



Improving Public Health Services through Space Technology and Spatial Information Systems

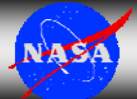
Stan Morain

Earth Data Analysis Center

University of New Mexico

Work performed under NASA NNSO4AA19A

**Ericc International Seminars on Planetary
Emergencies, 40th Session
August 19-24, 2008**



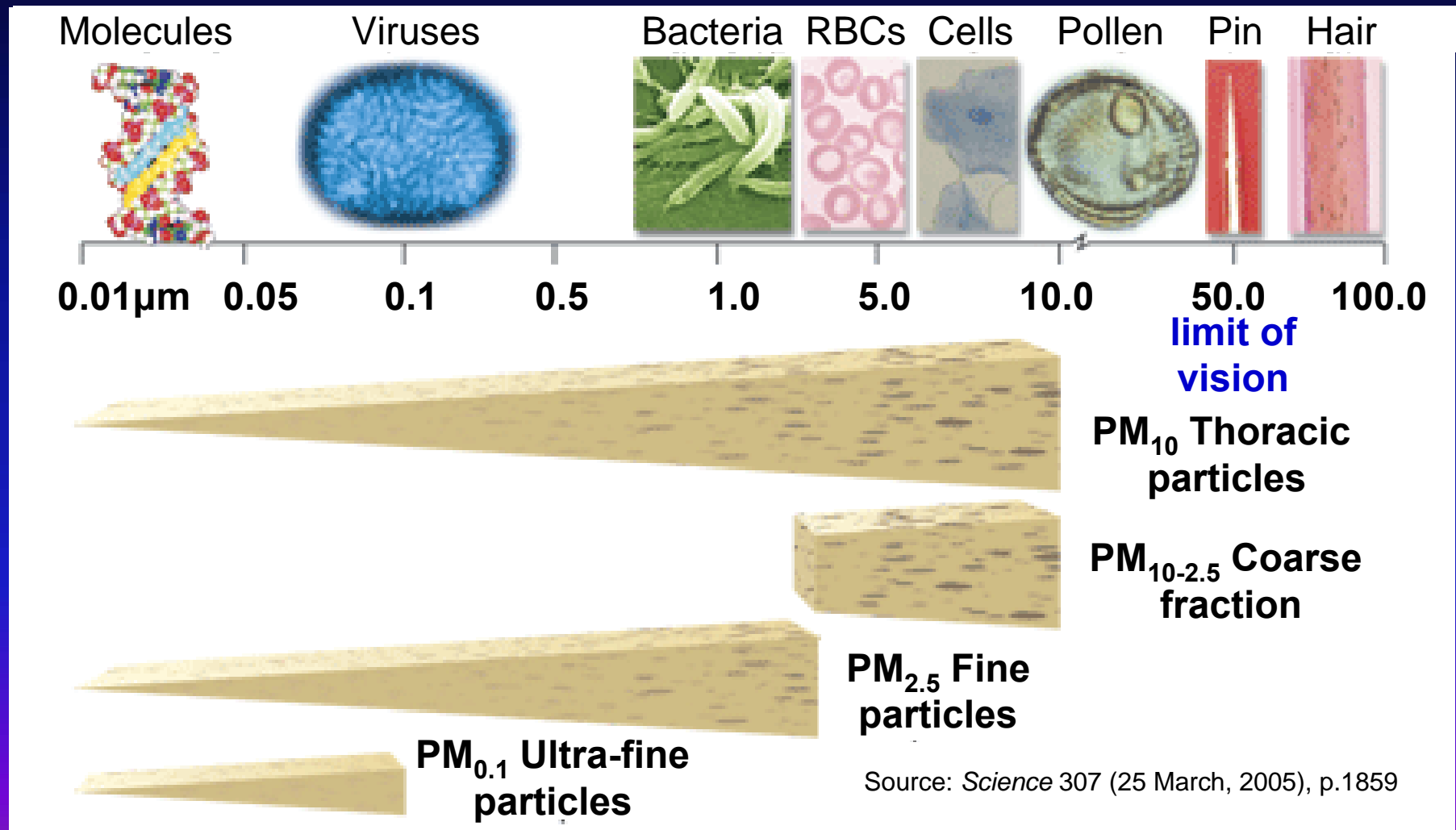


Classification of Diseases

- Infectious and zoonotic
 - e.g., AIDS, TB, Influenza, plague, hantavirus,
- Degenerative
 - e.g. Arteriosclerosis
- Environmental
 - e.g. Asthma, cholera, meningitis, malaria, yellow fever
- Neoplastic
 - e.g. Cancer
- Metabolic
 - e.g. diabetes



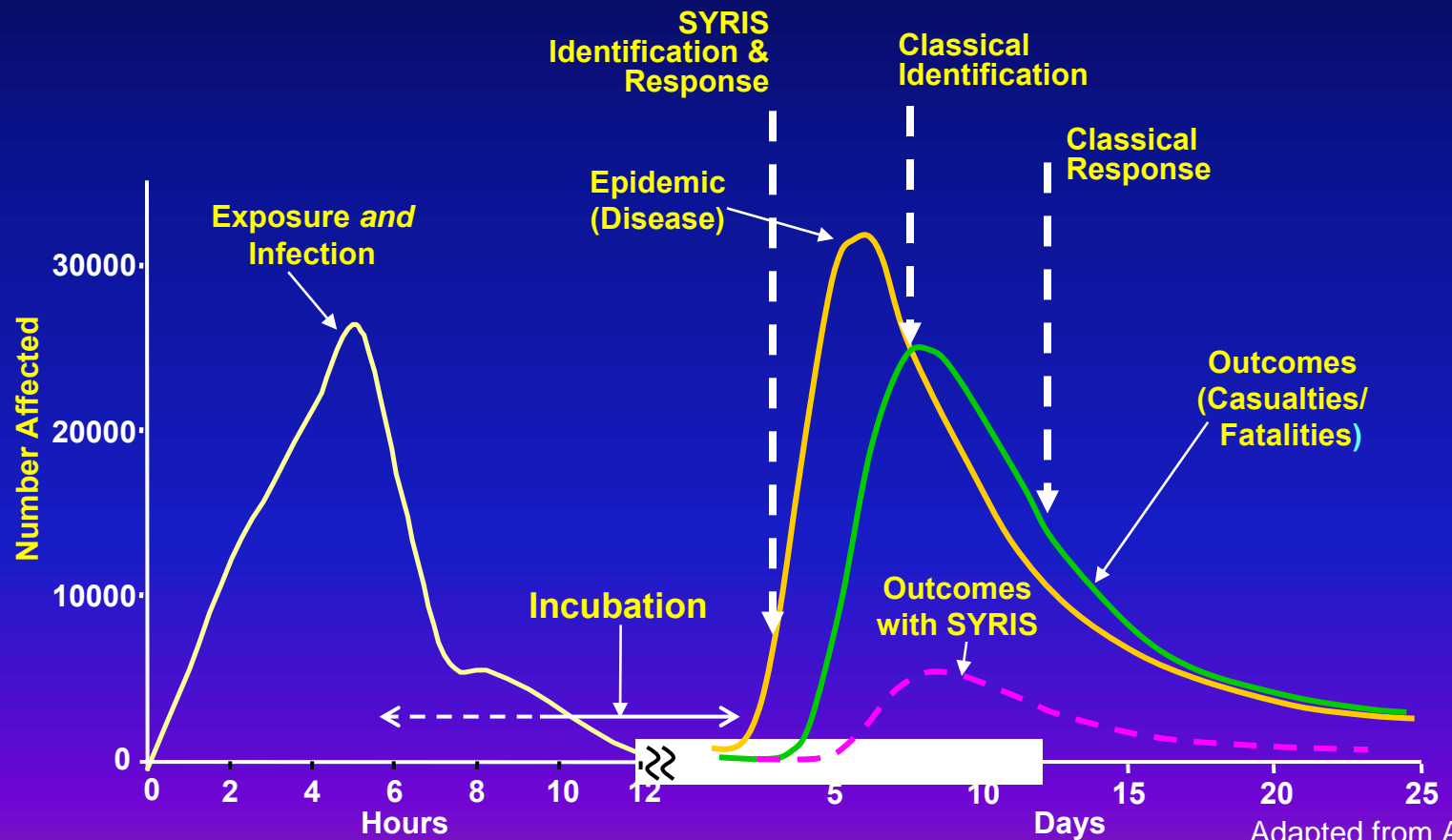
Components and Sizes of Particulate Matter





SYRIS = Earlier Detection and Immediate Response to Outbreaks

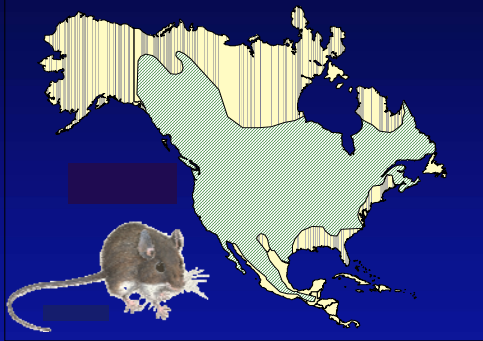
- Exposure: People / Animals are exposed to infectious agents
- Epidemic: People / Animals begin to show signs of infection
- Outcome: People / Animals begin to die or get very sick
- SYRIS Outcome: 80% fewer People / Animals get sick or die



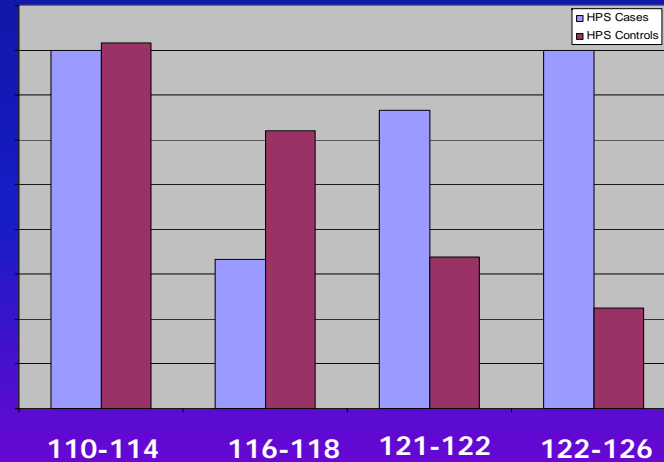
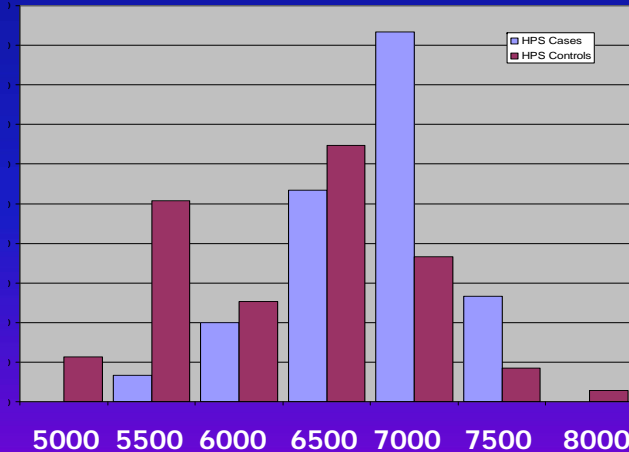
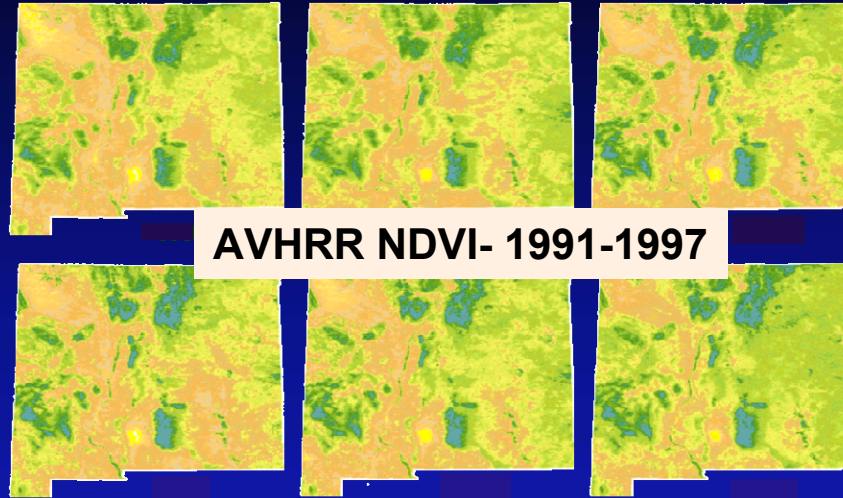


Hantavirus Pulmonary Syndrome

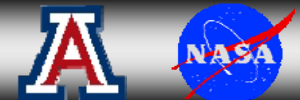
Peromyscus Maniculatus



Reservoir for
Sin Nombre Virus



HPS Cases & Controls as a Function of Elevation % Frequency of HPS and Control Sites w/i NDVI Intervals





