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Stochastic Modeling of Isolated Wetland Hydrologic Variability: Effects of Hydro-climatic Forcing, Wetland Bathymetry, and Groundwater-Surface Water Connectivity

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Hydrological regimes regulate many wetland eco-hydrological functions, such as aquatic habitat integrity and biogeochemical processes. We examined hydrologic temporal variability of geographically isolated wetlands (GIWs), and derived analytical expressions for probability density functions (pdfs) of water storage volume, water stage, and water surface area. We conceptualize a GIW as a non-linear reservoir, subject to stochastic "shot-noise" (Poisson rainfall inputs) modulated by recession through evapotranspiration and drainage during inter-event periods. The derived analytical pdfs are defined by three dimensionless parameters: scaled aridity index; mean daily stage increment (during rainfall events); and wetland shape coefficient. These key parameters define the similarity or diversity of hydrologic regimes of different GIWs at a location, or at different sites by capturing the essential features of the wetlandscape: stochastic hydro-climatic forcing, bathymetry, and connectivity to groundwater and/or upland. Numerical simulation of hydrologic variability of groundwater-dependent GIWs allowed us to further examine the role of groundwater-surface water connectivity, and how an adjustment to the effective rate of water loss can be made to match the derived analytical pdf solutions. We also compared the analytical pdfs with observed data from an isolated wetland in Florida. This model framework has utility for managers seeking to achieve target eco-hydrological regimes of GIWs.