

1 **Supplementary Information for “Alternate oscillations of Martian hydrogen and oxygen**
2 **upper atmospheres during a major dust storm”**

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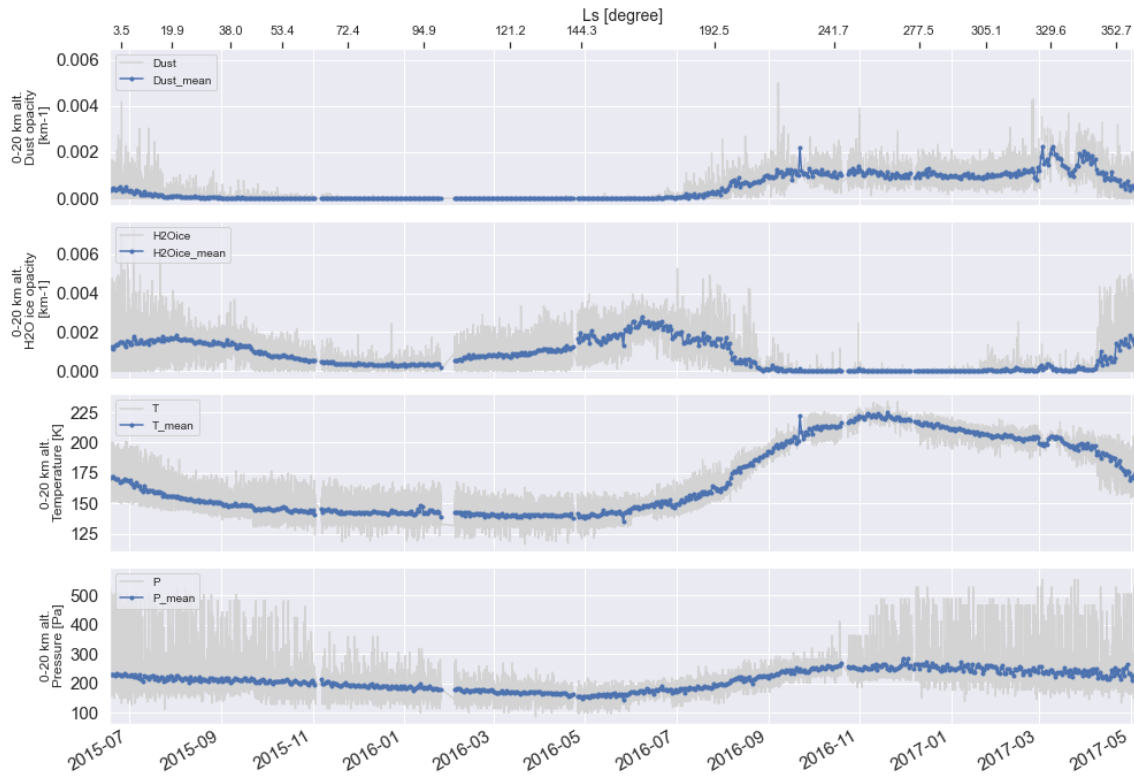
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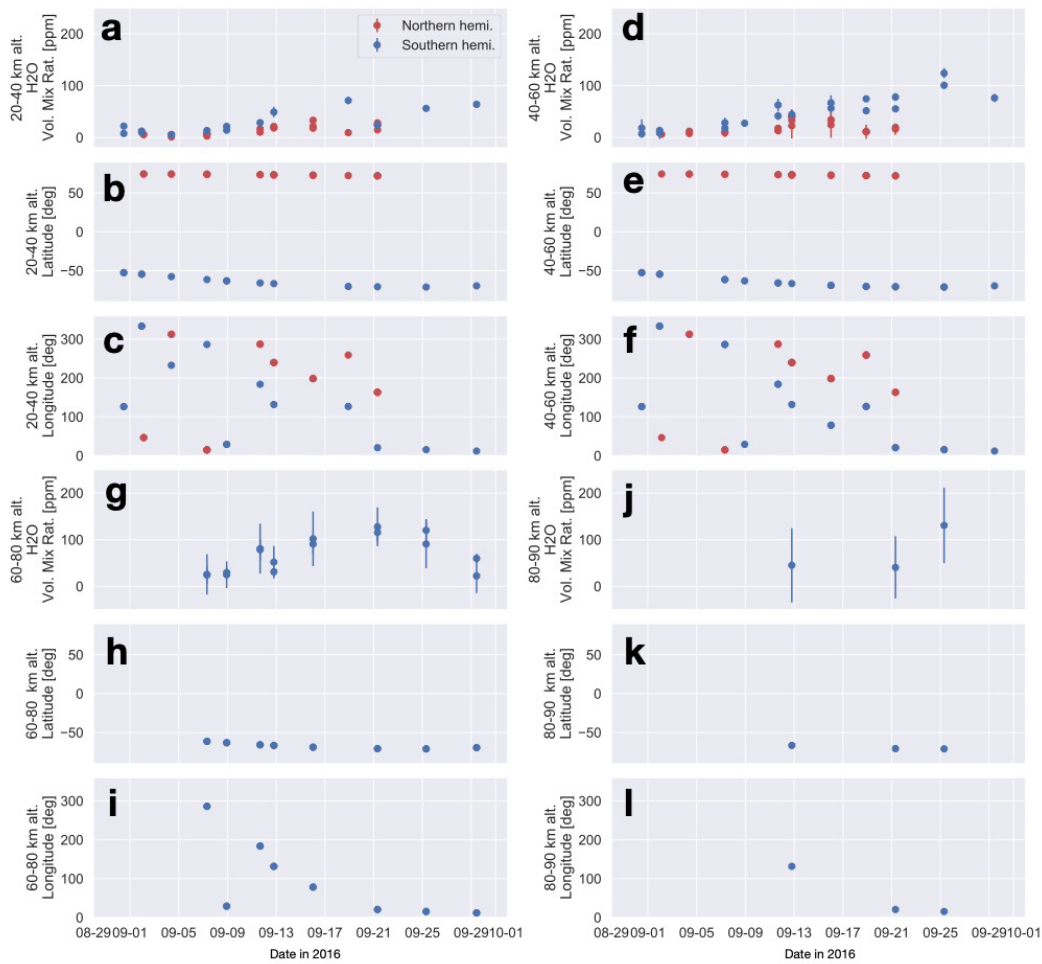


