Projecting Pollen Allergens and their Health Implications in a Changing World

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Project Objectives

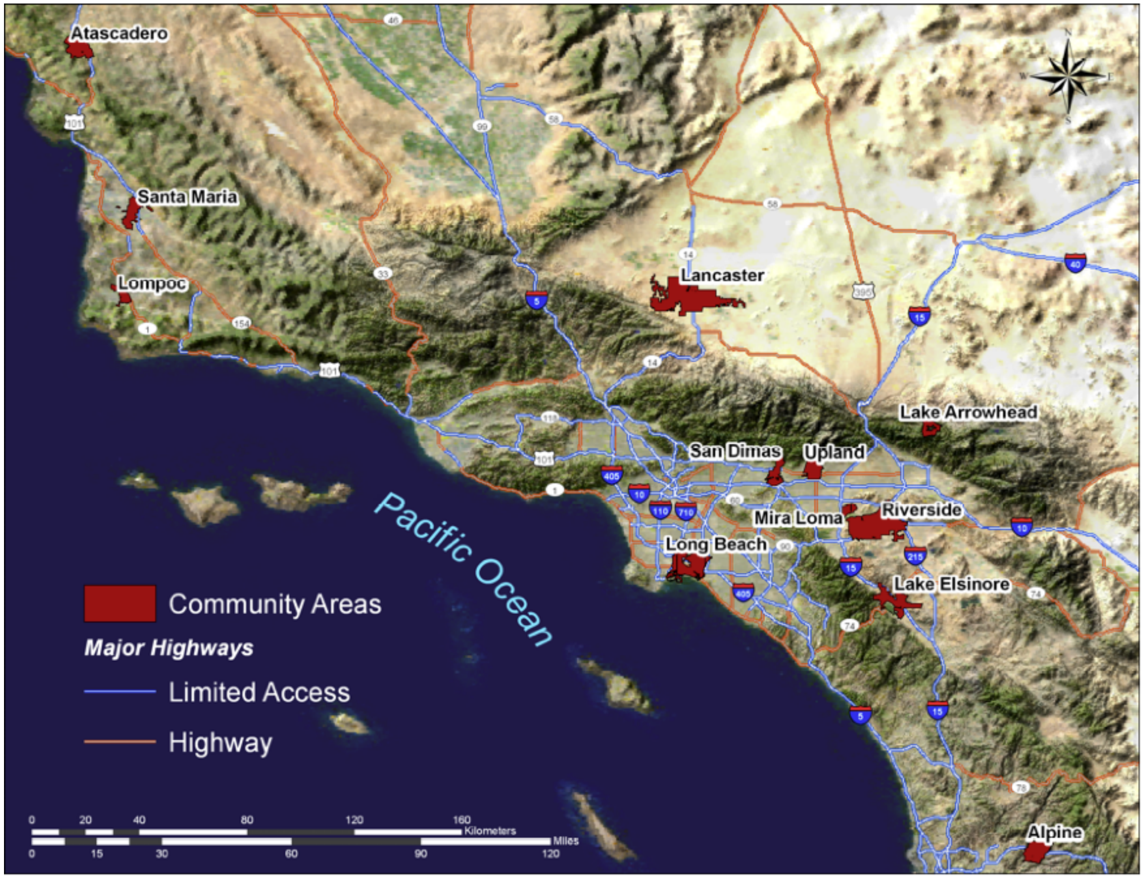
Project Objectives:

- To improve our understanding of the linkages among global change, pollen allergens, air pollution, and respiratory allergic airway disease

Approach:

- Measure pollen and pollen antigen at multiple sites within study area to facilitate pollen model development and validation
- Expand MEGAN (Model of Exchange of Gases between the Atmosphere and Nature) to include primary biological particle emissions
- Integrate pollen and pollen antigen sources into air quality models to enable pollen exposure estimation within domain of the Southern California Children's Health Study
- Develop dose response functions through retrospective and ongoing examination of Children's Health Study data in light of pollen exposure estimates
- Evaluate pollen and respirable allergen levels for both present and future climate conditions
- Estimate future health impacts based upon dose response functions and combined air pollution and pollen allergen exposures

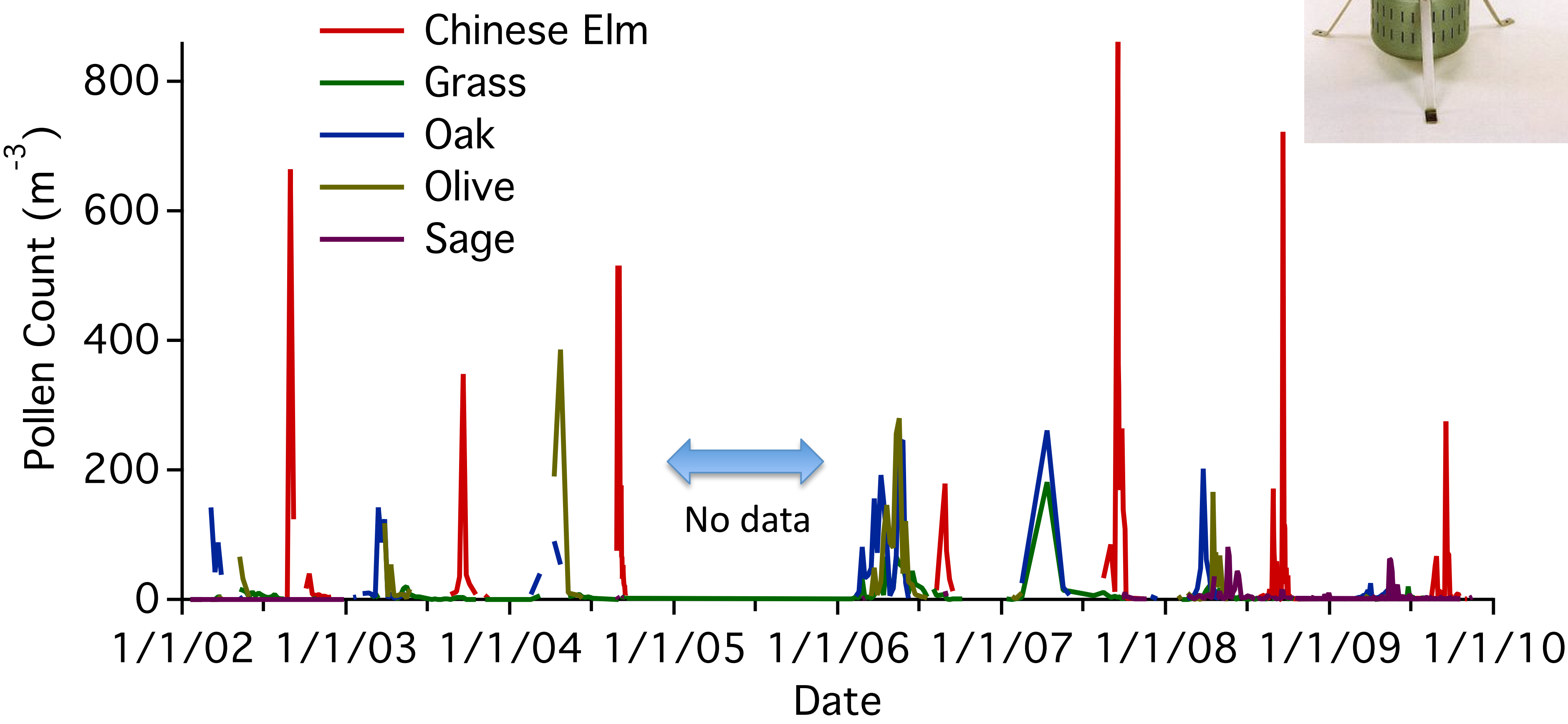
Source of Health Effects Data: Southern California Children's Health Study



