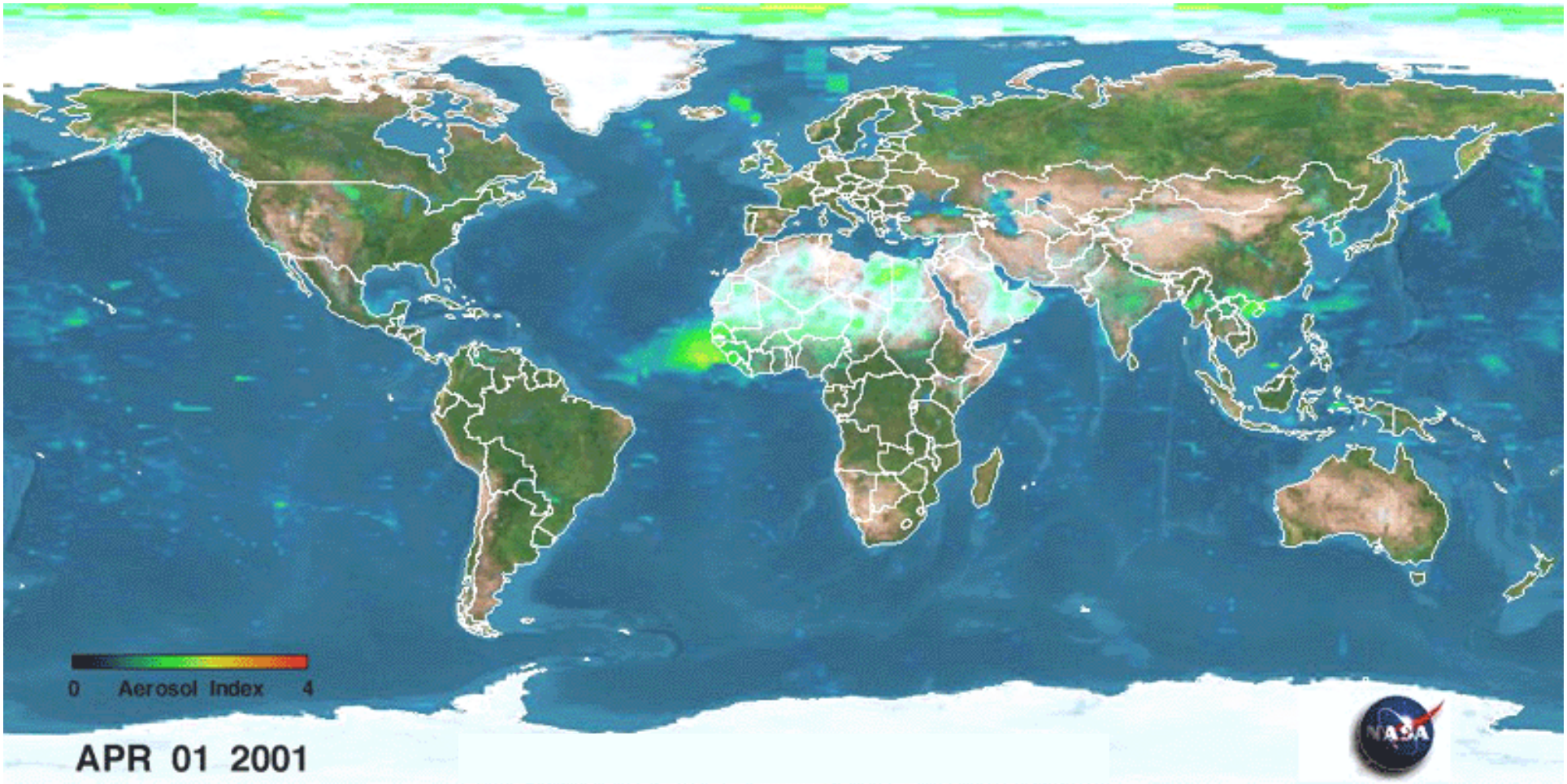
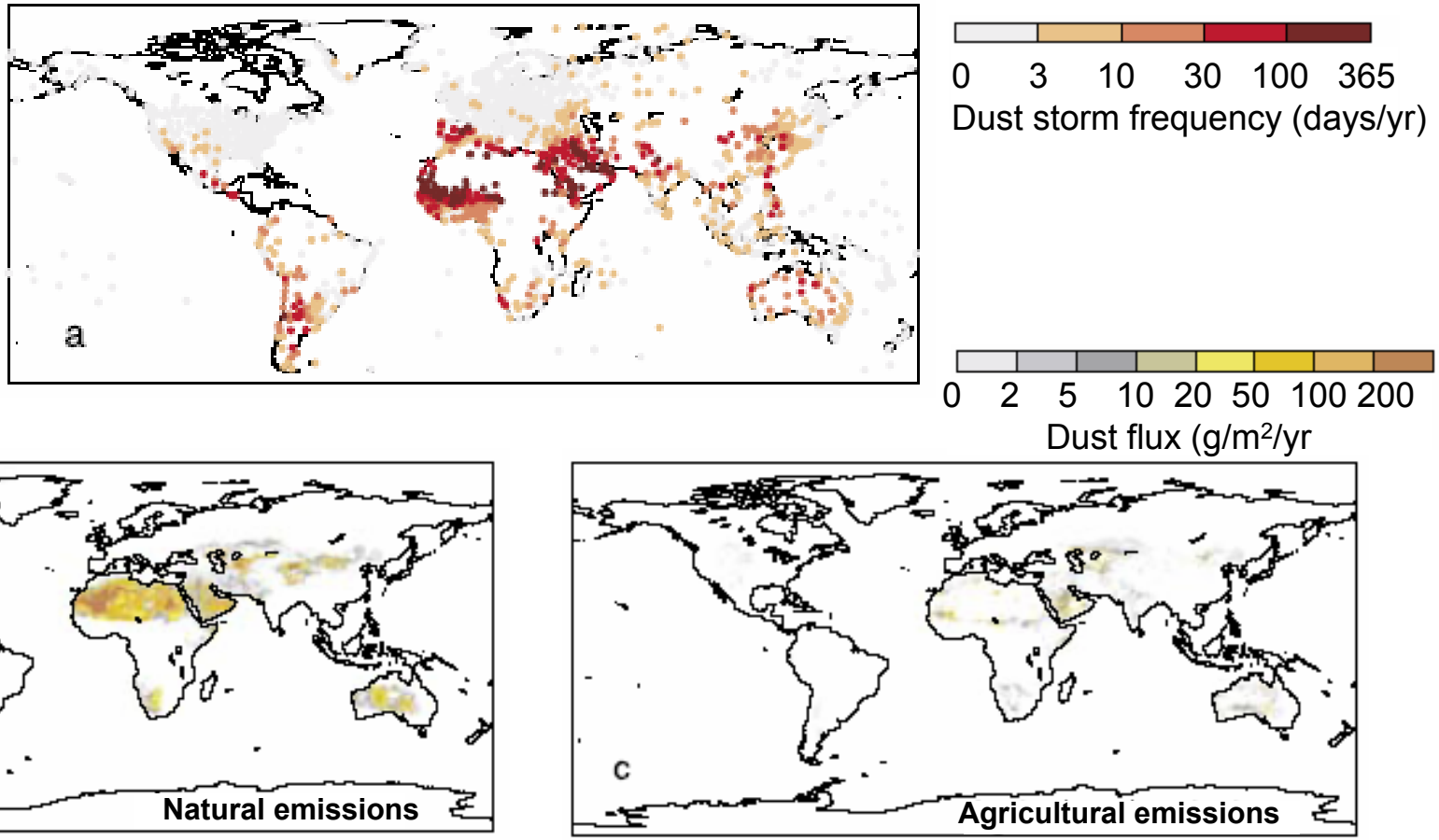
Engineering Satellite Data for Environmental Health Issues

Stan Morain & Amelia Budge
Remote Sensing Arabia
Riyadh
May 8-11, 2005

Temporal Visualization of Aerosols

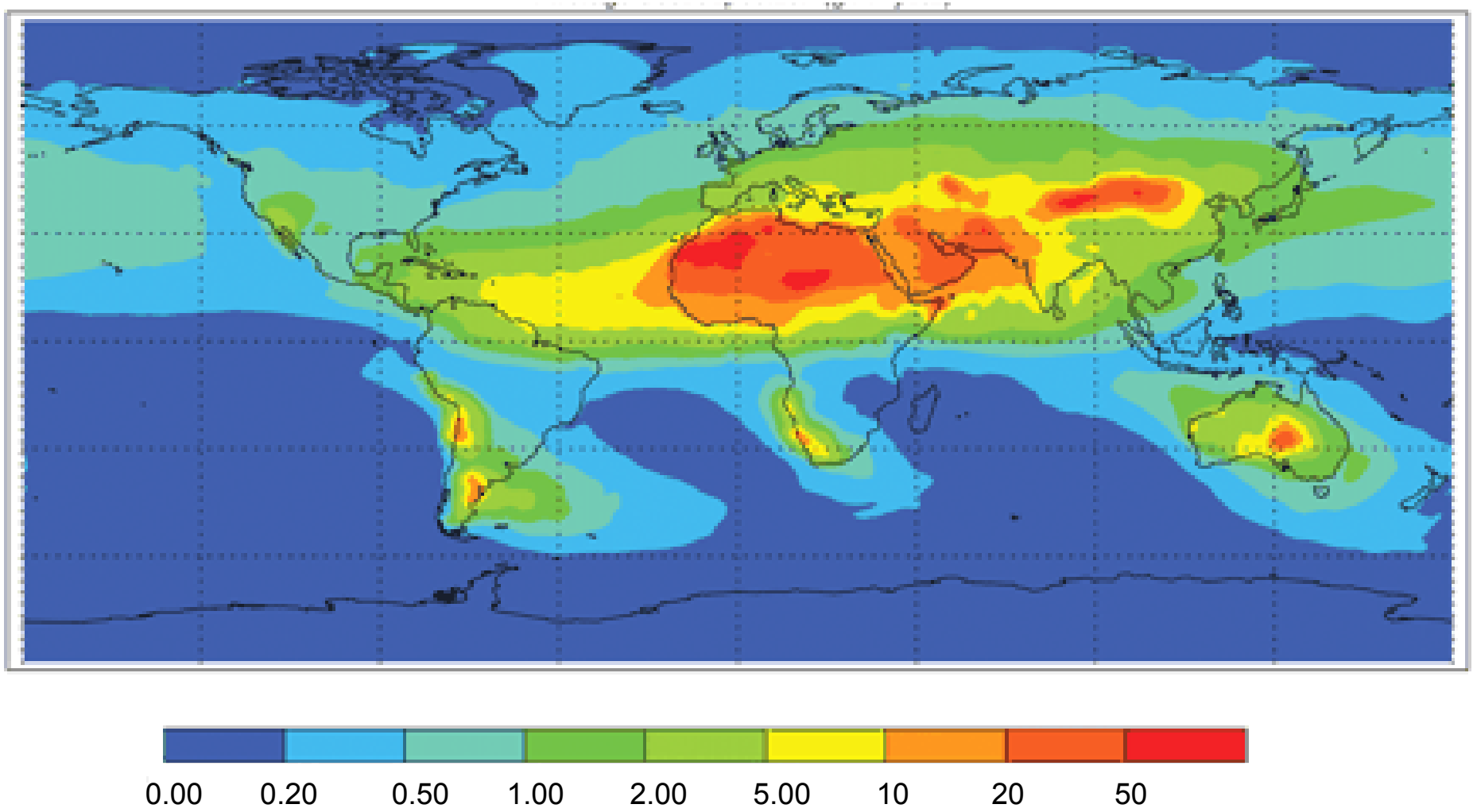


Dust Storm Frequency And Estimated Emissions 1963-1992 (averaged)



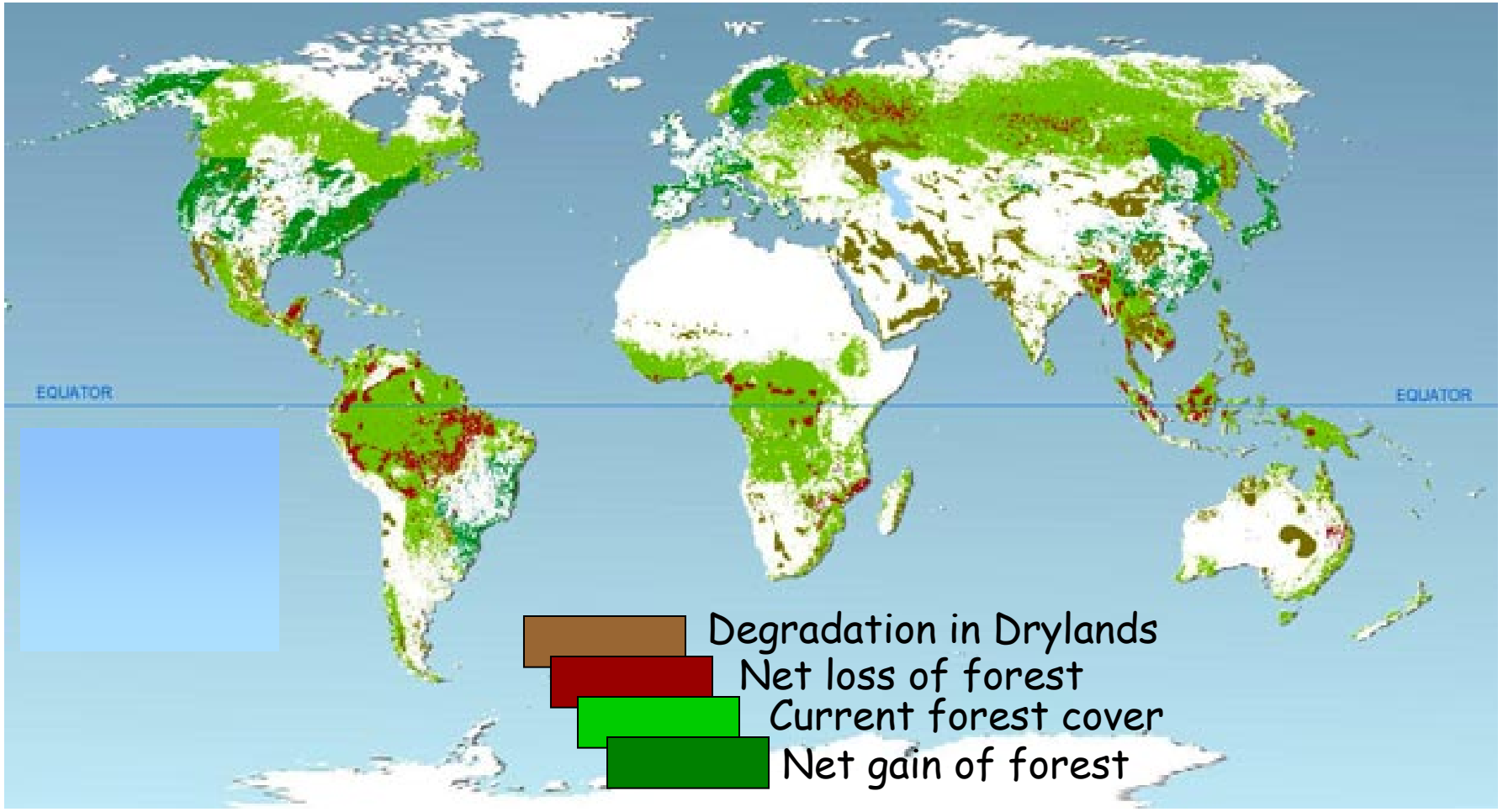
Courtesy, Global Change Newsletter # 58, June 2004

Average Dust Deposition ($g/m^2/year$)



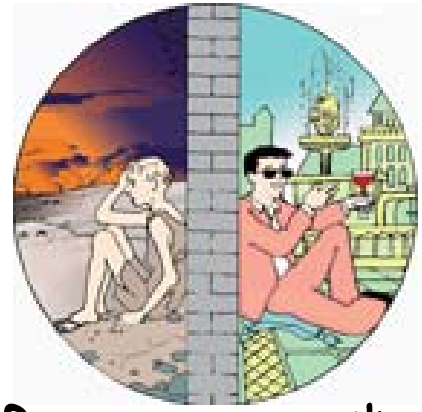
Source: *Science* 308 (1 April, 2005) p.70

