Monitoring Data Sets and Analysis Tools for the VIEWS/TSS Web Sites

5/12/08

INTRODUCTION

The WRAP 2008-12 Strategic Plan calls for regional analysis efforts to move beyond and build upon existing regional haze analysis and planning efforts to a one-atmosphere approach including multiple pollutants of local and regional interest. This effort includes assessing and integrating policy changes related to energy development/production and climate change mitigation/adaptation occurring outside the air quality control and management arena.

The specific goals of this paper are three-fold:

- To introduce the concept of adding air quality monitoring data to the VIEWS/TSS database;
- To present several examples of how VIEWS/TSS web site tools and products could be developed to support the one atmosphere approach; and
- To foster discussion on these concepts among workshop participants.

BACKGROUND

Air pollutants rarely occur in isolation. Rather, many sources produce and emit a mixture of pollutants and pollutant precursors. Emissions sources contributing to regional haze have been shown to be as complex as the particulate constituents which degrade visibility. These same emissions sources are responsible for creating other air quality pollutants not directly associated with visibility degradation. Moreover, modeling techniques can address the formation and impacts of many pollutants simultaneously. For this reason, WRAP has decided to take a one-atmosphere approach to pollutant analyses and attempt to extract local value from regional data sets. At this time, the major pollutants of interest are:

- Regional haze
- Particulate matter (PM)
- Ozone
- Nitrate deposition
- Mercury deposition

Regional haze data and associated analyses are currently data based in, and accessible through, the VIEWS/TSS web sites. These sites are complementary, both designed not just to archive data, but to help analysts understand the data. The VIEWS site presents a wealth of haze-related data and provides complex tools for data mining. Its database originally contained only IMPROVE aerosol data, but quickly developed into a more comprehensive resource with the addition of many other data sets (e.g., optical, particulate, ozone, and meteorology data). VIEWS is supported and used by all of the regional planning organizations. The (WRAP-only) TSS site presents data specific to regional haze planning and tracking. The TSS shares the

VIEWS database, which was, in fact, expanded to include TSS-relevant information. WRAP proposes to enhance the VIEWS/TSS database to include these new pollutant data sets. Many of the review and analysis tools developed for VIEWS/TSS can be modified or enhanced to meet the needs of WRAP members.

Air quality-related data are collected with a variety of intended purposes:

- Regulatory compliance (e.g., NAAQS, Regional Haze Rule)
- General analyses:
  - Tracking trends
  - Determining transport patterns
  - Investigating exceptional events
- Quality control
- Model performance evaluation

The first two items fit well within the conceptual framework of the VIEWS/TSS web sites. There are other resources available to states to support NAAQS analyses, including EPA and state agency tools already in place. VIEWS/TSS could offer additional, complementary tools, if states desire this. Tools for general analyses, especially tools that can mine multiple data networks for multiple parameters, are less readily available to states. The ability for users to access a variety of parameters across many networks in an effort to understand relationships and interactions is, in fact, the most compelling reason for WRAP to pursue this work.

PRESENTATION OF EXAMPLES

Four conceptual examples of data tools are presented to suggest how the VIEWS/TSS web sites could be used to analyze new data sets. In each of the following, the selection of pollutants or parameters, reporting metric, and time period should be considered examples only. It is not suggested that these specific designs necessarily be implemented. After reviewing these examples and synthesizing other information presented at the workshop, WRAP members are asked to think about and comment on the following questions:

- There are many monitoring networks that collect data across the WRAP region. Which of these networks provide the most useful data and thus should be incorporated into the VIEWS/TSS framework?
- What tools (if any) related to regulatory compliance would most benefit states?
- What general analyses for PM, ozone, mercury, and nitrogen deposition do states need?

Example 1
Pollutant rose combined with data timeline

The first example, presented as Figure 1, combines an annual pollutant rose for hourly $PM_{2.5}$ with a timeline of 24-hr average $PM_{2.5}$ compared to the daily NAAQS. Conceptually similar to a wind rose, a pollutant rose summarizes wind and pollutant data such that:

- Each bar length indicates the percentage of time wind blew from that sector; and
- The patterns shown in each bar represent the fraction of time the reported pollutant fell within a specified magnitude category (see the Key to the right).

