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Observation of the 2011 Tohoku earthquake and tsunami with use of the DONET stations

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Ocean bottom pressure and acceleration data were simultaneously recorded by the DONET seafloor network during the 2011 Tohoku, Japan earthquake (Mw9.0) at distance of approximately 800 km from the earthquake epicentre. The close location of pressure gauge (PG) and ocean-bottom seismometer (OBS) as well as the high sampling rate of data make it possible for the first time to quantitatively examine and interpret pressure variations together with ocean bottom acceleration. In order to interpret the observed data we introduce a set of characteristic frequencies that allow us to identify physical processes responsible for the behaviour of water layer in frequency dependence by ocean bottom oscillations. The characteristic frequencies give us ground to introduce non-overlapping frequency bands; 'hydroacoustic waves', 'forced oscillations', and 'gravitational waves'. The physical correction of such a subdivision is proved by high coherence and nearly zero phase difference between in-situ measured variations of pressure and acceleration that are observed in the 'forced oscillations' frequency band. Within 'forced oscillations' frequency band neither hydroacoustic nor gravitational waves can be generated by ocean bottom oscillations; water layer simply follows the ocean bottom making some kind of forced oscillations. By applying numerical filtering, we select pressure variations peculiar to different frequency bands. According to our identification based on frequency variations, dominant and long-lasting pressure fluctuations recorded by DONET during the earthquake are the 'forced oscillation' type, more exactly 'water and sedimentary layer coupling oscillation'. In the frequency band of 'hydroacoustic waves', the signal is slightly weaker but virtually at the same level of magnitude. In the frequency band 'gravitational waves' pressure variations, i.e. tsunami signal is an order of magnitude smaller. In any case, the tsunami signal is clearly observed by DONET during more than one day after the earthquake. In contrast to the DART records, the phase dispersion was not manifested in the tsunami signals registered by DONET.