Integration of Airborne Aerosol Prediction Systems and Vegetation Phenology to Track Pollen for Asthma Alerts in Public Health Decision Support Systems

Jeffrey C Luvall Marshall Space Flight Center

William A. Sprigg, Alfredo Huete, Goran Pejanovic, & Slobodan Nickovic
University of Arizona,

Heide Krapfl
Environmental Health Epidemiology Bureau, NM Department of Health

Amy Budge Earth Data Analysis Center, Alan Zelicoff, Dept of Family &
Community Medicine, Orrin Meyers University of New Mexico

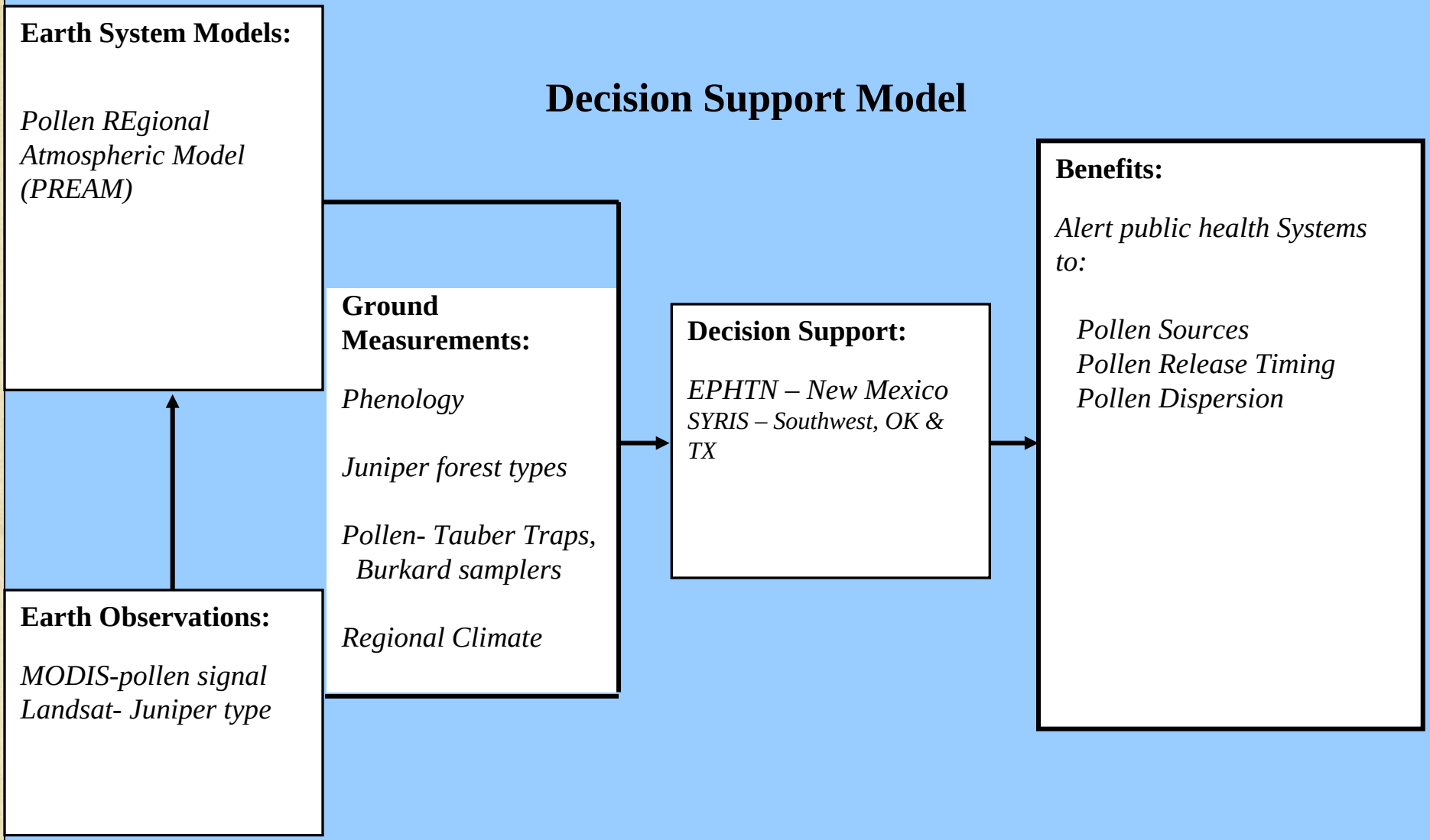
ARES Corporation

Peter K. Van de water California State University, Fresno

Estelle Levetin Dept. Biology University of Tulsa

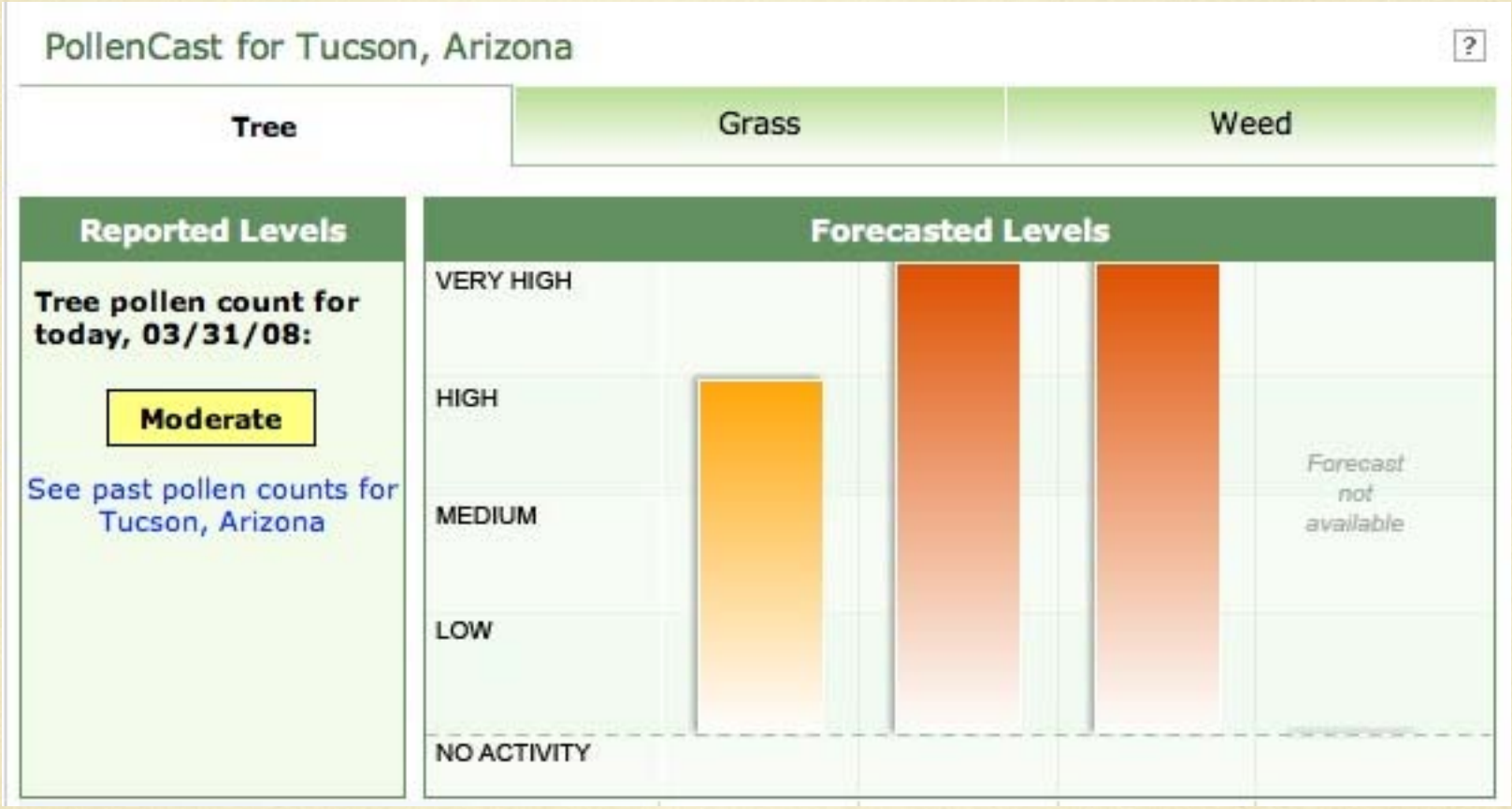
Mark Losleben & Jake Weltzin USGS National Phenology Network

