Cloudbridge Meteorological Update 2013

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Background

Cloudbridge is situated in a Tropical Montane Forest on the Western slope of the Talamanca mountain range in south-western Costa Rica. Located at roughly 9° 28' N and 83° 34' W, it is located farther south and east from Monteverde, Costa Rica's more famous Tropical Montane Forest (10° 15' N and 84° 46' W). Despite this fact, day lengths can still be compared. Monteverde's sunlight ranges from 11 hr 32 min in December, to 12 hr 42 min in June (Nadkarni and Wheelwright 2000). Due to the lack of reliable daylight data here at Cloudbridge, we can use Monteverde's daylight hours as a proxy for our own. This rigid sunlight regime, attributable to the low latitude, helps create a stable climate.

Like Monteverde, Cloudbridge is at elevation—though a little higher (Monteverde ~1440 m, Cloudbridge ~1520). This feature is perhaps the most distinguishing factor in create the Cloud Forest, as the elevation is the component that allows moisture in the air to condensate and form clouds. The elevation also keeps the average temperatures lower than the surrounding lowlands on the coast.

Another geographic characteristic that affects Cloudbridge's climate is the relative thinness of Costa Rica. Because Costa Rica is part of the isthmus that separates the Caribbean Sea from the Pacific Ocean, it does not generate continental low pressure areas, and thus relies on the maritime weather fronts to bring wind and precipitation. Most notably, the migration of the Inter-Tropical Convergence Zone (ITCZ) brings moisture to Costa Rica via the trade winds, creating the phenomenon known as the rainy season. Typically from April to November, the rainy season experiences a marked increase in precipitation. The trade winds also drive clouds and fog into the area, which alone constitute large moisture inputs into the environment, keeping the forest wet and cool.

All of these characteristics make the Tropical Montane Forest unique, cresting an extremely bio-diverse flora and fauna that we are lucky to study.

Temperature

The two most significant factors in determining the temperatures at Cloudbridge are the elevation and the cloud cover. The relationship between elevation and temperature can be described by the adiabatic process. With an increase in elevation, the density of gas decreases. This phenomenon is important, because when warm air rises, it expands to compensate for its lower density. In expanding, the air's internal energy decreases, and it loses heat. Thus, at higher elevations, air temperatures a colder.

With the Data we have collected since 2003, we have daily high and low daily temperatures. Because our data are incomplete (we have roughly 35% of 2003-2012), looking at the results in aggregate is more accurate than tracking the change over time. Here are the aggregate high and low temperatures by month from the data we have:

