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Winter 2018 major sudden stratospheric warming impact on midlatitude mesosphere from microwave radiometer measurements

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S1 The description of the data used for analysis

The Aura MLS CO values have been taken from version 4.2x Aura MLS Level 2 data (https://mls.jpl.nasa.gov/data/readers.php). Aura MLS v4.2x data have 37 pressure levels. The useful range of CO data is from 215 hPa to 0.0046 hPa with corresponding height is from ~11 km to ~86 km. The satellite observation data points are divided into 20° longitude × 2° latitude grids. That means: longitude is divided into 180°:20°:180° and latitude is divided into 90°:2°:90° segments. Then the average value of the data is taken in the grid as the value of the center of the grid. For instance, the average in the grid of 180°–160° in longitude and 90°–88° in latitude is taken as the average value of 170° degrees in longitude and 89° in latitude.

Data are removed (replaced by 'NaN') if they do not meet the quality criteria described in 'Version 4.2x Level 2 data quality and description document' (https://mls.jpl.nasa.gov/data/v4-2_data_quality_document.pdf). The five-day average (Fig. S1 and S2) is not simply a sum, divided by five. If the data of a certain area is blank, the data of that area will be ignored on that day. For example, if the data of a certain area in five days are: A, B, NaN, C, NaN, the average value of this area is (A+B+C)/3.

Daily datasets from ERA-Interim global atmospheric reanalysis of European Centre for Medium-Range Weather Forecast have been used for comparison with microwave radiometer observations (https://www.ecmwf.int/en/forecasts/datasets/archive-datasets/reanalysis-datasets/era-interim). Two types of level in the ERA-Interim database were used: 'Model level' and 'Pressure level'. The number vertical levels in 'Model level' and 'Pressure level' datasets are 60 and 37, respectively. The pressure ranges in 'Model level' and 'Pressure level' datasets are from the surface up to 0.1 hPa and 1 hPa, respectively. Horizontal dimension resolution (longitude×latitude) is selected as 0.75°×0.75°. The 'Model type' data are used for drawing temperature and zonal wind velocity profiles from surface up to 0.1 hPa in order to compare with the data measured by microwave radiometer in Kharkiv, which extends up to 87 km altitude. The 'Pressure level' data were used to create geopotential height plots (Fig. 1).