Decision Support Model



Limitations of Pollen Sampling

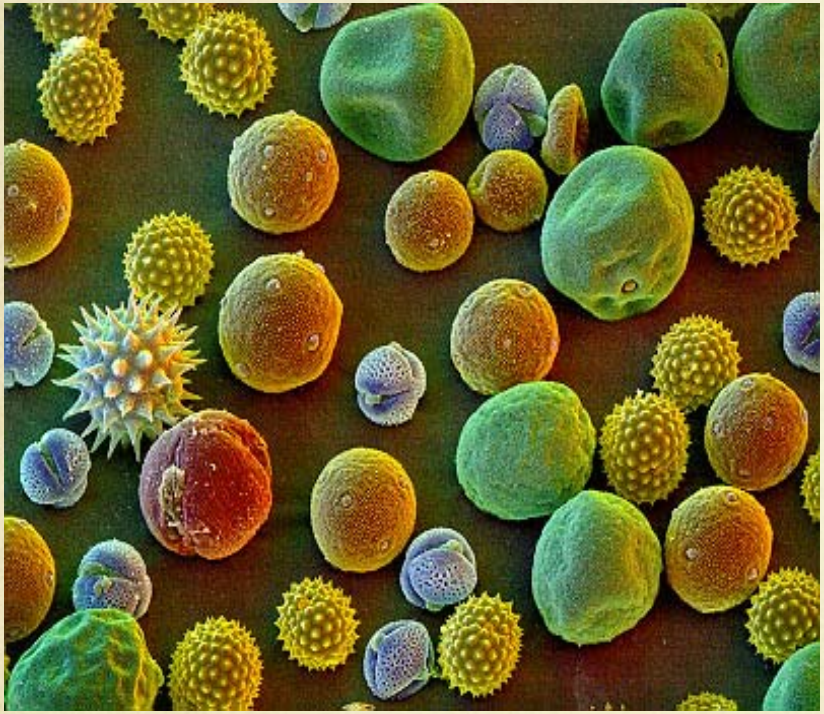
- Lack of stations
- Count frequency & reporting lag time
- Different sampling instruments Rotorod Sampler/Burkard Spore Trap
- Only indentifiable pollen "grains"
- Expertise in counting/indentification
- Refusal to release sampling information-"*We do not reveal the sources for our data for privacy and proprietary, competitive reasons. Some pollen counts are conducted privately, and are not meant to be broadcast to the public*"


PollenCast for Tucson, Arizona
?
Tree
Grass
Weed
Reported Levels
Tree pollen count for today, 03/31/08:
Moderate
See past pollen counts for Tucson, Arizona
Forecasted Levels
VERY HIGH
HIGH
MEDIUM
LOW
NO ACTIVITY
Forecast not available

Pollen Timing

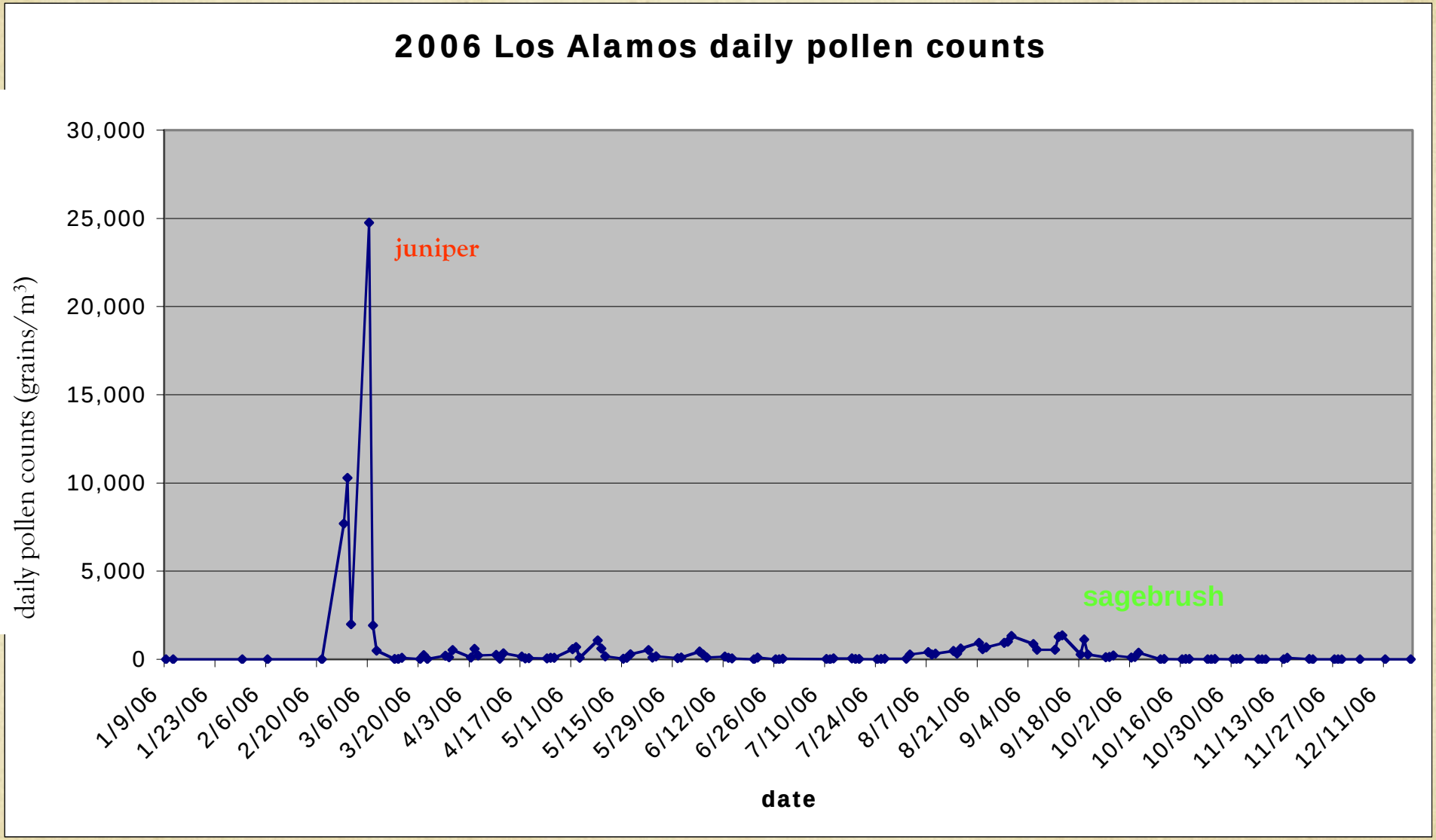
- Growing Degree Days - the average of the daily maximum and minimum temperatures compared to a base temperature, T_{base}, (usually 10 °C)
- Response to length of day
- Phenology- first bud break observations
- Climate
- Weather
- Species differences

