J2.14

FROM RAW AIR QUALITY DATA TO THE NIGHTLY NEWS: AN OVERVIEW OF HOW EPA'S AIRNOW PROGRAM OPERATES.

Timothy S. Dye*, Alan C. Chan, Craig B. Anderson, David E. Strohm
Sonoma Technology, Inc., Petaluma, CA
Richard A. Wayland, John E. White
U.S. Environmental Protection Agency, Research Triangle Park, NC

1. INTRODUCTION

Like many countries around the world, the United States (U.S.) experiences air pollution problems. The two major pollutants of concern are ground-level ozone and particulate matter ($PM_{2.5}$ and PM_{10} – also called particle pollution). While ozone is mostly a summertime problem, PM can occur throughout the year. The U.S. National Ambient Air Quality Standard (NAAQS) for ozone is a daily 8-hour average of 85 parts per billon (ppb). The standard for $PM_{2.5}$ is a 24-hour average concentration of 65 $\mu g/m^3$ and an annual standard of 15 $\mu g/m^3$. Ozone can be harmful to human health and plant life and is created by emissions from man-made and natural sources. Particulate matter is a complex mixture of solid and liquid particles that vary in size and composition, and remain suspended in the air. Over the past decade, many health effect studies have shown an association between exposure to PM and increases in daily mortality and symptoms of certain illnesses (HEI, 2002; Dockery and Pope, 1994; Schwartz, 1994).

Historically, air quality data collected by local, state, and federal air quality agencies in the U.S. have been quality-controlled and calibrated and sent to the U.S. Environmental Protection Agency (EPA) approximately three to six months after data collection. While this decentralized collection program is adequate for regulatory purposes and for evaluating long-term trends, real-time data and forecasts were not widely available to decision makers, the public, and the media.

EPA's AIRNow program consists of a centralized Data Management Center (DMC) that receives real-time ozone data from more than 100 U.S. and Canadian agencies as well as air quality forecasts from over 300 U.S. cities. AIRNow also maintains an informational web site (www.epa.gov/airnow) where the principal products are posted: ozone and PM maps and city air quality forecasts. Current air quality is shown with point and contoured maps that are animated with color-coded pollutant concentrations according to the EPA's Air Quality Index (AQI). The animated contour maps, much like radar images showing precipitation, display the hourly formation and movement of ozone or particle pollution.

* *Corresponding author address*: Timothy S. Dye, Sonoma Technology, Inc., 1360 Redwood Way, Suite C, Petaluma, CA 94954-1169; e-mail: tim@sonomatech.com

This paper provides an overview of the components that make this voluntary program successful. This includes how the DMC coordinates with over 100 air quality agencies that supply hourly air quality data and issue air quality forecasts; develops software and database systems to quality-control and process the data; and works with media outlets to distribute this air quality information. Examples of how the media uses AIRNow data and information are also given.

2. BACKGROUND

Because of the regional nature of ground-level ozone and the need to inform the public of possible health effects, the EPA developed the AIRNow system to provide easy access to national air quality information.

The roots of the AIRNow program were established in 1995 when the American Lung Association of Maryland developed ozone pollution maps that regularly appeared on television weather broadcasts in the Washington, D.C. area. Although very useful and informative to the public, the manual effort needed to produce these maps (data transfer, quality control, processing, etc.) was substantial and too costly to continue the following year. A northeastern U.S. regional Ozone Mapping System was developed in 1997 and funded by the Northeast States for Coordinated Air Use Management (NESCAUM), Mid-Atlantic Region Air Managers Association (MARAMA), and the Ozone Transport Commission (OTC). In 1998, the AIRNow system was created to serve as a centralized, nationwide repository for these real-time data collected by the local, state, and federal agencies.

Air quality forecasts are used to alert the public of future pollution conditions. Air quality forecasting, compared to weather forecasting, is a young science with its roots dating back to the early 1960s. Air quality forecasting is growing with the emergence of real-time data from AIRNow and requirements for operating effective public health notification and voluntary emission reduction programs. Forecasts for ozone and PM are currently issued by over 80 state and local air quality agencies for over 300 cities throughout the U.S. as part of the EPA's AIRNow program (Wayland et al., 2002). These air quality agencies represent local authorities who have the responsibility (mandate, in some cases) to predict and communicate local air quality to the public, to encourage voluntary actions, and to issue health advisories.

