DOES EVIDENCE SUPPORT THE HYPOTHESIS OF AN INTENSIFICATION OF COSTA RICA HYDROLOGICAL CYCLE

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Why is this important?

Regarding Central America as a climate change hotspot, several questions on how significant long term precipitation and temperature changes are still open. Observational analysis often fail to provide robust evidence of long term trends mainly due to data scarcity and poor quality. Climate projections suggest the increase of temperature and rainfall in locations such as Costa Rica. The projected easterlies intensification has been pointed out as a trigger of a regional hydrological cycle intensification. In order to evaluate this hypothesis, a detailed analysis of historical meteorological records was conducted. Long term variations of precipitation, number of rainy days and temperature extremes were studied. The latter in order to question whether observations support or not the proposed intensification of the hydrological cycle in the region and to evaluate the role of precipitation deficits for the increase of temperature extremes.

The long term meteorological record analyzed for Costa Rica

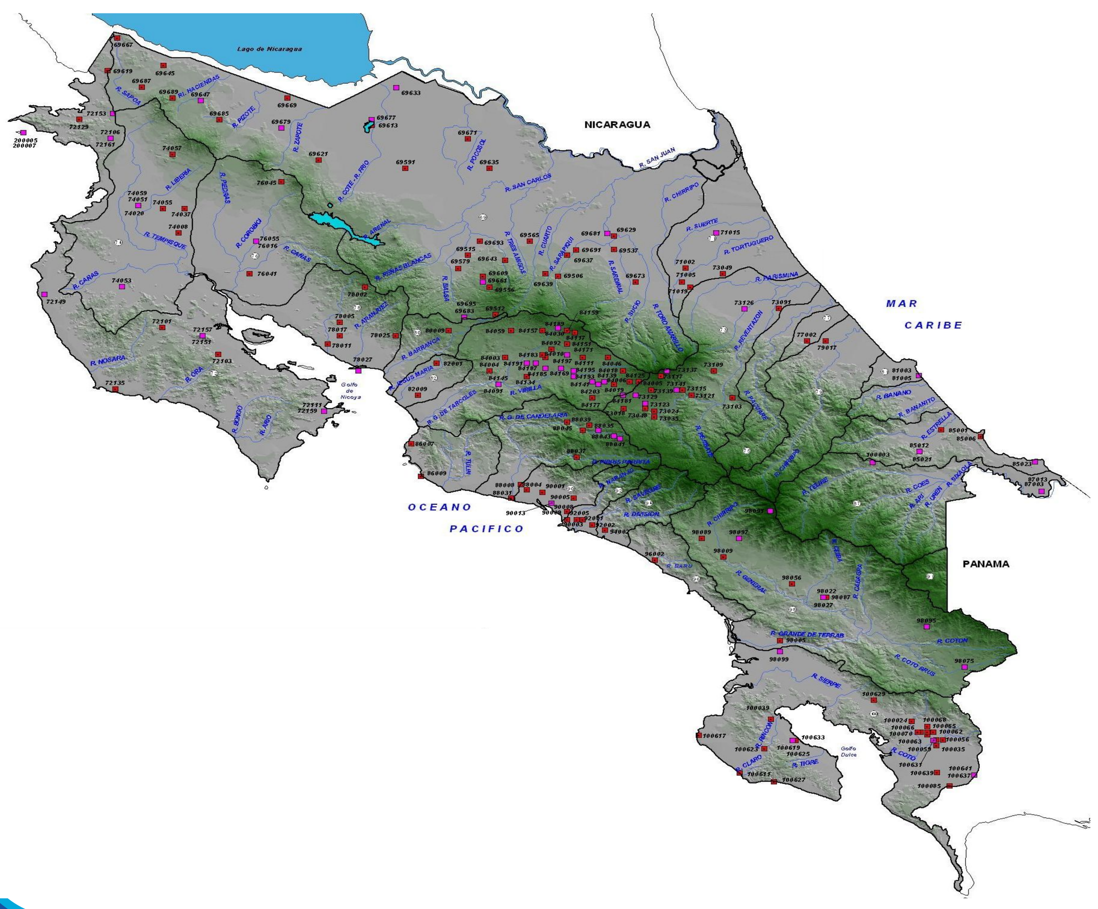


Figure 1: Location of meteorological stations used for the analysis, red squares indicate mechanical stations and pink squares automatic meteorological stations. 198 of the stations are operated by the NMI, 36 stations from additional sources are also included in the dataset.

