Public Health Applications in Remote Sensing

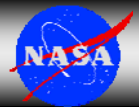
Overview of PHAiRS

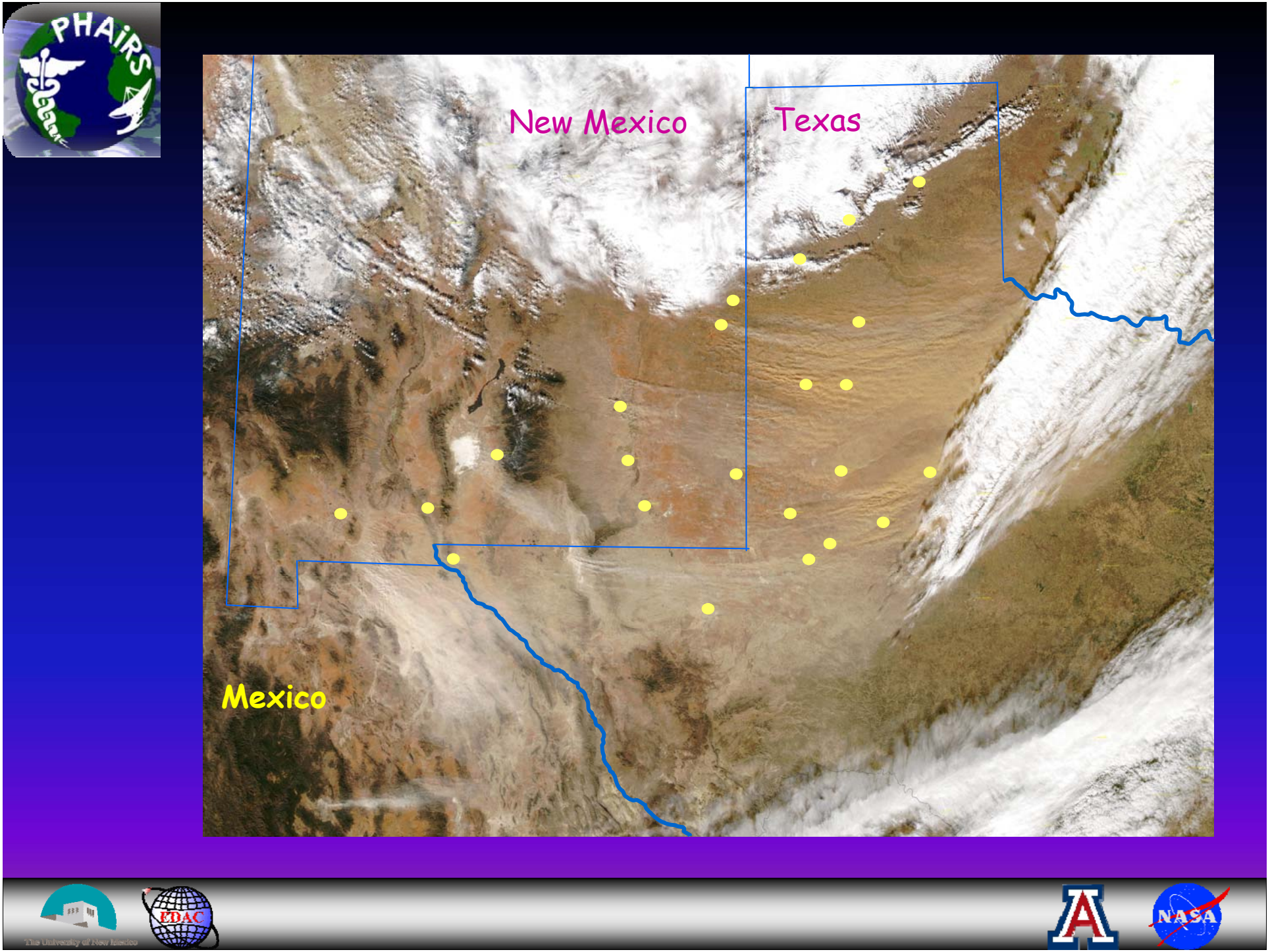
Stan Morain, PI

Amelia Budge, Project Coordinator

UMMC, Jackson MS, March 5, 2008

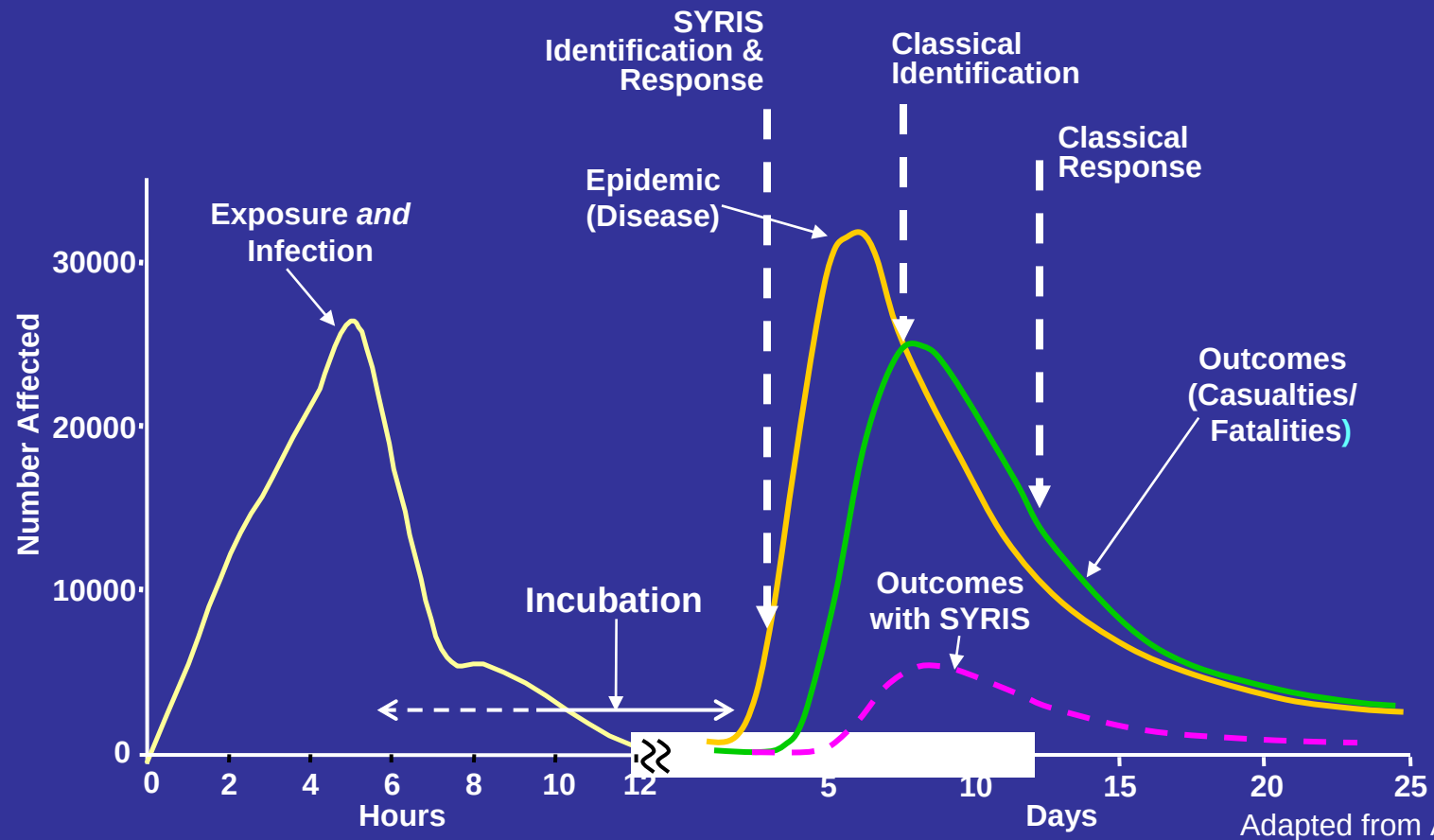
Project Stimuli




PHAIRS
New Mexico
Texas
Mexico
The University of New Mexico
EDAC
NASA

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



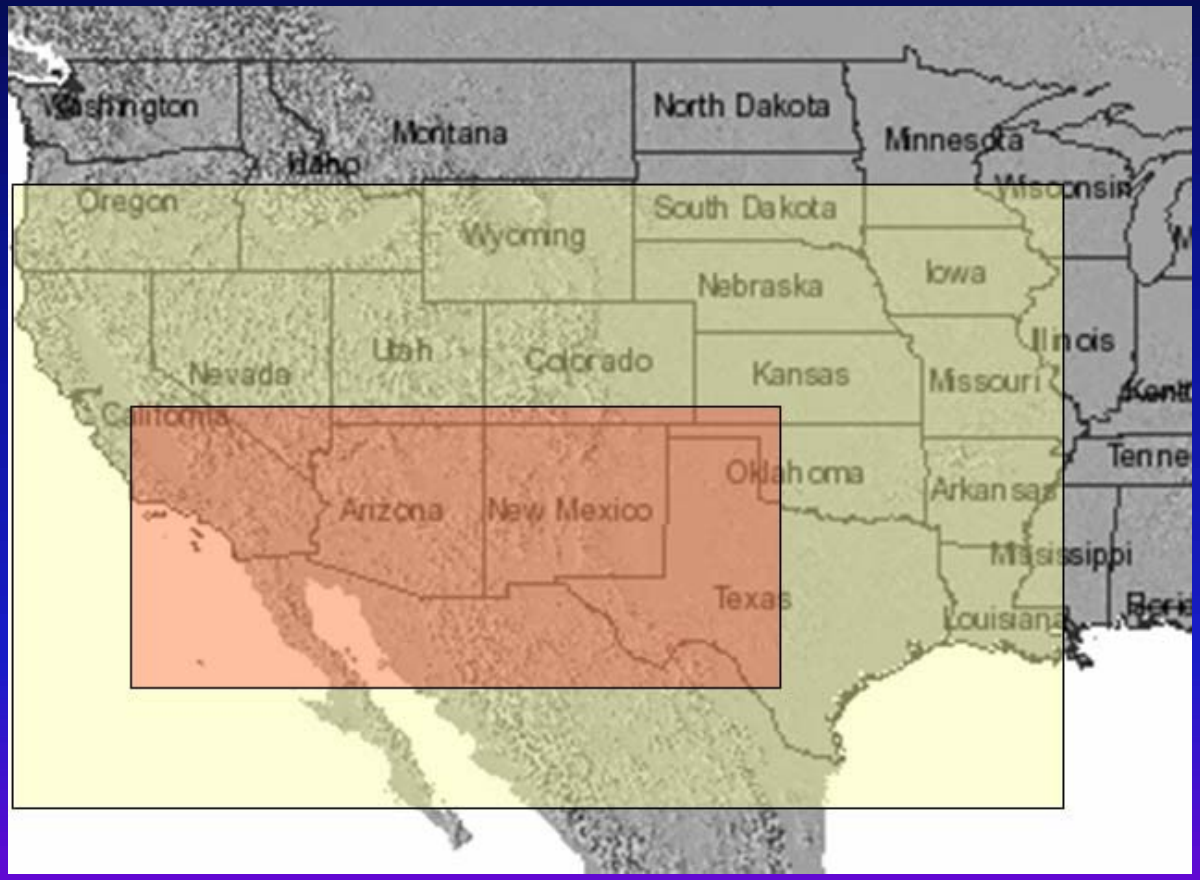
Adapted from ARES, 2007

PHAiRS Team

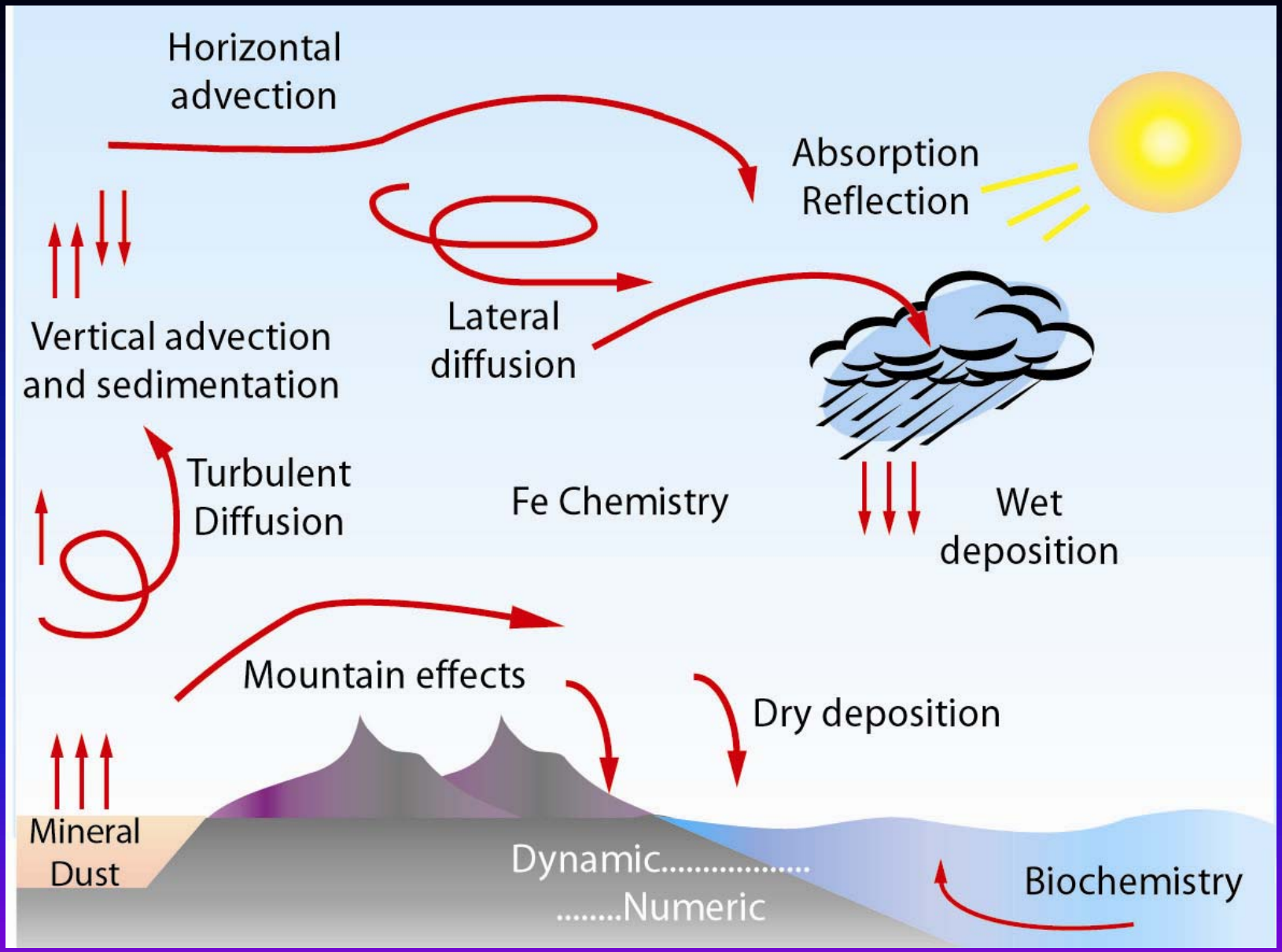
- UNM- EO data inputs; DSS integr.; PH links
  - Karl Benedict-Info tech.; interoperability
  - Tom Budge-EO prod. assess.; data assim.
  - Bill Hudspeth-Web client & DSS products
- UA- Model inputs / outputs & improvements
  - Dazhong Yin-Modeling NCEP/Eta + DREAM
  - Brian Barbaris-V&V; EPA Air Quality data
  - Patrick Shaw-Stat. analys.; $PM_{2.5-10}$ character.

Modeling System

Model Domain



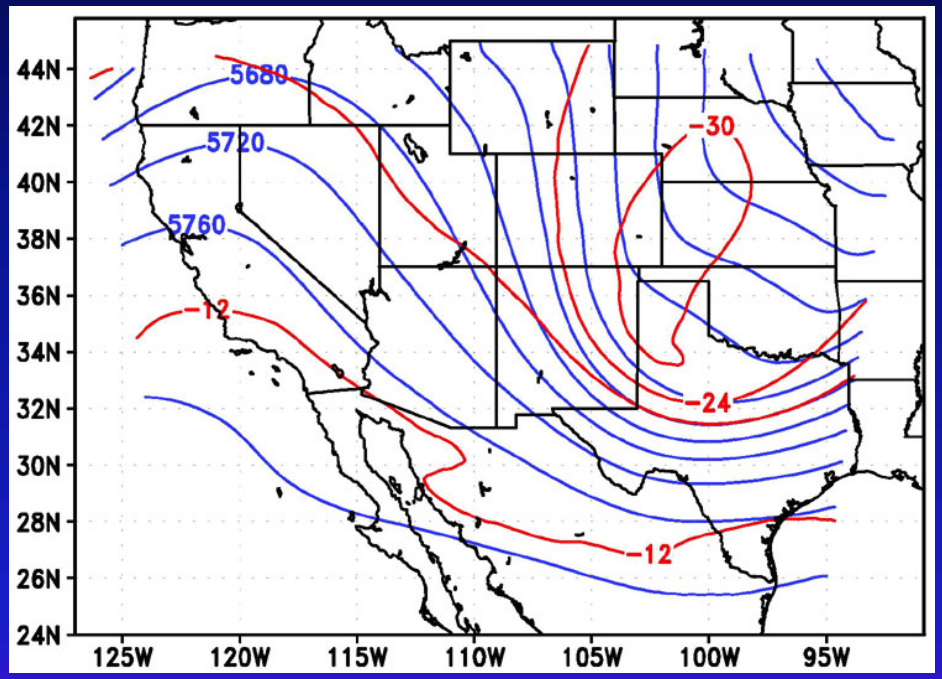
