Public Health Applications For Remote Sensing and Atmospheric Modeling

William A. Sprigg

The University of Arizona

For

The Institute of Atmospheric Physics

Chinese Academy of Sciences

Beijing, September 2006

Predicting Airborne Particulate Concentrations For Public Health Decision Making

Beijing, April 17, 2006

Lubbock, December 16, 2003

OUTLINE

- The Problem: Respiratory and Cardiovascular Disease
- Simulating & Predicting Airborne Dust With Weather Models & Remote Sensing Improvements
- Case Studies
- Future Applications

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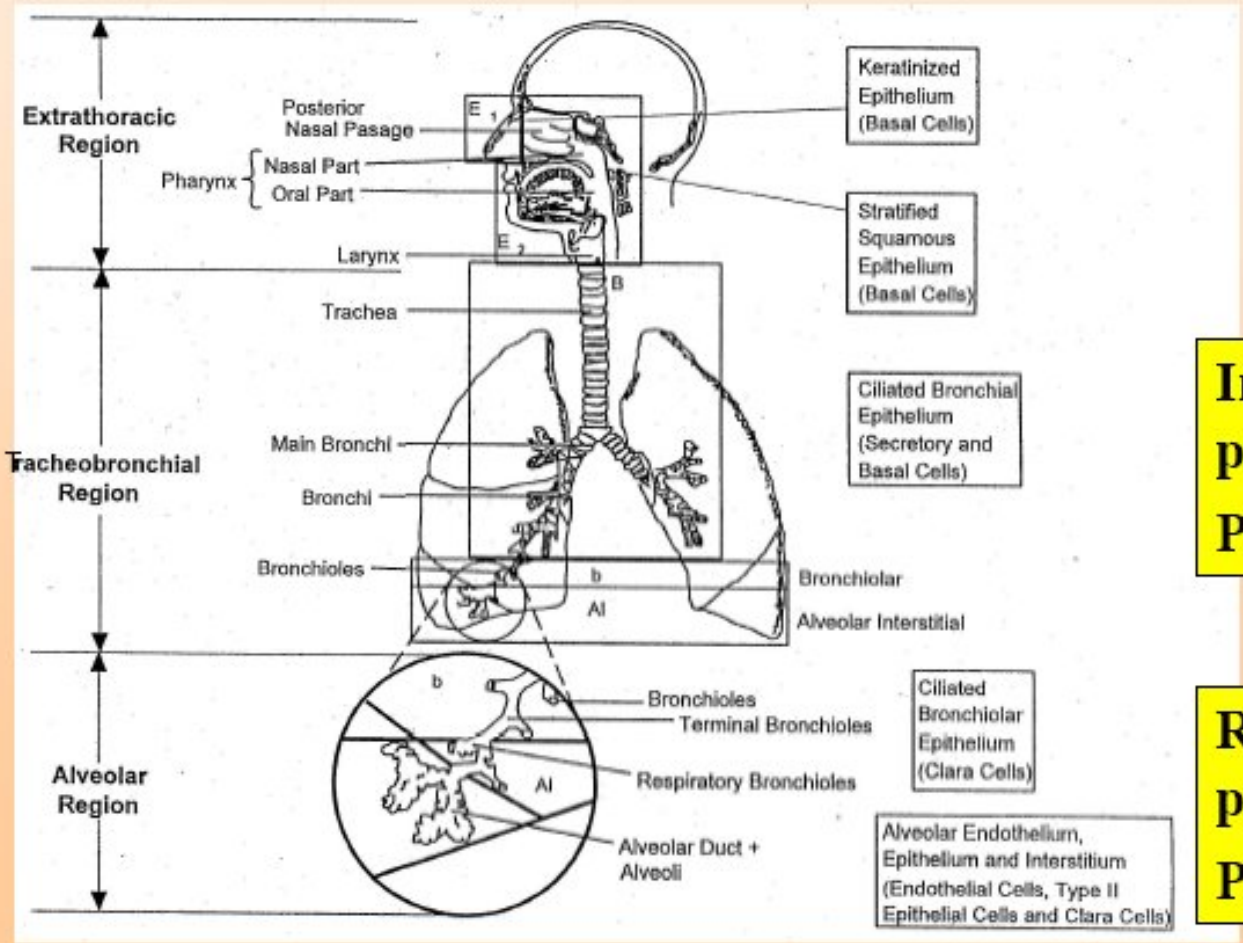
Working for public health!



Inhalable particles: PM_{10}

Respirable particles: $PM_{2.5}$

(Picture courtesy of Mike Moran)

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Valley Fever

- Valley fever caused by soil-dwelling fungi
- Fungus responds to weather & climate
- When fungal spores become airborne and are inhaled, infection may occur
  - Flu-like symptoms (fever, cough, etc.) in early stages
  - May move from lungs to other parts of body
- Range of cases
  - Asymptomatic/Inapparent - 60%
  - Mild to Moderate - 30%
  - Complications - 5% to 10%
  - Fatal - less than 1%
- Regional mortality/morbidity
  - 2004 severe cases: AZ = 3665, USA = 6056
  - Deaths: 6-10% of reported cases (estimated in AZ)

Adapted from Andrew Comrie

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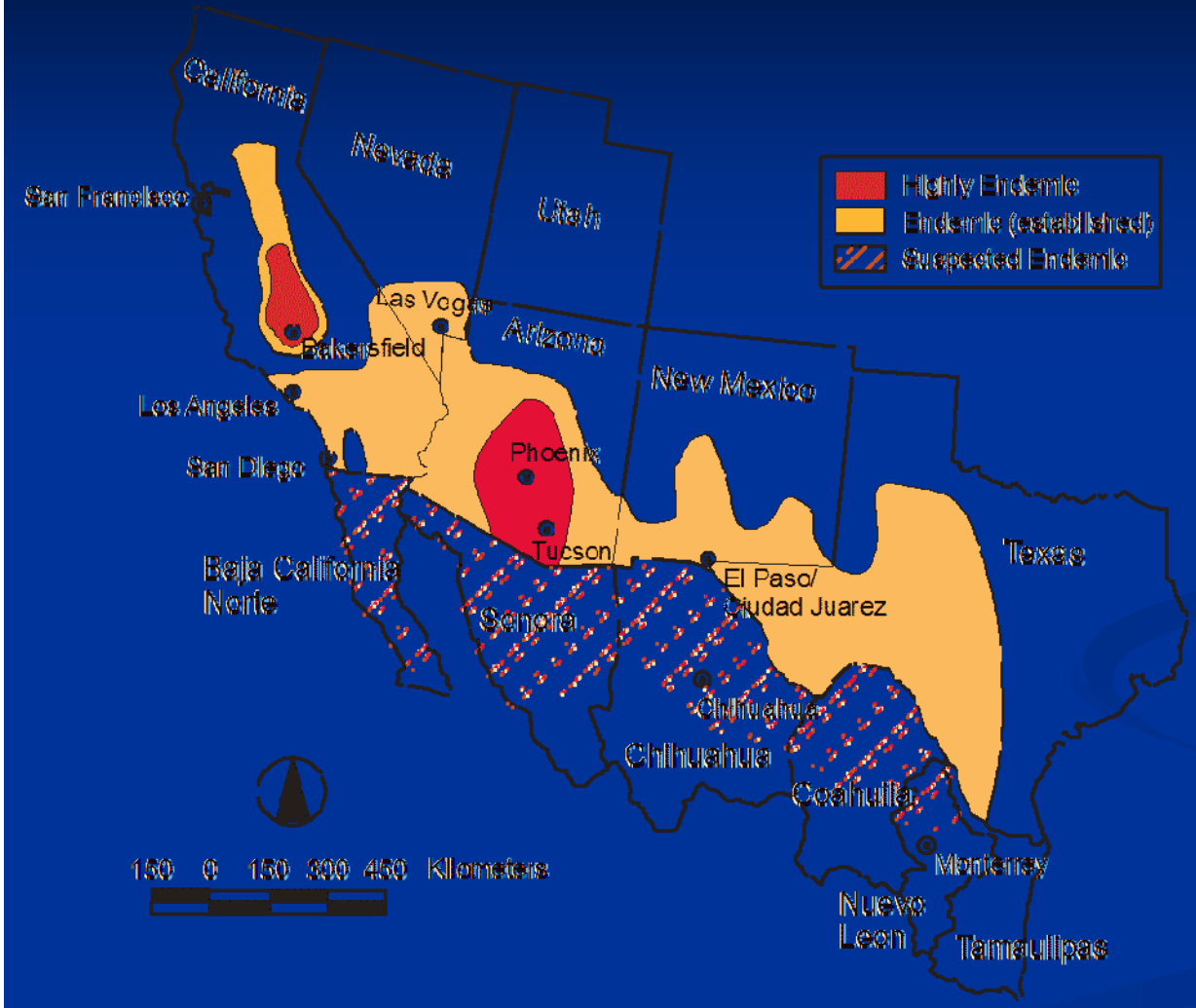
Valley Fever Endemic Zone



From Andrew Comrie

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- **Objective:** an operational (dust) forecast system for human health decision support
- **Principles:**
  - Numerical models, for objectivity & multiple use
  - NWS models, for world-wide use & operational continuity
  - Satellite sensors, to cover the globe
  - High resolution, for greater accuracy
  - International, for an intercontinental problem
  - Public Health Advisors, for practical design

Public Health Applications in Remote Sensing

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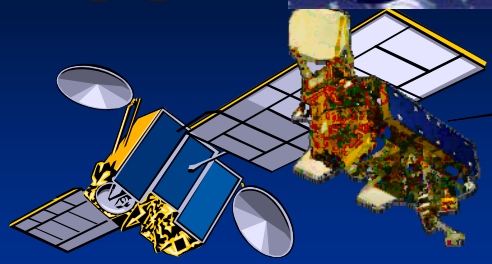
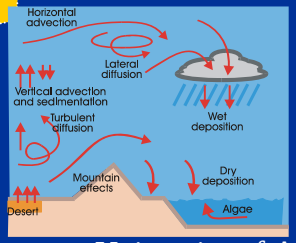


Terra & Aqua

Direct Broadcast
Receiving Station

AZ & NM
AQ and Health Offices
Beta Testing

NASA
AERONET



Simulated, Real-Time
and Forecasted
Dust Events

EDOS

http://modis.gsfc.nasa.gov

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Dust Model & Forecast System
http://www.atmo.arizona.edu

