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Effective Uncertainty Visualization for Aftershock Forecast Maps

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Seismicity rate estimates and the earthquake forecasts they yield vary spatially and are usually represented as heat maps. While visualization literature suggests that displaying forecast uncertainty can improve how forecast maps are used, research on uncertainty visualization (UV) is missing from earthquake science. We present a pre-registered online experiment to test the effectiveness of three UV techniques for displaying aftershock forecasts. These maps show the expected number of aftershocks at each location for a week following a hypothetical mainshock, and we develop maps of the uncertainty around each location's forecast. Human participants complete experimental tasks using the aftershock forecast displayed with its uncertainty. Three different UVs are producted: (1) forecast and uncertainty maps adjacent to one another; (2) the forecast map depicted in a color scheme, with the uncertainty shown by the transparency of the color; (3) two maps that show the lower and upper bound of the forecast distriubiton at each location. We compare task performance using UVs and using the forecast map shown without its uncertainty (the current practice). Subjects complete two map-reading tasks that target several dimensions of the readability of the three UVs. They then perform a comparative prediction task, which demonstrates whether a UV is successful in reaching two key communication goals: indicating where an aftershock and no aftershocks are likely ("sure bets") and where the forecast is low but the uncertainty is high enough to imply potential risk ("potential surprises"). All UVs perform equally well in the goal of communicating "sure bet" situations. But the UV with lower and upper bounds is significantly better than the other UVs at communicating "potential surprises." We discuss the implications of these results for communication of forecast uncertainty within and beyond earthquake science.