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Direct measurements demonstrate how density currents evolve in Monterey Canyon

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Acoustic Doppler Current Profilers (ADCPs) have previously been deployed in submarine channels to measure density current flow structure and suspended sediment concentration at a single location. Here, we present results from the Monterey Coordinated Canyon Experiment, the most detailed study of a submarine channel undertaken thus far, which demonstrates how flows evolve as they pass through an array of instruments, including six moored ADCP, that were deployed along the channel axis in water depths from ∼300 m to ∼1850 m. Paull et al. (2018) have demonstrated that the flows are initially driven by a fast moving, dense basal layer. However, fundamental questions remain regarding the sediment concentration of the flows, and whether the basal layer persists, or if flows transition to a state in which turbulence alone supports sediment.

A total of 15 flows were observed by the instruments during the 18 month study period. Three of these flows ran out through the full array of instruments. The largest of these, on January 15th 2016, transported heavy objects several kilometres down the upper canyon.

Our acoustic inversions demonstrate that, even for the largest of the flows, the suspended sediment concentration remains relatively dilute (<1%). However, periods of acoustic noise were observed in the ADCP data commencing with flow arrival at the moorings. This phenomenon was observed for all flows and was only occasionally absent in the some of the distal observations of the flows. We infer that the noise is generated by particle collisions from a high concentration of sediment (> 9%) at the top of a dense basal layer that is mostly less than 1 m thick. We conclude that dense basal layers are present for the majority of the duration of the flows and that dilute suspensions run out for only a relatively short distance beyond the terminal location of the dense layer.

We relate the particle collision noise magnitude to the velocity of the basal layer and demonstrate that there is low shear between the dense layer and overlying dilute suspension in the body of the flows. This helps to explain the large density contrast (two to three orders magnitude) between the thin dense layer and the dilute suspension just a few metres above.

For the largest flow, the longest observed duration of the basal layer is ∼ 1 hour 50 minutes at ∼780 m water depth. In contrast, the shortest duration of ∼ 30 minutes was observed at the distal end of the array. The basal layer stretched as it progressed down the canyon and was still flowing over a distance of greater than 26 km by the time the flow front reached the most distal mooring. The particle collision noise ceased nearly simultaneously (within a ∼10 minute window) at all moorings between ∼780 m to ∼1850 m water depth, indicating that the dense basal layer slowed, then stopped, at around same time over a vast distance along the canyon floor.

Paull, C. K., et al., (2018), Powerful turbidity currents driven by dense basal layers, Nature Communications, NCOMMS-18-09895A.