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Spatio-temporal patterns of hydrological processes on non-floodplain wetlands in an upstream basin of Pampa Plain (Argentina) during present wet conditions

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This work aims at deepening the knowledge of the mechanisms that govern the response of small temporary non-floodplain wetlands (NFWs) of neotectonic origin in the North Pampa under wet conditions. The study focuses on the Vila-Cululú upstream sub-basin (973 km^2), a tributary of the Salado River belonging to the Paraná River basin. The Pampa Plain has been affected by more frequent high-intensity rainfall events during the last five decades giving rise to a steady increase in the water table and a decrease in soil infiltration, leading to flood events that impact both rural and urban environments. Under wet conditions, a flat landscape alters the surface runoff and favors the development of temporary NFWs, increasing flood vulnerability and jeopardizing human activities. Structural depressions with polygonal patterns and a network of Late Pleistocene (ca. 100 ka. BP) parallel ENE-trending fluvial palaeochannels characterize the study area. These palaeochannels were deactivated by neotectonics and covered by loess, Last Glacial Maximum in age. In some sectors, the palaeochannels intercept the small tectonic depressions and significantly restrict the present drainage network (low-order streams and artificial channels). The research involved an integrated approach, including geomorphic and morphometric analyses based on remotely sensed satellite imagery in a GIS platform and fieldworks, and 2D hydrologic-hydraulic simulations using HydroBID Flood (hydrobidlac.org) to capture the system behavior for an extraordinary rainfall event (December 2016-March 2017). Simulation results show that the model represents hydrodynamics fairly well. The flooded areas were comparable to those obtained from the analysis of satellite images. The dendritic runoff pattern towards the tectonic depressions, the water storage evolution, and the hydraulic connectivity were numerically replicated. In particular, the Vila-Cululú sub-basin points out a significant delay in the hydraulic response downstream since the system must first satisfy groundwater and surface water storage. Once storage capacity is exceeded, the hydraulic behavior results in a dynamic process that involves the spilling and merging of ponds generated in small deflation hollows, generally nested within fluvial

palaeochannels. Such a hierarchical structure controls surface runoff towards the shallow tectonic depressions. This mechanism gives rise to the development of NFWs as simulation time evolves. Besides, the surface runoff flow pattern also highlights the poor capacity of both natural and artificial drainage networks, displaying highly lateral mobility and scarce connectivity downstream. However, these NFWs eventually might connect to a more hierarchical drainage network downstream at the final stage of the storm event. The dense network of artificial channels started to develop in the 1940s to evacuate water excess to the outlet. Despite the anthropic interventions, geomorphologic thresholds finally control hydrodynamics adding to surface water storage and limiting channel conveyance. This work is one of the first studies in North Pampa that combines hydrological and geomorphological data to explain the present hydrodynamics. These could be applied to palaeoflood hydrology. Identifying critical geomorphological thresholds adds to the knowledge of different levels of hydrologic connectivity, providing a better assessment of flood hazards on large plains.