In Figure 1, the wind direction is shown to have been most often from the WNW (~12% of the time), and the $PM_{2.5}$ levels associated with that wind direction are generally in the range 0-9 $\mu g/m^3$ about 5% of the time, 10-19 $\mu g/m^3$ about 5% of the time, and higher than 19 $\mu g/m^3$ about 2% of the time. This data presentation is useful to determine if high or low pollutant concentrations are tied to specific wind directions and could be used to help identify local sources. The addition of a daily timeline below the pollutant rose allows the user to review the data for temporal patterns as well as individual exceedances of the NAAQS.

This tool could be designed to allow user input of the time period, pollutant, and averaging period.

Example 2
Comparison of urban vs. rural ozone combined with assessment of nitrogen plume age

Figure 2 compares timelines of hourly summer ozone concentrations at an urban site (top) and rural site (bottom) in Georgia. Note that the urban ozone trace exhibits both higher peak daytime ozone (implying a generally higher level of precursor emissions and/or more favorable chemistry) and lower nighttime ozone (implying a generally higher level of pollutants to scavenge ozone) than the rural site.

Also shown in Figure 2 are timelines of the NOx/NOy ratio for both sites. NOx is defined as the sum of NO and NO_2, and constitutes the emissions of nitrogen oxides responsible for the creation of ozone. NOy is defined as NOx plus other reactive oxides of nitrogen that form through chemical interactions of NOx with other gases. A fresh plume will have a NOx/NOy ratio close to 1, indicating that the NOy is nearly all NOx. An aged plume will have a NOx/NOy ratio less than 1, indicating that some NOx has begun chemically transforming. A direct linkage between the ratio and age of the plume has not been established, so this is only a semi-quantitative indicator. For the example shown here, the rural data show a relatively aged plume compared to the urban data.

Example 3
Dynamic contour maps combining multiple networks

Contour maps can be useful but sometimes deceptive tools for data analysis. They are useful to identify geographic changes in pollutant concentrations, for example, but can lead to inaccurate interpretations if the density of sites is too low. Contours maps of IMPROVE data have in the past exhibited a subtler bias: IMPROVE sites are, by design, located in rural areas, and contours produced from IMPROVE data ignore the reality of urban areas.

Figure 3 presents two complementary contour maps of sulfate across the U.S. The top map was created from IMPROVE data, collected almost exclusively at rural sites associated with Class I areas. The bottom map was created from STN data, collected almost exclusively in urban areas.

At a high level these maps tell the same story about higher sulfate in the east and lower sulfate in the west. A closer look shows the differences in site densities, and thus the detail of the contours. A contour map created using data from both networks would enhance the understanding of sulfate across the country by including both rural and urban areas and significantly increasing the site density. Ideally, contours maps could be generated dynamically, with the user selecting the geographic region and networks to use.

Example 4
Site selection and regional analysis

The third example is more complex than the previous two, combining several aspects of analysis together. Figure 4 presents a map of the 4^{th} highest 8-hour ozone averages at non-urban sites for 2006. This particular metric is significant because it is the annual NAAQS for ozone; any site represented by an orange bubble (> 75 ppb) exceeded the standard for 2006. Other metrics could be available for selection. It is important to note that the non-urban data shown in the example come from several independent networks (NPS, USFS, CASTNet, state networks). Contextual information includes major cities and designation of counties without ozone monitoring. Additional contextual information could be included.

In this example, Figure 4 presents a regional summary snapshot of ozone but also functions as a gateway to examine data behind the map. Figure 5 presents how this might work conceptually. The user may be interested in comparing the Wind Cave (South Dakota network) monitoring data with other nearby sites to investigate individual episodes or general trends. The 3 closest (rural) ozone sites are Badlands (NPS network), Campbell County and Thunder Basin (Wyoming DEQ network). All of the 2006 data for these sites is presented in timeline format, and the user could refine the view to a specific, shorter time period. Figure 6 presents a view showing 9 days of data surrounding the maximum Wind Cave ozone peak for the summer. In this example, wind direction timelines have been included to help understand potential transport issues among the sites.

