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3D absolute hypocentral determination - 13 years of seismicity in Ecuadorian subduction zone

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In Ecuador, the Nazca plate is subducting beneath the North Andean Block. This subduction triggered, during the last century, 4 major earthquakes of magnitude greater than 7.7. Between 1994 and 2007, the Geophysical Institute (Escuela National Politecnica, Quito) recorded about 40 000 events in whole Ecuador ranging from Mb 1.5 to 6.9. Unfortunately, the local network shows great density discrepancy between the Coastal and Andean regions where numerous stations were installed to survey volcanic activity. Consequently, seismicity in and around the interplate seismogenic zone – producer of the most destructive earthquakes and tsunamis - is not well constrained.
This study aims to improve the location of 13 years seismicity occurred during an interseismic period in order to better localize the seismic deformation and gaps.
The first step consists in the construction of a 3D "georealistic" velocity model. Because local tomography cannot provide satisfactory model, we combined all local crustal/lithospheric information on the geometry and velocity properties of different geological units. Those information cover the oceanic Nazca plate and sedimentary coverture the subducting plate dip angle; the North Andean Block margin composed of accreted oceanic plateaus (the Moho depth is approximated using gravity modeling); the metamorphic volcanic chain (oceanic nature for the occidental cordillera and inter-andean valley, continental one for the oriental cordillera); The continental Guyana shield and sedimentary basins. The resulting 3D velocity model extends from 2°N to 6.5°S and 277°E to 283°E and reaches a depth of 300 km. It is discretized in constant velocity blocks of 12 x 12 x 3 km in x, y and z, respectively.
The second step consists in selecting an adequate sub-set of seismic stations in order to correct the effect of station density disequilibrium between coastal and volcanic regions. Consequently, we only keep the most representative volcanic stations in terms of azimuthal coverage, record frequency and signal quality. Then, we define 5 domains: Offshore/coast, North-Andean margin, Volcanic chain, Southern Ecuador, and a domain deeper than 50 km. We process earthquake location only if at least 3 proximal stations exist in the event's domain. This data selection allows providing consistent quality location.
The third step consists in improving the 3D MAXI technique that is well adapted to perform absolute earthquake location in velocity model presenting strong lateral Vp heterogeneities.
The resulting catalogue allows specifying the deformation in the subduction system. All seismicity previously detected before trench occurs indeed between the trench and the coastal range. South of 0°, facing the subducting Carnegie Ridge, the seismicity aligns along the interplate seismogenic zone between an updip limit shallower than $\sim$8 km and a downdip limit that reaches up to 50 km depth. The active seismogenic zone is interrupted by a gap that extends right beneath the coastal range. At these latitudes, a diffuse intraplate deformation also affects the subducting plate, probably induced by the locally thickened lithosphere flexure. Between the trench and the coast, earthquake distribution clearly defines a gap, which size is comparable to the 1942 M7.9 asperity (ellipse of axes $\sim$55/35 km). A slab is clearly defines and dips around 25 to 30°. The slab seismicity is systematically interrupted between 100-170 km, approximately beneath the volcanic chain. North of 0°, i.e. in the megathrust earthquake domain, the interseismic activity is clearly reduced. The interplate distribution seems to gather along alignments perpendicular to the trench attesting probably of the margin segmentation. The North Andean overriding margin is undergoing active deformation, especially at the location where the Andean Chain strike changes of direction. At these latitudes, no earthquake occurs deeper than 100 km depth.