ICRC-CORDEX 2023
International Conference on Regional Climate
25-29 September 2023

MEDIUM-TERM AND LONG-TERM CHANGES IN THE EXTREME PRECIPITATION INDICES IN COLOMBIA, USING THE CORDEX-RCM SAM-20-CCCMA-CANESM2-ETA

Juan Diego Giraldo-Osorio
j.giraldoo@javeriana.edu.co
Researcher at *Instituto Javeriano del Agua*, and in the research Group *Ciencia e Ingeniería del Agua y el Ambiente*.
Pontificia Universidad Javeriana, School of Enginnering, Civil Enginnering Deparment.
Bogotá D. C., Colombia.

INTRODUCTION

Extreme precipitation events (EPE), including heavy rain and droughts, are becoming more frequent and intense in many parts of the world due to climate change [1, 2]. This increase in EPE can lead to more flooding and landslides, which can cause significant damage to infrastructure and communities [3]. At the same time, climate change can also lead to more frequent and severe droughts, particularly in regions that are already experiencing water scarcity [1]. Understanding the causes and impacts of EPE is essential for developing effective strategies for managing and adapting to climate change. This requires combining observational data, climate models, and statistical analyses [4]. Using these tools, the complex relationships between climate variability, climate change, and extreme precipitation events can be better understood.

Colombia is a country characterized by complex topography and diverse climatic conditions. The study by [5] analyzed the ENSO-driven variability and long-term changes in extreme precipitation indices in Colombia, using satellite rainfall estimates (CHIRPS). The authors found that extreme precipitation events in Colombia have become more frequent and intense in recent years, with significant variations depending on the region. For instance, the study found that in the Andean region of Colombia (the most populated of the country), EPE have become more frequent and intense during the La Ni˜na phase of ENSO, while in the Pacific and Caribbean regions, extreme precipitation events have become more frequent and intense during both El Niño and La Niñaa phases (depending on the specific area). These findings highlight the need for region-specific strategies for managing and adapting to EPE in Colombia. The impacts of EPE in Colombia can be severe, with flooding and landslides causing significant damage to infrastructure and communities. For example, in 2017, Colombia experienced one of the deadliest landslides in its history, which killed more than 300 people and caused extensive damage to the town of Mocoa (southern part of the country, in the Amazonian region of Colombia; [6]).

STUDY AREA AND DATASET

The study area corresponds to the whole continental territory of Colombia. Colombia is located in the northwest corner of South America, and the country has shorelines to both the Pacific and the Atlantic Ocean, through the Caribbean Sea (see Fig. 1).