Top pollen-producing species



Los Alamos	Albuquerque
juniper	mulberry
sagebrush	juniper
pine	ash
Alternaria*	goosefoot
oak	cottonwood
grass	grass
ragweed	sagebrush
goosefoot	pine
Cladosporium*	elm
Myxomycete*	aster
cottonwood	ragweed
mulberry	sycamore
aster	oak
elm	willow

*fungal / slime mold spores


2006 Los Alamos daily pollen counts
daily pollen counts (grains/m3)
30,000
25,000
20,000
15,000
10,000
5,000
0
juniper
sagebrush
1/9/06
1/23/06
2/6/06
2/20/06
3/6/06
3/20/06
4/3/06
4/17/06
5/1/06
5/15/06
5/29/06
6/12/06
6/26/06
7/10/06
7/24/06
8/7/06
8/21/06
9/4/06
9/18/06
10/2/06
10/16/06
10/30/06
11/13/06
11/27/06
12/11/06
date

Top pollen-producing species and their pollen/spore sizes

SPECIES	SIZE (µm)
Myxomycete*	5-15
Cladosporium*	16-18
Alternaria*	15-90
mulberry	15-25
aster	18-25
ash	18-28
ragweed	19-20
sagebrush	19-24
juniper	20-30
oak	20-35
grass	20-100
goosefoot	20-35
willow	24
cottonwood	25-35
elm	25-35
pine	45-85

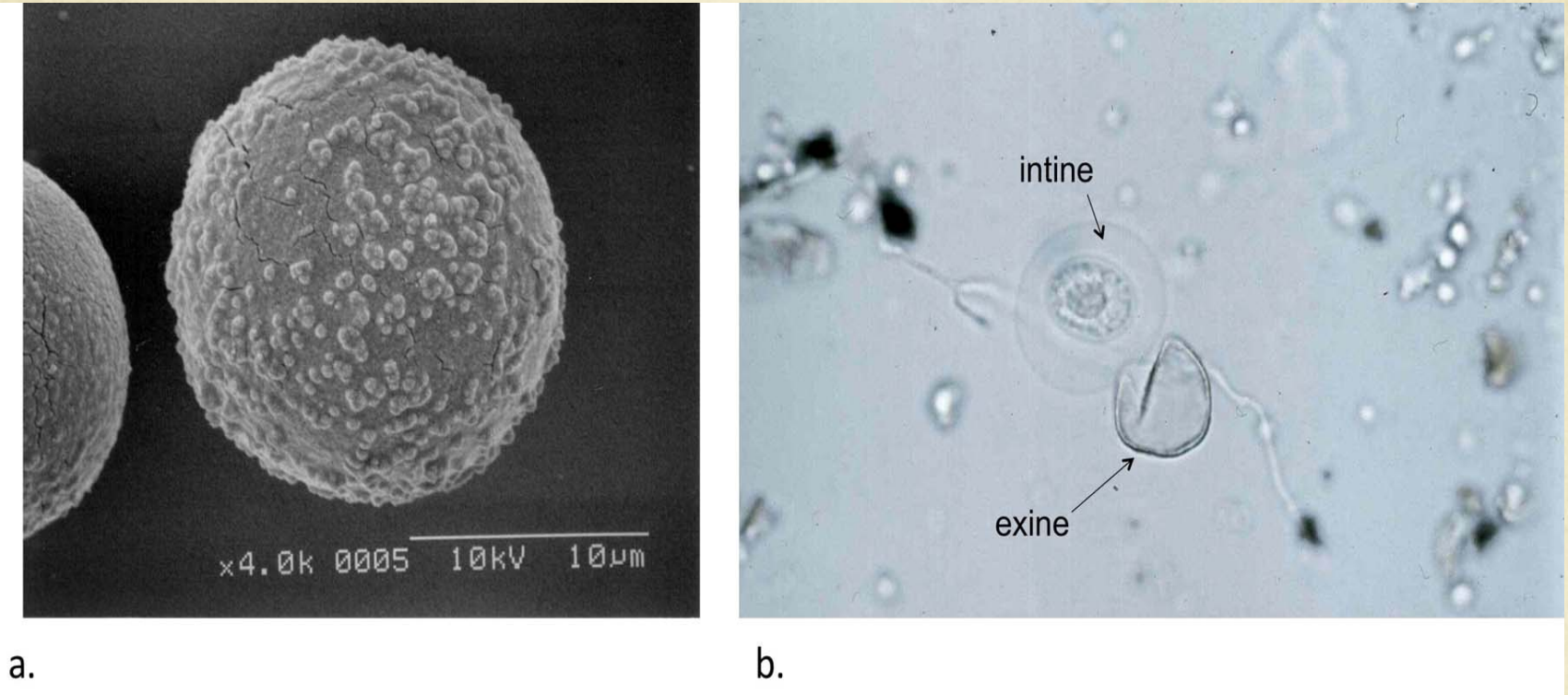


Fig. a. Juniperus virginiana pollen grain. b. Response of Juniperus sp. pollen grain to hydration were the interior germ plasma (intine) separates from the outer wall (exine).

