Public Health Applications For Remote Sensing and Atmospheric Modeling

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For

Beijing Normal University
Tsinghua University
CAS Institute of Hydrology & Water Resources
CAS Institute of Geographic Sciences & Natural Resources

Beijing, 27 September 2006

Predicting Airborne Particulate Concentrations For Public Health Decision Making

Beijing, April 17, 2006

Lubbock, December 16, 2003

OUTLINE

- Problem: Respiratory and Cardiovascular Disease
  - **Simulating & Predicting Airborne Dust With Weather Models & Remote Sensing Improvements**
- Problem: Flash Floods, Water Pollution, Soil Erosion
  - **Simulating & Predicting Surface Hydrology in Complex Terrains**
- Future Work

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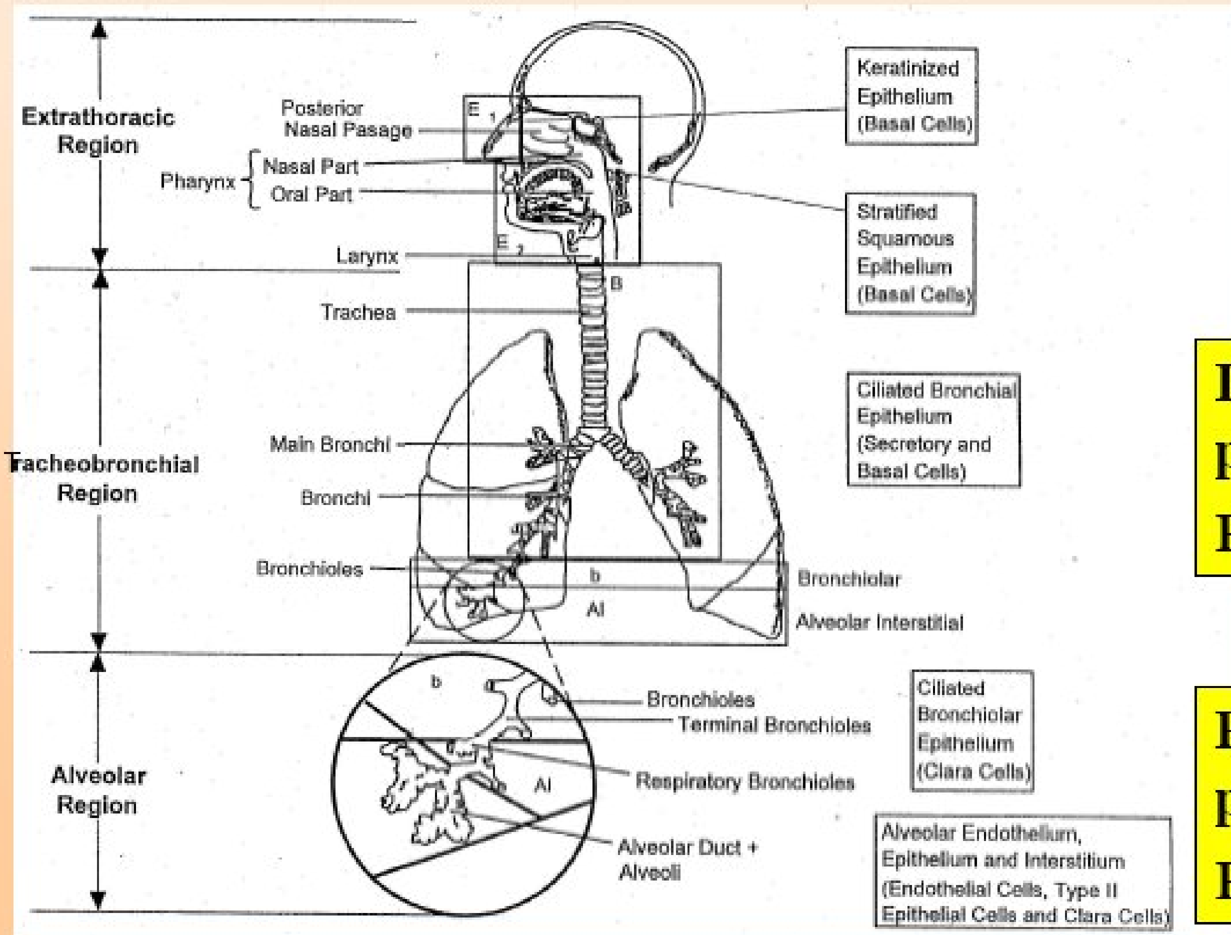
Working for public health!



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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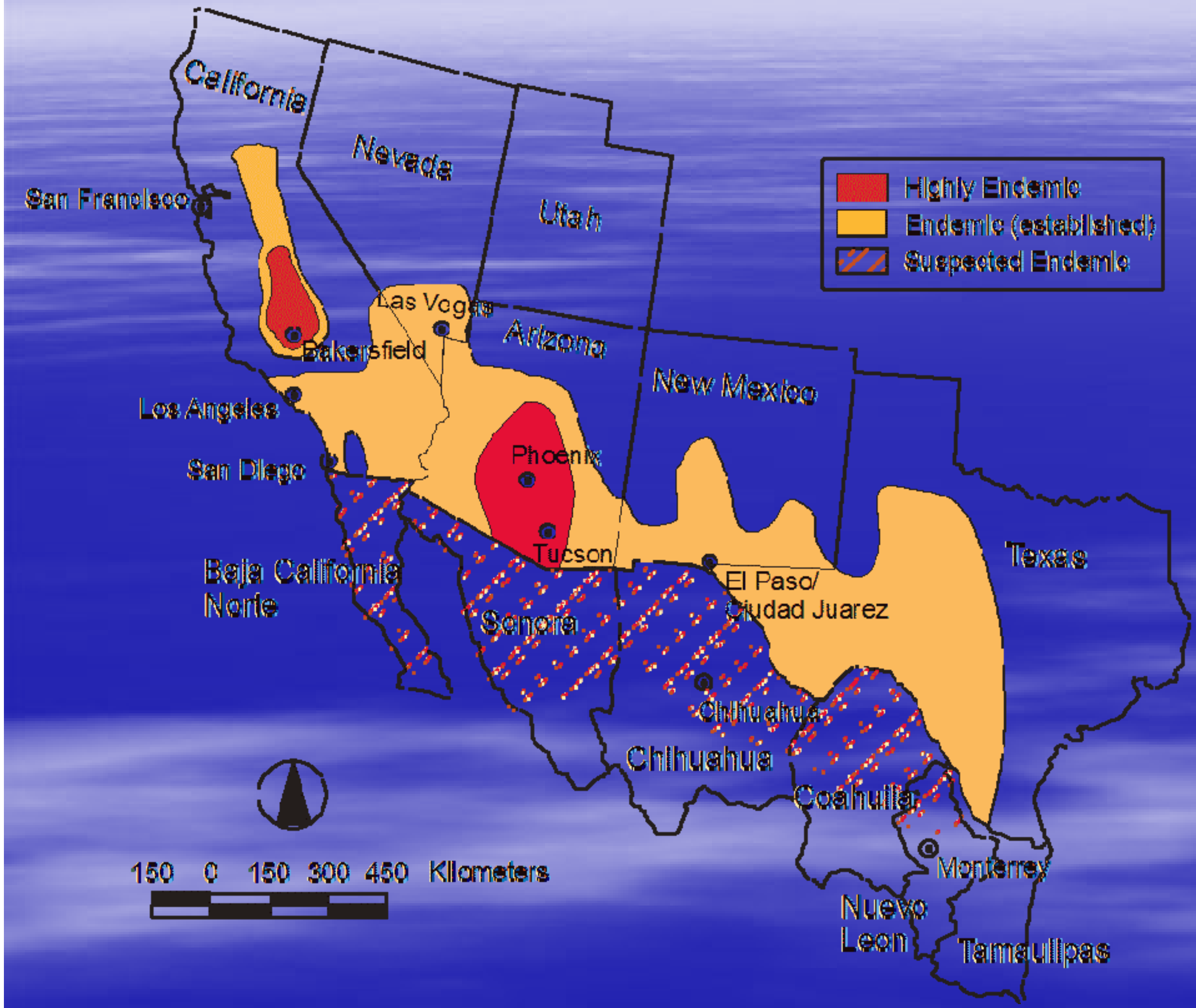
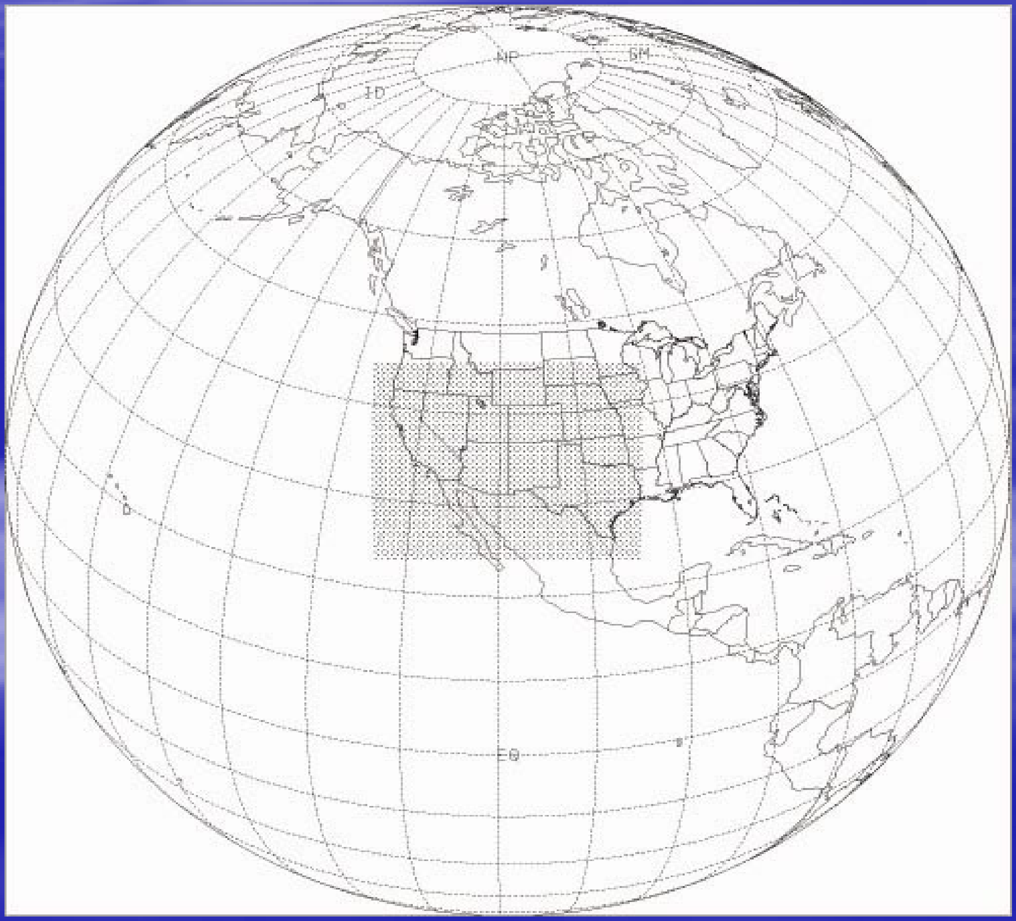
Valley Fever Endemic Zone



