Utilizing continuous multi-component MAX-DOAS observations for the near-surface ozone sensitivity diagnosis at Tsukuba and Chiba, Japan for 2013-2019

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In the troposphere, ozone (O_3) plays a critical role not only as a critical photochemical oxidant but also as the third most important greenhouse gas. In recent years, its importance has been more widely recognized as a major short-lived climate pollutant. However, recent trends of concentrations of the near-surface O_3 and its major precursors, namely nitrogen oxides (NOx ≡NO + NO_2) and volatile organic compounds (VOCs), and the relationship among them have not been fully understood yet. Here, we utilized the multi-axis differential optical absorption spectroscopy (MAX-DOAS) to conduct continuous simultaneous observations of NO_2 (as a proxy for NOx), formaldehyde (HCHO; as a proxy for VOC), and O_3 concentrations in the retrieved lowermost troposphere (0-1 km) at Tsukuba (36.06ºN, 140.13ºE, 35 m asl) and Chiba (35.63ºN, 140.10ºE, 21 m asl), Japan for seven years from 2013 to 2019. For a spatially-representative analysis around Chiba situated in an urban area, four MAX-DOAS instruments directed to four different azimuth directions (north, east, west, and south) were operated simultaneously. The seven-year-long period was a unique target as satellite observations indicated an abrupt improvement in the tropospheric NO_2 concentration level over East Asia, including China. Considering this with other observational evidence from literatures, the transboundary transport of ozone originating from the Asian continent was likely suppressed or unchanged. Over such a unique time period, MAX-DOAS observations at both Tsukuba and Chiba showed almost-constant variations or rather an increasing tendency in the near-surface O_3 concentration, although reductions in NO_2 and HCHO concentrations by as much as 30% were observed simultaneously. These results provide observation evidence that decreasing NOx concentration significantly reduced the amount of O_3 quenched through the NOx titration.

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