The diurnal and annual cycles of precipitation in the transition of an Andean valley to the Amazon basin

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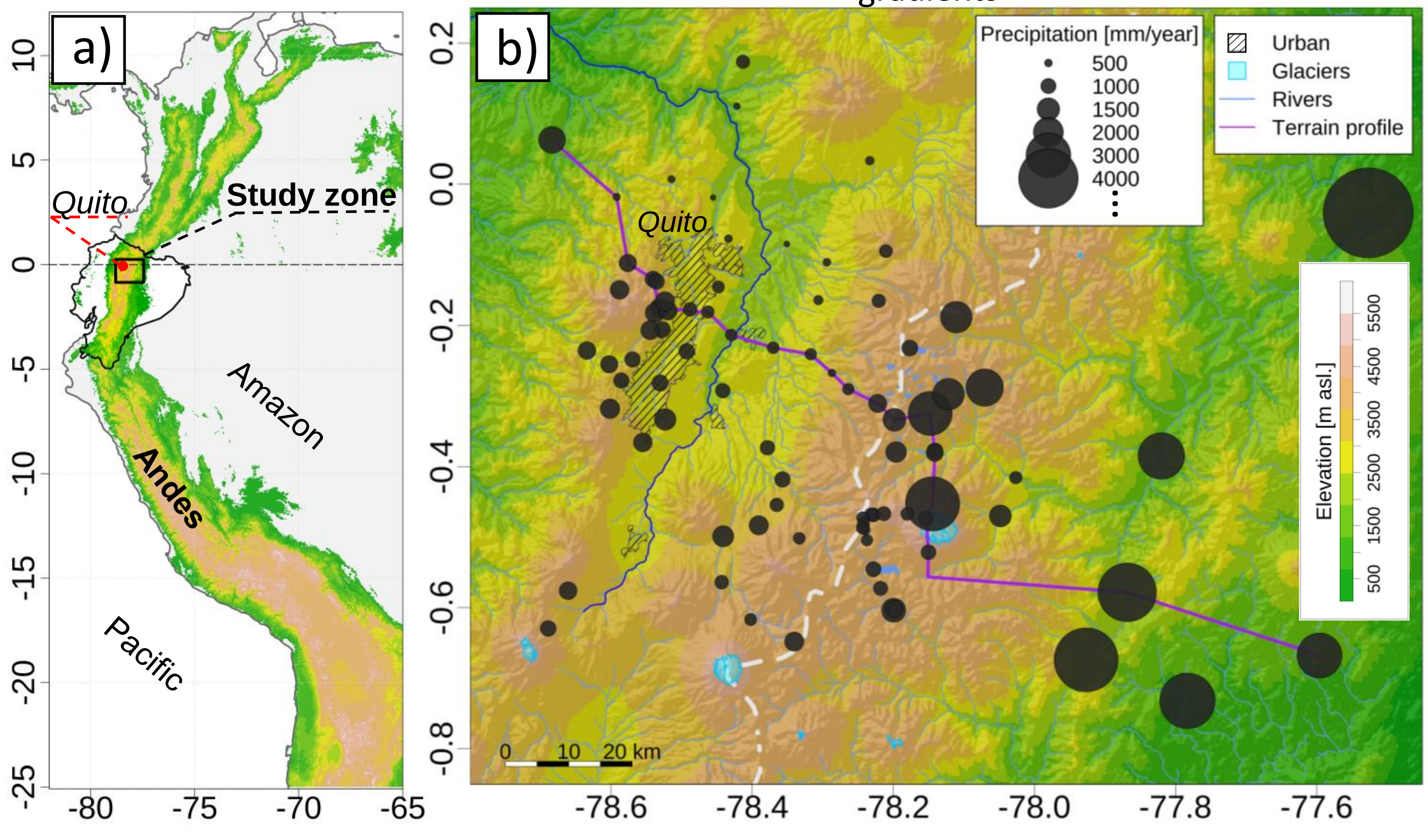
1. Introduction

The Andes is one of the largest mountains chains in the world characterized by **complex topography** and acts as a barrier between **cold and dry** eastern Pacific and **warm and moist** Amazonia giving rise to complex precipitation patterns (Fig b).

The **study zone** is located on the Equatorial Andes-Amazon transition zone (Fig. a) and it is particularly important because over this area a wide meteorological monitoring network has been deployed to retrieve information and improve water management practices and ecosystem services specially with regards to Quito's water supply .

