Health and Environment Linked for Information Exchange (HELIX)-Atlanta: A CDC-NASA Joint Environmental Public Health Tracking Collaborative Project

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Georgia Division of Public Health
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NASA Workshop on Applications of Environmental Remote Sensing to Air Quality and Public Health
Potomac, MD. May 8-9, 2007

HELIX ATLANTA
Bridging Health & Environment

Team Members and Acknowledgements

Member's Name, Affiliation

- (*Co-Chair)* Kafayat Adeniyi, Centers for Disease Control and Prevention,
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- Rob Blake, DeKalb County Board of Health
- David Blaney, Georgia Division of Public Health
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- Dale Quattrochi, National Aeronautics and Space Administration
- Amber Sinclair, Kaiser Permanente
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- Denis Tolsma, Kaiser Permanente
- Linda Thomas, Environmental Protection Agency, Region 4
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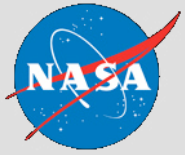
Acknowledgments

- Leslie Fierro, Centers for Disease Control and Prevention
- Gabriel Rainisch, Centers for Disease Control and Prevention
- Pamela Meyer, Centers for Disease Control and Prevention
- Jeff Shire, Centers for Disease Control and Prevention
- Emily Hansen
- HELIX-Atlanta Partners

HELIX-Atlanta Overview

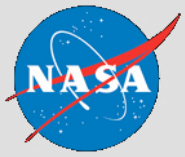
CDC's National Environmental Public Health Tracking (EPHT) Program initiated in 2002

- Congressional funding for *development and implementation of a nationwide environmental health tracking network and capacity development in environmental health at State and local health Departments"*

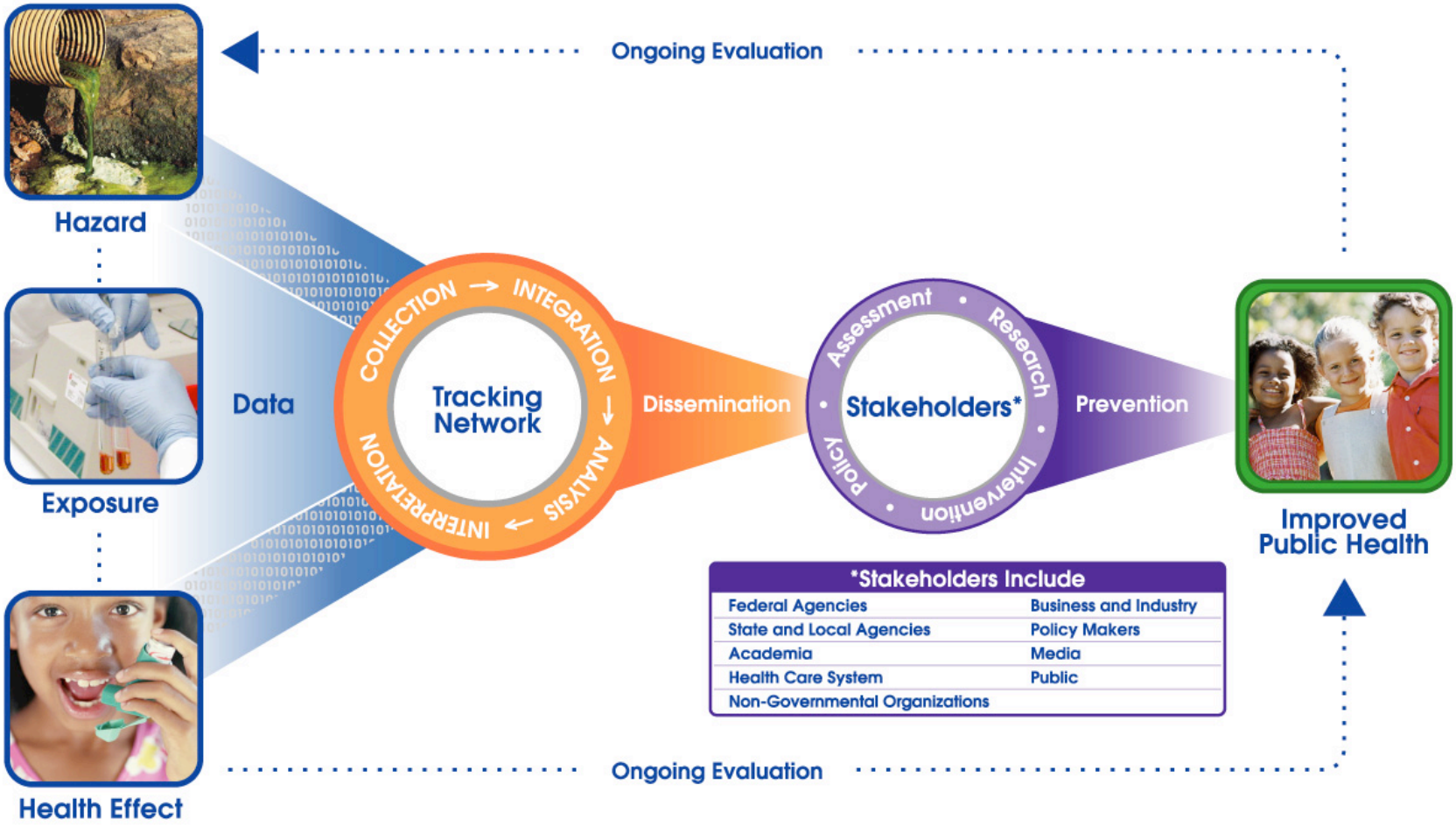


Selected EPHT Network Features

- Tools for linkage, visualization, analysis, generation of alerts, & reporting
- Internet-based
- Standards-based
- HIPAA compliant
- Access to the network is based on role & purpose



Environmental Public Health Tracking



Department of Health and Human Services
Centers for Disease Control and Prevention
Safer • Healthier • People

HELIX-Atlanta

- Provide information regarding the 5-county Metro-Atlanta Area
  - Clayton, Cobb, DeKalb, Fulton, & Gwinett
- Integrate environment & public health data into a local network that is part of a national network
- Take action to prevent & control environmentally related health effects

HELIX-Atlanta Overview

- HELIX-Atlanta was developed to support current and future state and local EPHT programs to implement data linking demonstration projects which could be part of the EPHT Network.
- HELIX-Atlanta is a pilot linking project in Atlanta for CDC to learn about the challenges the states will encounter.
- NASA/MSFC and the CDC are partners in linking environmental and health data to enhance public health surveillance.
- The use of NASA technology creates value – added geospatial products from existing environmental data sources to facilitate public health linkages.
- Proving the feasibility of the approach is the main objective

HELIX-Atlanta Challenges

- Sharing data between agencies with different missions and mindsets
- Protecting confidentiality of information
- Ensuring high quality geocoded data
- Ensuring appropriate spatial and temporal resolutions of environmental data
- Developing sound resources and methods for conducting data linkages and data analysis

HELIX-Atlanta Respiratory Health Team

RH Team Pilot Data Linkage Project:

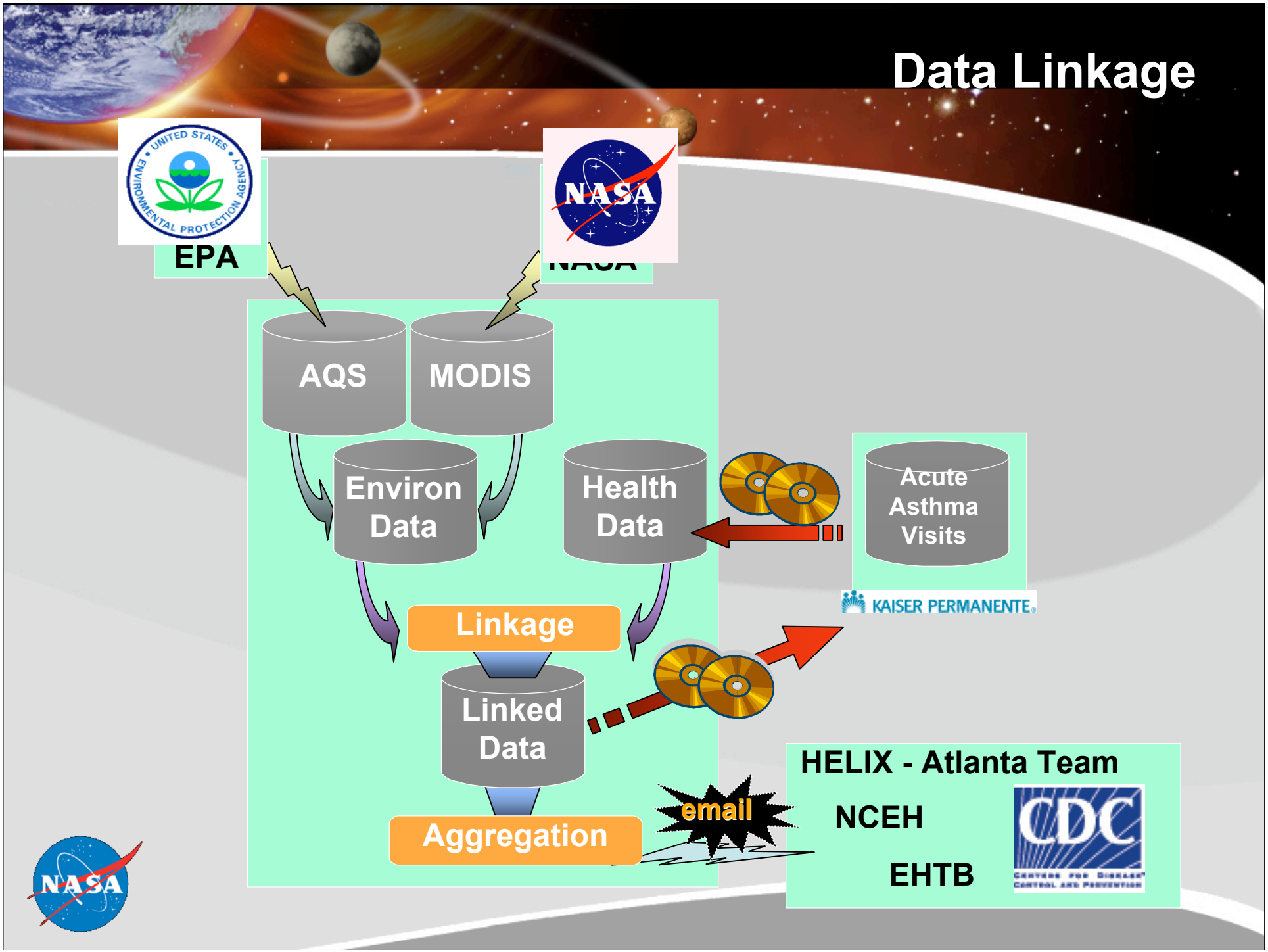
Link environmental data related to ground-level $PM_{2.5}$ (NASA+EPA) with health data related to asthma

Goals:

- **Produce and share information on methods useful for integrating and analyzing data on asthma and $PM_{2.5}$ for environmental public health surveillance.**
- **Generate information and recommendations valuable to sustaining surveillance of asthma with $PM_{2.5}$ in the Metro-Atlanta area.**

Environmental Hazard Measure: Daily $PM_{2.5}$
Asthma Measure: Daily acute asthma office visits to KP-GA Medical Facilities
Time period: 2001-2003
Linkage Domain: 5-county metropolitan Atlanta

