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Study of diurnal pattern of surface ozone with special emphasis to nighttime ozone at multiple urban sites in the United Kingdom

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Analysis of diurnal patterns of surface ozone (O_3) at multiple urban sites in the United Kingdom shows the occurrence of prominent nighttime enhancements during the winter months (Nov-Mar).Whilst nocturnal surface ozone (NSO) enhancement events have been observed at other locations, this is the first time that such features have been demonstrated to occur in the UK and the second location where they have been shown to be so clearly discernible in monthly diurnal cycles averaged over several years of data. Long term (2000-2010) analysis of hourly surface ozone (O_3) data from 18 urban background stations shows bimodal diurnal variation with a nighttime peak around 0300 hr in addition to a daytime peak during the winter months. The frequency distribution analysis of daily maximum NSO concentrations during winter months shows that, for all but one site, the daily maxima NSO concentrations during the winter months exceeded 60 μg/m^{3}on $>$20% of the nights and exceeded 80 μg/m^{3}on $>$10% of the nights at more than 7 sites which is considerably higher than the monthly averaged minima ($\sim$25 μg/m^3). The highest NSO value recorded was 118 μg/m^3. In the months of January, November and December, the averages of the monthly averaged O_3concentrations observed at nighttime (0300 hr) even exceed that observed in the daytime (1300 hr). The analysis also shows that these NSO enhancements can last for several hours and extend spatially at a regional scale across several stations simultaneously. Interestingly, the urban sites in the north of the UK exhibit higher NSO than the sites in the south of the UK, despite their daily maxima being similar. This seems to be partially related to the fact that sites in the north typically have lower concentrations of nitrogen oxides.