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Downscaling CESM2 in CLM5 to Hindcast Pre-Industrial Equilibrium Line Altitude for Tropical Mountains

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Highland environments are rarely preserved in the geological record, particularly from as early as the Paleozoic Era. However, several stratigraphic locations are now known which definitely or potentially preserve such environments near the paleoequator during the Late Carboniferous and Early Permian Periods, during which the Earth was in the depths of an icehouse climate like that of the Pliocene and Pleistocene Epochs, the Late Paleozoic Ice Age (LPIA). Several of these locations contain evidence of mountain glaciation at altitudes below 2000 m, leading to questions about the significance of tropical mountain glaciation for global climate during this interval of geologic time. However, climate model simulations for the LPIA have not been able to simulate mountain glaciation like that inferred from the geological record, possibly because of low resolution, incorrect boundary conditions, or climate model bias resulting from incomplete representation of moist convective processes impacting tropical lapse rates.

The overarching purpose of this study is to develop a climate modeling framework that enables the significance of mountain glaciation for global paleoclimate to be evaluated. Ideally, such a framework would allow low-resolution global model output to be downscaled to the scale of a mountain range to calculate the equilibrium line altitude and similar parameters, enabling evidence of mountain glaciation in the deep past to be used to constrain/tune the low-resolution global models. While this study was designed to inform a specific problem in deep time paleoclimate, its results are likely broadly applicable to assessing how well mountain glaciation is captured by global climate modeling of the past, present, and future.

Here, I present a framework in which the CMIP6 pre-industrial control simulation for the Community Earth System Model version 2 (CESM2) at 0.9°x1.25° resolution is used to generate a data atmosphere for the Community Land Model version 5 (CLM5) run at 0.01° resolution in 10 tropical and 1 mid-latitude domain to study the surface mass balance over the domain. For computational reasons, glaciation is assumed to cover a small portion of each grid cell, but surface mass balance still can be evaluated. Topographic boundary conditions come from GMTED2010, but most other information is directly interpolated from the CESM2 simulation. CLM5 simulations require a fixed lapse rate to be assumed, which is varied in each CLM5 simulation across six different values. The CLM5 simulation output along with the mean tropical lapse rate in the CESM2 simulation is then used to evaluate the various biases of this framework in comparison with

estimated pre-industrial equilibrium line altitudes for the studied domains.

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