From Andrew Comrie

- **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

Model Setup



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

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

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

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

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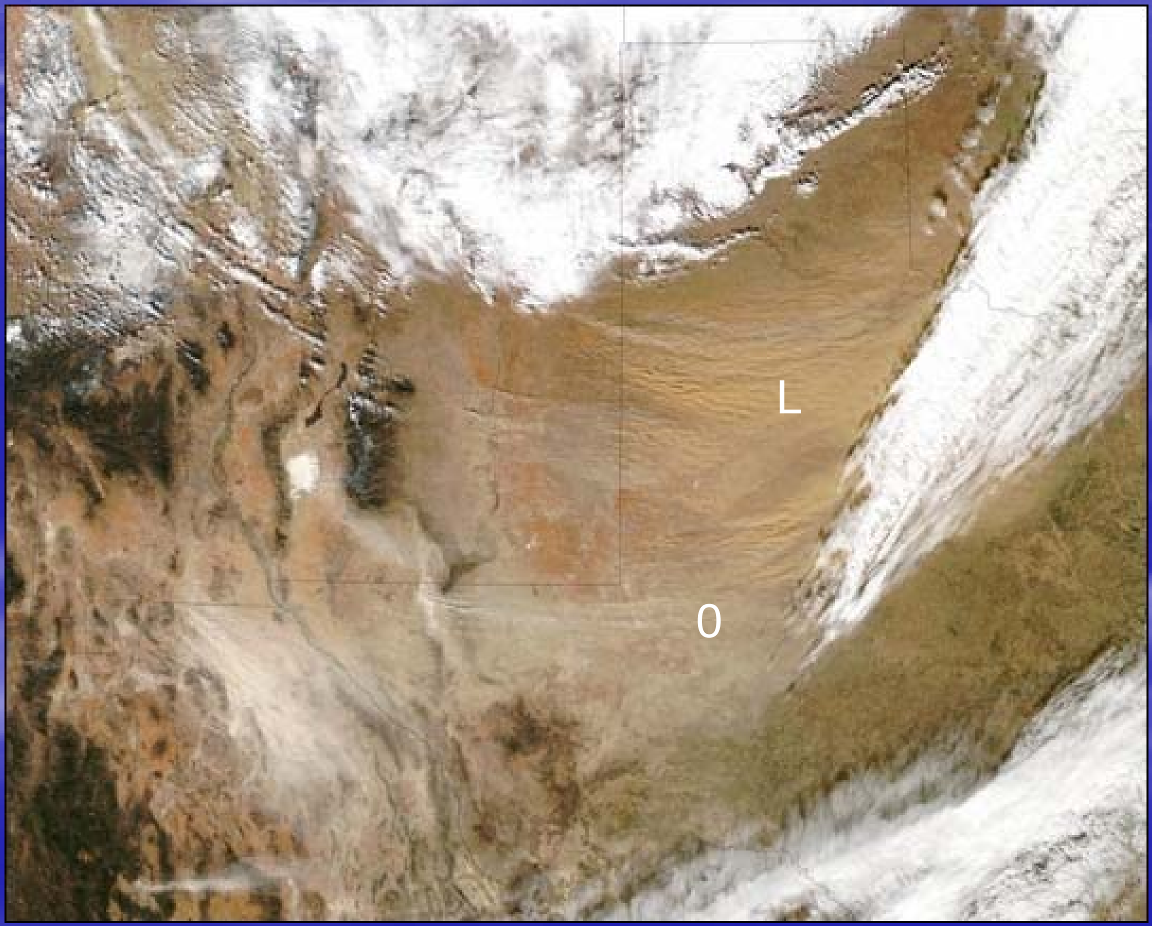
A CASE STUDY

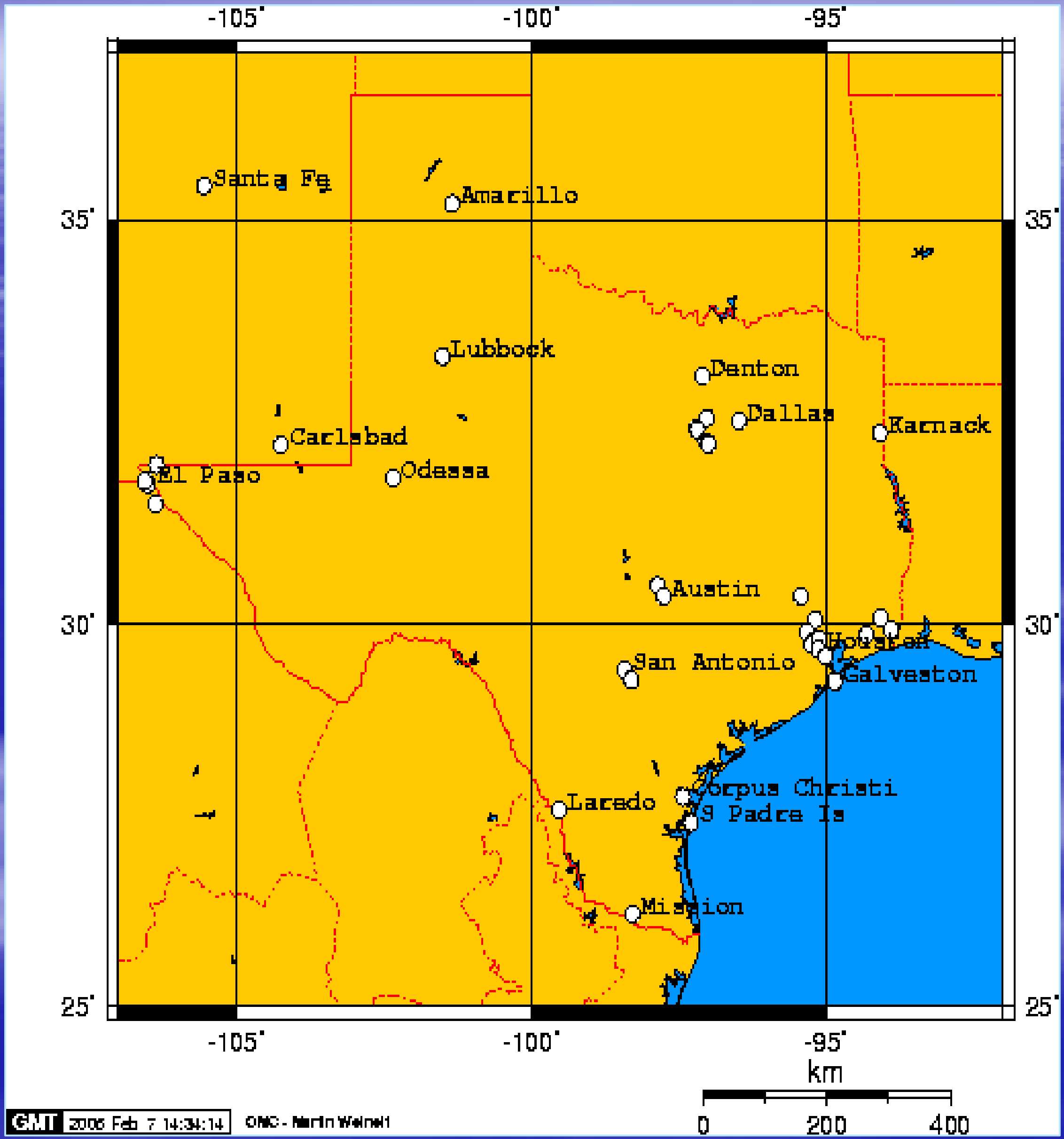
DECEMBER 15-17, 2003, A FRONTAL SYSTEM SWEPT ACROSS NEW MEXICO, TEXAS AND NORTHERN MEXICO CREATING A SIGNIFICANT DUST STORM for Odessa (O) and Lubbock (L)



