Source-to-Sink: Connecting Hyperpycnal-Flow Deposits to River-Flood Dynamics

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Hyperpycnal flows are turbid river plumes that can plunge to form turbidity currents where they enter a water body of lesser density. Because these flows provide one of the most direct connections between terrestrial sediment sources and marine depositional sinks, their deposits preserve an important record across a variety of climatic and tectonic settings. A leading hypothesis assumes that hyperpycnal-flow velocity scales directly with river discharge, such that individual turbidites record the rising and falling discharge of a flooding river. Using a 1D numerical model and flume experiments, we test this hypothesis and find that turbid river flow must move through a backwater zone, depth-limited plume, and plunging zone before becoming a turbidity current. These zones can extend tens of kilometers offshore and significantly affect the transfer of momentum from river to turbidity current. Counter to the proposed hypothesis, our results indicate that local flow velocities within hyperpycnal flows can be uncorrelated or even anti-correlated with inlet river discharge because of translation of the plunge point resulting from temporal variations in discharge and sediment concentration through the course of a river flood. Furthermore, hyperpycnal flow deposits can be influenced by both local plunge-point dynamics and inlet river conditions, and the relative degree of influence depends on the advection length scale of settling sediment. Results also suggest that the criteria used to identify plunging hyperpycnal flows (a flow density in excess of the ambient fluid) is a necessary, but not sufficient condition. The basin also must be deep enough, in cases greater than tens of meters, in order for the plume to collapse and form a turbidity current.