Data from nearly 240 meteorological stations was compiled to create the analysis dataset spanning from the late 19th century to 2015. After the quality control, the period 1943-2015 was selected to be used for 147 stations. A second QC process was applied based on homogeneity and low number of missing data criteria, final dataset includes 64 observation sites for precipitation and 32 sites for diurnal temperature range (DTR). Statistical analysis was implemented to precipitation, number of rainy days and DTR to obtain information of anomalies (baseline period 1981-2011), long term trends (based on non-parametric Mann-Kendall and Sen test) and differences between the last two decades.

Precipitation climatology

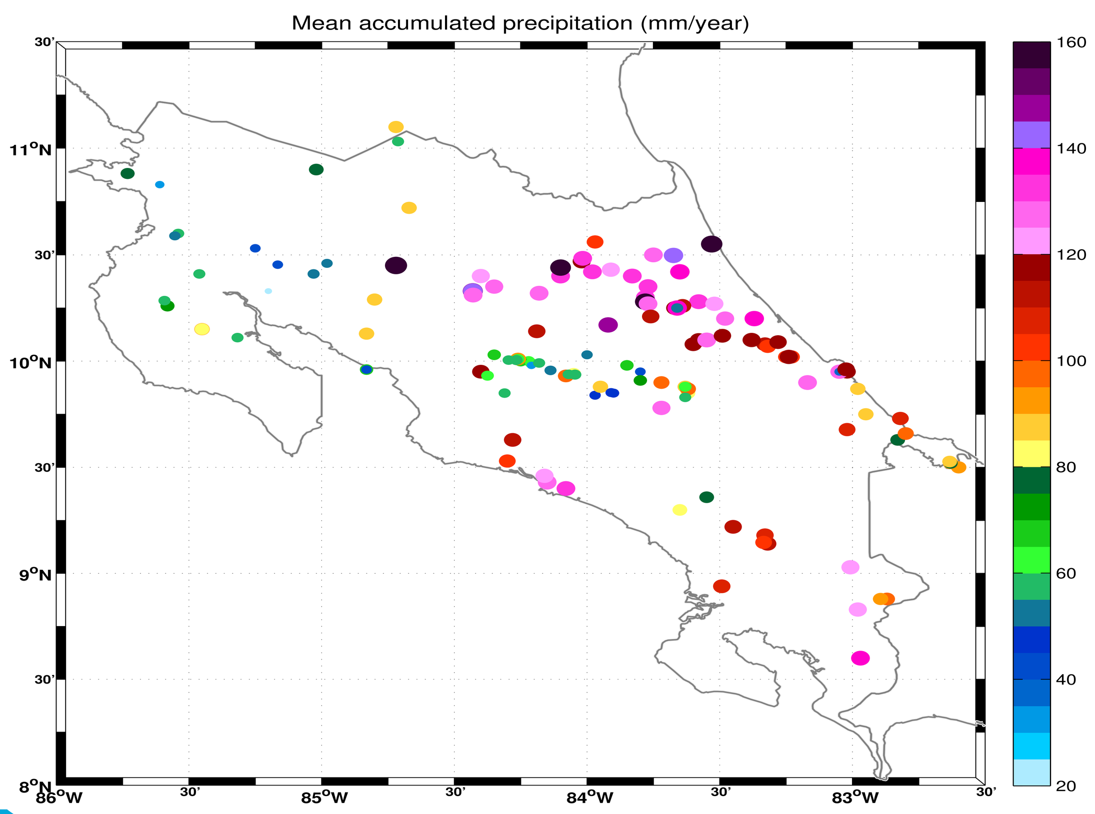
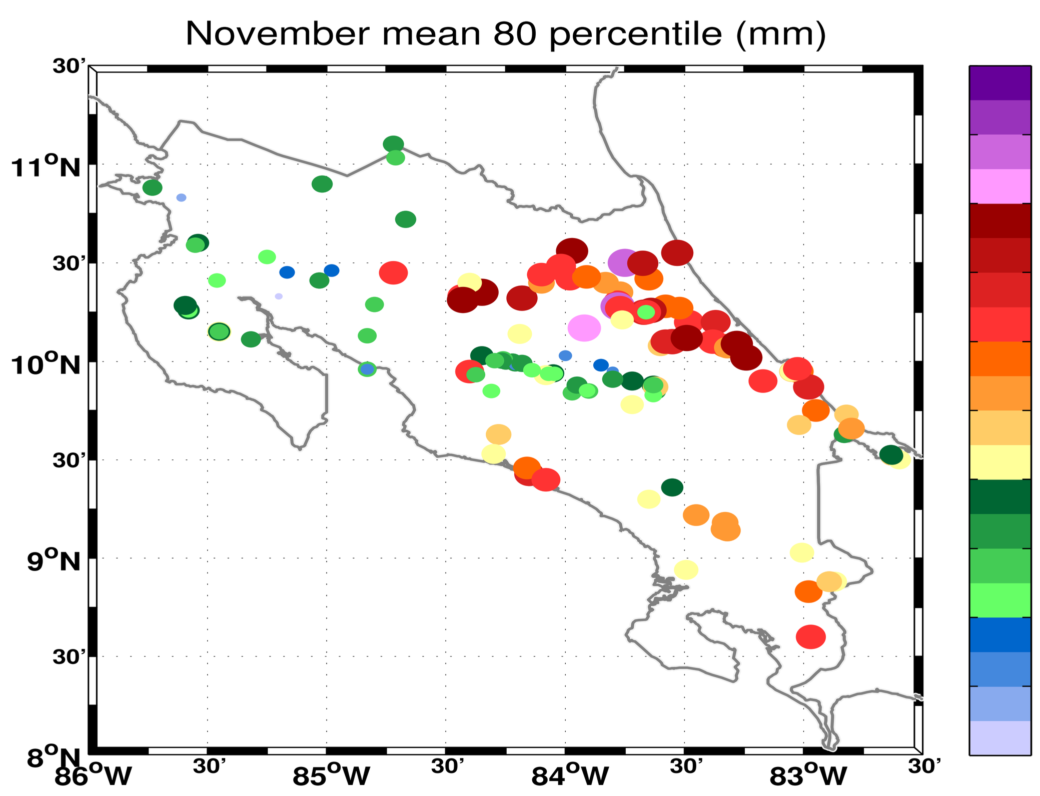