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

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

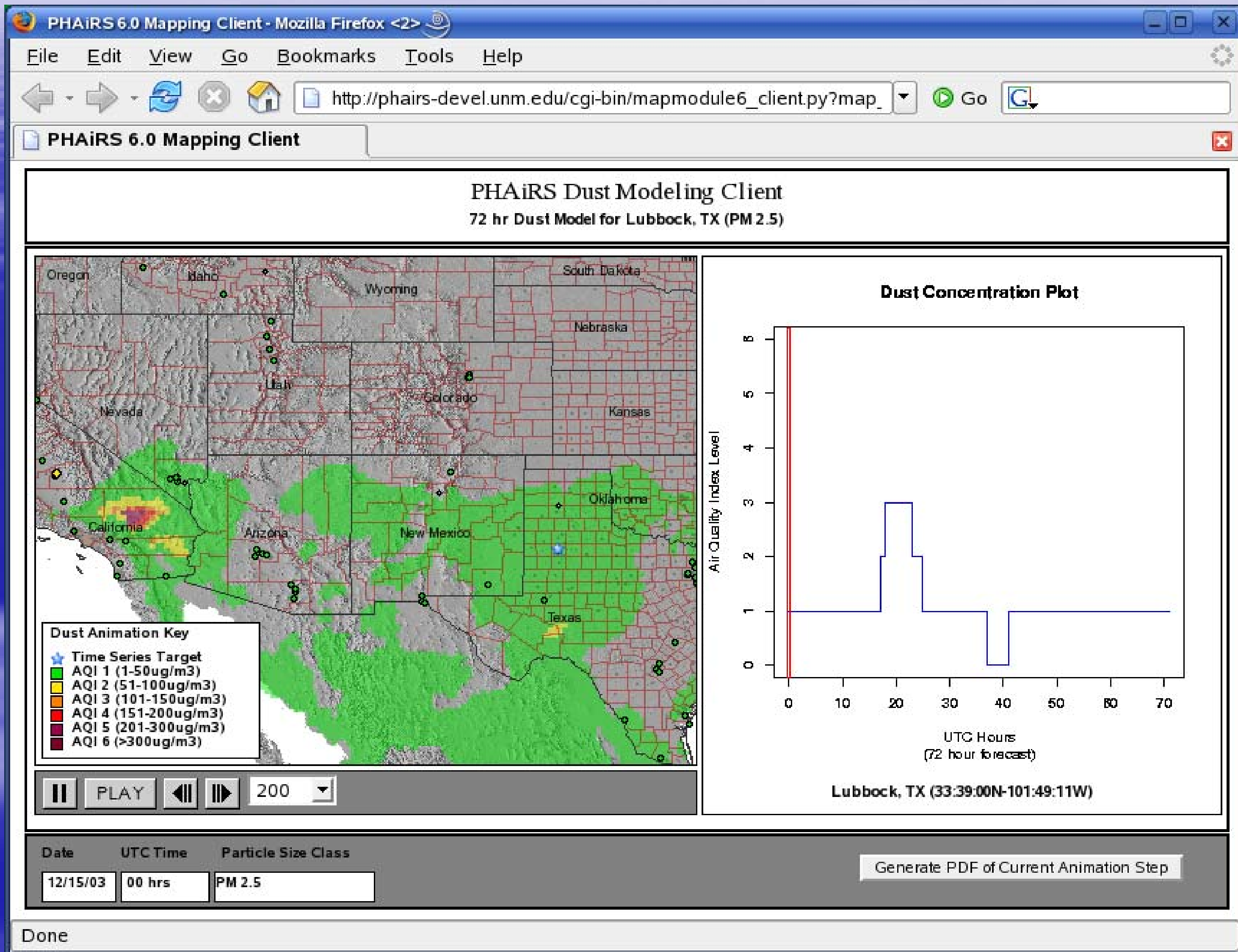
Monitoring Sites



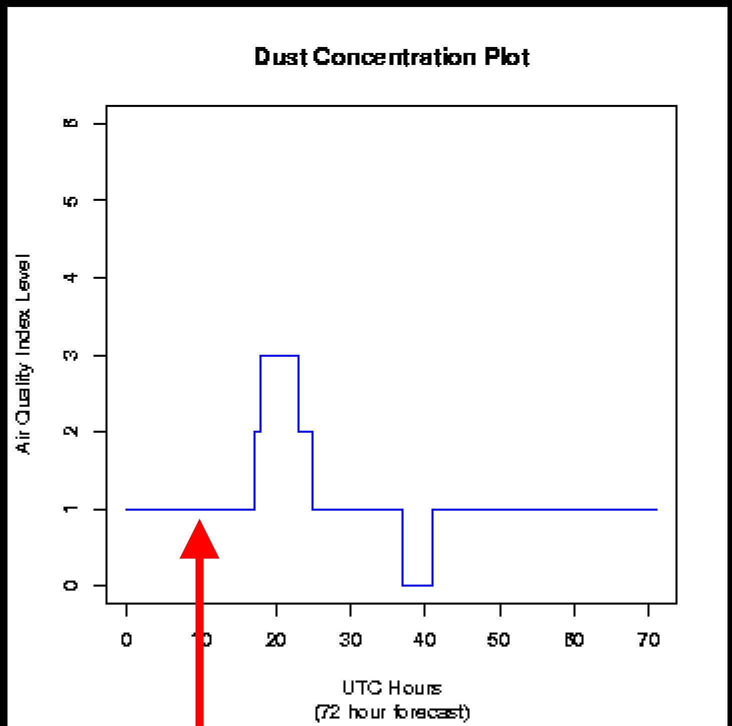
Forty air monitoring stations in NM and TX, continuously measured the fine fraction ($PM_{2.5}$) of aerosol dust.

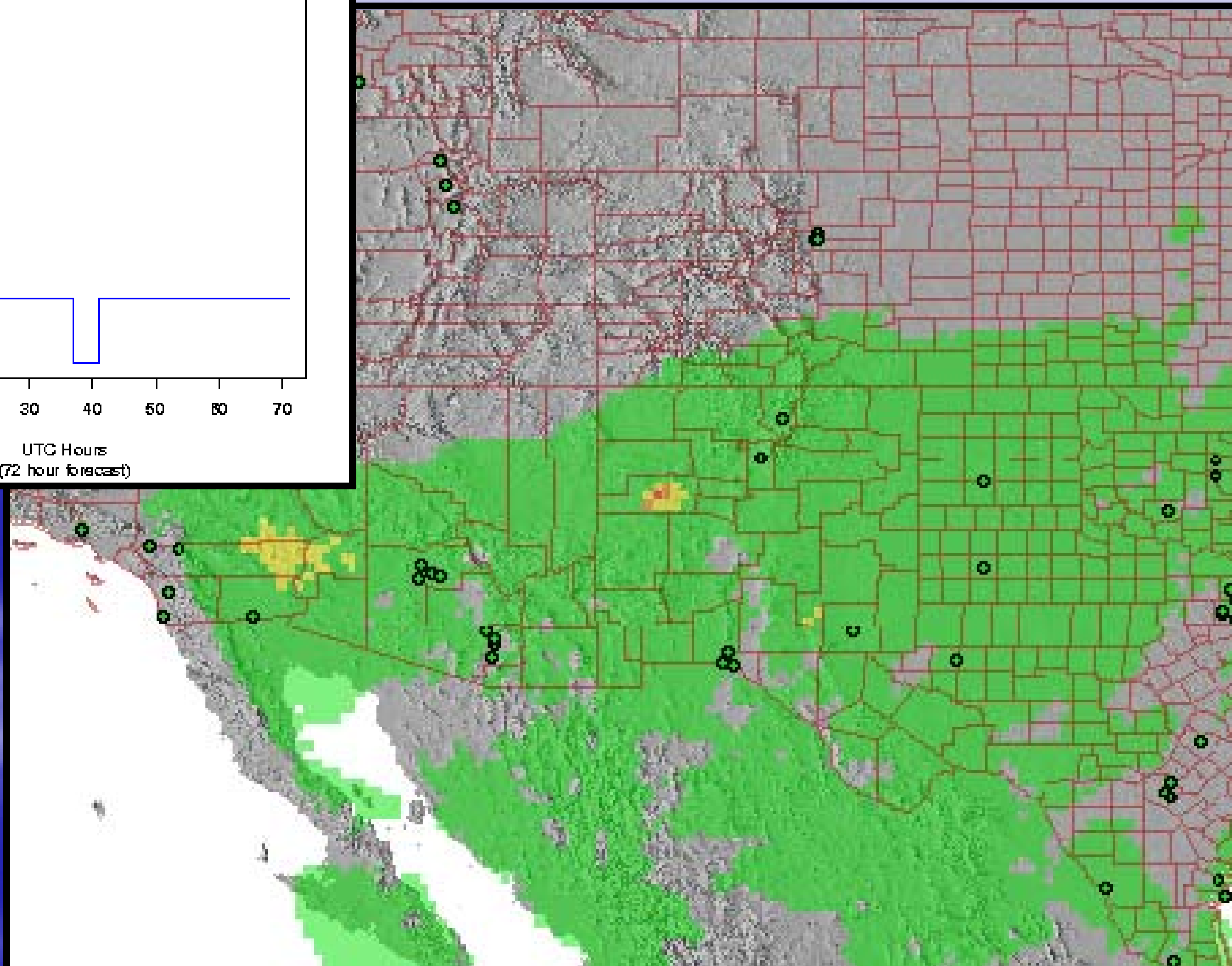
How well did the DReAM model perform in predicting the timing, duration and magnitude of the event at each of these stations for the three events?

