

Analysis of the seasonal and inter-annual variations, and long-term trends of ozone in the metropolitan area of Monterrey, Mexico

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Since 1993, high-precision and high-frequency measurements of ambient O_3 have been recorded at 5 sites within the metropolitan area of Monterrey, the third largest city in Mexico. O_3 was measured by the Integral Environmental Monitoring System of the Nuevo Leon State Government using commercially available, conventional UV photometry instrumentation (precision better than ± 1 ppb). The datasets exhibit variations on differing time-scales of minutes to hours, with evidence of seasonal cycles and inter-annual variability. The O_3 diurnal cycles vary with length of daylight, which influences its formation and loss via photochemistry. No apparent influence is observed in the amplitudes of O_3 diurnal cycles recorded during weekdays with higher emissions from fossil fuel combustion than at weekends, although larger amplitudes occur at sites with polluted air from industrial areas. Seasonal cycles are driven by the variation in solar radiation and changes in emissions of primary precursors, VOCs and NO_x . Maximum O_3 mixing ratios were recorded in spring, and minimum values in winter, with a secondary trough during summer due to the advection of clean air masses from the Gulf of Mexico. The largest spring maxima are recorded downwind of an industrial area likely due photochemical processing of VOCs and NO_x , with the lowest recorded in a highly populated area due to reaction of O_3 and NO. At all sites, decreasing seasonal amplitudes were observed during 1993-1998, followed by persistent increases from 1998 to 2014. Wind sector analyses were carried out by splitting the wind direction into 8 categories (45°). At all sites, the highest O_3 mixing ratios were recorded from the E and SE sectors, with lowest values recorded in air masses from the W and NW. Wind sector analysis of primary precursors (such as VOCs, CO, NO_x) reveal that sources are dominated by emissions from industrial regions in Monterrey and surrounding areas. The largest annual growth rates for the E and SE sectors and for all sites are 0.50 and 0.66 ppb O_3 yr^{-1} , whereas the lowest are 0.36 and 0.25 ppb O_3 yr^{-1} , respectively. In the metropolitan area of Monterrey, O_3 has increased at an average annual rate of 0.20 ppb O_3 yr^{-1} ($p < 0.001$), which is in marked contrast with the decline of 0.71 ppb O_3 yr^{-1} ($p < 0.001$) observed at Mexico City during the same period and the variable levels at Guadalajara from 1996 to 2014. The analysed O_3 records imply that controls on primary precursor emissions have been successful in Mexico City, whereas more measures to improve air quality should be introduced in Guadalajara and Monterrey.