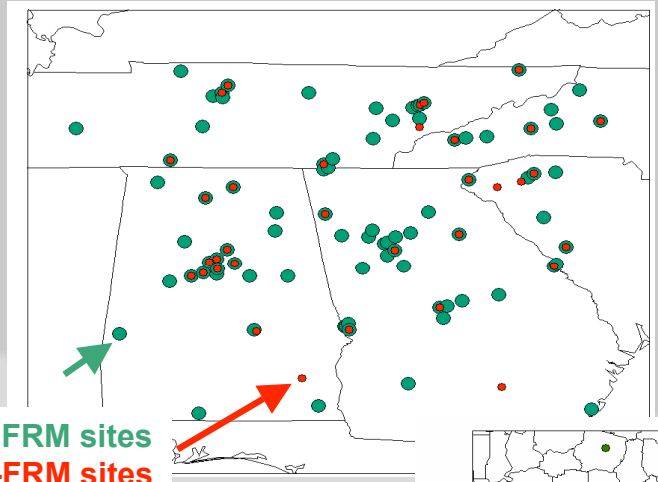
Data Linkage

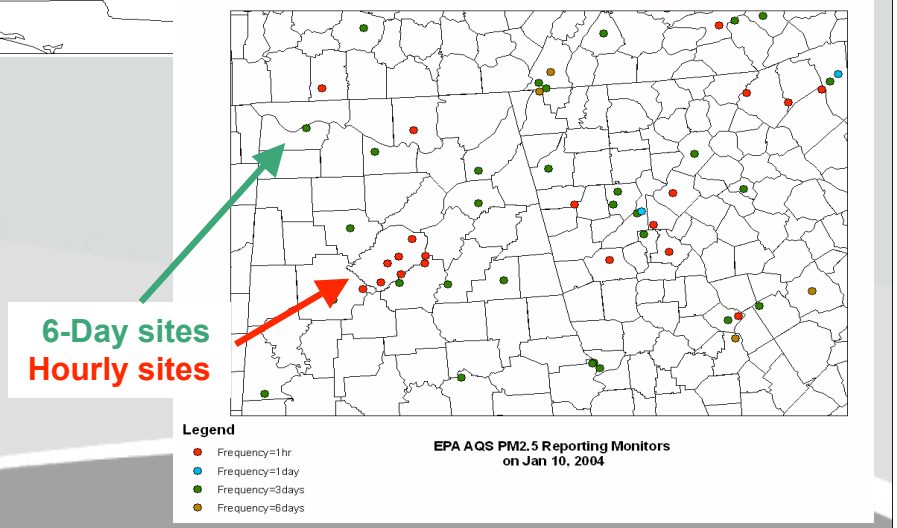


Sources of $PM_{2.5}$ data: EPA AQS

EPA Air Quality System (AQS) ground measurements

- National network of air pollution monitors
- Concentrated in urban areas, fewer monitors in rural areas
- Time intervals range from 1 hr to 6 days (daily meas. every 6th day)
- Three monitor types:
  - Federal Reference Method (FRM)
  - Continuous
  - Speciation
- FRM is EPA-accepted standard method; processing time 4-6 weeks





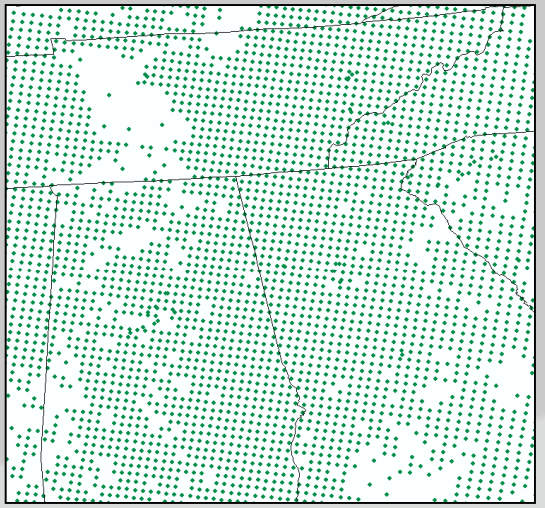
Sources of $PM_{2.5}$ data: MODIS

MODIS Aerosol Optical Depth (AOD)

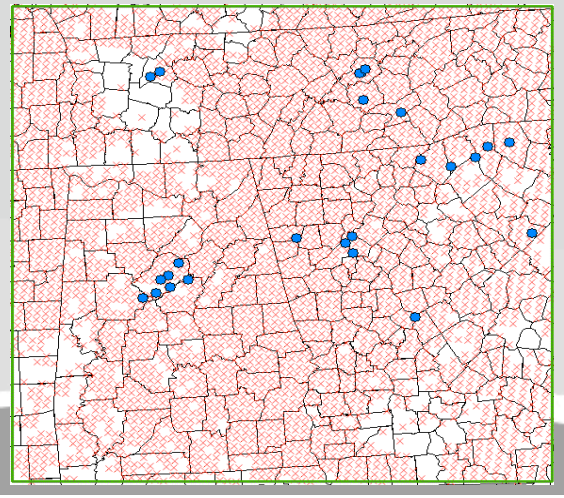
- AOD is a measure of the total particulate in the atmosphere
- If atmosphere is well mixed, AOD is a good indicator of surface $PM_{2.5}$
- Enhanced Spatial Coverage
- Provided on a 10x10 km grid
- Available twice per day

(Terra ~10:30 AM, Aqua ~1:30 PM)

- Clear-sky coverage only
- Available since spring 2000



MODIS

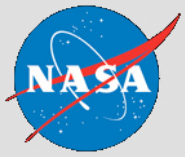


AQS

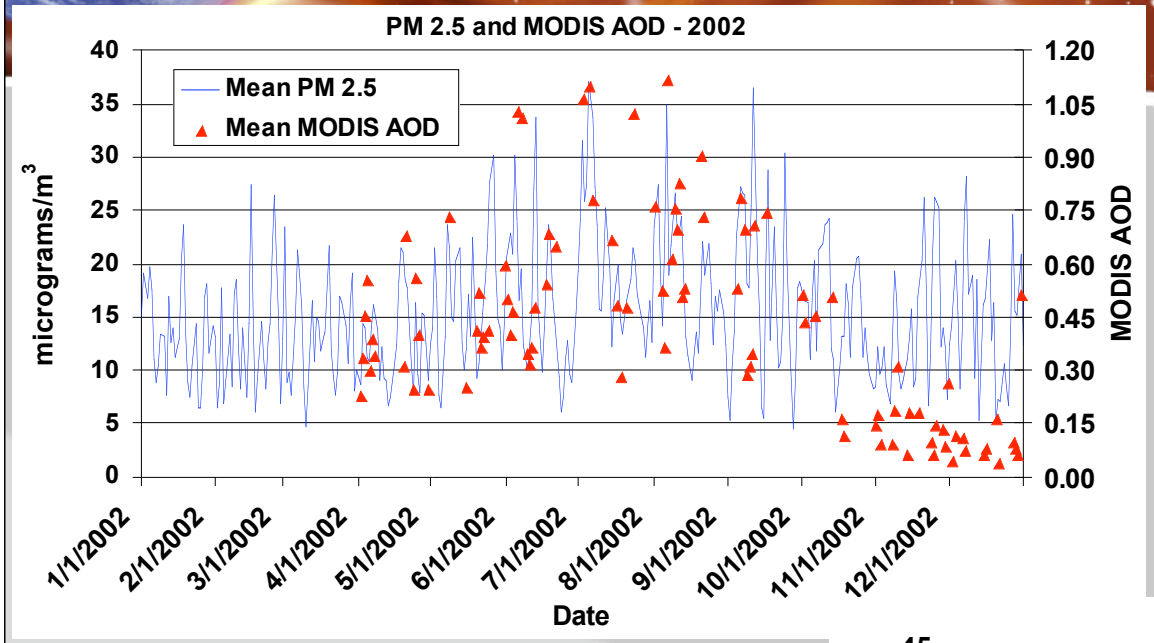
June 25, 2003

Estimating $PM_{2.5}$ from MODIS data

- For 2000-2003, obtain MODIS AOD and EPA AQS $PM_{2.5}$ data
- Extract AOD data for 5 AQS site locations
- Calculate daily averages from hourly AQS $PM_{2.5}$ data
- Using daily $PM_{2.5}$ averages from all 5 Atlanta AQS sites, determine statistical regression equations between $PM_{2.5}$ and MODIS AOD
- Apply regression equations to estimate $PM_{2.5}$ for each 10 km grid cell across region



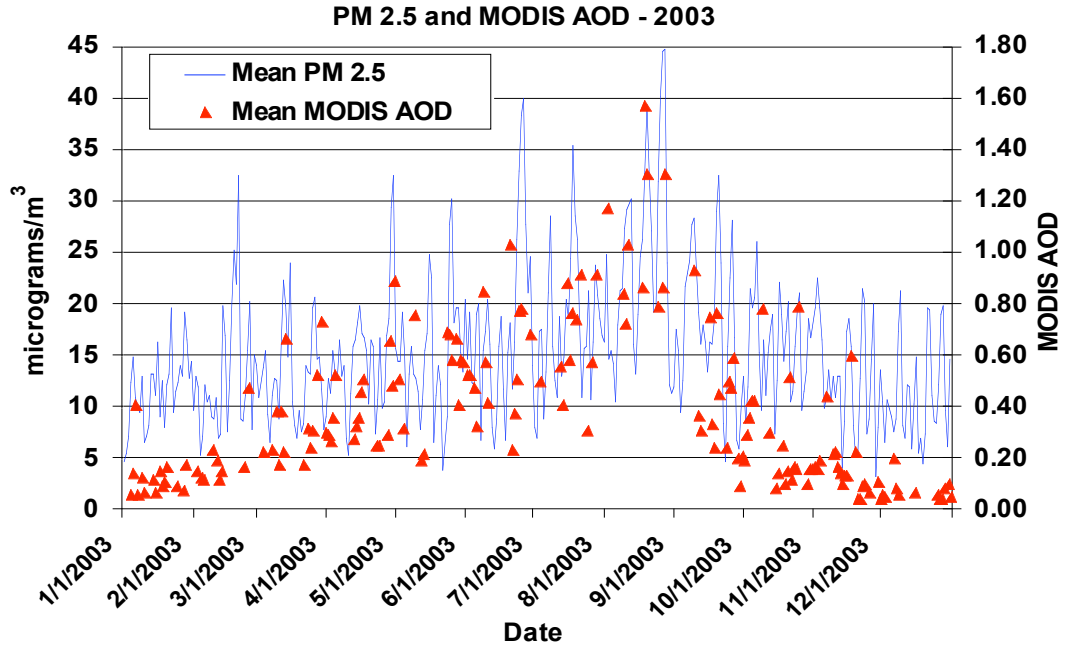
MODIS AOD - $PM_{2.5}$ Relationship



- Daily 5-site means of observed $PM_{2.5}$ and MODIS AOD
- MODIS data not available every day due to cloud cover
- MODIS AOD follows seasonal patterns of $PM_{2.5}$ but not the day-to-day variability in fall and winter

