3.3 METEOROLOGICAL DIFFERENCES BETWEEN NEAQS 2002 and ICARTT/NEAQS 2004

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1. INTRODUCTION

During the summers of 2002 and 2004, two New England Air Quality Study (NEAQS) campaigns were conducted. These were two of the largest air quality measurement and modeling efforts ever conducted in this region. During 2002, the study primarily focused on New England coastal and offshore areas from Bar Harbor down to Cape Cod, whereas in 2004 this region was extended to include the entire Gulf of Maine and adjacent coastal areas extending over to western Nova Scotia. The 2004 study was also part of the larger International Consortium for Atmospheric Research on Transport and Transformation (ICARTT) campaign, a major field campaign to study air pollution transport and its chemical transformation, to evaluate air quality forecast models, and to investigate direct and indirect cloud radiative effects over a much larger area.

However, this paper will focus primarily on the NEAQS 2002 study region and the meteorological patterns and conditions associated with elevated ozone episodes as measured along the New Hampshire seacoast areas for both campaigns. During July-August 2002, there were a significant number of days with elevated levels of ozone, but during this same period in 2004, there were remarkably fewer elevated pollution episodes in this area and throughout New England. This paper will present some preliminary findings on the meteorological differences that led to the contrasting air quality outcomes encountered during these two summers.

2. BACKGROUND

We used ozone data from two University of New Hampshire (UNH) air quality monitoring sites at Thompson Farm (TF) near Durham, NH, and the Isle of Shoals (IOS), an offshore site several kilometers away from Portsmouth, NH, to classify ozone pollution episodes.

If either site measured ozone levels at or above 100 ppbv at anytime on a given day, we classified that day as an elevated pollution day. From the NEAQS 2002 study, Angevine et al. (2004) reported that elevated ozone pollution episodes in New England tended to be more acute when associated with trajectories that first carried emissions offshore and then back onshore, rather than trajectories that brought source emissions over land into the region. Hence, coastal areas usually saw some of the highest ozone readings, providing our motivation for using the TF and IOS data for pollution episode classification.

Koermer et al. (2003) presented supporting evidence that 12-24-hour trajectory source regions were typically from S through SW regions (i.e. primarily had some over water components) and preceded most of the summer 2002 elevated ozone events.

Based on the TF and IOS data, there were 198 10-minute ozone readings spanning 11 days during the period of July-August 2002 that were at or above the 100 ppbv ozone level. During this same time frame in 2004, there were only 32 10-minute readings over 3 days that met the elevated criteria (see Table 1).

Date		2002			2004	
	Loc	No.	Max	Loc.	No.	Max
01Jul	IOS	7	104.6	TF	1	100.2
02Jul	IOS	17	127.8			
03Jul	IOS	5	108.2			
04Jul	IOS	12	105.2			
09Jul	IOS	2	100.9			
14Jul	IOS	2	102.4			
22Jul				TF	9	114.9
23Jul	IOS	24	124.8			
30Jul				IOS	22	115.2
04Aug	IOS	4	100.7			
12Aug	both	17	118.8			
13Aug	both	63	141.0			
14Aug	both	45	150.9			

Table 1. Dates, location (Loc.), number (No.) of 10-min. ozone readings at or above 100 ppbv, and maximum (Max.) reported ozone in ppbv units for July-August 2002 and 2004.

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It is interesting to note that high IOS readings were associated with every elevated episode in 2002, but only with the July 23 date in 2004. The TF readings were at or above 100 ppbv only during the major 2002 episode of 12-14 August. However, the first two events of 2004, were only noted from the TF readings and not those from IOS. Based on these data, we can easily conclude that the summer of 2002 was generally more polluted than that of 2004. There were also several consecutive day events during 2002 and only some scattered single day events in 2004.

3. METEOROLOGICAL CHARACTERISTICS

One of the most notable meteorological differences between the two campaigns was the overall cooler temperatures during 2004 versus those encountered during 2002. Figures 1 and 2 below depict the maximum temperatures measured at IOSN3 (Isle of Shoals) and KPSM (Portsmouth, NH, near TF), based on hourly temperature reports. Note that IOSN3 temperature data were not available during the period of July 1-8, 2002.

