- 247: Implications of Central America Hydroclimatic Changes on Water Security III Online Discussion Session
- Online Session - Online Session IV

11:00am - 12:00pm. Tue, Jun 21 GMT-04:00

- Primary Convener:

Hugo Hidalgo, University of Costa Rica

Convener:

Iris Stewart, Santa Clara University

Edwin Maurer, Santa Clara University

Eric Alfaro, University of Costa Rica

Chair:

Iris Stewart, Santa Clara University

Adolfo Quesada-Román, University of Costa Rica

Eric Alfaro, University of Costa Rica

Smallholder livelihoods throughout Central America are built on rain-fed agriculture and depend on seasonal variations in temperature and precipitation. The effects of global change in this highly diverse region are not well understood due to sparse observations and complex interactions between the land and seas bounding the isthmus. We invite presentations that focus on the causes, signals, measurement, and impacts of changes in precipitation, aridity and drought in the region. We are particularly interested in connecting hydrologic changes to implications for water access, water resources, and water conflict at the local scale.

Index Terms

1812 Drought

1833 Hydroclimatology

1834 Human impacts

1854 Precipitation

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247-01 - Future Changes in Simulated Streamflow in Costa Rica from CMIP6 climate models

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Frontiers in Hydrology Meeting, American Geophysical Union

June, 2022

Title: Future Changes in Simulated Streamflow in Costa Rica from CMIP6 climate models

Authors: Hidalgo, H.G.; Alfaro, E.J., Quesada-Román A.

Abstract:

Statistically downscaled daily data from an ensemble of five General Circulation Models (GCMs) from the Climate Model Intercomparison Program 6 (CMIP6) will be used to determine changes (with respect to a baseline historical scenario) in the magnitude of the 20-year return period streamflow for 34 basins covering Costa Rica at horizons corresponding to mid-century and end-of-century. The climate models used were selected according to Almazroui et al. (2021), which proved to have the lower biases in reproducing the region's climate. The chosen downscaling method corresponds to a delta approach described in Navarro-Racines et al. (2020). The hydrological simulations were computed using the HBV model. The concentration scenario selected for this study is SSP5-8.5, considered a pessimistic scenario. Preliminary results show precipitation increases in the Pacific Slope, however, the increases in actual evapotranspiration due to warming over exceeds the precipitation effects, causing a future reduction in streamflow in basins in the Pacific Slope and reductions in the Northern Caribbean region of Costa Rica. This is important as it suggests that the North Pacific, a climatologically drier region, will experience significant increases in aridity. This region is known to present social and economic vulnerabilities, as it is part of the Central American Dry Corridor.

Plain Language Summary

Future changes in river streamflow in Costa Rica were computed using a suite of climate, statistical and hydrological models. These projections imply reductions in the amount of water resources in the Pacific Slope of Costa Rica, a region with relative higher aridity and social and economic vulnerabilities.

References

Almazroui, M., Islam, M.N., Saeed, F. et al. Projected Changes in Temperature and Precipitation Over the United States, Central America, and the Caribbean in CMIP6 GCMs. Earth Syst Environ 5, 1–24 (2021). https://doi.org/10.1007/s41748-021-00199-5

Navarro-Racines, C., Tarapues, J., Thornton, P., Jarvis, A., & Ramirez-Villegas, J. (2020). High-resolution and bias-corrected CMIP5 projections for climate change impact assessments. *Scientific data*, *7*(1), 1-14.

