum	32%
	Mulberry	36%

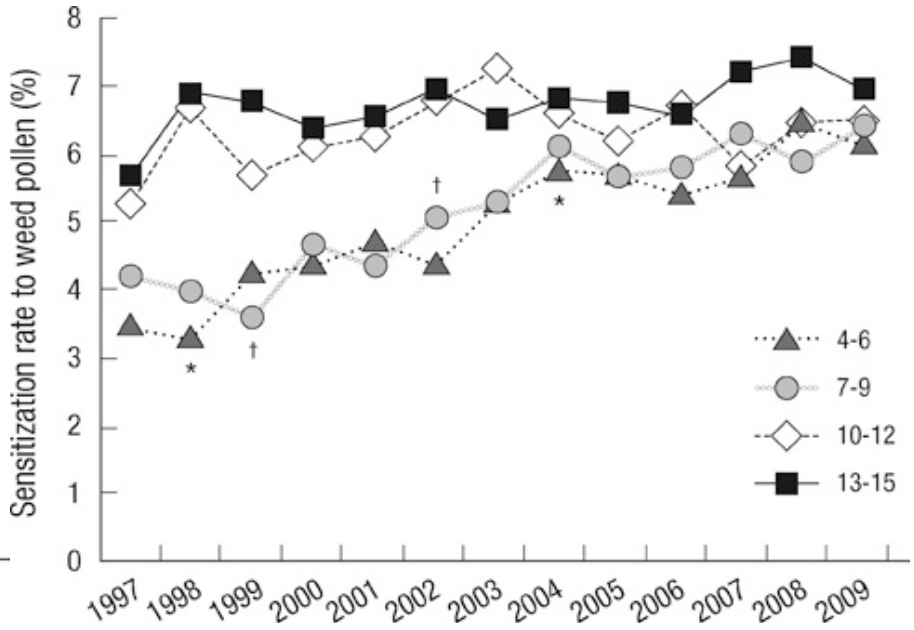
Prevalent allergens in the Great Basin

Wong et al. 2012

Sensitization correlated with pollen exposure



Annual weed pollen counts from 1997 to 2009 in Seoul.
Weed pollen included ragweed, Japanese hop and mugwort.



Annual sensitization rates to weed pollen allergens according to age.
Weed pollen included ragweed, Japanese hop and mugwort.

Kim et al. 2011

Challenges for pollen and health

- What we need:
  - Consensus regarding the issue's priority
  - Credible global exposure estimates
  - Generalizable PAF estimates across age spectrum

- What we have:
  - Concern without concerted action
  - A handful of local pollen observations
  - Partial PAF estimates for certain populations and age strata

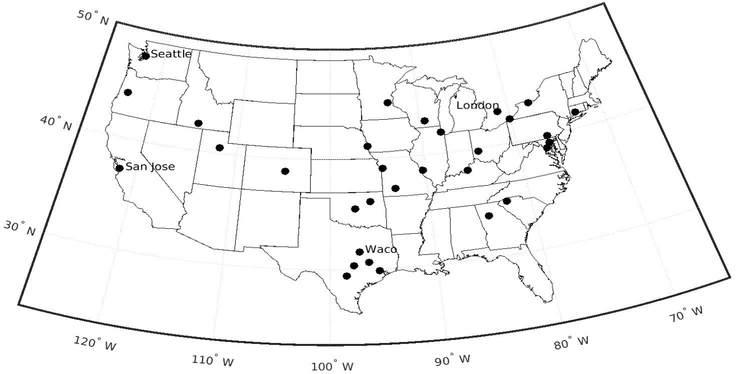
Overall plan

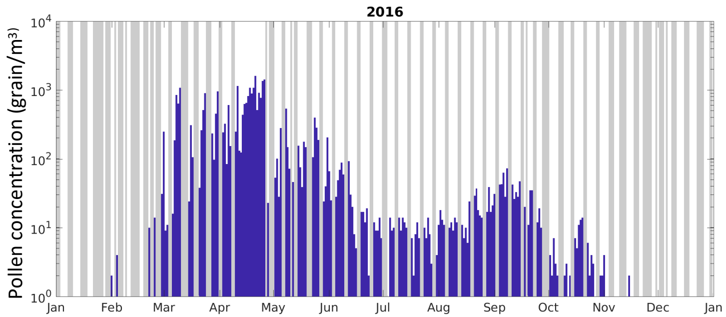
1. Describe available pollen observations in CONUS
2. Link observations and proxies with health effects
3. Assess possible proxies to extend spatial coverage
4. Explore ways to leverage satellite observations

1. Describing pollen observations

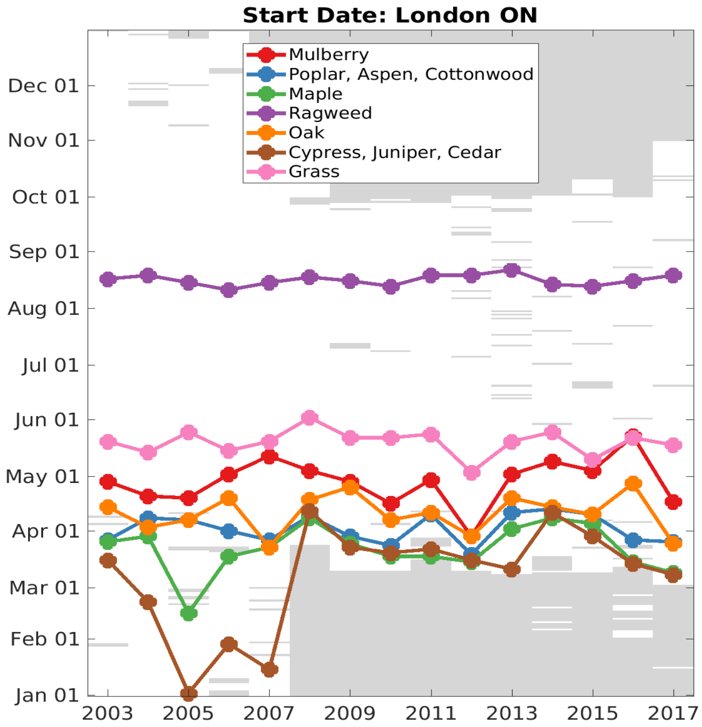
- Pollen data requested for all available years between 2003 and 2016 for 74 stations; received data from for 51
- Convenience samples, machine collected, visually analyzed
- Required to collect data on 4 out of 7 days; no standardization re: start and end
- Substantial missingness; missing value treatment depends on analytical needs (none, exclusion, imputation)

Spatial and temporal coverage





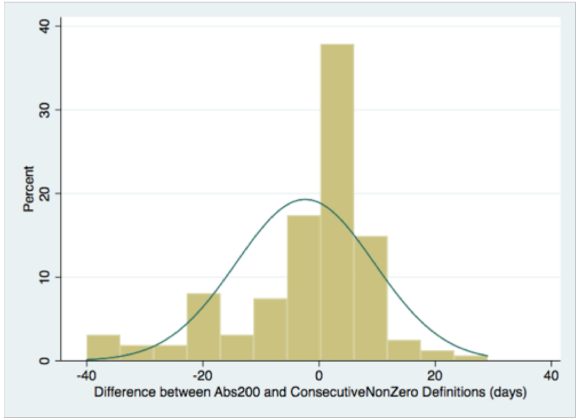
US Army Centralized Allergen Extract Lab, Silver Spring, MD



