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Comparison of ozone pollution levels at various sites in Seoul, a megacity in Northeast Asia

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ABSTRACT

Concentrations of ozone were continuously measured at four urban monitoring sites (Gu Ro (G); No Won (N); Song Pa (S); and Yong San (Y)) in Seoul, Korea from 2009 to 2011. The annual mean concentrations of ozone (in ppb) at these sites were found on the order of N (21.8 ± 19.3) > S (21.4 ± 20.14) > G (20.9 ± 18.0) > Y (18.8 ± 17.4). During peak hours (12–6 pm), the ozone concentrations were significantly higher (75, 69, 67, and 64% at site S, Y, N, and G, respectively) than overall 24 hour mean values. Seasonal variations of ozone have quite similar patterns at every site with systematic increases during spring (March–May) and summer (June–August) with the summer daytime mean (12–6 pm) values of 40.7 (site Y)–49.3 ppb (site S). The concentrations of ozone exhibited strong inverse correlations with other criteria pollutants (e.g., oxides of nitrogen and carbon monoxide), while a significant positive correlation was observed with some meteorological parameters (e.g., ultraviolet ray and solar radiation). Evidence collected in this study confirm that the spatio-temporal distribution of ozone in the study areas should be affected by the anthropogenic sources (e.g., vehicles, residential, and industrial sources) in concert with such well-known variables as the NO_x–VOC chemistry and a number of natural parameters (e.g., wind speed, geographic position, and solar radiation).

1. Introduction

Tropospheric ozone is one of the most alarming scientific issues related to urban air quality. Photochemical production of ozone intimately depends on its two major anthropogenic precursors, oxides of nitrogen (NO_x) and volatile organic compounds (VOCs) (Akritidis et al., 2013; Zhang et al., 2013). Ground level ozone is a major environmental concern because of its adverse impact on both the climate and human health (Herckes et al., 2013). Photochemically formed ground level ozone smog has been proved to be a direct threat to both humans and plant ecology (Ashmore et al., 1980; Wang and Mauzerall, 2004). As ozone is a strong oxidant and can destroy noxious pollutants, its anthropogenic use includes large-scale industries such as water purification and paper pulp processing, while photocopiers, laser printers, and fax machines are important small scale sources in the indoor environment (Oyama, 2000; Singla et al., 2011).

In the northern hemisphere, the annual average background ozone concentration is estimated to be in the range of 20–45 ppb and is increasing at a rate of approximately 0.5–2% every year (Vingarzan, 2004). According to the environmental white book of Korea (by the Korean Ministry of Environment (KMOE)), ozone emerged as the main air

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pollutant in Seoul during the 1990s (KMOE, 2008). According to KMOE, the annual concentration levels of ozone in Seoul increased gradually from 9 (1990) to 14 ppb (2002) (KMOE, 2008; Yoo et al., 2008). During recent years, ozone concentration of Seoul ranged between 13 (2003) and 19 ppb (2008) (Shin et al., 2012). The surface ozone concentration at any given area depends on the combined effects of both natural (e.g., photochemical fields, elevation, and biogenic VOC emissions) and anthropogenic processes (e.g., vehicular emission and urban building structure), which control the formation, transportation, destruction, and deposition of ozone (Llusiá et al., 2002; Vingarzan, 2004; Lee et al., 2008). Evidence suggests that biogenic volatile organic compounds (BVOCs) should also play a vital role in the photochemical formation of ozone (Kanakidou et al., 2005; Ng et al., 2006; Calfapietra et al., 2013; Situ et al., 2013).

The increase of global ozone may affect human health via the rate of premature mortality, cardiovascular and respiratory diseases, and chronic childhood asthma (White et al., 1994; Lasry et al., 2005; West et al., 2007). In Seoul, it was reported that the increase of ozone raised the relative risk of low birth weight and childhood asthma as well as daily mortality (Ha et al., 2001; Lee et al., 2002; Kim et al., 2004). The overall grain production rate throughout Northeast Asia

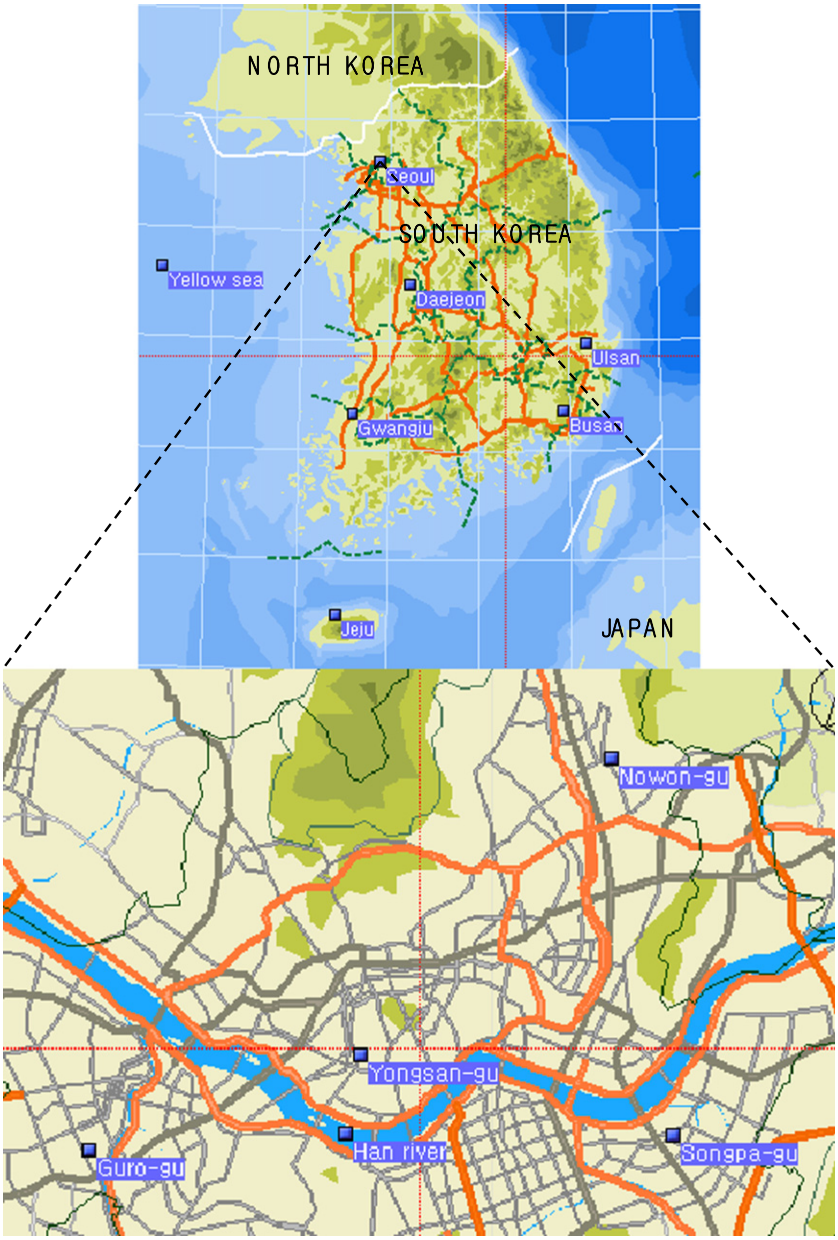

Fig. 1. Locations of the four AQM stations in Seoul, Korea investigated in this study: Gu Ro (G); No Won (N); Song Pa (S); and Yong San (Y).