Missouri Department of Natural Resources

METEOROLOGY OF 8-HOUR OZONE FORMATION IN MISSOURI

The Environmental Protection Agency has defined the ozone season for Missouri as April 1st through October 31st. During this time, the synoptic scale climatological pattern over Missouri is one in which local weather conditions are dominated by subtle shifts in the position of the Bermuda high located over the western Atlantic Ocean. The flow around this high-pressure center typically brings southerly flow to the region along with warm, humid air that often leads to hazy conditions during the summer months. Other smaller-scale weather features that accompany the dominant Bermuda high – transient features such as frontal boundaries and thunderstorms can create highly variable spatial and temporal ozone concentrations.

In order to reduce the frequency and severity of future ozone exceedances, the Department's Air Pollution Control Program (APCP) conducted a study to identify key meteorological conditions that repeatedly led to ozone concentrations in excess of 75 parts per billion. Due to spatial, climate and/or source location differences the analysis was divided into Springfield, Kansas City, St. Louis and Southeast and Southwest Missouri regions. The meteorological parameters the APCP staff determined significant were analyzed using synoptic scale, mesoscale, and microscale information. The analysis included the identification of meteorological regimes, an air parcel trajectory analysis, and a wind rose evaluation.

The identification of the meteorological regimes revealed that the severity of meteorological conditions necessary to cause 8-hour ozone exceedances under the previous standard of 85 parts per billion did not have to be present for 8-hour ozone exceedances to occur under the revised standard of 75 parts per billion. Using air parcel trajectories, the transport path of pollution during and prior to exceedance days was revealed, which indicated where the plume was traveling from. Likewise, the wind rose plots provided an indication of localized pollution movement during the ozone season.

It is important to note that this evaluation is essential because it can aide in the selection of episodes for photochemical modeling, the determination of control strategies, tracking trends in ozone concentrations, and identifying areas that have emission sources which contribute to elevated ozone. The steps taken to during this analysis are documented below along with the results obtained from the analysis.

AIR QUALITY MONITORING AND METEOROLOGICAL DATA

Ambient air quality monitoring and meteorological data for the most recent five year period in which comprehensive data was available was selected for this analysis. The five year period included the following years: 2003, 2004, 2005, 2006, and 2007. The use of the latest five years of air quality data reduced concern regarding significant differences in ozone precursor emissions due to controls and/or growth within each area. However, the use of five years does not provide a comprehensive examination of all meteorological conditions that will cause exceedances of the 8-hour ozone National Ambient Air Quality Standard (NAAQS).

For the purposes of this study, an ozone event was defined as one or more day(s) that either had concentrations over the 8-hour ozone NAAQS (75 parts per billion) or days that were part of an increasing pattern of ozone in the region. The days leading up to ozone concentrations in excess of the NAAQS allowed data reviewers to determine what type of meteorological pattern was in place during ozone events. The identification of these events will also provide valuable information regarding the appropriateness of these potential episodes for input into future photochemical modeling studies that may be required under the Clean Air Act. The events identified for the Springfield, Kansas City, St. Louis and Southeast and Southwest Missouri regions are contained in Tables 1, 2, 3, 4A, and 4B respectively.

Surface maps, 850 hectopascal (hPa) maps, and hourly surface data concerning the meteorological conditions surrounding these ozone events were obtained from the National Climatic Data Center (NCDC). The hourly surface data included National Weather Service ASOS measurements from the Springfield regional Airport (KSGF), Kansas City International Airport (KMCI), Lambert International Airport (KSTL), and St. Louis Downtown Airport (KCPS).

METEOROLOGICAL REGIME DEVELOPMENT

In order to identify typical meteorological conditions that led to elevated 8-hour ozone concentrations, the Department's Air Pollution Control Program reviewed each day contained within Tables 1, 2, 3, 4A and 4B. The events chosen for this analysis were based upon concentrations approaching, or exceeding the NAAQS standard of 75 parts per billion, and the majority of 8-hour exceedances were multi-day events, or "episodes".

Under the previous 8-hour ozone NAAQS of 85 ppb, only the very favorable conditions would produce monitored exceedances. To get an eight hour average reading over 85 ppb meant that solar, wind and thermal profiles had to coincide and persist for several hours. With the lowered 8-hour standard of 75 ppb, the weather pattern of influence did not necessarily require the strength or persistence of solar, wind, or thermal profiles as under the previous NAAQS. When developing regimes to categorize the ozone exceedance days, some of these less-ideal setups did not fit into a broad category of synoptic scale flow as analyzed in previous years. Instead, a smaller mesoscale or microscale weather feature was the dominant influence over ozone readings in a given area. The meteorological regimes identified in this section refer to the prevailing synoptic, mesoscale, or microscale meteorological conditions that impacted the monitor area of interest.

The weather systems influencing the formation, concentration, and transport of ozone and it's precursors vary in size and duration from the large synoptic scale features such as a Bermuda high, to smaller transient mesoscale high pressure systems, to narrow, microscale fronts. Because ozone forms in the presence of sunlight, weather features that affect the duration and intensity of incoming solar radiation, or insolation, are very influential on monitored ozone concentrations. Subsidence, or sinking motion, can concentrate ozone near the surface; the proximity of a mesoscale center of high pressure can be influential on ozone concentration on small time and area scales. The horizontal near-field transportation of ozone is primarily determined by the low level wind direction and speed, both of which are determined by the prevailing pressure pattern at a regional or local scale.

Because of the transient nature of weather systems, the regime of influence may change for a given Missouri location over an ozone episode. In addition, when smaller scale weather features are the dominant influence on ozone exceedance, the regime classification may differ across the state on any given day. Maps containing examples of the synoptic conditions associated with each regime are contained in Figures 1 - 7. The maps were provided by the National Climatic Data Center (NCDC).

Meteorological Regime #1: "Progressive Northerly Flow"

Synoptic Features

Regime #1 occurs as a mobile high pressure system develops over the Ohio Valley or Great Lakes and moves toward the east coast. Frontal systems are often present over the Northern Plains and/or the Lower Mississippi Valley or Southeast United States. The large-scale surface wind flow over Missouri is from the east to south. Regime #1 frequently transitions into Regime #2 as the center of high pressure moves east off the Atlantic coast. Days, monitors that exceeded, and the values of the monitors that exceeded from Regime #1 can be found in Table 5.

Meteorological Regime #2: "Bermuda High"

Synoptic Features

Regime #2 occurs as a strong Bermuda high forms over the Atlantic Coast. The high pressure center may be present over the Southeastern US, Mid-Atlantic US, or off the Atlantic coast. The strength and location of the Bermuda high will determine the southern extent of a common frontal boundary that lies north of Missouri across the northern Plains. The large-scale surface flow is generally from the south across Missouri with Regime #2. It is important to note that this is a persistent pattern that generally lasts multiple days and often leads to severe ozone episodes. This regime can transition to Regime #3 if the Bermuda High moves southeast or weakens, allowing the frontal boundary north of Missouri to advance south through the state or Regime #6 if the front stalls over Missouri. This regime can also transition to Regime #7 if a secondary high center develops near Missouri and becomes the dominant influence over ozone formation and transport. Days, monitors that exceeded, and the values of the monitors that exceeded from Regime #2 can be found in Table 5.

Meteorological Regime #3: "Frontal Passage"

Synoptic Features

The synoptic setup over Missouri is usually in transition with Regime #3; one air mass is being displaced as a frontal boundary moves across an area of interest. The front acts on the microscale to concentrate and push the ozone plume in the direction of frontal motion. A specific pattern in monitor exceedances had to be seen across the area of interest, and wind flow patterns vary depending on the direction of air mass and frontal motion. This regime can transition into Regime #4 or #5 depending on the location of high pressure behind the front and proximity of a secondary front. Days, monitors that exceeded, and the values of the monitors that exceeded from Regime #3 can be found in Table 5.

Meteorological Regime #4: “Transient Northern High”

Synoptic Features

Regime #4 represents a localized high pressure system that moves towards the south from the Iowa vicinity into Missouri and then continues on an eastward path. This system is smaller in scale than the Bermuda high, bringing with it generally light easterly winds, subsidence, and clear skies. Days, monitors that exceeded, and the values of the monitors that exceeded from Regime #4 can be found in Table 5.

Meteorological Regime #5: “The Box”

Synoptic Features

This less-frequent regime occurs as an initial frontal boundary passes through Missouri and high pressure builds in behind the front. A second front approaches Missouri from the west and acts to trap pollutants in the lowest levels of the atmosphere between the boundaries, essentially boxing in the state of Missouri. Days, monitors that exceeded, and the values of the monitors that exceeded from Regime #5 can be found in Table 5.

