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Braid bar and island dynamics of the multi-threaded Rio Paraná, Argentina

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Here we report results from a three year study of channel dynamics and bar evolution in one of the World's largest rivers, the multi-threaded Rio Paraná, Argentina. The Rio Paraná is a sand-bed river (D50 $\sim$ 0.35 mm) with a channel pattern that is characterised by stable vegetated islands, dynamic sandy braid bars, partially-coupled floodplain wetlands and, in many reaches, a dominant meandering thalweg. Mean channel width and depth at bankfull conditions are $\sim$2-3 km and $\sim$7-8 m, respectively. Thalweg scour depths are up to 25-30 m. Channel and bar morphodynamics were monitored during this study using a range of techniques including repeat bathymetric surveys, using single- and multi-beam echo sounding, acoustic Doppler current profiler surveys of flow structure and suspended sediment concentration, and analysis of historic bathymetric maps and satellite imagery. Channel hydrodynamics and morphodynamics were also investigated using a range of numerical modelling strategies. These included a 3D Computational Fluid Dynamics model, a 2D physically-based morphodynamic model that solves the shallow water form of the Navier-Stokes equations, and a reduced-complexity model that neglects much of the physics governing fluvial processes. Here we focus on a comparison of numerical model results and field evidence in order to evaluate which modelling strategies have the greatest potential for elucidating process-form relationships within the World's largest multi-threaded rivers. We show that all three modelling approaches are capable of predicting observed depth-mean flow structures within a 30 km study reach of the Rio Paraná. However, we conclude that models of intermediate complexity, based on the depth-averaged shallow water equations, may provide the most effective tools for simulating bar formation and river evolution over time periods of decades to centuries. Results from our morphodynamic model simulations and field data analysis provide insight into mechanisms of braid bar formation, the construction and composition of larger stable islands, and the role of thalweg switching in controlling channel pattern evolution.