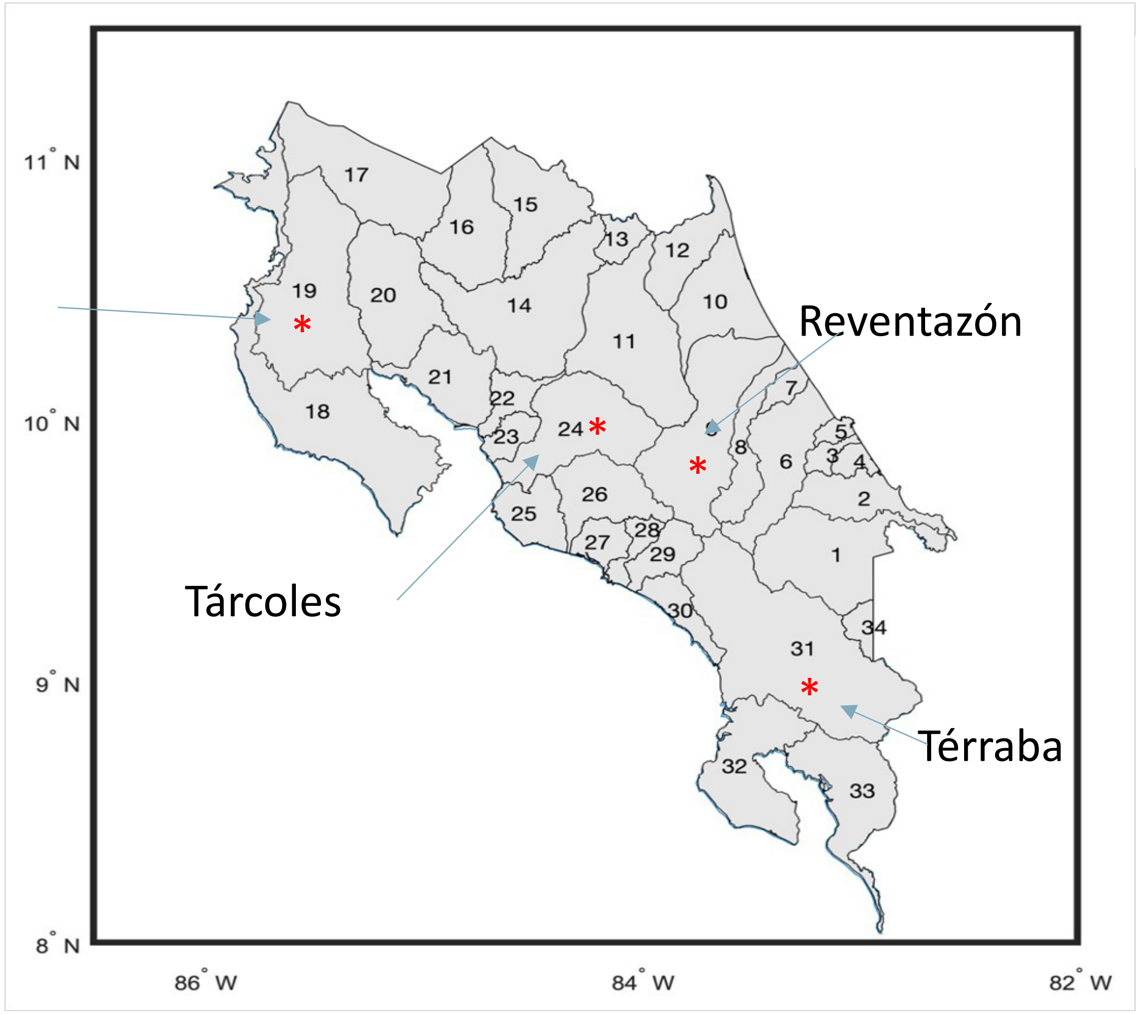
Objectives

- To downscale daily precipitation and temperature GCM data from the CMIP6 generation
- To generate daily streamflow and other hydrometeorological projections from the 34 main basins of Costa Rica using HBV model.
- To study the future changes in the simulated hydrological and meteorological variables that compose the water balance of the basins.
- To determine changes in the Q_{20}

Data and methods

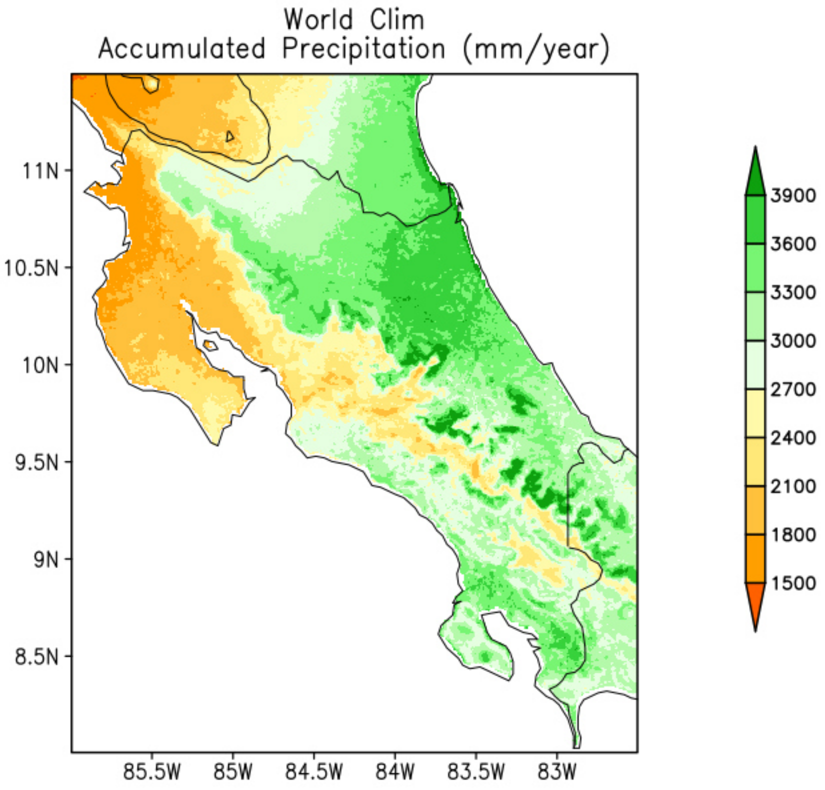
- WorldClim (1 km) monthly climatologies, interpolated to daily using a 2nd degree polynomial
- Potential evapotranspiration: Thorthwaite (1948) with linear adjustment using Penman-Monteith (Monteith, 1965; Maidment, 1993) estimates from six stations
- Maximum missing data requirement: 15%
- Missing data filling: “method of normals”
- Land cover: REDD+ Project for Costa Rica
- Downscaling method: Navarro-Racines (2020) with bias correction using WorldClim (1 km) climatologies
- GCM models: EC_earth3, GFDL_ESM4, MPI_ESM1_2_HR de 1979-2100, for scenario **SSP5-8.5**
- Hydrological model: HBV (Hydrologiska Byråns Vattenbalansavdelning; Bergström, 1976)

