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A variety of strain changes in the anticipated Tokai earthquake area

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Great interplate earthquakes have occurred at the Nankai Trough at a recurrence interval of approximately 100 to 150 years due to the subduction of the Philippine Sea plate beneath southwestern Japan. In addition to such a regular Nankai Trough earthquake cycle, there is a hyperearthquake cycle of 300 to 500 years. A Tokai earthquake has not occurred for more than 150 years since the 1854 Ansei Tokai earthquake. Tokai, Tonankai, and Nankai consolidated earthquakes have not occurred for more than 300 years since the 1707 Hoei earthquake. The Japanese government is taking the Tokai earthquakes seriously and has charged the Japan Meteorological Agency (JMA) with predicting the next one. There is now a dense array of instruments placed to accumulate a continuous stream of data related to seismicity, strain, crustal expansion, tilt, tidal variations, ground water fluctuations and other variables. They are watching for an anomaly in these data that might precede the next major Tokai earthquake. However the earth's surface is continuously influenced by of a variety of natural forces such as earthquakes, waves, winds, tides, air pressure changes, precipitation and by a number of human induced sources. These generate variations in geodetic data that may mask precursory signals. Eliminating unwanted changes in the raw data requires appropriate statistical modeling, for detailed and accurate processing of geodetic data. We show that applying state space modeling is valuable for removing extraneous influences in order to enhance detection of possible precursors of the anticipated Tokai earthquake. On 11 August 2009 the intraslab Suruga Bay earthquake (M6.5) occurred in the Philippine Sea plate under the Tokai area. The JMA network of strainmeters has already been monitoring short-term slow slip events (SSE) synchronized with nearby low frequency earthquakes or tremors since 2005 (Kobayashi, et al., 2006). Although the 2009 Suruga Bay earthquake was an intraplate earthquake in the Philippine Sea plate, it was immediately followed by a sudden increase in interplate earthquakes in the Tokai area for the following month (Aoi et al., 2010). No pre-slip was detected by land-based observations in the Tokai area, even though it appears that the post-stress state at the subducting plate boundary was strongly affected. We here try to isolate tectonic strain behavior before the 2009 Suruga Bay earthquake by applying the state space modeling and Kalman filtering/smoother to the volumetric strain data at the Tokai network of JMA. In summary we show: (1) The strain extracted by the state space modeling demonstrates that the shallow volumetric strainmeters deployed at depths less than 200m can provide high quality strain behavior. (2) The resulting strain time series can be divided into three groups: one composed of stations near Omaezaki, characterized by a very stable behavior; a second group, at large distance from the hypocenter, shows no significant changes; and a third group, the west coastal stations of Suruga Bay, is characterized by a synchronous change except for an irregular change just before the 2009 Suruga Bay earthquake. The unusual irregular changes occur at stations located on the landward side of tectonic boundary extended from Suruga Trough. Finally, the present study reveals an uncommon strain change just before the 2009 Suruga Bay earthquake.

Keywords: State space modeling, Volumetric strain data, 2009 Suruga Bay earthquake, Anticipated Tokai earthquake, Philippine sea plate, Slow slip event