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Exploring southern African Plateau uplift with landscape evolution model inversion and erosion history data

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The southern African plateau is a dominant feature of African topography but there is considerable debate about when and how it formed. Cretaceous kimberlite activity and the presence of a large low shear seismic velocity province (LLSVP) in the deep mantle below southern Africa have lead many to propose uplift related to mantle processes. Better constraints on the timing of uplift have the potential to constrain the nature of the LLSVP and the source of support for southern Africa's anomalous elevations. However, surface uplift is difficult to detect directly in the geologic record and the relationships between mantle-sourced uplift and erosion are not necessarily direct. Here, we use a landscape evolution model combined with data constraining the spatiotemporal erosion patterns across southern Africa to explore how topographic development and erosion are related. This is an ideal location to utilize this approach because several recent studies have helped to constrain the erosion history of this region over different spatial and temporal scales but the uplift history is still widely debated. We integrate a highly efficient landscape evolution model (FastScape, Braun and Willett, 2013) and a thermal module with a large low temperature thermochronology dataset, sedimentary flux volumes for the major offshore basins, and geologic observations to address these questions. We used inversion methods based on the Neighborhood Algorithm to investigate how data is best simulated by the model while varying model parameters related to plateau uplift and the physical characteristics of the eroding material. This is a powerful approach because we are able to compare model outputs to many aspects of topographic shape and constraints on the erosion history simultaneously. Results from the inversions show that the data are sufficient to constrain many model parameters. Additionally, we show that the combination of different types of data, and in particular the spatiotemporal erosion information from the thermochronologic results, is valuable for constraining many of these parameters. We show that the geometry and physical characteristics of the overlying sedimentary basin, as well as the characteristics of the geodynamic forcing, have significant control on plateau erosion patterns. It is therefore important to consider both geodynamics and surface controls on erosion when interpreting erosion patterns. Inversion methods with FastScape can be a valuable tool for examining the linkages between processes at the surface and at depth.