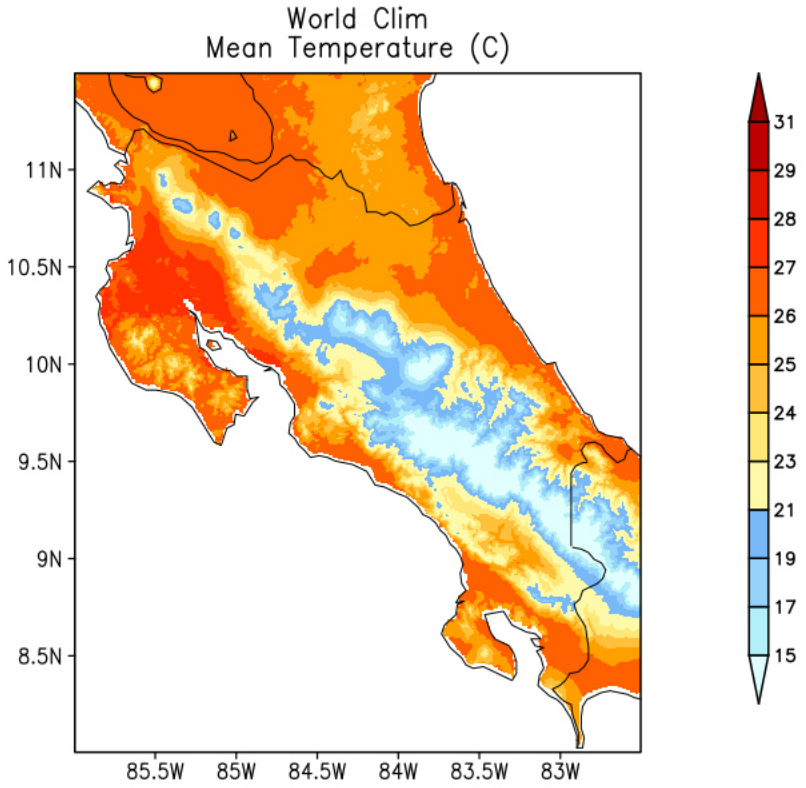
Costa Rica’s 34 main basins



1) SIXAOLA
2) LA ESTRELLA
3) BANANO
4) BANANITO
5) MOIN
6) MATINA
7) MADRE DE DIOS
8) PACUARE
9) REVENTAZON
10) TORTUGUERO
11) CHIRRIPO
12) SARAPIQUI
13) CUREÑA
14) SAN CARLOS
15) POCOSOL
16) RIO FRIO
17) ZAPOTE
18) PENINSULA DE NICOYA
19) TEMPISQUE
20) BEBEDERO
21) ABANGARES
22) BARRANCA
23) JESUS MARIA
24) TARCOLES
25) TUSUBRES
26) PARRITA
27) DAMAS
28) NARANJO
29) SAVEGRE
30) BARU
31) TERRABA
32) PENINSULA DE OSA
33) ESQUINAS
34) CHANGUINOLA

