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# Abrupt increase of nitrate in PM2.5 during winter haze in Seoul

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In January 2018, PM2.5 warnings have been issued for three days across the Korea peninsular, when it was increased up to 106 $\mu$g/m3. The rapid increase of PM2.5 mass was associated with increase in nitrate by 10 $\mu$g/m3 and $NO_2$ by 103 ppbv within 3 hours from 10:00 and 13:00. In Seoul, the maximum $NO_2$ is usually found around 9 am. While the PM2.5 mass was best correlated with ammonium (r= 0.95), the increase in sulfate was insignificant. Therefore, it is critical to understand the rapid conversion mechanism of nitrate and the plausible pathways. The contribution of $HNO_3$ is very unlikely under overcast conditions in winter (average cloud coverage of almost around 10). In fact, the calculated $HNO_3$ was not sufficient to explain the observed $NO_3$ concentration. It might be possible that N2O5 was heterogeneously converted into $HNO_3$ in liquid droplets during nighttime and mixed with surface air rich in NH3 during the daytime, leading to NH4$NO_3$ formation. However, it is quite not likely because of the low temperature (minimum surface temperature of -2.5 °C) and low $O_3$ concentration (maximum $O_3$ of 40 ppbv). The ceilometer and LIDAR measurements reveal the shallow thin cloud and boundary layer height during the night, which started expanding around 9 10 am. Therefore, we suggest that the vertical mixing played a key role in increase of nitrate, which was enriched in cloud droplets (ice crystal) aloft. Regarding ammonium, it is not clear if it was combined with $NO_3$ or partitioned into aerosol after being mixed with surface air, which will be further investigated.