A graph-theoretic approach to infer process from patterns in deltaic systems.

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River deltas are drained by channel networks that self-organize to a variety of stunning and complex patterns. Although these patterns are expected to encode to a large degree the signature of their forming processes, e.g., climate, tide and wave influence, sediment cohesion, vegetation, etc., no formal framework exists to test this hypothesis and quantitatively relate process and form. Here we present a quantitative framework based on spectral graph theory within which a systematic study of the topology and transport dynamics of river deltas can be performed. Specifically, this framework which conceptualizes a delta channel network as a directed graph where channels are modeled by edges and junctions as vertices (Figure 1), allows us, from algebraic computations, to depict structural features of the delta system such as sub-networks (from apex to shoreline outlets), and contributing and nourishing areas within any point in the network. Using this framework we also introduce metrics of topologic and dynamic complexity and define a multidimensional complexity space where each delta projects. By analyzing field, numerical and experimental deltas we present encouraging results towards a quantitative classification of deltas to replace the qualitative approach still in use today [*Galloway*, 1975; *Orton and Reading*, 1993]. We also show that the framework offers the potential to quantify the heterogeneity of spatial patterns within a given delta and provide a formalism for interrogating system vulnerability in response to perturbations. Using simulated deltas, for which the explicit spatial-temporal structure is available over the full history of the delta, the question of what can be learned about the past from a frozen spatial image of a delta is also addressed.

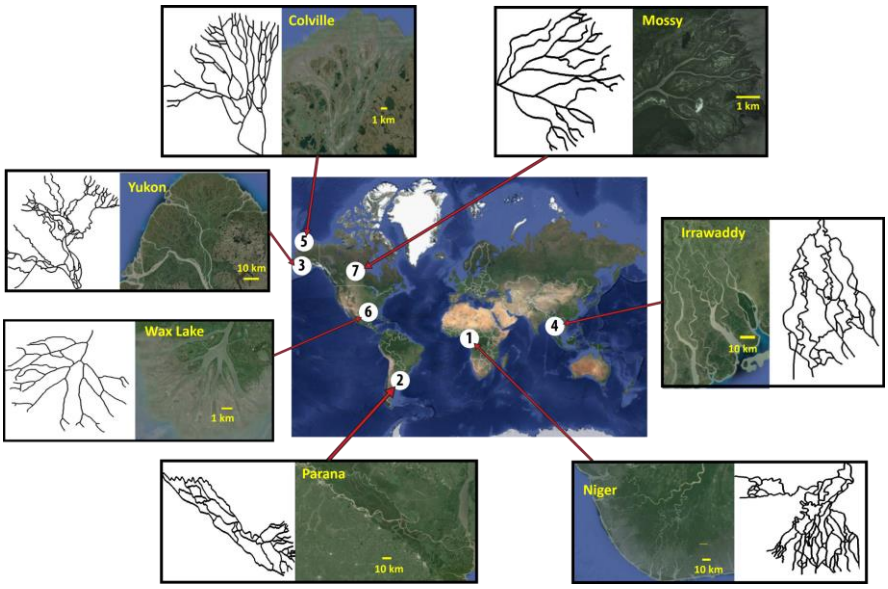

Figure 1. Seven deltas and their corresponding channel networks numbered according to size (largest to smallest area)