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The effect of stress changes on time-dependent earthquake probability: an example from the Wasatch Fault Zone, Utah, USA.

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Static and quasi-static Coulomb stress changes produced by large earthquakes can modify the probability of occurrence of subsequent events on neighbouring faults. In order to better understand and minimize the uncertainties in this kind of approach based on physical (Coulomb stress changes) and statistical (probability calculations) models, we focused our study on the Wasatch fault zone (WFZ), a well-studied active normal fault system having abundant geologic and paleoseismic data. Paleoseismic trench investigations of the WFZ indicate that at least 24 large, surface-faulting earthquakes have ruptured the fault's five central, 35–59-km long segments since ∼7 ka. Our goal is to determine if the stress changes due to selected paleoevents have significantly modified the present-day probability of occurrence of large earthquakes on each of the segments.

For each segment, we modeled the cumulative (coseismic + postseismic) Coulomb stress changes (ΔCFScum) due to earthquakes younger than the most recent event and applied the resulting values to the time-dependent probability calculations. Results from the probability calculations predict high percentages of occurrence for the Brigham City and Salt Lake City segments, due to their long elapsed times (>1-2 kyr) when compared to the Weber, Provo, and Nephi segments (< 1 kyr). We also found that the Brigham City, Salt Lake City, and Provo segments have accumulated ΔCFScum larger than 10 bar, whereas the Weber segment has experienced a stress drop of 5 bar.

Our results indicate that the ΔCFScum resulting from earthquakes postdating the youngest events on the segments significantly affect the probability calculations only for the Brigham City, Salt Lake City, and Provo segments. In particular, the probability of occurrence of a large earthquake in the next 50 years on these three segments may be underestimated if a time-independent approach, or a time-dependent approach that does not consider ΔCFS, is adopted.