



Exploring causal relationships between vegetation coverage and the environmental parameter of Budyko-type models in the Nakanbe nested watersheds in West African Sahel

Patrick Yetchékpo Gbohoui^{1,2}, Tazen Fowé¹, Jean-Emmanuel Paturel², and Hamma Yacouba¹

¹Institut International d'Ingénierie de l'Eau et de l'Environnement (2iE), Ecole Doctorale, Laboratoire Eaux, HydroSystèmes et Agriculture (LEHSA), Burkina Faso (patrickgbohoui@gmail.com)

²HydroSciences Montpellier, Univ Montpellier, CNRS, IRD, 163 rue Auguste Broussonnet, 34090 Montpellier, France (jean-emmanuel.paturel@ird.fr)

Abstract:

Budyko's conceptual framework is recognized in hydrology for its concise and accurate representation of long-term water and energy balances of watersheds. Based on the climate-environment coevolution, Budyko-type models capture the signature of environmental dynamics through climate. Many studies have shown a good correlation between the environmental parameter (u) of Budyko-type models and the vegetation coverage (M), but the analysis of the causal relationships between these two parameters has often received little attention. In this study, Convergent Cross Mapping, a causal discovery method, was applied to identify the causality between u and M from seven nested watersheds (areas ranging between 38 and 21,178 km²) of the Nakanbe River located in West African Sahel. The Budyko-type model developed by Chen and Sivapalan (2020) was forced with the climate data (precipitation, potential evapotranspiration, and actual evapotranspiration) to calculate u values for 11-years moving windows between 1977 and 2018. The vegetation coverage (M) was deduced from the Normalized Difference Vegetation Index. The results showed causal relationships between vegetation coverage and Budyko model parameter (convergence at a positive prediction skill) for all the watersheds. The causal influence detected is reciprocal (M influences u , and u influences M : $M \rightarrow u$) for four of the seven watersheds studied. These results highlighted the existence and reciprocity of climate-environment interactions at different spatial scales.

Keywords:

Causal relationships, Budyko-type models, climate-environment interactions, Nakanbe River watersheds.