2002

2003

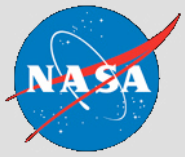


PM 2.5 – MODIS AOD Correlations

April - September

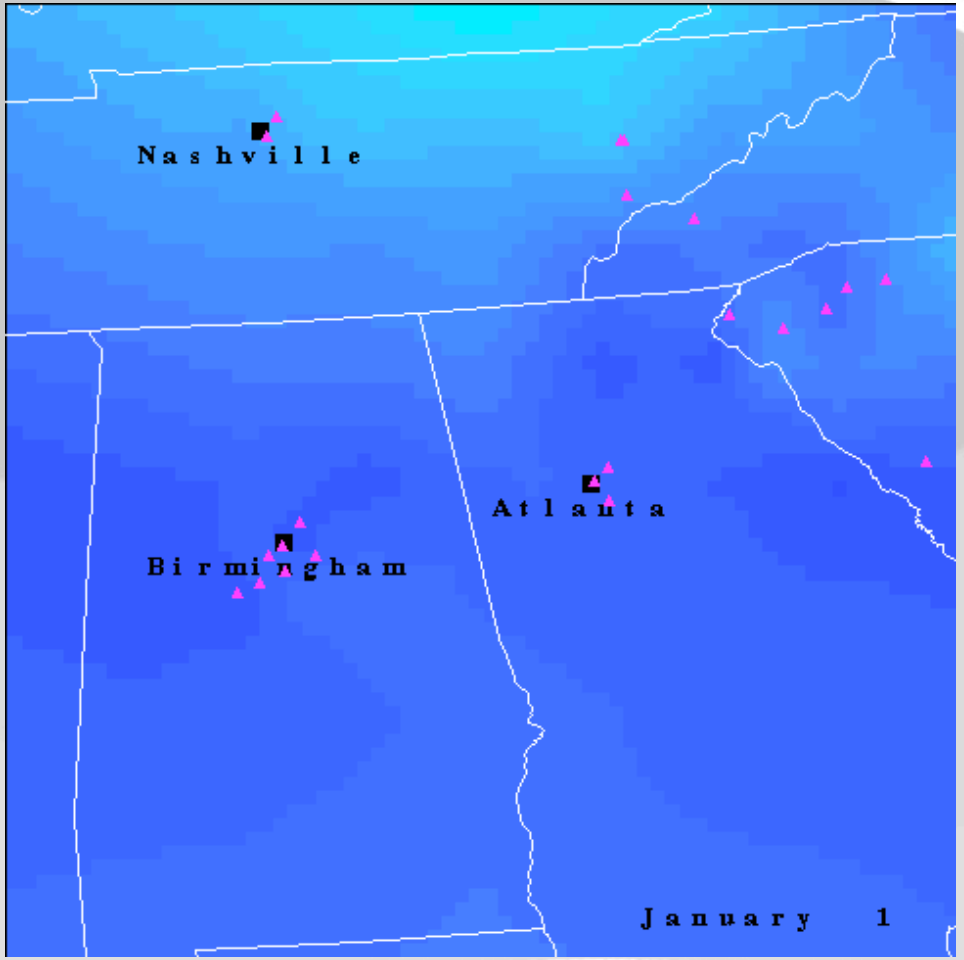
	MODIS-Terra	MODIS-Aqua
2000 -->	0.579	
2001 -->	0.643	
2002 -->	0.559	0.401
2003 -->	0.661	0.727

- Correlations between $PM_{2.5}$ and MODIS AOD are generally high (> 0.55) for the warm season.
- The lower correlation for MODIS-Aqua in 2002 is for July-September only.



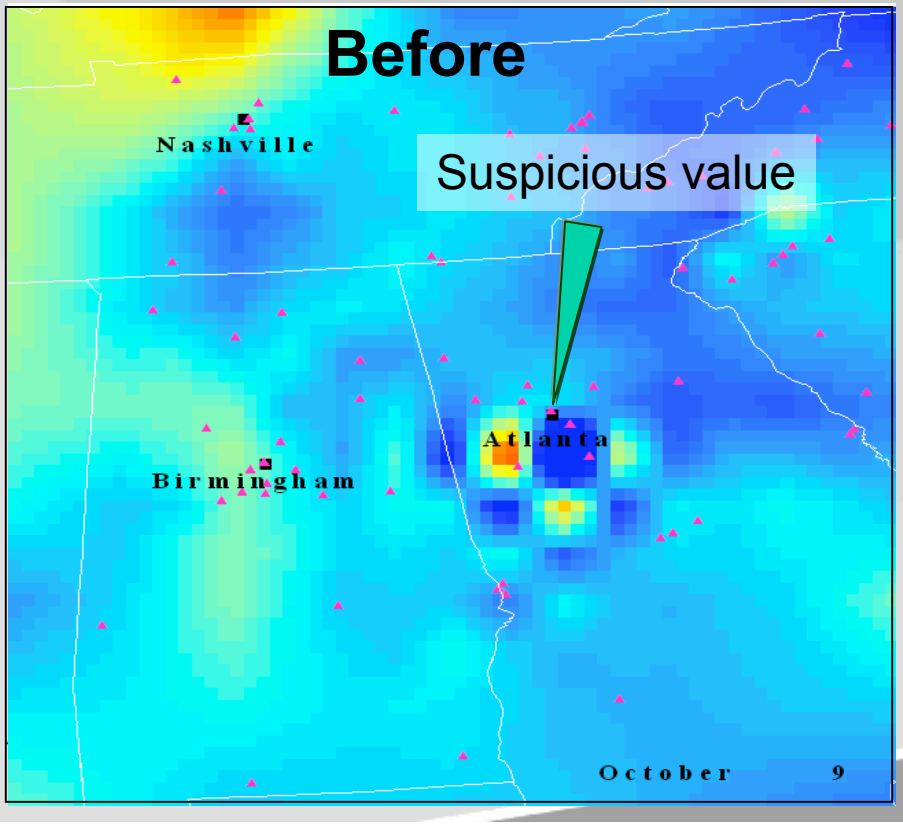
PM2.5 Exposure Assessment- Spatial Surfacing

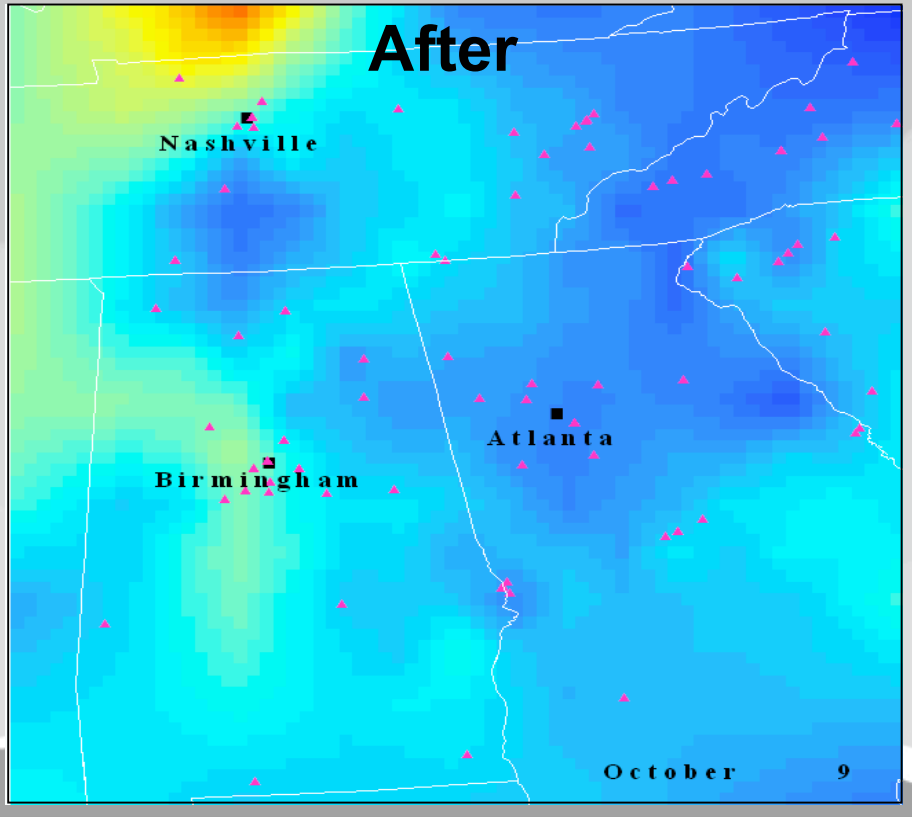
- 1st degree recursive B-spline in x- and y-directions
- Inverse Distance Weighted (IDW)
- Daily surfaces created on a 10x10 km grid
- Variable number of measurements available each day



Quality Control Procedure for AQS $PM_{2.5}$ data

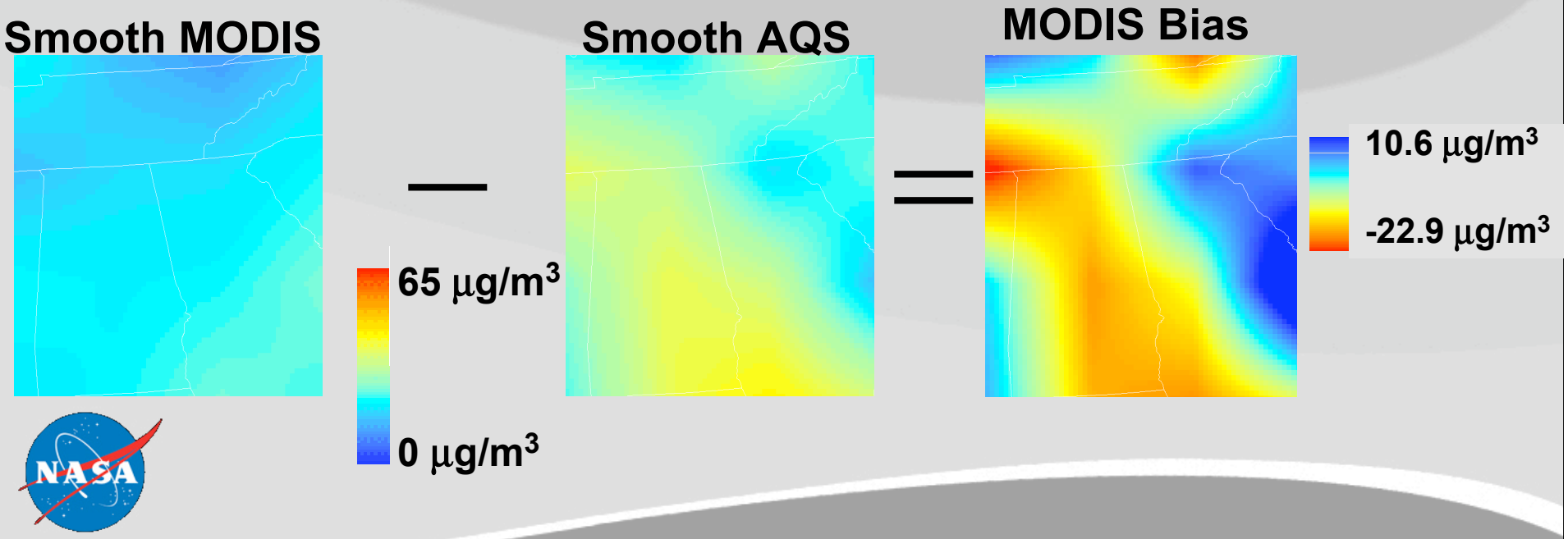
- Eliminates anomalous measurements based on a non-parametric rank-order spatial analysis
- Applied to all daily AQS $PM_{2.5}$ measurements before spatial surfaces are built





