Improve EPA's Air Quality Index Maps with NASA Satellite Data

AirNow Satellite Data Processor (ASDP) Project Update

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U.S. Environmental Protection Agency

2013 NASA Health and Air Quality Applications Program Review

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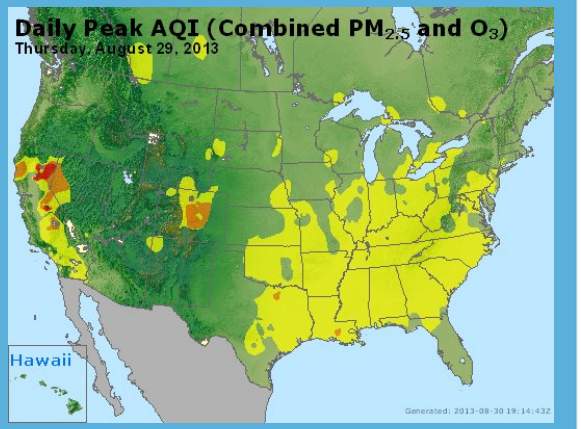
United States Environmental Protection Agency

AirNow Background

AirNow is the <u>national framework</u> for acquiring and distributing <u>air quality information</u>

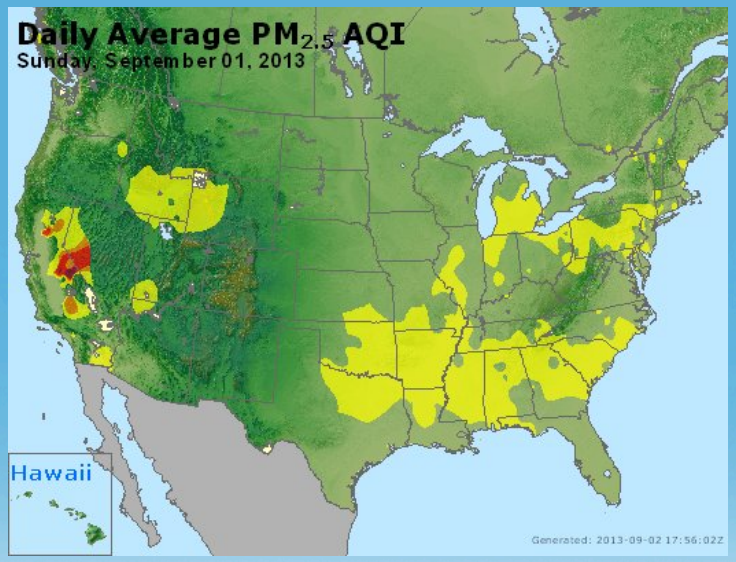
- Collects, quality assures, and <u>transfers</u> real-time and forecasted air quality information to the public
- Gathers data <u>provided</u> by 130+ federal, state, and local air quality agencies (2500 monitoring sites)
- Issues weather/air quality news stories
- Partners with national media and other agencies
- Provides air quality education and outreach

America's "go to" resource for <u>current</u> and <u>forecasted</u> air quality information

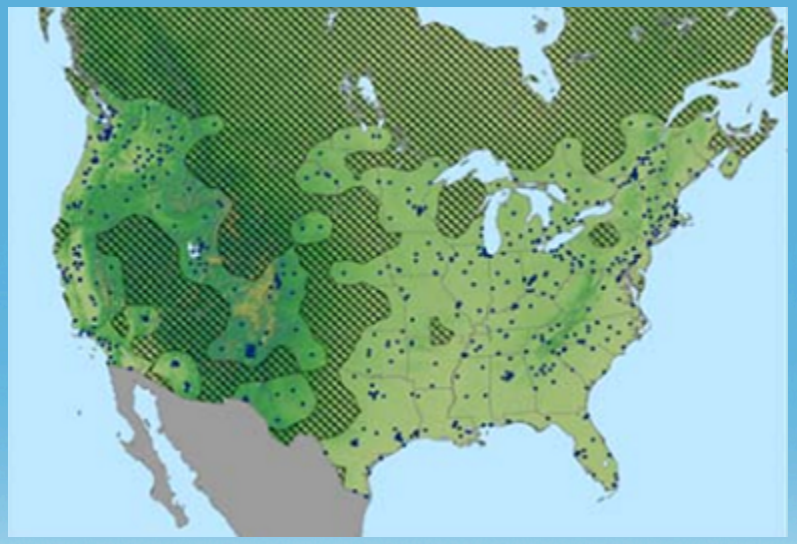


Background

- Spatial coverage of current AirNow maps is limited…
- There are significant data gaps resulting in over 36 million Americans (~40% of the area) not covered by a monitoring network
- Satellite data, specifically aerosol optical depth (AOD) can provide information to "fill-in" these gaps



AirNow Operational Map (airnow.gov)

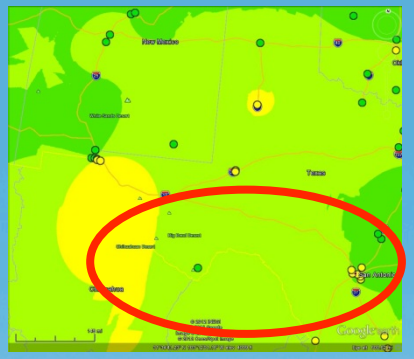


Without satellite data, no contouring is possible in the hatched areas

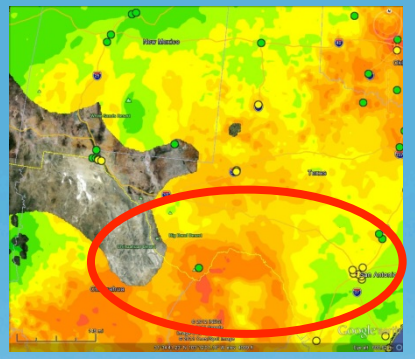
ASDP Project Objectives

- **Improve operational air quality maps currently in AirNow**
- **Provide satellite data products in AirNow-Tech**
- **Improve tools for air quality forecasting**

