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

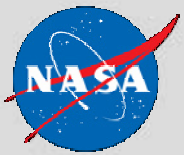
Mohammad Al-Hamdan
Bill Crosson, Maury Estes, Ashutosh Limaye, Dale Quattrochi, Doug Rickman, Carol Watts
NASA/MSFC/NSSTC

Judy Qualters, Pamela Meyer
Centers for Disease Control and Prevention

Amanda Niskar
Israel Center for Disease Control

Partners

Kaiser-Permanente Georgia
U.S. Environmental Protection Agency
Georgia Environmental Protection Division
Georgia Division of Public Health
Emory University
Georgia Institute of Technology



The CDC Environmental Public Health Tracking 2006 Conference (TRACKS 2006)
"Implementing the Tracking Network". Atlanta, GA. Aug. 9-11, 2006

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:

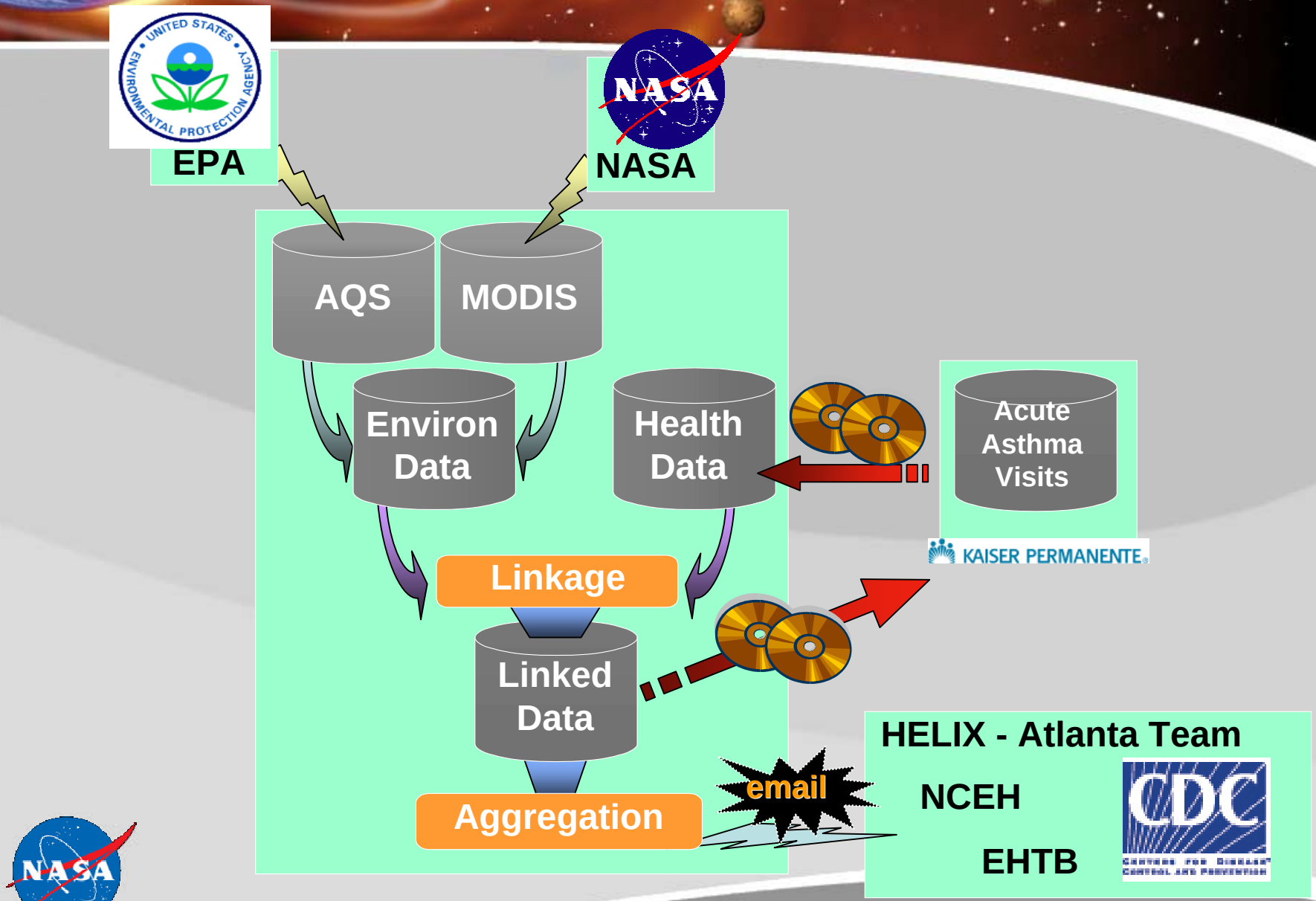
Link environmental data related to ground-level $PM_{2.5}$ (NASA+EPA) with health data related to asthma

Goals:

1. **Produce and share information on methods useful for integrating and analyzing data on asthma and $PM_{2.5}$ for environmental public health surveillance.**
2. **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

