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Detection of short-term slow slip events along the Nankai Trough by observations of groundwater level or pressure

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Non-volcanic deep low-frequency (DLF) tremors are detected on plate boundaries along many subduction zones around the world [Obara,2002; Ide, 2012]. Short-term slow slip events (S-SSEs), which cause small crustal deformation with no usual seismic waves, are also detected in subduction zones [Rogers and Dragert, 2003; Schwartz and Rokosky, 2007; Sekine et al., 2010]. There is a close spatial and temporal correlation between DLF tremors and S-SSEs. However, S-SSEs do not always occur in areas where DLF tremors occur and vice versa. Therefore, it is important to clarify the detailed spatial and temporal correlations in order to know what occurs on the plate boundaries along subduction zones. In general, detecting S-SSEs via crustal deformation is more difficult than with DLF tremors when using a seismograph. One major reason for this is that the decay of crustal deformation by distance is much larger than that of seismic waves. Therefore, it is necessary to develop new tools or techniques to detect S-SSEs. For this purpose, we attempted to detect S-SSEs in the Nankai Trough, Japan by conducting groundwater pressure observations at ANO station in Mie Prefecture, Japan. The ANO is a groundwater observation station operated by the Geological Survey of Japan, AIST, for earthquake prediction research. The groundwater pressures changed due to six S-SSEs that occurred near ANO from June 2011 to April in 2013. The fault models of these S-SSEs, which were estimated mainly by observing the crustal strains and tilts, explained the changes in the groundwater pressures. We also considered the conditions for detecting S-SSEs via groundwater observations. The volumetric strain changes caused by the S-SSEs along the Nankai Trough were 10-20 nstrain/day at most [Kobayashi et al., 2006], where nstrain means 10^{-9} strain. Therefore, the strain-converted noise level should be 5 nstrain/day or smaller to detect the S-SSEs. Taking the actual conditions of groundwater observation into consideration, it is necessary that the noise level should be smaller than 50 mm/day and that the strain sensitivity of the groundwater pressure or level should be larger than 1 mm/nstrain for the required strain-converted noise level.

Keywords: Slow slip event, Deep low-frequency tremor, Groundwater, Poroelastic theory, Strain, Earthquake forecast