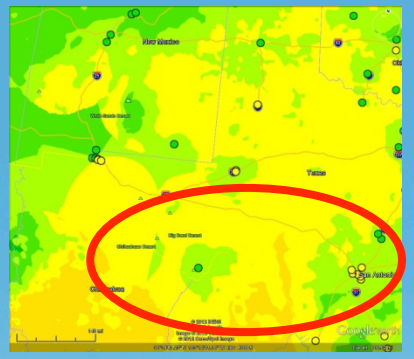
AirNow Observations



Satellite Data

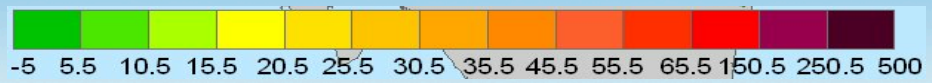


Fused Data



Satellite data captures the smoke and observed aerosols not in the AirNow data.

Concentration (µg/m^3)



Project Background

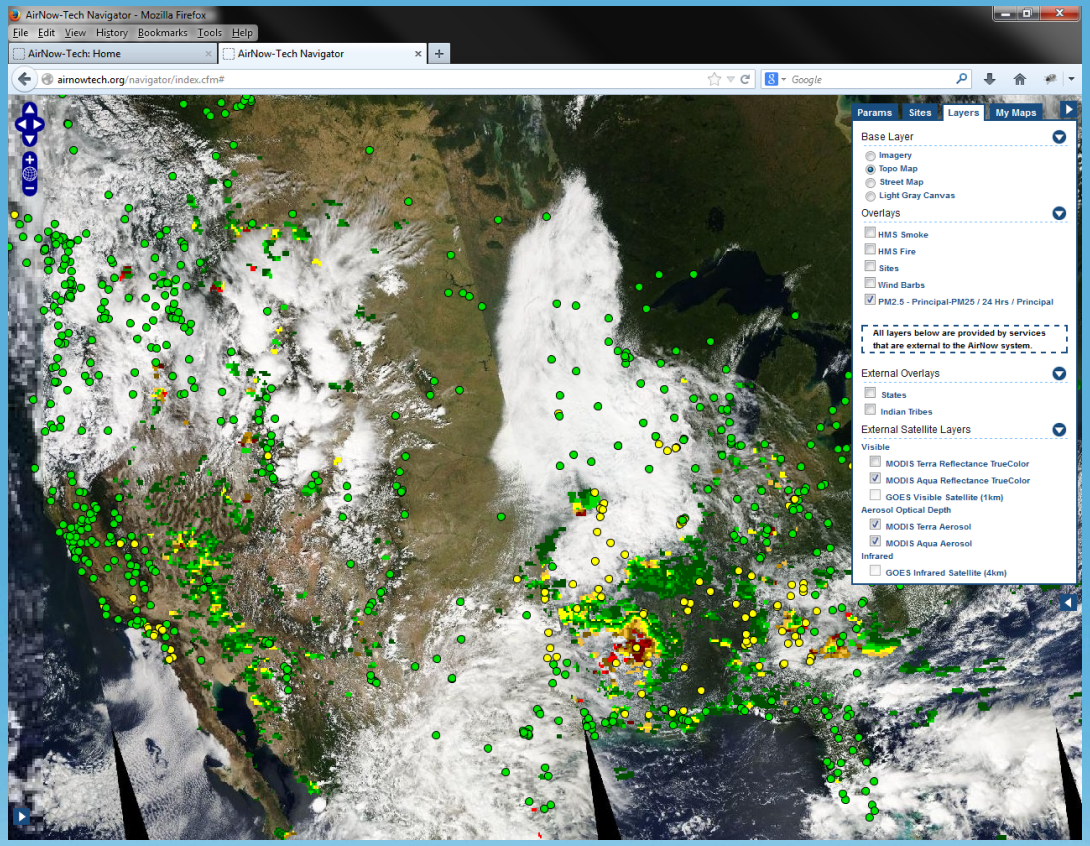
- **Satellite data:**
  - A variety of satellite products can be used for the ASDP
  - ASDP using MODIS (Terra/Aqua -- passes over each region twice daily)
  - Team developed sophisticated algorithms to estimate 24-hr ground-level $PM_{2.5}$ concentrations based on AOD and GEOS-Chem simulations
  - Estimates are dependent on data availability (e.g., no satellite data are available in areas with significant cloud cover or bright surfaces)
- **Ground observations:**
  - Using hourly observations from AirNow to calculate $PM_{2.5}$ 24-hr averages
  - Point data are interpolated using kriging method
- **Fused map product:**
  - Ground observations are fused with satellite estimates
  - Fusion employs an algorithm that assigns relative weights to each observation and estimates according to the data's uncertainty at that point
  - Satellite weight + ground observation weight = 1 at any given point

Project Team

- **Philip Dickerson, John E. White, James J. Szykman - EPA**
- **Allen Chu, UMBC, Baltimore, MD**
- **Shobha Kondragunta, NOAA/NESDIS, Washington D.C.**
  - Infusing satellite Data into Environmental Applications (IDEA), running algorithms developed by Dalhousie University
  - Provide to AirNow DMC on an operational basis as part of IDEA processing
- **Randall Martin, Dalhousie University, Nova Scotia, Canada**
  - Developed algorithms to estimate surface $PM_{2.5}$ concentrations from AOD and characterize kriging uncertainty
- **Sonoma Technology, Inc. (STI), Petaluma, CA**
  - Developed ASDP software module, provided overall coordination with team
- **Center for Technology and Government at the University Albany (CTG), Albany, NY**
  - Socioeconomic benefits analysis of adding NASA satellite data to AirNow