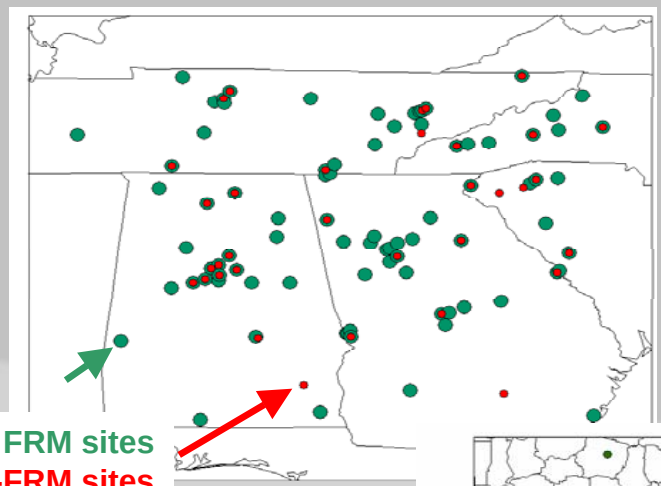
Data Linkage

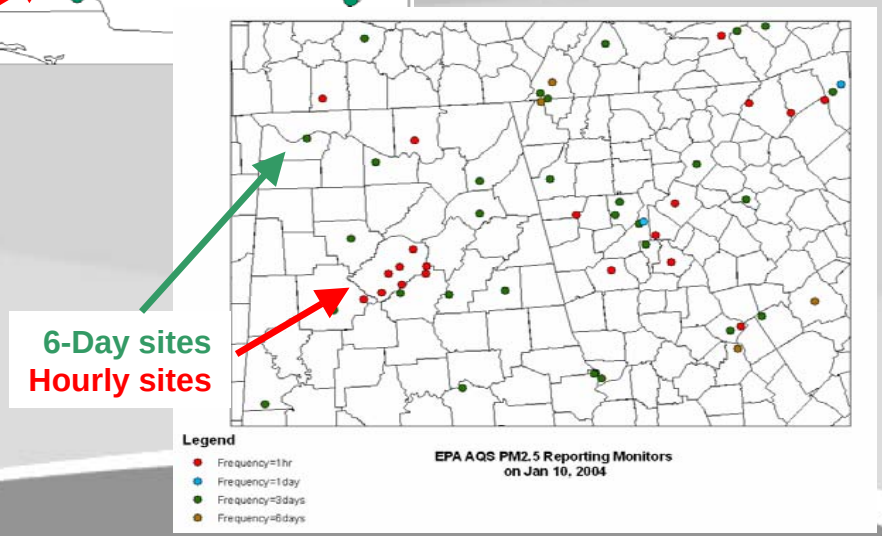


Sources of $PM_{2.5}$ data: EPA AQS

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





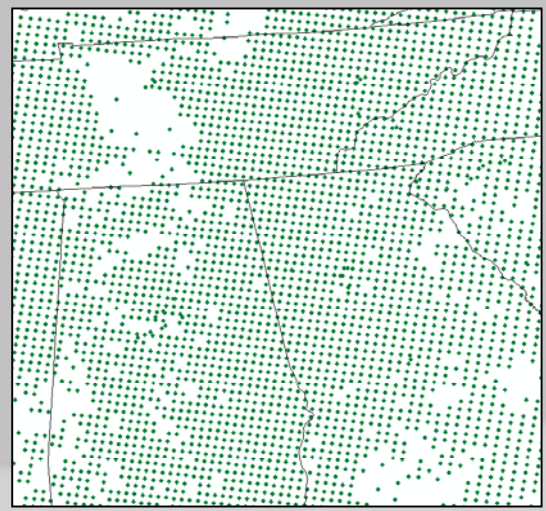
Sources of $PM_{2.5}$ data: MODIS

MODIS Aerosol Optical Depth (AOD)

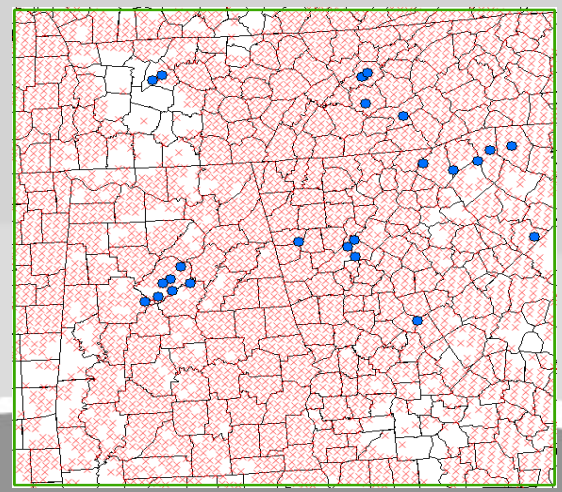
- AOD is a measure of the total particulate in the atmosphere
- If atmosphere is well mixed, AOD is a good indicator of surface $PM_{2.5}$
- Enhanced Spatial Coverage
- Provided on a 10x10 km grid
- Available twice per day