Syris and State
Health Offices

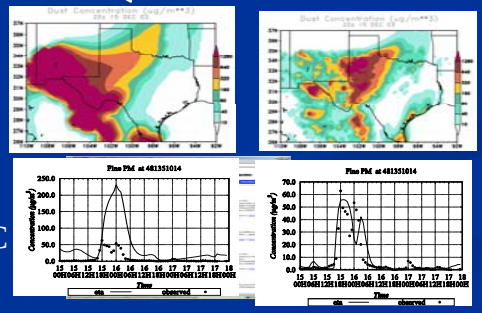
MODIS Land Cover +
Current Weather + EPA AQ Data

University of New Mexico
EDAC & Syris

GES DAAC
NASA/GSFC

National Weather
Service - NCEP

University of New Mexico - EDAC
and NASA Earth Observatory
http://earthobservatory.nasa.gov



Without (L), With (R) NASA Data

DUST REGIONAL ATMOSPHERIC MODEL (DREAM): CORE ATTRIBUTES

- Two Basic Components:
  - NCEP/Eta Regional Atmospheric Model
  - Nested Desert Dust Model
- Driven on-line by NWS Operational Model
- Used in Both Prognostic and Research Modes

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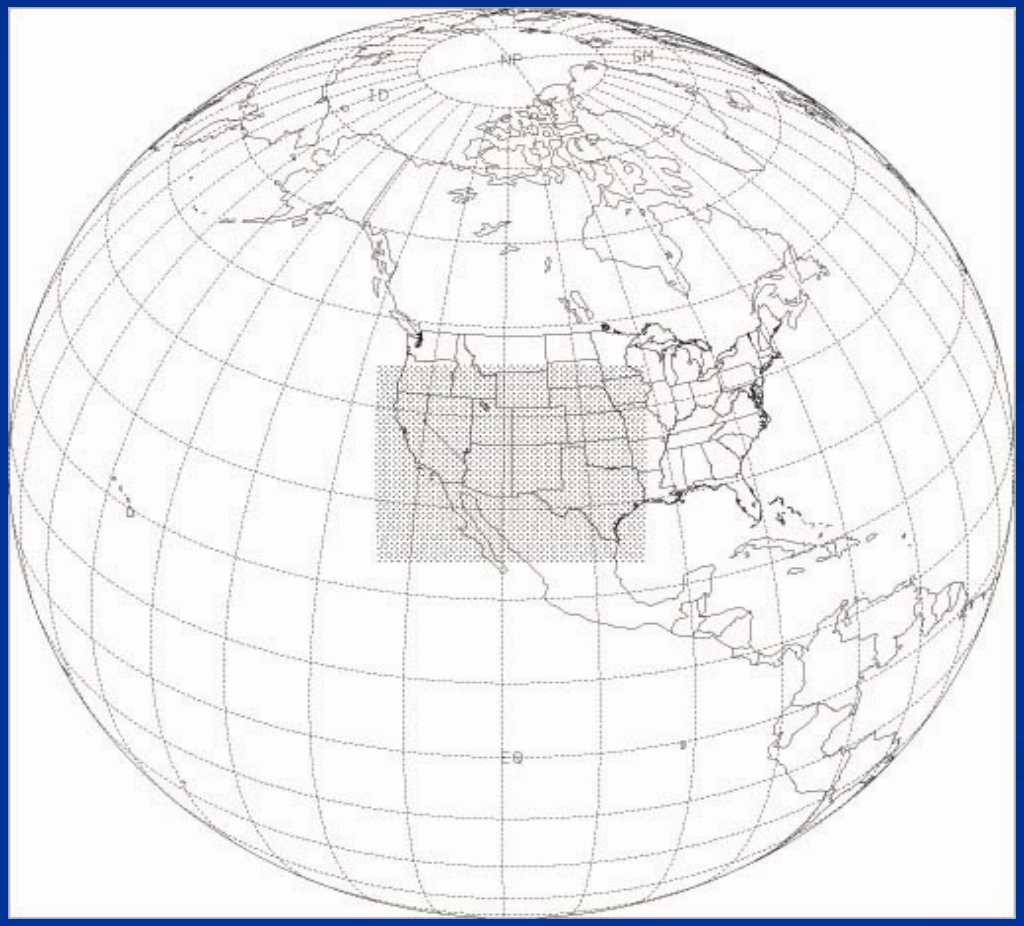
Model setup



- Domain center at (109°W, 35°N)
- Horizontal grid spacing 1/3 degree

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DREAM – AVAILABLE DATA

- **NWS Global/Hourly Weather Products**
- **Vegetation**

  1km x 1 km USGS Global Vegetation Data to Define Dust Source Areas
- **Topography**

  1km x 1 km USGS Global Topography Data to Define the Model Topography
- **Soil types**

  FAO Global Soil Types Converted Into Model Soil Texture Types

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Current Product Aims

- 72-48-24-12-6-hour Forecasts
  - Regional, city-wide, or in your district
  - Dust concentration at any height
  - 'Critical-concentration-level' arrival/departure time
  - Map, 3-D visualization, …
- Past dust event simulations
  - pinpoint dust sources & simulate areas/times affected

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STRATEGY FOR MODEL DEVELOPMENT

- **SIMULATE SELECT PRIOR STORMS**
- **VERIFY**
- **TEST IN PUBLIC HEALTH SERVICE**
- **IMPROVE …**
- **TEST REAL-TIME FORECAST MODE**
- **INSTALL OPERATIONAL FORECAST MODEL**
- **DEVELOP OTHER APPLICATIONS**

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Airborne Particulate Forecasts: An Emerging Tool in Medical Science and Health Services

- **Case studies:**
  - Odessa & Lubbock, Texas
  - Phoenix, Arizona

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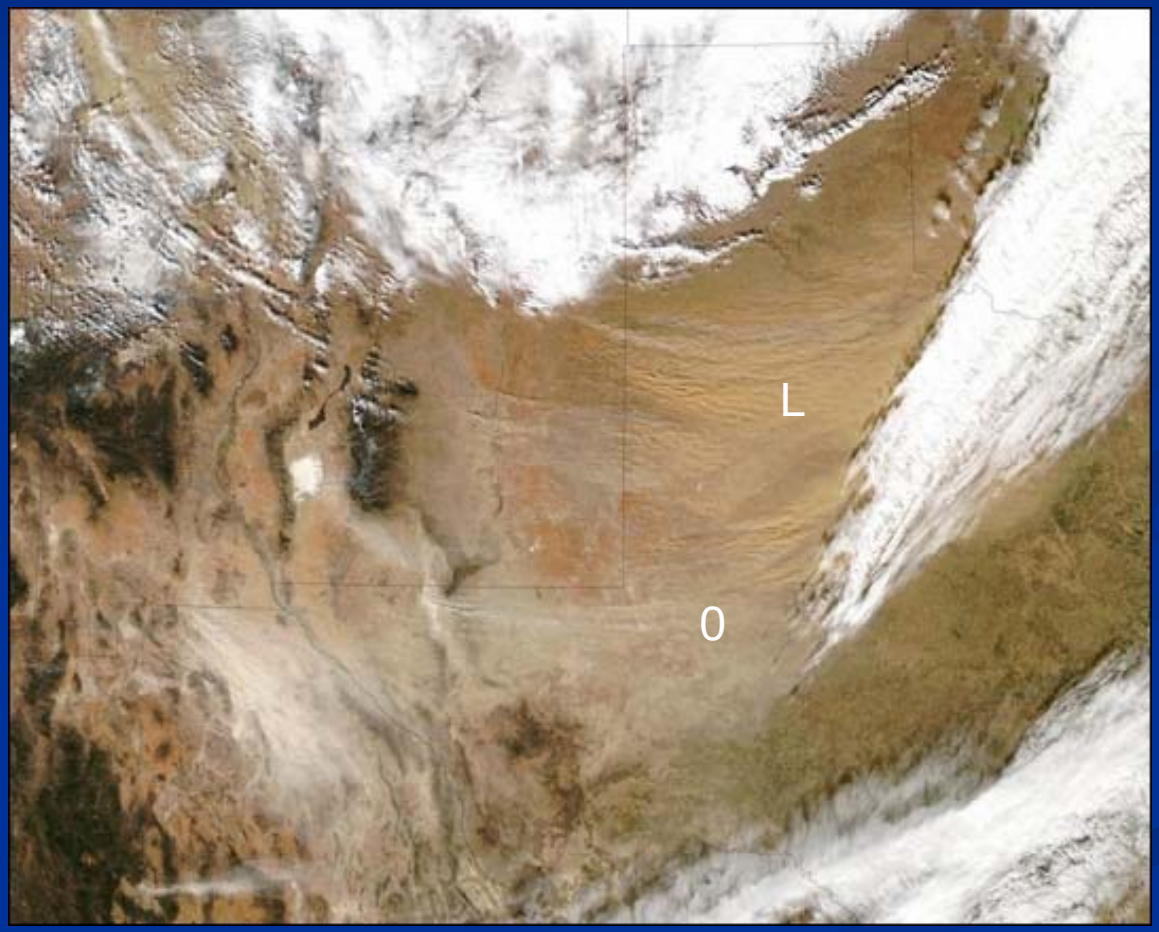
A CASE STUDY

DECEMBER 15-17, 2003, A FRONTAL SYSTEM SWEPT ACROSS NEW MEXICO, TEXAS AND NORTHERN MEXICO CREATING A SIGNIFICANT DUST STORM

