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Long-term seismic observation and intensity distribution of great earthquakes: new constrain for earthquake hazard assessment of the Central Himalaya

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We critically examine the incidences of moderate to great earthquakes in the backdrop of converging Indian plate deformation, topography, and the late Tertiary regional tectonics, to improve understanding of the evolving dynamics of the Central Himalaya and of the related hazards. We find segment-specific distribution of moderate to great earthquakes along this arcuate belt. The segment-specific clustering of seismicity is identified to be the manifestation of variable order of decoupling between the overthrusted Asian landmass and underthrusted Indian lithosphere. The geometry of the epicentral distribution of seismicity is found to be elliptical, with major axis parallel to the strike of the Himalayan orogeny towards the western segment, and the ellipticity reduces towards the eastern part. We also found that the higher topographic areas are likely associated with the zones of depressions, and the lower topographic areas are found to lie around the ridges located in the frontal part of the orogen. These NNE-SSW trending ridges, interacting from south with the Himalayan Foot-hills, are presumably prohibiting the generation of moderate to large earthquakes in the Himalayas.

Six depth-sections of seismicity show that the clustered seismicity is significantly associated with the sharp bending segments of the Indian mid-upper crust (IMUC), Indian lower crust (ILC) or mantle lithosphere, and apparently indicate the bending zone to be the nodal area of stress accumulation. In fact, it was observed elsewhere that the portion of sharp bending of the subducting lithosphere is the most active zone of seismic slip accumulation in many convergence margins.

We analysed the intensity distribution of 12 damaging earthquakes (e.g., 1803 M7.7 Garhwal, 1833 M7.6 Nepal-Bihar, 1905 M7.8 Kangra, 1934 M8.1 Nepal-Bihar, 1945 M6.3 Chamba, 1975 M6.8 Kinnaur, 1986 M5.5 Dharmasala, 1987 M6.8 North Bihar, 1991 M6.8 Uttarkashi, 1999 M6.5 Chamoli, 2011 M6.9 Sikkim, and 2015 M7.9 Nepal). It was observed that the elongated axes of the isoseismals and strike of ruptures for shallow earthquakes are almost parallel with strike of the Himalayan arc. We found the deeper events are more influenced by the bending of the penetrating Indian lithosphere, whereas the shallower events are principally controlled by the obliquity. A positive correlation between eccentricities and obliquity obviously supports this inference. For moderate to great damaging shallow-level (focal depth $< \sim 35$ km) earthquakes, it was noted that earthquake related ruptures, eccentricities of isoseismals, and trends of major axes are possibly controlled by the changes in Indian plate obliquities. On the other hand, earthquakes at greater depths are prevalently controlled by the bending of the northward penetrating Indian lithosphere. These observations provide new constraint about the location of possible large earthquakes, as well as about the related affected area, which are essential for an improved assessment of the seismic hazard in the Himalaya region.