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AN INVESTIGATION OF AIR QUALITY INDEX CHARACTERISTICS AND BEHAVIORS FOR SOUTHERN NEW JERSEY DURING SPRING 2004 AS A FUNCTION OF SYNOPTIC WEATHER PATTERNS

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1. INTRODUCTION

Since its inception and subsequent revision, the air quality index (AQI) as disseminated by the United States Environmental Protection Agency (EPA) has served as a reliable summary measure of how air chemistry may affect the broader population. The AQI also readily shows variation from day-to-day and region-to-region based upon weather conditions and the monitoring sites (and their locations) used in calculating the value.

Therefore, it is a useful indicator of the general air quality across a region and may be used to identify "hotspots" of good or poor air quality as well as possible causes. In an effort to explore these for New Jersey, the AQI was examined for the spring and early summer season of 2004. This is typically a time of year when ozone and particulate levels may be high resulting in a deterioration of air quality across the region. In particular, the southern two-thirds of the state were of greatest interest given their significant population and economic growth.

The intent was to provide greater insight to the population distributions of the AQI by county, and statewide, according to the associated attributes and patterns in order to provide some guidance as to what role synoptic patterns may play in the spatial and temporal variations observed. This provides insight as to the local generation, persistence, and transport of pollutants in a regional setting and thus may be of value in the operational production of short-term air quality forecasting and advisories.

2. DATA COLLECTION & METHODOLOGY

Data for New Jersey AQI were obtained and summarized from the AIRNOW program of EPA (online) based on monitoring sites in New Jersey (Fig. 1) for select counties (Table 1) in New Jersey and Pennsylvania for the 122 day period April through July 2004. This collection provided a large number of days for analysis and a sequence of synoptic weather patterns that could be used to separate the data. The Pennsylvania counties were included after initial work due to concerns over data from Burlington County in New Jersey as discussed below.

Initial inspection of the data focused on construction of a database for basic statistical analysis, and later a parsing of this data according to synoptic regimes. Therefore each county's data was examined through the use of box and whisker plots (not shown), to determine any inconsistencies and for comparison with all other counties, and simple statistics were generated (Table 1). Based on these, it was determined that data for Burlington County was very different from all other counties in the study in for all values of the AQI and spatial plots confirmed the discrepancy.

As a result, additional data were obtained from three Pennsylvania Counties (Bucks, Delaware, and Montgomery) so as to "surround" the area in question. The intent was to identify whether the Burlington County values were accurate or in error. Analysis of the data set over time and in a mean sense indicated that the Burlington County data were inconsistent (see Fig. 2 a and b) with those of the surrounding area and therefore, data from Burlington County were removed from further consideration in the study. This decision was also supported by the fact that the air quality monitoring sites in Burlington County (and therefore the actual equipment) was located within several miles of those in Pennsylvania.

The remaining data were retained for further analysis according to synoptic weather regimes. In order to better understand how the AQI varied according to the synoptic weather patterns, the NOAA NCEP Daily Weather Map Series (see www.hpc.ncep.noaa.gov/dwm/dwm.shtml) was used. Analysis focused on surface features in order to allow the events to "self-sort" themselves into the weather patterns associated with their occurrence and this resulted in three basic weather "types" of high pressure, low pressure, and fronts. These were then subdivided according to the location (or type) of the feature with regard to New Jersey and composite

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maps generated to ensure consistency and basic statistics were generated for each by county.

The synoptic types and subtypes, and their box-and-whisker plots, were also examined to discern any significant variations in the population of AQI values from county to county. Spatial plots of the summary data (means of types and subtypes) were also examined in order to reveal any features in the distribution as a function of synoptic type and county (not shown). In addition, composite maps were generated online (Climate Prediction Center) to further define the synoptic patterns and characteristics for each subtype. Each of these analyses led to the closer examination of patterns in AQI as related to prevailing weather conditions across the study area.

Composites were generated of mean geopotential heights at 500 mb, surface pressure, and vector wind (see Fig. 3 a, b, c) for the entire data period. These revealed a prevailing westerly flow for the period in which highest mean values of AQI were over southeastern Pennsylvania and eastern New Jersey. Minima were over northern and southern portions of the study area and thus provided some evidence of a general gradation in the pattern and the possibility of transport across the region, at least in a mean sense.