Meteorological Regime #6: “Stationary Front”

Synoptic Features

As high pressure builds over the eastern US, a stationary front lies in an east-west orientation across Missouri. The boundary advances and retreats little over the course of several days. Each small push acts to concentrate ozone on one side of the boundary and push it toward a specific portion of the area of interest. Large scale wind flow is light and usually converges at the stationary frontal boundary. If the frontal boundary eventually migrates north of Missouri and a Bermuda high builds southeast of Missouri, then Regime #6 can transition to Regime #2. Days, monitors that exceeded, and the values of the monitors that exceeded from Regime #6 can be found in Table 5.

Meteorological Regime #7: "Bermuda High Retrogrades/Subsidence"

Synoptic Features

With the strong Bermuda High southeast of Missouri, secondary weaker centers of high pressure form near or just south of Missouri. These smaller highs tend to create light winds over the state, bring stronger subsidence to the region, and show little movement. Days, monitors that exceeded, and the values of the monitors that exceeded from Regime #7 can be found in Table 5.

METEOROLOGY AND SEVERITY/FREQUENCY OF OZONE EPISODES BASED ON REGIME

The number of monitor sites exceeding 75 parts per billion and the relative concentration reported at each site revealed that the severity and frequency of each ozone event differed from the Springfield, Kansas City, St. Louis, Southeast and Southwest Missouri regions. Additionally, when each day was placed within its meteorological regime it was noted that although the regimes overlap, the synoptic pattern leading to the most frequent and severe ozone concentrations also varied across the state, see Table 5.

In the St. Louis region the meteorological conditions associated with Regimes #2, #3, #5, #6, and #7 all resulted in at least one monitor reporting 8-hour concentrations greater than 100 parts per billion during the 5 year period; however, only Regimes #2, #3, #5 and #7 had multiple monitor exceedances over this threshold. Regimes #1 and #4 remained below 100 parts per billion.

In the Kansas City region the meteorological conditions associated with Regimes #2, #5, and #7 resulted in 8-hour average ozone concentrations exceeding 100 parts per billion. Only Regime #2 had multiple monitor exceedances over the 100 parts per billion threshold. The remaining regimes all had concentrations less than 100 parts per billion.

The Springfield and Southeast and Southwest Missouri regions had no exceedances greater than the 100 parts per billion threshold.

In addition to reviewing the severity of ozone concentrations under certain meteorological conditions, the likelihood that ozone concentrations in excess of the 8-hour ozone standard would occur was evaluated. In the St. Louis region, Regimes #1 and #2 occurred most frequently and often were associated with the same episode. Regimes #3, #4, and #7 all regularly occurred, with Regimes #5 and #6 being the least frequent.

Much like St. Louis, the Kansas City region had the most frequent ozone exceedances occur under Regimes #1 and #2. Unlike St. Louis, the Kansas City region only had Regimes #4 and #7 occur regularly, leaving the frontal passage regime, Regime #3, as a less frequent regime. Along with Regime #3, Regimes #5 and #6 also were relatively infrequent when compared to Regimes #1, #2, #4, and #7.

The Springfield region also had Regimes #1 and #2 result in the most frequent ozone exceedances. Like St. Louis, Regimes #3, #4, and #7 were the next most frequent, with Regimes #5 and #6 not occurring at all.

The Southeast and Southwest Missouri regions had Regimes #1, #2 and #3 occurring most frequently, with Regime #3 occurring as frontal passages through the St. Louis and Kansas City regions pushed ozone concentrations towards the El Dorado Springs, Bonne Terre, and Farrar monitors. Regimes #4, #5, and #7 were the next most frequent, with Regime #6 not occurring at all. It is important to note that since the Southeast and Southwest Missouri monitors are spread over a large area, comparing the frequencies of these regimes may not be as significant.

When looking specifically at the Farrar monitor, it showed the same pattern of meteorological regime influences. For the 36 days when the Farrar monitor exceeded the 8-hour average of 75 ppb, almost half of the days were under Regime #2 (see Table 6), under the influence of the Bermuda High. The southerly winds that dominate with Regime #2 do not favor ozone or precursor transport from St. Louis directly influencing the Farrar monitor; instead, the dominant southerly wind direction would indicate an influence from the Memphis area. Regimes #1 and #7 together account for another almost 38% of Farrar exceedance days, and with both regimes the dominant wind is from the east, suggesting an influence from the Ohio Valley. Meteorological Regime #3 on June 9, 2006 was analyzed with a frontal passage from north to south across the St. Louis area, favoring the transport of ozone and it's precursors toward the Farrar monitor; this is the only case out of 36 Farrar exceedance days where the meteorological regime favored St. Louis as an ozone source region for Farrar.

Bonne Terre exceedances number 41 days with 8-hour average ozone readings over 75 ppb between 2003 and 2007; meteorological Regimes #1, #2, and #3 account for over 70% of exceedance days. The general wind flow pattern with Regimes #1 and #2 are from the southwest to the east, all directions that favor transport regions from far southern Missouri or the Memphis region east to the Ohio Valley. Regime #3, associated with frontal passages that concentrate and transport ozone or its precursors, has a varied dominant wind direction because of the localized areal and temporal nature of frontal boundaries. On three of the nine frontal passage regime days, August 22, 2003, July 22, 2005, and June 9, 2006, frontal passages through the eastern half of Missouri created wind flow patterns passing south from St. Louis toward the Bonne Terre monitor site. These numbers indicate that less than 10% of Bonne Terre exceedances can be attributed to St. Louis when looking strictly at meteorological regimes. For a further analysis of Bonne Terre exceedances, see Table 7.

When comparing the Southeast exceedance regimes, notable differences were apparent. A higher percentage of Regime #1 exceedances occurred for Bonne Terre than Farrar. With a dominant easterly wind flow under Regime #1, a simple comparison shows that the transport region east of Bonne Terre contributes more toward the number of exceedances than does the region directly east of Farrar. In contrast, there is a higher percentage of Regime #2 occurrences on Farrar exceedance days than Bonne Terre; this result suggests that the transport region southwest to southeast of Farrar (mainly along the Mississippi and Ohio River corridors) contributes to more exceedances than the area southwest to southeast of Bonne Terre (mainly southeastern Missouri). Regime #3 exceedances that can be attributed to a general wind flow from St. Louis were also more frequent for Bonne Terre than Farrar, possibly because Bonne Terre is closer to St. Louis.

The El Dorado Springs monitor is located between Kansas City and Springfield, and it experienced exceedances on 25 days from 2003 to 2007. The most frequent regime again is Regime #2 with 40% of days attributed to a Bermuda High pressure bringing general southerly flow to southwest Missouri, but subtle differences from SE to SW cause the source region of influence to vary. On five days, Springfield is more of an influence on the El Dorado Springs monitor under Regime #2 because of southeasterly flow and Springfield's upwind position, but three days showed more southwesterly flow, suggesting southeast Kansas or northeastern Oklahoma were the source regions of interest. The next most prevalent regime was #3 with a quarter of the events occurring with a frontal passage; the subtle deviation in wind direction away from south suggests transport regions from Oklahoma to Springfield. Regimes #1, #4, #5 and #6 do not indicate direct influences from either Kansas City or Springfield, leaving open the possibility of other transport regions. For a further analysis of El Dorado Springs exceedances, see Table 8.

The most notable difference in ozone exceedance regime between regions was the frequency of Regime #2. The St. Louis region had significantly more occurrences than the other regions. Being closer in proximity to the Bermuda High, St. Louis was more significantly influenced by this summer climatological feature, resulting in the higher number of Regime #2 events in St. Louis. Also important to note is that Regime #3 ozone exceedances were noted more frequently in the St. Louis and Kansas City regions than in the Springfield region. This occurred as fronts often stalled and/or fell apart prior to reaching southern Missouri. Ozone may have been focused and concentrated downwind of Springfield on frontal passage days, but with only two monitor locations, the direction of plume movement may not have been captured by the network.

Tables 9-12 were also used in the frequency/severity analysis. Table 9 includes the number of regime exceedances per year broken down by region. Table 10 is an incremental breakdown by monitor and by regime. Table 11 is broken down into the increments that were used in the trajectory analysis. More information on Table 11 can be found in the trajectory analysis section below. Table 12 includes exceedances by site and by regime for all levels of exceedance.

The analysis of the meteorological regimes and the exceedances associated with each provides insight into the severity of ozone episodes and the typical weather patterns that occurred. In agreement with the 2003 Eight Hour Ozone Boundary Recommendation, typically the most severe Missouri ozone episodes occurred with a strong, persistent Bermuda high pattern. The current analysis also points to a broadening of the weather patterns associated with exceedances of the new lowered 8-hour ozone standard.