Pollen and Respiratory Disease: What little is known[2]

Increase in mortality of these disorders:

	Poaceae pollen concentrations (grains per m³ air)			
	<22	22–77	78–135	>135
	Relative risk	Relative risk (95% CI)	Relative risk (95% CI)	Relative risk (95% CI)
Cardiovascular disease	1·000	1·015 (1·002–1·029)	1·012 (0·994–1·029)	1·061 (1·038–1·084)
Chronic obstructive pulmonary disease	1·000	1·095 (1·053–1·139)	1·124 (1·069–1·181)	1·150 (1·079–1·225)
Pneumonia	1·000	1·104 (1·049–1·163)	1·093 (1·023–1·168)	1·168 (1·077–1·266)
Total	1·000	1·019 (1·010–1·028)	1·019 (1·008–1·031)	1·043 (1·028–1·058)

- High concentrations of pollen allergens have also been shown to occur in thoracic particles (<10 microns in diameter) and respirable particles (<2·5 microns and these correlated well in time with airborne pollen concentrations. … airborne pollen results in exposure of the lower airways and lung to pollen allergens.

- The association between air pollution and the number of daily deaths may be related to the inflammatory potential of very small particles

- …suggests that high airborne pollen concentrations, which nowadays are mainly seen as triggers of allergic symptoms, may have far more serious effects than previously thought."

[2] Bert Brunekreef, Gerard Hoek, Paul Fischer, Frits Th M Spieksma. Relation between airborne pollen concentrations and daily cardiovascular and respiratory-disease mortality. Lancet Vol 355 (2000): 1517-8.

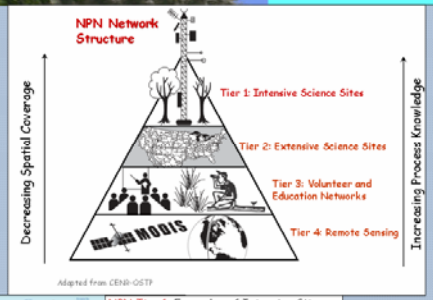
March 2008

PHENOLOGY as an INTEGRATIVE SCIENCE for ASSESSMENT of GLOBAL CHANGE IMPACTS

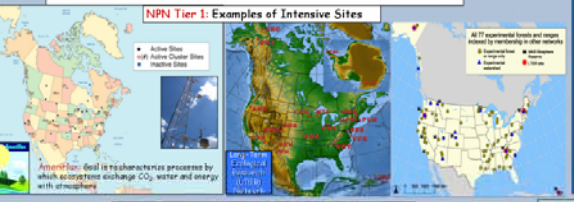
Jake F. Weltzin and Mark Losleben

USA National Phenology Network, National Coordinating Office, Tucson, Arizona

NPN Network Structure



NPN Tier 1: Examples of Intensive Sites



Tier 2: Example of Spatially Extensive Science Network

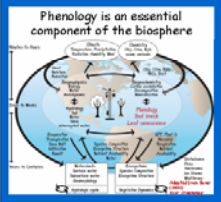
USA-NPN Observers

Tier 3: Volunteer & Education Networks: Citizen Science, Education, and Outreach

Why employ citizen scientists?

- Distributed data collection network
- Casual observers become dedicated observers
- Engagement in meaningful activities
- Education/awareness engenders science literacy
- Generation of political/policy support
- Historic/baseline data (pre-network)
- Potentially rich datasets collected by individuals

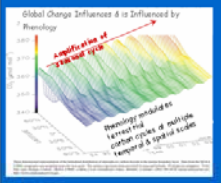
A National Phenology Network

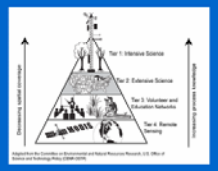


Phenology is the study of periodic plant and animal life cycle events and how these are influenced by seasonal and interannual variations in climate. Examples include the timing of leafing and flowering, agricultural crop stages, insect emergence, and animal migration. All of these events are sensitive measures of climatic variation and change, are relatively simple to record and understand, and are vital to both the scientific and public interest.

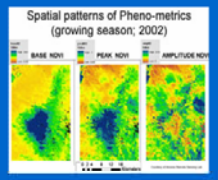
Phenology can be used as a predictor for a variety of processes and variables of importance at local to global scales. Phenology modulates the abundance and diversity of organisms, their inter-specific interactions, their ecological functions, and their effects on fluxes in water, energy, and chemical elements at various scales. Phenological data and models are useful in agriculture, drought monitoring, and wildfire risk assessment, as well as management of invasive species, pests, and infectious diseases. **Integration of spatially-extensive phenological data and models with both short and long-term climatic forecasts offer a powerful agent for human adaptation to ongoing and future climate change.** To fully utilize the value in phenological data, however, a new data resource is required – *a large-scale network of integrated phenological observations, linked with other relevant data sources, and the tools to analyze these data at multiple scales.*

A USA National Phenology Network (USA-NPN) is currently being designed and organized to engage federal agencies, environmental networks and field stations, educational institutions, and mass participation by citizen scientists.





Spatial patterns of Pheno-metrics (growing season; 2002)



PHENOLOGY: THE PULSE OF OUR PLANET

USA-NPN Collaboration Plan

GOALS

-To advance the USA-NPN scientific mission to understand and predict shifts in phenological cycles due to climate change and natural variability.

-benefit from and contribute to many existing organizations that are concerned about nature and climate.

-Maximize resources through close collaboration with organizations. This represents not only the best use of available resources but also the best scientific practice.

PLAN

-Coordinate research activities with existing networks to advance phenological science and develop mechanistic phenological models to support improvement of climate and ecosystem models.

-Maximize the representation of phenological monitoring sites at the national and regional scale to enable biological baseline characterization and trend detection.

- Provide data and information to policy makers to support land management decisions in regard to the mitigation of climate change impacts.

PRIORITIES

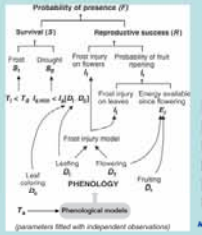
- Establish coordination between NPN and existing networks
- Identify constraints and needs of existing networks and develop tailored collaborative items suitable for each network
- Nurture common interests/develop collaborative research projects
- Organize joint workshops
- Distribute NPN newsletters

PRINCIPLES

- Mutually beneficial activities
- Shared vision on science / education / outreach
- Minimizing the demand on the capacities of partners
- Feedback to improve collaboration
- Transparent data and information sharing policy

Integration of spatially-extensive phenological data and models with both short and long-term climatic forecasts offer a powerful agent for human adaptation to ongoing and future climate change.