Accomplishments/Outcomes

- **Developed the ASDP modules**
  - Dalhousie developed uncertainty algorithm for the surface monitoring data (similar to satellite estimates)
- **Added satellite data, using NASA's GIBS, and ASDP products to AirNow-Tech**
  - ***AirNow-Tech Webinar October 3rd for EPA, but others are welcome***
- **Created a draft article describing 2 case studies using ASDP products (** http://www.Earthzine.org **)**
- **Created 2 outreach videos with 2 more in progress**



MODIS True Color, AOD, and $PM_{2.5}$ source: AirNow-Tech Navigator

Accomplishments/Outcomes

- **Created a Task Force of AirNow stakeholders for ongoing evaluation and to provide feedback**

New AirNow Product: Call for Evaluators

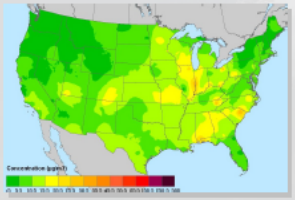
We're considering adding a new product to AirNow and evaluators are needed in your area. Join the ASDP Task Force and help assess the product's accuracy and usefulness to local agencies and the AirNow community. Your participation will ensure that the ASDP system delivers accurate, reliable, comprehensive coverage in your area and across the nation.

What is the ASDP?

- The AirNow Satellite Data Processor (ASDP) system fuses satellite data with ground observations of $PM_{2.5}$ to create a more complete picture of air quality across the U.S.
- The ASDP project team developed an algorithm to estimate surface $PM_{2.5}$ concentrations from satellite-measured aerosol optical depth.
- The ASDP fused $PM_{2.5}$ map product is created using uncertainty information to assign appropriate weighting to both ground monitor data and satellite estimates of $PM_{2.5}$.

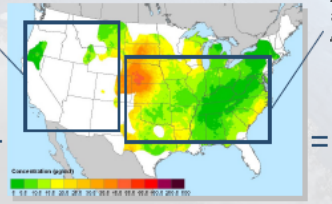
Gaps in the current monitoring network (red) leave 36 million people without accurate air quality information.

If you live in a sparsely monitored region, help us measure the accuracy and completeness of satellite data in your area.



Interpolated $PM_{2.5}$ ground observations

+



Satellite $PM_{2.5}$ estimates

If you live in a high-coverage area, help us assess and improve the accuracy of the ASDP product in your region.

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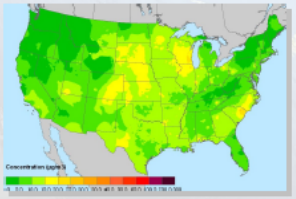

ASDP fused $PM_{2.5}$ coverage

Join the ASDP Task Force!

- Spend a few minutes each week evaluating the product and join us for eight monthly conference calls in 2013.
- Your participation will determine whether the ASDP becomes part of the AirNow program.

asdp.airnowtech.org

Watch videos | View ASDP products | Learn about the science behind the ASDP

Sign up by January 31st

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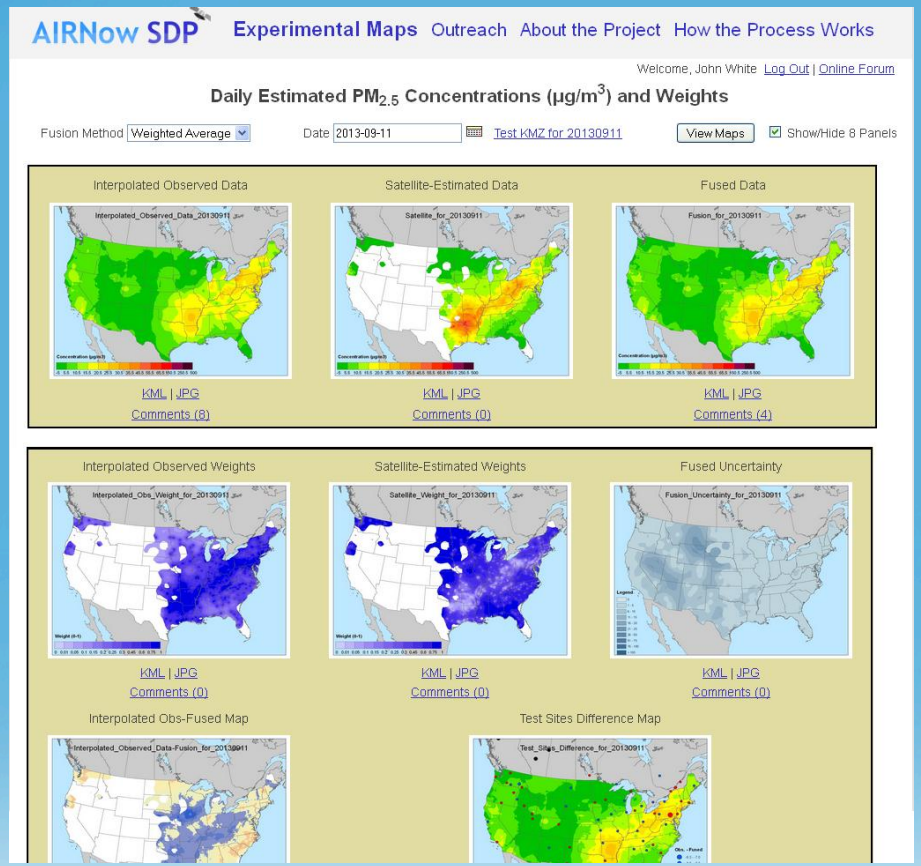
dickerson.phil@epa.gov

The ASDP project team sincerely appreciates your participation.