3. ANALYSIS OF EVENTS

Plotted mean values of AQI for all counties for the basic synoptic types were constructed (not shown) and revealed minimal differences or variation other than by county. However, when synoptic subtypes were examined distinct patterns began to emerge. For example, "GOOD" to "MODERATE" air quality subtypes included low pressure west and high pressure north. Generally "POOR" air quality was associated with low pressure northwest and high pressure southeast. The best air quality occurred most consistently in Atlantic and Monmouth Counties with the worst being Camden.

Additional analysis focused on whether AQI values and their spatial patterns reflected local air quality problems and/or the potential transport across the region. Composite maps highlighted these and provided explanation of likely causation in the region. This examination of the AQI in the southern two-thirds of the state of New Jersey revealed that a variety of synoptic patterns may affect its distribution and thus serve as a proxy in forecasting air quality changes. Further efforts will continue to analyze the data to extract significant patterns and behaviors for the region as well as with time.

In the subtype low pressure northwest (see Fig. 4) maximum AQI were found on a line and focused from southeastern New Jersey into the higher elevations of southeastern Pennsylvania. However, the values were not continuous indicating local origination as well as some transport. In addition, secondary maxima were evident in east central and northeastern New Jersey. While the pattern of AQI was similar for the high pressure southeast (see Fig. 5), the secondary maxima became much more apparent in northeastern and east central New Jersey with an obvious minimum in Monmouth County.

Although each of these subtypes share a common synoptic flow, it is believed that the greater magnitudes of AQI maxima are related to the general subsidence found with high pressure systems. Similar to these were also the cold front subtype (Fig. 6) with a similar pattern, but reduced values as compared to the low pressure northwest and the high pressure southeast subtypes. In fact, the local minima in AQI are more distinct and may reflect mixing processes that are more localized and/or a broader mixing-out of air pollutants in these regions as a function of the advective flow preceding the front.

Several of the composite maps (not shown) supported these assessments by showing a similarity in the 500 mb flow (west to west southwest) with a tendency for higher pressures in the Atlantic (whether the high pressure or low pressure subtype) and fairly strong gradient flow for transport. The data and the analyses require further investigation to focus on the impact of local versus transported pollutants and a tracking of AQI from event to event as well as when transitioning between subtypes.