TRAJECTORY ANALYSIS

Trajectory plots were created in order to understand air movement on a sub-regional scale. This understanding is important because it helps determine the main transport corridors where pollution sources can have downwind impacts and as a result cause elevated ozone concentrations.

Trajectory plots present an aerial view of the path an air parcel travels both horizontally and vertically before reaching its final destination. Ozone exceedances measured at a monitor location are directly influenced by transport of ozone precursors prior to the exceedance time and date; therefore, back trajectories were used to help identify the dominant precursor transport corridors.

The trajectory evaluation was conducted for every 8-hour ozone exceedance day at all monitors during 2003, 2004, 2005, 2006 and 2007 using the Hybrid Single-Particle Langrangian Integrated Trajectory (HYSPLIT) model. The model start time was at 00 Coordinated Universal Time (UTC) the day following the exceedance (either 6 pm or 7 pm local time on the day of the 8-hour average exceedance) and the air parcel was modeled to see the horizontal and vertical transport during the previous 24 hours. This start time captured the afternoon/morning hours of the exceedance date and the night from the day prior.

The HYSPLIT model allows the user to specify the type of meteorological dataset that will be used to compute the trajectory plots. For 2003, Eta Data Assimilation System (EDAS) data with a horizontal resolution of 80 km was used, and for 2004 - 2007 the newly available and higher-resolution 40 km horizontal resolution EDAS data was used. EDAS data covers the continental United States and contains three-hourly grids of wind, temperature, moisture, and surface characteristics; higher resolution data (the smallest available grid size) was chosen because the fine-scale details of flow patterns will be better depicted compared to a coarser grid. In all cases, the HYSPLIT model was used to analyze parcels beginning at the surface.

As stated previously, the trajectory plots included all exceedance days for each monitor. The trajectory was plotted starting at the monitor of interest and followed the meteorological conditions of the prescribed timeframe. After generating all of the trajectory plots, the outputs were formatted and then plotted in a Geographic Information System (GIS). In order to capture flow patterns, the plots were created by site and by the severity of the exceedances. In the St. Louis and Kansas City regions, the threshold for “high” exceedances were exceedances greater than or equal to 85 parts per billion and greater than or equal to 84 parts per billion respectively. The Farrar, Houston, and Bonne Terre monitor sites were set to the St. Louis threshold, while Linn County and El Dorado Springs were set to the Kansas City threshold. The threshold for the Springfield region included exceedances greater than or equal to 82 parts per billion. The upper thresholds included roughly 30%-35% of all monitor exceedances from each region, with the percentage of exceedances depending on which region was evaluated. The monitors broken down by threshold can be found in Table 11. Each site had the upper and lower exceedances plotted, with the upper limits on plotted over the lower limits. The upper limits are denoted in red and the lower limits in blue. These trajectory plots are Figures 8-47.

CONCLUSIONS

<u>St. Louis</u> – The wide array of monitor locations in the St. Louis region makes identifying a specific trajectory direction difficult; however, in many cases a southerly component was present. As the previous trajectory analysis revealed in 2003, the dominant pattern were exceedances at sites that were downwind of the metropolitan area. Even the Mark Twain monitor, located around 100 miles northwest of St. Louis, showed exceedance day transport when the monitor was downwind from the metropolitan area. A link to the meteorological regimes appears in the clockwise curvature noted in many trajectories; the clockwise flow around high pressure systems such as the dominant Bermuda High and transient Northern High is a strong signal that there are some recurring weather patterns on ozone exceedance days. The visual results from the trajectory analysis can be found as Figures 8 – 30.

Kansas City – Unlike St. Louis, the bulk of the trajectories for the Kansas City region revealed a strong southerly component. As in St. Louis, the trajectories indicated that monitors were generally located downwind of the metropolitan area. Important to note is that a strong transport signal seemed apparent from Southeast Kansas and Northeast Oklahoma. The visual results from the trajectory analysis can be found as Figures 31 – 40.

Springfield – The sparse monitor coverage and recorded exceedances made the trajectory analysis in the Springfield area difficult and resulted in few identifiable patterns. A slim majority of trajectories ending at the Hillcrest monitor originated west to south of the site, corresponding to the location of the primary metropolitan area. The visual results from the trajectory analysis can be found as Figures 41 and 42.

Southwest Region – In the case of El Dorado Springs, only one trajectory originated near Kansas City and only one trajectory passed near Springfield. The majority of El Dorado Springs trajectories came from the southwestern quadrant, suggesting far Southwest Missouri and Northeast Oklahoma as likely transport regions. Linn County trajectories also showed little transport near Kansas City or Springfield, instead suggesting transport from Southeast Kansas or Northeast Oklahoma. The visual results from the trajectory analysis can be found as Figures 43 and 44.

Southeast Region – The Farrar monitor, southeast of St. Louis, showed no exceedance day trajectories directly from the St. Louis area, but a small sample of the lower limit exceedance days showed transport from a northwestern quadrant. The majority originated from southern to eastern directions, suggesting areas from Southern Illinois toward Memphis are important transport corridors 24 hours before the Farrar monitor exceedances. The Houston trajectories show only a small fraction of paths travelling from the St. Louis area; the majority of 24 hour trajectories travelled from Southeast Missouri into Southern Illinois. The trajectories ending at Bonne Terre travel from widely distributed regions with only a signal toward the St. Louis region in the high exceedance cases (85 ppb or higher concentration). Source or transport regions of interest for Bonne Terre stretch from south-central Missouri to Southern Illinois. The trajectory analysis results can be found as Figures 45 – 47.

The trajectory analysis allows the major transport corridors and geographic areas of influence to stand out on days with high ozone concentrations. The results obtained from the trajectory analysis will allow the APCP to combine meteorological and geographic components of ozone formation and transport to better assess the various influences on ozone concentrations across the state.

WINDROSE EVALUATION

In order to have a full understanding of meteorological significance on events during the ozone season, a wind rose evaluation was conducted at the airports in Kansas City (KMCI), Springfield (KSGF) , and St. Louis (KSTL) using data from the NCDC for 2003, 2004, 2005, 2006, and 2007. It is important to note that the winds were broken up into sixteen 22.5 degree sectors. When creating these plots three questions were considered: what is the entire season for that region, during what months did the bulk of the events occur and what months had relatively few events? After these questions were answered for each region, wind rose plots were generated using these parameters as variables.

In the St. Louis region (including Farrar, Houston, and Bonne Terre due to lack of meteorological data), ozone exceedances occurred from April to September. The bulk of the exceedances occurred from June to September with relatively few exceedances in April and May. In the Kansas City region (including Linn County and El Dorado Springs due to lack of meteorological data), ozone exceedances occurred from April to September. As in St. Louis, the bulk of the exceedances occurred from June to September with relatively few exceedances in April and May. In order to be consistent with the St. Louis and Kansas City regions, April to September was considered to be the time of possible ozone exceedances for the season, even though no exceedances occurred during May or September. The bulk of the exceedances occurred from June-August with a few exceedances in April. A wind rose was developed for each of these scenarios using a 24-hour or diurnal period (12am-12am).

In St. Louis, the diurnal cases in both the June to September and the April to September periods had a wide variance in wind direction but in general a southerly component was dominant. The wind roses for the monitors in the St. Louis area can be found as Figures 48 and 49. In Kansas City, the signals were much different with dominant directions very apparent. The diurnal rose during the April to September and June to September periods showed strong southerly components with significant signals between the south and east sectors. The wind roses for the monitors in the Kansas City area can be found as Figures 50 and 51. In Springfield, the signals were also very clear. The diurnal period showed very strong signals from the south and south-southeast sectors. The wind roses for the monitors in the Springfield area can be found as Figures 52 and 53.

Evaluating these roses was helpful in determining what was “normal” over the large time scale evaluated for this analysis. In many cases it revealed where normal transport of pollutants such as ozone would come from. However, it is important to note that in the future, comparisons of the trajectory analysis and the regime analysis with the data from the wind rose evaluations could also be used to find significant microscale or synoptic scale meteorological anomalies that lead to some monitor exceedances. The results obtained from the regime analysis, in conjunction with the trajectory and windrose analysis, will allow the Department’s Air Pollution Control Program to combine meteorological and geographic components of ozone formation, concentration, and transportation to better assess the various influences on ozone concentrations across the state.

