Modeling Atmospheric Dust for a Public Health Decision Support System

Stan Morain
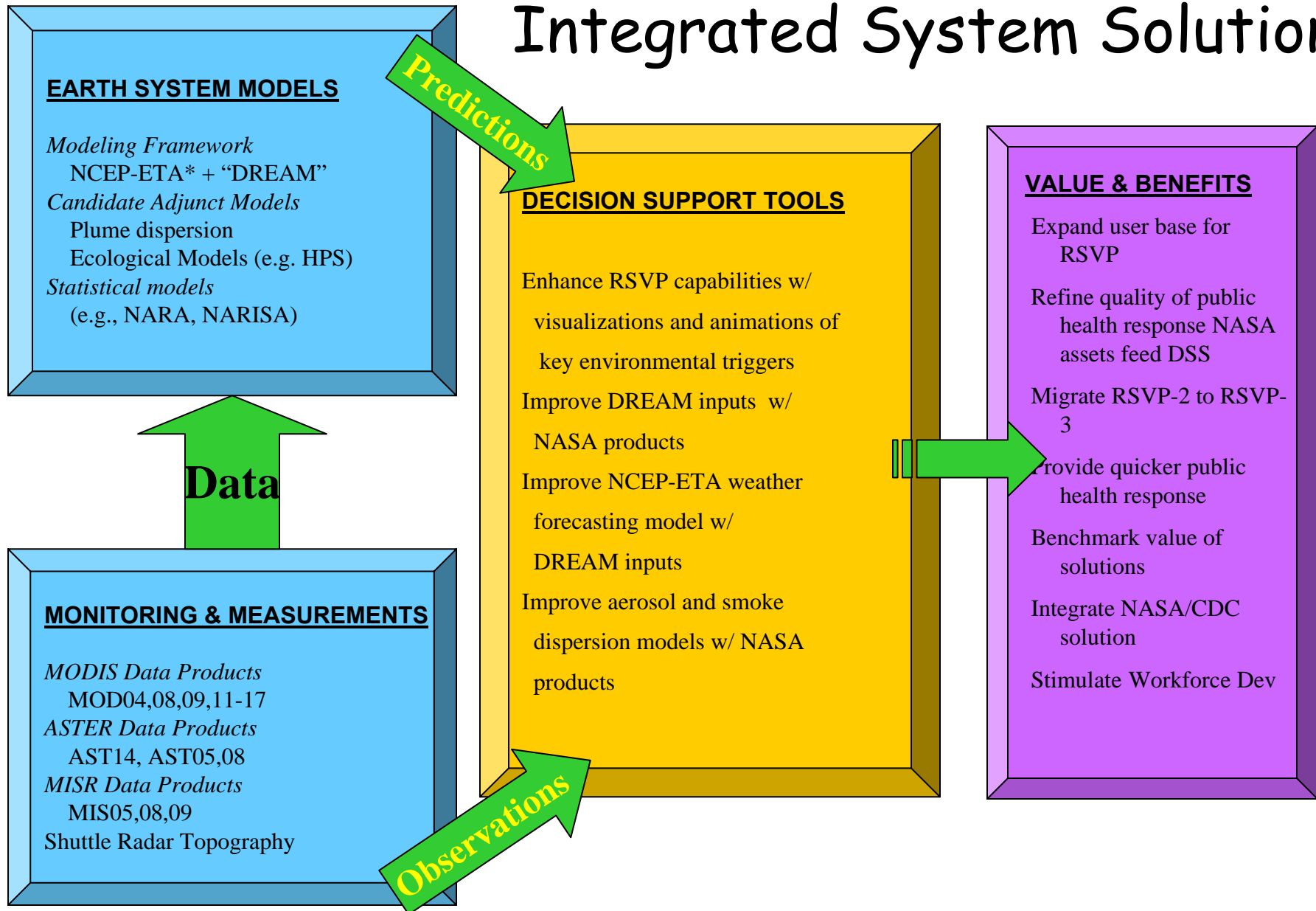
31st ISRSE

St. Petersburg, Russia
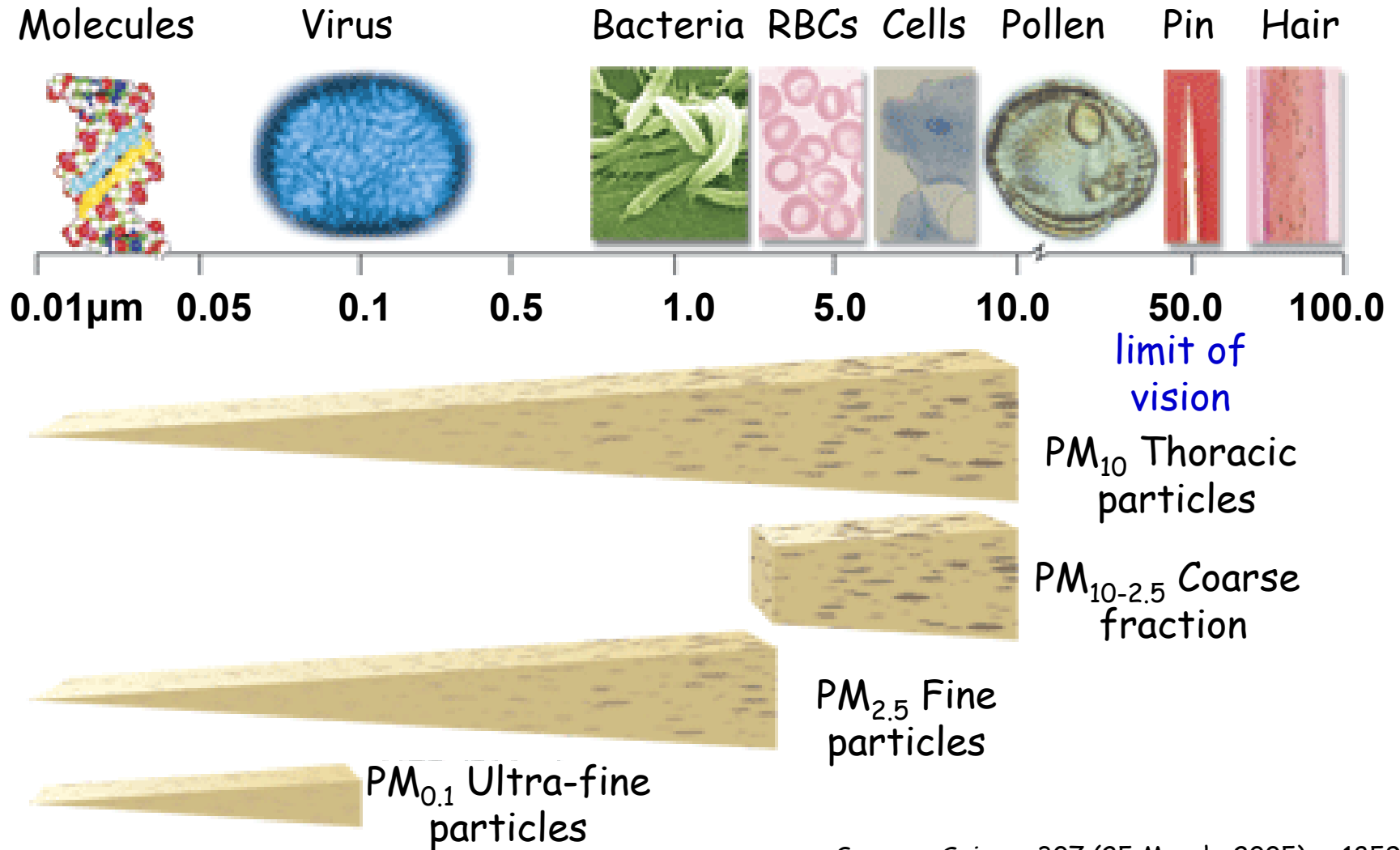
June 22, 2005

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Integrated System Solution

EARTH SYSTEM MODELS

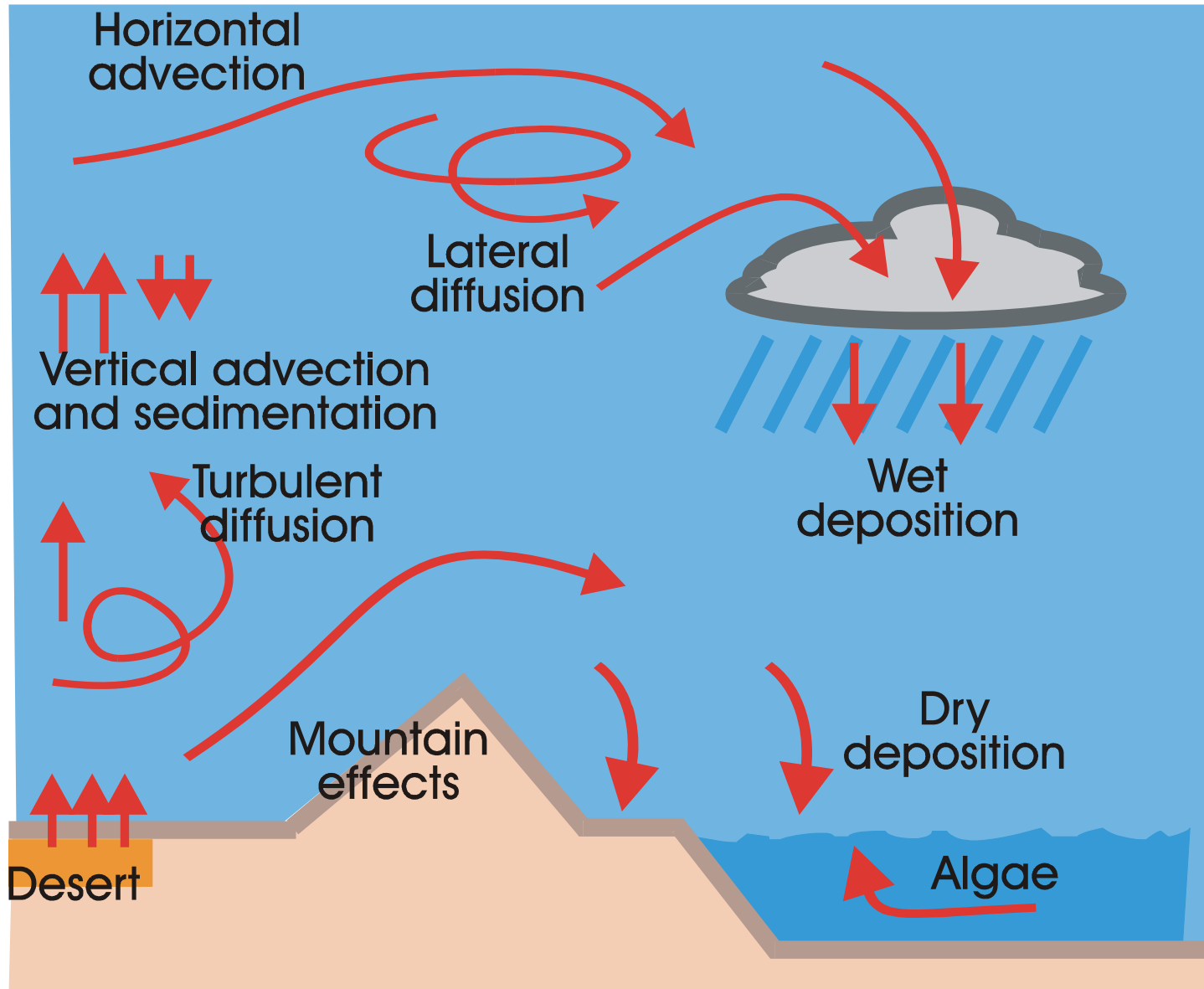*Modeling Framework*
    NCEP-ETA* + "DREAM"
Candidate Adjunct Models
    Plume dispersion
    Ecological Models (e.g. HPS)
Statistical models
    (e.g., NARA, NARISA)

Predictions

Data

MONITORING & MEASUREMENTS

MODIS Data Products
    MOD04,08,09,11-17
ASTER Data Products
    AST14, AST05,08
MISR Data Products
    MIS05,08,09
Shuttle Radar Topography

Observations

DECISION SUPPORT TOOLS

Enhance RSVP capabilities w/

    visualizations and animations of

    key environmental triggers

Improve DREAM inputs w/

    NASA products

Improve NCEP-ETA weather

    forecasting model w/

    DREAM inputs

Improve aerosol and smoke

    dispersion models w/ NASA

    products

VALUE & BENEFITS

Expand user base for
    RSVP

Refine quality of public
    health response NASA
    assets feed DSS