Sample Web Output: 72-hr Forecast



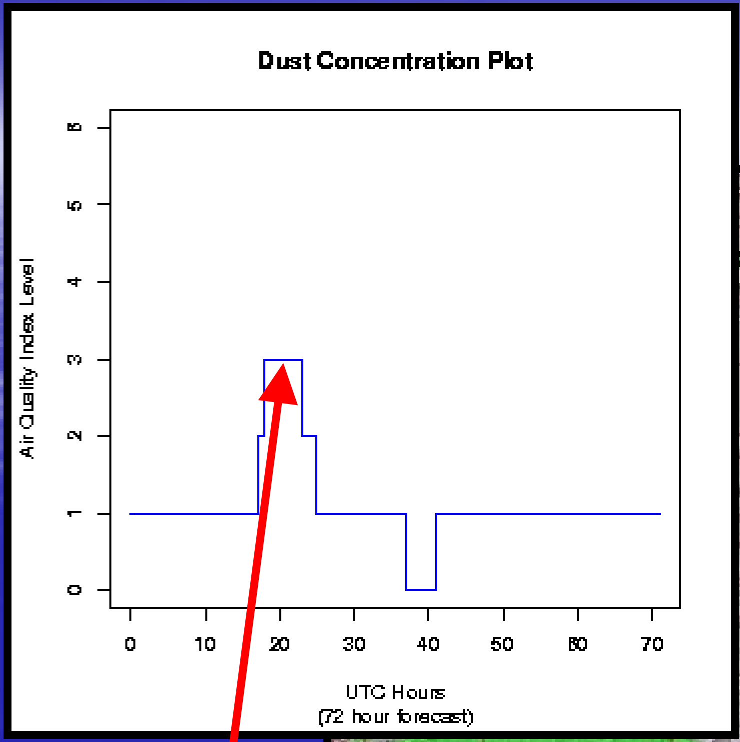
PM2.5 Lubbock, TX 12/15/03

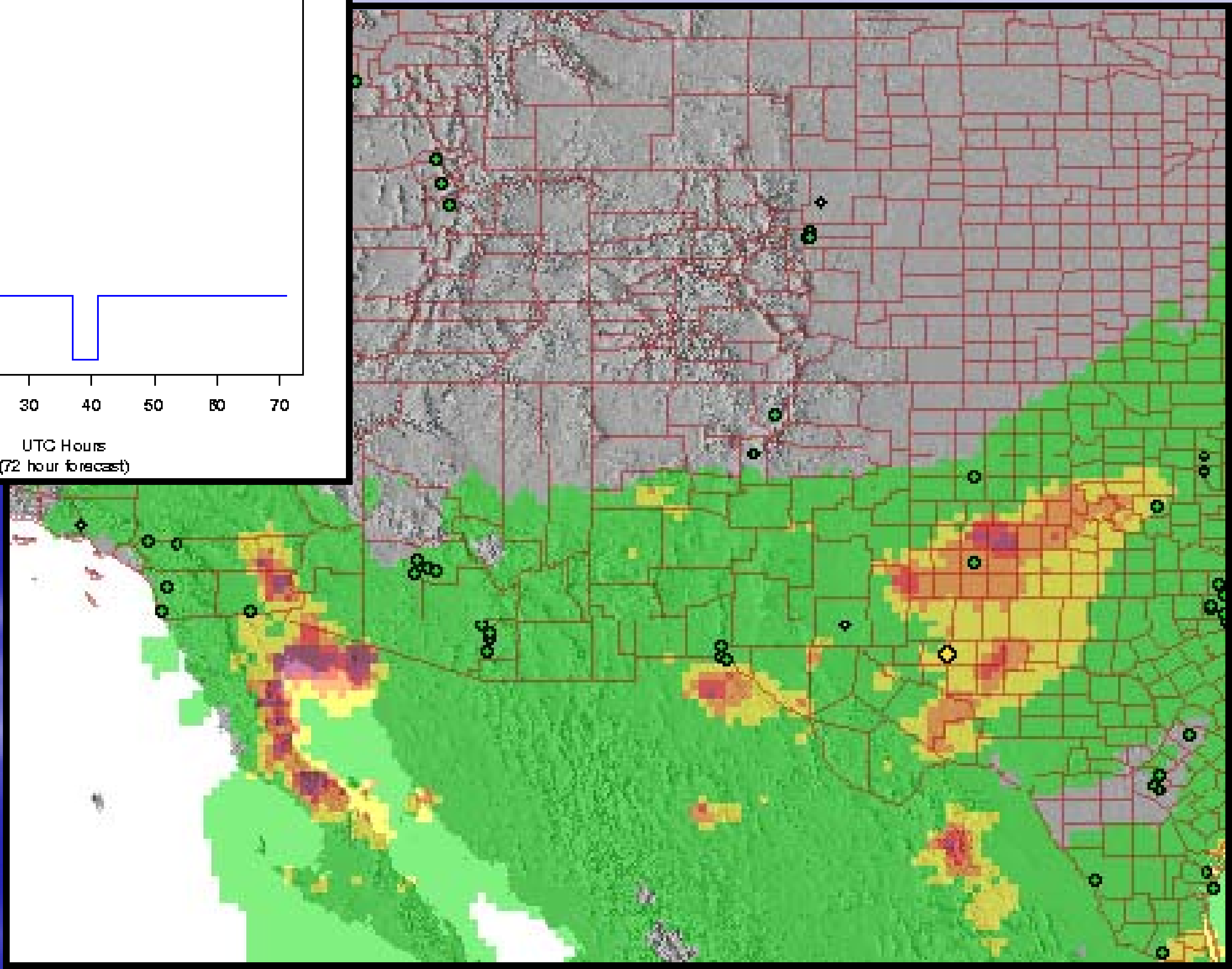




T = 10 hours

PM2.5 Lubbock, TX 12/15/03





T = 20 hours

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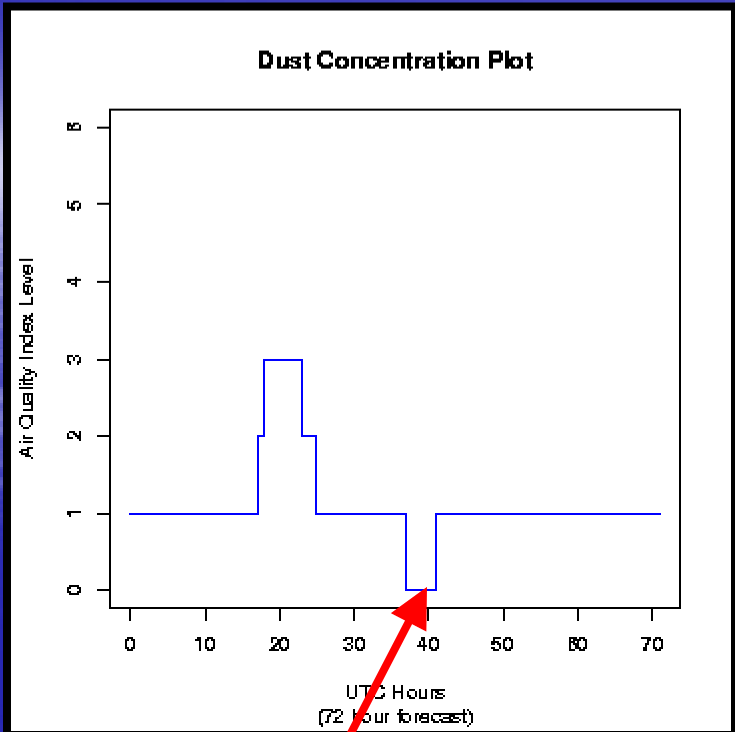
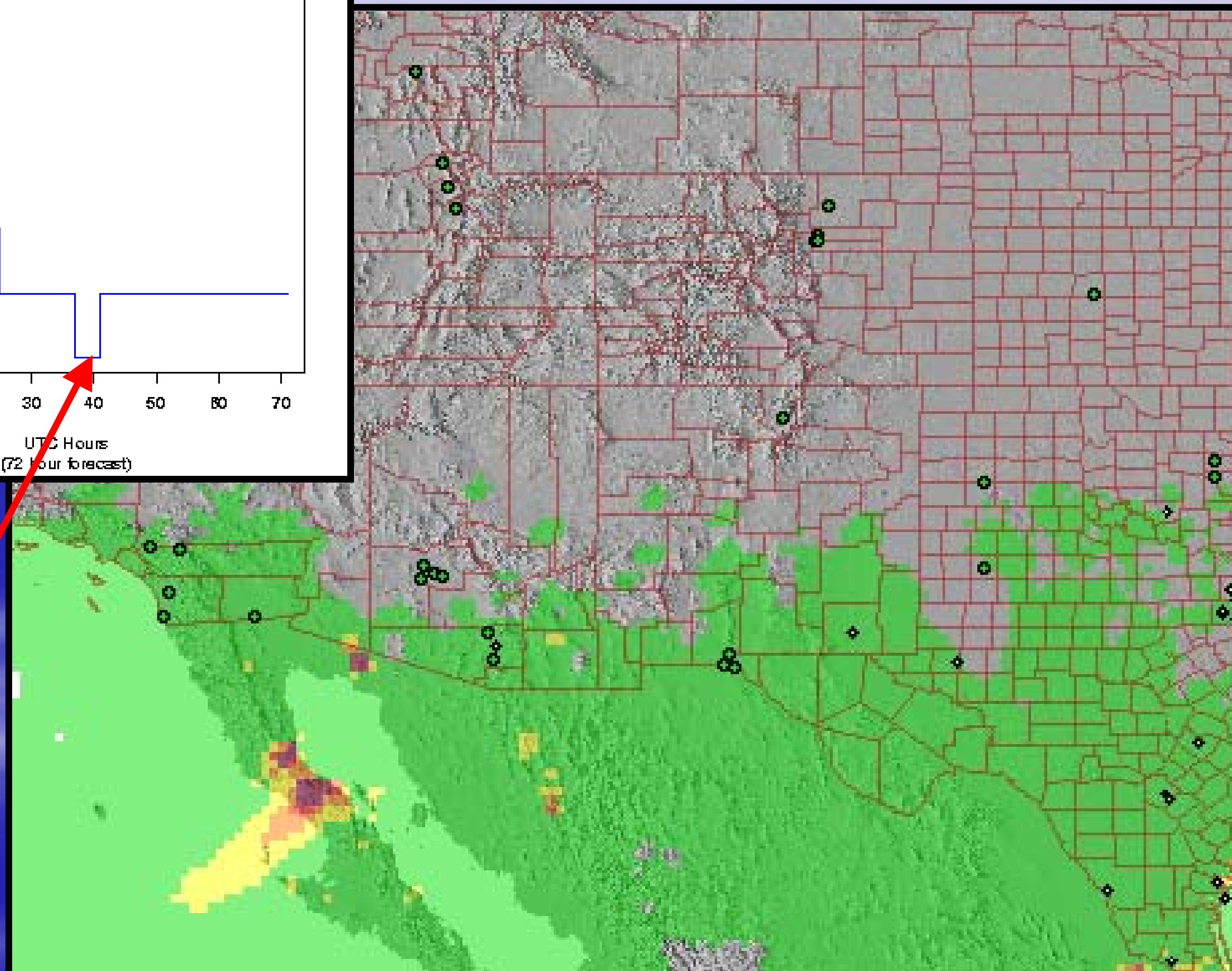
PM2.5 Lubbock, TX 12/15/03





T = 40 hours

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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 μg/m3 for $PM_{2.5}$)