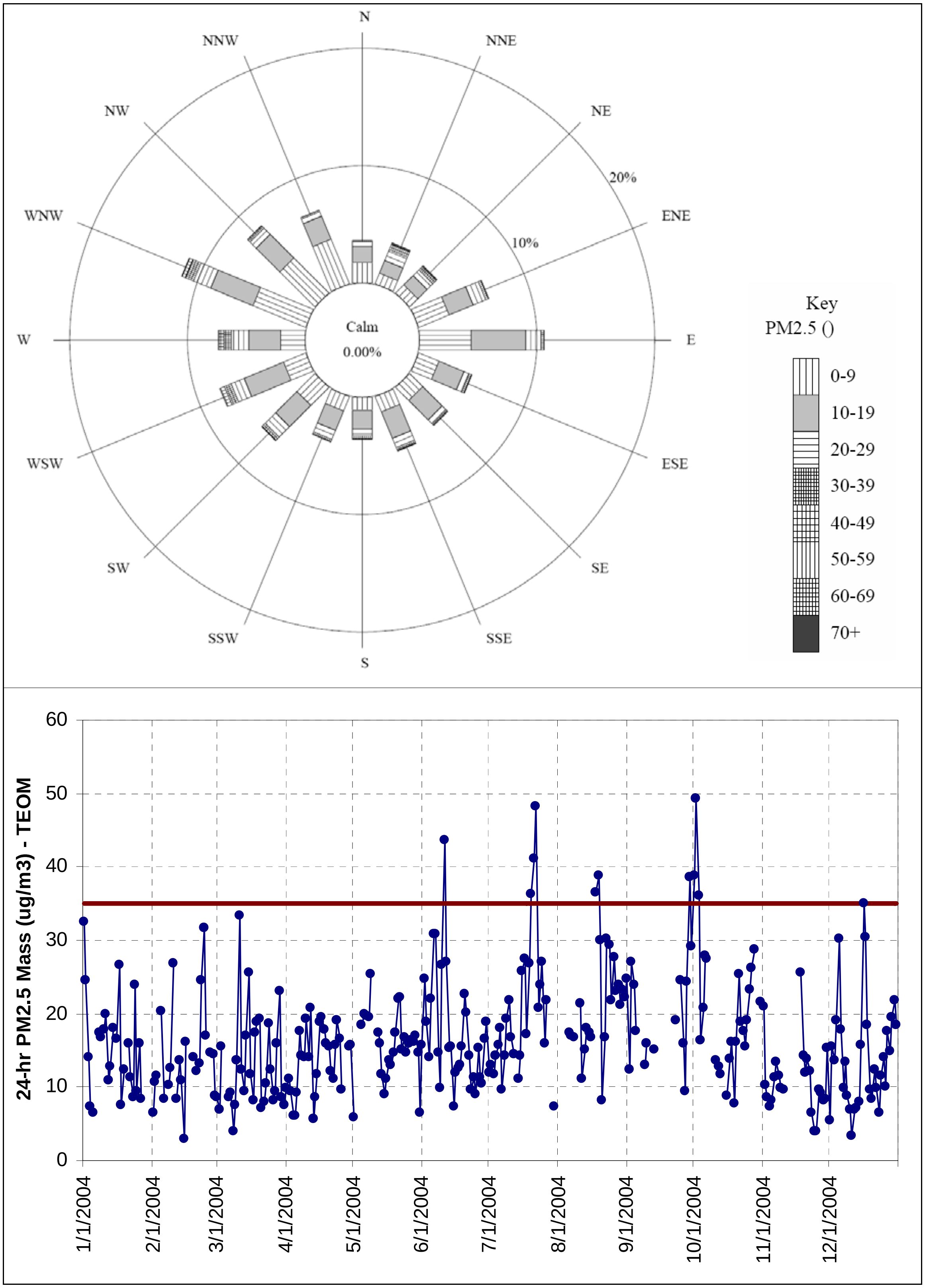
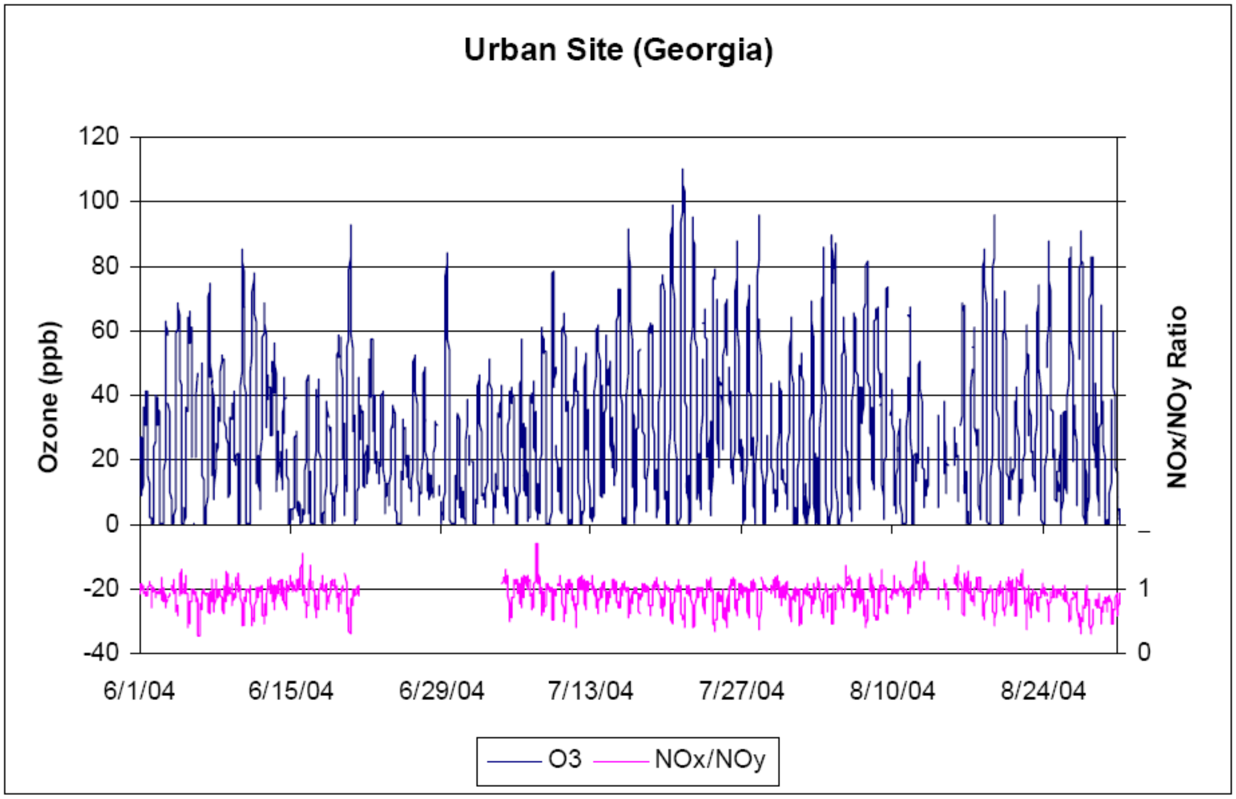


