Geophysical Research Abstracts
Vol. 15, EGU2013-3661, 2013
EGU General Assembly 2013

Extensive spatio-temporal analysis of surface ozone over South Korea for 1999-2010 considering meteorological factors

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Spatio-temporal variations of surface ozone are investigated using the KZ-filter considering meteorological factors based on measurement data at 124 air quality monitoring sites and 72 weather stations over South Korea for the time period of 1999-2010. We use hourly data of ozone (O_3), nitrogen dioxide (NO_2), temperature (°C), dew-point temperature (°C), sea-level pressure (hPa), wind speed (m/s) and direction (16 cardinal directions), relative humidity (%), and solar insolation (W/m^2). Over the Korean peninsula, surface O_3 levels at the coastal cities are generally high due to the dynamic effects of the sea breeze and short-lived chlorine species from the sea salt, while those at the Seoul metropolitan area and other inland cities are low due to the NO_x titration by anthropogenic emissions. The concentrations of surface O_3 have generally increased for the analyzed period with the nationwide average linear trend of +0.26 ppbv/yr (+1.15 %/yr). We also examine the meteorological influences on the surface O_3 levels over South Korea using a combined analysis of KZ-filter and multiple linear regressions between surface O_3 and meteorological variables. Time-series of surface O_3 are decomposed into the short-term, seasonal, and long-term components by the KZ-filter and regressed on meteorological variables. Through probability distribution analysis of the decomposed O_3 time-series classified by wind direction, the O_3 short-term variation at monitoring sites shows transport effects from the source regions. Impacts of surface temperature on the surface O_3 levels are found to be significantly high in the highly populated metropolitan area and inland cities. It implies that those regions will be experiencing more frequent high-ozone events in the future climate conditions with the increase of global temperature. Especially in Seoul, the most populated area in South Korea, the probability of high O_3 exceeding air quality standard is almost doubled for the temperature increase of about 4°C. Additional SVD analysis between O_3 and NO_2 shows similar temporal evolution with spatial patterns of the long-term O_3 and NO_2 components. This study would provide a reference for appropriate ozone control policy and for the performance evaluation of chemistry climate models over East Asia.