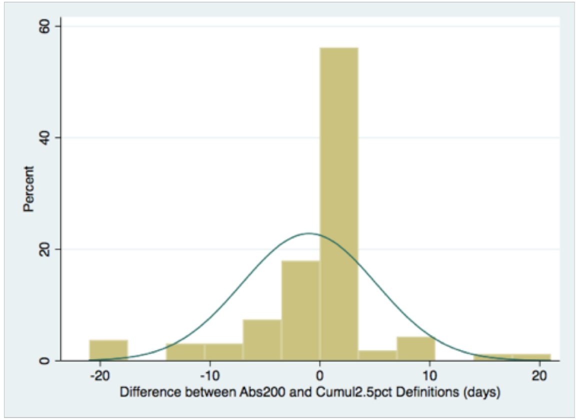
Lo et al., submitted

Variability in season start date metrics

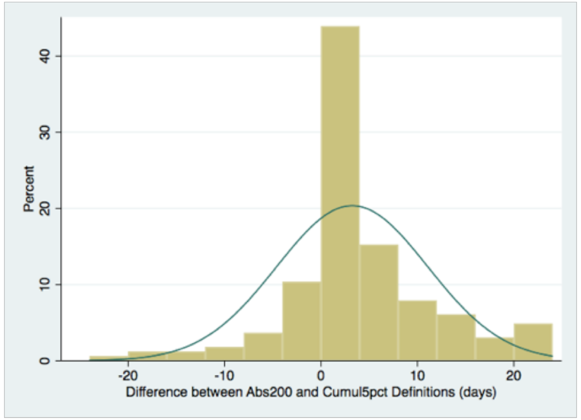
Difference between season start definitions in literature vs. our symptomatic threshold of absolute pollen count = 200



4 days non-zero data, consecutive

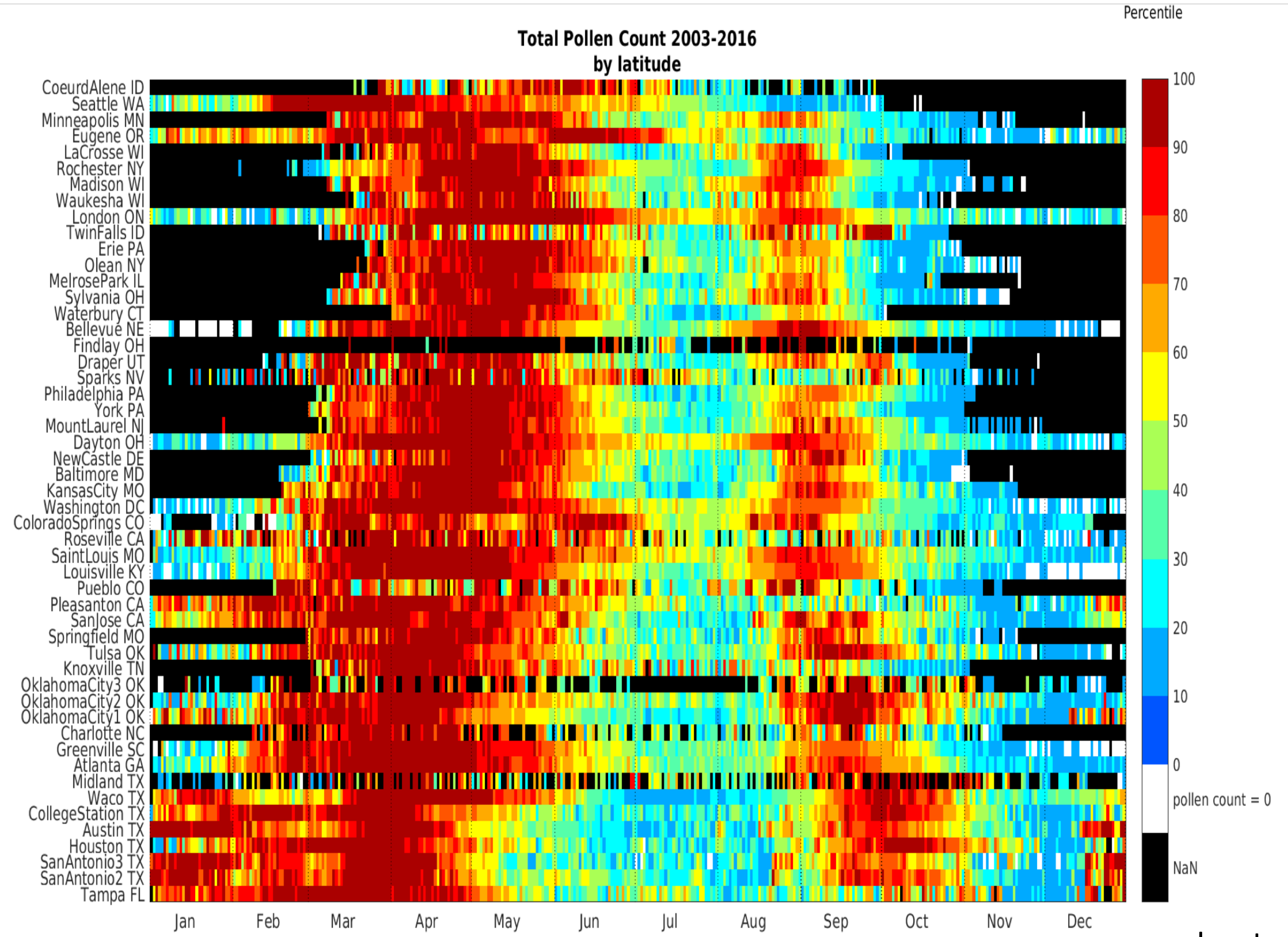


Cumulative reaches 2.5% of annual



Cumulative reaches 5% of annual

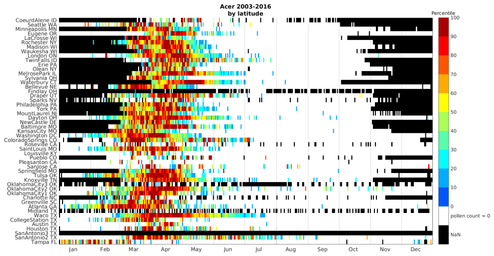
Note: These graphs show the data without the top 10% of outliers, for readability.



