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Evaluating NO_x/NO_y Ratio as a Method for Determining Distant Vs. Local Sources of Pollution in New England.

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Figure 1: Thompson Farm site location

Background: 1

The complexity of New England's weather and air quality rivals any location in the United States. The terrain varies from sea level to the high peak of Mt. Washington (1917 meters). The varying elevation combined with complex terrain and fluctuating route of air masses entering the region dramatically effect the climate. Air masses flow up the eastern seaboard, from the Mid West, from the Atlantic Ocean and from the Canadian Plateau. These factors subsequently complicate our understanding of air pollution in the area.

It is becoming increasingly more evident that persistent air pollutants (ozone and fine particles) are inherently a regional problem requiring a regional approach. Understanding regional air pollution events (primarily ozone and smog) is complicated due to a series of chemical reactions that occur to form ozone. Anthropogenic emissions from both inside and outside the region can cause elevated levels of ozone and smog. The rise in these levels are directly responsible for reduced visibility, increased respiratory ailments and elevated acid rain (Brassur et. al., 1999).

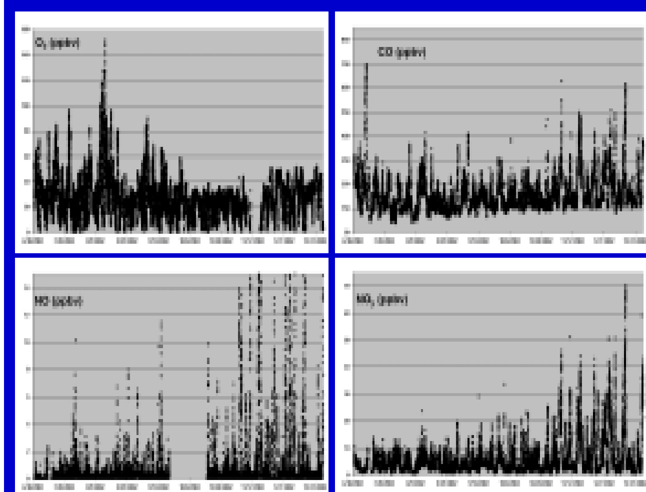
Developing a detailed understanding of the processes contributing to these pollution events will benefit policy makers and the public directly. Understanding the influence of regional emissions and transport vs. local emissions and transport will guide more effective management strategies while contributing to a better understanding of the process which control the distribution and formation of air pollution in our region.

Overview: 2

The NO_x/NO_y ratios have been used in past studies to determine relative ages of air masses (Chin, M. et. al., 1994). Here we evaluate the use of this ratio with data collected at a air quality monitoring site (Figure 1.) operated by the Atmospheric Investigation, Regional Modeling, Analysis and Prediction (AIRMAP) program as a method for determining distant versus local sources of pollution at Thompson Farm. The site is located in a rural New Hampshire setting in the town of Durham and pictured in Figure 2. The gas phase species O_3, CO, NO, NO_y were used to identify pollution events over a six-month period from July 2002 through December 2002. A total of 46 individual events were identified which lasted longer than 30 minuets at or above the 95 percentile level of the selected species. The 95 percentile level of CO, O_3, NO and NO_y for each species was 346 ppbv, 65 ppbv, 5.46 ppbv and 19.0 ppbv respectively. Backward trajectories were calculated for each event and the dominate source region (local or distant) was determined. The trajectory analysis and selected volatile organic compounds (VOC's) were used to verify source regions calculated by the NO_x/NO_y ratio. The frequency of local and distant sources for the pollution events was quantified and their monthly variability assessed.

Data: 3

5 Minute averaged results from AIRMAP's Thompson Farm Air Quality Station.



Results: 4

Event Identification Results (Table 1)

Events lasting 30 min. or more above the 95 percentile level by species investigated.

