Overview of Air Quality Monitoring in the U.S. and the EPA AirNow Program

John E. White, US EPA
white.johne@epa.gov

NCAR/ASP 2016 Summer Colloquium on Air Quality

Outline

- **Air Quality Monitoring in the United States**
  - Overview
  - Objectives/Siting
  - Current Network
  - NAAQS
  - Innovative Programs
- **EPA AirNow Program**
  - Goals/Purpose
  - History
  - AQI/Outreach
  - Embassies/Tools
- **Upcoming Challenges/Opportunities**
  - Low cost Sensors
- **Air Quality Monitoring in Canada**
  - Network and AQHI

Overview of Air Monitoring Efforts

- **Vast majority of ambient sites operated by state and local agencies**
  - EPA provides oversight
  - Costs for "routine" monitoring are shared 60/40 (Federal/State)
  - Locations for sites/monitors are identified by state and local (county) agencies
    - *meet minimum monitoring requirements and satisfy other monitoring objectives*
    - *meet the combination of site types and spatial scales appropriate to answer pertinent monitoring questions*
    - *be compliant with probe siting criteria*
- **EPA provides technical guidance, support with methods development and approval, quality assurance, network revisions/updates and database infrastructure for data reporting and archiving**
- **Key objectives include:**
  - enforcement of National Ambient Air Quality Standards, Air Quality Index reporting, trends analysis, health and ecological studies, and accountability programs

Success through Partnerships

State, Local, and Tribal Agencies – EPA's Role

- Establishes minimum national monitoring requirements for methods, quality assurance, network design, and monitoring siting through the Code Of Federal Regulations and guidance documents
- Provides funding through the State and Tribal Assistance Grants (STAG)
- Support IT infrastructure through maintenance of data repositories such as the Air Quality System (AQS) and AirNow
- Training and conference support to encourage information exchange
- Provides technical and advisory support to ensure consistent interpretation of rules and policies

Monitor Siting Considerations

- Highest concentrations expected to occur in the area covered by the network.
- Typical concentrations in areas of high population density.
- Impact of significant sources or source categories on air quality.
- General background concentration levels.
- Extent of regional pollutant transport among populated areas; and in support of secondary standards.
- Measure air pollution impacts on visibility, vegetation damage, or other welfare-based impacts.

Site Spatial Scales

The goal in locating monitors is to correctly match the spatial scale represented by the sample of monitored air with the spatial scale most appropriate for the monitoring site type, air pollutant to be measured, and the monitoring objective.

smaller

larger

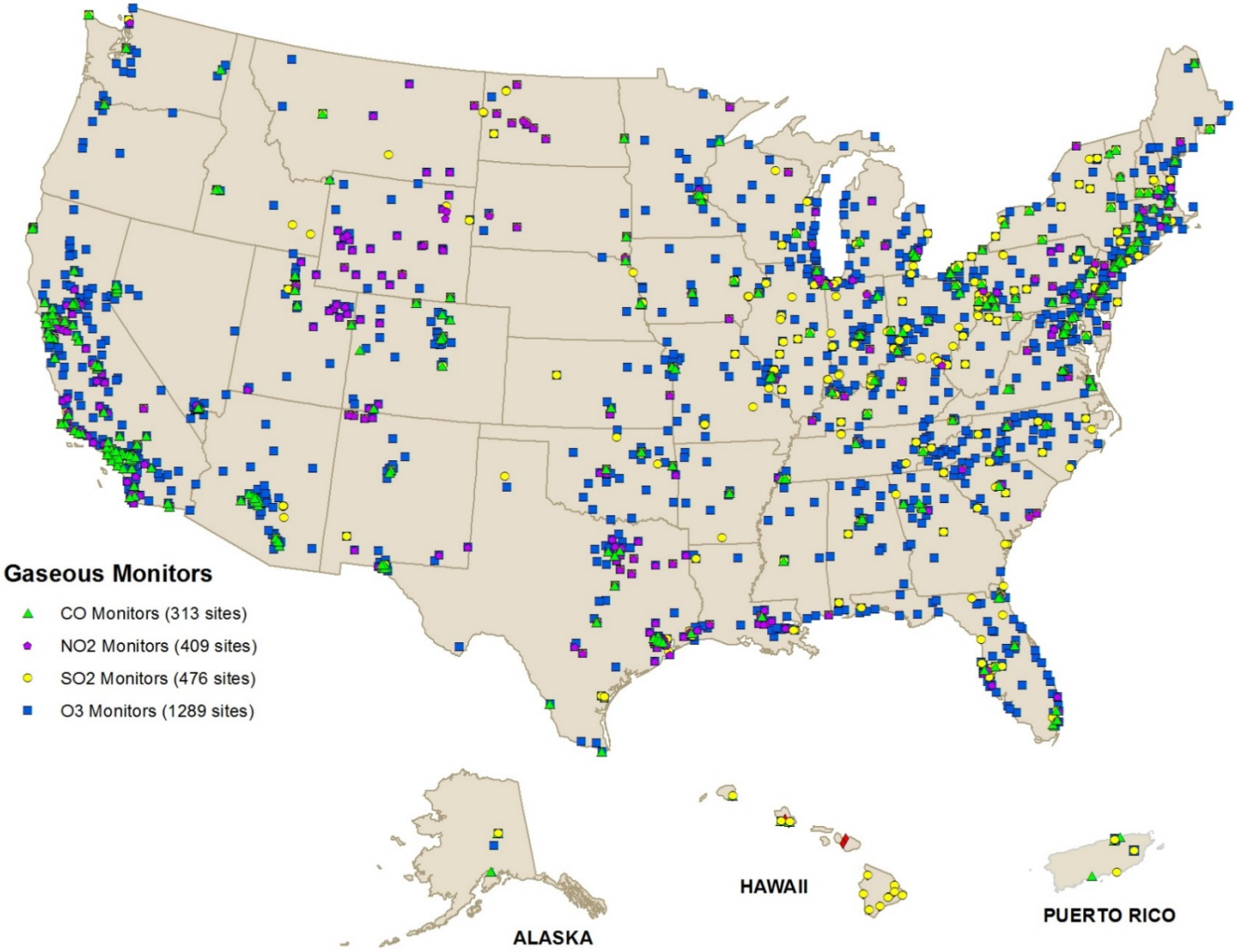
1) Microscale--defines the concentrations in air volumes associated with area dimensions ranging from several meters up to about 100 meters.
(2) Middle scale--defines the concentration typical of areas up to several city blocks in size with dimensions ranging from about 100 meters to 0.5 kilometer.
(3) Neighborhood scale--defines concentrations within some extended area of the city that has relatively uniform land use with dimensions in the 0.5 to 4.0 kilometers range. The neighborhood and urban scales listed below have the potential to overlap in applications that concern secondarily formed or homogeneously distributed air pollutants.
(4) Urban scale--defines concentrations within an area of city-like dimensions, on the order of 4 to 50 kilometers. Within a city, the geographic placement of sources may result in there being no single site that can be said to represent air quality on an urban scale.
(5) Regional scale--defines usually a rural area of reasonably homogeneous geography without large sources, and extends from tens to hundreds of kilometers.
(6) National and global scales--these measurement scales represent concentrations characterizing the nation and the globe as a whole.

