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A multi-instrument approach to monitoring turbidity currents: Case study from the Squamish Delta, British Columbia (Canada)

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Turbidity currents are volumetrically the most important process for moving sediment in submarine environments. They may travel at high speeds, thereby posing a threat to important and expensive seafloor infrastructure. Despite their importance, we still know little about their flow dynamics because direct monitoring is challenging and consequently rare. Additionally, the few settings in which monitoring has been feasible, have generally involved a single instrument approach, either measuring flow velocity, sediment concentration or grain size. Here we present results issued from a multi-instrument study where a single turbidity current was observed with several instruments at the same location and time using different measuring frequencies.

Three types of geophysical sensors were deployed from a single vessel moored over a turbidity current channel on the Squamish Delta in British Colombia, Canada. First, two 500 kHz multibeam sonars suspended from the bow of the ship imaged the incoming turbidity current and documented its interaction with the crescentic bedforms on the channel thalweg. Second, a 600 kHz downward-looking Acoustic Doppler Current Profiler (ADCP) lowered from the back of the ship provided vertical profiles of velocity through time. Third, a 1.0-24.0 kHz Chirp profiler enabled for the first time imaging of the dense near-bed zone of the turbidity current, which has so far been largely impenetrable using higher frequency sonar and ADCP instruments. Besides the stationary deployment, a repetitive multibeam survey was also performed using a moving vessel in order monitor temporal evolution of the seafloor morphology resulting from turbidity currents.

By combining the measurements from each system, a single turbidity current was characterised in unusually high resolution. This current was 6 to 8 meters thick and at least 40 meters wide according to the multibeam sonars. The ADCP measured a front speed of around 1.5 m/s, higher than the internal velocities which decreased from 1.1 m/s to 0.3 m/s over 4 minutes. The fast-moving flow was followed by at least 15 minutes in which there was a sediment cloud in the water column that was visible both from the multibeam sonars and the ADCP. The Chirp sensor revealed that the incoming current excavated a thin layer of sediment from the seafloor.

Conclusions from this experiment are that each instrument has its own benefits. Their combination and deployment over a single fixed location are therefore needed if we are to characterise turbidity currents in detail. This provides new methodological insights on how to monitor turbidity currents in general.