Species	Total # of Events	95% level (ppbv)
CO	28	347.00
O_3	18	65.00
NO	24	5.46
NO_y	23	19.02

46 Individual Events were identified for the 6 month period of July 1 through Dec. 31, 2002

Ratio Classification Results (Table 2)

Of the 46 identified events 24 were classified using the NO_x/NO_y and CO/NO_x ratios. NO_x calculations for the remaining events were not possible due to missing JNO_2 data (Night time or cloudy days).

Number of events primarily as a result of:	Local Sources	Distant Sources
➢ Classification using CO/NO_x ratio	15	9
➢ Classification using NO_x/NO_y ratio	15	9

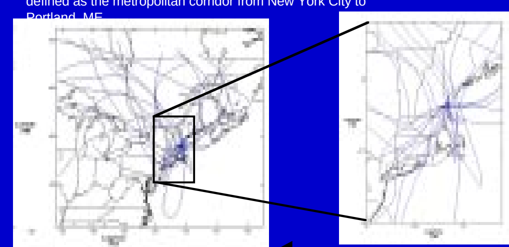
CO/NO_x ratios < 60 ➔ local sources while ratio >453 ➔ distant sources

NO_x/NO_y ratios > 64% ➔ local sources while ratio < 11% ➔ distant sources

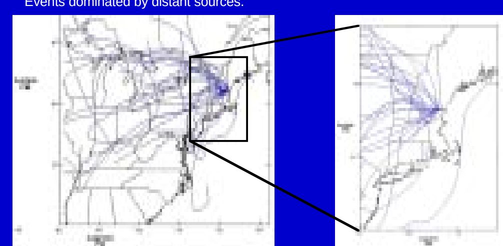
Time weighted average: Short Range ➔ 70% Long Range ➔ 30%

Trajectory Analysis: 5

Events dominated by local sources. Local sources were defined as the metropolitan corridor from New York City to Portland, ME.



Events dominated by distant sources.



Backward Trajectories were produced using NOAA's Air Resources Laboratory (ARL) HYSPLIT transport and dispersion model from the READY website (http://www.arl.noaa.gov/ready.html). The model was run using the vertical velocity method with the EDAS data set and starting at 300 meters.

Figure 2: Thompson Farm in Durham, NH

Summary: 6

Trajectory Summary (Table 3)

46 Events were classified using trajectory analysis which identified event source regions as:

Local source region events	22
Distant source regions events	20
Mixed (local & distant) source events	4

Ratio vs. Trajectory Summary (Table 4)

A comparison of Trajectory analysis with the NO_x/NO_y ratios for each event resulted in:

Matches	18
Misses	2
Mixed trajectory	4

Monthly Variability Summary (Table 5)

Number of events per month Identified by method type:	Local source Ratio	Local source Trajectory	Distant source Ratio	Distant source Trajectory
July	2	6	1	5
August	1	2	5	7
September	3	3	3	4
October	2	3		1
November	5	5		2
December	2	3		1

Concluding Remarks: 7

- 4 Events of the 46 identified exceeded EPA Pollutant Criteria guidelines (All 4 events exceeded the O_3 8 hour EPA standard). Of these 4 events both methods indicated that 1 was primarily a result of local emission sources while 3 were primarily a result of distant emission sources.
- The evaluation of the NO_x/NO_y ratio vs. backward trajectory analysis of event source regions resulted in a 90% agreement. Analysis of the NO_x/NO_y ratio indicated that 70% of the pollution events identified were primarily a result of local emission sources and 30% primarily a result of distant emission sources.
- Results from the monthly analysis of the ratios indicated a significant prevalence of local emission sources from October through December, which could be attributed to the decrease in the conversion rate of NO_x to HNO_3 and thus a larger NO_x to NO_y ratio for the cooler months. Trajectory analysis confirmed this variability, which would indicate that the prevalence of local emission sources from October through December are not solely a result of the decreased NO_x to HNO_3 conversion rate but probably a result of a shift in the dominate air mass source regions.

References:

Brassur, P. G. et. al., Atmospheric Chemistry and Global Change, Oxford Univ. Press, New York, 1999.

Chin, M. et. al., Relationship of ozone and carbon monoxide over North America, J. Geophys. Res. 99, 14,565 , 1994.

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