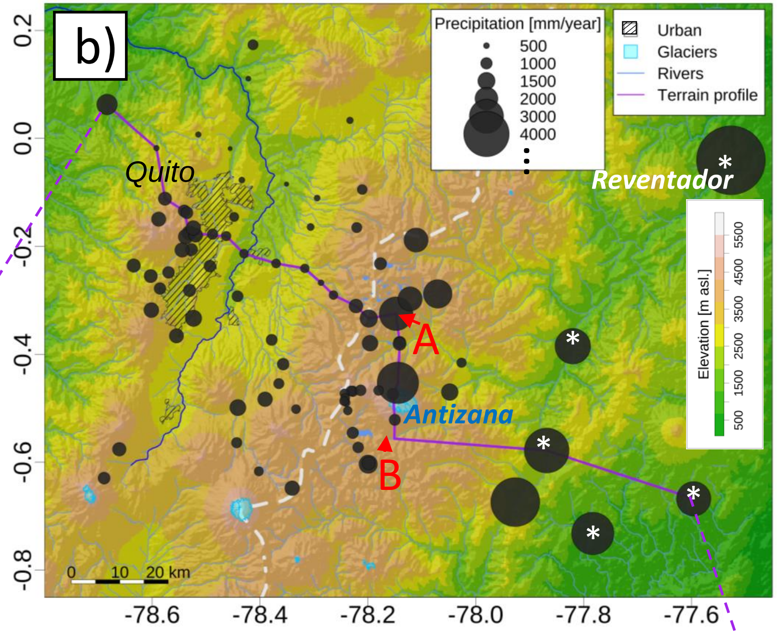
Mean Annual precipitation of the study zone. The **purple** line is a topographical transect to further describe spatial precipitation gradients

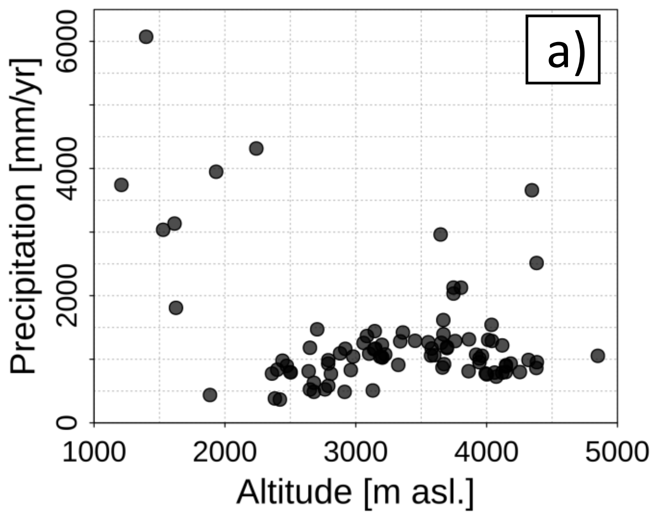


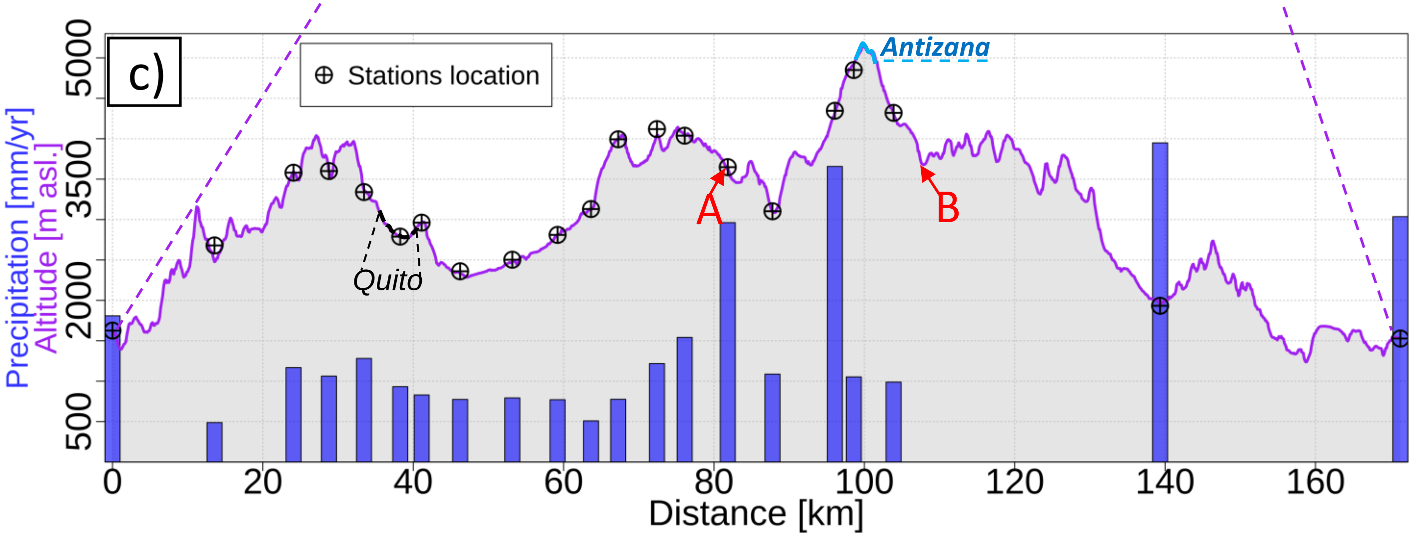
Therefore, in this work we aim to characterize the diurnal and annual cycle of this region with a highly contrasted precipitation between eastern and western sides

