



Tracer hydrology in a hydrometric data-limited and complex tropical mountainous region: the case of the Central American Isthmus

Ricardo Sánchez-Murillo (1), Germain Esquivel-Hernández (1), Leonardo Corrales-Salazar (1), Laura Castro-Chacón (2), Ana María Durán-Quesada (3), Manuel Guerrero-Hernández (4), Valeria Delgado (5), Javier Barberena (5), Katia Montenegro-Rayó (5), Heyddy Calderón (6), Carlos Chevez (7), Tania Peña-Paz (8), Saúl García-Santos (8), Pedro Ortiz-Roque (9), Yaneth Alvarado-Callejas (10), Laura Benegas (10), Arturo Hernández-Antonio (11), Marcela Matamoros-Ortega (12), Lucía Ortega (13), and Stefan Terzer-Wassmuth (13)

(1) Stable Isotope Research Group, UNA-SIL; Universidad Nacional, Heredia, Costa Rica (ricardo.sanchez.murillo@una.cr), (2) Empresa de Servicios Públicos de Heredia, ESPH S.A., Heredia, Costa Rica, (3) Atmospheric, Planetary and Oceanic Physics Department, School of Physics and Center of Geophysical Research, University of Costa Rica, San José, Costa Rica, (4) Foundation for the Development of the Volcanic Central Cordillera, FUNDECOR, San José, Costa Rica, (5) Centro para la Investigación en Recursos Acuáticos de Nicaragua, CIRA/UNAN-Managua, Universidad Nacional Autónoma de Nicaragua, Managua, Nicaragua, (6) Institute of Geology and Geophysics, IGG-CIGEO, Universidad Nacional Autónoma de Nicaragua, Managua, Nicaragua, (7) Water Resources Department, Nicaraguan Institute of Territorial Studies, Managua, Nicaragua, (8) Instituto Hondureño de Ciencias de la Tierra, IHCIT, Universidad Nacional Autónoma de Honduras, Tegucigalpa, Honduras, (9) Servicio Autónomo Nacional de Acueductos y Alcantarillados, Gobierno de la República de Honduras, Tegucigalpa, Honduras, (10) Centro Agronómico Tropical de Investigación y Enseñanza, CATIE, Turrialba, Costa Rica, (11) Centro del Agua para América Latina y el Caribe, Escuela de Ingeniería y Ciencias, Tecnológico de Monterrey, México, (12) Escuela de Biología, Universidad Nacional Autónoma de Honduras, Tegucigalpa, Honduras, (13) International Atomic Energy Agency, Isotope Hydrology Section, Vienna International Center, Vienna, Austria

Numerous socio-economic activities are dependent on the seasonal rainfall and groundwater recharge cycle across the Central American Isthmus. Demographic growth and unregulated land use changes resulted in extensive surface water pollution and large dependency of groundwater reservoirs. This chapter synthesizes stable isotope variations in rainfall, surface water, and groundwater of Costa Rica, Nicaragua, El Salvador, and Honduras. A regional rainfall isoscape, isotopic lapse rates, spatial-temporal isotopic variations, and air mass back trajectories were combined to determine potential mean recharge elevations, moisture circulation patterns, and surface water-groundwater interactions. Intra-seasonal rainfall modes resulted in two depleted incursions (W-shaped isotopic pattern) during the wet season and two enriched pulses during the Mid-Summer Drought and the months of the strongest trade winds. Notable isotopic sub-cloud fractionation and near-surface secondary evaporation were identified as common denominators within the Dry Corridor. Groundwater and surface water isotope ratios depicted the strong orographic separation into the Caribbean and Pacific domains, mainly induced by the governing moisture transport from the Caribbean Sea, complex rainfall producing systems across the N-S mountain range, and the subsequent mixing with local evapotranspiration, and, to a lesser degree, the eastern Pacific Ocean fluxes. Groundwater recharge was characterized by: a) depleted recharge at the highland areas (72.3%), b) rapid recharge via preferential flow paths (13.1%), and enriched recharge due to near-surface secondary fractionation (14.6%). Median recharge elevation ranged from 1,104 to 1,979 m a.s.l. These results are intended to enhance forest conservation practices, inform water protection regulations, and facilitate water security and sustainability planning in the Central American Isthmus.