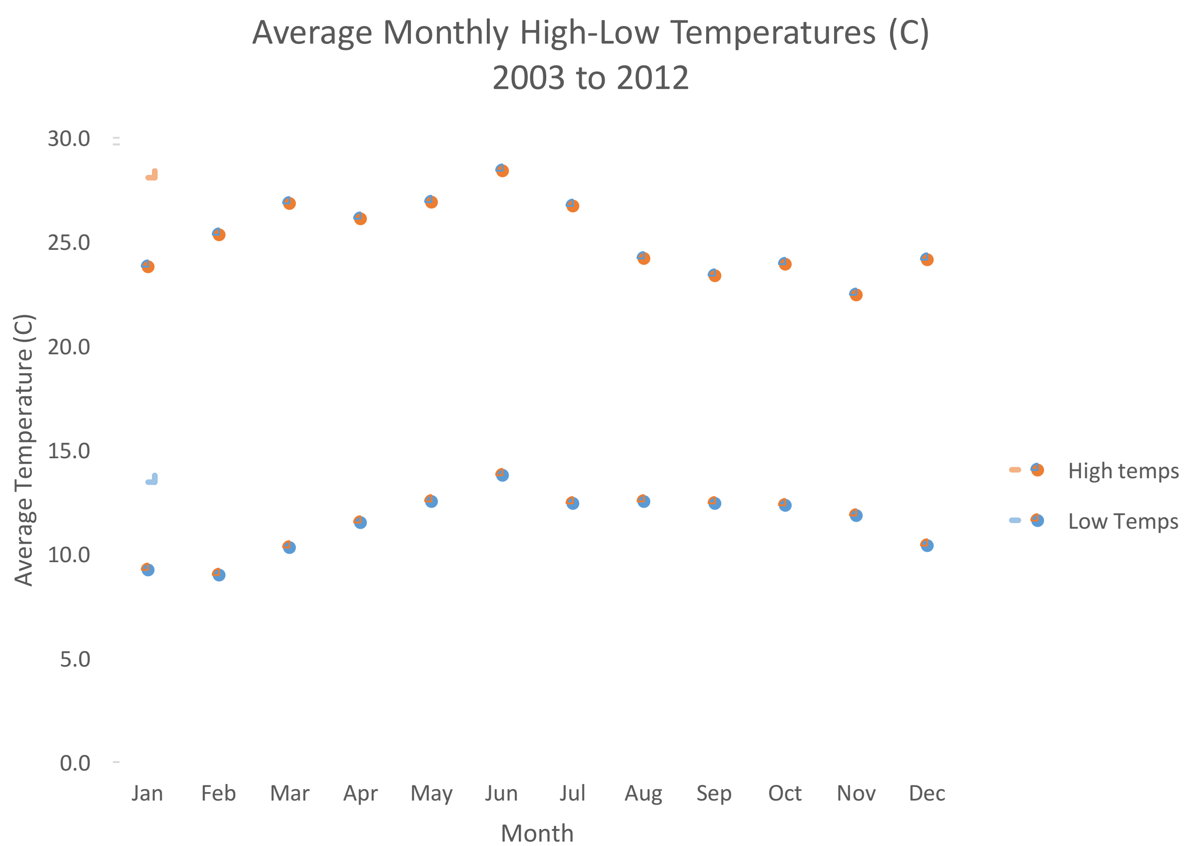

Figure 1. Average Monthly High-Low Temperatures (° C).

These data clearly show that June is by far the hottest month, which can be attributed to the prolonged hours of sunlight received. There is also a peak in high temperatures during March, however, the lows do not show a comparable spike. We can also see that the spread of temperatures is not uniform. The period from August to November has a smaller difference between high temperatures and low temperatures, while the months from January to June have a much wider distribution. In short, the days are hotter and the nights are colder during the dry season, while the rainy season is characterized by more consistent temperatures. Perhaps this phenomenon can be explained by the constant cloud cover during the rainy season that insulates the forest at night, and keeps the sun off during the day.

Rainfall

Similar to the Temperature data, we do not have a complete record of rainfall here at Cloudbridge. Thus, it is hard to compare rainfall trends over time due to missing data (see figure 2). However, monthly aggregate data are useful in visualizing the yearly trend in the rain regime. Here is a graph of monthly rainfall averages over the period of 2003 to 2012:

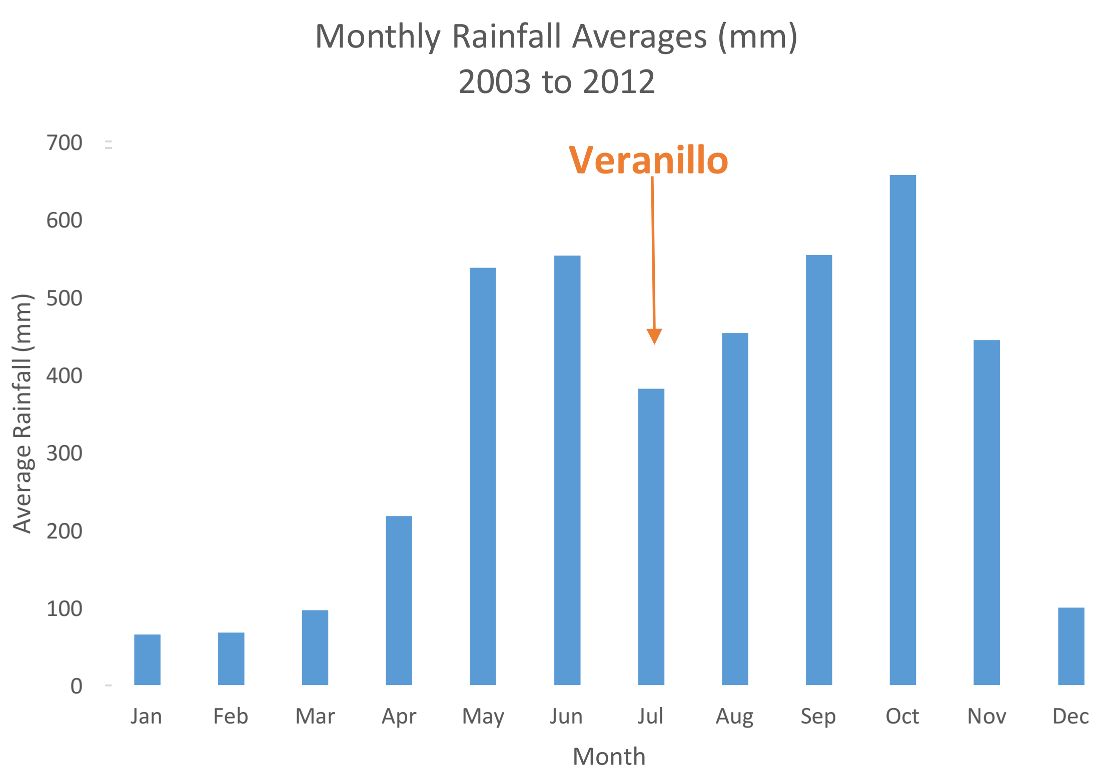

Figure 2. Cloudbridge Monthly Rainfall Averages (mm) 2003-2012.