Reported Predictors & Triggers Of Asthma

Respiratory Predictors

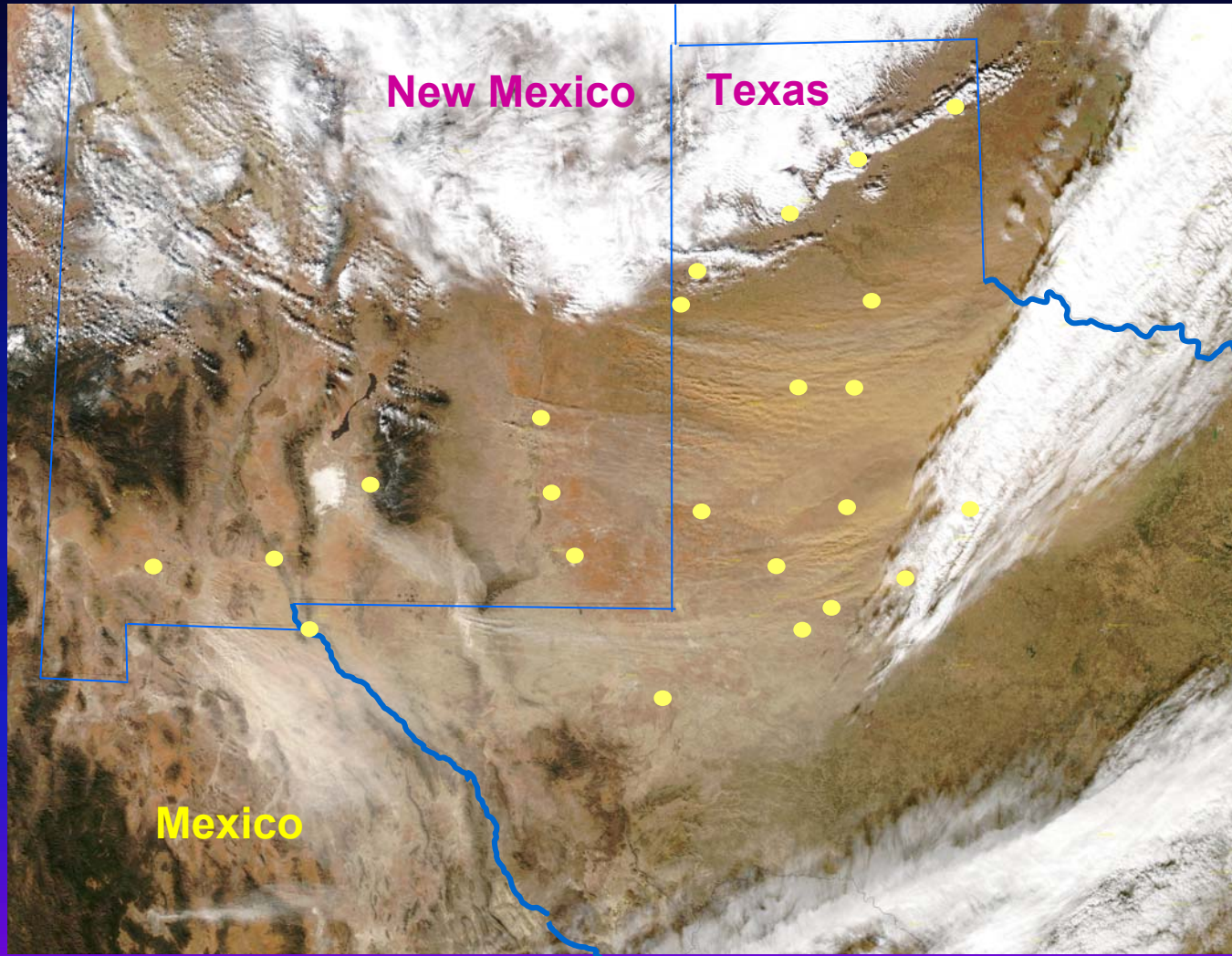
1. Temperature
2. Precipitation
3. Humidity
4. Gender
5. Age
6. Urbanicity
7. Traffic density

Respiratory Triggers

- A. Outdoor Environment
 1. Dust
 2. Pollen
- B. Indoor Environment
 1. Wall-to-wall carpet
 2. Cockroaches
 3. Stuffed toys



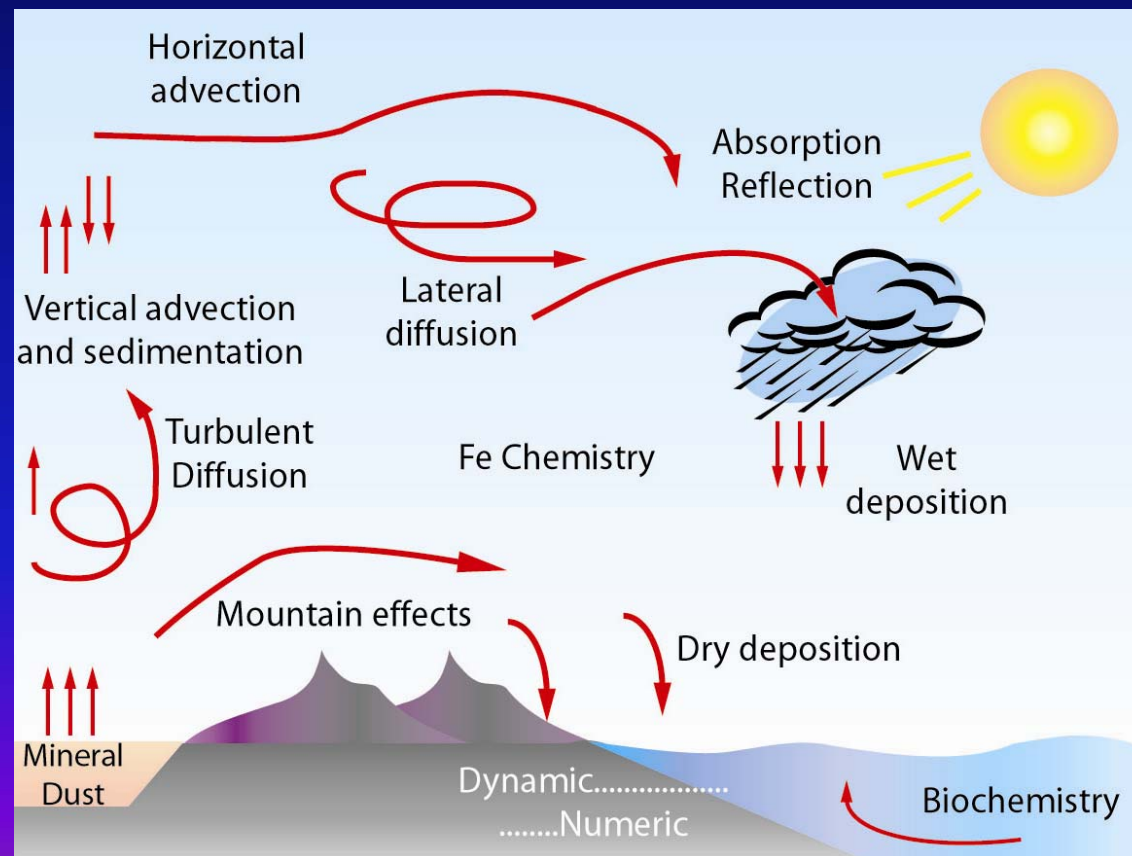
Dust Sources and Dust Transport





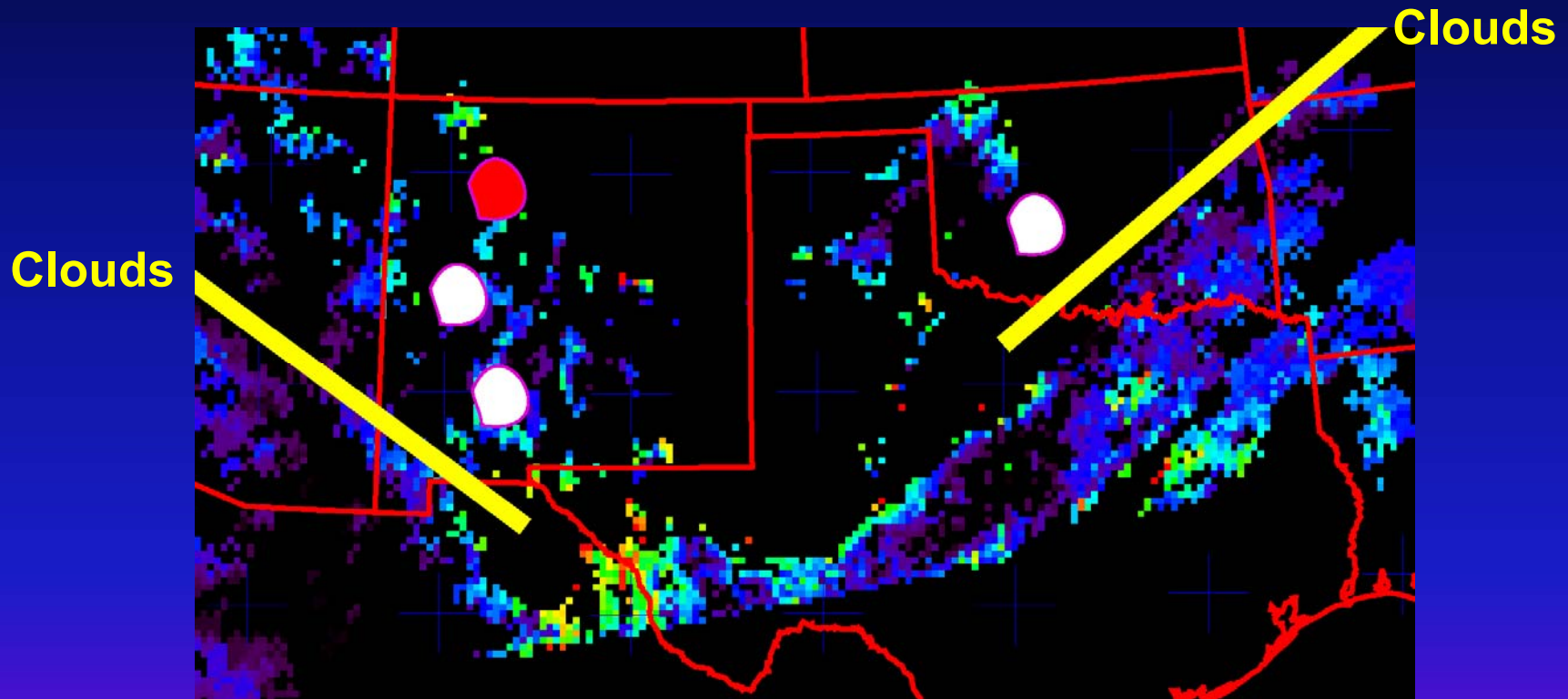
DREAM Equation

$$\frac{\partial C_k}{\partial t} = -u \frac{\partial C_k}{\partial x} - v \frac{\partial C_k}{\partial y} - (w - v_{gk}) \frac{\partial C_k}{\partial z} - \nabla \cdot (K_H \nabla C_k) - \frac{\partial}{\partial z} \left(K_Z \frac{\partial C_k}{\partial z} \right) + \left(\frac{\partial C_k}{\partial t} \right)_{SOURCE} - \left(\frac{\partial C_k}{\partial t} \right)_{SINK}$$



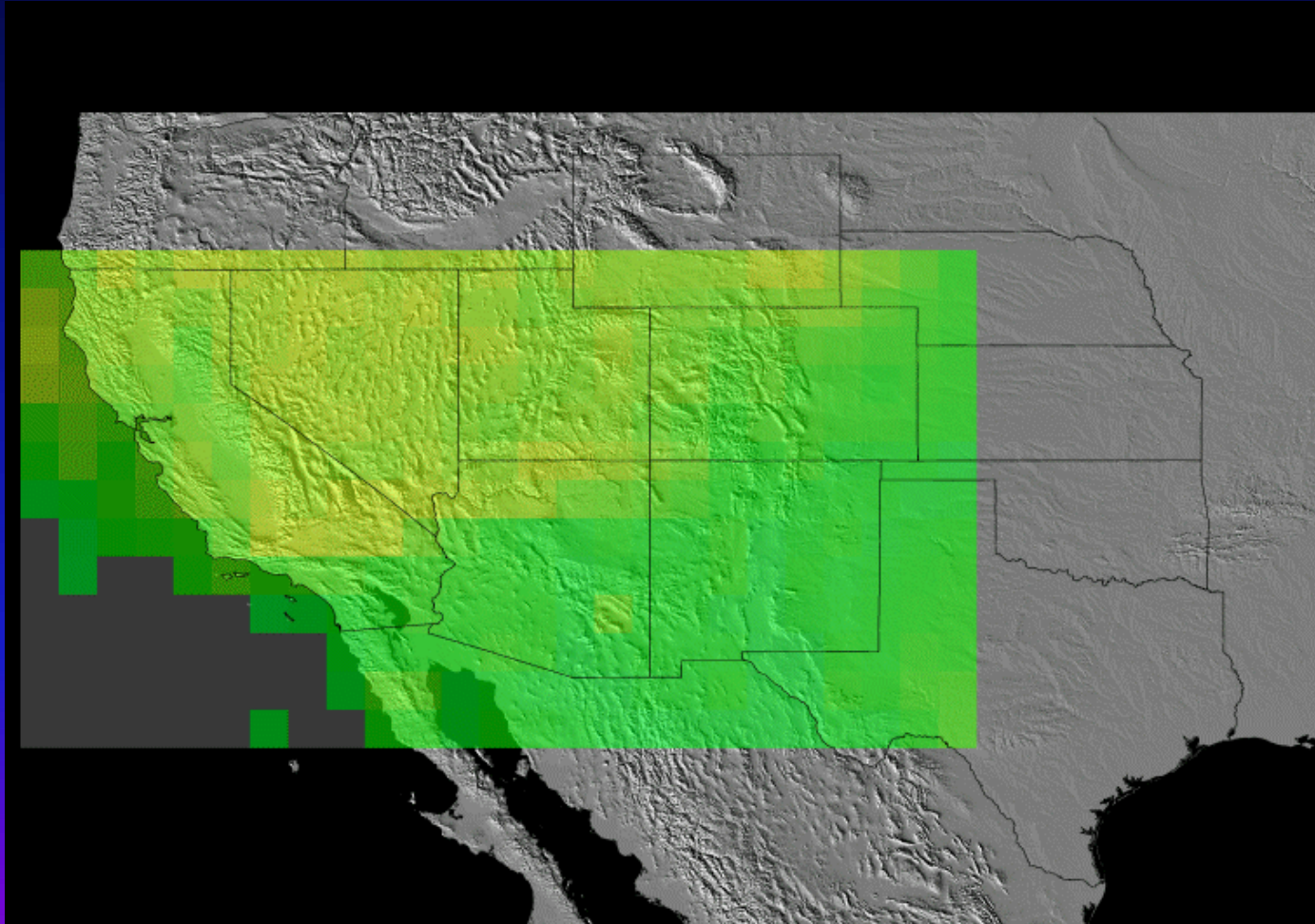


MODIS Aerosol Optical Depth Dec. 15, 2003 (2055 UTC)