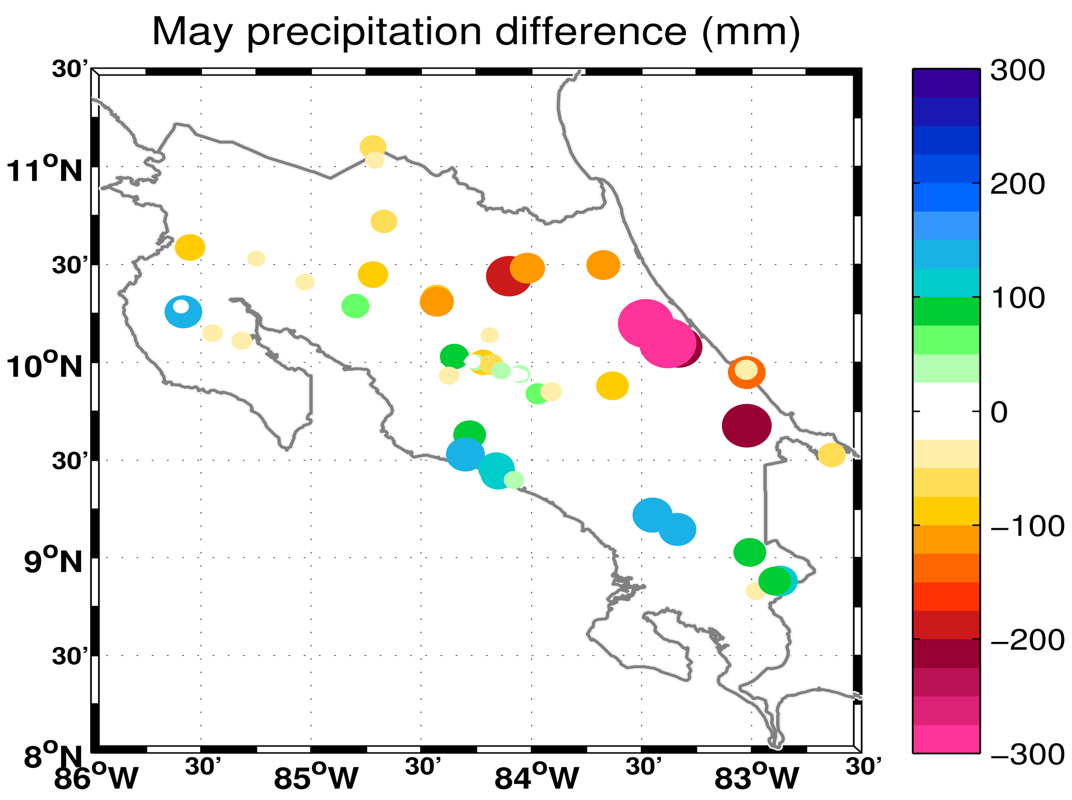
Figure 2: Mean accumulated rainfall in mm/year based on the dataset record .

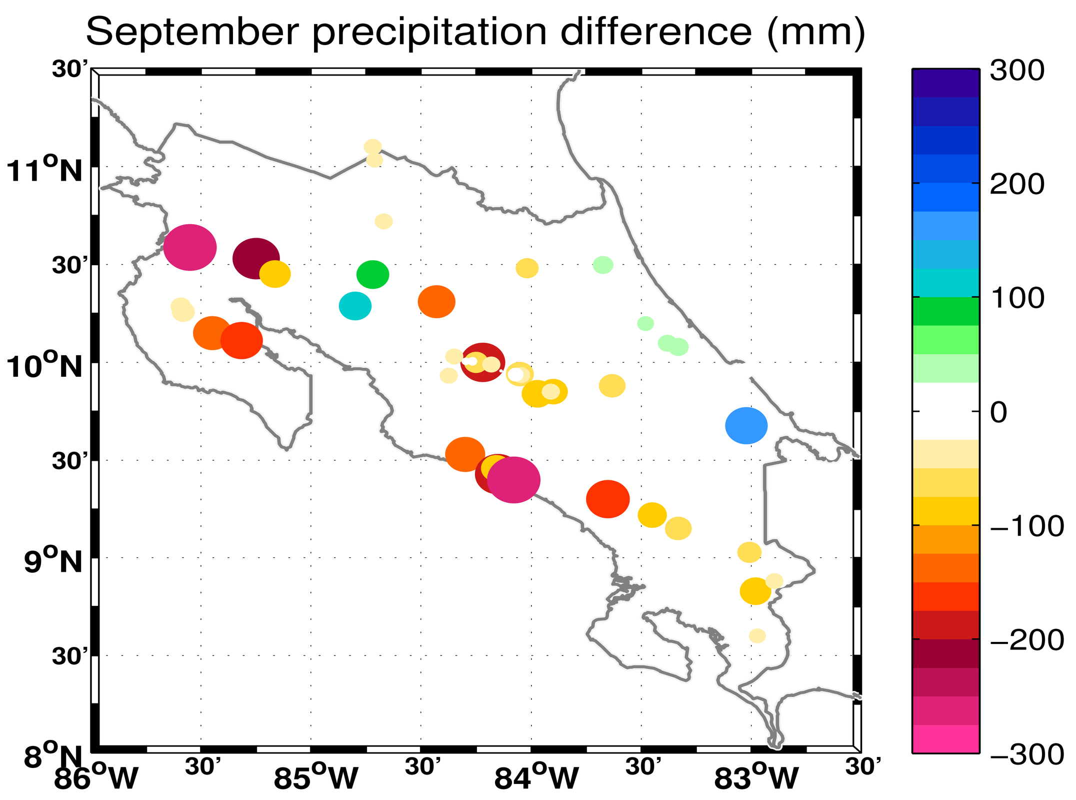
Historically, annual average Costa Rica rainfall exceeds 240 mm with locations in which total rainfall values can be larger that 325 mm. Figure 2 shows mean accumulated precipitation for the baseline period, from which the Pacific-Caribbean contrast is remarkable. The Caribbean and South Pacific regions are featured as the wettest locations in the country with the coastal areas highly sensitive to floods.This contrast is enhanced as the region experiences the effect of different tropical perturbations. A similar pattern is observed during the year with variations corresponding to the rain producing systems activity.