Migrate RSVP-2 to RSVP-
    3

Provide quicker public
    health response

Benchmark value of
    solutions

Integrate NASA/CDC
    solution

Stimulate Workforce Dev

Particulate Matter Size Distribution & Their Related Biophysical Impacts

Molecules   Virus   Bacteria   RBCs   Cells   Pollen   Pin   Hair

0.01μm   0.05   0.1   0.5   1.0   5.0   10.0   50.0   100.0

limit of vision

PM_{10} Thoracic particles

$PM_{10-2.5}$ Coarse fraction

$PM_{2.5}$ Fine particles

$PM_{0.1}$ Ultra-fine particles

Source: *Science* 307 (25 March, 2005), p.1859

DREAM's GOVERNING Concept

Horizontal advection

Lateral diffusion

Vertical advection and sedimentation

Turbulent diffusion

Wet deposition

Mountain effects

Dry deposition

Desert

Algae

AERONET (AErosol RObotic NETwork)

AERONET is a collection of radiometers on the ground that view the sun and sky in order to characterize the atmospheric aerosol

Tucson
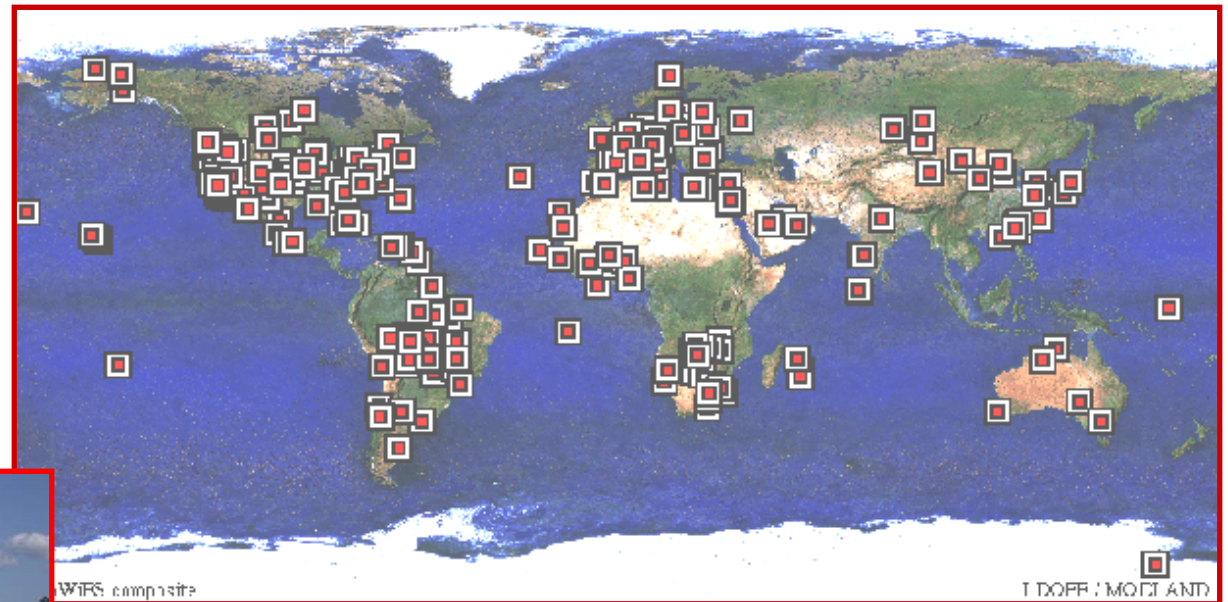
Image courtesy NASA-GSFC

AERONET

Measurements used to derive information about aerosol (size, composition, spectral thickness) are useful for validating satellite-based aerosol products (e.g., MODIS, MISR, Landsat)