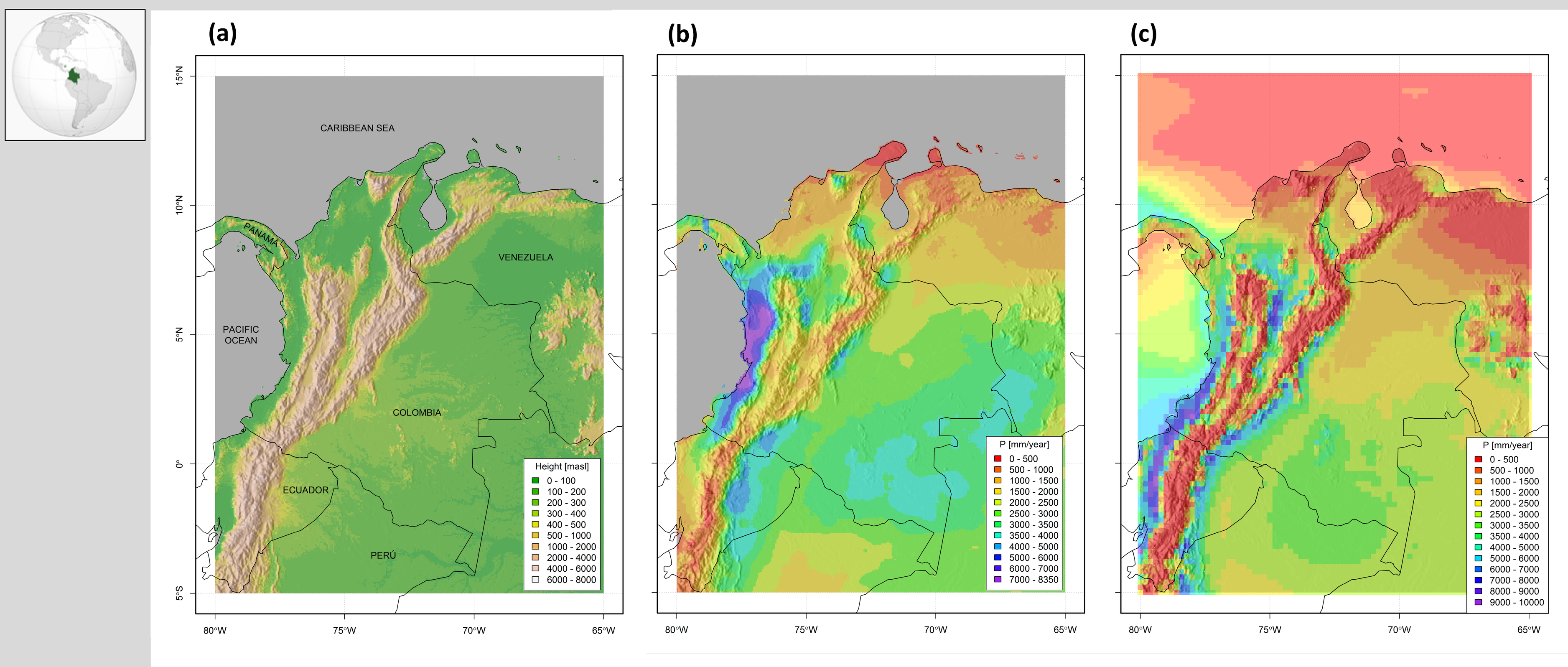


Fig. 1. Location of the study area. The topography of Colombia (a), and the mean annual precipitation computed using CHIRPS (b) and the selected RCM (c), are shown. As can be seen, the precipitation in Colombia is strongly driven by the Andean Mountain Chain, that is coarsely caught by the RCM. Colombia can be divided into four main climatic areas: the Caribbean coast in the north (the driest one), the Pacific coast in the west (the wettest one), the Andean region (center), and the eastern plains of Orinoco and Amazonas basins (east).

The precipitation data were collected from CHIRPS database (*Climate Hazards Group InfraRed Precipitation with Station* as observed data for comparison purposes), and the CORDEX Regional Climate Model (RCM) *CCCma-CanESM2-Eta*. The selected RCM has 0.2° spatial resolution (South America's SAM-20 domain) and daily time resolution. The RCM maps were spatially trimmed off, in such a way the study area was completely covered (between 5°S-15°N and 80°W-65°W, 76x101 pixels; see Fig. 1c).

EXTREME PRECIPITATION INDICES (EPI) DEFINITION

The CCI/CLIVAR/JCOMM/ETCCDI group developed a set of 27 climatic indices, which should be computed using daily rainfall and/or temperature data. The subset of indices related to precipitation was selected for this work. (from now on, *Extreme-Precipitation Indices* -EPI-), with slight modifications in the original definitions, which can be found in Zhang et al. (2011). It is important to highlight the most important modification is about the time slides to compute the EPI: the *hydrological year* was taken between one-year's June, and next year's May as in [5].

In each *gridpoint* of the study area, EPI time series were built, according to the definition given in Table 1. As can be seen in Table 1, EPI have been defined with annual temporary resolution (i. e. according to the previously defined *hydrological year*). So, annual series between 1960/61-2098/99 were built (i. e. the time series length was 139 years).

Table 1. Extreme precipitation indices definitions, as they were used in this work. The definitions are based on both Zhang *et al.* (2011) and ETCCDI web page http://etccdi.pacificclimate.org/list_27_indices.shtml.