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

- Clear-sky coverage only
- Available since spring 2000



MODIS



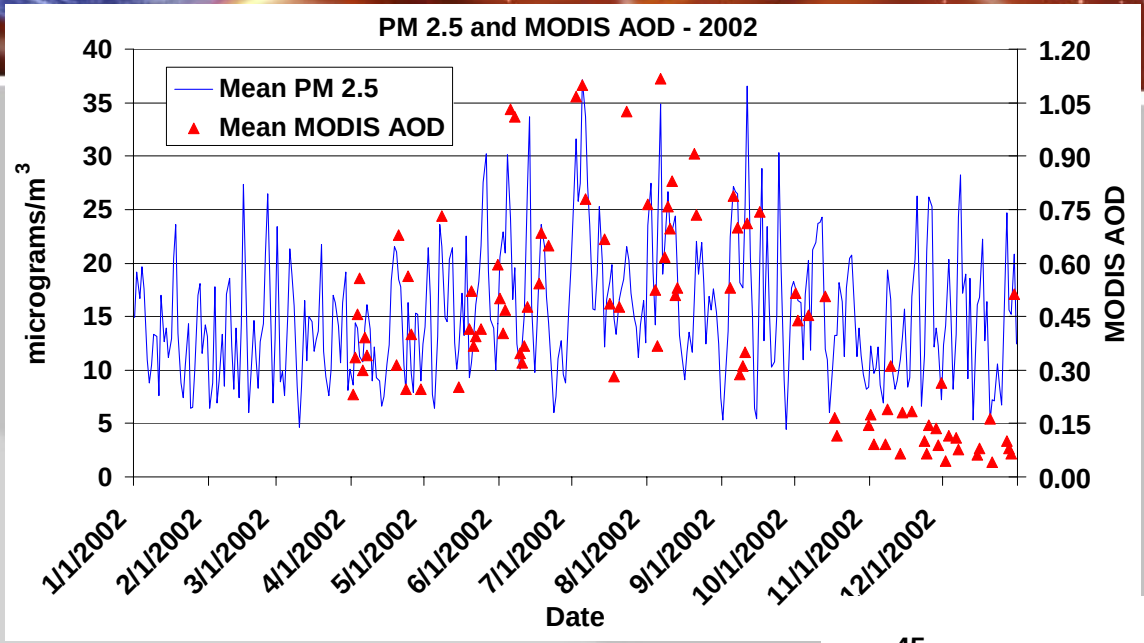
AQS

June 25, 2003

Estimating $PM_{2.5}$ from MODIS data

- For 2002-2003, 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

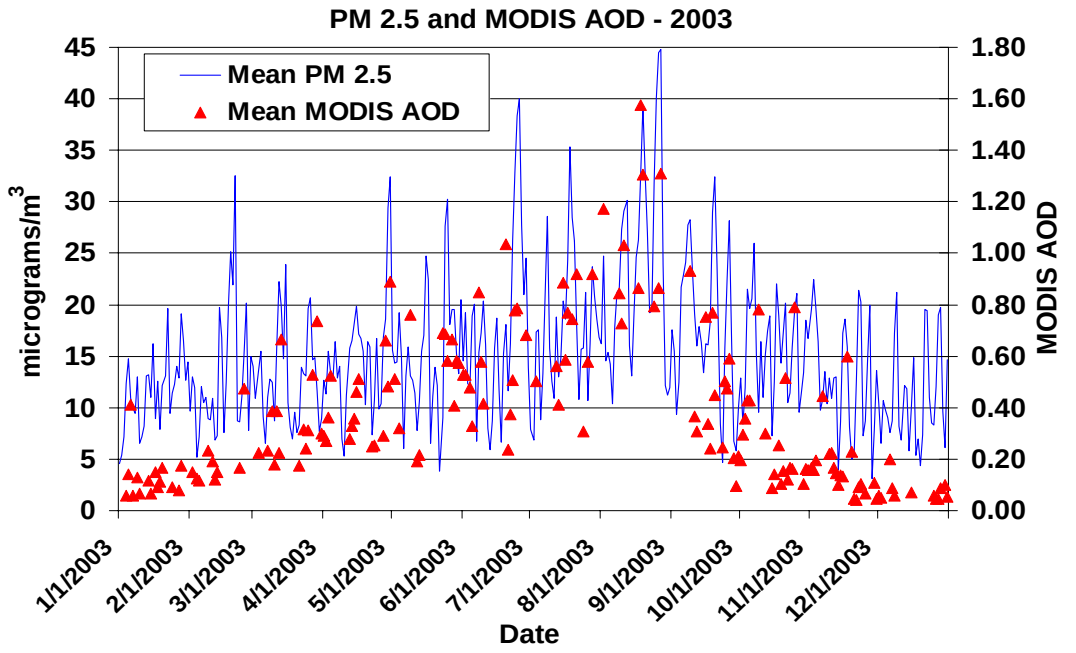
MODIS AOD - $PM_{2.5}$ Relationship



- 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