Before passage of smoke   Smoke particles
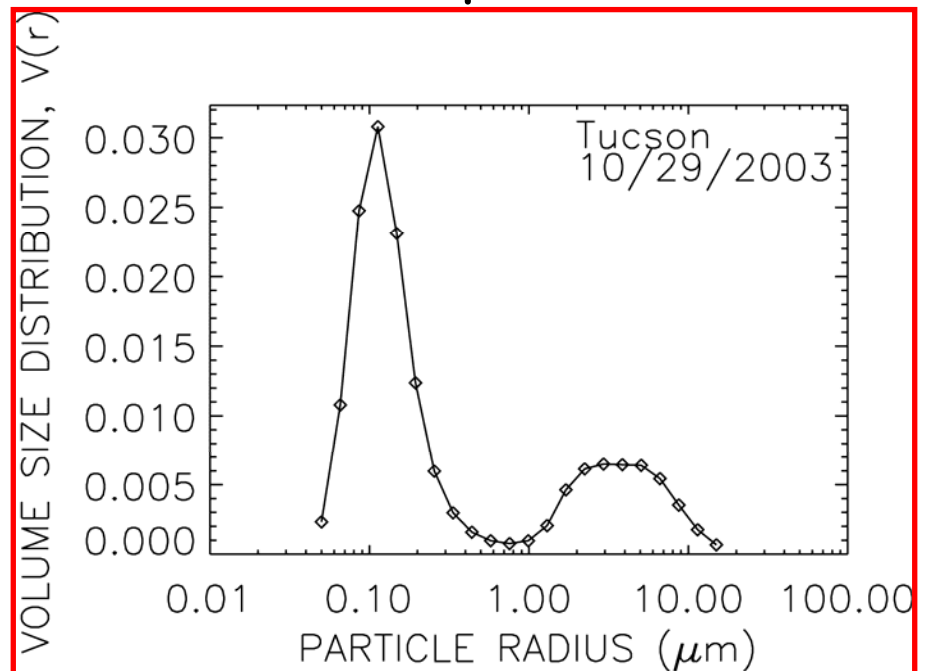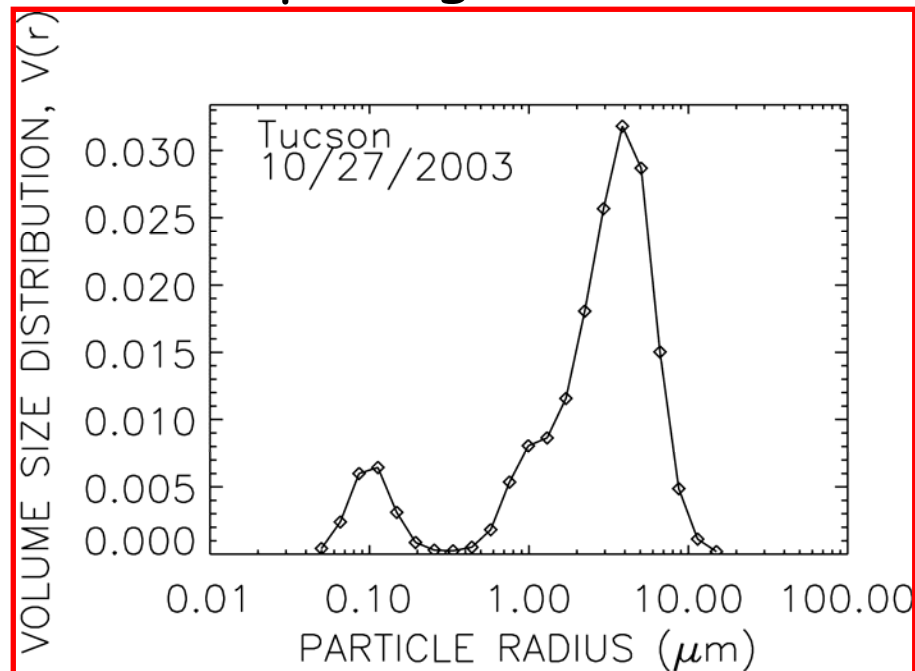
Texas PM$_{2.5}$ Monitoring Network
As of March 2001
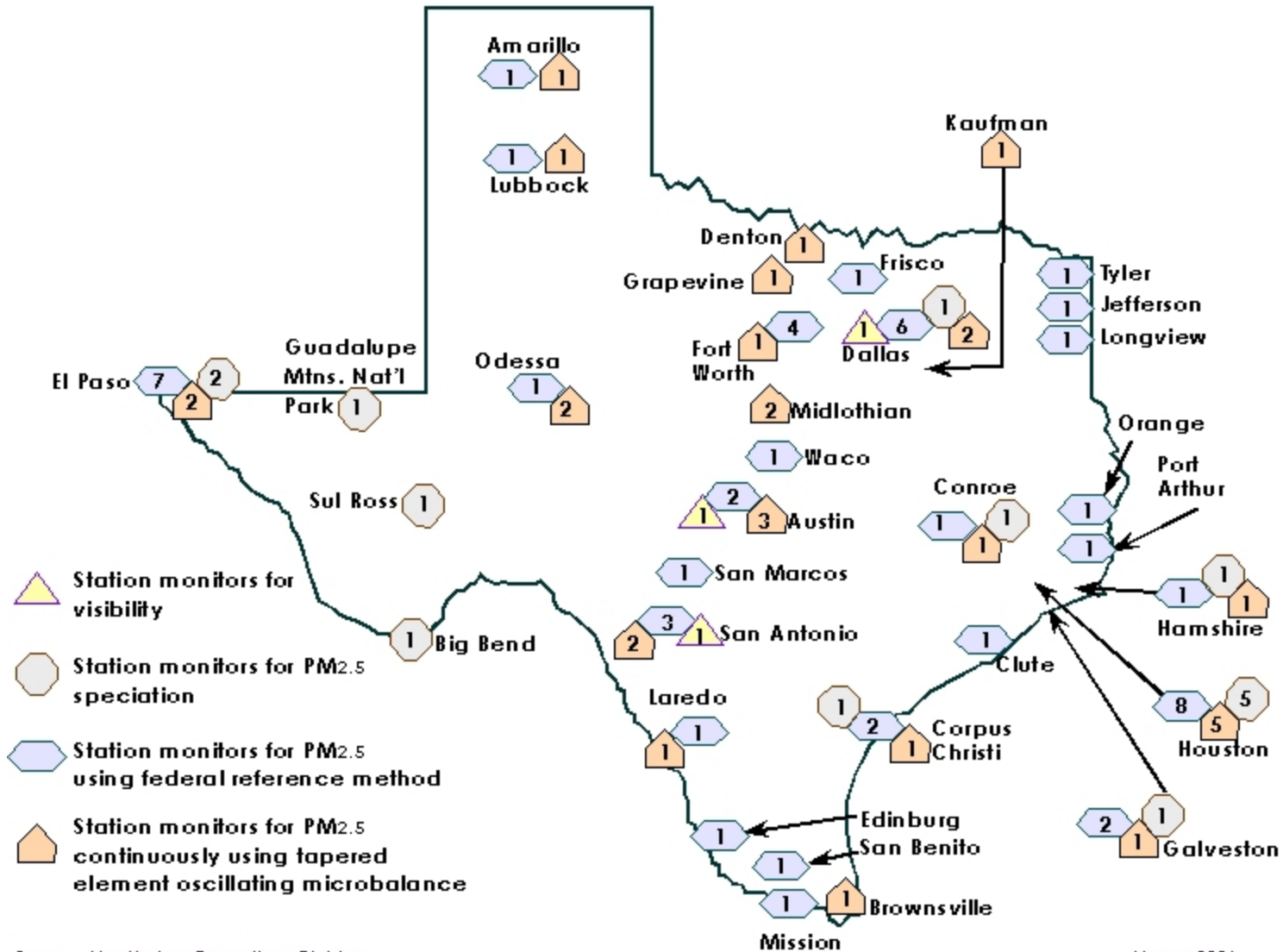
Source: Monitoring Operations Division

March 2001

Lubbock, TX Air Quality Monitoring Station

EPA site number: 48-303-0001
State: Texas
County: Lubbock
City: Lubbock
Address: 5th Street at Avenue K
Site coordinates:
   Latitude: 33° 35' 27" North (+33.590833°)
   Longitude: 101° 50' 51" West (-101.847500°)
   Elevation: 963 m (3160 ft)
Maintained by: TCEQ Lubbock Regional Office

1-9-03

Remote Sensing of Aerosols from MODIS

Pre-compute look-up table of radiance values (geometry, aerosol type, aerosol amount, surface type)

After determining surface type, compare measured radiance with pre-computed values; the solution is that which best matches the observed radiance

Thus, aerosol type and amount are not measured quantities but inferred from radiance measured at the satellite.

Aerosol Optical Depth @ 550 nm Observed by MODIS Aqua at Lubbock, TX December 15, 2003 (2055 UTC)

Cloud

Cloud

0   0.06   0.11   0.17   0.23   0.29   0.34   0.40   0.46   0.51
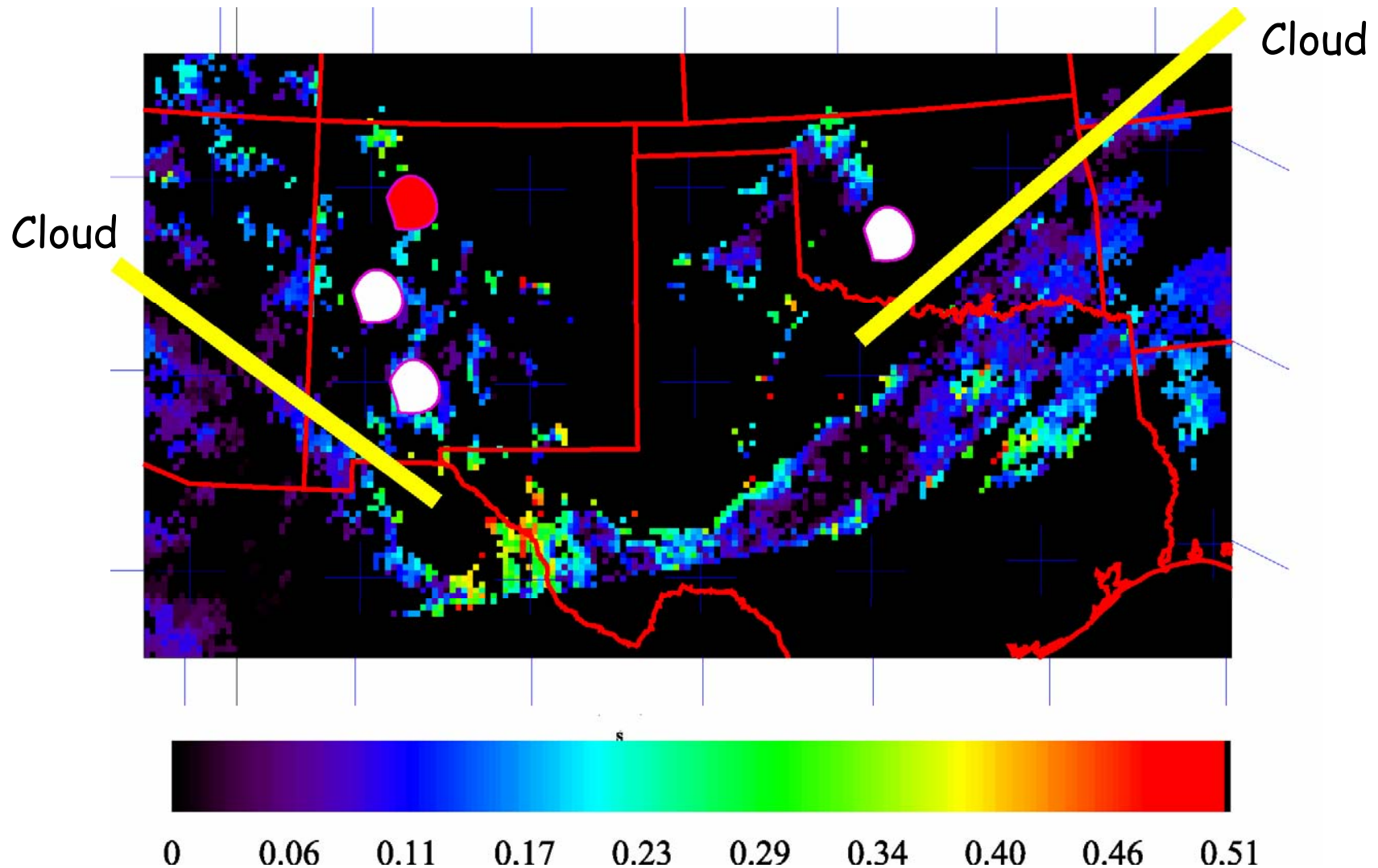
DREAM Inputs & Upgrade Potential

