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Key Points:

- Land surface models have grown in complexity, and new methods of managing this complexity are required for scientific understanding
- New methods are also needed to represent, classify, and benchmark models across the multidimensional heterogeneity of the land surface
- A further challenge is to constrain model parameters in ways that are consistent with allowing long-term ecological dynamics to occur

Perspectives on the Future of Land Surface Models and the Challenges of Representing Complex Terrestrial Systems

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Abstract Land surface models (LSMs) are a vital tool for understanding, projecting, and predicting the dynamics of the land surface and its role within the Earth system, under global change. Driven by the need to address a set of key questions, LSMs have grown in complexity from simplified representations of land surface biophysics to encompass a broad set of interrelated processes spanning the disciplines of biophysics, biogeochemistry, hydrology, ecosystem ecology, community ecology, human management, and societal impacts. This vast scope and complexity, while warranted by the problems LSMs are designed to solve, has led to enormous challenges in understanding and attributing differences between LSM predictions. Meanwhile, the wide range of spatial scales that govern land surface heterogeneity, and the broad spectrum of timescales in land surface dynamics, create challenges in tractably representing processes in LSMs. We identify three “grand challenges” in the development and use of LSMs, based around these