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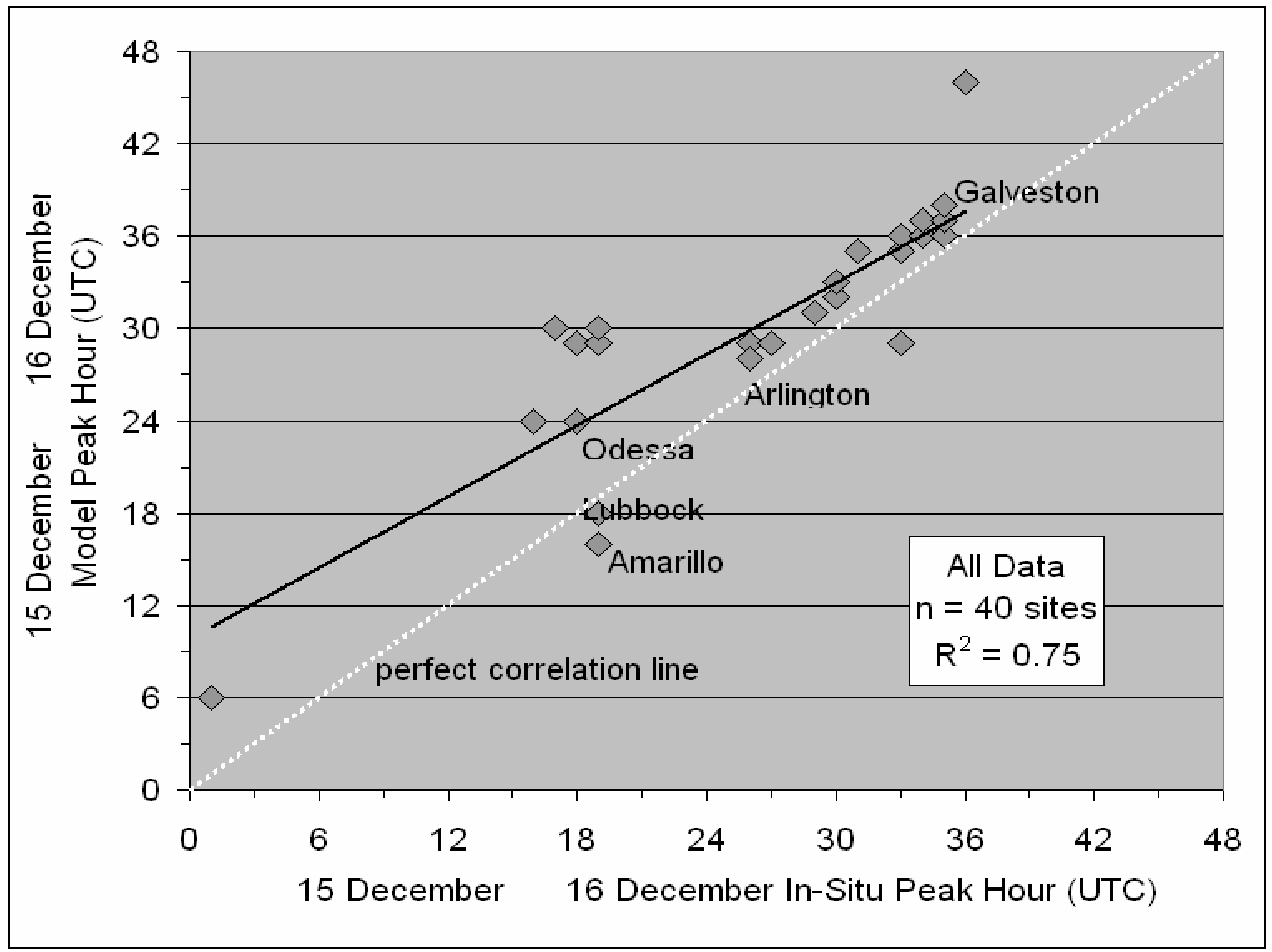
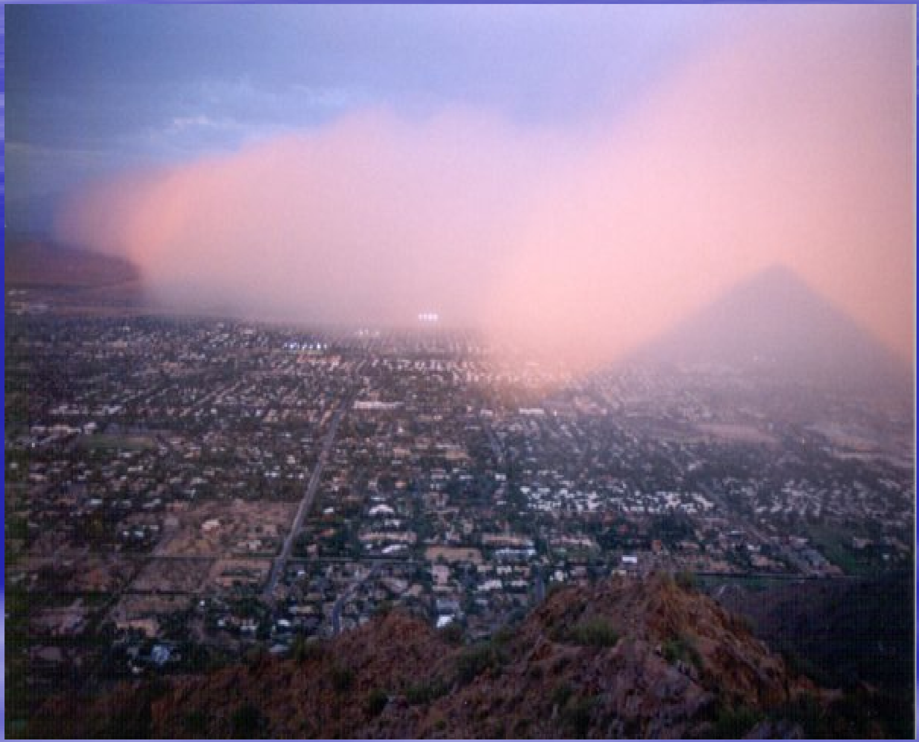
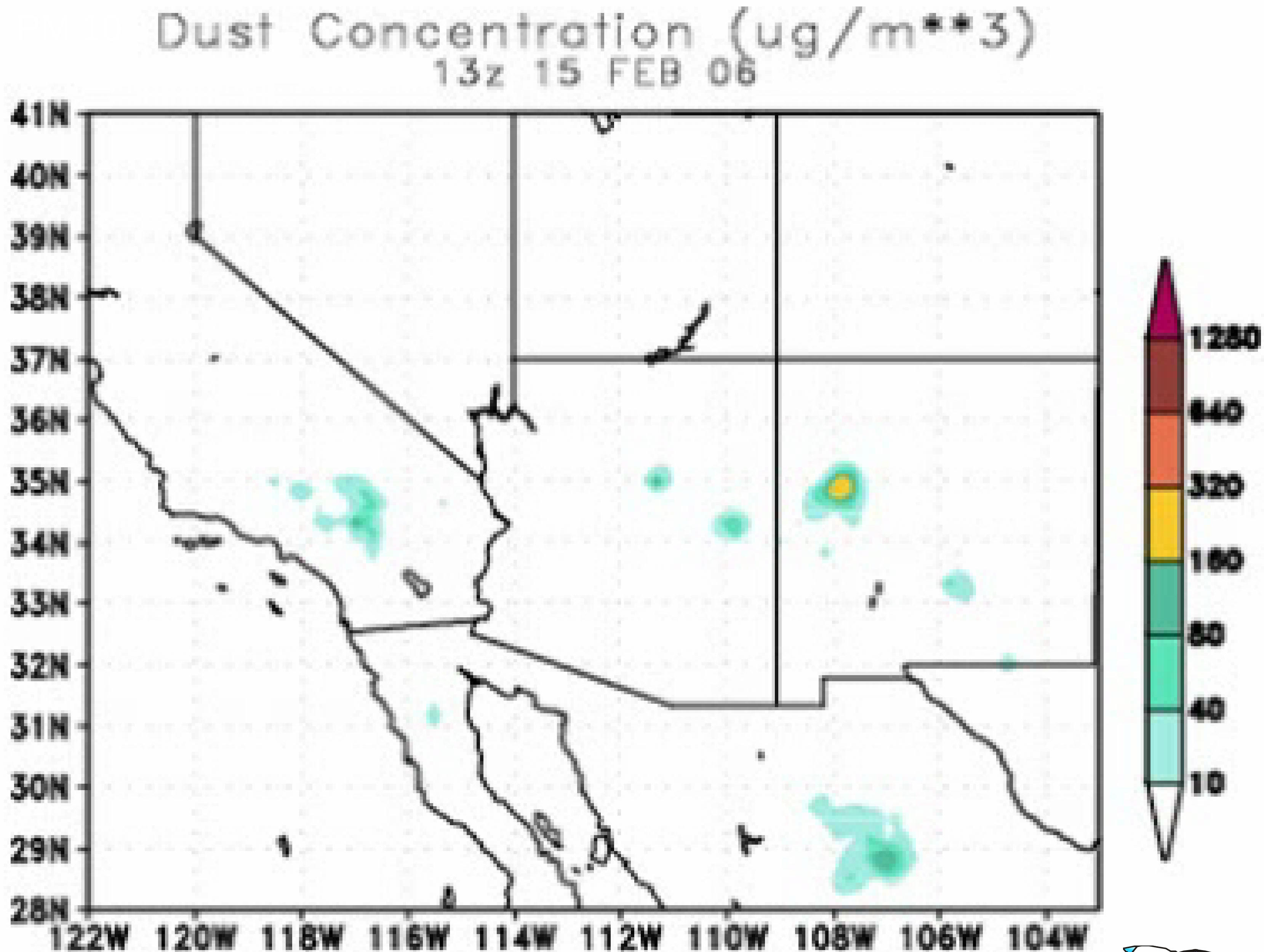
Peak Hour Comparison – All Sites



Case Study
South of Phoenix



Next: 72-hr PM10 concentration forecast…



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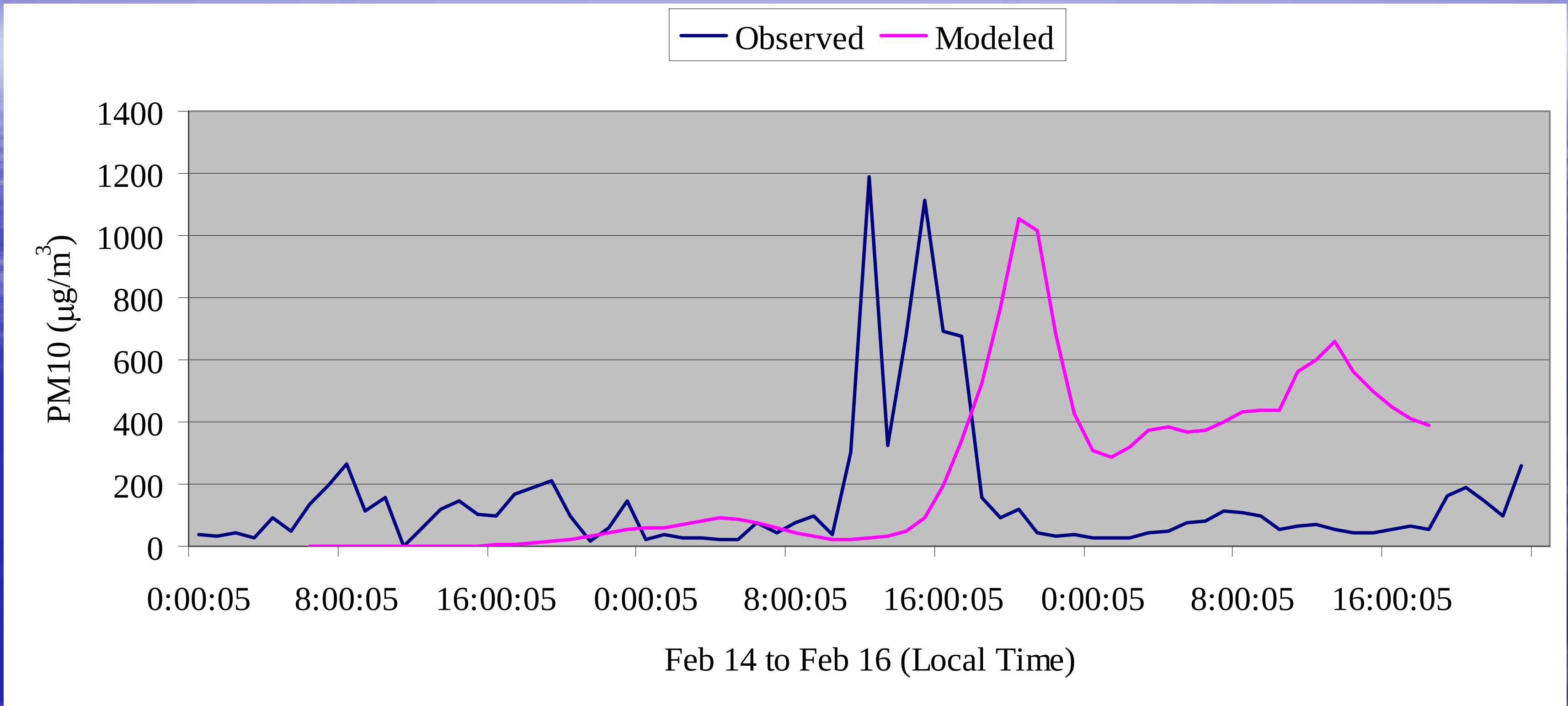

