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Prediction of Ignition of a Turbidity Current in a Submarine Canyon Using a Reduced Model

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A turbidity current is a submarine sediment flow which propagates from the continental shelf and into into the deep ocean. Turbidity currents can occur randomly and without much warning and consequently are hard to observe and measure. The driving force in a turbidity current is the presence of sediment in the current - gravity acts on the sediment in suspension, causing it to move downstream through the ocean water. A phenomenon known as 'ignition' or 'autosuspension' can be observed in turbidity currents, and occurs when a current travelling downslope gathers speed as it erodes sediment from the sea floor in a self-reinforcing cycle.

By considering the turbidity current model of Parker, Fukushima and Pantin (1986) which models ignition in submarine canyons, two reduced models are presented and investigated. The first, a steady state model, focuses on determining the conditions required for ignition. We assume that we are considering a very large downstream length scale in our equations and by assuming a constant sediment concentration and scaling downstream distance with our sediment flux we find a reduced form of our model in terms of a scaled velocity and scaled turbulent kinetic energy. We use phase plane analysis to investigate our equations. We conclude that regions of ignition and extinction are present in our phase plane and are separated by an 'ignition line' where the wavespeed of our velocity equation is zero. Our model is limited at this stage by the absence of time-dependence and so we move on to consider our time-dependent reduced model.

The second model, a time-dependent one-equation reduced model which considers only the behaviour of the velocity, looks at how we can model the slope of the sea floor and how this affects the conditions for ignition. We use the same scalings as for our steady-state equations, but reduce our model to one equation. We have two forms of this equation a 'depositional' model given by taking the sediment concentration to be zero, and an erosional model, given by taking the sediment concentration to be a constant not equal to zero. In our depositional model we find currents become extinct in finite time and finite distance, as expected. However the erosional model shows ignition. We find we cannot control ignition by modelling the downstream slope as a constant, but by taking the downstream slope as a decreasing function of downstream distance we find that the velocity of a turbidity current approaches a steady profile which becomes extinct in finite time and distance, thus eliminating ignition from our system.