WorldClim annual precipitation and temperature





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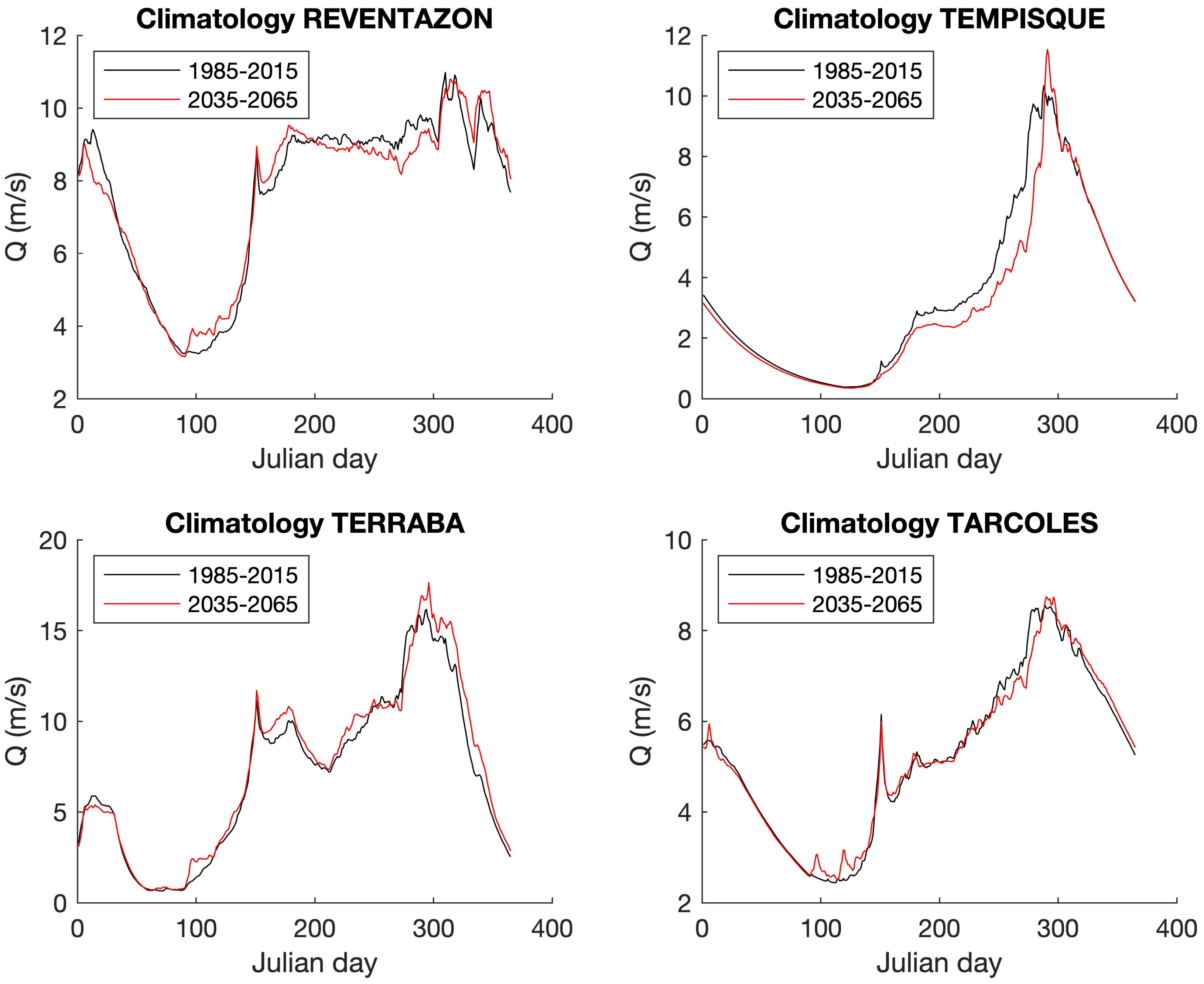
Daily streamflow climatologies for selected basins