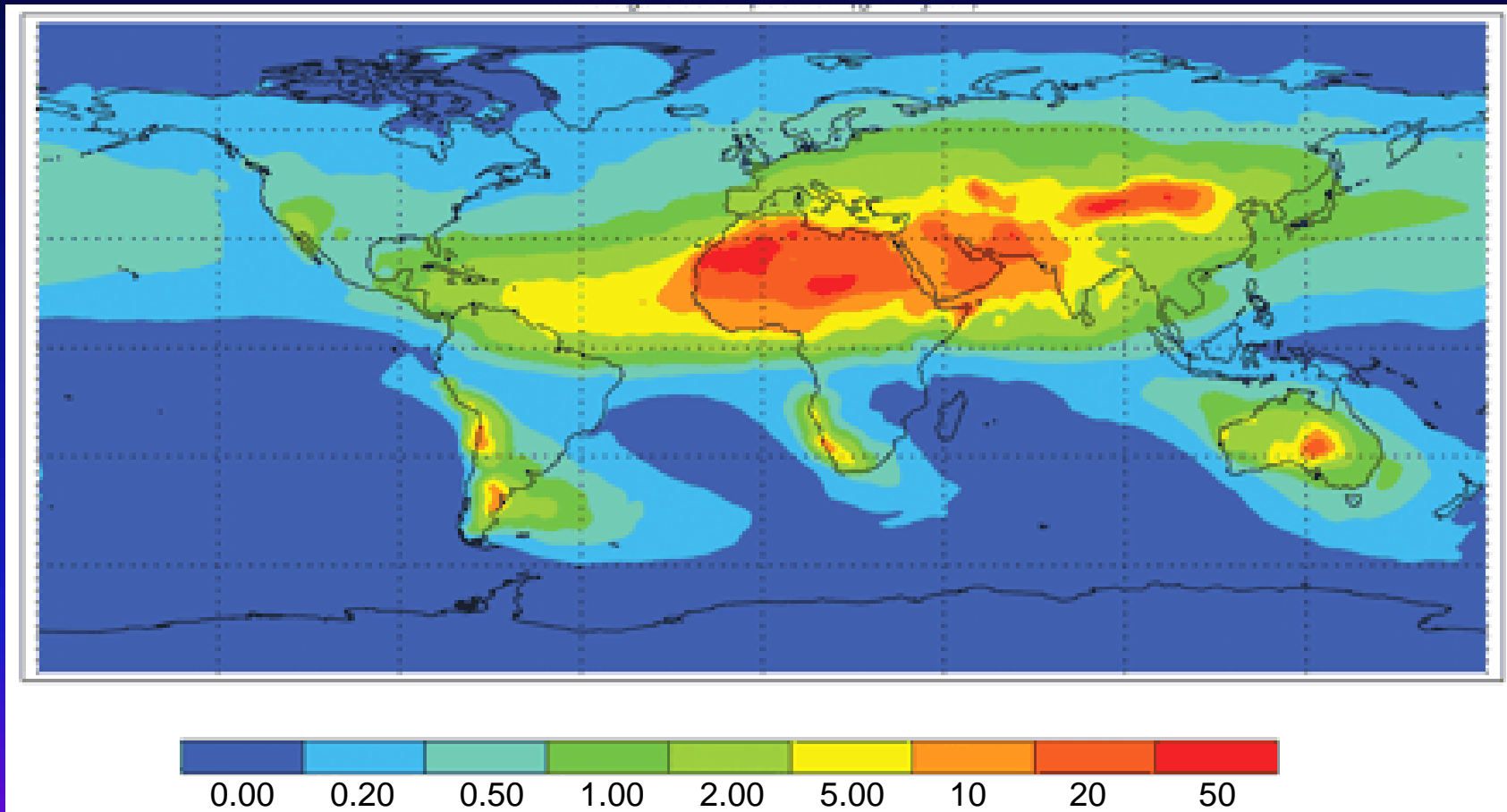


Changing Ozone Patterns— Southwest USA





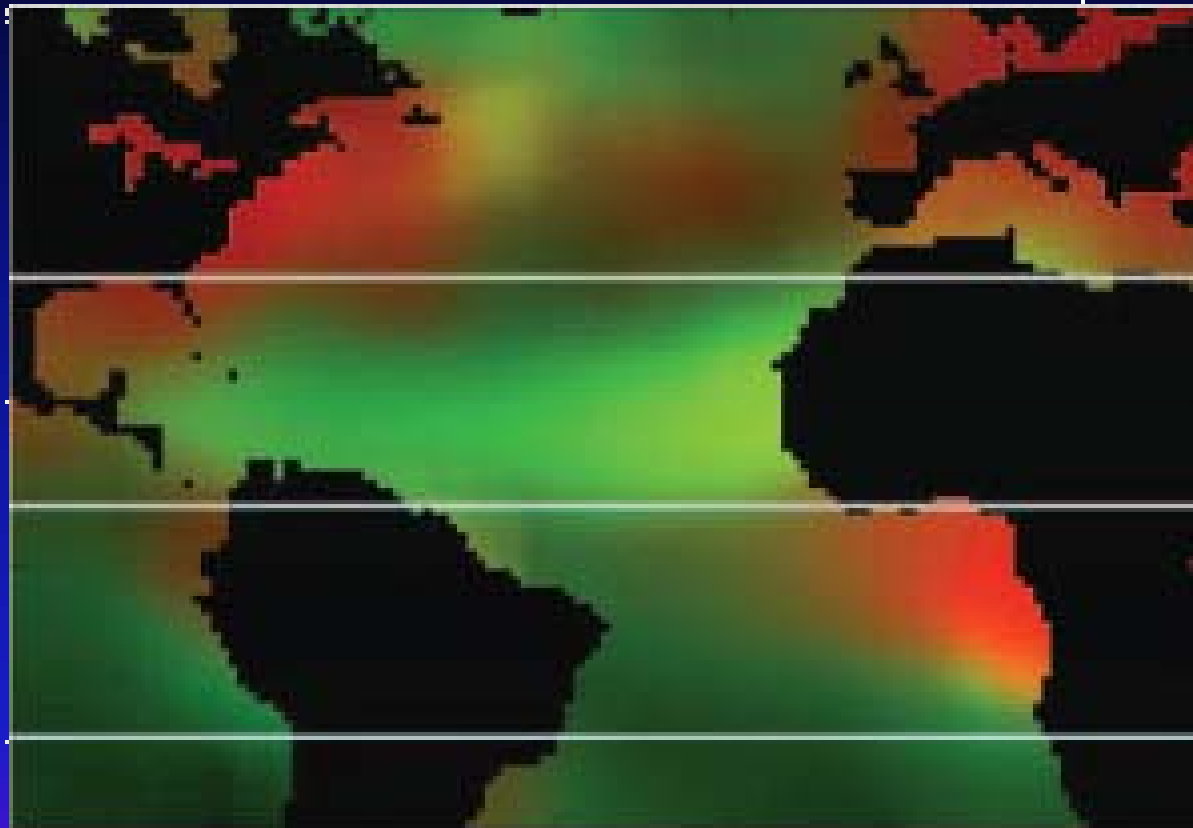
Average Dust Deposition (g/m²/year)



Source: *Science* 308 (1 April, 2005) p.70



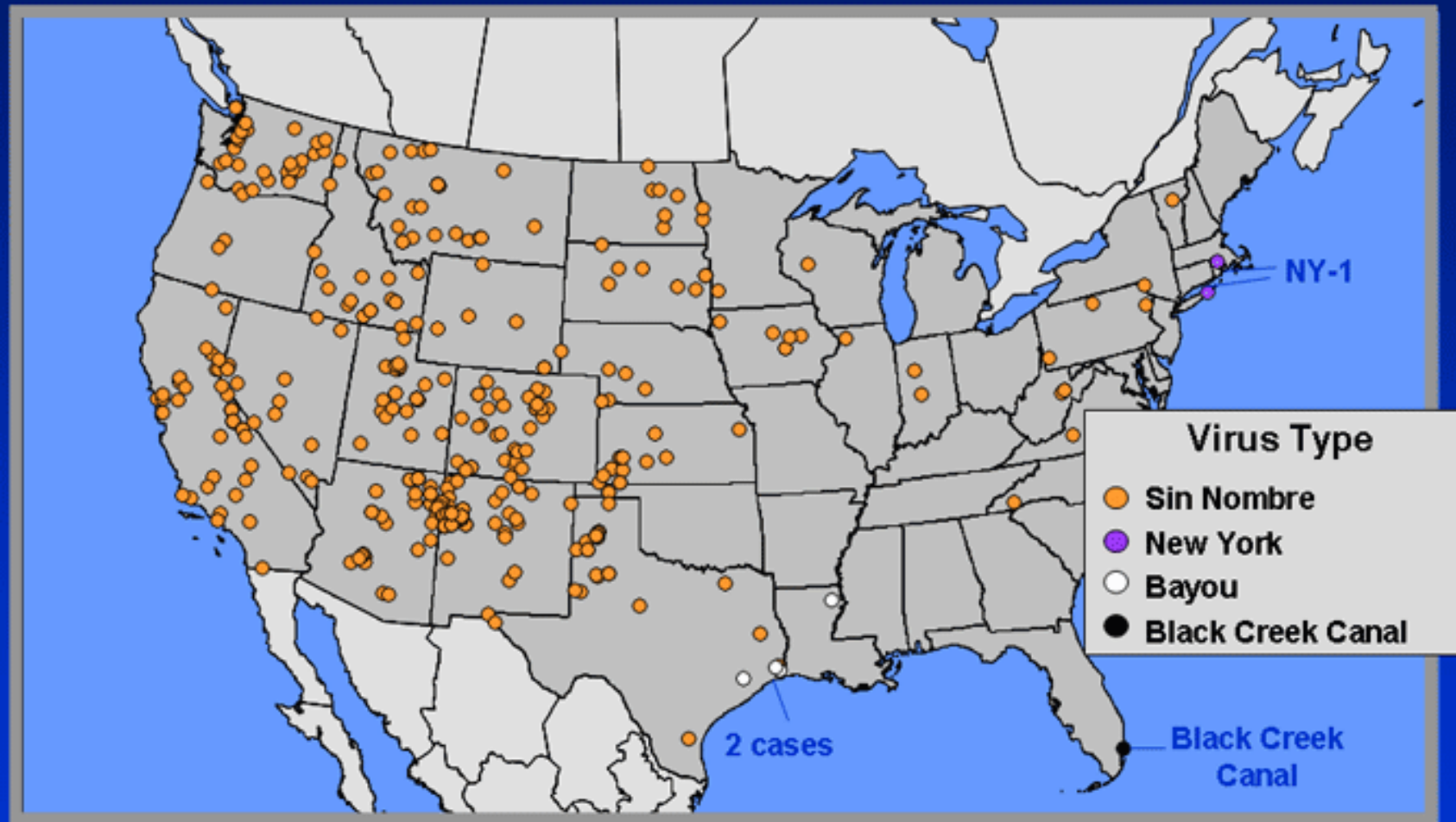
AOD Column Concentration and Type, Atlantic, Jun-Aug 2002, MOD04-L2



Optical thickness is represented by the brightness of the image; type by color.
Red = sub- μm particles (smoke, NO_x, SO_x, and other pollutants);
Green = dust or sea salt.