- Cohort of >11000 children in southern California since 1993
- Current cohort enrolled from kindergarten and first grade classrooms in 2002 was evaluated in 2009-2010

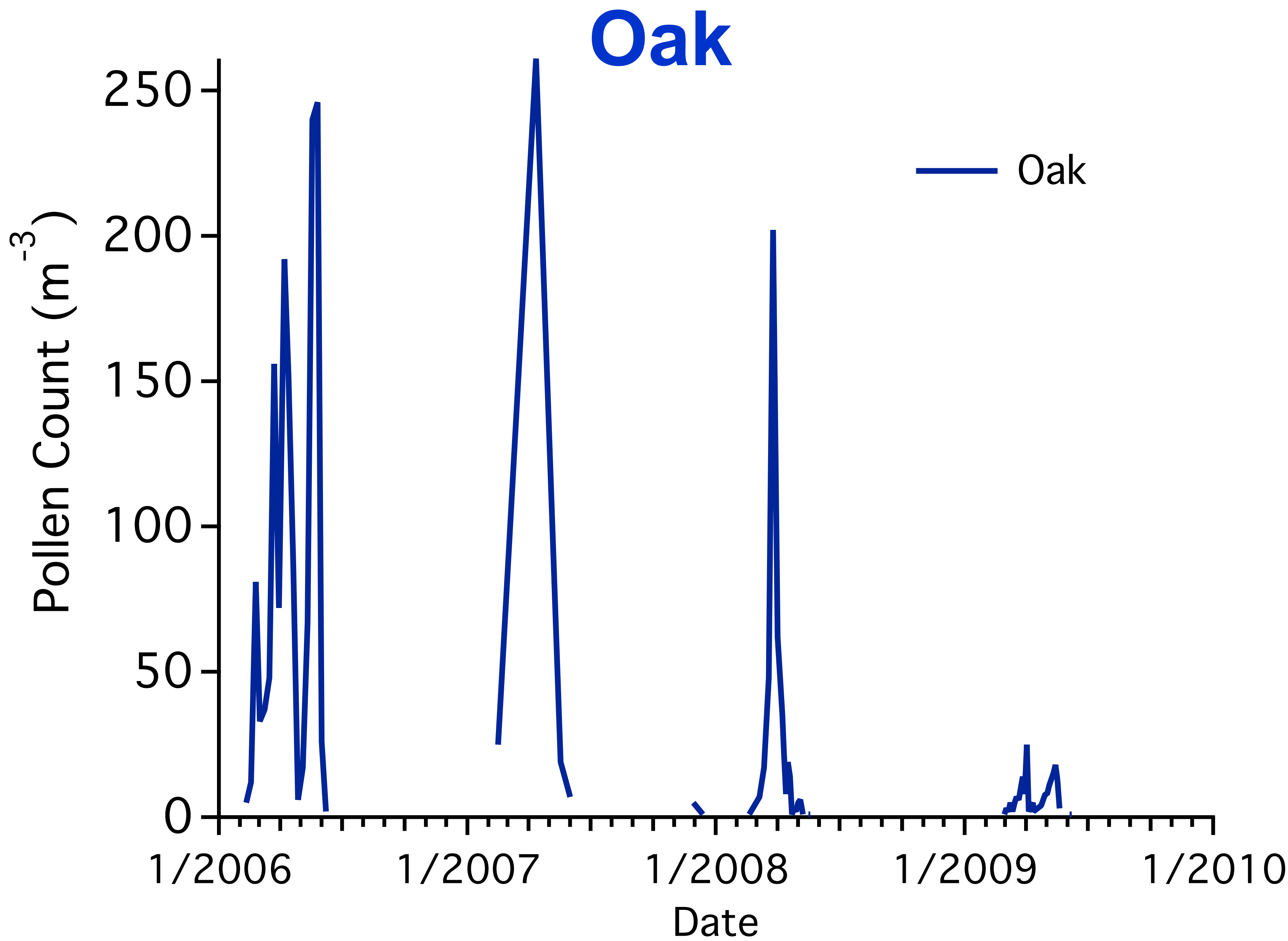
- Preliminary data from the CHS suggests tree and grass pollen are strongly associated with sensitization and new onset asthma and rhinitis in older children who were disease-free at age 5 years.