Black lines: historical (1985-2015),

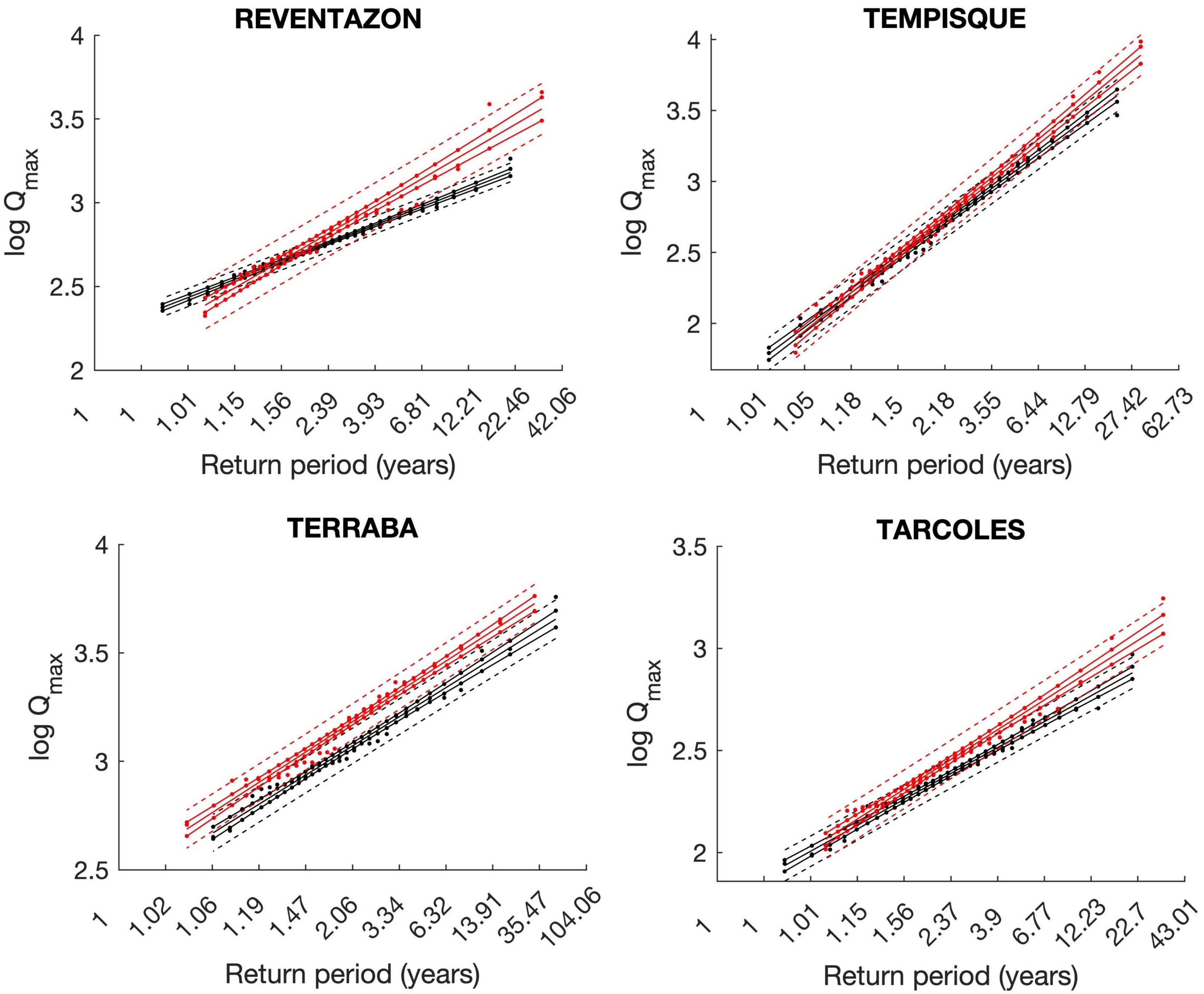
Red lines: Mid-century projections (2035-2065) SSP5-8.5



Flood Frequency Analysis

Black lines: historical (1985-2015),

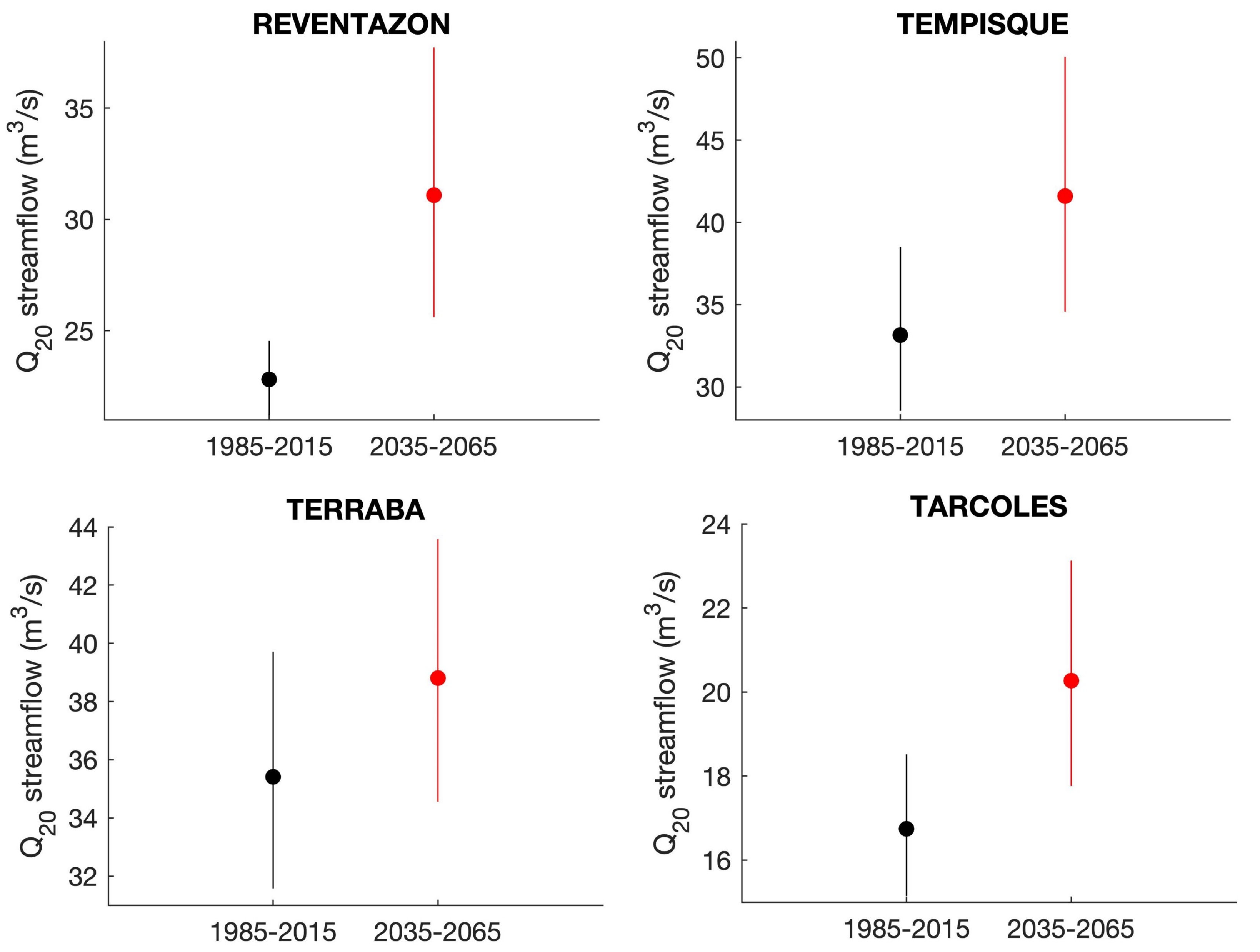
Red lines: Mid-century projections (2035-2065) SSP5-8.5