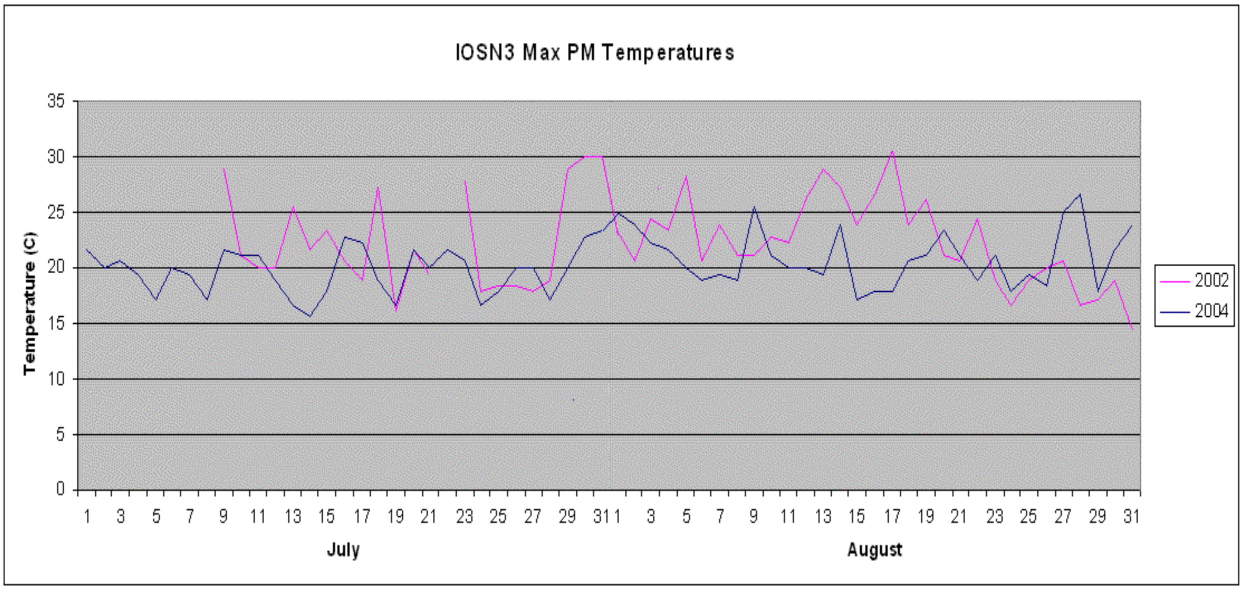
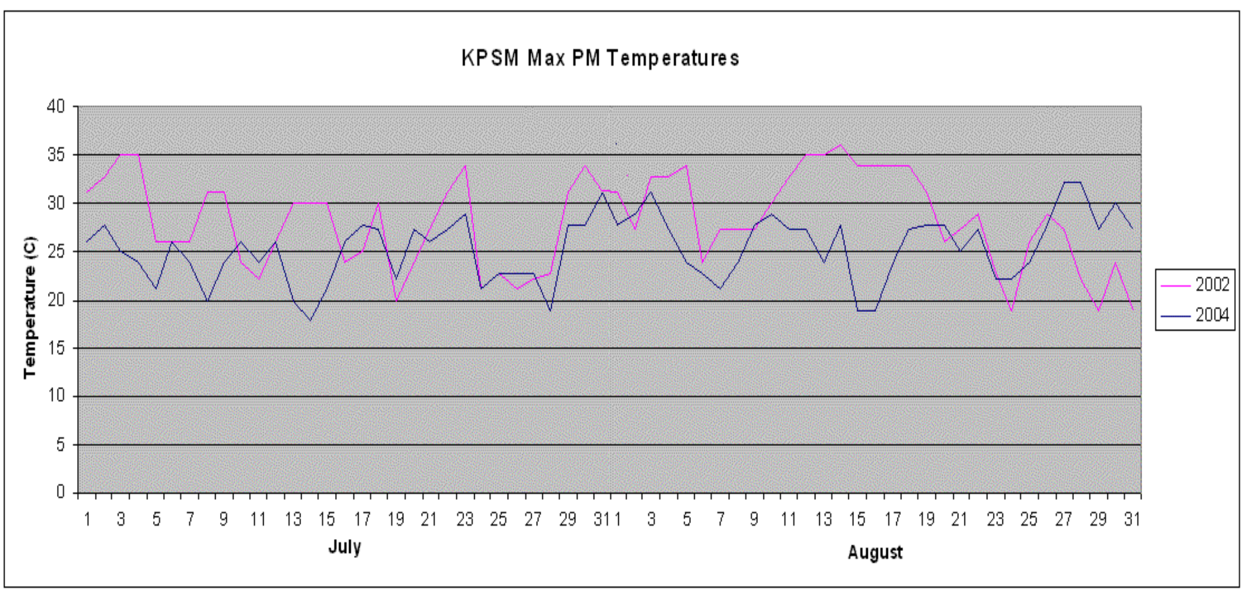


Figure 1. IOSN3 maximum temperature record for the July-August periods of 2002 and 2004.



Figures 2. KPSM maximum temperature record for the July-August periods of 2002 and 2004.

Although it is fairly easy to see from Figures 1 and 2 that 2002 was generally much warmer than 2004 at both locations, it helps to summarize this fact with the monthly means in Table 2.