Location of HPS Cases by Virus Type as of September 1, 2004 Total Cases (N=379 in 30 States)



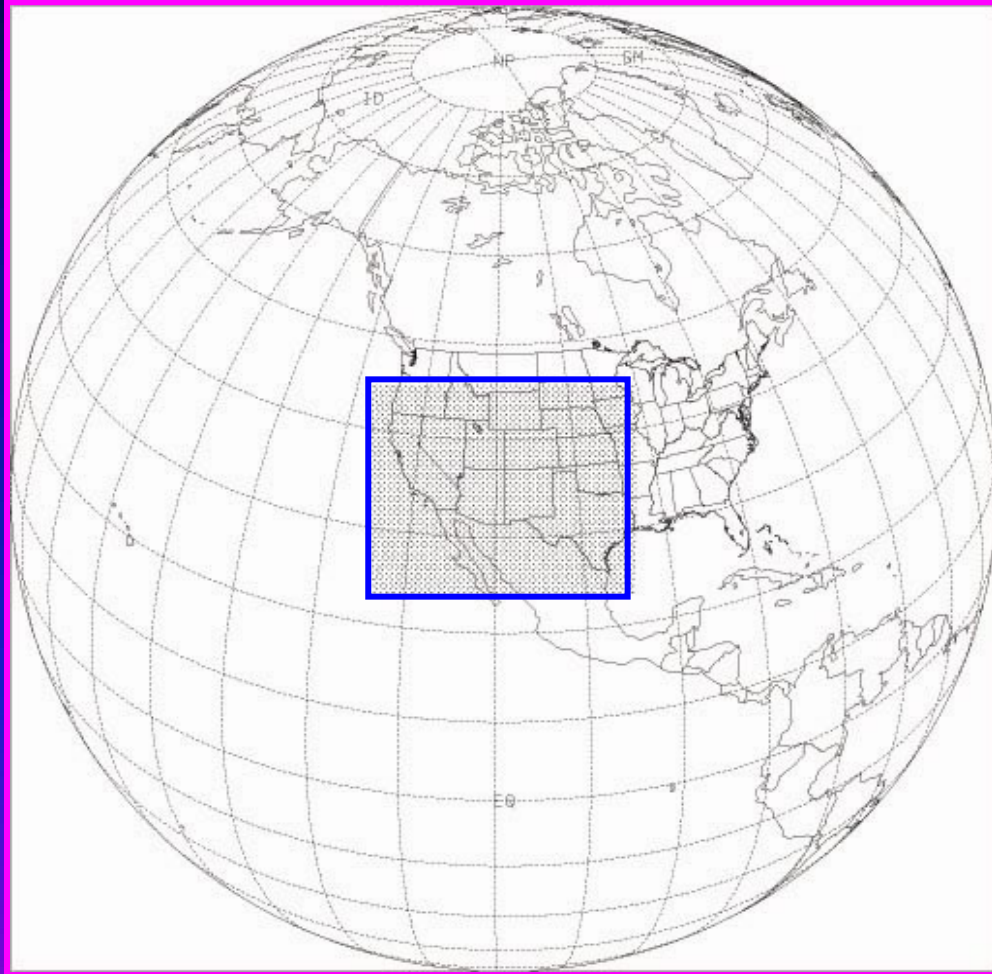


Aims and Goals

- **Focus on SW, dust storms, respiratory diseases, and syndromic surveillance**
- **3 thrusts**
 - **Assimilate EO data into DREAM as part of NCEP/eta forecasting system (DREAM/eta)**
 - **Verify and validate incremental improvements to DREAM/eta outputs as inputs to SYRIS**
 - **Collaborate with public health authorities to assess relationships between dust episodes and respiratory conditions**



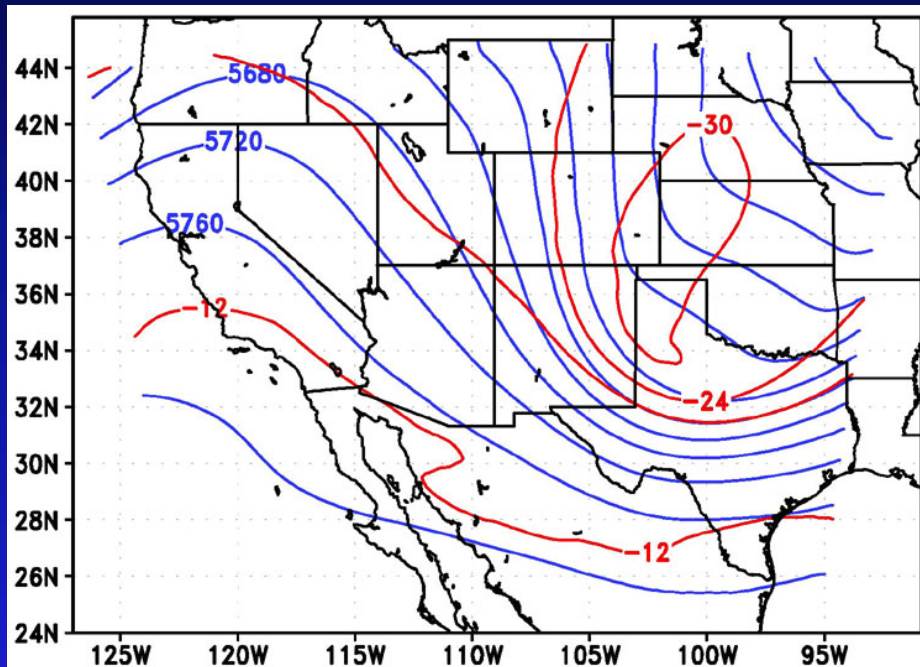
DREAM/eta Model Domain



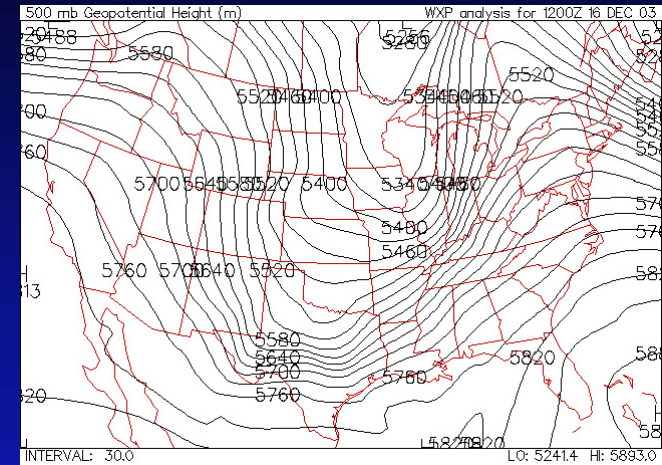
- Domain center at (109°W, 35°N)
- Horizontal semi-staggered Arakawa E grid
- Horizontal grid spacing 1/3 degree



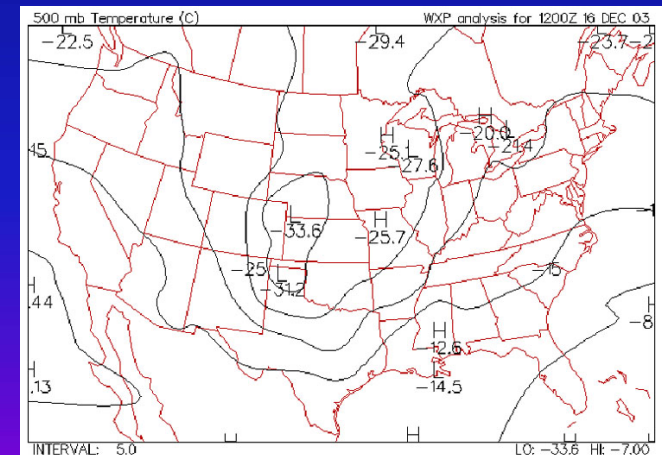
DREAM/eta vs Observed Synoptic Patterns, 12Z 16 Dec 03



Baseline DREAM/eta Simulation
red isolines = temperature
blue isolines = geopotential height



Observed Geopotential Height



Observed Temperature

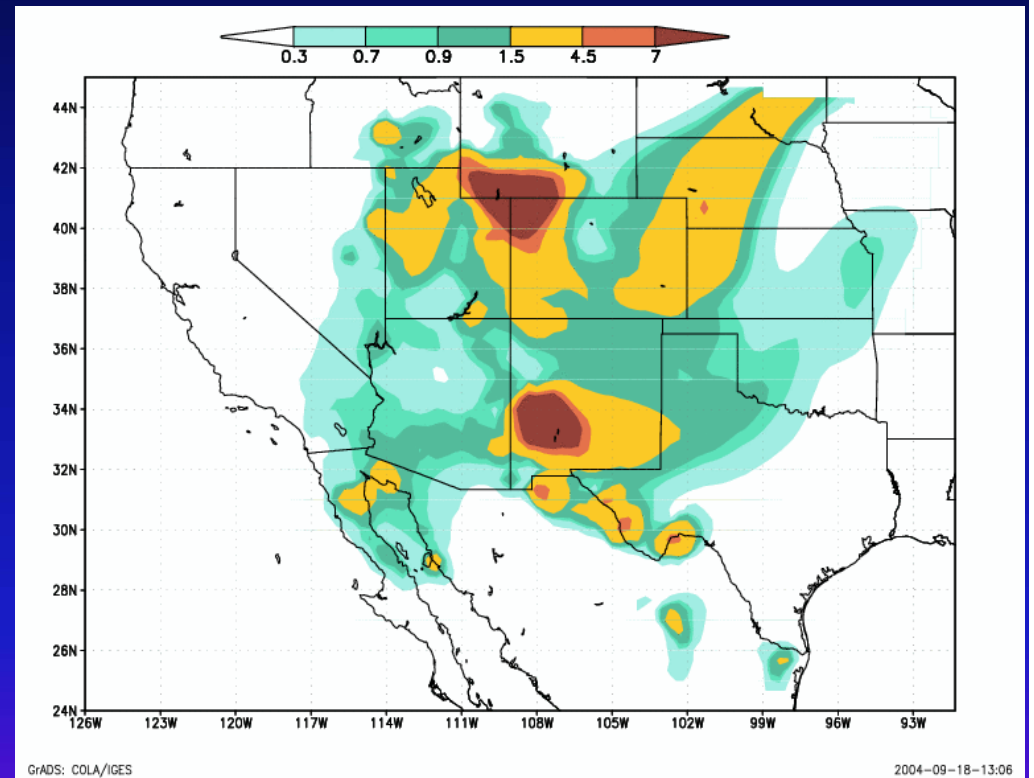


Observed Visibility vs. DREAM/eta Dust Concentrations Dec. 15-16, 2003

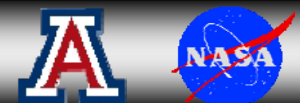


Texas

Continuous Air Monitoring Stations



Baseline DREAM/eta



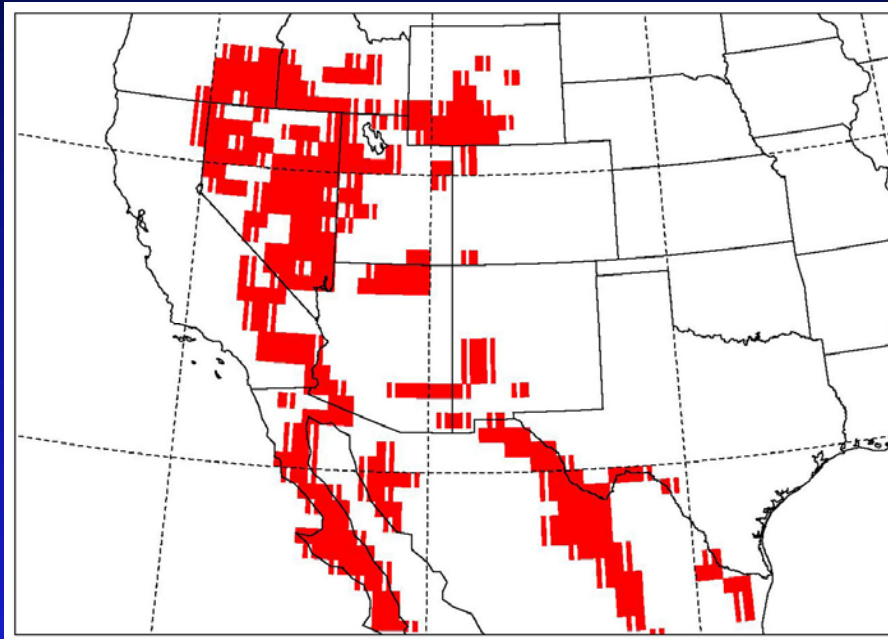


Baseline and Replacement Parameters

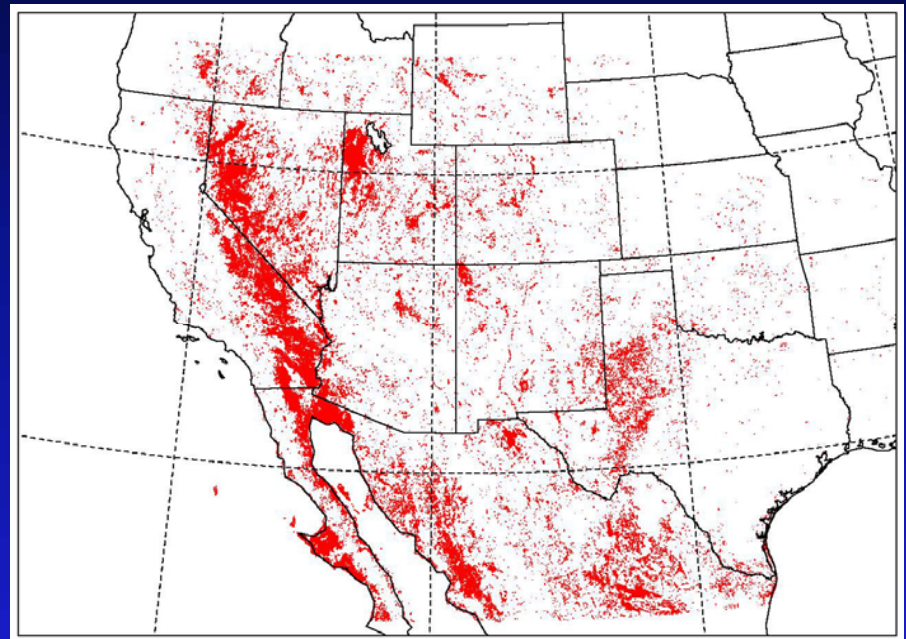
Baseline DREAM/eta Parameters	Function/Purpose	Enhanced DREAM/eta Parameters
ECWMF medium-range weather forecast model	Initial & boundary conditions; Res.=1°	NCEP/eta global forecast model
Olsen World Ecosystems	Land cover; Res.=10min.	MOD12 Res.=1km
USGS terrain data	Res.=1km	SRTM30 Res.=1km
Aerodynamic roughness length: based on 12 SSiB land cover types	Estimate dust entrainment potential	Look-up table based on MOD12 land cover
Soil Moisture: simulated land surface model	Res.=2min.; categories reduced to texture categories	AMSR-E



Barren Ground (Most Likely Dust Sources)