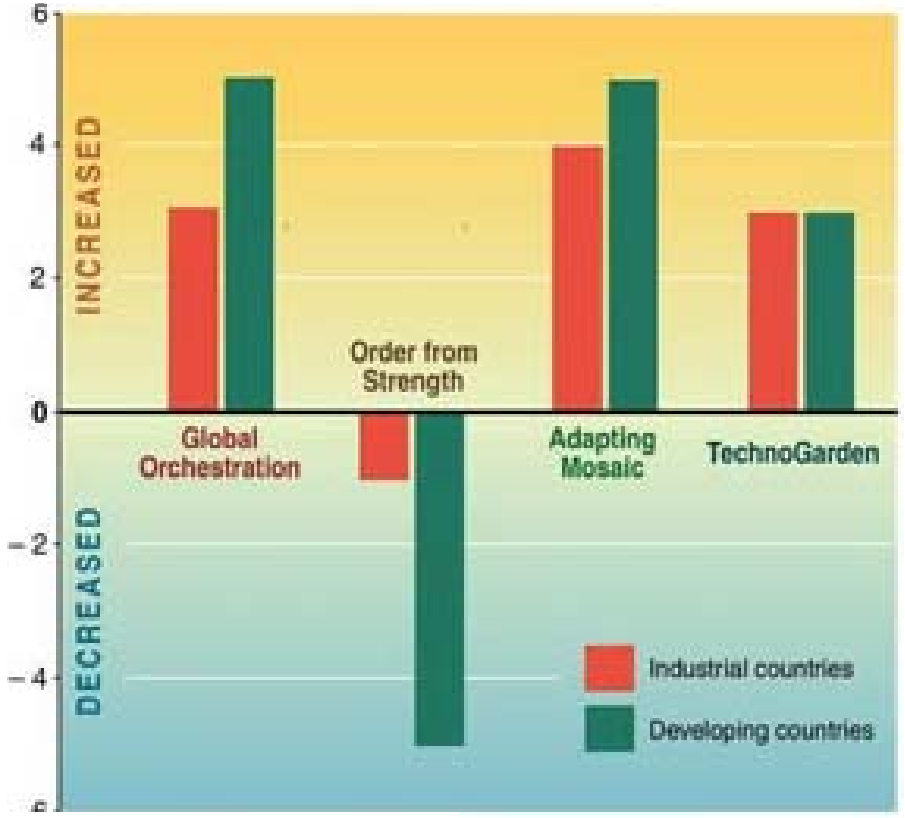
Areas Reportedly Undergoing High Rates of Land Cover Change---last few decades



Source: Millennium Ecosystem Assessment

Net Change in Components of Human Well-being

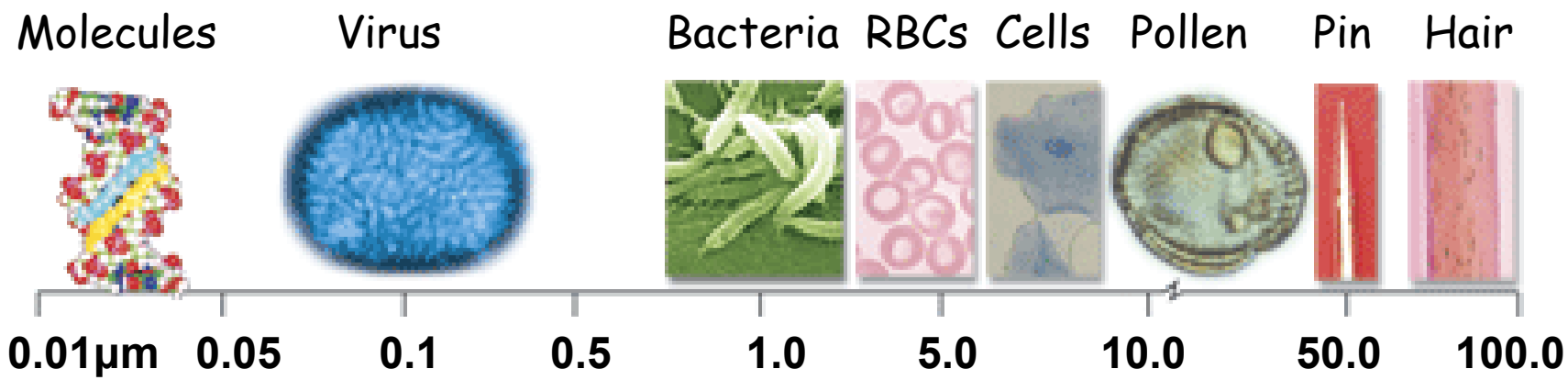




Scenarios:
Reactive on left; Proactive on right

Source: Millennium Ecosystem Assessment

Particulate Matter Size Distribution & Their Related Biophysical Impacts



limit of vision

PM_{10} Thoracic particles

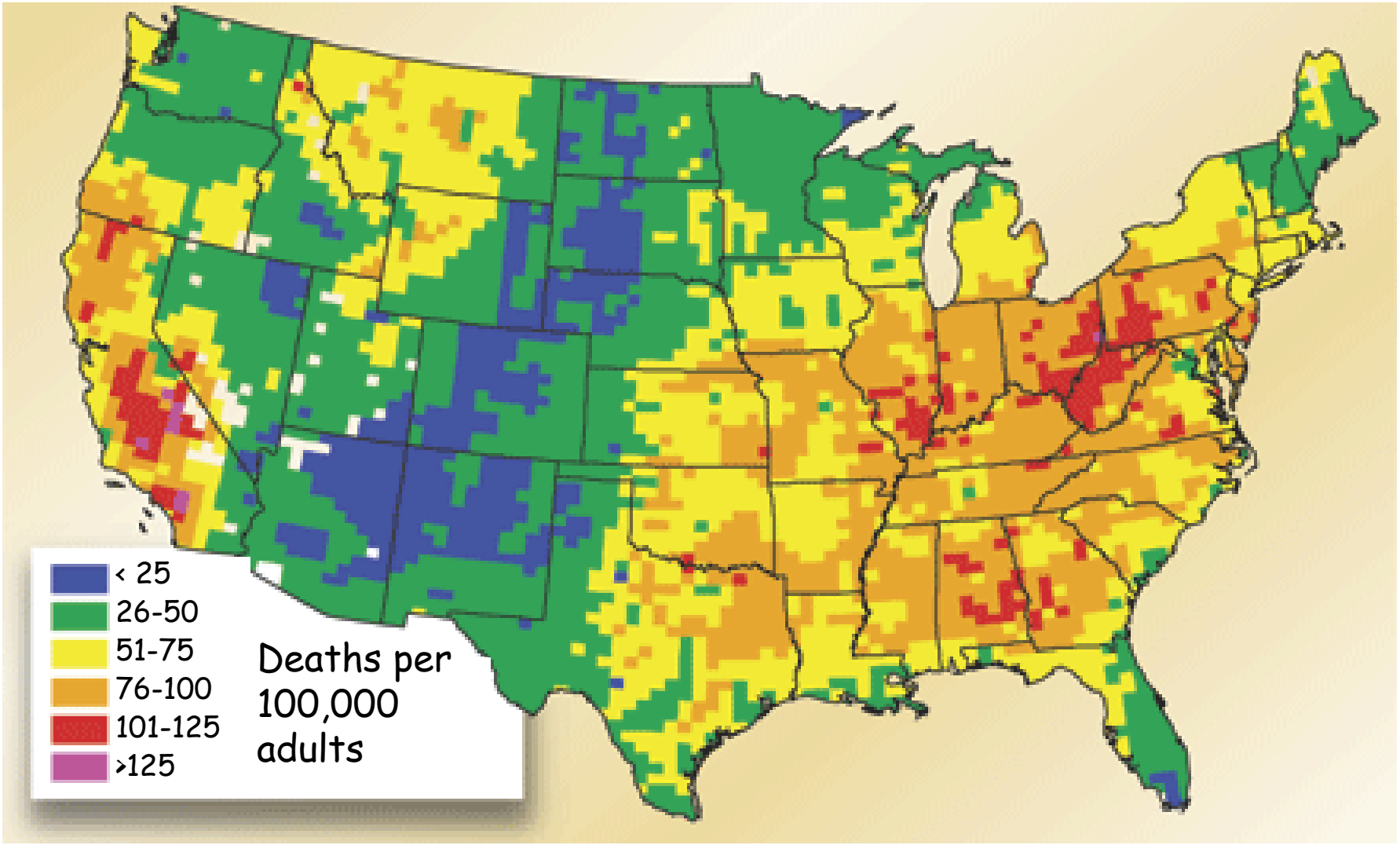
$PM_{10-2.5}$ Coarse fraction

$PM_{2.5}$ Fine particles

$PM_{0.1}$ Ultra-fine particles

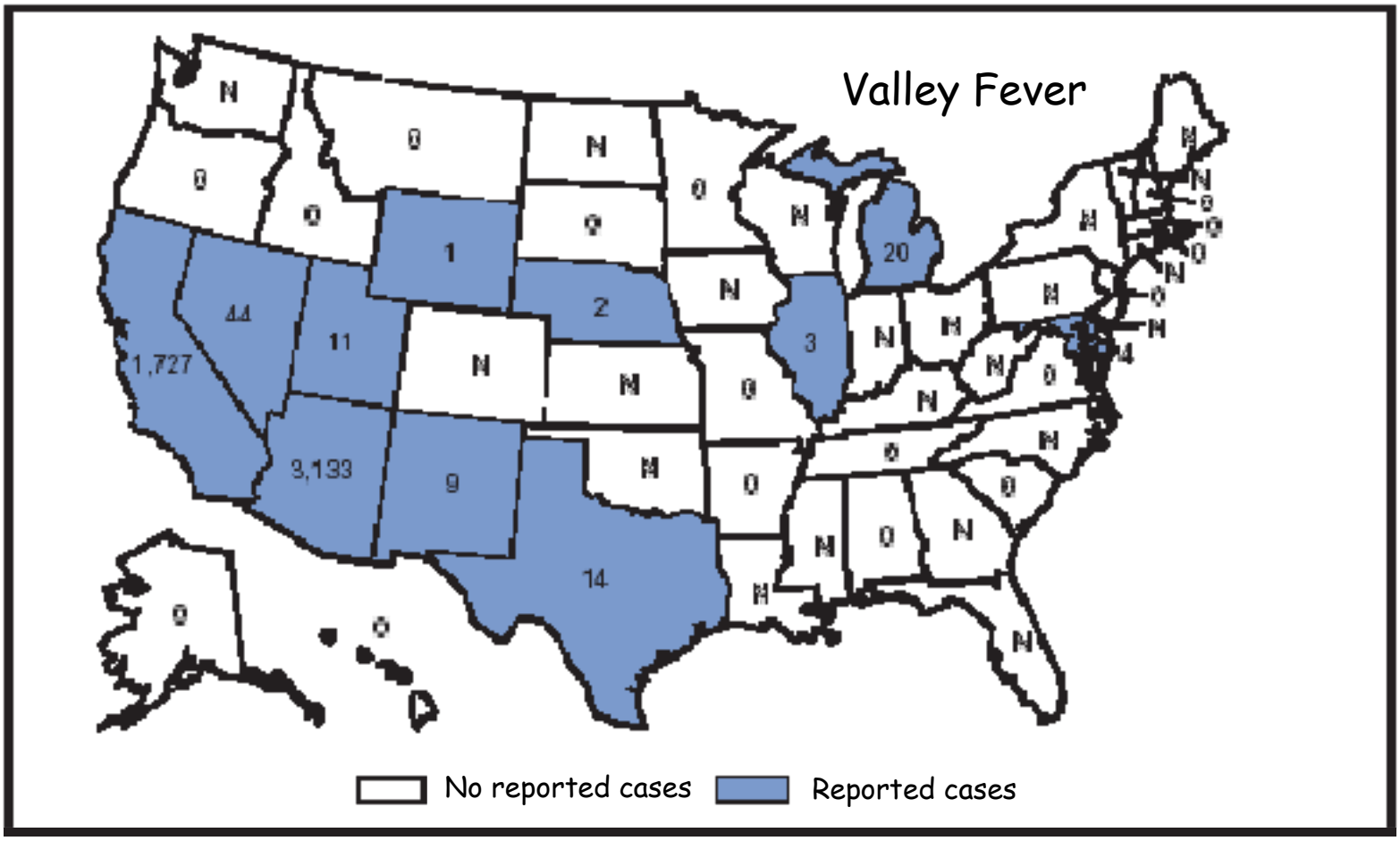
Source: *Science* 307 (25 March, 2005), p.1859