2. Spatial distribution of precipitation

We used a set of **90 rainfall stations** mostly at **hourly time step** to characterize diurnal and annual cycles of precipitation in the study zone during the **2014-2019** period. Figure b) evidently shows the high contrast between the Andean valley and the Amazon slope (see **Reventador**, one of the rainfall hotspots documented along the Andes Cordillera eastern side). The white dashed line is the local boundary between the Pacific and Amazon basins where different precipitation regimes are expected to be superposed. The topographic transect highlights high precipitation spatial gradients mainly in the section **A-B** where differences up to 1500 mm/yr have been observed between stations located at shorter distances than 5 km (Fig. c). Additionally the **Antizana** glacier where several glaciological studies are conducted is located here. On the other hand, altitude seems not to be an explanatory variable of rainfall variability in the zone (Fig. a)



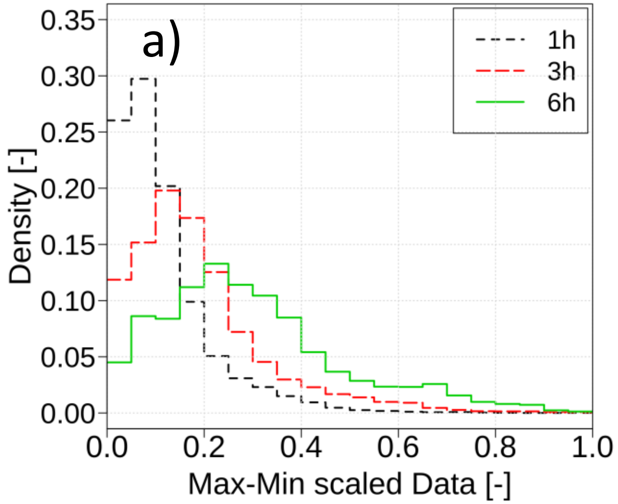




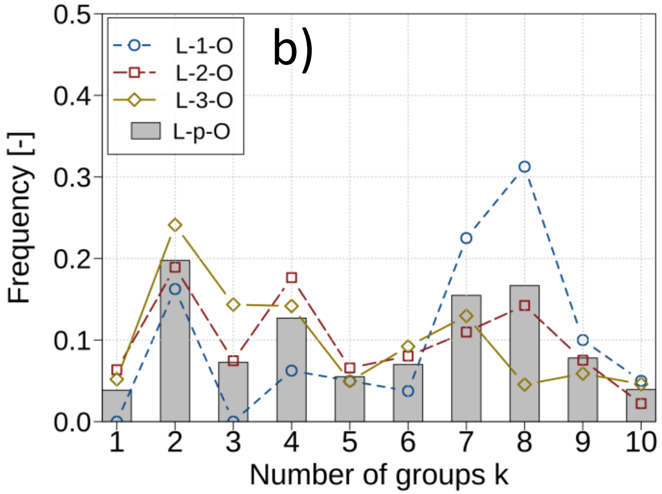
3. How to obtain information from the diurnal cycle ?

As shown before, high variability of annual precipitation could skew or conduct to wrong interpretations of the diurnal cycle (Poveda et al. 2005, Bedoya et al. 2019). Therefore, we investigate as suggested by these authors the distribution of the seasonal diurnal cycle implementing the following procedure:

1. Computation of the distribution of seasonal diurnal cycle for each rainfall station.
2. Reduction of the skewness of data through aggregation until it can be grouped by a clustering method.
3. Investigation of a suitable number of groups to perform a Partitioning Around Medoids. In this case a medoid is a representative station of the group.
4. And localize geographically this groups and medoids in the study zone.



Data is aggregated until 6h time steps in order to keep sub-daily precipitation features. This **6h-data** is suitable to be clustered (Fig. a).



