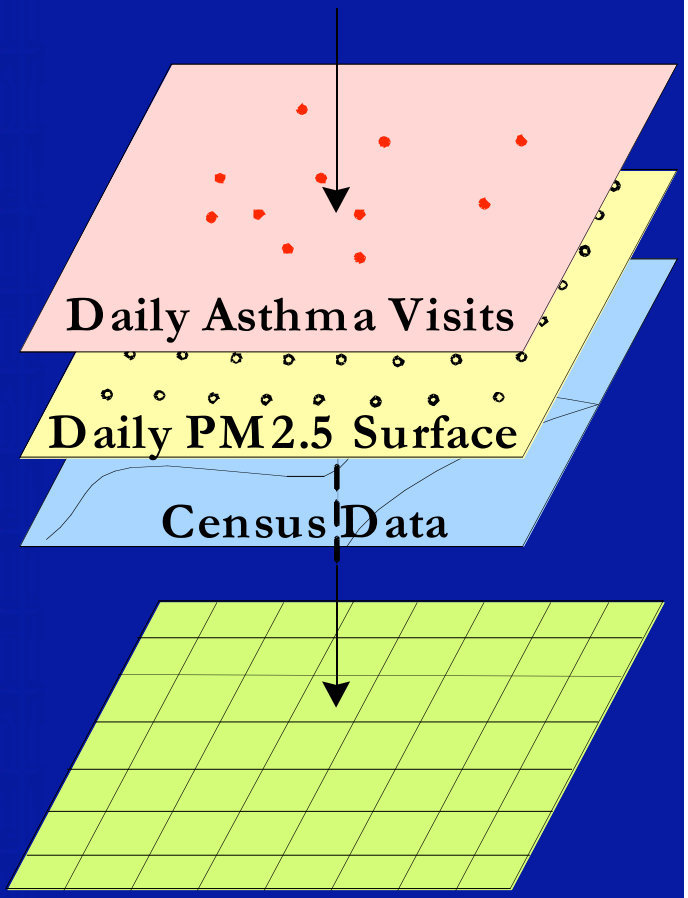
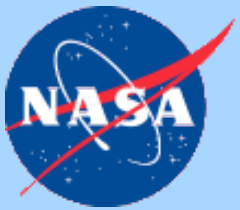
Enhancement of GeoMedStat for asthma surveillance, prediction, and intervention by integrating with NASA research results



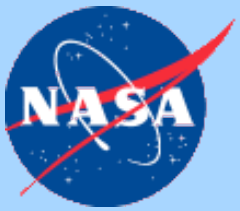
NASA Workshop
Applications of Environmental Remote Sensing
to Air Quality and Public Health
May 8-9, 2007 / Potomac, Maryland

Few Highlights

- Background
- Data
- GeoMedStat
- Significance

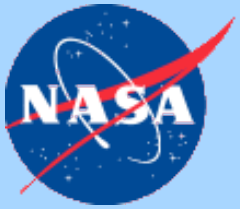


Background



Asthma defined

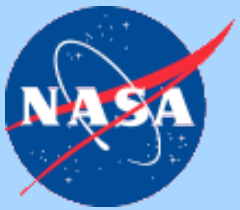
"Asthma is a chronic *inflammatory* disorder of the airways in which many cells play a role, including mast cells and eosinophils. In susceptible individuals, this *inflammation* causes symptoms which are usually associated with widespread but variable airflow obstruction that is often reversible either spontaneously or with treatment, and causes an associated increase in airway responsiveness to a variety of stimuli."



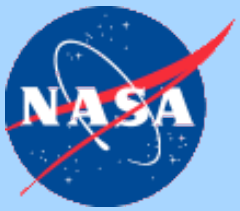
International Consensus Report, NIH Publication No. 92-3091, 1992

Major Pollutants Involved in Asthma

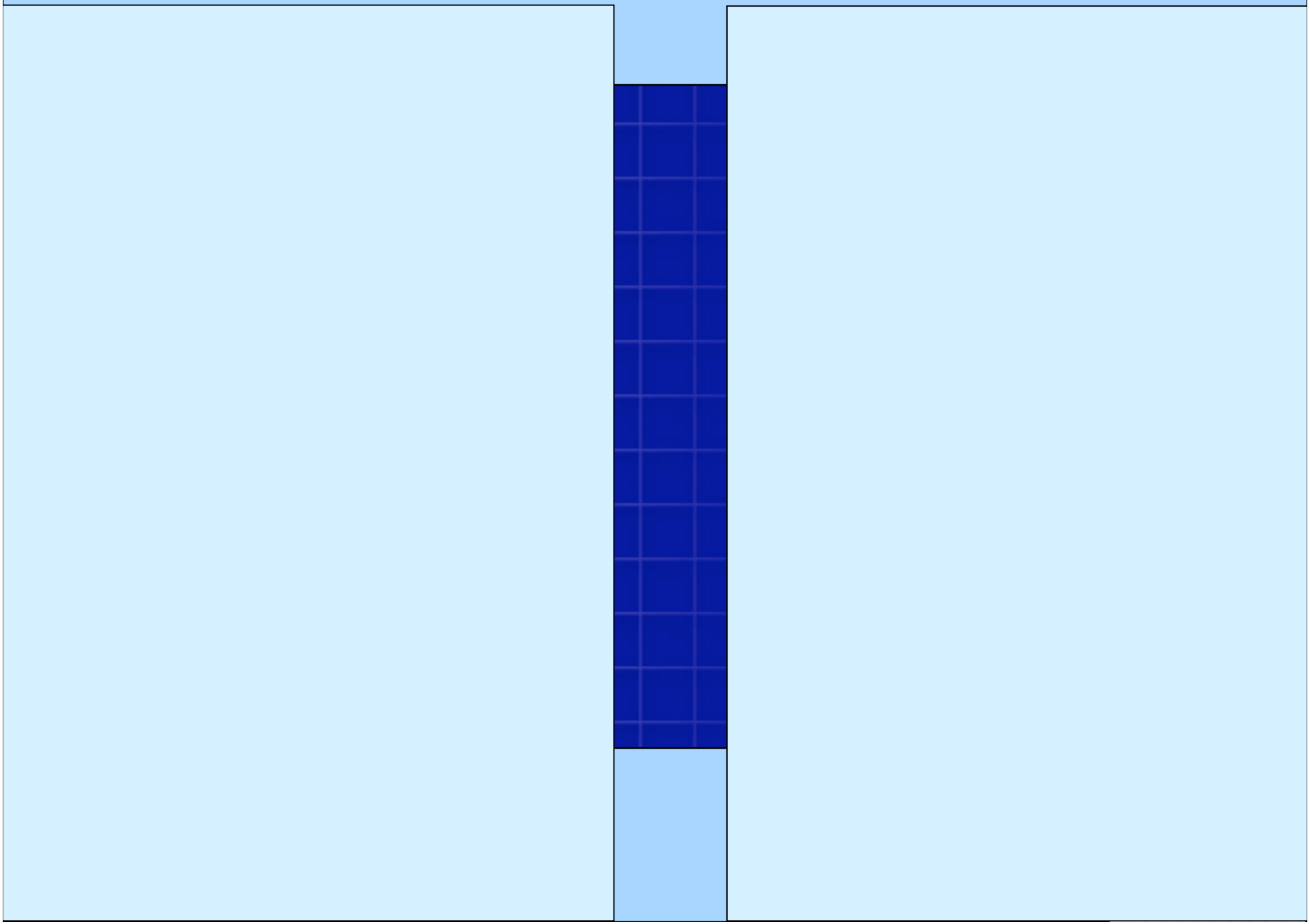
- Ozone
- Particulates
  - Pollutants containing carbon or metals
  - Diesel exhaust particles
  - Biologic material (eg, endotoxin)

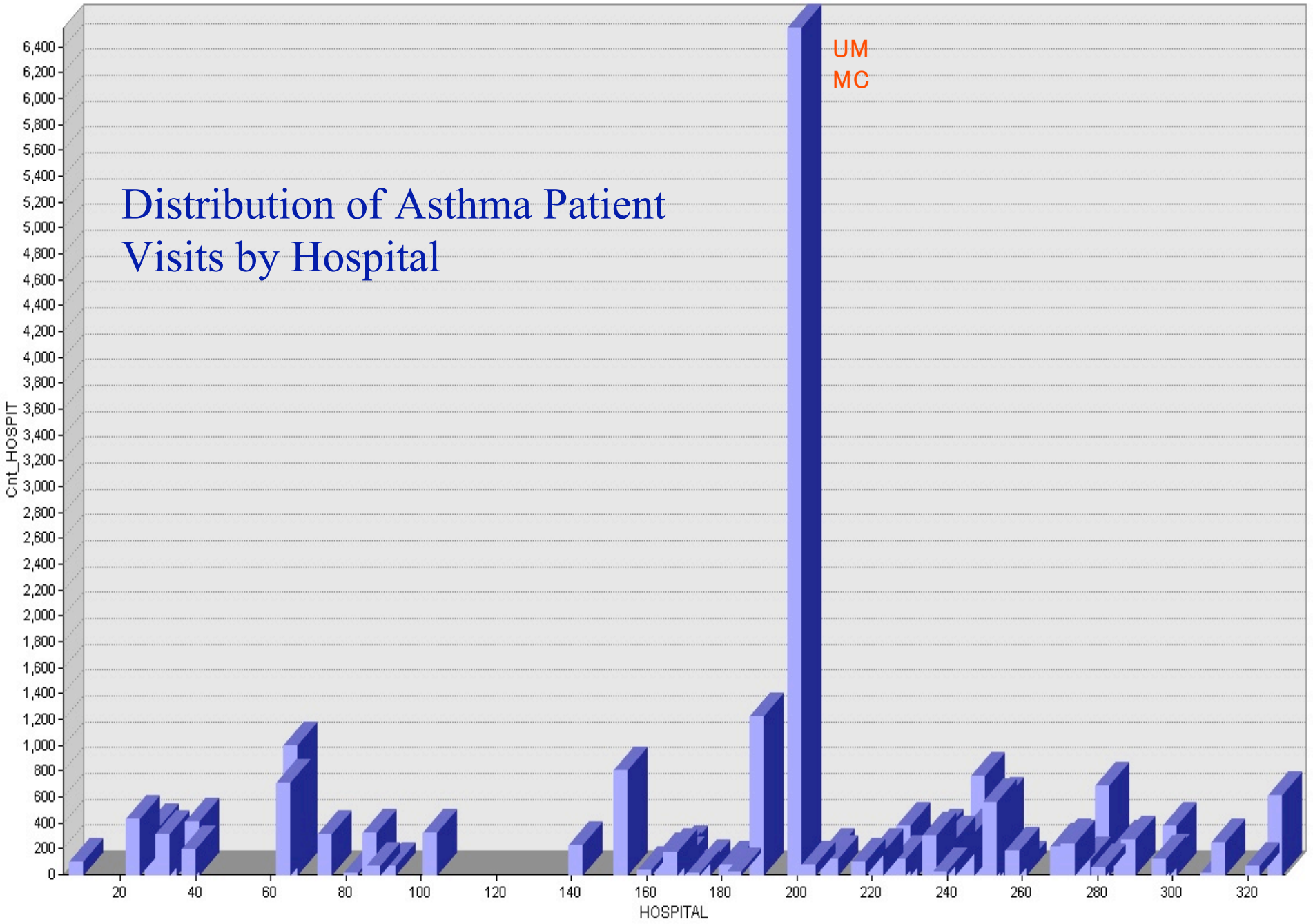


Data



Distribution of Participating Hospitals

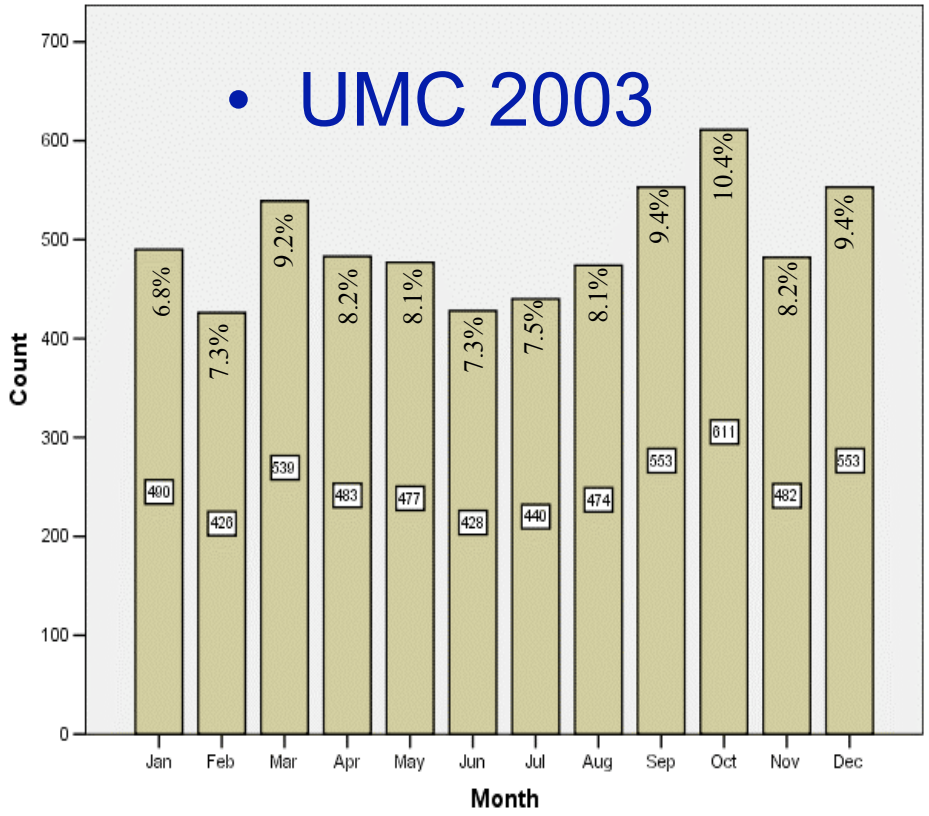




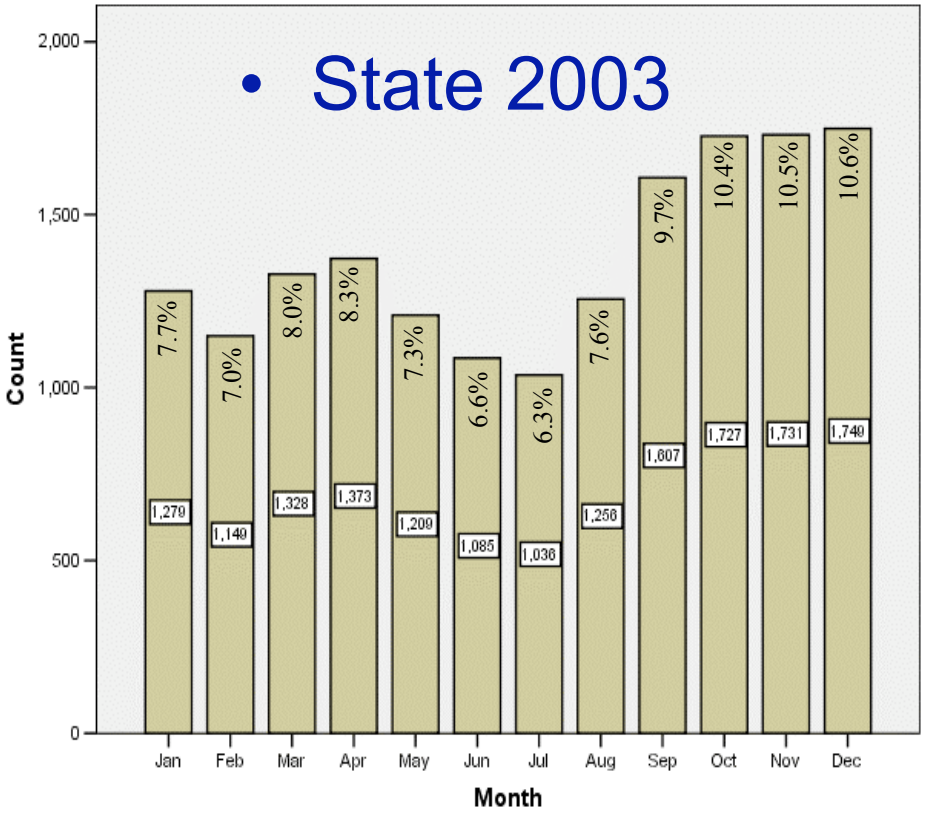
ER: 9,704 **Outpatient: 8,667** **Inpatient: 4801** **Total: 23,172**