Figure 1. Example pollutant rose for hourly annual $PM_{2.5}$ combined with a timeline of 24-hr $PM_{2.5}$ compared with the daily NAAQS.



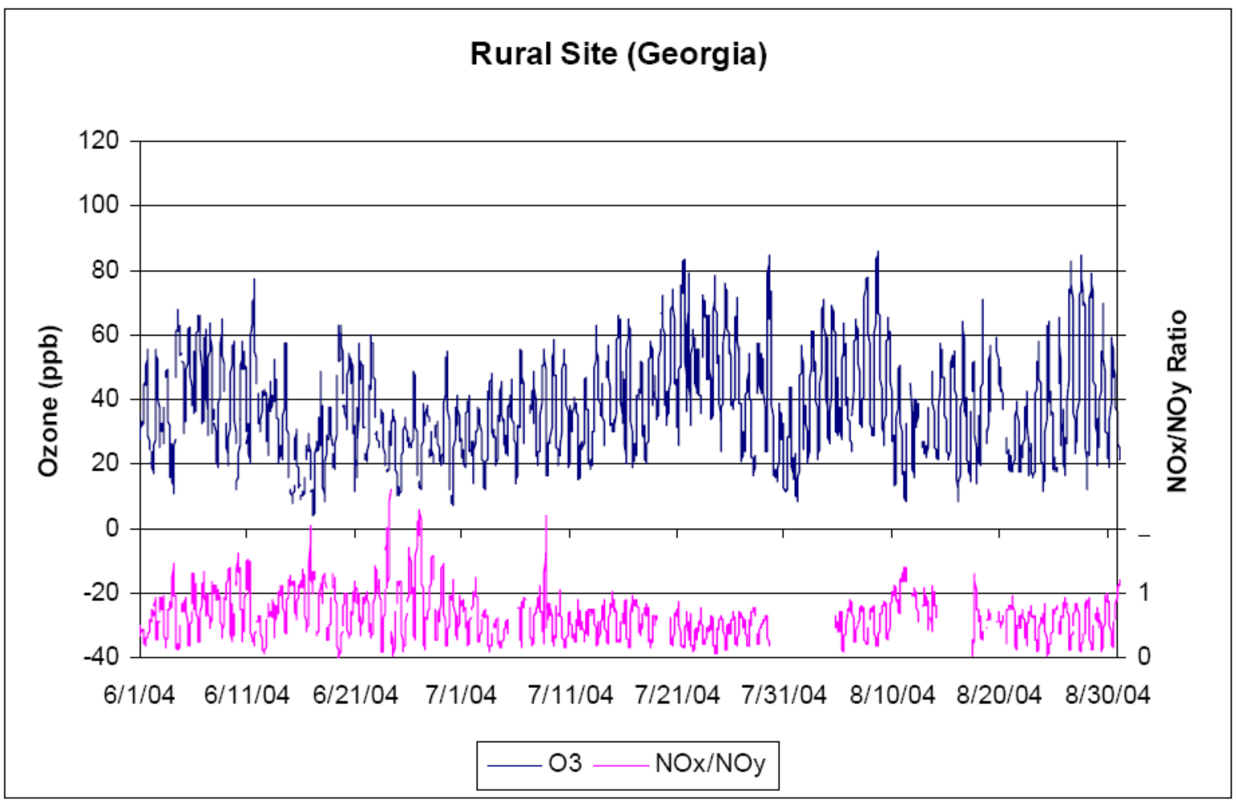


Figure 2. Comparison of urban vs. rural ozone combined with assessment of nitrogen plume age.