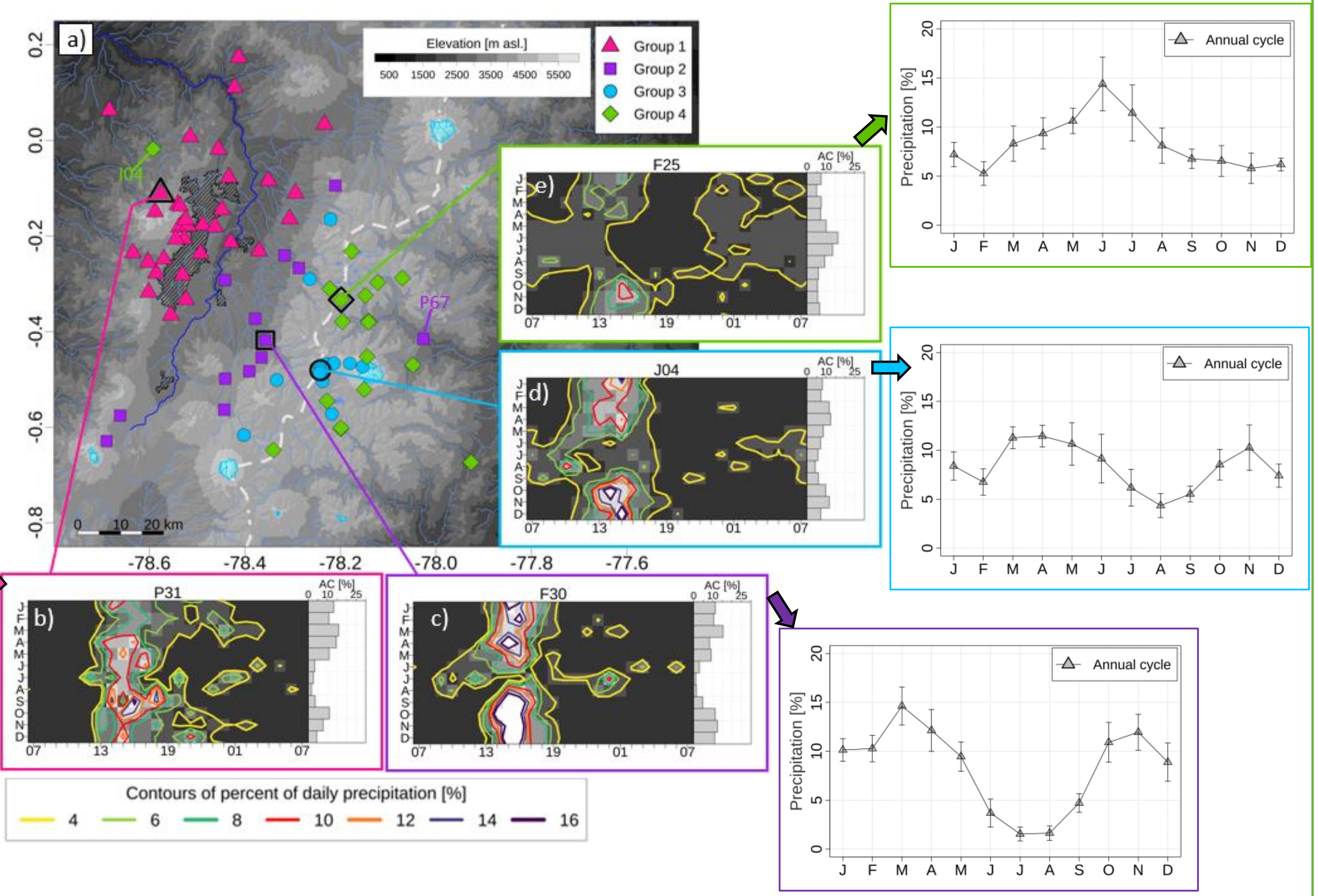
Three tests **Leave-p-Out** stations (L-p-O), with **p=1,2,3** using the **Gap Statistic** (Tibshirani et al. 2001) was performed and we registered the frequency of each number of groups suggested. To identify an appropriate number of groups we **averaged the three tests**. We found that **4 groups** are coherent with the aim of our study although higher number of groups are recommended. The measure to choice a group is the height of the gray bars (Fig. b).

