Seasonal Land Use Change Impacts on Regional Climate of Mount Kilimanjaro

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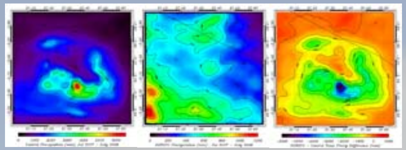
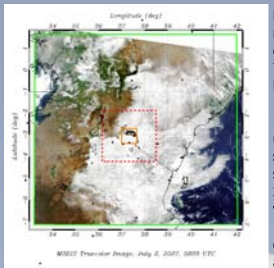
Introduction

Receding glaciers at the peaks of Kilimanjaro has become an iconic symbol of climate change. Glacier recession at Kilimanjaro been attributed to large scale changes in tropical climate. However, regional climate forcing could be potentially important since substantial amount of precipitation is generated by the interaction of the mountain with the large scale flow. Prior studies show that montane climate is sensitive to regional climate forcing such as land use change (*Lawton et al.*, 2001*; Nair et al.*, 2010). *Fairman et al.* (2011) performed an experiment for land use change impacts during the dry season. We extend that analysis to include the wet seasons, looking at the effects of land use change near Kilimanjaro for 1 year.

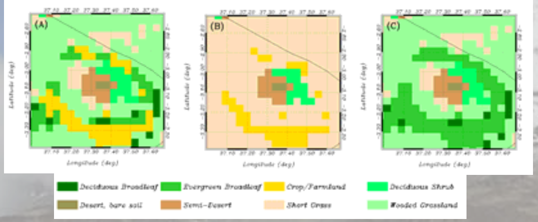


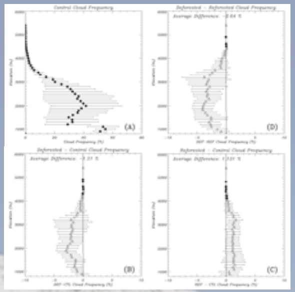
Large scale vs terrain generated precipitation: Numerical simulations show that substantial amount of the precipitation at the mountain peak is caused by terrain generated circulation.

Regional climate forcing: dry season

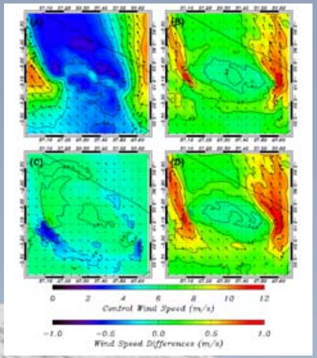


Mount Kilimanjaro is located near the northern border of Tanzania with Kenya and occupies an area of approximately 75 km x 75 km, with three peaks (Shira, Mawenzi and Kibo) rising from 800 m in the savanna plain to over 5800 m at the peak of Kibo. Studies (*Soini*, 2005) suggest drastic increase in land used for farming as the population on the south side of the mountain, increasing steadily over the time period from 1961 to 2000. Since 1976, multiple changes to the vegetation (*Hemp,* 2005; 2009) has occurred in this region, including fire and logging, contributing to a 33% loss of total forested area since 1929 (*Hemp*, 2009).