ID	Index name	Index definition	Units
Rx1day	Maximum 1-day precipitation amount	Annual* maximum 1-day precipitation	mm
Rx5day	Maximum 5-day precipitation amount	Annual* maximum 5-consecutive-days precipitation	mm
PRCPTOT	Total wet-day precipitation	Annual* total precipitation from wet days	mm
Wet days	Wet days	Annual* number of days with P ≥ 1 mm	day
SDII	Simple daily intensity index	Total wet-day precipitation (PRCPTOT) to wet days ratio	mm/day
R10mm	Number of heavy precipitation days	Annual* number of days with P ≥ 10 mm	day
R20mm	Number of very heavy precipitation days	Annual* number of days with P ≥ 20 mm	day
CDD	Consecutive dry days	Annual* maximum dry spell length (consecutive days), where P < 1 mm	day
CWD	Consecutive wet days	Annual* maximum wet spell length (consecutive days), where P ≥ 1 mm	day
R95	Yearly very wet precipitation amount	Precipitation annual* amount which belongs to 95th percentile	mm
R95pTOT	Total precipitation on very wet days	Annual* total precipitation from days where P > R95	mm

**Annual* is referred to a period between the day June the 1th in year *i*, and May the 31th in year *i+1*.

DISCUSSION

Preliminary results show that, in general, there is a tendency for the EPIs to become drier (i.e., fewer days with heavy rain, lower intensity of extreme events, longer dry spells, shorter wet spells, etc.) for both scenarios (changes with larger negative/positive magnitudes for the RCP85 scenario). However, as in the work of [5], the trends highly depend on the selected region. For example, Fig. 3 (top) shows the RCP45 results for the EPI *Rx1day* in the two future windows considered; positive changes were observed in the Andean region of Colombia (these changes will be more accentuated in the distant future). Still, the observed difference is scattered in the remaining Colombian regions. Fig. 3 (bottom) shows the results obtained for the RCP85; a scattered behavior of the trends can be observed for the near future, but unambiguous positive (Andean region) or negative changes (Orinoco river plain of Colombia and Venezuela) for the far future.

EPI TIMESERIES

In order to get an idea of EPI magnitude in the study area, the EPI time series in each gridpoint.