Accomplishments/Outcomes

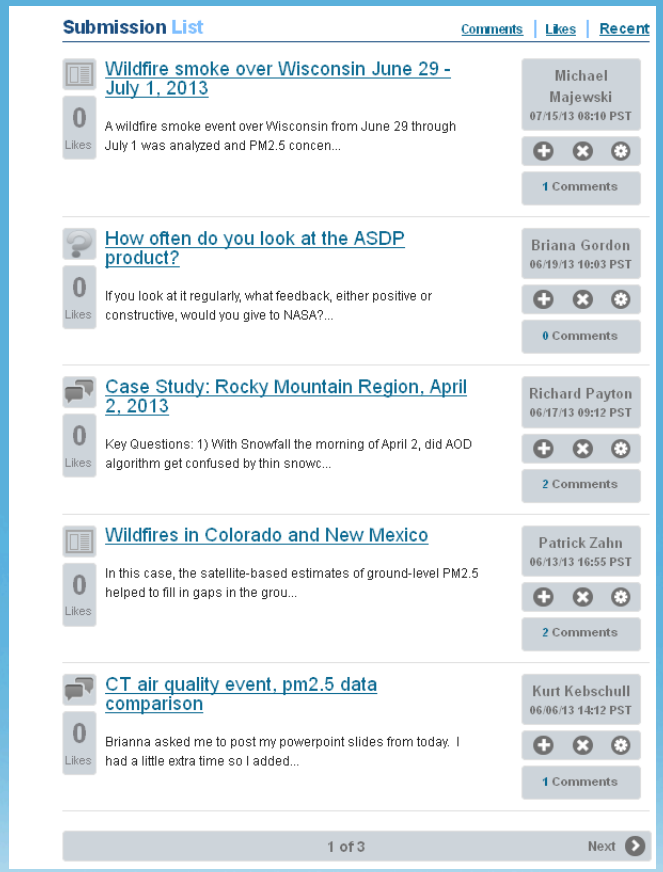
Developed a project website:

aspd.airnowtech.org



Developed an ASDP Online Forum:

share.airnowinternational.org



Accomplishments/Outcomes

Finalizing a Socioeconomic and Economic Evaluation

- **Socioeconomic**
  - Community-level assessment and interviews through three regional case studies (Denver, CO; Atlanta, GA; and Kansas City, MO)
  - Satellite data's benefits are not only cost saving/cost avoidance, but a series of more complex interactions
  - Interviews assessed the public value of adding satellite data to AirNow
    - Public values have intrinsic $ cost, or can be related to $
- **Economic**
  - Evaluated spatial representativeness of current $PM_{2.5}$ monitoring network
  - Estimated cost savings provided by NASA satellite data compared to installing new monitors to provide AQ info for public health decisions to underrepresented populations

Accomplishments/Outcomes

Example Socioeconomic Results - Public value impacts

CTG assessed the following during the 3 community case studies:

- **Economic** → impacts on current or future income, asset values, liabilities, entitlements, or other aspects of wealth or risks to any of the above
- **Mission** → impacts that sustain, enhance, or validate the mission-critical goals of a particular jurisdiction, agency or program
- **Social** → impacts on family or community relationships, social mobility, status, and identity
- **Quality of Life** → impacts on individual and household health, security, satisfaction, and general well-being
- **Strategic** → impacts on person's or group's advantages or opportunities, goals, and resources for innovation or planning
- **Stewardship** → impacts on the public's view of government as steward of public assets, trust, integrity, and legitimacy

Accomplishments/Outcomes

Example Socioeconomic Results

- **Economic**
  - Fills in gaps in the existing ground monitoring network without having to purchase and maintain new monitors (cost avoidance, ties to the economic analysis)
  - Helps identify the most optimal and cost-effective placement of new monitors (cost savings)
- **Mission/Political**
  - Provides local governments impacted by budget cuts with additional tools and data to help convince legislatures of the need for additional AQ funding
- **Social**
  - Provides additional information for K-12 education
  - Provides community groups with new tools to help educate citizens about air quality issues

