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Convergence between the Georgian Lesser and Greater Caucasus: Implications for seismic risk around Tbilisi

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The Caucasus region, including the Lesser and Greater Caucasus Mountains and intervening Rioni, Kartli and Kura basins, defines the northern margin of the Arabia-Eurasia continental collision between the Black and Caspian Seas. Although geodetic, geologic and seismological data attest to active crustal shortening in the region, both the structures accommodating this deformation and the potential seismic hazards they pose remain unclear. Here we present and interpret newly determined site motions derived from GPS observations made at 21 campaign sites and 4 continuous GPS stations in the Republic of Georgia from 2008 through 2015. The sites are located along two, $\sim$ 160 km-long, range-perpendicular profiles crossing the Lesser-Greater Caucasus boundary zone. The Racha profile in the west spans the Rioni Basin and epicentral area of the 1991 Mw6.9 Racha earthquake. To the east, the Tbilisi profile crosses near the capital city of Tbilisi, with a population of $\sim$ 1.2 million. To estimate site velocities, we processed the GPS observations using the GAMIT/GLOBK software package, and then combined new and previously published velocities in a common Eurasian reference frame. Both profiles indicate $\sim$ 3 mm/yr of shortening between the Greater and Lesser Caucasus. On the Racha profile, the locus of shortening roughly coincides with the Main Caucasus Thrust Fault as defined by the location of the 1991 Racha earthquake. In contrast, on the Tbilisi profile shortening is concentrated $\sim$ 40–60 km further south, in the vicinity of the Lesser Caucasus Thrust Fault (locally, the Adjara-Trialeti Fault). Simple elastic models of planar faults in an elastic half-space indicate that convergence along the Racha profile is consistent with strain accumulation on a north-dipping thrust fault rooting beneath the Greater Caucasus, generally consistent with the coseismic fault parameters for the 1991 Racha earthquake. In contrast, principal convergence along the Tbilisi profile appears to be associated with a fault that roots near the northern boundary of the Lesser Caucasus. This change in the location of active convergence may be related to incipient collision between the Lesser and Greater Caucasus blocks that is occurring along this section of the boundary ($\sim$ 44°E). Focused geodetic, seismic and neotectonic investigations are continuing to better characterize the underlying structures accommodating shortening, and associated seismic hazards around Tbilisi.