A class activity illustrating earthquake probabilities and uncertainties

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A classic unresolved question in earthquake physics is whether to regard the recurrence of large earthquakes as time-independent or time-dependent. In the first model, a future earthquake is equally likely immediately after the past one, so an earthquake cannot be "overdue." In the second, the probability is small shortly after the past one, and then increases with time. The two models often predict quite different earthquake hazards. The differences are nicely illustrated using the classic probability model of drawing balls from an urn (Stein and Stein, 2013). We developed a class exercise to do this for a Central U.S. EarthScope Teachers Workshop at Illinois State University. First, each teacher was given a container with an unknown number of marbles (in fact, 36 white and 4 black) and used the results of ten draws in which the marble was replaced to estimate the time independent probability of drawing a black "earthquake" marble in the eleventh draw. Next, we examined time dependent probability in that each time a white marble was drawn, it was not replaced, increasing the probability of drawing a black marble. Finally, we explored the effects of stress transfer by having teachers work side-by-side. On command, each teacher drew a marble. If they drew a black marble, they raised their hand and announced "EARTHQUAKE". A prearranged mixture of white and black balls was added to that container to reduce the likelihood of another event on the next draw. Moreover, a prearranged mixture of white and red balls was added to the containers of either side of to raise the likelihood of drawing a colored ball (red or black). After the fourth trial, locations of the next earthquakes were forecast.

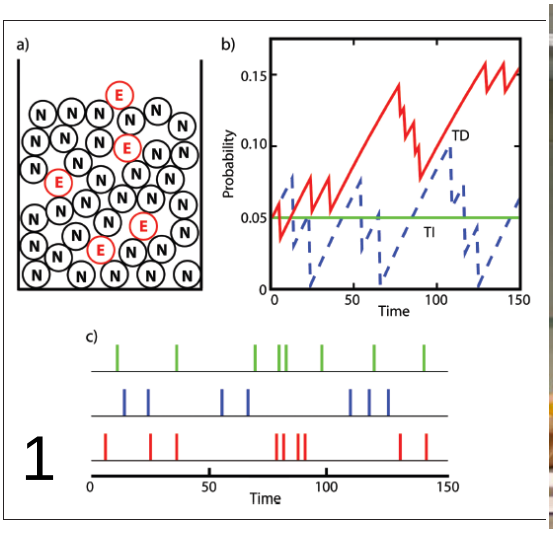

Figure 1: a) Model for the probability of an event as drawing from an urn with balls labeled "E" for event and "N" for no event. b) Comparison of the probability of an event as a function of time for time-independent (green line) and time-dependent (red and blue lines) models. c) Sequence of events as a function of time for the three models in b). (Stein and Stein, EOS, 4/2/2013)

Figure 2: Master Teacher Clark Ingwersen, collecting and mapping time independent data.