PHENOFIT: A process-based tree distribution model

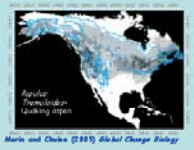


What you need to know to run model:

phenology: budburst, flowering, fruit maturation, leaf coloring

frost hardiness: minimum temperature sustained during active growth and dormancy

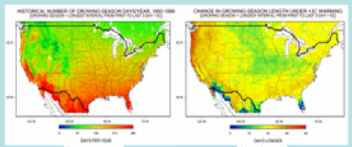
drought tolerance



Mario and Chaine (2005) Global Change Biology

Mean length of historical (1950-1999) growing season, defined as the longest interval in a given year with no daily mean temp. in 3-day periods < 5°C

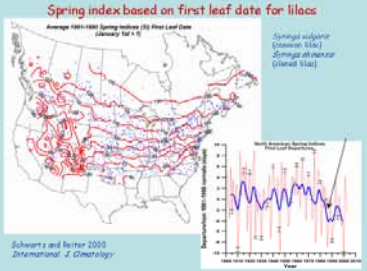
Different sensitivities with uniform 3°C warming, probably due to relative importance of advective vs. radiative freezing



Historical data from Variable Infiltration Capacity model input fields (Maurer et al., 2002)

Courtesy of Mike Dettinger, USGS

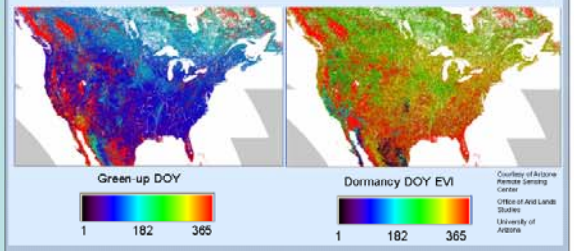
Spring index based on first leaf date for lilacs



Schwartz and Reiter 2000 International J. Climatology

Phenology influences interactions among organisms

NPN-Tier 4: REMOTE SENSING can fill gaps between ground observations to produce a continuous surface of phenology estimates at the continental scale



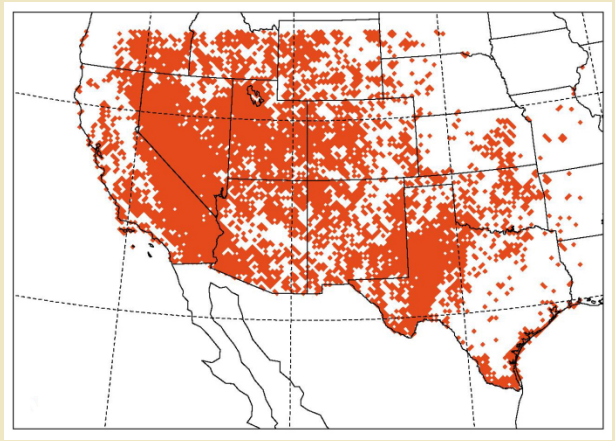
NATIONAL PHENOLOGY NETWORK (USA-NPN)
NATIONAL COORDINATING OFFICE
1955 E. Sixth Street
Tucson, AZ 85719
FAX 502-621-3816
www.usanpn.org

Jake Weltzin
Executive Director
jweltzin@usgs.gov
520-626-3821

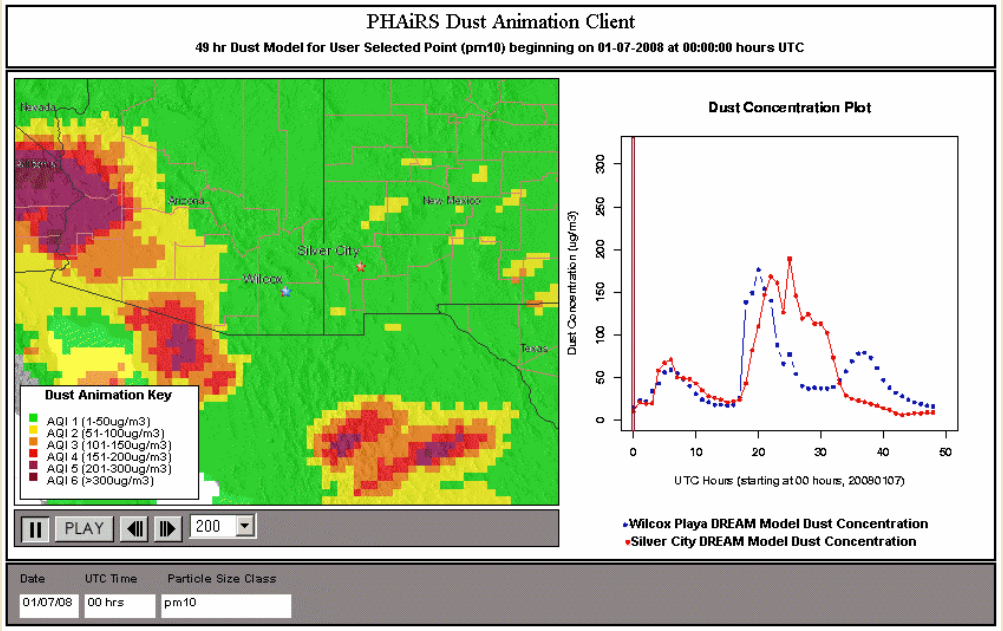
Mark Losleben
Assistant Director
losleben@email.arizona.edu
520-626-4696

