A study on the effects of sea surface height and density of sea water on bottom pressure off the southeastern coast of Hokkaido, Japan after El Nino events using a high-spatial-resolution ocean assimilation data

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To investigate the effects of sea surface height (SSH) and sea water density on bottom pressure (BP) off the southeastern coast of Hokkaido, Japan after El Nino events, a state-of-the-art high-spatial-resolution (1/12 degree) ocean assimilation data of the JCOPE2M for the period of 2001-2018 are analyzed. On year-to-year timescale, after the weak El Nino events occurring in 2004/05, 2006/07 and 2009/10, positive SSH anomalies less than 0.15 m appear off the southeastern coast of Hokkaido, while stronger SSH anomalies greater than 0.2 m exist after the very strong El Nino event of 2015/16. The result shows that although such positive SSH anomalies have effect of increase of BP, density changes of sea water from the sea surface to the ocean bottom (i.e., steric effect), in general, cancel out the effect of SSH anomalies on BP change. In offshore area (i.e., area with bottom depth of deeper than 1000 m), roughly 90 % of the effect of the SSH anomaly is cancelled out by the density change of sea water, and roughly 80 % in near-coastal area with bottom depth from 500 m to 1000 m. In the area very close to the coast with bottom depth less than 500 m, density change of sea water cannot cancel adequately the SSH anomalies as compared to the offshore area; for example, from 20 % to 50 % in the area with bottom depth of around 100 ~ 200 m. Thus, it can be said that oceanic isostasy is generally well established especially in the offshore area, as contrast to the shallow area.To check further the strength of the oceanic isostasy, oceanic isostasy anomaly (OIA) is newly introduced in this study. The OIA is defined as a sum of SSH anomalies and geopotential distance (GPD) anomalies from bottom to sea surface. If value of OIA is zero, it means that oceanic isostasy is perfectly established; if OIA is positive (negative), oceanic fluid can lead increase (decrease) of BP. The value of OIA ranges from -0.025 to +0.025 m for both weak and strong El Nino events. For example, at PG1, OAI shows 0.003 m in July 2015, then becomes to 0.015 m in July 2016, showing a change rate of roughly +0.01 m/year during this period. OIA again becomes to be a small value (0.003 m) in July 2017, showing roughly -0.01 m/year change rate of OIA from July 2016 to July 2017. It is also shown that spatial pattern of OIA is not same for each El Nino event. This means that effect of oceanic fluid on BP change shows a spatio-temporal change in association with El Nino events at year-to-year timescale. The present results indicate that effect of oceanic fluid due to both SSH and sea water density changes on BP change cannot be neglected when BP change (or change rate of BP) should be evaluated with order of 1 cm (or 1 cm/year) at year-to-year scale. Therefore, to better take the year-to-year scale BP changes due to crustal deformation related to such as long-term slow slip events (SSEs) or plate convergence, OIA should be removed from the total value of BP.

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