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Changing climate in the Andes: Temperature and hydrological responses

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We study vertical profiles of atmospheric warming, related hydrological changes, and processes that induce these changes in one of the most under-researched regions of the world in this regard: the Andes. The Andes have an extensive distribution of glaciers from tropical ice bodies to the Patagonian Icefields, many of which have experienced a dramatic retreat in response to environmental changes in recent decades. Observed and projected climatic changes in the Andes have serious consequences for the stability of fragile mountain ecosystems and for the livelihoods of mountain populations by exerting a strong control on water resources crucial for domestic, agricultural and industrial use. This study proposes to supplement available ground climate observations in the Andes with high resolution satellite products and regional climate model (RCM) simulations to understand climatic changes at spatial scales appropriate for impact studies. Through multiple (and independent) lines of inquiry - observations, RCM simulations and simple physics-based analytical model - we hope to address the climate change related issues in the Andes such as: how do warming trends vary with elevation and what are the related hydrological changes? What are the observed trends in snow cover and the meteorological factors controlling snow cover variability in the Andes? Can changes in snow cover partially explain the observed local temperature trends through snow-albedo feedback? The PRECIS RCM and the RegCM4 are employed at 50-km resolution that allows determination of climatic changes as a function of elevation and also separately along the eastern and western slopes of the American Cordillera, which experience sharply contrasting climatic conditions. In general, the PRECIS RCM has a cold bias that increases with grid-point elevation and also has a wet bias in the tropical Andes. The annual cycle and interannual variability of temperature and precipitation are simulated well by the PRECIS RCM. Under the SRES A2 scenario, the western slopes of the subtropical Andes warm more compared to the eastern slopes. This signal is reversed in the tropical Andes and seem to be associated with projected changes in precipitation. The difference between surface-air temperature (SAT) and equivalent (i.e., at same altitude) free-air temperature changes - arising from the dependency of SAT trends on location, altitude and feedbacks involving clouds and land-surface characteristics - is also investigated. Satellite data (ISCCP, MODIS), with its high temporal resolution and spatial coverage, will allow estimation in snow cover variability (and hence changes in the albedo) over the entire Andes region. Using a simple energy-balance model discussed in Groisman et al (1994), the role of snow-albedo feedback in the observed temperature trends will be determined.