Premature Mortality Risk Attributable to $PM_{2.5}$

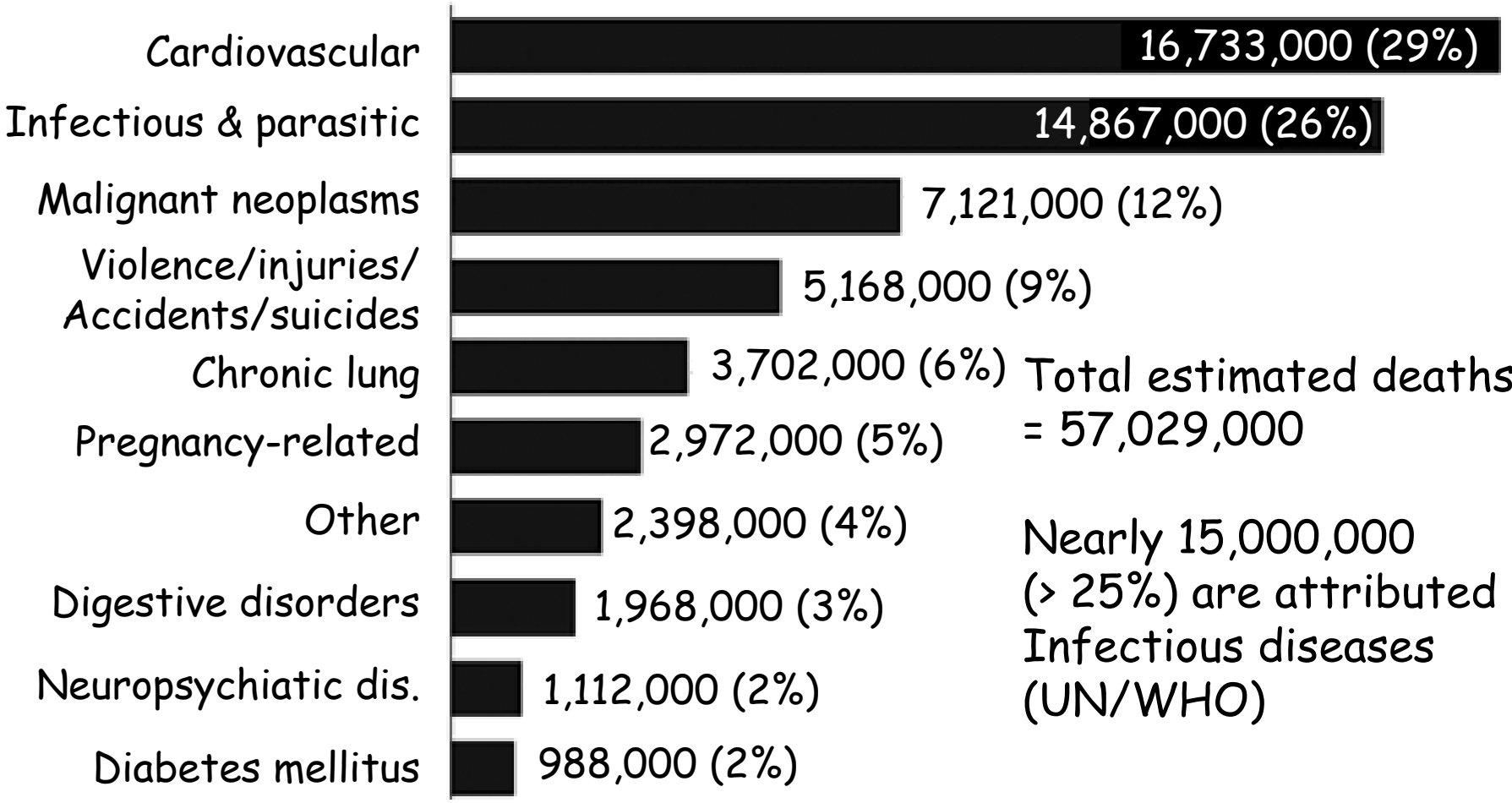


Source: *Science* 307 (25 March, 2005), p.1860

Reported Coccidioidomycosis Cases U.S. & Territories 2002



Leading Causes of Death, Worldwide: Est. for 2002

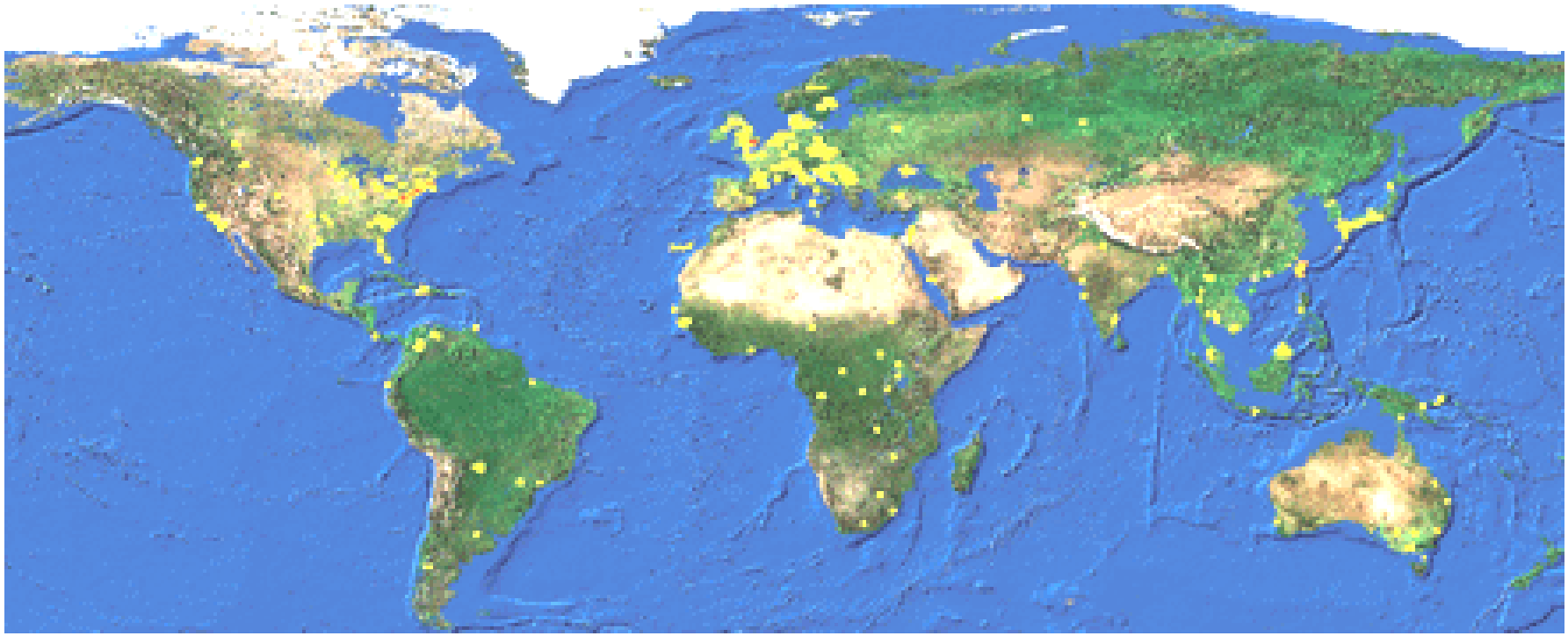


Total estimated deaths = 57,029,000

Nearly 15,000,000 (> 25%) are attributed to Infectious diseases (UN/WHO)

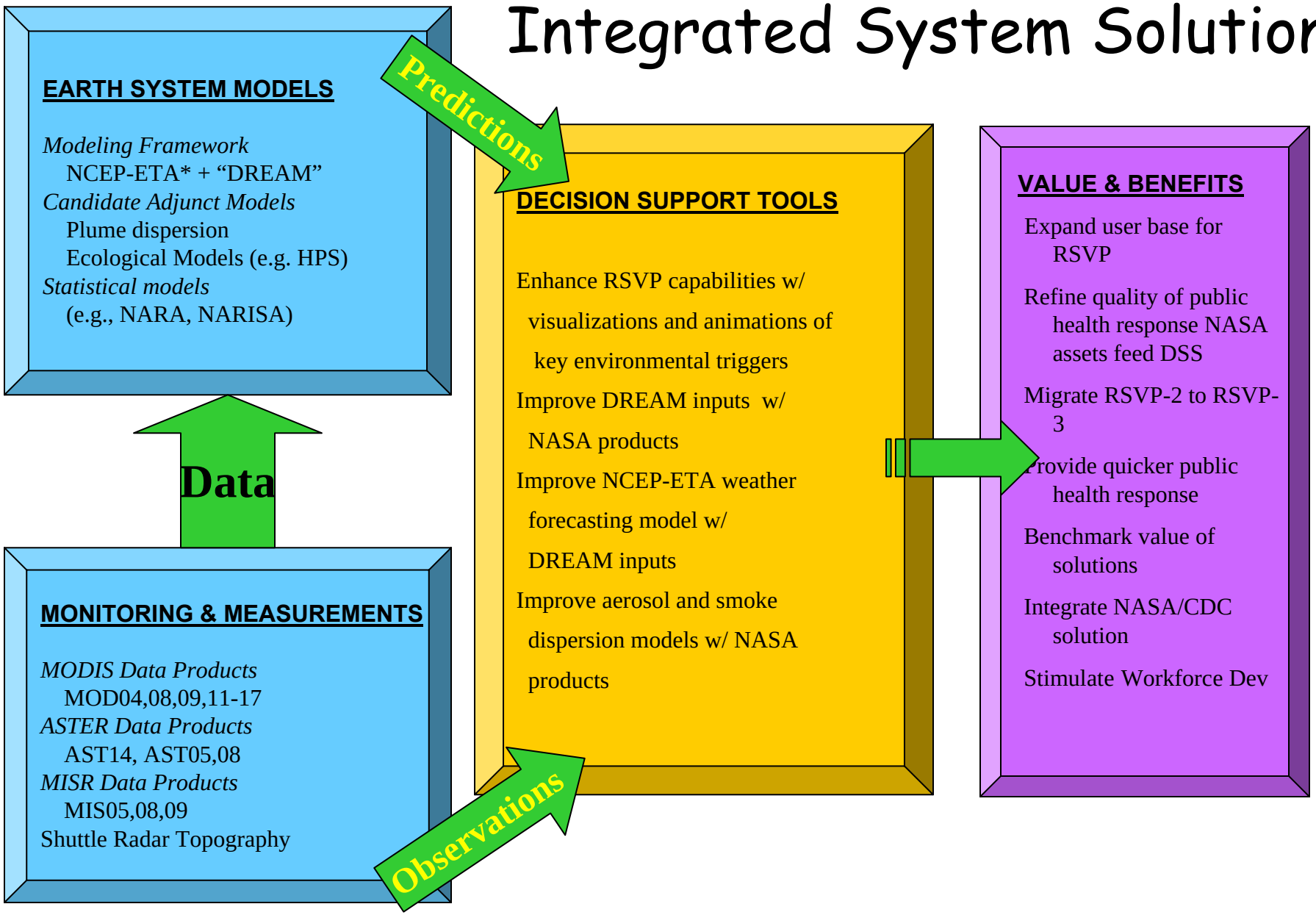
Source: Emerging Infectious Diseases, 2005
Centers for Disease Control and Prevention

Locations of Emerging Infectious Diseases



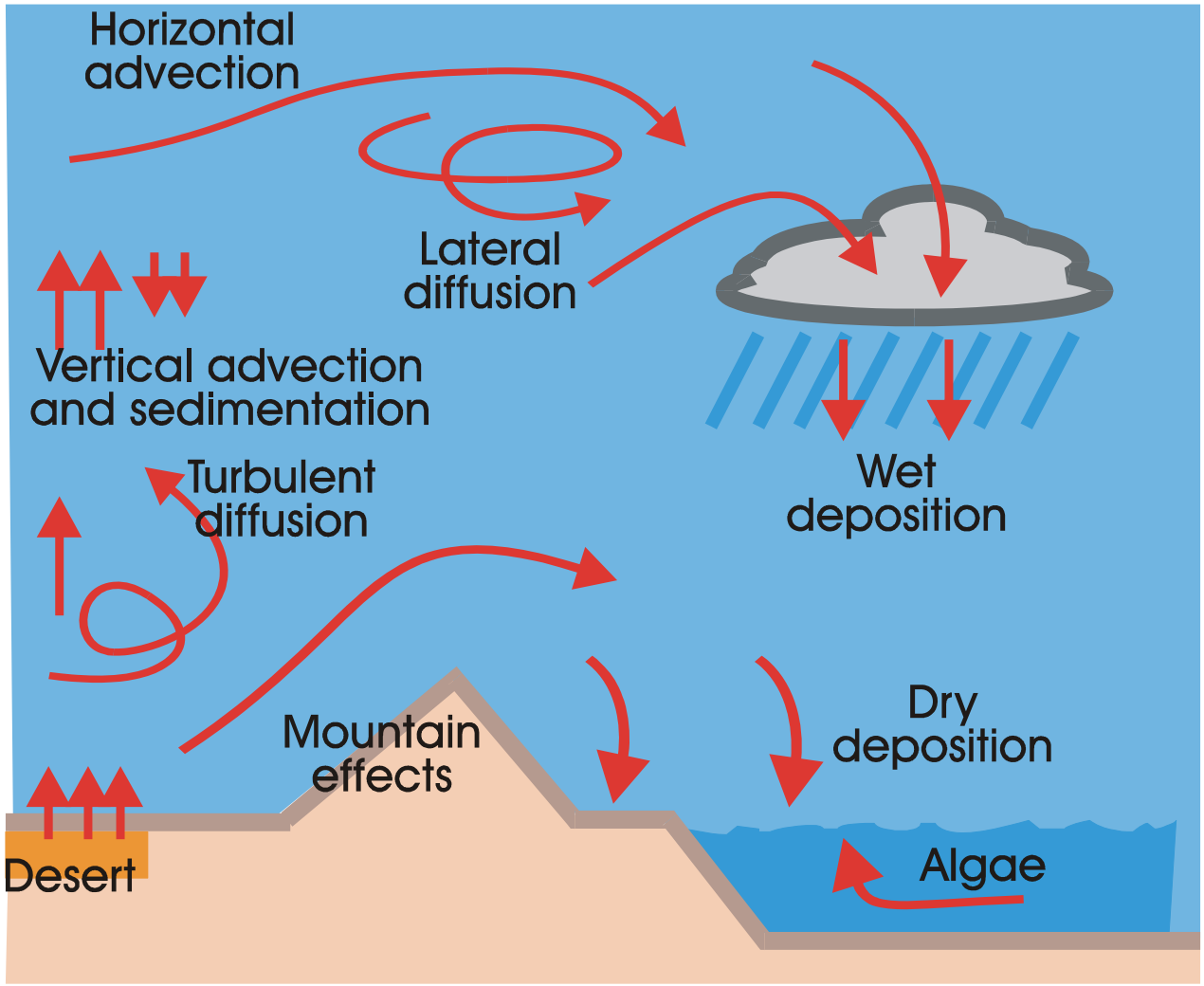
Source: U.S. Centers for Disease Control, 2005

