Utility of MODIS Aerosol Optical Depth for Estimating $PM_{2.5}$ Exposure in Public Health Surveillance

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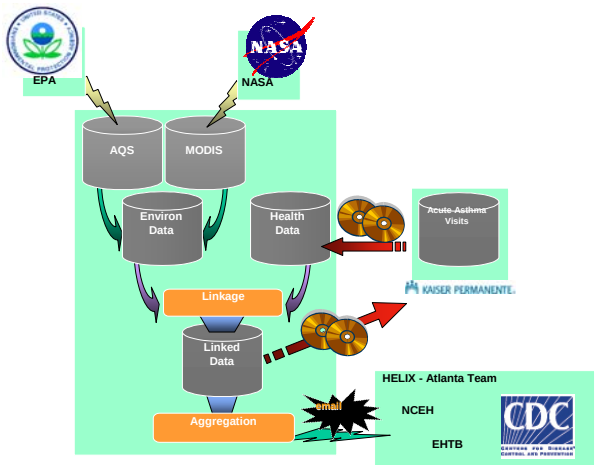
INTRODUCTION

- Health and Environment Linked for Information Exchange in Atlanta (HELIX-Atlanta) was developed to support current and future state and local environmental public health tracking (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.
- One of HELIX-Atlanta's teams is a respiratory health team (RHT) focusing on asthma.

GOALS

- Link environmental data (MODIS) related to ground-level $PM_{2.5}$ with health data related to asthma.
- 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.



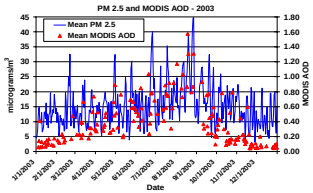
ENVIRONMENTAL DATA SOURCES

- U.S. EPA Air Quality System (AQS): Daily $PM_{2.5}$ measurements
- NASA EOS Data Gateway: MODIS Aerosol Optical Depth (AOD), used to estimate ground-level $PM_{2.5}$ concentrations.

METHODS

- Obtain MODIS AOD and EPA AQS $PM_{2.5}$ data for 2002-2003.
- Extract AOD data for AQS site locations within Atlanta metropolitan area.
- Calculate daily averages from hourly AQS $PM_{2.5}$ data.
- 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.
- Generate daily $PM_{2.5}$ surfaces using EPA and MODIS-estimated $PM_{2.5}$ data.
- Link $PM_{2.5}$ to the acute asthma office visit data.
- Send linked data with individual health information to the health data provider.
- Aggregate the linked data into surfaces of 10 km by 10 km.
- Send the aggregated data set to the CDC and publish for the public.

RESULTS

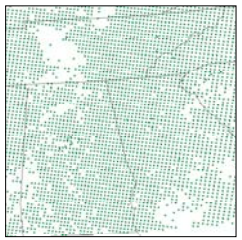


MODIS AOD - $PM_{2.5}$ Relationship:
- Daily 5-site means of observed $PM_{2.5}$ and MODIS AOD
- MODIS data not available every day due to cloud cover
- MODIS AOD follows seasonal patterns of $PM_{2.5}$ but not the day-to-day variability in fall and winter

	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.

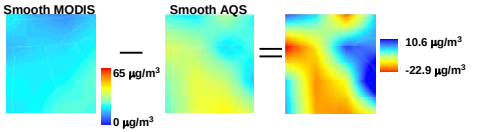
June 24, 2003



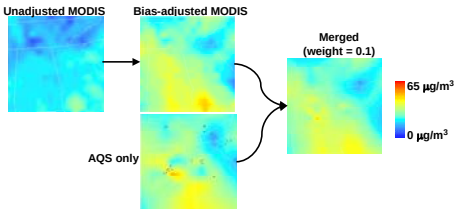
EPA AQS Data:
- Concentrated in urban areas
- fewer monitors in rural areas
- Time intervals range from 1 hr to 6 days

MODIS Data:
- Provided on a 10x10 km grid
- Available twice per day
- Clear-sky coverage only

RESULTS continued

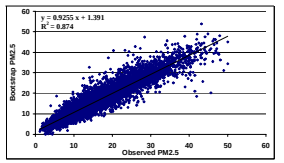


- MODIS $PM_{2.5}$ Bias Adjustment: Assuming AQS measurements are unbiased relative to the local mean, but MODIS $PM_{2.5}$ estimates may have biases.
- Prefer a 'regional-scale' bias adjustment (as opposed to local scale)



- MODIS and AQS data have been merged to produce final $PM_{2.5}$ surfaces. MODIS data are weighted lower than AQS.
- Weights derived through a simplified, time-invariant Kalman filter approach have been derived and applied to the MODIS $PM_{2.5}$ estimates.

- '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



Surfacing technique and data	R^2	Slope	Intercept
B-Spline, AQS only, no QC	0.795	0.895	1.970
B-Spline, AQS only, with QC	0.840	0.925	1.447
B-Spline, merged AQS/MODIS	0.870	0.925	1.390

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
B-Spline, merged AQS/MODIS	N/A	2.756

Date	Cell	Lat	Lon	County	State	FC	MC	FA	MA
200301	1	99.045	-87.855	Fulton	GA	0	1	1	0
200301	2	99.045	-87.734	Fulton	GA	0	0	0	0
200301	3	99.045	-87.613	Fulton	GA	0	0	2	1

Simulated example of the linked data set consisting of visit counts by analysis grid cell. The full data set covers the entire year of 2003 and all 4624 grid cells. F=female, M=male, A=adult, C=child.

Date	Member ID	Member Lat/Lon	Cell	Cell Lat/Lon	County	State	Gender	Age	$PM_{2.5}$
200301	11511	99.572	-87.105	134	99.552	-87.198	Carroll	GA	M	C	15.2
200301	27312	99.063	-89.036	798	99.104	-89.102	Cobb	GA	M	A	19.6
200301	106534	99.727	-86.212	4011	99.731	-86.244	DeKalb	GA	F	A	23.5

Simulated example of the linked data set consisting of $PM_{2.5}$ values corresponding to the residential location of each patient experiencing an acute asthma office visit. The full data set consists of all office visits for 2003.

CONCLUSIONS

This method of estimating $PM_{2.5}$ concentrations by merging MODIS remote sensing data with surface observations of $PM_{2.5}$ not only provides a more complete daily representation of $PM_{2.5}$ than either data set alone would allow, but it also reduces the errors in the $PM_{2.5}$ estimated surfaces with respect to observations. This study has proven the feasibility of linking environmental data (MODIS $PM_{2.5}$ estimates and ground observations) with health data (asthma). The applicability of this method for estimating $PM_{2.5}$ concentrations in other parts of the country and world merits further study.

REFERENCES

Centers for Disease Control and Prevention, Atlanta, GA, HELIX-Atlanta, http://www.cdc.gov/nceh/tracking/helix.htm

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ACKNOWLEDGMENT: The authors acknowledge the generous support of NASA Applied Sciences Public Health Program, CDC National EPHT, and HELIX-Atlanta Partners.

2006 IEEE International Geoscience & Remote Sensing Symposium & 27th Canadian Symposium on Remote Sensing "*Remote Sensing: A Natural Global Partnership*", Denver, CO, July 31-Aug 4, 2006.