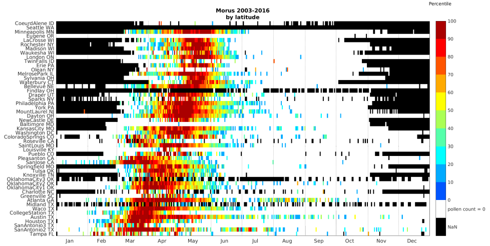
Lo et al., submitted

Allergenic Trees

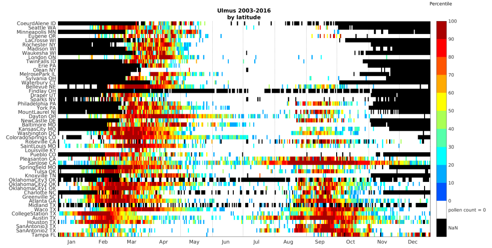
Acer (Maple)



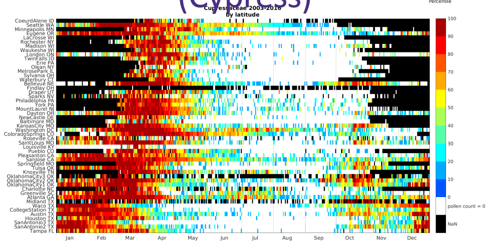
Morus (Mulberry)



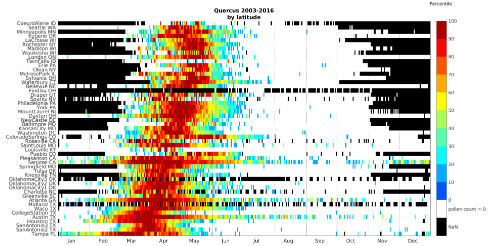
Ulmus (Elm)



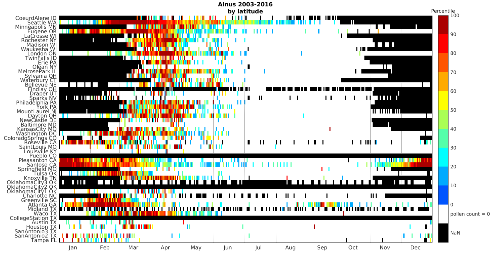
Cupressus (Cypress)



Quercus (Oak)



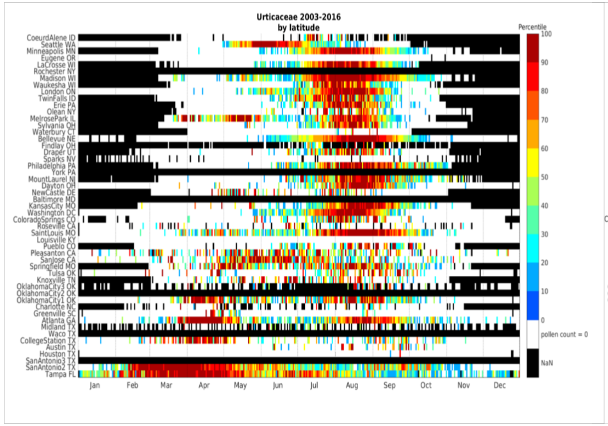
Alnus (Alder)



