S208-016 **Room: 201A** **Time: May 14 14:12-14:24**

Pining effect of fault bends on slip-length scaling in earthquakes

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The existence of non-planar geometry such as bends is a well-known characteristic of natural faults with its fractal nature. It is also known that these bends arrest slip like as pines on faults. In this study, we theoretically investigated this effect of pinning on the scaling law of slip by taking account of local planarization of fault bends due to slip in short wavelength. For the purpose of simplification to extract the effect of the fault bends in an elastic media, we first assume a finite monotonically wavy fault with no friction under a homogeneous confining load condition, and then we investigate the effect of different wavelengths keeping a similar shape. As a result, we find that the mean slip on the entire fault is a decrease function of the assumed wavelengths of the fault bends with a rate larger than a linear function. In other words, the overall behavior on the entire fault is sensitive to the geometry in shorter wavelength; therefore it is crucial to consider how the geometrical irregularity in the short wavelengths behaves during slip events. In order to address this problem, we next assume that wearing or plastic deformation associated with slip instantaneously planarizes the bends up to an effective length Leff that is determined by the value of mean slip S.

As solutions of this model, we find that mean slip linearly increases with fault lengths if Leff is proportional to S and the fault has self-similar geometry although the value the mean slip is smaller than the planar fault case. In this case, the value of mean stress becomes also scale independent. On the other hand, if the above condition is not satisfied, mean slip is shown to depend non-linearly on the fault length and then mean stress drop becomes scale dependent. The former case seems to correspond with observations in nature where many ones suggest stress drop is a scale invariant.