The air quality forecasting community ranges from very experienced forecasters to individuals with modest meteorological and air quality experience and knowledge. The AIRNow program is actively training new and existing air quality forecasters in new prediction methods and techniques (U.S. EPA, 2003; Dye et al., 2003). In addition, new forecasting guidance, generally considered to be methods, tools, and models that provide predictions, are being created by National Oceanic and Atmospheric Administration and the private sector to help local forecasters produce final air quality forecasts.

Another important component of the AIRNow program is the EPA's AQI (EPA, 2000). Under the Clean Air Act, the EPA established a nationally uniform air quality index for reporting air quality data to the public. The resulting AQI provides a simple, uniform system to report levels of air pollutants. It also links health impacts to air pollutant concentrations and provides the public with easy-to-understand information about air quality so that citizens can determine their own levels of health concern. The AQI converts a measured pollutant concentration to a number on a scale of 0 to 500, as shown in Table 1. The AQI value generally corresponds to NAAQS established for pollutants under the Clean Air Act. An AQI above 100 indicates that the air could be unhealthy to certain individuals.

Table 1. Air Quality Index numbers, categories, and concentration cut points for ozone, $PM_{2.5}$, and PM_{10}.

AQI	AQI Category	AQI Color	O_3 (ppb) (8hr)	O_3 (ppb) (1hr)	$PM_{2.5}$ ($\mu g/m^3$)	PM_{10} ($\mu g/m^3$)
0 -50	Good	Green	0 – 64	–	0 – 15	0 – 54
51-100	Moderate	Yellow	65 – 84	–	16 – 40	55 – 154
101-150	Unhealthy for Sensitive Groups	Orange	85 – 104	125 – 164	41 – 65	155 – 254
151-200	Unhealthy	Red	105 – 124	165 – 204	66 – 150	255 – 354
201-300	Very Unhealthy	Purple	125 – 374	205 – 404	151 – 250	355 – 424
301+	Hazardous	Maroon	–	405 – 604	251 – 500	425 – 604

Providing educational materials and training about the health effects of air quality is just as critical as providing the real-time data and forecasts. The EPA has developed numerous brochures about the AQI (EPA, 2000), ozone health effects (EPA, 1999a,b), and the differences between ground-level and stratospheric ozone (EPA, 1997a), as well as guidance on how to provide AQI forecasts to the public (EPA, 1999c). The media and the public must understand the relationship between air quality and health so that forecasts and real-time data can be used to make health-based decisions.

3. DATA FLOW

The flow of data through the AIRNow system and the resulting products are shown schematically in Figure 1. Each hour, the data flow starts at over 1300 ozone and 300 $PM_{2.5}$ monitoring sites covering 44 states, the District of Columbia, and Canada. More than 100 state, local, and federal air quality agencies then collect the data and submit them via file transfer protocol (FTP) to the DMC. Once at the DMC, software loads the ozone and PM data into an Oracle relational database. Data then undergo automated quality control (QC) checks to ensure that erroneous data are not used in the ozone or PM maps. The QC checks include maximum and minimum thresholds, rate of change, and other more advanced checks to detect inconsistencies with surrounding sites and monitors reporting a constant value. All QC criteria and thresholds are set for each monitor, pollutant, and hour of the day. Next, air quality data are converted to the AQI. At 30 minutes past every hour, local, regional, and national animated ozone and $PM_{2.5}$ maps are generated. These maps are transferred to the EPA's AIRNow web site, media outlets, and ultimately to the public. Figure 2 shows an example of the local, regional, and national ozone and PM maps available on the AIRNow web site.

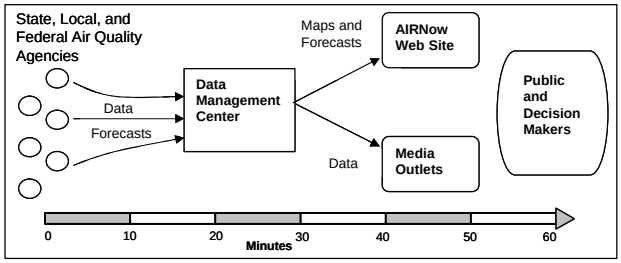


Figure 1. Schematic showing the data flow and resulting product distribution to the public.