Federal Ambient Monitoring Objectives

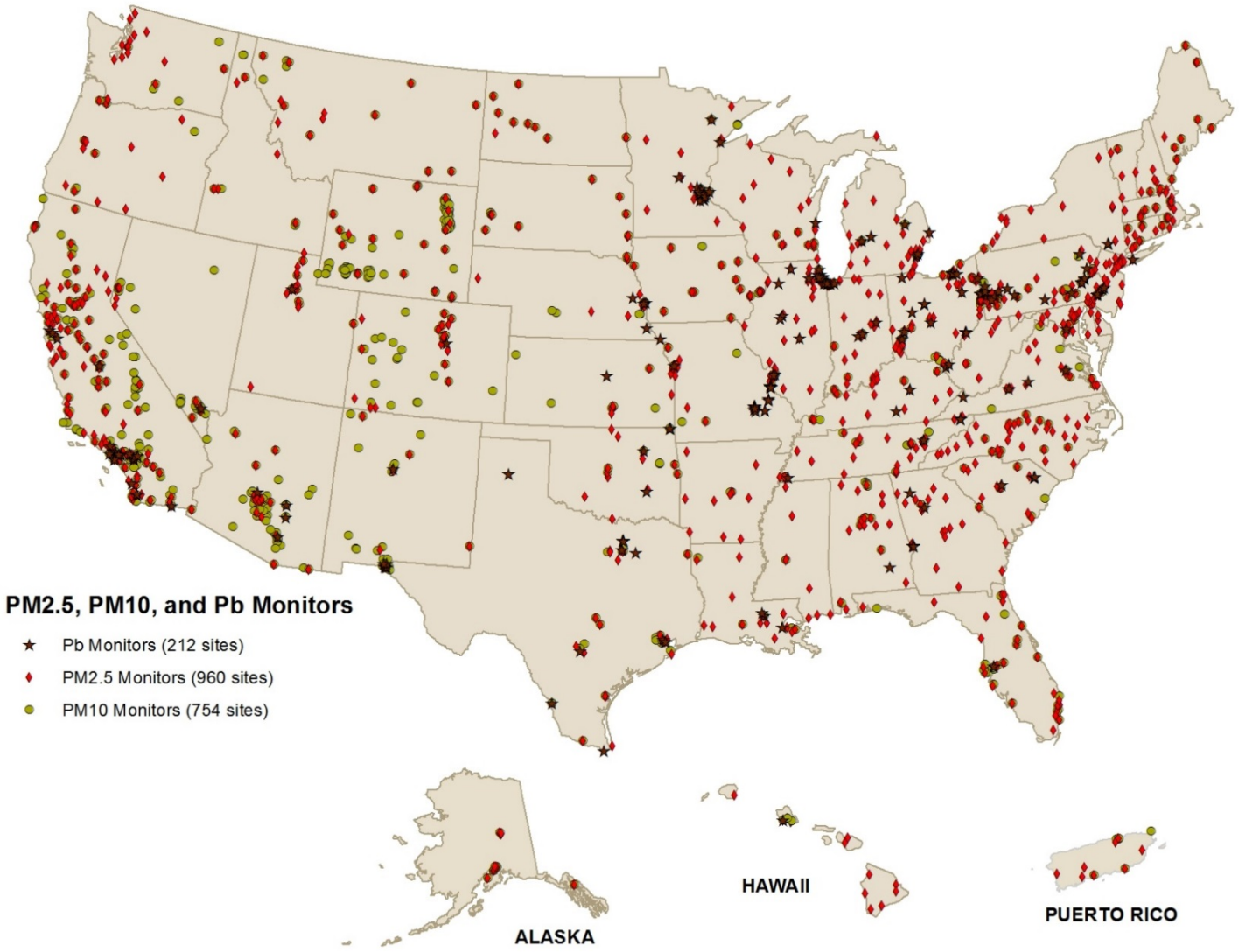
- Assess compliance with air quality standards for criteria pollutants (CO, SO_2, NO_2, O_3, Pb, PM_{10}, $PM_{2.5}$)
- Characterize air toxics and criteria trends
- Support accountability programs
  - Demonstrate success of emissions control programs
  - Validate modeling analyses
- Provide air pollution data to the general public in a timely manner
- Support air pollution research studies
  - Health effects
  - Ecosystem impacts
  - Atmospheric chemistry
  - Methods development

Network design requirements are referenced in 40 CFR 58 Appendix D.

Nationwide monitoring network



Nationwide monitoring network



National Ambient Air Quality Standards

The Clean Air Act, which was last amended in 1990, requires EPA to set National Ambient Air Quality Standards (40 CFR part 50) for pollutants considered harmful to public health and the environment.

The Clean Air Act identifies two types of national ambient air quality standards:

- ***Primary standards*** provide public health protection, including protecting the health of "sensitive" populations such as asthmatics, children, and the elderly.
- ***Secondary standards*** provide public welfare protection, including protection against decreased visibility and damage to animals, crops, vegetation, and buildings.

National Ambient Air Quality Standards

Pollutant [links to historical tables of NAAQS reviews]		Primary/ Secondary	Averaging Time	Level	Form
Carbon Monoxide (CO)		primary	8 hours	9 ppm	Not to be exceeded more than once per year
			1 hour	35 ppm	
Lead (Pb)		primary and secondary	Rolling 3 month average	0.15 µg/m^3 (1)	Not to be exceeded
Nitrogen Dioxide (NO_2)		primary	1 hour	100 ppb	98th percentile of 1-hour daily maximum concentrations, averaged over 3 years
		primary and secondary	1 year	53 ppb (2)	Annual Mean
Ozone (O_3)		primary and secondary	8 hours	0.070 ppm (3)	Annual fourth-highest daily maximum 8-hour concentration, averaged over 3 years
Particle Pollution (PM)	$PM_{2.5}$	primary	1 year	12.0 µg/m^3	annual mean, averaged over 3 years
		secondary	1 year	15.0 µg/m^3	annual mean, averaged over 3 years
		primary and secondary	24 hours	35 µg/m^3	98th percentile, averaged over 3 years
	PM_{10}	primary and secondary	24 hours	150 µg/m^3	Not to be exceeded more than once per year on average over 3 years
Sulfur Dioxide (SO_2)		primary	1 hour	75 ppb (4)	99th percentile of 1-hour daily maximum concentrations, averaged over 3 years
		secondary	3 hours	0.5 ppm	Not to be exceeded more than once per year