S2 CO movements in stratosphere and mesosphere

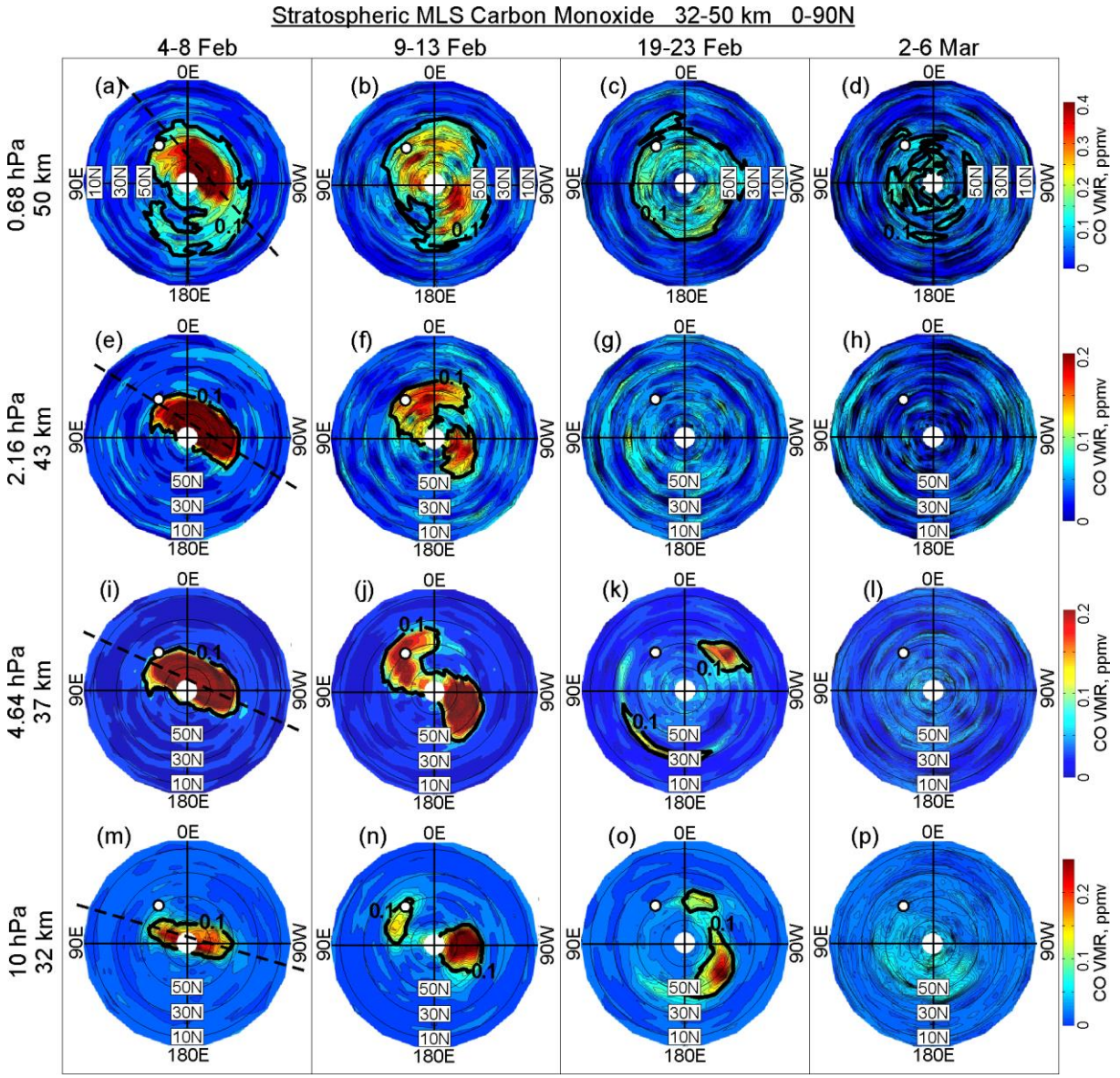

Figure S1. The 5-day mean CO field in the NH stratosphere (0–90°N, between 32 km and 50 km) from the MLS measurements before (first column, 4–8 February), during (second and third columns, 9–13 and 19–23 February, respectively) and after (forth column, 2–6 March) the SSW 2018. White circle shows location of the MWR site Kharkiv relatively the high/low CO amounts marked off by the black contours. Note that Kharkiv falls under the area of high CO amount just after the SSW start (second column, 9–13 February) due to the westward rotation of the polar air mass caused by the zonal wind reverse from westerly to easterly. The high CO anomalies disappear after the SSW (right column, 2–6 March). Dashed lines indicate planetary wave westward tilt with altitude.