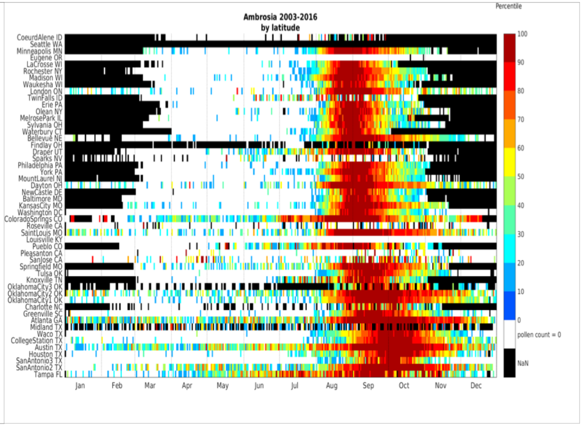
Lo et al., submitted

Allergenic Weeds

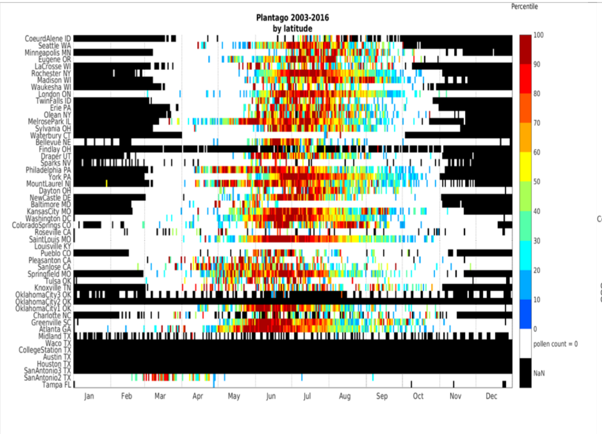
Urticacae



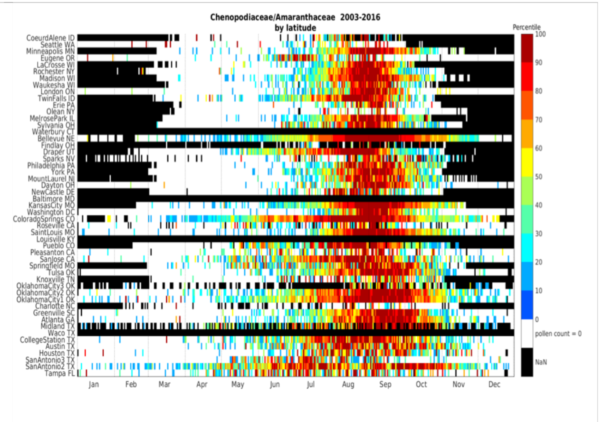
Ambrosia



Plantago



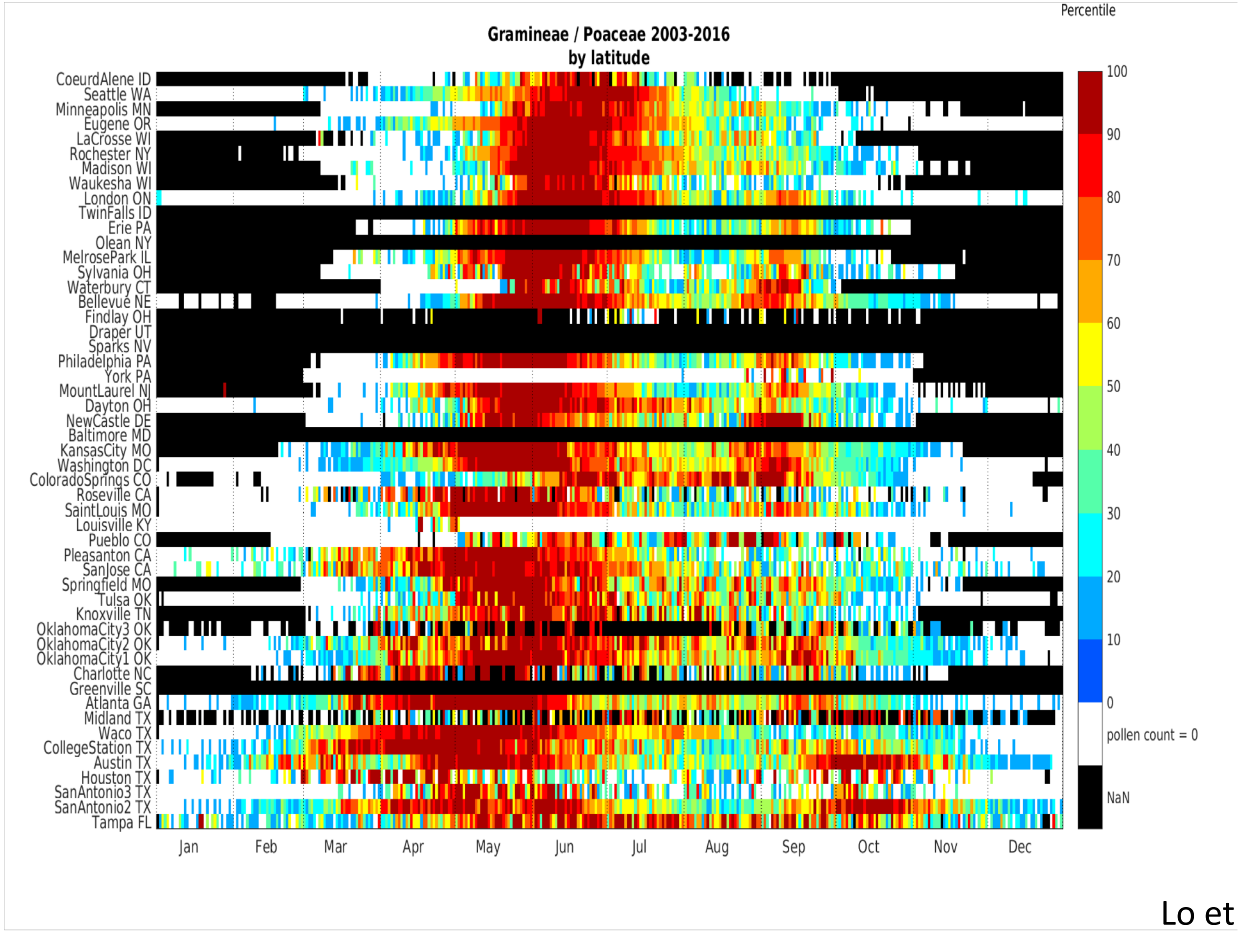
Chenopodiaceae/Amaranthacae



Lo et al., submitted

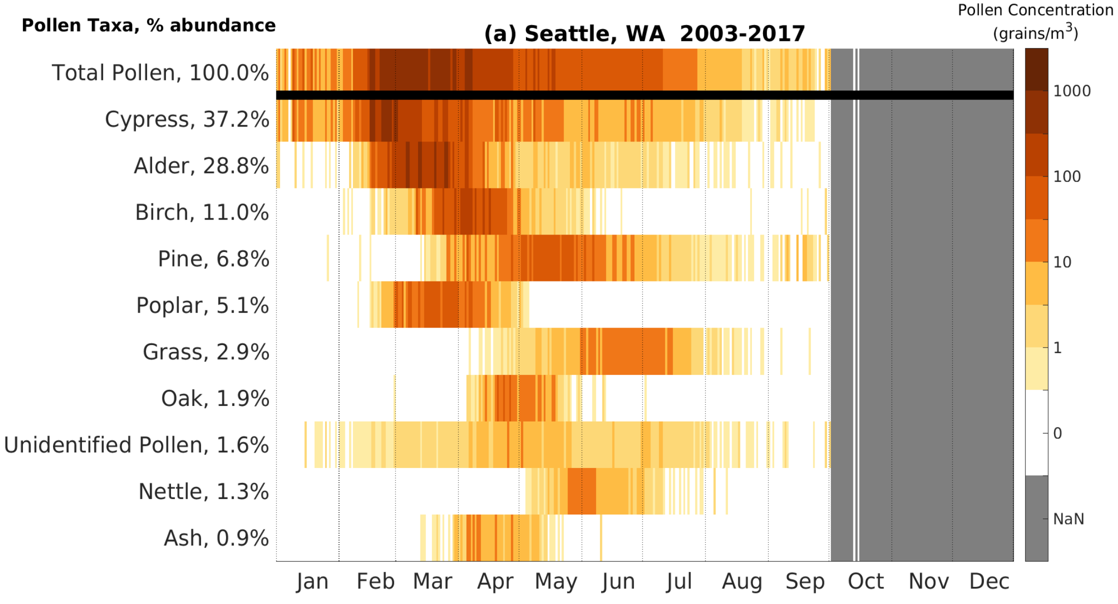
Allergenic Grass

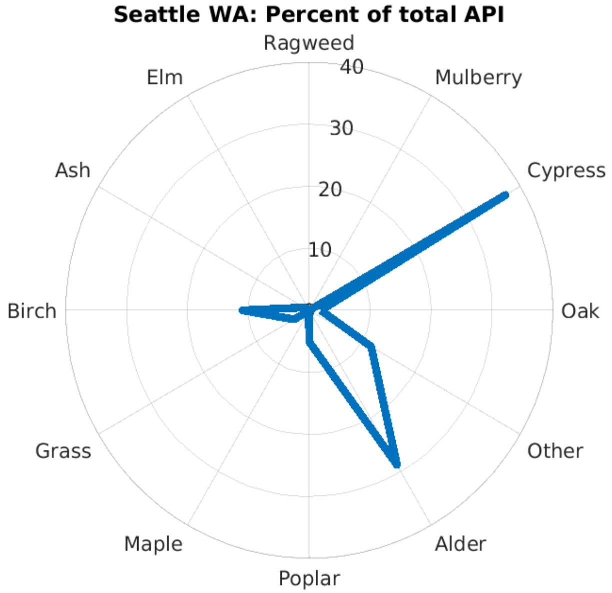
Gramineae/Poaceae



Lo et al., submitted

Site-specific exposures - Seattle





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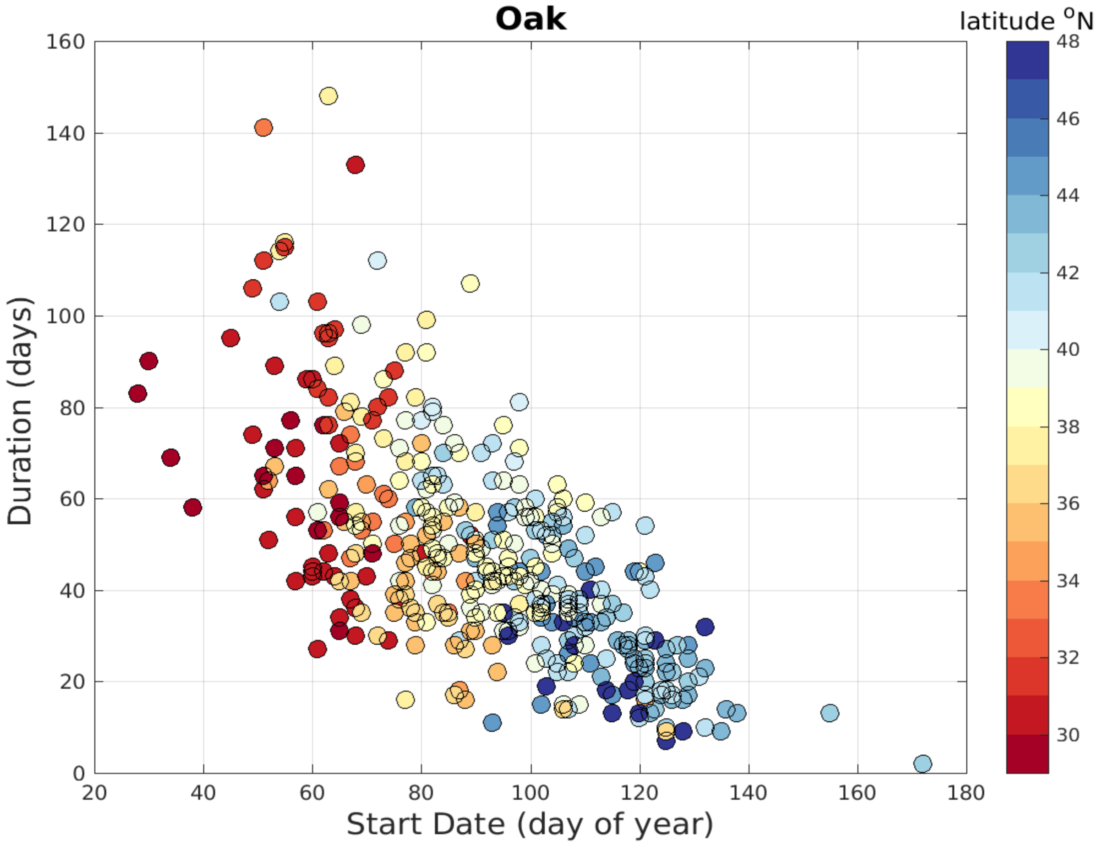
Lo et al., submitted

