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Impact of atmospheric gravity waves on the Martian global water cycle during dust storms

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Effects of atmospheric gravity waves (GWs) on the global water cycle in the middle and high atmosphere of Mars during the global dust storms (Martian years 28 and 34) have been studied for the first time using a general circulation model. Dust storm simulations were compared with those utilizing the climatological distribution of dust in the absence of a GW parameterization. The dust storm scenarios are based on the observations of the dust optical depth by the Mars Climate Sounder instrument on board Mars Reconnaissance Orbiter. The simulations show that accounting for the influence of GWs leads to a change in the concentration of water vapor in the thermosphere. The most significant effect of GWs is twofold. First, cooling of the thermosphere at the poles leads to a decrease in the water vapor abundance during certain periods. Second, heating in the regions representing the main channels of water supply to the upper atmosphere (the so-called water "pump" mechanism) increases, on the contrary, its concentration. Since the temperature increase provides more intensive atmospheric mixing, and also expands the supply channel through an increase in saturation pressure. The dynamic balance of these basic mechanisms drives the changes in the distribution of water vapor in the upper atmosphere. Dust storms enhance pumping of water vapor into the upper atmosphere. Seasonal differences in the storm occurrences in different years allow for tracking the paths of water vapor transport to the upper atmosphere.