Table 13 SE MO Composite Regime Analysis

	Bonne Terre	Farrar	Houston	Regime	Bonne Terre	FARRAR EAST	FARRAR SOUTH	Comments
6/17/05	0.084	0.072	0.064	4	0.020			STL impact on BT
6/21/05	0.076	0.078	0.074	7				
6/22/05	0.085	0.085	0.074	7		0.011		Easterly impact on both
6/23/05	0.072	0.093	0.079	2			0.014	Mixed south impact on FAR
6/24/05	0.077	0.091	0.078	2			0.013	SSW impact on FAR
6/25/05	0.069	0.079	0.066	2			0.013	Mixed south impact on FAR
6/26/05	0.076	0.077	0.069	2			0.008	LV, some signal from S and E
6/30/05	0.062	0.062	0.076	3				LV, some NW influence (STL on HOU)
7/7/05	0.093	0.071	0.064	1	0.029			N, NE (STL impact on BT)
7/8/05	0.078	0.069	0.066	1	0.012			LV, mixed N (STL impact on BT - less pronounced)
7/10/05	0.078	0.076	0.071	1		0.005		East impact
7/16/05	0.079	0.056	0.058	2				LV, no strong wind signal
7/22/05	0.084	0.064	0.059	3	0.025			N winds (STL impact on BT)
7/31/05	0.076	0.072	0.068	1		0.004		LV, mixed E after 11:00
8/1/05	0.076	0.076	0.065	1		0.011		Early E, then S/E
9/10/05	0.072	0.076	0.070	1			0.006	SSE
9/11/05	0.070	0.080	0.071	2			0.009	SSE
6/9/06	0.078	0.080	0.073	3	0.005			W, N impact from STL on BT, impact from Ste. Gen on FAR
6/15/06	0.077	0.079	0.077	2				LV S/SE, high regional impact
6/16/06	0.076	0.085	0.076	2			0.009	SSE
6/30/06	0.078	0.083	0.072	3	0.006			W, N impact from STL on BT, impact from Ste. Gen on FAR
7/19/06	0.067	0.080	0.069	3			0.011	SSE
8/22/06	0.091	0.055	0.054	5	0.037			NE, N (STL impact on BT)
8/24/06	0.034	0.076	0.066	5		0.010		Null values at BT, E, NE
5/21/07	0.074	0.079	0.073	2			0.006	SSE
5/22/07	0.074	0.076	0.071	2			0.005	SSW
5/23/07	0.068	0.076	0.069	2			0.007	Mixed south impact on FAR
6/12/07	0.085	0.081	0.075	1		0.006		E, ESE
6/13/07	0.087	0.081	0.072	7		0.009		E
6/14/07	0.091	0.079	0.074	7		0.005		LV, mixed E
6/15/07	0.078	0.076	0.067	2		0.009		LV, E
6/16/07	0.080	0.078	0.078	7				LV, mixed E,S,W
6/17/07	0.085	0.087	0.077	7			0.010	S, SSW higher WS
7/25/07	0.091	0.076	0.070	2		0.006		LV, calm with mixed ESE
8/1/07	0.089	0.079	0.073	4		0.006		Calm, LV mixed E
8/2/07	0.079	0.074	0.079	2				CALM, LV
8/10/07	0.098	0.065	0.061	4	0.037			N, NNE (STL impact on BT)
8/12/07	0.073	0.076	0.081	2				mixed, late NNW (possible impact on HOU from STL)
8/13/07	0.086	0.068	0.064	3	0.022			N, NNE (STL impact on BT)
8/14/07	0.064	0.080	0.070	2			0.010	S, SSE
8/16/07	0.080	0.077	0.069	3				FROPA, no strong local signal
8/18/07	0.078	0.085	0.075	1			0.010	S, SSE
8/28/07	0.069	0.078	0.070	2		0.008		NE, E
9/2/07	0.074	0.082	0.074	1				no strong signal (maybe late E)
9/20/07	0.075	0.081	0.073	1			0.008	mixed SSE
9/21/07	0.081	0.093	0.082	2			0.011	SSW
9/22/07	0.072	0.080	0.074	3				calm, local impacts near monitor
Exceedences	32	36	10			12	16	
85+	11	7	0			0.0075	0.009375	
Farrar 85 S		6						
Farrar 85 E		1						
BT STL	10							
BT East	10							
Farrar S		16		9.3 ppb avg diff from HOU				
Farrar E		12		7.5 ppb avg diff from HOU				
Far NW		3						
Far Calms		1						
Far Other		4						