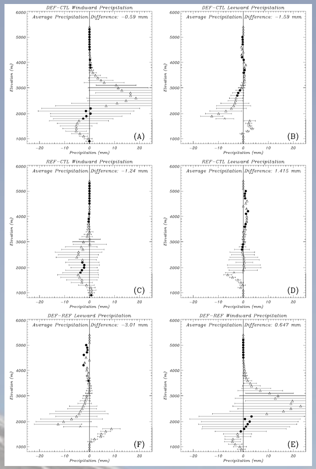




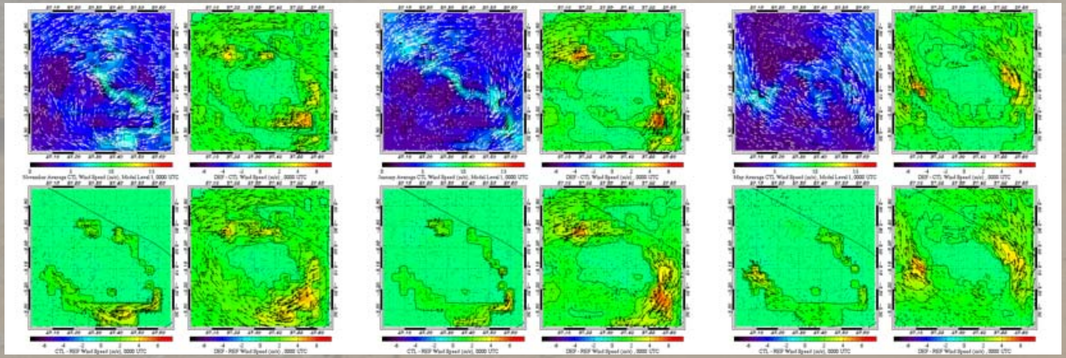
In order to examine the impact of land use change on orographic cloud and precipitation processes, the Regional atmospheric Modeling System (RAMS), assuming three land use scenarios (current, forested and deforested) were used to simulate cloud and precipitation patterns. Cloud and precipitation patterns in the control experiment (current scenario) show good agreement to satellite observations and altitudinal patterns of observed precipitation (*Fairman et al.*, 2011).



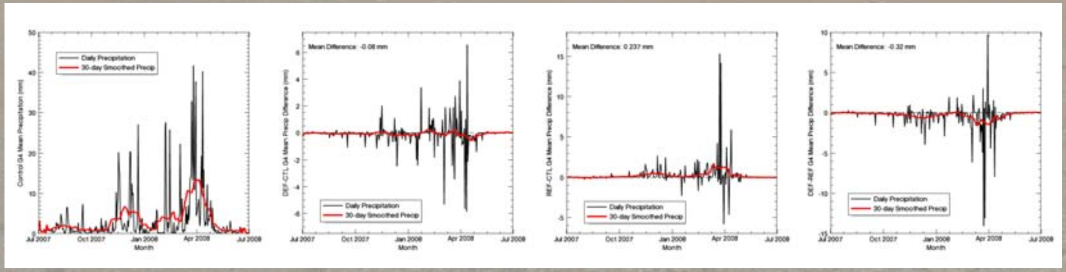
The RAMS simulations show that differing land use scenarios cause different climate patterns around the peak, the peak is not affected during the dry season. However, this does not imply that any effect may not exist during other months.



Regional climate forcing: seasonal variations



There are differing effects of land use change over the course of the year in the Kilimanjaro region. Results show that the areas of wind speed changes differ based on flow direction. While the winds are mainly from the south during July, the apparent direction rotates throughout the year due to transition of the Intertropical Convergence Zone. This causes the wind to shift to easterlies during November and from a northeasterly direction during the secondary dry season in January. Winds originate from the southeast during May, which is during the end of the primary wet season. There are differences in the areas of maximum wind speed difference for all of these months due to the deflection caused by the terrain surface as well as the amount of deforested or reforested area that the winds encounter. There is also a change in the definition of "leeward" and "windward" for each month.



Variations in precipitation are present on a seasonal basis for the control run as well as the differing land use scenarios. Kilimanjaro has a bimodal peak in precipitation coinciding with the transition of the ITCZ, which appears in the grid-averaged daily precipitation totals and is clearly evident doing 30-day boxcar smoothing. The most significant differences in grid averaged precipitation is found during the wet seasons, with the reforested scenario increasing the average precipitation compared to the control run and the deforested scenario decreasing average precipitation. However, there are complex signals that exist in the daily totals due to the mechanisms of the orographic precipitation formation that differ between the deforested and reforested scenarios.

Conclusions

Large scale flow interactions with terrain is responsible for the formation of majority the precipitation at Kilimanjaro. Thus, regional climate forcing, including land use change, may contribute to the observed climate variations at Kilimanjaro. The mechanisms and locations of these regional changes vary with season due to the differences in large-scale wind patterns and atmospheric moisture content associated with the transition of the ITCZ. This leads to a complex response for regional climate patterns, highlighted by a large impact on the amount of precipitation. Both deforested and reforested scenarios show a complex response with the total amount of precipitation over the course of the year, with the majority of the influence occurring during the wet seasons. Wind speeds increase with decreasing forest cover, however the areas differ based on the large scale wind direction.

Acknowledgements

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