Habitable-zone planets maintain stable surface liquid water over geological time through equilibrium between greenhouse-gas consumption by weathering, and resupply by other processes. All reported small-radius exoplanets, and anticipated M-dwarf habitable-zone rocky planets, should be tidally locked. We will discuss two different feedbacks that can destabilize climate equilibrium on planets in 1:1 spin-orbit resonance. (1) If small changes in pressure alter the temperature distribution across a planet's surface such that the weathering rate goes up when the pressure goes down, a runaway positive feedback between pressure, surface temperature, and weathering rate near the substellar point takes place - enhanced substellar weathering instability (ESWI). (2) When decreases in pressure increase the fraction of surface area above the melting point (through reduced advective cooling of the substellar point), and the corresponding increase in volume of liquid causes net dissolution of the atmosphere, further decreases in pressure can occur. This substellar dissolution feedback (SDF) can also cause a runaway climate shift. We use an idealized energy balance model to illustrate the scope of these instabilities. In this simplified model, the weathering runaway can shrink the habitable zone. Mars may have undergone a weathering runaway in the past. Substellar dissolution is usually a negative feedback or weak positive feedback on changes in atmospheric pressure, and can only cause runaway changes for small, deep oceans and highly soluble atmospheric gases. Both instabilities are suppressed if the atmosphere has a high radiative efficiency. Our results are most relevant for atmospheres that are thin, have low greenhouse-gas radiative efficiency, and where the principal greenhouse gas is also the main constituent of the atmosphere.

These results identify a new pathway by which habitable-zone planets can undergo rapid climate shifts and become uninhabitable.

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