Fundamental problems concerning the evolution of planetary atmospheres

ABSTRACT:

Problems concerning the evolution planetary atmospheres on geologic timescales were once reserved for conceptual models. However, three-dimensional climate models are now commonly used to simulate extremes of planetary climate for Earth, other solar system objects, and most recently extrasolar planets. In this study, I use a modified version of the Community Earth System Model to examine two fundamental problems concerning the evolution of Earth’s atmosphere: the faint young Sun paradox and the runaway greenhouse. Both problems are motivated by the long-term evolution of the solar constant. All stars gradually brighten over their main sequence lifetimes. Thus, if we wind the clock backwards, the early Earth was irradiated by up to ~25% less solar energy than the present day, yet geologic evidence indisputably points toward a warm planet that teemed with life. Conversely, as time marches into the future the Sun will continue to brighten, inevitably pushing the Earth into a thermal runaway and thus permanently ceasing habitability. While this study remains geocentric in nature, results are considered within the broader context of planetary atmospheres.