Accomplishments/Outcomes

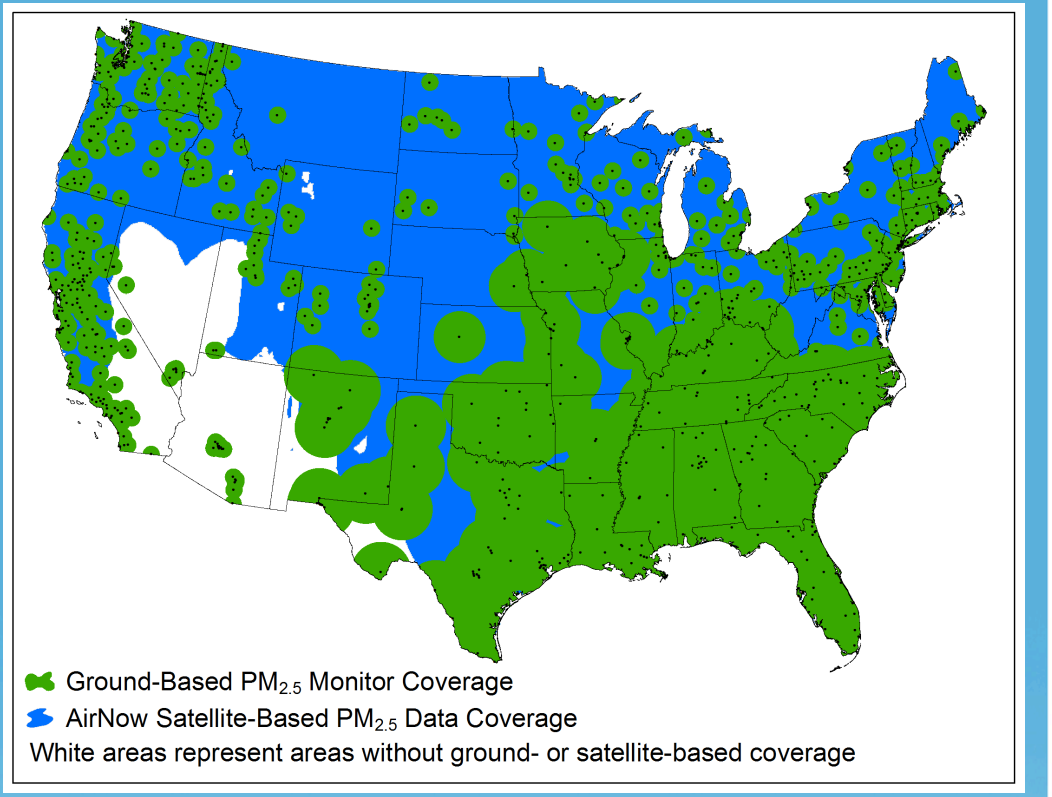
Example Socioeconomic Results

- **Quality of life**
  - Provides AQ information to underrepresented populations (such as in rural and agricultural areas)
  - Provides state forecasters with additional AQ information for use in AQ public health warnings in underrepresented areas
- **Strategic**
  - Provides AQ information for state and regional AQ monitoring and modeling for emerging concerns (e.g., oil and gas exploration) and interstate transport
- **Stewardship**
  - Increases the public's opinion of federal agencies like NASA and EPA as good stewards of the environment

Accomplishments/Outcomes

Economic Results

- **Satellite data**:
  - Fills data gaps, saving tens of millions of dollars in ground monitoring costs to provide AQ info to currently underrepresented populations
  - Provides additional AQ info (92% of population) in unmonitored regions
  - Extends globally, especially in developing countries with severe AQ problems
- **Additional higher-resolution satellite data needed to:**
  - Improve the relationship between satellite-measured data and surface AQ data
  - Provide data in near real-time (e.g., hourly)



Schedule/Milestones

Task	PY2010				PY2011				PY2012				PY2013			
	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3
	OND	JFM	AMJ	JAS	OND	JFM	AMJ	JAS	OND	JFM	AMJ	JAS	OND	JFM	AMJ	JAS
Derivation of satellite-based surface $PM_{2.5}$																
Preliminary gridded monthly AOD/PM2.5 ratios and error estimates																
Gridded monthly AOD/PM2.5 ratios and error estimates																
Report on the necessary steps for creating an hourly satellite-estimated surface PM2.5 product																
Baseline study on the relationship between AOD and $PM_{2.5}$ using high spectral resolution LIDAR.																
Comparison of MODIS and GOES AOD to develop regional uncertainty factors																
Journal article on daily satellite-based estimate of ground-level $PM_{2.5}$																
Derivation of satellite-based surface NO_2 concentrations																
Monthly gridded climatology of the relationship between tropospheric NO2 column and surface NO2 concentration																
Report on other progress and recommendations related to the inference of NO_2 from satellite observations																
Creation of AirNow Satellite Data Processor																
Selection and initial evaluation of data fusion techniques																
Research and development of a prototype data fusion software system to researched and selected data fusion techniques																
Development of a community and project website to display preliminary results as a mechanism for feedback																
Developing the ASDP modules, including data selection, weighting and uncertainty, data fusion, and testing applications																

KEY	
Color	Status
	Completed
	Progress Started
	Task to begin in the next Project Year

Schedule/Milestones

Task	PY2010				PY2011				PY2012				PY2013			
	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3
	OND	JFM	AMJ	JAS	OND	JFM	AMJ	JAS	OND	JFM	AMJ	JAS	OND	JFM	AMJ	JAS
Satellite data in AirNow-Tech																
Proof-of-concept website for AirNow-Tech using open-source GIS tools combined with a web services to display NASA satellite data, and AirNow																
AirNow Satellite Data Processor Documentation																
Functional Specification Document																
Initial User's Guide																
Socioeconomic Analysis																
Professional Communication																
13th Conference on Atmospheric Chemistry AMS Annual Meeting						X										
AGU Fall Meeting									X				X			
Integrated Annual Progress Report					O			O								

KEY	
Color	Status
	Completed
	Progress Started
	Task to begin in the next Project Year

Upcoming Plans

- **Project ends October 2013**
  - Will continue as operational product within AirNow program
- **AirNow Satellite Data Processor**
  - Integrate ASDP in AirNow Information Mapping System (IMS) and continue to evaluate and test the results
- **Socioeconomic Evaluation (finalizing report now)**
  - Present results at AGU (hopefully) along with 2 other ASDP talks/posters
- **Outreach Videos**
  - Two videos detailing ASDP case studies of two $PM_{2.5}$ events; one is a dust event and one is a smoke event
- **Investigation into other sources of funding to extend the methodology globally**

Project Risks/Challenges

- **Technical Risks**
  - Loss of satellites is a big risk
  - Team is looking into using data from VIIRS and GASP (in preparation for GOES-R)
- **Stakeholder Support/Buy-in**
  - Engaged them early to help with the evaluation of the product and received great feedback (product changes/availability/desired features)
  - Created outreach section of Project website (meeting minutes, ppts, journal articles)
  - Created ASDP Online Forum to facilitate discussion and sharing of results among Stakeholders evaluating the product
  - Task Force calls throughout the year to supplement ASDP Forum discussions
- **Operational Challenges**
  - Satellite algorithms are running in a research capacity at NOAA NESDIS as part of IDEA; EPA has little control since NOAA has agreed to run (w/o receiving funding support)
  - Periodic data loss issues (ftp server, network connections, software upgrades)
- **Management Issues (*none to report*)**