MODIS $PM_{2.5}$ Bias Adjustment

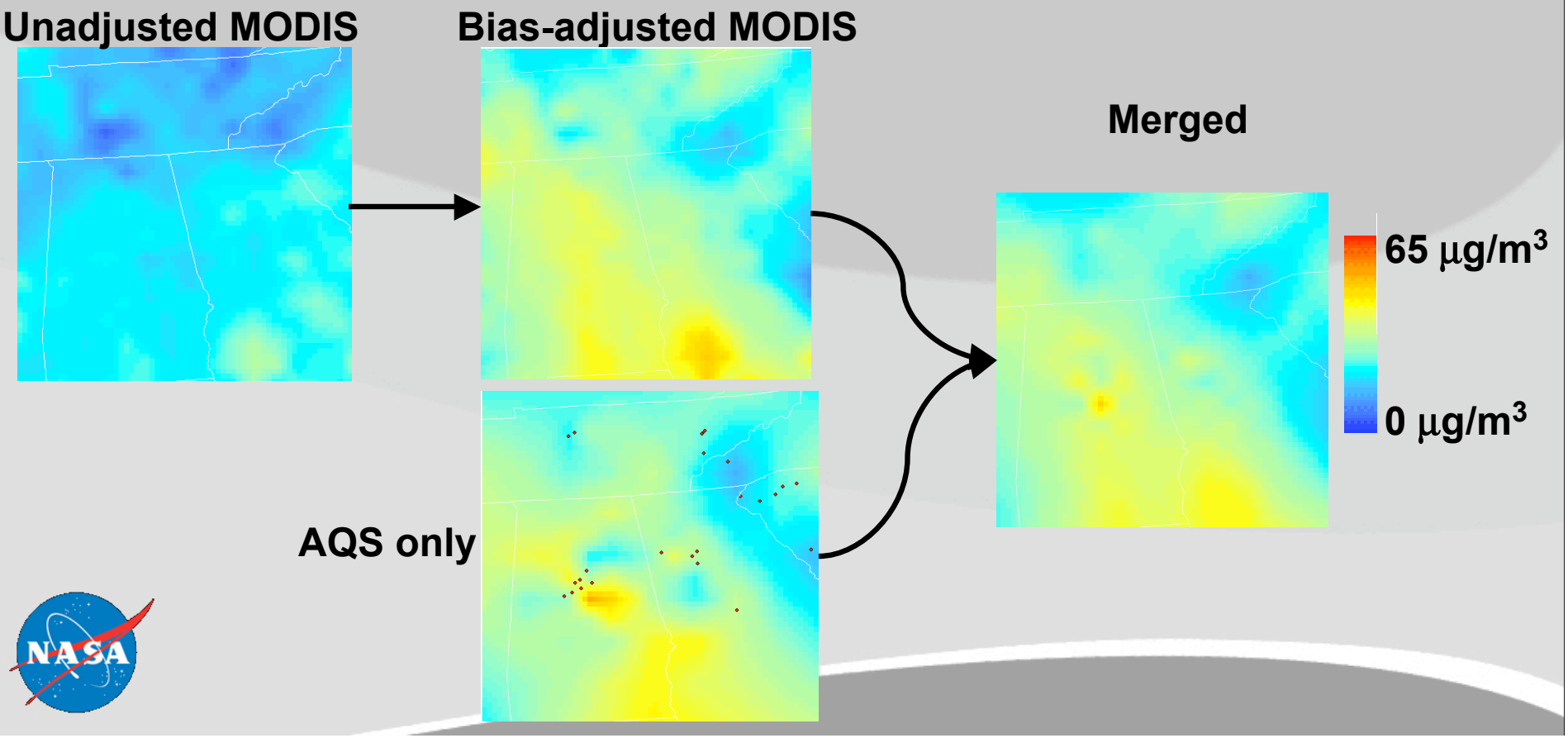
- **Assumption: AQS measurements are unbiased relative to the local mean, but MODIS $PM_{2.5}$ estimates may have biases.**
- **Procedure:**
  - **Use a two-step B-spline algorithm to create highly smoothed versions of the MODIS and AQS $PM_{2.5}$ daily surface**
  - **Compute the 'Bias' as the difference between the smoothed fields**
  - **Subtract the bias from the MODIS $PM_{2.5}$ daily surface to give the 'bias-corrected' MODIS daily surface**



Merging MODIS and AQS $PM_{2.5}$ Data

- MODIS and AQS data have been merged to produce final $PM_{2.5}$ surfaces.

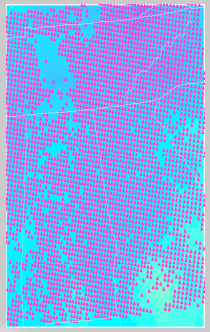
B-Spline Surfacing



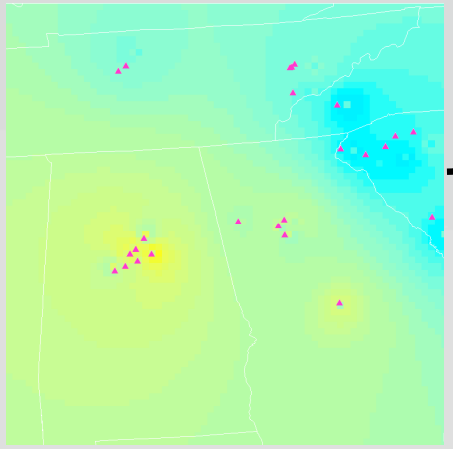
Merging MODIS and AQS $PM_{2.5}$ Data

IDW Surfacing

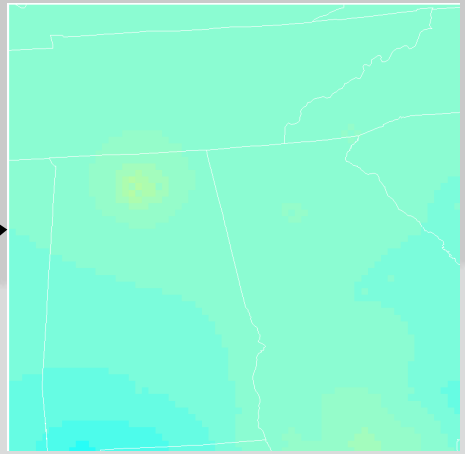
MODIS Only



AQS only



Merged

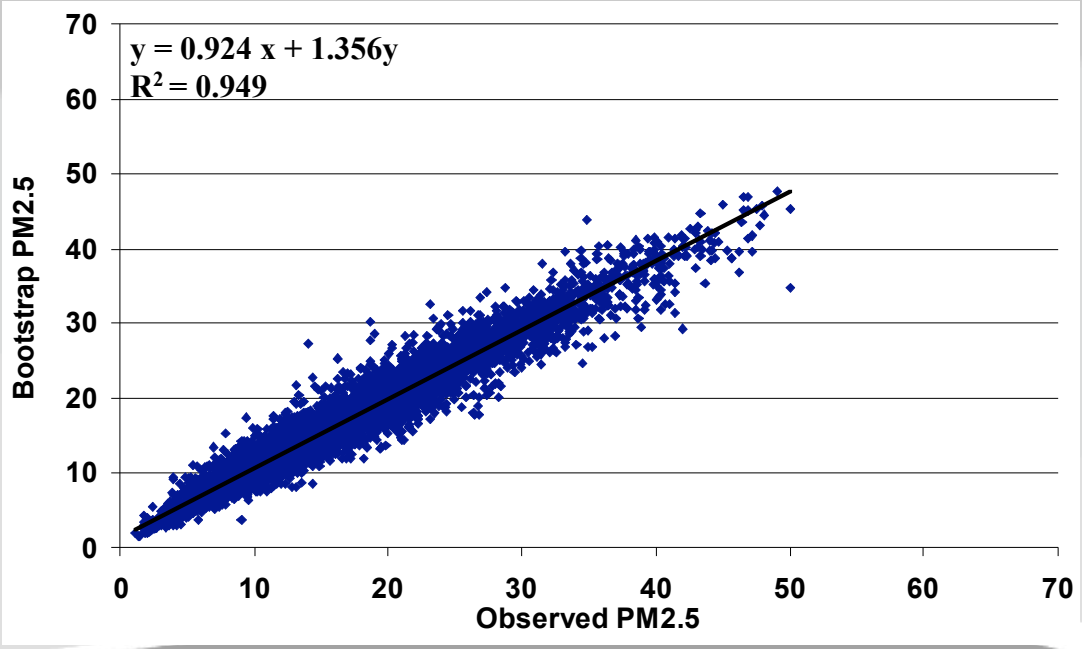


65 µg/m³

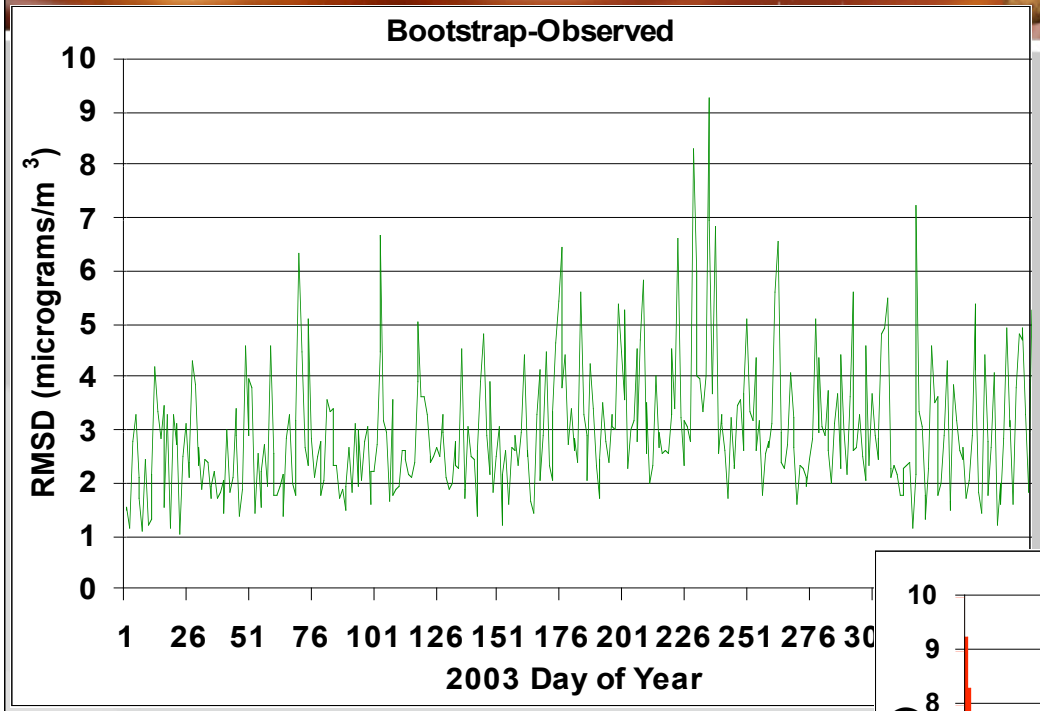
0 µg/m³

Cross-Validation

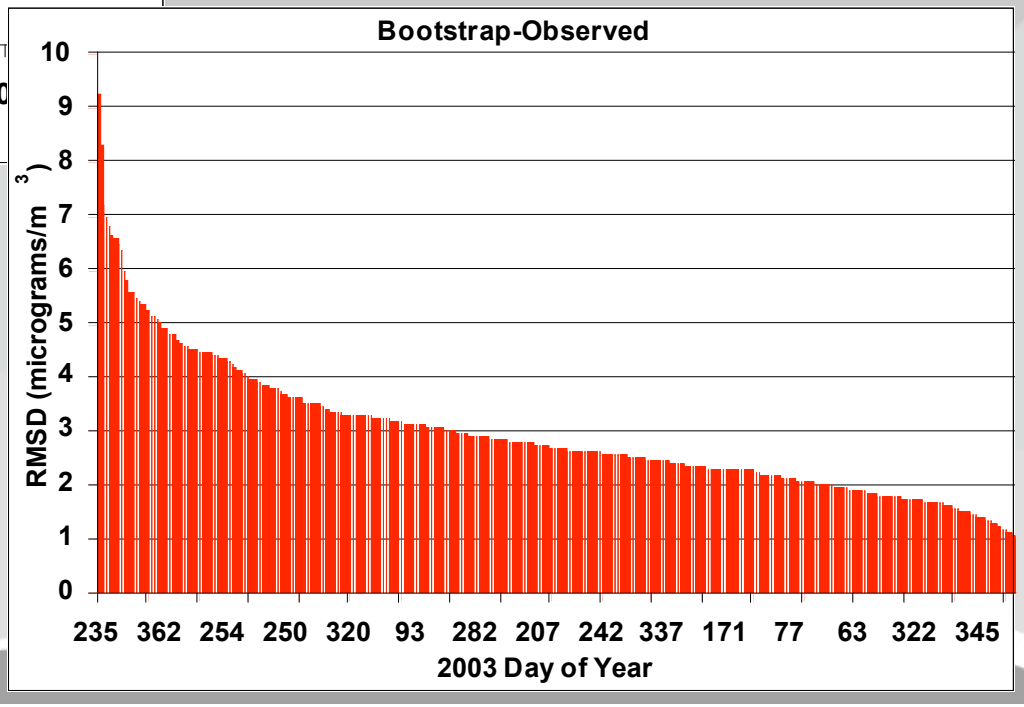
- a.k.a. ‘bootstrapping’ or ‘omit-one’ analysis
- Objective: Estimate errors associated with daily spatial surfaces
- Procedure:
  - Omitting one observation, create surface using N-1 observations
  - Compare value of surface at location of omitted observation with the observed value
  - Repeat for all observations
  - Calculate error statistics by day or site