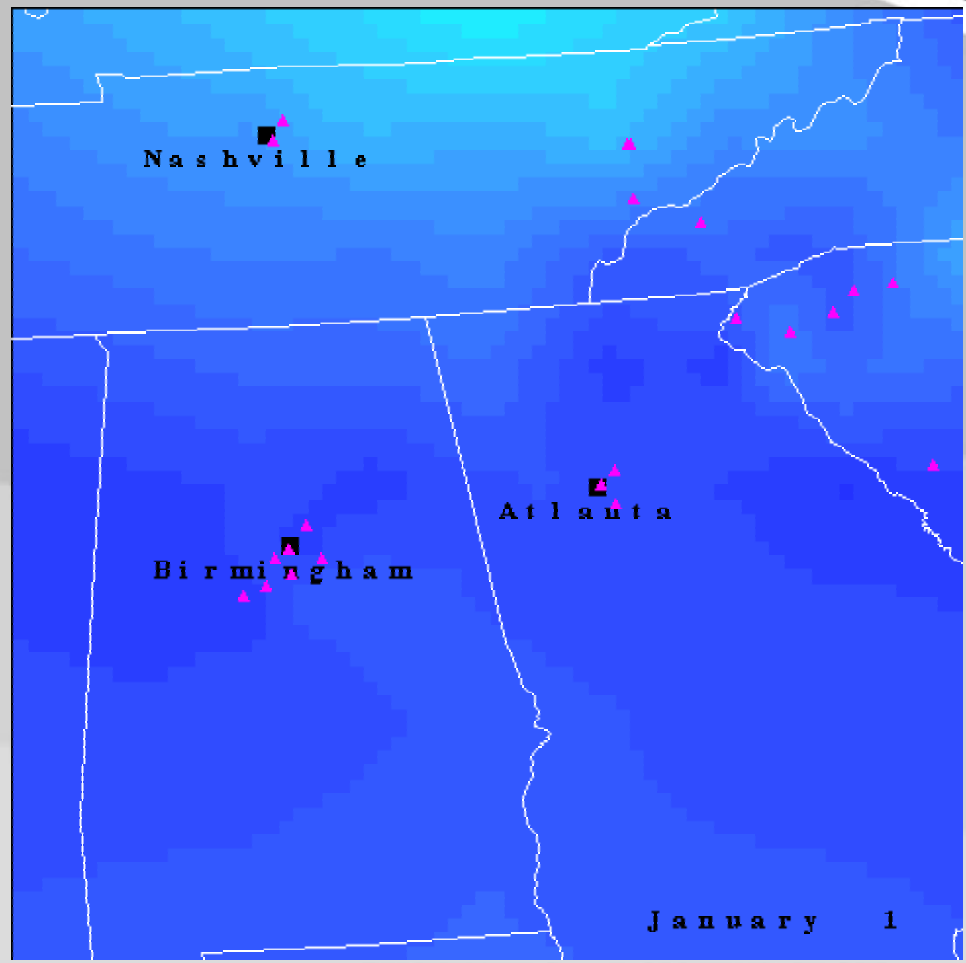
April - September

	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



$PM_{2.5}$ Concentration

High : 50 μg/m³

Low : 0 μg/m³

EPA sites

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

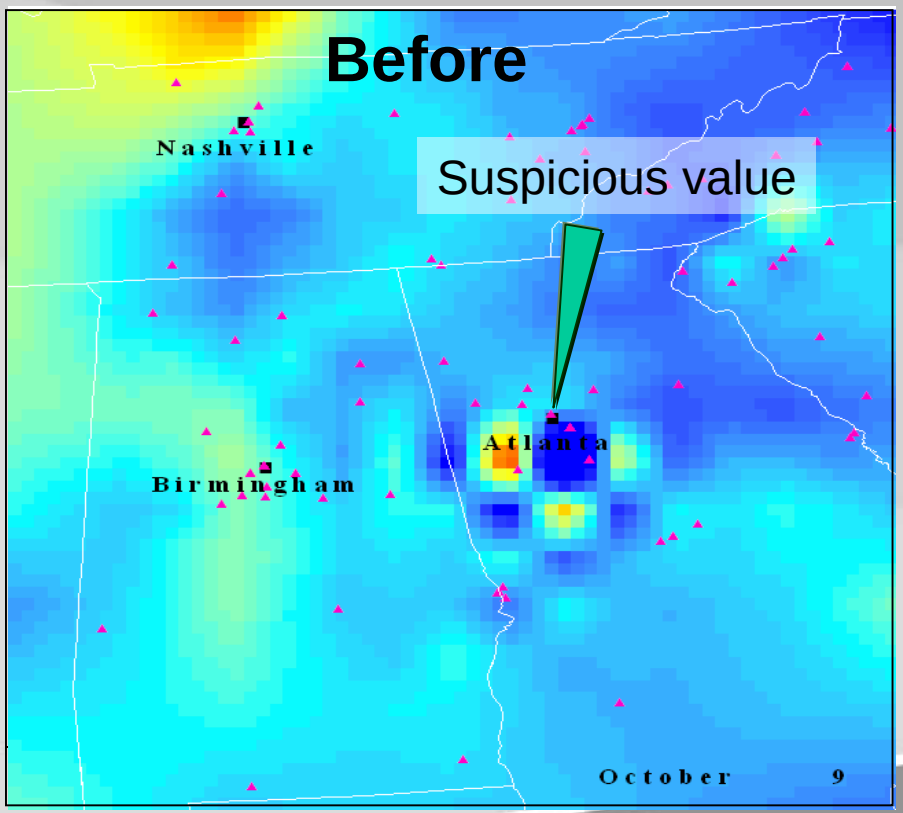
- Eliminates anomalous measurements based on a non-parametric rank-order spatial analysis
- Applied to all daily AQS $PM_{2.5}$ measurements before spatial surfaces are built