Application Readiness Level

ARL 2 Application Concept (Invention)	• 2009 – ASDP project began at ARL 2
ARL 4 Initial Integration & Verification (Prototype/Plan)	• August 2011 – ARL 4
ARL 7 Application Prototype in Partner's Decision Making (Functionality Demonstrated)	• July 2012 – ARL 7
ARL 8 Application Completed & Qualified (Functionality Proven)	• October 2012 – ARL 8
ARL 9 Approved, Operational Deployment & Use in Decision Making (Sustained Use)	• October 2013 – ARL 9

Project Budget

- **Project Funding Obligated to Date – Total - $1,234,457.00**
  - Base Funding Summary $260,594 (FY10), $267,676 (FY11- received late), $272,691 (FY12), $228,509 (FY13)
  - Supplemental Awards
    - Socio-economic Study ($185,213 FY12)
    - Outreach videos ($29,733 total, $19,744 obligated so far)
- **Project Funding – Pending Total - $1,244,416.00**
  - Supplemental Awards
    - Outreach videos ($29,733 total, $9,959 for FY13/14 received by EPA in August).
    - Interagency agreement recently modified to add these funds to contract (aiming to be obligated next month)

Thank you

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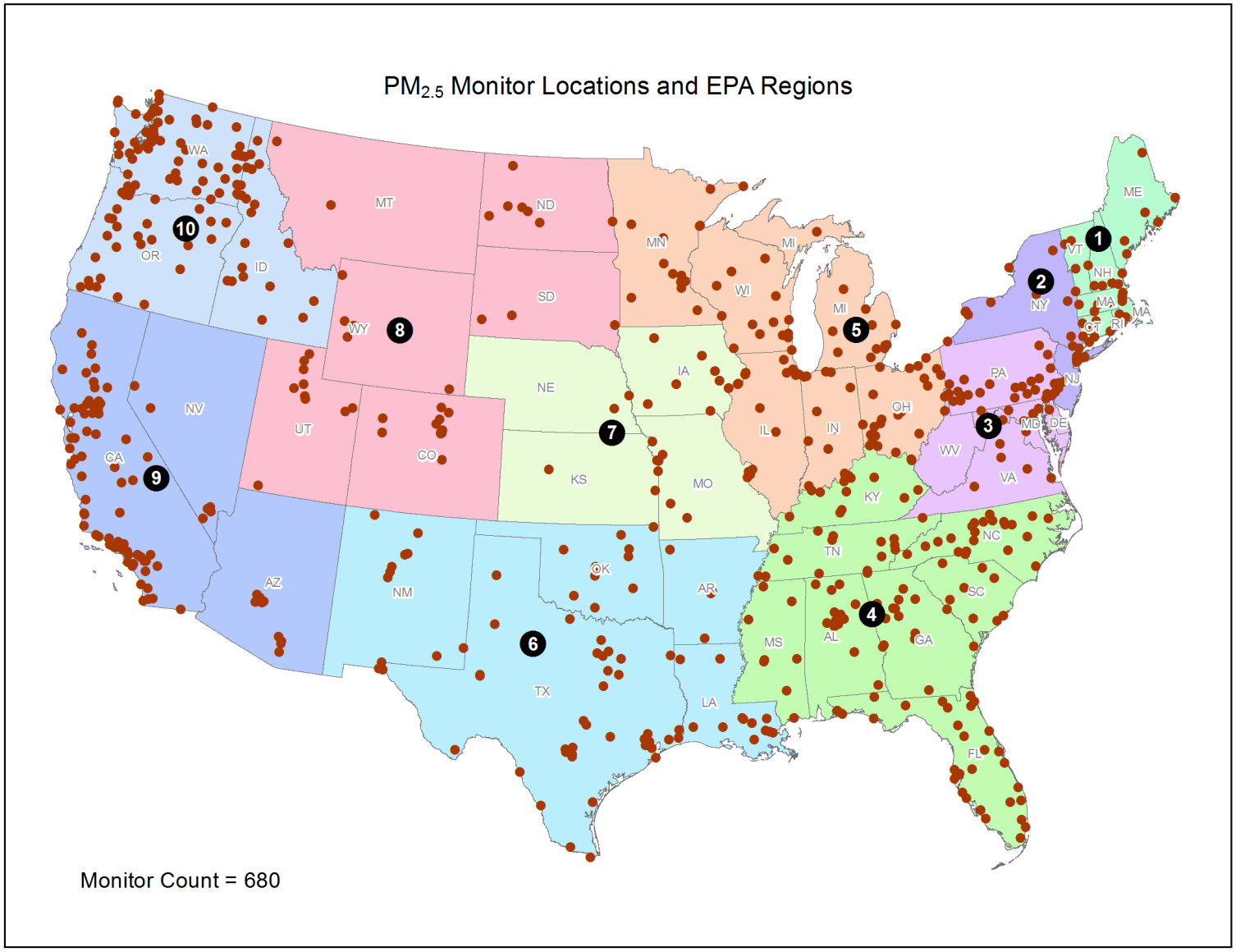
EPA United States Environmental Protection Agency