Figure 1: Regime #1 Example

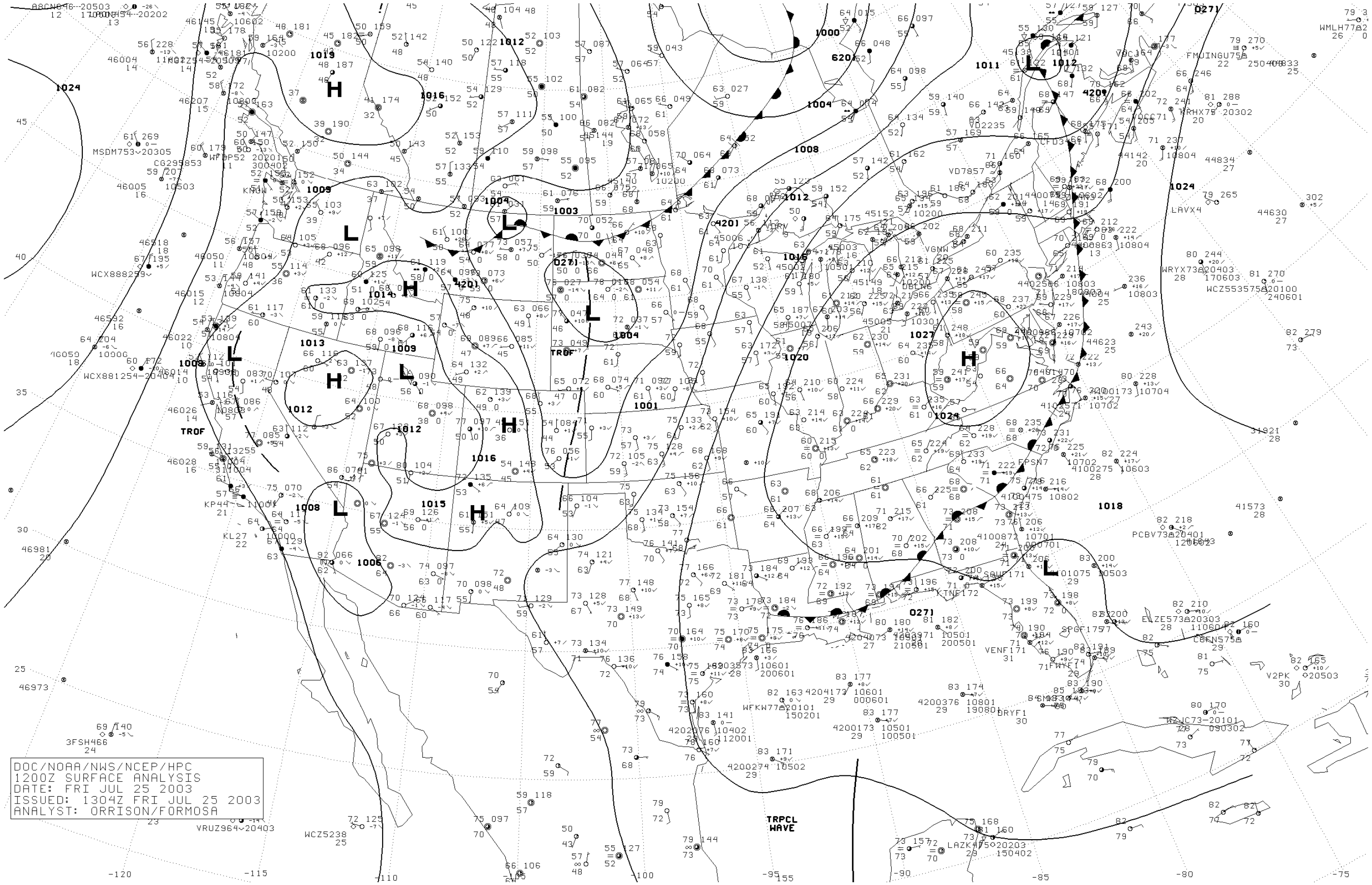


Figure 2: Regime #2 Example

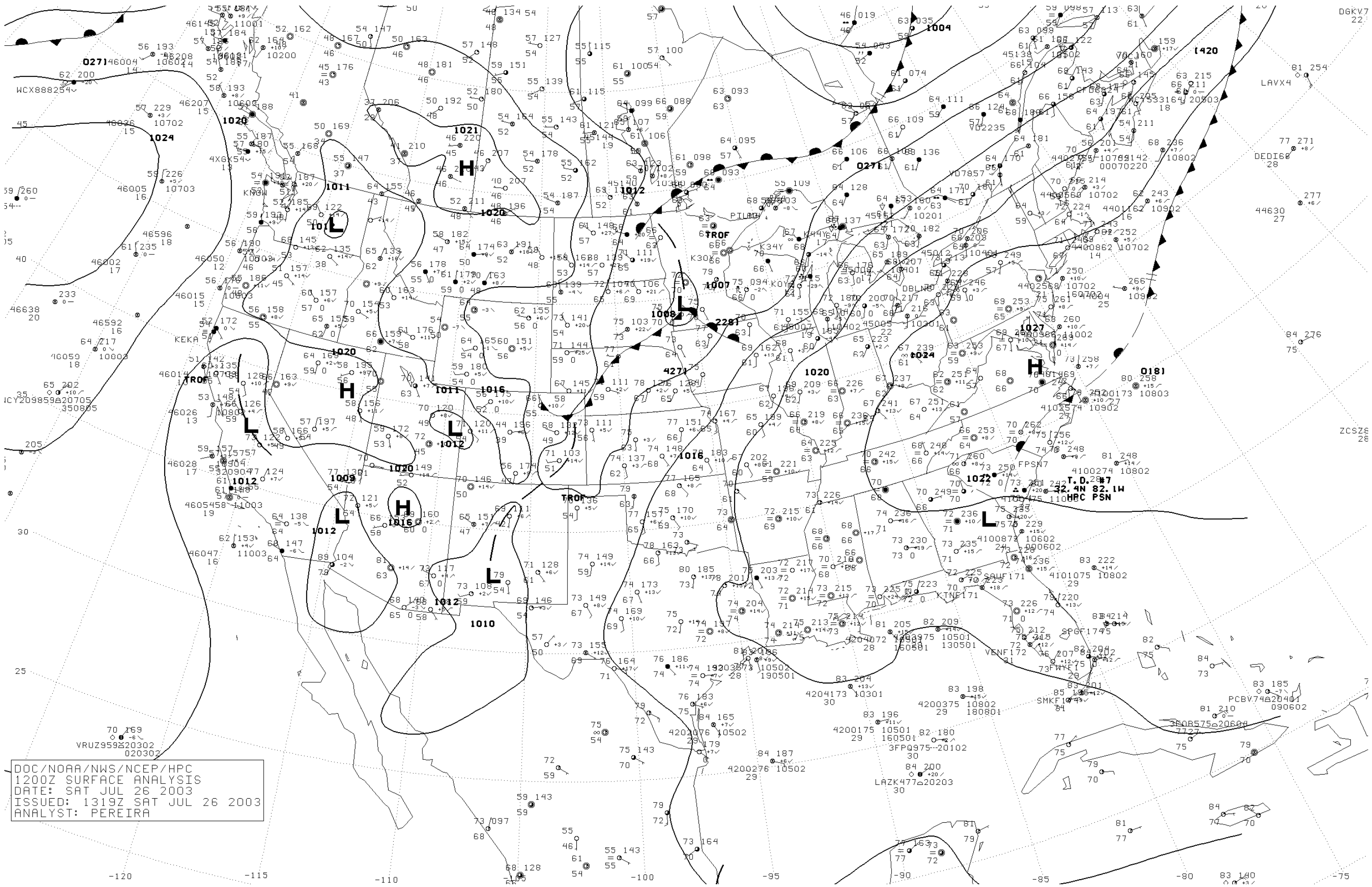
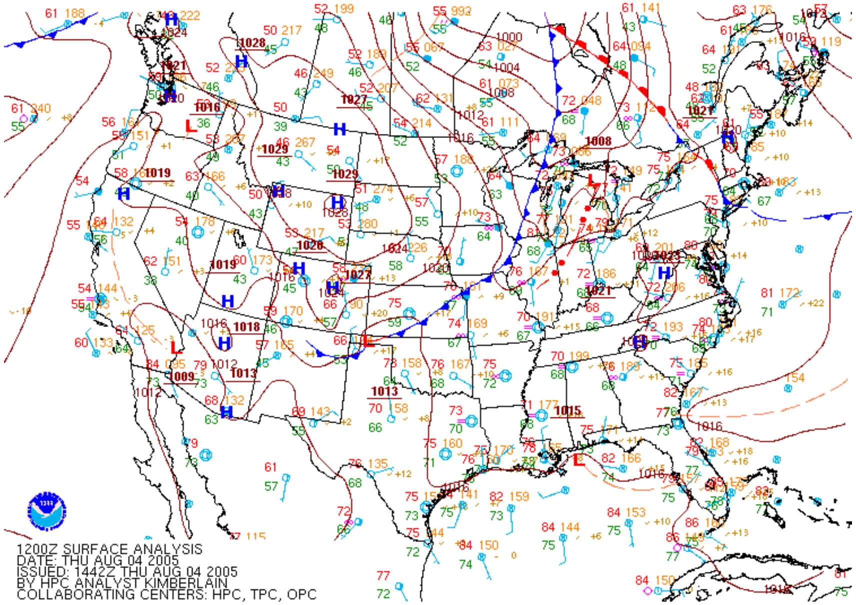