PM10 at Stanfield (miles away from the accident scene), Arizona

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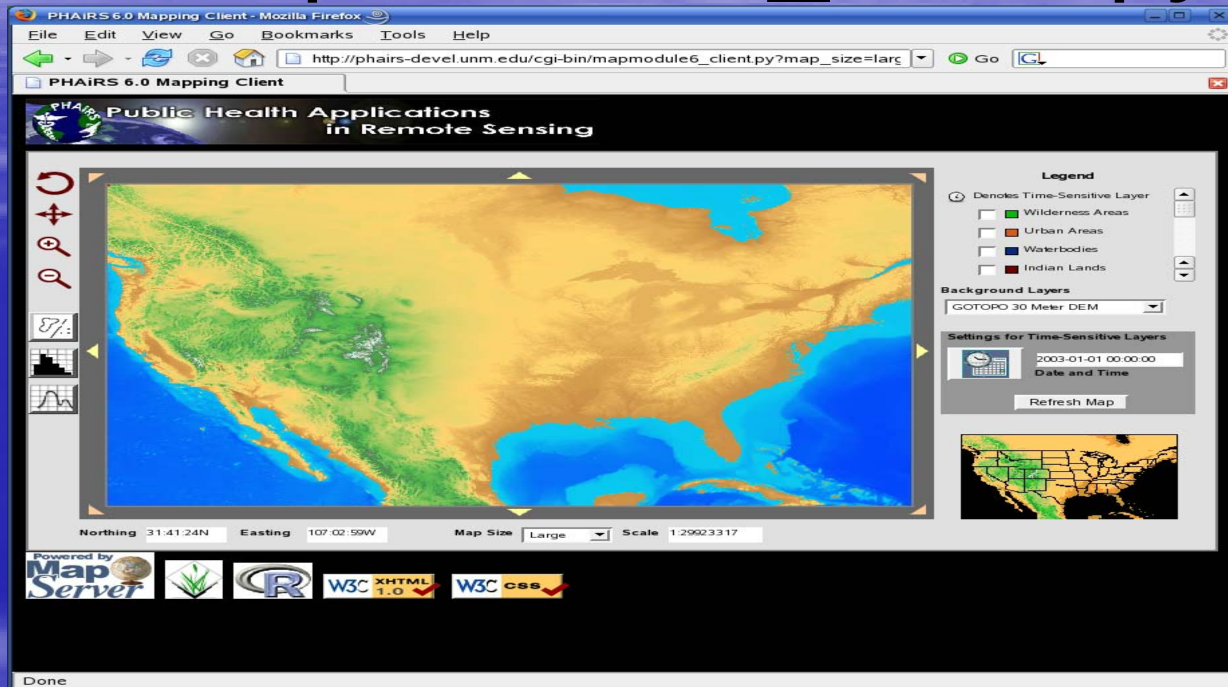
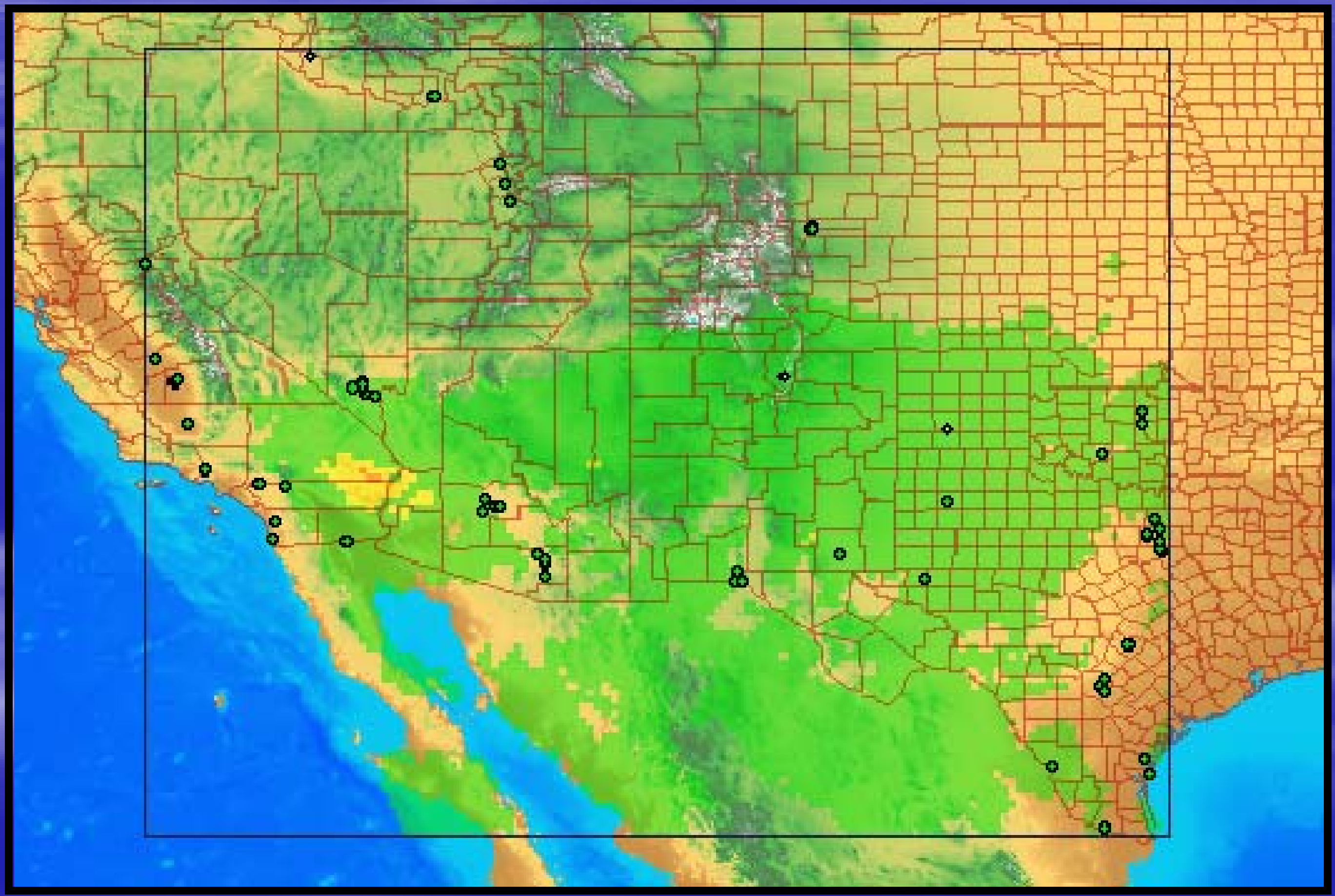
http://phairs-devel.unm.edu/cgi-bin/mapmodule6_client.py



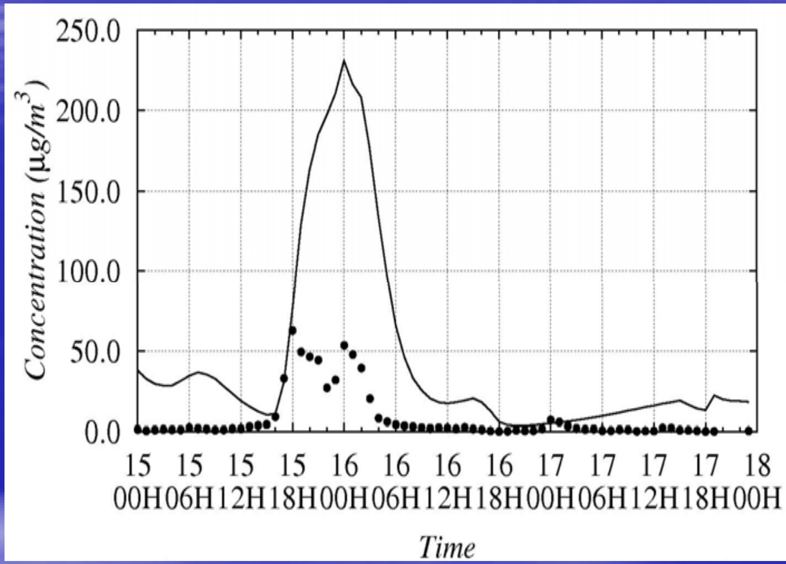
Project Web Site
http://phairs.unm.edu

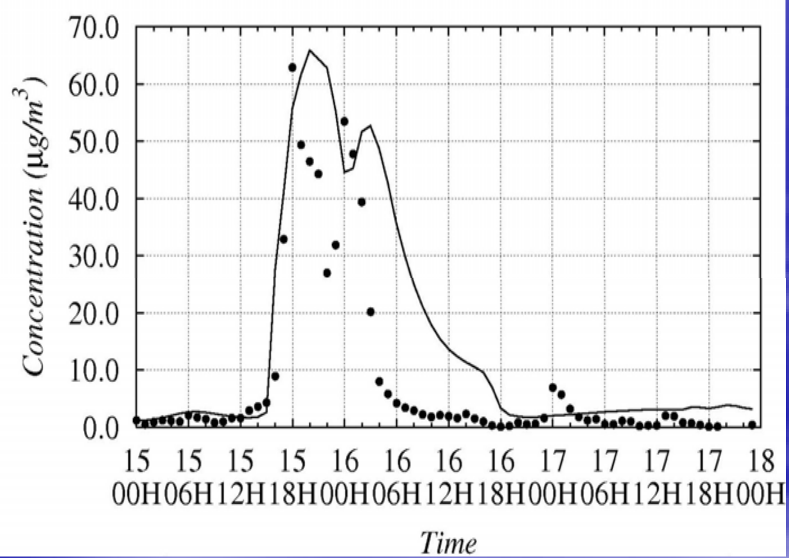
What Next?

