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Where did Martian water and volatiles go? A space mission to study Martian escape

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Present escape processes on Mars are poorly constrained. Most of the present escape occurs through dissociative recombination and sputtering, with some contribution of ion escape. In the past, when the Sun was brighter in the UV, sputtering played a much more important role and probably dominated escape. Up to 1 bar of CO2 and tens of meters of H2O could have been removed by escape to space, but these numbers are uncertain by one or two orders of magnitude. In order to give a quantitative estimate of the cumulated effect of escape, two kinds of observations are necessary : (i) neutral and ion populations presently escaping, under the effect of solar flux and wind interaction, in such a way to get a complete view of present escape, (ii) accurate noble gas isotopic ratios, and stable isotopes, in order to test escape models extrapolated to the past and their cumulative escape. In order to reach the first objective, a low periapsis orbiter (120 km) of Mars is required, with a suite of in-situ instruments. The second objective requires isotopic measurements, with an accuracy significantly better than 1%, from a lander. A Mars mission coupling an escape-devoted orbiter and a lander is potentially able to elucidate the fate of the ancient atmosphere and hydrosphere of Mars.