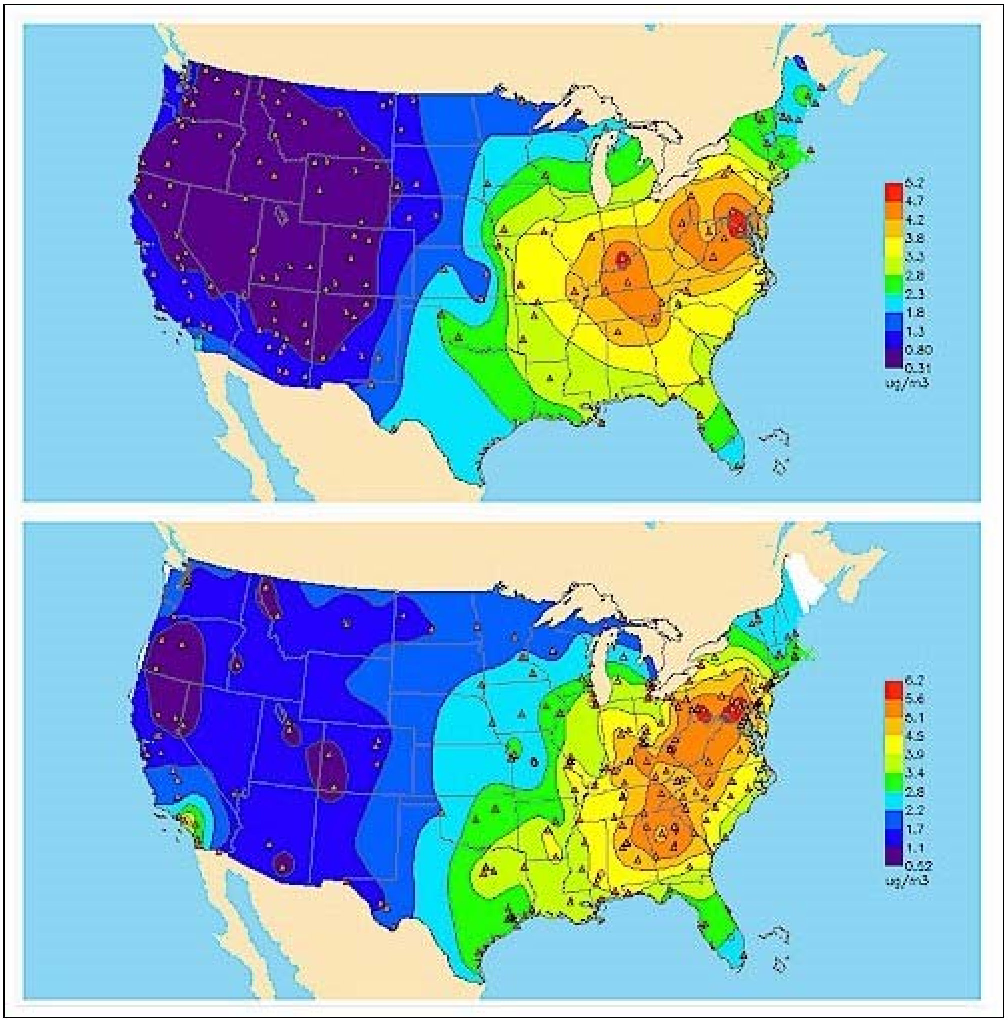


Figure 3. Dynamic contour maps which can combine data sets from multiple networks. Note that the complementary site densities between the IMPROVE western and STN eastern networks.