Model Simulations & Forecasts fill gaps of Particulate Monitoring Network



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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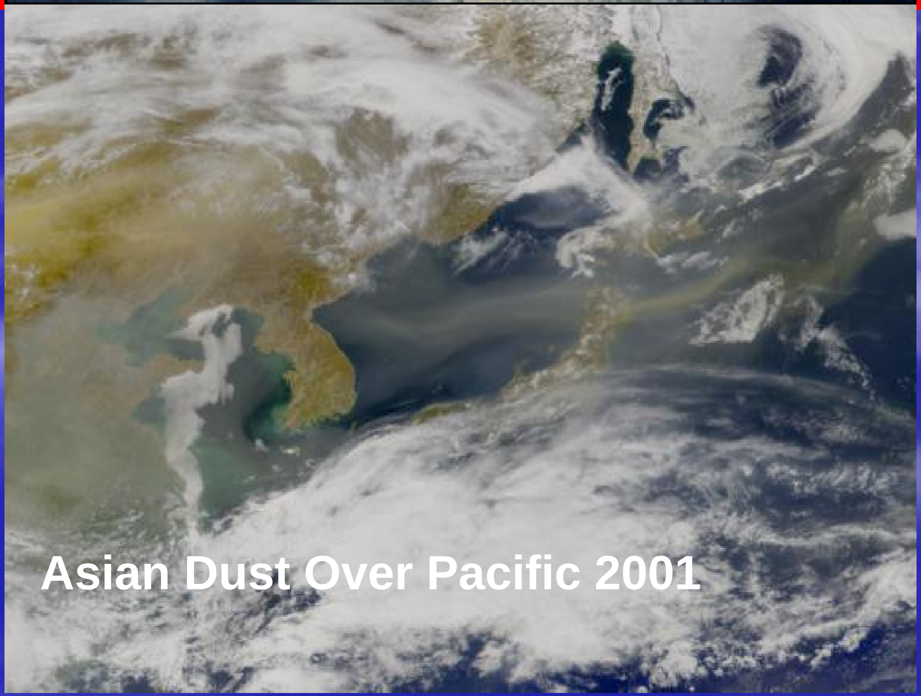
Phoenix, AZ 2004
VF?

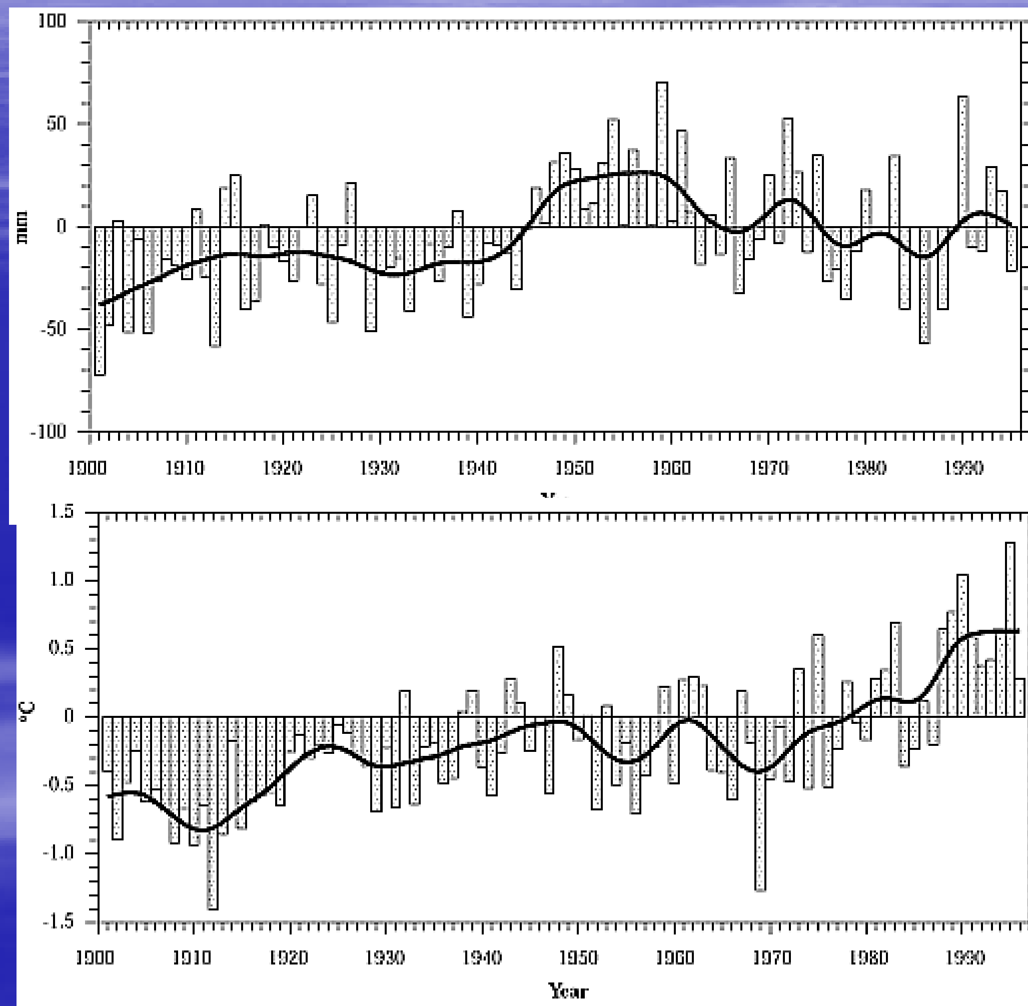

California Wildfire 2003


St Francis, KS 5/29/04


Asian Dust Over Pacific 2001

Hydrology, Weather & Climate?

Note: Asian Precipitation (top) Temperature (bottom)



http://www.grida.no/climate/ipcc/regional/305.htm

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River Runoff

- “Haihe basin and area to the north will see reduced runoff due to higher temperatures and reduced rainfall, especially in summer, adding with population growth to cause socioeconomic problems.”

IPCC Special Report on The Regional Impacts of Climate Change: An Assessment of Vulnerability

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Hydrology Modeling

Research objectives

- Develop a new generation hydrology model
- Test under real conditions

Goals

- Operational watershed forecasts
- Understand shallow water processes

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COMPLEXITY OF THE MODELED

HYDROLOGICAL PROCESS

Natural environments involved

- ***Atmosphere*: rainfall, evaporation, transpiration**
- ***Soil*: infiltration, surface and deep soil runoff**
- ***Hydrosphere*: watershed process, rivers**

Simultaneous interaction of three environments!

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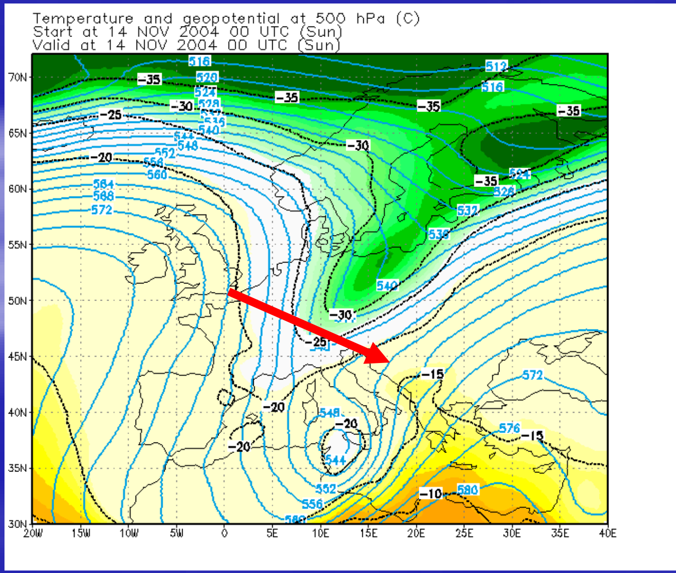
MODEL TEST