Static Inputs	Dynamic/Variable Inputs	Assimilation Potential
Global topography (1x1 km)	Latitude/longitude, thinned grid standard	ASTER-AST 14/SRTM Digital elevation
Global soil types FAO 2x2 minute (converted into texture classes)	10 pressure levels	NRCS: SSURGO and STATSGO
Global vegetation types USGS (1x1 km)	Geo-potential height	MOD 15 vegetation LAI, FPAR (1km)
Items in blue are NASA-generated products. Idea is to migrate from static to dynamic inputs	Wind components	Addressed by NCEP/Eta
	Specific humidity	AIRS/AMSU-A atmospheric humidity
	Surface fields (soil temp, moisture, and albedo)	MOD 11 soil temp TRMM 3A-53 5-day rain map (2 x 2 km)

New Mexico/Texas Dust Storm

Visibility Analysis
12/15/03 9 a.m. CST
Yellow < 7 miles
Orange < 3 miles
Red < 1 mile

2004-09-18-13:06
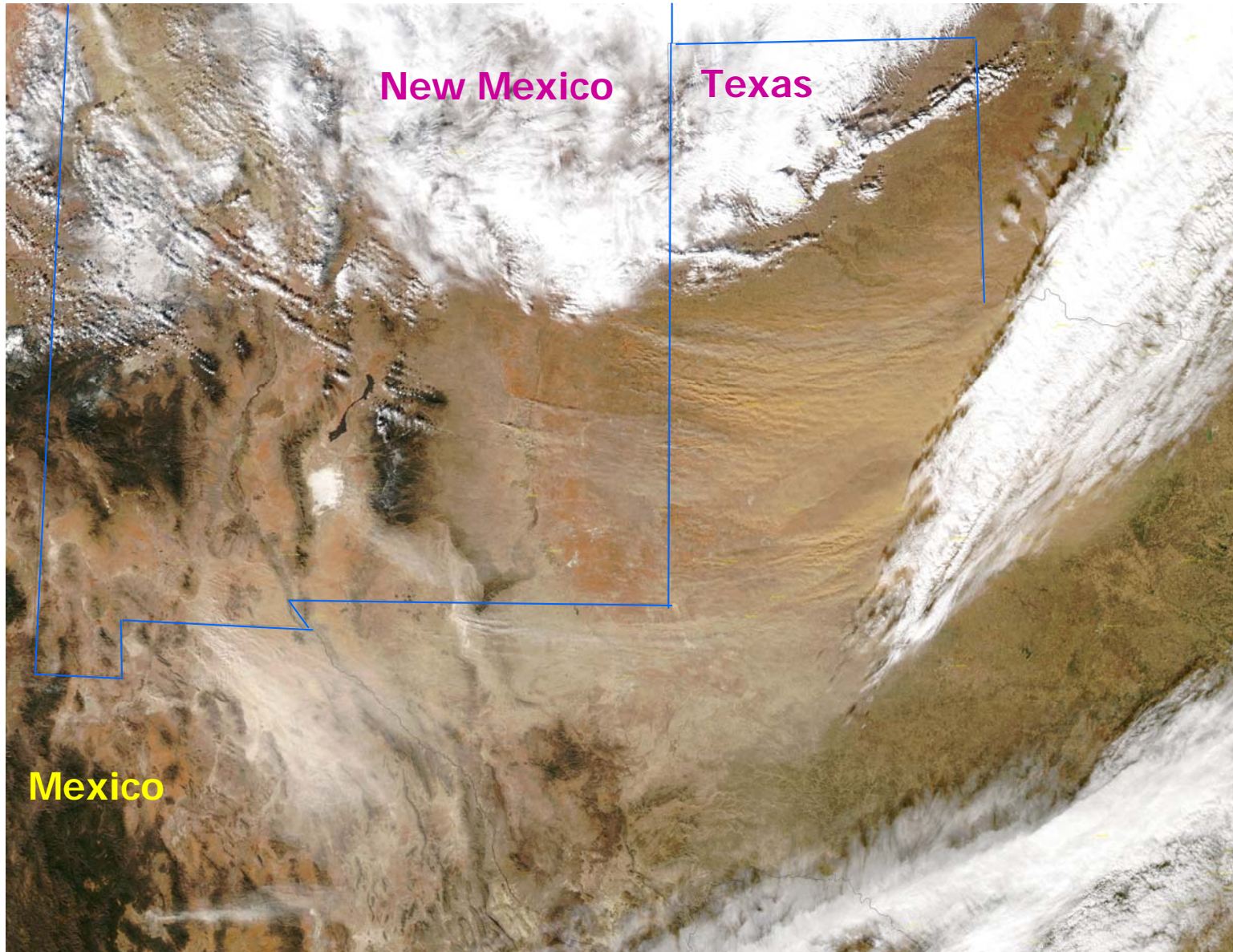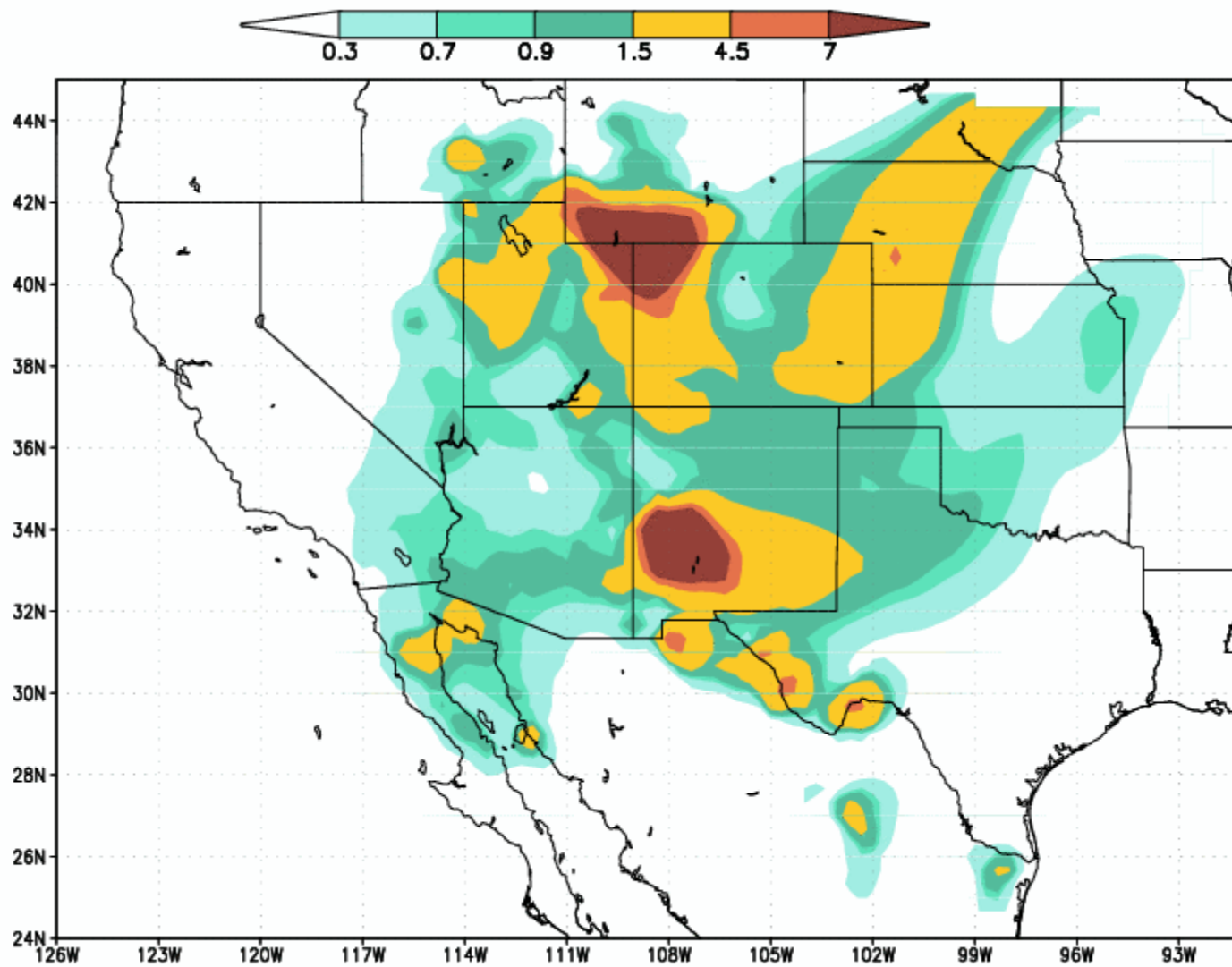
Modeled Dust Concentrations vs Ground Visibility at Weather Stations

