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**Article** *in* Hydrological Processes · November 2019

DOI: 10.1002/hyp.13648

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PREFACE

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# Hydrological Processes Special Issue "Hydrological processes across climatic and geomorphological gradients of Latin America"

## 1 | PREFACE

In this special issue of *Hydrological Processes*, we showcase the variety of ongoing research in catchments of the hydrometeorological, geomorphological, and biogeographical megadiverse region of Latin America and the Caribbean (LAC). The papers of this special issue address hydrological processes that regulate storage, mixing, and fluxes of water and solutes from the driest Atacama Desert in Chile (annual precipitation lower than 10 mm in some places) to the wettest mountainous areas of Central America (annual rainfall up to 8,000 mm), including the richest biodiversity on Earth present in the Amazon. Not only are tropical rainforest ecosystems poorly represented in hydrologic research, the LAC contains a myriad of unique lowland to montane ecosystems across the climate gradient that also includes snow and ice processes. Opportunities to advance understanding of how vegetation and landforms redistribute moisture abound in the remote reaches of Latin America. Such modulation of the hydrological cycle by vegetation and large-scale connecting driving forces of rainfall generating moisture transport is the topic of the contributions briefly introduced in the following section.

There are three major transcending themes covered in this special issue:

1. hydrological processes across climate gradients,
2. unique ecosystems with limited hydrological research,
3. effects of land use change on hydrology.

Over long time scales, water actively shapes the structure and evolution of LAC catchments through its physical and biogeochemical actions. Water organises landscapes across the climatic and geomorphological gradients of LAC. We contend that this region is still surprisingly underrepresented in the hydrological literature, disproportional to its extensive land area and relevance to the global hydrologic cycle. In an effort to fill this knowledge gap and motivate new research, this special issue expands the geographical influence beyond the recent and very successful South American Virtual Hydrology special issue edited by Boutt and Iroume (2017) towards the whole region of LAC, and further catalyses the exciting research that is being conducted across the whole region from Mexico in the north to the southern tip of Patagonia in Chile. In this context, the invited Scientific Briefing of Riveros-Iregui et al. (2018) highlights the need for more experimental work and data collection in the tropics of LAC, particularly the value of using high-resolution but short-term measurement campaigns to inform hypothesis testing and foster longer term monitoring efforts. Despite economic limitations to conduct research in most LAC countries, the paper provides concrete examples of new, partly low-cost, and accessible sensor technology to motivate scientifically rigorous studies.

## 2 | HYDROLOGICAL PROCESSES ACROSS CLIMATE GRADIENTS OF LATIN AMERICA

The contributions herein cover almost the entire LAC climate gradient, from arid to humid tropical and from sea level to high Andean elevations. Such climate feedbacks over diverse geomorphic provinces are explained at a large spatial scale by Oertel et al. (2019), who focused on drought propagation and the relationship to coupled oceanic–atmospheric circulation patterns in semi-arid to temperate river basins of Chile. Their study highlights the potential use of teleconnection indices to improve drought forecasts over large spatial and seasonal time scales. Similarly, the comparative study of high-elevation ecosystems across eco-climatic gradients in Costa Rica and Ecuador by Esquivel-Hernandez et al. (2018) uses stable isotope analysis to better understand rainfall generation processes and moisture transport in the Páramo ecosystem, with emphasis on the strongest El Niño event recorded in history (2014–2016). Here, it becomes clear that rainfall generating moisture transport acts as a bridge over large spatial scales connecting montane ecosystems in the tropics. Detailed headwater catchment scale experimental work was used in the study by Dehaspe et al. (2018) to test a spatially distributed tracer-aided rainfall–runoff model in a pristine humid pre-montane rainforest. Their model was able to reproduce a fast-responding hydrological system with likely little resilience to climatic perturbations. A simpler approach, based on the conceptual GRJ4 model, was used by Rau et al. (2018) to simulate monthly long-term runoff in Peru and to evaluate the impacts of climate change on the hydrology in these semi-arid, snow-driven catchments. They observed a positive trend of discharge in the Pacific drainage basin of Peru over the last decades. Burger et al. (2018) pushes the field of glacier hydrology with a physically based glacio-hydrological model used to simulate the effects of debris cover and snow avalanche accumulation on runoff in Central Chile. Such

  

incorporation of local-scale processes into models highlight the increased dependency of runoff on decreasing glacier cover during dry years. Considering the dominant focus on northern latitudes in the literature, the potential loss of glaciers and decreasing snowpack under ongoing climate change is and will be a critical topic for new research in the isolated high mountain regions of southern latitudes.

