# 四国における臨時広帯域地震計設置で観測された2015年豊後水道浅部超低周波地震活動

# Swarm of shallow very low frequency earthquakes in the Bungo channel region in 2015 observed by temporal broadband seismic stations in the Shikoku island, southwest Japan

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The Bungo channel region in southwest Japan is one of regions where various types of slow earthquakes are observed at the top surface of subducting Philippine Sea plate. The slow earthquakes includes (i) long-term slow slip events (SSEs) at depths around 30 km and short-term SSEs at deeper depths recorded by geodetic instruments, (ii) shallow/deep low frequency tremor recorded by short-period seismometers at 1-10 Hz, (ii) and shallow/deep very low frequency earthquakes (VLFEs) recorded by broadband seismometers at 10-100 s. Although the coincidence of long-term SSEs and shallow VLFEs indicates relationship between them, there still exists a gap area between their estimated source areas without detection of any slow earthquake at this moment. For further understanding of slip distribution at the plate interface, we installed one Guralp CMG-3T (100 s) broadband seismometer and two Nanometrics Trillium (120 s) broadband seismometers in the southwestern part of the Shikoku island in February 2015 and June 2015, respectively. The observation plan at least continues to 2020.

The preliminary records showed seismic waves from shallow VLFEs activated in early June 2015. The data quality of vertical components was comparable to that of permanent stations of F-net broadband seismograph network operated by National Research Institute for Earth Science and Disaster Prevention at a period range of 20–50 s. We first applied the GRiD MT method (Tsuruoka et al. 2009) to records of 18 F-net stations as well as three new stations on June 8th filtered at a period range of 20–50 s for determining location and focal mechanism of each VLFE. We then applied the matched filter technique (Shelly et al. 2007) to detect similar events for eight months from May to December in 2015 by using a Mw4.1 event as a template event. The total number of detection is 1,476. We also determined the amplitude and location of each event with respective to the template event by grid search and waveform fitting.

The space-time plot of detected events showed two migrationg sequences of shallow VLFEs from southwest to northeast for two times, and several rapid reversal movements in June 2015. The cumulative number plot of time interval between adjacent events shows power-low distribution, which is different from exponential distribution for normal earthquakes and may characterize the swarm-like activity of VLFEs. The cumulative number of amplitude could be explained by both exponential and power-low functions due to limited range of amplitudes. Further discussion about the detection level for small amplitude is needed to conclude which function better explains the obtained distribution.

We also applied various band-pass filters to the waveforms at the time-windows aligned by the origin time of detected events. As a result, we could observe coherent signals between each time-windows at a period range of 10–100 s. Since the data quality was limited especially at periods longer than 50 s, we improved the signal-to-noise ratio by calculating station-averaged waveforms for each event. The averaged waveforms showed constant phase shifts between each time-windows at least at a period range of 20–100 s. This result indicates that the moment release function of each VLFE has a typical duration less than ~20 s.

 

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