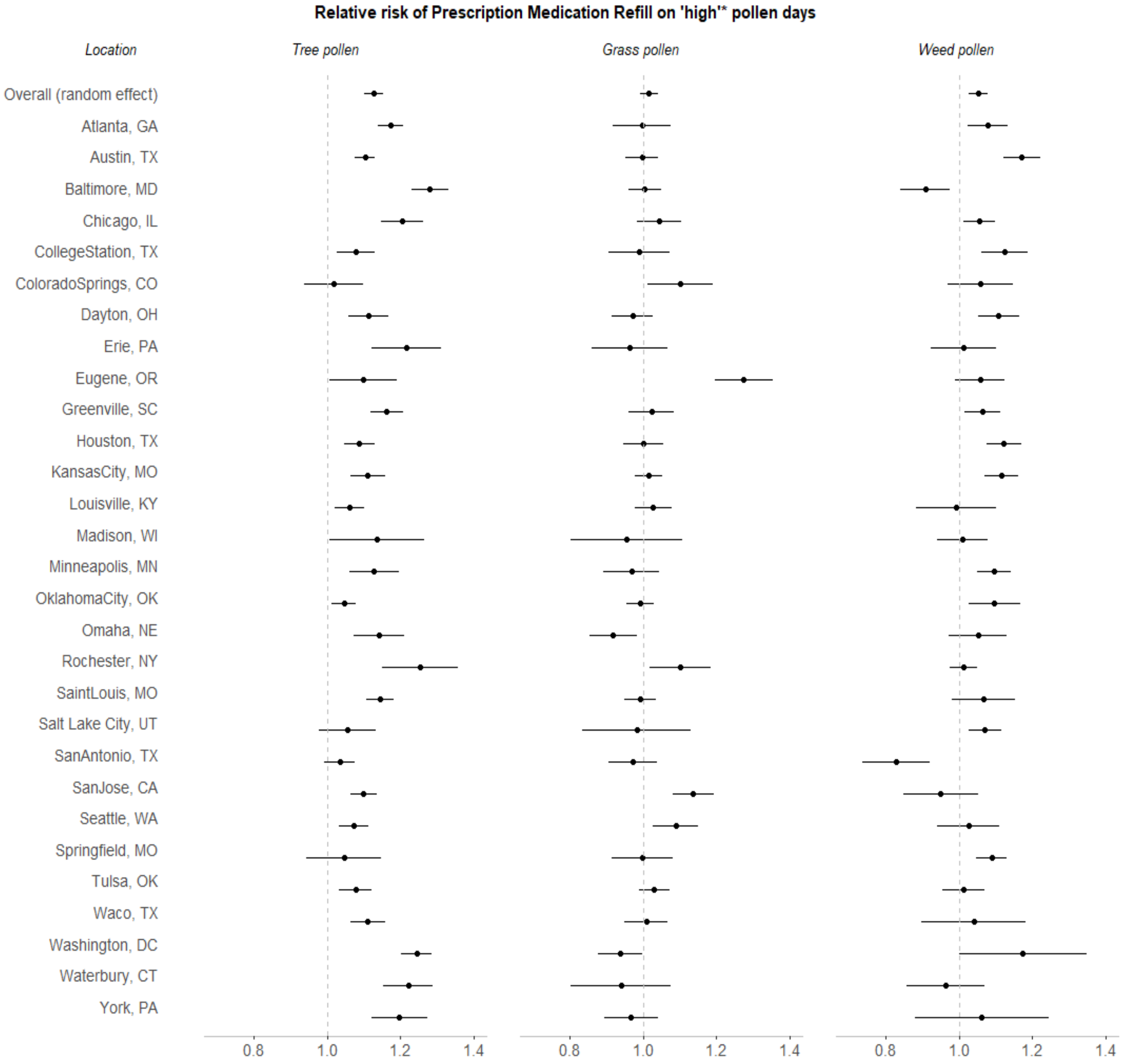
Relationship between temperature and season