ACKNOWLEDGEMENTS

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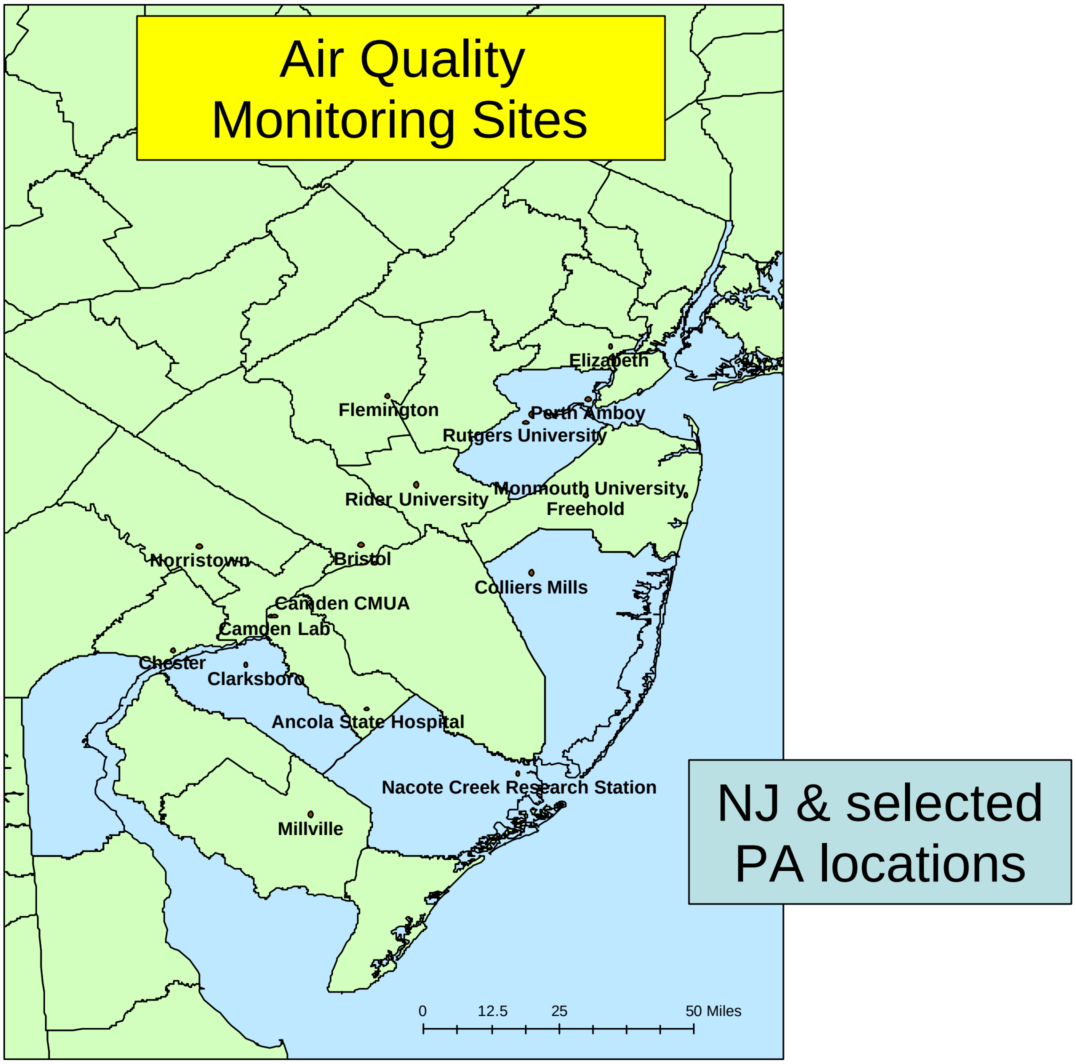
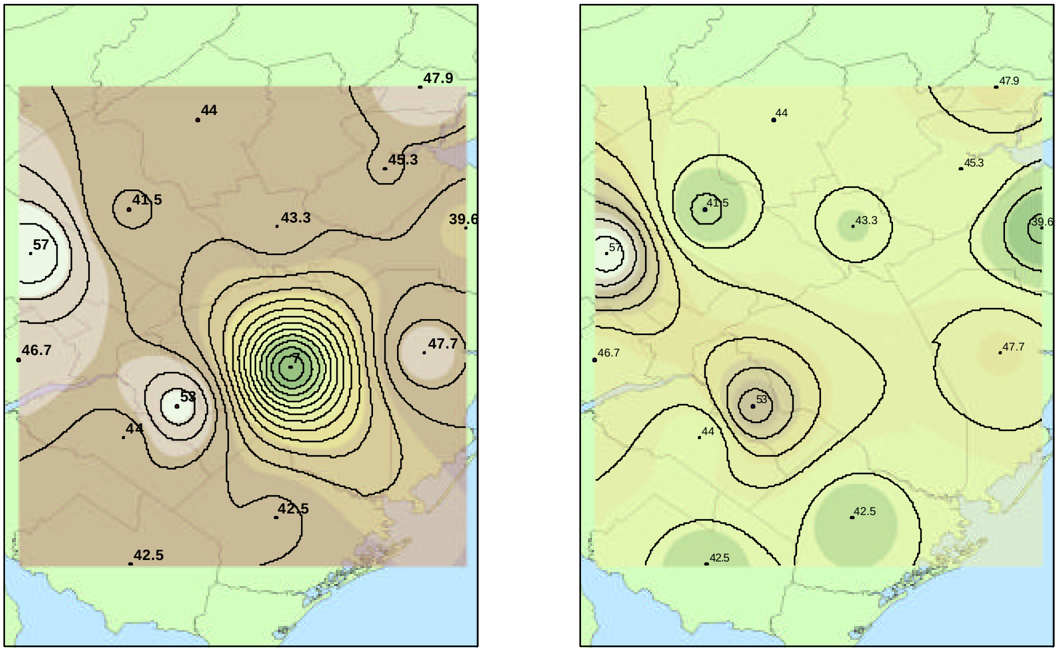


Figure 1. Selected air quality monitoring sites in New Jersey and Pennsylvania as used by EPA to calculate the Air Quality Index (AQI).

