Lahar monitoring in the Belham Valley, Montserrat, West Indies: flood bores and flow behaviour

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In March 2012, a camera was permanently installed overlooking a relatively straight section the Belham Valley, on the Soufrière Hills volcano, Montserrat. The remote site provides a new vantage point on lahar activity and overcomes challenges of monitoring an aggrading channel in an inaccessible mid-reach location. High quality (1296 × 960 pixel) images were captured continuously at >1 frame s^{-1} and stored in-situ on a field computer. This allows objects, 10 cm and greater, travelling up to 9 m s^{-1}, to be tracked between sequential images.

On 13-14th October 2012, tropical storm Raphael deposited 2×10^6 m^3 of rain on the 15.35 km^2 catchment, generating seven lahars in the Belham Valley that were identified on the MVO seismic record. Rainfall measurements were derived from Meteo France radar images and one local rain gauge. Five lahars that occurred during daylight were captured by the remote camera and simultaneously observed in person. These were strongly unsteady, turbulent, sediment-laden, shallow (<1 m) flows. Suspended sediment concentrations changed dramatically (4.9 to 106.5 g l^{-1}), and support visual observations that flows rapidly transformed from dilute to hyperconcentrated streamflow.

Three hundred and forty-nine bores were recorded within lahars observed by the camera. These bores are mechanically similar to breaking front tidal bores and arid flood bores. The bores created a depth increase of a few centimetres to 0.3 m, and had an average velocity of 5 m s^{-1}; the average flow velocity before and after these bores was 3.5 m s^{-1}. Their occurrence was not periodic; the interval between successive bores varied from 6 to 6×10^3 s. Flood bores were not observed by eye-witnesses in the lower reach indicating that they attenuated as they travelled downstream.

Multiple peaks and fluctuations in discharge are thought to result from the complex catchment response to rainfall patterns. Imagery suggests that the bores transfer significant amounts of sediment downstream, as well as rapidly changing channel boundaries. Critically, the passage of each flood bore results in a sudden increase in flow depth and velocity, highlighting the importance of better understanding the rapidly varying, unsteady nature of lahars to inform hazard assessment beyond forecasting location and timing.