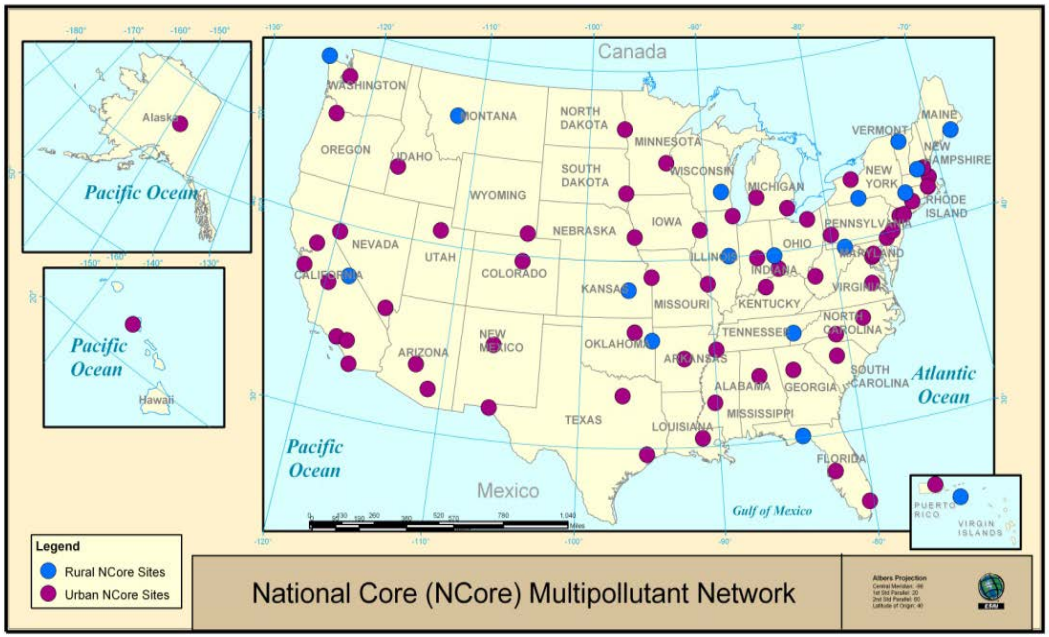
Periodically, the standards are reviewed and may be revised. Units of measure for the standards are parts per million (ppm) by volume, parts per billion (ppb) by volume, and micrograms per cubic meter of air (µg/m^3).

Monitoring – Innovative Programs

NCore Multipollutant Network

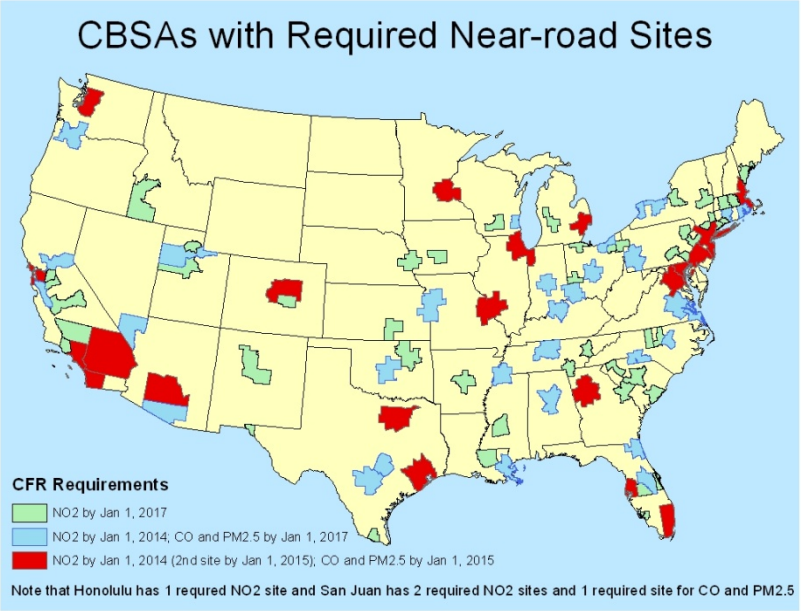
- A new (2011) national air quality monitoring network comprised of 80 stations (63 urban, 17 rural) to support a wide variety of science and policy objectives
- Sites located in representative locations away from biasing sources
- Focus on technological advancement, high time resolution, and multiple measurements per location

Measurements
$PM_{2.5}$ mass
$PM_{2.5}$ speciation
$PM_{10-2.5}$ FRM mass
continuous $PM_{2.5}$ mass
ozone (O_3)
carbon monoxide (CO)
sulfur dioxide (SO_2)
nitrogen oxide (NO)
total reactive nitrogen (NO_y)
surface meteorology



Near-Road Monitoring Network

- Monitoring stations designed to characterize exposure to key mobile source pollutants in areas adjacent to major roads
- Phased deployment schedule between 2014 and 2017 to include required compliance measurements for NO_2, CO, and $PM_{2.5}$
- Additional discretionary measurements expected to include black carbon, EC/OC, ultrafine particles, and air toxics such as benzene and 1,3-butadiene
- EPA developed detailed Technical Assistance Document to assist with evaluation of candidate site locations
  - http://www.epa.gov/ttn/amtic/nearroad.html



Key Air Monitoring Tools

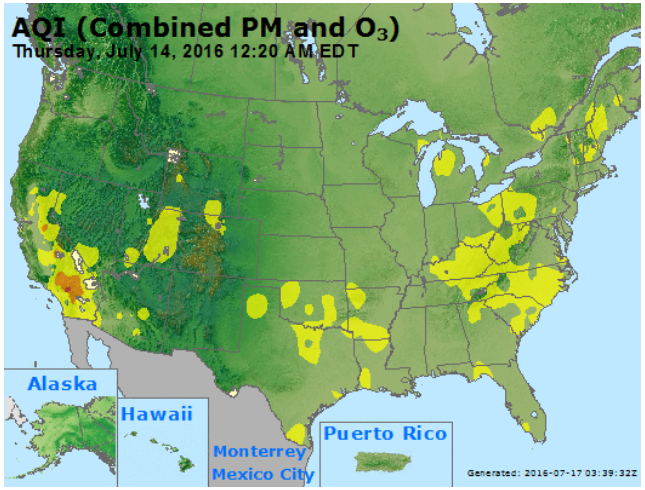
- **AirData** http://www.epa.gov/airdata/
  - Access to reports, data visualization tools, interactive mapping, and data downloads
- **AirNow** http://airnow.gov/
  - Focus on real-time data for public information, with forecasts, maps, and educational tools
- **Air Quality System** http://www.epa.gov/ttn/airs/airsaqs/
  - Official repository for air quality data collected and reported by state, local, and tribal monitoring agencies
- **Ambient Monitoring Technical Information Center (AMTIC)** http://www.epa.gov/ttn/amtic/
  - Information on ambient air quality monitoring programs, monitoring methods, quality assurance and control procedures, and federal regulations related to ambient air quality monitoring.

