INVESTIGATION OF THE AIR QUALITY INDEX AS RELATED TO WEATHER REGIME

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Abstract

Daily Air Quality Index (AQI) values reported by the United States Environmental Protection Agency were examined for the months of April through July of 2004 in the northern Mid-Atlantic region. Data were stratified by county for Delaware, Maryland, New Jersey, New York, and Pennsylvania and included maxima, minima, and mean AQI values for each day. Summary information for each of the 45 counties revealed both a similarity of behaviors, such as variations in maxima and minima, as well as a dichotomy and divergence of values based on their positions relative to obvious sources and sinks in the area, such as urban versus rural locations. Possible relationships to physical features, including mountain-valley and coastal plain regions were also noted. Data were also separated according to the prevailing weather regimes and flows (upper air and surface) to determine any apparent dependencies on specific weather features. Basic weather regimes included 500 hPa features (trough, zonal, ridge) and flow directions (north, northwest, et cetera); and surface features (high pressure, low pressure, cold front, and warm front). The surface features were further separated into subtypes that specified the position of the weather feature relative to the study region. Mean AQI values plotted for the region according to these prevailing weather regimes, flows, and subtypes revealed several instances in which variations in the orientation, gradients, and characteristic patterns of AQI were related to the weather patterns. This was particularly evident when subtypes were grouped according to the location of the weather feature relative to the study area. These variations suggest a general basis exists to improve operational prediction and assessment of AQI patterns according to specific weather regimes. In other situations the patterns reflected topographic variations, urban or industrial centers or pollution sources, and the possibility of observational network bias, or the role of mesoscale phenomena.

1. Introduction

The occurrence of poor air quality, and even those instances of moderate or fair air quality, due to a single, or combinations of several pollutants, poses a significant health risk to the general population (Lippman 1989). More than 100 million people in the United States live in counties with poor air quality (e.g., Neher and Koenig 1994) and experience its associated impacts (e.g., Bascom 1996a,b; and Fauroux et al. 2000). These may include degradation of soil and water quality and aesthetic changes in the local environment. In addition, air quality impacts plants and animals (e.g., Haagen-Smit et al. 1951; Heck et al. 1982; or Godish 1997) – such as habitat contamination and disruption of reproductive cycles – and has been documented with regard to its impacts on exposed structures as well as ongoing industrial or commercial processes. In New Jersey concerns have included acid rain related to pollution in the area (e.g., Lecher 1974, 1976) and particulate matter loading downstream of sources (e.g., Beresford and Murphy 1978).

For these reasons, air quality is monitored on a daily basis by the United States Environmental Protection Agency (EPA) through state networks for the public's health and well-being. The EPA provides daily predictions of air quality (e.g., see www.epa.gov) in a collaborative effort between the National Oceanic and Atmospheric Administration (NOAA) and EPA (http://www.emc.ncep.noaa.gov/mmb/aq) for the purpose of planning and response by the general public and various government agencies. As part of this effort the EPA provides an air quality index (AQI) value daily intended to portray the quality of the air and its attendant risks to, or impacts on, the population. This index is an outgrowth of the original Pollutant Standards Index previously used by the agency.

The AQI was developed by the EPA in concert with NOAA, the National Park Service, and state and local agencies. The AQI is a summary measure based upon the criteria pollutants specified in the National Ambient Air Quality Standards (NAAQS as per Table 1; or see http://epa.gov/air/criteria.html). Five of the criteria pollutants (ozone, particulate matter, carbon monoxide, sulfur dioxide, and nitrogen dioxide) are standardized against their maximum allowable value (see http://airnow.gov/index.cfm?action=aqibroch.index) so as to assign a normalized weighting factor so that the observed concentration of all pollutants combined may be expressed on an incremental scale of impact (Table 2). This provides a summative measure of air quality based upon the pollutants present and their concentration relative to the NAAQS.

