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Simple Physics Explains a Common Temperature Minimum in Thick Atmospheres of Planets and Large Moons

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Atmospheric temperature minima are fundamental for understanding many planetary processes. Inversions in the upper atmospheres of Earth, Jupiter, Saturn, Titan, Uranus, and Neptune lead to temperature minima that, remarkably, all occur near 0.1 bar, despite very different radiation environment, atmospheric composition, gravity, and internal heat flux. We examined the atmospheric thermal structure of these worlds with an analytic 1-D radiative-convective model, which assumes gray thermal transfer of radiation. We find that tropopause temperature minima always lie in the radiative regime, above the radiative-convective boundary. Thus, the shared 0.1 bar tropopause arises from the common physics of infrared radiative transfer. Our findings imply that the common 0.1 bar tropopause levels seen in the solar system atmospheres are more universal. Thus, we hypothesize that many worlds orbiting other stars (exoplanets) will possess a 0.1 bar tropopause temperature minimum.