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Slip distribution of the 1960 Chile earthquake using a FEM with precise geometry

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The 1960 Chile earthquake (M_w=9.5) is the largest recorded seismic event. It caused a ∼950-km-long rupture between the subducting Nazca plate and the South American continent. Ongoing postseismic mantle relaxation, interseismic strain accumulation, motion of a forearc sliver, and block rotation controlled by crustal faults have been documented in the vicinity of the earthquake rupture zone. A variable slip distribution for this event has been made using a dislocation model with simple planar slab geometry (Barrientos and Ward, 1990), based on the inversion of sea-level changes and elevation differences. We use the same 155 vertical displacements of the land relative to sea-level (Plafker and Savage, 1970) to determine the slip distribution of the source, applying a finite element model (FEM) with precise geometry. The Green's function matrix containing the kernel of the coseismic model displacements is constructed. Classic Laplace constraints on the slip distribution can not be applied due to the complexity of the geometry. Therefore, we implemented isoparametric finite element constraints to smooth the slip of neighbor nodes on the rupture. An optimization routine is used for matrix inversion with positive constraint allowing only thrust slip. This improved FEM inversion method can handle very complex nodes distributions, include viscosity effects and implement layering of different material properties, providing a precise tool to estimate unknown fault slip distribution. Our results are significantly smoother than the previous results based on planar geometry. The obtained rupture zone (38-46°S) is restricted to the continental shelf in contrast to Barrientos and Ward (1990) finding that extended to below the volcanic arc. A ∼300-km-long asperity with slip over 30 m is located at the northern segment of the rupture near of Valdivia. The faulting area narrows southward, showing two peaks of slip at 42° and 43°S. Our results give a geodetic moment of $\sim 1 \times 10^{23}$Nm, which corresponds to ∼45% of the seismic moment, confirming a moment deficit. The missing moment could reflect non-linear deformation near the megathrust and/or different sensitivity of both seismic and geodetic methodologies.