The AQI is determined operationally for each county in the United States so that air quality can be qualitatively described according to a quantification of the relationship between pollutant values and measured health impacts. Since it is not dependent upon any one particular pollutant, it may be used to examine the prevailing day-to-day air quality across a region regardless of source locations. This suggests that the AQI may be examined with regard to prevailing weather conditions across a multi-county region to establish whether the observed behavioral characteristics of the values are related to the weather pattern and any local features.

The calculation of AQI values for each county is based upon an existing network of air quality monitoring devices and therefore is dependent upon the local distribution of sites as well as the character of pollutants measured. For example, it is possible for one county to measure only ozone and particulate matter, another carbon monoxide, sulfur dioxide, and nitrogen dioxide; and yet another to have no monitoring equipment. There are three scenarios that may occur for observing sites: they may be located (1) within the county, (2) outside the county, or (3) within and outside the county. These variations arise as specific monitors for the criteria pollutants are placed by state agencies (in coordination with and according to EPA approval) to record the air pollutants that are most likely to be exceeded in that local area. Therefore, while the AQI are reported by county, there may be instances in which the calculated value is dependent upon nearby counties in which the monitoring equipment is located. The sites may also be clustered in only a portion of a county based on knowledge of the sources in that region.

In spite of these limitations, the AQI can offer valuable information for a region in an urban zone in which there is a diversity of landscapes and land use with a high population density – such as that found in the northern Mid-Atlantic region in the United States. While regional variations in the local landscape pose multiple issues of concern (Dabberdt et al. 2000) with many impacts, their impacts may vary considerably from place to place (e.g., Smoyer et al. 2000) as well. The New Jersey region is prone to periods of poor air quality (e.g., Zhang et al. 1998) and certain types of pollutants (e.g., ozone; Sistla et al. 2001) of an episodic nature as well as throughout the year that require predictive methods to protect the local population (e.g., Ryan et al. 2000). In some instances these may lead to air pollution episodes or long term hazards that have far reaching implications (e.g., Kuni et al. 2002; or the Donora, PA event – Davis 2002), and some of which are favored during certain times of day and/or seasons of the year (e.g., Godish 1997).

Therefore, air quality forecasting is of significant value, as evidenced by various workshops (e.g.¸ Dabberdt et al. 2006) and related mitigation strategies (Boylan et al. 2005). The AQI approach is universal (Mohan and Kandya 2007) with similar methods in development (e.g., Kyrkilis et al. 2007 and Cheng et al. 2007) and is relevant to the EPA air quality forecasting system (Ottea et al. 2005). This system provides regional predictions for both urban and rural environments across the United States. For example, the EPA Airnow system online (www.airnow.gov) provides forecasts that are readily disseminated to broad user communities (e.g., web based information systems as per Triantafyllou et al. 2006). Forecast information includes a "National Outlook", "Ozone Now", and "Particle Now" for all regions of the United States. Therefore it is of interest to examine the values, trends, and spatial distributions of AQI, particularly in relation to local weather regimes and physical features.

While a number of studies have examined the relationships between select pollutants and specific atmospheric variables (whether observed or modeled; e.g., Clark and Karl 1982), few have considered the use of a summative measure such as the AQI. The AQI provides greater continuity in the examination of air quality variations from day to day as individual pollutant values may change substantially from hour to hour. In addition, the use of prediction methods is particularly sensitive to the numerical models used to generate the predicted values, and also to the model chemistry (e.g., Alapaty et al. 1995). Therefore, in order to ascertain how air quality varies in a more consistent manner, the use of AQI across a region, and its variations according to the prevailing weather regime, would be of greater value.