- Domain center at (109°W, 35°N)
- Horizontal semi-staggered Arakawa E grid
- Horizontal grid spacing 1/3 degree


Horizontal advection
Absorption
Reflection
Vertical advection and sedimentation
Lateral diffusion
Turbulent Diffusion
Fe Chemistry
Wet deposition
Mountain effects
Dry deposition
Mineral Dust
Dynamic.....
.....Numeric
Biochemistry

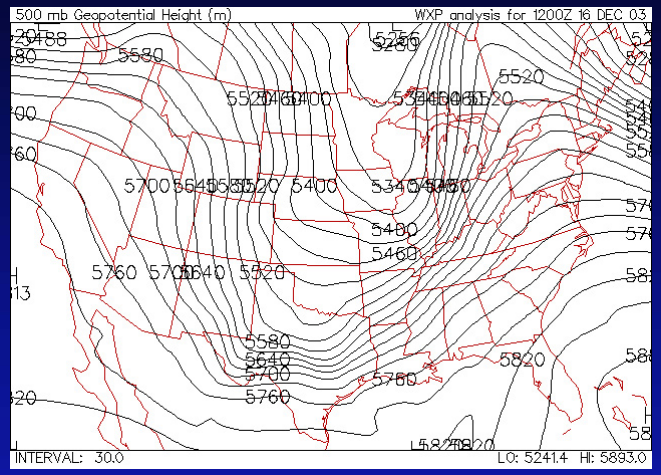
Design & Replacement Parameters

Baseline Parameters	***Assimilated Parameters***
Land Cover: Olson World Ecosystem 10-min. (19km) Res	MOD-12 1km resolution
Elevation: USGS 1km terrain data	SRTM-3 arcsec (90m) terrain data* resampled to 30 arcsec (1km)
Aerodynamic roughness length: predicted using 12 SSiB land cover types	Look-up table linked to MOD-12 land cover
Dust source areas	FPAR “Fill” class 254-255
Soil Moisture: simulated using a land surface model	AMSR-E

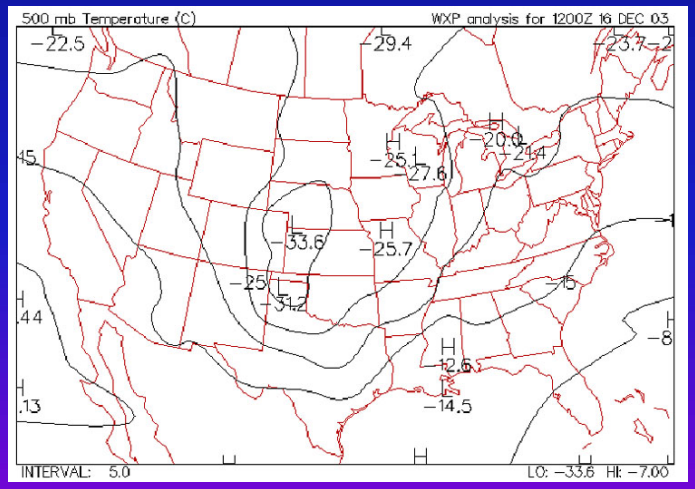
Modeled vs Observed Synoptic Patterns
12 Z 16 Dec 03



