A GPS Constrained Deformable Block Motion Model of Continental East Asia

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We develop a deformable block motion model to quantify kinematic deformation of continental east Asia, constrained by GPS measurements. We synthesize a GPS data set composed of multiple campaign mode measurements during the last decade, particularly data of about a thousand sites in China from the Crustal Motion Observation Network of China (CMONOC) and about a hundred sites from surveys in Mongolia and the Lake Baikal area. Using the GAMIT and QOCA softwares we processed the GPS data to obtain station velocities with respect to the stable Eurasia plate. A deformable block motion model is prescribed to describe the velocity field, i.e. deformation is modeled as relative motion across block boundaries plus uniform strain within blocks. The model is started with 34 initial blocks, delineated based on geological and seismological a priori information and deformation pattern identified in the GPS velocity field. Block angular velocities with respect to the stable Eurasia plate and horizontal strain rates within blocks are evaluated. A series of F-tests is then performed to test independence of neighboring blocks as well as significance of strain rate parameters for each block, and blocks are merged and strain rate parameters eliminated if their statistics do not demonstrate enough independence or significance. Our final result is composed of 28 blocks, within which only the ones located in the Tibetan plateau and Tien Shan require internal deformation. Our major findings include: (1) fault slip rates along major strike slip faults are slower than geological estimates in general. For example, the central segment of the Altyn Tagh fault slips right-laterally at ~8 mm/yr, Kunlun fault right-laterally at ~10 mm/yr, Xianshuihe fault left-laterally at ~10 mm/yr, Xiaojiang fault left-laterally at ~7 mm/yr, Altai fault right-laterally at ~5 mm/yr, and Lake Baikal rift opens at ~3 mm/yr. (2) The Shanxi rift is barely active at present time. The relative block motion across the rift is small and shows no statistical significance. (3) The east-southeastward motion of eastern China with respect to the Eurasia plate is progressively slower from south to north, ~8 mm/yr for south China, ~6 mm/yr for north China, and ~3 mm/yr for northeast China (the Amurian plate) respectively. (4) Part of the eastward motion of the Tibetan plateau is resisted by the relatively stable Sichuan basin, and splits into northeastward motion and south- to southeastward motion for the northern and southern branches. The southern branch moves along the Xianshuihe-Xiaojiang fault system which slips left-laterally at 7-10 mm/yr, and the northern branch moves along the Songpan-Xihe deformation zone located about 150 km northwest of the Longmen Shan fault which slips right-laterally at 4-6 mm/yr, respectively. In conclusion we find that the deformation pattern of the continental east Asia is consistent with a rheologically controlled crustal deformation model, in which deformation is broadly distributed for regions with thickened and mechanically weak lower crust such as the Tibetan plateau and Tien Shan.