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Andean Uplift in the Context of Global Climate Change

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The two primary causes of South American climate change over the last 40 million years are global climate change and the uplift of the Andes Mountains. Quantifying spatial and temporal variations in climate over the duration of Andean surface uplift is necessary for interpreting palaeoclimate, erosion and palaeoelevation records from the region. This study utilises an atmospheric general circulation model (GCM) to investigate the magnitude and relative importance of 1) global climate and 2) Andean surface uplift to South American climate during the last 40Ma. Combined with knowledge from the geologic record, the results constrain the controls on, and timing of, landscape development.

Three different atmospheric CO2 levels (1, 2 and 4x pre-industrial levels - 280ppm) are used to simulate the range of global climate since the early Cenozoic. Surface uplift of the Andes is examined with simulations at three different Andean elevations (100%, 50% and 5% of modern heights). The importance of feedbacks associated with global climate change is assessed with additional simulations incorporating 1) no Antarctic Ice Sheet and 2) an equilibrium vegetation model coupled to the climate model.

Initial results show that the elevation of the Andes exerts a much stronger control on South American precipitation than does the atmospheric CO2 level. The presence of the Andes leads to an increase in annual average precipitation rates of up to 8 mm/day at 20^0S on the eastern flanks of the mountain range. An increase in CO2 levels from 1x to 4x pre-industrial levels increases the intensity of the global hydrological cycle with annual average precipitation rates increasing by up to 5mm/day. At 50% and 5% Andean elevation, precipitation patterns over South America are independent of atmospheric CO2 concentration. However, at 100% Andean elevation South American precipitation is sensitive to high (4x) CO2 levels. Most large-scale circulation patterns over South America are consistent between all simulations. However, the presence of the Andes deflects low-level winds, switching the moisture source for Andean precipitation from the Pacific to the Atlantic Ocean.

Surface temperatures in the Andes decrease by up to 26^0C in response to an increase in elevation from 5% to 100% of modern Andean elevation. This is greater than expected for a 5^0C/km tropical lapse rate alone, indicating that additional cooling mechanisms are acting on the plateau when the topography is raised. The magnitude of temperature change due to surface uplift is not dependent on CO2 level. The global average temperature of the 4x CO2 simulation is $\sim 6^0$C warmer than the 1x CO2 case. In South America, the location of temperature increase due to elevated CO2 is dependent on the elevation of the Andes, with CO2 concentration having a reduced affect on Andean temperatures at higher elevations. Both Andean elevation and global climate therefore determine South American surface temperatures but Andean elevation is a stronger control on precipitation and low-level wind patterns.