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GPS/acoustic measurement using a multi-purpose moored buoy system

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For monitoring crustal deformation and tsunami occurrence in the source region of the upcoming Nankai and Tonankai earthquake, JAMSTEC, JAXA, and Tohoku University have jointly developed a realtime continuous observation system using a moored buoy, called m-TRITON, and have started its sea-trial. The system consists of a seafloor pressure sensor for monitoring tsunamis and vertical crustal deformation, a GPS system for monitoring sea-level and position/attitude of the buoy, and a GPS/acoustic system for monitoring horizontal crustal deformation. Measuresd data are transmited to onshore station via satellite communication so that they can be monitored in realtime. The first sea-trial was carried out in Kumano-nada in 2013, and the second trial has been started in 2014 after improvement of the system. In this presentation, we focus on the issues particular to acoustic ranging of GPS/acoustic measurement for the purpose to remedy the system based on the data acquired in 2013, and report new data being acquired in the ongoing second trial in 2014.

The GPS/acoustic system measures horizontal movement of a seafloor banchmark, which consists of six transponders by combining GPS analysis of the buoy and acoustic ranging between the buoy and seafloor transponders. Considering bit-rate of the satellite communication, it is not realistic to send full acoustic waveform. So, it is required to send only the result processed on the buoy. In order to proceed acoustic wave with a low-powered device on the buoy, it is necessary (1) to cut out recorded waveform to the minimum requirement and (2) to send the processed data containing minimum but sufficient information. As for (1), in the current system recorded acoustic waveform is cut out by a window of $\pm$ 20 ms centered at synthetic traveltime calculated from provisional position of the buoy and each seafloor transponder. After that, cross-correlation waveform between the transmitted signal and the received signal is calculated to obtain an accurate observed traveltime. Then (2) send the correlogram only a 1 ms window centered at the maximum correlation peak, which is sufficient to include the sidelobe. Since correlation wave is represented in 8 bit and the sampling rate is in 100 kHz, the size-per-signle wave to be transmitted can be reduced only to 101 byte.

As a result of considering the fluctuating range for the uncertainty of provisional position obtained by the NMEA output of the GPS (~10 m at most) and the average sound speed variation (~2 m/s) that affect the synthetic traveltime, the window width of $\pm$ 20ms employed in (1) is a minimum requirement. In order to certainly cut out maximum correlation peak for all acoustic ranging, it is desirable to set the width to $\pm$ 30 ms. As for correlogram to be sent to onshore station, since the envelope of the correlation peak is within the 1 ms, current width is reasonable. However, apparent maximum correlation peak often known to appears due to multiples at sea surface. In that case, it is not possible to achieve proper adjustment only by the width. Therefore the development of an algorithm to detect the true correlation peak is required. We verified based on actual data about the condition that the multiple occurs, and found that it is explained by the incident angle of the sound wave and the directivity of transducer. We are developping an algorithm that automatically detects the true correlation peak based on this hypothesis.

Keywords: crustal deformation, moored buoy