J5.8

OZONE TRENDS AND CHARACTERISTICS OF OZONE EPISODES IN CORPUS CHRISTI, TEXAS

Sunil Kumar and Kuruvilla John *
Texas A&M University-Kingsville, Kingsville, Texas

1. INTRODUCTION

Tropospheric ozone is one of the most widespread air pollution problems currently affecting major urban areas across the United States. It is formed by a series of photochemical reactions involving its precursors namely, oxides of nitrogen (NOx) and volatile organic compounds (VOCs) under favorable meteorological conditions. Even at very low levels, ozone can cause a variety of respiratory problems, coughing, nasal discharge, headache, dizziness, and sore throat. It can also increase asthma and allergy problems and susceptibility to lung infections.

Corpus Christi is a semi-arid coastal city located in south Texas. Although Corpus Christi is still in attainment of the 1-hour National Ambient Air Quality Standard (NAAQS) for ozone prescribed by the United States Environment Protection Agency (US EPA), it is very close to the new 8-hour ozone standard recently prescribed by the agency. Therefore, it has been termed as a near nonattainment area. Both the 1-hour and 8-hour average ozone levels have been varying in this city over the years. This study discusses in detail the trends in ozone levels and characteristics of high ozone episodes in this city so that characteristic meteorological features and pollutant source regions associated with high ozone levels could be identified and suitable actions could be taken to mitigate the high ozone levels here.

2. DATA ANALYSIS

One-hour average data on ozone concentration, temperature, wind direction, and wind speed from two monitoring stations namely, CAMS 04 & CAMS 21 located in Corpus Christi were obtained from the Texas Natural Resource Conservation Commission (TNRCC). 1-hour average values of these parameters for Houston, San Antonio, Austin, and Victoria were also obtained from the TNRCC in order to undertake spatial analysis. All these data were extracted for the period between 1986-2000. Time-series analysis techniques were employed to analyze the ozone data for Corpus Christi to decipher the inter-annual trend in maximum 1-hour average and 3-year average of the 4^{th} highest 8-hour average ozone concentrations at the two monitoring stations. For undertaking analysis related to high ozone days, these days were identified and their corresponding data on ozone concentration, wind direction, wind speed, and temperature were extracted from the main data set.

* *Corresponding author address*: Kuruvilla John, Department of Environmental Engineering, Texas A&M University – Kingsville, Kingsville, TX 78363, phone: (361) 593-2096, email: K-John@tamuk.edu

The criteria of selection of high ozone days were when the 1-hour or 8-hour ozone concentrations exceeded 100 or 75 ppb, respectively. The EPA prescribed NAAQSs for ozone are 125 ppb (1-hour average) and 85 ppb (3-year average of the 4^{th} highest 8-hour average ozone concentration).

Selected high ozone days in Corpus Christi were examined to identify the specific months in which they occur. Percentages of occurrence of high ozone days on weekdays versus weekends were also computed to examine the pattern. Wind directions and wind speeds related to both high and low ozone days were studied to observe their characteristics during these two different types of days. Windroses were drawn and studied for this purpose. Windroses for morning and afternoon winds for both high and low ozone days were generated for CAMS04 and CAMS21 for the period between 1995-2000. In this study, a software program called "WRPLOT View" was employed to generate windroses for Corpus Christi. Details of this program may be found in the operation manual (Lakes Environmental, 2000).

Sources located long distance can also contribute to the Corpus Christi ozone levels through long-range transport and this can be studied with the help of backward trajectories. These trajectories can effectively integrate winds in the transport layer over the time, distance, and source regions involved. Though trajectories have limitations in depicting air parcel transportation accurately, they can be used as a diagnostic tool to evaluate the flow field at various levels of the atmosphere (NOAA, 2002a). In this study, the HYSPLIT4 model developed by the National Oceanic and Atmospheric Administration (NOAA) was applied to generate backward trajectories of air parcels affecting the study region (NOAA, 2002b). HYSPLIT4 was employed to generate 32-hour back trajectories. Wind field data was extracted from the Nested Grid Model (NGM) dataset for 1993-1997 and then from Eta Data Assimilation System (EDAS) dataset for 1998-2000. These trajectories denoted air parcels coming from different locations and arriving at Corpus Christi. The model starting height was set at 500 m, which is approximately in the middle of the mixed layer. Model start times were selected when the highest ozone concentrations were recorded in the city. Back trajectories were drawn for 64 high ozone days. These trajectories were then used for studying ozone transport patterns.

3. RESULTS AND DISCUSSION

It was found that there were exceedances of the 1-hour NAAQS at CAMS04 during 1990 and 1994 and at

CAMS21 during 1987, 1993, and 1995. Overall reductions in the 1-hour ozone levels were observed since 1995. Exceedances of the 8-hour NAAQS (proposed in March 1997) were observed at CAMS21 during 1988 and 1989, but no exceedances were observed at CAMS04 during the study period. An increasing trend was observed during 1988 to 1995 at CAMS04, while a decreasing trend was found during 1989 to 1994 at CAMS21. However, after 1998 an increasing trend is visible even here. Overall it appears that while the 1-hour ozone level is decreasing, 8-hour level is on the rise, though both the sites remained well below the NAAQS during the study period.