Monthly Asthma Patient Distribution

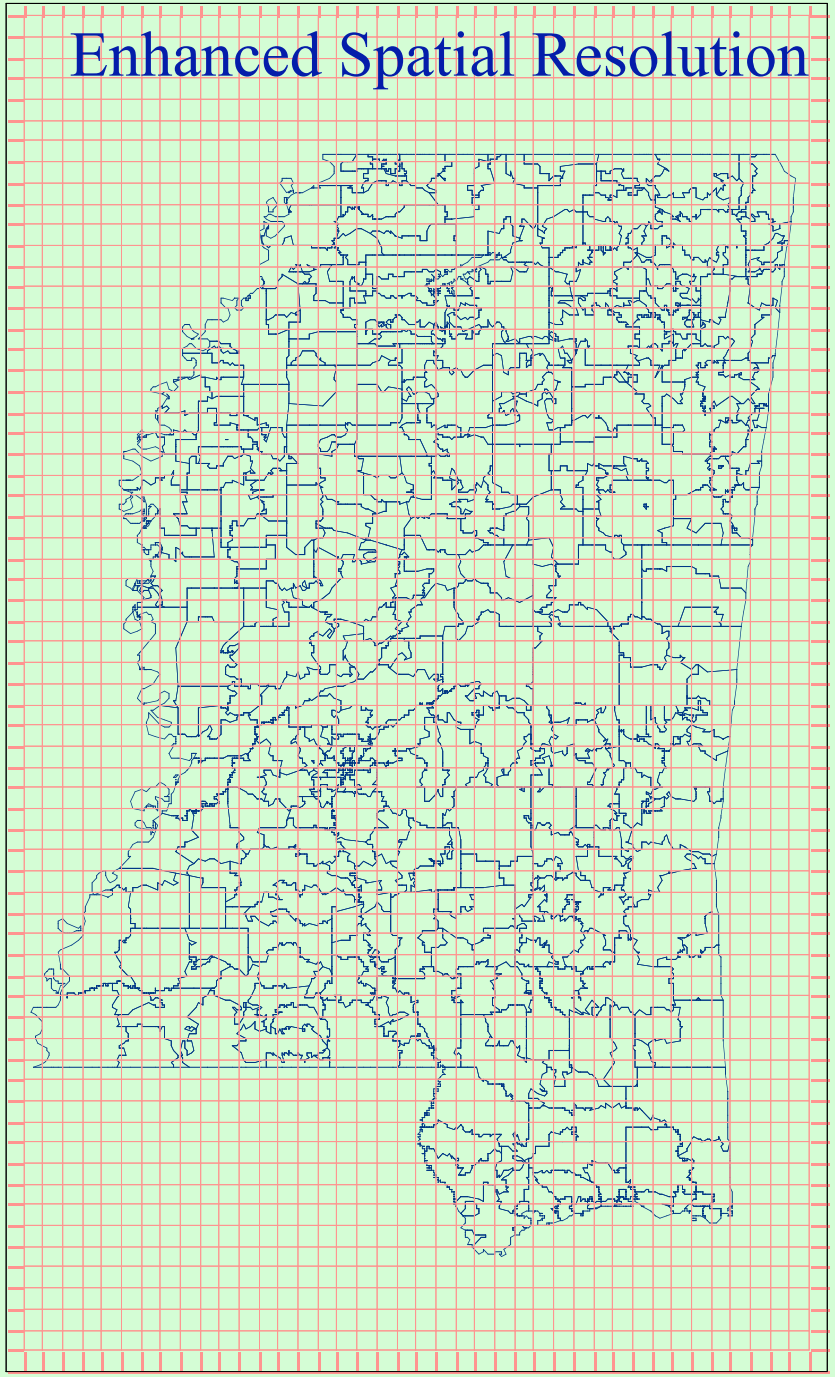
- UMC 2003



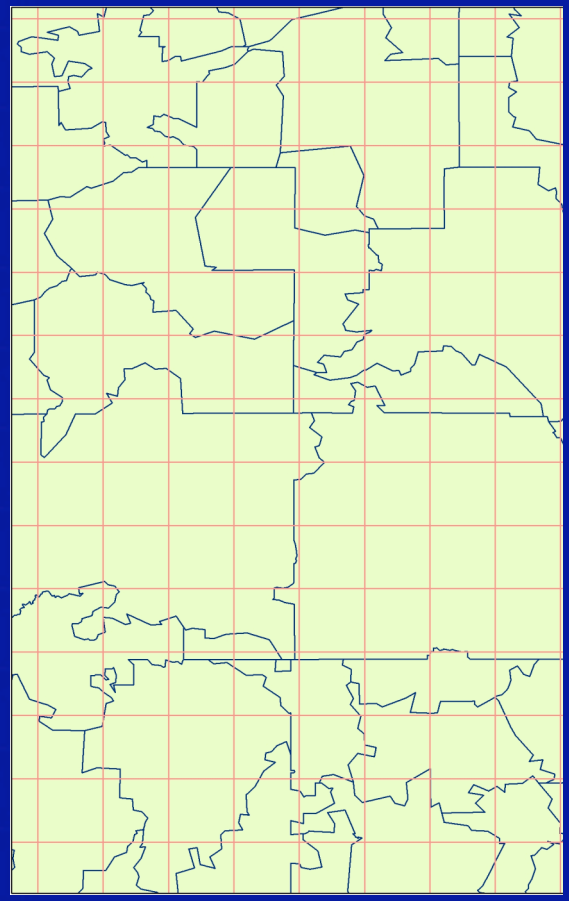
- State 2003



Enhanced Spatial Resolution



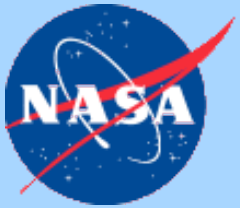
Zip Code = 385



Grid = 1548

Improved Geocoding Solution

Method	Street Match	Zip Code Match	Total
ESRI	15887	4632	20,519
UMC-IGS	2620	33	2,653
Total	18507	4665	23,172
ESRI	68.56%	19.99%	88.55%
UMC-IGS	11.31%	0.14%	11.45%
Total	79.87%	20.13%	100.00%



Total = 23172, M = 18197, T = 310, Z = 4665

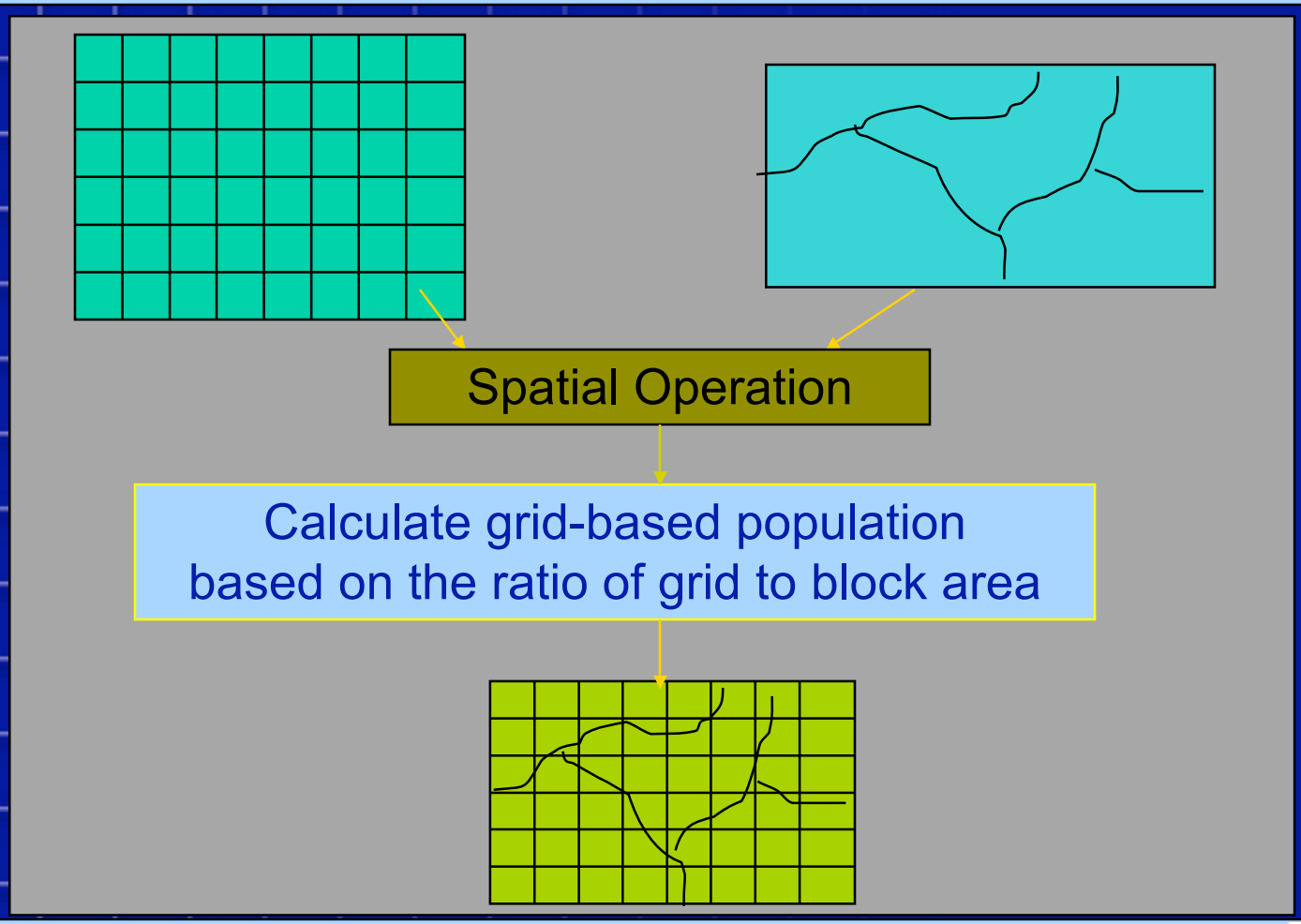
Demographic Data

From Census Unit to Grid

- Purpose:
  - Interpolate demographic data from census block group level to grid level for 2003 - 2005
- Demographic Data Source:
  - ESRI TAPESTRY 2005 Data
- Approach (diagram)

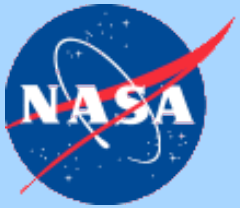
Demographic Data

From Census Unit to Grid



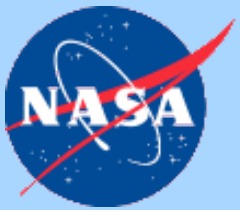
Data Types in GeoMedStat

- Pollution that can trigger asthma exacerbation
  - PM2.5 (EPA/AQS and NASA)
  - Ozone (EPA/AQS and NASA)
- Asthma Patient Visit
  - MDH
  - UMMC

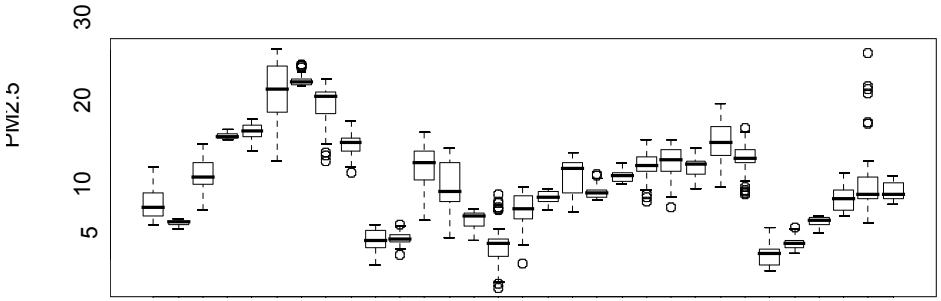


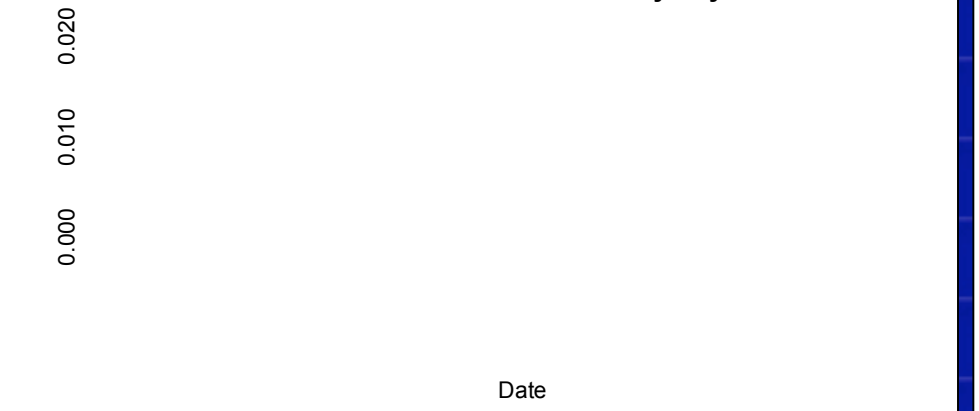
Historical and Real-Time Data

- Historical Data
  - Statewide
    - ❖Association between pollutants and asthma visit
- Real-time Data
  - UMMC
    - ❖Preparedness

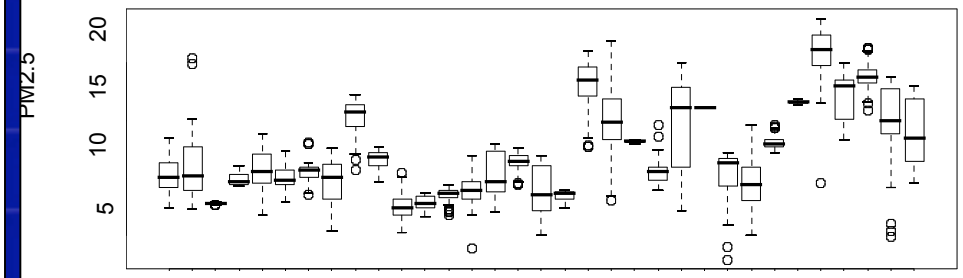


Initial Prediction Analysis





October 2003: Visit rate by day

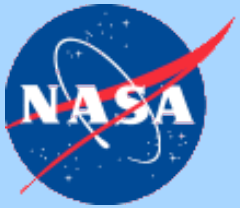


July 2003

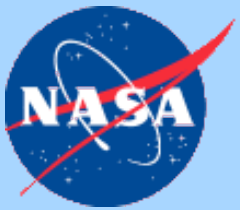
PM2.5 and Asthma Visit Rates
(July and October of 2003)

Initial Prediction Analysis

Daily boxplots for observed asthma visits, modeled PM 2.5 for July and October 2003, illustrate a **variation** by days across the grid cells. Poisson regression results suggest **significant association between visits and local demographics**, illustrating the importance of adjusting for demographics when assessing the impact of local PM 2.5 values. Analyses incorporating both demographics and daily PM 2.5 and Ozone are underway to estimate and map the impact of the modeled values on asthma visits.