Therefore, the intent of this study was to determine whether any easily recognized patterns of the AQI existed for individual counties, or across a region, and to determine whether these had any dependence upon the prevailing weather regime or local features. Historically, similar efforts have been applied over a lengthy period of time (e.g., Holzworth 1962 or Panofsky and Prasad 1967 versus Beaver and Palazoglu 2006) for many locations (e.g., McKendry 1994; Niccum et al. 1995; and Pryor et al. 1995) and with many different methods (Angevine et al. 2006 and Schwarzhoff and Reid 2000). This approach – the use of specific synoptic weather patterns – would ideally identify patterns that may reflect monitoring site placement, equipment behaviors unique to each location, and allow inferences to be made as to the role of sources, sinks, and local physiography (i.e. the physical features of the region and related human interactions) in the observed patterns of air quality for the region as a function of the local weather conditions. Operationally, these would have the potential to improve forecasts of the spatial distributions of AQI in real-time and possibly relate features to mesoscale phenomena.

2. Methods

The study area selected for investigation was designed to include coastal, interior, varying terrain, and physiographic regions in and around the Northern Mid-Atlantic region (Fig. 1a). These included counties in Delaware, Maryland, New Jersey, New York, and Pennsylvania (Table 3) and were sorted according to their location type (i.e. coastal plain – blue, metropolitan and/or suburban with varying terrain – yellow; and higher elevation - green). The 'higher elevation' locations were identified as those regions where altitude was the dominant feature as compared with 'metropolitan and/or suburban with varying terrain' regions. The study region is quite varied in terms of its physiographic relief (Fig. 1b) and thus represents an amalgam of distinct and overlapping climatic zones as part of the megalopolis corridor that runs from Washington, D. C. to Boston, Massachusetts. Basic statistical and spatial analyses were completed in lieu of complex methodology (e.g., Lu 1995 or Riccio 2005) for the sake of brevity and clarity. The approach of this study was to establish simple relationships for easy operational implementation and to build the case for the application of more sophisticated techniques.

For this investigation, mean daily AQI values were gathered for 117 of 122 days from April through July of 2004 (five days of data were missing or unavailable). The year selected for study was based upon a review of the same seasons in surrounding years from 2000 to 2007. The year 2004 was observed (by inspection of daily weather maps) to contain a greater frequency of multiple weather regimes as compared with other years such that the dataset would provide a sufficient number of samples of each weather regime for study. The April through July period was selected to provide a glimpse of potential health impacts that are typically exacerbated during this time of year by the weather regime (e.g., pollen season and windy weather; intense sunshine with dry atmosphere and ozone production). For the 117 days selected, the majority (85%) indicated ozone as the primary pollutant (used in the AQI calculation) for the majority of sites (i.e. often 90% or more each day) and therefore no further breakdown by pollutant type was performed for this sample set.

Missing data (Table 3) were the result of (1) a lack of AQI values (five days), (2) missing data for select counties, and/or (3) suspect or poor data quality. In the first instance, the missing days represented a very small percentage of days and were not considered (4%). When each county was examined for missing data it was determined that Essex and Warren (New Jersey) reported more than 70 percent of AQI values missing. However, these counties were retained for analysis given the network of monitoring sites and data-rich region (Essex, near New York City) as well as the limited region (Warren, in western New Jersey) covered and the AQI as determined from surrounding counties was deemed appropriate. However, Burlington County (southern New Jersey) was excluded from study based on suspect data as described in the next section.

3. Results

a. Basic AQI Statistics & Analysis

The AQI data were examined to determine distribution and behavior characteristics for reference according to the prevailing weather regime and local features in the study region. This was first accomplished by calculation and graphing of the basic statistical parameters of AQI for each county (Table 4) and the examination of box plots. The values indicate that most of the study area can experience unhealthy air quality (AQI > 100) as well as extremely good air quality (AQI < 50). Mean and median values were in close proximity for the majority of counties. While the average AQI varied from higher to lower according to location, it did so inconsistently. Lowest mean values tended to be at higher elevations and select coastal sections.

An examination of each county's box plots (Figure 2, with counties numbered as in Table 3) provided a more comprehensive view for comparison and indicated that most locations shared AQI values from the same population (based on simple inspection of the median). This commonality in the county sample distributions might be expected given the contiguous nature of the study region and when transport and mixing are considered. This similarity is also seen according to location type (i.e. coastal plain, et cetera). The plot also identified the presence of an outlier distribution for Burlington County which was removed from further analysis due to: (1)

large distributional inconsistencies with regional and nearby AQI sample distributions; and the fact that (2) monitoring sites in the county measure only carbon monoxide and sulfur dioxide (Table 3).