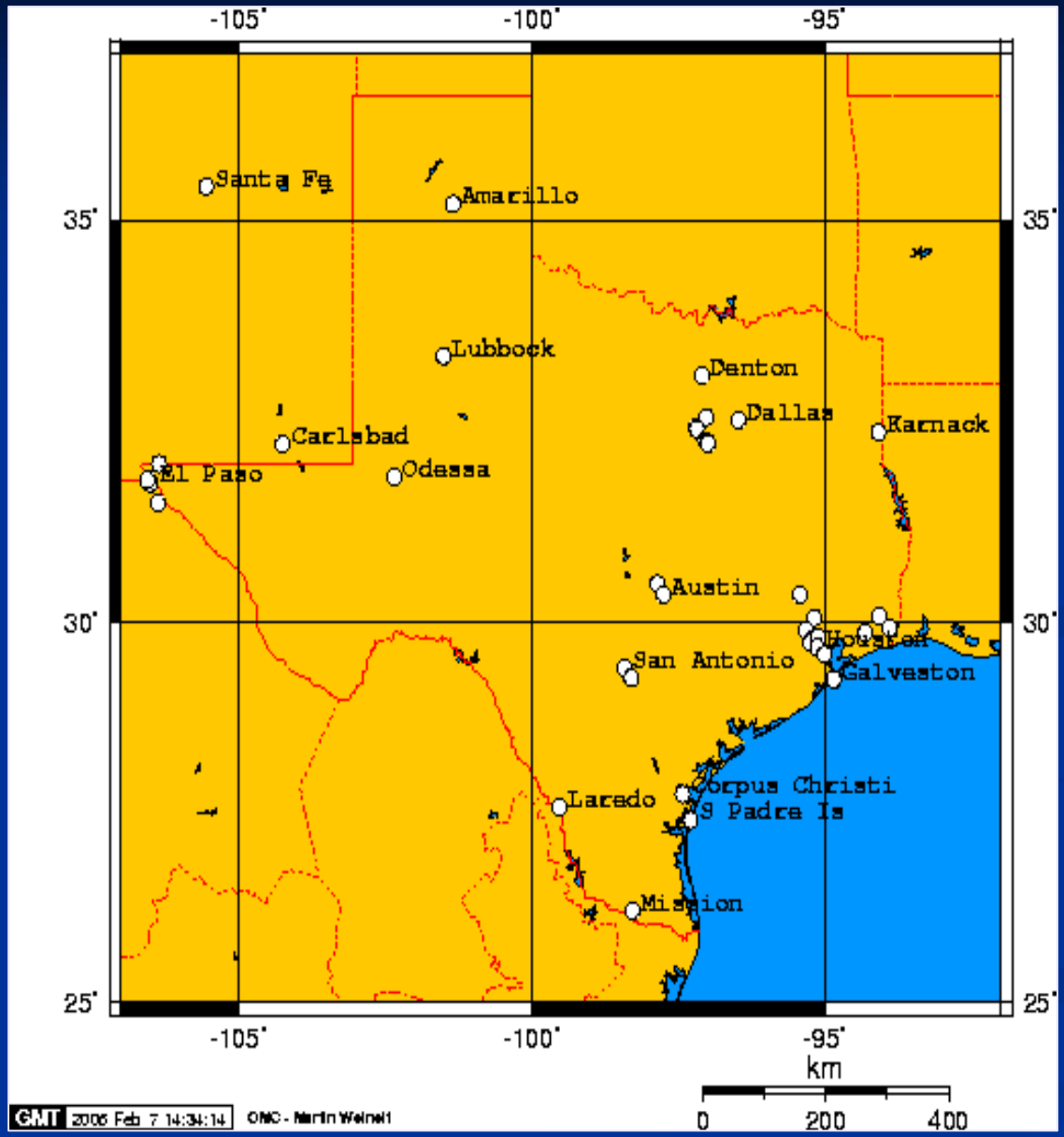
for Odessa (O) and Lubbock (L)



GOES 12 Vis/IR Composite, 12/15/03 @ 1426 CST

W.A.Sprigg to ATS,San Diego, 5/24/06

Monitoring Sites



Forty air monitoring stations in NM and TX, continuously measured the fine fraction ($PM_{2.5}$) of aerosol dust.

How well did the DReAM model perform in predicting the timing, duration and magnitude of the event at each of these stations for the three events?

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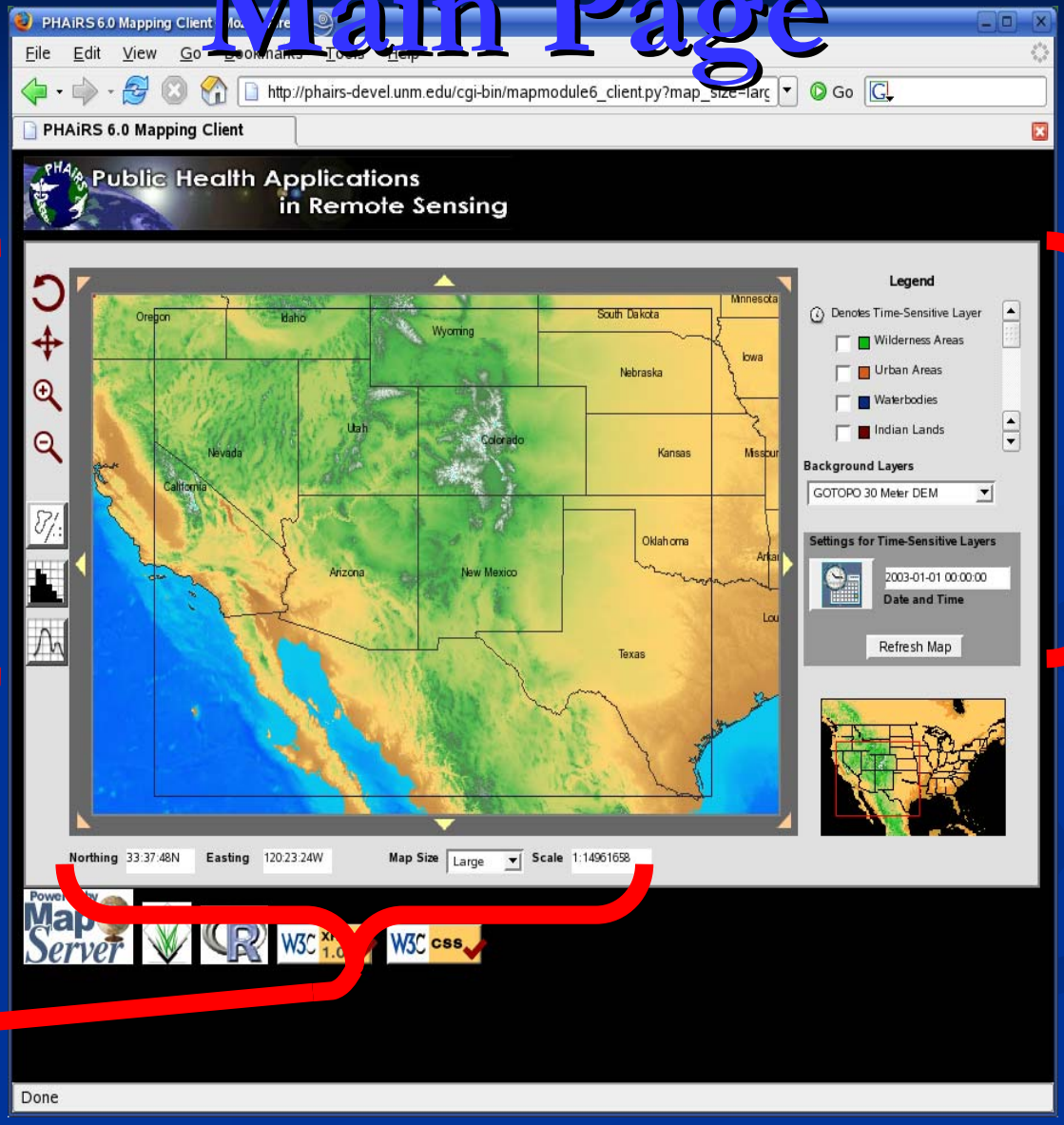
PHAiRS Mapping Client Main Page