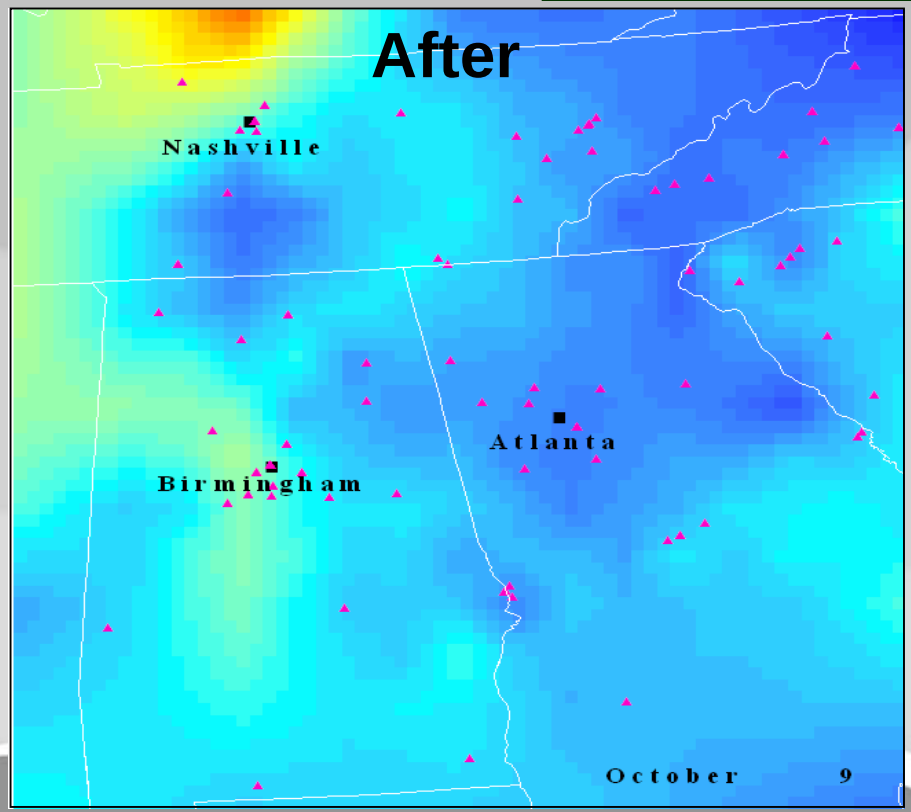
$PM_{2.5}$ Concentration

High : 50 μg/m³

Low : 0 μg/m³

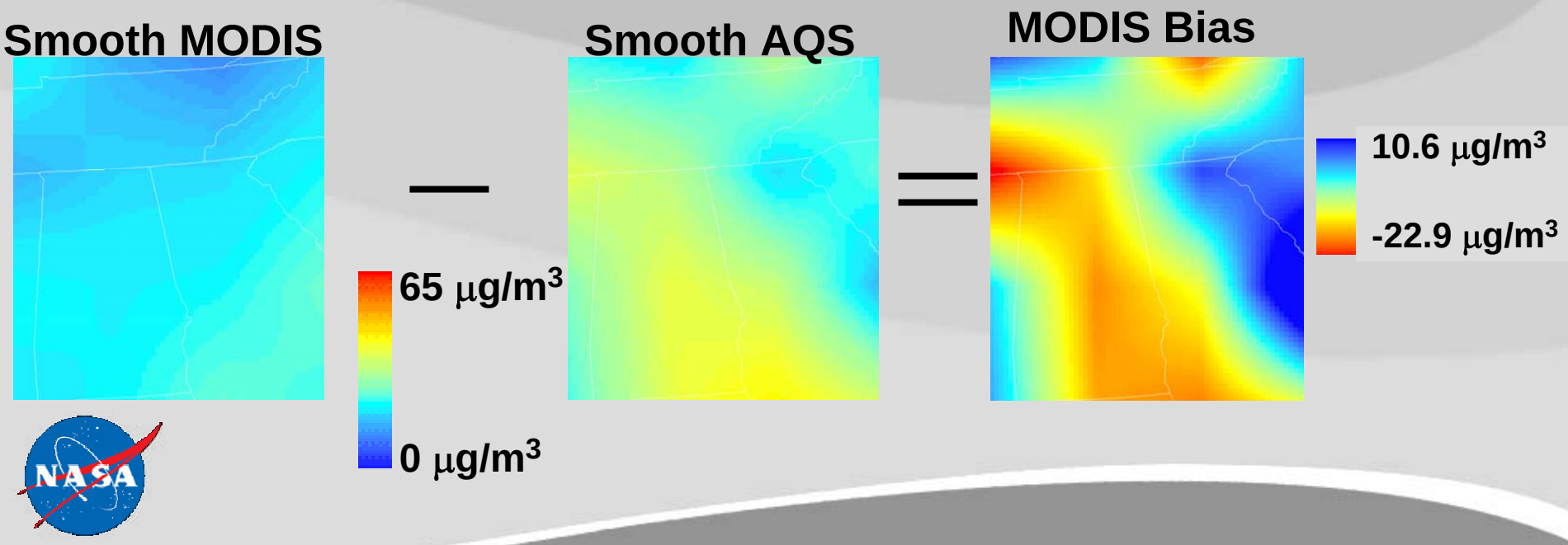
EPA sites





MODIS $PM_{2.5}$ Bias Adjustment

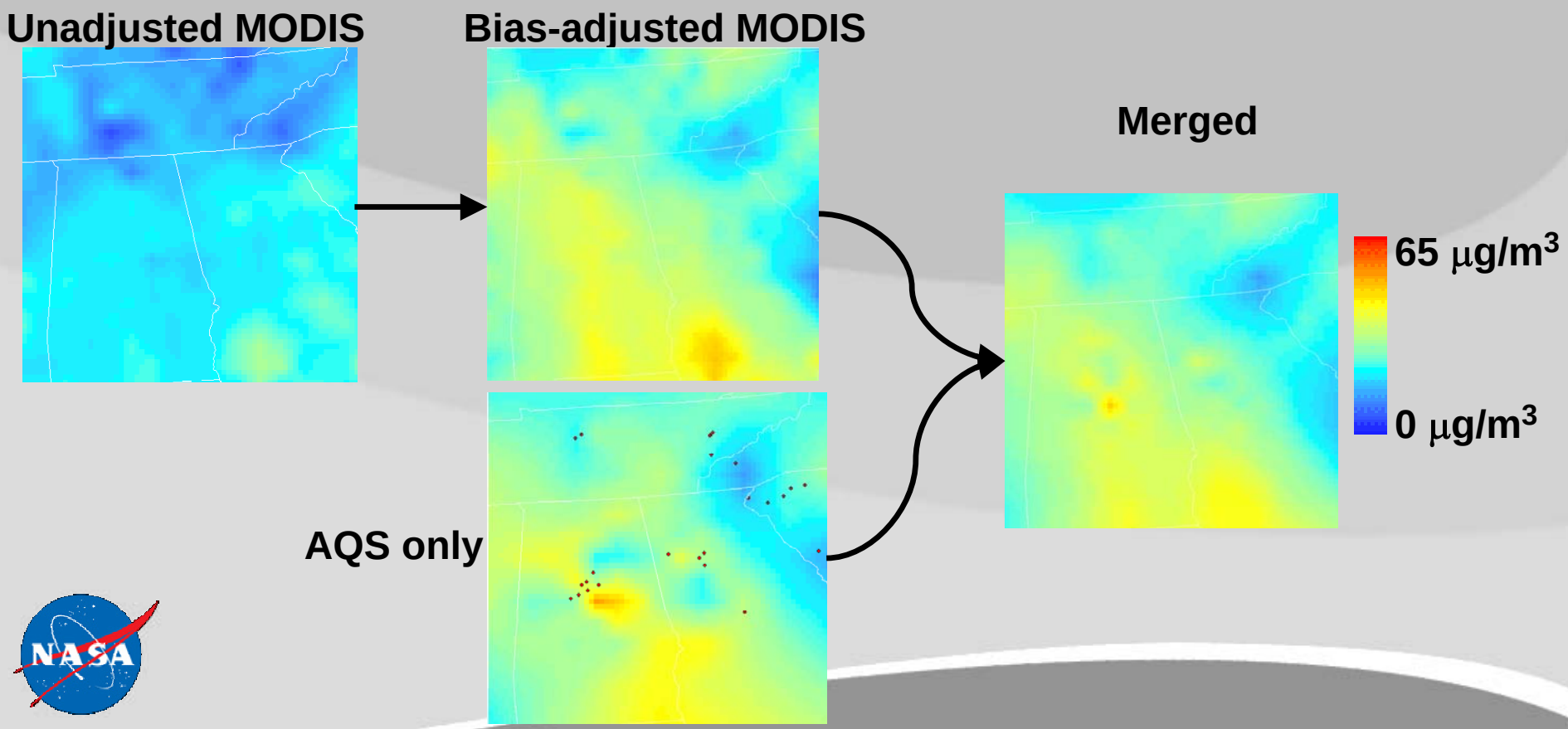
- **Assumption: AQS measurements are unbiased relative to the local mean, but MODIS $PM_{2.5}$ estimates may have biases.**
- **Procedure:**
  1. **Use a two-step B-spline algorithm to create highly smoothed versions of the MODIS and AQS $PM_{2.5}$ daily surface**
  2. **Compute the 'Bias' as the difference between the smoothed fields**
  3. **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

