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A spherical model of lithospheric dynamics and seismicity

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The dynamics of lithospheric plates is approximated by an interaction of rigid blocks of the modeled lithosphere (spherical segments) and faults separating them. The spherical block-and-fault dynamics (BAFD) model consists of fifteens blocks approximating tectonic plates and several additional blocks representing parts of the plates, where deep seismicity is observed. The blocks move as a consequence of the prescribed underlying mantle motion. The block displacements at any time are defined so that the system of the blocks is in a quasi-static equilibrium state. Because of the block rigidity, all deformations take place in the fault zones. The interaction between the spherical blocks is visco-elastic (a state of stress accumulation), so long as the ratio of the stress to the pressure is below a certain strength level. When this level is exceeded in some part of a fault, a stress-drop (a synthetic earthquake) occurs in accordance with the dry friction law. Immediately following the earthquake and for some period of time, the corresponding parts of the faults are in a state of creep. Catalogs of synthetic earthquakes are produced as results of numerical simulations. Using the catalogs of synthetic events we study frequency-magnitude relationships, clustering of the events, long-range interaction of earthquakes, earthquake mechanisms, and fault slips. The model catalogs obtained reflect important features of global seismicity: (i) two large seismic belts, the circum-Pacific and Alpine-Himalayan; (ii) extensive, but less pronounced, seismicity at mid-oceanic ridges; and (iii) increased seismic activity associated with triple junctions of plate boundaries. The model results are consistent with the observations: Nazca/South America, Cocos/Caribbean, India/Eurasia, California region, Arabia/Eurasia, northern Australia, and the Philippine plate margin are marked in the model as the regions prone to strong earthquakes. The modeled seismic activity is moderate at the boundaries such as the southern Pacific plate, Nazca/Pacific, east and southwest of Africa, India/Australia, and North America/ Eurasia.