Phenology and Pollen Transport

NASA Remote Sensing



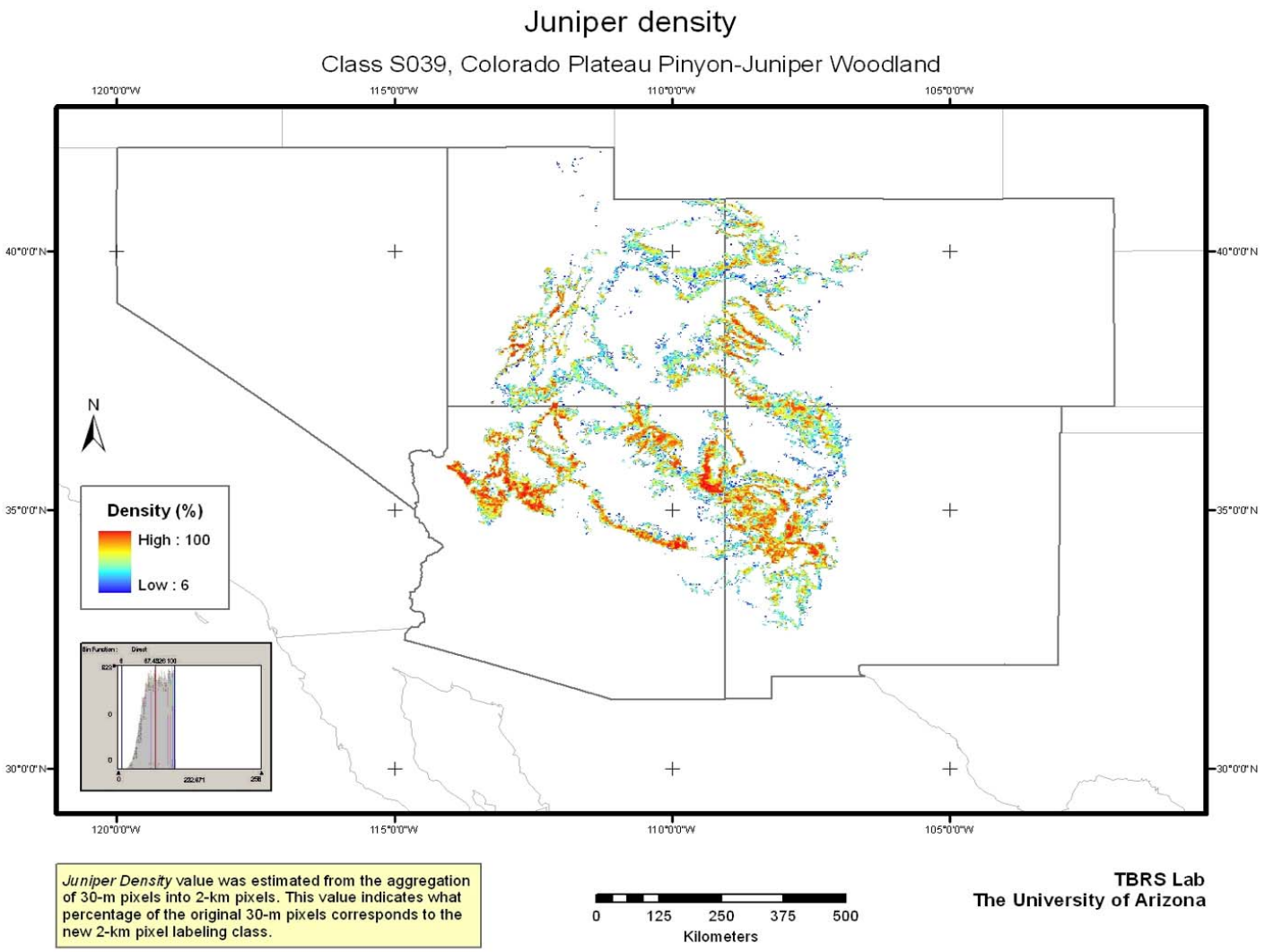
DREAM – UofA numerical meteorological particulate transport model



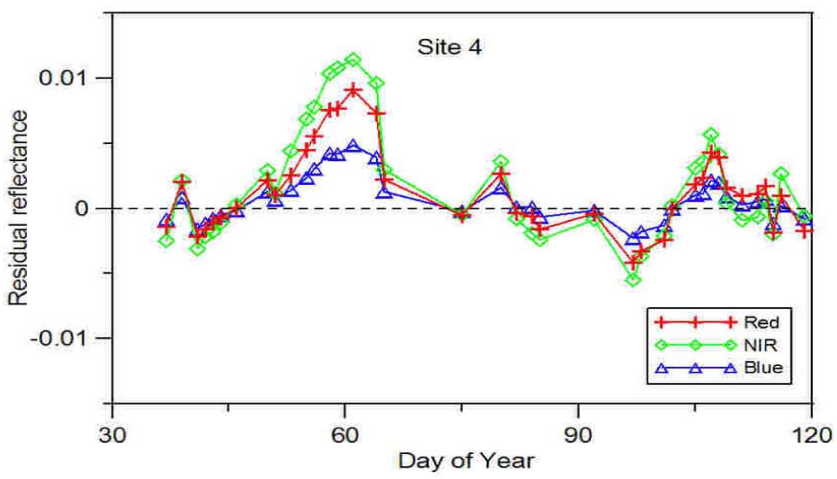
Currently – dust source regions
Future – pollen sources derived from phenological maps

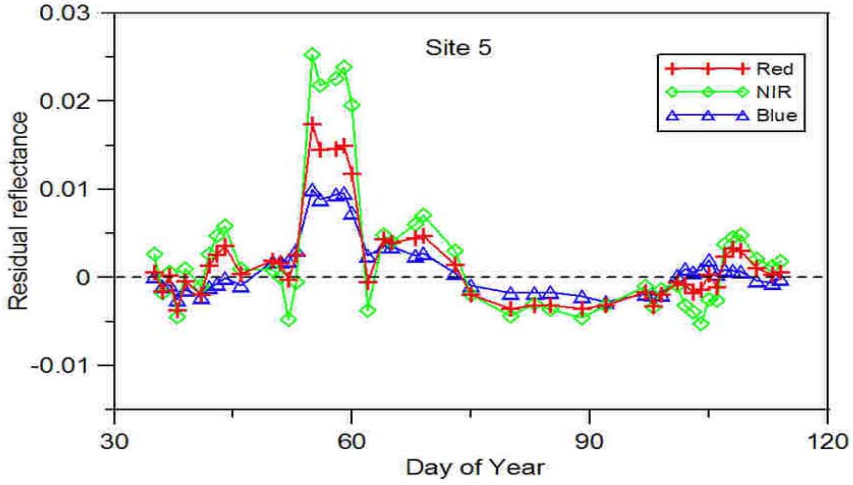
Final Product – predicted concentrations of pollen in time and space

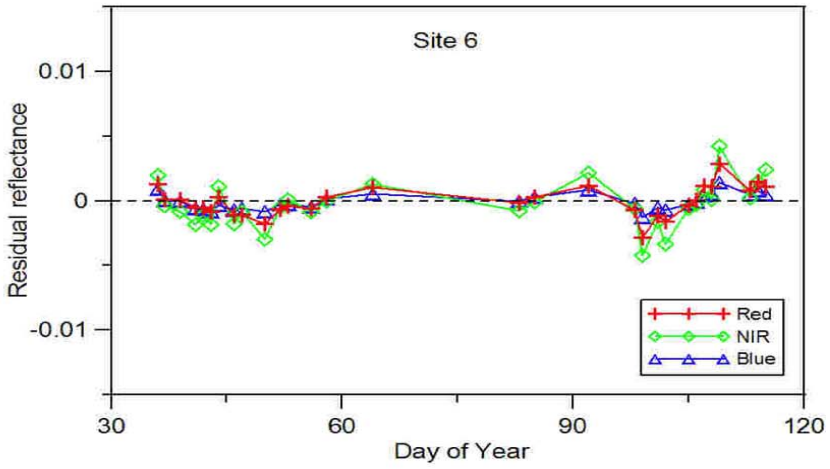
http://www.atmo.arizona.edu/research/dust/dust.html

