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Retention of Habitable Atmospheres in Planetary Systems

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The ability of a planet to retain an atmosphere influences whether water can be stable as a liquid at the planet's surface. A planet's atmospheric state is the result of source, loss, and modification processes that have acted on the atmosphere over time. The loss of atmosphere to space is therefore an important component in assessing planetary surface habitability. 'Atmospheric escape' is a catch-all term that refers to distinct processes that provide sufficient energy to particles for escape to space. Escape processes include thermal escape, hydrodynamic escape, ion loss, photochemical escape, and sputtering. At present, scientists who study atmospheric escape processes at Earth, solar system planets, and exoplanets each employ different and often siloed strategies to estimate escape rates. This fractured approach has hindered development of a comprehensive understanding of how atmospheric escape works at any planet. Here we present an overview of a team science effort to estimate atmospheric escape rates for a wide variety of star-planet combinations. Our goal is to determine which regions within the parameter space of stellar and planetary properties relevant for atmospheric escape are most likely to result in planets that retain habitable atmospheres. Our effort consists of four objectives: (1) We will compute stellar EUV and wind inputs for atmospheric escape for an ensemble of star-planet scenarios; (2) We will improve and link models for atmospheric escape from any planet via each major escape process, validating them against observations; (3) We will construct a multi-dimensional end-to-end model library for atmospheric escape based on more than 200 star-planet combinations, making it publicly accessible via a web portal; and (4) We will apply the model library to understand the connection between atmospheric escape, habitability, and observations.