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Mars H Escape is potentially dominated by a high-altitude water source

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H escape from the Mars atmosphere has removed a large part of Mars' initial water inventory. Until recently, this escape was thought to be slow and steady, sourced from long-lived molecular hydrogen whose lightness and volatility in comparison with water allow it to penetrate the upper atmosphere. Contradicting this thinking, observations from the Hubble Space Telescope and Mars Express, as well as more recent MAVEN measurements, indicate that H escape varies by at least a factor of ten over the Mars year and is largest in Southern Summer near perihelion. At the largest rates, H escape exceeds the ability of molecular hydrogen to supply the escape fluxes observed. At the same time in Southern Summer, Mars Express solar occultations have shown unexpectedly large concentrations of water at high altitude, potentially providing a source of escaping H unaccounted for in standard models. Here we show via photochemical modeling that the presence of this high altitude water can partially explain the large escape rates observed in Southern Summer. We further show that this escaping H is not in immediate balance with O escape, and therefore that short-term atmospheric dynamics can drive long-term variations in the oxidation balance and volatile content of planetary atmospheres. Future simultaneous observations by MAVEN, Mars Express, and the Trace Gas Orbiter may provide a direct test of this mechanism.