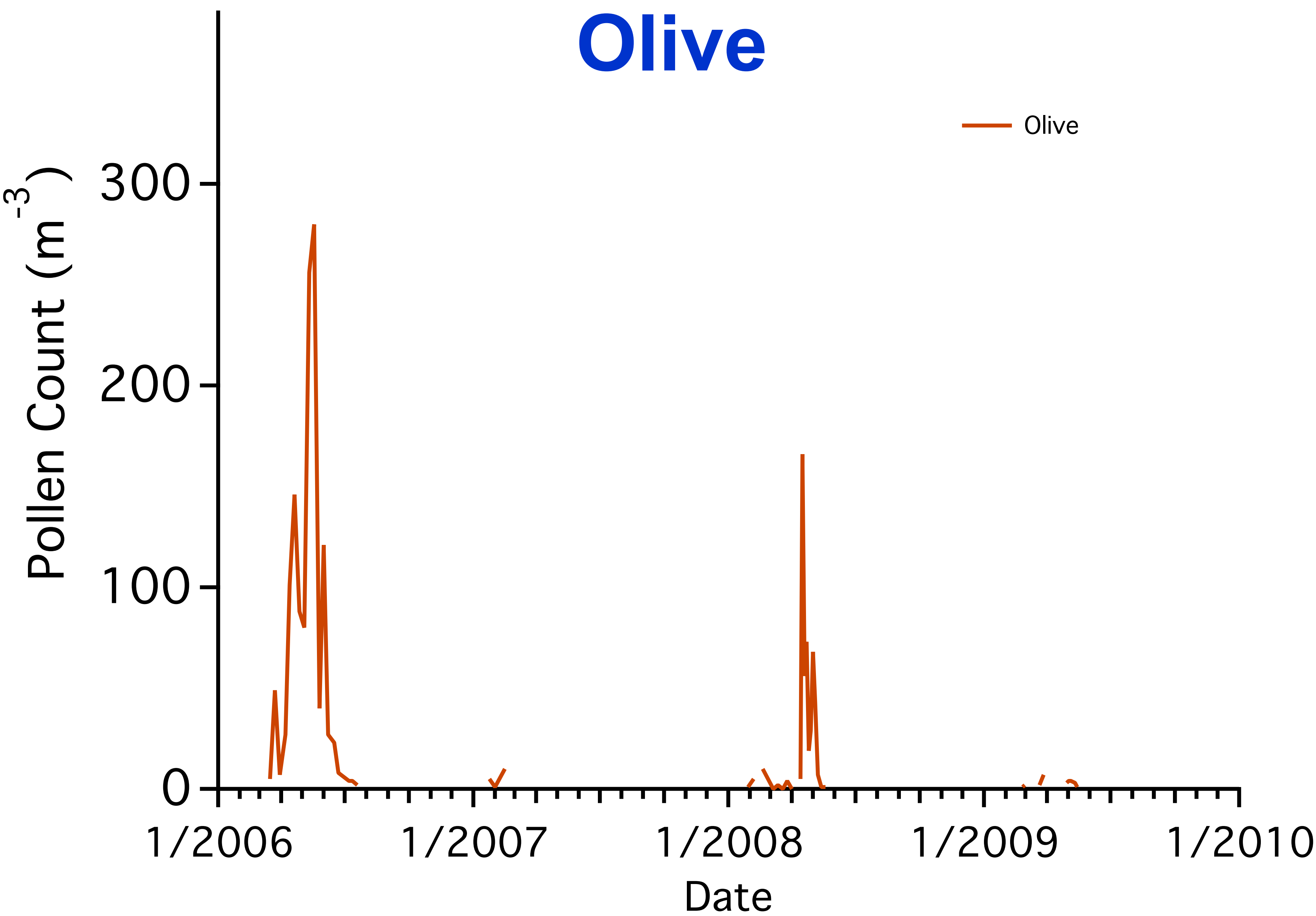
Local (Pasadena) Pollen Data



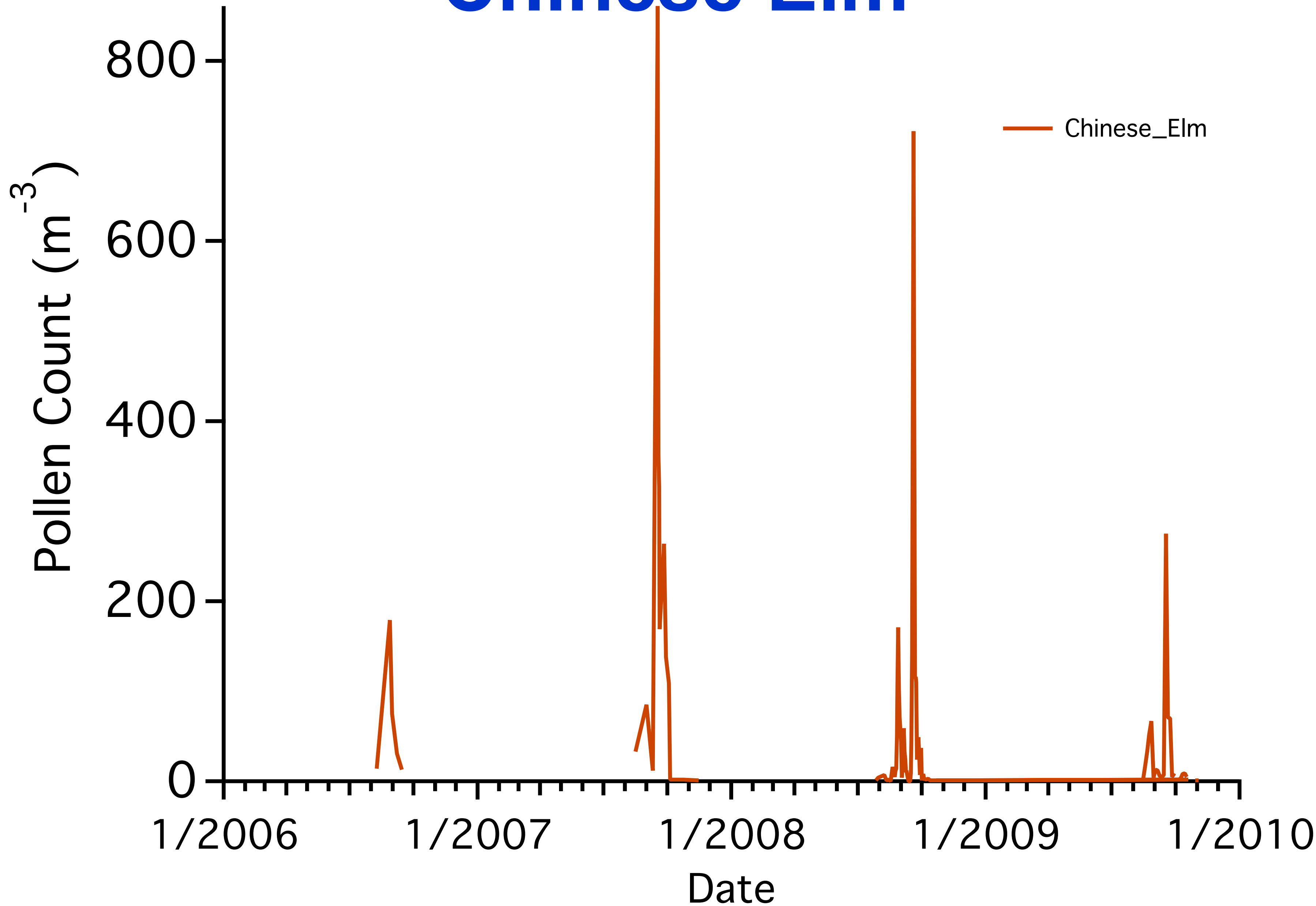
Pollen Data

- **Pollen of particular interest**:
  - Olive, Oak, Sagebrush, Grass (Timothy, Rye, Bermuda) and Chinese Elm
- **CHS pollen sampling 2010**
  - Expanded measurements in CHS study communities to determine spatial variability
  - 7-14 days of sampling at eight communities coordinated with ongoing respiratory health evaluations
  - Not all measurements available
  - Short-term spatial distribution
  - Not measured in Chinese Elm season (Aug-Oct)

