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A regional fault-specific earthquake recurrence interval map for the Italian Apennines derived from post 15 ka strain-rate fields: implications for surpluses and deficits of seismic strain.

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A key unknown is how far a fault can stray from its long-term slip rate, both at a timescale equivalent to the interseismic period (10^2-10^3 years), and over timescales equivalent to several seismic cycles (10^3-10^4 years). The lack of such knowledge impedes our ability to perform probabilistic seismic hazard assessments and understand the underlying physics that controls repeated earthquake slip. In order to study the existence of possible deficits or surpluses of geodetic and earthquake strain in the Italian Apennines compared to 15 $\pm$3 kyr multi-seismic-cycle strain-rates, horizontal strain-rates are calculated using slip-vectors from striated faults and offsets of Late Pleistocene-Holocene landforms and sediments, using an adaptation of the Kostrov equations.

Strain-rates calculated over 15 $\pm$3 kyr within 5km x 5km grid squares vary from zero up to 2.34 $\pm$0.54 x 10^{-7} yr^{-1}, 3.69 $\pm$1.33 x 10^{-8} yr^{-1}, and 1.20 $\pm$0.41 x 10^{-7} yr^{-1} in the central Apennines Lazio-Abruzzo region, the Molise-North Campania region, and the southern Apennines South Campania-Basilicata region, respectively, and resolve variations in strain orientations and magnitudes along the strike of individual faults. Strain-rates over a time period of 15 $\pm$3 kyrs from 5km x 5km grid squares integrated over an area of 1.28 x $10^4$$km^2$ (80 km x 160 km), show the horizontal strain-rate of the central Apennines is 1.18 (+0.12/-0.04) x 10^{-8} yr^{-1} parallel to the regional principal strain direction (043-223^o $\pm 1^o$). In Molise-North Campania, the horizontal principal strain-rate calculated over an area of 5 x 10^3 km^2 (50 km x 100 km) is 2.11 (+1:14/-0:16) x 10^{-9} yr^{-1} along the principal horizontal strain direction (039-219^o $\pm 3^o$). Within the southern Apennines region with an area of 8 x 10^3 km^2(50 km x 160 km), the average horizontal principal strain-rate is 3.70 $\pm$0:26 x 10^{-9} yr^{-1} along the horizontal principal strain direction (044-224^o $\pm 2^o$).

Strain-rates calculated within 5 x 5 km and 20 x 20 km grid squares, and at a regional scale, are highest in the central Apennines, medial in the southern Apennines and lowest Molise-North Campania. At the regional length-scale, the strain-rates are comparable in direction but smaller in magnitude to strain-rates calculated using GPS over 11 years and earthquake moment tensors over 700 years (except in the central Apennines where long-term strain-rates are comparable in magnitude to strain-rates calculated using historical earthquakes). Smaller areas ($\sim$2000-7000 km^2), corresponding to polygons defined by geodesy campaigns (126 years) and seismic moment summations (700 years) show higher 10^2 yr strain-rates than 10^4 yr strain-rates in some areas, with the opposite situation in other areas where seismic moment release rates in large ($>$ Ms 6.0) magnitude historical earthquakes have been reported to be as low as zero. This demonstrates that strain-rates vary spatially on the length-scales of 10^{1-2}km and on a timescale between 10^{1-2} yr and 10^4 yr in the Italian Apennines. The multi seismic cycle strain-rates are used to calculate earthquake recurrence intervals for a given earthquake slip magnitude, at the scale of individual seismic sources; these value are compared to palaeoseismic data. The results are used to discuss spatial and temporal earthquake clustering and the natural variability of the seismic cycle.