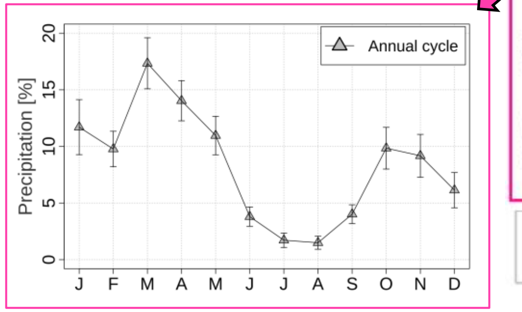
4. The diurnal cycle groups and the related seasonality

The four types of Diurnal Cycle (tDC) and medoids (bold shapes) are displayed in Figure a). From a general point of view groups are distributed in NW-> SE direction.

tDC1 (Fig. b) concentrates precipitation around 13:00-19:00 LT and shifts until 01:00 LT during March and November. tDC2 (Fig. c) concentrates precipitation around 13:00-19:00 LT and increase its amplitude to 08:00-01:00 LT during July and August. tDC3 (Fig. d) concentrates precipitation around 10:00-18:00 LT and increase its amplitude to 01:00-18:00 LT during June-August. Finally, tDC4 (Fig. d) concentrates precipitation almost all day with little absence of precipitation around 17:00-22:00 LT during January-September.

Concerning to seasonality, tDC1 and tDC2 are related to bimodal regime with higher precipitation occurring during March-April and October-November, tDC3 is also related to bimodal regime but with a slight contrast between rainy and little rainy months. On the other hand, tDC4 is related to unimodal regime with its maxima in June.



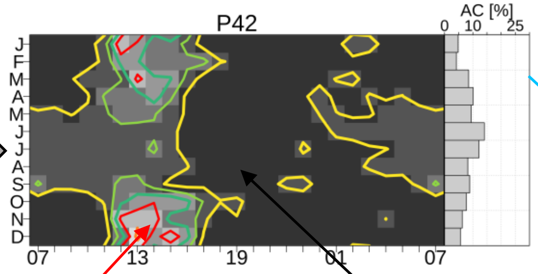


5. Conclusion and final remarks

1. A set of 90 rain stations describes the diurnal and annual cycles contrast between the Andean valley and the Amazon slope in the equatorial Andes-Amazon transition zone (78.5°W, **0.5°S**, land area of ~18000 km^2)
2. The diurnal cycle captured by stations is strongly related to seasonality and shows a high spatial variability regardless of altitude in a **relatively small zone**.

Among all the applications of this detailed description of the diurnal cycle, a practical example is described in the following scheme:

Diurnal and annual cycles of a station close to a current meter gauging point.

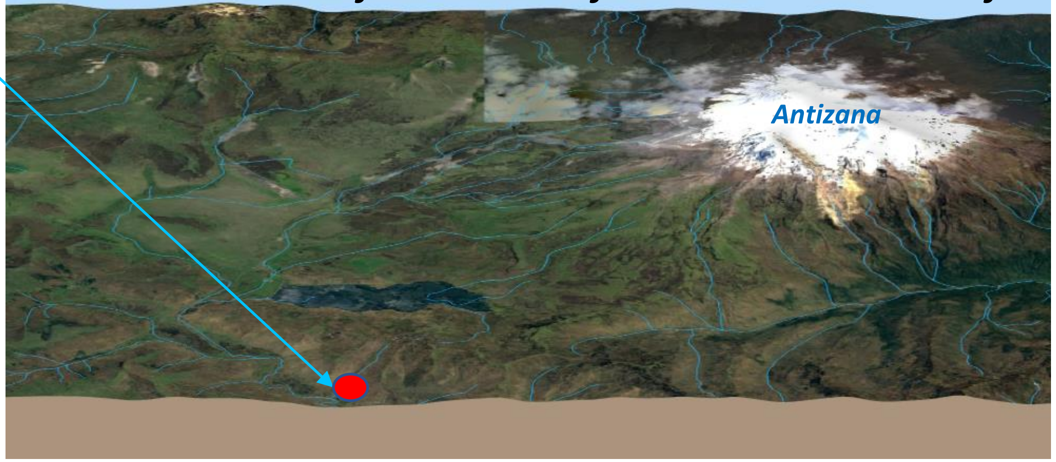


Red contoured areas show some months and specific hours when precipitation is highly concentrated relatively to the annual cycle.

As opposite to red contours, shaded areas show smooth precipitation daily concentrations during months when the annual cycle reaches its maxima

New insights for field work planning in order to capture either high or low streamflow

Southern view of a section of the Antizana massif



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A. Supplementary

Mosaic of diurnal and seasonal cycles of the Group 2

Here, we present all the members of the Group 2 related to tDC2. In this case, precipitation is concentrated around 13:00-19:00 LT and increase its amplitude to 08:00-01:00 LT during July and August.