	IOSN3 Jul	IOSN3 Aug	KPSM Jul	KPSM Aug
2002	23C	22C	27	29
2004	20C	21C	25	26

Table 2. Summary of average maximum temperatures in degrees Celsius for IOSN3 and KPSM over the two NEAQS periods.

Koermer et. al. (2003) noted that the elevated ozone episodes during NEAQS 2002 occurred on days with relatively high maximum surface temperatures, especially over land. Table 3 summarizes the individual daily maximum temperatures reported on the high ozone days during 2002 and 2004 for KPSM (Portsmouth, NH) near TF and for IOSN3 (Isle of Shoals) based on the hourly surface reports.

Date	2002		2004	
	IOSN3	KPSM	IOSN3.	KPSM
01Jul	N/A	31C	22C	26C
02Jul	N/A	33C		
03Jul	N/A	35C		
04Jul	N/A	35C		
09Jul	29C	30C		
14Jul	24C	30C		
22Jul			22C	27C
23Jul	28C	34C		
30Jul			23C	28C
04Aug	26C	33C		
12Aug	26C	35C		
13Aug	29C	35C		
14Aug	27C	36C		

Table 3. Maximum temperatures in degrees Celsius at KPSM and IOSN3 during the elevated ozone days during July-August of 2002 and 2004.

The NEAQS period of 2002 was not only warmer, but generally drier than in 2004. KPSM reported measurable precipitation on 16 days during July-August 2002, but during 2004, it had nearly twice that amount with 29 days. Indeed, many sites throughout coastal New England that reported below normal precipitation in 2002 had above normal readings in 2004. Most of this difference is probably due to the greater frequency of low level trajectories with easterly components.

Based on trajectory maps generated from the NOAA Air Resource Laboratory READY site (https://www.arl.noaa.gov/ready/hysplit4.html), we can see the increased easterly paths of air parcels affecting the New Hampshire coastal region. We generated maps of 12-24 hour backward trajectories from IOSN3 based on ETA model analyses for base times of 00, 06, 12, and 18 UTC. The results of analyzing the different maps are summarized in Figures 3 and 4.

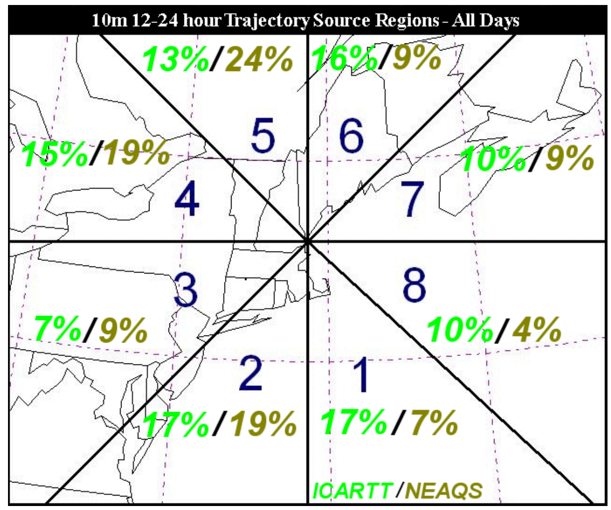


Figure 3. Octant diagram depicting summary of 12-24 hour backward trajectory locations for all days during July-August 2002 (denoted NEAQS in tan) and 2004 (denoted as ICARTT in green).

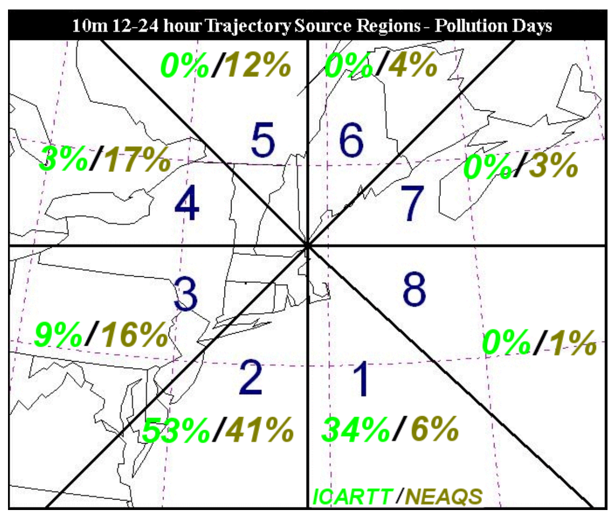


Figure 4. Same as Figure 3 except only for the elevated pollution days.

From Figure 3, there is clearly an increase during 2004 in the frequency of the flow from the east, especially the southeast (octants 1 and 8). This generally would equate to cooler and wetter conditions for the region. It is also interesting to note that overall the flow frequency from the usual pollution source regions (octants 2 and 3) is not that much different between the two years. However, clean northwesterly flow (octants 4 and 5) was more prevalent during the summer of 2002.