Figure 3: Regime #3 Example

7AM



4PM

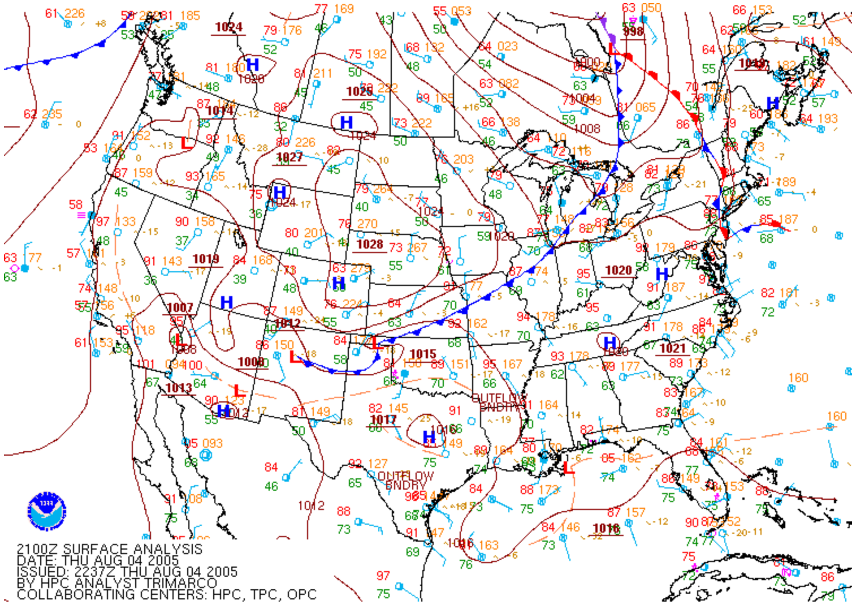


Figure 4: Regime #4 Example

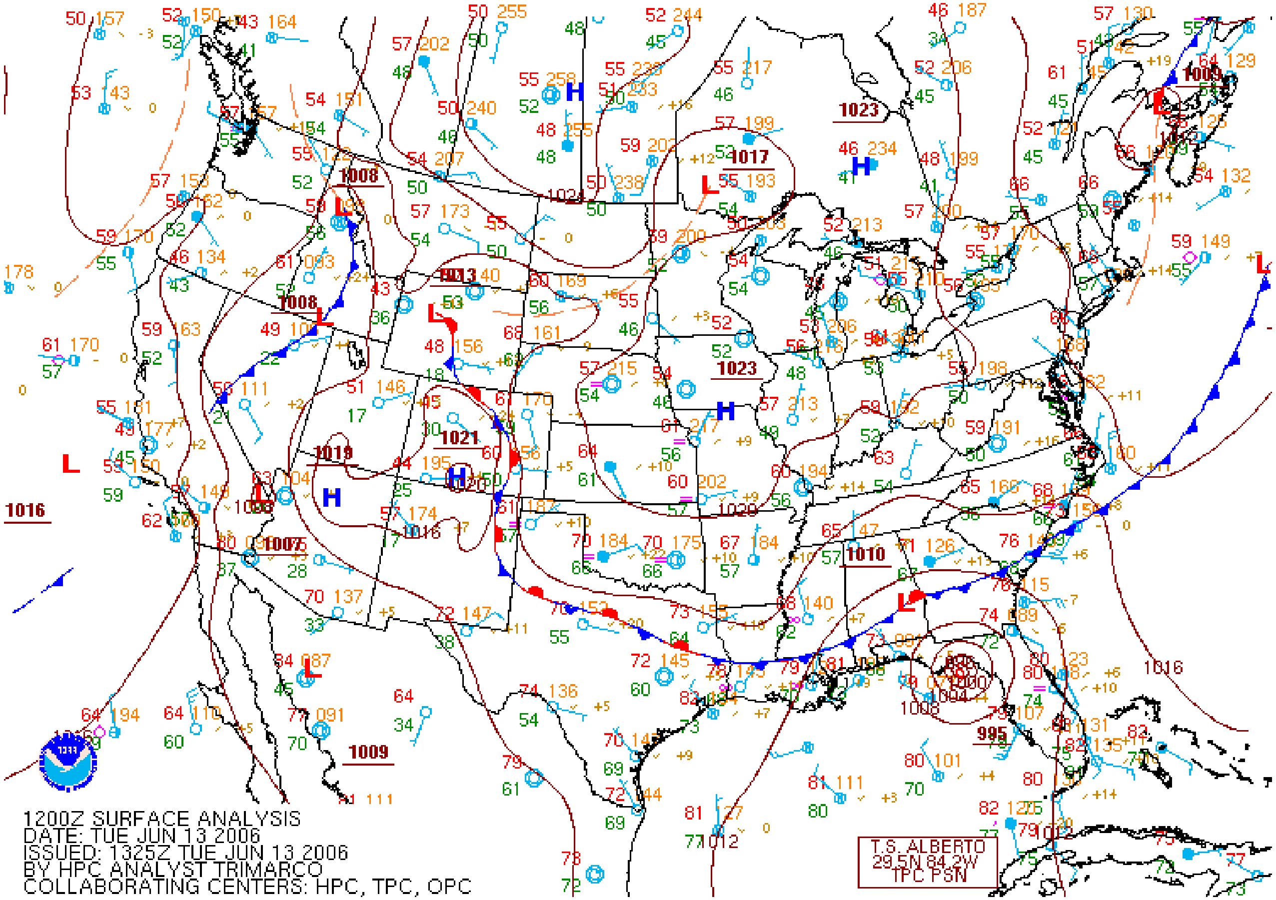


Figure 5: Regime #5 Example

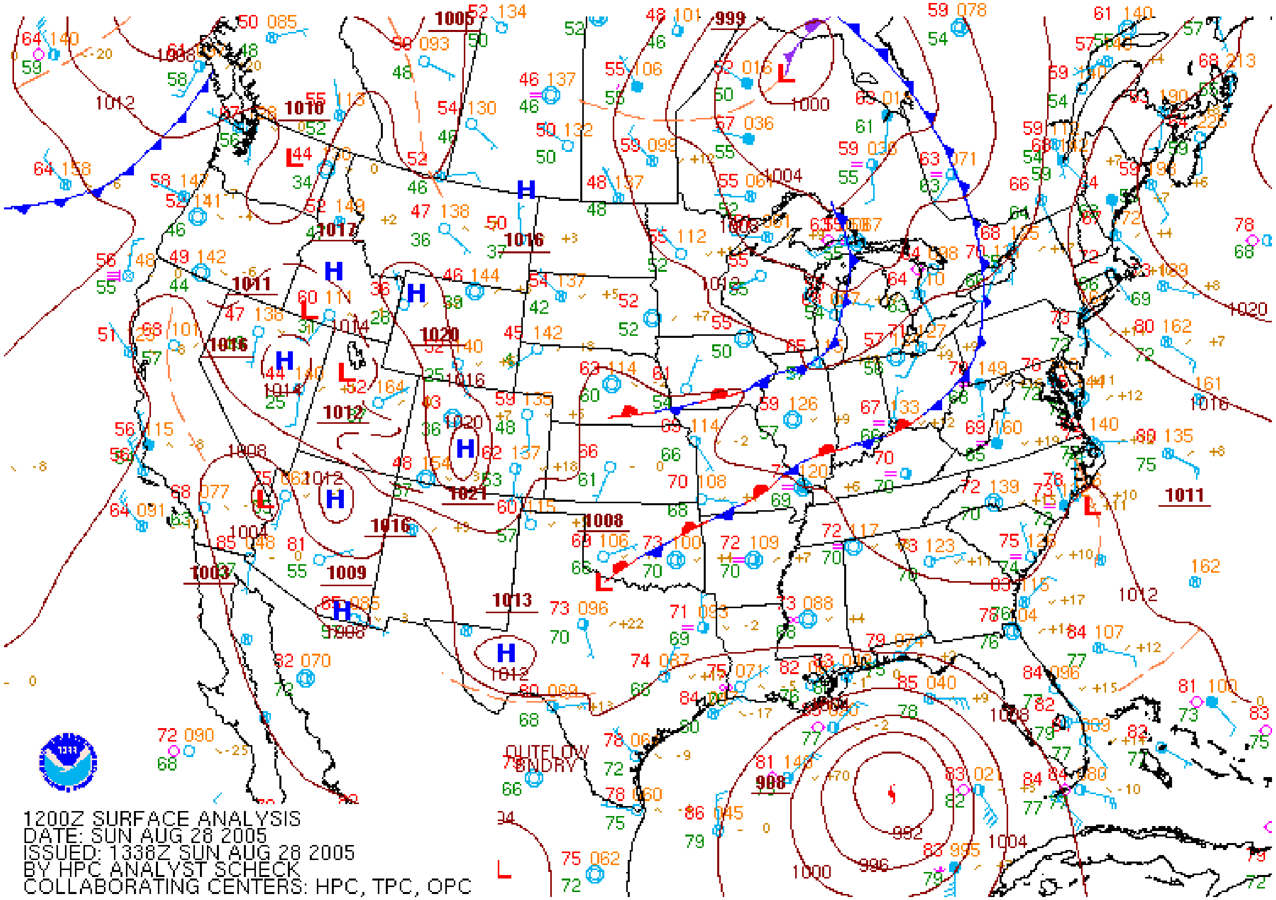


Figure 6: Regime #6 Example