Integrated System Solution

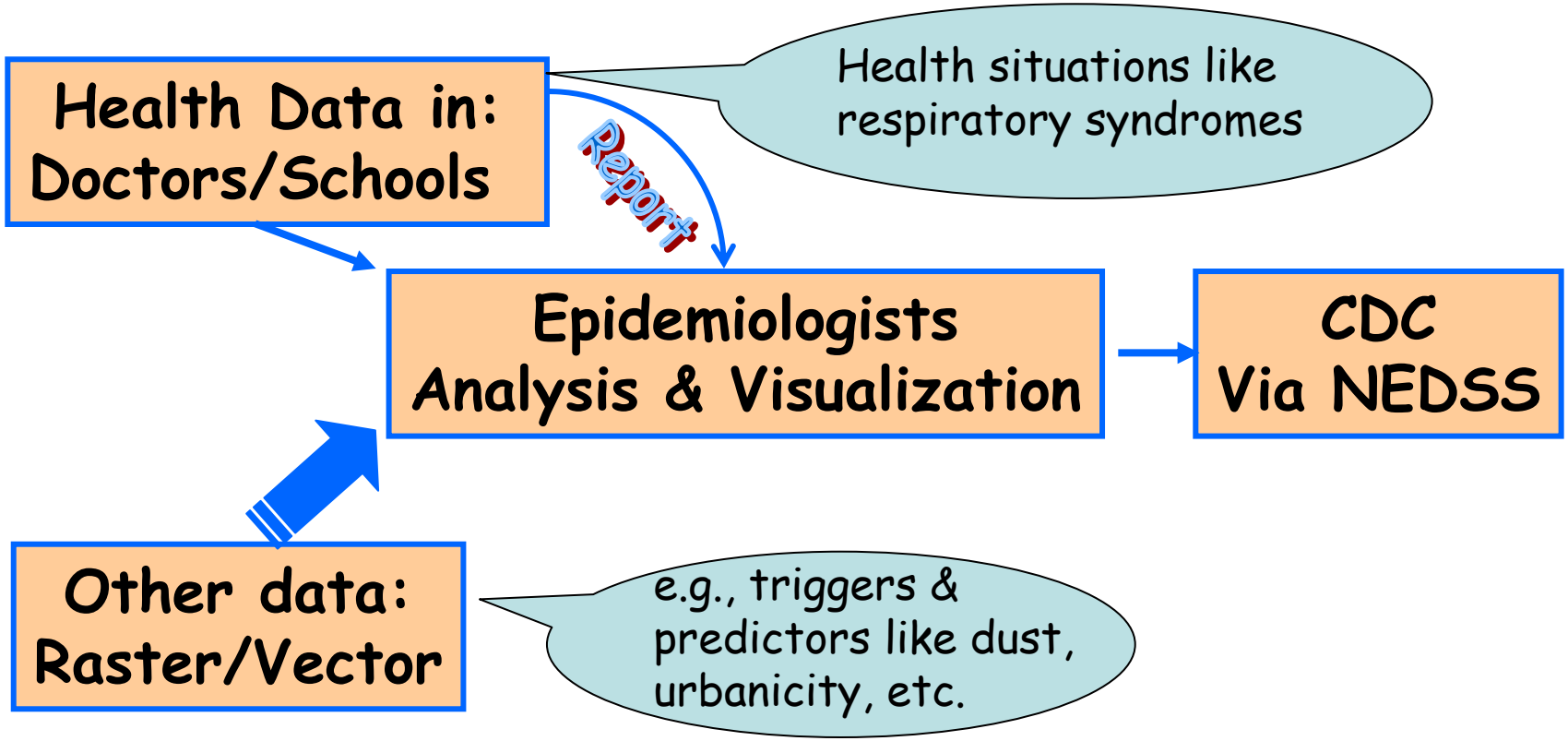


DREAM's GOVERNING EQUATION

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



Data Assimilation Concept



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

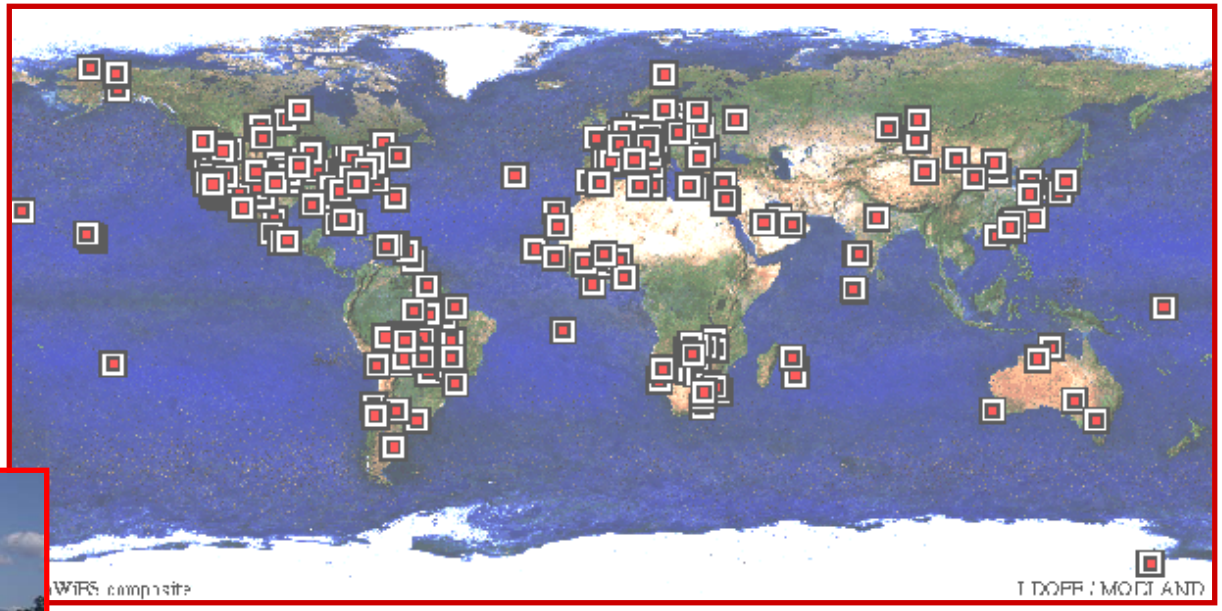
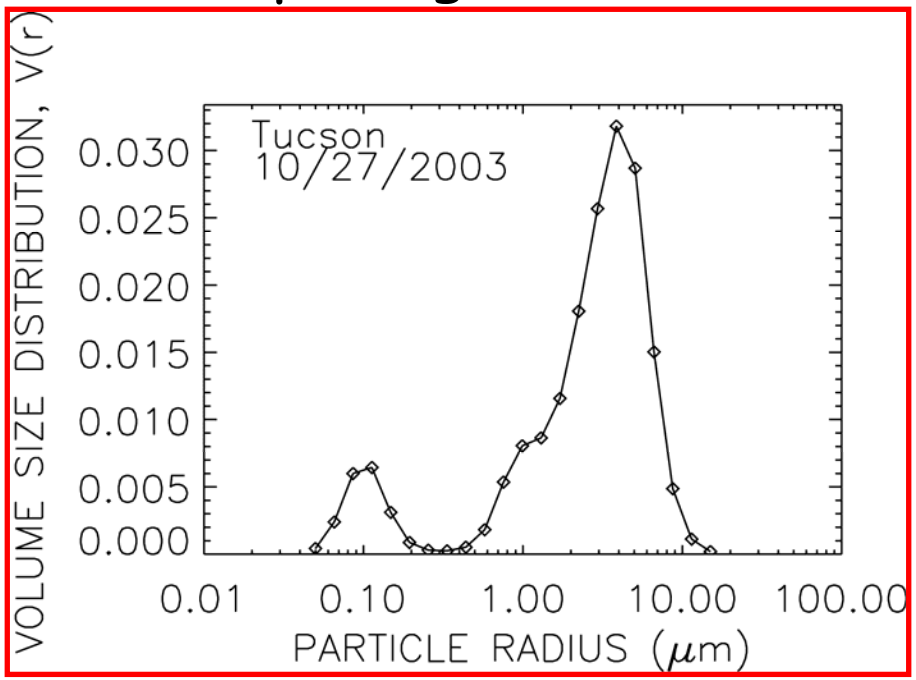


Image courtesy NASA-GSFC

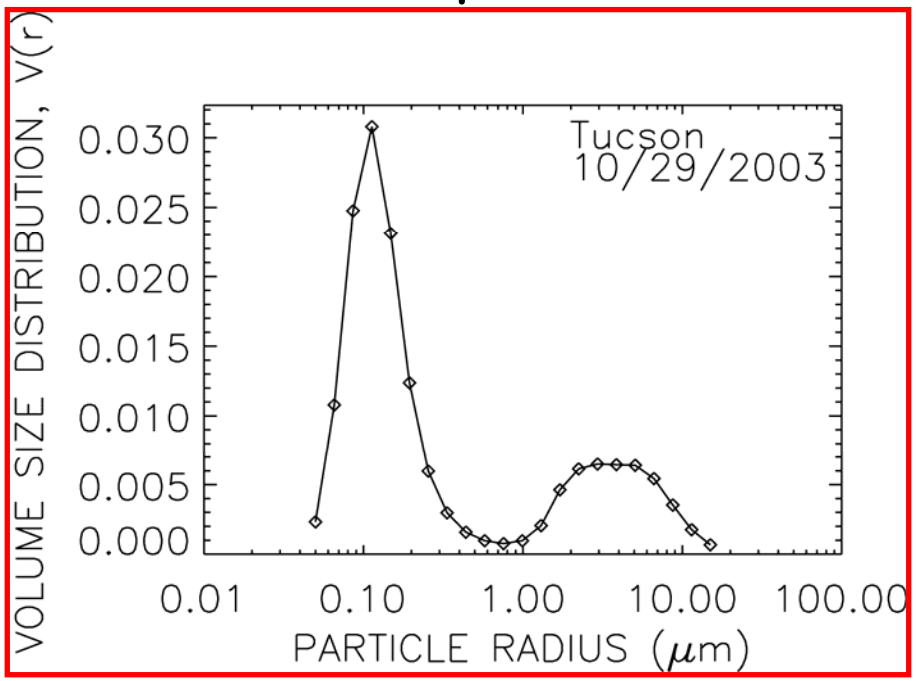
AERONET

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

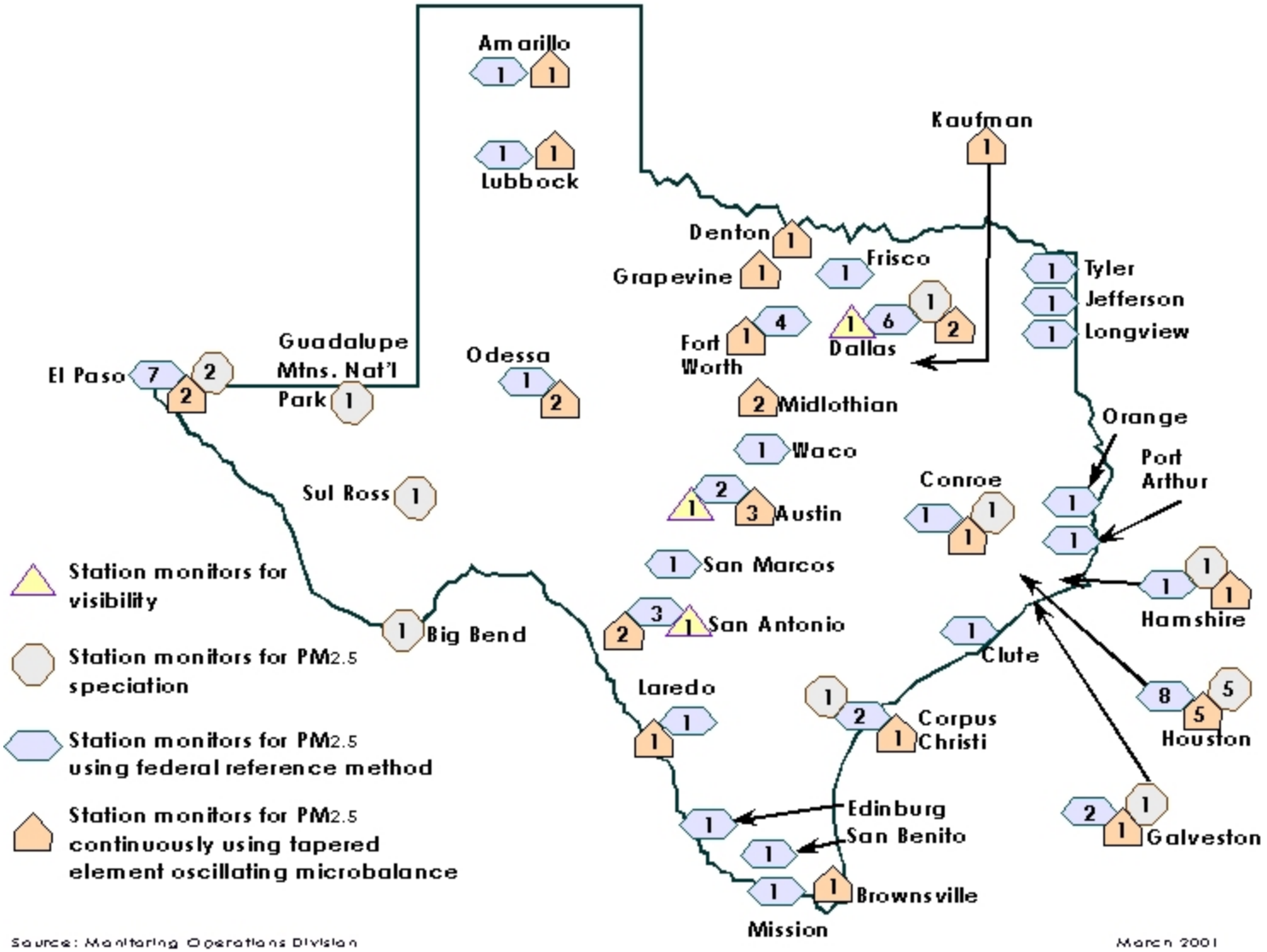


Smoke particles



Courtesy Christopher Cattrall and Kurt Thome, University of Arizona

Texas $PM_{2.5}$ Monitoring Network As of 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

Remote Sensing of Aerosols from MODIS

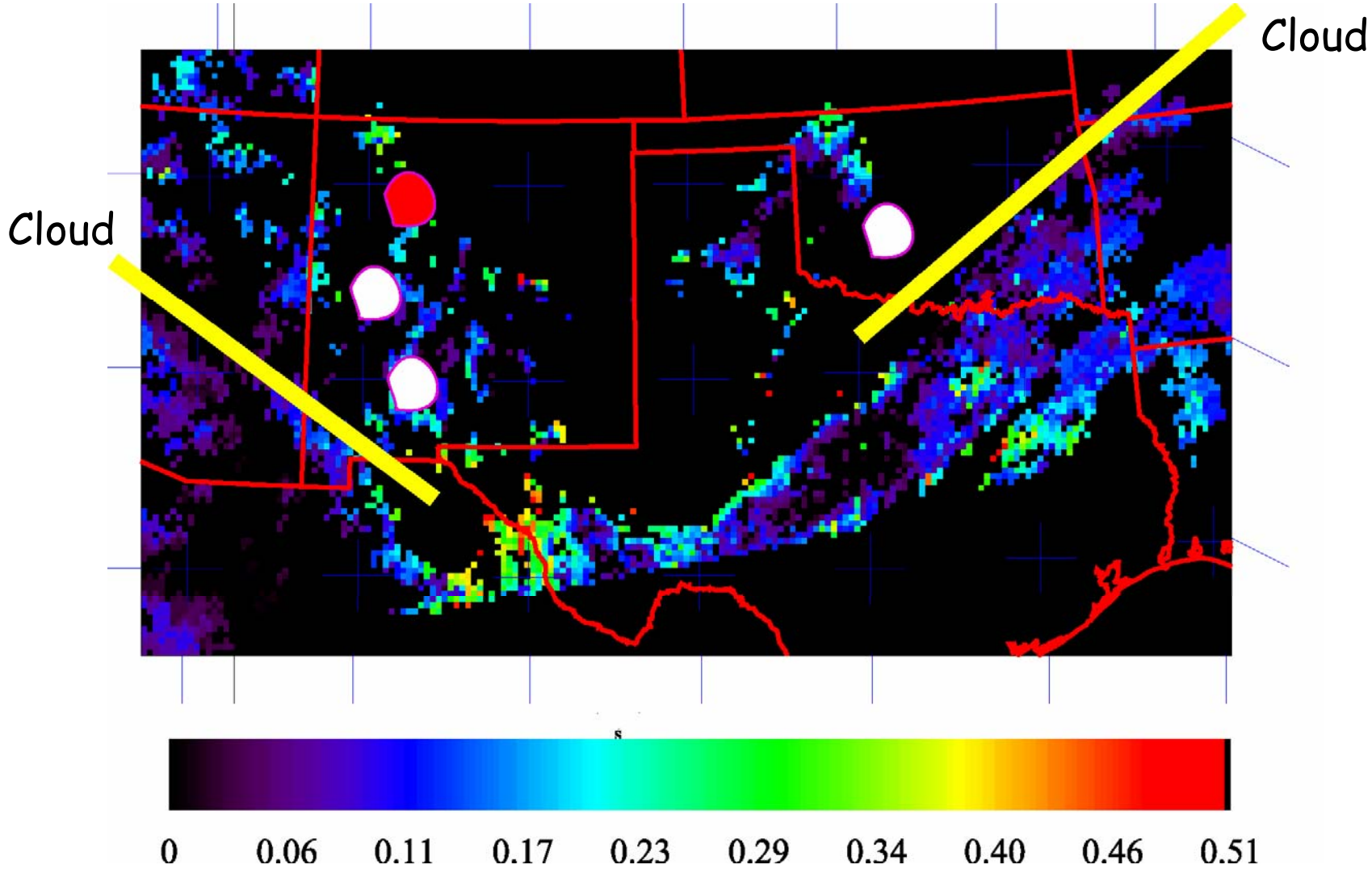
Pre-compute look-up table of radiance values (geometry, aerosol type, aerosol amount, surface type)

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.

Courtesy, Christopher Cattrall and Kurt Thome, University of Arizona

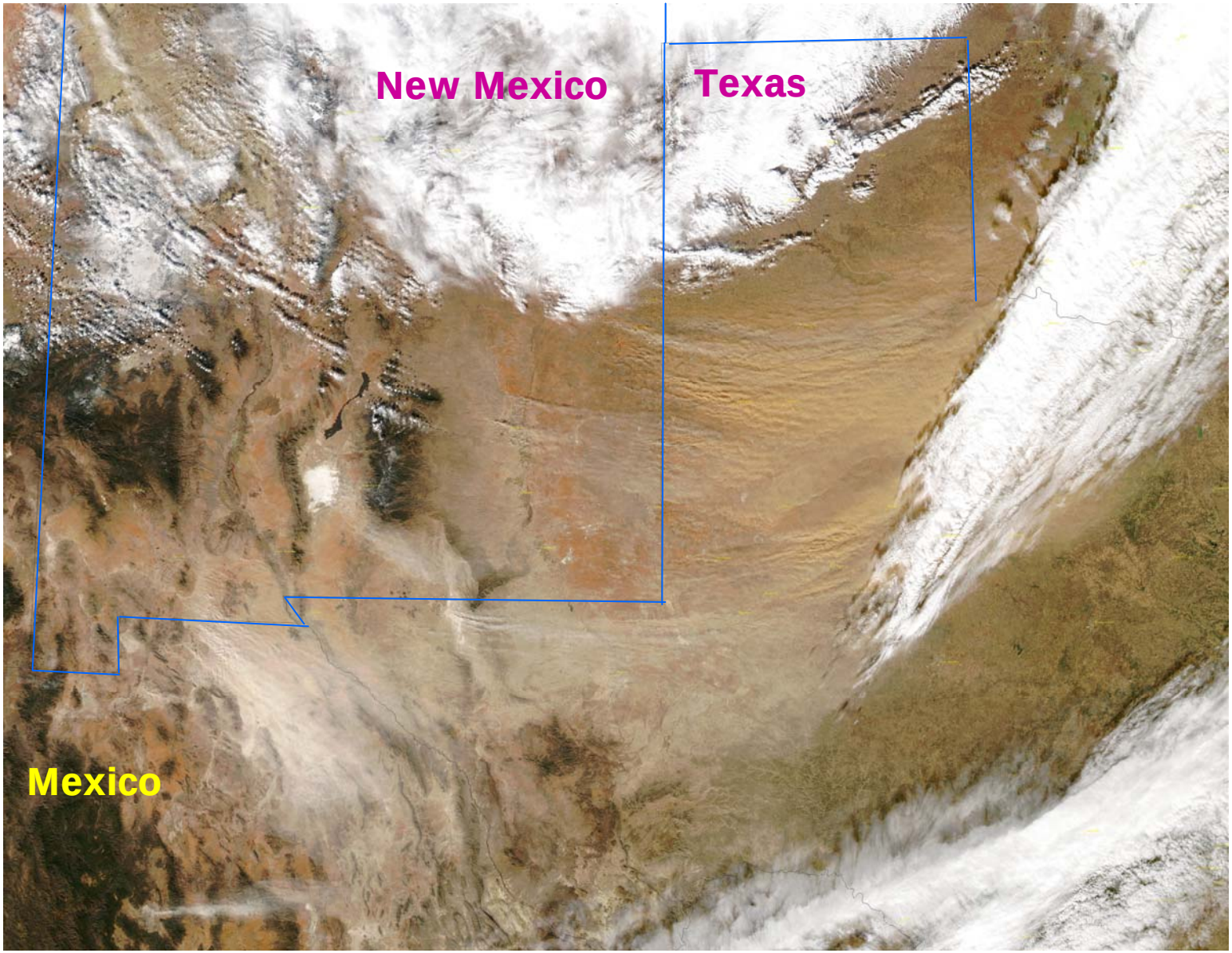
Aerosol Optical Depth @ 550 nm Observed by MODIS Aqua at Lubbock, TX December 15, 2003 (2055 UTC)



