Geophysical Research Abstracts
Vol. 13, EGU2011-5226, 2011
EGU General Assembly 2011
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How do climatic changes in the Andes vary with elevation and location (eastern versus western slopes)?

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Observed 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. 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. Due to lack of observations as a result of poor station density and coarse climate model resolution, climate change information over the Andes is still inadequate for impact studies. This study involves investigation of vertical profiles of atmospheric warming, related hydrological changes, and processes that induce these changes in the Andes using regional climate model (RCM) simulations. High spatial resolution of the RCM (50 km) allows determination of climatic changes not only as a function of elevation but also separately along the eastern and western slopes of the Cordillera, which experience sharply contrasting climatic conditions. A regional climate model PRECIS was used in this study to carry out two experiments: (i) the baseline (present-day) run and (ii) the scenario (SRES A2) run. Two sets of RCM experiments over northern and southern parts of the Cordillera are combined to produce results for the entire stretch of the Andes.

The preliminary analysis of the RCM simulations does suggest the dependence of climatic changes on location (eastern versus western slopes) and elevation. The eastern slopes are projected to warm more than the western slopes in the tropical Andes particularly below 2000 m. South of 18^{o}S, the signal is reversed where the western slopes warm more than the east between 1000 and 3000 m. It remains to be seen if such a trend continues along the entire subtropical Andes. In the tropical Andes, the more moderate warming along the western slopes is associated with a more significant increase in precipitation, while in the east the larger warming is associated with less of a precipitation increase (in relative terms). This relationship does not hold between 18^o-23^{o}S, the most arid stretch of the Atacama desert, where a large relative increase in precipitation is not associated with large changes in absolute terms. Additionally, the difference between surface-air temperature (SAT) and equivalent (i.e., at same altitude) free-air temperature (FAT) changes will also be investigated. In the tropical Andes, FAT trends mimic the behavior of the SAT tends with larger warming on the eastern side. However, in the subtropical Andes, around 36^o-39^{o}S, SAT warming is larger at higher elevations than the equivalent FAT warming. This difference could arise from the dependency of SAT trends on location, altitude and feedbacks involving clouds and land-surface characteristics (e.g., snow-albedo feedback). This exercise will not only help explain the difference between SAT and equivalent FAT trends, but also estimate regional changes in the 0^{o}C isotherm. Since the 0^{o}C isotherm determines the rain-snow line, such information is especially crucial for glacier mass and energy balance in the Andes.

In addition, the performance of the RCM is tested by comparing the baseline simulations to gridded observations (CRU, GPCC, etc.). Furthermore, the RCM results are also compared with the coarse resolution IPCC AR4 models to highlight the added value of the RCM in this topographically complex region. These analyses will help us design future RCM experiments to study climate change impacts in these sensitive environments.