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Supplemental Information

An Unreported Asian Dust (Kosa) Event in Hokkaido, Japan: A Case Study of 7 March 2016

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SI Text

1. Weather report at Sapporo on 7 March 2016 by JMA

On 7 March 2016, no Kosa event was reported at Sapporo by Japan Meteorological Agency (JMA) (http://www.data.jma.go.jp/gmd/env/kosahp/kosa_table_2016.html). At the JMA's Sapporo station, the weather report on this day said that relatively larger amounts of clouds were reported on this day except for at around 6:00 JST (http://www.data.jma.go.jp/obd/stats/etrn/view/hourly_s1.php?prec_no=14&block_no=47412&year=2016&month=3&day=7&view=; hereafter called Website 1). Furthermore, intermittent and very weak precipitation (less than 0.5 mm per hour) was also sometimes observed (see Website 1). In addition, during 20:50 and 22:30, the station reported haze (enmu, 煙霧, in Japanese; the symbol is ∞) but no Kosa was observed. The guidelines for ground-based weather observations (Chijyoukisyoukansokushishin, 地上気象観測指針, in Japanese) by JMA (2002) said in Section 11.3.3, "*Even if there was visibility failure phenomenon, the phenomenon may not be reported if the phenomenon was very weak and the horizontal visibility was ≥ 10 km*" (p.117). The visibility on 7 March at Sapporo was ≥ 10 km during around the noon to the early afternoon (see Website 1). Therefore, in case, JMA could not report any visibility failure during the period based on their definition. In any case, the JMA observations on this day did not mention any information, referring to a Kosa event.

2. Additional information on method and data

For the particle number concentration (PNC) data by the aerosol sensor, the default unit in particles per 0.01CF were converted to particles per cubic meters (particles m^{-3}). We also used the calculated hourly mean PNC data from the measurement by the aerosol sensor (hereafter called, Sensor Station: SS) and KC-01D (hereafter called, Optical Particle Counter: OPC) at Sapporo with their standard deviations within each one hour. Those 1-hourly mean PNC data were calculated based

on the available data during 12:00 JST, 25 November 2015, and 10:00 JST, 30 March 2016 (For the SS data, the available data during 12:15 JST, 25 November 2015, and 9:59 JST, 30 March 2016, were used for the calculations). The positive values of the data by the aerosol sensor were only used for the comparisons with the PNC data obtained by OPC, excluding missing data. Note that sometimes the number of available data of the aerosol sensor within one hour were pretty small. However, we did not exclude those hours for the hourly mean data comparisons because we focus more on the data continuity for the inter-comparisons. The aerosol sensor for the ambient air environment version, in general, has the upper limits guaranteed by the company (ULGC) of 6.0E06 particles $(28.3L)^{-1}$ (i.e., approximately 2.1E08 particles m^{-3}) and 1.0E06 particles $(28.3L)^{-1}$ (i.e., approximately 3.5E07 particles m^{-3}) for the particle size ranges of ≥ 0.3 μm and ≥ 0.5 μm, respectively (Shinyei Technology Co. Ltd., 2017, personal communication). These apply to the data for the same particle size ranges measured by our SS too. The measured data by SS sometimes showed the values beyond ULGC. The percentages of the number of the data exceeded ULGC during the time period for the 1-hourly mean calculations were just 0.668% and 0.008% for the particle size ranges of ≥ 0.3 μm and ≥ 0.5 μm, respectively. These results indicate that most of the measured data were below ULGC. However, for better discussions, we excluded those data beyond ULGC for the 1-hourly mean data calculations. For the 1-hourly mean data in the particle size range of 0.3-0.5 μm, we only used the 1-min data only when both the data for the two particle size ranges were below ULGC. For Fig. 4, we didn't apply this treatment to the data because all the 1-min data for the particle size range of ≥ 0.5 μm at Sapporo and Takikawa on 7 March were below ULGC. However, compared to the observed OPC data and $PM_{2.5}$ data in Fig. 4, the SS data in the evening on 7 March 2016, in case underestimated the PNC for finer particles in the SS particle size range (i.e., the particle size range of ≥ 0.5 μm) because of the aerosol sensor characteristics on weaker sensitivities for finer particles based on the interchangeability comparisons between SS and OPC as shown in Fig. 3. This is one of the possible

reasons for the difference of the data between SS and OPC in the evening as mentioned in the main text.

For the lidar data, the definition and the retrieval method of dust (non-spherical) extinction coefficient (Fig. 5), and the methodology of cloud-base/rain/snow detection are explained in Shimizu et al. (2017).

For the horizontal mapping of $PM_{2.5}$ in Japan (Mov. S2), hourly mass concentrations $PM_{2.5}$ (filled circle in color) were obtained from the Atmospheric Environmental Regional Observation System (AEROS) managed by the Ministry of Environment, Japan (http://soramame.taiki.go.jp) as well as the $PM_{2.5}$ data in Sapporo (see the main text). The horizontal wind data (at 10-m above ground) were obtained from the Grid-Point Value Meso-Scale Model (GPV-MSM) data, which was distributed by JMA. The surface level data of the GPV-MSM cover the areas over/around Japan (22.4˚-47.6˚N, 120.0˚-150.0˚E). The data also contain 3-hourly analysis and hourly forecast in 0.05˚×0.0625˚ horizontal grid intervals. The surface wind data were re-sampled in 0.20˚×0.25˚ horizontal grid resolution.