Looking at just the pollution day trajectories, the primary octant for both years is number 2. During 2004, octant 1 played a more significant role on the few cases of elevated ozone. This octant usually comes into play, when a pollution plume comes off the New York City metropolitan area and heads east-northeastward south of Cape Cod and then wraps back towards the New Hampshire and southern Maine seacoast areas. During the intensive measurement period of 2004, the July 22 case clearly demonstrated this concept, when research aircraft started measuring a large pollution plume on July 20 that gradually moved over Long Island and south of Cape Cod by July 21, then back towards the northwest on July 22.

Koermer et al. (2003) had also identified some common pressure patterns and wind distributions associated with elevated pollution events during NEAQS 2002. This can be illustrated by examining Figure 5 for the 12 August 2002 episode.

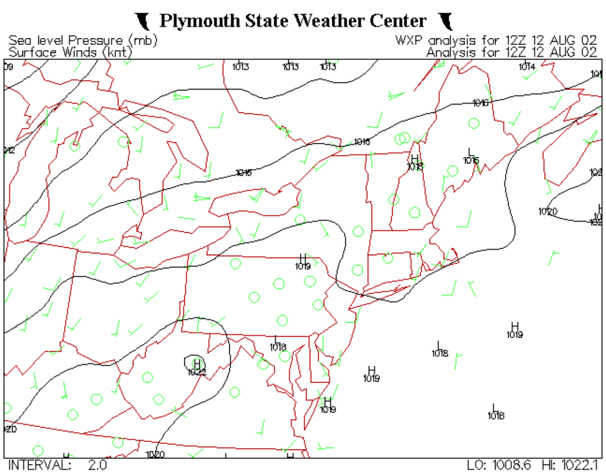


Figure 5. Isobaric analysis for 12 UTC on 12 October 2002 with a contour interval of 2 kPa and the plot of surface wind barbs. Note that circles indicate a report of calm winds.

Figure 5 shows a very weak pressure gradient over New England with weak ridging along the Appalachians and weak southwesterly flow just offshore. Similar 12 UTC features were present in nearly every 2002 elevated ozone event.

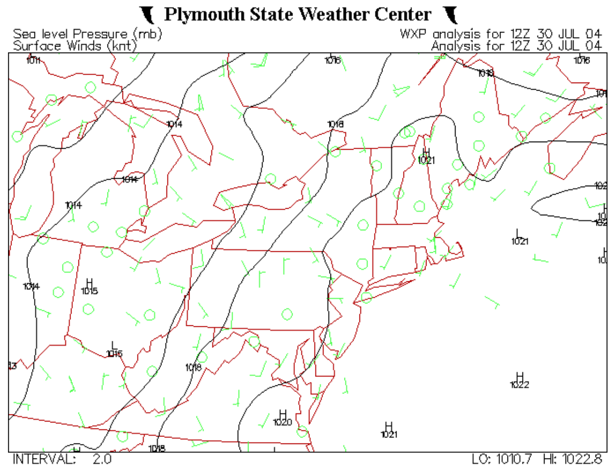


Figure 6. Same as Figure 5 except for 30 July 2004.

Figure 6 is the same analysis except for the 30 July 2004 episode. It also depicts a very weak pressure gradient over New England and weaker offshore southwesterly flow. In this case, there is still a very weak ridge over the Appalachians, but generally confined to New England.

The weak ridging and calm winds probably help to cause some slight subsidence and help to reduce mixing. This may maintain existing pollutants and/or may allow additional pollutants to build up in these regions of New England.

Cold fronts were often slowly approaching from the west during pollution regimes, but the summer ozone episodes nearly always ended, when the cold front finally moved into the region from the northwest and brought in cleaner air.

4. CONCLUSIONS

Although there were some similarities between the weather conditions encountered during the actual pollution days of NEAQS 2002 and NEAQS 2004, there were significant enough differences between the years that led to many fewer elevated ozone events during 2004. The similarities lay in the precursor conditions of weak pressure gradient, weak ridging, and weak southwesterly offshore flow. Short-term trajectories from the south-southwest also were also quite common.

However, cooler temperatures and greater precipitation frequency in 2004 led to less favorable conditions for ozone production. The differences in overall air trajectories help to explain these conditions. An airmass change, ushered in by a cold front usually ended these elevated ozone episodes.

5. ACKNOWLEGEMENTS

The UNH NOAA-funded AIRMAP program, the NASA Space Grant program, and Plymouth State University all provided support for this research. The statements, findings, conclusions and recommendations are those of the authors and do not necessarily reflect the views of NASA, NOAA or the Department of Commerce.

6. REFERENCES

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