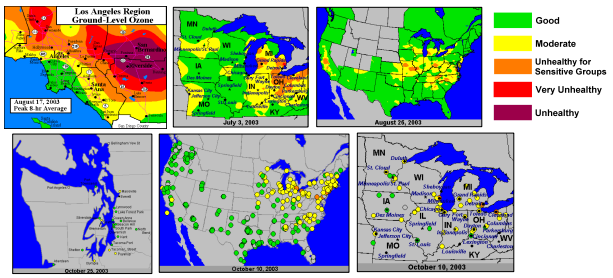


Figure 2. Local, regional, and national maximum daily ozone and PM AQI maps.

Air quality forecasts are issued for ozone and PM by local meteorologists for over 300 cities across the U.S. as part of the AIRNow project, as shown in Figure 3. Forecasters use a variety of tools and techniques to predict daily peak air quality values (Dye et al., 2000; Ryan, 1994; Comrie, 1997). An Internet-based submittal system allows state and local air agencies to enter their forecasts up to five days in advance. Most forecasters submit their forecasts daily to AIRNow by the early afternoon. Forecasts are stored in the Oracle database at the DMC.

4. HOW THE PUBLIC AND MEDIA USE AIRNOW PRODUCTS

AIRNow is the public's focal point for accessing current air quality conditions and forecasts for the U.S. and Canada. Effective communication of air quality information to the public requires distributing this

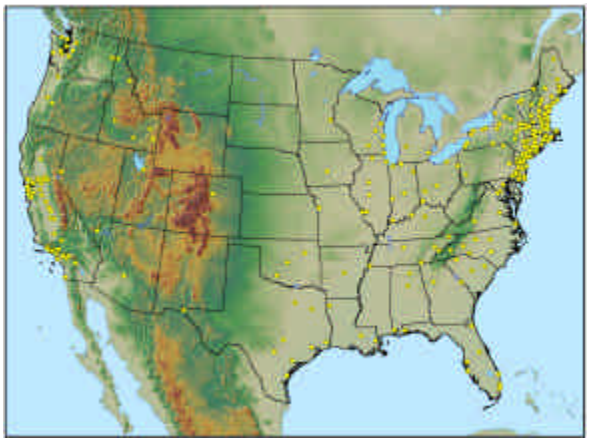
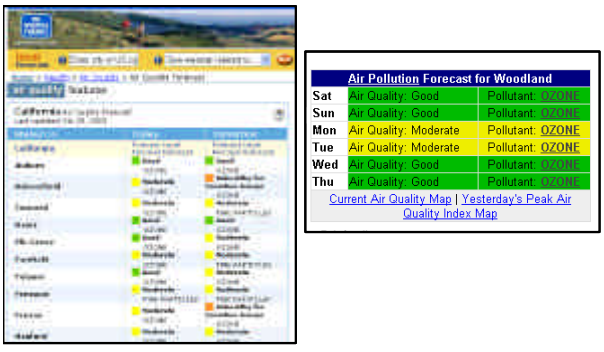


Figure 3. AIRNow Forecast Cities.

information to media outlets via Internet content providers and commercial weather service providers (WSPs) for television weathercasts and newspapers.

On the Internet, the AIRNow web site provides easy access to real-time local, regional, and national air quality maps, displays air quality forecasts, and offers suggestions about what individuals can do to improve air quality. These maps and forecasts are also available on several commercial web sites, for example, www.weather.com and www.weatherunderground.com as shown in Figure 4. Decision makers can use the information to convey messages to the public, alert the public to possible health impacts, encourage voluntary emission reduction actions, and implement public outreach and education programs. Numerous local programs use AIRNow's ozone maps directly as part of their local outreach programs. One example is the "Spare The Air" program (www.sparetheair.com) in Sacramento, California.



Air Pollution Forecast for Woodland		
Sat	Air Quality: Good	Pollutant: OZONE
Sun	Air Quality: Good	Pollutant: OZONE
Mon	Air Quality: Moderate	Pollutant: OZONE
Tue	Air Quality: Moderate	Pollutant: OZONE
Wed	Air Quality: Good	Pollutant: OZONE
Thu	Air Quality: Good	Pollutant: OZONE

Current Air Quality Map | Yesterday's Peak Air Quality Index Map

Figure 4. Air quality forecasts from the AIRNow project used on Weather.com and Weatherunderground.com.