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29 **Supplementary Fig. 1. Mars Climate Sounder (MCS) measurements throughout Mars Year**
30 **33.**

31 MCS measurements of dust opacity, H₂O ice opacity, air temperature, and air pressure observed
32 at an altitude of 0–20 km at a local time of 11–13 h throughout Mars Year 33 (gray lines). The
33 blue dots denote the average values of every Martian day, as shown in Figs. 1 and 2.

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36 **Supplementary Fig. 2. Spectroscopy for the Investigation of the Characteristics of the**
 37 **Atmosphere of Mars (SPICAM) measurements and its observation geometry.**

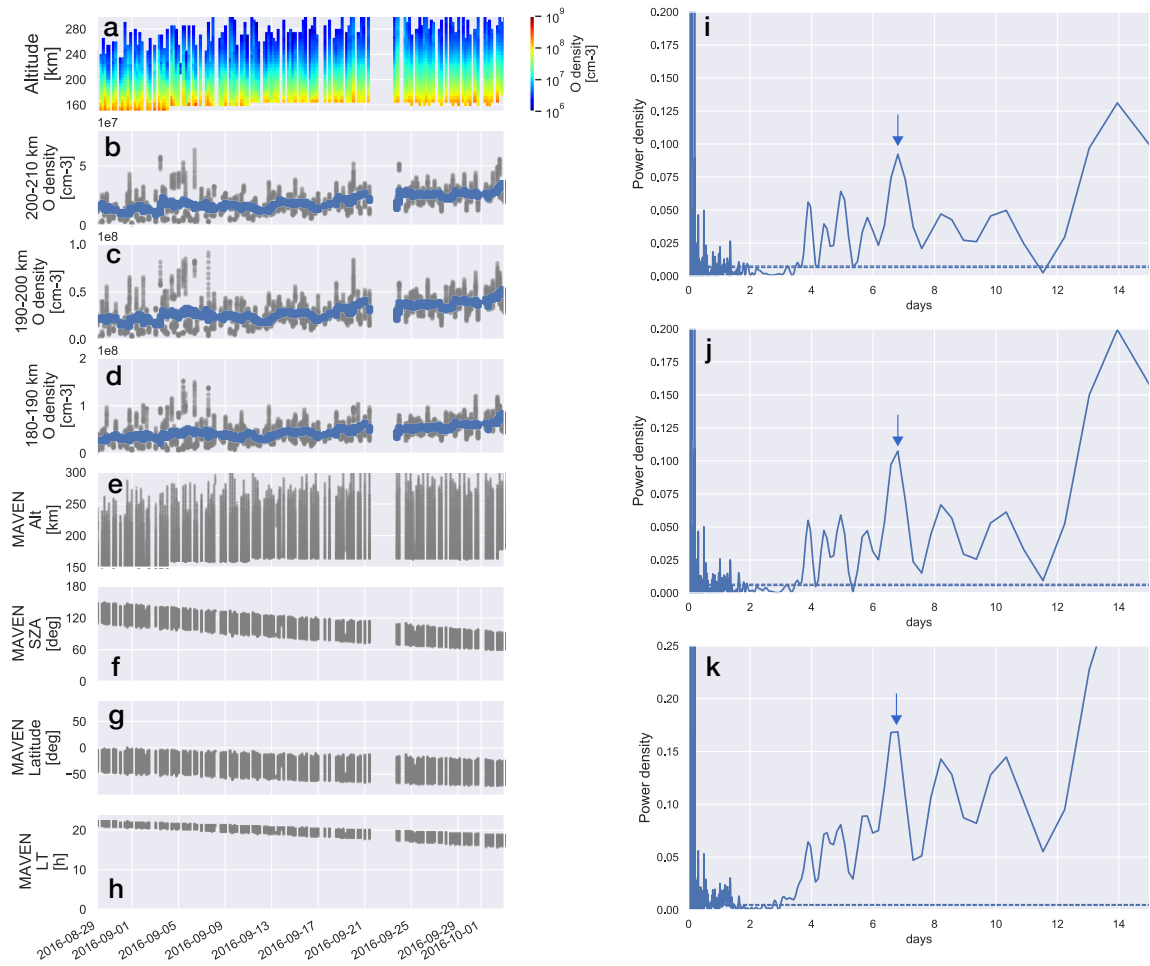
38 SPICAM measurements of water vapor mixing ratio in four altitude ranges (20–40 km, 40–60
 39 km, 60–80 km, and 80–90 km) and their observed latitude and longitude. The two colors (red
 40 and blue) denote measurements on the northern and southern hemispheres, respectively.

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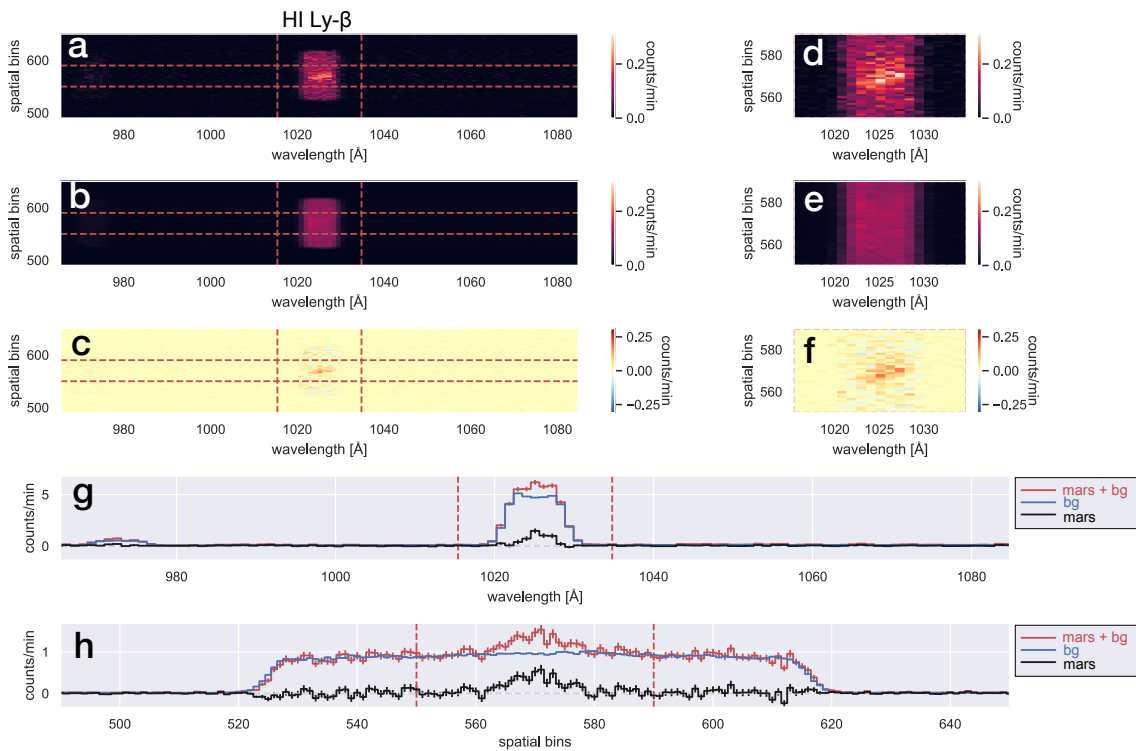