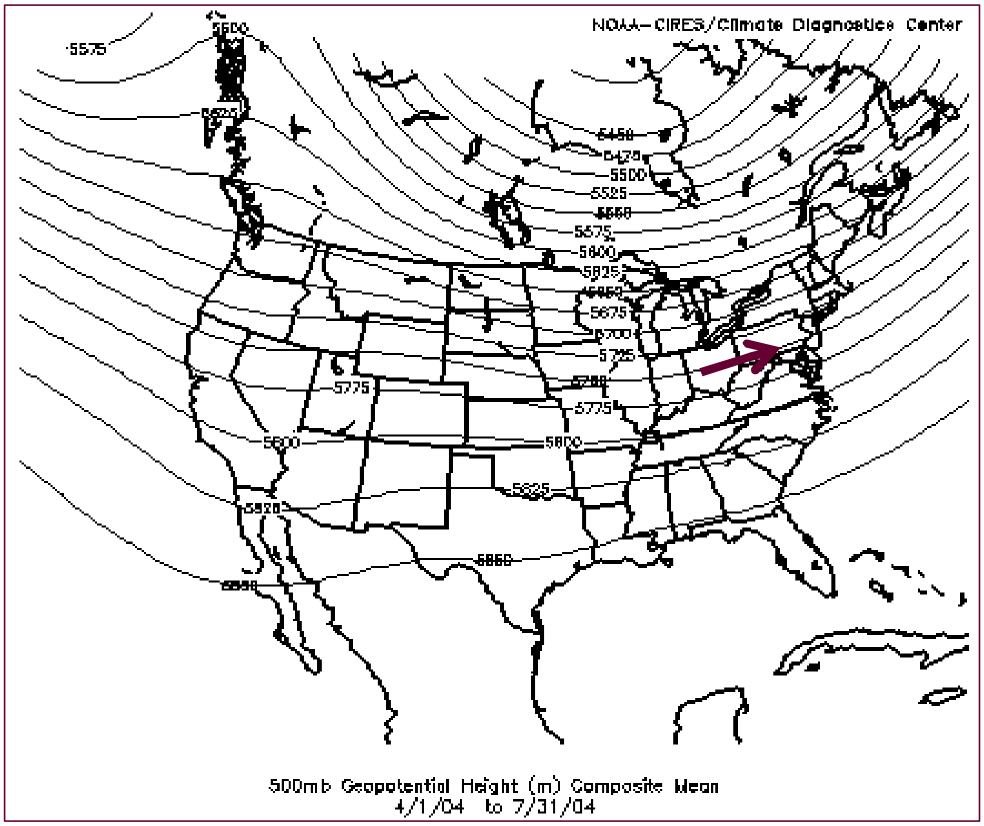
County	**Max**	**Min**	**Mean**	**Median**	**Range**
Atlantic, NJ	111	20	42.5	39	91
Burlington, NJ	15	3	7.0	7	12
Camden, NJ	147	22	53.0	45	125
Cumberland, NJ	111	20	42.5	39	91
Gloucester, NJ	129	16	44.0	39	113
Hunterdon, NJ	135	14	44.0	38	121
Mercer, NJ	105	13	43.3	38	92
Middlesex, NJ	114	18	45.3	40	96
Monmouth, NJ	90	16	39.6	37.5	74
Ocean, NJ	122	19	47.7	41	103
Union, NJ	141	8	47.9	46	133
Bucks, PA	109	11	41.5	36	98
Delaware, PA	114	18	46.7	44	96
Montgomery, PA	150	22	57.1	55	128

Table 1. Counties included in study area (defined as “southern” New Jersey) of concern and their associated summary statistics for the AQI based on the period April through July 2004, inclusive. Maximum, minimum, mean, median, and range are indicated for each as derived from the daily AQI data. Data from Burlington County, New Jersey are highlighted to illustrate the anomalous AQI values as compared to those of surrounding counties in the study area.