## 3 | UNIQUE ECOSYSTEMS ACROSS LATIN AMERICA WITH LIMITED HYDROLOGICAL RESEARCH

Uuh-Sonda et al. (2018) explores the intimate and complex water-climate-biodiversity feedbacks across an eco-climatic gradient over the savanna and tropical dry forest ecosystems of the Yucatan Peninsula in Mexico. They conclude that the ecosystem resilience to climatic perturbations strongly depends on the plant water use strategies in response to hydrologic variability. At a much smaller spatial scale, other studies spotlight unique biologically important and threatened ecosystems that are poorly represented in the hydrologic literature. For instance, the tropical cloud forest ecosystem in Mexico with its particular interception dynamics of atmospheric water is the focus of the paper by Gonzalez-Martinez and Holwerda (2018). They determined that the average rainfall event size and canopy water storage capacity were the main factors dominating altitudinal variations of rainfall. Moving further up in elevation to extreme high-altitude environments, Huerta et al. (2019) investigated the contribution of snow processes and interception to the total water budget in a biodiversity hotspot of native Nothofagus forest in Chile, resulting in around 24% of intercepted snowfall of the total water budget.

## 4 | EFFECTS OF LAND USE CHANGE ON HYDROLOGY IN LATIN AMERICA

Land-cover change across different climate gradients of Latin America has important physical, ecological, and socioeconomic consequences. Several studies in this special issue address the impacts of this critical issue on hydrology. Krishnaswamy et al. (2018) applied a Bayesian statistical model to test hypotheses of how forest cover changes affect dry season streamflow in a seasonally humid tropical forest. They clearly showed the positive effect of forest cover on higher dry season streamflows in tropical Costa Rica. According to Pesantez et al. (2018), land cover, together with climate, controlled soil water dissolved organic carbon concentrations of organic-rich histosol soils in high-elevation and wet Andean Páramo ecosystems. Such a direct land cover influence on soil infiltration was also shown by Litt et al. (2019), but for a lowland, humid tropical catchment in Panama with implications for land cover change and use of soil resources. Barrientos and Iroumé (2018) found in their paper that deciduous forest and topography can explain variations of water storage at the catchment scale in more humid central-southern Chile. Link et al. (2019) provides a unique paleo-hydrogeomorphology, hydraulic and historical urban development perspective on extreme flood generation, and how such insights should be used to improve flood risk management in complex urbanisation scenarios.

Together, these 14 papers form this special issue on "Climatic and geomorphological gradients of Latin America" covering the northernmost part of LAC in Mexico down to southern Chile, from the tropical lowlands to high-elevation glacierised catchments in the Andes, using field-based and remotely sensed data along with modelling approaches to address hydrological processes ranging from droughts and floods to carbon export and forest interception, which are all most relevant issues to water resources management. This special issue truly provides a transformative vision of the complex hydrological processes in LAC. We hope this special issue further motivates researchers worldwide to undertake new research in this fascinating, megadiverse, and crucial region of our planet.

## ACKNOWLEDGMENTS

We thank all the authors for the hard work pulling together their papers and particularly the many reviewers for thoughtful and constructive criticism that helped shape this special issue. We also thank the editor-in-chief, Professor Doerthe Tetzlaff, for her support and encouraging advice. CB would like to acknowledge support by the University of Costa Rica Advanced Studies (UCREA—B8276). MZB acknowledges support by CONICYT/FONDAP 15110009.

