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# Statistical analysis of $CO_2$ supersaturation in the Martian atmosphere observed by MGS radio occultation measurements

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## Abstract

The main constituent of the Martian atmosphere is carbon dioxide ($CO_2$). The previous literatures have shown that the extremely low temperature, which is around or even below the $CO_2$ saturation temperature (Ts), is frequently observed in the mesosphere [1][6][7] and in the lower atmosphere [2][3][5]. The laboratory experiments [4] showed that $CO_2$ condensation on $H_2O$ ice nuclei does not occur until the degree of supersaturation (S) attains 34% in average. This corresponds to the temperature 2-3K lower than Ts, and some of the previous literatures mentioned that the observed cold temperature was actually 2-3K lower than Ts. In the present study, we carefully analyzed pressure-temperature profiles obtained by MGS radio occultation measurements (1998-2007) [8], and we found that severer supersaturation events (S>34%) than those shown in the laboratory experiments occurred in the Martian lower atmosphere (up to ~35km) during polar nights (Fig. 1). In our analysis, we regarded $CO_2$ partial pressure as the total pressure obtained by the radio occultation measurements. The existence of $H_2O$ vapor could increase the total pressure, but $H_2O$ saturation pressure is much smaller than $CO_2$ saturation pressure in the extremely cold temperature domain (approximately 120-170K) focused on in the present study. Therefore, we can neglect $H_2O$ vapor pressure for the total pressure in this analysis. Those severe supersaturation events are found more frequently in the southern hemisphere (12% of all the saturation events in the southern hemisphere) than in the northern hemisphere (3% of all the saturation events in the northern hemisphere). This result might be inconsistent with the previous study, which suggested that the weaker polar vortex in the South allows $H_2O$ ice nuclei-rich air to intrude from lower latitudes into the polar region, resulting in lower amounts of convective available potential energy by supersaturation [3].

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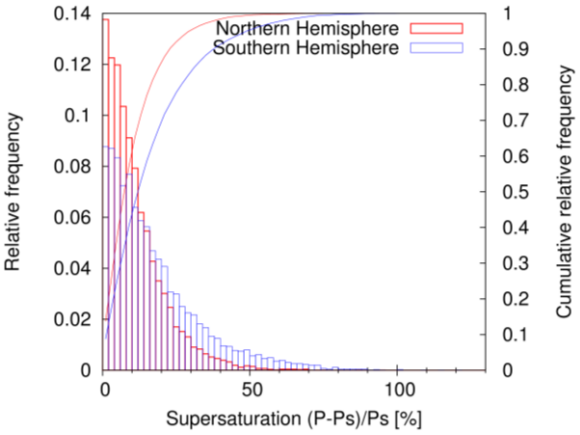


Figure 1: Relative frequency (histograms) and cumulative relative frequency (curves) of supersaturation events observed by MGS radio occultation measurements in the northern hemisphere (in red) and in the southern hemisphere (in blue). The horizontal axis indicates the degree of supersaturation (S) defined as (P-Ps)/Ps, where P is the total pressure observed and Ps is the saturation vapor pressure of $CO_2$.

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