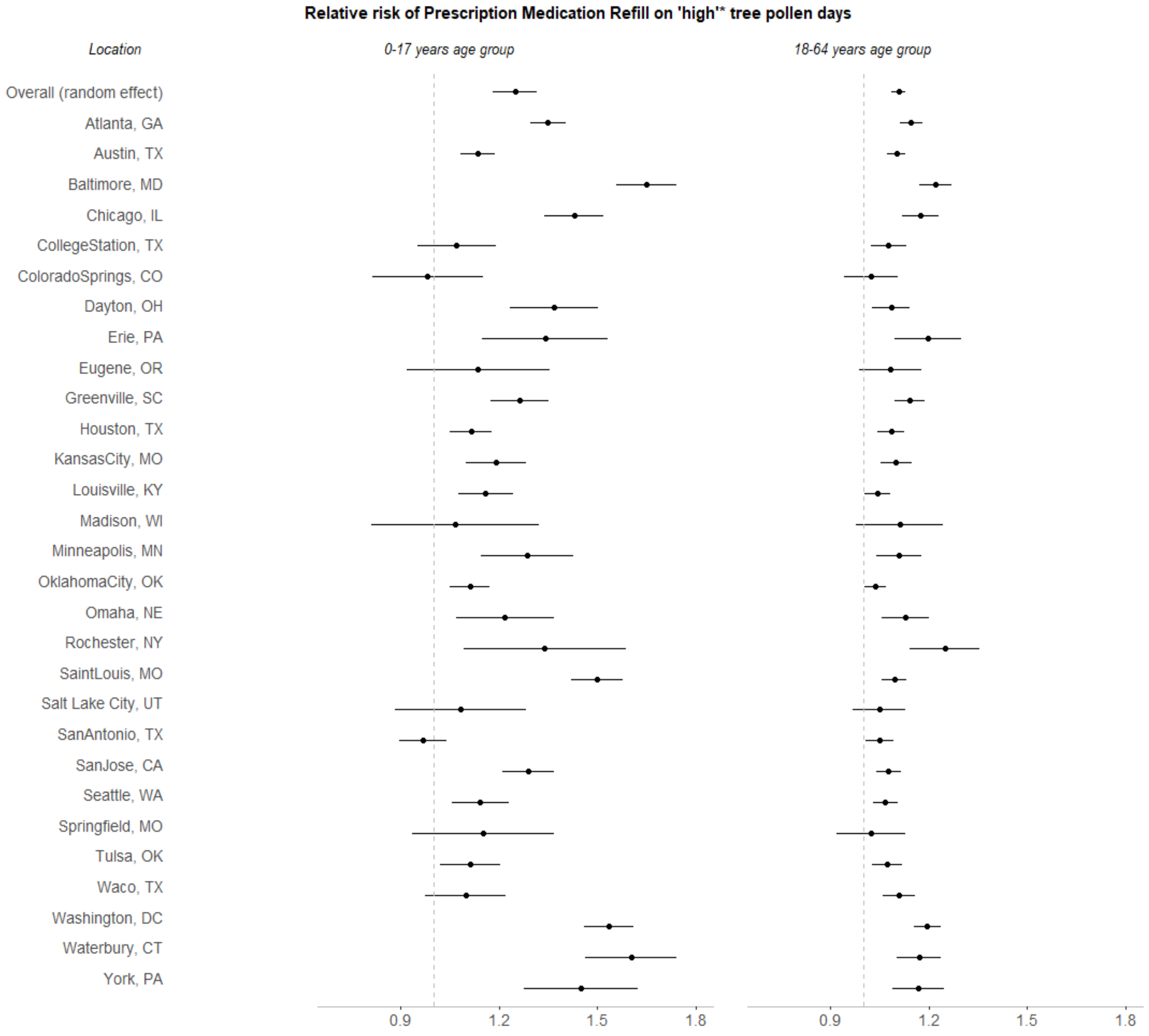
Lo et al., submitted

2. Linkage with health outcomes

- Retrospective analysis of associations between tree, weed, and grass pollen and several morbidity measures in the continental US, controlling for particulate air pollution, ozone, and influenza-like illness
- Set season start at cumulative count of 50 grains/m^3 unless mean seasonal total count ≤2,000 grains, then 2.5%
- Metropolitan Statistical Area (MSA) linked with NAB stations, county $PM_{2.5}$ and O_3, weekly CDC ILI prevalence
- GEEs used to estimate daily counts



Saha et al. in preparation

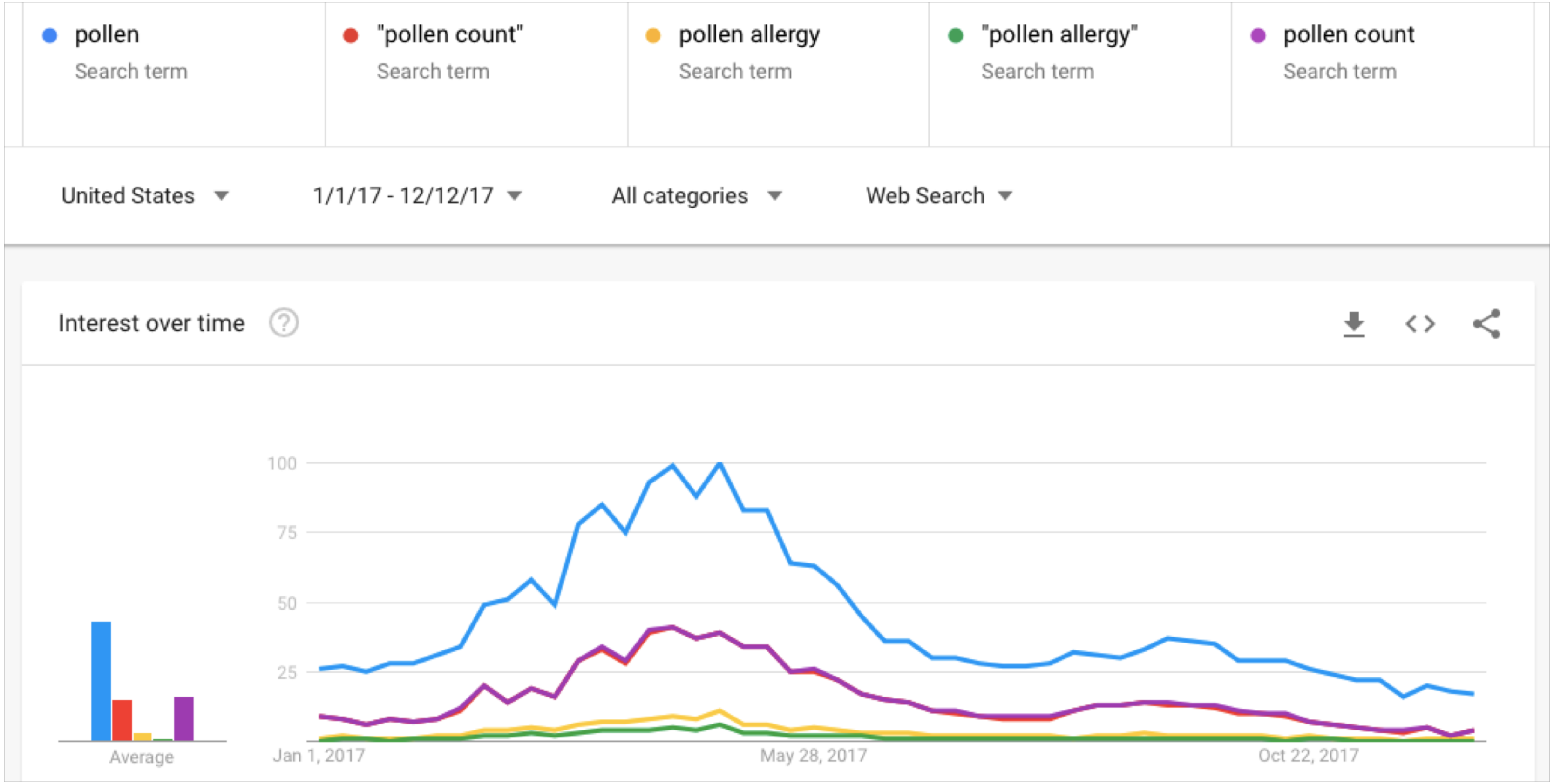


Saha et al. in preparation

3. Proxies for NAB pollen observations

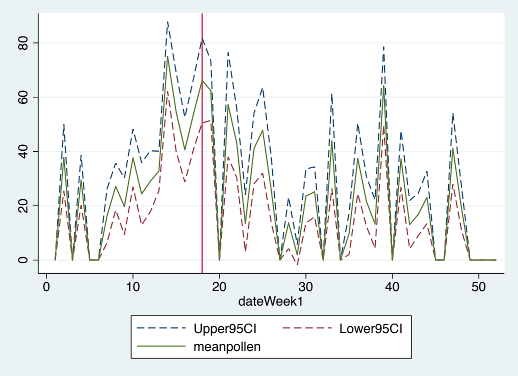
- Google Trends web searches
  - Analysis of search terms
  - Correlation of season start dates
  - Evaluation of potential for identifying speciated trends
- National Phenology Network observations