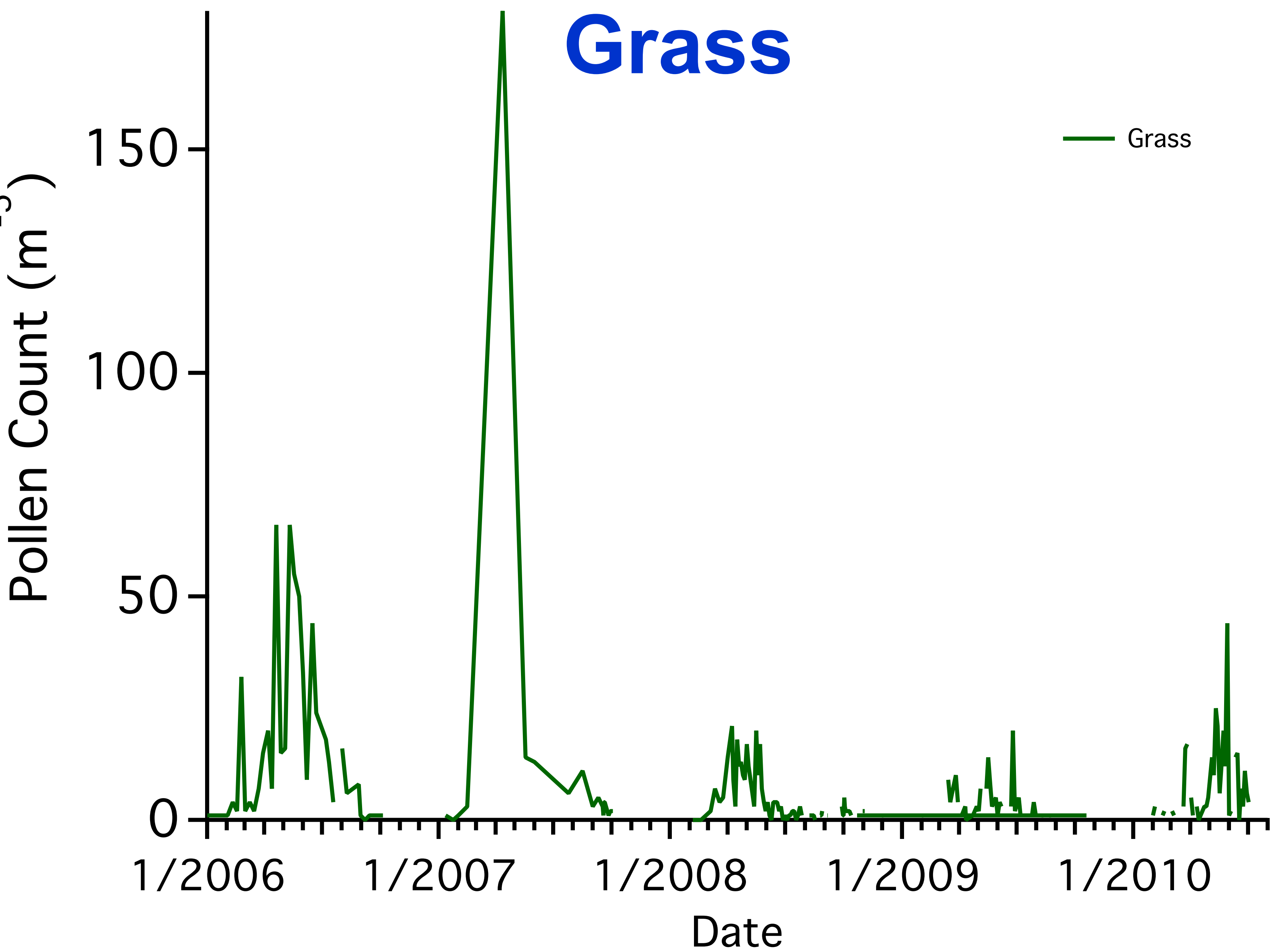

Oak
Oak
Pollen Count (m^-3)
250
200
150
100
50
0
1/2006
1/2007
1/2008
1/2009
1/2010
Date


Olive
Olive
Pollen Count (m-3)
300
200
100
0
1/2006
1/2007
1/2008
1/2009
1/2010
Date

Chinese Elm

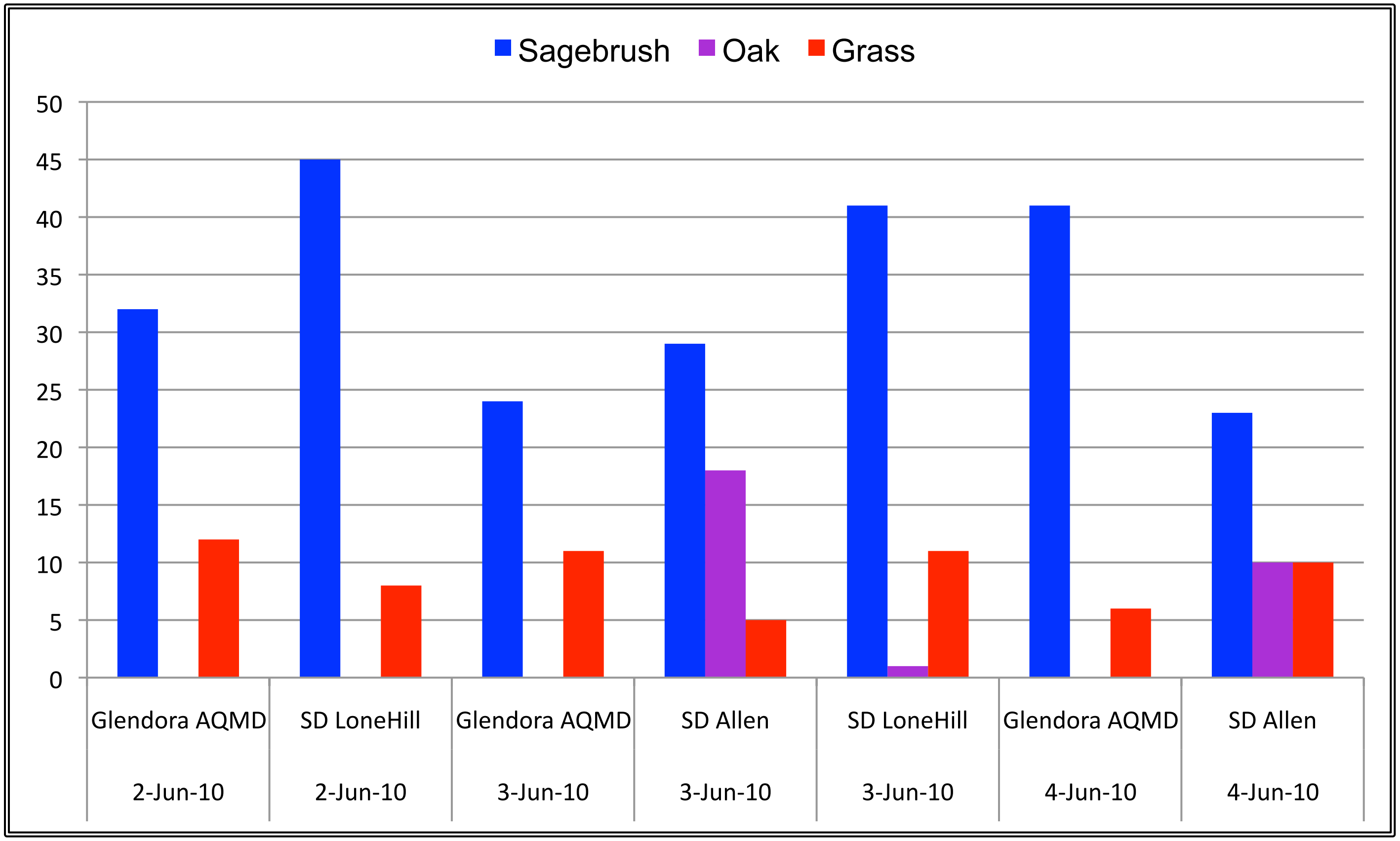


Pollen Count (m^-3)
800
600
400
200
0
1/2006
1/2007
1/2008
1/2009
1/2010
Date
Chinese_Elm