Olson World Ecosystems
barren ground class



MOD12Q1 Land cover
reduced to binary format



Assimilation Strategy

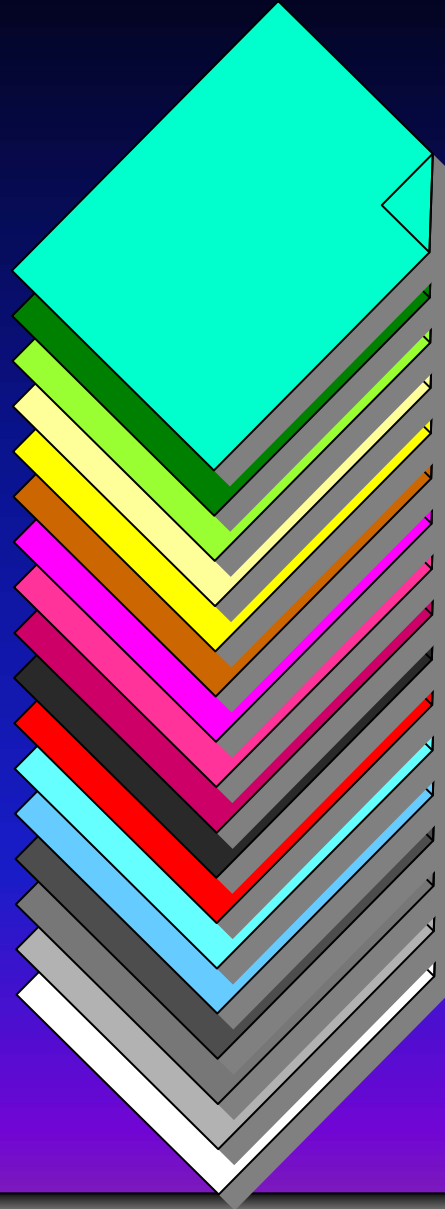
Surface conditions

Terrain

Atmospherics

Geospatial base

- FPAR
- Leaf area index
- Land cover
- Soil moisture content
- Soil temperature
- Soil texture
- Surface roughness length
- Aspect
- Slope
- Digital elevation
- Air temperature at ground
- Humidity
- 24, 48, 72 Hour precipitation
- Wind speed
- Wind direction
- Geopotential height
- Geographic grid

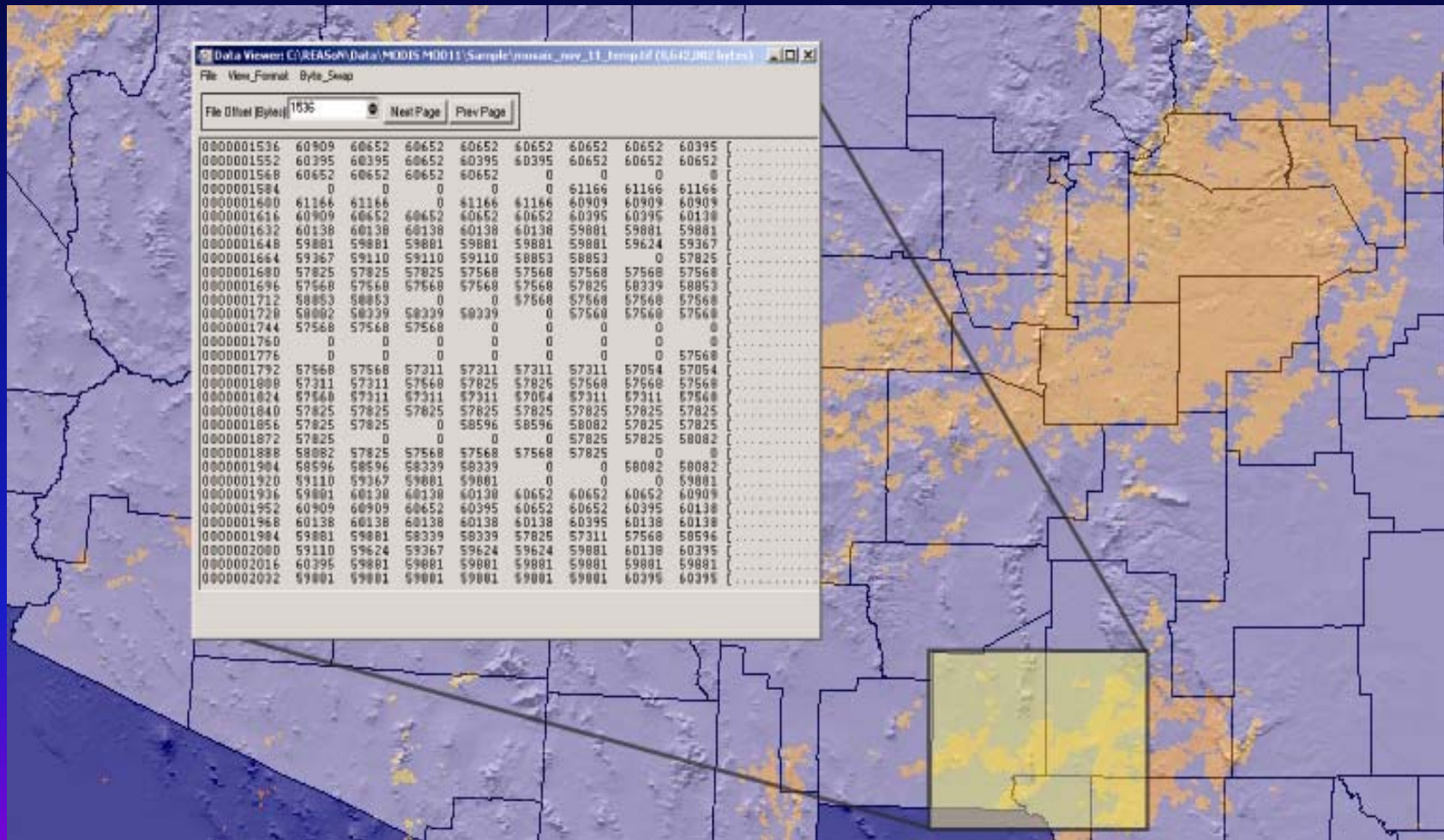


Aims are to:

- (1) replace selected data sets in the model with higher spatial and spectral resolution data that characterize surface conditions, and atmospheric parameters that drive DREAM/eta;
- (2) improve model output without altering the validity of the model's original function;
- (3) convert the model to a dynamic forecast.



MODIS MOD11A1 Land Surface Temperature/Emissivity, Daily @ 1-km





Sample Model Runs of DREAM/eta and Assimilated Parameters

Run #	MOD12	SRTM	Surface roughness length	FPAR	AMSR-E
Run 1a					
Run 2c	Y				
Run 4a	Y	Y			
Run 5a	Y	Y	Y		
Run 5b	Y	Y	Y		
Run 6a	Y			Y	
Run 15a	Y				Y
Run 10a	Y	Y	Y		Y



DREAM/eta vs. Enhanced DREAM/eta (model run 1a vs model run 10a)

Metrics	Wind Speed (m/s)	Wind Direction (°)	Temp. (K)	Definition (M = modeled; O = observed)
Mean observed	5.53	231.40	276.74	$\frac{1}{N} \sum_{i=1}^N O_i$
Mean modeled	4.65 4.37	226.60 230.38	275.56 277.48	$\frac{1}{N} \sum_{i=1}^N M_i$
Mean bias	-0.88 -1.16	-4.80 -1.02	-1.20 0.72	$\frac{1}{N} \sum_{i=1}^N (M_i - O_i)$
Mean error	1.97 2.03	51.76 47.85	4.09 2.67	$\frac{1}{N} \sum_{i=1}^N M_i - O_i $
Agreement index	0.74 0.75	0.74 0.76	0.71 0.95	$1 - \frac{\sum_{i=1}^N (M_i - O_i)^2}{\sum_{i=1}^N (M_i - \bar{O} + O_i - \bar{O})}$

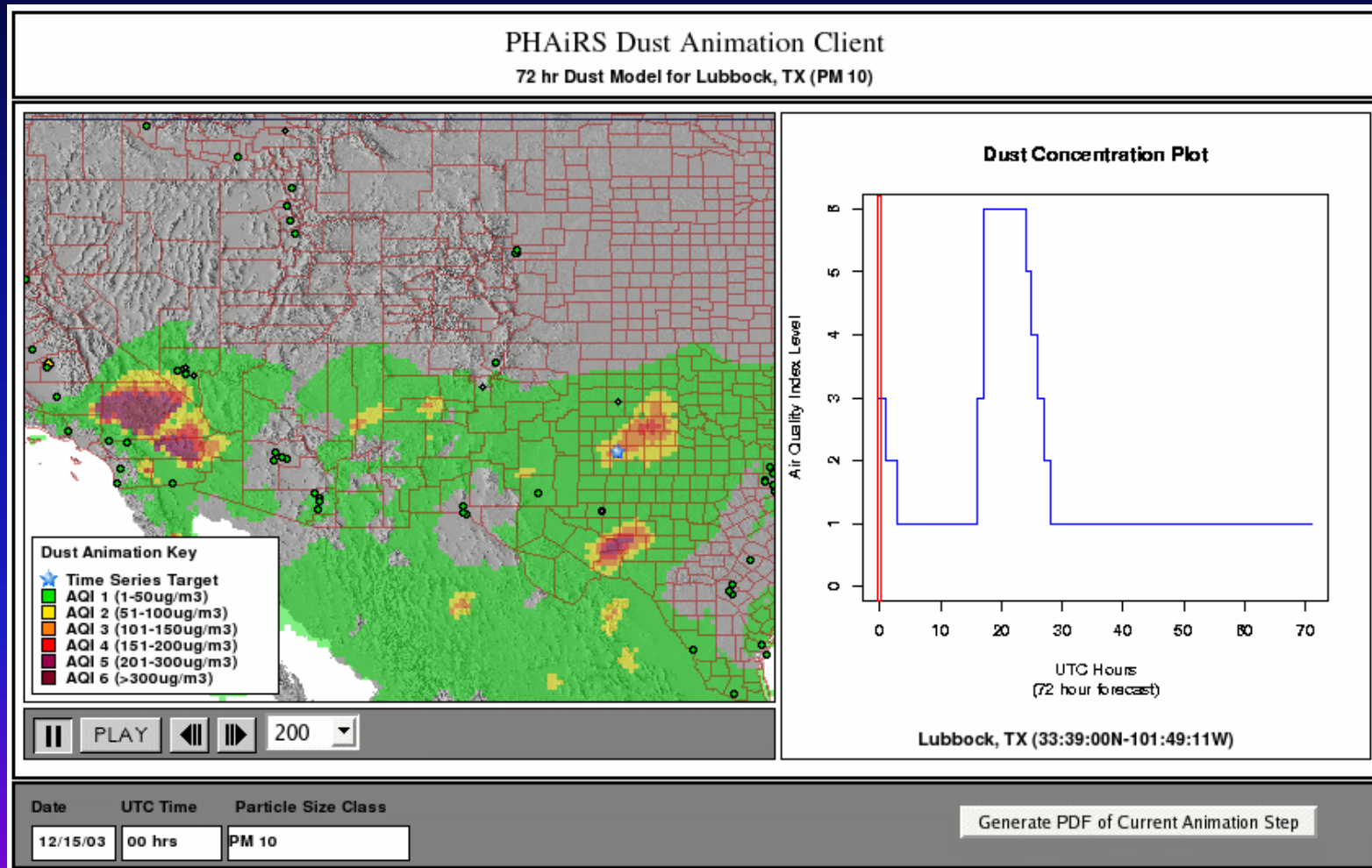
Blue = DREAM/eta (model run 1a)

Red = Enhanced DREAM/eta (model run 10a)



Dust Storm of December 15-17, 2003

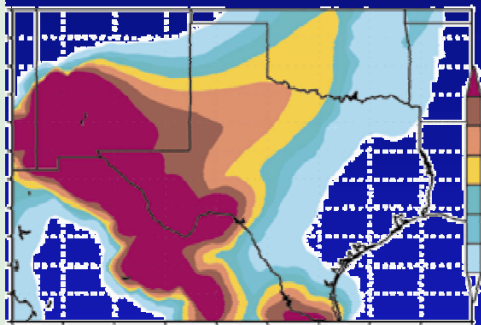
PM₁₀, Lubbock





Incremental Improvements to Model Performance

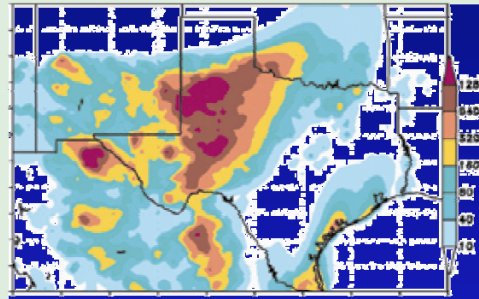
Baseline Model Performance



University of Malta
University of New Mexico
University of Arizona

Baseline DREAM/eta

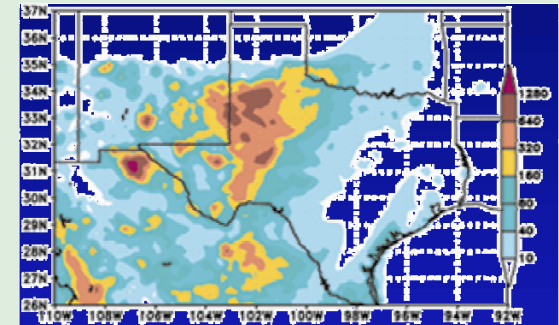
Model Performance After
Assimilating Earth Observation Data



NASA / University of New Mexico
University of Arizona
World Meteorological Organization