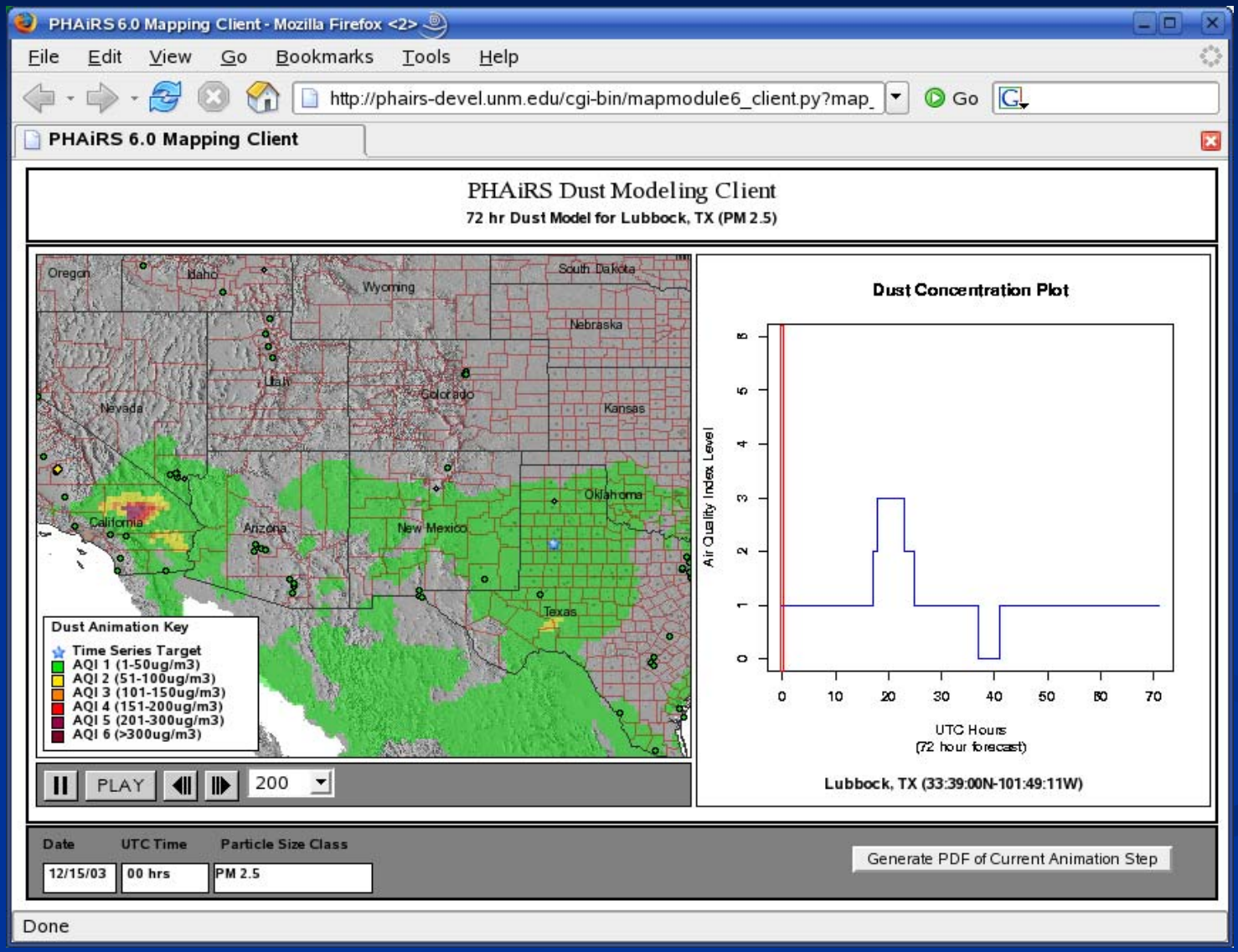


Zooming and Plot Options

Boundary and Time Options

Lat/Lon and Map Size

Sample Web Output: 72-hr Forecast



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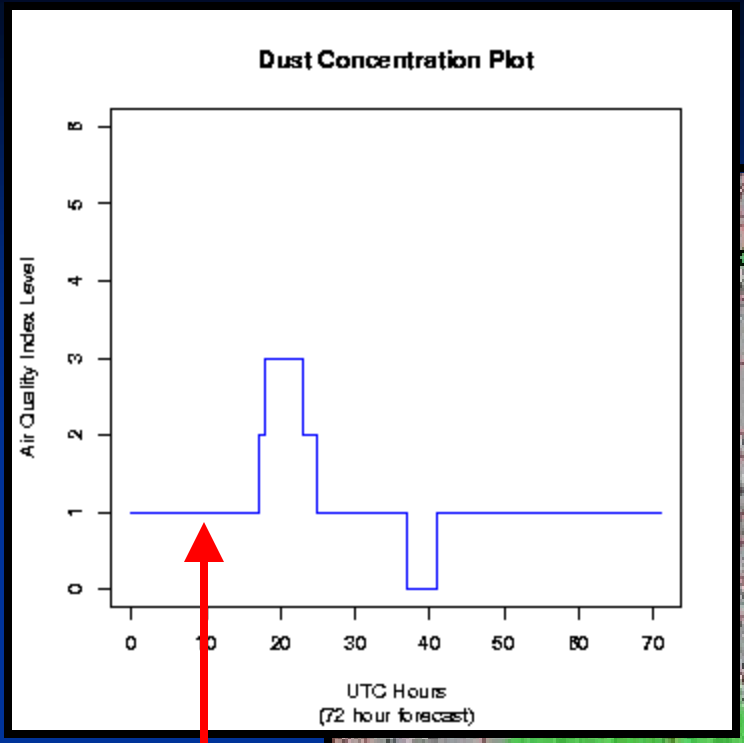
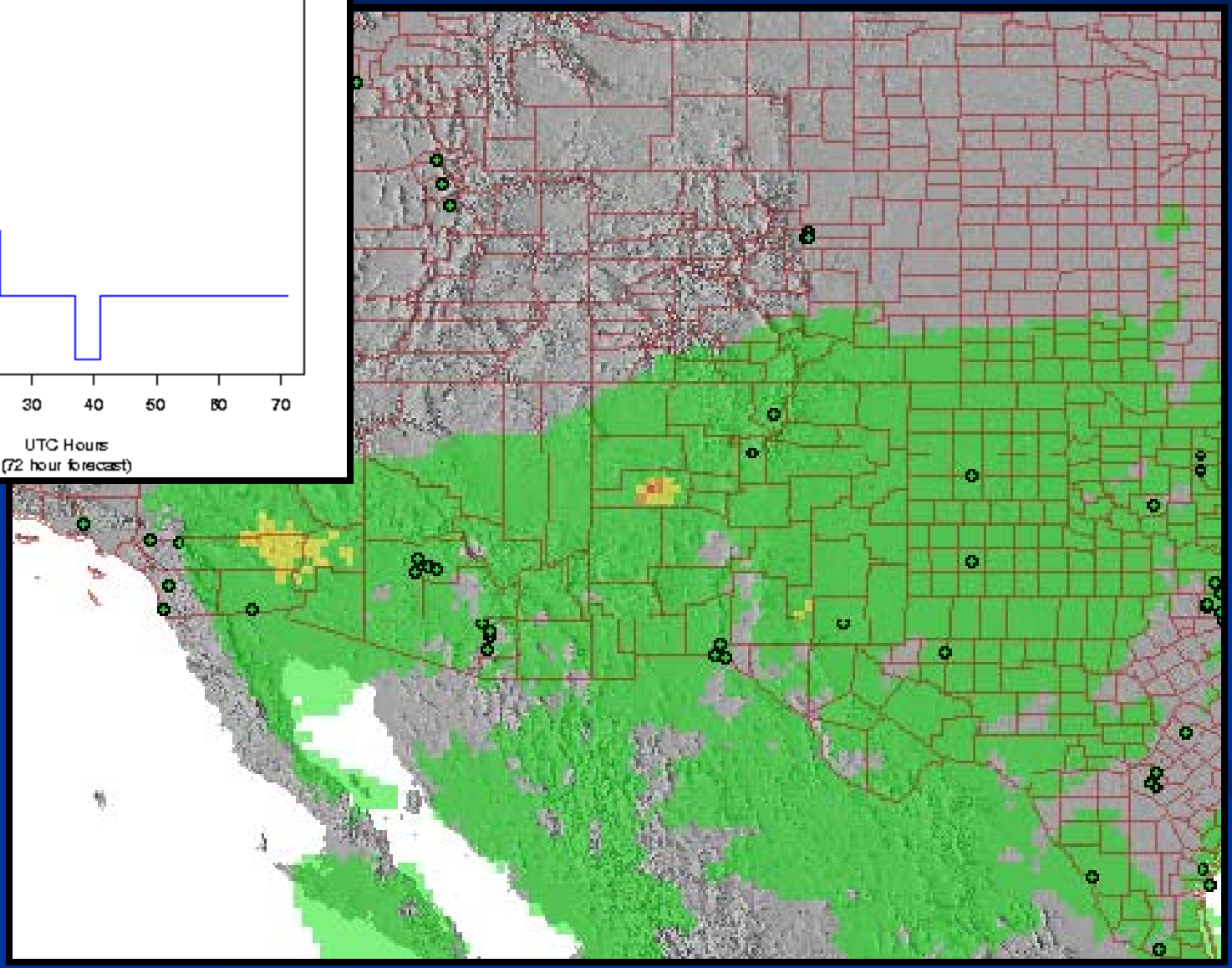
PM2.5 Lubbock, TX 12/15/03



T = 10 hours



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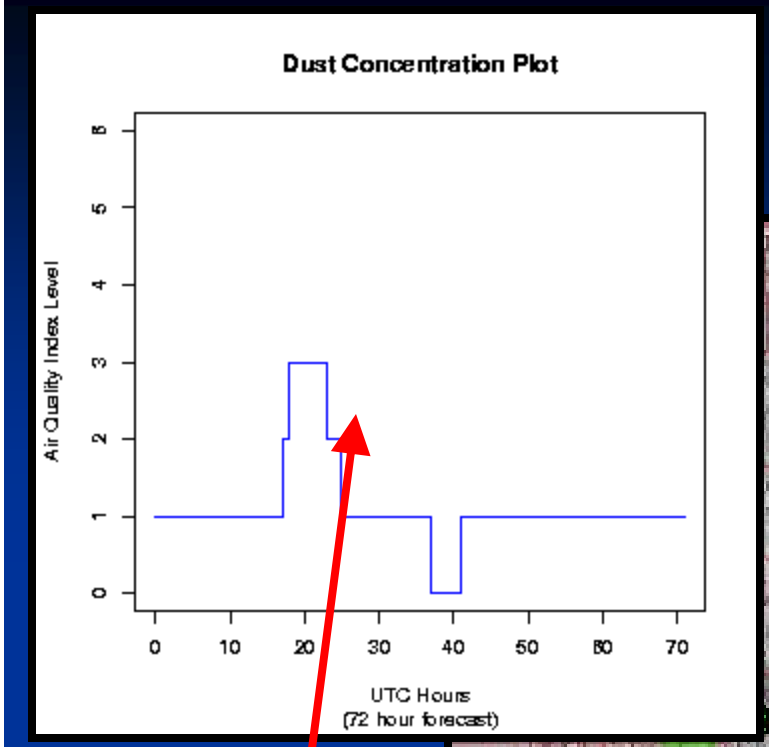
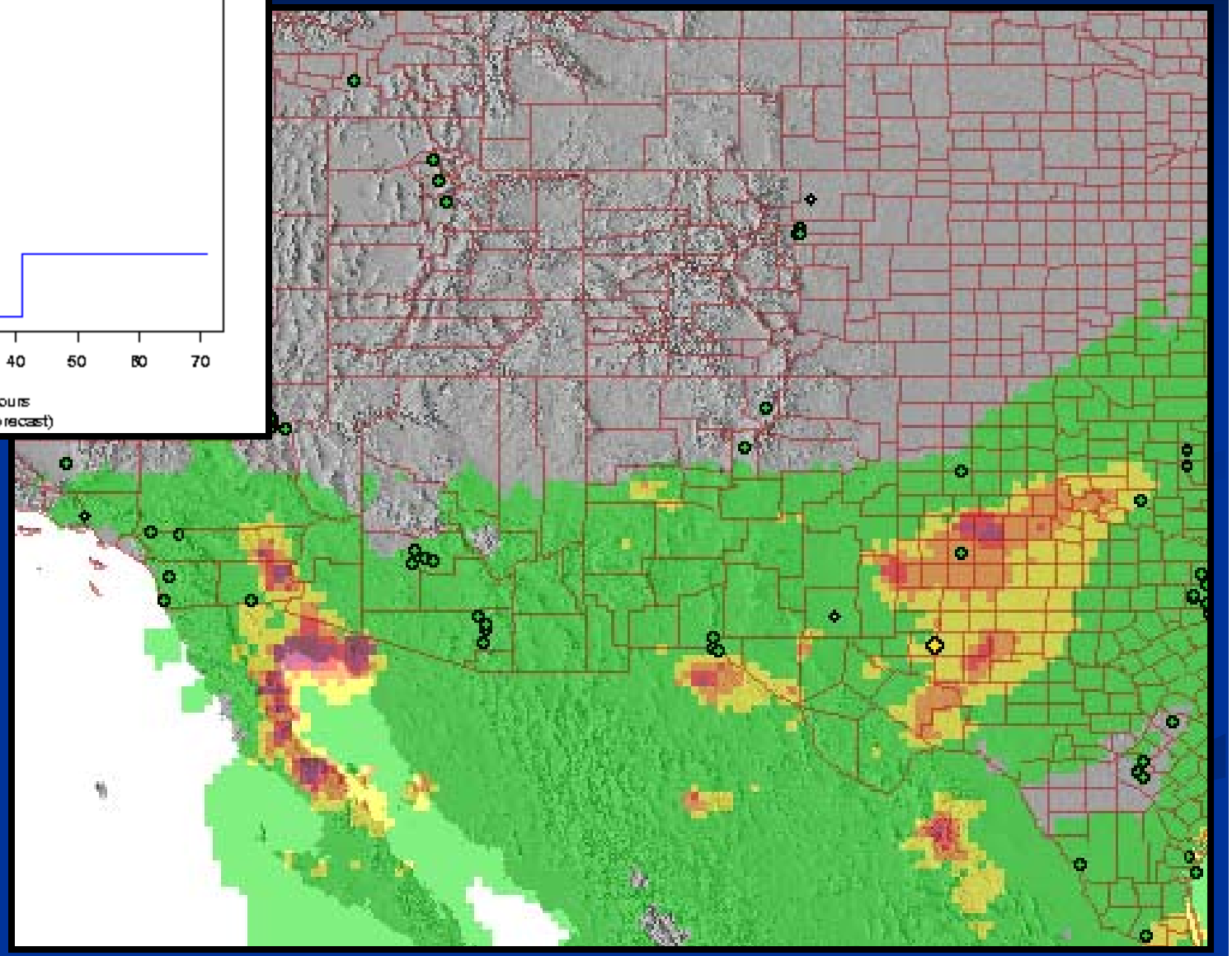
PM2.5 Lubbock, TX 12/15/03