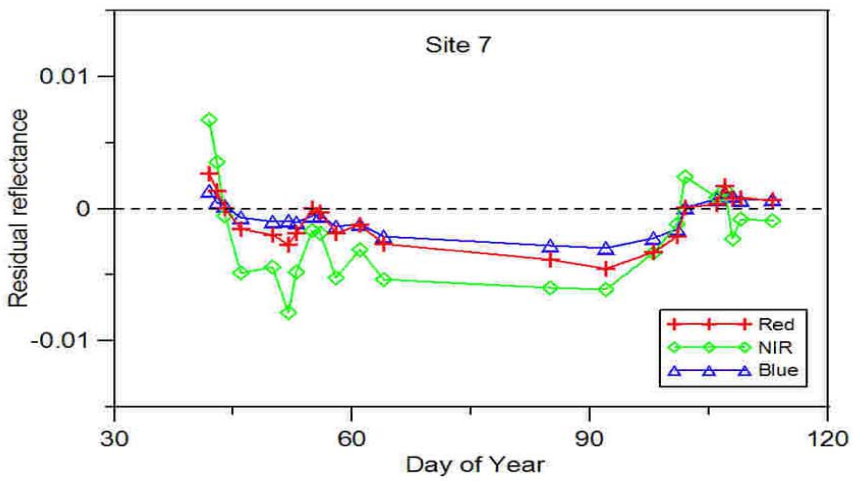


Percent Juniper density for land cover class SO39.

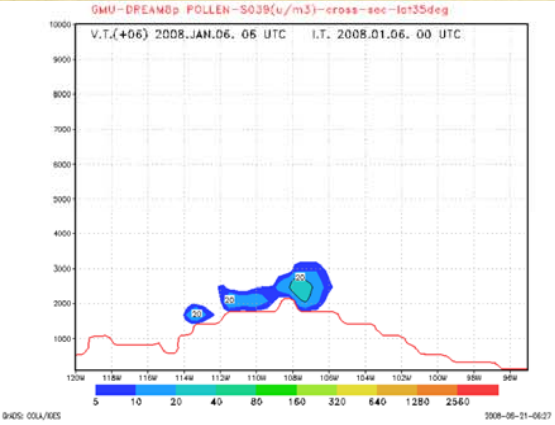




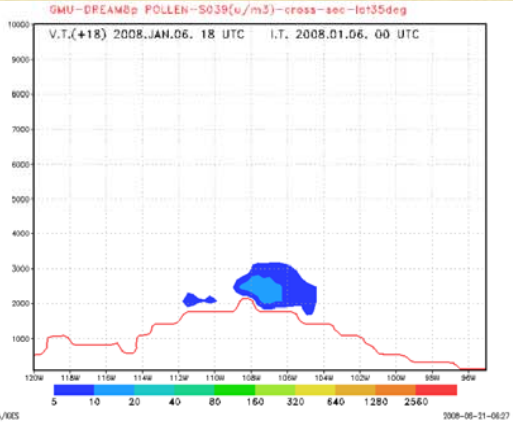




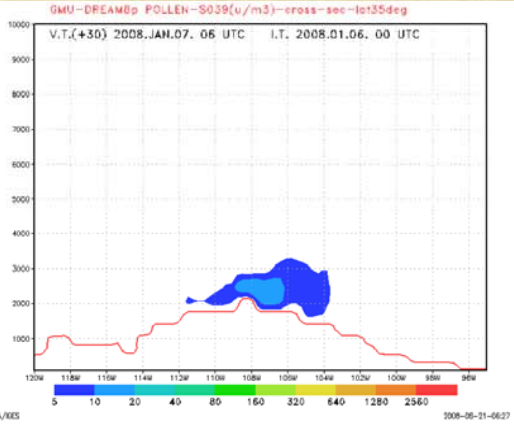
Temporal profiles of residual MODIS reflectances at the four study sites.