Higher frequency of ozone exceedances was noticed during May through June and September through October with the highest levels usually occurring in September. Roughly 77% of high ozone days occured on weekdays compared to about 23% during weekends.

Predominant wind directions are north and northeast during the morning hours and east during the afternoon hours on high ozone days compared to south-southeasterly wind on low ozone days (Figure 1). Back-trajectory analysis using the HYSPLIT4 model revealed that during high ozone days in Corpus Christi, the air parcels came from places located far-off between north and east suggesting possible long-range transport from those areas (Fig. 2). Another analysis also found that when high ozone levels usually persisted for a few days in Houston, other areas including Corpus Christi also experience one or two days of high ozone concentrations indicating that ozone might probably be getting transported to Corpus Christi from the Houston airshed. The urban and industrial sources located in the Houston-Galveston area northeast of Corpus Christi thus appears to be a prominent source of ozone and precursors. Based on both the local wind analysis and back-trajectory study, it appears that Corpus Christi is strongly influenced by both local and distant upwind sources.

4. CONCLUSION

Overall there seems to be an increasing trend in the 8-hour average ozone concentration and a decreasing trend in the 1-hour average ozone concentration in Corpus Christi. Ozone levels at CAMS04 seem to be very close to the 8-hour NAAQS and this is a certainly a matter of great concern. Abatement measures necessary to control the emissions of ozone precursors in Corpus Christi needs be continued so that ozone levels remain below the NAAQS. Weekdays are more polluted than weekends. Highest level of ozone is generally found during September. Winds from north and northeast during the morning hours and from the east during the afternoon hours dominate on high ozone days compared to south-southeasterly wind on low ozone days. A significant percentage of back trajectories come from the North and East directions suggesting possible contribution of ozone from those areas.

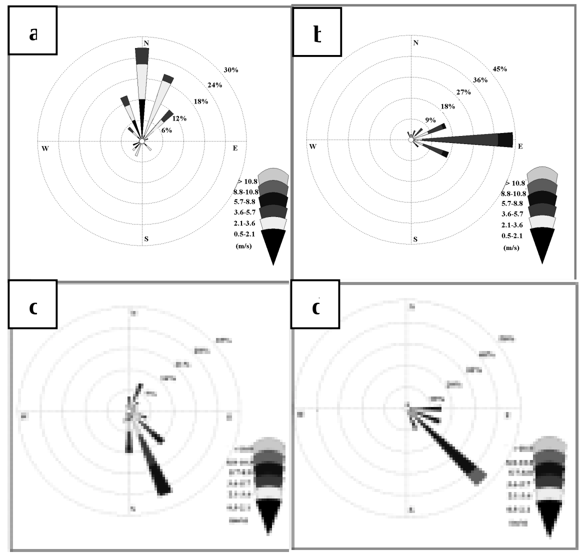

Figure 1: Windrose: (a) High ozone days (Morning) (b) High ozone days (Afternoon) (c) Low ozone days (Morning) (d) Low ozone days (Afternoon)

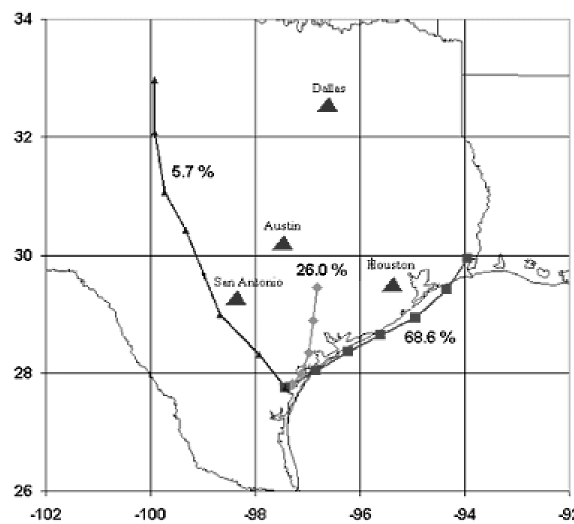

Figure 2: Back-trajectories for high ozone days (1995-2000)

5. REFERENCES

Lakes Environmental, 2000: WRPLOT View Help Manual. [Available from http://www.lakes-environmental.com.]

NOAA, cited 2002a: What are the limitations of trajectories? [Available on-line from http://www.arl.noaa.gov/slides/ready/traj/traj3.html.]

NOAA, cited 2002b: HYbrid single-particle Lagrangian integrated trajectory model version updated: 24 April 2001. [Available on-line from http://www.arl.noaa.gov/ss/models/hysplit.html.]