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46 **Supplementary Fig. 3. Neutral Gas and Ion Mass Spectrometer (NGIMS) measurements,**
 47 **its observation geometry, and periodogram result.**

48 (a-h) NGIMS measurements of O number density in the 150–300 km altitude range and density
 49 variations at 200–210 km, 190–200 km, and 180–190 km altitudes are shown along with
 50 MAVEN geometric information. Grey dots represent original data, and blue dots are running
 51 average values using 1-day window. (i-k) Power spectra of O densities calculated using the
 52 periodogram method. Horizontal dashed lines show the 99 % confidence level and the blue
 53 arrows indicate the detected 6.8-day periodicity.

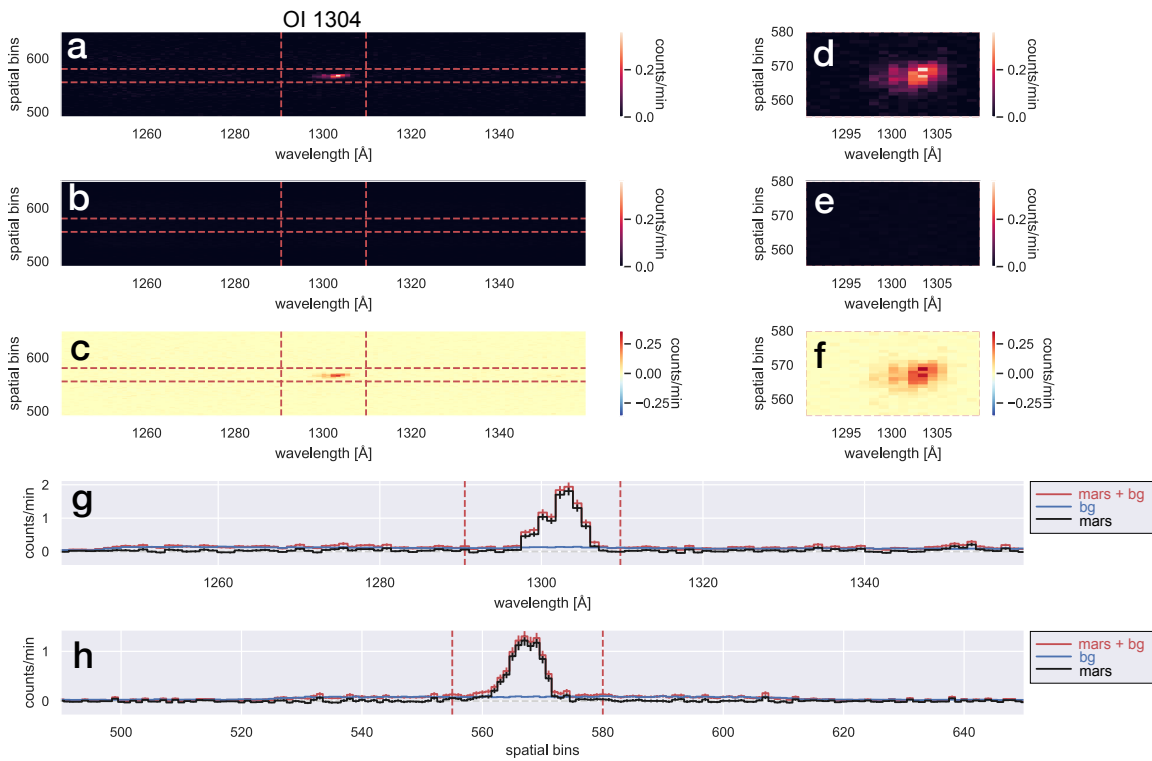
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56 **Supplementary Fig. 4. HI Ly- β airglow observed by Hisaki.**

