The Spatial Distribution of Afterslip Provides new Information about the Coseismic Slip Distribution of the July 29, 2021, Mw 8.2 Chignik Earthquake

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On 29 July 2021, an Mw 8.2 megathrust earthquake struck the Alaska Peninsula. Quantifying the coseismic slip and the afterslip that followed this earthquake provides us the opportunity to clarify the megathrust slip budget and the earthquake hazard potential there. However, the coseismic slip distribution inversion result is hugely affected by some chosen parameters, including the extent of the rupture plane allowed in the model. In this study, we found that the spatial pattern of afterslip is mainly controlled by the coseismic slip distribution, which means the afterslip spatial pattern provides new information about the coseismic slip distribution.

In order to isolate afterslip, we first tested possible viscoelastic relaxation contributions to the observed postseismic signal based on different assumed viscosity structures. We then subtracted the predicted value of the viscoelastic relaxation from the observed postseismic signal and get the afterslip-only displacements for the first three months after the earthquake. Using the data set and method of Elliott et al. (2022) we estimated coseismic slip models with different maximum down-dip widths, leading to ruptures that were more compact or more expanded in the downdip direction. A rupture that is more compact in the downdip direction leads to afterslip being located farther offshore. We find that whatever viscosity structures we assume, a narrower fault rupture improves the 3-month afterslip-only model prediction.

We also use 3-week displacements from continuous GPS sites to search for the best afterslip frictional parameters, with coseismic fault planes of different fault width as input. Then we use the coseismic models and their best-fit frictional parameters to predict the 3-week coseismic + postseismic deformation at GPS campaign sites measured ~3 weeks after the earthquake. Again, we find that a narrower fault rupture is preferred, as it minimizes the angular misfit at two island sites with large displacements (YUK and SEMI).