While the above analyses were useful, it was important to consider AQI values across the study region to discern any patterns that might suggest physical relationships between AQI and the local weather regime and physiography. Therefore, a plot of the mean AQI observed in each county during the period of study was constructed to examine the spatial characteristics or behaviors of the AQI distribution (Figure 3). The analysis revealed that although within the realm of GOOD to MODERATE air quality for the region, urban maxima (New York City vicinity, Philadelphia-Metro, and Baltimore) and coastal and higher terrain minima were present. This analysis spans the period from April through July during which a wide variety of atmospheric conditions may occur.

The “lambda-like” pattern of peak AQI values in southeastern Pennsylvania (as shown in Fig. 3) suggested possible land use (and cover) impacts and the interactive role of changing elevations and coastal environments in association with local sources and sinks. When specific features of the region were superimposed (e.g., see Fig. 1b), there is a suggestion that local features may modulate AQI values and behaviors, particularly as a function of wind directions (e.g., as evidenced by studies such as Guerra et al. 2006). The pattern observed suggests that AQI values offer a realistic portrayal of regional air quality. This is similar to results by Ryan et al. (2000) for the Baltimore and Washington, DC region.

b. AQI and 500hPa Regimes

While the first analysis provided some insight as to the observed pattern variations in overall mean AQI values, it did not identify synoptic scale contributions from an upper air (e.g., 500mb) or surface synoptic perspective. In an effort to better understand the distribution of mean AQI values, as well as the relative influence of synoptic scale (upper air and surface) or local features, the data were parsed according to the 500 mb flow pattern (e.g., trough, zonal flow, ridge) and flow direction (i.e. north, northwest, et cetera). Each of these allowed for an investigation of their contributions to the observed pattern, mean values, and the variability of AQI across the study region. All cases were then collected for the 500 mb feature according to their number and relative frequency: trough (53; 47%), zonal flow (13; 11%), and ridge (51; 42%).

Plots of the mean AQI values (Fig. 4 a – c) indicated that the zonal flow and ridge patterns (b, c) at 500mb appear to be the key contributors to the overall “lambda-like” mean pattern observed for the entire data set (Fig. 3). The ridge pattern generally had higher mean values of AQI within the “lambda” region. Peak mean values were observed in the Philadelphia region and northern Delaware and were evident in both the zonal flow and ridge cases. The zonal flow and ridge patterns would be expected to provide regional subsidence that could enhance or maintain higher AQI values and thus the “lambda-like” pattern. In contrast, the trough situations – which accounted for nearly half of all cases – yielded a relatively flat pattern of mean AQI with lower values throughout and local maxima found primarily in urban and industrial locations. In these situations it appeared that local effects or monitor location could be the more important factor.

Plots of the mean AQI values were also prepared for 500 mb flows (Fig. 5 a – c), regardless of feature, for cases in which sufficient sample size existed: northwest (26; 21%), west (52; 43%), and southwest (36; 30%). When compared with the overall mean AQI analysis (Fig. 3) it was clear that an upper air flow from the northwest and west not only dominated the flows (78 cases) but was also integral to producing the "lambda-like" pattern and had high mean values. These would more likely be associated with the ridge or zonal flow patterns in the study region (as per Fig. 4b and c) which accounted for 64 of the cases examined. While the westerly flow cases had higher mean values (and twice as many occurrences) the northwest flow cases indicated a greater range of peak mean values. The southwest cases showed only a weak reflection of the overall pattern of AQI values.