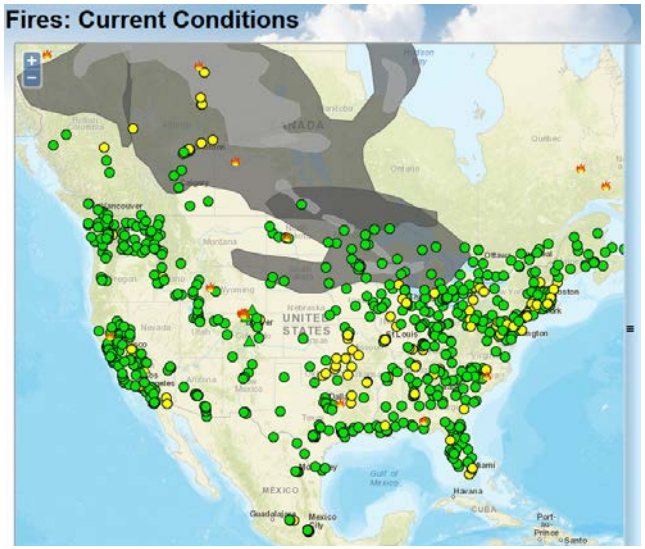
AirNow Program

AirNow is the national framework for acquiring and distributing air quality information

- Gathers and quality assures data provided by 140+ federal, state, tribal, and local air quality agencies
- Transfers real-time and forecasted air quality information to the public
- Provides air quality data feeds
- Partners with national media
- Educates public on air quality and health

America's "go to" resource for current and forecasted air quality information





Air Quality Index (AQI)

- **Air Quality Index (AQI) creates consistency**
- **Links concentrations to health effects and actions**
- **Ranges from 1 to 500; 101+ is unhealthy**

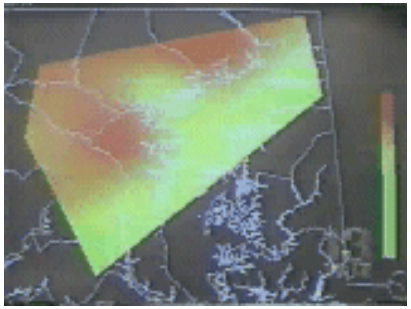
Air Quality Index (AQI) Values	Levels of Health Concern	Colors
When the AQI is in this range:	*..air quality conditions are:*	*...as symbolized by this color:*
0 to 50	Good	Green
51 to 100	Moderate	Yellow
101 to 150	Unhealthy for Sensitive Groups	Orange
151 to 200	Unhealthy	Red
201 to 300	Very Unhealthy	Purple
301 to 500	Hazardous	Maroon

Note: Values above 500 are considered Beyond the AQI. Follow recommendations for the Hazardous category. Additional information on reducing exposure to extremely high levels of particle pollution is available here.

AirNow Program History

Roots of AirNow started in northeastern U.S.

- 1995 – American Lung Association of Maryland created a daily ozone map
- 1997 – Consortium of northeastern states produced maps of ozone using the Pollutant Standard Index
- 1998 – EPA began operating the hub portion of the system and called it AirNow (data a few times a day)
- 1998-2008 – Coverage expanded and timeliness of data and product delivery improved
- 2009 – System architecture overhauled, including new mapping and database
- Currently all states, Canada, portions of Mexico flowing data in hourly



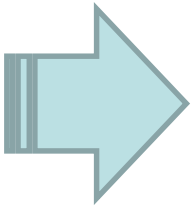
The goals of the US EPA's AIRNOW website are to: 1) provide real-time air pollution data in an understandable, visual format, 2) provide information about the public health and environmental effects of air pollution, 3) provide the public with information about ways in which they can protect their health, and actions they can take to reduce pollution.

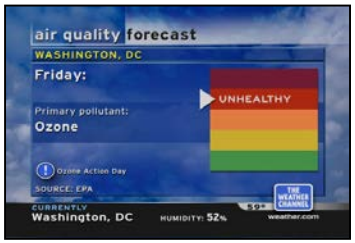
This website currently focuses on ground-level ozone (smog). Future plans for this website are to expand the geographic coverage of the current ozone maps and to include other pollutants.

The Ozone Mapping Project is part of EPA's Environmental Monitoring for Public Access and Community Tracking (EMPACT) initiative - a new approach to providing timely environmental information to communities.

AirNow Goals

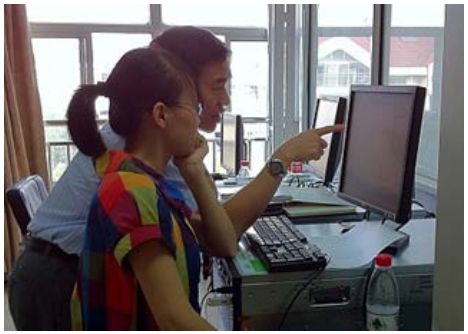
- **Protect public health and promote data exchange**
- **Stakeholder participation through technical support, guidance, tools and assistance**
- **High-quality products for health-based decision-making**
- **Timely and reliable operations**
  - ✓ Widespread usage/critical data to other systems
  - ✓ 24/7
  - ✓ Tight media deadlines
- **Flexibility and innovation**
  - ✓ Adding new features
  - ✓ addressing media/outside requests





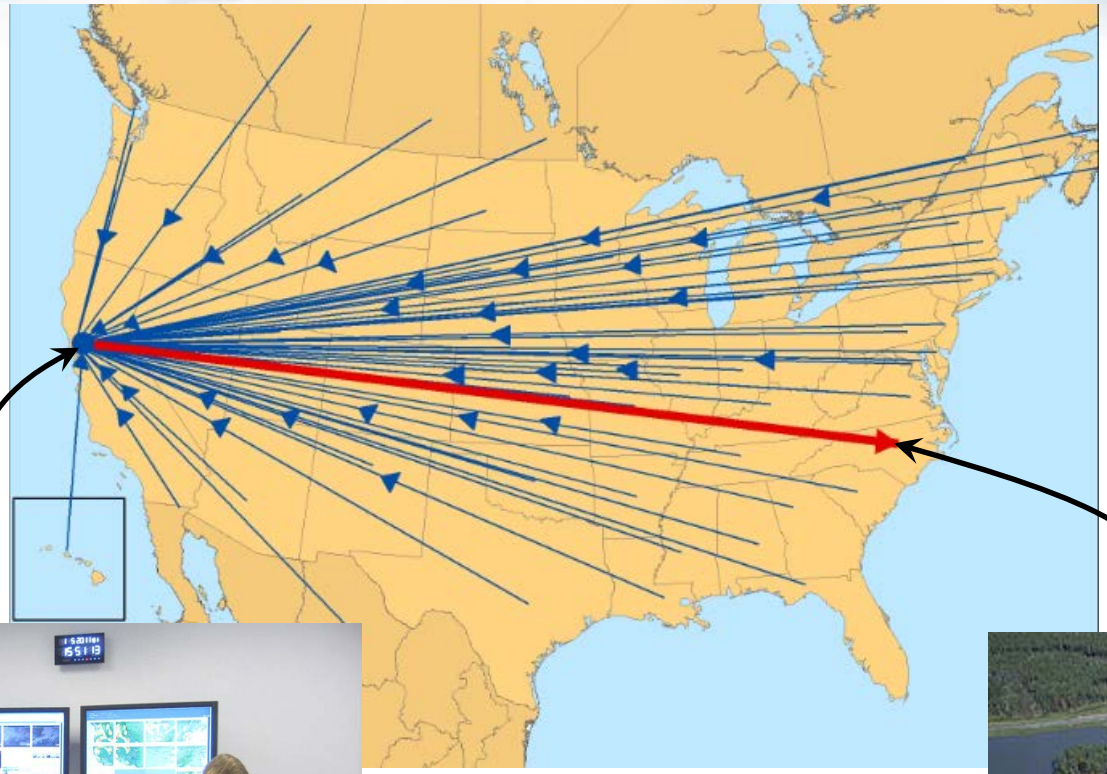
AirNow Goals

- **Provide the tools for air quality management and health-based decision making to other countries**
- **Exchange environmental data internationally**
- **Make advances in air quality knowledge and applications**
- **Improve public health globally**
- **Build a community of people and organizations**