To reach television audiences, the AIRNow program works with commercial weather service providers that supply television stations (and other media outlets) with graphics and weather data. This allows air quality information to reach millions of people. For example, air quality forecasts have been routinely featured on television on the Cable News Network's (CNN) weathercasts and The Weather Channel, as shown in Figure 5. Additionally, *USA Today* publishes AQI forecasts for 36 major U.S. cities, Monday through Friday, as shown in Figure 6. In addition, the AIRNow program provides educational stories to news media to help explain important weather and air quality phenomena as shown in Figure 7.

Figure 5 Air quality forecasts and ozone maps from the AIRNow project used on The Weather Channel (top) and CNN (bottom).

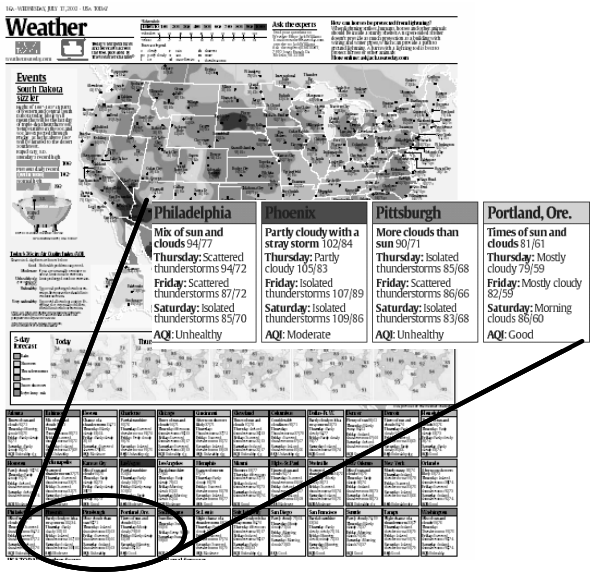


Figure 6. An example of a USA Today Weather Page. The AQI forecasts are printed below the weather forecasts for 36 U.S. Cities.

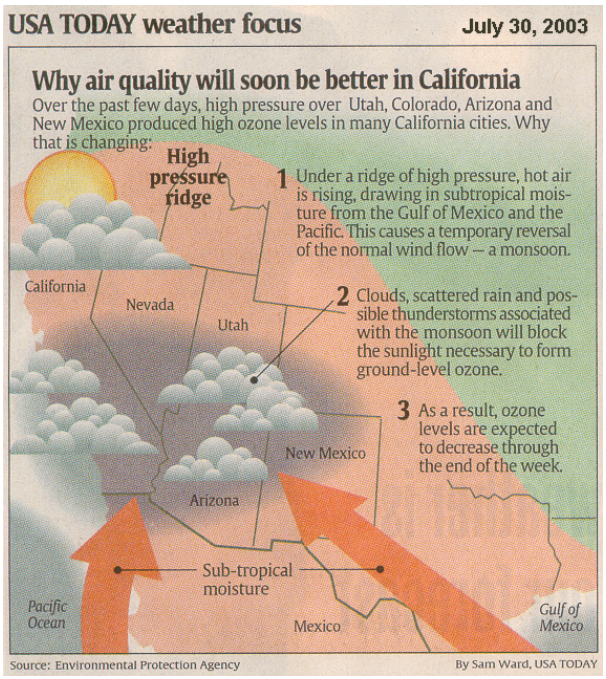


Figure 7. An educational story on the western monsoon's influence on air quality conditions, which appeared on the USA Today Weather Page.

The distribution of air quality information to media outlets accomplishes the ultimate goal of the AIRNow program: to provide air quality forecasts and real-time air quality information in a visual, easy-to-understand format to decision makers and the public.