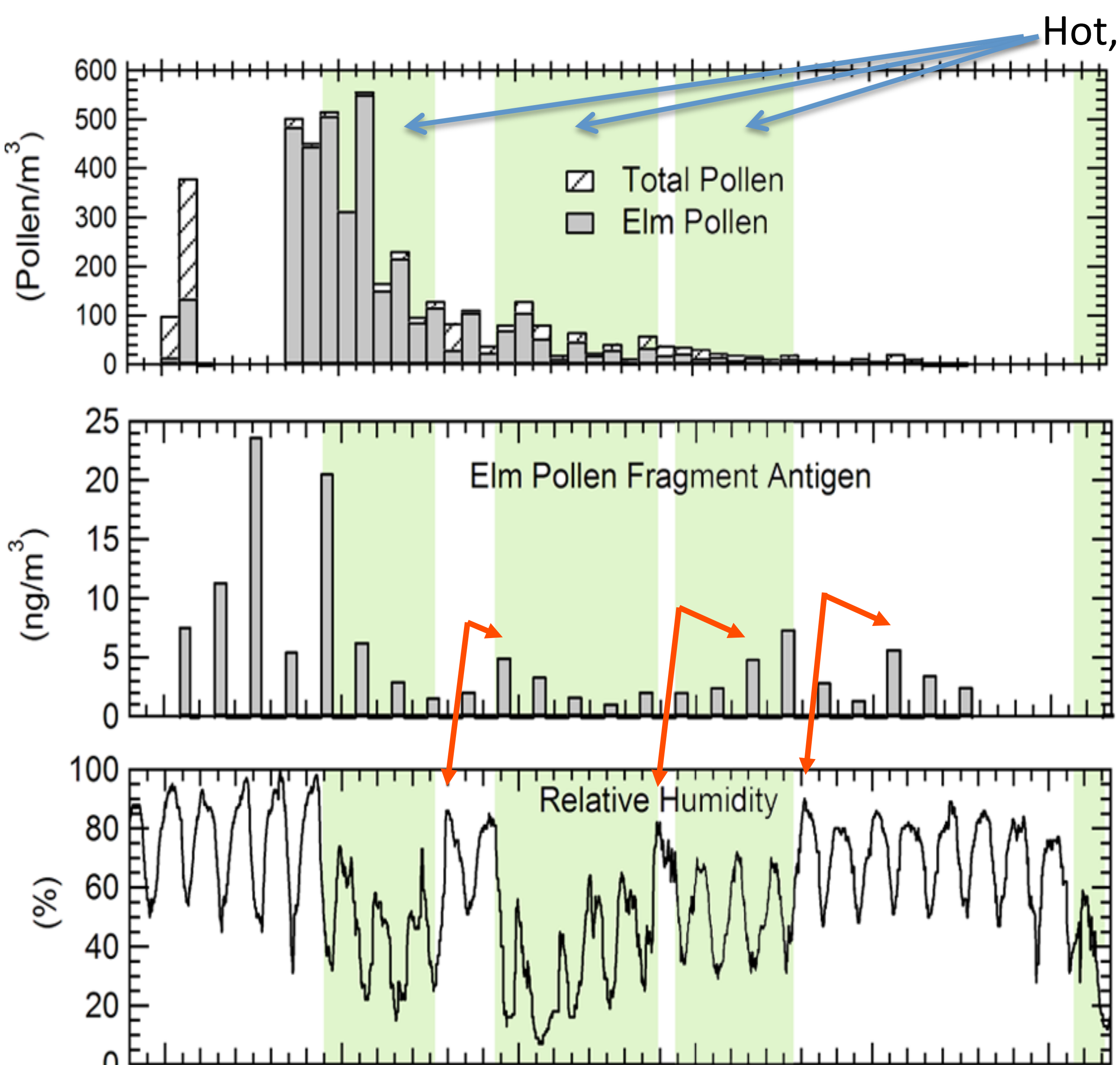

Grass
Grass
Pollen Count (m^-3)
150
100
50
0
1/2006
1/2007
1/2008
1/2009
1/2010
Date

Pollen Data in CHS

Overlapping data from Glendora AQMD and San Dimas (SD) Lone Hill Middle School and Allen Avenue Elementary School



Chinese elm pollen and pollen fragments



- **80% Relative Humidity leads to pollen fragment release with ~ 2 - day lag**

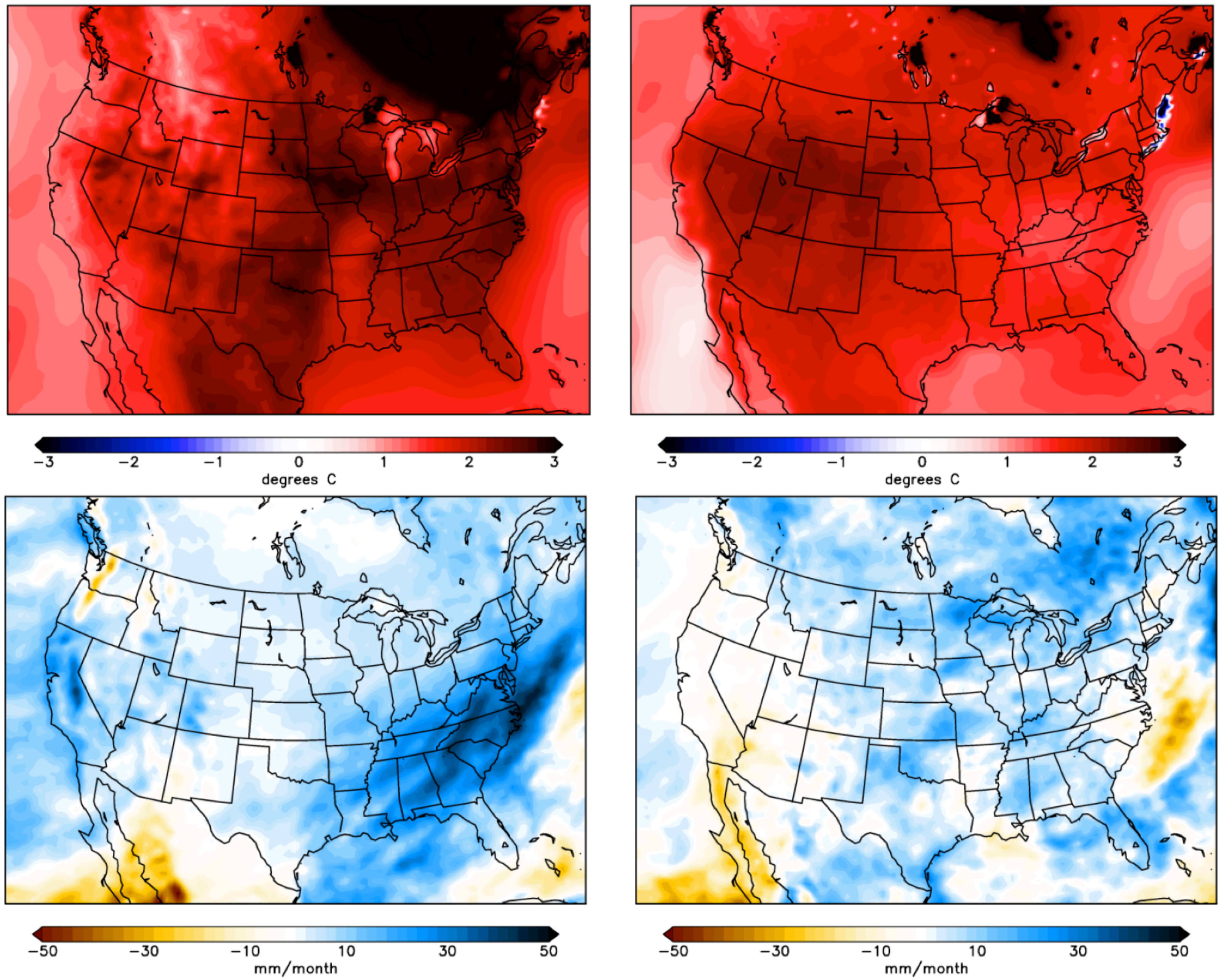
Miguel et al. (2006) *Aerosol Sci. Technol*. **40:** 690-696

