Solid Earth Discussions

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Review of manuscript se-2021-148

Anonymous Referee #2

Referee comment on "Earthquake ruptures and topography of the Chilean margin controlled by plate interface deformation" by Nadaya Cubas et al., Solid Earth Discuss., https://doi.org/10.5194/se-2021-148-RC2, 2022

In the present manuscript, Cubas et al. estimate the distribution of different forms of plate interface deformation (accretion, basal erosion, underplating) along the Chilean margin using critical taper theory, and compare their findings to the rupture extents of large earthquakes, regional uplift and interplate coupling. The subject is highly interesting, and the findings provide some reason to believe that plate interface deformation indeed plays a very important role in shaping the long-term and short-term behavior of the plate boundary.
The manuscript is well-written and illustrated and fits very well into the scope of the journal. My main concern about the manuscript is that it was apparently written for a shorter-format journal and not adapted (much) before submission here, so that it is unnecessarily brief and condensed in places, which negatively affects readability and clarity. Moreover, in some places choices that were made need to be better explained (or explained at all) since they currently appear like "magic", and it is not always clear if the presented correlations critically depend on said "magic" or not. I thus recommend moderate revisions and will describe these concerns in more detail below, before presenting less important specific comments by line number.

General comments:

I think the authors should invest some time to transform their manuscript into a longer-format version that is less condensed and thus easier to read and comprehend. As is, I find some of the figures to be too complex (sometimes unnecessarily so; see comments to Figures below), and some important issues are not or only very tersely described. It would also be nice if the manuscript tried to go step by step and separated observations from interpretations (first describe results, then interpret). Examples of where more detail would be nice to have will be provided below.
In some places, there needs to be a better (or any) explanation of how things were actually done. For instance, Figure 4 correlates the lengths of determined segments in accretion, basal erosion and underplating with other parameters (interplate coupling, rupture extents of historical earthquakes etc.). While the principle of how the segments were obtained is shown in Figure 2c and d, what lacks is a clear description of when such

segments were kept or discarded. The text only mentions that only segments with "extremely low misfits" were kept, without mentioning what that means or even how the misfit was defined in the first place. Moreover, a relatively arbitrary depth threshold of 20 km is the only parameter that separates basal erosion from underplating. I think such critical choices and procedure need more in-depth explanation, otherwise it is very hard to judge whether correlations like the ones shown in Figure 4 are robust.
Also, the utilized inversion procedure is kept completely in the dark, and it is not clear how the probability density distributions shown in Figure 3 are obtained. I understand that the methodology has already been published elsewhere, but at least a short summary of what are inputs, tuning parameters and outputs is necessary in my view.

Specific comments:

Title: it should mention that this is a study of the Chilean margin
l.2: "earthquake ruptures" should maybe be replaced by "earthquake rupture extents", to make clear that prediction here only refers to the size and location, not to the time of occurrence
l.3/4: seismic and aseismic patches is a bit unclear, maybe better say strongly and weakly coupled? If one looks at the interseismic period, strongly coupled patches ("seismic" because they produce large earthquakes) show nearly no microseismicity, whereas weakly coupled regions ("aseismic" because they don't produce large earthquakes) show a constant background of small events
l.8ff: better to say south and north of 35 degrees S (or S and N of where the Juan Fernandez Ridge is subducted). Even the southern termination of the study area is usually referred to as Central (sometimes South-Central) Chile
l.10: "all major earthquakes" here refers to two events (Illapel and Maule), correct?
ll.26ff: one could add pore fluid pressure variations (e.g. Moreno et al., 2014, NGeo) and plate interface geometry (e.g. Bletery et al., 2016, Science).
l.32: remove "the" before million years
l.34: also elsewhere, see e.g. Malatesta et al. (2021, JGR)
l.46: this may be true for single seamounts, but there are quite a few correlations of rupture extents with larger incoming seafloor features such as ridges or fracture zones. Both ends of the Illapel earthquake rupture can, for instance, be associated with such features (Challenger Fracture Zone and Juan Fernandez Ridge).
l.60: Unclear what "To do so" refers to...better leave out.
l.94: is latitudinal degree meant? or every 0.1 degrees along-trench? Longitudinal does not make sense, since the margin is nearly north-south
ll.93-105: this paragraph needs extension and clarification; it is not clear to me what exactly is done. The authors should give a quick summary of what the utilized inversion approach does, what are the inputs (only bathymetry/topography and slab dip or is there more?) and assumptions/parameter choices. What is this rectangular window that is used for smoothing (window length, how is smoothing done; also that a triangular window has been tried out in Figure S5 is not even mentioned here), and how are its parameters chosen? I also don't understand what segments parallel to critical envelops are (this becomes somewhat clear when looking at the Supplementary figures, but needs to be at least briefly described here...also, how was this selection done, visually or automatically; if the latter what were the criteria?).
ll.101/102: this means that results falling outside this range were simply discarded? Also, what are extremely low misfits? I recommend being clearer here.
l.113: I think 35 degrees S is meant
l.119: what is the motivation/reasoning for this choice? Also, should this not be mentioned previously (i.e. before the previous paragraph), where erosion and accretion have already