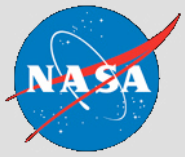
Cross-Validation for B-Spline Surfaces
Daily Error Statistics



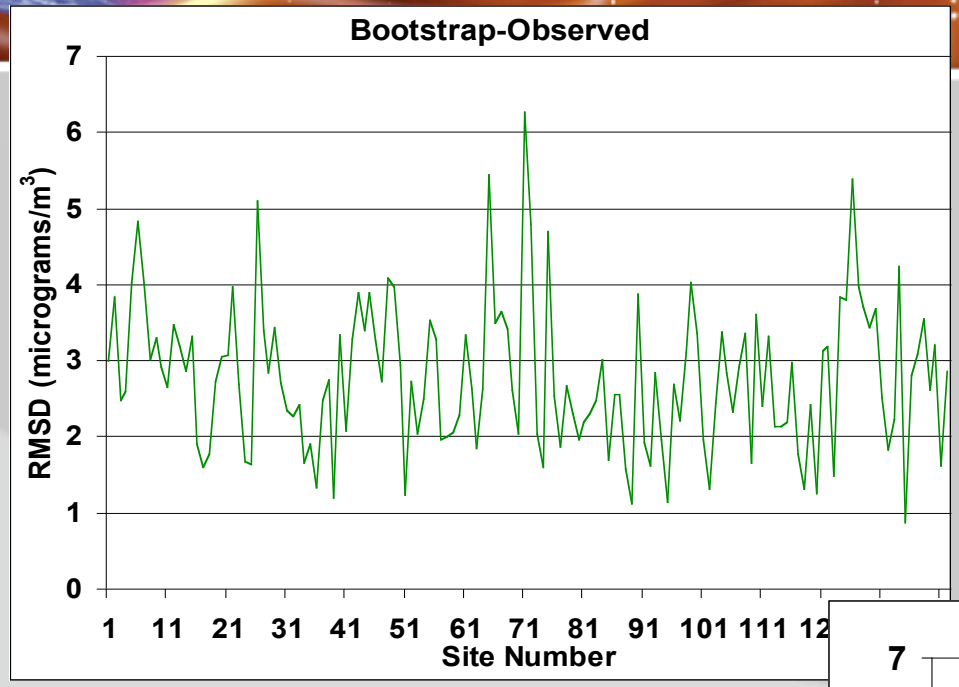
Time Series



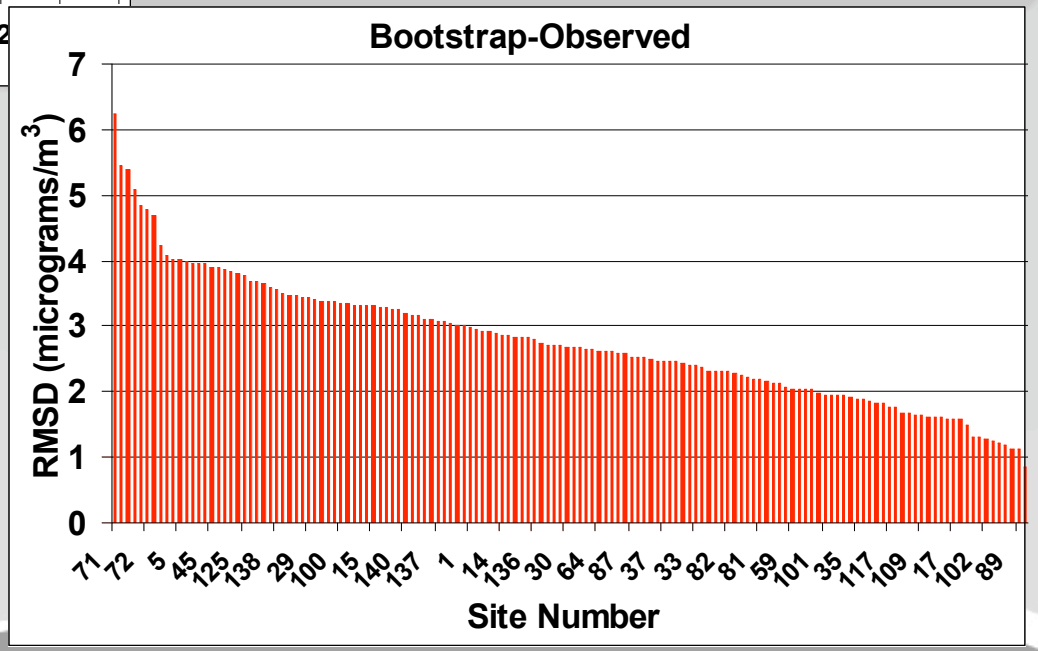
Rank Order



Cross-Validation for B-Spline Surfaces
Error Statistics by Site

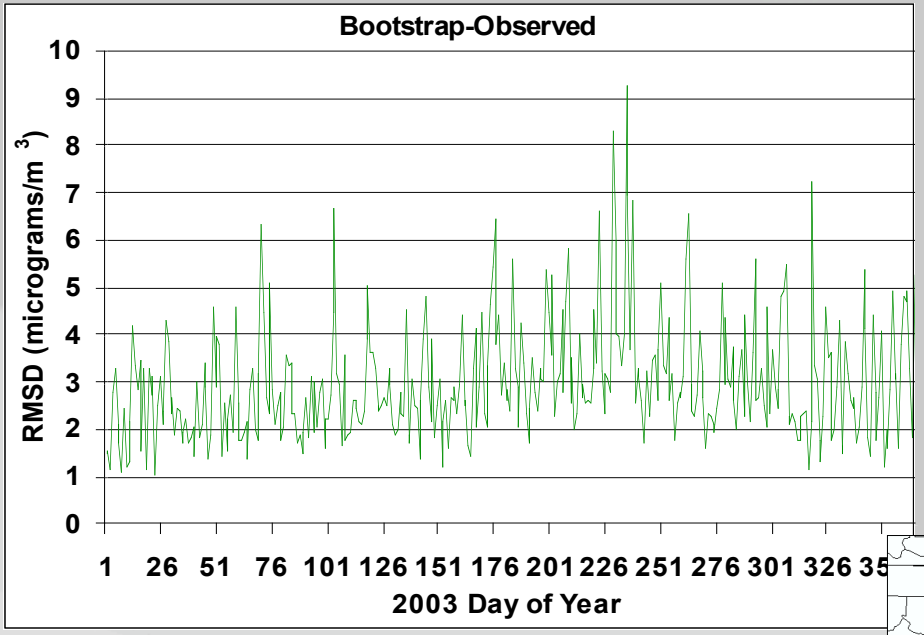


RMSD by Site



Rank Order

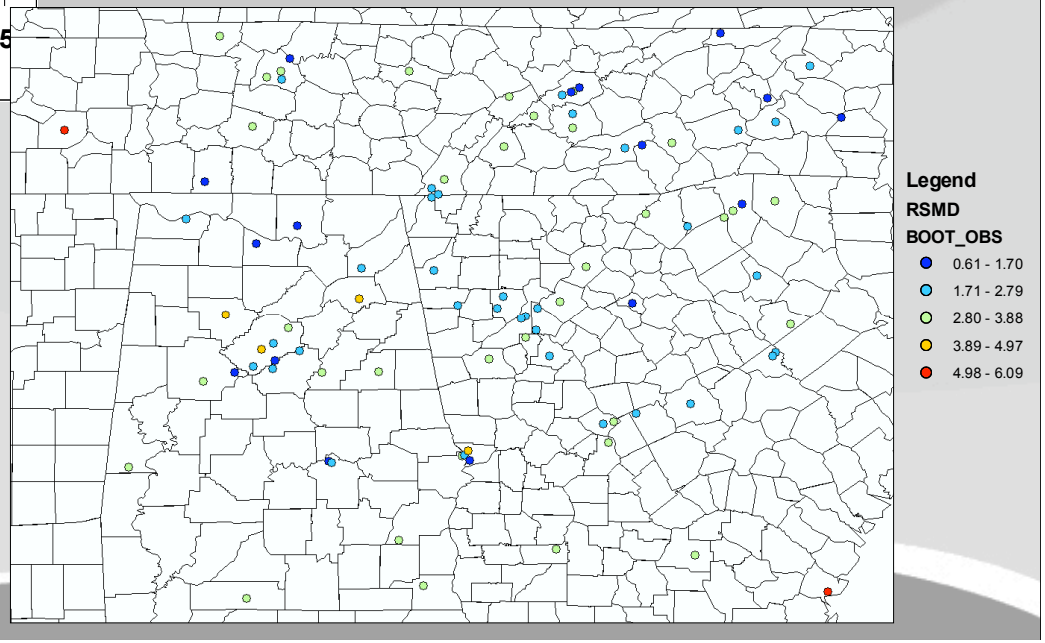
Cross-Validation Error Statistics



Time Series

RMSD = 2.7 μg/m^3

RMSD by Site



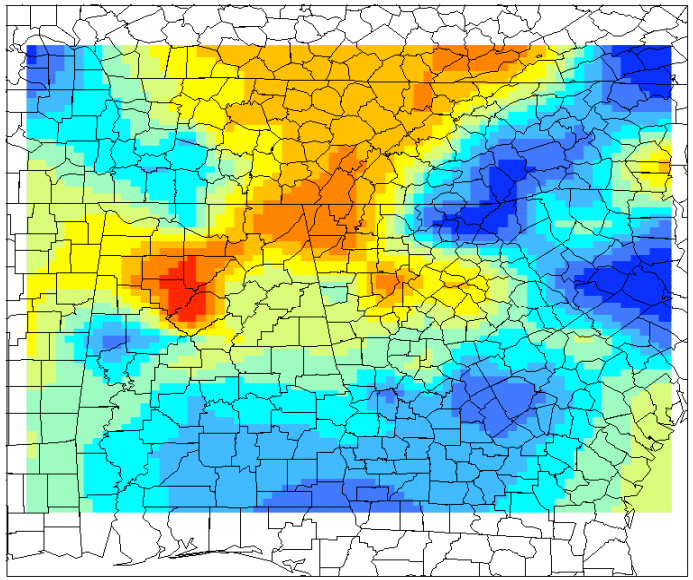
Surfacing Methods Comparison

Surfacing Technique and Data Source	RMSD (All Days)	RMSD (Warm Season - Days 91-273)
Bspline, AQS only, no QC	3.30	3.56
Bspline, AQS only, with QC	2.93	3.16
IDW, AQS only	2.45	2.69
B-Spline, merged AQS/MODIS	N/A	2.76
IDW, merged AQS/MODIS	N/A	1.61