Changes in Streamflow with Tr=20 years

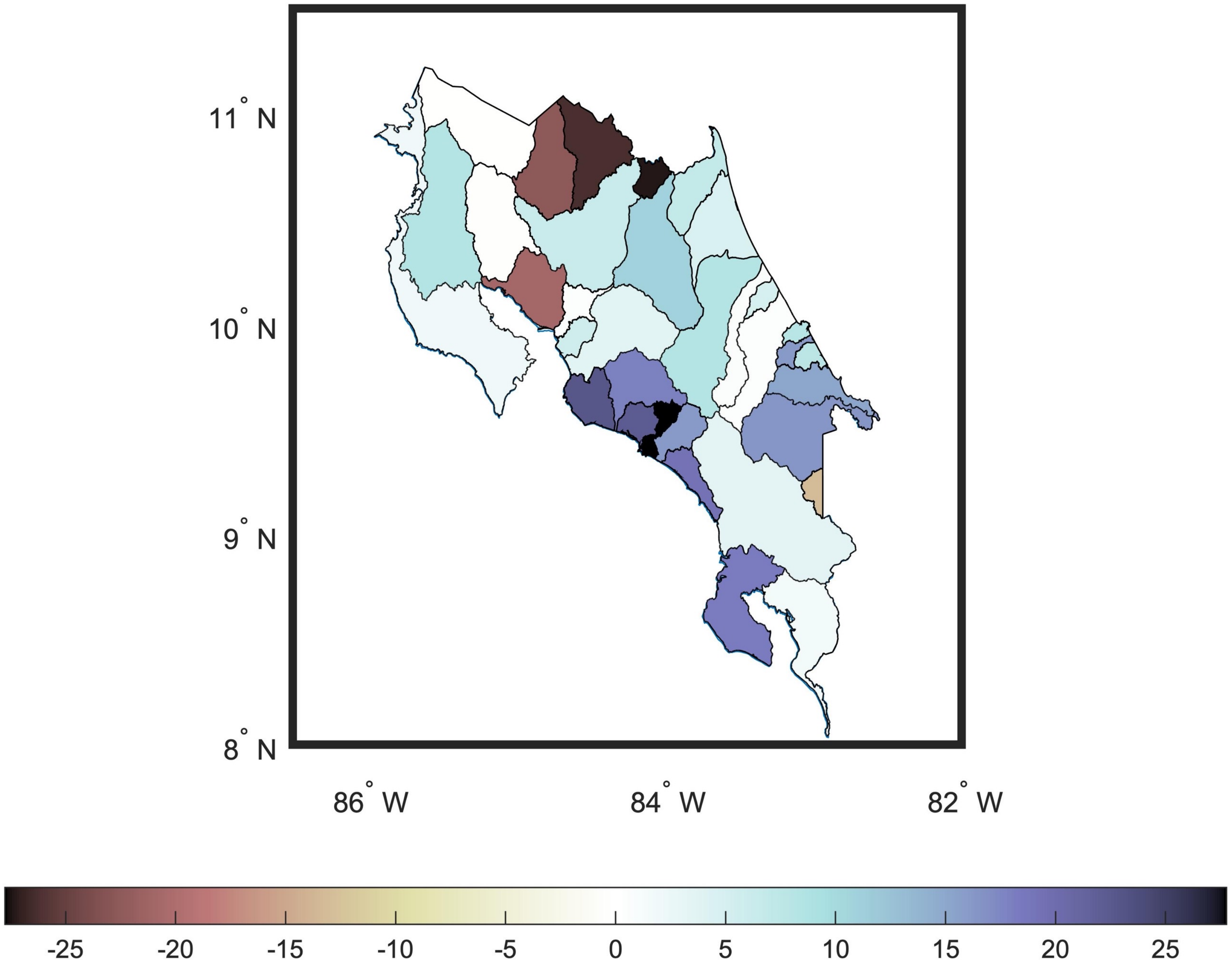
Black lines: historical (1985-2015),

Red lines: Mid-century projections (2035-2065) SSP5-8.5



Changes in Streamflow with Tr=20 years future vs. baseline for 34 main basins

(4 basins were significant)