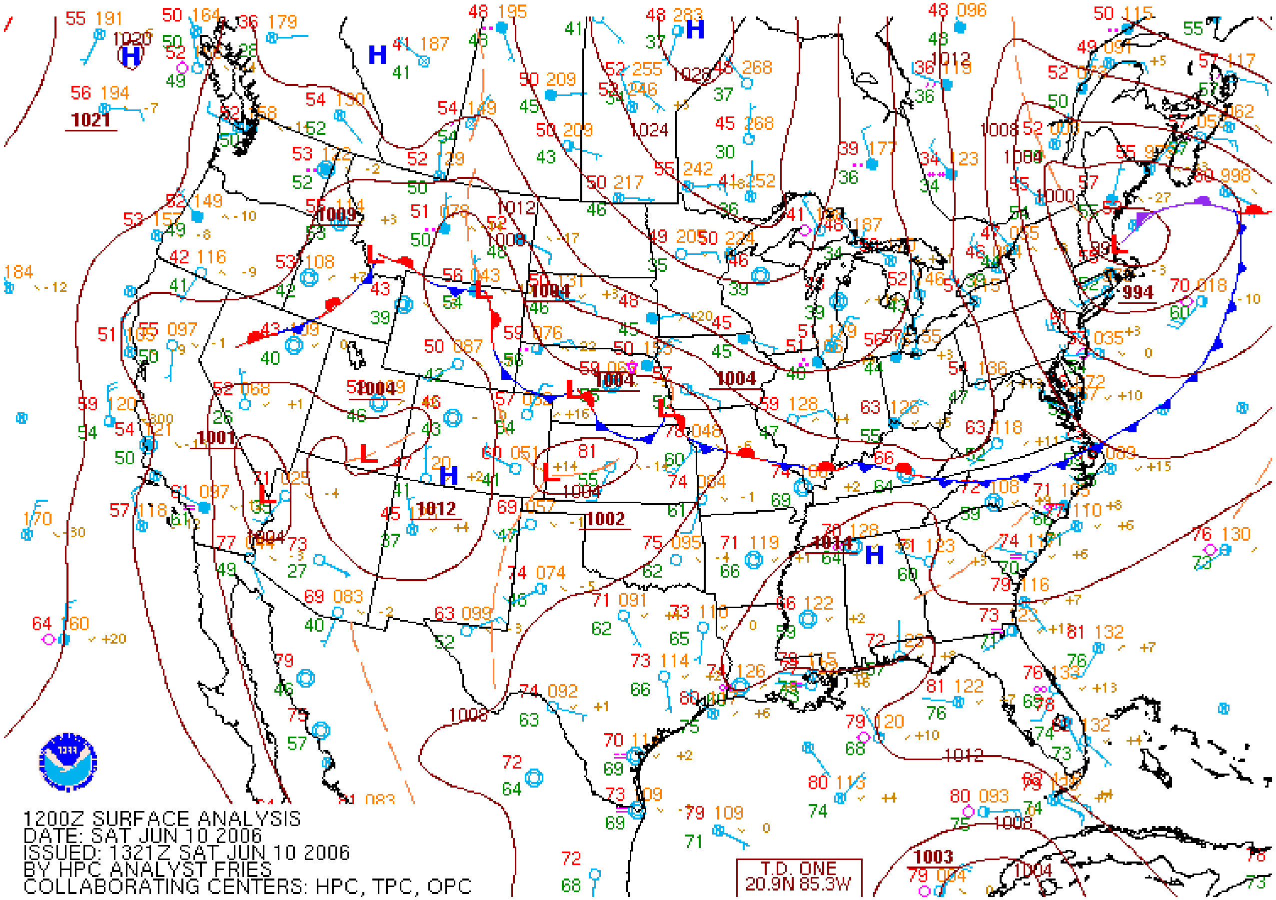


Figure 7: Regime #7 Example

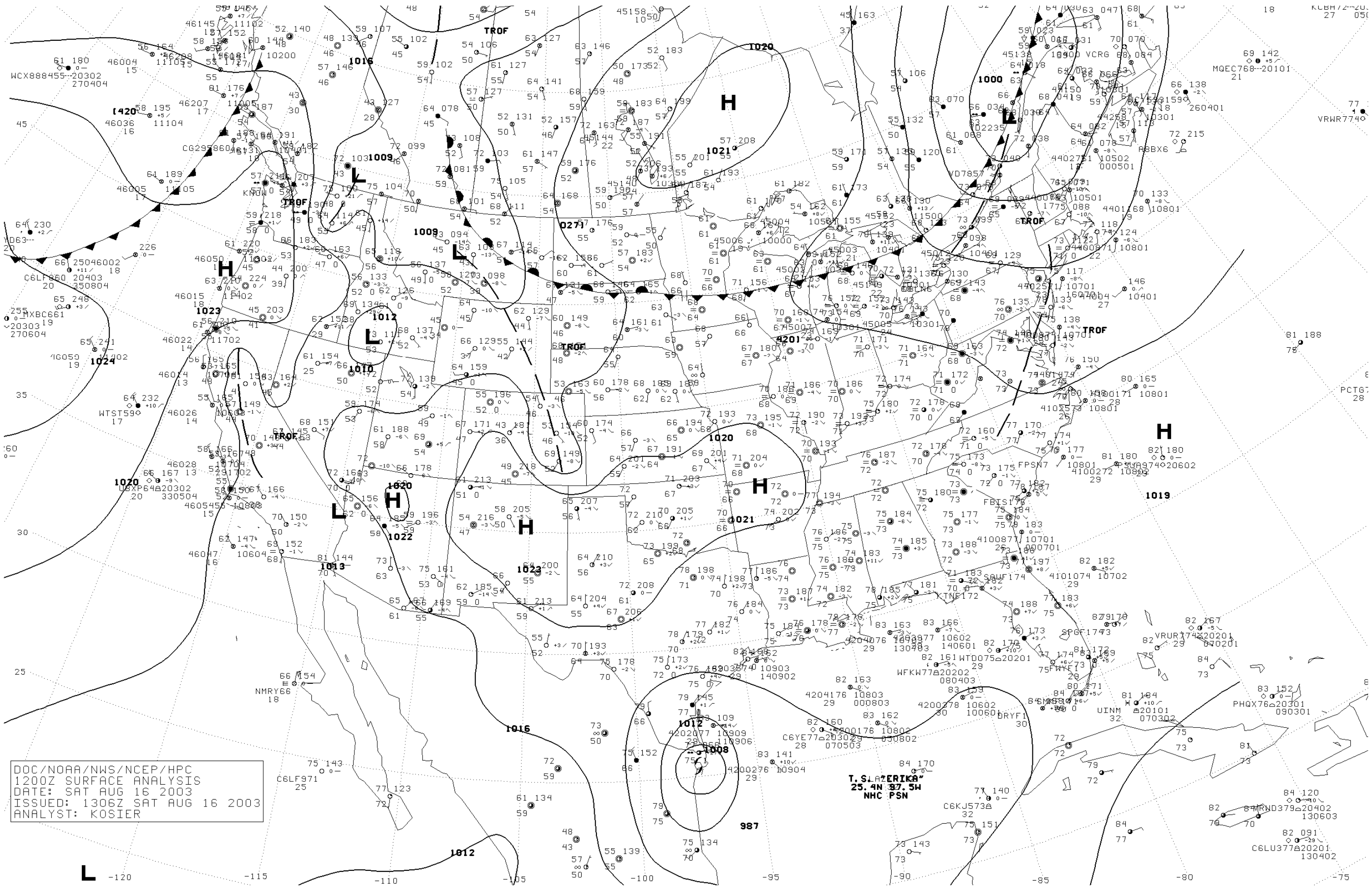


FIGURE 48
KSTL APRIL - SEPTEMBER (DIURNAL)

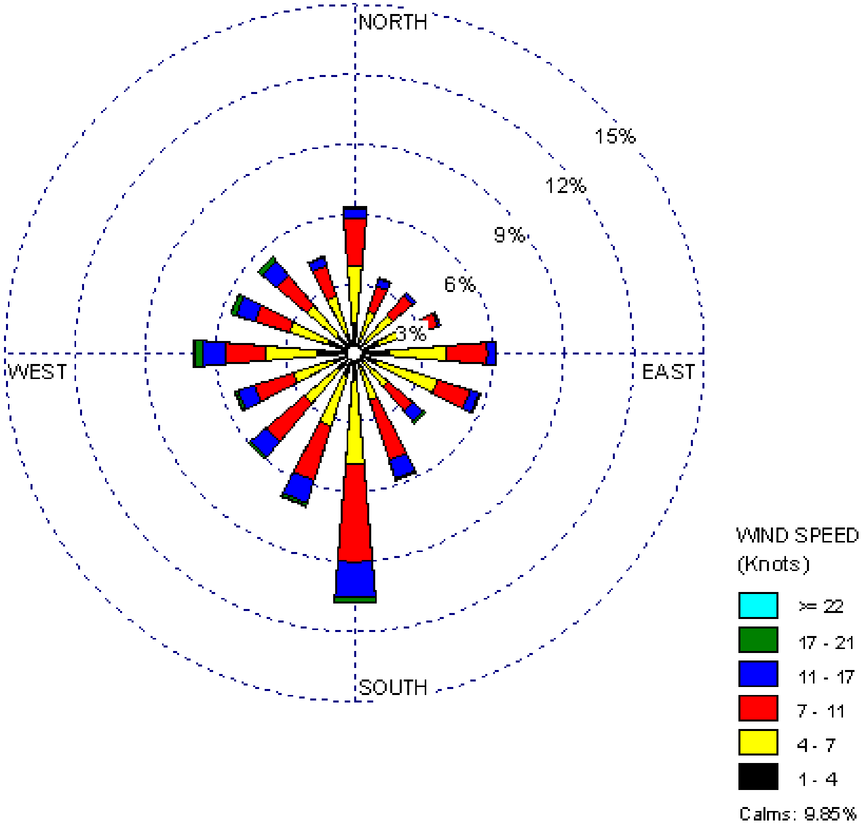


FIGURE 49
KSTL JUNE - SEPTEMBER (DIURNAL)

