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High-frequency stable isotope tempestology of tropical cyclones across the Atlantic, Caribbean Sea, Gulf of Mexico, and eastern tropical Pacific Ocean basins

RICARDO SÁNCHEZ-MURILLO[1], KEGAN FARRICK[2], GERMAIN ESQUIVEL-HERNANDEZ[3], ROLANDO SANCHEZ-GUTIERREZ[3], JAVIER BARBERENA[4], JORGE GUATEMALA[4], YELBA FLORES[4], ROBERTO CERON[5], LAURA GIL[5], JORGE CARDONA[6], TANIA PEÑA-PAZ[7], JUNIOR HERNANDEZ-ORTIZ[7], WENDY HARRISON[8], GEOFFREY MARSHALL[9], AUREL PERSOIU[10], JUAN PÉREZ-QUEZADAS[11], MIGUEL MEJÍA-GONZÁLEZ[12], LUIS GONZÁLEZ-HITA[12], MARCIA BARRERA[13], ALEJANDRO GARCIA-MOYA[14], DEBORA HERNÁNDEZ-FLORES[15], KRISTEN WELSH[16], RENE PRICE[17], DIEGO RIVEROS-IREGUI[18], MINERVA SÁNCHEZ-LLULL[14], CARLOS M. ALONSO-HERNANDEZ[19], SAÚL SANTOS-GARCÍA[20], ANA MARÍA DURÁN-QUESADA[21], NY RIAVO G VOARINTSOA[22], JAN BOLL[23], CHRISTIAN BIRKEL[21], DIMITRIS HERRERA[24] AND JOSHUA BREGY[25]

[1]University of Texas at Arlington
[2]The University of the West Indies
[3]Universidad Nacional
[4]Universidad Nacional Autónoma de Nicaragua
[5]Ministerio de Medio Ambiente y Recursos Naturales
[6]Universidad Nacional de Agricultura
[7]Universidad Nacional Autónoma de Honduras
[8]National Water Commission
[9]Water Resources Authority of Jamaica
[10]Emil Racovita Institute of Speleology
[11]Universidad Nacional Autónoma de México
[12]Mexican Institute of Water Technology
[13]Universidad de El Salvador
[14]Centro de Estudios Ambientales de Cienfuegos
[15]Centro de Aplicaciones Tecnológicas y Desarrollo Nuclear
[16]University of The Bahamas
[17]Florida International University
[18]University of North Carolina at Chapel Hill
[19]IAEA Environment Laboratories
[20]Secretaría de Infraestructura y Transporte
[21]Universidad de Costa Rica
[22]University of Houston
[23]Washington State University
[24]University of Tennessee-Knoxville
[25]Clemson University

Presenting Author: ricardo.sanchezmurrillo@uta.edu

The Gulf of Mexico, Caribbean Sea, and eastern tropical Pacific Ocean basins have been identified as ‘hot spots’ for their sensitivity to global climate variability. Across these regions, tropical cyclones (TCs) are one of the major natural hazards of fragile coastal ecosystems and low-income communities. Despite the well-known TC seasons, detailed ground-based information is still lacking about the interaction of TC synoptic characteristics, moisture transport evolution, and the propagation of isotopically distinct pulses across surface water bodies and subsurface reservoirs. This study aims to a) evaluate the isotopic characteristics of TCs (from low-pressure systems to Category 5 hurricanes) using recent (N=792; 2012-2023) and archived (N=236; 1984-1995) observations (from hourly to daily sampling) (Fig. 1) across the Atlantic, Caribbean Sea, Central America, Gulf of Mexico coast (USA and Mexico), and eastern tropical Pacific Ocean and c) analyze whether the observed inter-annual isotope variability in precipitation (daily to monthly, N=7,739; 2013-2023), surface water, and shallow groundwater (daily to weekly, N=6,013) can be used as a reliable predictor to enhance paleotempestological reconstructions (i.e., intensity, frequency, relative cyclonic contribution to the regional water cycle). Recent samples correspond to concerted monitoring efforts of the following storms: Dolly (2014), Otto (2016), Matthew (2016), Nate (2017), Irma (2017), Maria (2017), Bud (2018), Willa (2018), Sergio (2018), Dorian (2019), Isaias (2020), Nana (2020), Hanna (2020), Eta (2020), Iota (2020), Elsa (2021), Ida (2021), Grace (2021), Olaf (2021), Agatha (2022), Ian (2022), Orlene (2022), Kay (2022), Julia (2022), Bonnie (2022), Lidia (2023), and Norma (2023). Inland-storm interactions result in more depleted compositions compared to coastal and maritime settings. Across these regions, offshore convection can result in large and enriched rainfall amounts during TC passages and landfalls, which may potentially bias paleo-reconstructions in favor of heavy water isotopes, typically linked to drier conditions. Our network increases the capacity to integrate processes and interactions among the compartments of the water cycle beyond idealized models. It contributes to advances in the understanding of the short-time scale impacts of heavy rainfall in the system that are often hindered by data scarcity at higher resolutions.