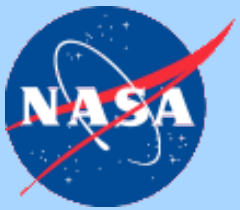


GeoMedStat

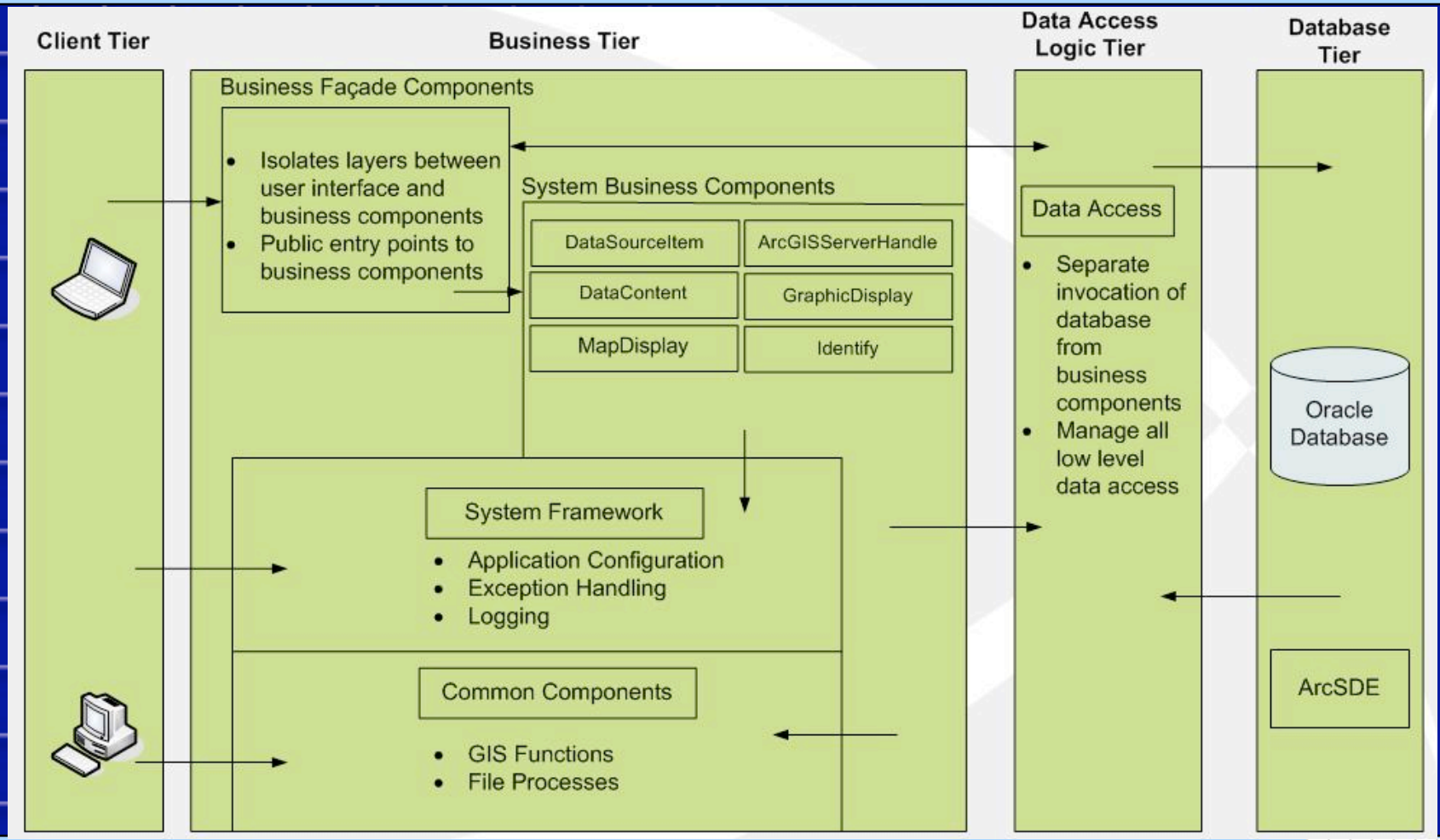


GeoMedStat

- Architecture
- Functions
- Data Flow Diagram
- Interaction
- Future Functions
- Demonstrations



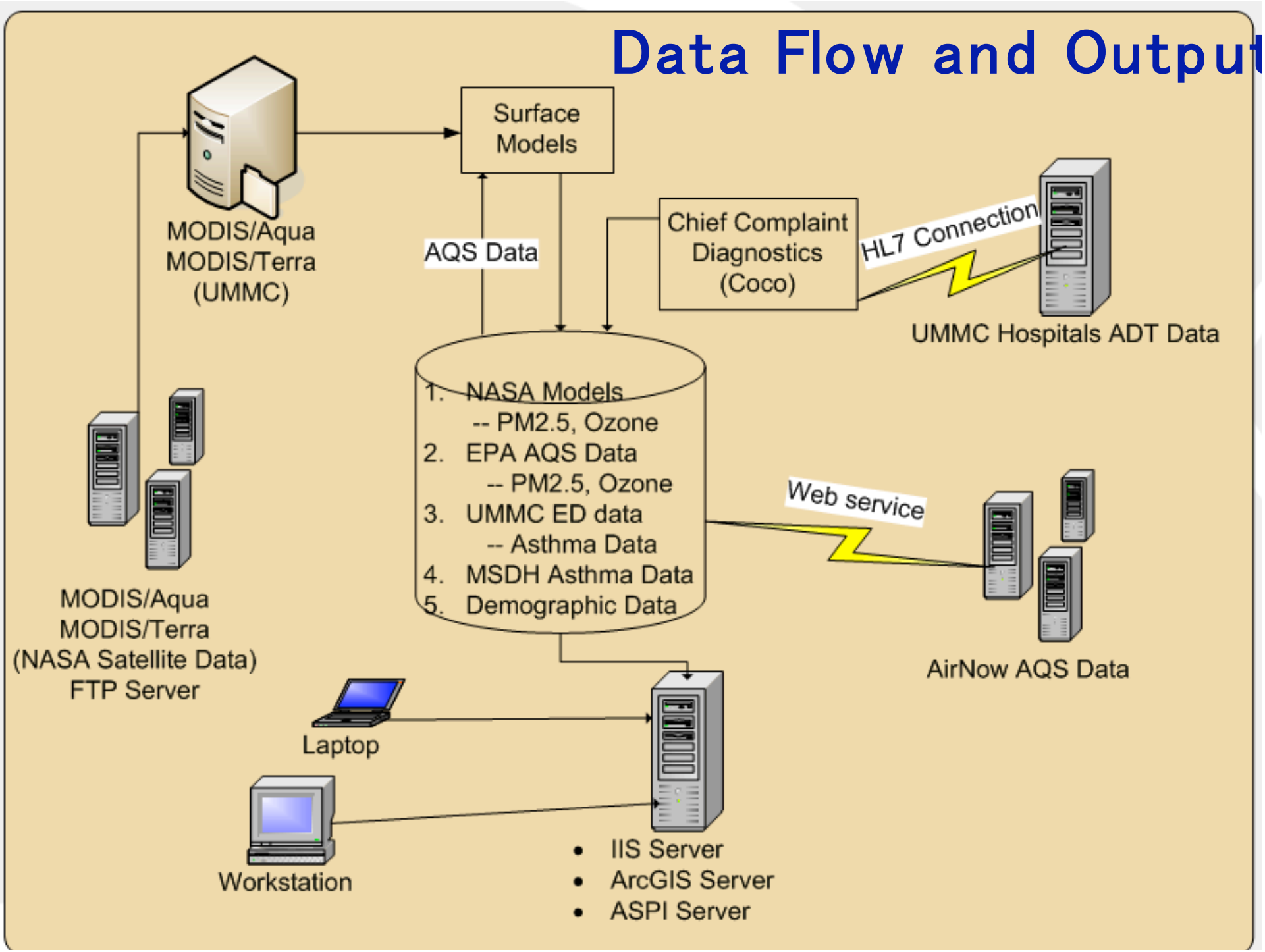
Multi-tier Architecture



Functions

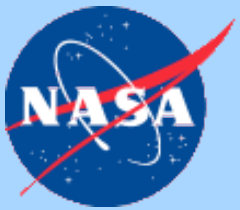
- Estimate real-time air pollutants (PM2.5 and Ozone) using NASA satellite and AQS data
- Collect real-time UMMC Hospitals ADT data (asthma and other patient visits) using HL7 interface
- Integrate asthma and air pollutants into a 10*8 km spatial resolution
- Provide GIS mapping functions to identify spatial changes
- Support chart functions to display temporal changes

Data Flow and Output



Future Functions

- Analytical Tools
  - Search
  - Buffer
  - Statistics
  - Spatial scan statistics
  - Data export
- Reports



GeoMedStat for Air Pollution
Asthma Surveillance System

CHART DISPLAY | MAP DISPLAY | HELP

Date Selection

Enter Date: 1 16 2003

Map Option

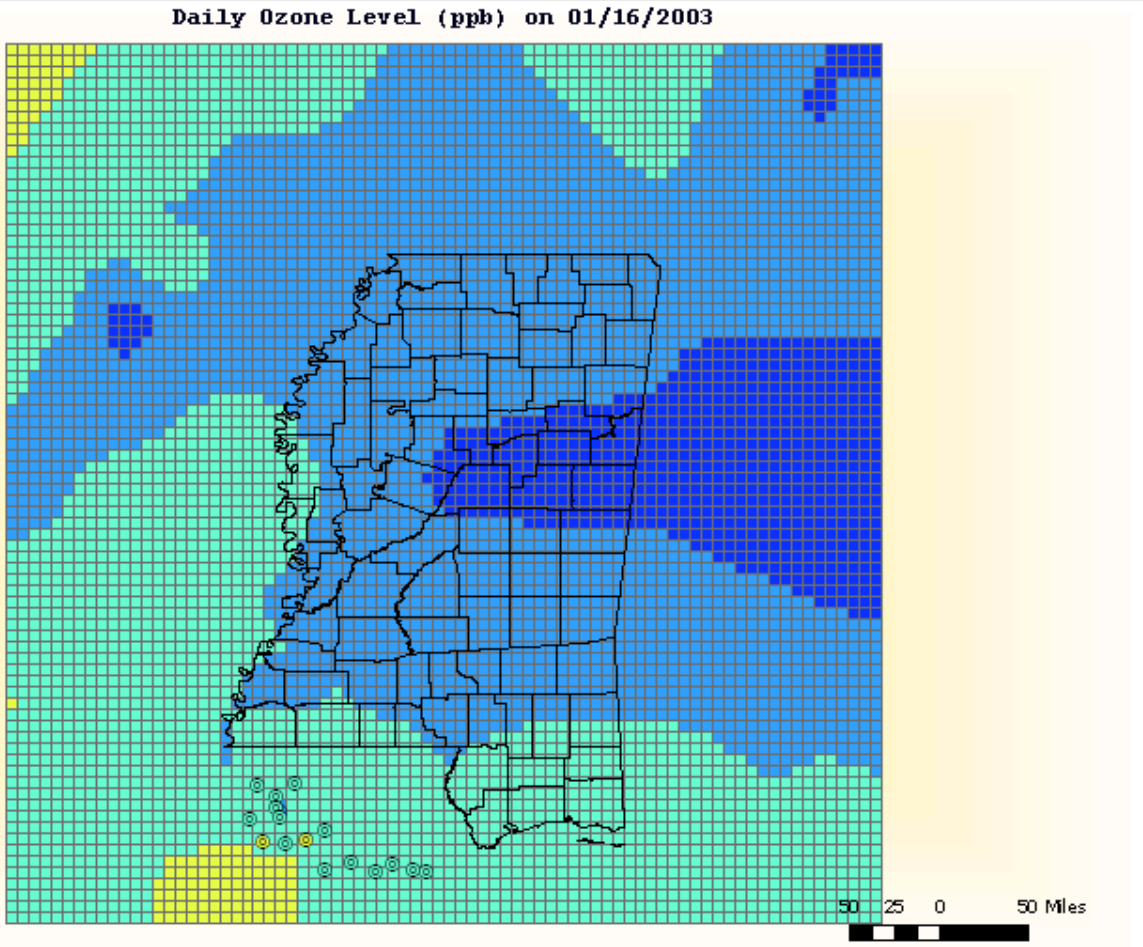
Pollutants

- PM2.5
- Ozone

Asthma Incidence

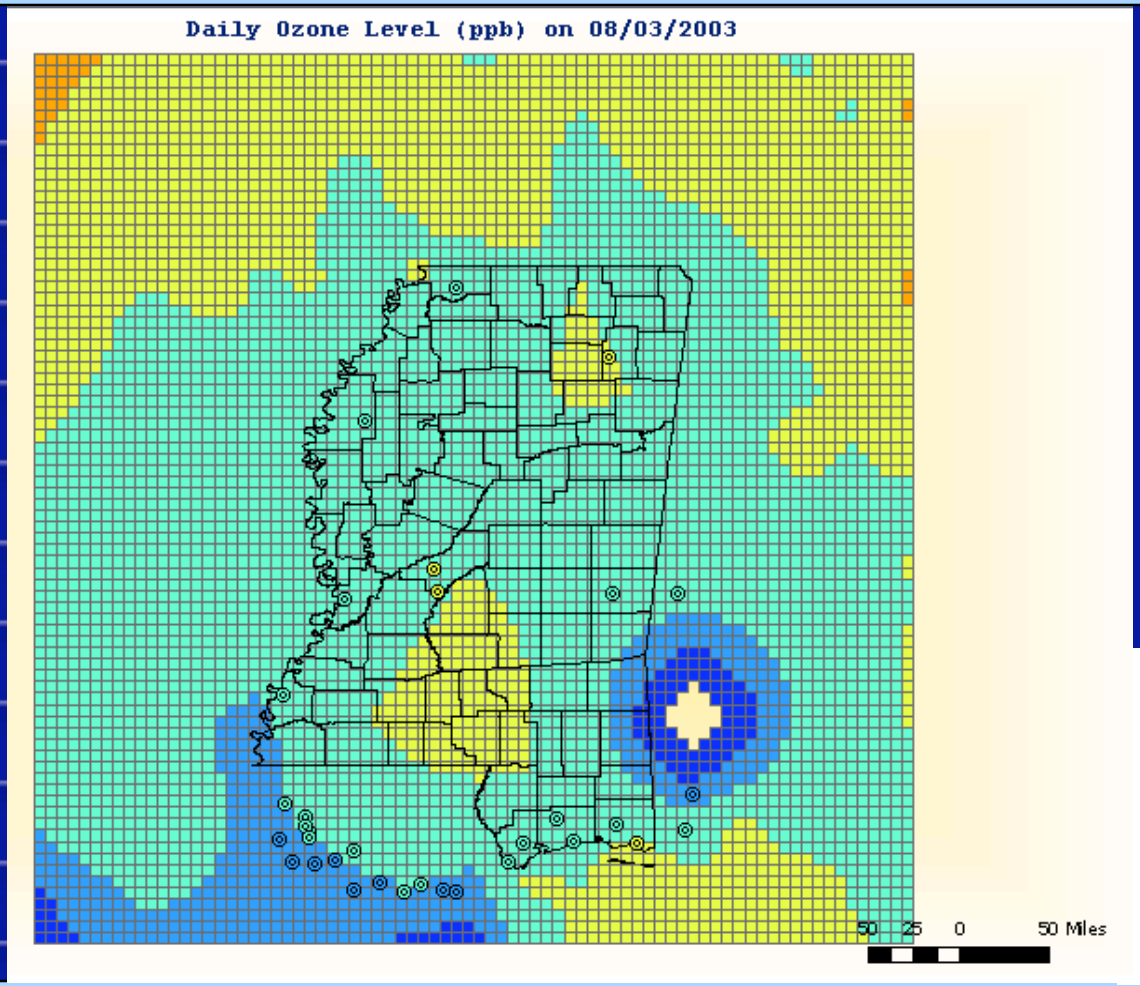
- Univ.of MS Medical Center
- MS Department of Health