Surfacing Technique and Data Source	Improvement
Bspline: QC vs. No QC	12 %
Bspline: AQS only vs. merged AQS/MODIS	16 %
IDW: AQS only vs. merged AQS/MODIS	40 %

Annual Composite Surfaces

PM2.5 B-Spline Surfaces Year 2003 Composite

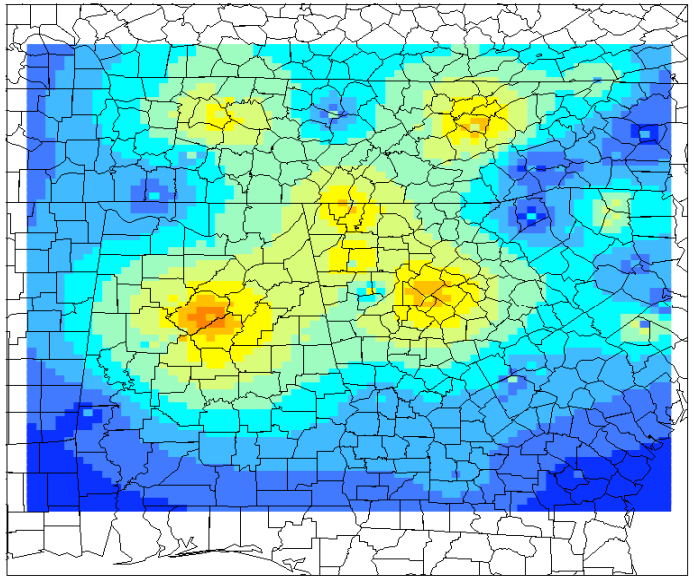


PM2.5 (ug/m^3)

- 10.24 - 11.97
- 11.98 - 12.57
- 12.58 - 12.97
- 12.98 - 13.35
- 13.36 - 13.74
- 13.75 - 14.23
- 14.24 - 14.85
- 14.86 - 15.54
- 15.55 - 16.50
- 16.51 - 18.36

B-Spline

PM2.5 IDW Surfaces Year 2003 Composite



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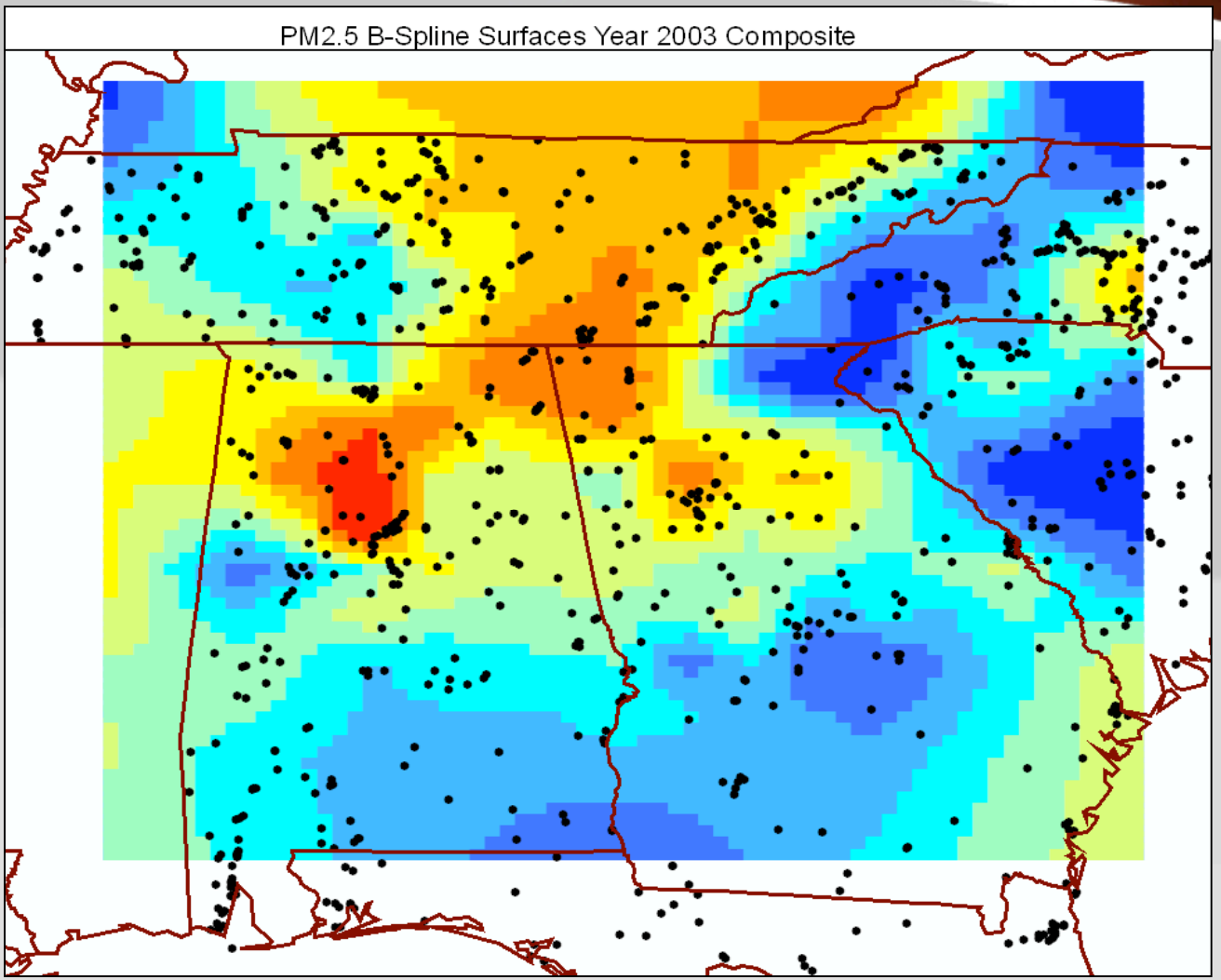
- 14.86 - 15.54
- 15.55 - 16.50
- 16.51 - 18.36

IDW

Point Source Emissions



Linkage of Environmental and Health Data

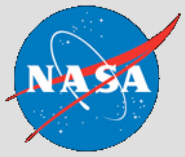
Health Data Set

Members

LON	LAT	ID	AGE	GENDER	YEAR/MO
-84.207	99.200	1	Child	M	200301
-84.802	99.359	2	Adult	M	200301
-83.798	99.993	4	Child	F	200301

Acute asthma office visits

ID	AGE	LON	LAT	GENDER	DATE
1811	Child	-84.179	99.118	F	1/1/2003
54767	Adult	-84.625	99.802	F	1/1/2003
84580	Adult	-84.679	99.691	F	1/1/2003



*Simulated Data Set. F=female, M=male, A=adult, C=child.

Linkage of Environmental and Health Data

Data Linkage Outputs

Visit counts by grid cell

Date	Cell	PM2.5	FC	MC	FA	MA
200301	1	21.74	1	0	2	0
200301	2	12.79	0	0	0	0
200301	3	12.21	0	1	0	1

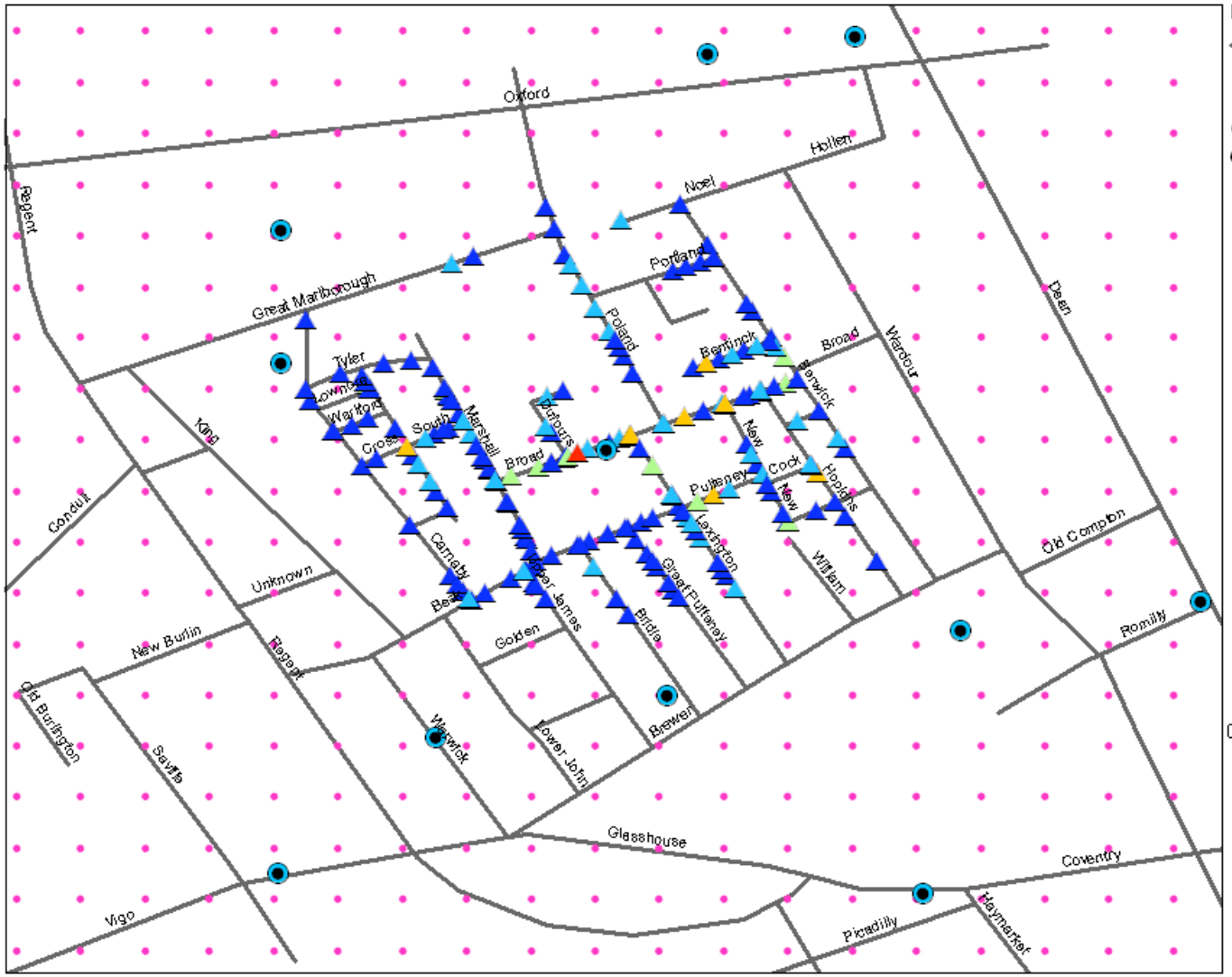
$PM_{2.5}$ for each visit

Date		ID	Member	Lat/Lon	Cell	Cell Lat/Lon		County	State	Gender	Age	PM2.5
1	1	1811	99.572	-84.251	1944	99.552	-84.284	Coweta	GA	F	Child	21.74
1	2	15299	99.063	-83.860	1608	99.104	-83.806	Upson	GA	F	Child	12.79
1	2	15879	99.727	-84.369	2079	99.731	-84.403	Fulton	GA	M	Child	12.21

*Simulated Data Set. F=female, M=male, A=adult, C=child.