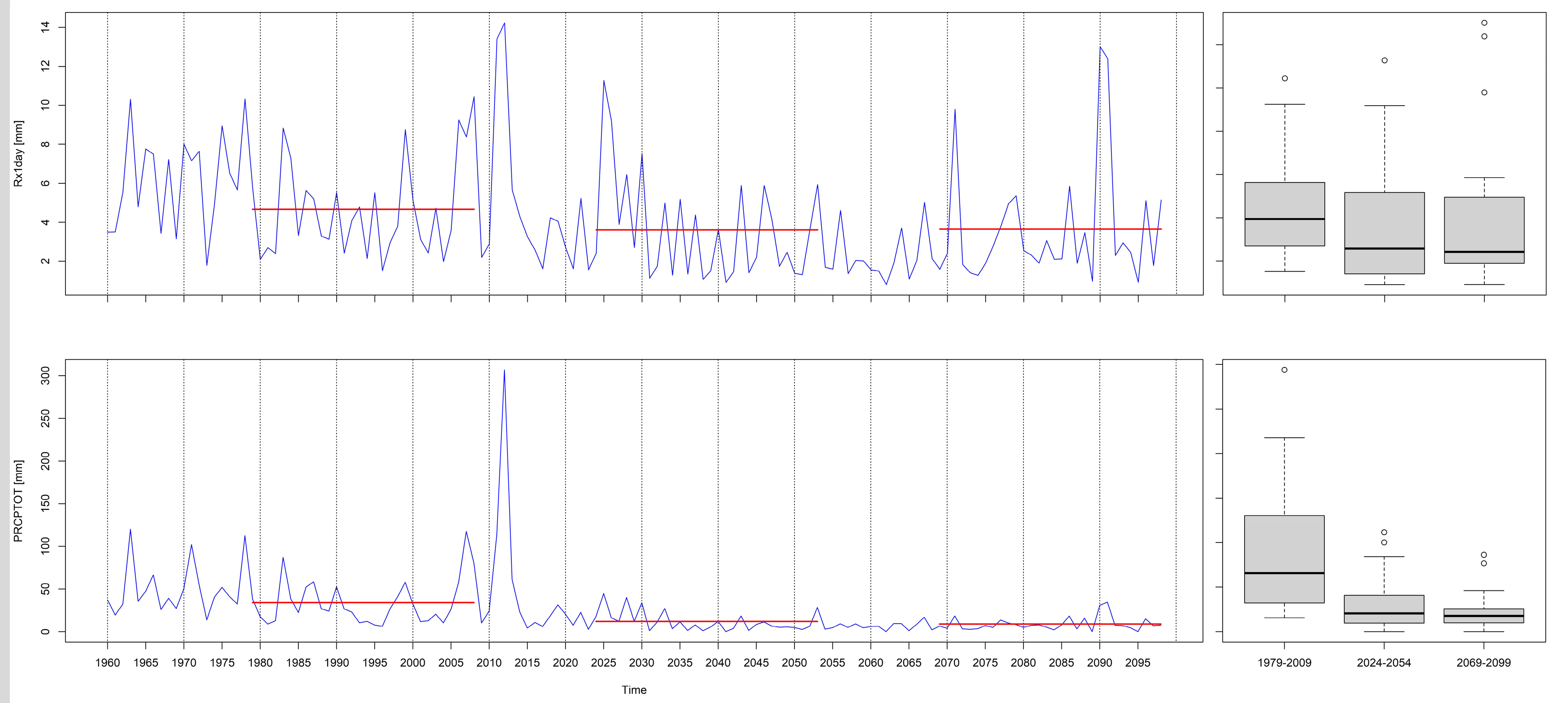


Fig. 2. Time series of selected EPI (top: *Rx1day*; bottom: *PRCPTOT*) at the example gridpoint (left panels), together with corresponding boxplots which depict the EPI distribution in the historical period 1979-2019, near future 2024-2054, and far future 2069-2099 (right panels).

LONG TERM CHANGES OF EPI

The Mann-Whitney-Wilcoxon (MWW) test was used to decide whether two samples, taken from each EPI time series, belonged to the same population. The samples to perform the MWW test were taken from three timespans (historical 1979-2019, near future 2024-2054, and far future 2069-2099). The maps in Fig. 3 show the relative change in the selected EPI, together with the *p-value* computed for the MWW test.

Fig. 3, Relative changes in the EPI *Rx1day*, computed as

$$\Delta EPI = 100 \cdot (\overline{EPI}_{scen} - \overline{EPI}_{hist}) / \overline{EPI}_{hist}$$

where
hist is the *historical period* 1979-2019
scen can be the two future periods:
- 2024-2054 -left panels, near future-, or…
- 2069-2099 -right panels, far future-.

Top panels: Results for RCP45.
Bottom panels: Results for RCP85.

