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Are subduction earthquakes a threat for Quito, capital of Ecuador, located ~170 km from the coast?

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The city of Quito (3M inhabitants), capital of Ecuador, is prone to seismic hazard and the associated risk is increasing due to its growing. The city has been damaged several times in the past by earthquakes that occurred on crustal faults around Quito or in the Cordillera (Beauval et al., 2010). As far as we know, the earthquakes that occurred along the subduction's interface have never strongly damaged Quito: such as the recent Pedernales earthquake (Mw 7.8, 2016) and also the largest known earthquake of Ecuador, the Esmeraldas earthquake (Mw> 8.4, 1906).

Nevertheless, can we be certain that very large subduction earthquakes could not treat the city of Quito (which extension is much larger than in 1906)? This question is particularly important since the recent discovery of a clear site effect in the southern part of the city that amplifies seismic waves (Laurendeau et al., 2017) at low frequencies (around 0.3Hz) and the future urban planning that considers high-rise buildings due to the saturation of usable land in the valley.

In order to investigate this question, we propose a simple method for estimating reliable values of ground motions due to a future earthquake and its variability. The method is based on a scheme of summation of small earthquakes used as empirical Green's functions, combined with constraints given by a global data base of STF (source time functions, SCARDEC database, Vallée et al., 2013). In this approach we use the mean value and the variability of the STF duration obtained in subduction domains (Courboulex et al, 2016) as constraints for the source variability. Indeed, STF duration naturally includes the effects of stress-drop, rupture velocity and it is independent of the source model.

In a first step, we test and validate the approach by simulating the ground motions in Quito generated by a Mw 7.8 earthquake, similar to the Pedernales earthquake that occurred on April 16th 2016 along the subduction zone. This event and its largest aftershocks have been well recorded by 18 permanent accelerometric stations (RENAC network) and then allowed us to compare the blind simulations and the Pedernales data. The good results obtained pushed us to simulate a larger earthquake, M=8.5 in the same zone. We considered 4 different simple scenarios with one to three sub-events and a propagation of the rupture towards the south and towards the north.

At high frequencies (PGA), the values obtained are not very high (PGA < 0.2g) and are comparable to the predictions using Abrahamson et al. (2016) ground motion prediction equations. However, at lower frequencies, the ground motion values are much stronger than expected, especially in the south of the basin. These results could be taken into account in the building codes to avoid possible future destructions of infrastructures that may resonate at these low frequencies.

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