Public Health Surveillance

Cholera Deaths Soho, London August-September, 1854



Legend

- Streets
- Wells
- Grid

Cholera Deaths Per Residence

COUNT

- 1 - 2
- 3 - 4
- 5 - 6
- 7 - 10
- 11 - 18

Integration Radius = 55m
Grid Spacing = 40m

N

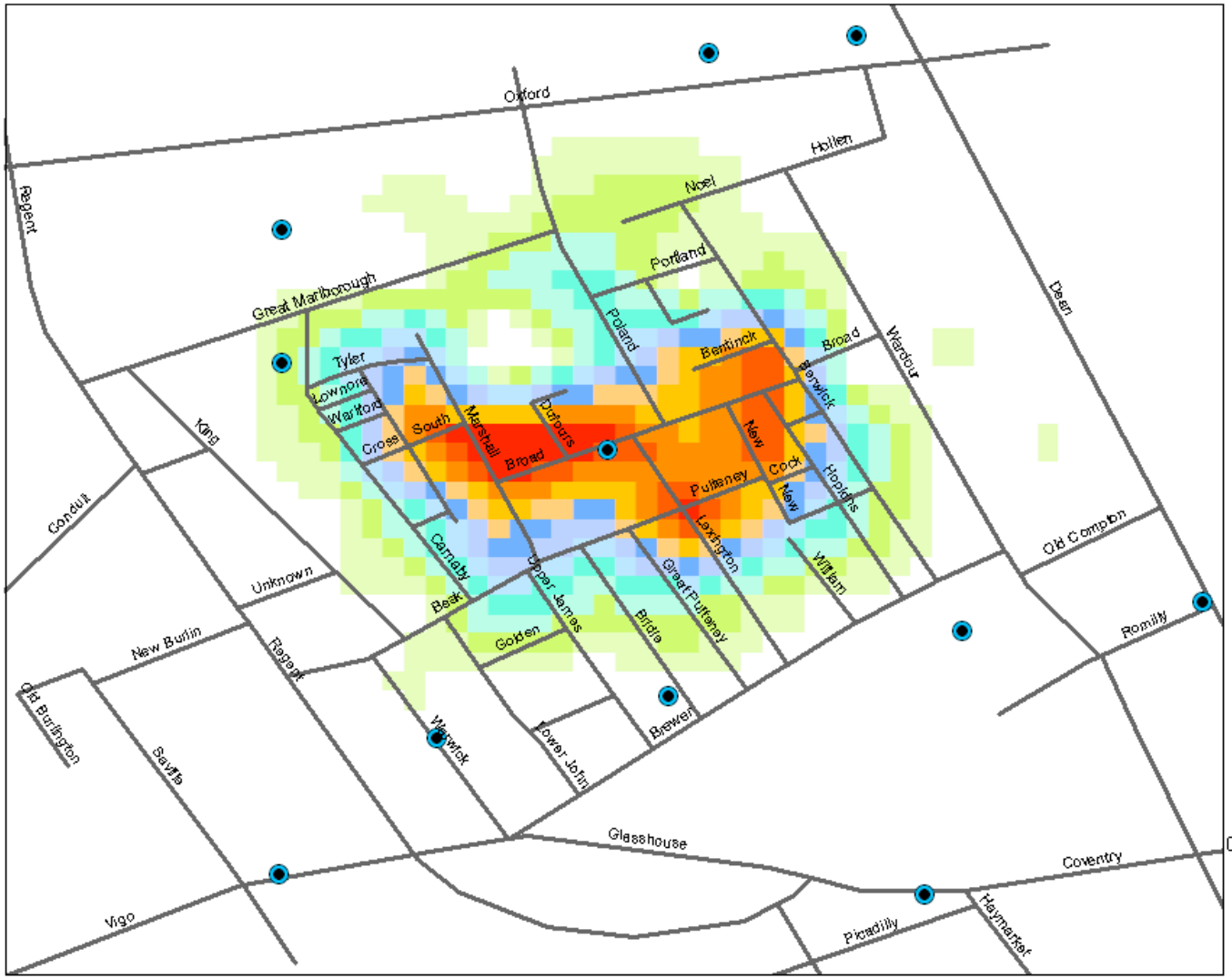
Meters
0 50 100 200

12/15/05 10:35am
Dr. Mohammad Al-Hamdan
USRA at NASA/MSFC
HELIX-Atlanta Project
mohammad.alhamdan@nasa.gov

*Original data were published by C.F. Cheffins, Lith, Southhampton Buildings, London, England, 1854 in Snow, John. On the Mode of Communication of Cholera, 2nd Ed, John Churchill, New Burlington Street, London, England, 1855.
**Digital Data of Streets, Wells, and Deaths Residences which were used to creat this surface were downloaded from the UCLA Department of Epidemiology Website at http://www.ph.ucla.edu/epi/snow.html.

Public Health Surveillance

Cholera Deaths Soho, London August-September, 1854



Legend

- Streets
- Wells

Deaths Per Unit Area

COUNT

- 0 - 1
- 1 - 5
- 5 - 10
- 10 - 15
- 15 - 20
- 20 - 25
- 25 - 30
- 30 - 35
- 35 - 40
- 40 - 45
- 45 - 50
- 50 - 55
- 55 - 63

Integration Radius = 55m
Grid Spacing = 40m

N

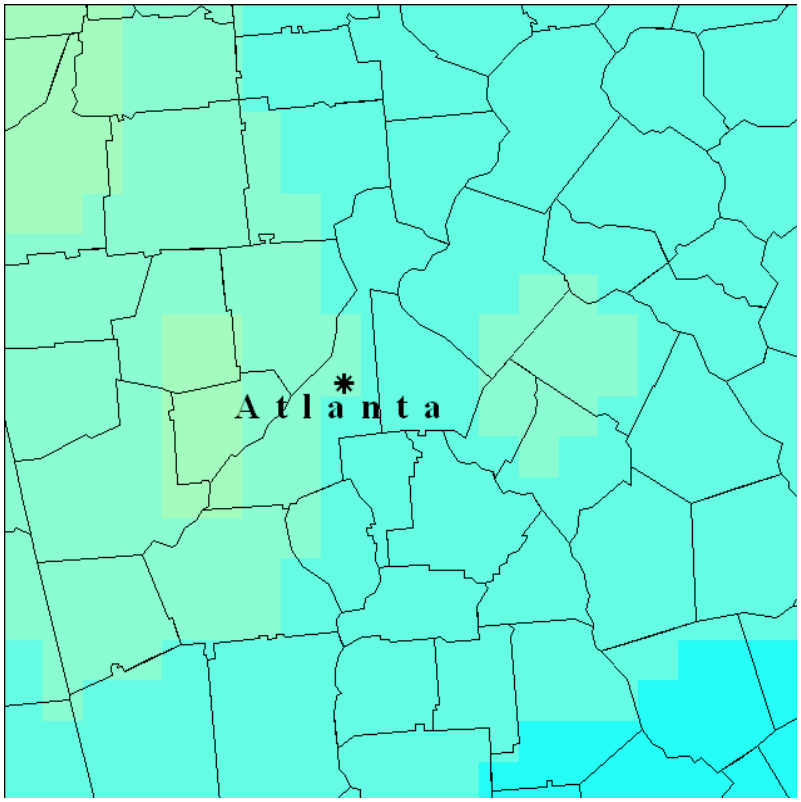
0 50 100 200 Meters

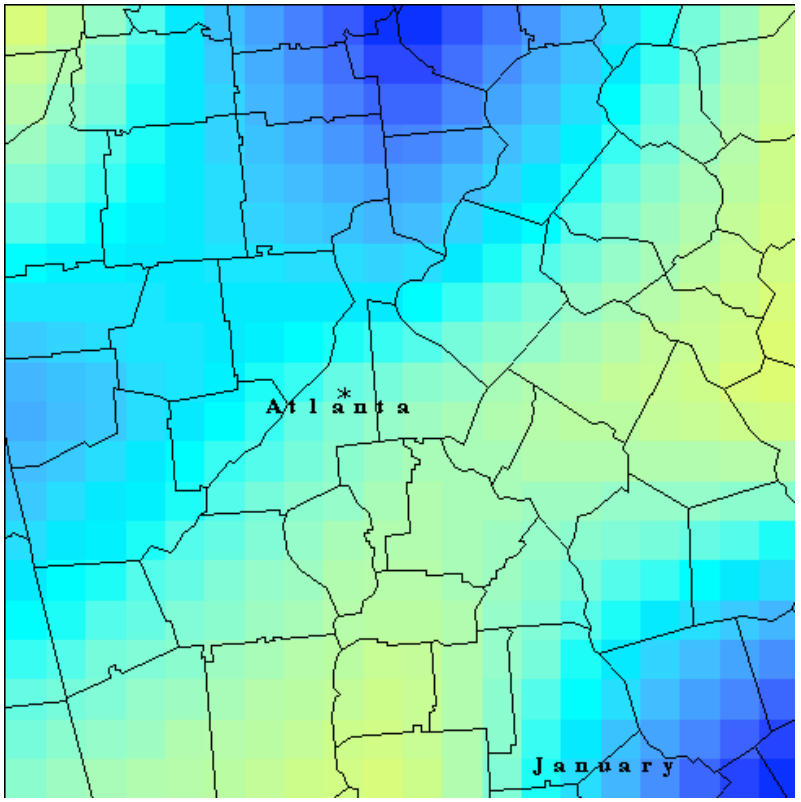
12/15/05 10:35am
Dr. Mohammad Al-Hamdan
USRA at NASA/MSFC
HELIX-Atlanta Project
mohammad.alhamdan@nasa.gov

*Original data were published by C.F. Cheffins, Lith, Southhampton Buildings, London, England, 1854 in Snow, John. On the Mode of Communication of Cholera, 2nd Ed, John Churchill, New Burlington Street, London, England, 1855.
**Digital Data of Streets, Wells, and Deaths Residences which were used to creat this surface were downloaded from the UCLA Department of Epidemiology Website at http://www.ph.ucla.edu/epi/snow.html.

Courtesy: Dr. Jeff Luvall, NASA/MSFC

Year 2002, R=50 km





Monthly Mean $PM_{2.5}$ (ug/m^3)

30

0

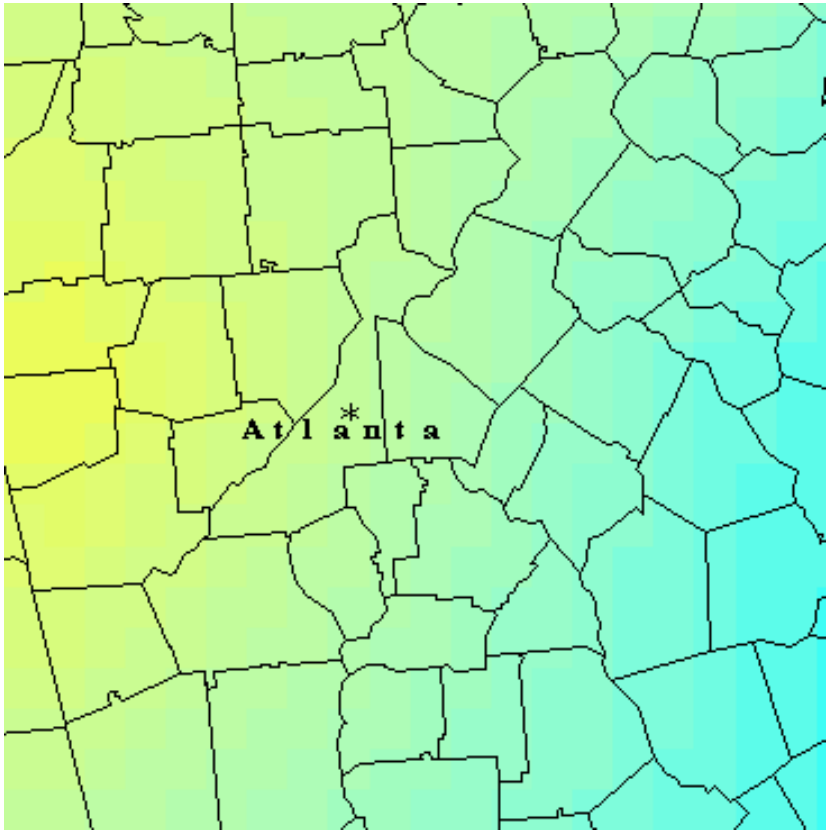
January

Monthly Rate (Per 10,000)