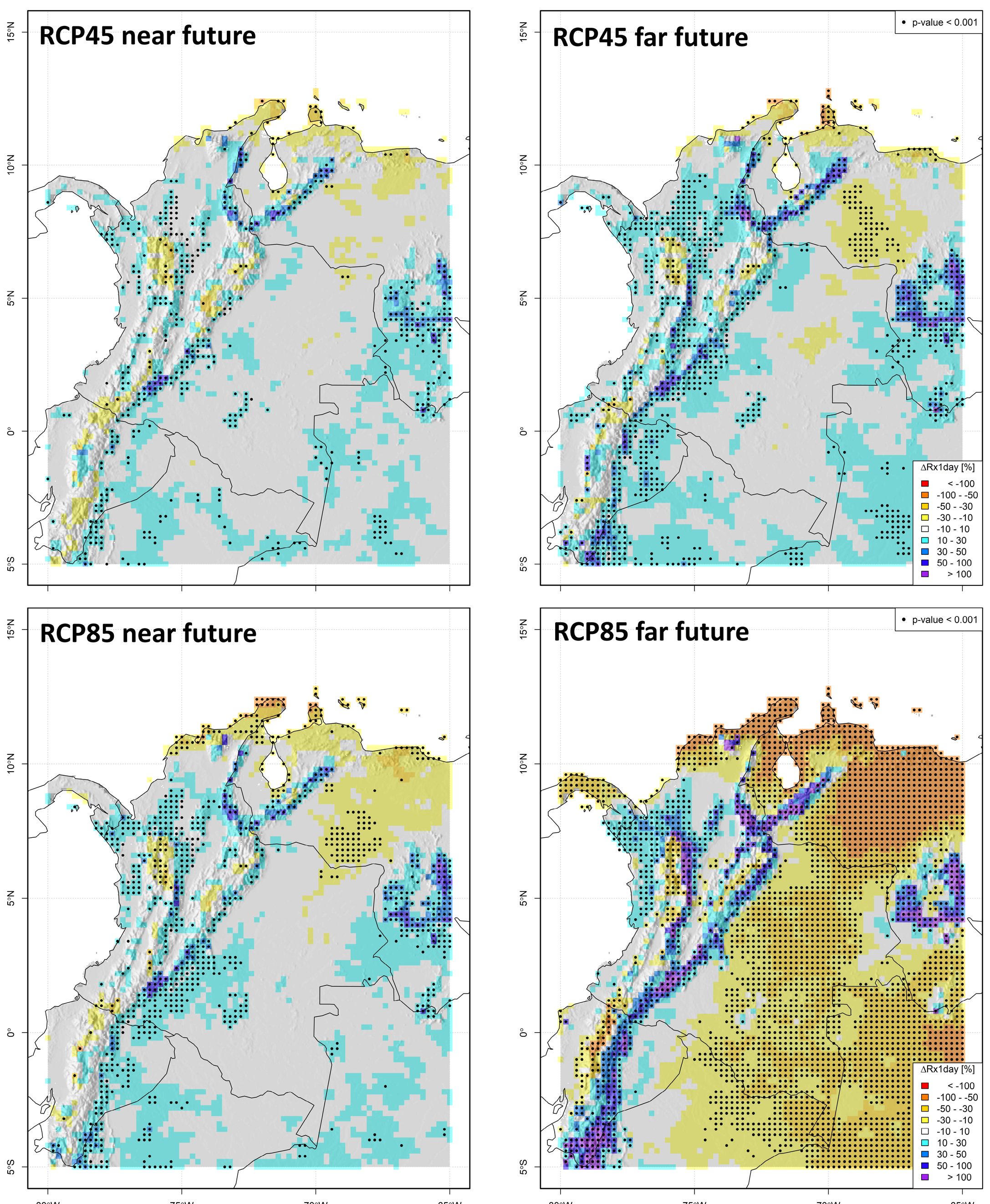
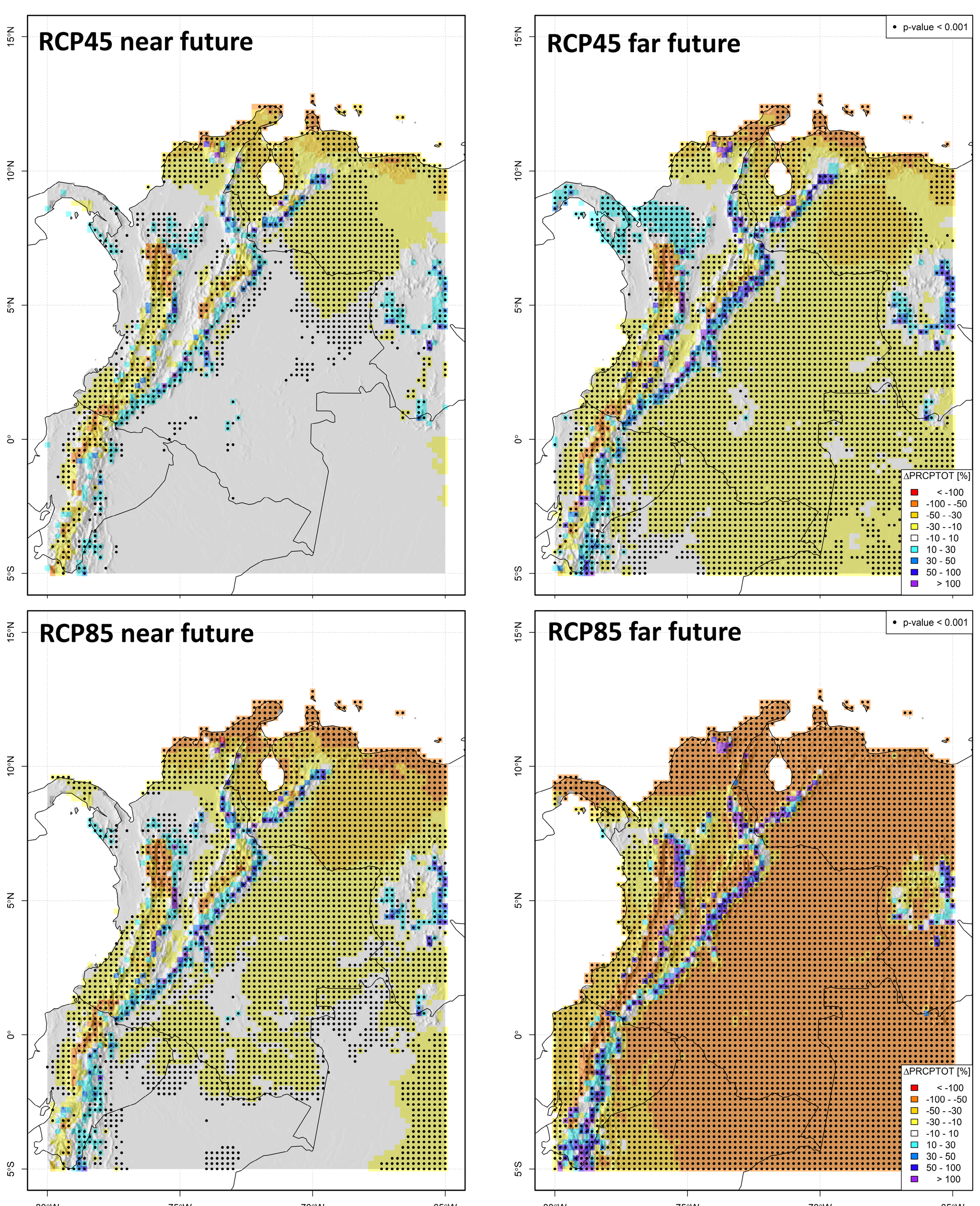