2030-2059s vs 1970-1999

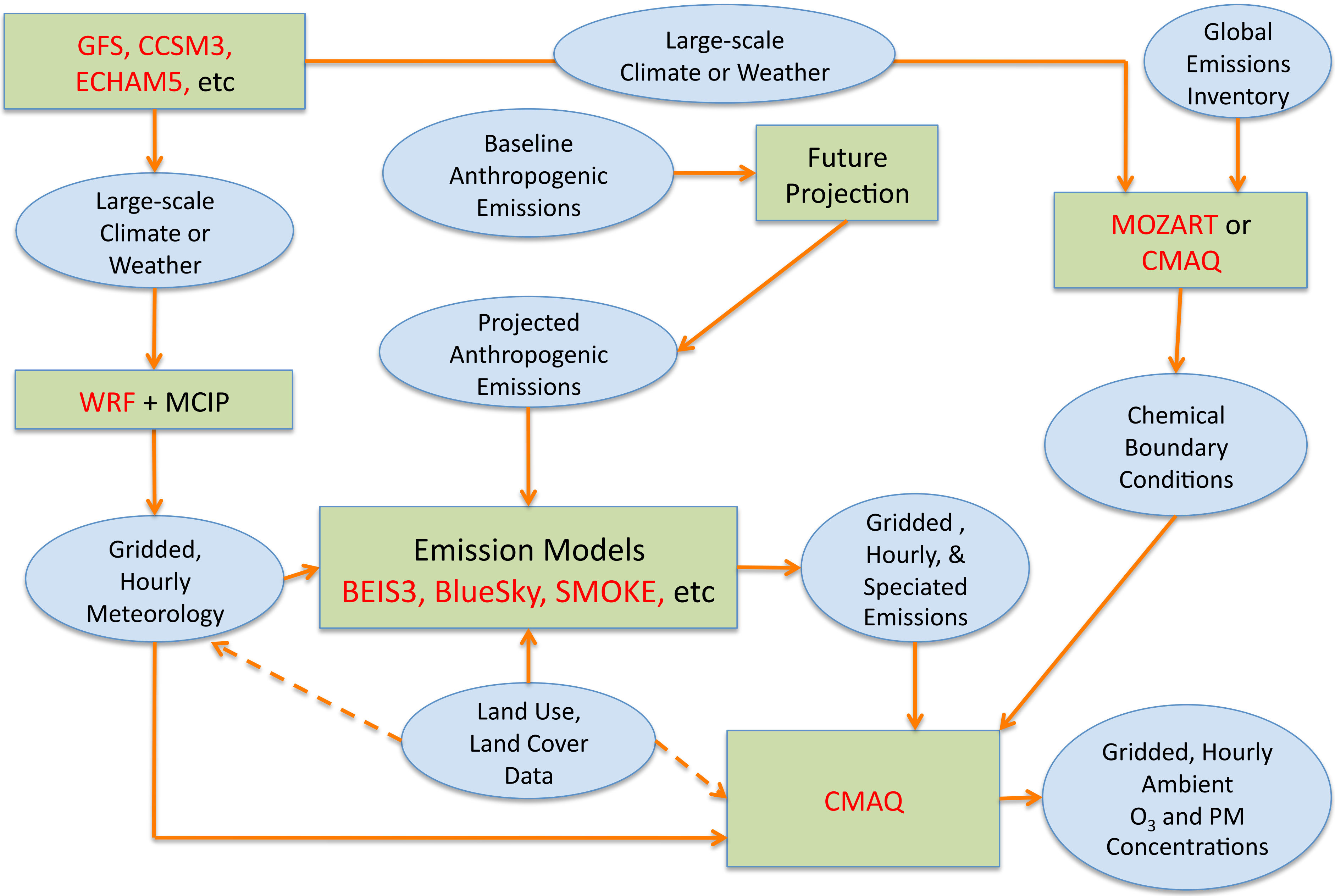
December-January-February | June-July-August

ΔT_{2m} (°C)

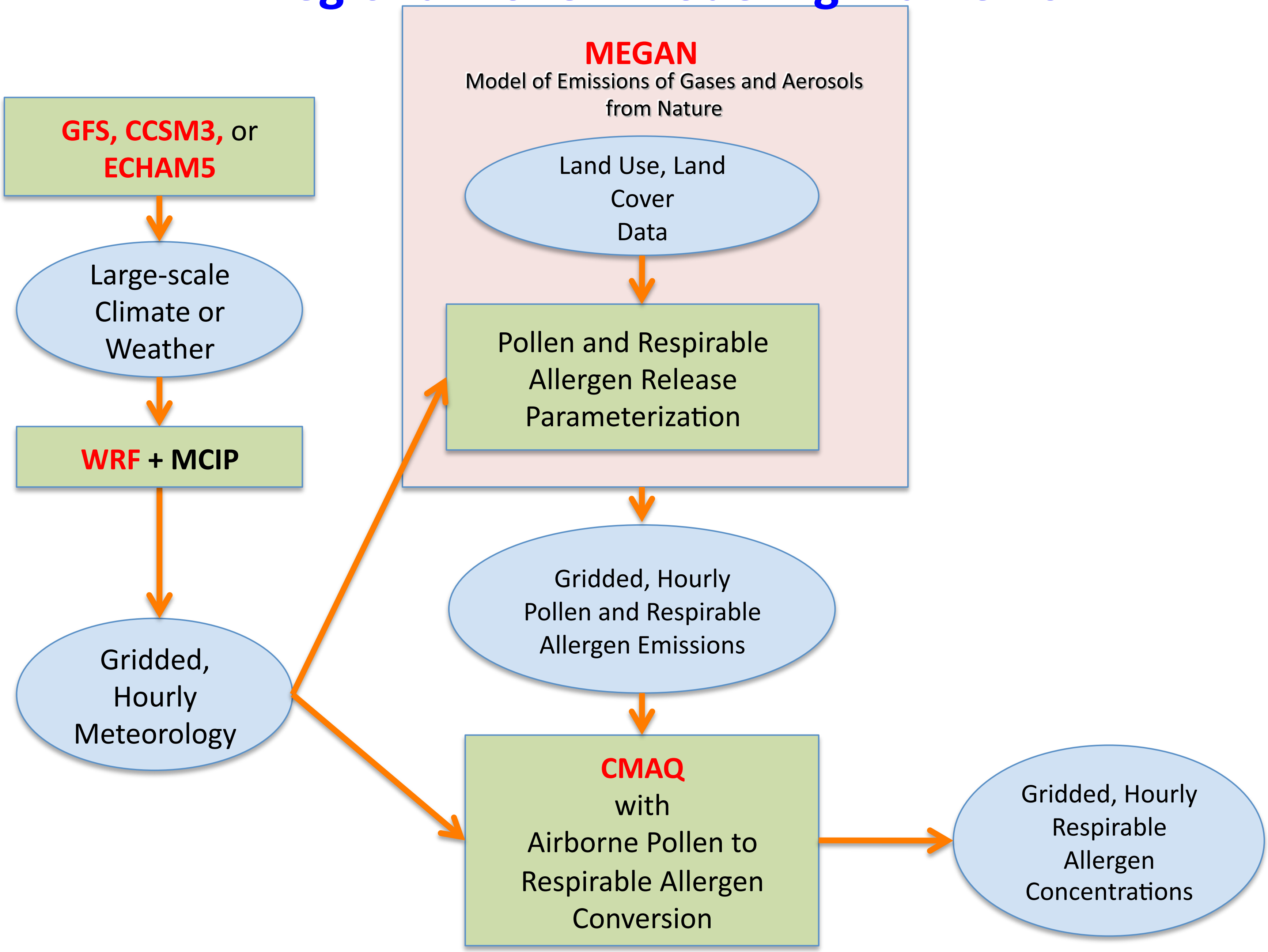
ΔRAIN (mm/month)



