Synthesizing and Visualizing the (Many Ways of) Evolution of Possible Precursory Phenomena to Occurrence of Megaquakes

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It has been known for a long time that earthquakes trigger other earthquakes with some probability (Omori's law). Based on such knowledge, routine communication of forecast information when earthquakes of moderate or larger size struck is in operation in a few places in the world. Slow slip phenomena will probably be additionally used in earthquake forecasts before too long, with increasing cases of slow slip events triggering large earthquakes, including 2011 Mw 9.0 Tohoku earthquake in Japan and 2014 Mw 8.1 Iquique earthquake in Chile.

In Japan, a new official forecast information service on impending Nankai trough earthquakes started in November 2017. Based on the earthquake activity and slow slip occurrence, the Japan Meteorological Agency will send warning information when the chances of a megaquake have become "higher than normal". This kind of forecast information is qualitative and includes large uncertainty. While it is challenging for the society to effectively use such obscure information, it is worthwhile (or even responsibility of the research community of disaster science) seeking the way of usage for disaster reduction, considering the huge damage and losses anticipated for the Nankai trough earthquakes. The authority estimates, in the worst-case scenario, more than 200 thousand victims from tsunami. According to their estimate, this number drastically drops to 85 thousand when prompt evacuation takes place. Since huge tsunami (say higher than 10 meters) is expected within a few minutes at many places, systems that issue warnings after the occurrence of earthquake or detection of sea height level change cannot provide enough lead time for everyone. The new kind of forecast information has a potential to solve this problem. Same kind of reasoning holds for earthquake-induced landslide hazard.

With my colleagues at IRIDeS, Tohoku University, we launched a project to develop event tree diagram that graphically shows evolution of geophysical phenomena (giving rough probability information for each branch) starting from precursory phenomena to leading to the occurrence of (or non-occurrence of) a megaquake(s). Of course, an M9 can occur without any precursory signal. But other scenarios are also possible. For example,

- An M8 earthquake occurs, followed by another M8 with some time lag (in fact this occurred multiple times in Nankai). The time lag can be in the order of minutes, hours, days, months, or years.
- Similarly but with smaller probability, an M7 occurs, followed by a megaquake (M8 or M9) with some time lag. (Note that having moderate to large interplate earthquakes is already abnormal in Nankai (we rarely have them), as is also the case for Cascadia.
- A series of smaller earthquakes occur (foreshocks), followed by a megaquake.
- One of the slow slips occurring regularly trigger a megaquake.
- Unusual type of slow slip occurs preceding a megaquake.

Our assumed main target users of the diagram are disaster management personnel (those who have to prepare response plans or manuals in advance for the occasions of warning issuance) of local governments, public institutions, and key private companies of the local society. The diagram will serve

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as a tool 1) for understanding the spectrum of possible scenarios, and 2) for planning and verifying the countermeasures (if they are inclusive and flexible enough).

I invite collaborators who can 1) help to build a solid conceptual framework, 2) bring perspectives from Cascadia and Chilean subduction zones and make comparisons with Nankai subduction case, and 3) contribute in synthesizing the precursory phenomena (e.g., probability calculation of abnormal phenomena leading to a megaquake) or raising ideas about the visualization method (e.g., design of graphical representation).