All of the 500 mb flow patterns and wind flow regimes were also examined according to a variety of parameter (or diagnostic) fields (e.g., contours, omega, and others – not shown) to determine any specific characteristics of each (not shown) with regard to the observed AQI patterns. For example, 500 mb trough cases indicated a weak omega axis located along an "alley" of peak mean AQI values (Delaware and southeastern Pennsylvania) and in the vicinity of the minimum mean wind – suggesting a pooling. In the case of zonal flow maximum mean AQI values were found within the eastern portion of a weak omega gradient (increasing from east to west) but with a gradient in motion showing reduced mixing inland (to the north and west) relative to the coastal region (south and east). The ridge cases indicated peak values just east of the mean ridge axis in the vicinity of the surface thermal ridge but with little distinction. Values were relatively invariant in regions where mixing (wind flow) was enhanced or reduced.

A similar analysis was performed for the 500 mb wind flow cases but yielded no distinctive information with regard to the observed AQI patterns. For example, northwest flow cases showed higher mean values in areas of higher heights, warmer surface temperatures, and very light winds but only weakly. While these analyses were useful in confirming “expectations” of the behavior of air quality value patterns according to basic meteorological principles, they did not provide a comprehensive operational understanding of the variations experienced across the region on a day to day basis. Therefore the investigation considered the use of simple surface synoptic weather regimes that result from the 500 mb patterns and flows.

c. AQI and Surface Synoptic Regimes

In an attempt to provide forecasters with useful guidance as to the spatial variations in air quality as related to specific weather conditions, surface synoptic regimes were considered. Such an application is not unusual (e.g., Yarnal 1993; El-Kadi and Smithson 1992; Elder et al. 1994; and Ortega et al. 2006) and may be accomplished through combined methods (e.g., Carroll and Baskett 1979) and application to specific locations (e.g., Rohli et al. 2004). This would be relevant to the use of AQI in air quality forecasting system and its verification and evaluation (e.g., Kang et al. 2007) when considering spatial variations in pollutant concentrations. It is also essential for application to an operational forecasting environment.

Therefore, an examination of the data according to specific weather regimes was considered in hopes of delineating regional variations and characteristic patterns in air quality associated with atmospheric flow, and in relation to local features. Data were parsed according to atmospheric conditions. Four basic weather patterns were used for each day based on the Daily Weather Map

Series (DWM; available online at www.hpc.ncep.noaa.gov/dwm/dwm.shtml) and included: (a) High Pressure, (b) Low Pressure, (c) Cold Front, and (d) Warm Front (Table 5). These simple weather regimes were selected because they represent basic atmospheric processes that can be used as a basis to develop air quality forecasting programs or for comparison to techniques using numeric model output (e.g., Touma et al. 2007).

Studies have shown that aerosol concentrations vary on the same scale as these simplistic types of weather systems (e.g., Targino et al. 2005). While more sophisticated synoptic techniques might prove useful (e.g., Kalkstein et al. 1998 and Bower et al. 2007) and provide very specific applications (e.g., Sheridan 2002 and 2003; or Rainham et al. 2005), this study's intent was to demonstrate whether relationships between AQI and weather regime exist by the investigation of a small sampling of AQI values. If so, forecasting applications and methods could be developed for operational use with specific scenarios modified according to local mesoscale phenomena.

The mean AQI values for each weather regime (High Pressure, Low Pressure, and each Frontal type) were plotted in order to assess any spatial patterns and/or variability based on the prevailing atmospheric conditions (Figure 6 a-d). Common to each weather regime to some extent was the "lambda-like" pattern previously identified (Figure 3) based on overall mean AQI values. In high pressure cases the pattern extended westward and shared similarities with the 500 mb ridge and northwest flow patterns (Fig. 4c and 5a). This would be consistent with a pattern of subsidence across the region. For the low pressure cases the portion of the "lambda-like" pattern extending into southern New Jersey was much less emphatic and the observed mean AQI pattern exhibited some similarity to those for the 500 mb trough and northwest flow cases (Fig. 4a and

5a). These would be consistent with a pattern in which lift and/or mixing could reduce AQI values in the region.