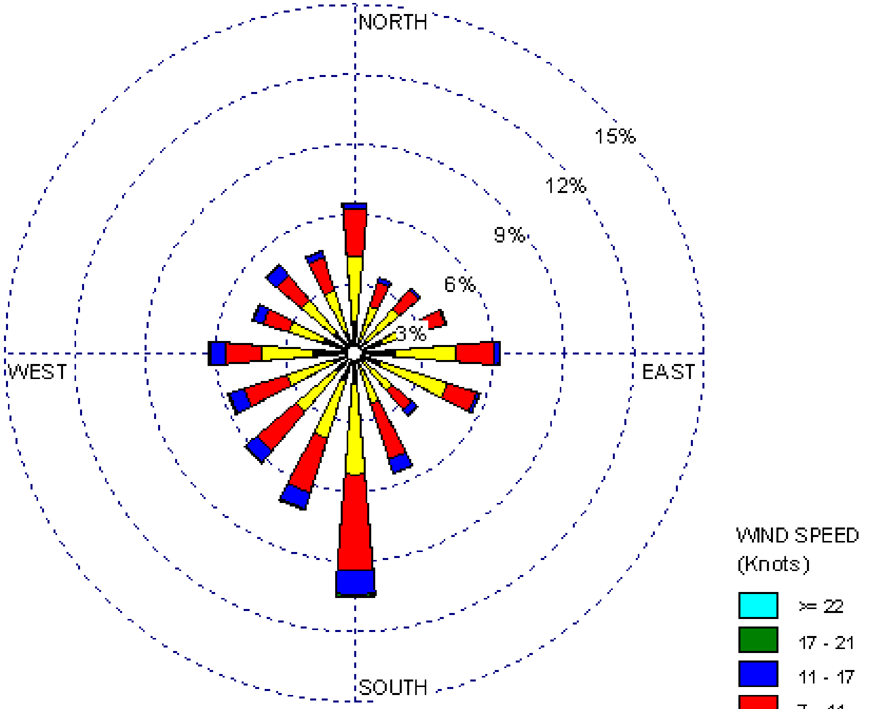


FIGURE 50
KMCI APRIL - SEPTEMBER (DIURNAL)

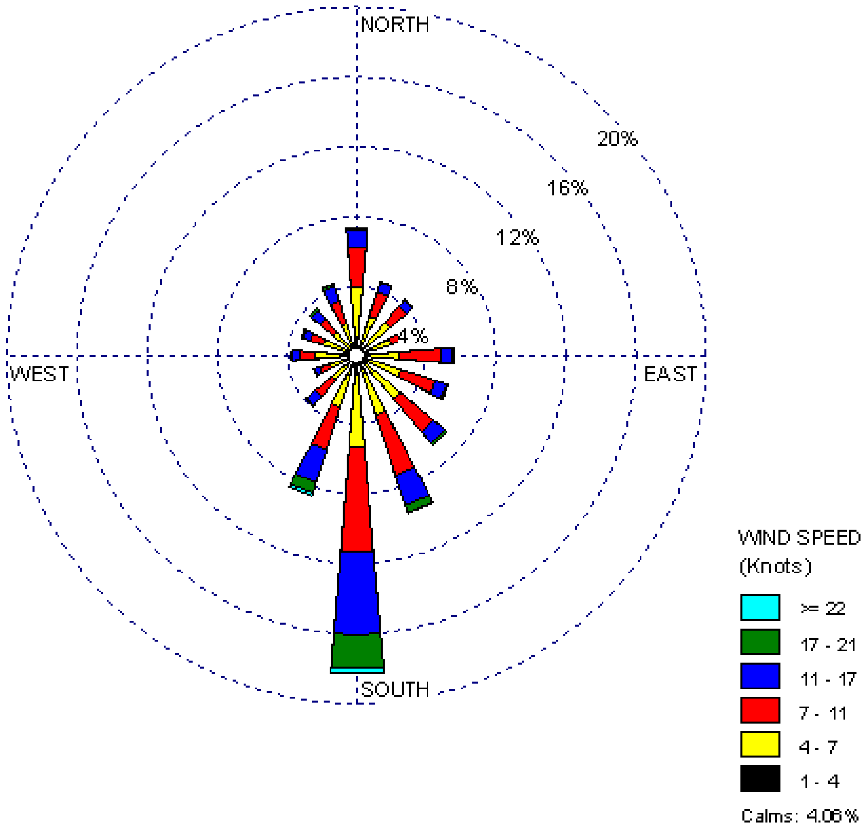


FIGURE 51
KMCI JUNE - SEPTEMBER (DIURNAL)

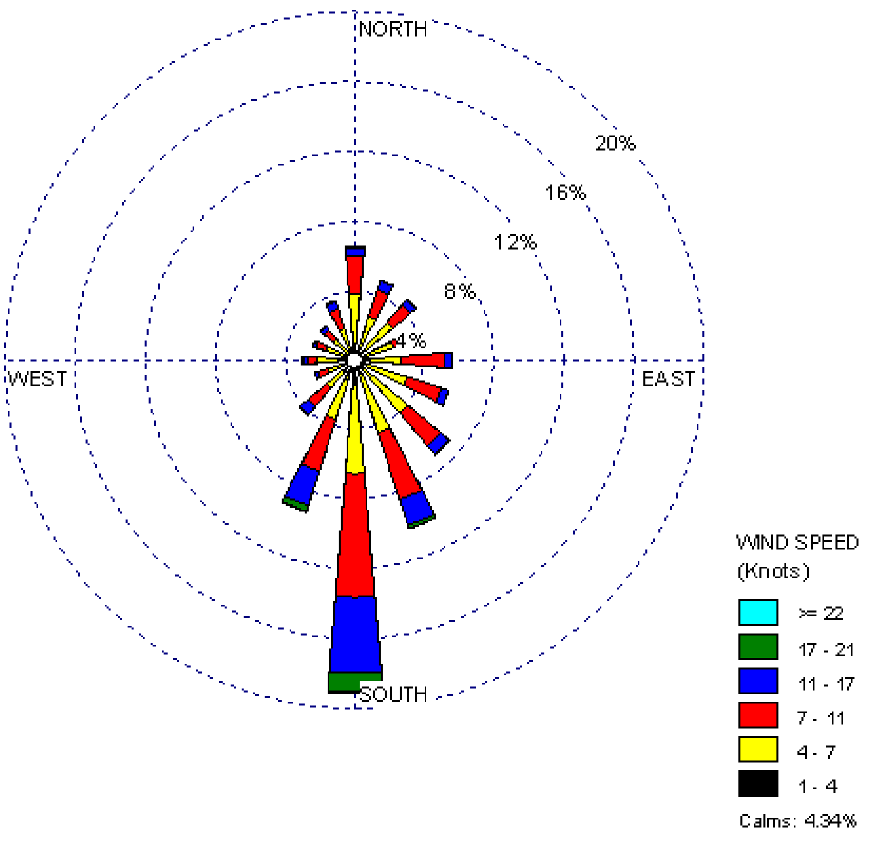


FIGURE 52
KSGF APRIL - SEPTEMBER (DIURNAL)

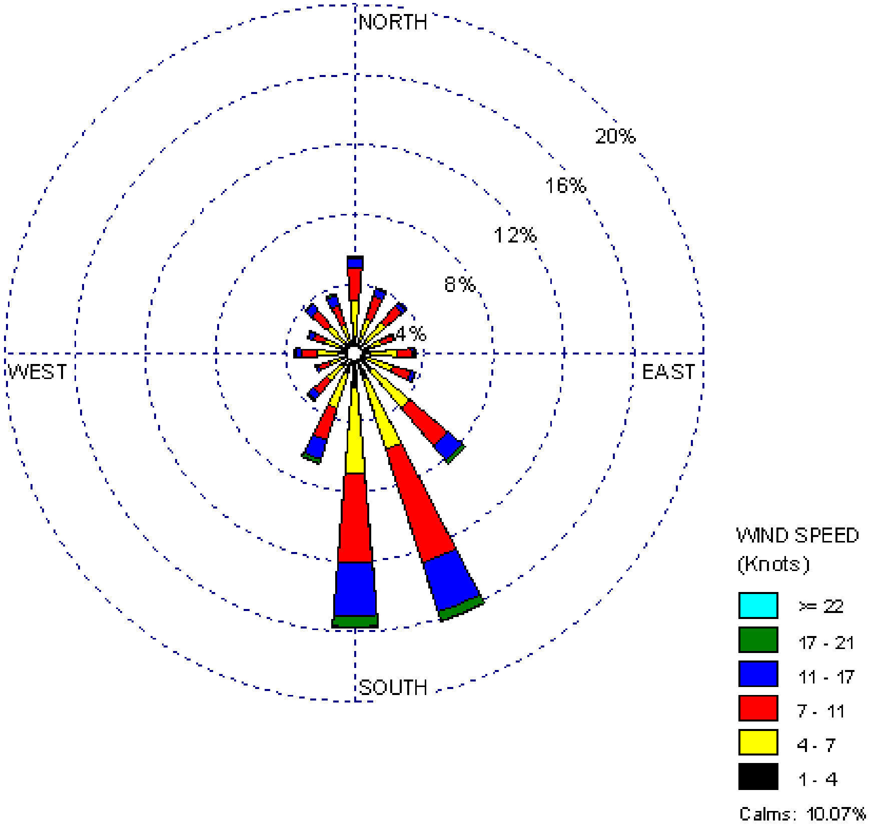


FIGURE 53
KSGF JUNE - AUGUST (DIURNAL)