DREAM Simulation

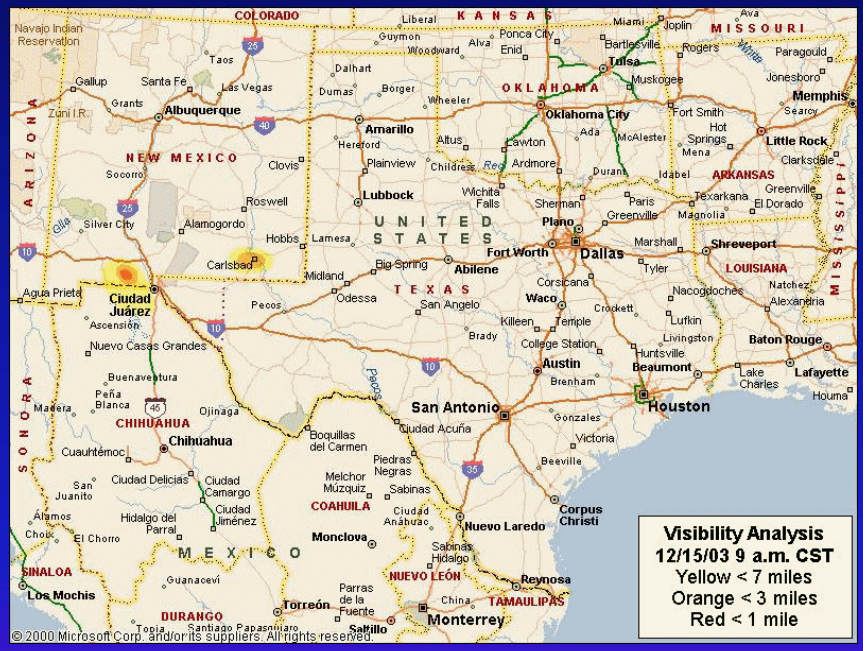


Observed Geopotential Height

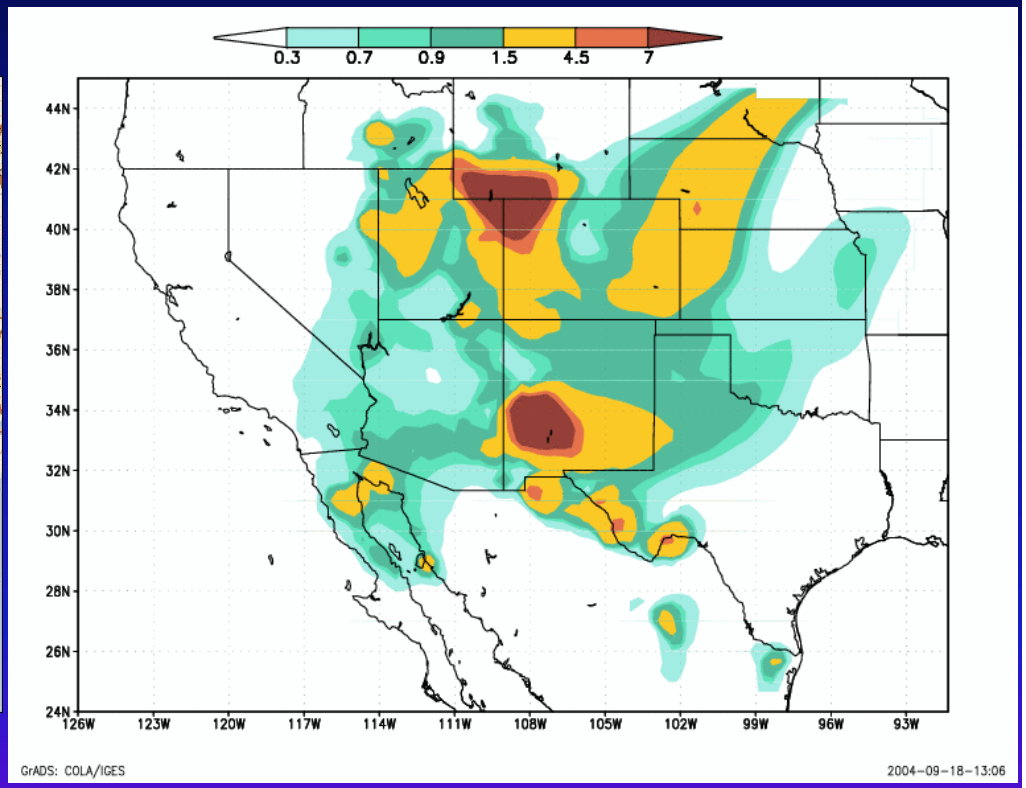


Observed Temperature

Observed Visibility vs. Modeled Dust Concentrations Dec. 15-16, 2003

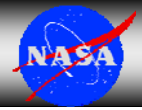


Texas
Continuous Air Monitoring Stations



DREAM Baseline (no EO data included)

Data Processing and Assimilation



Assimilation vs. Fusion

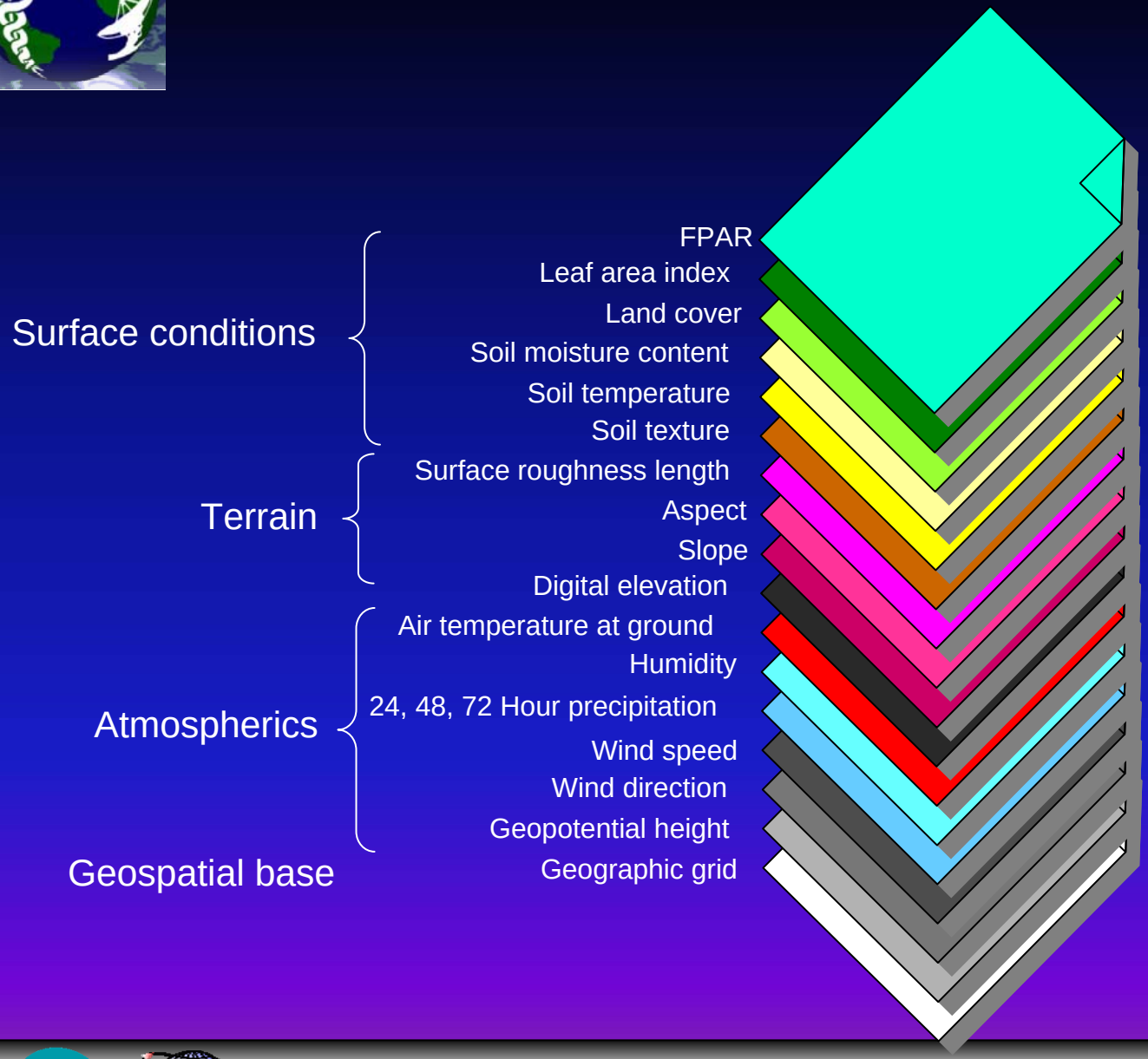
Assimilation: The process of replacing selected static parameters in an Earth system model with digital pixel values from Earth observation data sets to improve the model's performance and convert it into a more dynamic (forecasting) form without changing the model's intended purpose.

Fusion: The process of including EO image products (at any of several levels of processing) into a GIS architecture in such a way that the datasets, both vector and raster, are geospatially registered at a specified scale. This usually requires sub-setting, re-projection and rescaling of fused data.

Steps in Assimilation

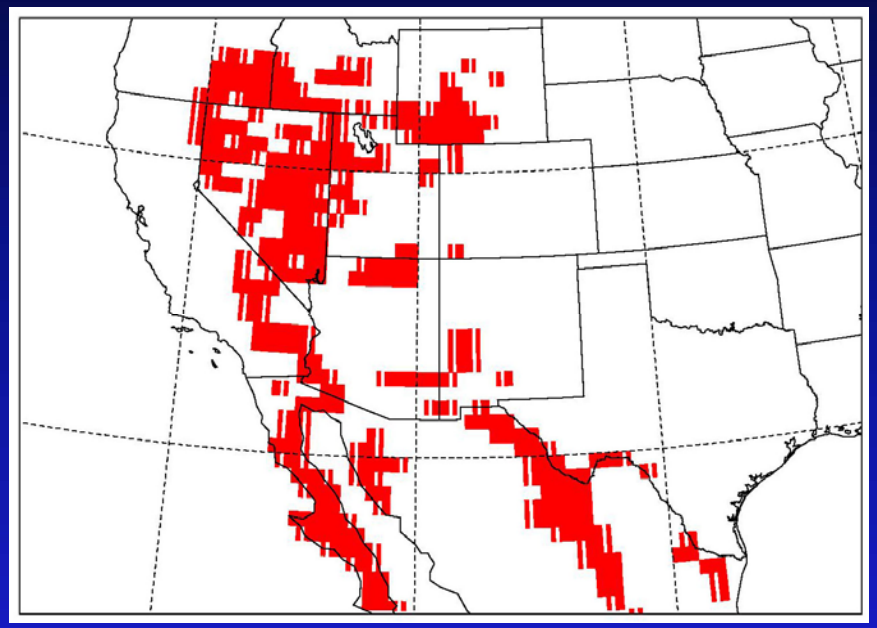
- Assess metadata & attributes of current model inputs and of possible EO inputs
  - Measurement units
  - x,y,z Resolution
  - Temporal frequency
  - Projection
  - File formats
  - Validity & accuracy
  - Error & error propagation
- Select EO inputs based on highest perceived benefit for enhancing model output
- Replace model input with EO data and compare model outputs
- Iterate with successive EO inputs
- Measure improvements at each stage and document overall performance improvements

The Baker's Rack

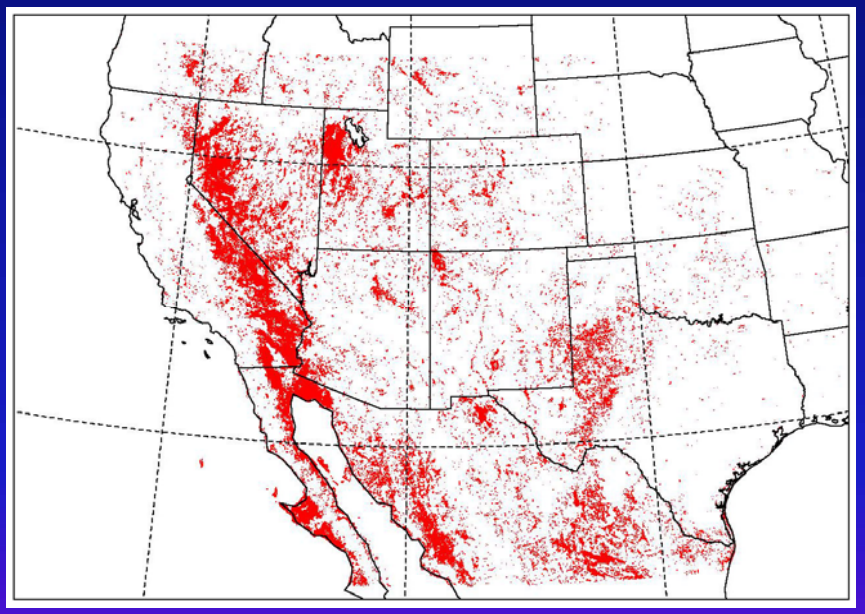


Aims are to: (1) replace selected trays in the rack with regularly refreshed EO digital data from the "terrain." "surface conditions," and "atmospheric" parameters that drive DREAM; (2) improve model output without altering the validity of the model's original function; and (3) convert the model to a more dynamic forecast.