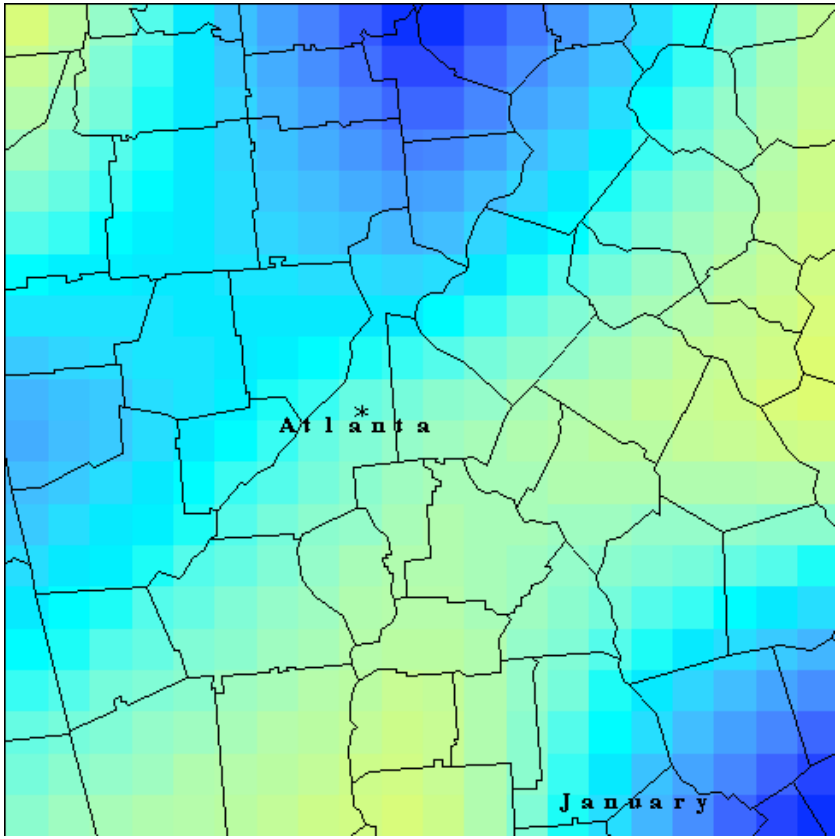
80

0

Year 2002, R=50 km

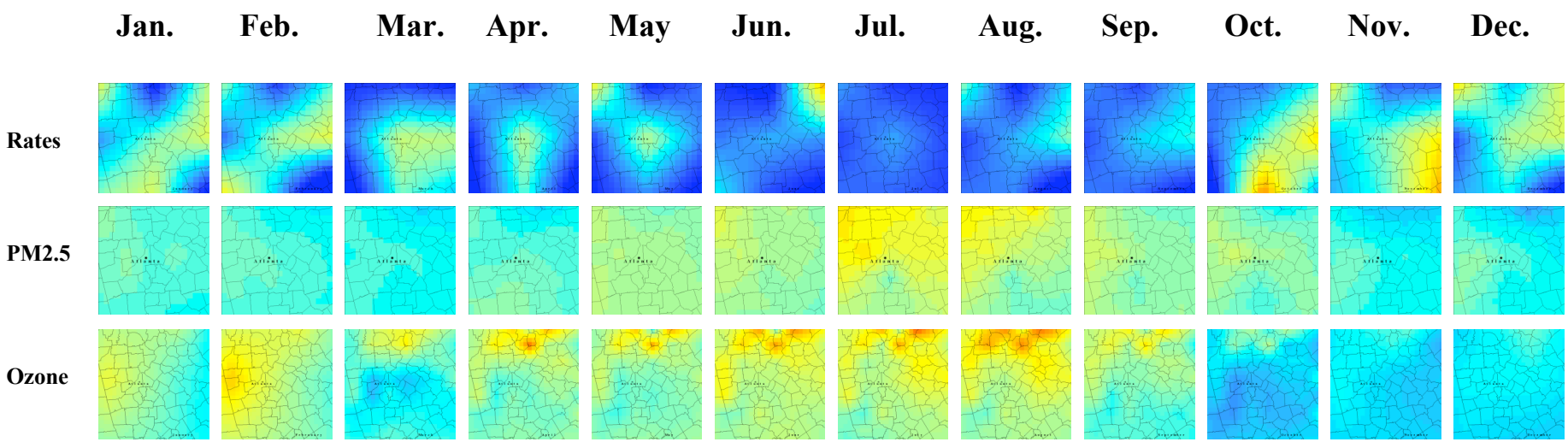


Monthly Mean Ozone (ppb)

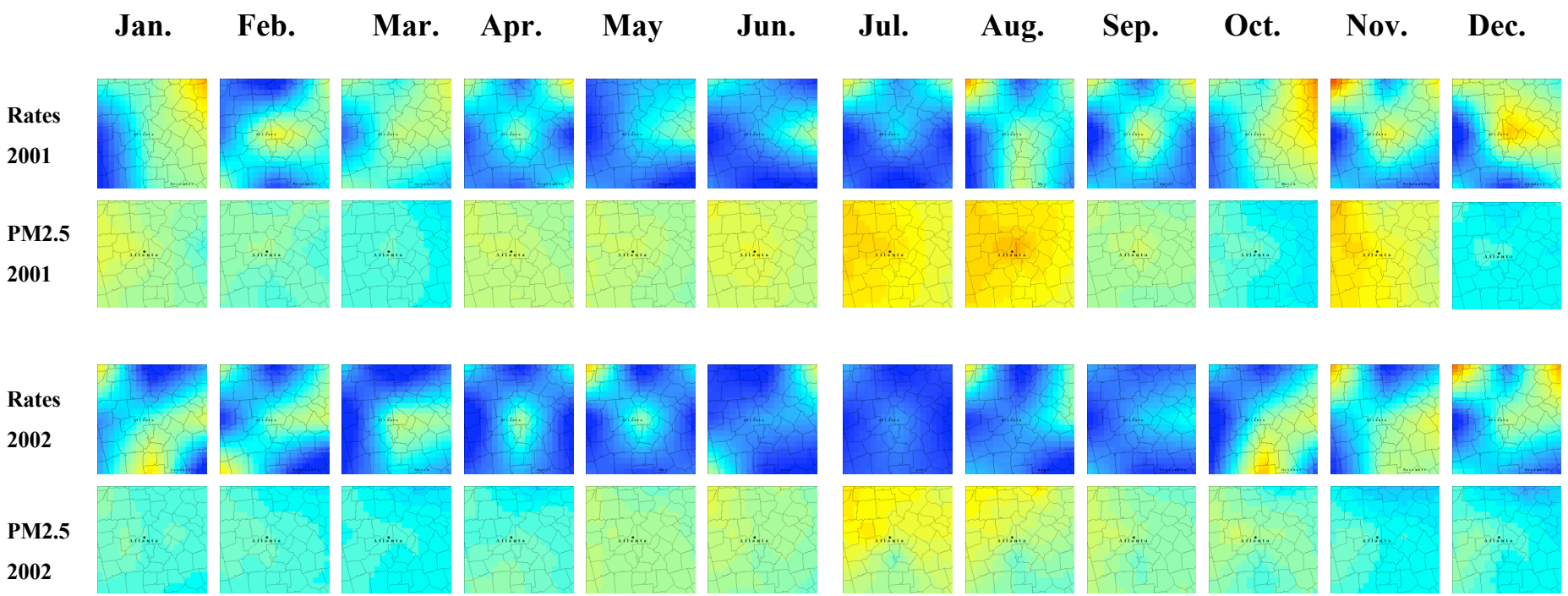


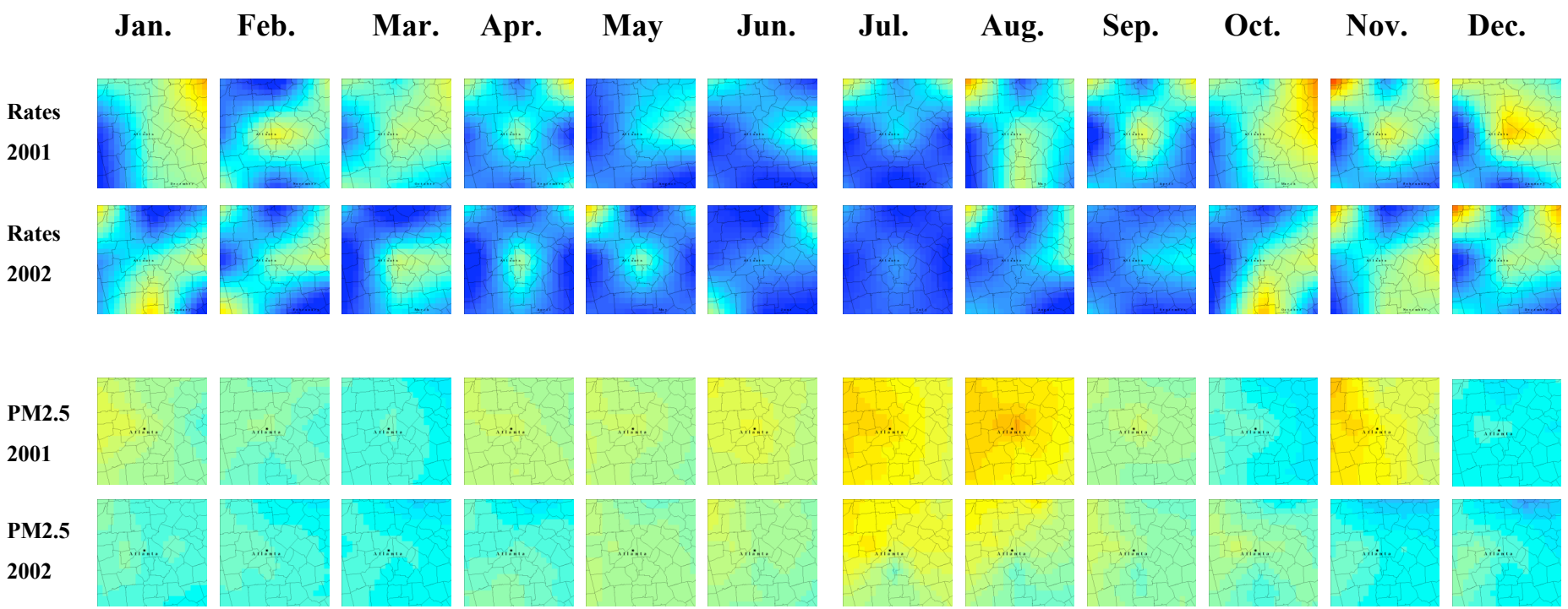
Monthly Rate (Per 10,000)

January


Jan.
Feb.
Mar.
Apr.
May
Jun.
Jul.
Aug.
Sep.
Oct.
Nov.
Dec.
Rates
PM2.5
Ozone

Year 2002


Jan.
Feb.
Mar.
Apr.
May
Jun.
Jul.
Aug.
Sep.
Oct.
Nov.
Dec.
Rates 2001
PM2.5 2001
Rates 2002
PM2.5 2002


Jan.
Feb.
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Oct.
Nov.
Dec.
Rates 2001
Rates 2002
PM2.5 2001
PM2.5 2002

Successes

- Proven the feasibility of linking environmental data (MODIS $PM_{2.5}$ estimates and AQS) with health data (asthma)
- Developed algorithms for QC, bias removal, merging MODIS and AQS $PM_{2.5}$ data, and others…
- Negotiated a Business Associate Agreement with a health care provider to enable sharing of Protected Health Information

Thanks!

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