T = 20 hours



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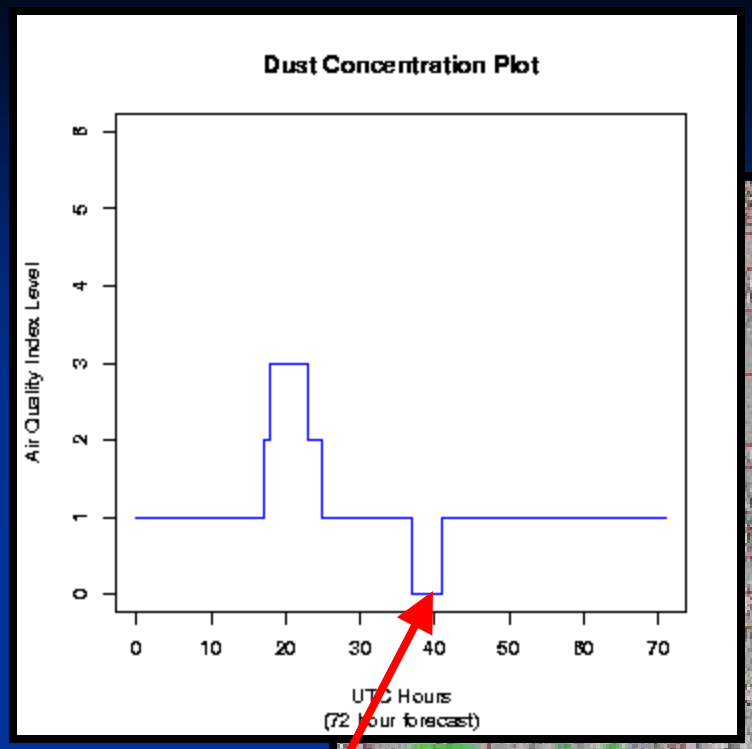
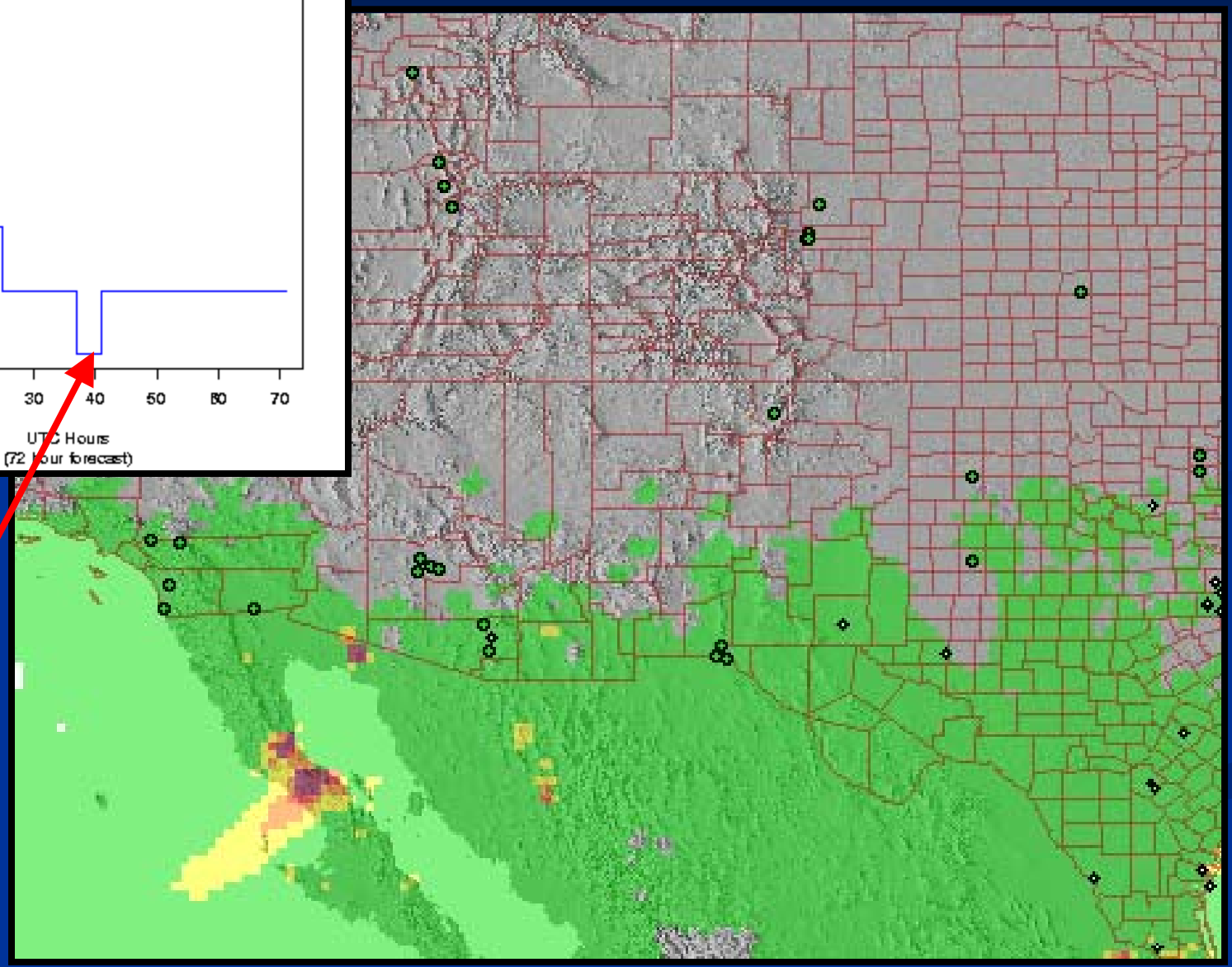
PM2.5 Lubbock, TX 12/15/03



T = 40 hours



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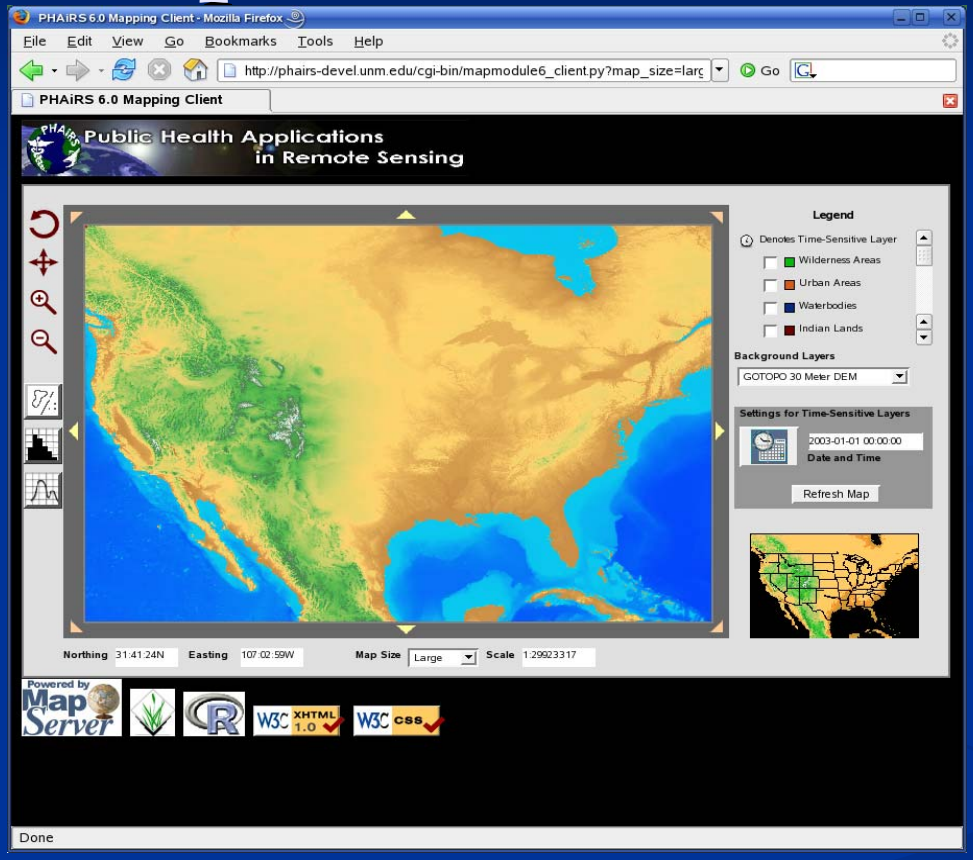
http://phairs-devel.unm.edu/cgi-bin/mapmodule6_client.py



Project Web Site
http://phairs.unm.edu

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Model Validation

Point-by-point comparison between model output and in-situ data

- Peak hour: the UTC time of day that the one-hour $PM_{2.5}$ maximum occurred
- Magnitude: the highest one-hour mean $PM_{2.5}$ ($\mu g/m^3$) concentration observed during the three events
- Duration: the length of time the local population may have been exposed to unhealthy dust levels according to EPA (daily averages of 65 $\mu g/m3$ for $PM_{2.5}$)