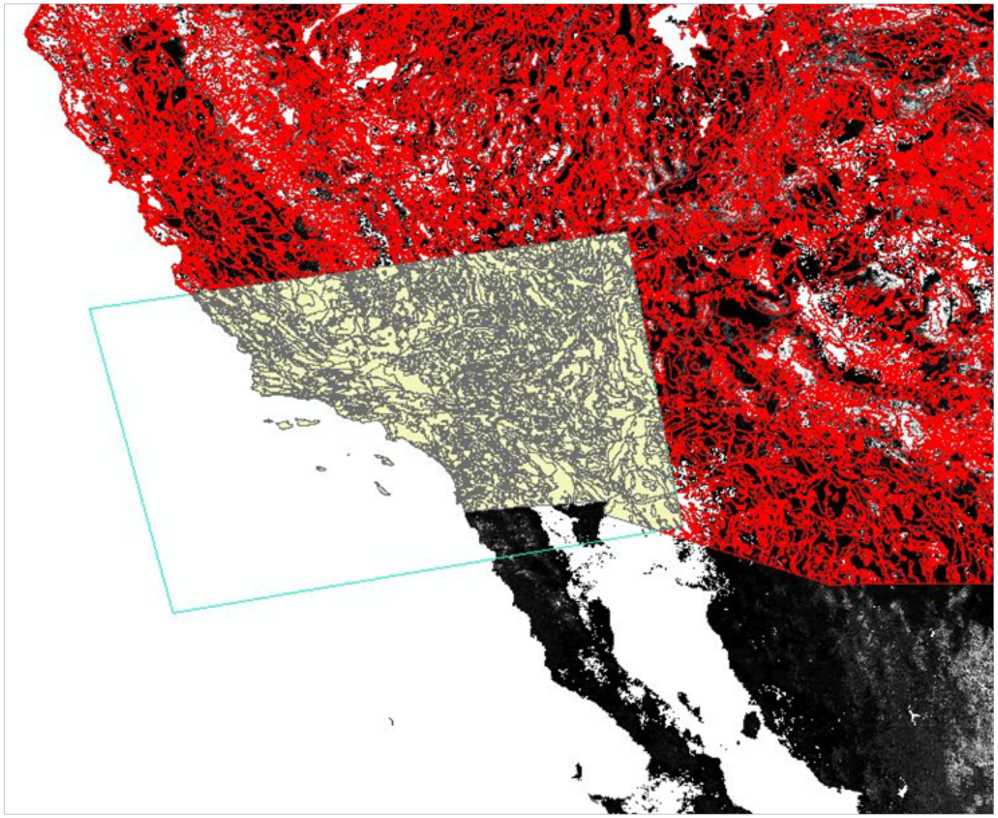
Typical Regional Air Quality Modeling Framework



Regional Pollen Modeling Framework



The MEGAN model



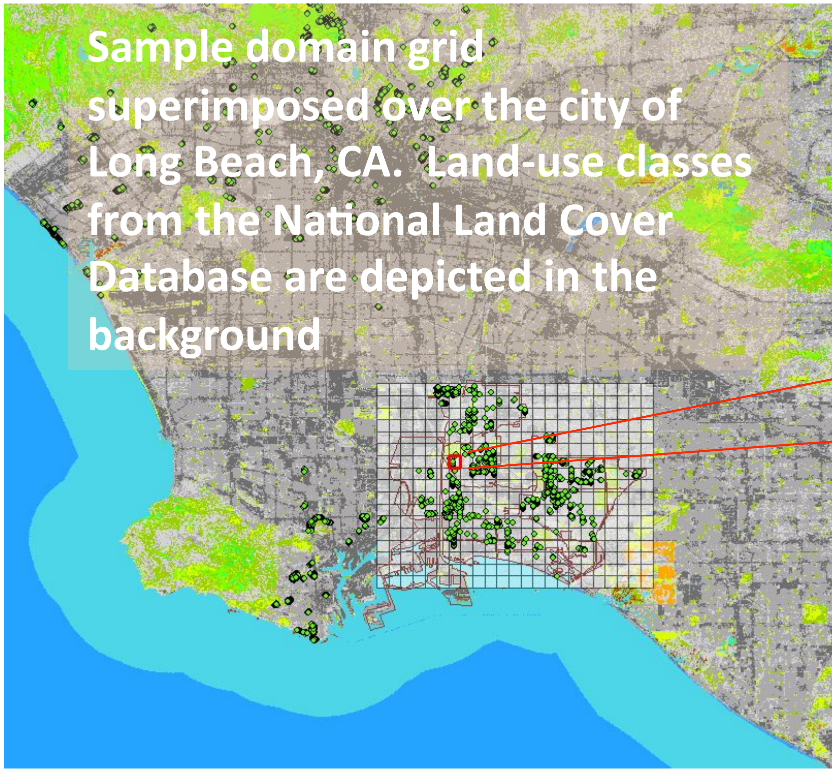
$$\gamma = \gamma_{CE} \cdot \gamma_{age} \cdot \gamma_{SM}$$

- MEGAN estimates emissions of non-methane biogenic volatile organic compounds (BVOC) using vegetation species distribution and density information

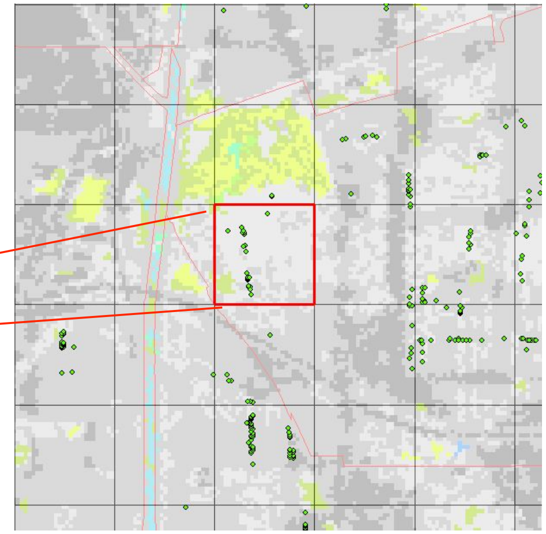
$$\text{Emission}=[\varepsilon][\gamma][\rho]$$

- ε = emission factor
- γ_{age} = effect of leaf age
- γ_{CE} = within-canopy conditions
- γ_{SM} = effect of soil moisture

Urban tree and non-tree vegetation cover determination

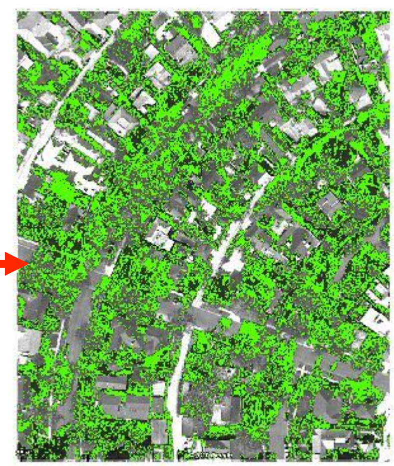


A.

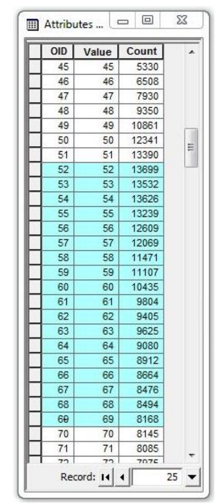


(A) Grid cells representing pure land use classes are randomly selected for characterization, then exported to Google Earth®

B.



C.



Attributes ...