Execute



Daily Ozone
Winter

GeoMedStat Demonstration



Daily Ozone
Summer

GeoMedStat for Air Pollution
Asthma Surveillance System

CHART DISPLAY | MAP DISPLAY | HELP

Date Selection

Enter Date: 1 16 2003

Map Option

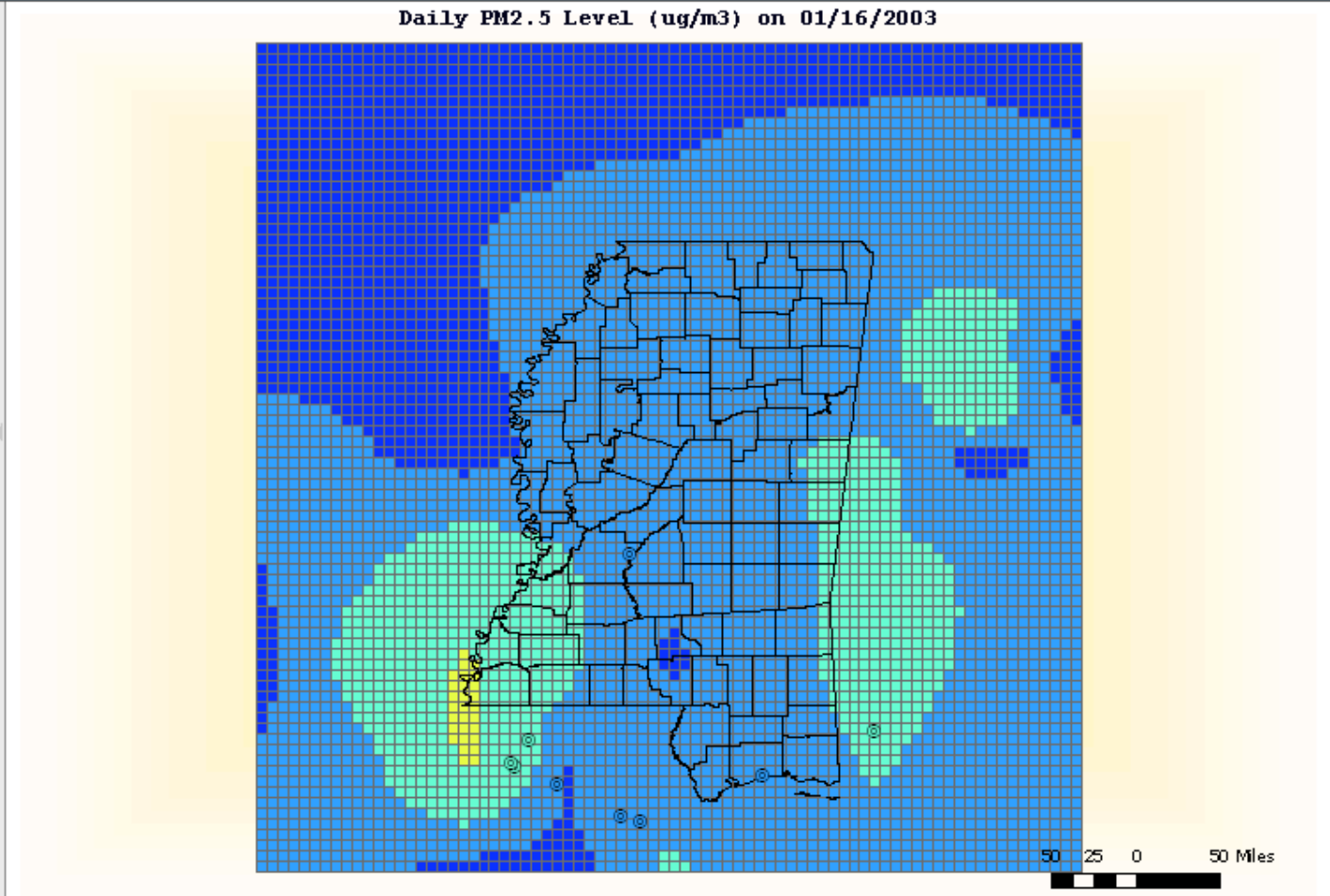
Pollutants

- (•) PM2.5
- ( ) Ozone

Asthma Incidence

- ( ) Univ.of MS Medical Center
- ( ) MS Department of Health

Execute



Daily PM2.5
Winter

GeoMedStat for Air Pollution
Asthma Surveillance System

CHART DISPLAY | MAP DISPLAY | HELP

Date Selection

Enter Date: 9 16 2003

Map Option

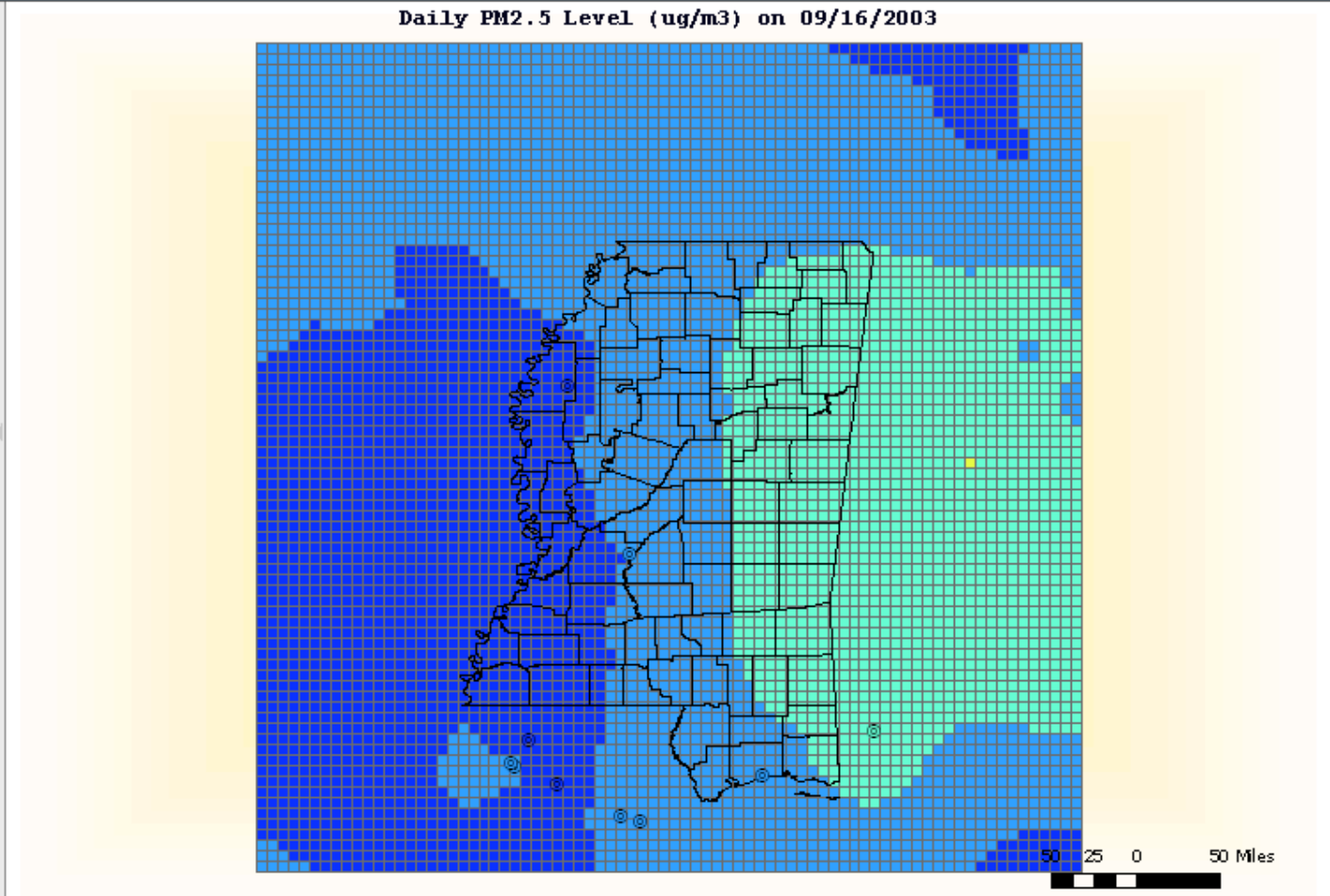
Pollutants

- (•) PM2.5
- ( ) Ozone

Asthma Incidence

- ( ) Univ.of MS Medical Center
- ( ) MS Department of Health

Execute



Daily PM2.5
Summer

GeoMedStat for Air Pollution
Asthma Surveillance System

CHART DISPLAY | MAP DISPLAY | HELP

Date Selection

Enter Date: 9 16 2003

Map Option

Pollutants

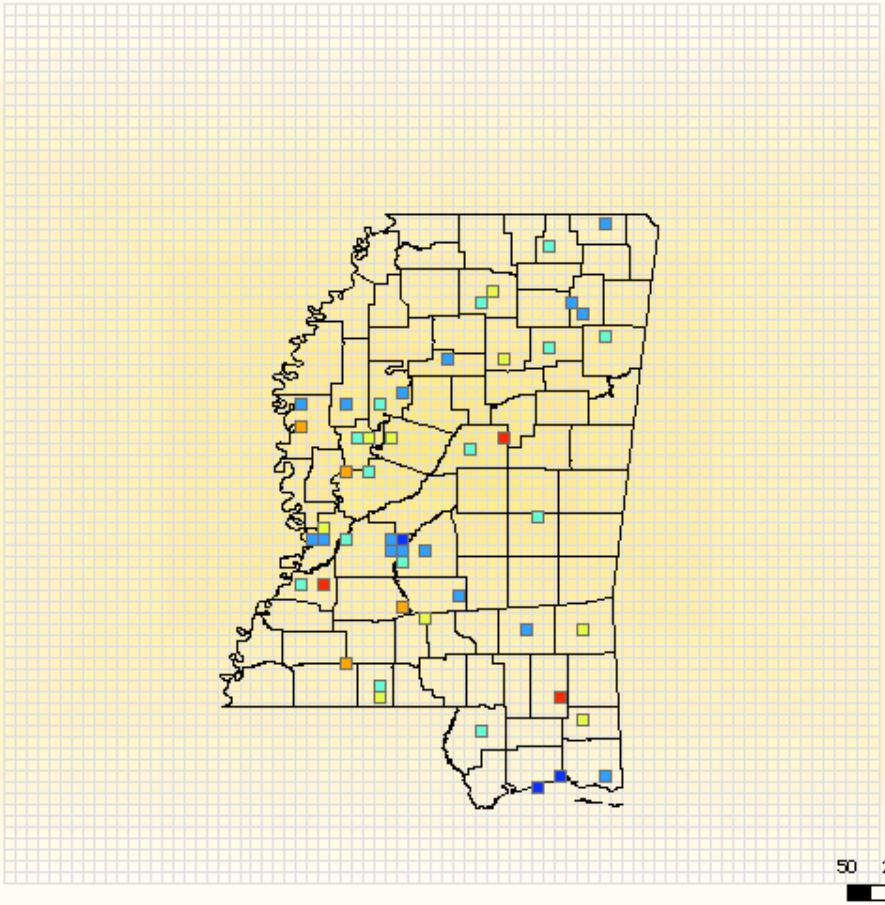
- ○ PM2.5
- ○ Ozone

Asthma Incidence

- ○ Univ.of MS Medical Center
- ◉ MS Department of Health

Execute

Daily Asthma Incident Rate per 10k Population on 09/16/2003



NASA

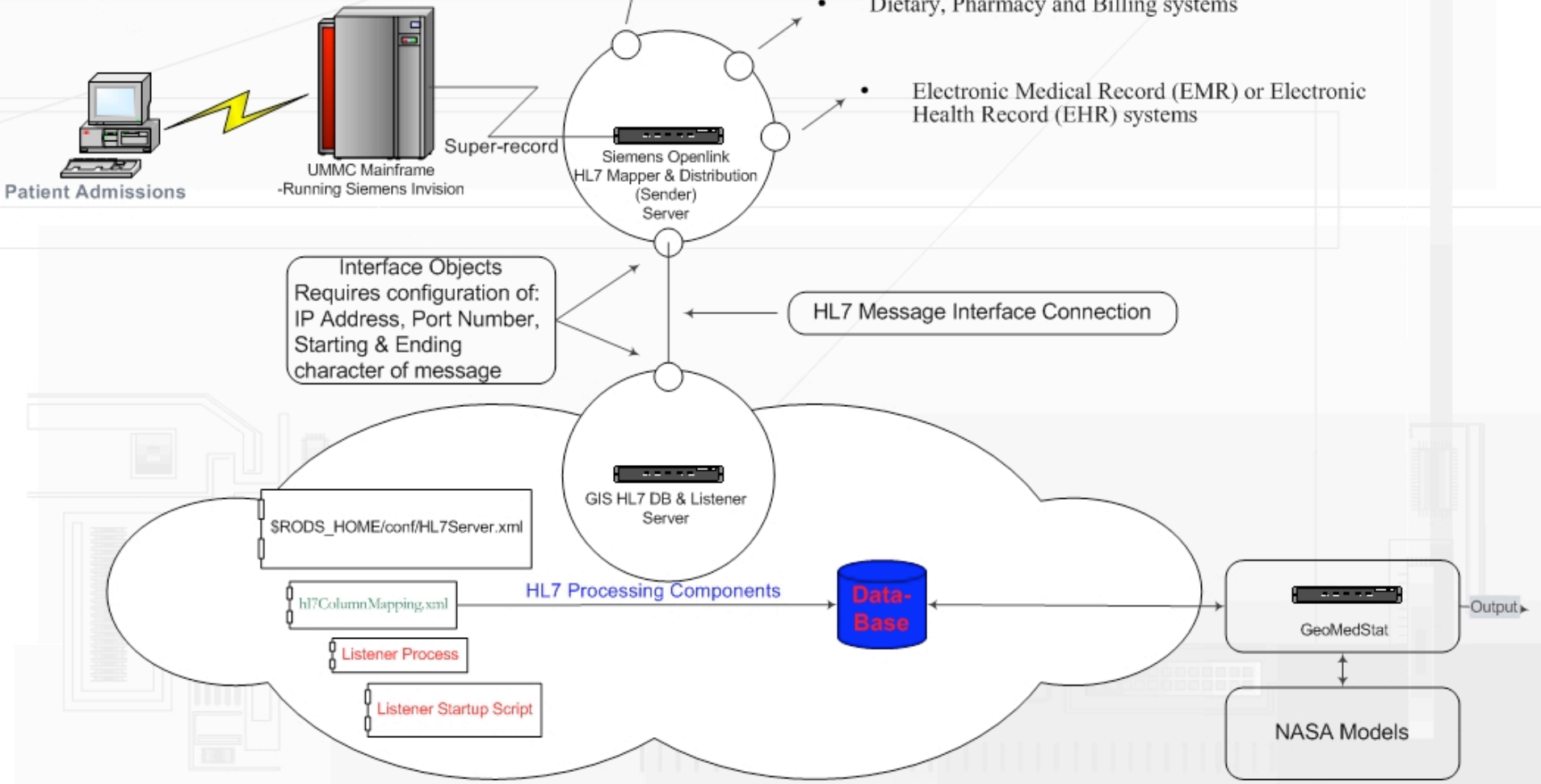
THE UNIVERSITY OF MISSISSIPPI MEDICAL CENTER 1955

University of Mississippi Medical Center

Real-time HL7 Listener Interface

HL7 Provides Interoperability for:

- Electronic Patient Administration Systems (PAS)
- Electronic Practice Management (EPM) systems
- Laboratory Information Systems (LIS)
- Dietary, Pharmacy and Billing systems
- Electronic Medical Record (EMR) or Electronic Health Record (EHR) systems



GeoMedStat for Air Pollution
Asthma Surveillance System

CHART DISPLAY | MAP DISPLAY | HELP

Date Selection

Enter Date: 2 26 2007

Map Option

Pollutants

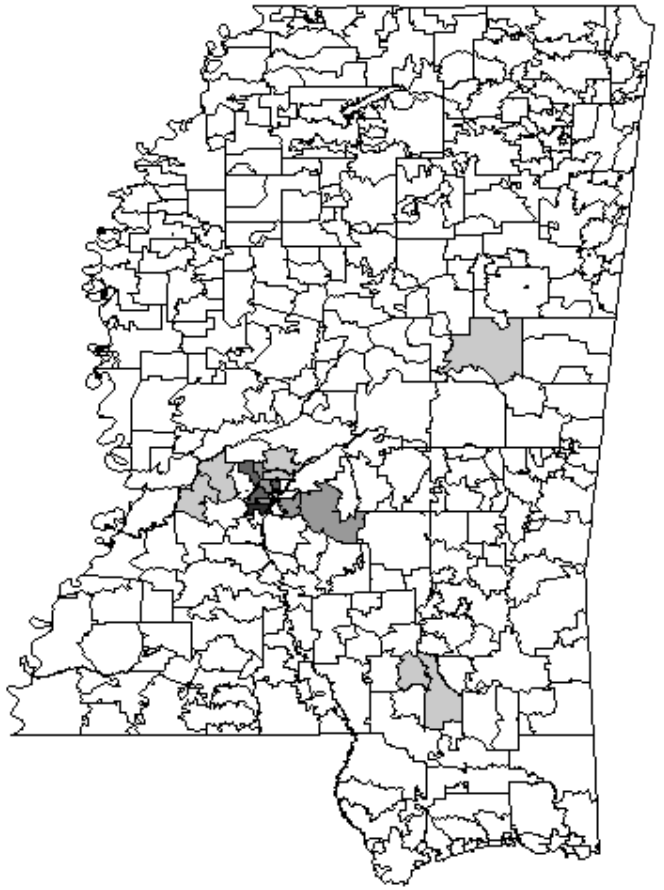
- PM2.5
- Ozone

Asthma Incidence

- Univ.of MS Medical Center
- MS Department of Health

Execute

Daily UMC Hospital Asthma Visit on 02/26/2007



30 15 0 30 Miles

NASA

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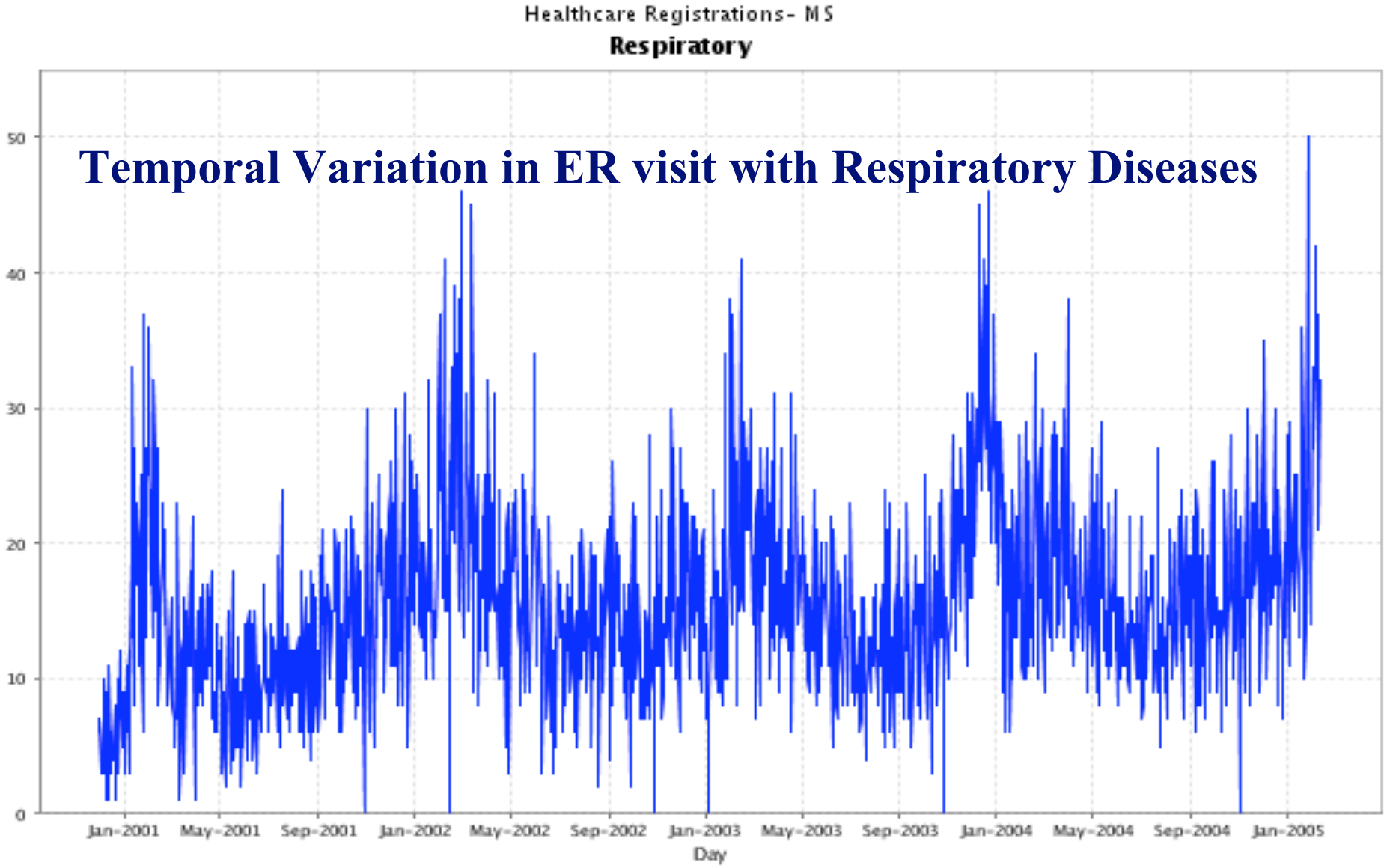

Healthcare Registrations- MS
Respiratory
Temporal Variation in ER visit with Respiratory Diseases
50
40
30
20
10
0
Jan-2001
May-2001
Sep-2001
Jan-2002
May-2002
Sep-2002
Jan-2003
May-2003
Sep-2003
Jan-2004
May-2004
Sep-2004
Jan-2005
Day

Background

GeoMedStat for Air Pollution
Asthma Surveillance System

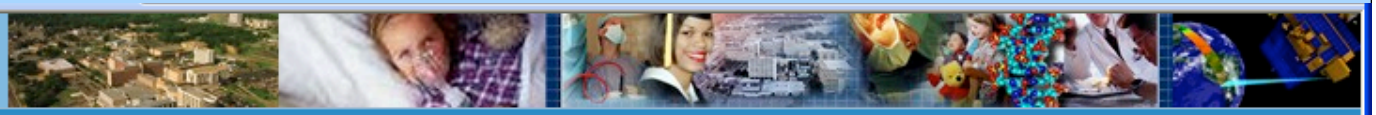


CHART DISPLAY | MAP DISPLAY | HELP

Date Selection

From Date: 1 1 2007

To Date: 4 29 2007

Chart Option

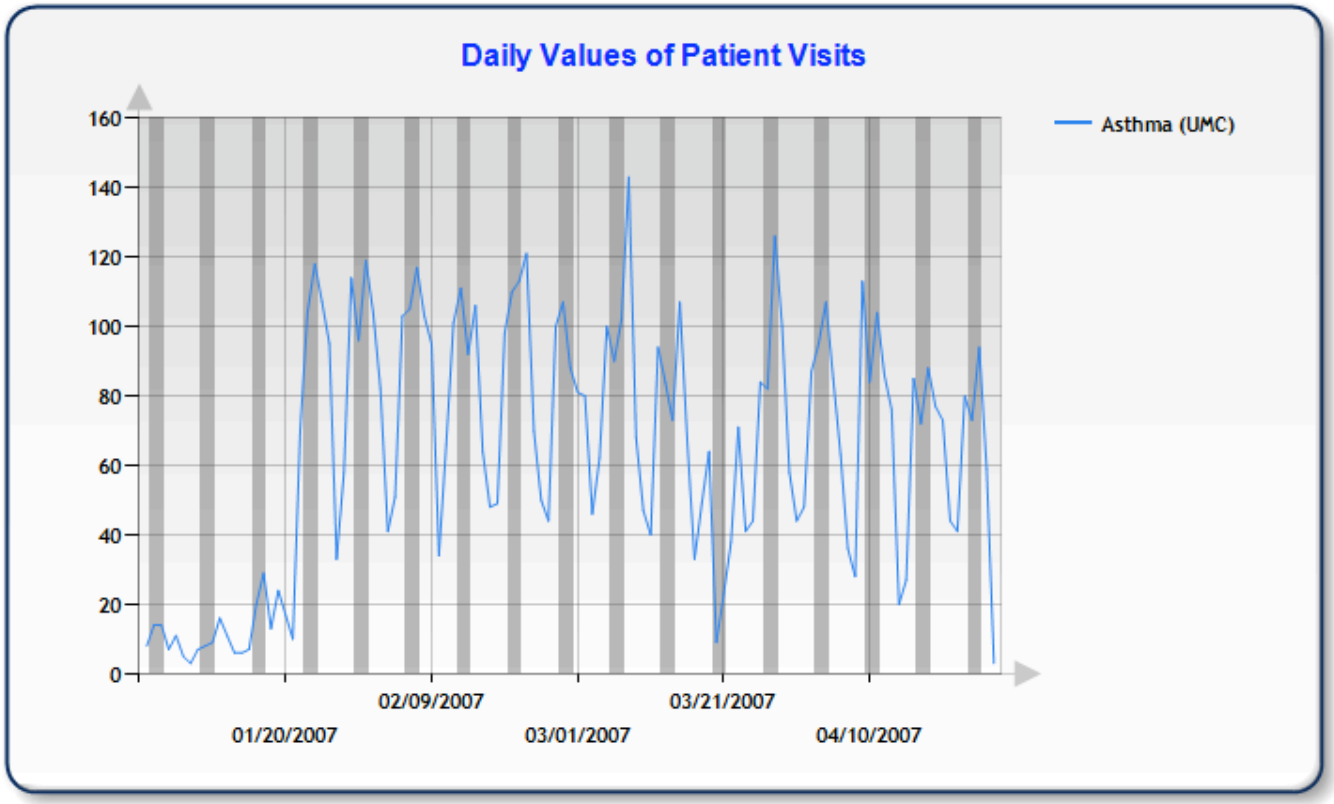
Pollutants

- [ ] PM2.5
- [ ] Ozone

Asthma Incidence

- [x] Univ.of MS Medical Center(UMC)
- [ ] MS Department of Health(MDH)