Fig. 4, Relative changes in the EPI *PRCPTOT*, computed as

$$\Delta EPI = 100 \cdot (\overline{EPI}_{scen} - \overline{EPI}_{hist}) / \overline{EPI}_{hist}$$

where
hist is the *historical period* 1979-2019
scen can be the two future periods:
- 2024-2054 -left panels, near future-, or…
- 2069-2099 -right panels, far future-.

Top panels: Results for RCP45.
Bottom panels: Results for RCP85.



REFERENCES

[1] IPCC. (2021). *Climate Change 2021: The Physical Science Basis*. Contribution of Working GroupI to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.
[2] Trenberth, K. E., et al. (2014). *Global warming and changes in drought*. Nature Climate Change, 4 (1), 17-22.
[3] Dai, A. (2013). *Increasing drought under global warming in observations and models*. Nature Climate Change, 3 (1), 52-58.
[4] Donat, M. G., et al. (2016). *Updated analyses of temperature and precipitation extreme indices since the beginning of the twentieth century: The HadEX2 dataset*. Journal of Geophysical Research: Atmospheres, 121 (22), 12,597-12,616.
[5] Giraldo-Osorio, J.D., Trujillo-Osorio, D.E. & Baez-Villanueva, O.M. (2022). *Analysis of ENSO Driven variability, and long-term changes, of Extreme Precipitation Indices in Colombia, using the satellite rainfall estimates CHIRPS*. Water, 14 (11), 1733.
[6] Velásquez, N., Hoyos, C. D., V´elez, J. I. & Zapata, E.. (2020). *Reconstructing the 2015 Salgar flash flood using radar retrievals and a conceptual modeling framework in an ungauged basin*. Hydrology and Earth System Sciences, 24, 1367-1392.