Conclusions

- Even that there is not much reduction in the daily streamflow mean for the studied scenarios, there is an increase in the floods in the Central Pacific and reduction in the floods in the Northern plains in the future, but only for 4 basins the Q_{20} changes are significant.
- Changes in streamflow with higher return period may show other significant changes in the basins

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Thank you

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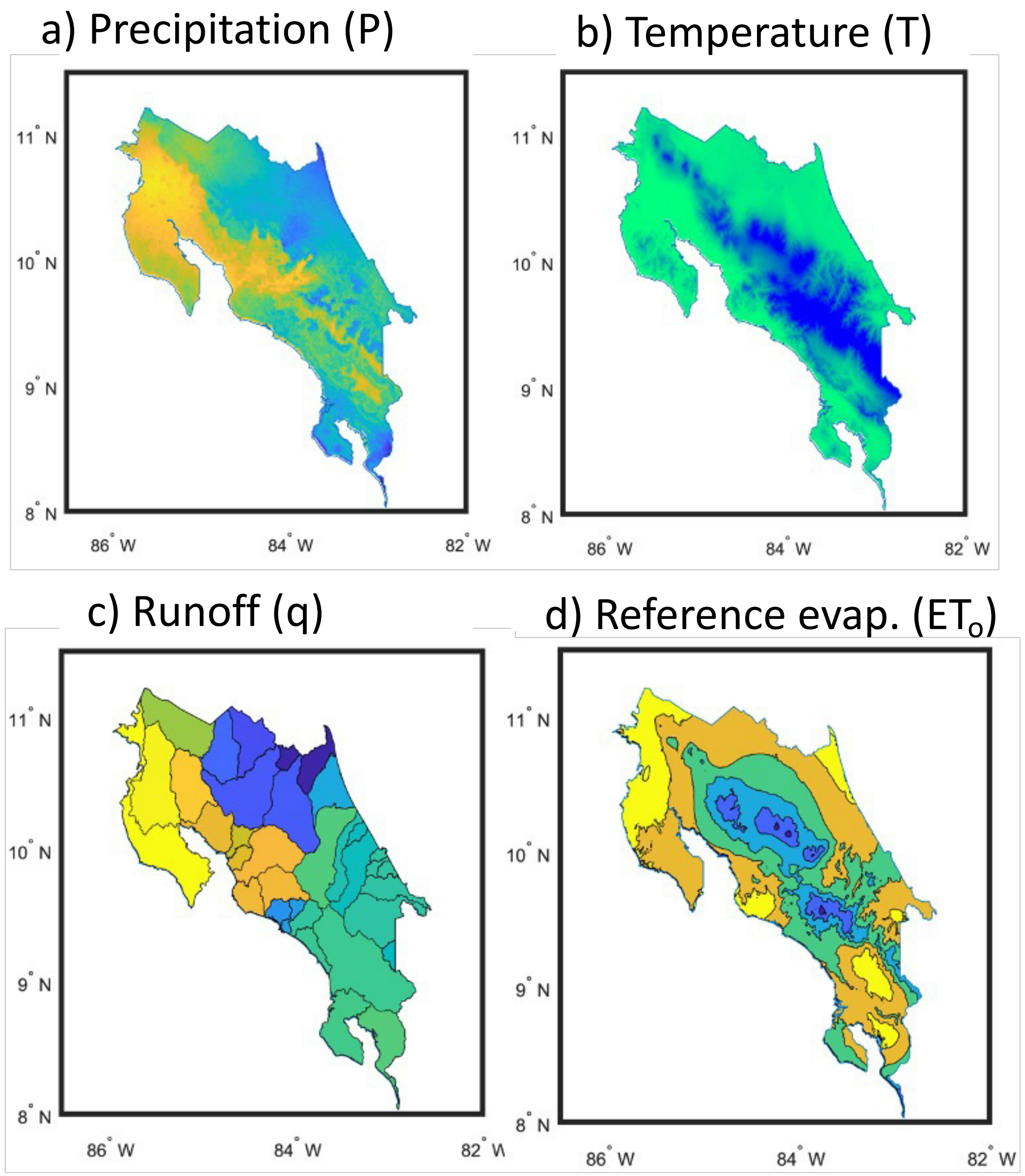
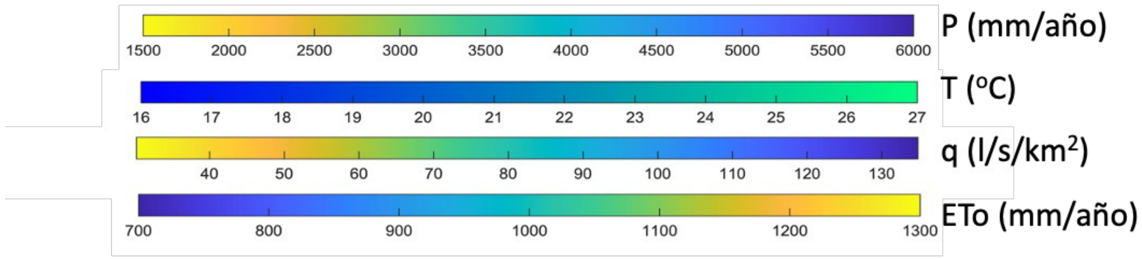
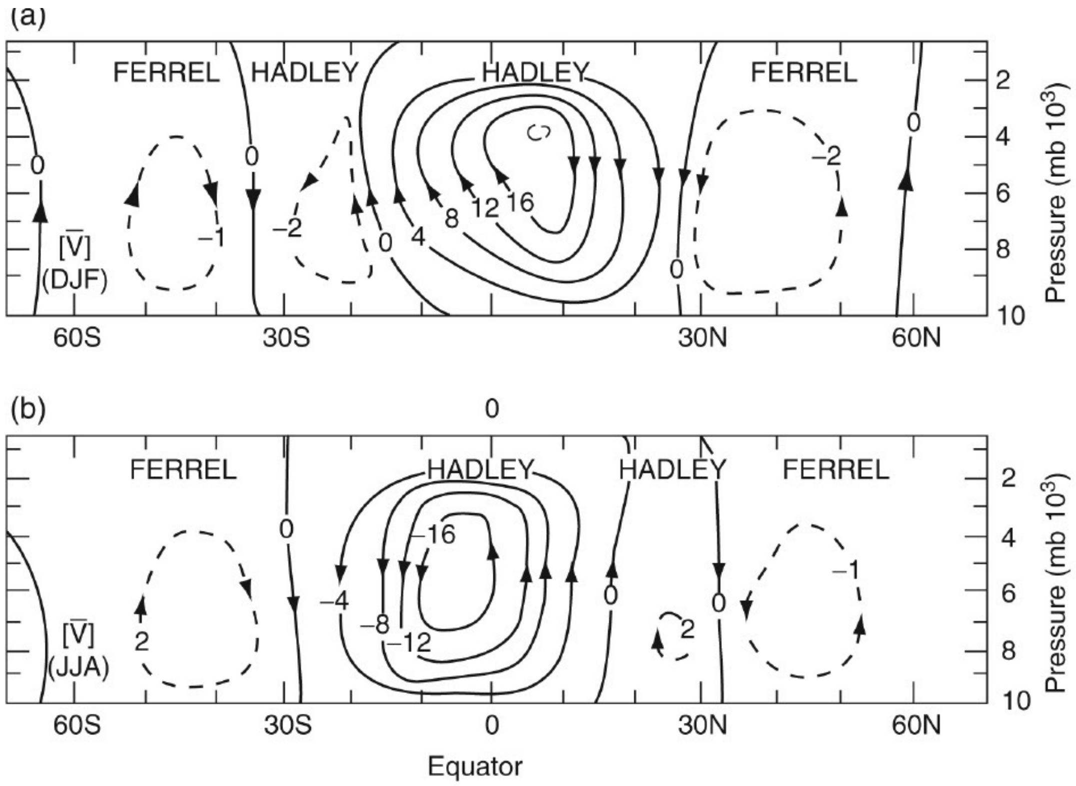
Results

Mean (1990-2020) annual values of hydrological and meteorological variables in Costa Rica





Circulación atmosférica global (Celdas Hadley)



Terrestrial Hydrometeorology, First Edition. W. James Shuttleworth.

Figure 9.4 Mean latitude average circulation of the atmosphere (a) December to February, (b) June to August. Values on the streamlines are total mass circulation between that streamline and the zero streamline. (From Rassmusson *et al.*,1993, published with permission.)

Circulación Hadley: En 1700 George Hadley un abogado inglés y meteorólogo aficionado argumentó que el calentamiento solar crea movimiento ascendente del aire ecuatorial y el aire de latitudes cercanas debe fluir para reemplazarlo y además el componente este de los vientos alisios estaba asociado con la rotación de la Tierra. La idea de celdas simétricas en cada hemisferio fue aceptada pero luego se descubrió que en realidad hay varias celdas en cada hemisferio. Sin embargo, debido a que la latitud de máximo calentamiento solar es fuertemente estacional, existe una estacionalidad marcada en las celdas Hadley y la circulación es solamente brevemente simétrica en los equinoccios de primavera y otoño.