been interpreted?
l.122: It would make sense to put these depths into relation with the depth of the continental Moho right here (maybe also show the range of continental Moho depths in the histograms of Figure 3a,b)
l.137: could the first peak for basal erosion in Figure 3e, the one at low pore fluid pressures, be there because the assumption of 20 km separating basal erosion and underplating is not perfect, and some underplating at shallower depth is mapped into the basal erosion plot?
ll.138ff: The length of segments critically depends on the fitting that was done (see comment above), which is not described in detail. I thus find it hard to judge whether such a property can be robustly compared with structures in nature
l.153: mention that this intercept is shown in Figure 1c and d as an orange line
l.159: I fail to see anything systematic in Figure 4c
l.175ff: According to some recent studies (Schurr et al., 2020, GRL; Sippl et al., 2021, JGR), interseismic microearthquakes along the plate interface may surround the later ruptures of large earthquakes, which means they occur in the same regions that emerge as featuring distributed deformation here. Could this seismicity be a fingerprint of distributed deformation, or would the involved processes be independent from each other?
l.186: word missing? (a long wavelength what?)
l.210: this sounds as if the results actually discriminate between basal erosion and underplating, but in truth this is an assumption (one occurs at depths shallower than 20km, the other deeper)
l.211: while this correlation between earthquake terminations and regions of decreased plate interface deformation is indeed apparent from Figure 4a,d, it would be wortwhile to mention that there are some exceptions to this (e.g. the 1617, 1730 and 1906 earthquakes in Central Chile appear to have ruptured clearly across such regions)
l.218: these studies indicate that the transient slip events ARE resolvable with geodetic means...it is just a matter of further developing detection approaches (the data are clearly good enough)
l.243: Could the Coastal Cordillera, present along much of the Chilean margin, be a consequence of such a slow uplift due to underplating?
l.252: provides; "faithful" is not a good word here (robust?)

Code and data availability: I recommend that the authors make the obtained data (i.e. the segments with the angle difference shown in Figure 1) available through a repository. Keeping all results closed is how science worked in the past, nowadays datasets should be open so that others can use and also validate them.

Figures:
Figure 1: The profiles shown in the upper panel of subfigure b are mislabeled, since they are not shown in Figure S2 but in Figure 2b,c. Those profiles that are shown in Figure S2 (in the southern part) should also be marked with their locations here. I do not like that different extents and contours are used for the different earthquake ruptures (2.5 m for Maule, 1 m for most others, 0.5 m for Iquique aftershock and Tocopilla)...a consistent value should at least be used for the extent of the pink regions, otherwise this leads to big distortions in terms of the represented rupture area
Figure 2: it would be nice if there could be a map view subfigure next to subfigures b and c where the position of the different stable and interface deformation segments could be shown. As the graphs are slab dip against topographic slope, there is no way to know which part of the plate interface is represented where (Figure S4 helps here - should be mentioned in the caption)
Figure 3: I find these plots difficult to read. Why are line representations and bar

representations of histograms mixed? I also do not see the use of subfigure c, or why it is placed in a position that implies a close relation to a and b. For subfigures e and f, please mention in the caption that a fixed depth limit of 20 km is assumed to separate basal erosion (at shallower depth) from underplating (at deeper depth). At the moment this is hidden in the text and not mentioned in the caption.
Moreover, I'm rather confused by subfigure c. I assume the probability density functions (Pdfs) are normalized so that the integral over them is 1 (also this should maybe be mentioned in the caption). If so, then how can one curve (interface deformation) be above the other (accretion) everywhere, unless the shown Pdf is truncated and there are significant values that are not shown? Or were massively different bin sizes used (if so, why? And it needs to be mentioned)?
Figure 5: Are the earthquake slip patches again using different values for Maule compared to the other earthquakes, as in Figure 1? This should at least be mentioned in the caption then.
Figure 6: Can the caption briefly explain what pink and blue areas on the megathrust are?