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Investigating seismic segmentation and recurrence patterns of great earthquakes along the Chilean megathrust.

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Megathrust earthquakes at subduction zones are one of the most devastating natural phenomena. Understanding the relationships between their temporal recurrence, spatial segmentation and the frictional structure of the megathrust is of primary relevance. We analyzed the common spatial variability of gravity anomalies, geodetic locking and wedge taper basal friction (three independent proxies for megathrust frictional structure) along the Chilean margin. A marked along-strike segmentation has emerged that is organized into three hierarchical levels. At a subcontinental-scale (10^3 km), we observe a first-order difference between Central (18-32°S) and Southern (32°-46°S) Andes. This is marked by a dominance of positive/negative gravity, high/low locking, high/low friction along the Central/Southern segments. We explain this as mainly reflecting the combined effect on effective normal stress (σ_{eff}) of a high/low density forearc and low/high pore pressure along both megathrust segments, in agreement with the geological structure of the forearc, sediment input at the trench and the long-term architecture of the Andes. Inside this large-scale subdivision, we identify a number of segments (10^2 km) that are limited by marked small-scale (10^1 km) changes in the first-order tendency of the three proxies coinciding with geological features of both plates. When we compare this against the paleoseismic, historic and instrumental record of past earthquakes in Chile, we note that segments largely coincide with seismic asperities, i.e. those regions of the megathrust concentrating the largest fraction of coseismic slip. Bridging these two scales, the rupture length of giant (Mw 8.5-9.5) earthquakes, which encompassed several asperities, define an intermediate hierarchic level of organization (10^2-10^3 km). Considering this segmentation into the conceptual framework of the rate-and-state friction (RSF) law, we infer that asperities inside the rate-weakening seismogenic zone of the Central Andean megathrust are dominantly unstable (i.e. $\sigma_{eff}>\sigma_c$ = the critical stress defined by RSF parameters) and therefore prone to initiate and concentrate the coseismic rupture. In contrast, most of the asperities along the Southern mega-segment are likely characterized by a conditionally-stable behavior ($\sigma_{eff}<\sigma_c$) that allows a rich and complex seismogenic behavior where interseismic creep and locking are both possible and large coseismic slip propagation is dominant. This can explain the apparent difference in the recurrence of giant earthquakes along both mega-segments, since the synchronization of unstable asperities in the Central Andean megathrust (2000-3000 yr recurrence time) is less probable than in the case of conditionally-stable asperities

in the Southern segment (300-500 yrs). We will test these hypothesis developing numerical simulations of multiple seismic cycles with setups representing the inferred contrast on the physical properties of the megathrust along the Chilean margin, and we will present preliminary results of this exercise.