Dust concentration (µg/m³)
15 December '03
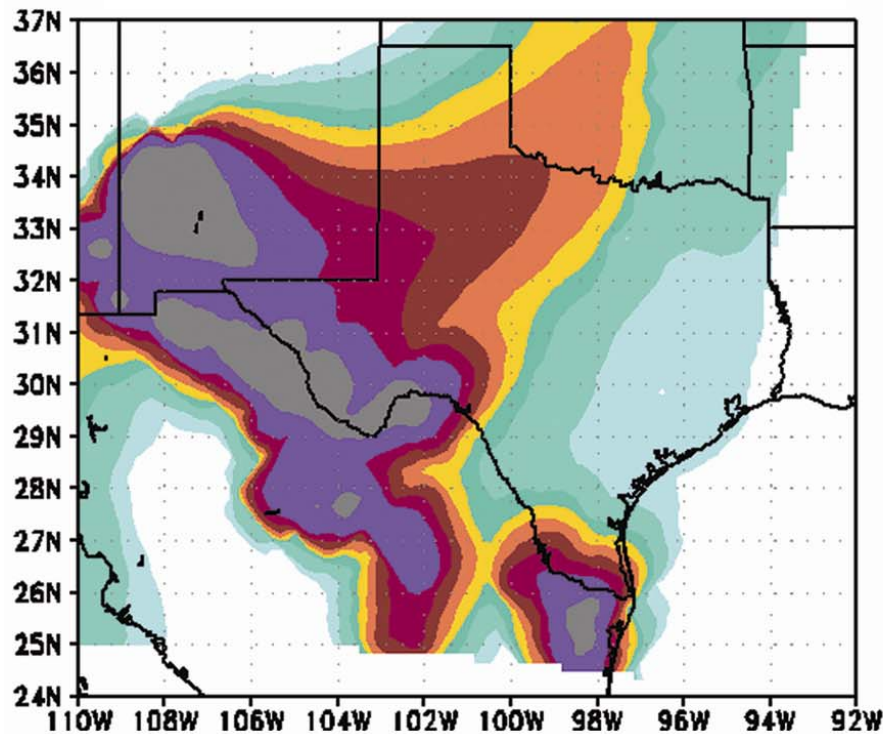
Measured visibility (miles)
15 December '03
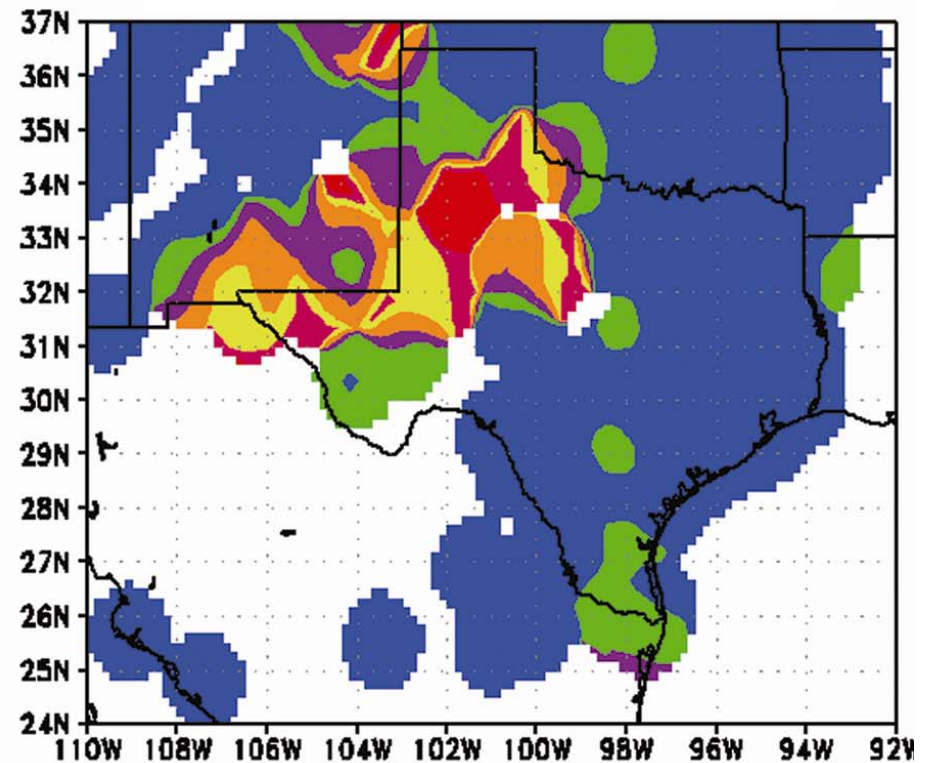
No NASA data in Model

Comparison of In-situ and Modeled PM$_{2.5}$
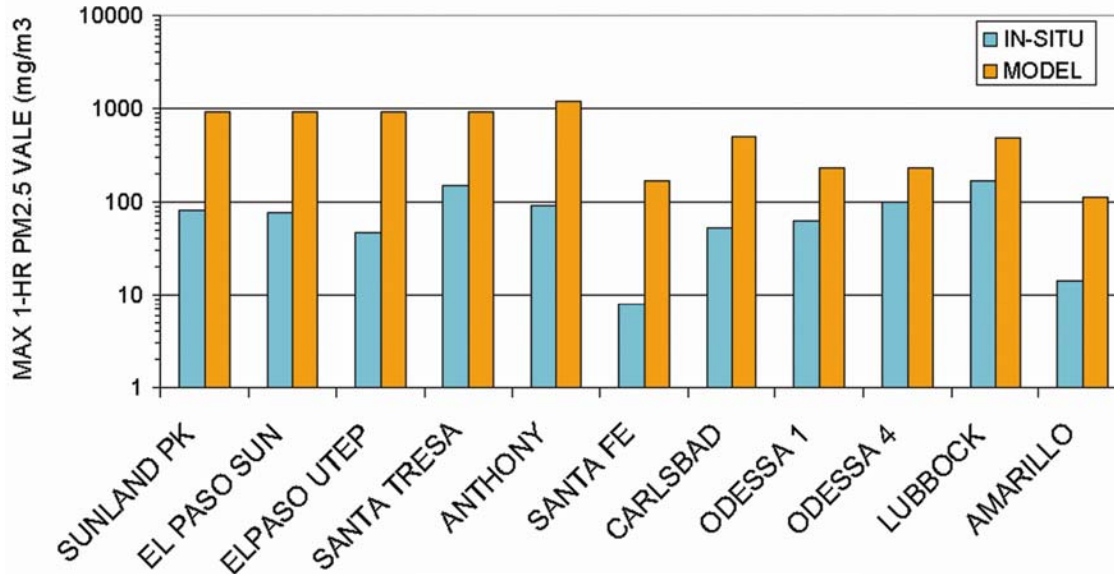
No NASA data in model
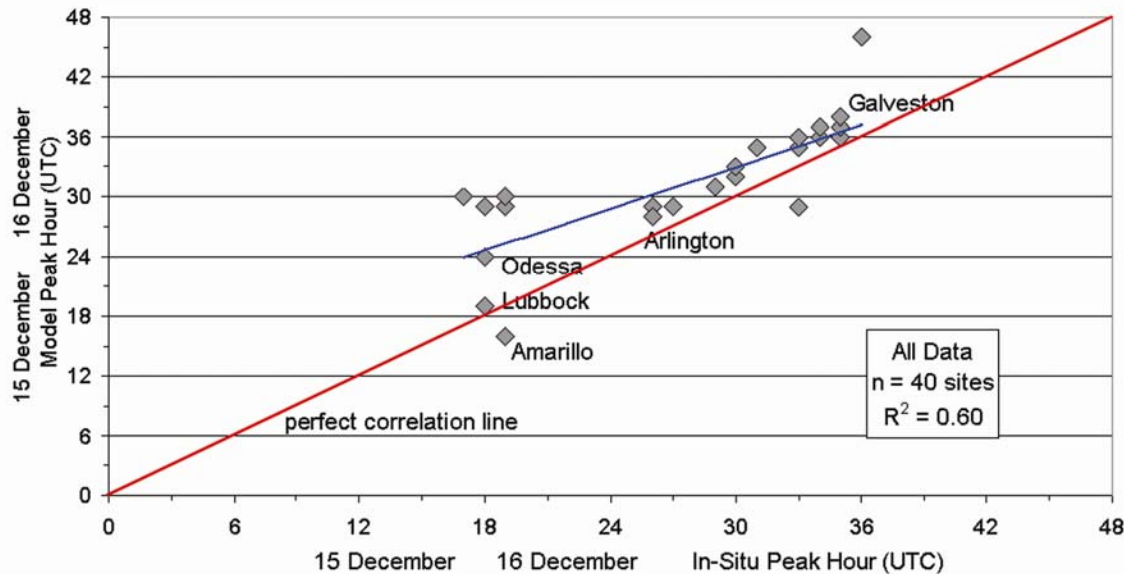
Peak 1 hr PM$_{2.5}$
N=40, R^2=0.60