A Step in the Right Direction



Bare ground class from Olson World Ecosystem Land Cover



Bare ground class from MOD12 product

Sample Model Runs

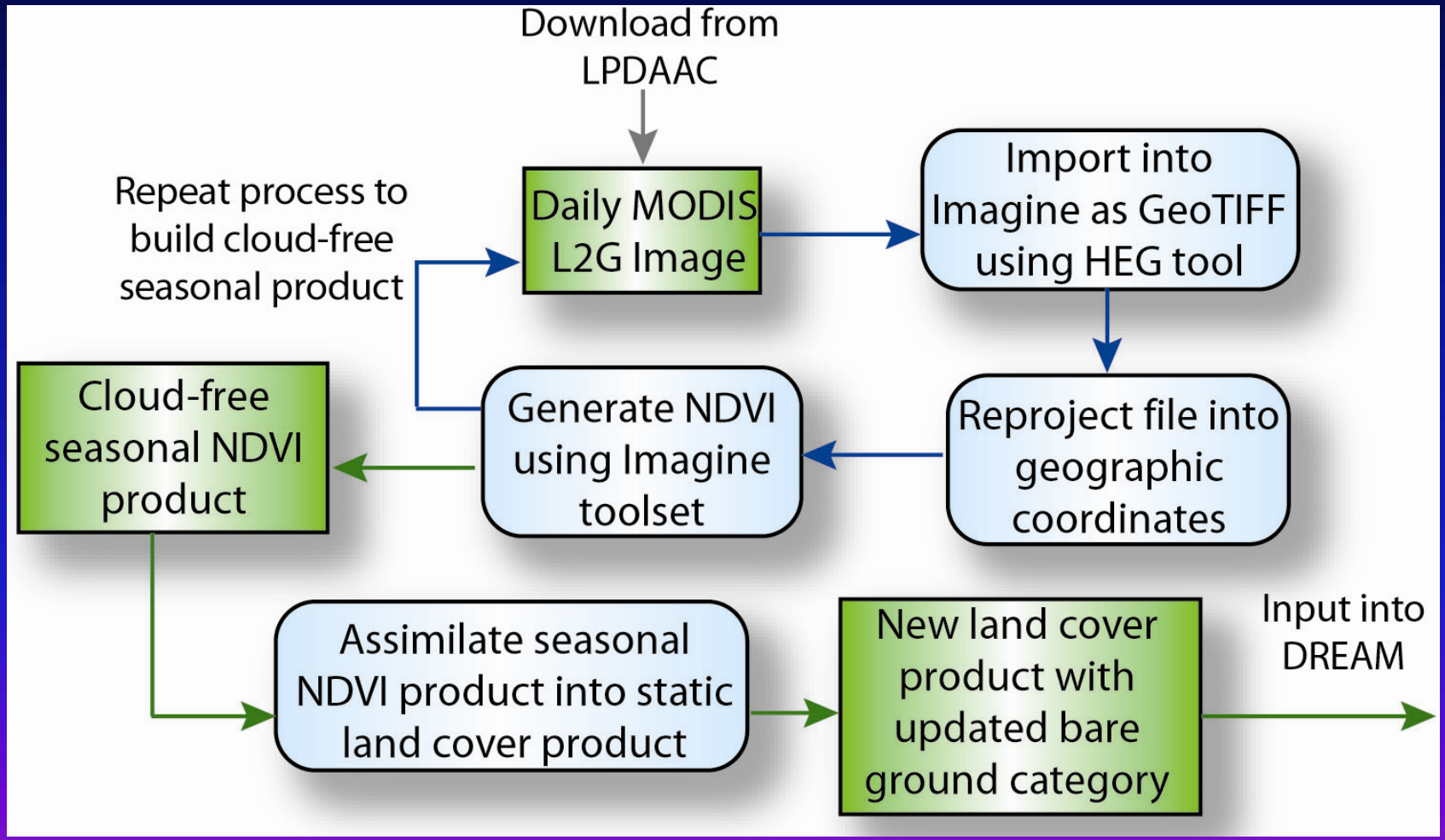
Run #	MOD12	SRTM	Surface roughness length	FPAR	AMSR-E
Run 1a					
Run 2c	Y				
Run 4a	Y	Y			
Run 5a	Y	Y	Y		
Run 5b	Y	Y	Y		
Run 6a	Y			Y	
Run 15a	Y				Y
Run 10a	Y	Y	Y		Y

DREAM Performance
Before & After EO Data Assimilation

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**	$\frac{1}{N}\sum_{i=1}^{N} \lvert M_i - O_i \rvert$
Agreement index	**0.74** **0.75**	**0.74** **0.76**	**0.71** **0.95**	$1 - \frac{\sum_{i=1}^{N} (M_i - O_i)^2}{\sum_{i=1}^{N} (\lvert M_i - \bar{O} \rvert + \lvert O_i - \bar{O} \rvert)}$

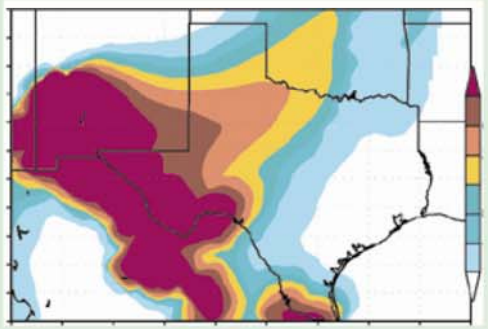
Yellow values = before EO Data Assimilation
Pink values = after EO Data Assimilation

Processing Scheme for Seasonal Bare Ground



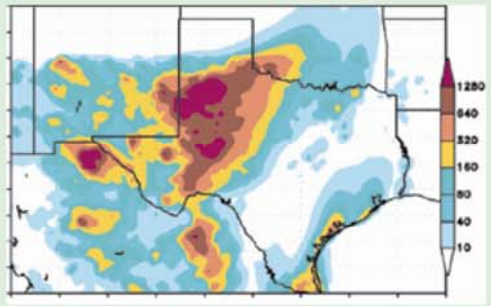
Incremental Improvements to Model Performance

Baseline Model Performance



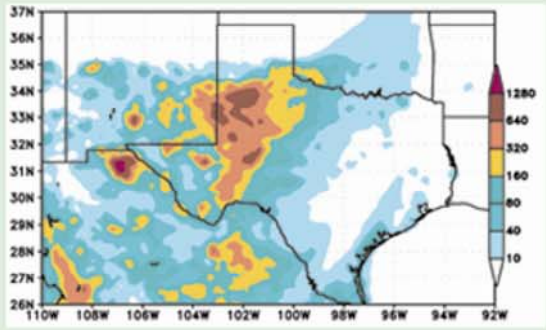
University of Malta
University of New Mexico
University of Arizona

Model Performance After Assimilating Earth Observation Data



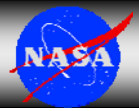
NASA / University of New Mexico
University of Arizona
World Meterological Organization

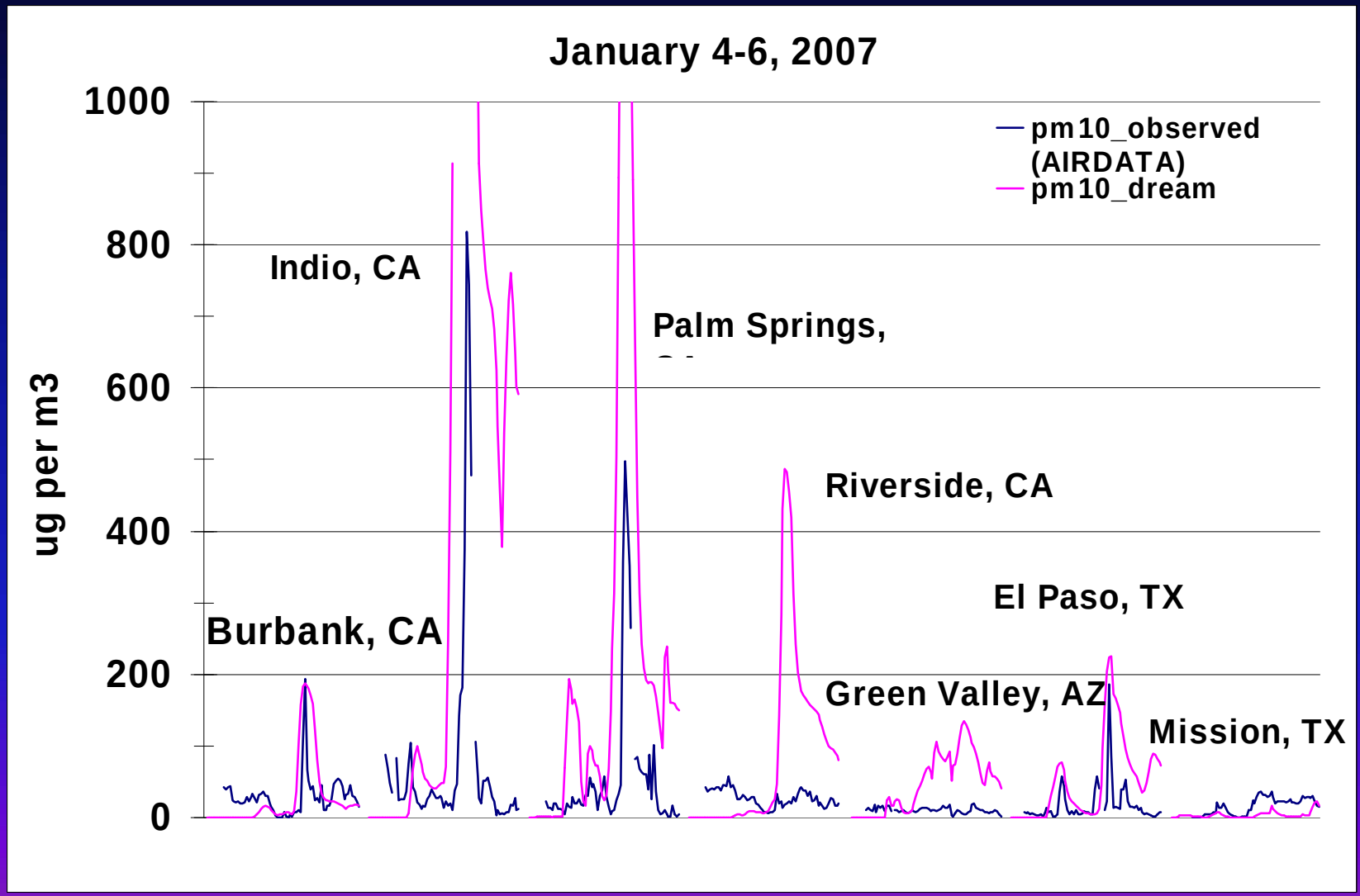
Model Performance Using NCEP/NMM Weather Forecast Model