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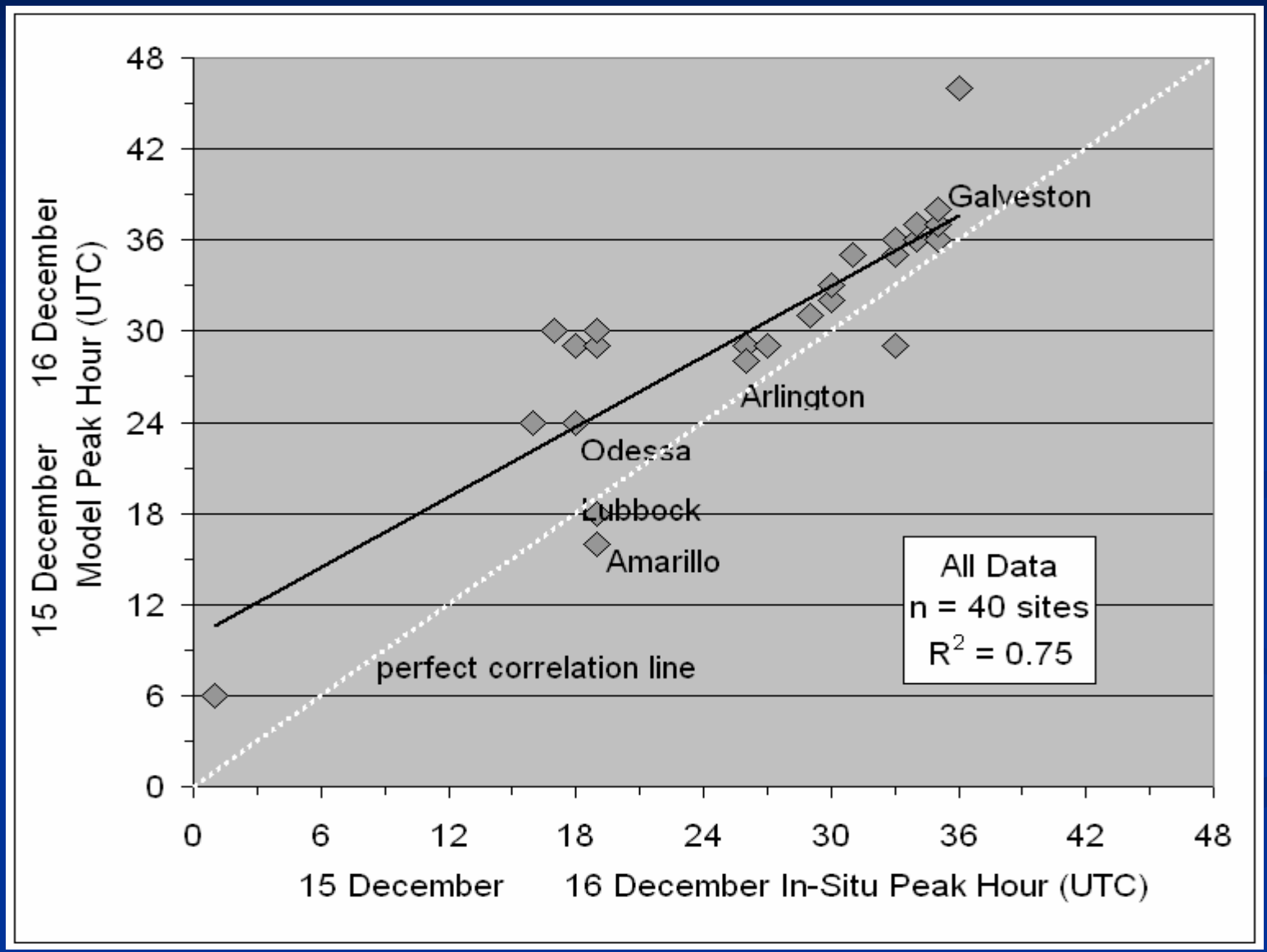
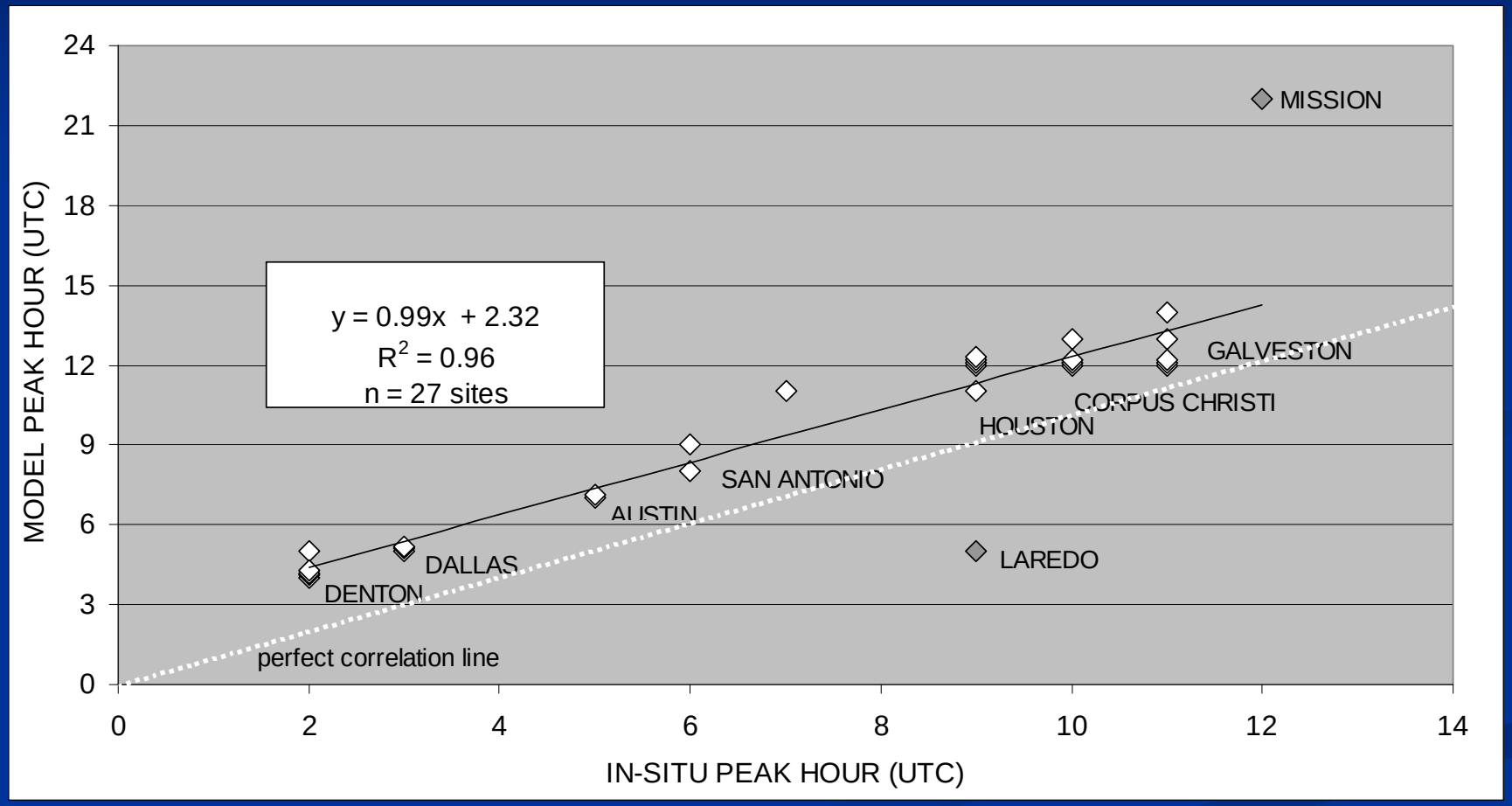
Peak Hour Comparison – All Sites



Peak Hour Comparison
16 December 2003 – Central, East Texas



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Case Study
South of Phoenix

Interstate 8, AZ
2/15/06

Next: 72-hr PM10 concentration forecast…

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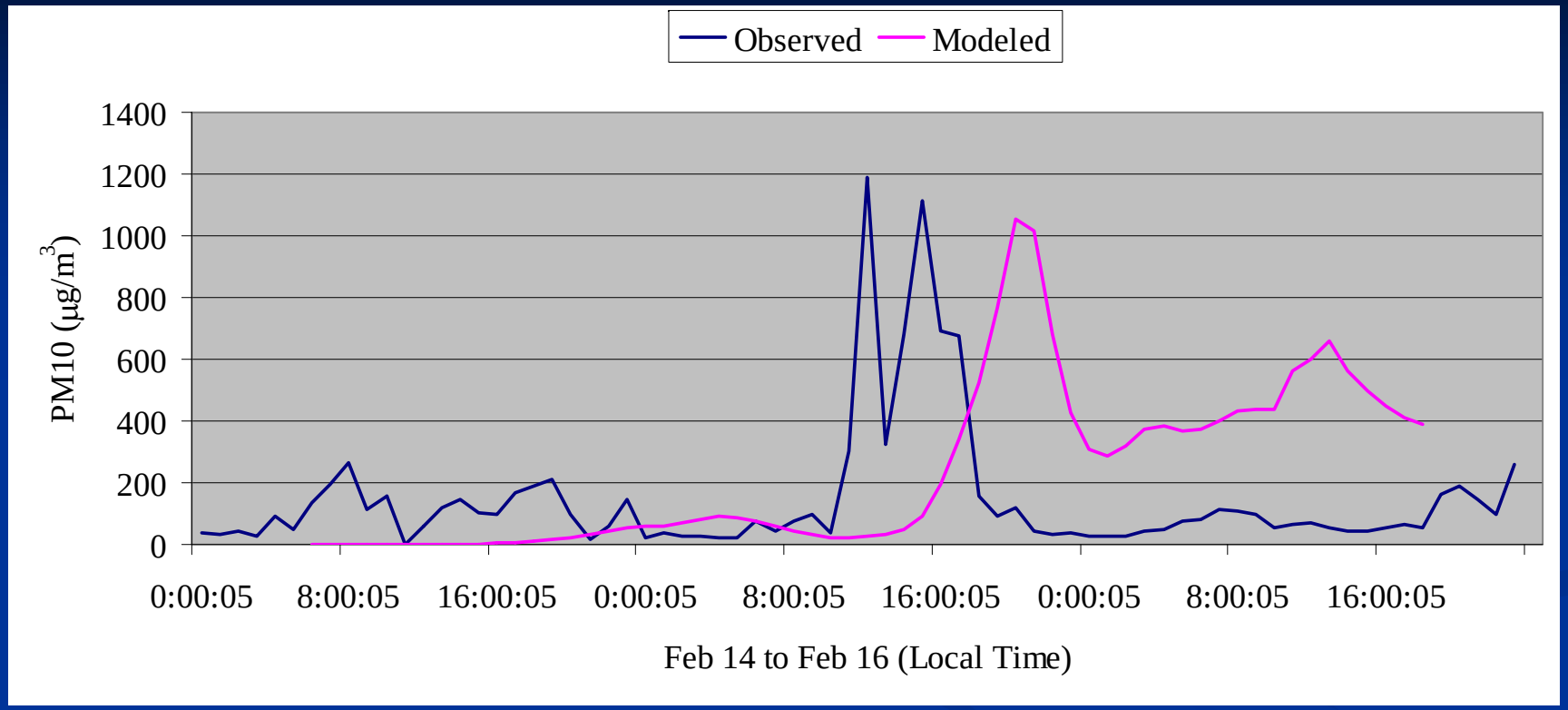