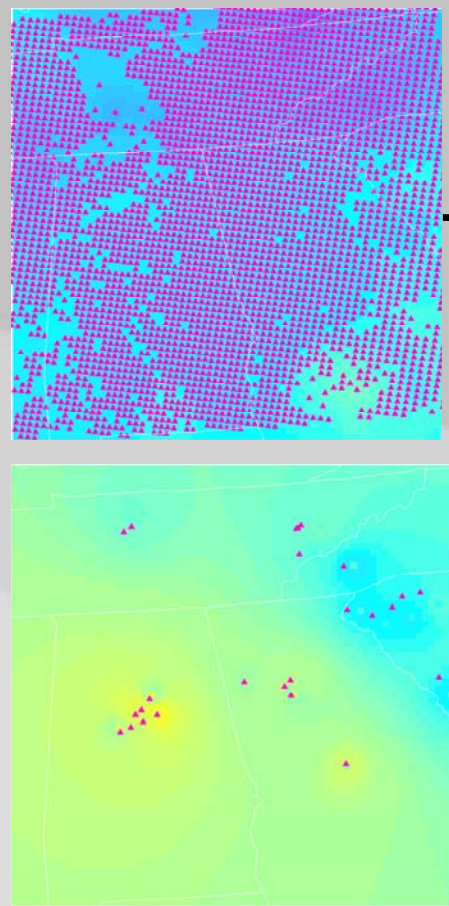


Merging MODIS and AQS $PM_{2.5}$ Data

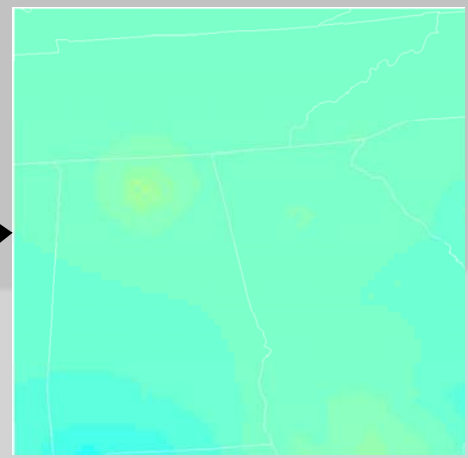
IDW Surfacing

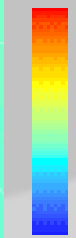
MODIS Only

AQS only



Merged



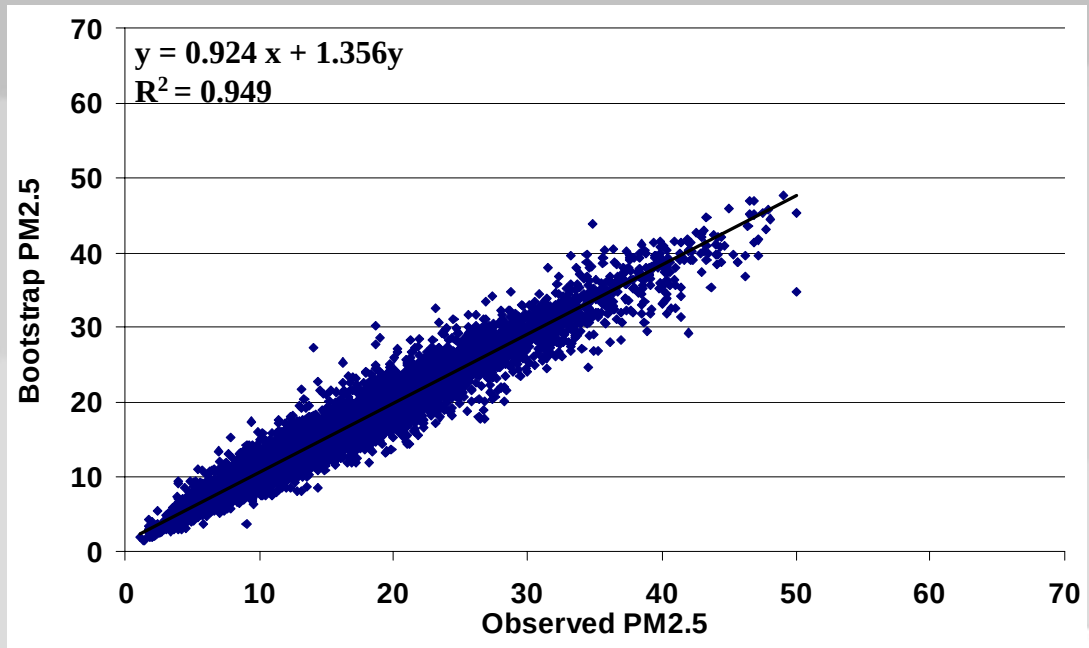


65 μg/m³

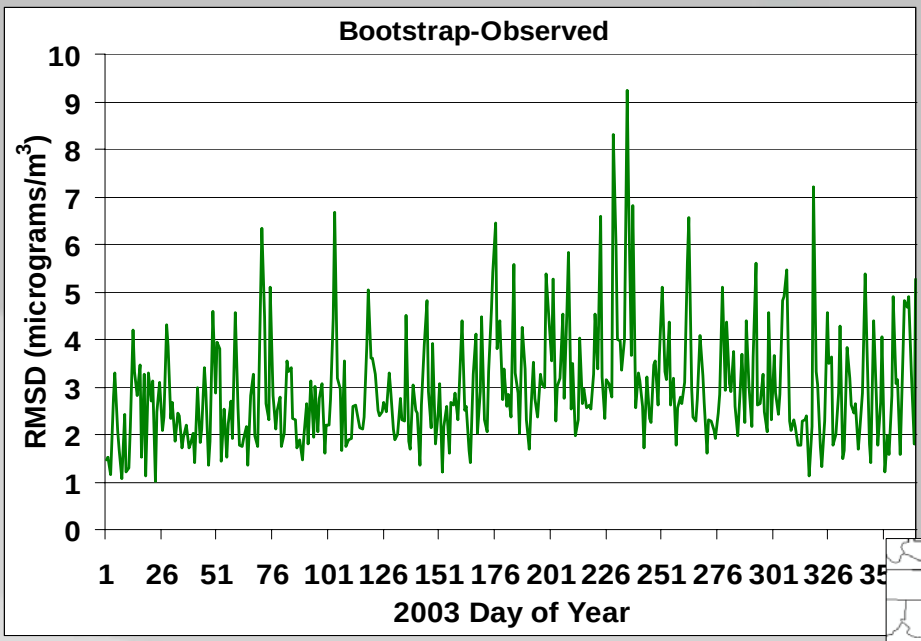
0 μg/m³

Cross-Validation

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



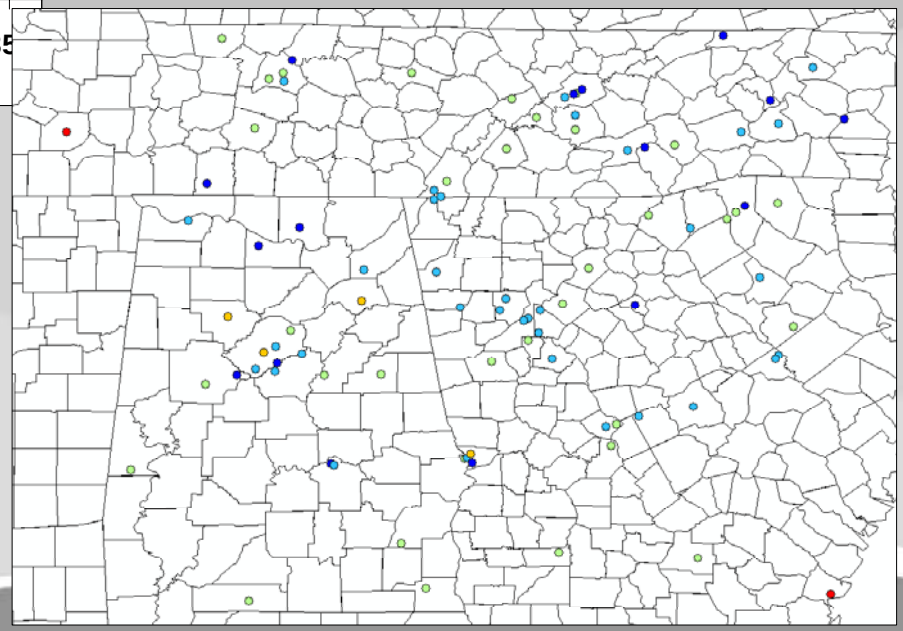
Cross-Validation Error Statistics



Time Series

RMSD = 2.7 μg/m^3

RMSD by Site

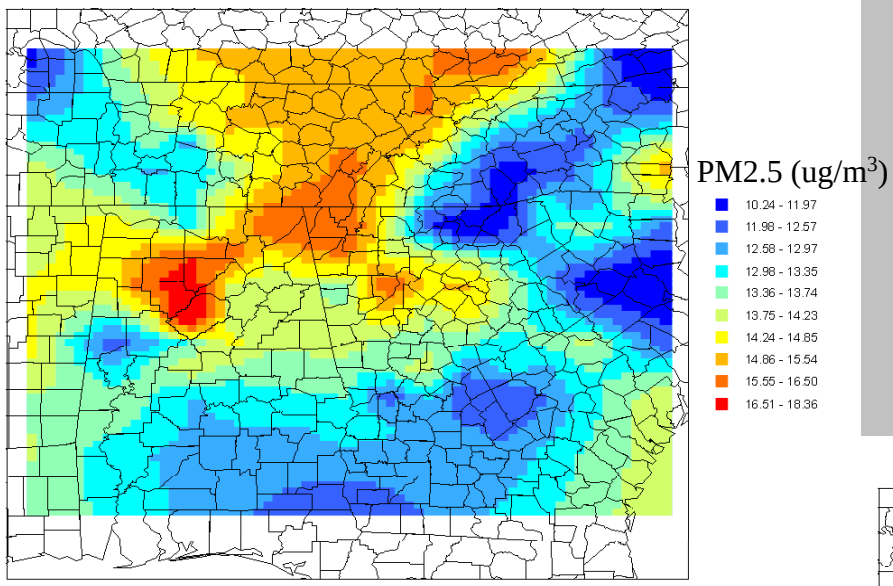


Surfacing Methods Comparison

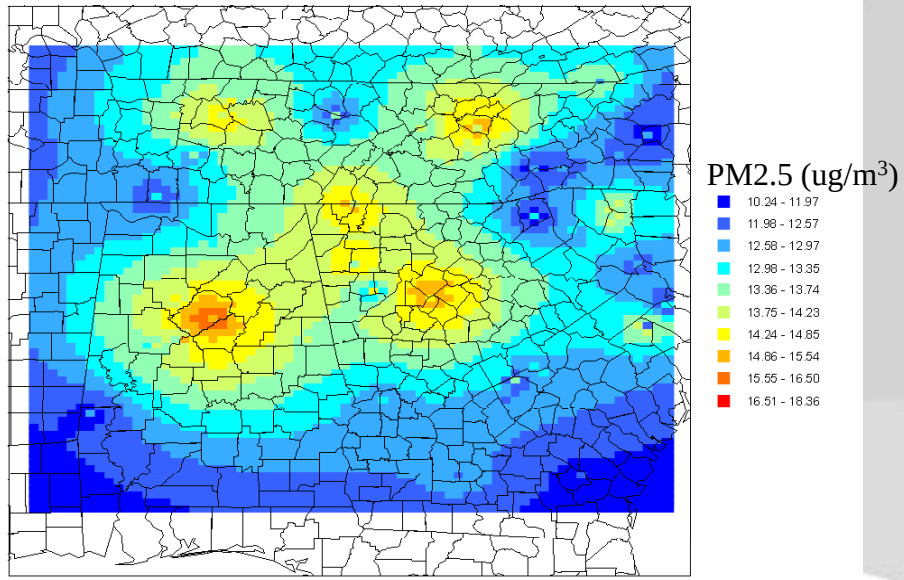
Surfacing Technique and Data Source	RMSD (All Days)	RMSD (Warm Season (Days 91-273))
Bspline, AQS only, no QC	3.302	3.556
Bspline, AQS only, with QC	2.927	3.164
IDW, AQS only	2.450	2.686
B-Spline, merged AQS/MODIS	N/A	2.756
IDW, merged AQS/MODIS	N/A	1.613

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



B-Spline



IDW

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.

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

Team Members and Acknowledgements

Member's Name, Affiliation

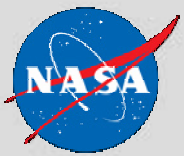
- (*Co-Chair)* Kafayat Adeniyi, Centers for Disease Control and Prevention,
- (*Co-Chair)* Solomon Pollard, Environmental Protection Agency (EPA), Region 4
- Mohammad Z. Al-Hamdan, National Aeronautics and Space Administration
- Rob Blake, DeKalb County Board of Health
- David Blaney, Georgia Division of Public Health
- Bill Crosson, National Aeronautics and Space Administration
- Kristen Mertz, Georgia Division of Public Health
- Amanda Sue Niskar, Centers for Disease Control and Prevention
- Dale Quattrochi, National Aeronautics and Space Administration
- Amber Sinclair, Kaiser Permanente
- Allison Stock, Centers for Disease Control and Prevention
- Denis Tolsma, Kaiser Permanente
- Linda Thomas, Environmental Protection Agency, Region 4
- Ntale Kajumba, Environmental Protection Agency, Region 4
- Carolyn Williams, Georgia Division of Public Health

Acknowledgments

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

Thanks!

Presenter's Contact Information:

Mohammad Z. Al-Hamdan, PhD

mohammad.alhamdan@nasa.gov