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## REFERENCES

Barrientos, G., & Iroumé, A. (2018). The effects of topography and forest management on water storage in catchments in south-central Chile. *Hydrological Processes.*, *32*, 3225–3240. https://doi.org/10.1002/hyp.13261

Boutt, D., & Iroume, A. (2017). Preface for the South American Hydrology Virtual Special Issue. *Hydrological Processes.*, 454–458. https://doi.org/10.1002/hyp.11166

Burger, F., Ayala, A., Farias, D., et al. (2019). Interannual variability in glacier contribution to runoff from a high-elevation Andean catchment: Understanding the role of debris cover in glacier hydrology. *Hydrological Processes.*, *33*, 214–229. https://doi.org/10.1002/hyp.13354

Dehaspe, J., Birkel, C., Tetzlaff, D., Sánchez-Murillo, R., Durán-Quesada, A. M., & Soulsby, C. (2018). Spatially distributed tracer-aided modelling to explore water and isotope transport, storage and mixing

in a pristine, humid tropical catchment. *Hydrological Processes.*, *32*, 3206–3224. https://doi.org/10.1002/hyp.13258

Esquivel-Hernández, G, Mosquera, GM, Sánchez-Murillo, R, et al. (2019). Moisture transport and seasonal variations in the stable isotopic composition of rainfall in Central American and Andean Páramo during El Niño conditions (2015-2016). *Hydrological Processes.*, 1802–1817. https://doi.org/10.1002/hyp.13438

González-Martínez, T. M., & Holwerda, F. (2018). Rainfall and fog interception at the lower and upper altitudinal limits of cloud forest in Veracruz. *Mexico*. *Hydrological Processes.*, *32*, 3717–3728. https://doi.org/10.1002/hyp.13299

Huerta, M. L. (2019). *Molotch*. McPhee, J. Snowfall interception in a deciduous Nothofagus forest and implications for spatial snowpack distribution. Hydrological Processes: NP. https://doi.org/10.1002/hyp.13439

Krishnaswamy, J., Kelkar, N., & Birkel, C. (2018). Positive and neutral effects of forest cover on dry-season stream flow in Costa Rica identified from Bayesian regression models with informative prior distributions. *Hydrological Processes.*, *32*, 3604–3614. https://doi.org/10.1002/hyp.13288

Link, O., Brox-Escudero, L. M., González, J., et al. (2019). A paleo-hydrogeomorphological perspective on urban flood risk assessment. *Hydrological Processes.*, 1–15. https://doi.org/10.1002/hyp.13590

Litt, G. F., Ogden, F. L., Mojica, A., et al. (2019). Land cover effects on soil infiltration capacity measured using plot scale rainfall simulation in steep tropical lowlands of central panama. *Hydrological Processes.*, https://doi.org/10.1002/hyp.13605

Oertel, M., Meza, F. J., Gironás, J. (2019). Observed trends and relationships between ENSO and standardized hydrometeorological drought indices in central Chile. *Hydrological Processes.*, https://doi.org/10.1002/hyp.13596

Pesántez, J., Mosquera, G. M., Crespo, P., Breuer, L., & Windhorst, D. (2018). Effect of land cover and hydro-meteorological controls on soil water DOC concentrations in a high-elevation tropical environment. *Hydrological Processes.*, *32*, 2624–2635. https://doi.org/10.1002/hyp.13224

Rau, P., Bourrel, L., Labat, D., et al. (2019). Assessing multidecadal runoff (1970–2010) using regional hydrological modelling under data and water scarcity conditions in Peruvian Pacific catchments. *Hydrological Processes.*, *33*, 20–35. https://doi.org/10.1002/hyp.13318

Riveros-Iregui, D. A., Covino, T. P., & González-Pinzón, R. (2018). The importance of and need for rapid hydrologic assessments in Latin America. *Hydrological Processes.*, *32*, 2441–2451. https://doi.org/10.1002/hyp.13163

Uuh-Sonda, J. M., Gutiérrez-Jurado, H. A., Figueroa-Espinoza, B., & Méndez-Barroso, L. A. (2018). On the ecohydrology of the Yucatan Peninsula: Evapotranspiration and carbon intake dynamics across an eco-climatic gradient. *Hydrological Processes.*, *32*, 2806–2828. https://doi.org/10.1002/hyp.13230

**How to cite this article:** Birkel C, Moore GW, Zambrano-Bigiarini M. Hydrological Processes Special Issue "Hydrological processes across climatic and geomorphological gradients of Latin America." *Hydrological Processes*. 2019;1–3. https://doi.org/10.1002/hyp.13648