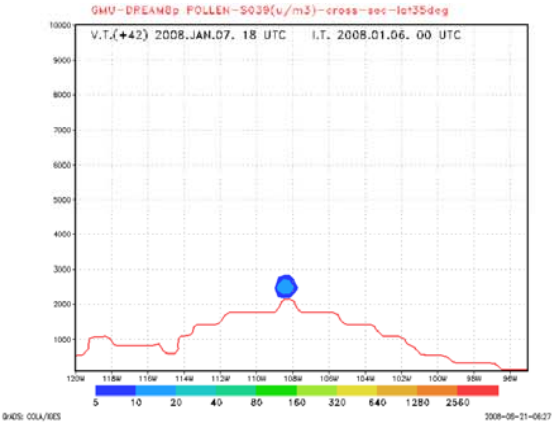
6 Jan 2008 + 06hr



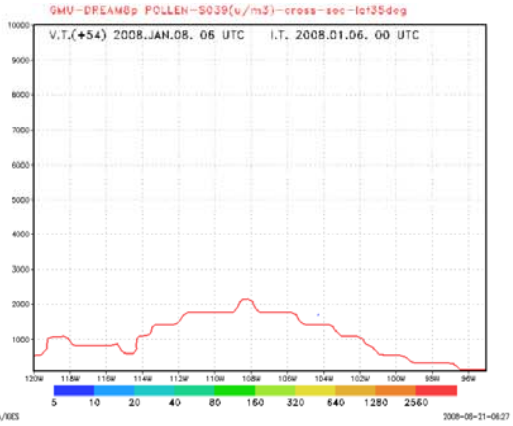
6 Jan 2008 + 18hr



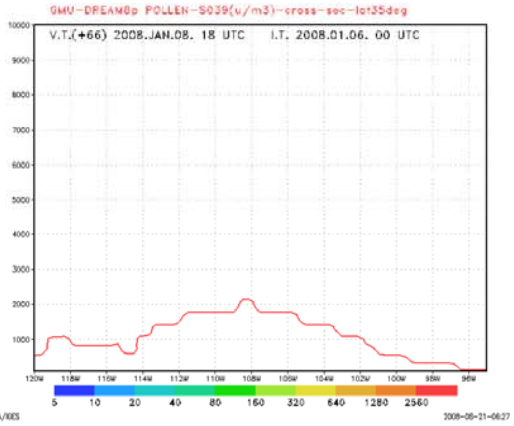
6 Jan 2008 + 30hr



6 Jan 2008 + 42hr



6 Jan 2008 + 54hr

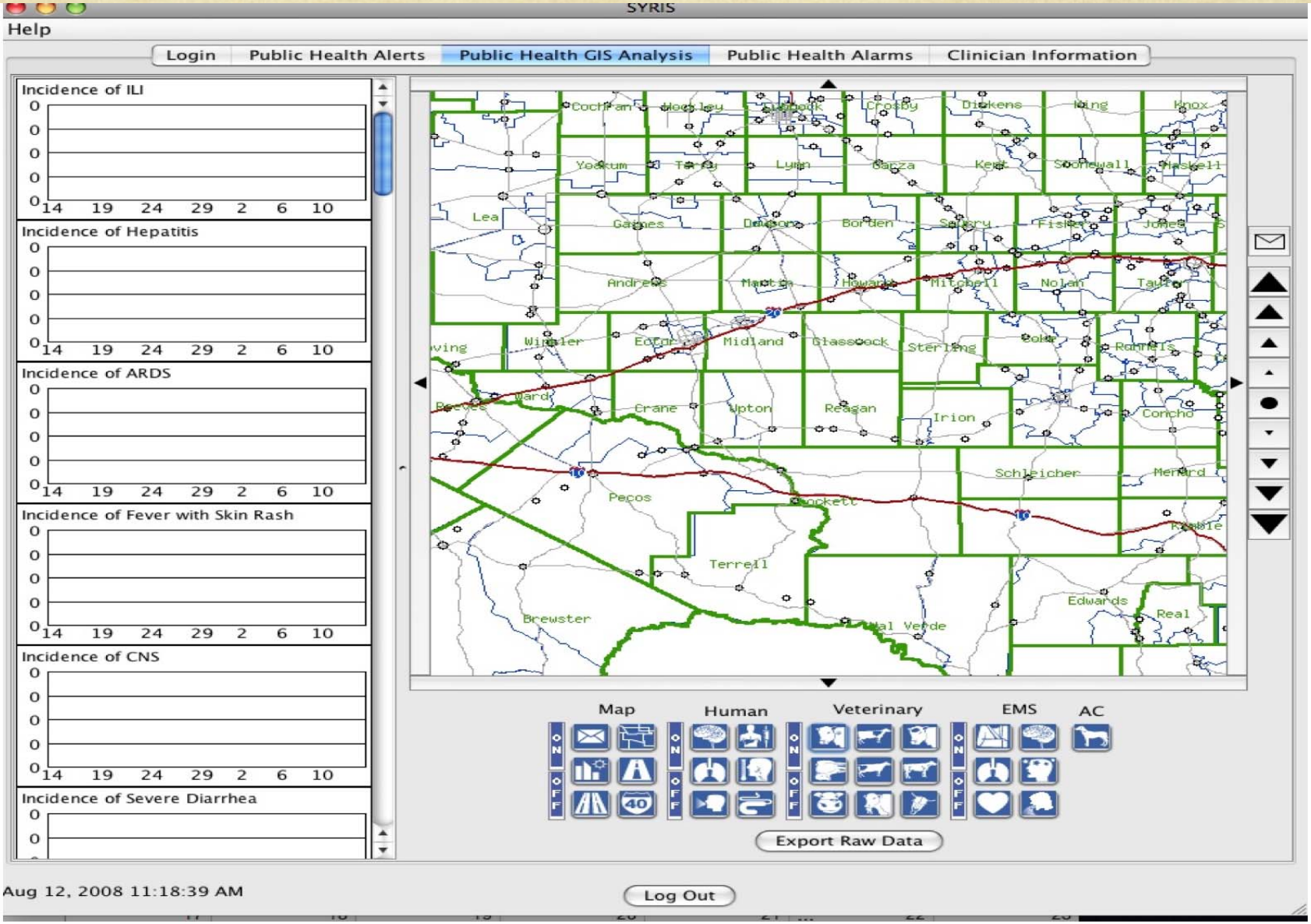


6 Jan 2008 + 66hr

Pollen concentration simulation for the S039 juniper class; section crossing at 35 deg N

The SYRIS system provides:

- Real-time, Syndrome-Based Reporting Tool
- 2-Way Real-time Communication System - 24/7
- Automated, Immediate 'Alerts' to Public Health Officials (PHO's)
- Health 'Alerts' to Vets, Doctors, Hospitals, & Schools
- Web-Based Tool for Easy Syndrome Entry and Communication
- Geographic Mapping of Disease Outbreaks
- Connects All Health Care Providers to a Common Database
- Instantaneous Geographic Mapping of Disease Outbreaks
- Full compliance with the requirements of Public Law 109-417 (the Pandemic and All-Hazards Preparedness Act)



SYRIS will be used by Public Health Officials for interactive display of PREAM pollen maps, syndrome reporting and alerts

Source Questions:

Pollen emission is controlled mainly by near-surface atmospheric conditions. Critical questions about pollen release and transport needed to be addresses to provide necessary data for verifying and validating PREAM inputs and outputs.

✧ What are the meteorological conditions that promote continual pollen release?

✧What is the quantity and pollen size distribution at time of release?

✧What is the effect of hydroscopic and weight gain on transport?

✧How can we verify our estimates of pollen production and transport?

✧What is the size and density of juniper populations? What is the percent of male trees in the population?

✧What percent of pollen is deposited beneath the tree and never entrained in the atmosphere?

Project Participants	Organizational Roles	Responsibilities
Luvall & Sprigg	MSFC- PI, UA science PI	Overall project science, model developement & application management
Losleben, Levetin, Van de Water	Nat'l Phenology Network Univ. Of Tulsa, California State Univ. Fresno	Juniper pollen data collection/analyses
Nickovic, Pejanovic	Consultants	DREAM & PREAM modeling
Levetin, Zelicoff	Univ. of Tulsa, UNMSM	Allergist contact
Huete, Luvall	UA, NASA	ESR data management & assimilation
Hudspeth, Budge	UNM Earth Data Analysis Center	Develop & test new inputs to PHAiRS client server and WMS system; Project reporting and documentation
Krapfl, Myers, Zelicoff	NMDOH, UNMSM and ARES Corp.	Defining end user products; Transitioning to end users, SYRIS

Year 1 Deliverables

Pollen Sampling Activities

Identification of Juniper communities – *Juniperus asheii Dec09, Juniperus sp. Feb-Nov*
Pollen timing concentrations/size distributions - Tauber Traps & Burkard samplers
Humidity effects on pollen weight/extine separation
ID & Obtain pollen count data from creditable sources

Remotely Sensed Data

Track phenology to ID pollen formation (MODIS)
Identification of Juniper communities (Landsat, GAP data)
Spectrometry measurements from of Juniper pollen phenology.

DREAM Modeling

Pollen size distribution characterization
Surface pollen concentrations
Humidity effects on weight
Spatial /time resolution
Parameterization & Optimization

Public Health Supp*ort*

Modification of SYRIS to accept pollen tracking data
Preliminary data products for EPHTN
Recruitment of allergists for SYRIS
Hospital records for asthma and COPD