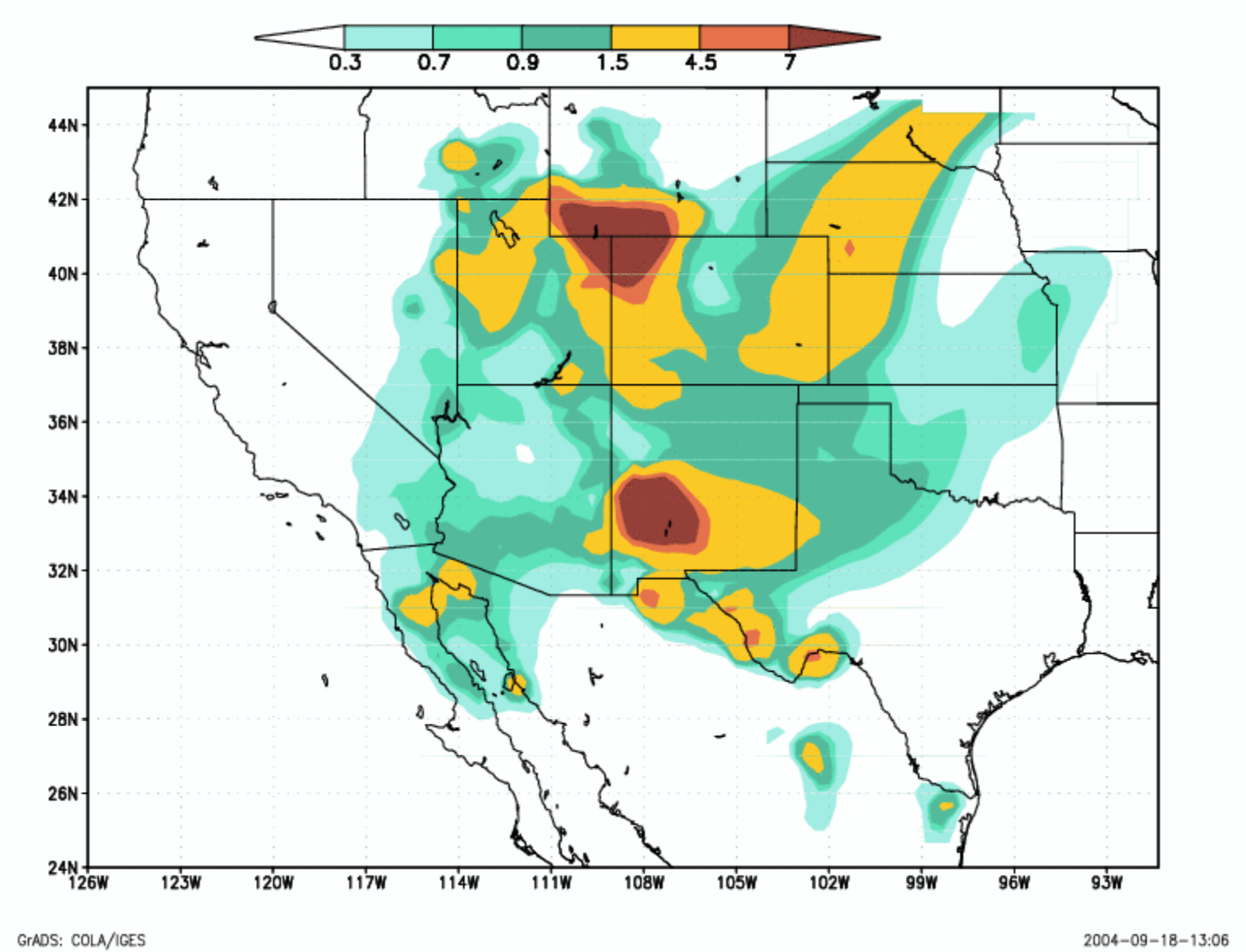
DREAM Inputs & Upgrade Potential

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

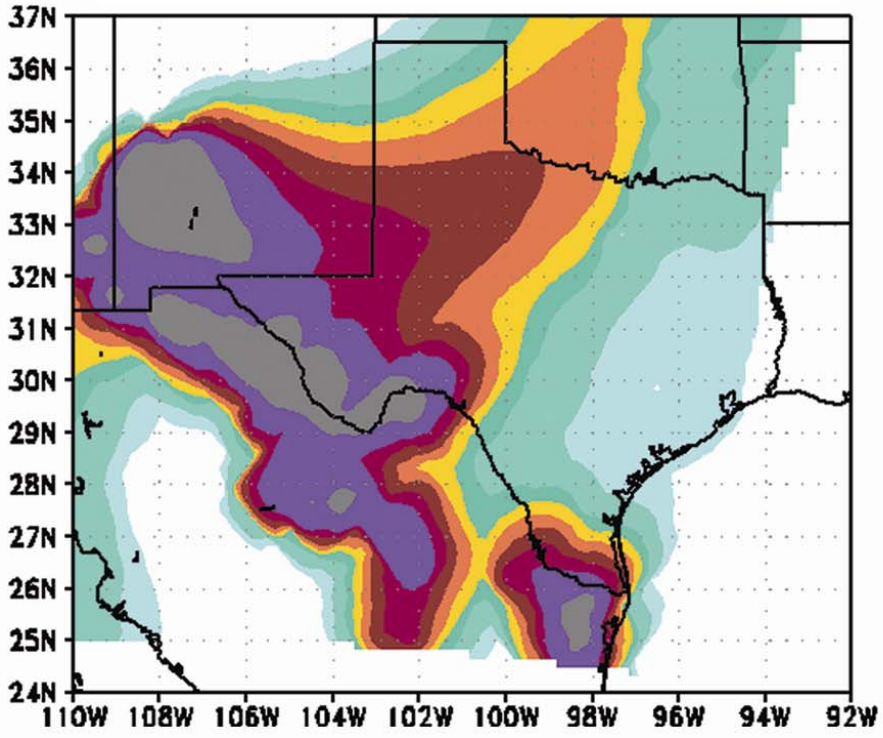



Visibility Analysis
12/15/03 9 a.m. CST
Yellow < 7 miles
Orange < 3 miles
Red < 1 mile
COLORADO
KANSAS
OKLAHOMA
NEW MEXICO
ARIZONA
UNITED STATES
TEXAS
MISSOURI
ARKANSAS
LOUISIANA
MISSISSIPPI
MEXICO
CHIHUAHUA
SONORA
COAHUILA
NUEVO LEÓN
TAMAULIPAS
SINALOA
DURANGO
Navajo Indian Reservation
Zuni I.R.
Albuquerque
Santa Fe
Gallup
Las Vegas
Taos
Grants
Socorro
Silver City
Alamogordo
Roswell
Carlsbad
Clovis
Hobbs
Lamesa
Amarillo
Lubbock
Plainview
Hereford
Dalhart
Dumas
Borger
Wheeler
Guymon
Liberal
Woodward
Alva
Enid
Ponca City
Oklahoma City
Tulsa
Bartlesville
Miami
Joplin
Muskogee
Fort Smith
Rogers
Paragould
Jonesboro
Memphis
Searcy
Little Rock
Hot Springs
Mena
Clarksdale
Greenville
Texarkana
El Dorado
Magnolia
Idabel
Ada
McAlester
Lawton
Altus
Childress
Ardmore
Durant
Wichita Falls
Sherman
Paris
Greenville
Plano
Dallas
Fort Worth
Marshall
Shreveport
Tyler
Abilene
Big Spring
Midland
Odessa
Pecos
San Angelo
Corsicana
Waco
Crockett
Lufkin
Nacogdoches
Natchez
Alexandria
Killeen
Temple
Brady
College Station
Livingston
Huntsville
Baton Rouge
Austin
Beaumont
Lake Charles
Lafayette
Houma
Brenham
Houston
San Antonio
Gonzales
Victoria
Beeville
Corpus Christi
Ciudad Acuña
Boquillas del Carmen
Piedras Negras
Melchor Múzquiz
Sabinas
Ciudad Anáhuac
Nuevo Laredo
Sabinas Hidalgo
Reynosa
Monclova
Parras de la Fuente
China
Monterrey
Torreón
Saltillo
Los Mochis
Guanaceví
Topia
Santiago Papasquiaro
Ciudad Juárez
Agua Prieta
Ascensión
Nuevo Casas Grandes
Buenaventura
Peña Blanca
Madera
Ojinaga
Chihuahua
Cuauhtémoc
Ciudad Delicias
Ciudad Camargo
Ciudad Jiménez
Hidalgo del Parral
San Juanito
Álamos
Choix
El Chorro
Pecos
Rio Grande
Red
White
Gila
© 2000 Microsoft Corp. and/or its suppliers. All rights reserved.

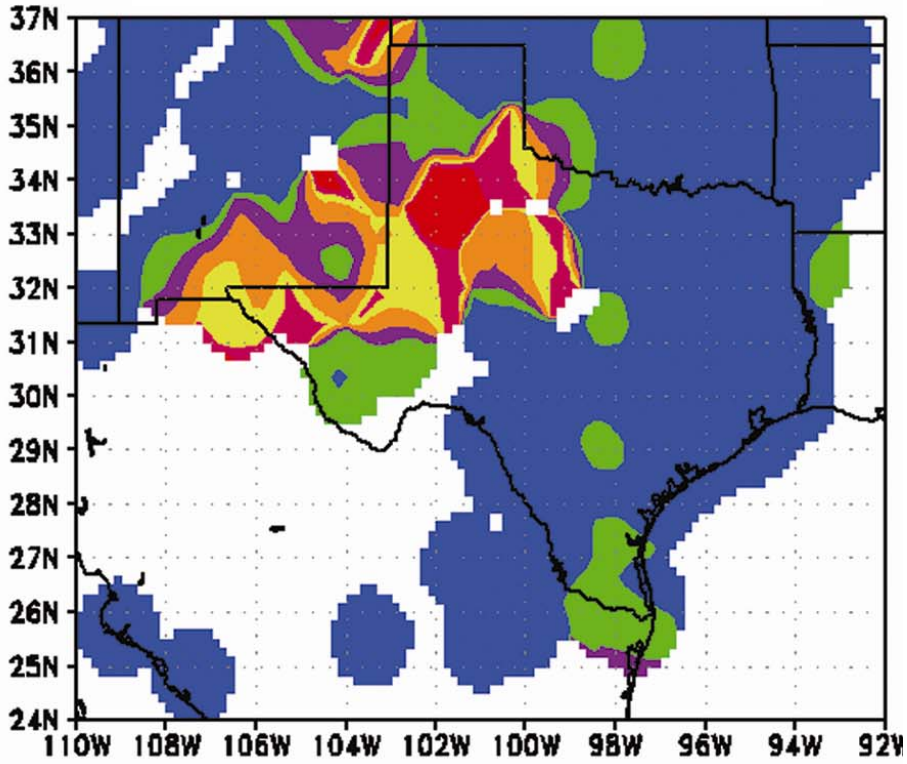

0.3
0.7
0.9
1.5
4.5
7
44N
42N
40N
38N
36N
34N
32N
30N
28N
26N
24N
126W
123W
120W
117W
114W
111W
108W
105W
102W
99W
96W
93W
GrADS: COLA/IGES
2004-09-18-13:06