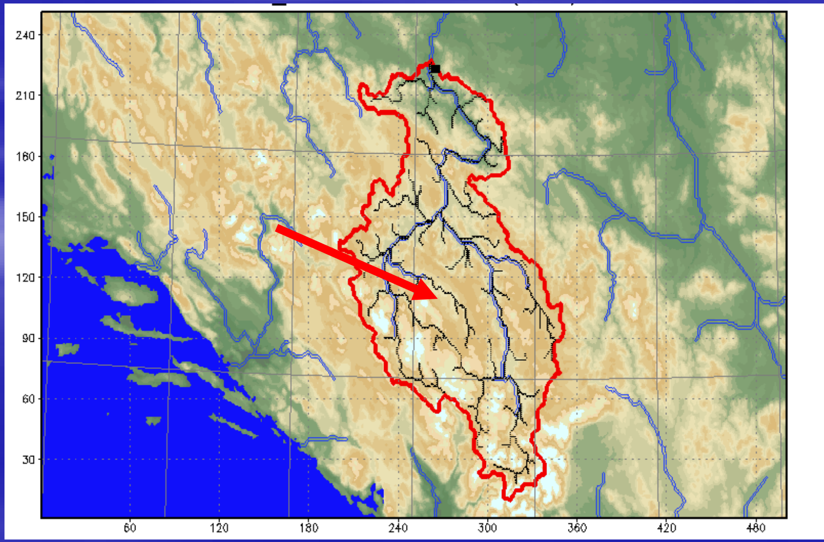
Nov 2004 precipitation case

Model resolution: 1km

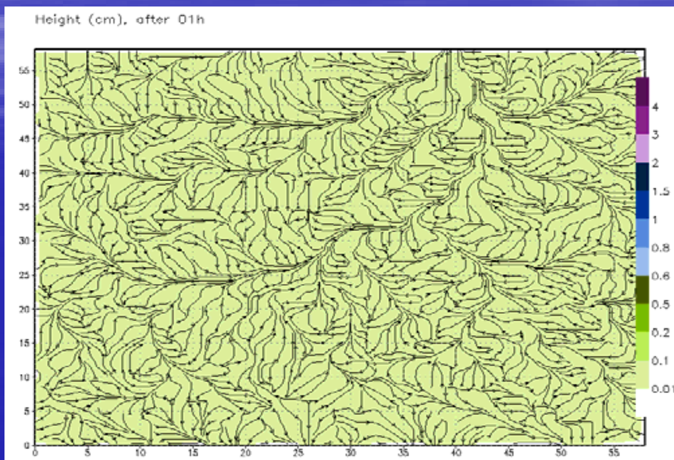
Domain: River Piva in Montenegro

3-day model simulation driven with observed precipitation

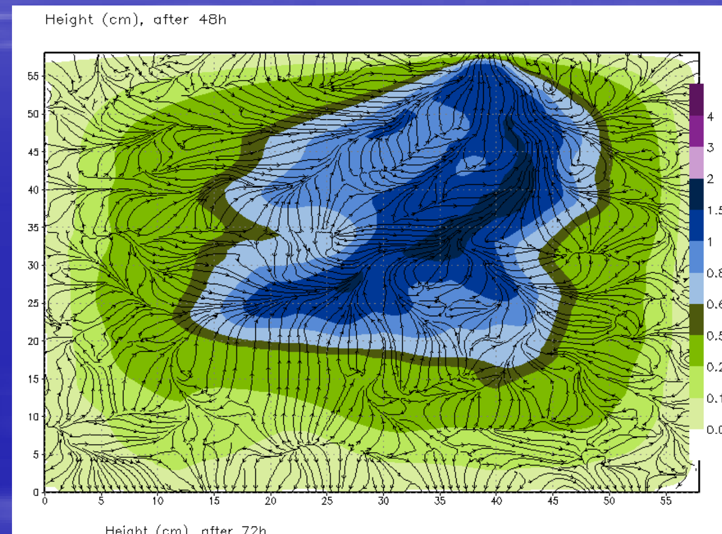




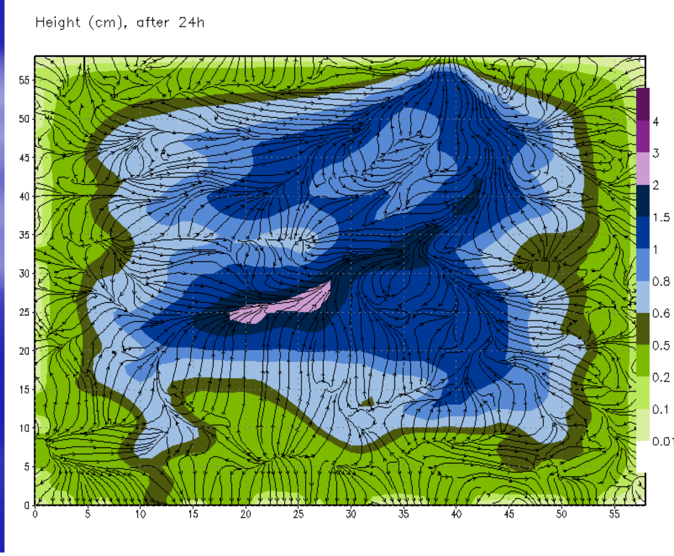
3-day model simulation driven with observed precipitation



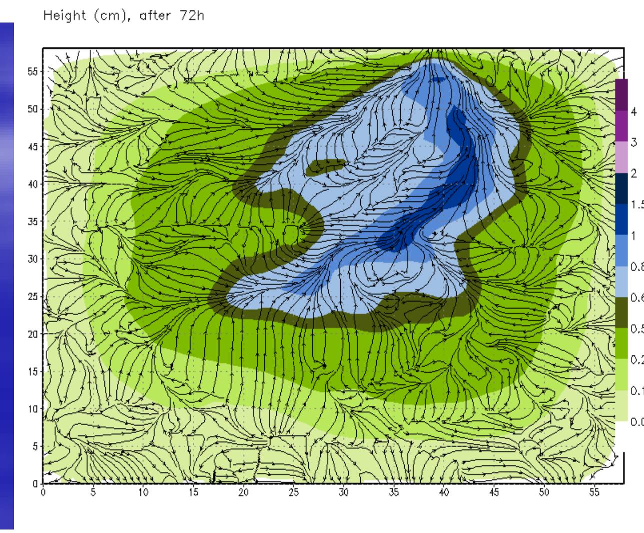
1st hour



48 hrs



24th hour



72 hrs

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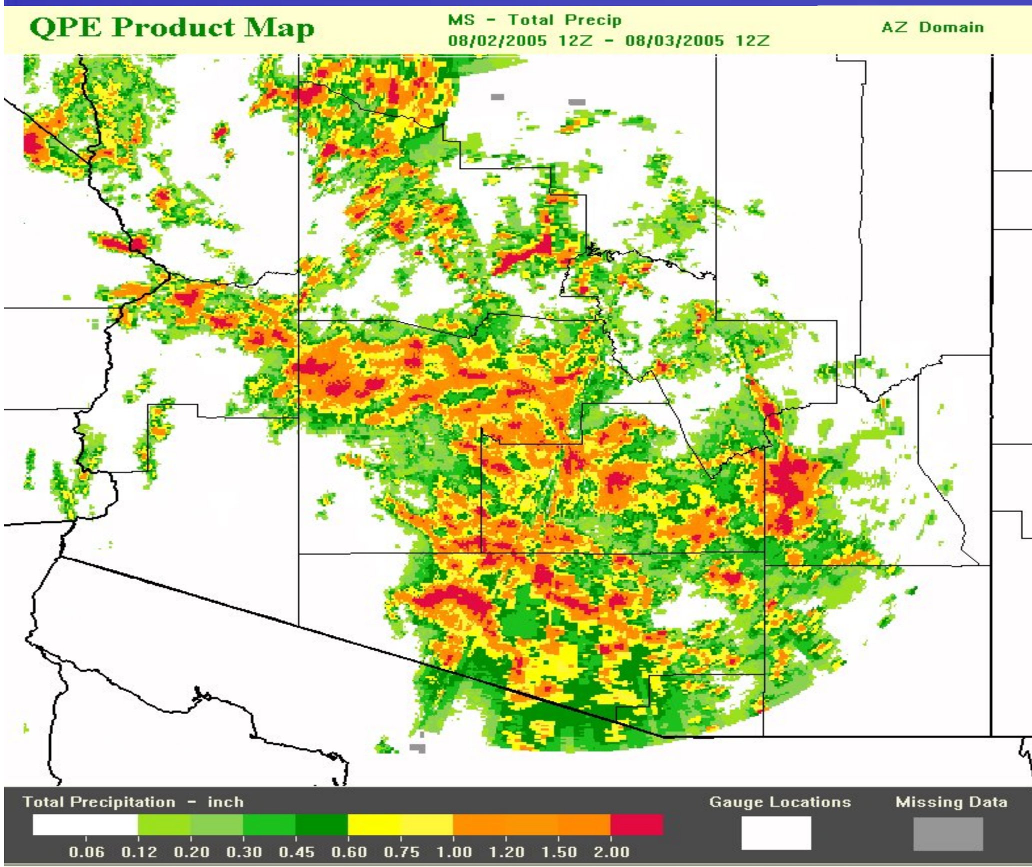

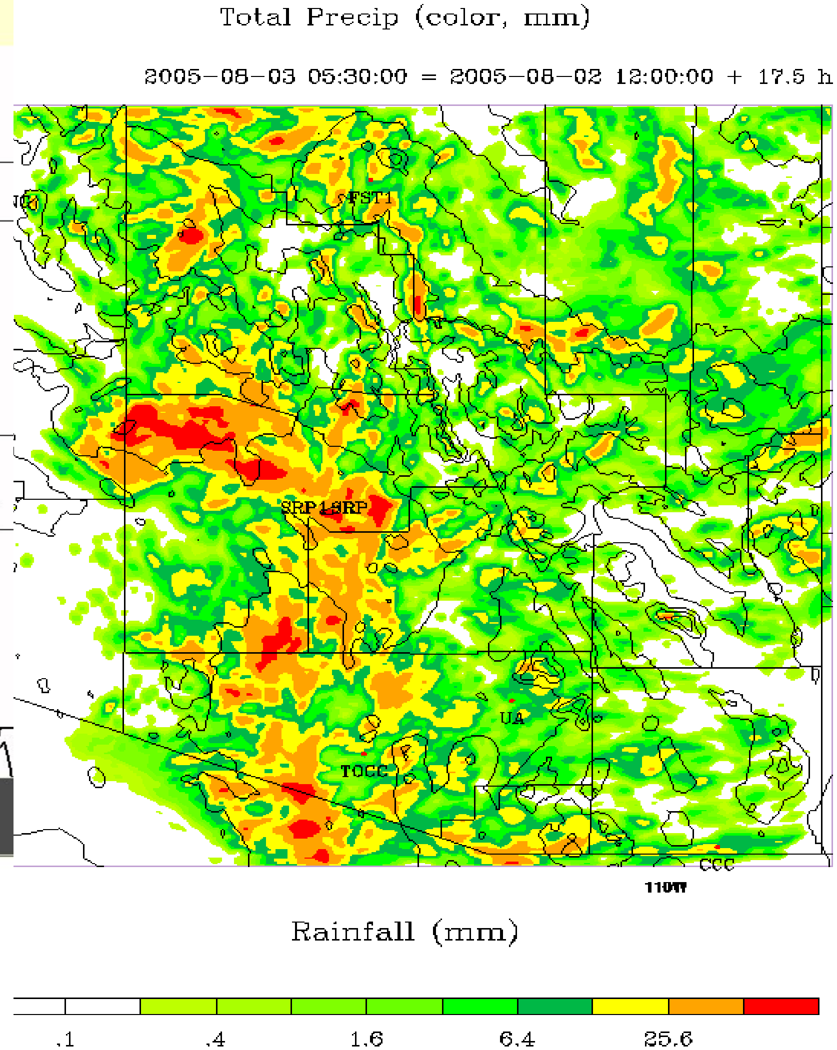

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Comparison of RADAR derived precipitation (L) vs the model (R) from a summer 2005 severe weather and flash flooding event over Phoenix. The model was 3 hours too soon with the convection, but did well for location and amount of rain. (courtesy Mike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

Possible Model Applications?

- Examine consequences of climate change?
- Develop flash flood warning system?
- Explore methods of soil erosion and water pollution control?

SUMMARY

- DUST MODEL SEMI-OPERATIONAL
- HIGH 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

- HYDROLOGY MODEL CAN BE TESTED FOR HAIHE BASIN

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Acknowledgements

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Special Appreciation to the Haihe River Conservancy Commission (MWR)

Delegation at the Grand Canyon & Central Arizona Project

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