AirNow Community

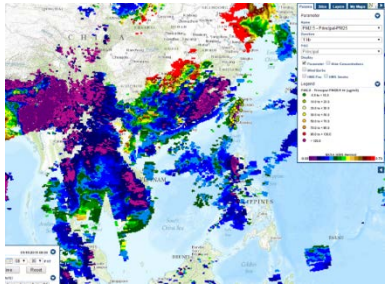
AirNow Data Management Center

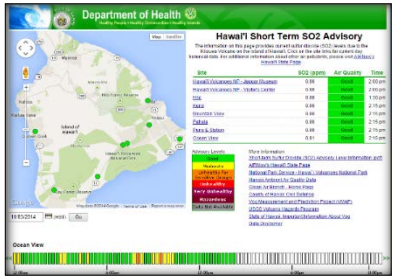


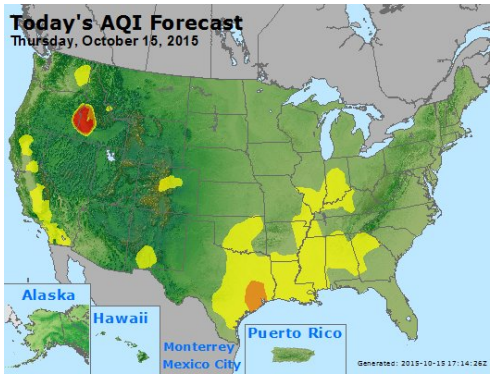
EPA

- 140+ agencies
- 5500+ stakeholders and users
- 2000+ monitoring sites
- 400+ forecast cities

Data Flow: AirNow Outputs



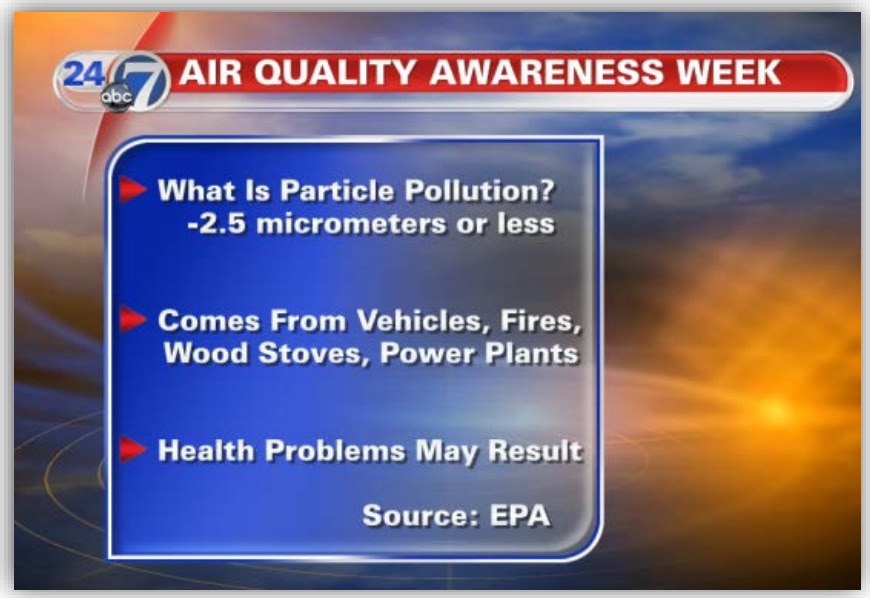




Public Information Service

AirNow products raise public awareness of air quality issues and support local and regional initiatives.

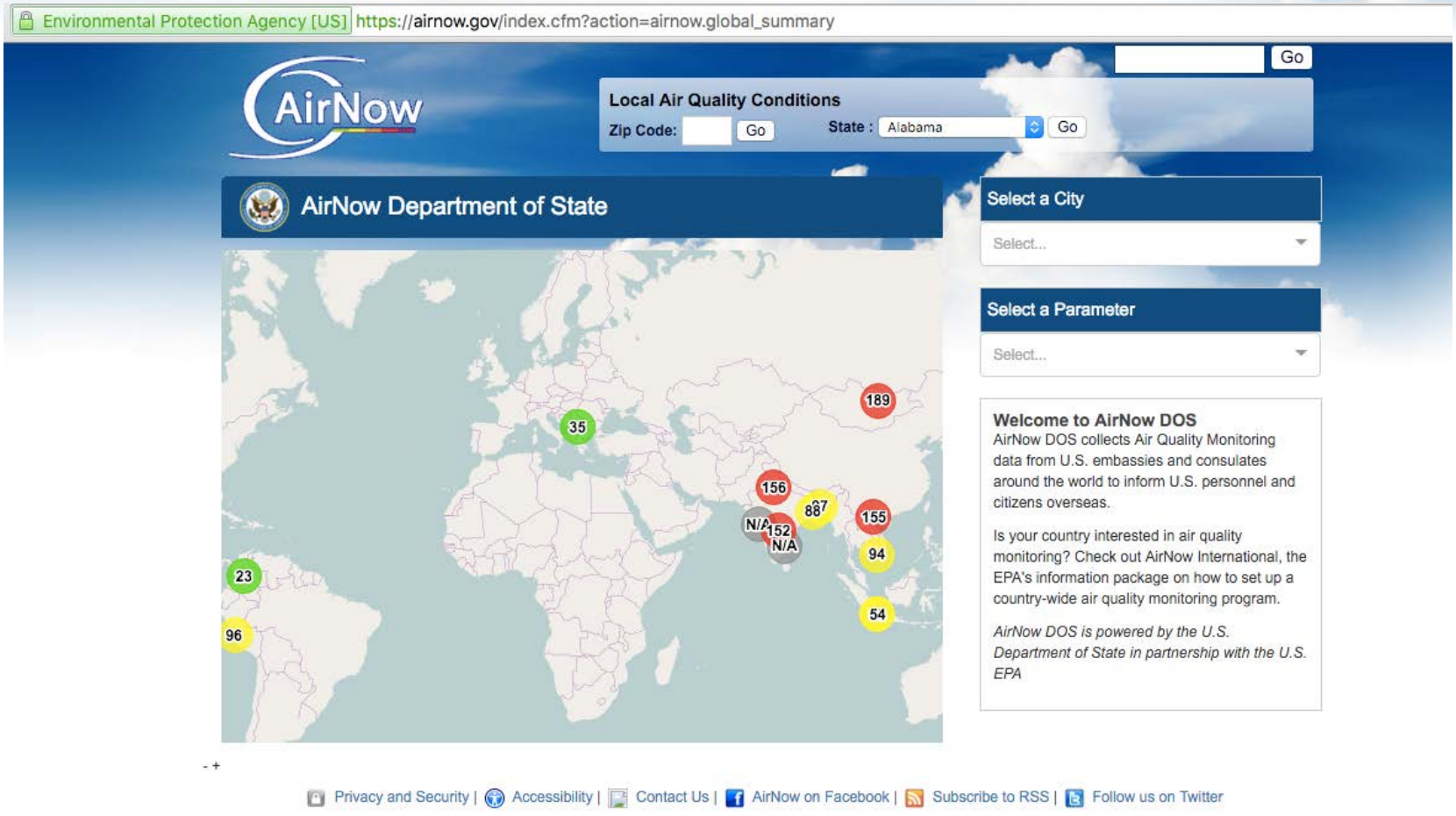
- Data feeds and web services to applications
- Air Quality Awareness Week to educate public on health effects from air pollution