(a) (b)

Figure 2. Mean values of AQI for all counties in the study area with isopleth analysis to illustrate spatial variations and to confirm the anomalous behavior of AQI values from Burlington County, New Jersey when the county was (a) included, versus (b) excluded.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4/1/04 to 7/31/04

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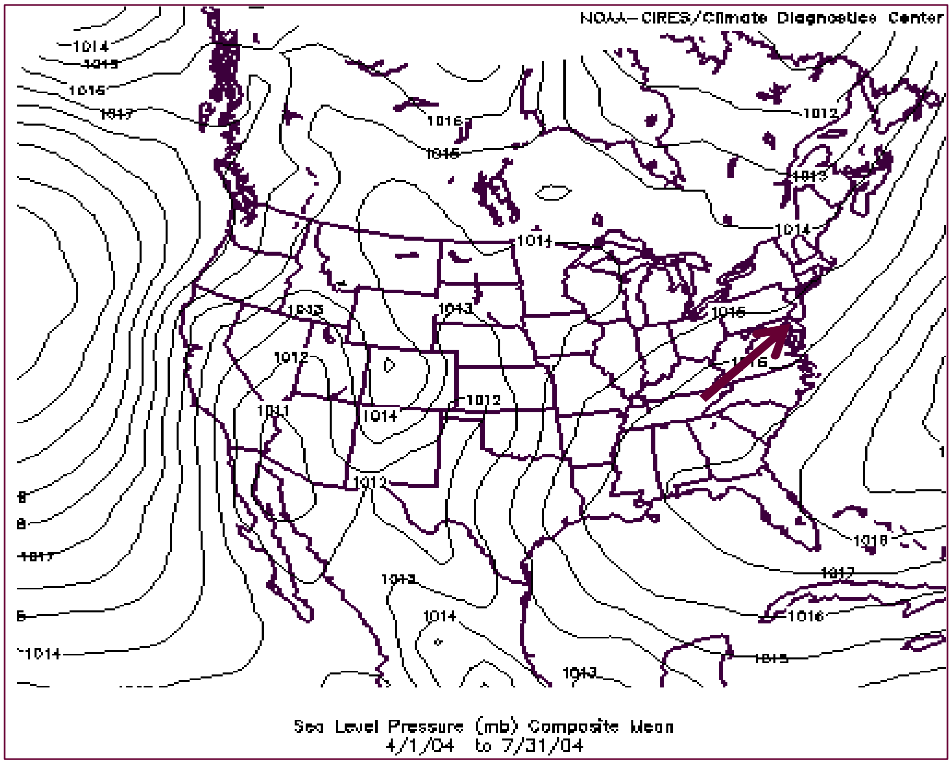
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Sea Level Pressure (mb) Composite Mean
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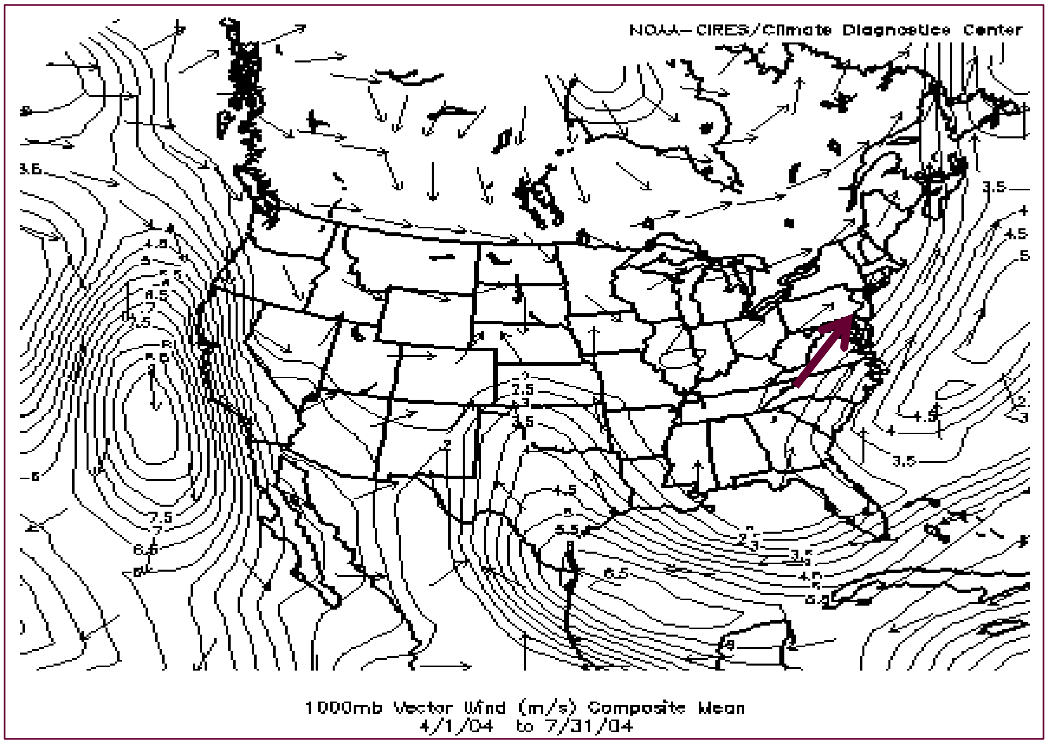
(b)



