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

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Overview

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

- Russian thistle: 68%
- Most common weeds:  
  - 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

At least one weed  
At least one grass  
At least one tree

Wong et al. 2012
Sensitization correlated with pollen exposure


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.
Acer (Maple)  
Morus (Mulberry)  
Ulmus (Elm)  
Cupressus (Cypress)  
Quercus (Oak)  
Alnus (Alder)
Allergenic Weeds

Urticaceae

Ambrosia

Plantago

Chenopodiaceae/Amaranthaceae

Lo et al., submitted
Gramineae/Poaceae

Lo et al., submitted
Site-specific exposures - Seattle

(a) Seattle, WA 2003-2017

Pollen Taxa, % abundance

- Total Pollen, 100.0%
- Cypress, 37.2%
- Alder, 28.8%
- Birch, 11.0%
- Pine, 6.8%
- Poplar, 5.1%
- Grass, 2.9%
- Oak, 1.9%
- Unidentified Pollen, 1.6%
- Nettle, 1.3%
- Ash, 0.9%

Pollen Concentration (grains/m³)

Seattle WA: Percent of total API

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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 $\leq$ 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
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

- pollen
- "pollen count"
- pollen allergy
- "pollen allergy"
- pollen count

United States  1/1/17 - 12/12/17  All categories  Web Search

Interest over time

Average

Variability in searches

Relationship between NAB and GT Data Variability (SD)

equation: $5.52 + 0.6x; r^2 = 0.22$
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
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 facilitate 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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