57 Average spectra of Ly- β for (a) on-Mars, (b) off-Mars (background), and (c) their residual
 58 observed on September 4, 2016. Zoom-in features are shown in panels (d), (e), and (f),
 59 respectively. Their spectral and spatial distributions are shown in panels (g) and (h).



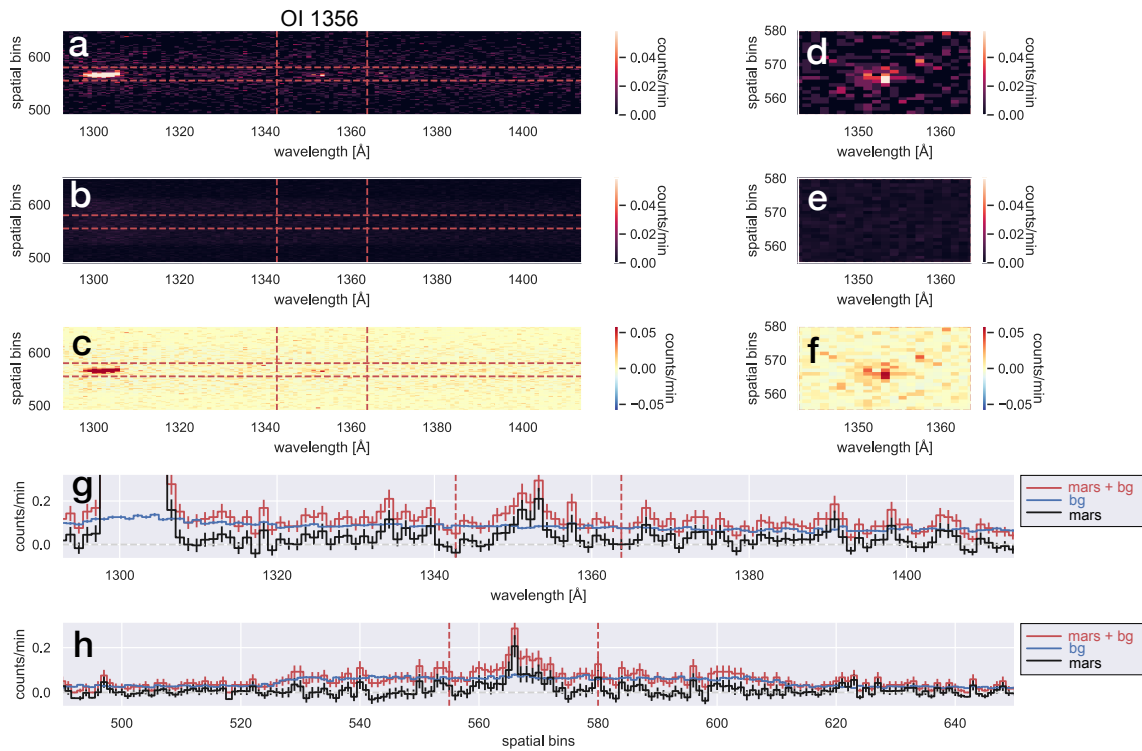
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61 **Supplementary Fig. 5. OI 1304 Å airglow observed by Hisaki.**

62 Average spectra of OI 1304 Å observed on September 4, 2016 in the same format as

63 Supplementary Fig. 4.

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66 **Supplementary Fig. 6. OI 1356 Å airglow observed by Hisaki.**