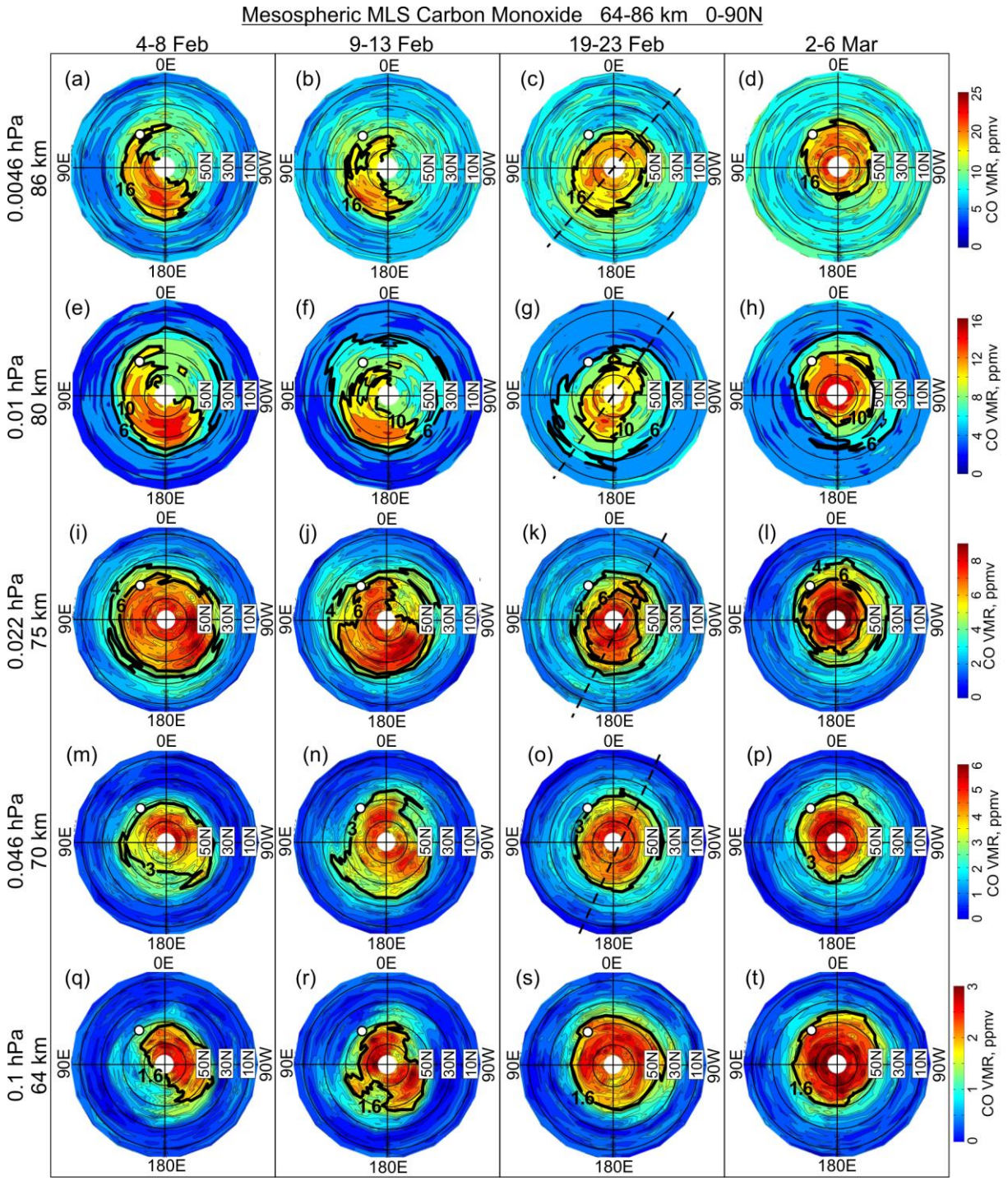

Figure S2. As in Fig. S1, but for the NH mesosphere (0–90°N, between 64 km and 86 km). Note that the lowest mesospheric CO levels observed with the MWR in February 2018 over Kharkiv (white curve for 6 ppmv in Fig. 3a) are explained by the westward displacement of the boundary between the low- and high-CO polar air mass (compare the Kharkiv location relative to the contour 16 ppmv in (a–c), 6 ppmv in (e–g) and 4 ppmv in (i–k) at 86, 80 and 75 km, respectively. Dashed lines indicate planetary wave westward tilt with altitude.

S3 Vertical profiles of the MLS temperature anomalies

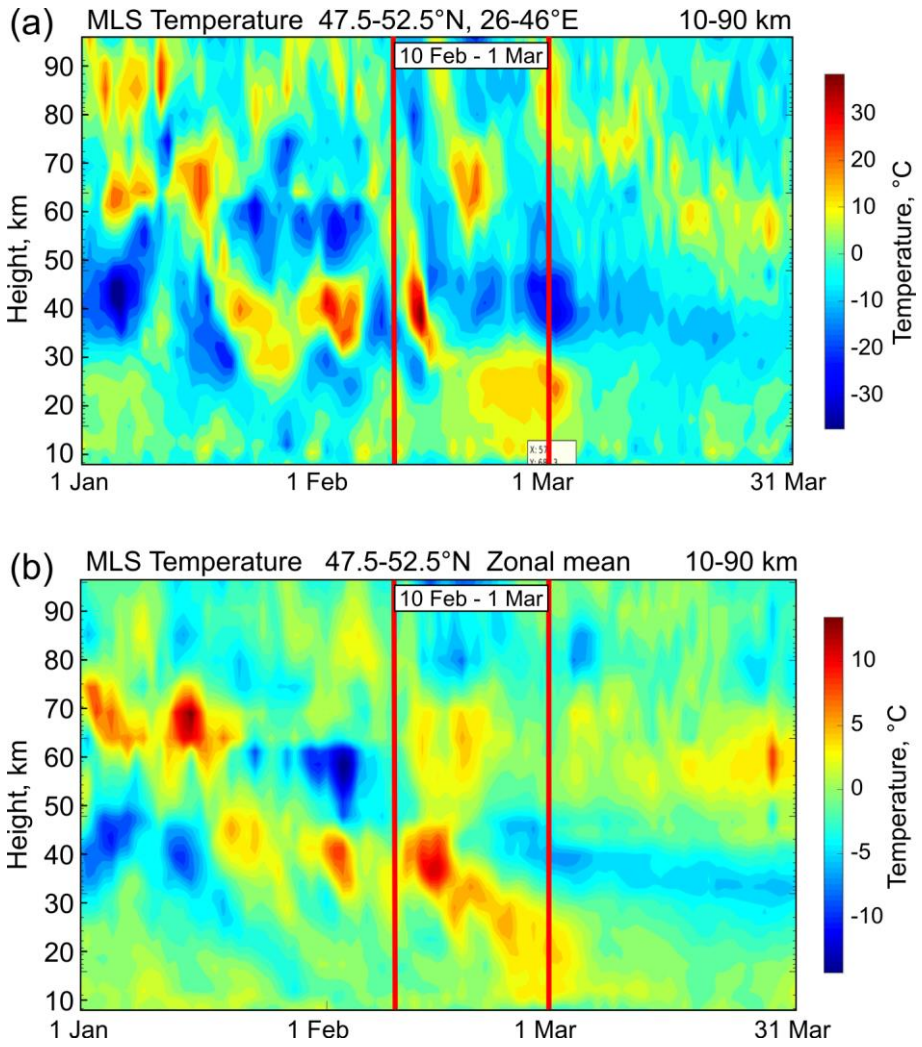

Figure S3. Vertical profiles of the MLS temperature anomalies in January–March 2018 with respect to the mean climatology 2005–2017 over (a) region 47.5–52.5°N, 26–46°E centered at Kharkiv and (b) 47.5–52.5°N zonal mean centered at the Kharkiv latitude. Red vertical lines confine the SSW event 2018.