Modeled Dust Concentrations vs Ground Visibility at Weather Stations

Dust concentration (μg/m^3)
15 December '03

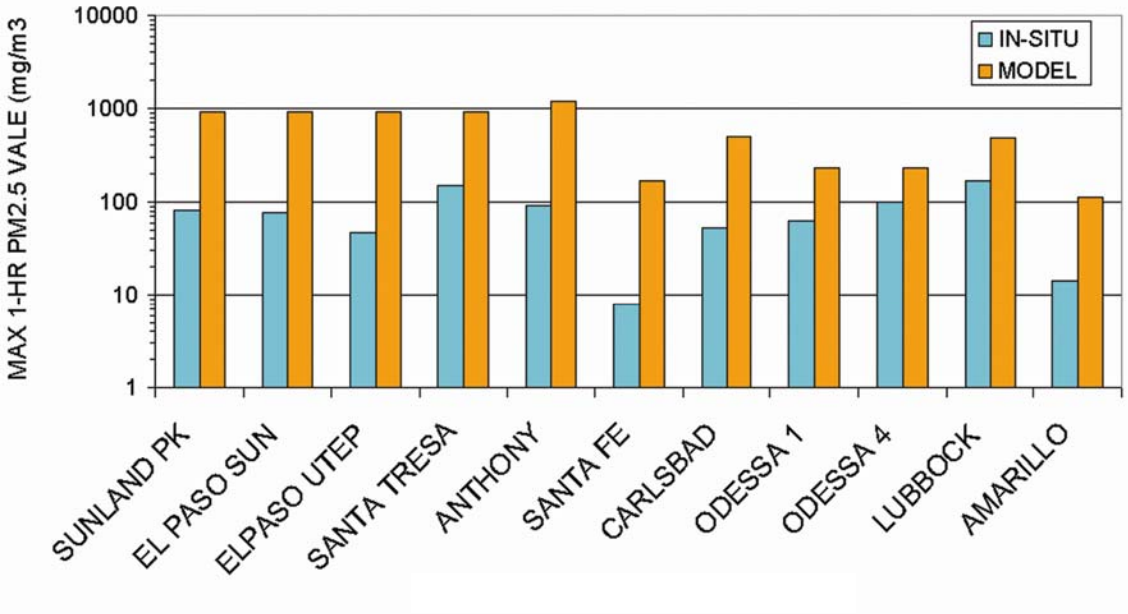


Measured visibility (miles)
15 December '03

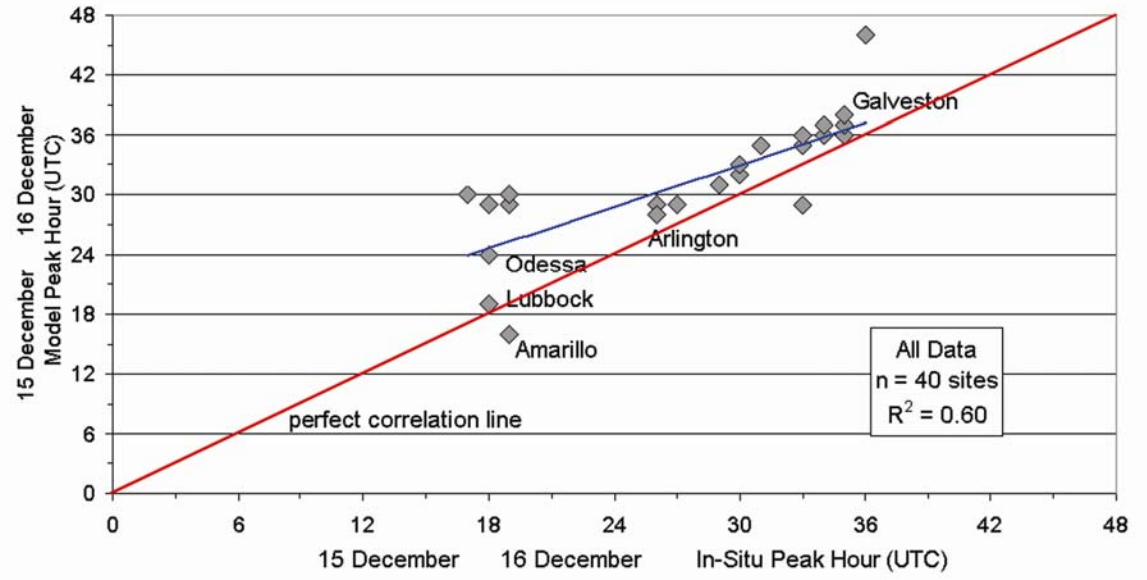


No NASA data in Model

Comparison of In-situ and Modeled $PM_{2.5}$

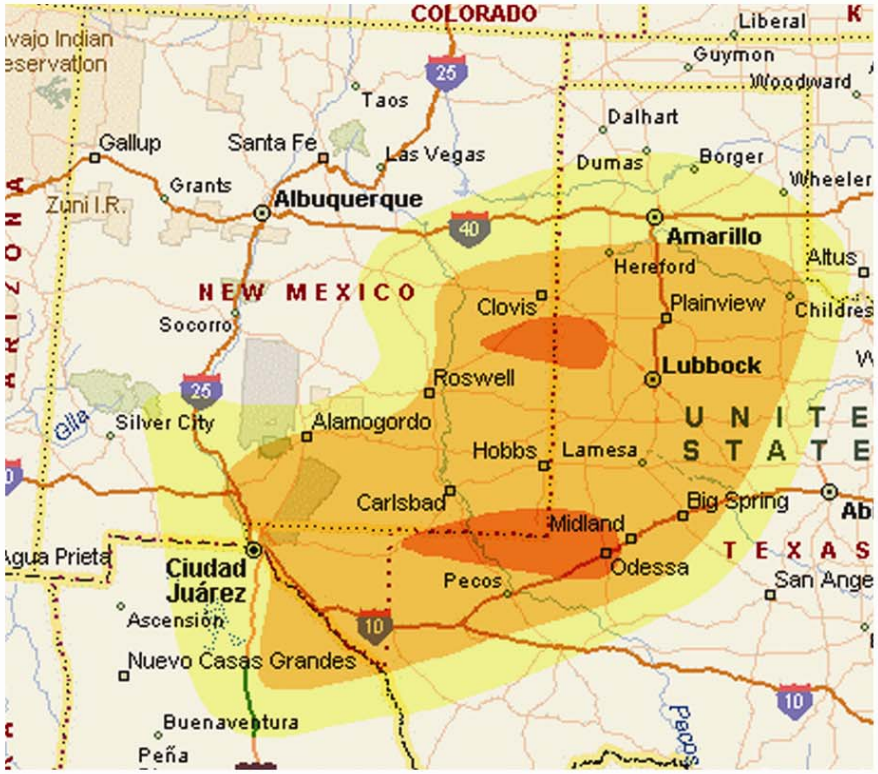


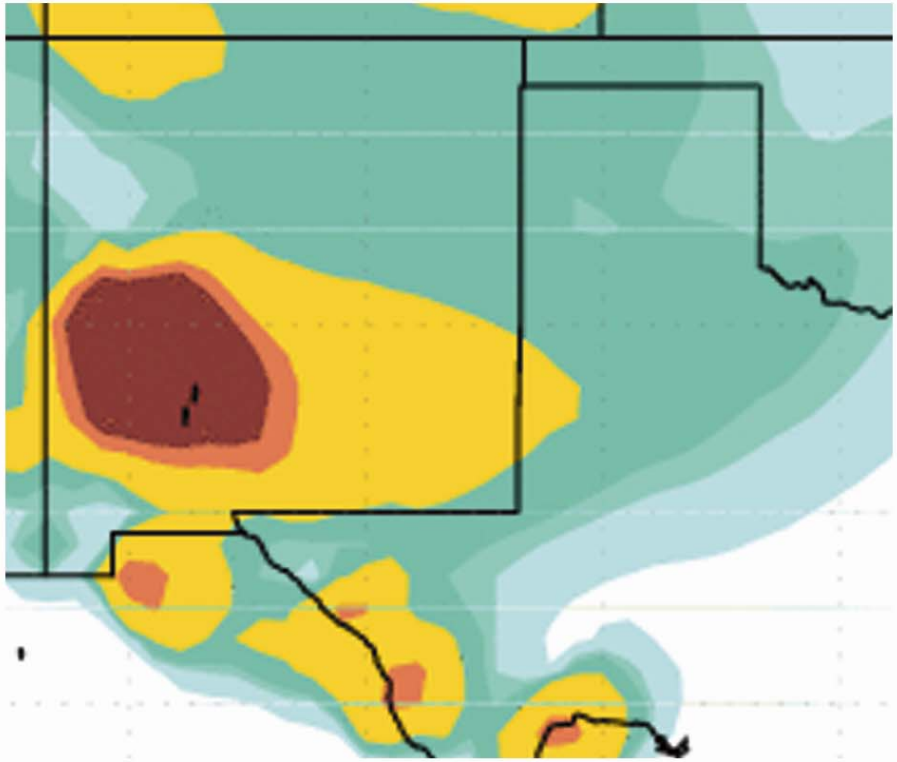
No NASA data in model



Peak 1 hr $PM_{2.5}$
N=40, R^2=0.60

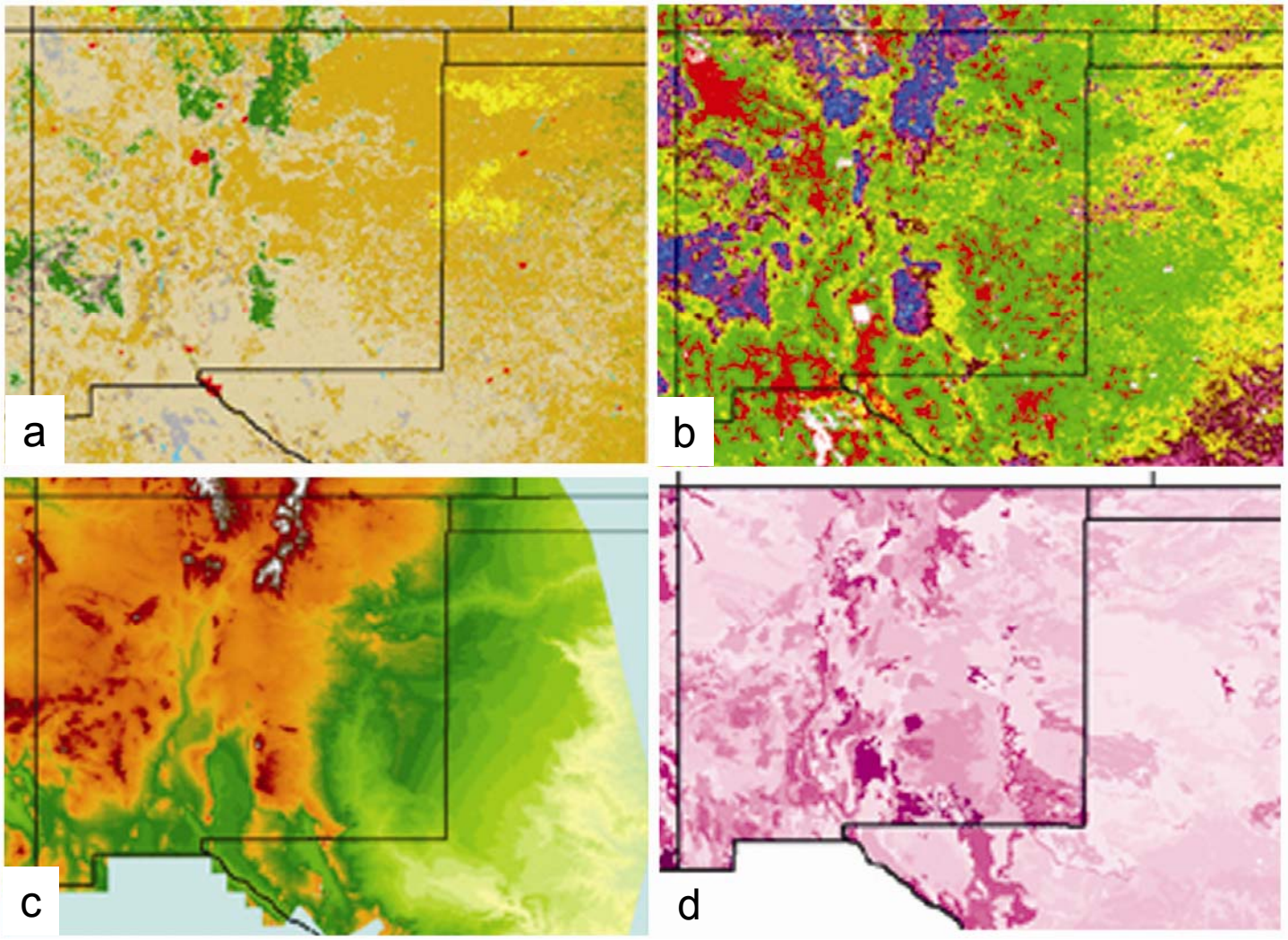
Patterns of Visibility Classes Vs Modeled Dust Loading





No NASA data in model

Visualizations of Four DREAM Replacement Parameters

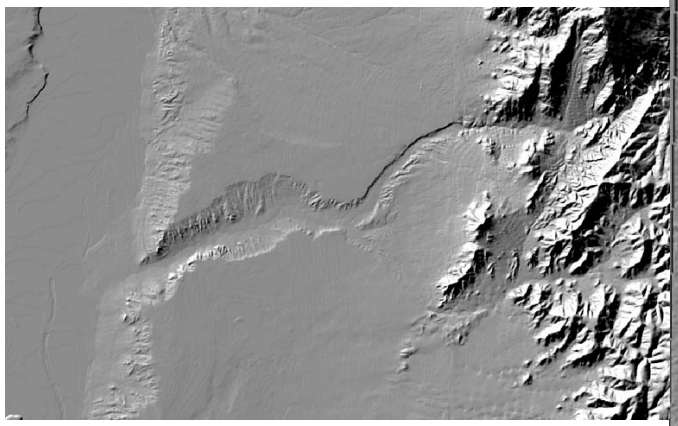


(a) MODIS Land Cover; (b) MODIS Leaf-area Index; (c) SRTM Elevation; (d) Soil Texture Classes

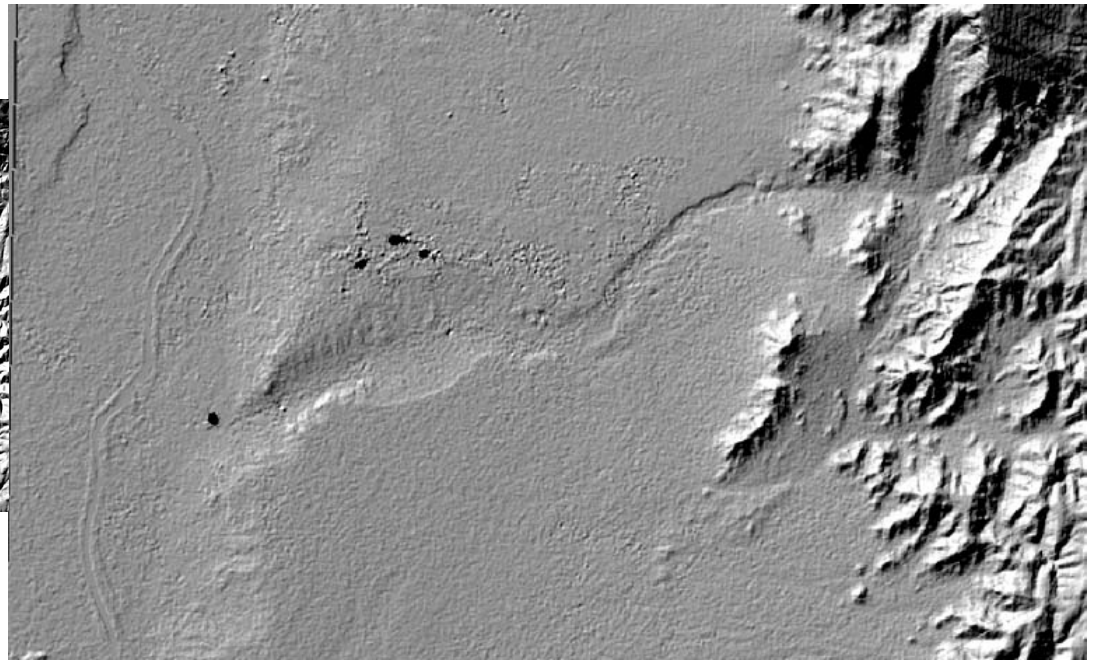
Surface Roughness

For DREAM we need *surface roughness length*, z_0

National Elevation Data

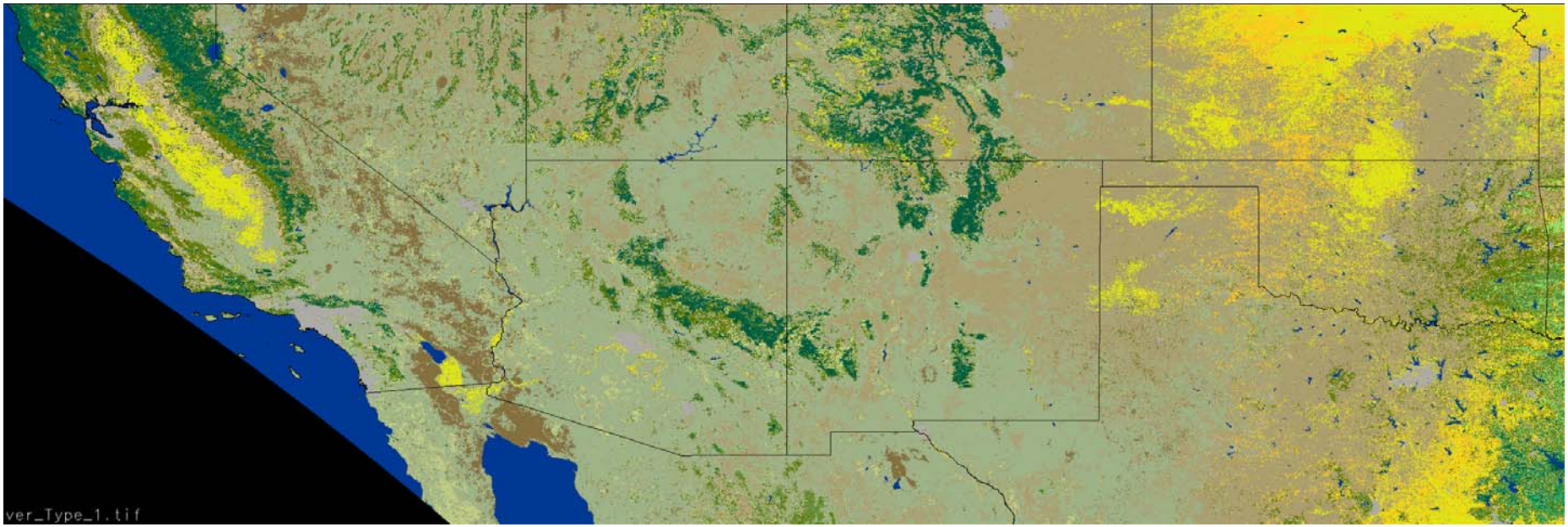


Shuttle Radar Terrain Mission Data

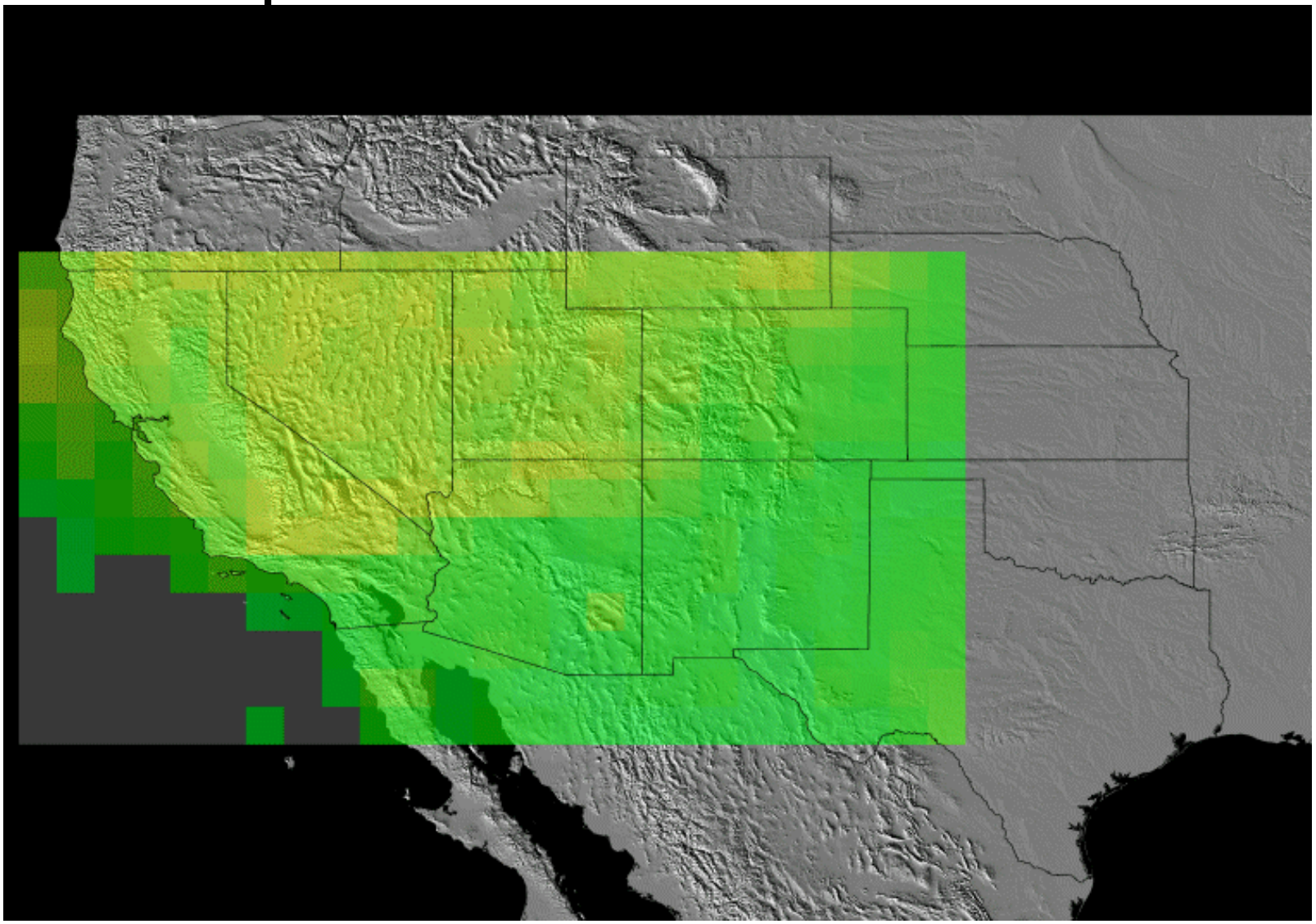


(Experimental)

