Quantifying suspended sediment dynamics in a large-scale turbidity currents: Direct measurements from full scale flows

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Turbidity currents that transport sediment to the deep ocean deposit a greater volume of sediment than any other process on Earth. To date, only a handful of studies have directly measured turbidity currents, with flow durations ranging from a few minutes to a few hours. Our understanding of turbidity current dynamics is therefore largely derived from scaled laboratory experiments and numerical modelling. Recent years have seen the first field-scale measurements of depth-resolved velocity profiles, but sediment concentration (a key parameter for turbidity currents) remains elusive. Here, we present high resolution measurements of deep-water turbidity currents from a range of global sites, incluidng some of the world's largest submarine canyons. Direct measurements using acoustic Doppler current profilers (ADCPs) show that flows can last for many days at some sites, rather than hours, and the data provide the first quantification of concentration and grain size within deep-water turbidity currents. Velocity and backscatter were measured at sub-minute intervals by an ADCP suspended above the submarine channel floor. Novel inversion methods using multiple ADCP frequencies enabled quantification of sediment concentration and grain size within the flows. In some of the flows we are able to identify high concentrations of coarse sediment within a thin frontal cells, which outruns a thicker, trailing flow bodies. We are also able to indintfy the impact of large scale knickpoints on the flow dynamics. These data reveal some distinct divergenes from classical models and other field-scale measurements of turbidity currents and our results provide a new quantification of suspended sediment within flows and the interaction with the surrounding fluid.
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