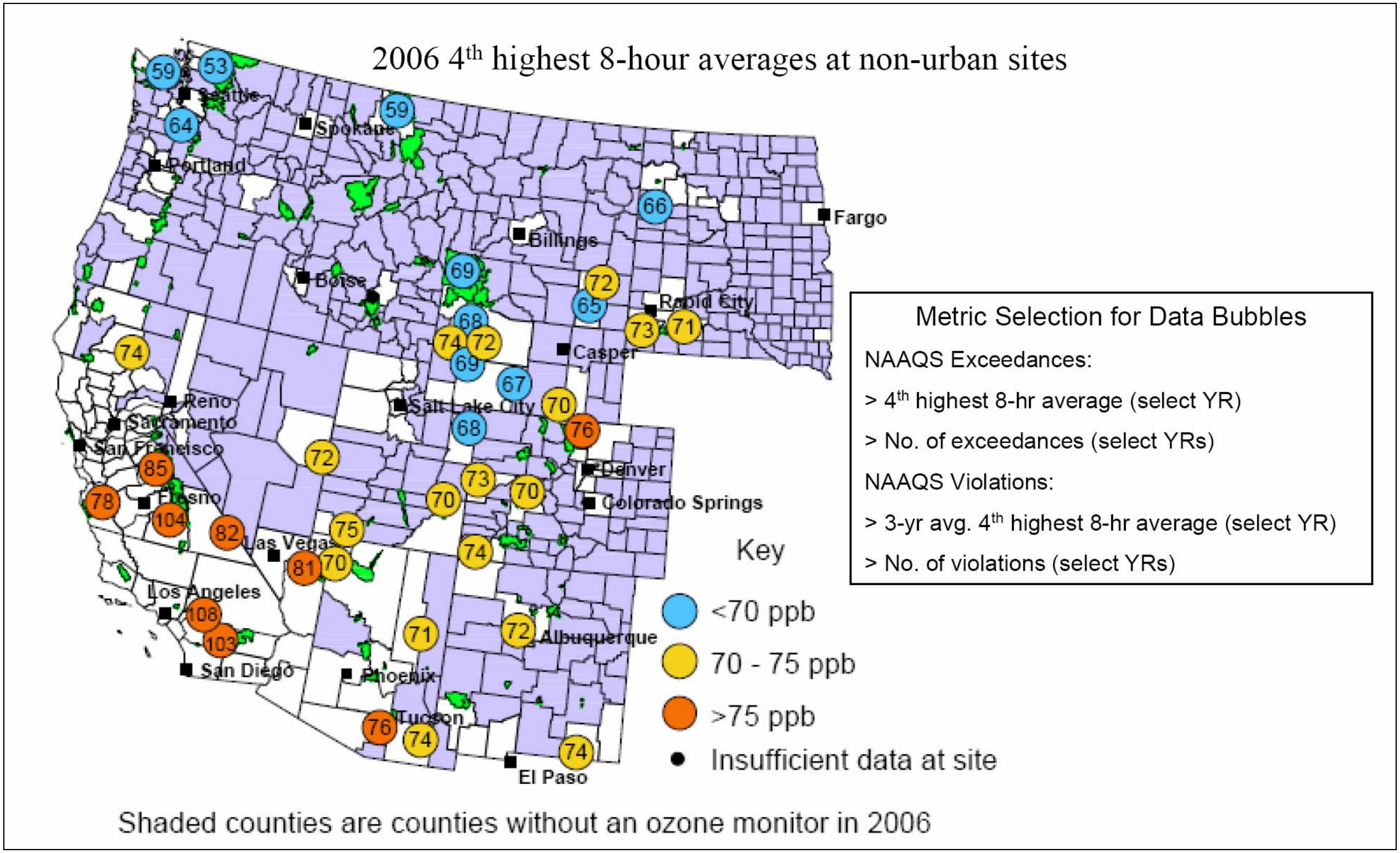


Figure 4. Summary map of non-urban ozone monitors in the WRAP. This map also functions as a gateway to examine the data behind the map.