(c)

Figure 3. Mean composites of (a) geopotential height (500 mb), (b) surface pressure, and (c) vector wind (1000 mb) for entire study period.

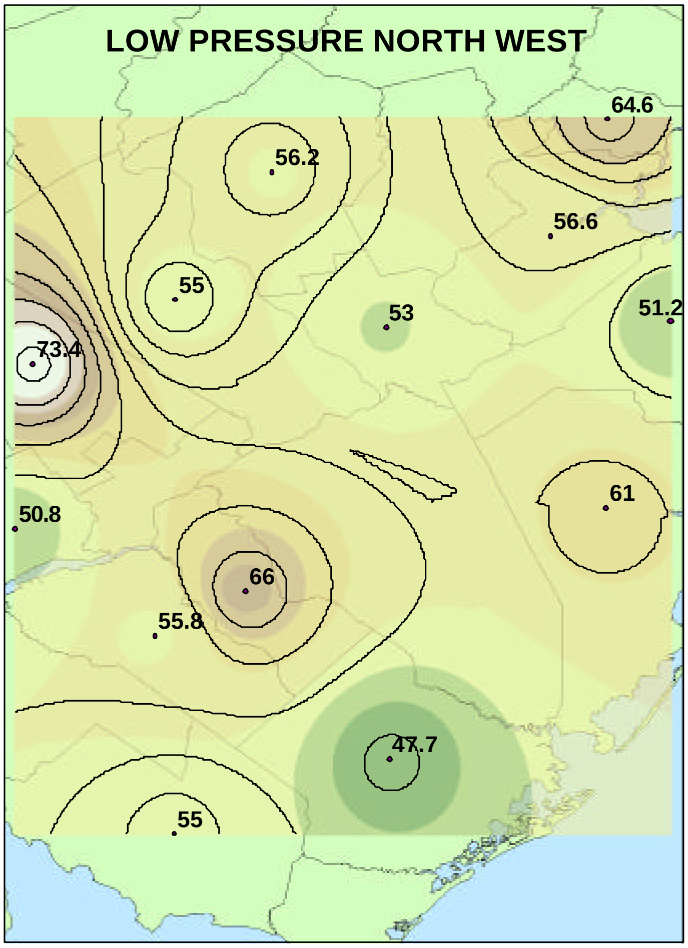


Figure 4. Mean AQI values across study area for low pressure northwest subtype.