The rainy season at Cloudbridge is generally from May to November, with November being the rainiest season. After November, the drop-off is dramatic, and December experiences little rainfall. April is a transition month towards the rainy season, and experiences about 40% of the rainfall of May, the true start of the wet season. A fairly regular period of less rain in the wet season occurs in late July or early August, and is known as *Veranillo*. This corresponds to the migration of the ITCZ to its northernmost boundary, and the decreased wind brings less precipitation to Costa Rica. This also corresponds to abatement in the rainy season at Monteverde. If a *Veranillo* comes early, closer to the end of June, it is known popularly as a "*Veranillo de San Juan*".

Comparing the rainy season at Cloudbridge to the rainy season at Monteverde, we see that ours lasts longer and is more severe (see Figure 3). Monteverde's rainiest month is October, and November (our rainiest month) is more of a transition to the dry season. Our rainiest month (November) has an estimated 100 mm more rainfall on average than Monteverde's rainiest month (October), and the rest of our rainy season—with the exception of our *Veranillo*—still receives more rain than their rainiest. Interestingly, April is not part of their rainy season, and is in fact the second driest month after March. So, Monteverde has a quick transition from dry to wet, and then finishes the rainy season with a transition back to dry. Whereas Cloudbridge has a transition from dry to wet during April, and then almost no transition from the rainiest Month of October to the dry days of December. This foil in rainy season characteristics may be due to the relative locations of Cloudbridge and Monteverde. Cloudbridge lies on the western flank of the Talamanca range, while Monteverde is situated on the eastern slope of the Tilarán range. So the difference may come from the Caribbean aspect of Monteverde and the Pacific aspect of Cloudbridge receiving winds carrying weather and precipitation from their respective oceans.

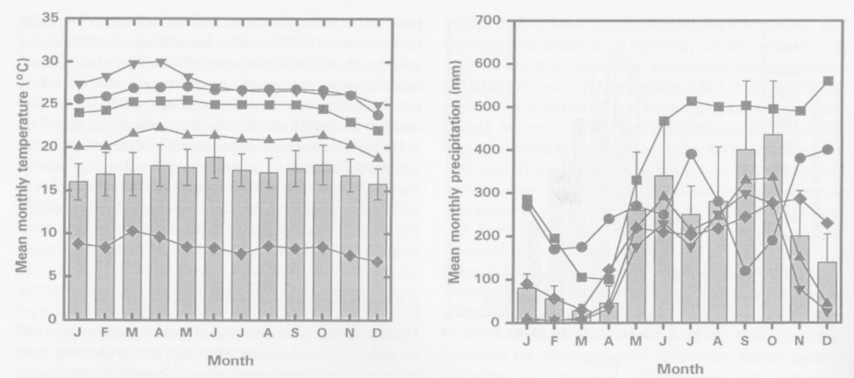

Figure 2.5. *(left)* Mean monthly temperature (°C) at 1460 m at Monteverde (■; mean ± mean monthly minimum and maximum values), Limón (●), Ciudad Quesada (■), Irazú (◆), San José (▲), and Puntarenas (▼). See Table 2.1 for site descriptions. Figure 2.6. *(right)* Mean monthly precipitation depth (mm) at 1460 m at Monteverde (■; mean ± 1 S.D.), Limón (●), Ciudad Quesada (■), Irazú (◆), San José (▲), and Puntarenas (▼). See Table 2.1 for site descriptions.

Figure 3. Monteverde Monthly Rainfall Averages (mm).

Sources of Error

Obviously the lack of data at Cloudbridge presents a source of error, but in looking at the aggregate data instead of yearly data, error is reduced. Another source of error in the collection of rain data is the fact that much of the water supporting the Tropical Montane Forest comes not from precipitation, but rather directly from the clouds. A study conducted at Monteverde estimates that wind-driven hydrologic inputs account for 22% of water in the system. Thus, a cloud water collector adds increased insight to standard rain gauge data, and should be considered for future research at Cloudbridge.

Conclusions

It is hard to deduce any temporal trend in the rainfall and temperature regimes at Cloudbridge due to the lack of data, but the aggregate comparisons by month are sufficient to explain trends in the data over the course of the year. The striking dry/wet seasons are the largest dictators of precipitation and temperature spread, and in the region are the main indicators of seasons. These seasons are created by the migration of the Inter-Tropical Convergence Zone (ITCZ), where increased activity of the trade winds brings precipitation and weather to the Tropical Montane Cloud Forests of Costa Rica. Much of the moisture is trapped in clouds, which both insulate the forest from hot and cold temperatures, as well as adds to the hydrologic model directly through the process of evapotranspiration occurring in vegetation.

Though similar in climate, seasonal precipitation varies slightly between Cloudbridge and Monteverde, showing different transitions zones and rainiest months. These differences can be explained by spatial variances between the two locations, specifically aspect and elevation.   However, despite their differences, the extensively studied Monteverde serves as a good supplement to bolster Cloudbridge's meteorological data.

References

Nadkarni, Nalini M. and Nathaniel T. Wheelwright (editors). 2000. "Monteverde: Ecology and Conservation of a Tropical Cloud Forest".Oxford University Press: New York, New York.