Execute



NASA

THE UNIVERSITY OF MISSISSIPPI MEDICAL CENTER 1955

GeoMedStat for Air Pollution
Asthma Surveillance System

CHART DISPLAY | MAP DISPLAY | HELP

Date Selection

From Date: 4 1 2003

To Date: 8 29 2003

Chart Option

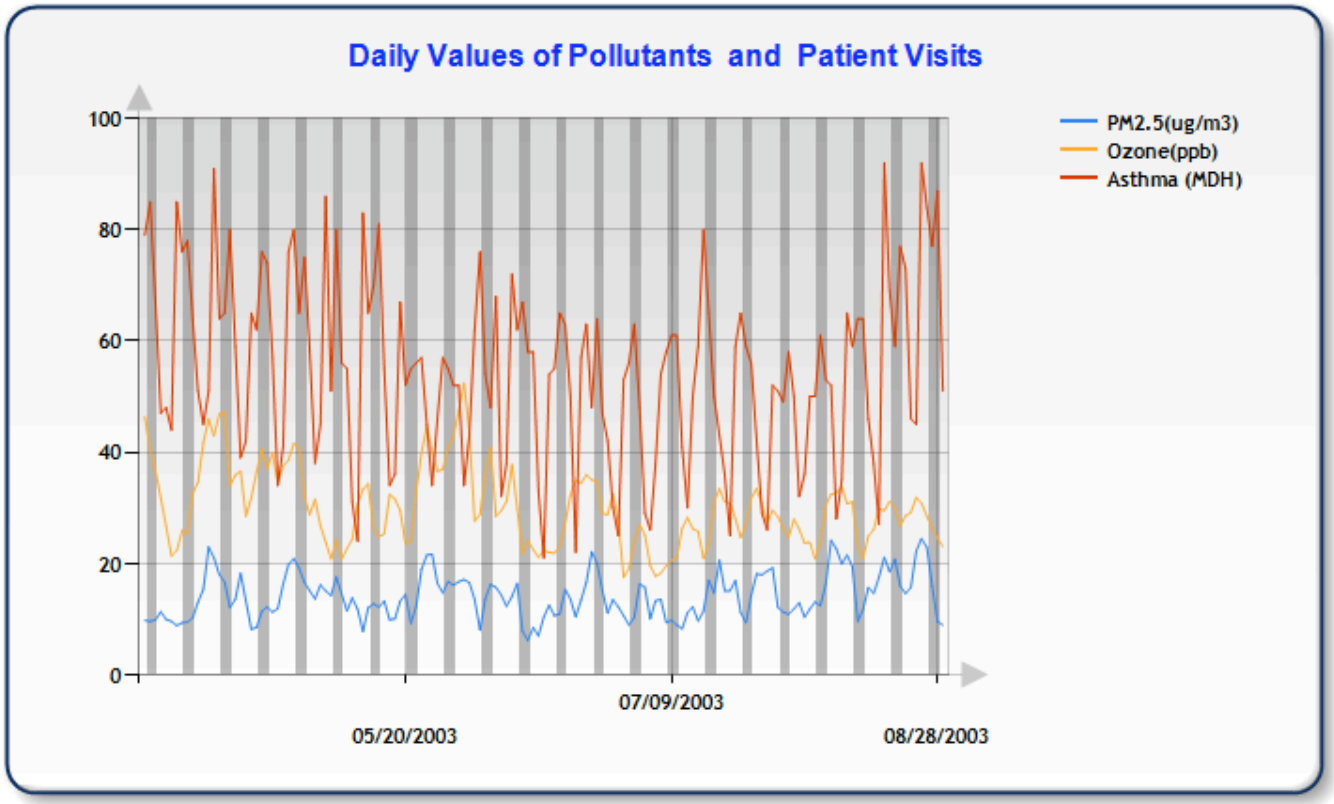
Pollutants

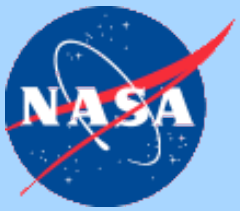
- [x] PM2.5
- [x] Ozone

Asthma Incidence

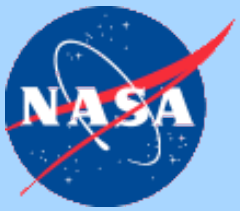
- [ ] Univ.of MS Medical Center(UMC)
- [x] MS Department of Health(MDH)

Execute

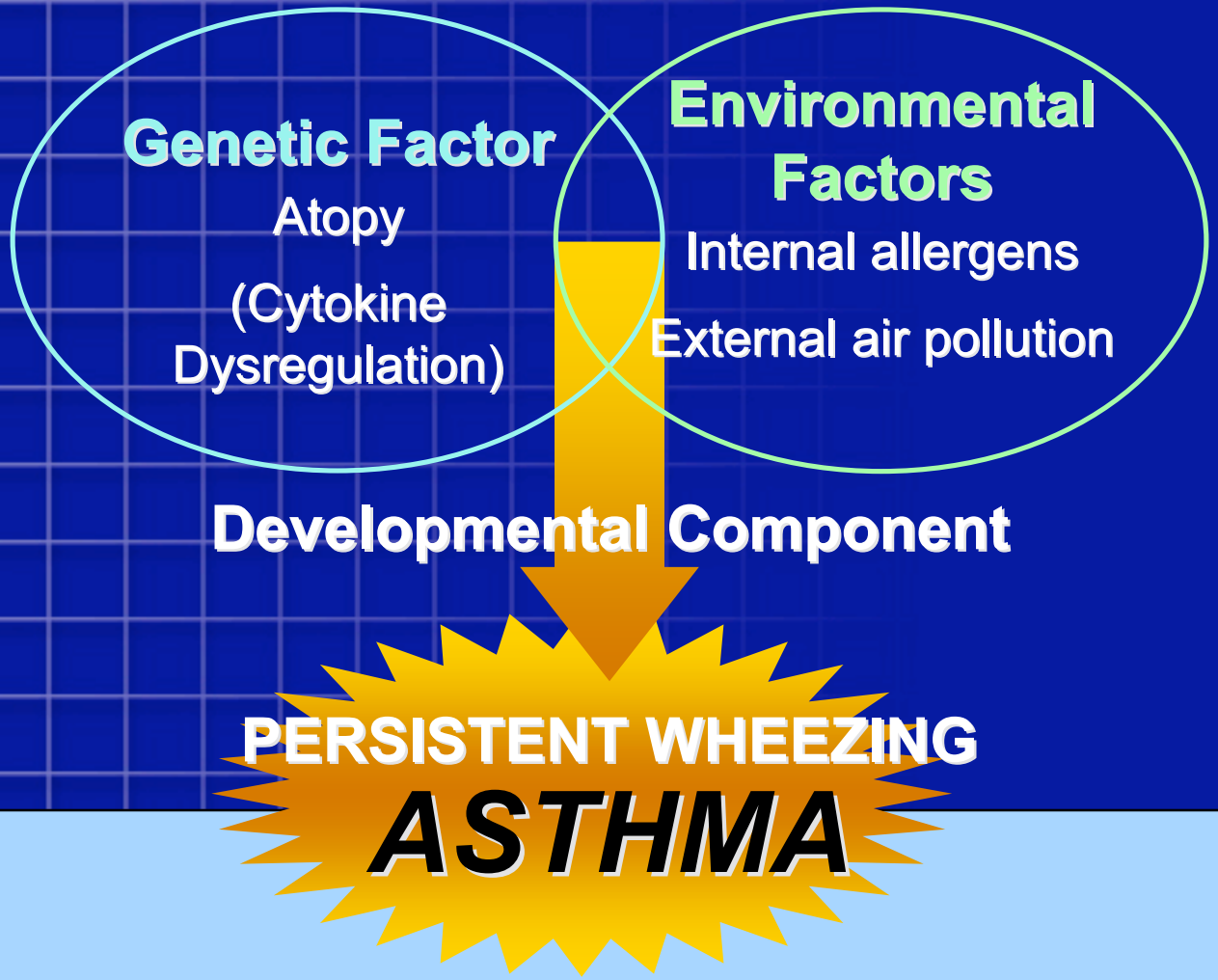




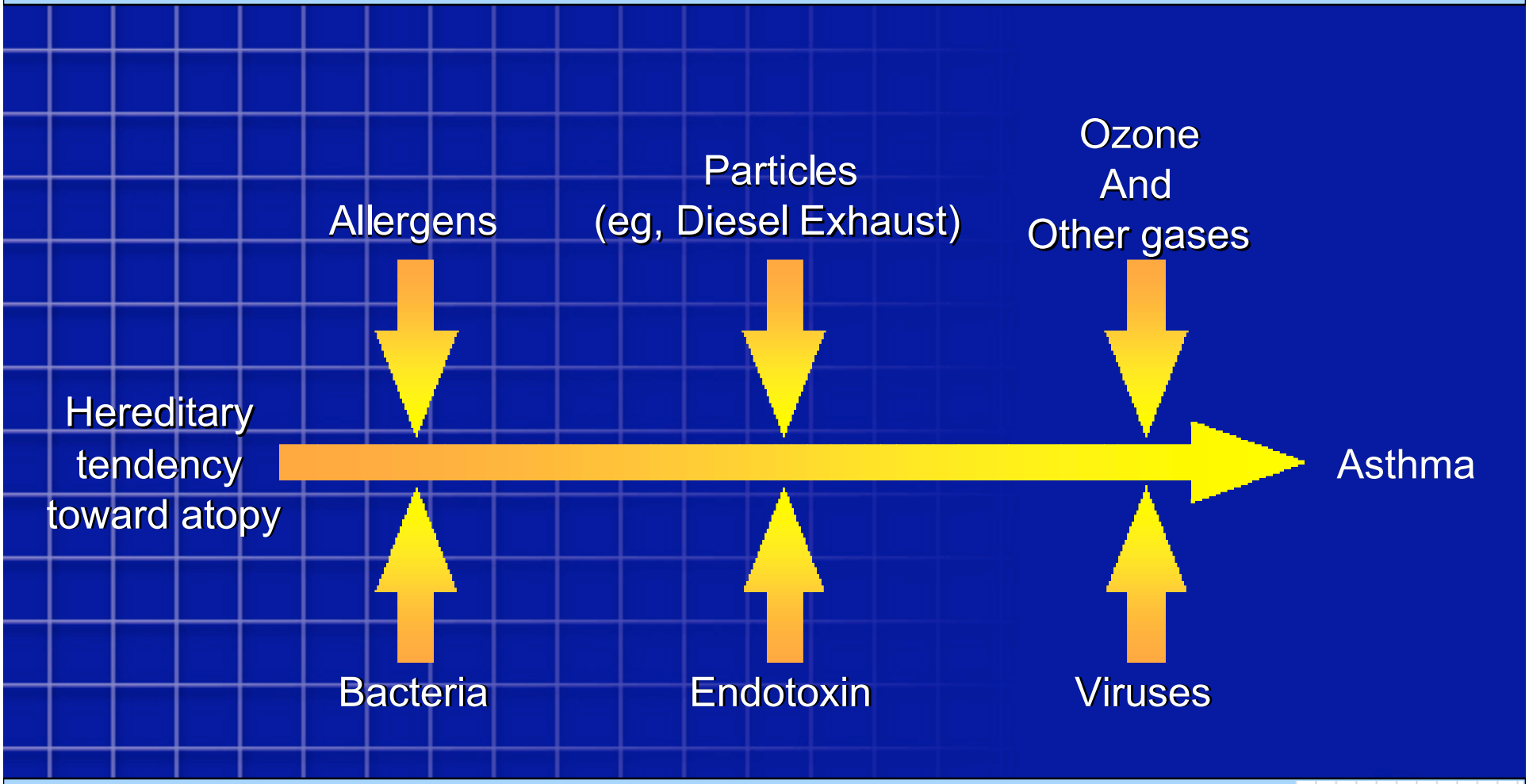
Significance



Factors Influencing Persistent Wheezing and Asthma



Influences on Asthma Development and Progression



Ozone and Asthma

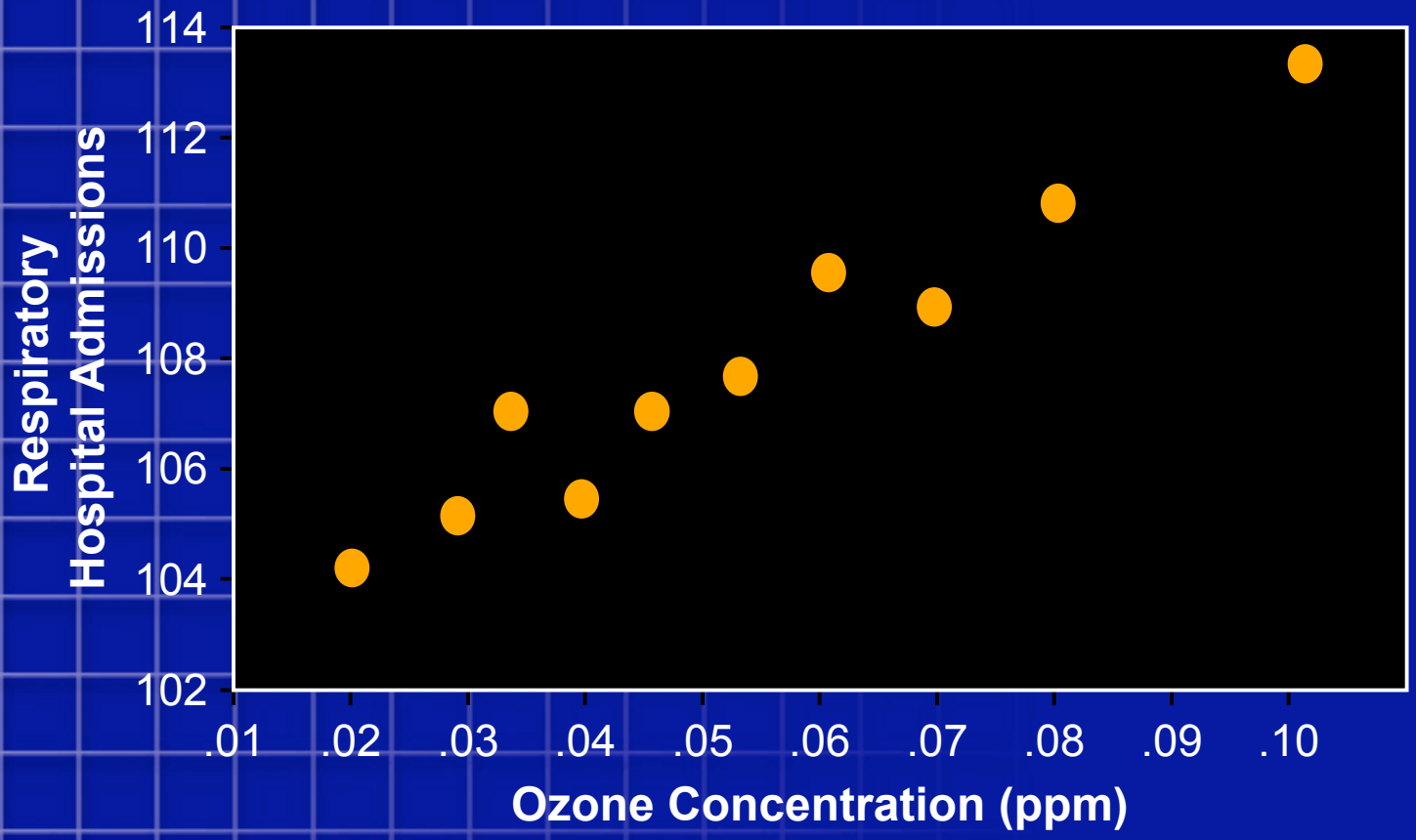
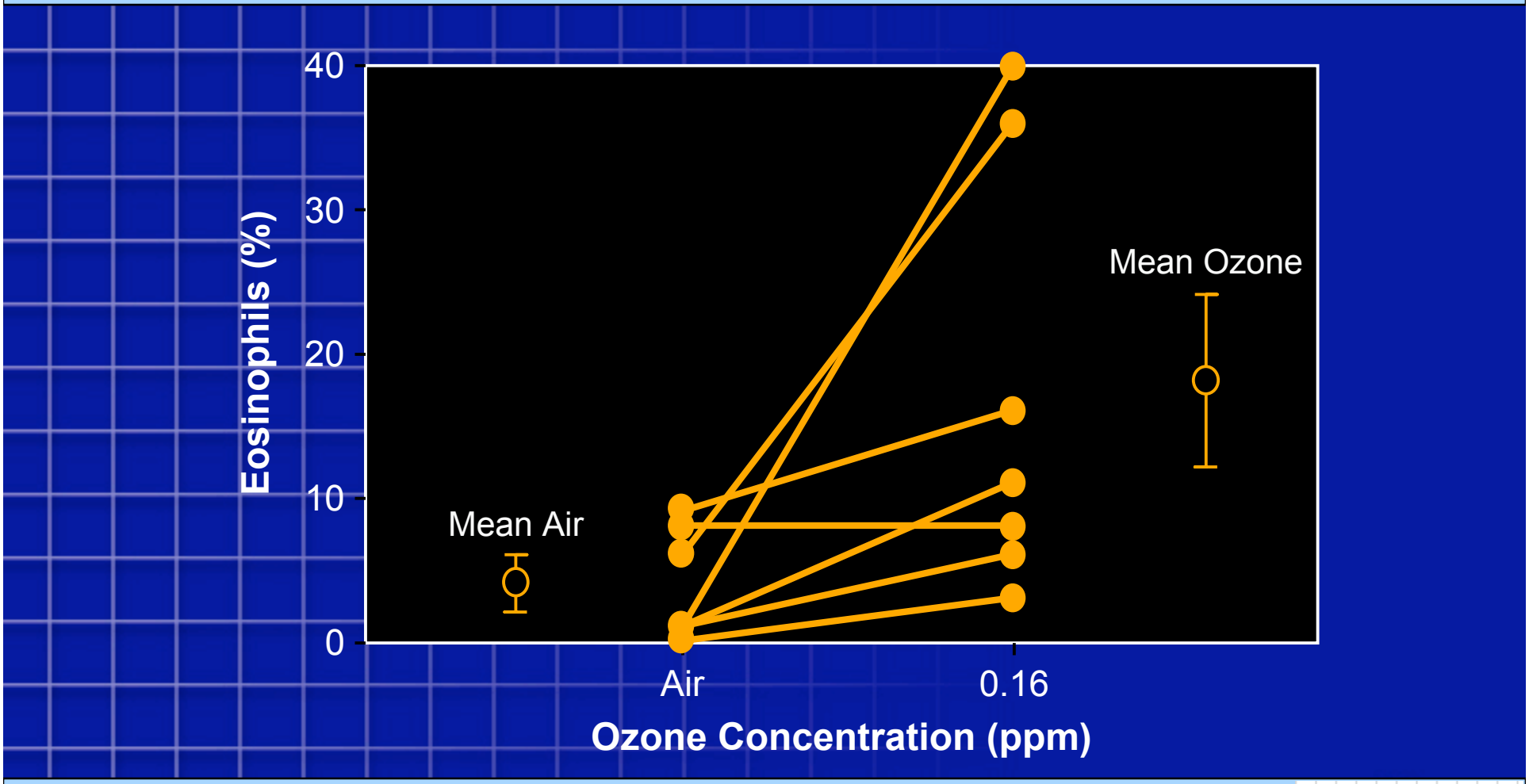