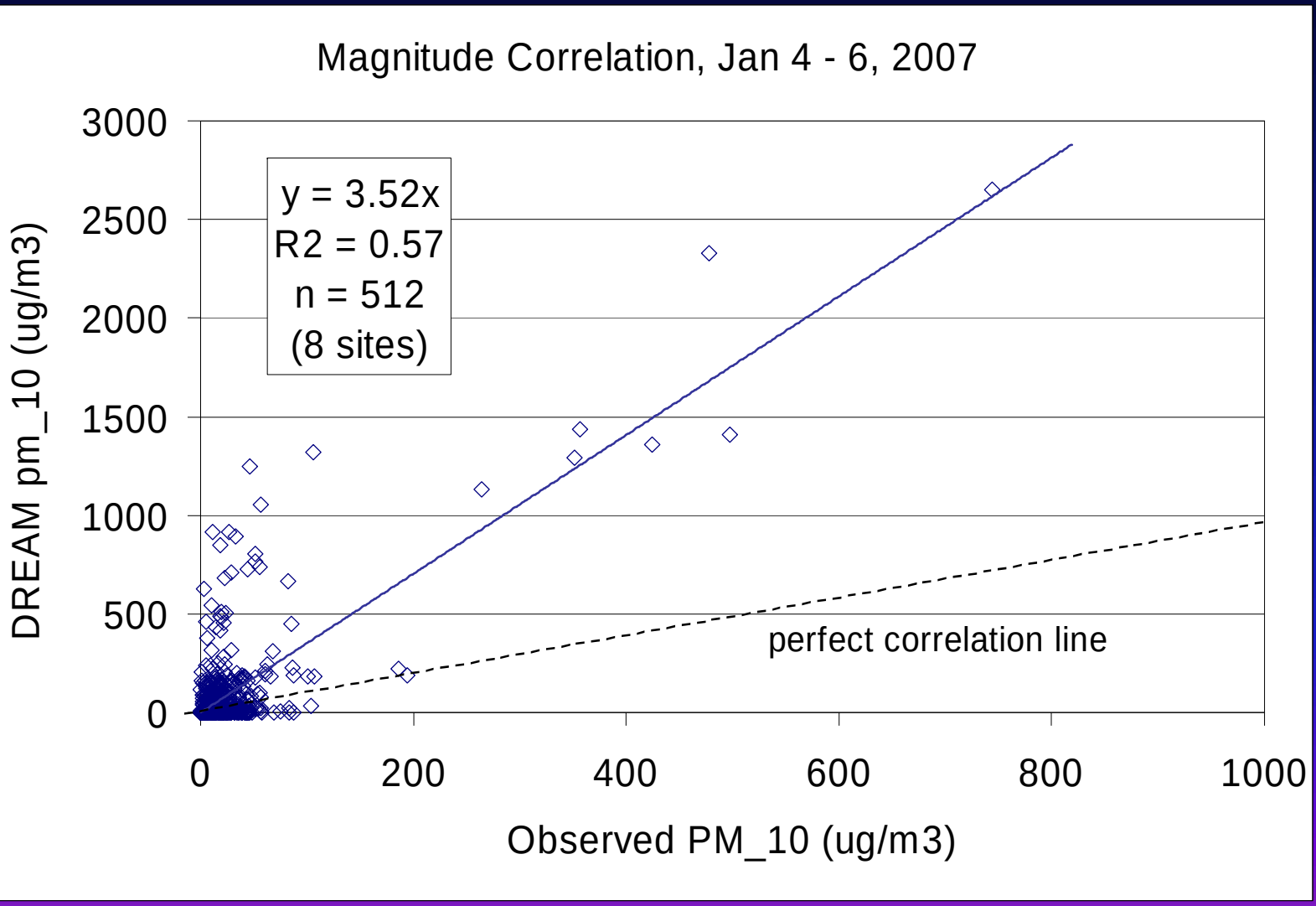


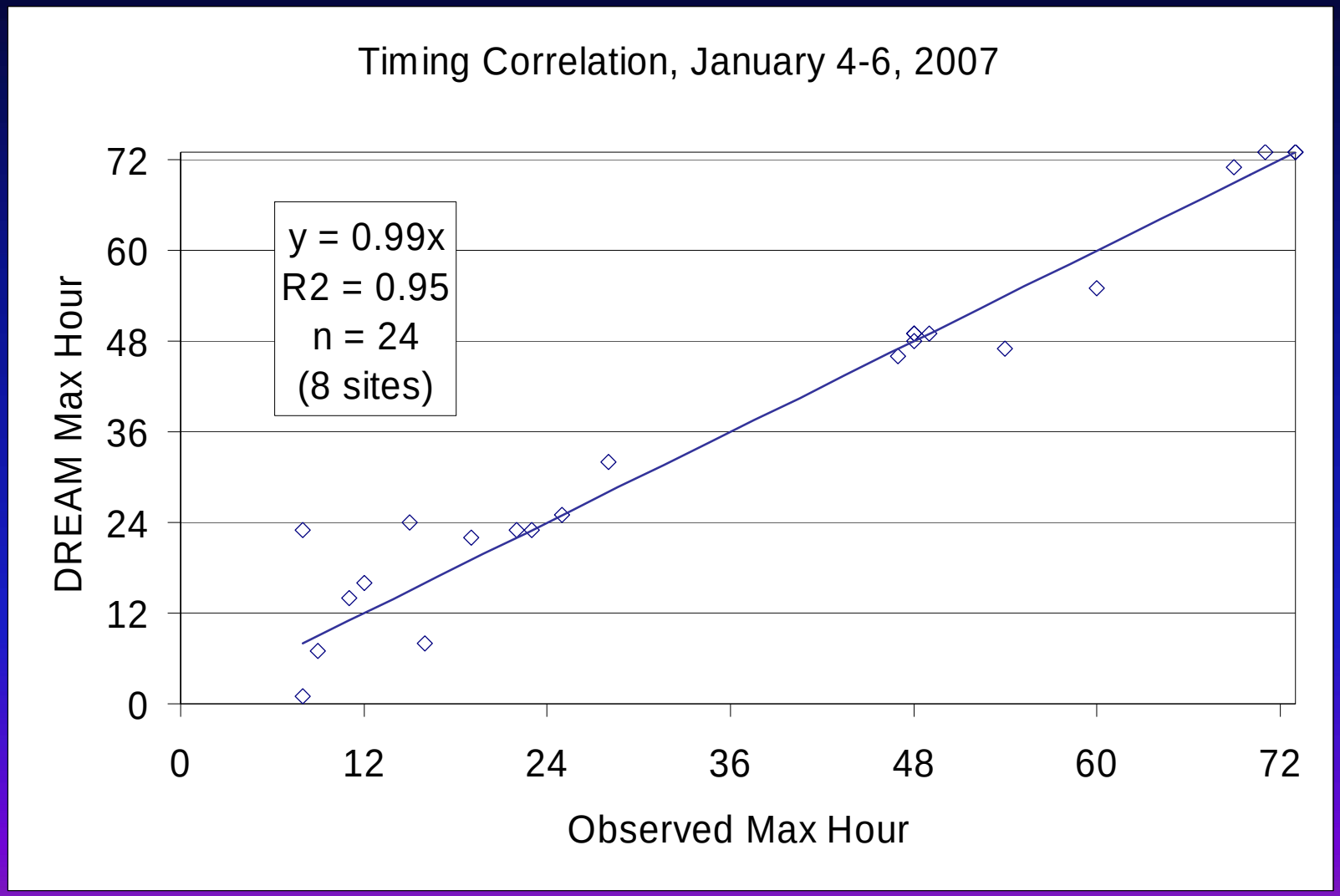
NASA / University of New Mexico
University of Arizona
World Meterological Organization

