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Tracing sediment pulses in lahars using multiparameter recording stations and serialised geophones.

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Intense rainfall at the active volcano of Mt. Semeru, Indonesia, regularly produces lahars affecting catchments at lower altitudes. Lahars go through distinct spatial and temporal rheological transformations, from dilute flood waves through to hyperconcentrated flows and occasionally debris laden debris flows, often returning to waning flood waves in their final stages. Erosion, bulking, deposition and de-bulking are thought to control these phases, yet real-time recording of sediment motion within the flow has proved elusive. The Lengkong river channel, 9.5 km from the summit of Mt. Semeru, has been used to capture in real time the physical characteristics of lahars and hyperconcentrated flows using a range of recording and sampling methods. The channel is a c. 30 m wide box-valley with a base of gravel and lava bedrock and provides an ideal “life-sized flume” to capture any sediment motion within a lahar or hyperconcentrated flow. Two recording sites were established in the channel, 510 m apart; an upstream ‘lava’ site (15-20 m wide, lava bedrock base), and a downstream ‘sabo’ site (25-30 m wide, concrete sabo dam). The two recording stations contained the following:

1. Pore pressure sensors (Hobo U20 Water and Solinst Levelogger) installed mid-channel, recording at 1 sps to determine stage height of the lahar through hydrostatic pressure,
2. Fixed 25 fps video cameras on the true left bank of both instrument sites.
3. direct suspended sediment samples were collected at each site by regularly weighing a 10 L dip sample of the lahars, providing estimates of particle concentration, grain size distribution and rheological properties.

In addition, a 3 component Guralp CMG-6TD broadband seismometer was located
10 m downstream of the upstream ‘lava’ site, on the true left bank. Seven newly constructed geophones, recording 25hz bulk (z-axis) vibrational energy to an inbuilt (sd-card) datalogger powered with a 12 V battery and 10 watt solar panel, were also equally spaced along the 510 m of channel between the recording sites. Pre and post event RTK-GPS cross-sectional surveys were made to gauge channel change.

A hyperconcentrated flow on the 26 February 2010 at 1555 (0955 GMT) provided the best integrated dataset. This flow occurred 30 mins after intense rainfall with stage heights increasing from 0.3-3 m in depth within 10-15 mins with observed velocities of 2-5 m/s. Rheologically, the flow exhibited standing waves, rolling boulders and suspended sediment loads of 30-40 weight %. From the video camera footage, measurements of the surface flow velocity were collected using Particle Image Velocimetry, in addition to qualitative measurements of the turbulence. The highest seismic energies were observed between 8-60 Hz. Geophones also recorded distinct peaks of energy that can be identified in individual sequential data streams. These are inferred to be separate pulses of sediment moving down the channel. The rates of rise of each bulk average energy peak may provide a proxy, in conjunction with velocity information between geophone sites and the suspended sediment record, for the quantification of sediment movement within the flow.