Figure 3: Mean accumulated rainfall for rainy events over the 80th percentile for November.



Precipitation detected significant changes





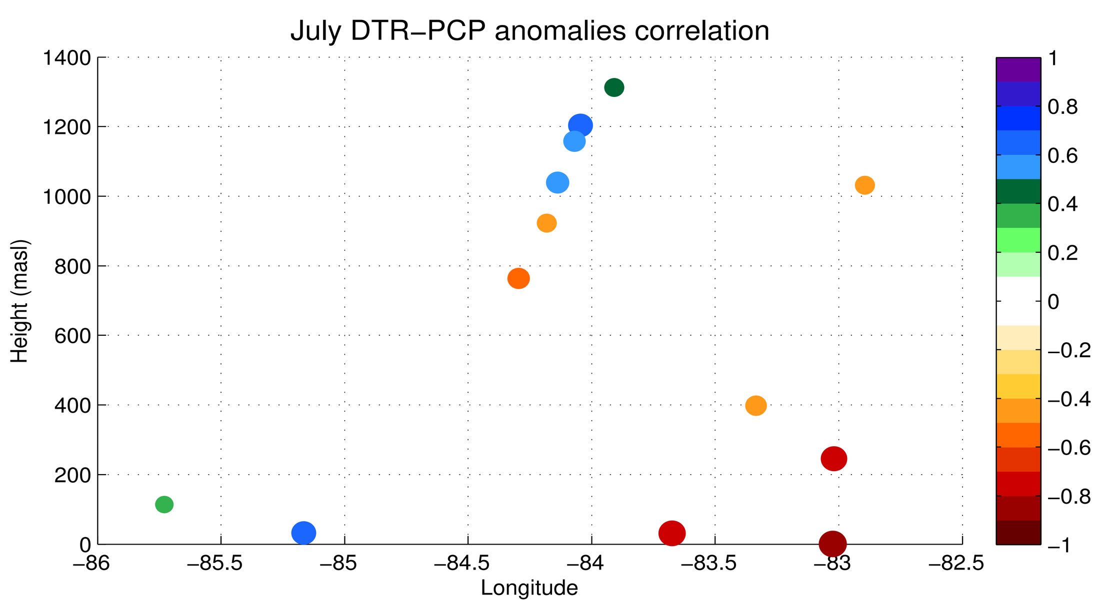
Figures 4 and 5: Mean accumulated precipitation difference in the last two decades.