The “lambda-like” feature was more pronounced (although somewhat distorted) and had higher mean values for the cold and warm front cases (based on a comparable sample size) than high and low pressure cases. The cold front pattern was consistent with the 500 mb zonal regime and west and southwest flows and suggests a greater significance to local sources and pooling. The warm front pattern, although more diffuse, shared some similarity to the 500 mb zonal regime but was a poor match to any of the 500 mb flows. To varying degrees each surface weather pattern retained the urban signatures found earlier (New York City, Baltimore, Philadelphia) and indicated minima at higher elevations and in the vicinity of coastal sections. Given the nature of the data set, and the use of mean daily values, relation of these to specific mesoscale phenomena was not possible.

However, while some common elements between various partitions of the data do exist in the analyses above, it must be emphasized that these are occurring during a period (April through July) in which surface and upper air parameters typically exhibit a very large range. Therefore, examination of the surface patterns also considered various diagnostic fields. For high pressure days there was some similarity between mean peak AQI values and the thermal and moisture fields (i.e. both higher in peak regions) as well as weak mean wind flow at the surface. In the cases of cold and warm fronts there was a tendency for the peak mean AQI values to follow the axis of mean rising motion (omega) yet exhibit some inconsistency with regard to values for urban and higher elevation locations. These mixed results suggested consideration of the location of the surface feature as a determinant in the observed AQI patterns.

d. AQI and Weather Regimes subtypes

The investigation considered mean AQI values as a function of the location of the surface weather regime feature. The intent was to determine whether the specific surface weather regime details were important to AQI spatial distributions, and/or related to local physical features. Therefore the basic weather regime types (except fronts) were broken-down into subtypes (Table 6) according to their location relative to the study region: (a) WEST (northwest, west, or southwest); (b) OVER (north, over, or south); and (c) EAST (northeast, east, or southeast). These groupings were made to ensure adequate sample size, to account for the typical west to east flow of weather sequences in the study region, and to consider the prevailing mean air flow that would be common or similar in direction – and thus important to transport. In each subtype weather conditions and air flow patterns would be expected to differ based on the location of the center of the high or low pressure system and its interactions with local features.

In the case of High Pressure subtypes (Figure 7 a-c) the pattern and magnitude of AQI in each is comparable to that for all cases of high pressure combined (Figure 6a) but with variation in the location and shape of the maximum AQI. The most extensive and highest mean AQI occurs when the high pressure center is to the EAST of the study region, the lowest and least extensive mean values occur when the high pressure center is located to the WEST. In each case, some remnant of the "lambda-like" pattern identified previously may be discerned – although the pattern is oriented more east to west across the region. This pattern is more obvious, albeit elongated, for the Low Pressure subtypes (Figure 8 a-c) and is comparable to all cases combined (Figure 6b). In general, AQI values for the low pressure cases are reduced compared with high pressure cases. The most extensive and highest mean values occur for low pressure WEST and least for EAST – the opposite of high pressure – which is not unexpected given that the air flow for low pressure EAST would be comparable with that for high pressure WEST. The AQI pattern for low pressure EAST is more similar to high pressure WEST given the comparable wind flow of the two subtypes (i.e. with a downslope component). In combination, these results suggest that the "lambda-like" pattern identified is more likely the result of specific sources and pooling of pollutants and could also represent a bias in the structure of the observational network.

e. AQI Operational Composites

In order to identify the potential factors creating these observed AQI patterns and variations composite weather maps were generated for further analysis. The composite maps (Figure 9 a-c) for each of the resulting mean weather pattern subtypes above were generated (based on the reanalysis data set as described by Kalnay et al. 1996) to indicate the mean location of the pressure system (or front) relative to the study region. Each map identifies: (1) the mean center of high (or low) pressure (or front), (2) the general surface wind flow (arrow) which has been added (when definitive) based on simple meteorological principles, and (3) the location and shape of the observed maximum AQI analyzed (derived from Figures 6c, d and Figures 7 a-c and 8 a-c). The composite maps (Figure 9 a, b, c) provide verification of the subtype classifications made during data analysis and provide some measure of the within subtype variability given they represent the mean state of the atmosphere. They also provide a basis for the development of specific operational air quality forecasting methods attuned to the study region.

