

UC SANTA BARBARA
Department of Earth Science

Earth Science Colloquium
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Clouds stabilize Earth's long term climate

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The Sun was dimmer earlier in Earth history, but glaciation was rare in the Precambrian: this is the "Faint Young Sun Problem". Most solutions rely on changes to the chemical composition of the atmosphere to compensate via a stronger greenhouse effect, whilst physical feedbacks have received less attention. Here we show that a strong negative feedback from low clouds has had a major role in stabilizing climate through Earth's history. We perform Global Climate Model experiments in which a reduced solar constant is offset by higher CO₂, and find a substantial decrease in low clouds and hence planetary albedo, which contributes 40% of the required forcing to offset the faint Sun. Through time, the climatically important stratocumulus decks have grown in response to a brightening Sun and decreasing greenhouse effect, driven by stronger cloud-top radiative cooling (which drives low-cloud formation) and a stronger inversion (which sustains clouds against dry air entrainment from above). This demonstrates the importance of physical feedbacks on long-term climate stabilization, and a smaller role for geochemical feedbacks.