PM10 at Stanfield (miles away from the accident scene), Arizona

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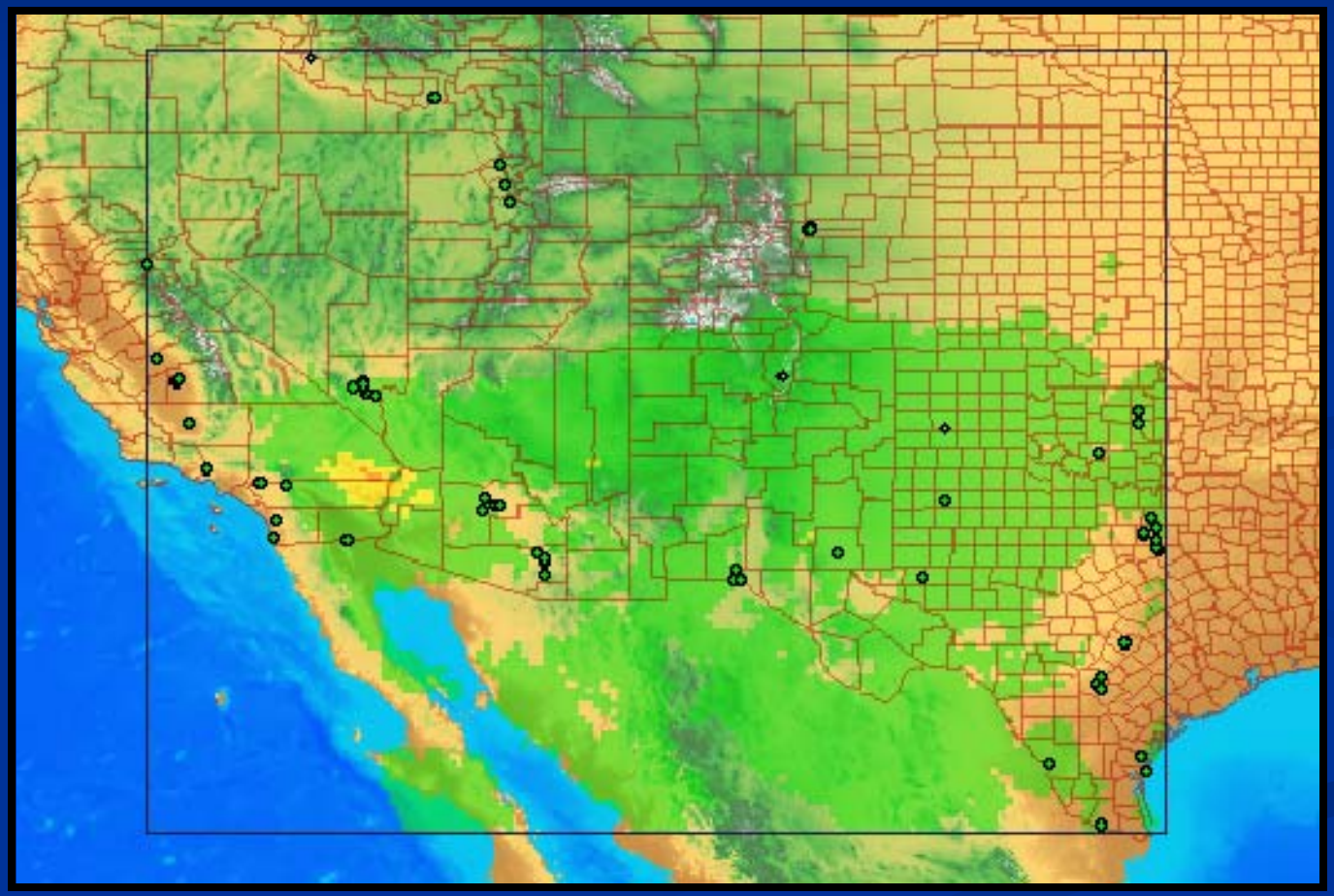
What Next?

Model Simulations & Forecasts fill gaps of Particulate Monitoring Network



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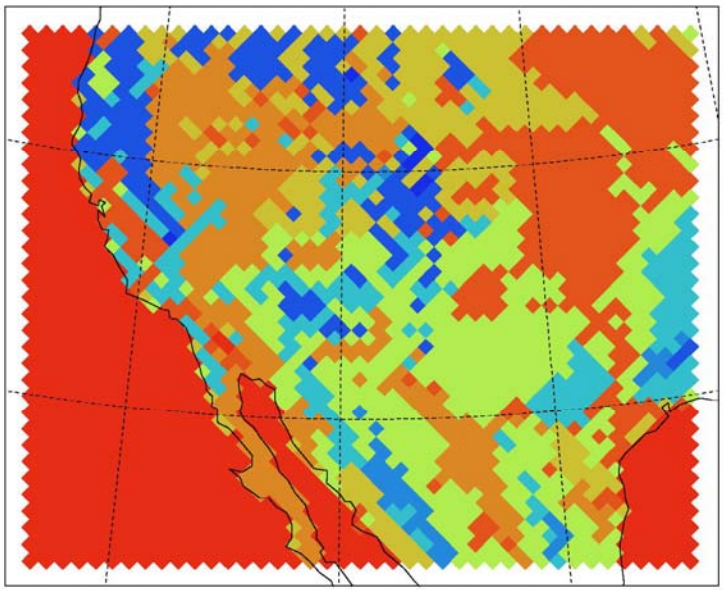
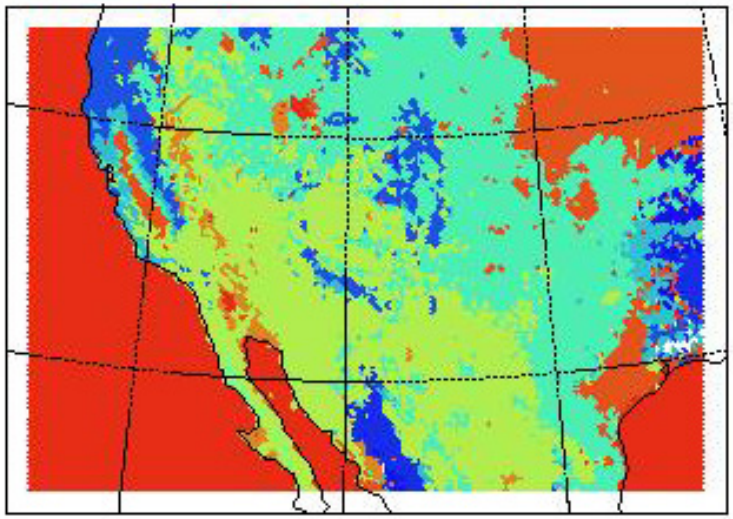
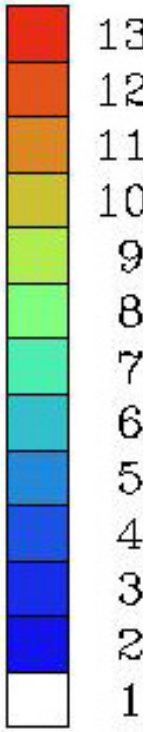
Landcover from Olsen World Ecosystem and MODIS







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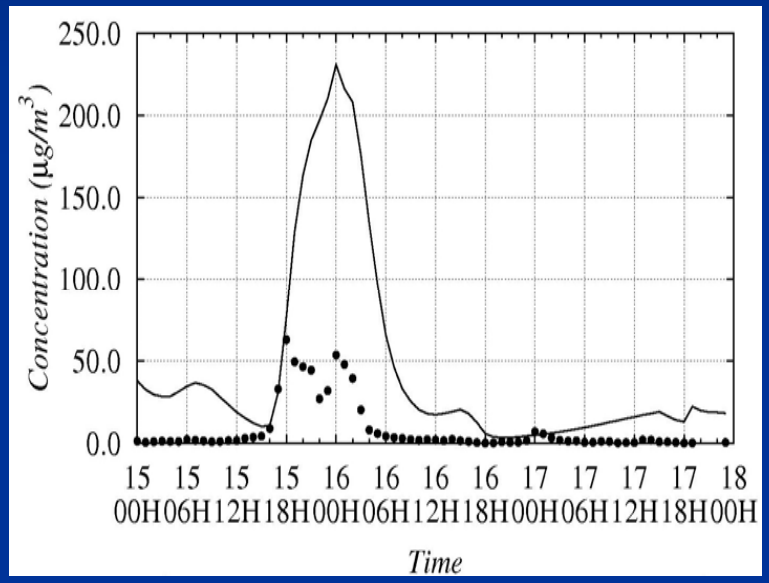
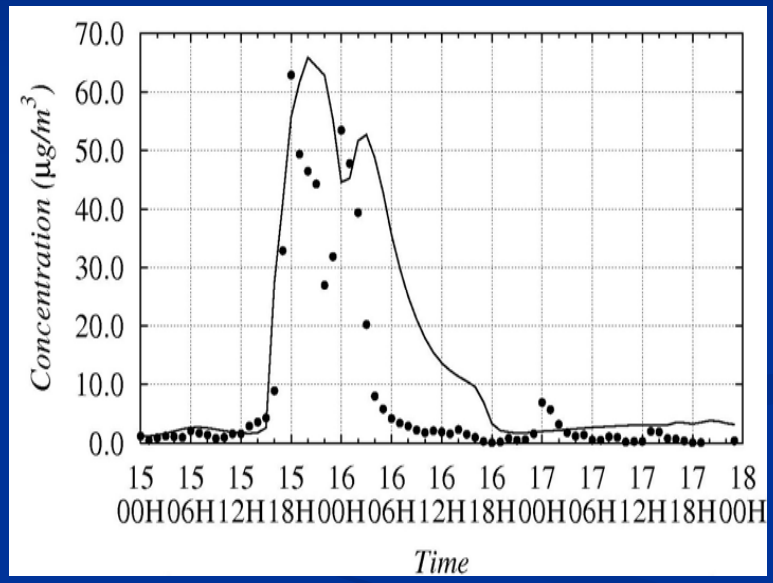
Comparison of Modeled and Measured PM2.5 Concentrations at Odessa (1014), Texas, Dec. 15, 2003