Enhanced DREAM/eta

Model Performance Using
NCEP/NMM Weather Forecast Model



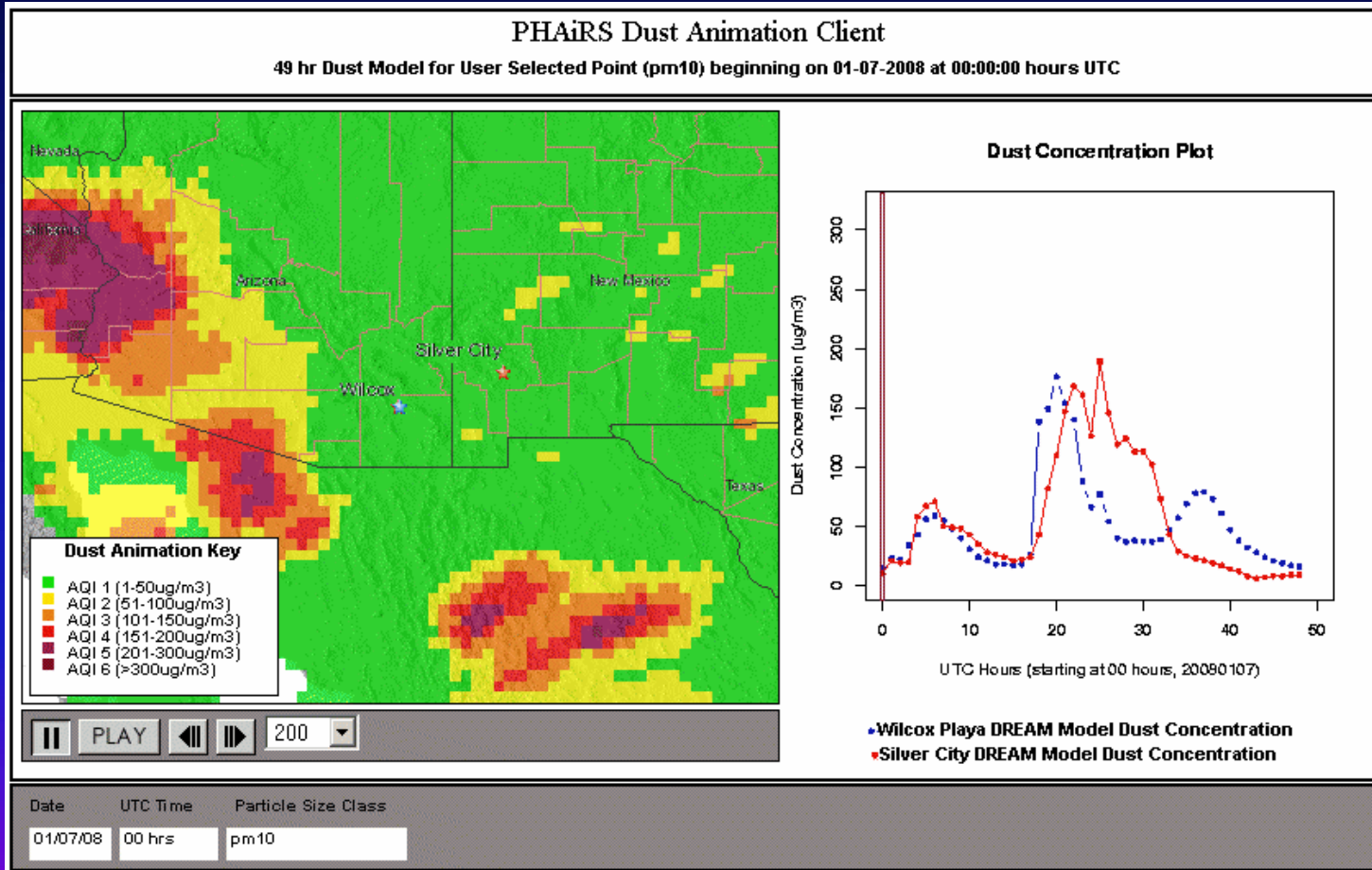
NASA / University of New Mexico
University of Arizona
World Meteorological Organization