Extra Slides

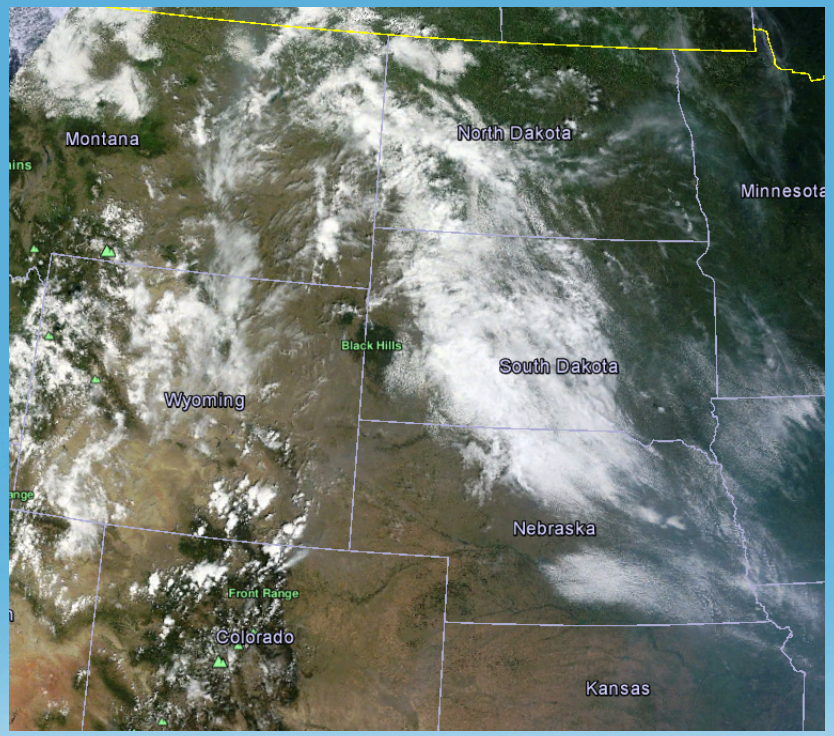
PM2.5 sites used in socio-economic study



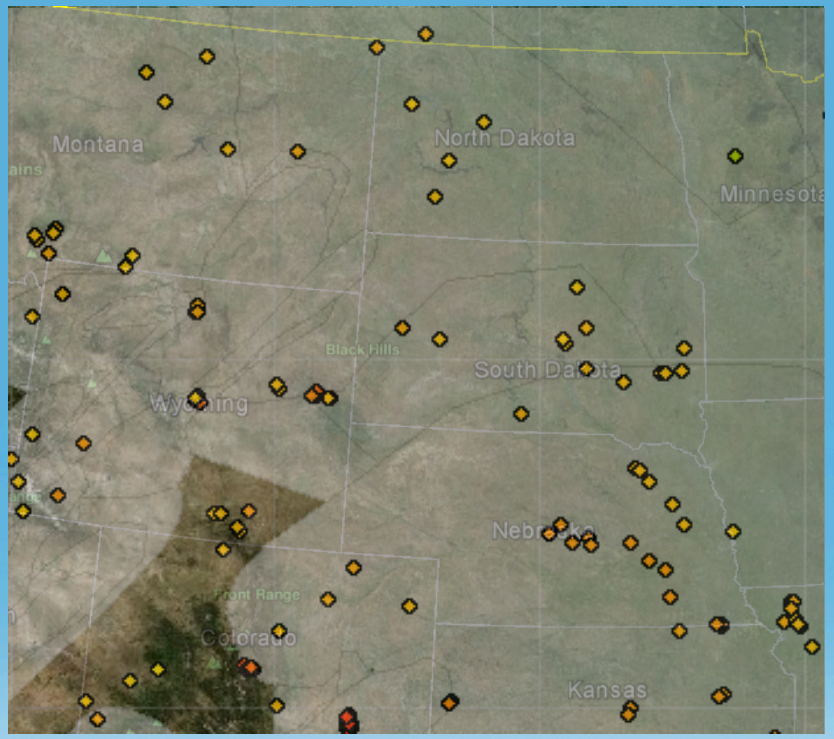
Example of Results: Northern Plains Smoke Event