Search terms comparison

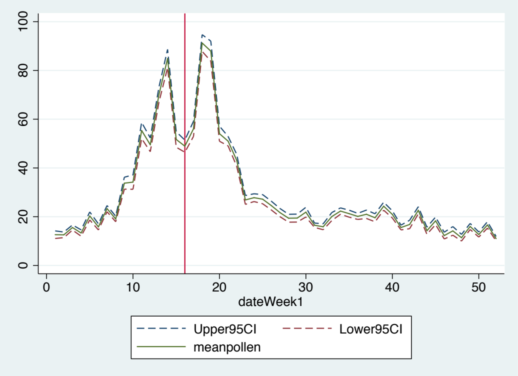


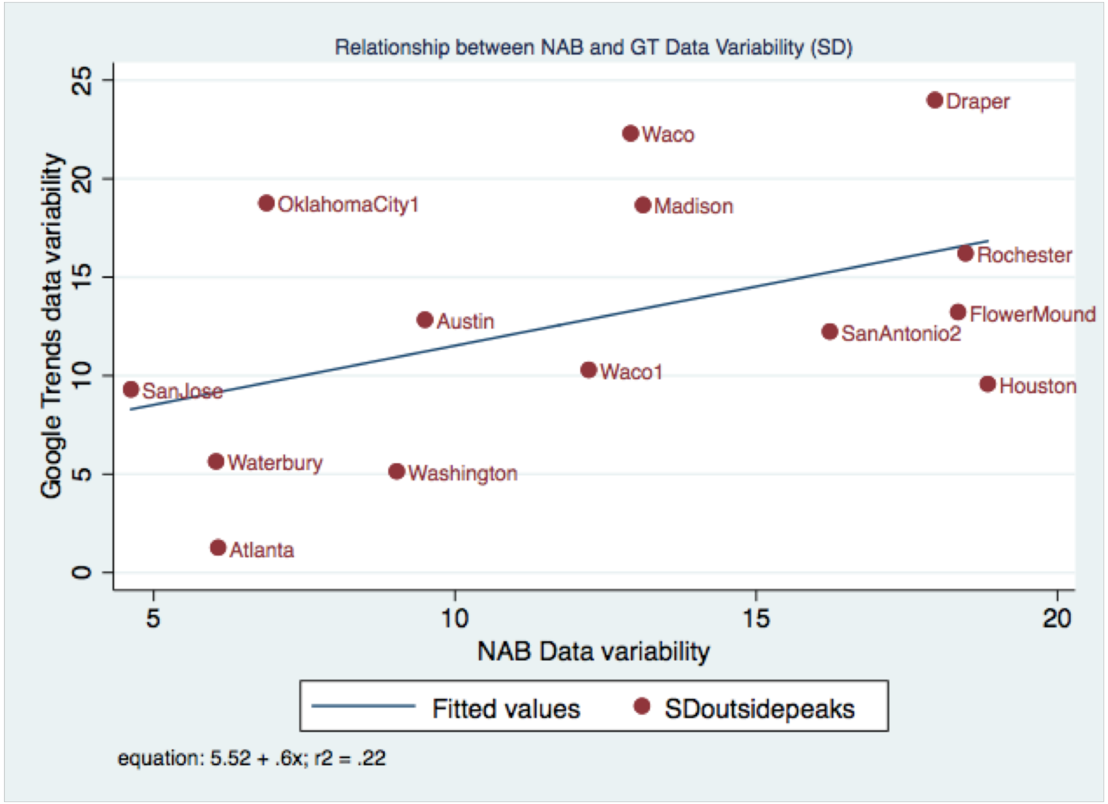
Variability in searches

Asheville 2008

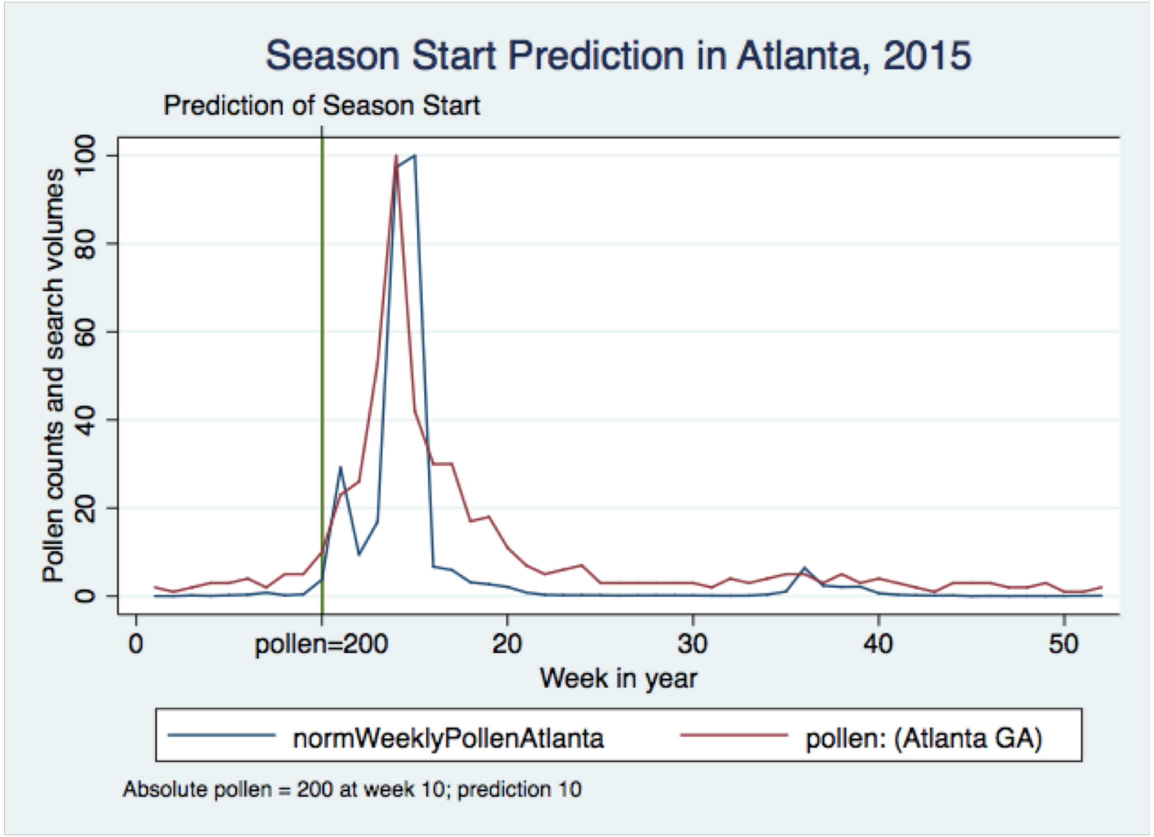


San Jose 2008

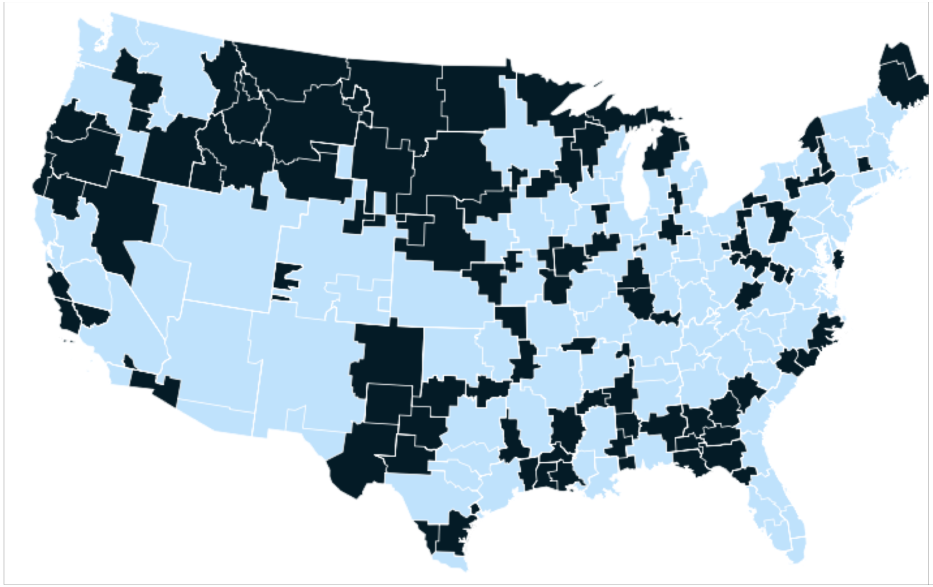




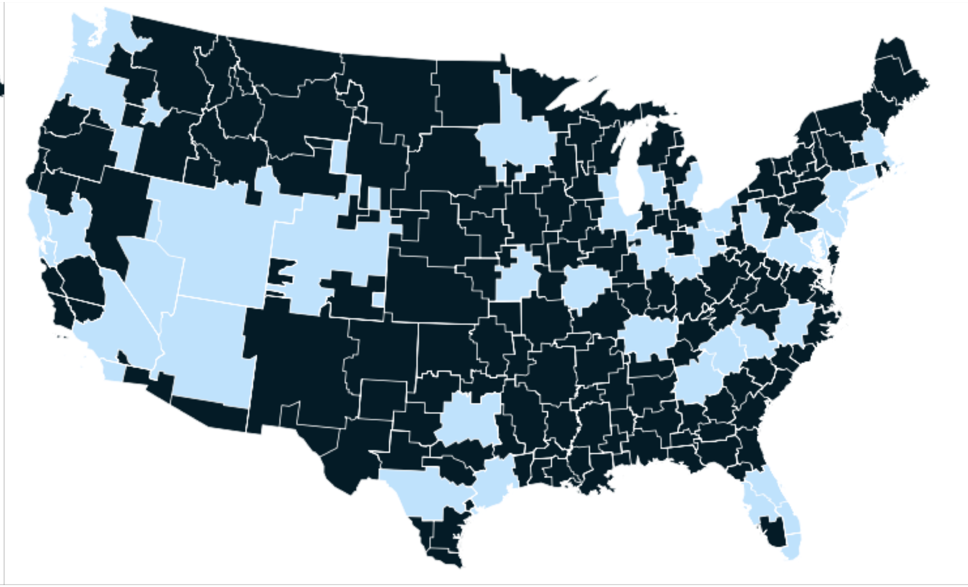
GT useful for predicting pollen season start date



Additional coverage conferred from GT data



Top 100 Markets

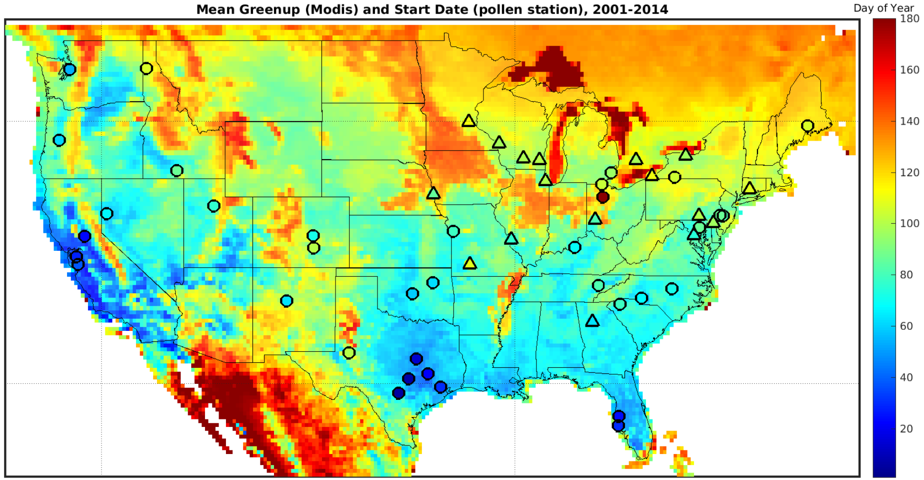


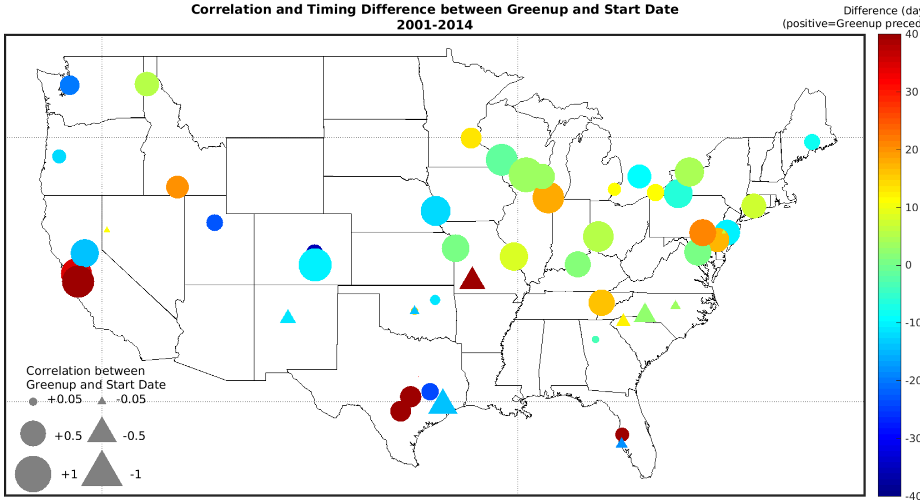
Markets Above Threshold

4. Using satellite observations

- MODIS Greenup
- MIRS

4. MODIS greenup correlations with pollen obs





Next steps

- Descriptive analyses
  - Finalize primary descriptive manuscript
  - Submit short analysis on start date metrics
  - Provide customized analyses to stakeholders
- Health analyses
  - Submit MarketScan analysis for publication
  - Develop PAR estimates and submit for publication
- Proxy analyses
  - Develop additional GT estimates, submit analysis for publication
  - Repeat analysis with National Phenology Network data
  - Explore possibilities for repeat of analyses internationally
- Correlation with satellite data
  - Analyze potential for MODIS greenup with expanded start date catalogue
  - Analyze potential for MIRS AOD analysis

Year 2.5 Progress Update, PI Hess

HAQAST

Pollen, Weather, Climate, and Health

1. *Advance understanding of the climatic and weather factors that affect the spatial and temporal characteristics of aeroallergens.*
   - Continuing regression analyses of weather factors associated with total and speciated pollen
   - Developing proxy factors that can increase spatial resolution of pollen season parameters to faciltate other analyses
2. *To forecast pollen conditions a season in advance.*
   - Related to above; have developed species-specific models that are modestly more skilled than published models to date
3. *To project pollen conditions 10-40 years in the future.*
   - Postponed until forecast models are developed
4. *To generate applications from this research to facilitate public health activities related to aeroallergens and climate change adaptation. .*
   - Continued development of exposure-outcome associations
   - Data visualization products to be prepared for allergy clinics

Tiger Team Participation

- Anenberg global climate and health metrics
  - Exploring potential for global estimation of pollen exposure
  - Working with Yang Liu on wildfire hotspot analysis for Lancet Countdown on Climate Change

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National Allergy Bureau pollen data providers and their clinics:

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