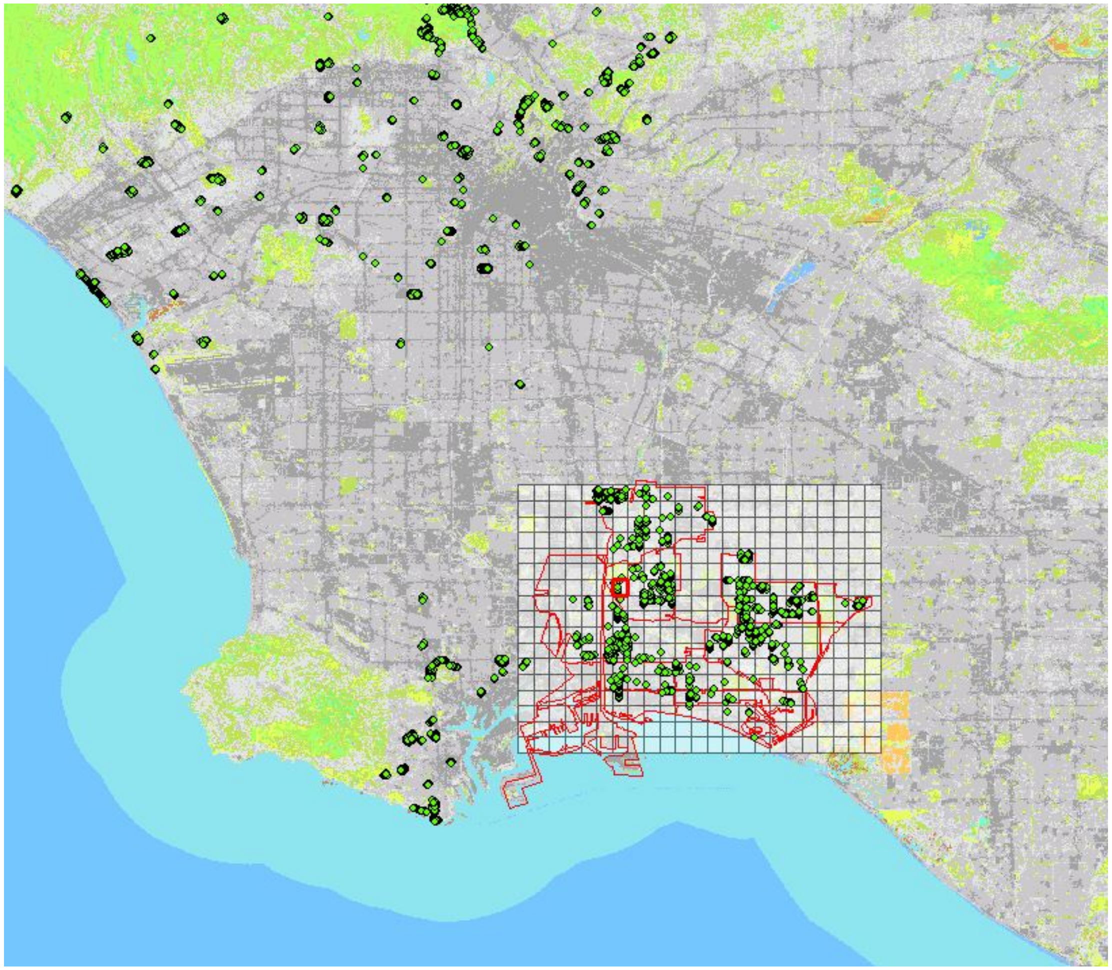
OID	Value	Count
45	45	5330
46	46	6508
47	47	7930
48	48	9350
49	49	10861
50	50	12341
51	51	13390
52	52	13699
53	53	13532
54	54	13626
55	55	13239
56	56	12609
57	57	12069
58	58	11471
59	59	11107
60	60	10435
61	61	9804
62	62	9405
63	63	9625
64	64	9080
65	65	8912
66	66	8664
67	67	8476
68	68	8494
69	69	8168
70	70	8145
71	71	8085

Record: 25

(B) The Google Earth® images are then captured and imported into a digital image processor, where individual pixels are reclassified as tree, non-tree vegetation, or other cover

(C) The vegetated fraction is estimated for all relevant urban land use classes in the domain

Urban tree species composition determination



- National Agricultural Statists Service cropland data
- Forest inventory Analysis Data
- Municipal urban tree inventories
  - Long Beach
  - Los Angeles

Model approach to parameterize pollen release: Trees and perennial species

- Based on García-Mozo et. al, (2002)
- Temperature
- Degree days (DD) above a threshold temperature → onset of pollen season for a given species

To be developed:

- Pollen potential model
  - How much pollen is produced?
- Parameterize the release process as affected by
  - Precipitation (which will stall pollen release
  - Relative humidity excursions
  - High wind events (which will accelerate release)

Model approach to parameterize pollen release: Annual species

ID	Plant Symbol	Scientific Name	Common Name	Mapunit Key
363245	AVFA	Avena fatua	wild oat	660482
363246	ERODI	Erodium	filaree	660482
363234	ARCTO3	Arctostaphylos	manzanita	660482
363235	ELGL	Elymus glaucus	blue wildrye	660482
363240	UNKNOWN	unknown scientific name	ripgut brome	660482
363231	TRIFO	Trifolium	clover	660482
363248	BRMO2	Bromus mollis	soft chess	660482

Species distributions and potential productivity data obtained using Natural Resources Conservation Service rangeland data. The figure on the left illustrates one NRCS polygon (highlighted in red) near the example domain used previously. The table below the image contains non-tree species composition information for the selected polygon

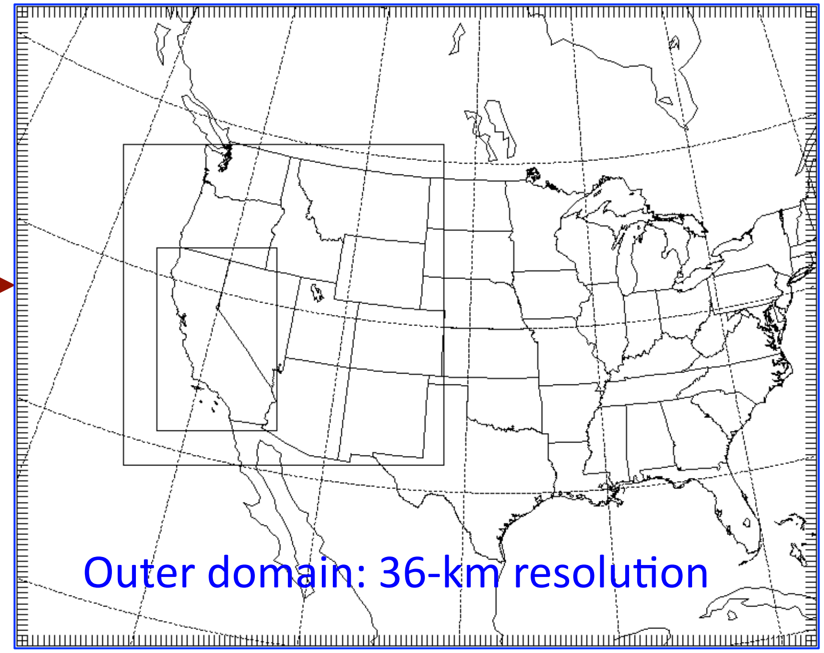
Pollen release from annuals is driven by precipitation & temperature, using observations taken from ragweed as an initial model species

Possible later phases:

- Differing parameterizations for plants that bloom in spring, summer, fall

Potential Simulation Setup for Model Evaluation

Global NCEP
GFS Final
Analysis
Output @ 1^{o}
& 6-hourly



- March – June, 2010 (CalNex field study period)
- Nested WRF simulations at 36-, 12-, and 4-km resolution
    - Takes ~ 4 days of compute time and ~2 TB of disk space
- MCIP simulations at 4-km resolution
    - Takes ~1 day of compute time and ~450 GB of disk space
- MEGAN at 1-km or even finer resolution, but sum emissions to 4-km grids
    - ~1 GB to store emissions at 4-km grids in CMAQ-ready format
- CMAQ simulations at 4-km resolution
    - ~few days of compute time and < a few GB of disk space

Summary

- Develop models of pollen and pollen antigen exposure
  - Retrospective analysis to determine
    - Dose response functions
    - Pollen potential
    - Pollen release dynamics
    - Respirable antigen release dynamics
- Integrate with air quality models
- Model exposures and health effects in future climate scenarios
- Leverage EPA support