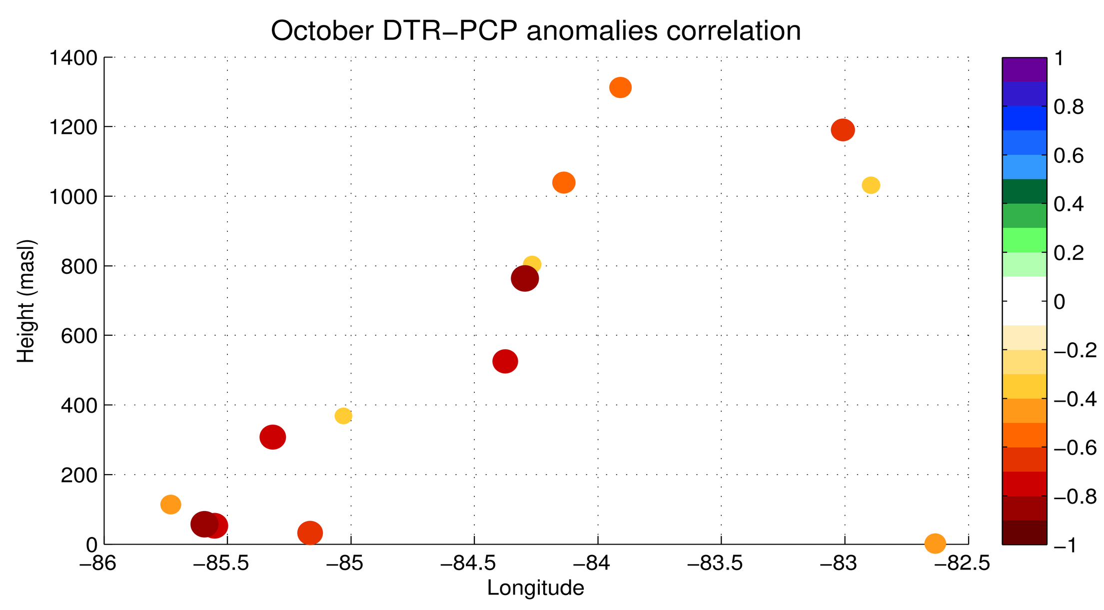
Significant precipitation trends were detected for several stations with locations showing a sustained change for more than 40 years . Considering the annual cycle and precipitation differences for the last two decades, the two peaks of the rainy season show an opposite behavior as during the first (second) peak the Caribbean (Pacific) slope is becoming drier. Rainfall increases are much smaller than the detected drying trends which implies new challenges for water and energy management. It was determined that the number of rainy days is also changing accordingly. It is not only the rainfall decreasing but the amount of rain producing systems affecting the region rainfall, whether caused by a an overall decrease of the systems or the displacement outside the influence area.

Precipitation-Diurnal Temperature Range links

Precipitation-DTR anomalies present a linear relationship. As deficits in precipitation has been linked with the increase of high diurnal temperature extremes and both DTR and precipitation trends were detected form the data. The DTR and precipitation long term trends and anomalies were analyzed in light of their linear relationship. It was found that there is a height threshold for which the link is reversed. A threshold was identified at approximately 1000m and the reversal only occurs during the transition period in the leeward side of the mountain range.

Figures 6 and 7: Correlation coefficient between DTR and precipitation anomalies time series. The plot shows the distribution of stations in height.





Remarks

1. The observations reveal long term significant trends in both DTR and precipitation unlike previous studies which state that precipitation trends are not significant.
2. The preliminary results of this research do not support the hydrological cycle intensification from the Clausius-Clapeyron relationship classical perspective. As the feedback between moisture and temperature trends is not positive for all the cases. Instead, it is proposed that the nature of large and local scale forcing variations should be considered. Remarking that for the region, the large scale forcing is a dominant feature of the rainfall intensity and distribution.
3. The DTR-precipitation relationship height reversal is a worth analyzing problem due to its implications for ecosystem transition studies.
4. Detected strongly negative precipitation trends point to new challenges in water resources and hydropower electricity plants management.

Acknowledgements

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