Patterns of Visibility Classes
Vs Modeled Dust Loading
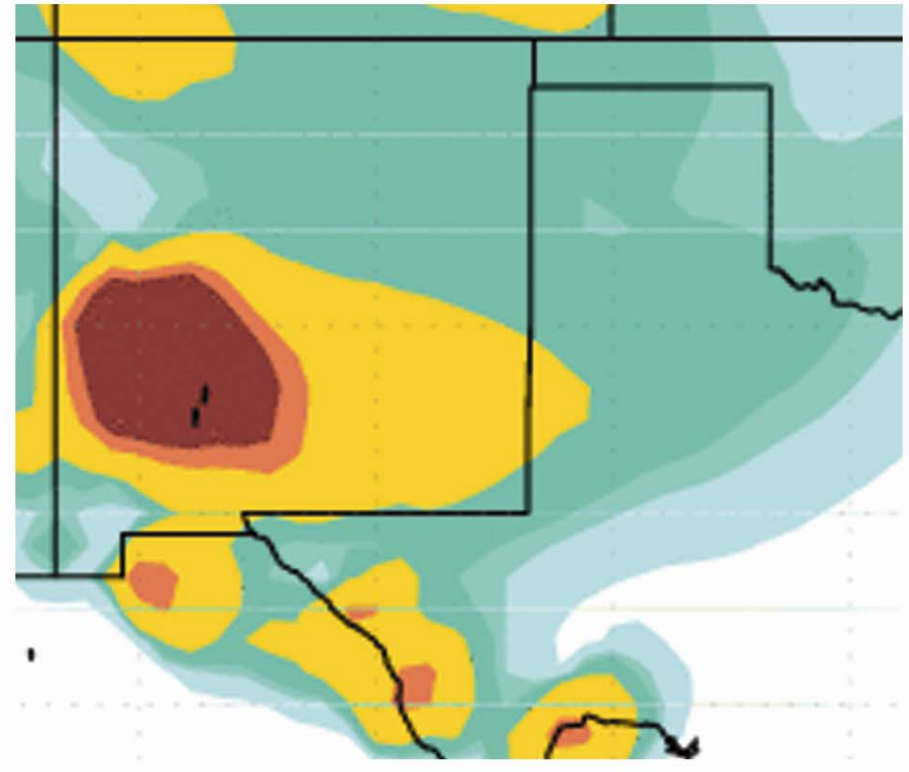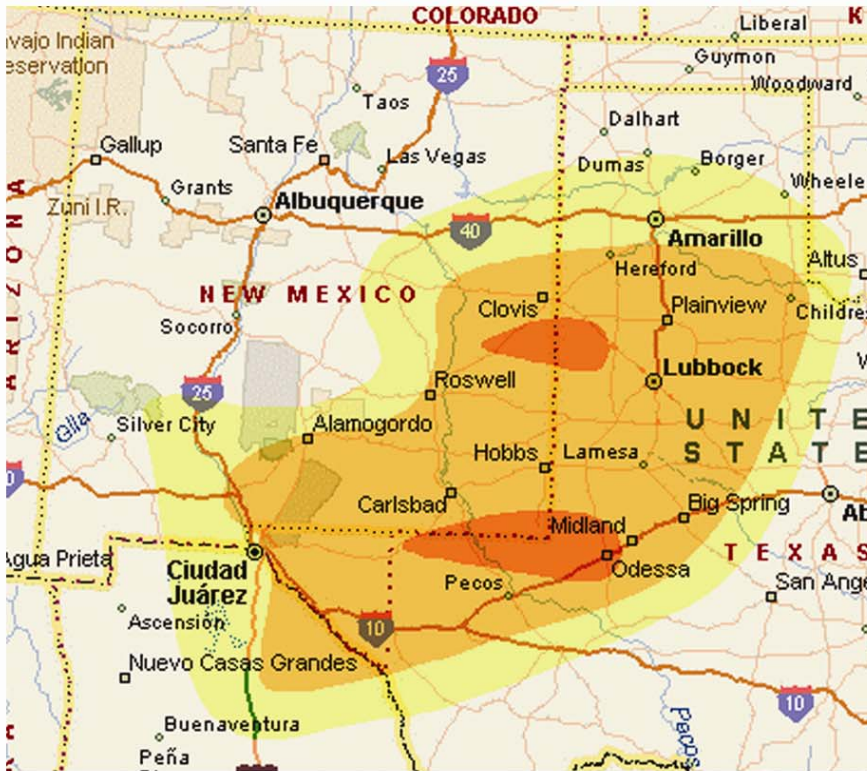
No NASA data in model

Visualizations of Four DREAM Replacement Parameters
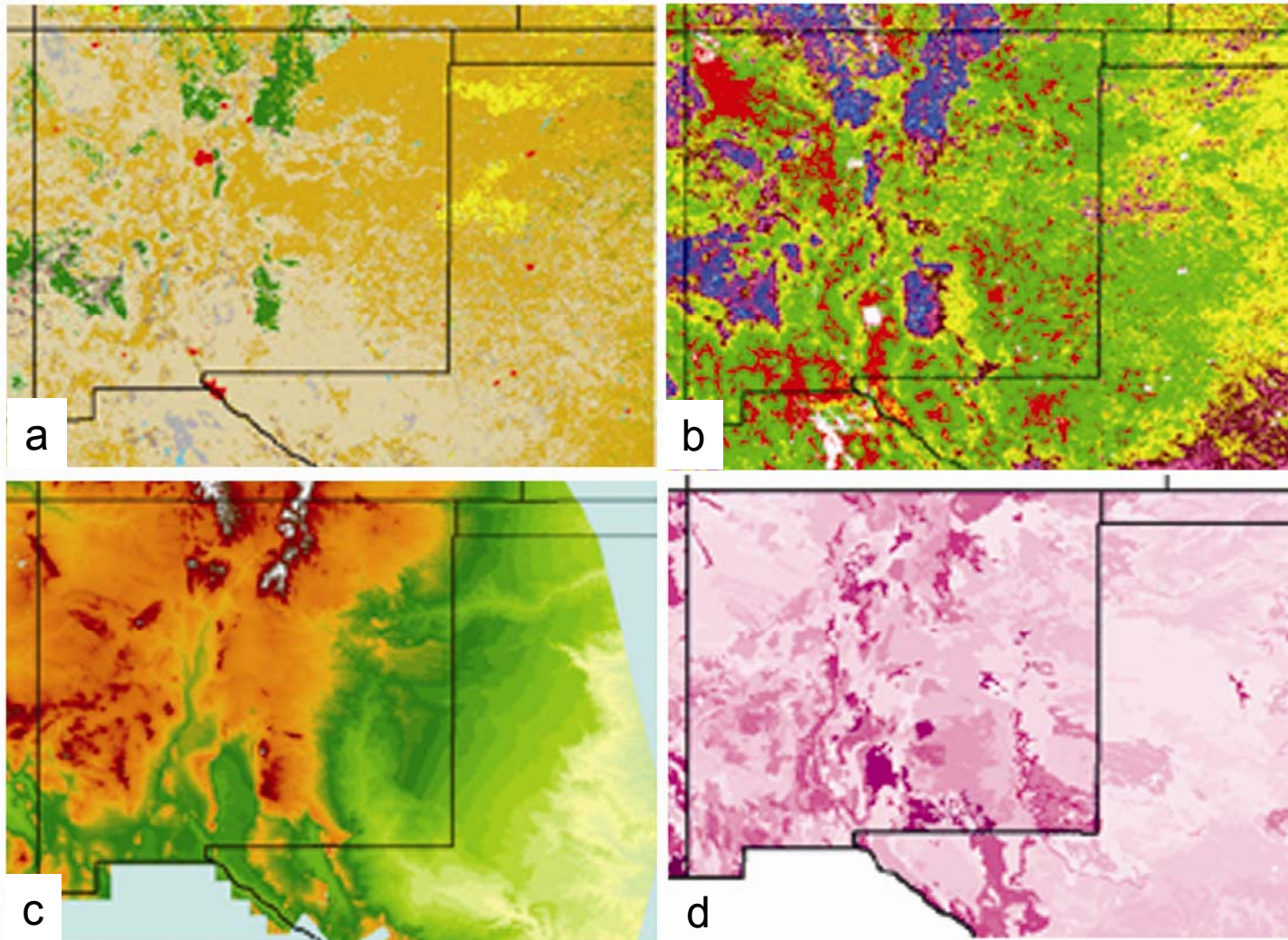
(a) MODIS Land Cover; (b) MODIS Leaf-area Index; (c) SRTM Elevation; (d) Soil Texture Classes

Surface Roughness

For DREAM we need *surface roughness length*, z_0

Shuttle Radar Terrain Mission Data

National Elevation Data
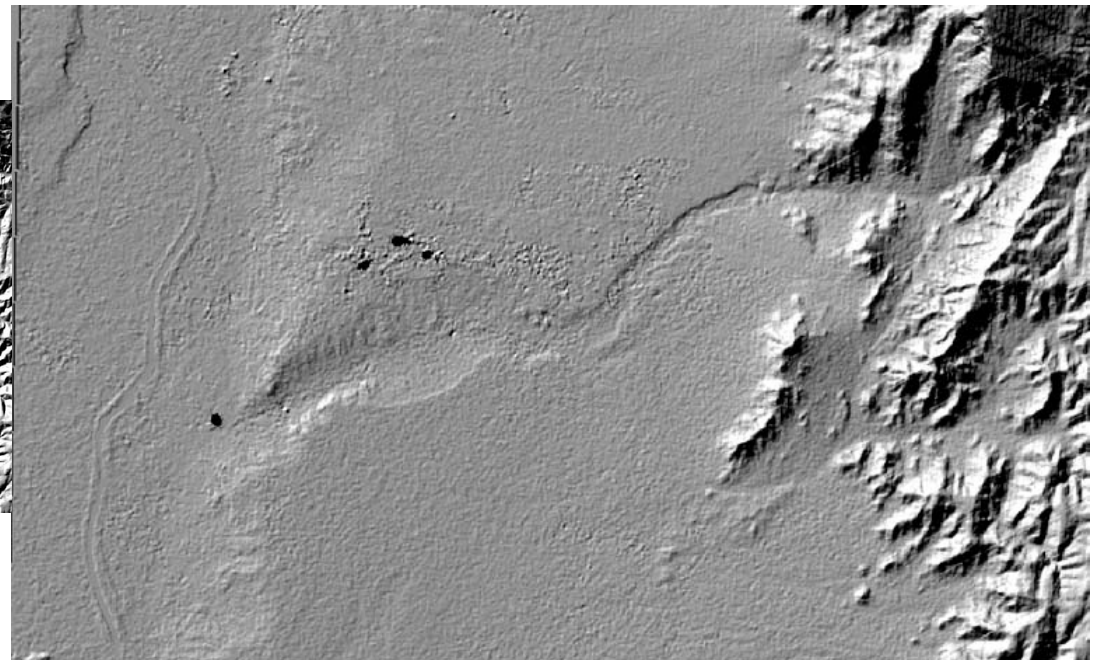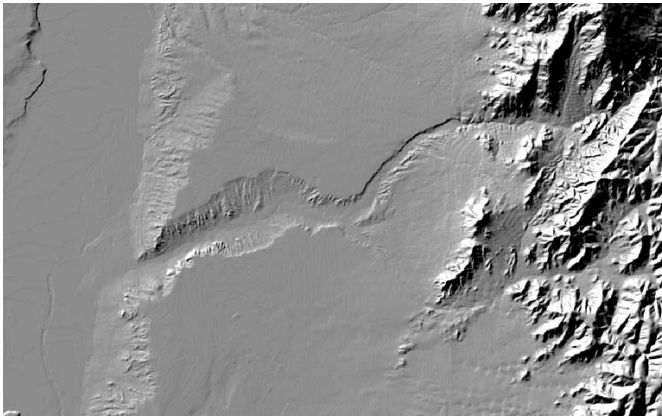
(Experimental)