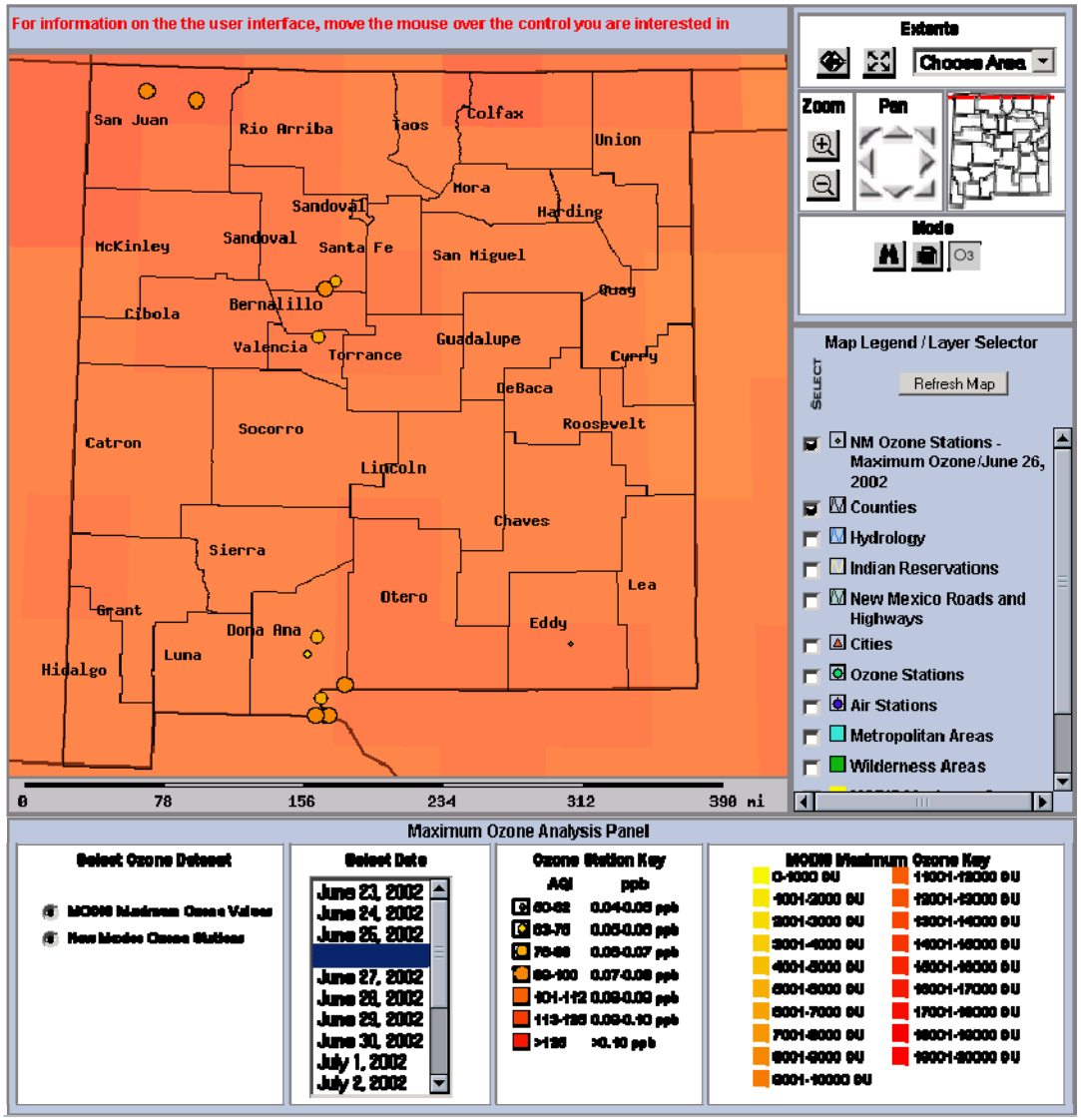
MOD12Q1—(Version 004) Land Cover Type for 2001



Migrating Ozone Concentrations Impact Incidence of Asthma



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

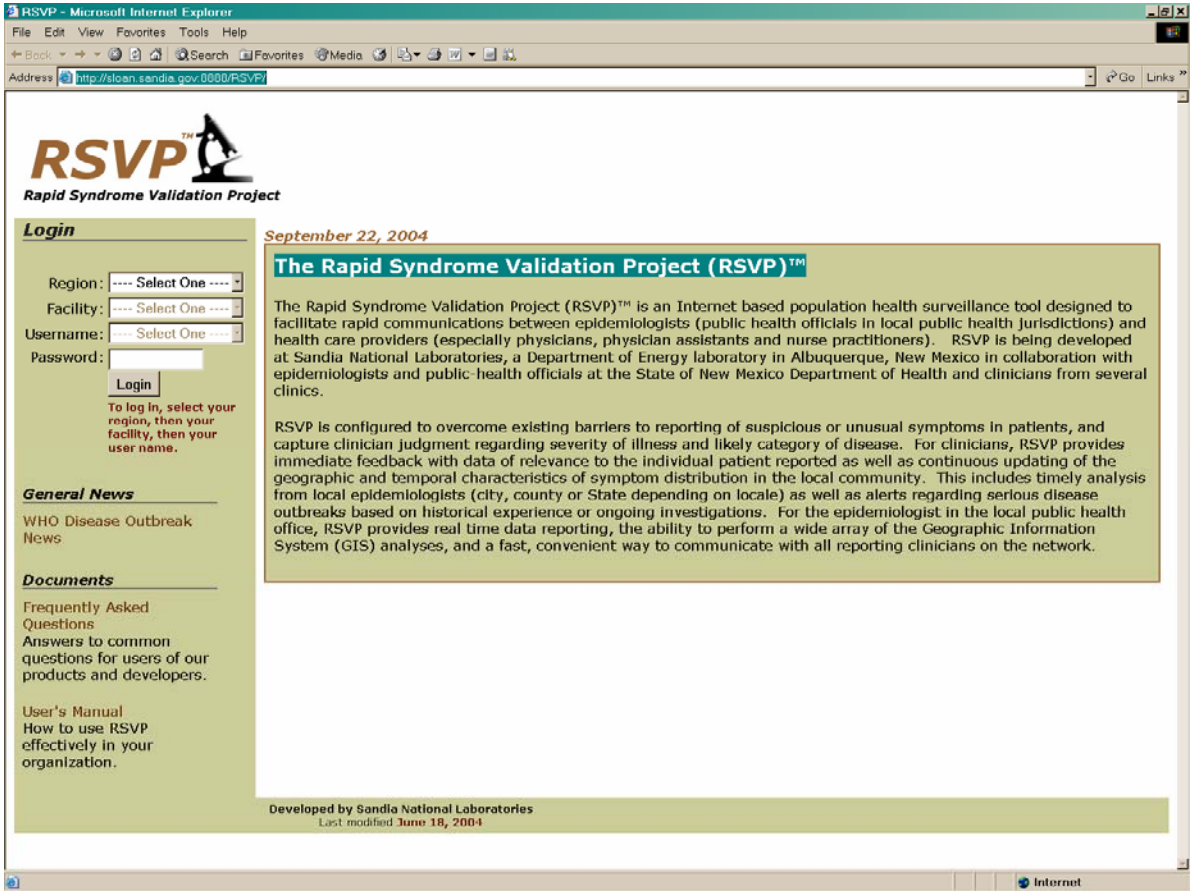
-classified in Dobson units that measure total atmospheric profile