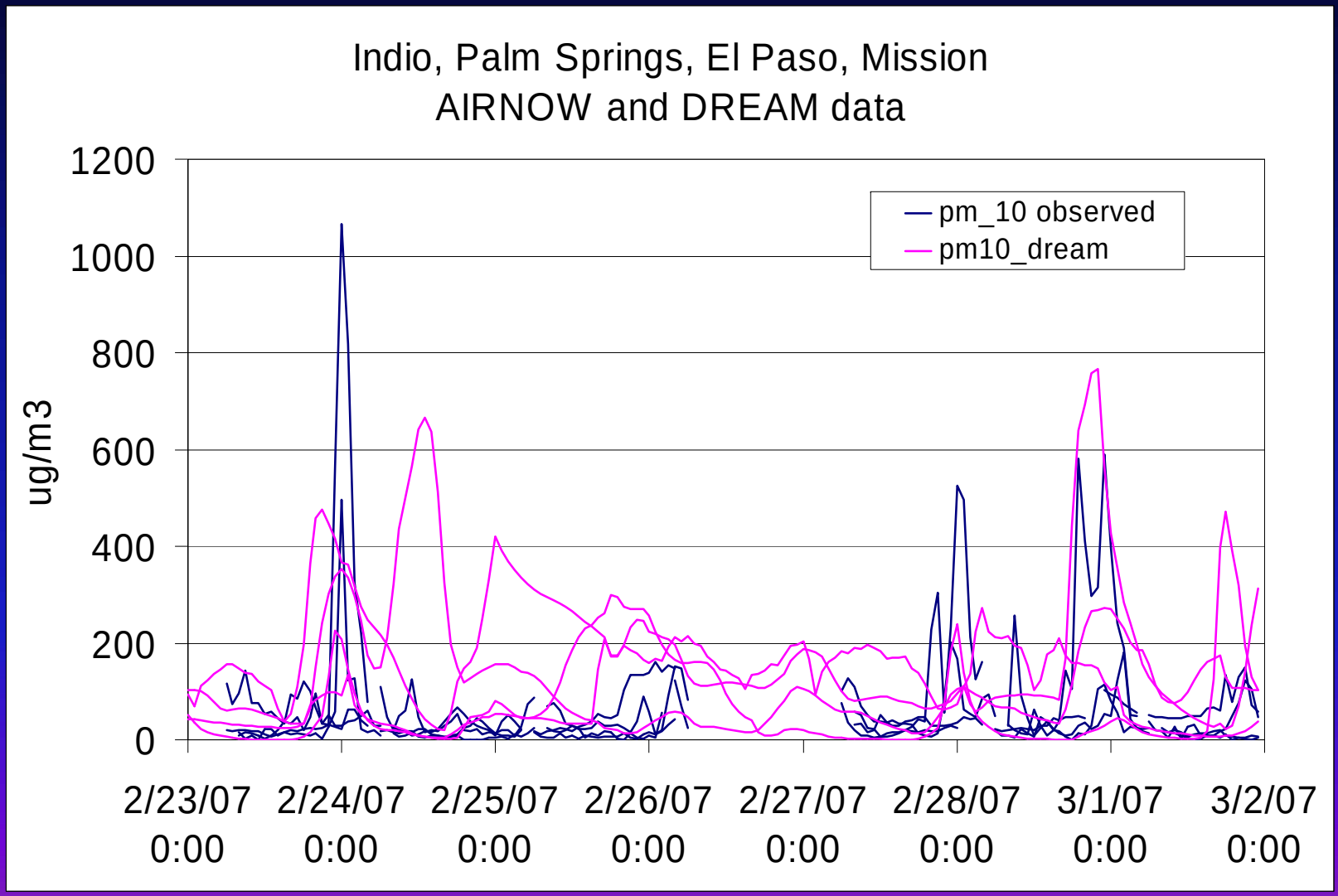
Verification & Validation

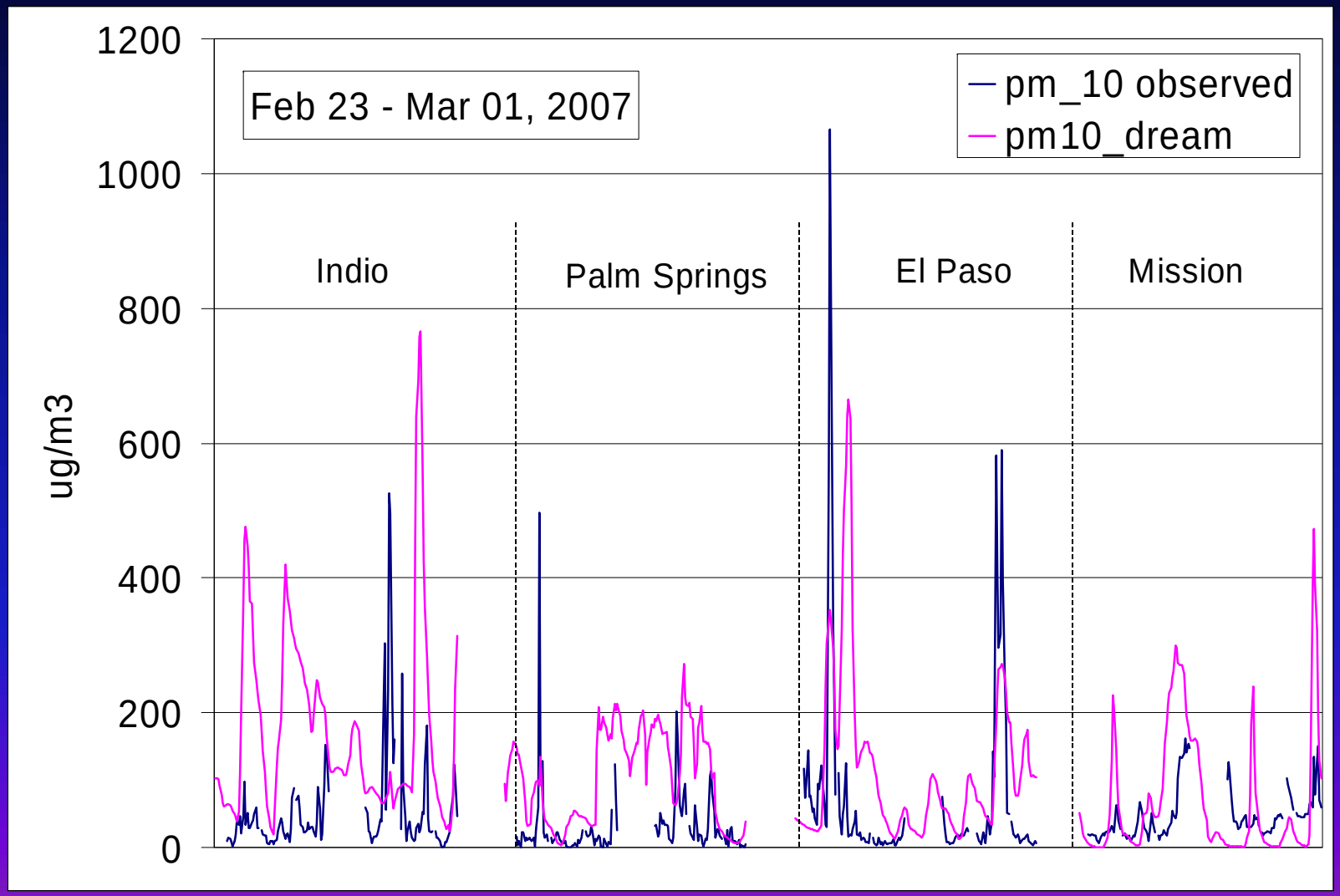



January 4-6, 2007
1000
800
600
400
200
0
ug per m3
pm10_observed (AIRDATA)
pm10_dream
Indio, CA
Palm Springs,
Riverside, CA
El Paso, TX
Burbank, CA
Green Valley, AZ
Mission, TX

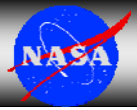

Magnitude Correlation, Jan 4 - 6, 2007
DREAM pm_10 (ug/m3)
Observed PM_10 (ug/m3)
y = 3.52x
R2 = 0.57
n = 512
(8 sites)
perfect correlation line
0
500
1000
1500
2000
2500
3000
0
200
400
600
800
1000


Timing Correlation, January 4-6, 2007
y = 0.99x
R2 = 0.95
n = 24
(8 sites)
DREAM Max Hour
Observed Max Hour
0
12
24
36
48
60
72

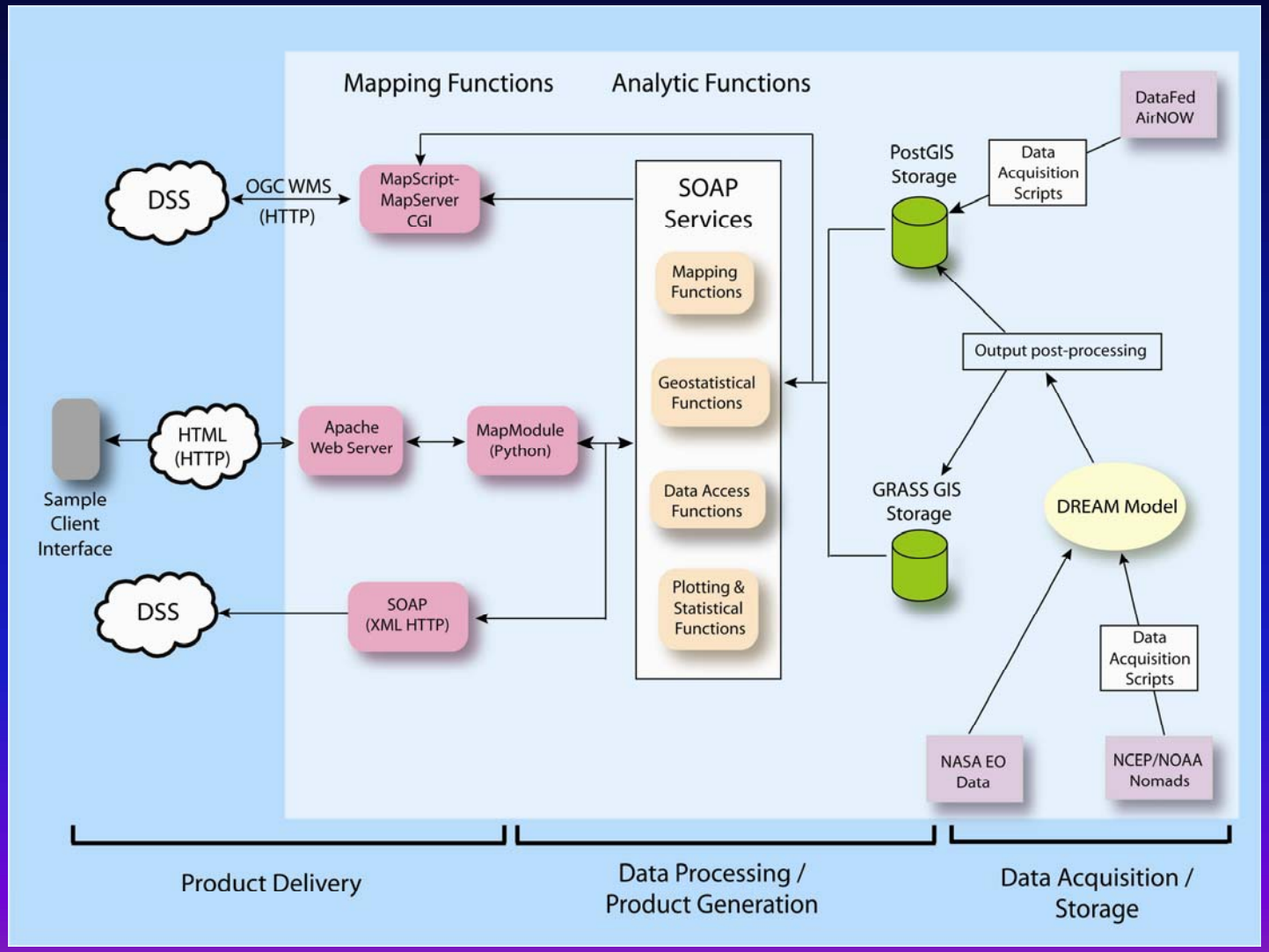

Indio, Palm Springs, El Paso, Mission
AIRNOW and DREAM data
ug/m3
1200
1000
800
600
400
200
0
pm_10 observed
pm10_dream
2/23/07 0:00
2/24/07 0:00
2/25/07 0:00
2/26/07 0:00
2/27/07 0:00
2/28/07 0:00
3/1/07 0:00
3/2/07 0:00


Feb 23 - Mar 01, 2007
pm_10 observed
pm10_dream
1200
1000
800
600
400
200
0
ug/m3
Indio
Palm Springs
El Paso
Mission

