Multidisciplinary observation of turbidity current and mudflows associated with earthquakes at JASMTEC’ s cabled observatories: A review

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Turbidity current and mudflows associated with earthquakes have been detected with JAMSTEC’ s cabled observatories around Japan. Those are the turbidity current associated with “Tokachi-oki Earthquake” on September 26th in 2003 which was observed at the cable-end station of off Kushiro-Tokachi observatory, the several mudflows associated with a series of earthquakes occurred east off Izu Peninsula in March 1997, April and May 1998, and in April 2006 which were observed at off Hatsushima Island observatory. The main feature of the JAMSTEC’ s cabled observatories is that the multidisciplinary observation is carried out with various kinds of sensors on deep seafloor. Individual observation results were published or presented at some articles or at the meeting fragmentarily. This time, I reviewed those results including new findings afterwards for the purpose of obtaining the perspective of the phenomena as a whole.

The turbidity current and the mudflow are mainly recognized by the characteristic increase of current velocity. In addition, the increase of water temperature and/or that of sub-bottom temperature are also detected. At off Hatsushima Is. observatory, visual observation with video cameras has been carried out. At both observatories, underwater acoustic signal has been obtained with a hydrophone.

About 2 hours after the Tokachi-oki earthquake in 2003 occurred, whose epicenter is located at 25 km west-northwest of the cable-end station of off Kushiro-Tokachi observatory, the turbidity current arrived at the station. Strong water current up to 1.5 m/s, which was observed with electro-magnetic current meter at the seafloor, continued for more than 10 hours. Acoustic Doppler Current Profiler (ADCP) detected characteristic feature of turbidity current including the reverse direction current in upper water column (Fig. 1).

In the acoustic data obtained with the hydrophone at the cable-end station whose sampling rate is 100 Hz, relatively broadband signal continued since the arrival of the turbidity current. And seven hours later, the peak frequency changed to 1 Hz. Meanwhile, this kind of signal was not observed with the hydrophone at OBS1 which is located 5 km north-northeast of the cable-end station. Although the reasonable rock size could not be estimated by applying those frequencies to the relational expression described in Rickenmann (2017), those observational results would indicate that the main body of the turbidity current, which contained relatively large rock that collapsed near the epicenter at the upper part of the landward slope of the trench, passed through the western side of the cable-end station.

On the occasion of the mudflows associated with east off Izu Peninsula earthquakes on March 4th and 5th 1997, and on April 21st 2006, the video image of the seafloor and the audible acoustic signal whose frequency range is less than 10 kHz are obtained. Observed water current was about 30 cm/s at most. Although the acoustic signal contained rather large electrical noise, impact signals of pebbles were sporadically heard from the occurrence of the earthquake to the arrival of the mudflow on March 4th 1997 and on April 21st 2006. At almost the same time in the latter event, white-noise-like sound with broad frequency band was also heard. The diameter of the pebble could be estimated about 10 cm based on the frequency of the impact sound and the relational expression described in Rickenmann (2017), under the assumption that impact velocity is 1 m/s. On the other hand, white-noise-like sound would probably be generated by pebbles and/or sands of various diameters that was moving slightly remote place from the observatory. Those observational results would indicate the collapse of pebbles at the western slope of the observatory accompanied by the mudflow. In the latter event in 2006, the increase of ^{40}K was detected with a gamma-ray sensor and the fluctuation of electric potential difference of the both ends of the cable was observed. Those results would indicate the water current ranging more than several hundred meters, which contained sediments originated from alkali rock, traveled across the submarine cable of the observatory.

Reference

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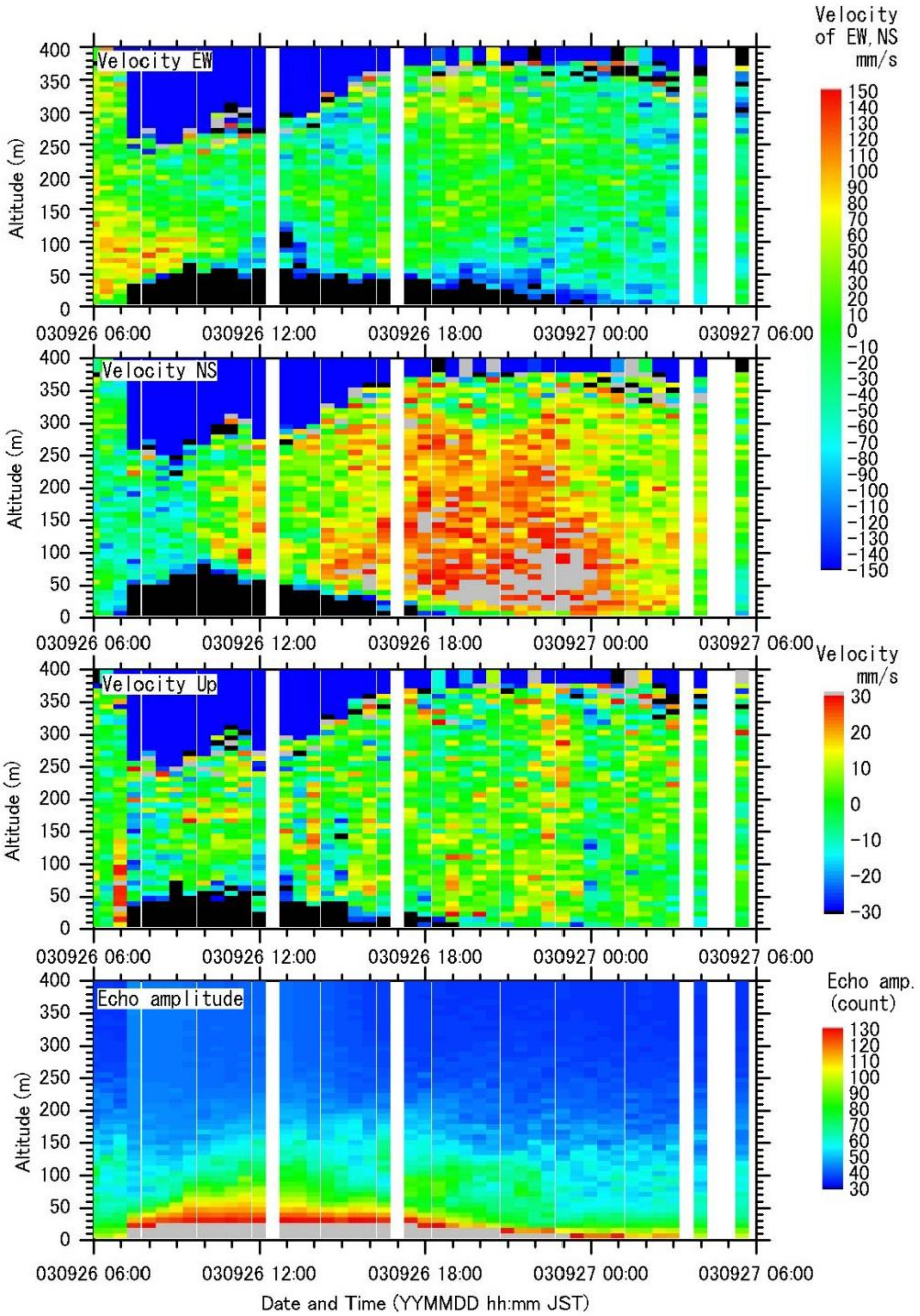

Fig. 1 24 hour ADCP profile from 06:00 JST on Sep. 26 2003.
From top: horizontal water current velocity of east-west, north-south and vertical component, and echo amplitude.
Warmer colors mean east, north and upward faster water currents