Final responses to referees #1 and #2

I experienced the referee process for Chaos of AIP so I know how much time referees have to spend in reviewing articles. I very much appreciate referee's time and comments.

It is, however, unfortunate that two referees were unfamiliar with the physical wavelet methodology used to find the deterministic physical laws for the precursory phenomena of impending large earthquake (EQ) events. They appear to confuse the deterministic methodology with statistical methods like natural time and chaos analyses. They also appear unfamiliar with the large earthquake phenomena observed in both seismicity and crustal displacements of GPS stations.

Clarifying some mix-ups on the methodologies applied to seismic observations may require a summarization as follows:

1) As stated in the introduction, both EQ events and the daily displacements of GPS stations quantify the stress state of the earth's lithosphere, which is deterministically controlled by tectonic forces.
2) The notion of a virtual particle for EQ events in the EQ source parameter space has been introduced since 2001 to find the deterministic physical laws for stress state that creates $d(c, m)$ where $c = LAT, LON, DEP, INT$ and MAG, and time m is the chronological event index that is uniquely related to origin time (real time).
3) The chaotic motion of the particle (shown in Figure 3a) has periodic fluctuations of about 64 events common to all c observed as in Figure 4. Their spectra are obtained from $d(c, m)$ whose time m runs from 1986 to the 1995 Kobe EQ.
4) The $d(c, m)$ is non-differentiable with respect to time m so that one needs a new mathematical tool of calculus to find the time derivatives.
5) The concise description of the tool with a mathematical proof is given in section 3. I have developed and used the tool for my private consulting works since 1985 as stated in sections 3.4 and 3.8.
6) The tool, named as physical wavelets, finds displacement $D(c, t)$, velocity $V(c, t)$ and acceleration $A(c, t)$ of the particle motion whose pathway is non-differentiable $d(c, m)$. The $d(c, m)$ has the periodic fluctuation components of about 64 events. As stated in sections 3.5 and 4.2, they are the Newtonian equations of particle motion in specific periodic fluctuations, which was masked by chaotic seismic noise.
7) Two types of anomalous accelerations, which are characterized by the phase relationship of $A(c, t)$ among $c = DEP, INT$ and MAG, are precursory to every large impending event with M ≧ about 6 throughout Japan. One is named as CQK after the 1995 Kobe M7.2 and another is CQT after the 2000 Tottotri M7.2.
8) CQK and CQT are the deterministic physical laws for precursory phenomena of impending large EQs, which then build the physical models of deterministic EQ predictions.
9) The CQK and CQT are in perfect harmony with other seismogenic observations of coda waves as stated in section 5.

10) Keiiti Aki had personally commented on the CQK and CQT which are the foundation of deterministic EQ prediction model as quoted in the response to referee #2.
11) Similarly, as stated in section 3.7, we have analyzed the daily displacements of GPS stations of $d(c, m)$ at time (day) m, where c is the geological axis E (west–east), N (south–north) and h (down–up). The $d(c, m)$ has various trends and $d(h, m)$ is completely masked by various environmental noises. So, $d(c, m)$ is non-differentiable. Physical wavelets find displacement $D(c, t)$, velocity $V(c, t)$ and acceleration $A(c, t)$ in selective frequency (being $1/m$), which are used for the quantitative analyses of the crustal motion in $D(c, t) - V(c, t)$ and $D(c, t)$ -$A(c, t)$ phase planes. For example, the trajectory drawn on $D(h, t) - V(h, t)$ plane with $w = 200$ days and $2n = s = 300$ days, has the resolutions of 0.1 mm and 0.0001 mm/day 5 orders of magnitude greater than the daily background noise level. Thus they have identified the precursory crustal motion to the great Tohoku M9 event.
12) Physical wavelets can be used for the statistical analyses of time series data. Its simplest application is given in section 3.9 to find the strain energy density of a regional seismicity. The rapid release of energy is identified as the phenomenon known as AMR. It is shown it can be used as a prediction of an impending large event as shown in section 4.6.
13) As for the comments that more case studies are needed, they are from the statistical point view of a false alarm rate. Any deterministic analysis of seismic fault motion and structure should be made only for a single event as seismic moment is formulated by Keiiti Aki in 1966. The fault plane may not be single (simple) like that of the 1995 Kobe EQ but complex as observed in many cases. Inclusion of this kind of case study requires a book size document with many references like my patent (Takeda. F., 2015) and a life time to write. We have tested many cases successfully for our physical model as stated in section 4.3 by using the empirical relations of fault size and magnitude.

In closing my summary, I would like to stress that physical wavelets have deterministic and statistical methodologies. The deterministic methodology has a profound application to the calculus of non-differentiable deterministic and stochastic processes as applied to our finding of the deterministic physical laws for precursory phenomena for large and great impending EQs.