Impact of large-scale synoptic circulation pattern on ozone forming mechanism in Shanghai, China

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As one of the largest metropolises in China, Shanghai faces serious air pollution problem. Due to stringent emission controls, $PM_{2.5}$ level has seen continuous decrease in recent years in Shanghai. In contrast, ozone pollution becomes significant, characterized by longer duration of ozone pollution episode and higher peak ozone level. As ozone is a secondary pollutant, it is essential to understand its formation mechanism and then to adopt synergistic controls on its precursors, VOCs and NOx, to reduce ambient ozone levels in an effective manner.

What makes things more complicated is that Shanghai is surrounded by the highly urbanized and industrialized Yangtze River Delta (YRD), one of the most developed regions in China. Pollutants emitted and formed over the YRD and beyond are readily transported to Shanghai, so that local formation of ozone is superimposed by that from regional and super-regional transport. In this study, we use the most updated pollutant emission inventory in the YRD and the WRF/SMOKE/CMAQ modeling system and adopt a series of scenario analysis to investigate the ozone formation mechanism in Shanghai over a long-lasting ozone pollution events during 1-10 August 2017. It is found that the ozone formation mechanisms on different days in different districts are different. Overall, ozone formation mechanism largely fluctuates from NOx-limited to transitional and to VOC-limited during this ten-day pollution event, suggesting the importance of dynamic pollution control measures on ozone precursors. Interestingly, the shifts of ozone formation mechanisms correspond well with the changes in summertime synoptic circulation patterns. Continental low pressure system brings about southwesterly air mass from Zhejiang and corresponds to NOx-limited regime, suggesting the air mass from Zhejiang is more VOCs abundant and local ozone control should be focused on NOx emissions. Weak coastal ridge hinders horizontal transport and corresponds to transitional regime, suggesting the local emissions ratio of VOCs and NOx may most effectively produce ozone. West Pacific subtropical high brings about northwesterly air mass from Jiangsu and corresponds to VOC-limited regime, suggesting the air mass from Jiangsu is more NOx abundant and local ozone control should be focused on VOCs emissions. As the large-scale synoptic circulation pattern can be well predicted a couple of days before, such a correspondence is indicative in adjusting the local control focus so as to maximize the effectiveness of peak ozone reduction in Shanghai.

Key words: ozone formation mechanism, circulation pattern, VOCs, NOx, Shanghai