Forecasting in AirNow

- **State, Local and sometimes city officials submit their forecasts**
  - ✓ Numerical, statistical, even neural network models are used
- **AirNow distributes the provided forecast**
- **AirNow provides some forecasting support**
  - ✓ NOAA Model output is available
  - ✓ Many resources for forecasters on AirNow.Gov and AirNowTech
  - ✓ Forecast verification system in AirNowTech allows agencies to evaluate their forecast accuracy
- **AirNow provides national consistency and a national data product for the media**

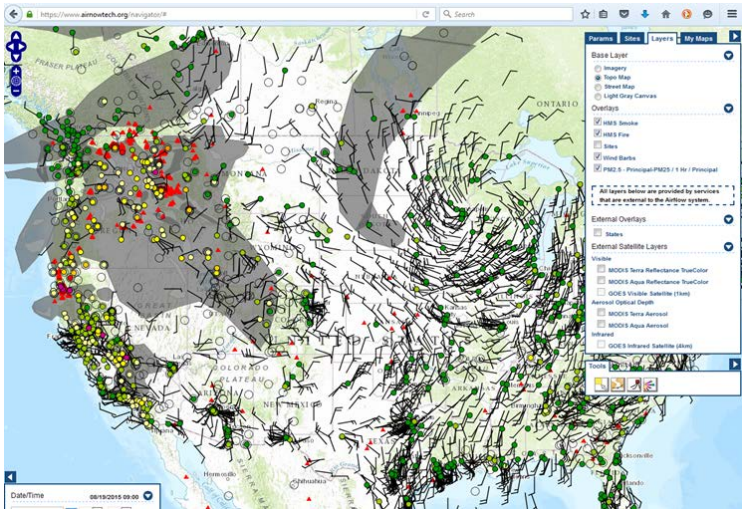
U.S. Embassy Data in AirNow

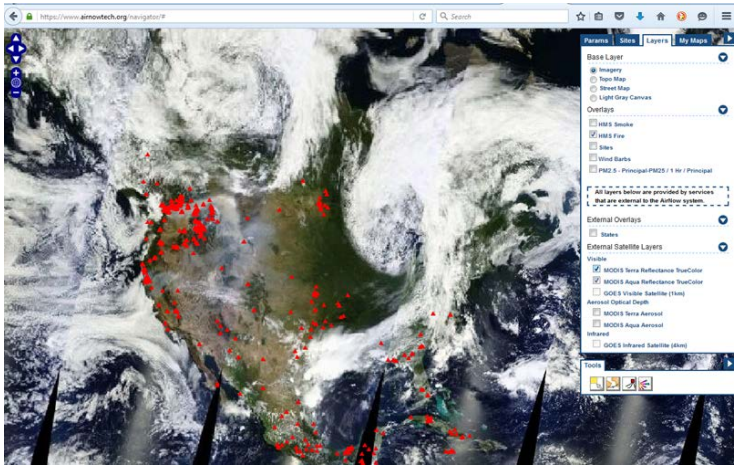


Currently 14 monitors around the world, 29 planned in the next year

AirNow-Tech: Tool for Partners

- Decision Support System – management and analysis tool for the AirNow and AirNow-I Program
- GIS functions – HYSPLIT trajectory tool, satellite, and smoke products
- Data queries, personalized tools, preferences, and services
- Ability to view meteorological and air quality data
- Worldwide satellite data
- Password-protected user accounts





Next Generation of Monitoring

Potential Game Changers for Air Quality Monitoring

- Low cost sensor technology is here and getting better
- Benefits to emerging or unmonitored areas to assess pollution and sources
- Citizen monitoring and access to information

Government Agencies must be ready

- Trust ("government" information versus individually monitored data)
- BIG Data
- Messaging Challenges!
  - ✓ Official monitoring and reporting on longer scale (one hour +)
  - ✓ Major health studies on air quality based on longer temporal scale (one hour +)
  - ✓ Low cost sensors typically report 1 minute values

Next Generation of Monitoring

The Challenge:

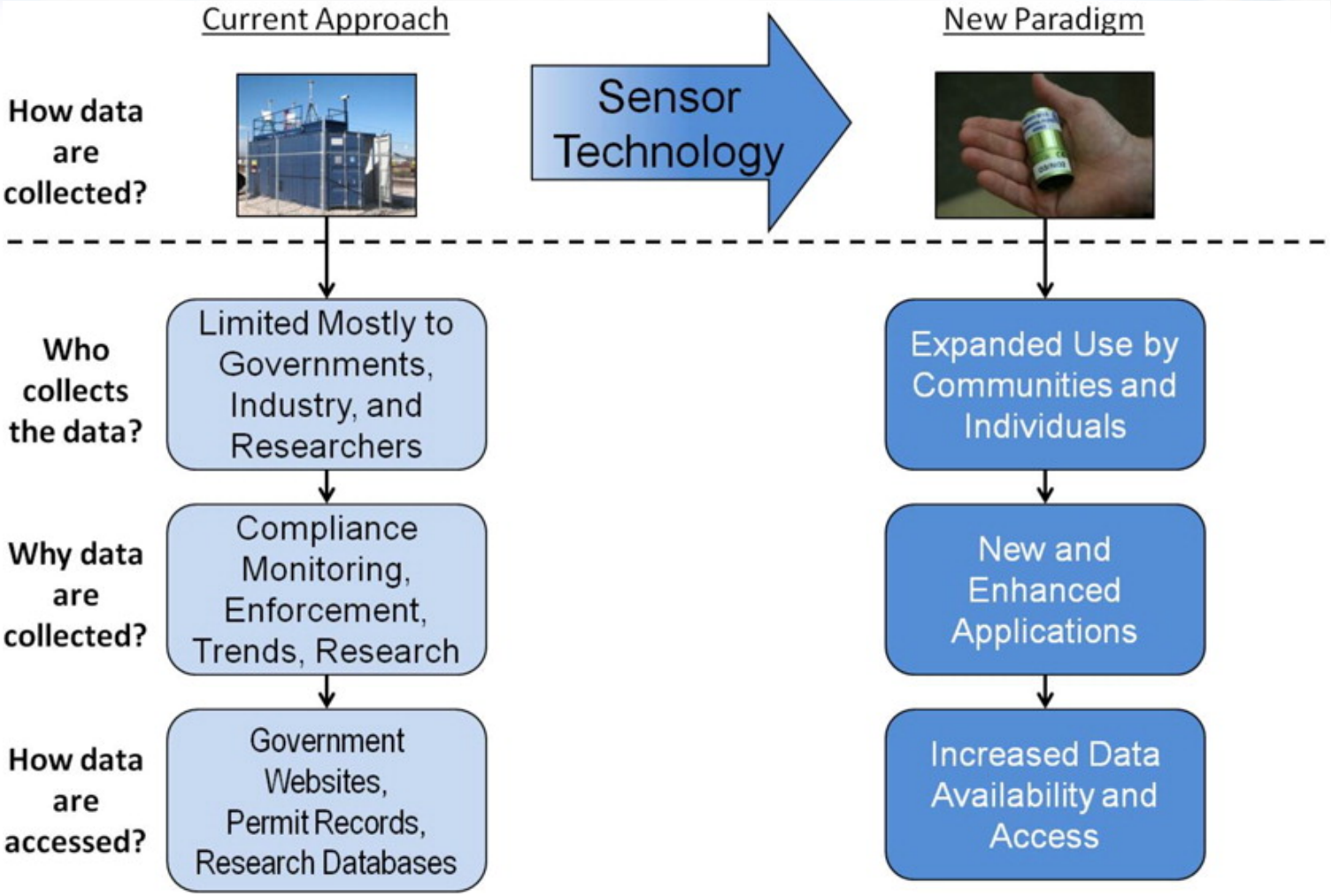
Government organizations need to prepare for data deluge and responses to concerned citizens

- What's the quality of the data?
- Comparisons!
- How to interpret data from sensors' short term measurements from a public health perspective?

The Opportunity:

- Government organizations will have new sources of data to better manage air quality and protect public health
- Engage/start conversation with community groups to educate one another
- Work with sensor developers on messaging

Next Generation of Monitoring



Published in: Emily G. Snyder; Timothy H. Watkins; Paul A. Solomon; Eben D. Thoma; Ronald W. Williams; Gayle S. W. Hagler; David Shelow; David A. Hindin; Vasu J. Kilaru; Peter W. Preuss; *Environ. Sci. Technol.* **2013,** 47, 11369-11377. DOI: 10.1021/es4022602

Example: Village Green Project

- **Village Green**
  - EPA has developed an innovative, solar-powered air-monitoring system designed and incorporated into a park bench
  - The Village Green Project is being conducted in partnership with state and local organizations to advance air quality measurement capabilities.
  - Incorporate real-time, 1-minute ozone and $PM_{2.5}$ sensor data into AirNow
- **Benches Located in:**
  - Durham, NC
  - Washington, DC
  - Philadelphia, PA
  - Kansas City, KS
  - Oklahoma City, OK
  - Hartford, CT

Example: Village Green Project

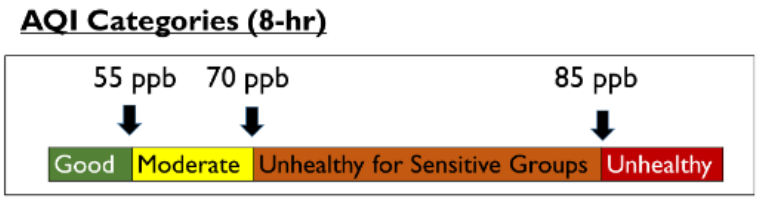
Small sensors in action: Inside a Village Green Bench

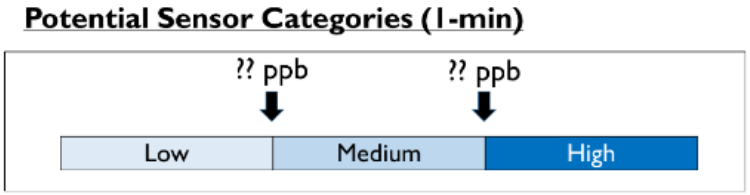
Power module:
Power inputs from solar
and/or wind
Rechargeable battery

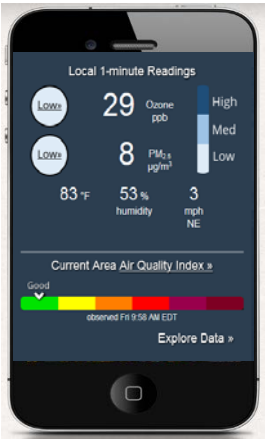
Instrumentation module:
PM2.5 and ozone instruments
Microprocessor
Cellular modem
Internal temperature sensor
Heater (new stations)

Messaging Small Sensor Data

- Communicating sensor data is complicated
- Potential for misleading comparison to the Air Quality Index (AQI)
- Health studies do not support short-term (e.g., 1-minute) health messages
- Behavioral messages can be useful







Messaging Small Sensor Data

Pilot Version* 1-Minute O_3 Readings *(Not for regulatory purposes)*	
Low **0-59 ppb**	Enjoy your outdoor activities.
Medium **60-89 ppb**	If medium readings continue, use the Air Quality Index to plan outdoor activities.
High **90-149 ppb**	If high readings continue, consider adjusting outdoor activities, especially if you are sensitive to ozone. Check the Air Quality Index to find out.
Very High **>150 ppb**	If high readings continue, consider adjusting outdoor activities. Check the Air Quality Index to find out. Very high readings may mean the sensor is not working properly.
	Sensor may be offline. Check the Air Quality Index.

* May be refined as data sources are periodically updated.

Pilot Version* 1-Minute $PM_{2.5}$ Readings *(Not for regulatory purposes)*	
Low **0 - 29 µg/m^3**	Enjoy your outdoor activities.
Medium **30 - 69 µg/m^3**	If medium readings continue (for an hour or more), use the Air Quality Index to plan outdoor activities.
High **70 - 499 µg/m^3**	You may be near a source of particle pollution like dust, smoke or exhaust. Check the Air Quality Index to plan outdoor activities.
Very High **> 500 µg/m^3**	You may be near a source of particle pollution like dust, smoke or exhaust. Check the Air Quality Index to find out if you should adjust outdoor activities. Very high readings may mean the sensor is not working properly.
	Sensor may be offline. Check the Air Quality Index.