Enhanced DREAM/NMM



Dust Storm of January 7, 2008

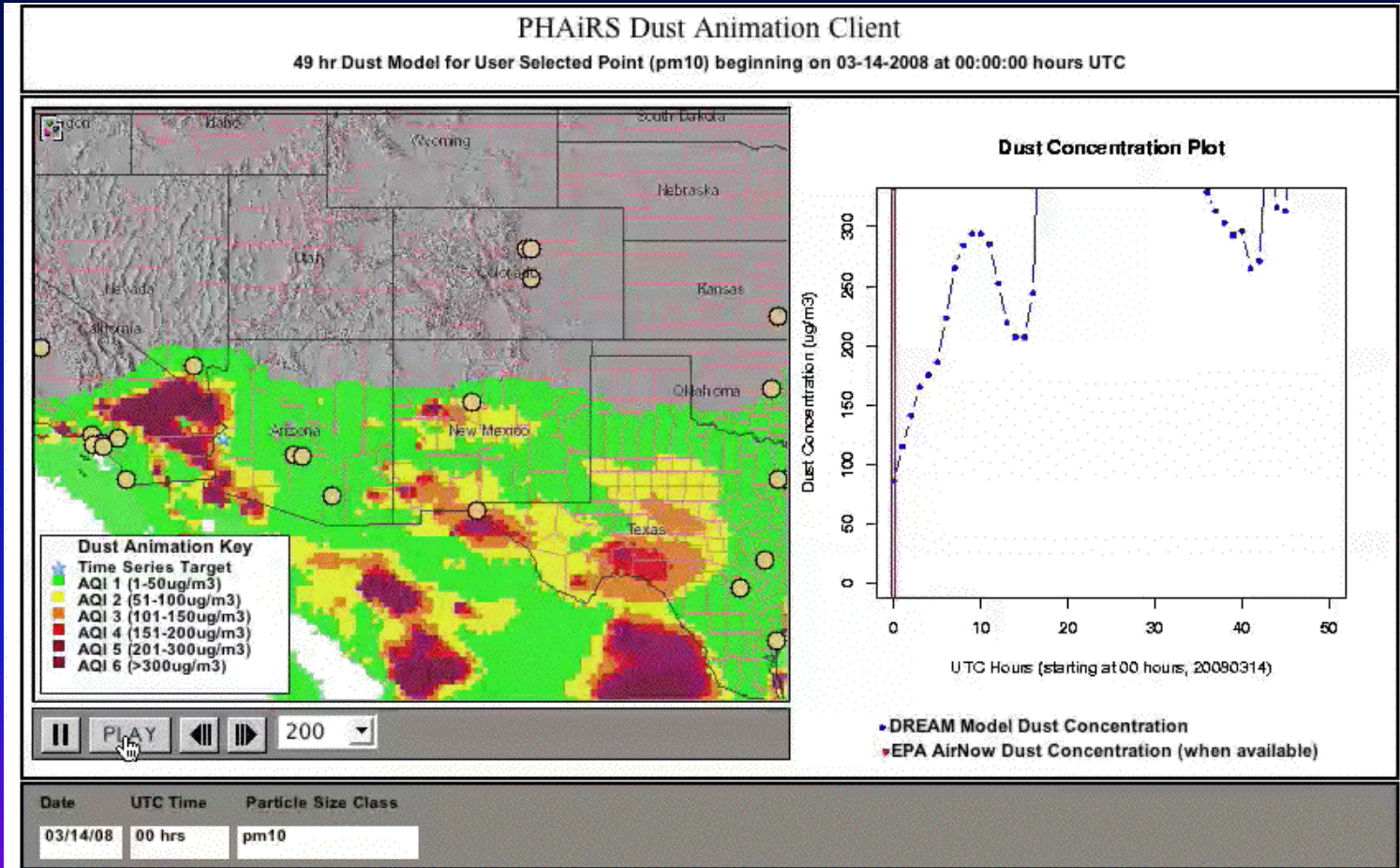
PM₁₀, Wilcox / Silver City





Dust Storm of March 14 2008

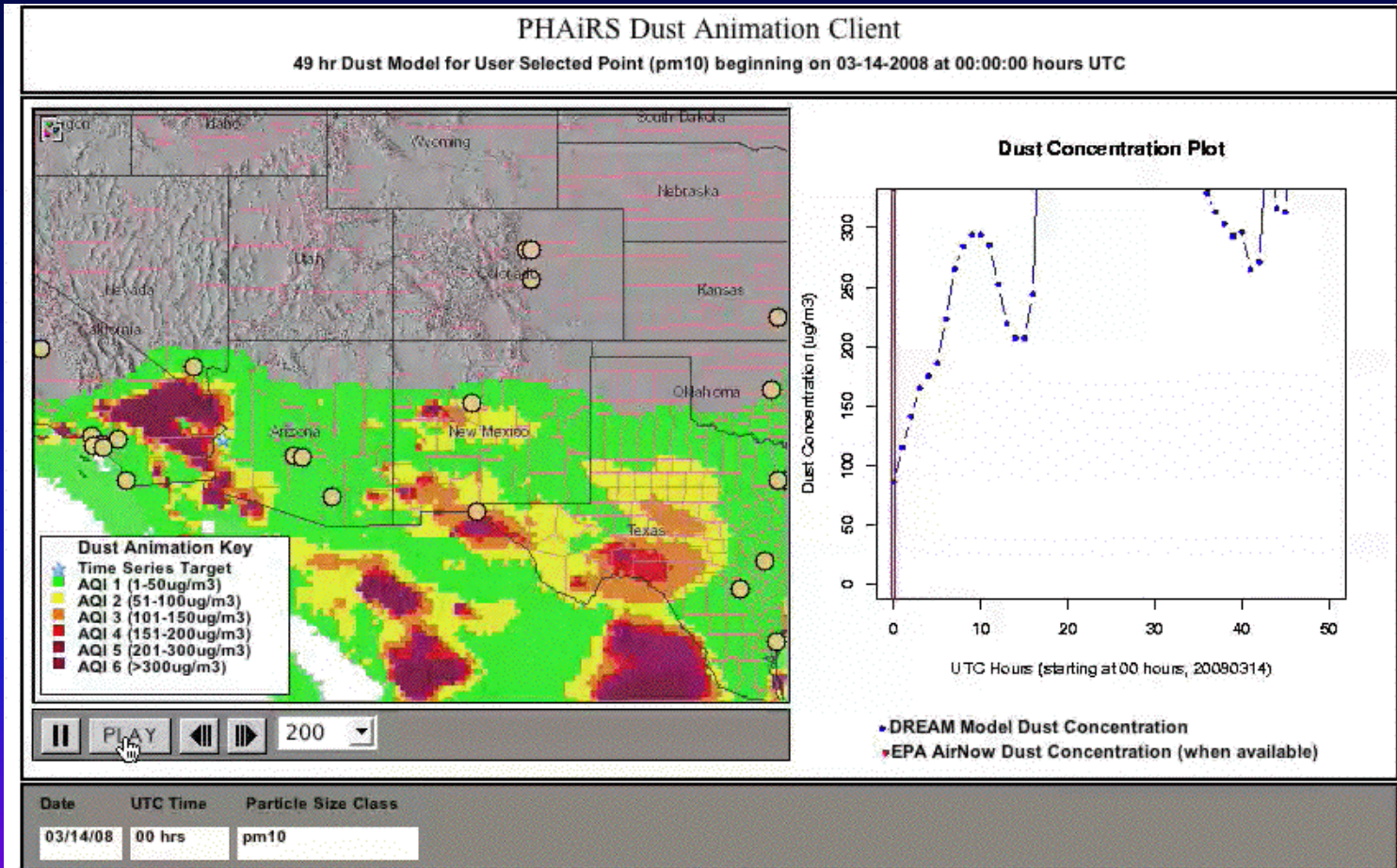
PM₁₀, Yuma





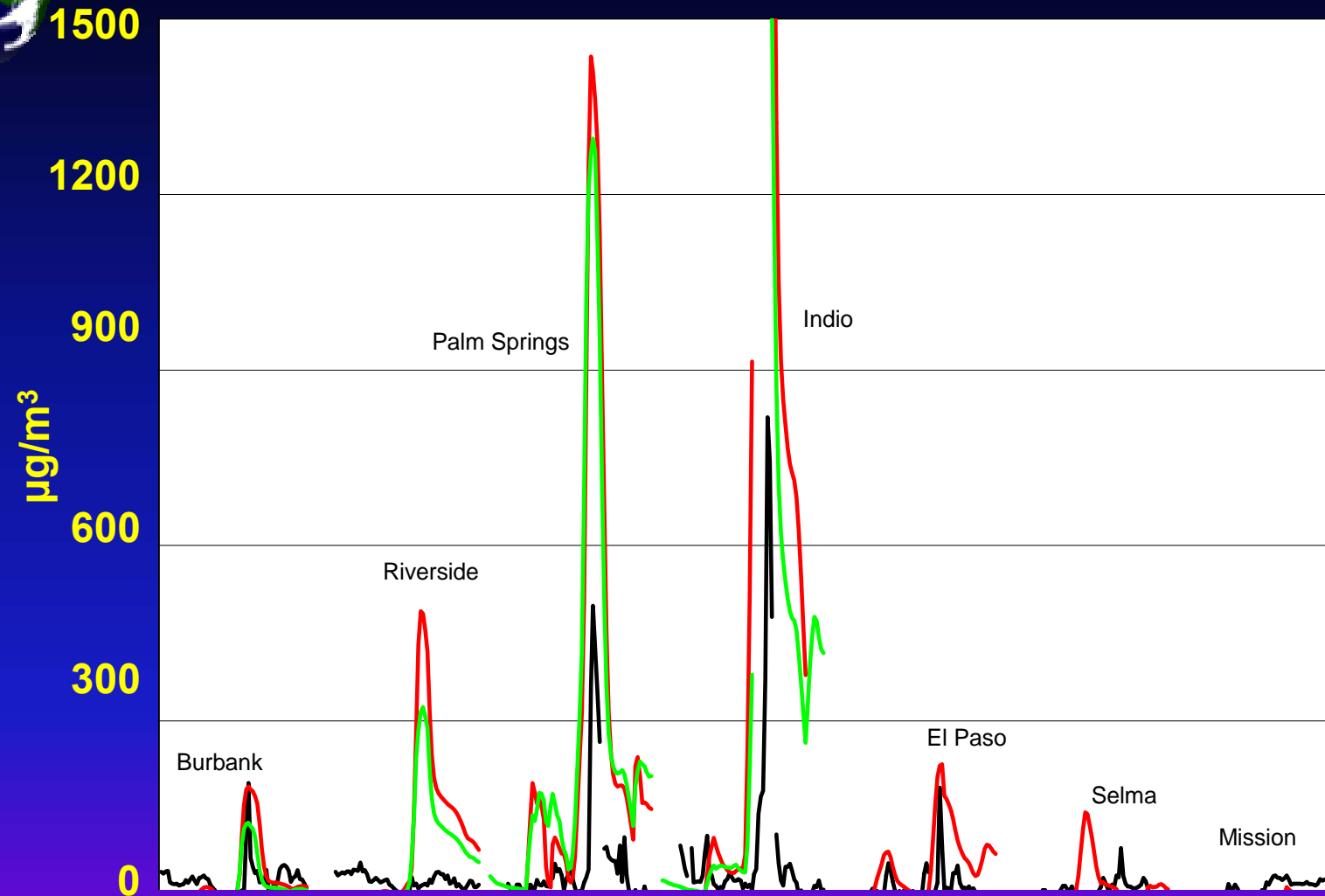
Dust Storm of March 14 2008

PM_{2.5}, Yuma

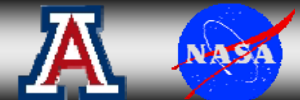




Dust Storm of January 4-6, 2007

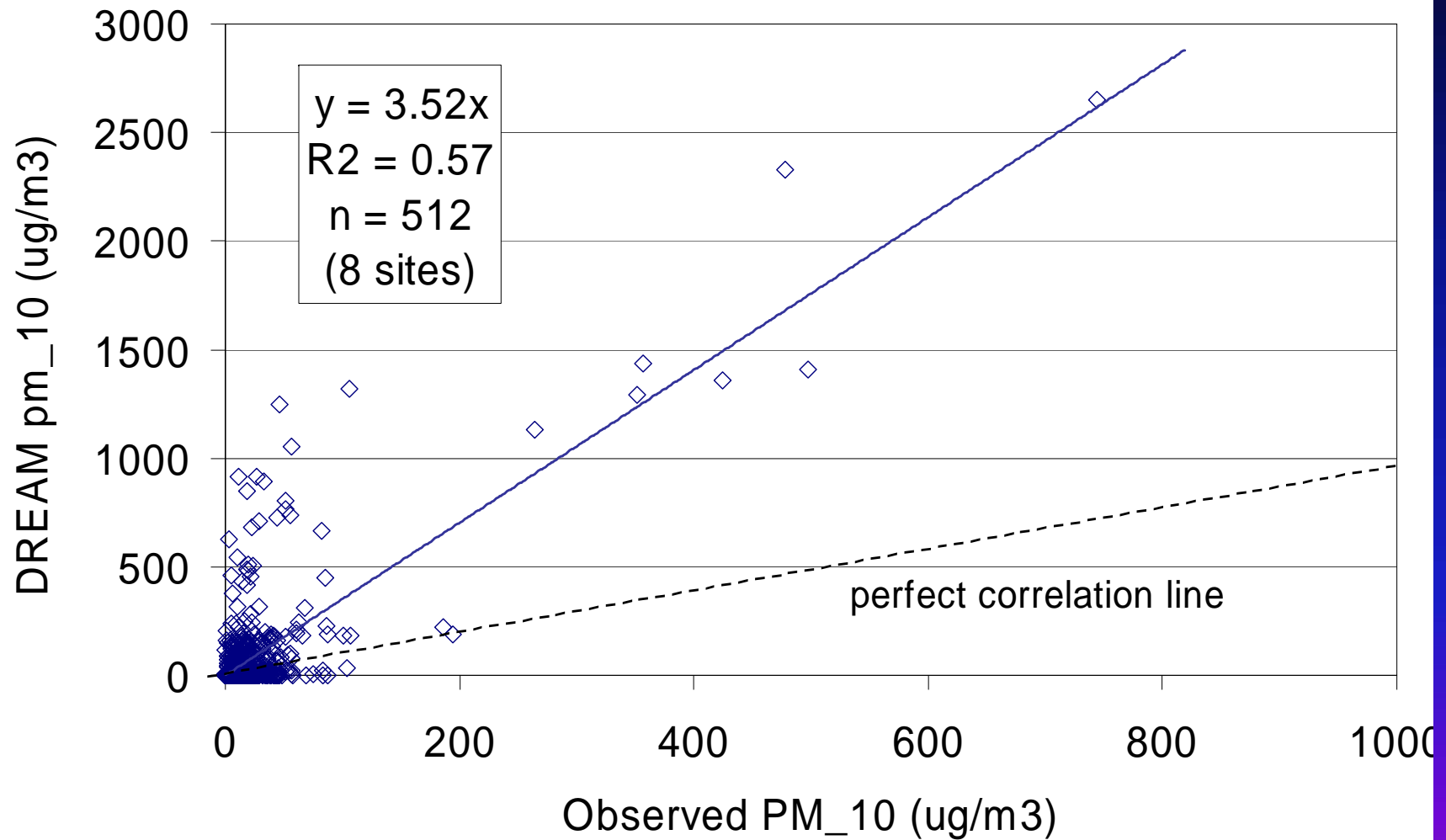


Black = PM₁₀ observed (AIRNow data); Red=PM₁₀ (ED/eta Run 15a); Green=PM₁₀ (ED/eta Run 20a)



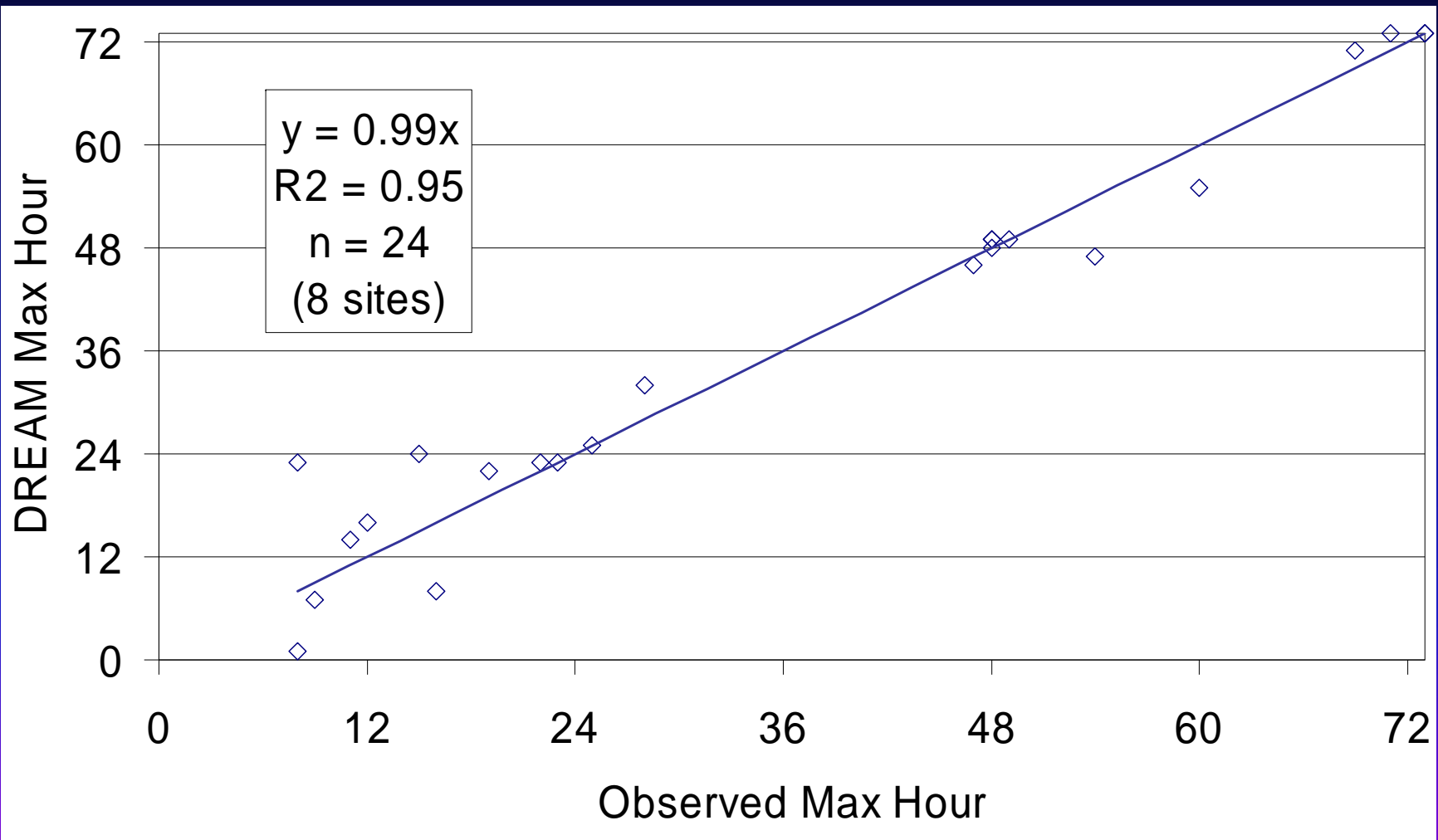


Magnitude Correlation - Jan 4-6, 2007





Timing Correlation - Jan 4-6, 2007





DREAM Data Access and Statistical Wizard

Data Access

Download EPA PM2.5 Data (returns all data for all sites within the DREAM domain area)

Begin Date (YYYYMMDD) End Date (YYYYMMDD)
 [Download PM2.5 File](#) [Clear Date Fields](#)

Download EPA PM2.5 Data for a Single Site Within the DREAM Domain Area

Begin Date (YYYYMMDD) End Date (YYYYMMDD) Station ID-Name
 4013401

Download EPA PM10 Data (returns all data for all sites within the DREAM domain area)

Begin Date (YYYYMMDD) End Date (YYYYMMDD)

Download EPA PM10 Data for a Single Site Within the DREAM Domain Area

Begin Date (YYYYMMDD) End Date (YYYYMMDD) Station ID-Name
 4013401

View a Table of Observed and Modelled Data for a Single Station

Date (MM-DD-YYYY) Time (HH:MM:SS)
 01-01-2006 00:00:00 UTC

View a Table of Observed and Modelled Data for a Single Station

Date (MM-DD-YYYY) Particle Size
 01-01-2006 PM 2.5

View a Table of Observed and Modelled Data for a Single Station Run

Date (MM-DD-YYYY) Station ID-Name
 01-01-2006 40134010-DYSART

View a Table of Observed and Modelled Data for a Single Station Run

Begin (MM-DD-YYYY) End (MM-DD-YYYY) Station ID-Name
 01-01-2006 01-01-2006 40134010-DYSART

Statistical Functions

Generate Statistics for a Single Station for a Single Run

Date (MM-DD-YYYY) Station ID-Name
 01-01-2006 40134010-DYSART

Generate Statistics for a Single Station for a Single Run

Begin (MM-DD-YYYY) End (MM-DD-YYYY) Station ID-Name
 01-01-2006 01-01-2006 40134010-DYSART

Table of Observed and Predicted (DREAM) PM25 Values for the 48-hour period beginning 04/15/2007 (Station No. 350011013 / North Valley)

To save as a CSV file, right click on the link below, select 'Save Link As', and then provide a new filename with a .csv extension in the dialog box

[Download CSV File](#)