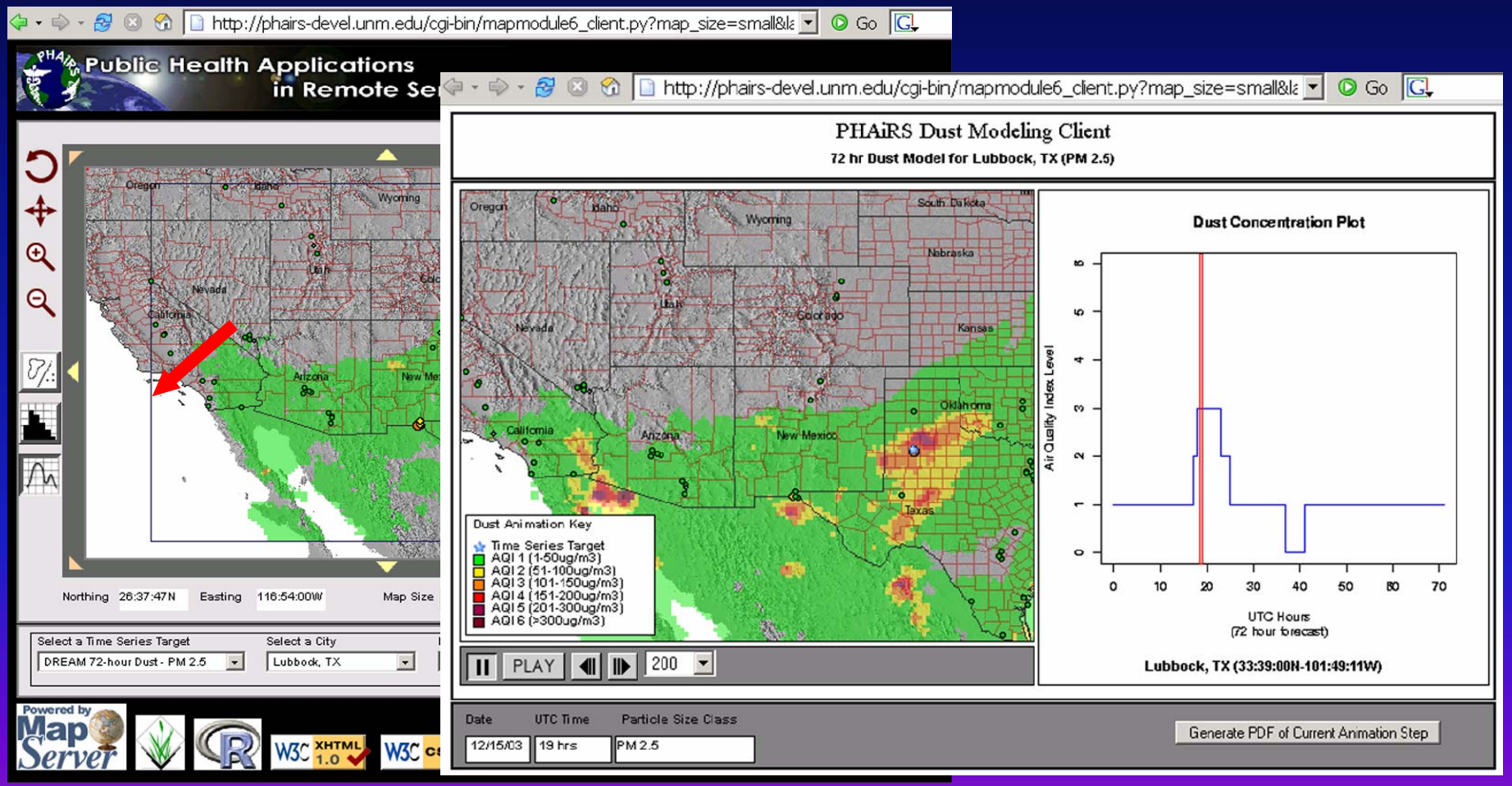
System Architecture



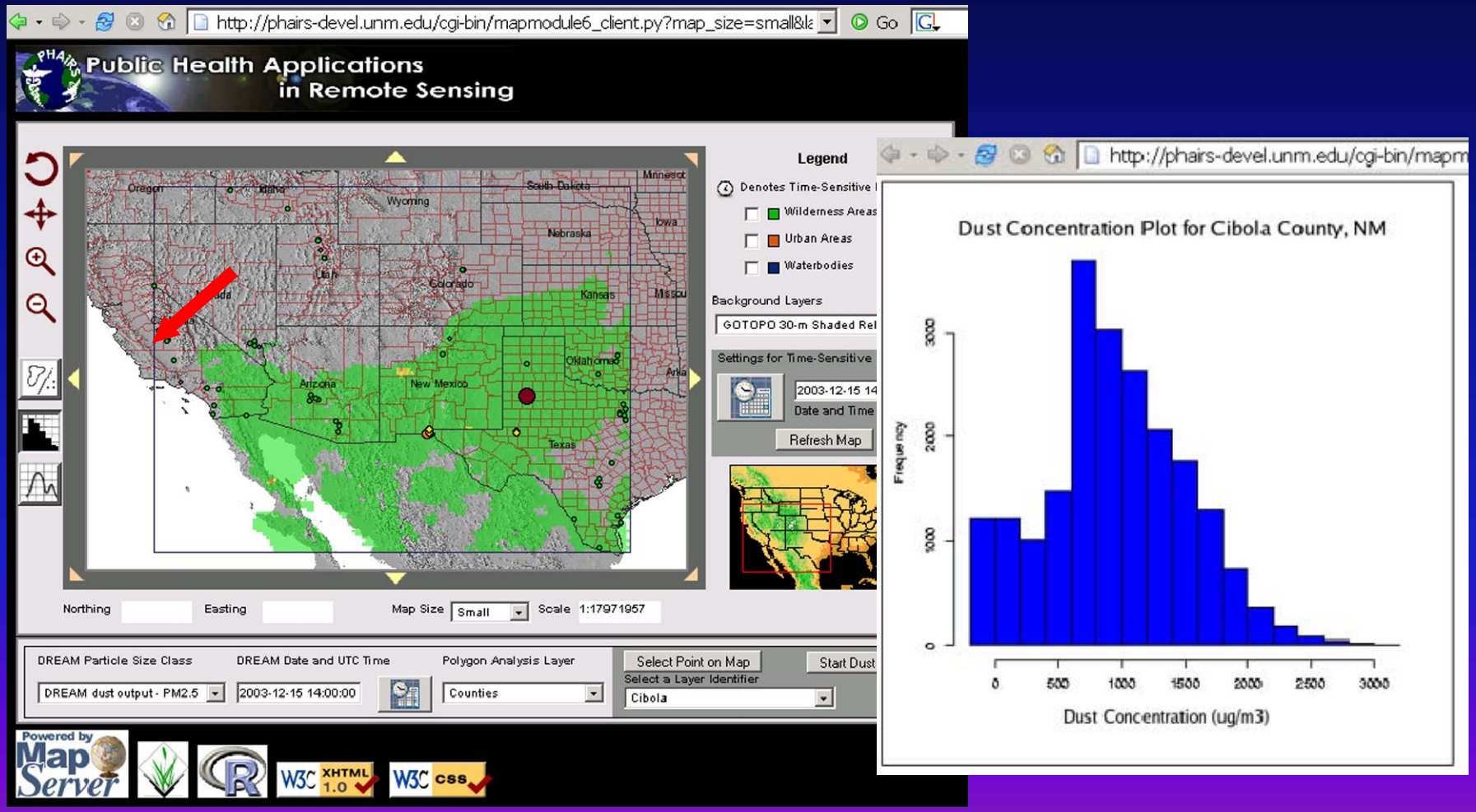
Basic Architecture



Client Interface Prototype: Time Series



Client Interface Prototype: Density Plot



Data Access & Statistics

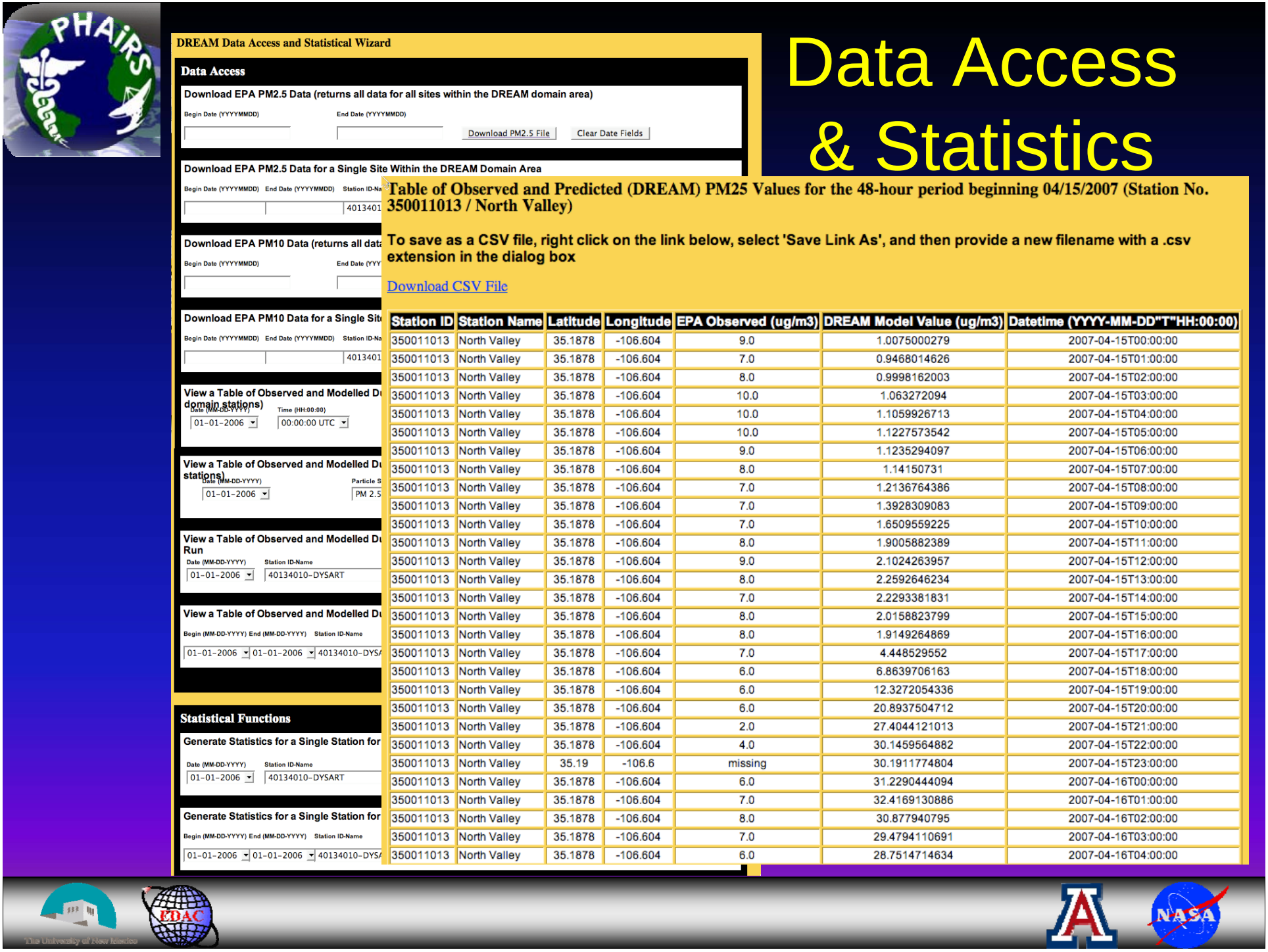


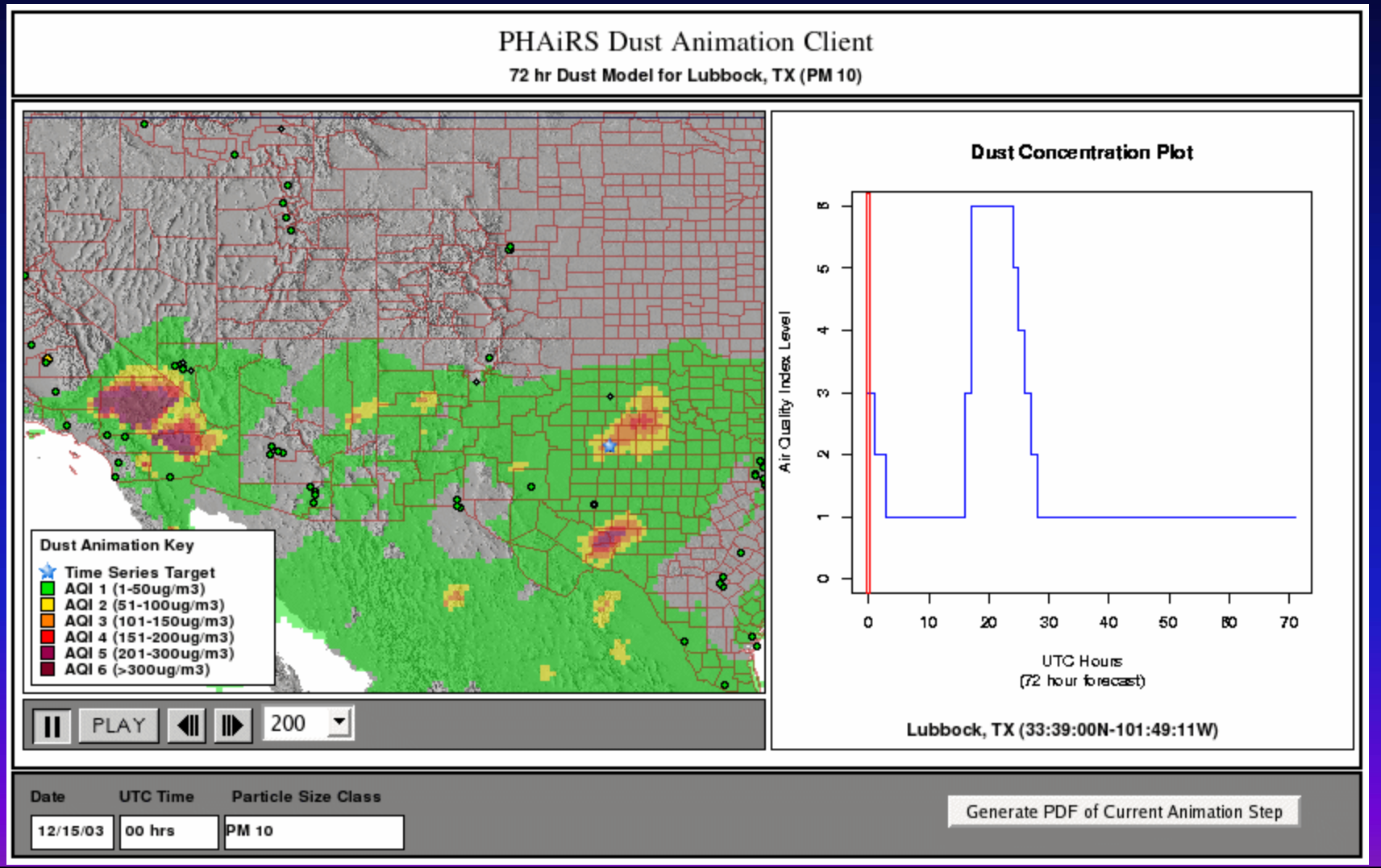
Table of Observed and Predicted (DREAM) PM25 Values for the 48-hour period beginning 04/15/2007 (Station No. 350011013 / North Valley)

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