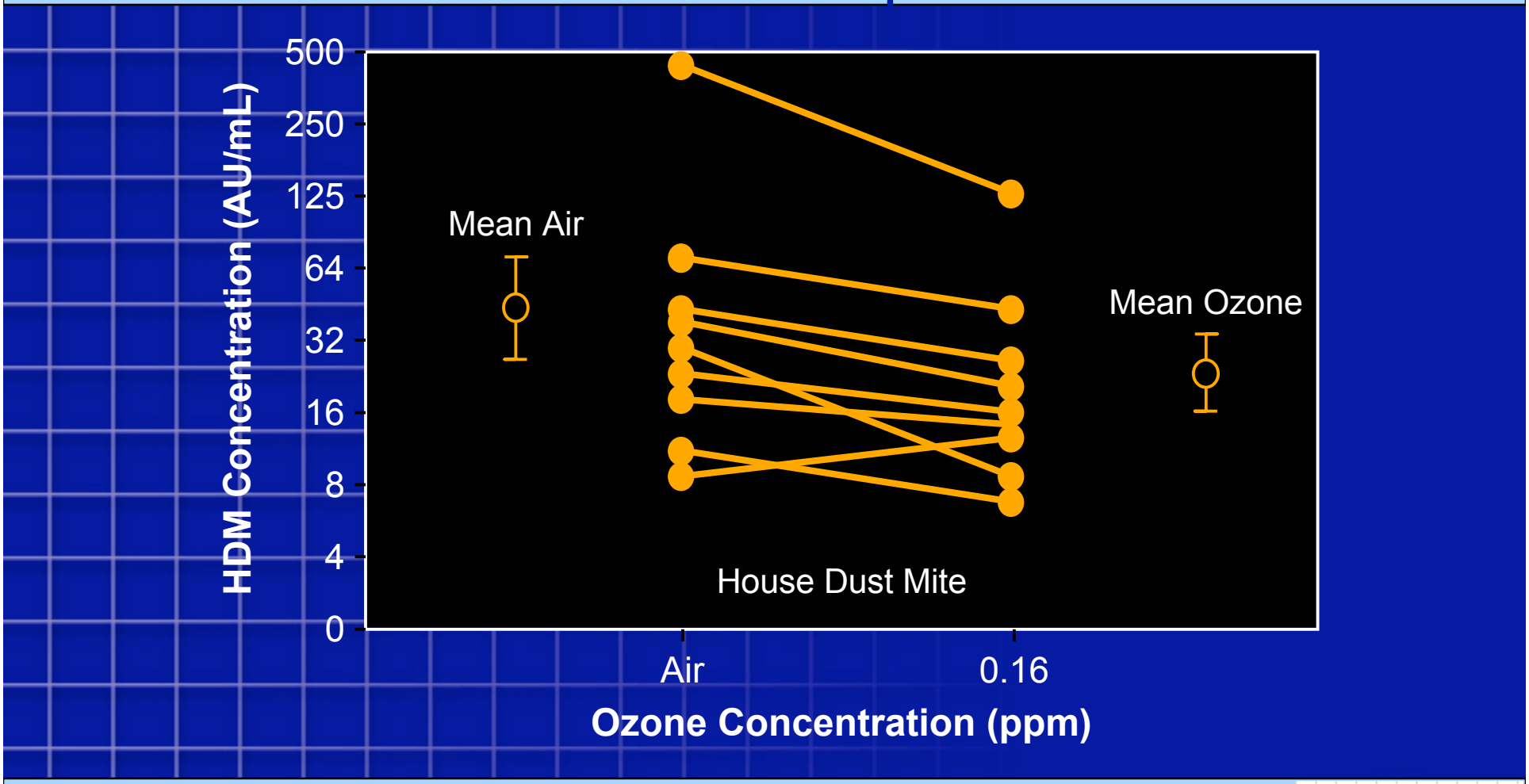
Figure from “Effects of Low Ambient Levels of Ozone and Sulfates on the Frequency of Respiratory Admission to Ontario Hospitals” in *Environmental Research*, Volume 65:172-194, Copyright © 1994 by Academic Press, reproduced by permission of the publisher.

Effect of Ozone on Airway Inflammation in Asthmatics



Reprinted with permission from Peden DB, et al. *J Allergy Clin Immunol.* 1997;100:802-808.

Ozone Reduces Threshold for Immediate Bronchial Response



AU, allergen units; HDM, house dust mite.

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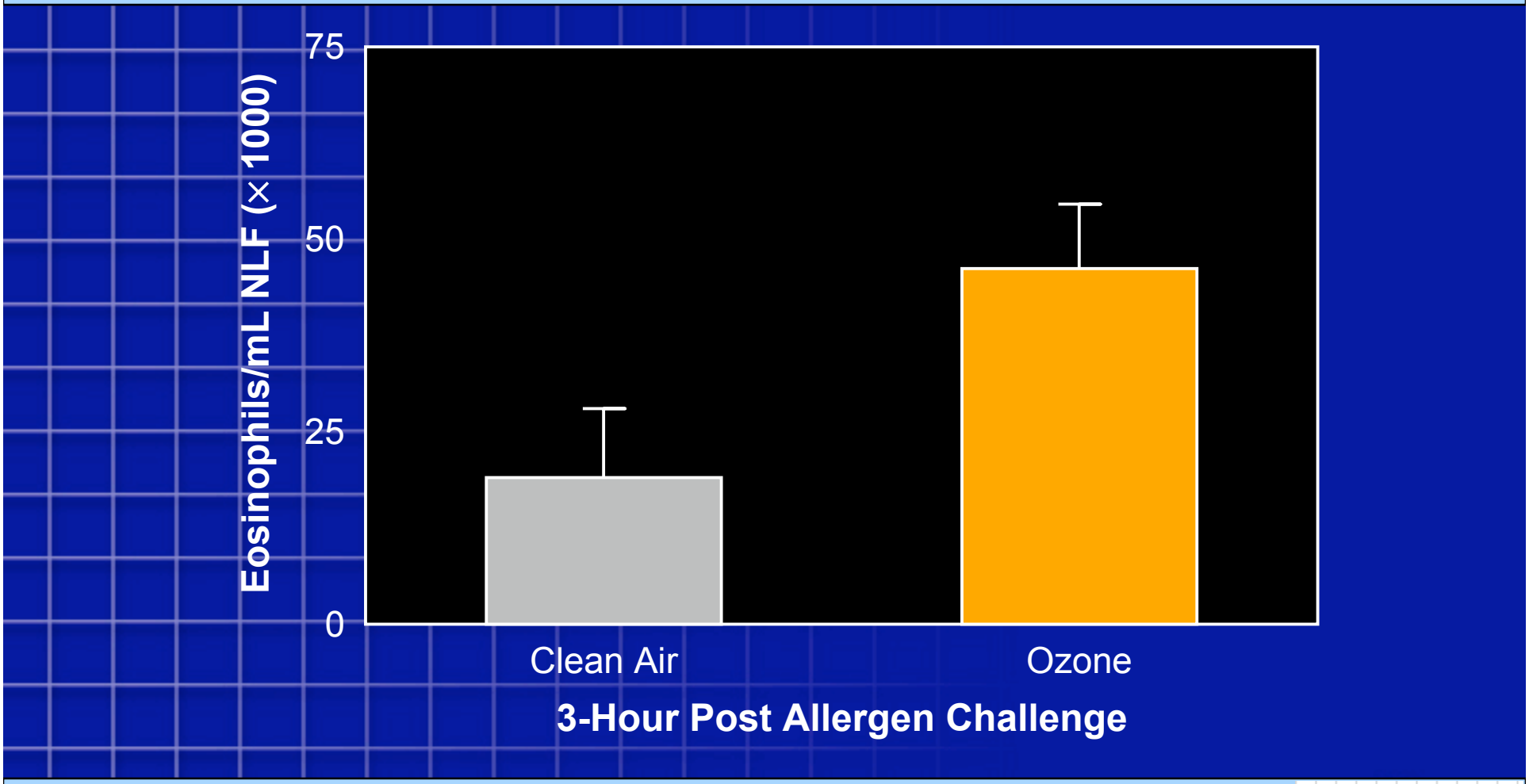
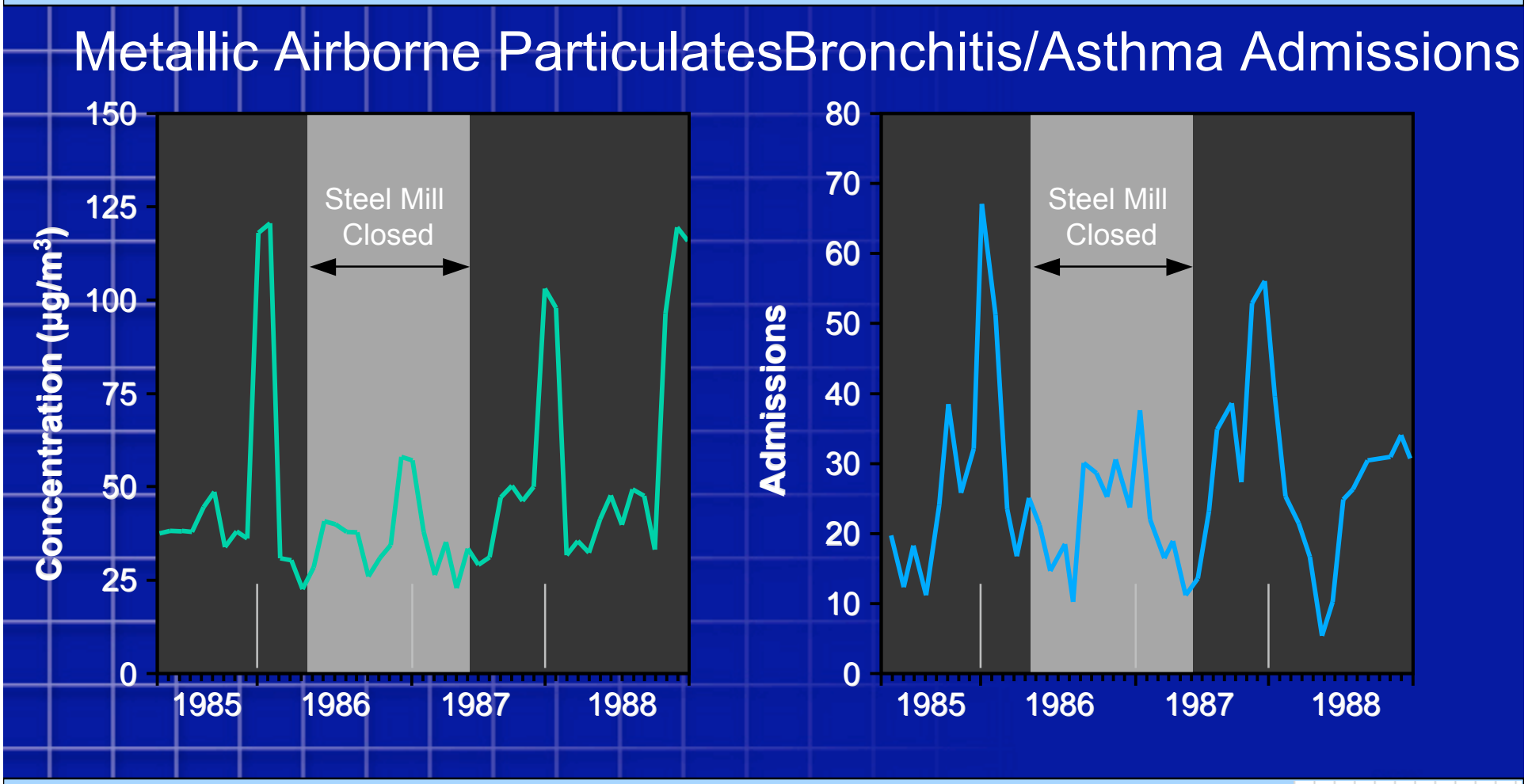
Ozone Worsens Late-Phase Response to Nasal Allergen



NLF, nasal lavage fluid.

Adapted from data published in Peden DB, et al. *Am J Respir Crit Care Med.* 1995;151:1336-1345.

