Update from the Ewaso Water Project: Weather Patterns of Central Kenyan Highlands

By Trenton Franz

The weather patterns of the Central Kenyan Highlands are a highly complex system influenced by various forces over a wide spatial scale. The annual weather pattern is typically broken into four distinct seasons, two rainy and two dry. There are two mechanisms that are primarily responsible for the four seasons. The Intertropical Convergence Zone (ITCZ) is a low pressure belt that circulates the globe and brings precipitation. The location of the ITCZ oscillates sweeping across the equator twice per year caused by the tilting of the Earth. Temperature and precipitation differences between the two dry seasons are due to the direction of the monsoonal winds. The primary direction of winds in January/February is from the northeast bringing the hot dry air from the Arabian Peninsula. In July/August the winds originate from the southeast bringing the cooler and moister air from the Indian Ocean. The moister air results in sporadic precipitation that punctuates the Laikipia dry season making it look like a small rainy season in the historical record.


Convective Storm - Lizzie King


Continental Storm - Lizzie King

Although the previous two mechanisms are primarily responsible for weather patterns in the region, there is still a great deal of variability. A large portion of the variability can be explained by Mt. Kenya and the steep elevation gradient. Mt. Kenya acts like a large water tower where storms form and distribute radially outward. While passing over the mountains the air masses cool and release moisture causing more precipitation on the windward side of the mountain. Therefore, the southeast face is much wetter than the northwest, known as an "orographic effect".

The other major source of variability is storm type. The two storm types in the area are continental and convective with examples shown in Figure 1. Continental storms originate over large bodies of water where evaporated moisture is transported to other regions by trade winds. The storms typically cover a larger spatial area and are less intense than convective storms. The abundance of large lakes (i.e. Lake Victoria), proximity to the Indian Ocean, and high solar energy input make many sources of precipitation available to the Kenyan Highlands. Convective or "thunderstorms" originate from more local evaporative sources of water from the landscape which are smaller in spatial extent and usually shorter and more intense in nature. The local topography influences the storms which are highly variable over the landscape.

Historical Precipitation Patterns in Kenyan Highlands

The issue of climate change is an enormous problem facing the world today as water becomes more scarce and precious. Long term precipitation datasets are very important for addressing issues such as climate change and identifying trends or cycles in the data. With the efforts of NRM3 and CETRAD there exists an excellent daily precipitation dataset over a wide range of the Highlands for analysis. I am extremely grateful for NRM3 and CETRAD's hard work and willingness to share the dataset, which I used to analyze long-term weather patterns in the Central Kenyan Highlands.

Detection of changes in precipitation patterns were performed on the daily reports from the eighty monitoring stations around Mt. Kenya and Laikipia, comprising over a million individual records. Three parameters were tested for each rainy season: total precipitation, average rain per storm, and average inter-storm arrival time between storms. The parameters were selected to test whether the frequency and/or intensity is changing with time. Figure 2 illustrates the three parameters for the long (March-May) and short (October-December) rainy seasons for Jacobson Farm. Jacobson Farm was selected because it has the longest record length of 68 years. Figure 2 illustrates that annual total rains are not changing but the average rain per storm and time between storms is increasing with time. The more intense infrequent storms coupled with degraded landscapes will result in greater water being lost to system and less moisture available for vegetation. As for the entire basin, the trend is more difficult to detect because of the changing record lengths of the stations. For example, stations with only 15 years of record length may not show significant trends in the parameters. In order to address this problem the stations were categorized by length of record. Table 1 illustrates the increasing percentage of stations with statistically significant trends by minimum record length. Unfortunately, the sample size shrinks from 40 to 11 to 4 for record lengths of 30, 40 and 50 years. However; if the historical trends for Jacobson Farm hold true, there will be serious impacts on the ecosystem.

Current and Future Work

Detection of changes in precipitation is just a first step in the scientific process. A deeper understanding of the mechanisms is essential in order to asses the extent and impacts of the potential change in precipitation. Analysis of the historical rainfall record indicates that a reasonable hypothesis is that convective storms are becoming more abundant in the Kenyan Highlands. The hypothesis is consistent with changing storm depths and frequencies driven by local increasing temperatures and evaporation. An important piece of the future work will be identifying the potential impacts to the vegetation composition from the changing rainfall regime. A way to address potential changes is through mathematical models of the system that are driven by the underlying mechanisms.