June 25th, 2012

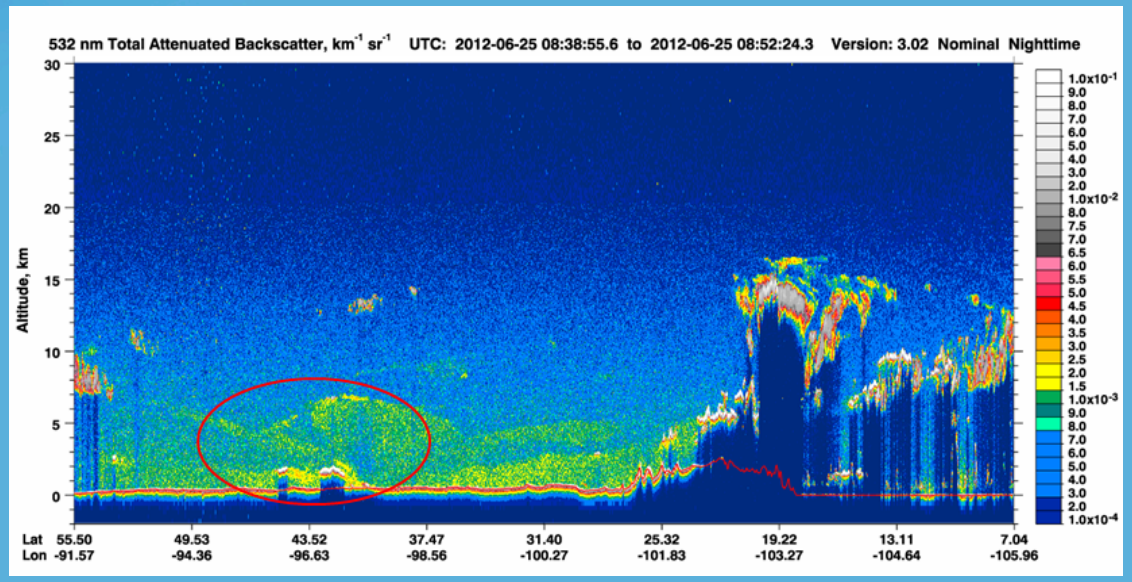
MODIS TERRA Visible Satellite

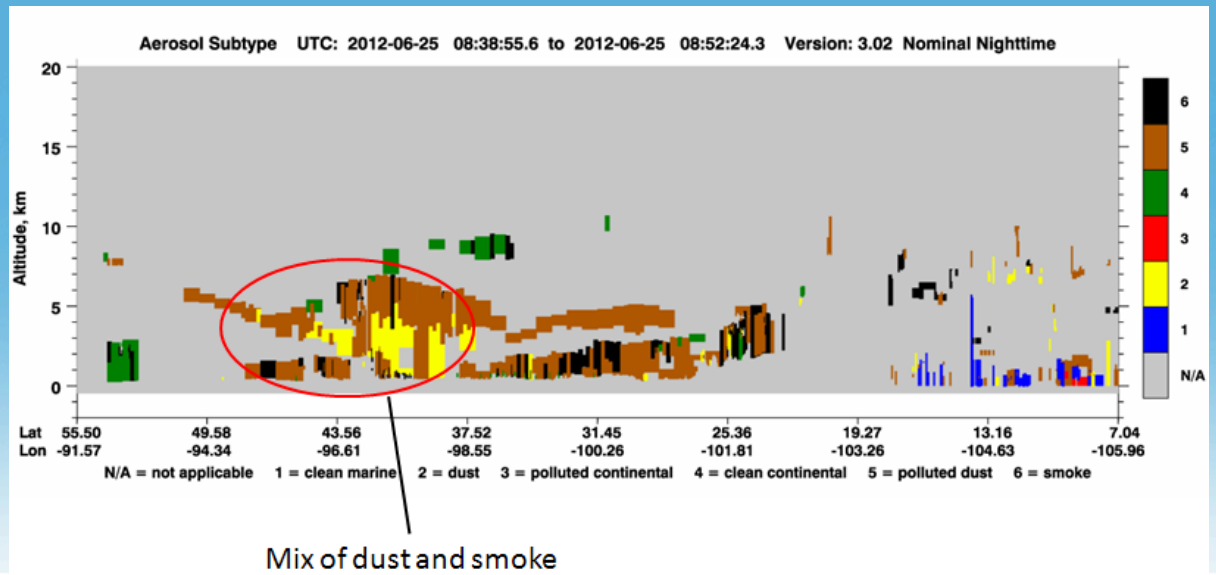


Smoke Plumes(Grey) and Fire Locations



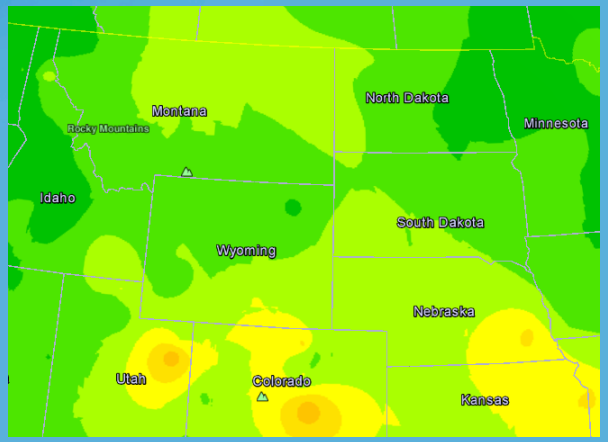
Example of Results: 6-25-2012 0838Z Calipso Pass



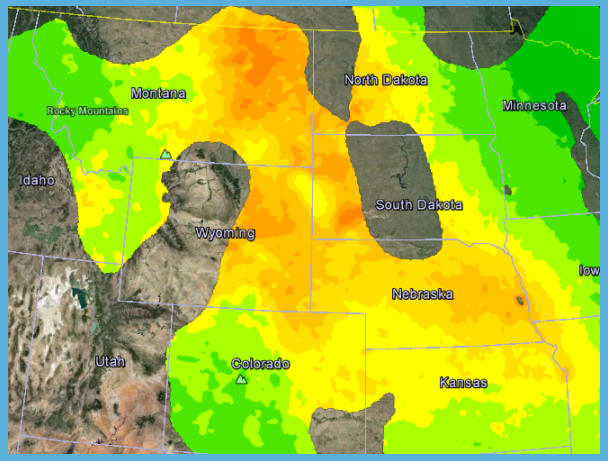


Example of Results: Northern Plains Smoke Event

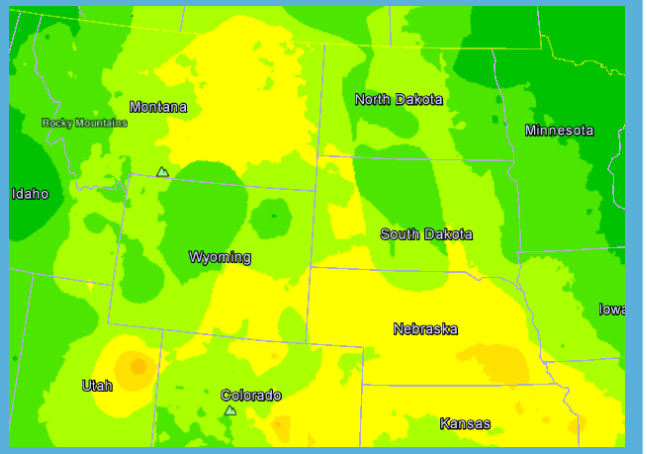
AirNow Observations



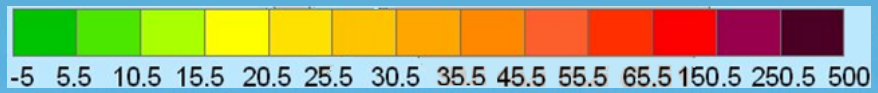
Satellite Estimates



ASDP Fused Product



$PM_{2.5}$ Concentration ($\mu g/m^3$)



- **Smoke in Northern Plains**
- **Limited Air Quality Monitors**
- **ASDP Product adds information (Moderate)**