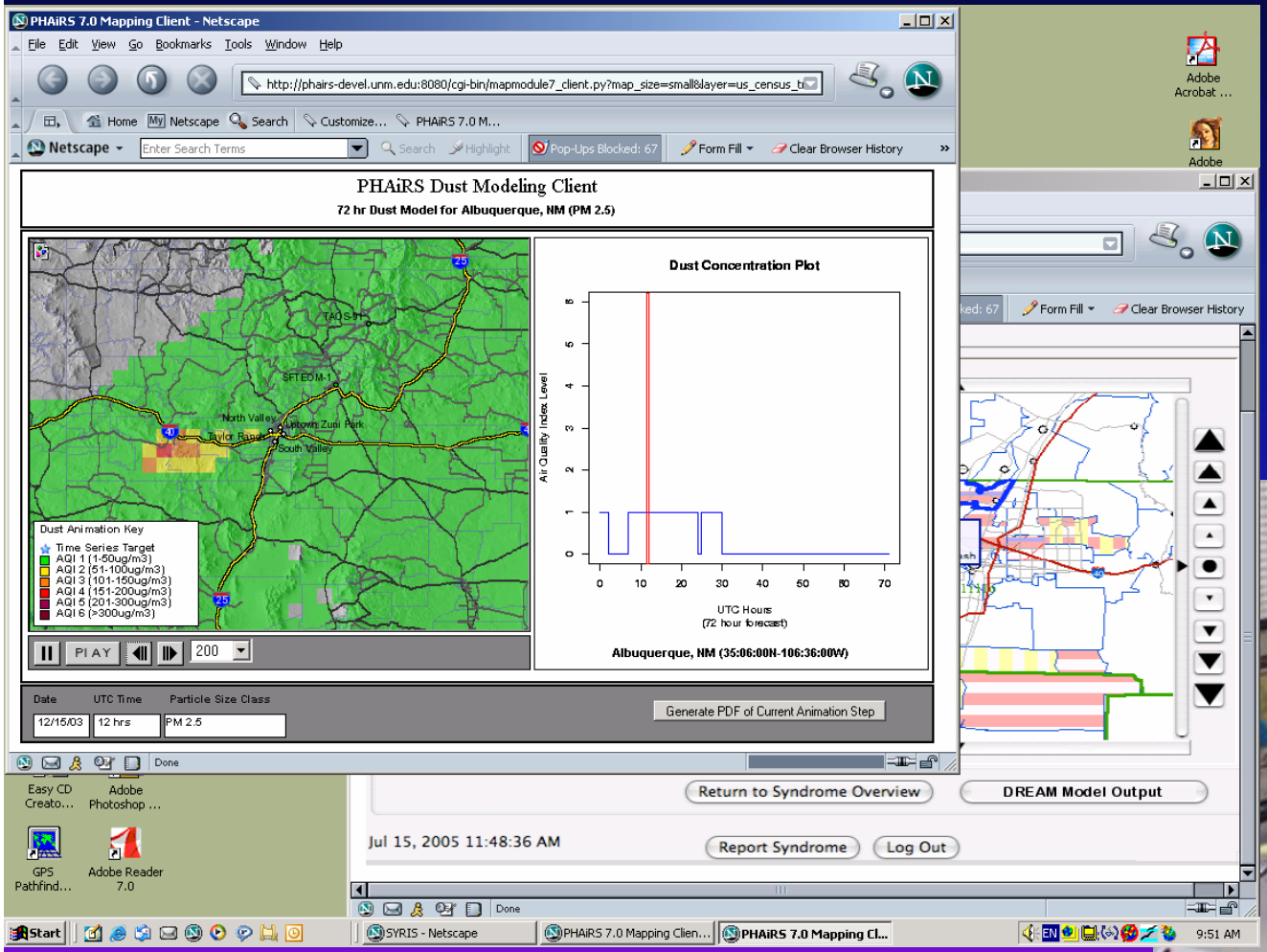
Download CSV File

Station ID	Station Name	Latitude	Longitude	EPA Observed (ug/m3)	DREAM Model Value (ug/m3)	Datetime (YYYY-MM-DD"T"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

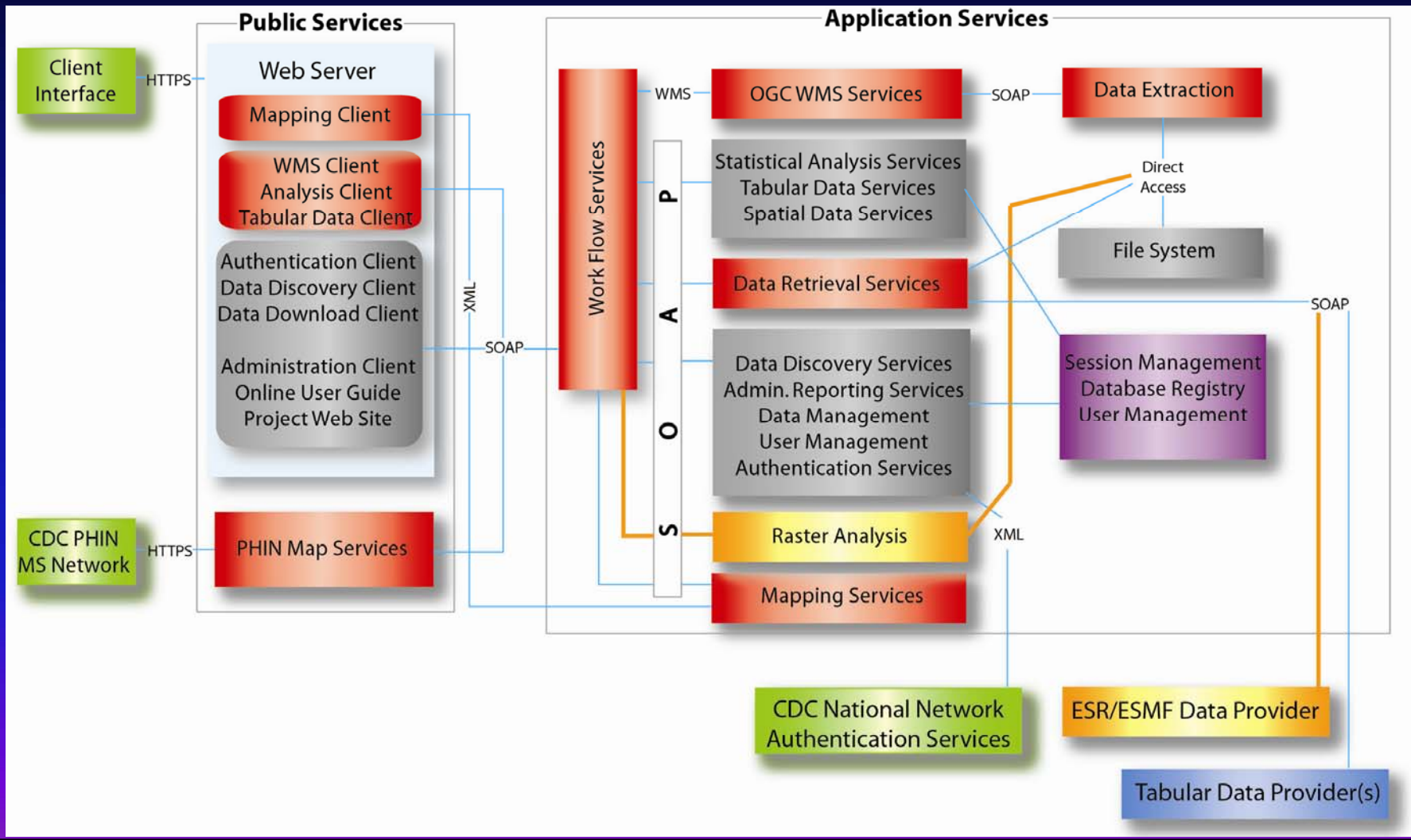
Animation of Dust Concentration



Enhancing SYRIS DSS



Enhancing EPHTS



New Directions

- Particle Speciation
- High Performance Computing
- Land Surface (Source) Updates
- Vertical Profile Verification