Examination of the composite maps under high pressure (Fig. 9a) reveals a simple tendency for the isolation or possibly pooling of higher AQI values in southeastern Pennsylvania (at low elevations) given the wind flow and topographic barriers. However, it is also quite possible that local emissions, warm temperatures, and local (or sea breeze) circulations may be responsible. Further investigation would be required in order to isolate and identify the precise cause. In addition, a secondary maximum occurs in the vicinity of the New York City area and other industrial or urban zones. The down slope flow of air, and the tendency for sinking and divergence, may be responsible for the minima observed from the higher elevations of Pennsylvania south and eastward to the coastal regions of New Jersey. However, when the high pressure system is located to the EAST of the study region higher AQI become pervasive and appear independent of the observational network site locations. This may be due to transport and forced upslope flow that allows penetration of valley regions in the higher terrain locations as the flow becomes parallel with the physiography. In these cases AQI minima occur along New Jersey coastal sections and in southern Delaware.

When considering low pressure systems (Fig. 9b), it appears that lower mean AQI values reflect air “cleansing” (possibly related to rainout, removal by cloud and hydrometeor production and/or washout, removal by the fall of hydrometeors) as well as a spatial “confinement” of higher AQI values to specific source regions and according to the local wind flow. In the case of low pressure located to the EAST of the study region the characteristic behavior and pattern of AQI mimics that of the high pressure sample population (particularly WEST) but with mean values slightly lower across the region. When low pressure is situated OVER or WEST of the region a distinctly different sample population characteristic is revealed as an isolated “lambda-like” pattern appears. This indicates a region of peak AQI that appears to be related to both local sources and the resulting transport of higher values – or the observational network itself. At the same time it provides for an air flow from the ocean to the east and south that results in minima for coastal areas. In each of these cases the local physiographic features may block or channel pollutants depending upon the actual wind flow (rather than mean).

4. Conclusions

An examination of mean AQI values during late spring and early summer of 2004 was completed to determine the ability of the EPA-derived measure to characterize air quality across a region. The intent was to ascertain any obvious patterns based on the location of air monitoring sites, local physiographic features, the prevailing weather regime, and any potential interactions between these factors. Analyses revealed that in the mean, air quality is GOOD to MODERATE (for the 2004 sample) and that most counties share similar statistical distributions from the same population. There was some evidence of AQI variation from coastal zones to metropolitan/suburban and higher elevation/terrain locations. When examined spatially, a “lambda-like” pattern of peak AQI appeared across the region with other maxima located in the New York City and Baltimore urban zones. This basic pattern was relatively invariant (i.e. apparent in most cases) when considering weather regimes characterized by high and low pressure or fronts and suggested a key source region (and/or pooling or transport along the I-95 corridor) – or potentially an observational bias resulting from the location of network sites.

However, when composites of synoptic subtypes were generated for these weather regimes (according to their location relative to the study area) it was apparent that some relationship existed between mean AQI values and the physiographic features, local and nearby source regions, and specific weather patterns. This implies that synoptic and mesoscale assessments of regional air quality and its change with time (and synoptic features) are possible in a systematic manner. The obvious AQI pattern variations suggest a strong potential for real-time operational prediction of AQI across the region according to specific weather patterns and local features. Thus case studies could also be performed and this information could be used with guidance products to more specifically convey any “call to action” that might be needed in the case of poor air quality episodes or as to how it might evolve over time across a forecast region (e.g., extended forecast and hazardous outlooks).

It is recommended that local studies be conducted to determine base AQI patterns and distributions for a region, including their sensitivity to weather regime and local features. This would serve as a conceptual model for the location so that day-to-day impacts could be effectively tracked and predicted with the use of real-time measurements and operational model guidance and forecast products.

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