Impact of Steel Mill Activity on Concentration of Metallic Airborne Particulates and Bronchitis/Asthma Admissions



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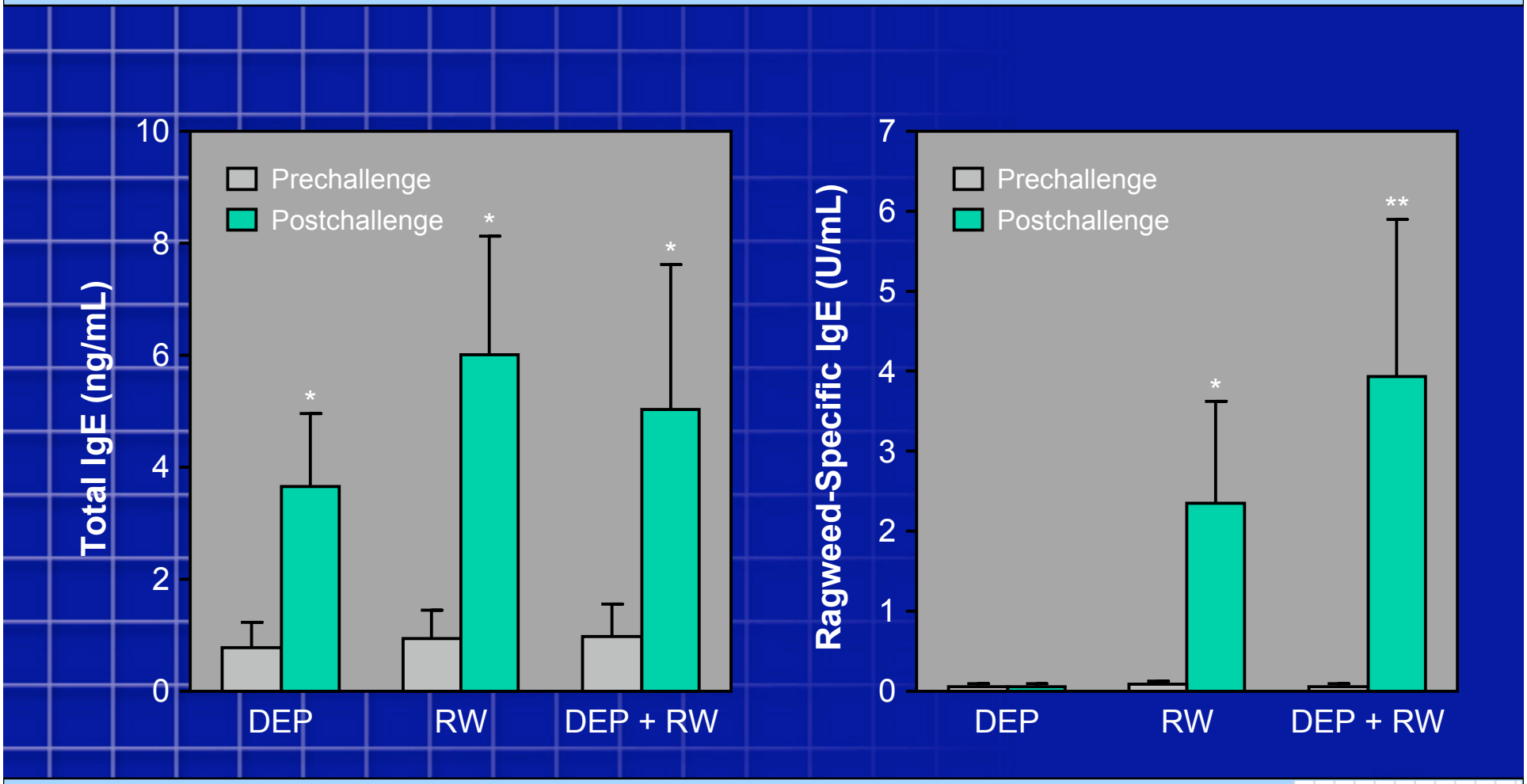
Diesel Exhaust Particles



*P<0.005, **P<0.001. DEP, diesel exhaust particles; RW, ragweed allergen.

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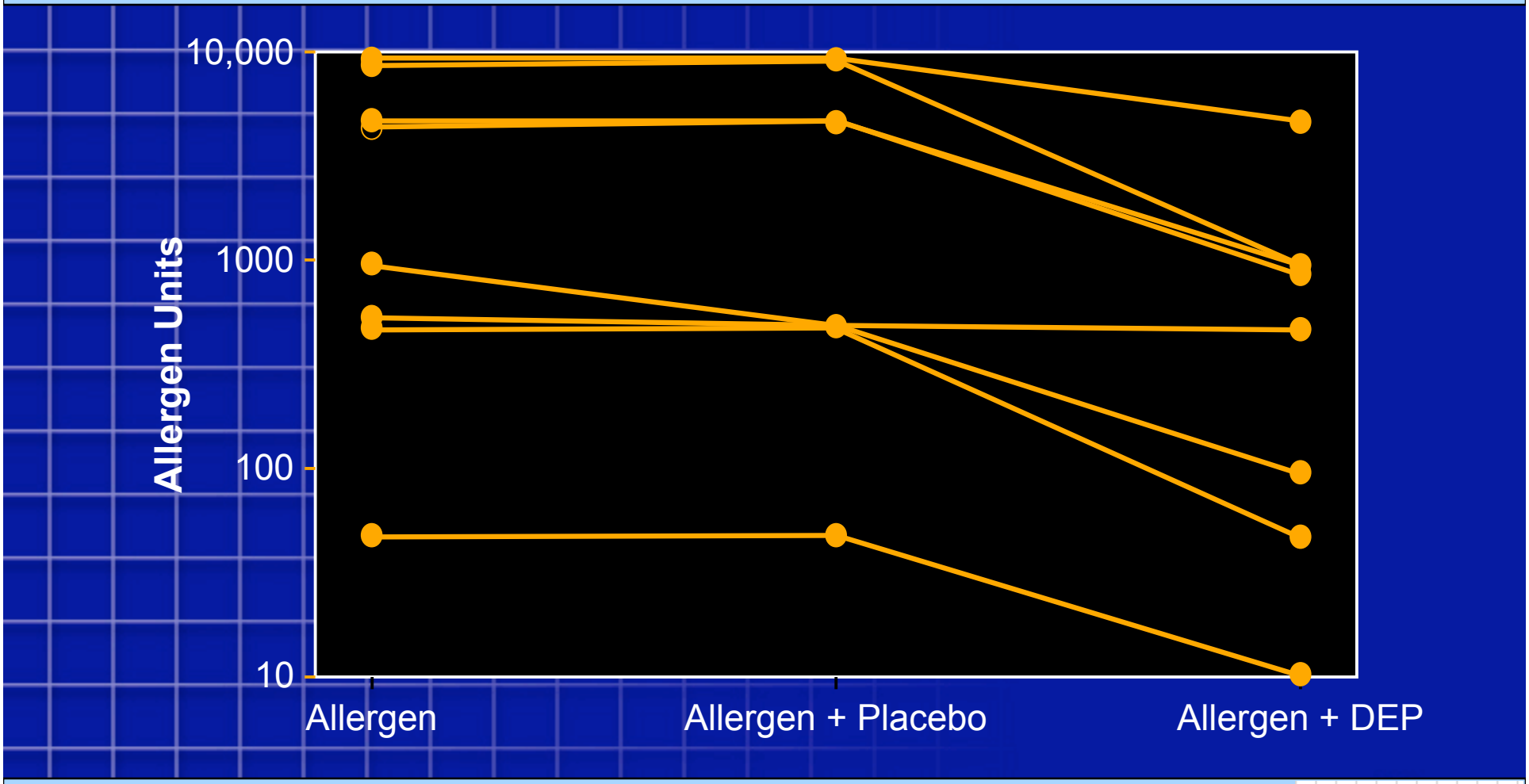
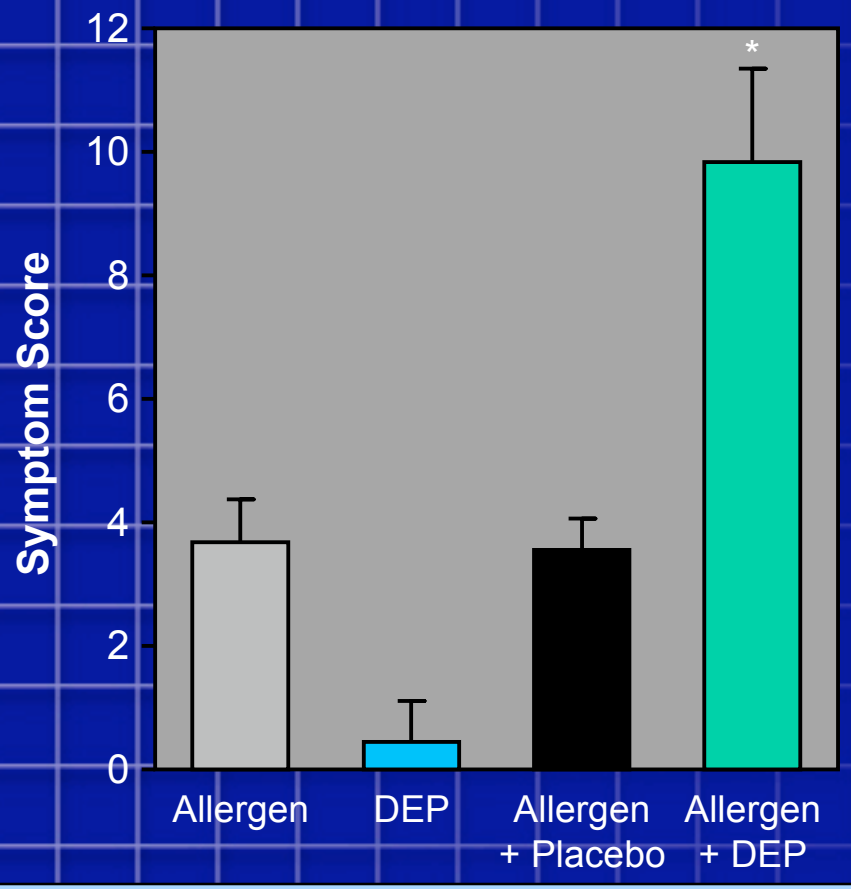
Diesel Exhaust Particles Lower Threshold for Allergic Symptoms

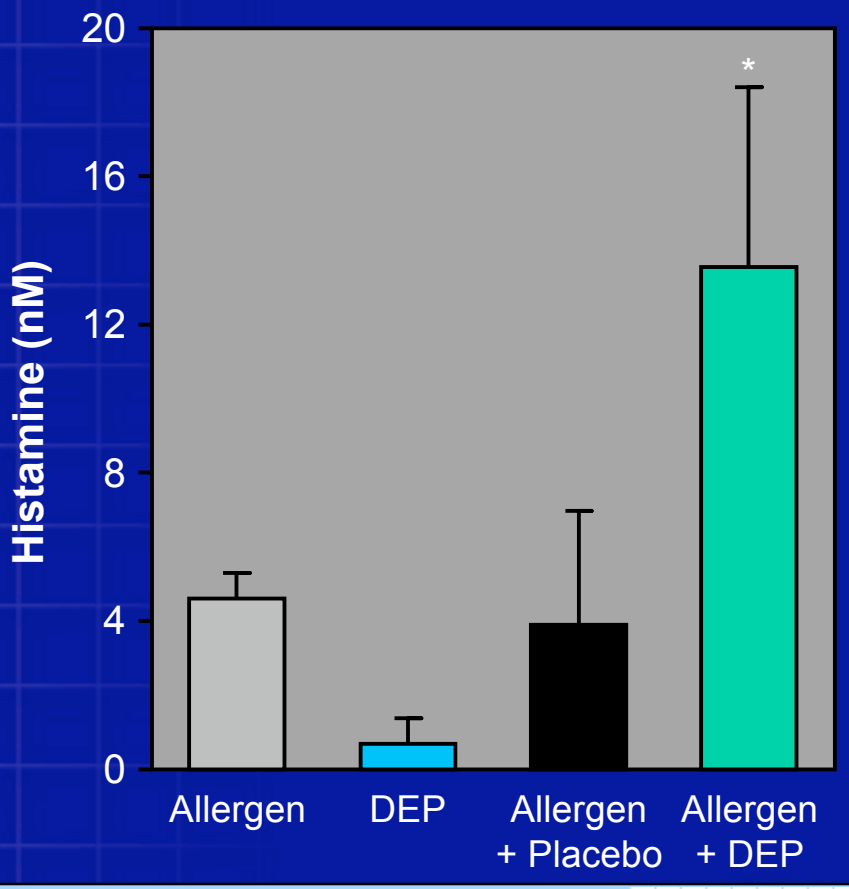


DEP, diesel exhaust particles.

Reprinted with permission from Diaz-Sanchez D, et al. *J Allergy Clin Immunol.* 2000;106:1140-1146.

Diesel Exhaust Particles Worsen Allergic Symptoms by Amplifying Histamine Release





*$P<0.01$ vs allergen control. DEP, diesel exhaust particles.

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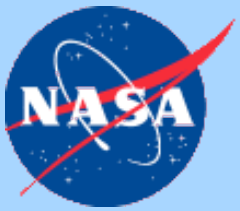
NAEPP Asthma Management Guidelines: Four Components of Asthma Management

- Measures of assessment and monitoring
- Control of factors that contribute to asthma severity
- Pharmacologic therapy
- Education for a partnership in asthma



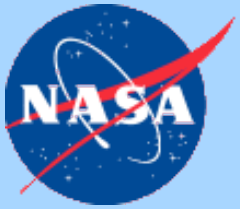
GINA 2006: Summary of Changes

- Shift of focus to asthma classification by control state
  - Controlled
  - Partially controlled
  - Uncontrolled
  - Exacerbation
- Goal of asthma treatment is to achieve and maintain control
- Introduces concept of difficult-to-treat asthma
- Increased emphasis on variability of symptoms and airflow limitation (spirometry, peak expiratory flow)

GINA. Global Strategy for Asthma Management and Prevention. 2006. Available online at http://ginasthma.org. Accessed November 28, 2006.

GINA 2006: Treating to Achieve Control

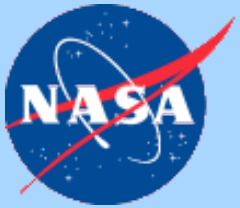
1. Assess level of asthma control; in the past week, has the patient had
   - Activity or exercise limited by asthma?
   - Daytime asthma symptoms more than twice?
   - The need to use rescue medication more than twice?
   - Peak flow or FEV_1 <80% of personal best?
   - Any exacerbations in past year?
   - 1-2 of the above = partially controlled; >2 of the above = uncontrolled
2. Identify patient's regular treatment
3. Adjust pharmacotherapy

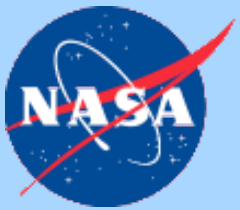


GINA. Global Strategy for Asthma Management and Prevention. 2006. Available online at http://ginasthma.org. Accessed November 28, 2006.

Conclusions

- Air pollutant effects on asthma
  - Modify inborn atopic phenotype to promote inflammation
  - Worsen clinical course of airway disease
  - Effects may be immediate or delayed depending upon severity of underlying illness and degree of pollution
- Reliably predicting environmental pollution levels should allow development of effective prophylactic strategies against asthma exacerbations



Conclusions

GeoMedStat, being able to access and display environmental data and asthma visit data both at same temporal and geographic frame, can track asthma rates and environmental risks