References

JMA, 2002: Chijyoukisyoukansokushishin (地上気象観測指針 in Japanese), Morimoto Print Co. Ltd., 176 pp.

Shimizu, A., T. Nishizawa, Y. Jin, S.-W. Kim, Z. Wang, D. Batdorj, and N. Sugimoto (2017), Evolution of a lidar network for tropospheric aerosol detection in East Asia. *Opt. Eng.*, 56(3), 031219, doi: 10.1117/1.OE.56.3.031219.

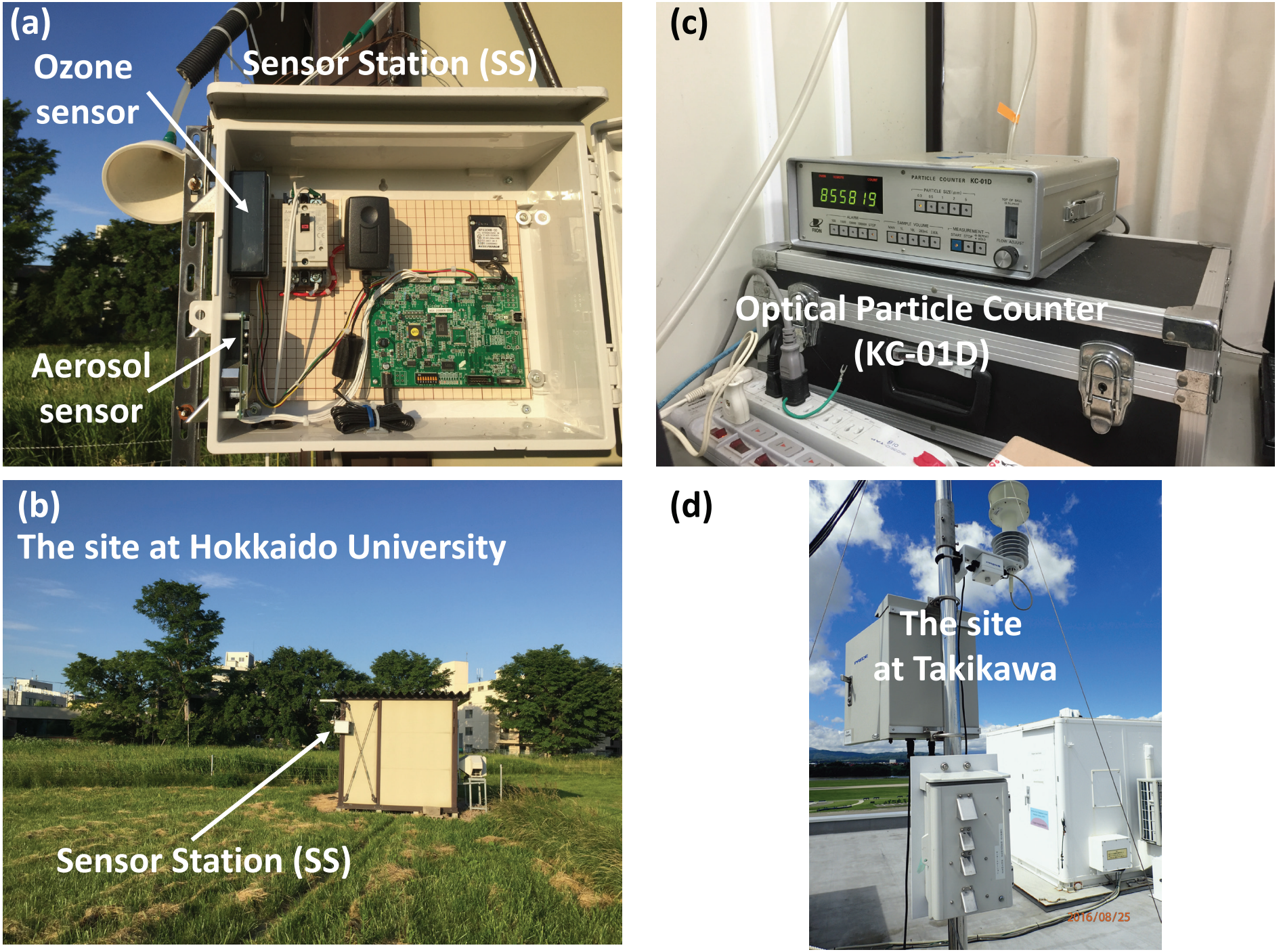

Fig. S1. Pictures of the sites at Sapporo and Takikawa with the instruments. (a) The Sensor Station (SS) with the aerosol and ozone sensors; (b) The site at Hokkaido University (Sapporo); (c) The Optical Particle Counter (OPC), KC-01D, at the site of Sapporo shown in Panel (b); (d) The site at Takikawa.