MOD12Q1—(Version 004) Land Cover Type for 2001
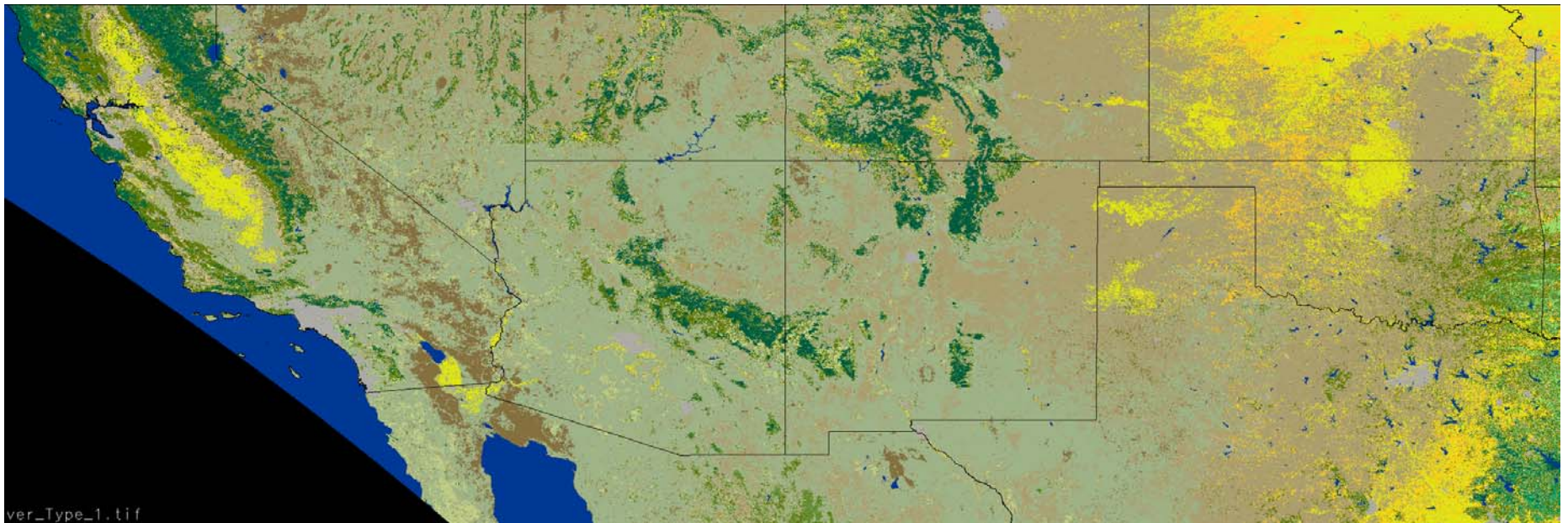
Migrating Ozone Concentrations
Impact Incidence of Asthma
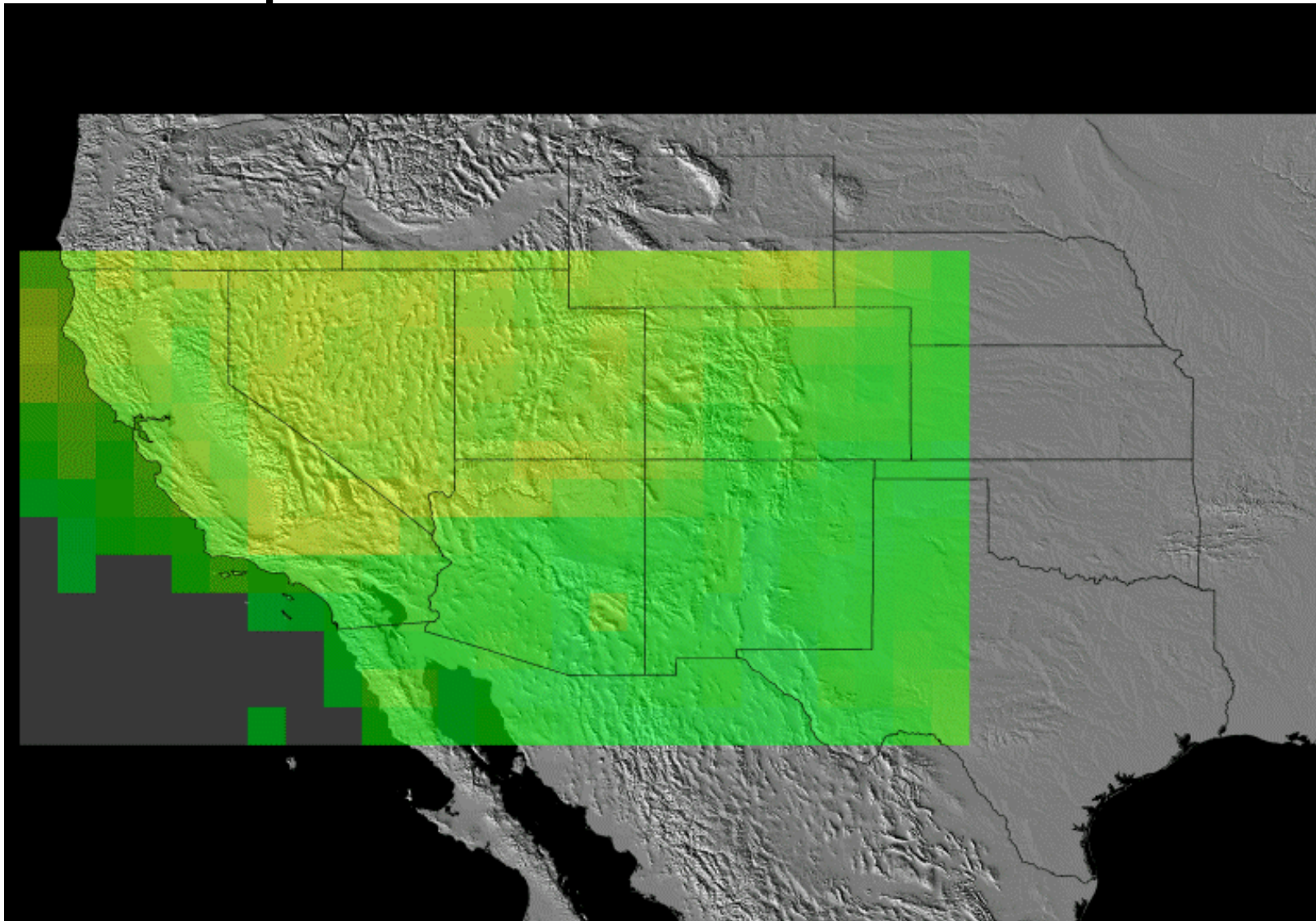
Data Assimilation Concept
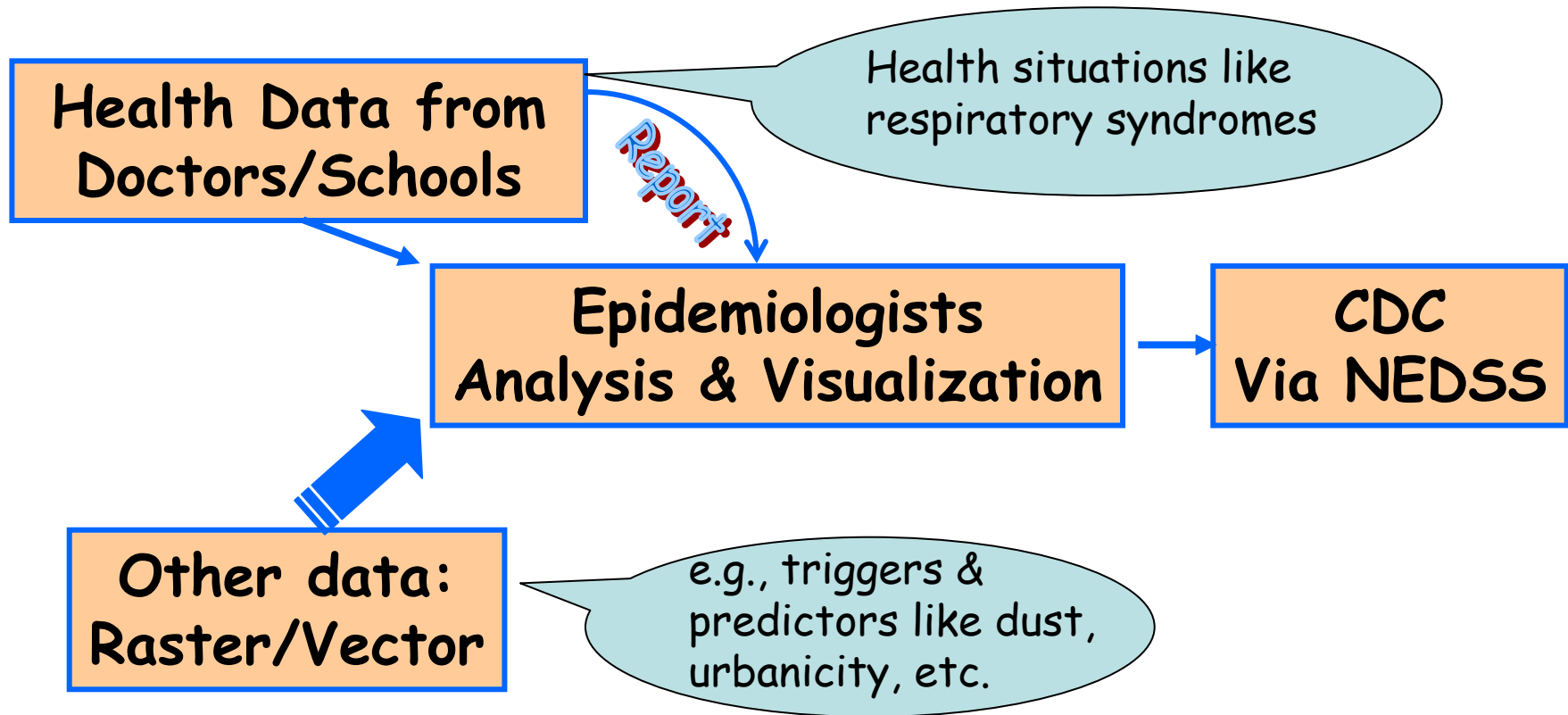
MOD08_473 – Maximum Daily Ozone and New Mexico Ground Station Locations
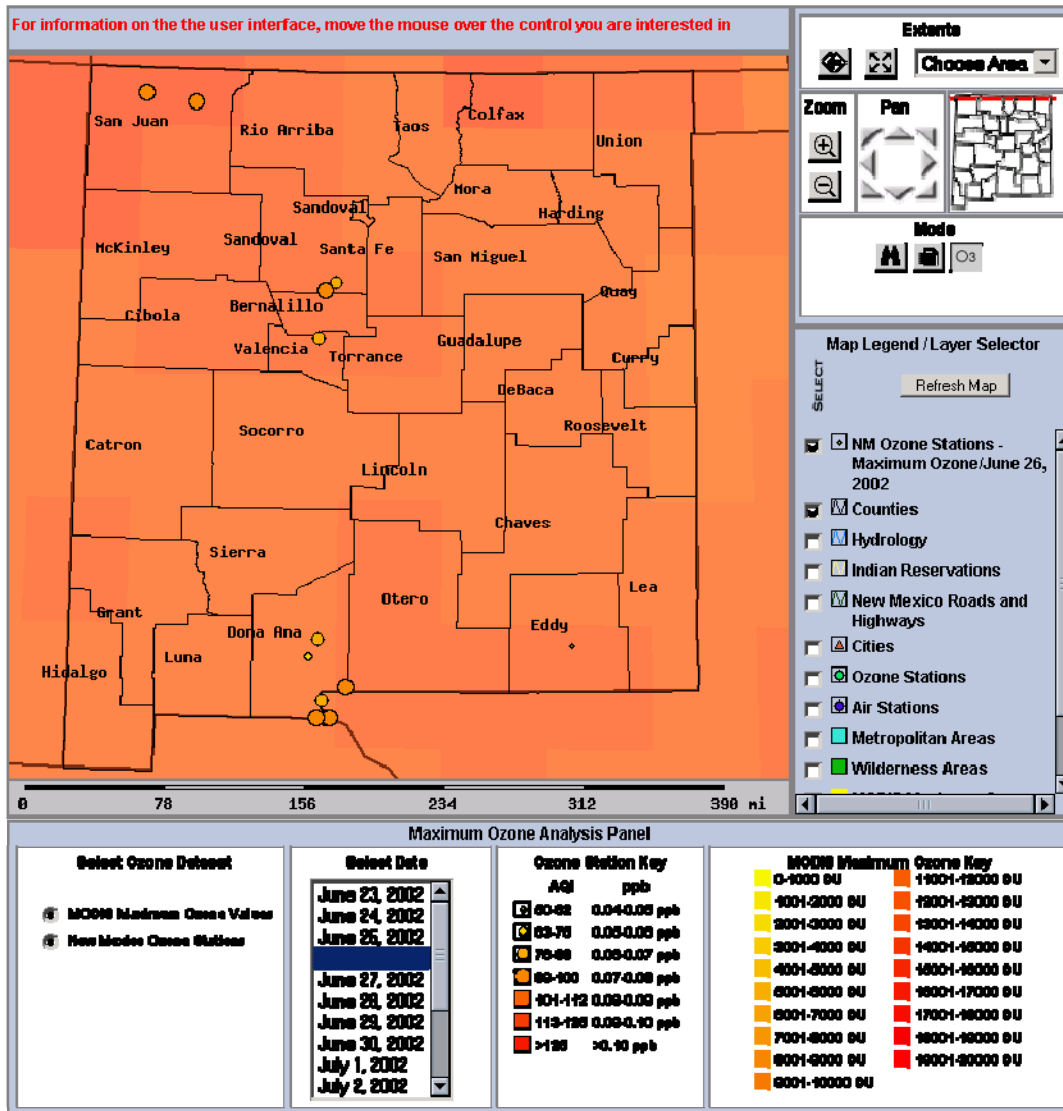
MODIS MOD08 Atmospheric Product

