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Response of the grassland ecosystem to climate change in a theoretical model

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The response of a grassland ecosystem to climate change was investigated within a theoretical model. An optimization approach, i.e., a conditional nonlinear optimal perturbation related to parameter (CNOP-P) approach, was employed in this study. The CNOP-P, which is a perturbation of a moisture index in the theoretical model, represents a nonlinear climate perturbation. A linear climate perturbation was also used in order to study the grassland ecosystem response to different types of climate change.

The numerical results show that the extent of grassland ecosystem variation caused by CNOP-P-type climate change is greater than that caused by the two kinds of linear climate change. In addition, the grassland ecosystem affected by CNOP-P-type climate change evolves into a desert ecosystem, while the two kinds of linear climate change fail within a specific amplitude range when the moisture index recovers to its reference state. This demonstrates that the grassland ecosystem response to climate change is nonlinear. Similar results were found for a desert ecosystem seeded with litter of both living and wilted biomass. The numerical analysis also accounts for the role of soil moisture in the root zone and the shading effect of wilted biomass on the grassland ecosystem through the nonlinear interaction between the soil and the vegetation. This study implies that the CNOP-P approach is a potentially effective tool for assessing the impact of climate change on the grassland ecosystem.