The Ewaso Water Project is currently setting up a study that will identify the source of precipitation, based on differences in the isotopic signature of rainwater from different sources. Using this data together with mathematical models of climate systems will hopefully illuminate the mechanisms that may be responsible for the shift in rainfall patterns. Clearer mechanisms will help scientists understand the ecosystem better and make recommendations to landowners and policymakers on the fate of the ecosystem. As of now, three sites have been selected for study: Mpala Research Centre, Mpala River Camp and Loisaba Lodge. The sites represent only a small portion of the Central Highlands, but cover a gradient of moderate to high year-to-year variability in rainfall. The data will be added to the global network of isotopes in precipitation (GNIP) and help answer questions about our most important natural resource. Collection of the samples is as simple as putting a lid on a glass bottle after a rain storm. If you would like to be a part of the isotope study or have any questions, contact Trenton Franz - tfranz@princeton.edu. Data for the article was collected by NRM3 & Cetrad and summarized in "Ecohydrology of the Upper Ewaso Ngiro River Basin, Kenya" by Trenton Franz, Princeton University, Masters Thesis, 2007. Future articles from the Ewaso Water Project will be addressing the feedbacks between the changing hydrology, vegetation and animals.

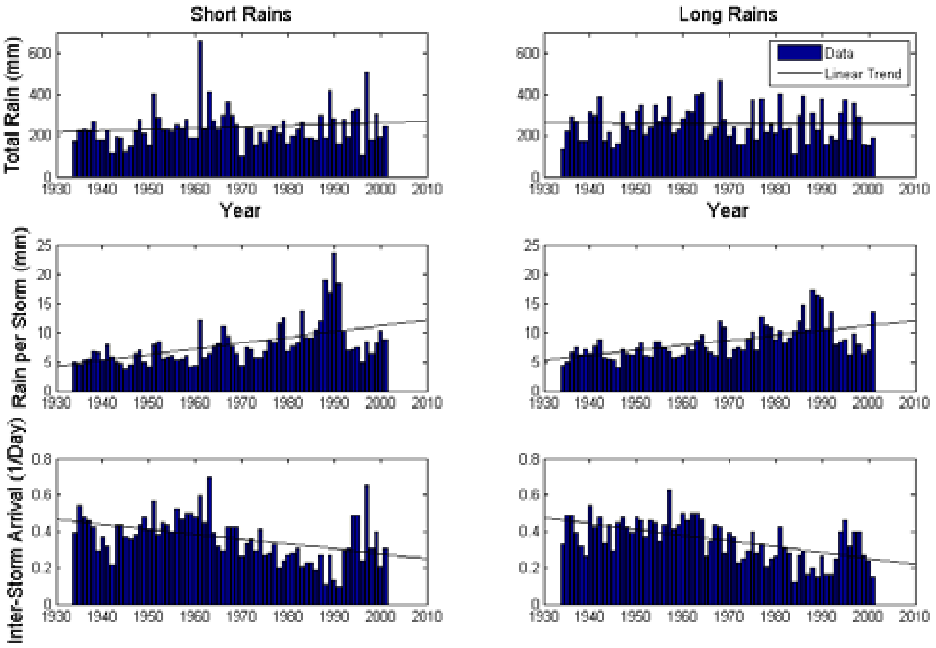

Figure 2. Historical precipitation by rainy season for Jacobson Farm. Flat linear trends indicate total rainfall is not changing but storms are becoming more intense and infrequent with time.

		% of Stations with Statistically Significant Trends			
		Short Rains		Long Rains	
Minimum Record Length (yrs)	Number of Stations	Rain per Storm (mm)	Storm Arrival (1/Day)	Rain per Storm (mm)	Storm Arrival (1/Day)
30	40	23%	33%	25%	35%
40	11	45%	36%	55%	45%
50	4	75%	50%	75%	50%

Table 1. Percentage of stations around the basin with statistically significant trends in average rain per storm and average arrival of storms. Stations with longer record lengths are more likely to have significant trends. Note sample sizes drop from 40 to 11 to 4 for record lengths of 30, 40 and 50 years.

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Borana
El Karama Ranch
Il N'gwesi Lodge
Koija Starbeds
Lewa Wilderness
Loisaba Wilderness
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Ol Gaboli Community Lodge
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Rutundu Log Cabins
Sabuk Lodge
Sosian
Tassia
The Sanctuary at Ol Lentille

RANCH HOUSES
Laragai House
Lewa House
Lolldaiga Hills
Mukima House
Mutamaiyu House
Ol Pejeta House

CAMPSITES
Bobong
Il Polei Conservancy
Kaptuya Community
Kuri Kuri Group Ranch
Morupusi Group Ranch
Mukogodo Forest
Ngare Ndare Forest
Nkiloriti Group Ranch
Tiemamut Group Ranch

TENTED CAMPS
Elephant Watch Camp
Kitich Camp
Lewa Safari Camp
Makena's Hills
Ol Pejeta Bush Camp
Sangare Ranch Tented Camp
Sarara Tented Camp
Sweetwaters Tented Camp

HOTELS
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Karisia Walking Safaris
Nanyuki River Camel Camp
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