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Influence of climate change and CO2 fertilization on vegetation and catchment erosion: A coupled modelling approach

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The Earth's surface is shaped by a complex interplay between tectonics, lithology, climate and biota. Previous work has shown that vegetation cover effects on erosion rates are non-linear and depend on the ecosystem investigated. Vegetation cover is not only influenced by climate (via changes in precipitation, temperature and solar radiation) but also by changes in the atmospheric CO_2 concentration through a fertilization effect and increased water use efficiency. However, disentangling the influence of variable climate or atmospheric CO_2 concentrations on vegetation cover, and hence erosion rates, is difficult. Here we present results from a series of coupled model runs aimed at quantifying the non-linear interactions between these different processes.

We apply a landscape evolution model (Landlab) that is coupled to a dynamic vegetation model (LPJ-GUESS) driven by general circulation model predictions of climate change over the last 21 kyr. Three different scenarios are simulated from the Last Glacial Maximum to present-day: 1) Changing climate and changing atmospheric CO_2 concentration; 2) Changing climate but constant atmospheric CO_2 concentration; and 3) Constant climate but changing atmospheric CO_2 concentration. The simulations are adapted to represent four study areas along the extreme climate and ecological gradient of the Chilean Coastal Cordillera (26 ° to 38° S). Results indicate that transients in climate and CO_2 from glacial to interglacial conditions induce a ~10-25% temporal change in catchment erosion, and should be detectable with different measurement techniques. In more detail, we find that precipitation changes exert a stronger influence on erosion rates than changing atmospheric CO_2 concentrations. However, the relative roles of precipitation vs. plant-physiological CO_2 effects on catchment erosion varies with the climate and ecological zone investigated such that the effects of CO_2 fertilization on erosion are larger in temperate than arid settings.