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From Field to Flow: Assessing River-Aquifer Dynamics in Tropical Regions with In-Situ Dataset Insights

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In recent years, the scientific community has directed significant attention towards understanding river-aquifer interactions due to their pivotal role in hydrological and biogeochemical processes with implications for solving diverse engineering challenges. Despite the growing focus on these interactions, most studies remain confined to local scales, hindering their incorporation into comprehensive continental-scale water resources management. Addressing this gap, our study pioneers the empirical verification of river-aquifer flow directions (characterizing losing or gaining rivers) in a tropical context. We leveraged an extensive database comprising approximately 150 thousand wells spanning the entirety of Brazil, and we developed empirical power equations using data from around 500 river gauge stations to estimate river water levels under low-flow conditions. To ascertain the flow direction of river-aquifer interactions, we compared hydraulic gradients between groundwater levels of wells and their nearest rivers. A river was classified as losing when its water levels were above those of neighboring wells, indicating potential water loss to underlying aquifers. Stringent connectivity criteria were applied, including a maximum distance of 1 km between wells and rivers, well depth not exceeding 100 meters, and exclusion of wells in confined aquifers. Our study conducted systematic robustness checks, exploring the sensitivity of the data to chosen time intervals, variations in river water levels under low-flow conditions, and the inclusion of confined aquifers. Our findings reveal that more than half of Brazilian rivers are prone to losing water to underlying aquifers. The results underscore the significance of our in-situ data-driven methodology, indicating that losing rivers, widespread throughout Brazilian territory, may serve as potential points of groundwater contamination. Particularly crucial in tropical regions with elevated organic matter input into rivers, given the inadequate wastewater treatment. The findings emphasize the critical necessity of analyzing river-aquifer interactions for effective water resource management on both local and continental scales.