-sub data set 473, Maximum Daily Ozone

-derived from EOS-HDF4 formatted file

-1 by 1 degree resolution
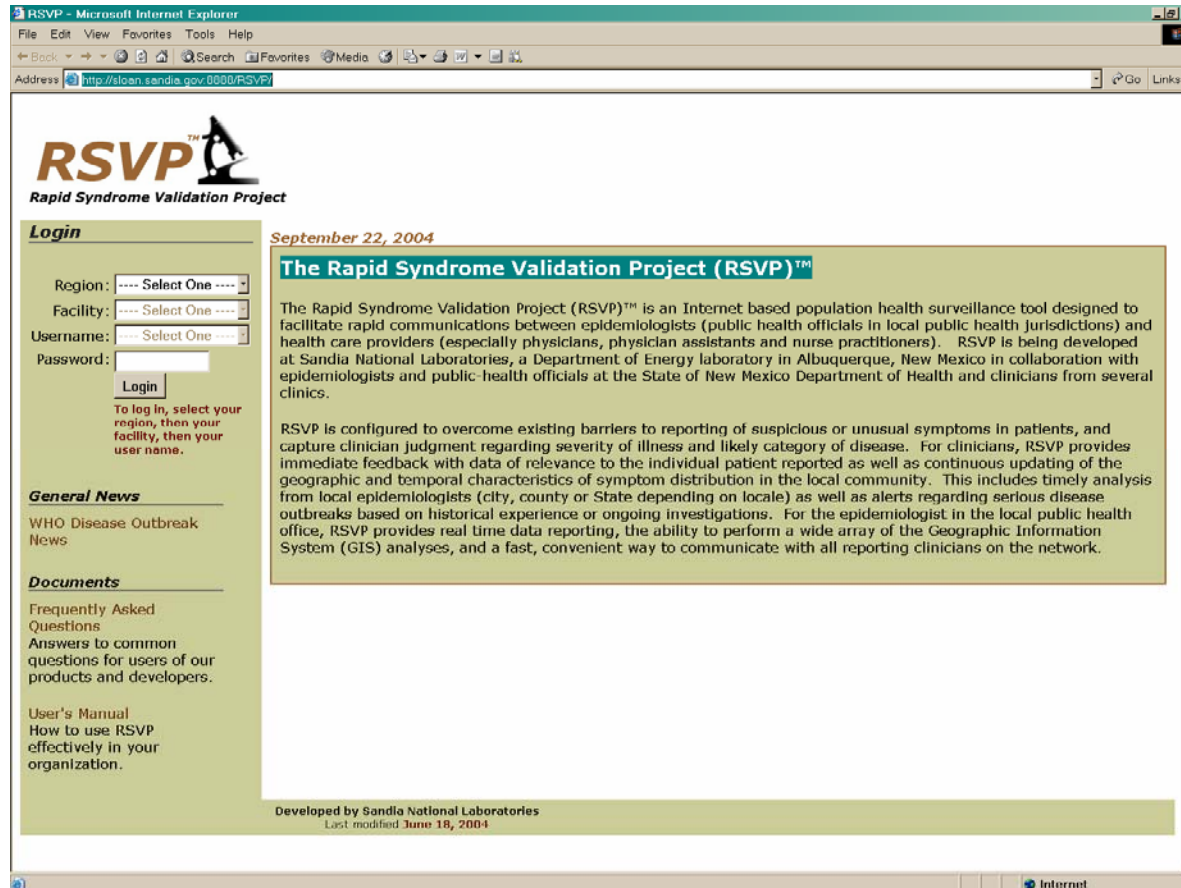
-classified in Dobson units that measure total atmospheric profile

New Mexico ground station network

-primarily in urban contexts

-classified in ppb ozone

The Rapid Syndrome Validation Project (RSVP)™

http://sloan.sandia.gov:8888/RSVP/

Rapid Syndrome Validation Project™

(Red indicates number of reported syndromes.)

RSVP Objectives

1. Illustrate how Earth observing satellite data can assist RSVP design goals
2. Identify and validate scientifically sound relationships between environmental stimuli and resulting human health responses
3. Integrate scientific relationships into spatially explicit products for use in RSVP delivery systems for public health officials