67 Average spectra of OI 1356 Å observed on September 4, 2016 in the same format as

68 Supplementary Fig. 4.

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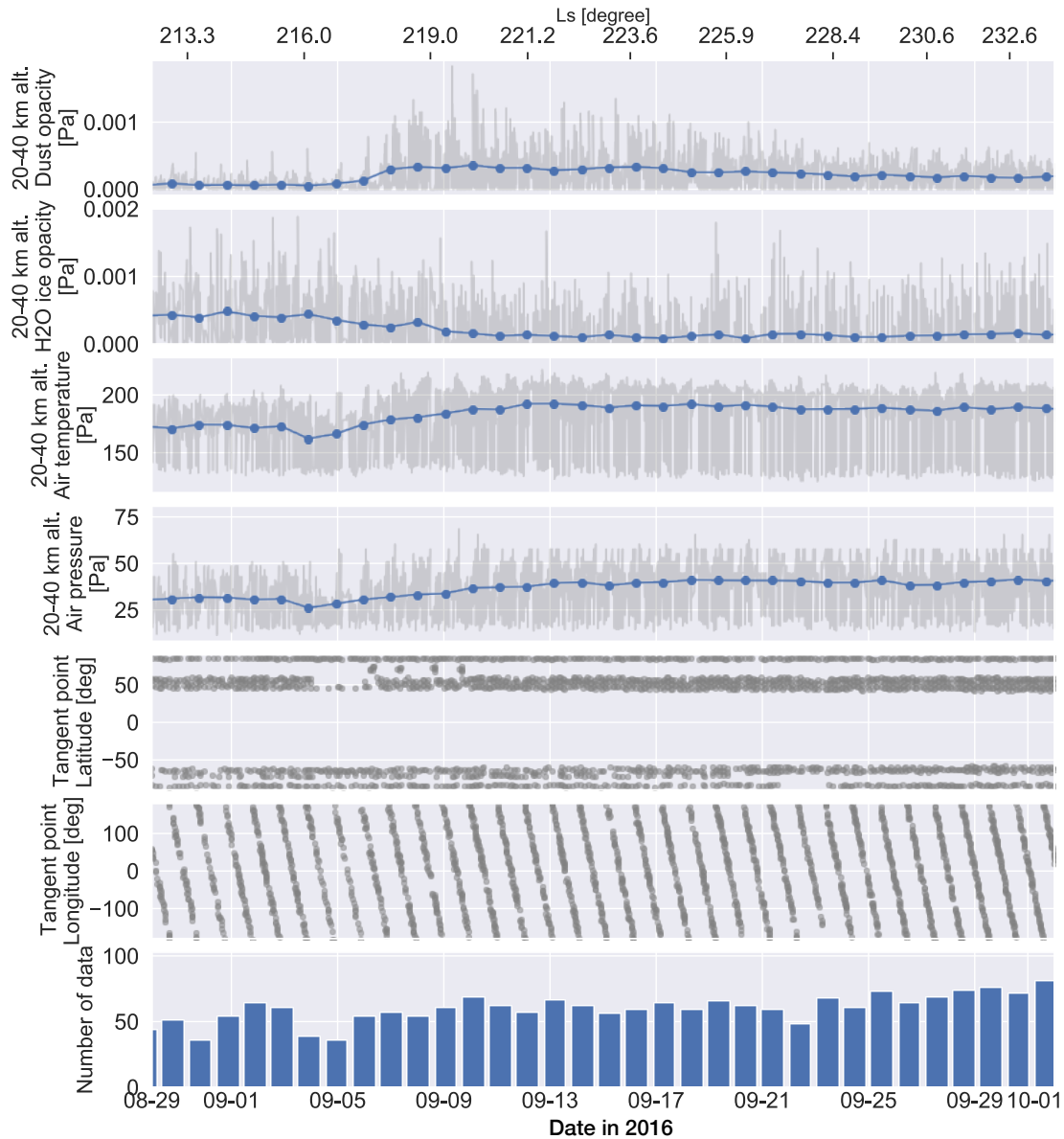
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76 **Supplementary Fig. 7. Mars Climate Sounder (MCS) measurements and its observation**
 77 **geometry.**

78 The top four panels show MCS measurements of dust opacity, H₂O ice opacity, air temperature,
 79 and air pressure observed at an altitude of 20–40 km at a local time of 11–13 h (gray lines). The

80 blue dots denote the average values of every Martian day, as shown in Figs. 1 and 2. Observation

81 latitude, longitude, and the number of data points per Martian day are also shown.