Left panel without NASA land surface data; right panel with NASA land data (dots show measured values and lines show modeled values)

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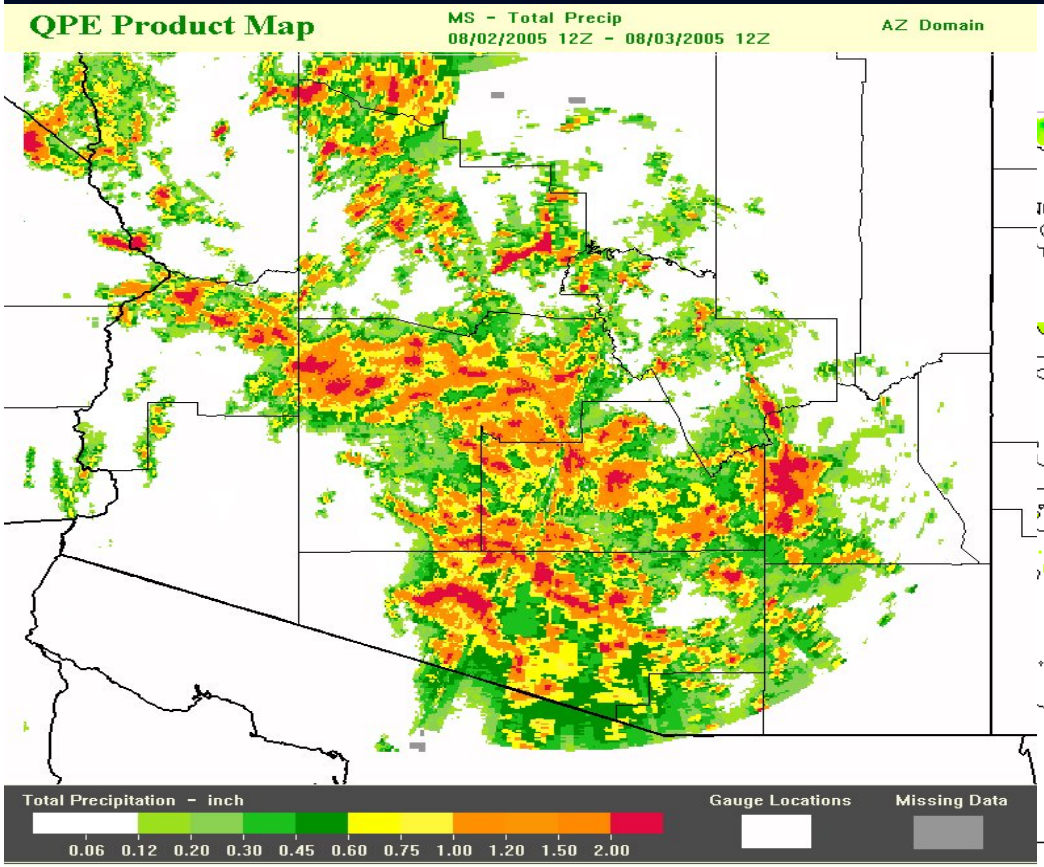

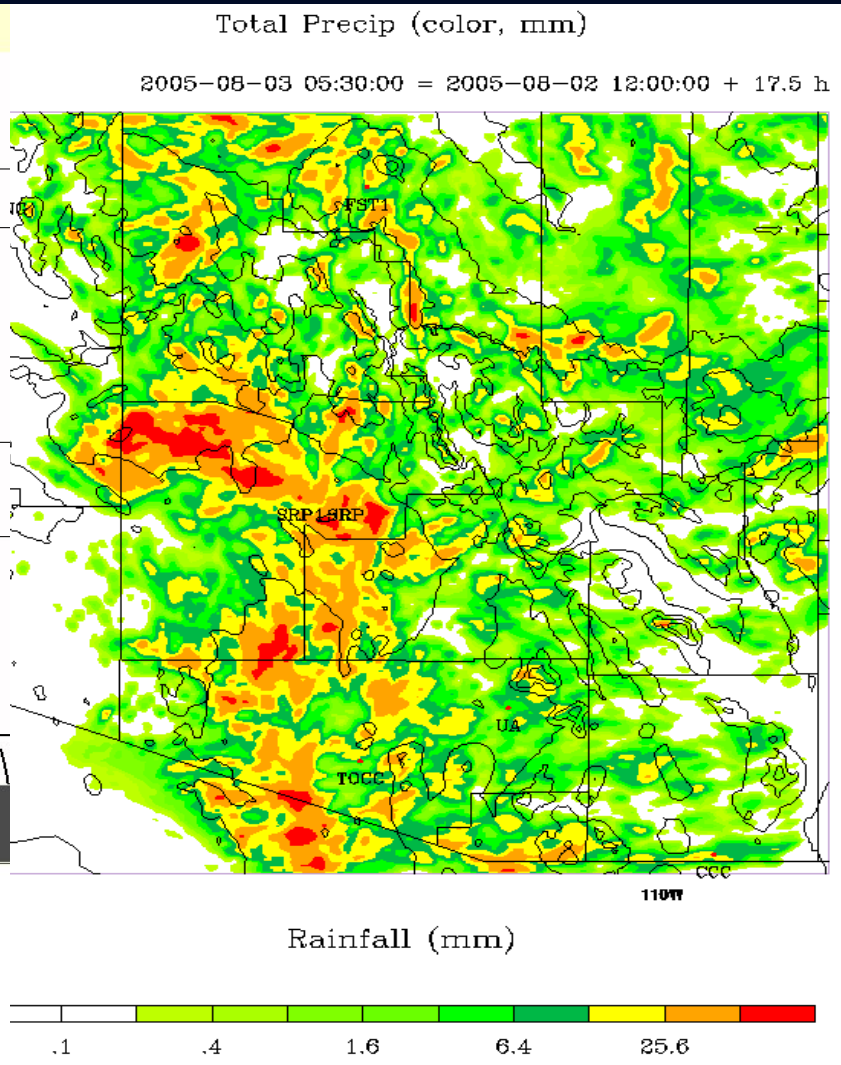

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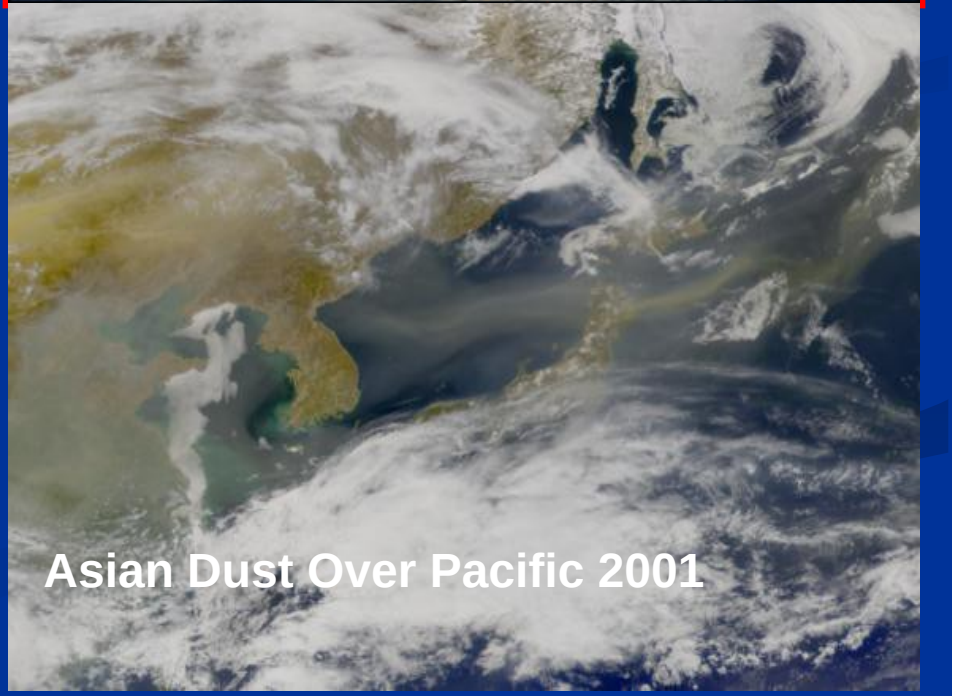
Comparison of RADAR derived precipitation (L) vs the model (R) from a summer 2005 severe weather and flash flooding event over Phoenix. The model was 3 hours too soon with the convection, but did well for location and amount of rain. (courtesy Mike Leuthold)


Phoenix, AZ 2004
VF?


California Wildfire 2003


St Francis, KS 5/29/04


Asian Dust Over Pacific 2001

SUMMARY

- DUST MODEL SEMI-OPERATIONAL
- HIGHER RESOLUTION DUST MODEL UNDER DEVELOPMENT (WRF/NMM)
- CLOUD-RESOLVING (1.8 Km WRF) OPERATIONAL FORECAST SYSTEM UNDER TEST FOR ARIZONA

http://www.atmo.arizona.edu/products/models/forecasts/forecast.html

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A Long History of Collaboration
TOGA Delegations
(L) US to China 1982 & (R) PRC to US 1983

W.A.Sprigg

Acknowledgements

Modeling: Dazhong Yin, Slobodan Nickovic, Zavisa Janjic, Michael Leuthold
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Health Applications: Susan Caskey, Chandra Bales, Shirley Baros, Mike Inglis, Alan Zelicoff
Product Design, WEB Page, Data Support: Bill Hudspeth, Karl Benedict, Marvin Landis
Advisors: Beth Gorman, Wayne Byrd, Ken Komatsu
Integration: Stan Morain, Amy Budge, Bill Sprigg

Appreciation is extended to the Pima County Department of Environmental Quality and the Arizona and New Mexico Departments of Public Health who review our work and keep us on a practical course. The project is sponsored by NASA's Earth System Science Directorate. Special appreciation is extended to China's Haihe River Conservancy Commission, Ministry of Water Resources, for their support in this technical exchange.

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