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Causes and consequences of time-varying climate sensitivity

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While constraining climate sensitivity has long been a focus of climate science, this global and equilibrium metric provides only limited understanding of transient and regional changes over the coming centuries. Indeed, pronounced spatial and temporal variability of climate change has been observed, and climate models diverge strongly in projections of future warming. This intermodel spread is due, in part, to different representations of how global climate sensitivity (set by feedbacks linking surface warming to top-of-atmosphere radiative response) will vary in time as the Earth warms. Here I discuss mechanisms governing the time variation of climate sensitivity, and consider its implications for future climate prediction. I show that climate sensitivity depends fundamentally on the respective geographic patterns of local radiative feedbacks and surface warming, and thus it naturally varies in time as the pattern of surface warming evolves, activating feedbacks of different strengths in different regions. Further, the pattern of surface warming and the strength of local radiative feedbacks themselves (shortwave clouds feedbacks in particular) depend on regional ocean circulations and the resulting time-varying geographic pattern of ocean heat uptake. These results imply that equilibrium climate sensitivity cannot be reliably estimated from transient climate observations.