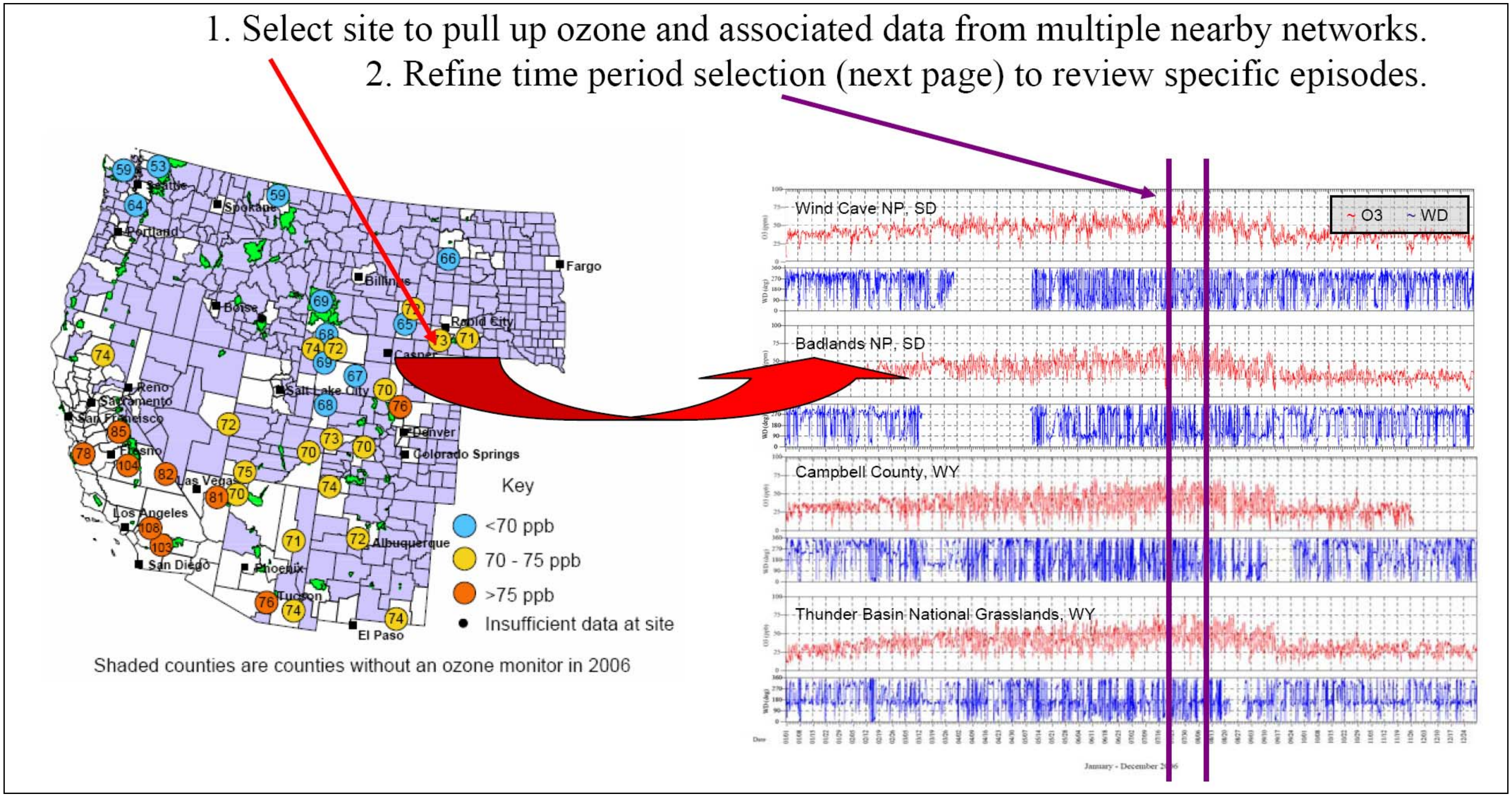


Figure 5. Conceptual illustration of how the pollutant summary map allows the user to further examine data from selected sites.