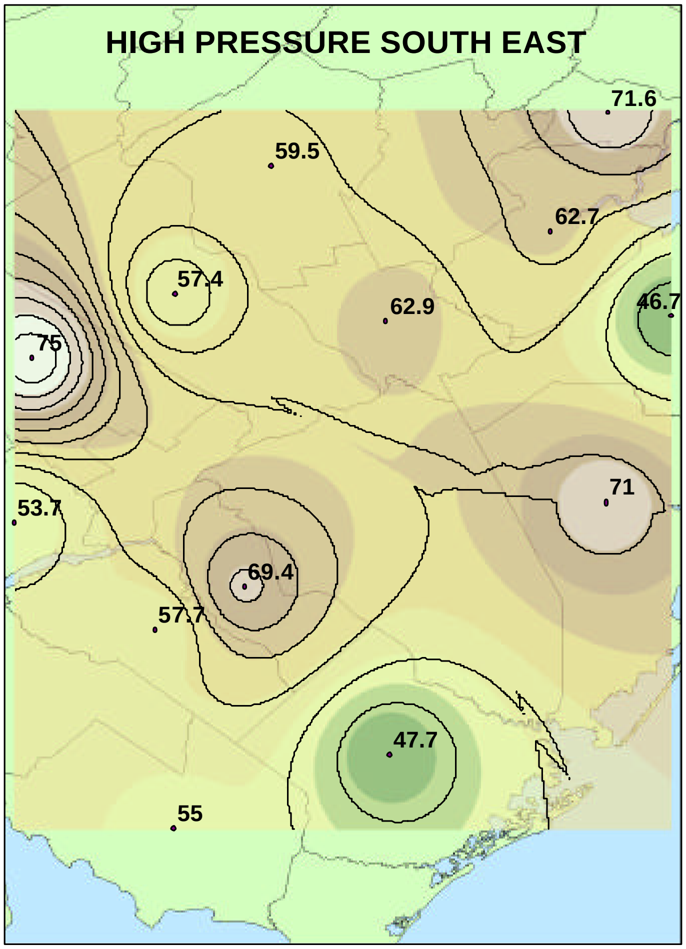


Figure 5. Mean AQI values across study area for high pressure southeast subtype.

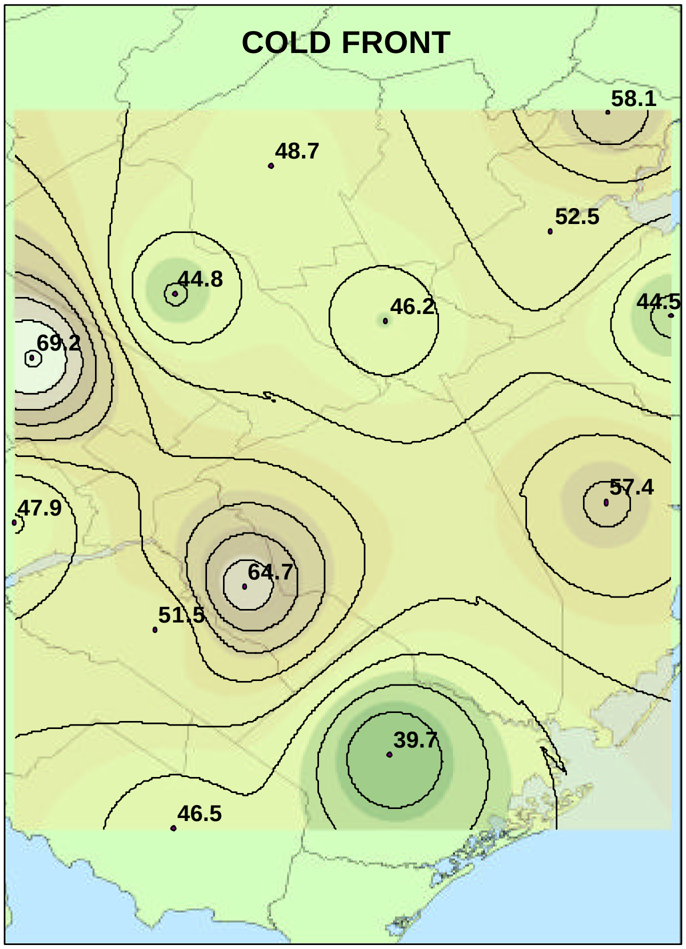


Figure 6. Mean AQI values across study area cold front subtype.