* May be refined as data sources are periodically updated.

Small Sensors - Information

Air Sensor Toolbox – Citizen Science

Main portal for EPA low cost sensor information

Air Sensor Toolbox for Citizen Scientists

EPA's Air Sensor Toolbox for Citizen Scientists provides information and guidance on new low-cost compact technologies for measuring air quality. Since citizens are interested in learning more about local air quality where they live, work and play, EPA scientists created the toolbox to provide citizens resources to effectively collect, analyze, interpret, and communicate air quality data.

The Air Sensor Toolbox resources include information about:

- Sampling methodologies
- Generalized calibration/validation approaches
- Measurement methods options
- Data interpretation guidelines
- Education and outreach
- Low cost sensor performance information

Communicating Instantaneous Data

EPA is conducting a pilot project to test a new tool for communicating data from air quality sensors. Learn more

Toolbox Resources

Related Topics

- Community Air Monitoring Training, July 2015
- Next Generation Air Measuring
- Village Green Project
- Real Time Geospatial Data Viewer (RETIGO)
- Small Business Innovation Research Program's Sensor Technology for the 21st Century

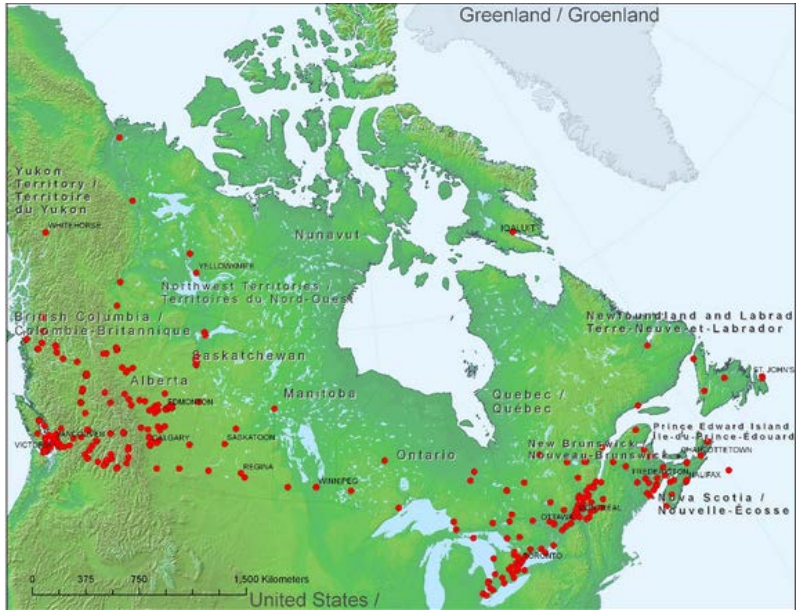
https://www.epa.gov/air-research/air-sensor-toolbox-citizen-scientists

Canada - NAPS

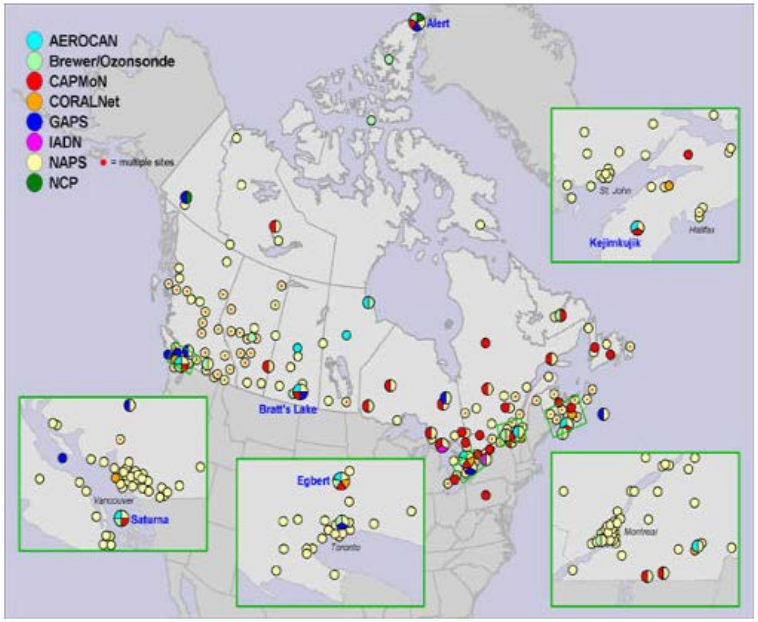
- **~300 stations in 200 communities in the ten provinces and three territories in** National Air Pollution Surveillance (NAPS)
- **Some stations are used by jurisdictions for:**
  - ✓ air quality index (AQI) reporting
  - ✓ trans-boundary transport monitoring or;
  - ✓ for special studies of local air pollution problems**.**
- **Some of the stations are air pollution oriented but not source-specific oriented**
- **The goal is to provide the best assessment of the air quality or of an air pollution problem, for the general population, with the most efficiency**

Canada – Monitoring Networks

Canada has many air quality monitoring networks…



NAPS



Networks that are part of global programs are:

- Global Atmospheric Passive Sampling (GAPS)

Networks with a regional focus are:

- Canadian Aerosol Baseline Measurement (CABM)
- Integrated Atmospheric Deposition Network (IADN)

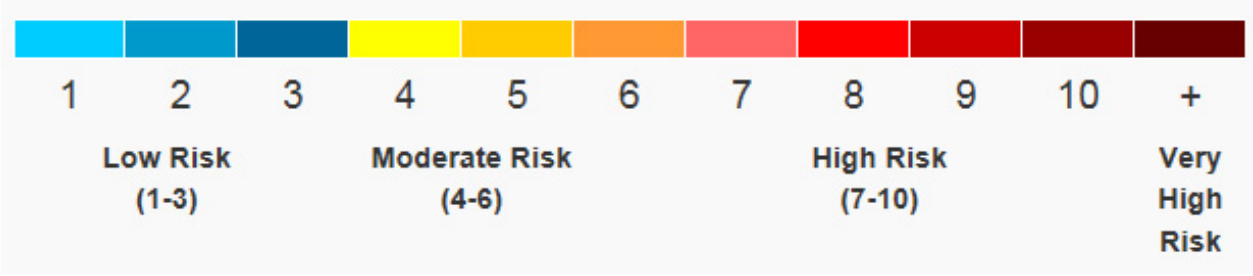
National monitoring networks are:

- The Canadian Air and Precipitation Monitoring Network (CAPMoN)
- National Air Pollution Surveillance (NAPS)

Canada - AQHI

AQHI differs from U.S. AQI!!!

- AQI communicates the air quality of a single pollutant
  – AQHI is the sum of the health risks from each of the pollutants in the index.
- Combined risks of O3, PM, NO2
- AQHI is hourly
- Have forecasts/current conditions for many cities



- 1-3 Low health risk
- 4-6 Moderate health risk
- 7-10 High health risk
- 10 + Very high health risk

Thank You!

John E. White

white.johne@epa.gov