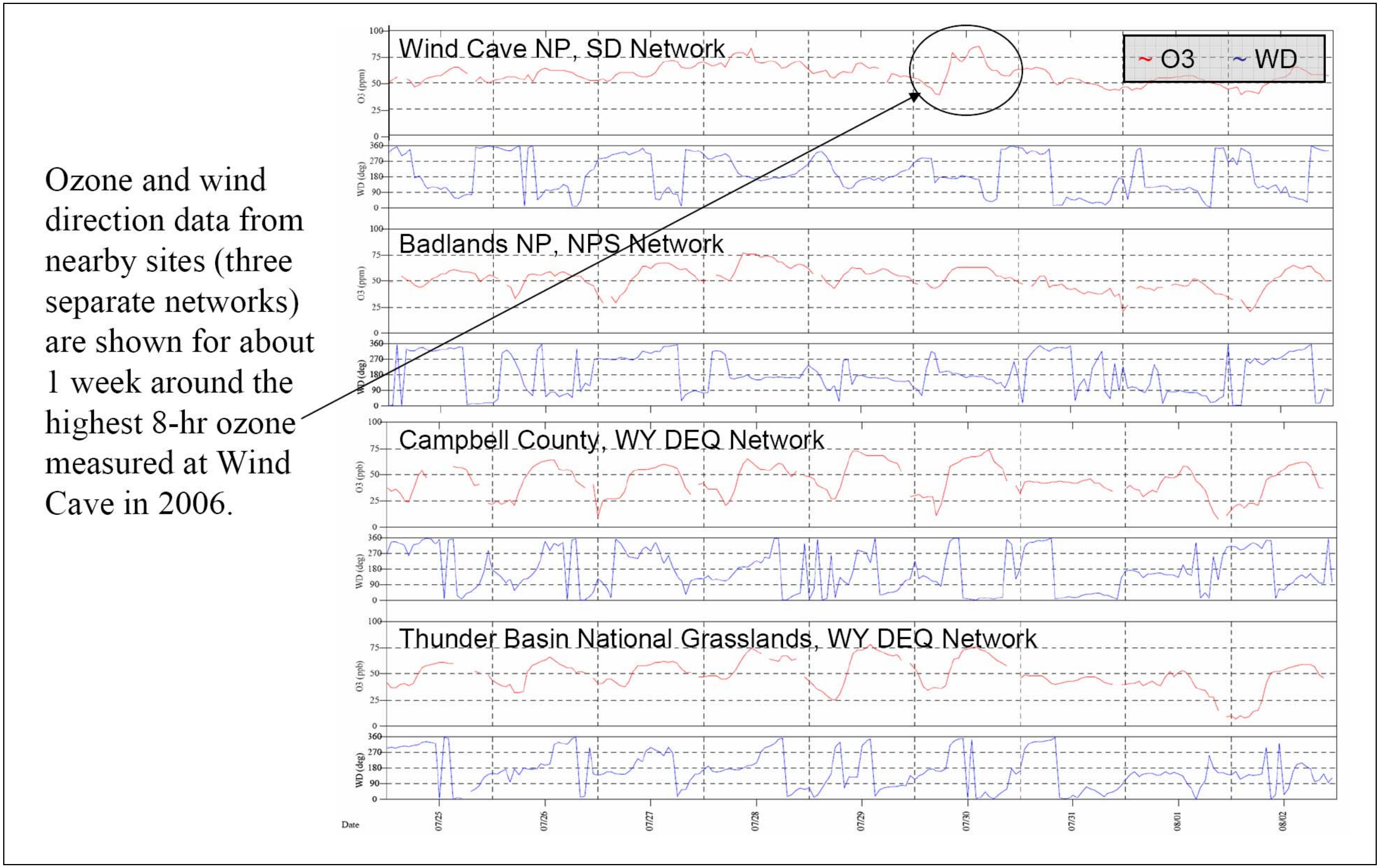


Figure 6. Ozone and wind direction data for Wind Cave and 3 close sites in southwestern South Dakota and northeastern Wyoming.