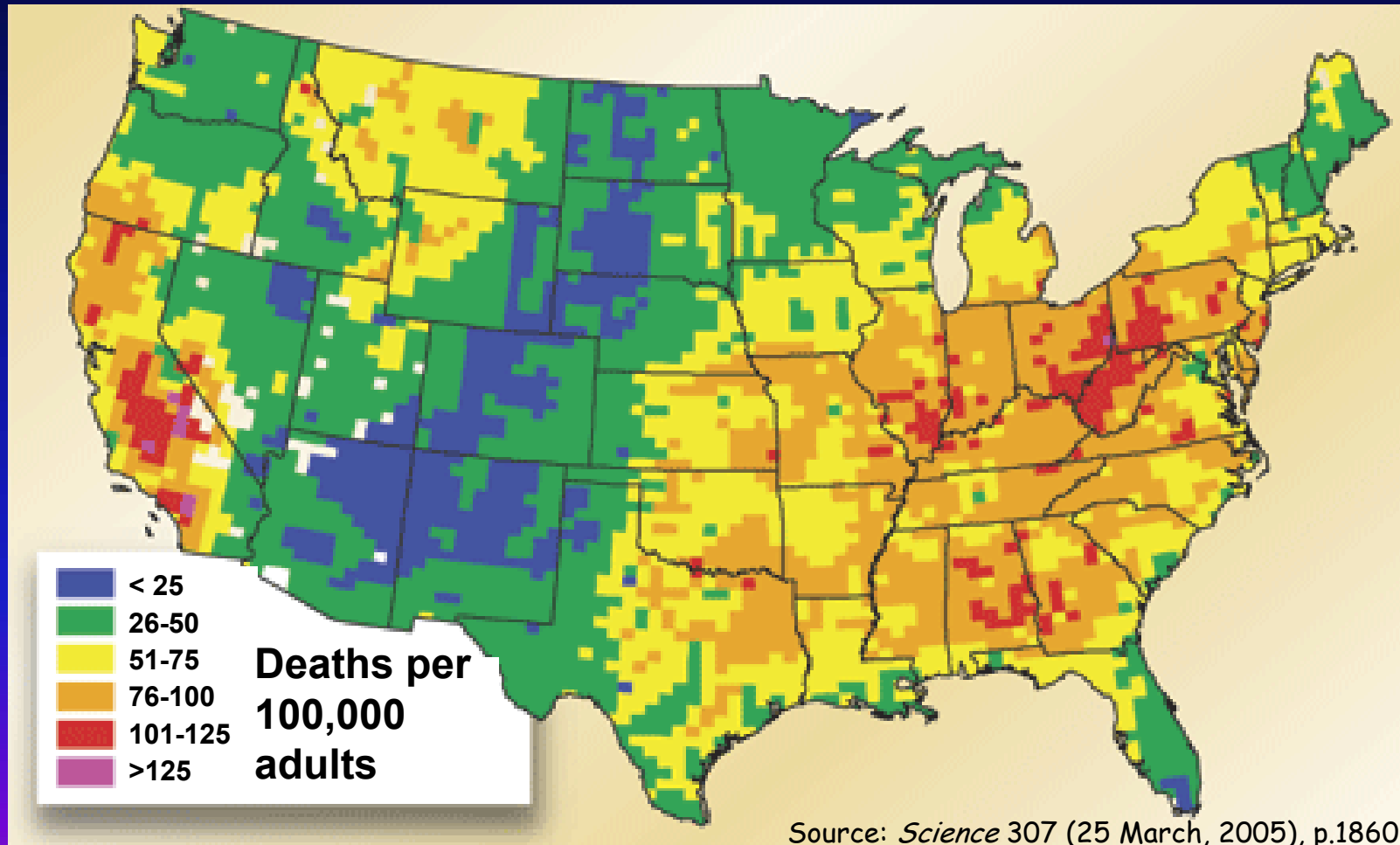
Station ID	Station Name	Latitude	Longitude	EPA Observed (ug/m3)	DREAM Model Value (ug/m3)	Datetime (YYYY-MM-DD"TT"HH:00:00)
350011013	North Valley	35.1878	-106.604	9.0	1.0075000279	2007-04-15T00:00:00
350011013	North Valley	35.1878	-106.604	7.0	0.9468014626	2007-04-15T01:00:00
350011013	North Valley	35.1878	-106.604	8.0	0.9998162003	2007-04-15T02:00:00
350011013	North Valley	35.1878	-106.604	10.0	1.063272094	2007-04-15T03:00:00
350011013	North Valley	35.1878	-106.604	10.0	1.1059926713	2007-04-15T04:00:00
350011013	North Valley	35.1878	-106.604	10.0	1.1227573542	2007-04-15T05:00:00
350011013	North Valley	35.1878	-106.604	9.0	1.1235294097	2007-04-15T06:00:00
350011013	North Valley	35.1878	-106.604	8.0	1.14150731	2007-04-15T07:00:00
350011013	North Valley	35.1878	-106.604	7.0	1.2136764386	2007-04-15T08:00:00
350011013	North Valley	35.1878	-106.604	7.0	1.3928309083	2007-04-15T09:00:00
350011013	North Valley	35.1878	-106.604	7.0	1.6509559225	2007-04-15T10:00:00
350011013	North Valley	35.1878	-106.604	8.0	1.9005882389	2007-04-15T11:00:00
350011013	North Valley	35.1878	-106.604	9.0	2.1024263957	2007-04-15T12:00:00
350011013	North Valley	35.1878	-106.604	8.0	2.2592646234	2007-04-15T13:00:00
350011013	North Valley	35.1878	-106.604	7.0	2.2293381831	2007-04-15T14:00:00
350011013	North Valley	35.1878	-106.604	8.0	2.0158823799	2007-04-15T15:00:00
350011013	North Valley	35.1878	-106.604	8.0	1.9149264869	2007-04-15T16:00:00
350011013	North Valley	35.1878	-106.604	7.0	4.448529552	2007-04-15T17:00:00
350011013	North Valley	35.1878	-106.604	6.0	6.8639706163	2007-04-15T18:00:00
350011013	North Valley	35.1878	-106.604	6.0	12.3272054336	2007-04-15T19:00:00
350011013	North Valley	35.1878	-106.604	6.0	20.8937504712	2007-04-15T20:00:00
350011013	North Valley	35.1878	-106.604	2.0	27.4044121013	2007-04-15T21:00:00
350011013	North Valley	35.1878	-106.604	4.0	30.1459564882	2007-04-15T22:00:00
350011013	North Valley	35.19	-106.6	missing	30.1911774804	2007-04-15T23:00:00
350011013	North Valley	35.1878	-106.604	6.0	31.2290444094	2007-04-16T00:00:00
350011013	North Valley	35.1878	-106.604	7.0	32.4169130886	2007-04-16T01:00:00
350011013	North Valley	35.1878	-106.604	8.0	30.877940795	2007-04-16T02:00:00
350011013	North Valley	35.1878	-106.604	7.0	29.4794110691	2007-04-16T03:00:00
350011013	North Valley	35.1878	-106.604	6.0	28.7514714634	2007-04-16T04:00:00

Data Access & Statistics



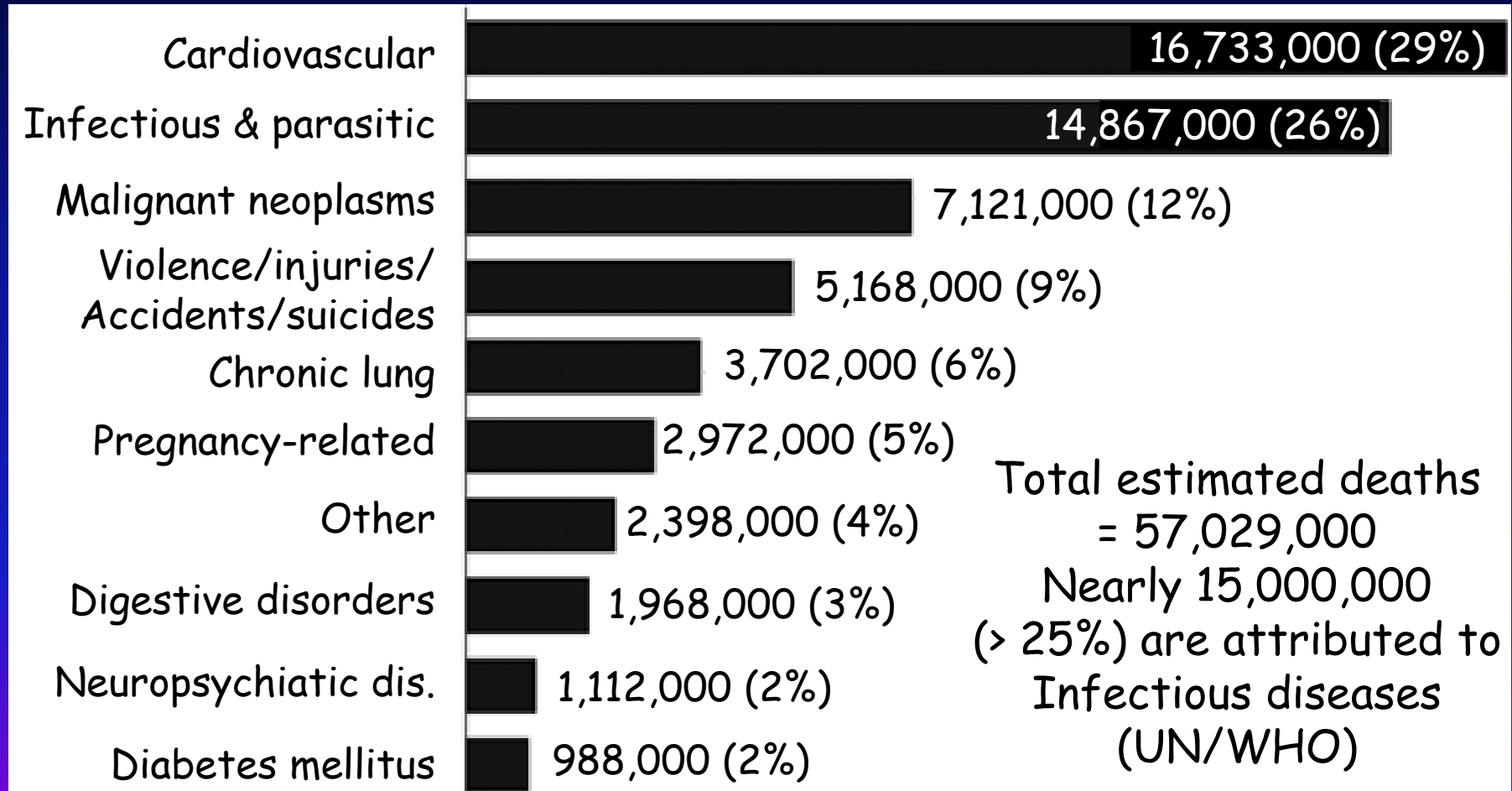


Premature Mortality Risk Attributable to PM_{2.5}

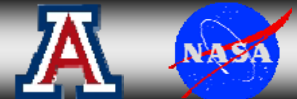




Leading Causes of Death, Worldwide: for 2002 (Estimated)



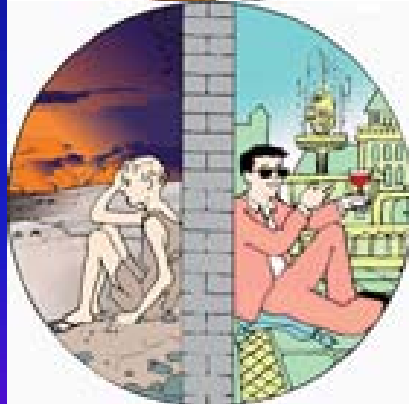
Source: Emerging Infectious Diseases, 2005 Centers for Disease Control and Prevention



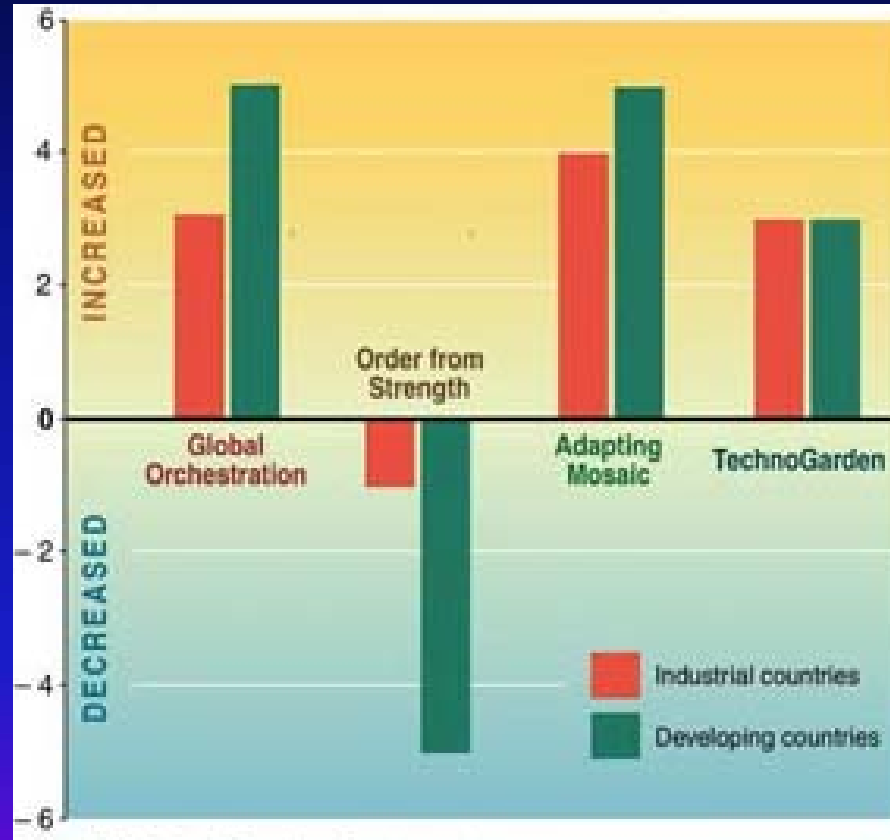


Net Change in Components of Human Well-being

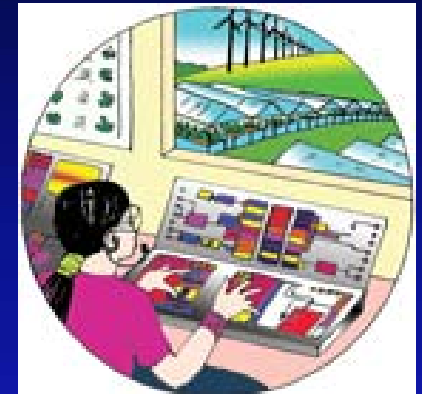
Global Orchestration



Order from Strength



TechnoGarden



Adapting Mosaic

Scenarios: Reactive on left; Proactive on right



PHAIRS Research Team

- **PI & Co-PI**

- S. Morain (UNM)
- W. Sprigg (UA)

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- K. Benedict (UNM)
- W. Hudspeth (UNM)
- T. Budge (UNM)
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- B. Barbaris (UA)
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- Chris Catrall (UA)
- Patrick Shaw (UA)

- **Public Health Partners**

- City of Lubbock Dept of Health
- Pima County Dept of Environmental Quality
- Arizona Dept of Health Services
- NM Dept of Health
- UNM Health Science Center
- ARES Corporation
- ABQ Air Quality Office

Management of the Urban Environment to Achieve Sustainable Human Health and Wellbeing