5. LESSONS LEARNED AND FUTURE PLANS

A number of important lessons have been learned in setting up and operating the AIRNow system:

- Working with the voluntary stakeholder community of over 100 state, local, and federal air quality agencies requires an effective way to communicate and resolve problems. The DMC staff has developed e-mail systems and Internet-based news pages and conducts conference calls to keep the stakeholder community informed. Keeping the stakeholder community satisfied with existing and new tools for AIRNow is critical to ensuring long-term participation.
- Running the DMC around the clock requires a robust and redundant infrastructure (Internet, web servers, and communications) and a diverse team of personnel with operational and development skills. Although AIRNow is an automated system, it requires human oversight to ensure the quality and consistency of the operations and data products.
- Distributing the AIRNow products to as many people as possible is the primary goal of the program. The data are freely available to anyone interested.
- Ensuring data quality is critical for this real-time system. This is accomplished by extensive QC procedures that involve five QC checks for each data value. These checks rely on site-specific and hour-specific QC criteria that require manual adjustments by DMC operators.

The AIRNow program is continually expanding. Continuous PM monitors are being deployed across the U.S. and Canada, and PM data are being sent to the AIRNow program. As more PM data become available, new QC procedures will be implemented so that reliable data can be readily obtainable by decision makers as well as the public. The AIRNow program is also seeking to expand coverage in the U.S. as well as abroad to include the remaining states and other counties.

6. CONCLUSIONS

Air pollution is a problem without boundaries, affecting millions of people in the U.S. and around the world. Only when real-time, dependable air quality data become accessible can decision makers take appropriate precautionary measures to alert the public and protect their health. The AIRNow program was developed for this very reason: to protect public health. It collects, quality controls, and distributes air quality data and forecasts through various media outlets. At the core of the AIRNow program are the voluntary stakeholder organizations that generously submit their air quality data and forecasts to help inform the public.

ACKNOWLEDGEMENTS

Sonoma Technology, Inc. is funded by the U.S. Environmental Protection Agency to operate and maintain the Data Management Center though contract #GS-10F-0181K. The AIRNow program also thanks the 300+ individuals at over 100 local, state, and federal air quality agencies who make this voluntary program possible.

REFERENCES

Comrie, A. C., 1997: Comparing neural networks and regression models for ozone forecasting. *J. Air & Waste Manag. Assoc.*, **47,** 653-663.

Dockery, D. W. and C. A. Pope, III, 1994: Acute respiratory effects of particulate air pollution. *Annu Rev Public Health*, **15,** 107-132.

Dye TS, MacDonald CP, Anderson CB., 2000: Air Quality Forecasting for the Spare The Air Program in Sacramento, California: Summary of Four Years of Ozone Forecasting. Preprints: 2nd Conference on Environmental Applications during the 80th Annual Meeting of the American Meteorological Society, January 9-14, Long Beach, CA. American Meteorological Society, Boston, MA.

Health Effects Institute (HEI), 2002: Perspectives: Understanding the Health Effects of Components of the Particulate Matter Mix: Progress and Next Steps, Boston, MA.

Ryan, W. F., 1994: Forecasting severe ozone episodes in the Baltimore metropolitan area. *Atmos. Environ.*, **29,** 2387-2398.

Schwartz, J., 1994: What are people dying of on high air pollution days? *Environ. Res.*, **64,** 26-35.

U.S. Environmental Protection Agency, 1997: Ozone: Good Up High, Bad Nearby. EPA-451/K-97-002. https://www.epa.gov/oar/aqps/gooduphigh.

U.S. Environmental Protection Agency, 1999a: Ozone and Your Health. EPA-452/R-99-003. http://www.epa.gov/airnow/brochure.html.

U.S. Environmental Protection Agency, 1999b: Smog—Who Does It Hurt. EPA-452/R-99-001. http//www.epa.gov/airnow/health/index.html.

U.S. Environmental Protection Agency, 1999c: Guideline for Reporting of Daily Air Quality—Air Quality Index (AQI). EPA-454/R-99-010.

U.S. Environmental Protection Agency, 2000: Air Quality Index, A Guide to Air Quality and Your Health.EPA-454/R-00-005. https://www.epa.gov/airnow/aqibroch.

U.S. Environmental Protection Agency, 2003: Guidelines for developing an air quality (ozone and $PM_{2.5}$) forecasting program. EPA-456/R-03-002. https://www.epa.gov/airnow/aq_forecasting_guidance 1016.pdf

Wayland, R. A., J. E. White, P. G. Dickerson, and T. Dye, 2002: Communicating real-time and forecasted air quality to the public: current state and future plans. *EM***,** 28-36.