New Mexico ground station network

-primarily in urban contexts

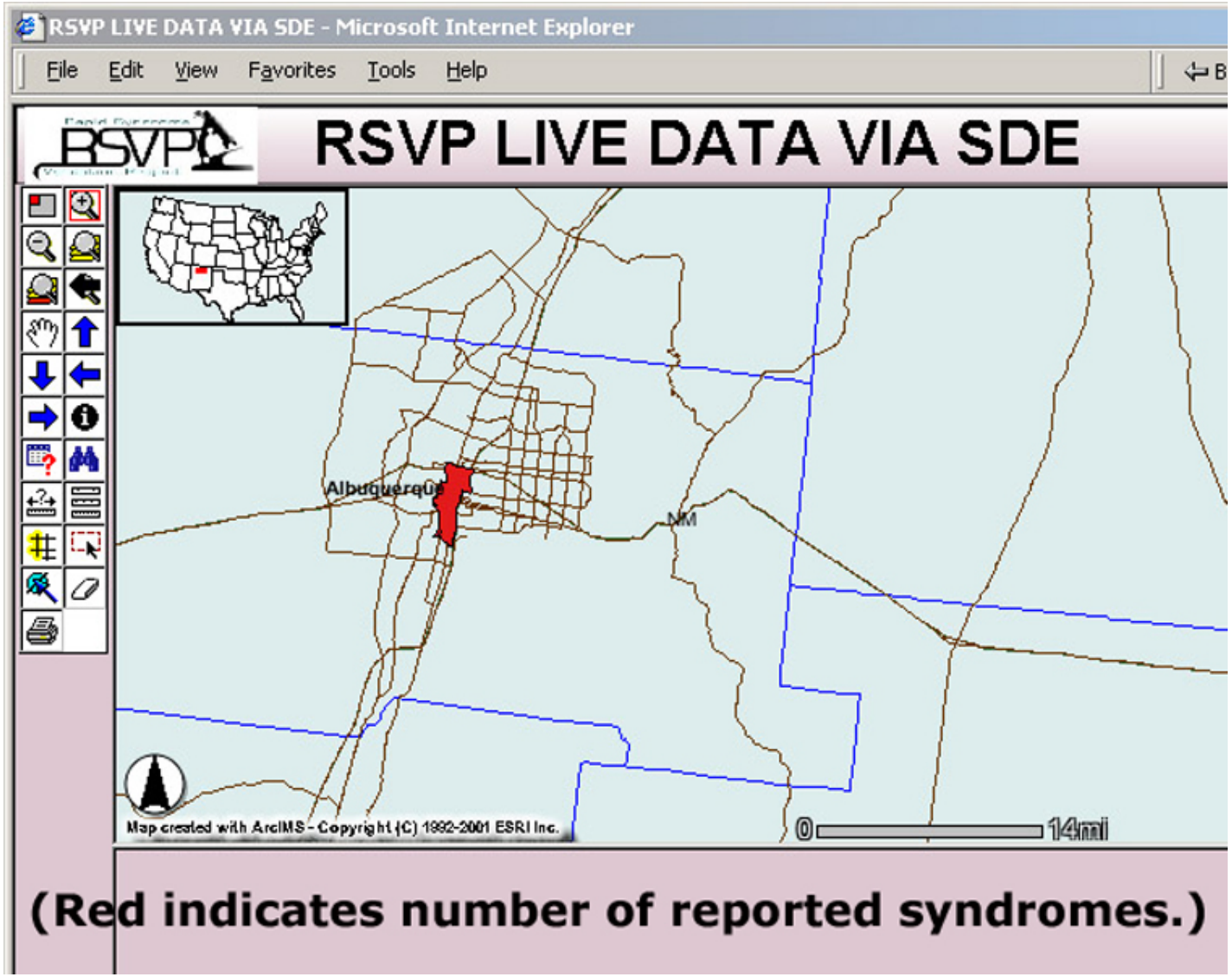
-classified in ppb ozone

The Rapid Syndrome Validation Project (RSVP)™



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

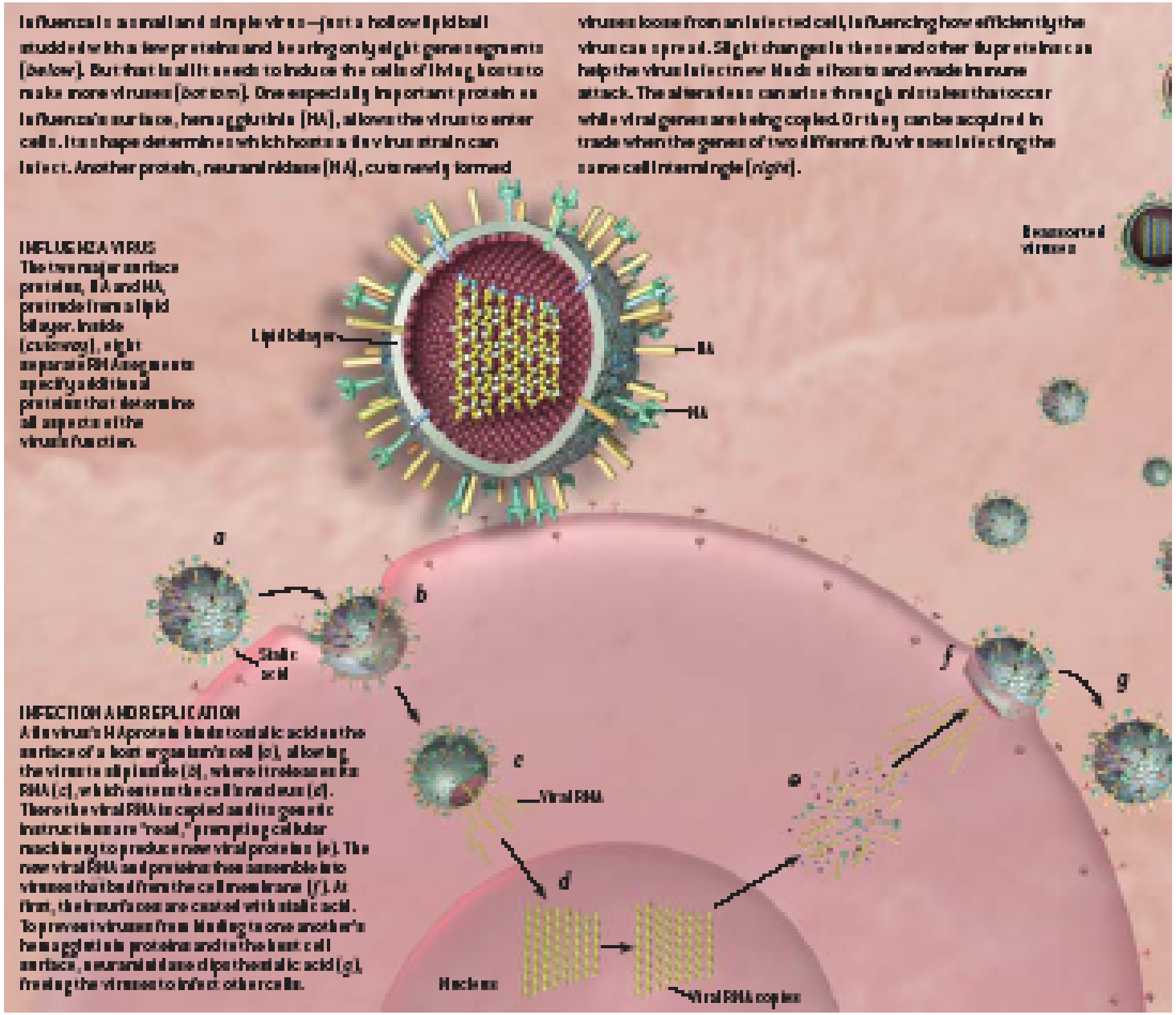
Rapid Syndrome Validation Project™

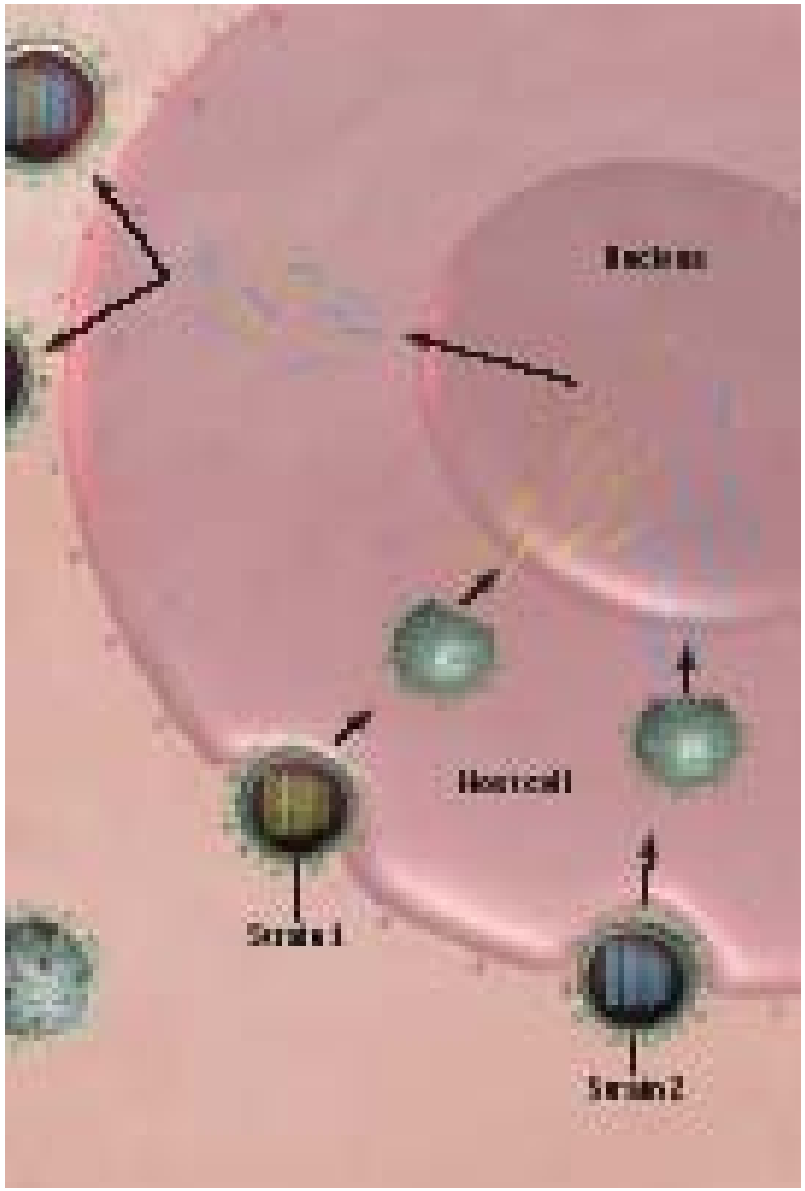


RSVP Objectives

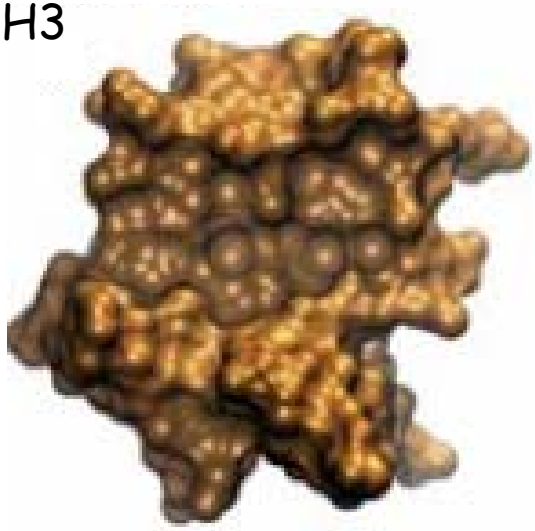
1. Illustrate how Earth observing satellite data can assist RSVP design goals
2. Identify and validate scientifically sound relationships between environmental stimuli and resulting human health responses
3. Integrate scientific relationships into spatially explicit products for use in RSVP delivery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

Influenza is a small and simple virus—just a hollow lipid ball studded with a few proteins and bearing only eight gene segments (below). But that is all it needs to induce the cells of living hosts to make more viruses (bottom). One especially important protein on influenza's surface, hemagglutinin (HA), allows the virus to enter cells. Its shape determines which hosts a flu virus strain can infect. Another protein, neuraminidase (NA), cuts newly formed viruses loose from an infected cell, influencing how efficiently the virus can spread. Slight changes in these and other flu proteins can help the virus infect new kinds of hosts and evade immune attack. The alterations can arise through mistakes that occur while viral genes are being copied. Or they can be acquired in trade when the genes of two different flu viruses infecting the same cell intermingle (*right*).

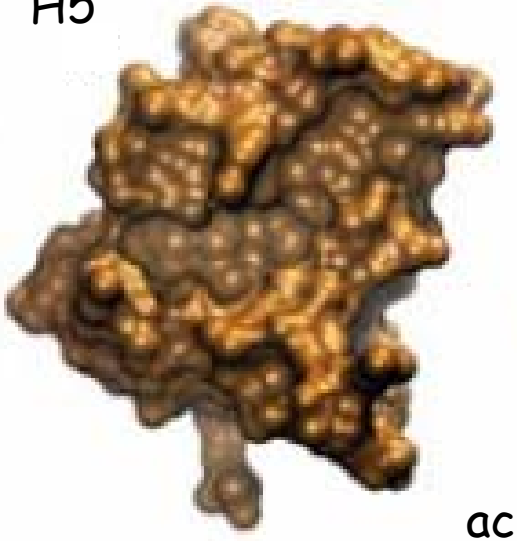



Nucleus
Histone

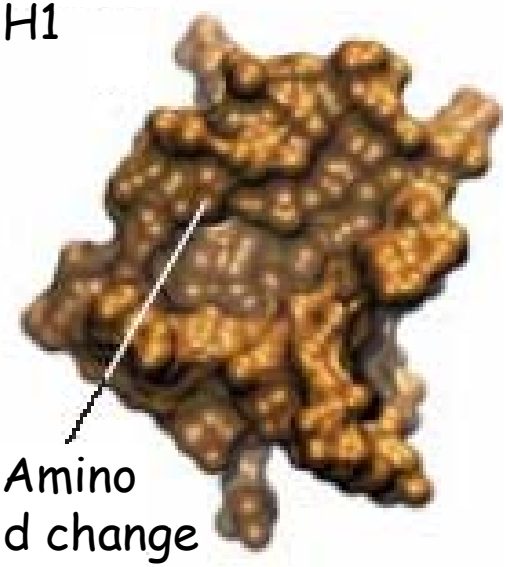
Human adapted
H3



Avian adapted
H5



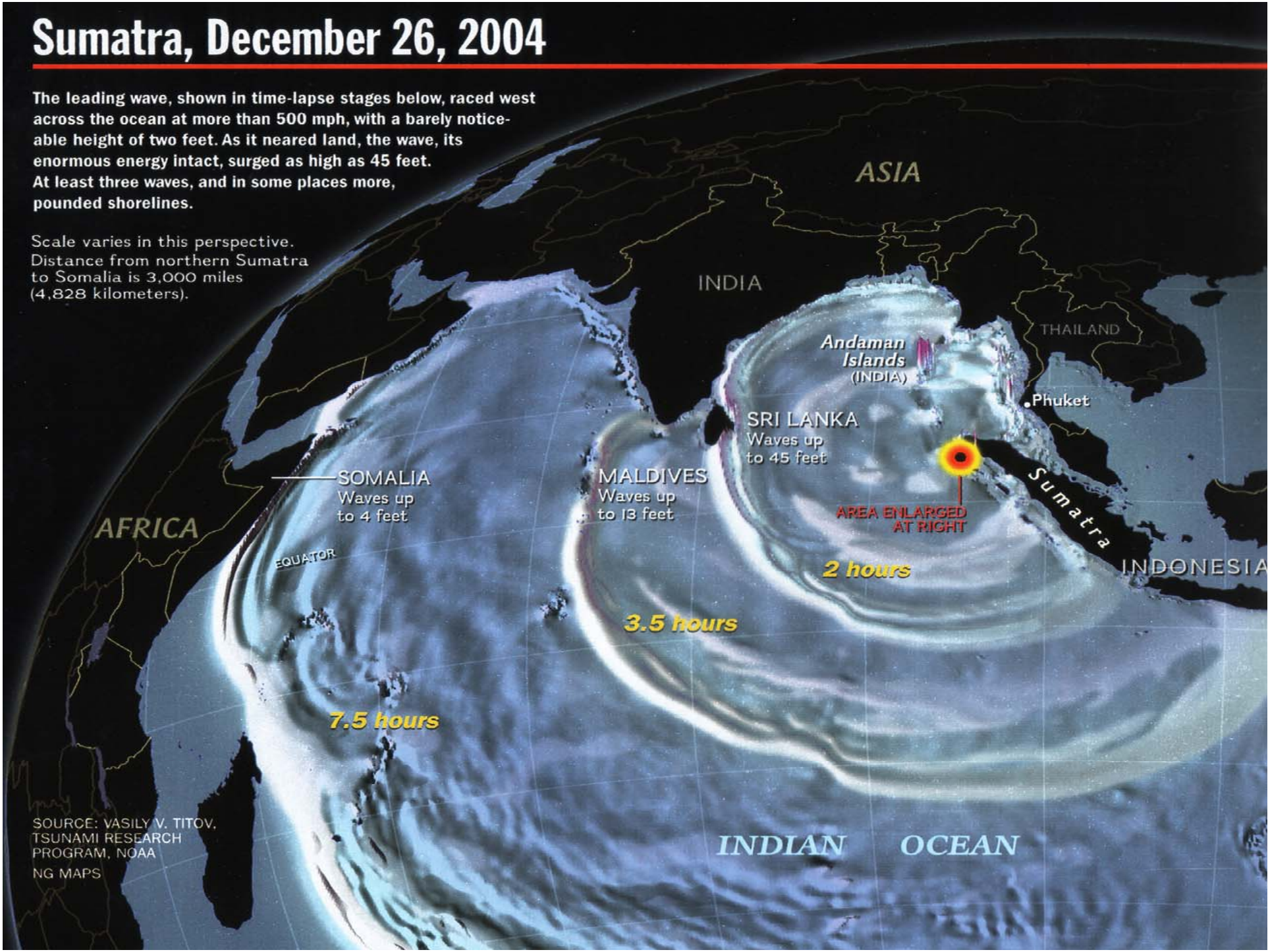
1918 Flu
H1



Sumatra, December 26, 2004

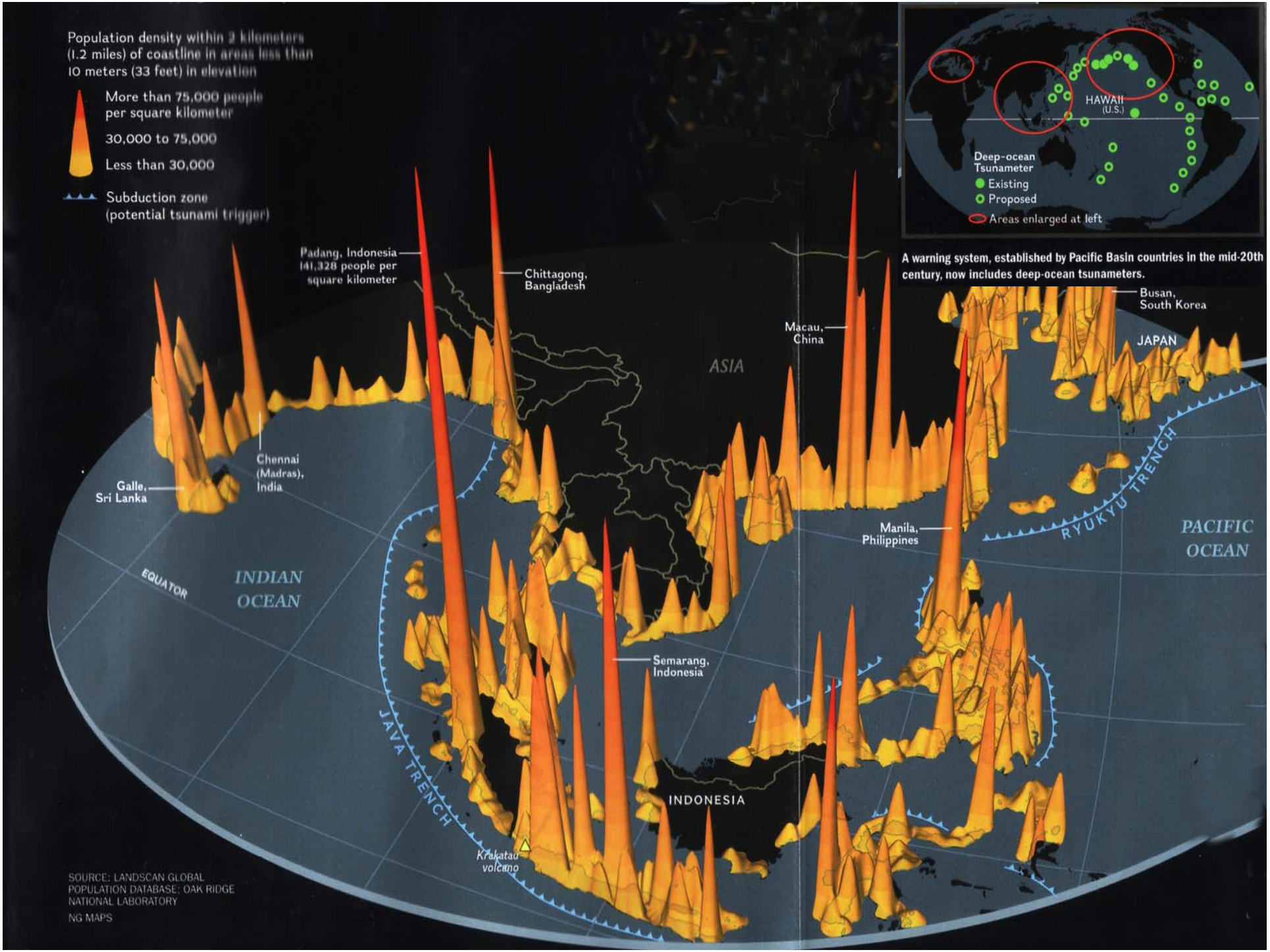
The leading wave, shown in time-lapse stages below, raced west across the ocean at more than 500 mph, with a barely noticeable height of two feet. As it neared land, the wave, its enormous energy intact, surged as high as 45 feet. At least three waves, and in some places more, pounded shorelines.

Scale varies in this perspective. Distance from northern Sumatra to Somalia is 3,000 miles (4,828 kilometers).



SOURCE: VASILY V. TITOV, TSUNAMI RESEARCH PROGRAM, NOAA

NG MAPS


Population density within 2 kilometers (1.2 miles) of coastline in areas less than 10 meters (33 feet) in elevation
More than 75,000 people per square kilometer
30,000 to 75,000
Less than 30,000
Subduction zone (potential tsunami trigger)
Padang, Indonesia 141,328 people per square kilometer
Chittagong, Bangladesh
Macau, China
Busan, South Korea
JAPAN
ASIA
Chennai (Madras), India
Galle, Sri Lanka
EQUATOR
INDIAN OCEAN
RYUKYU TRENCH
PACIFIC OCEAN
Manila, Philippines
Semarang, Indonesia
JAVA TRENCH
INDONESIA
Krakatau volcano
HAWAII (U.S.)
Deep-ocean Tsunameter
Existing
Proposed
Areas enlarged at left
A warning system, established by Pacific Basin countries in the mid-20th century, now includes deep-ocean tsunameters.
SOURCE: LANDSCAN GLOBAL POPULATION DATABASE; OAK RIDGE NATIONAL LABORATORY
NG MAPS