SCEC Earthquake Simulator Comparison Project

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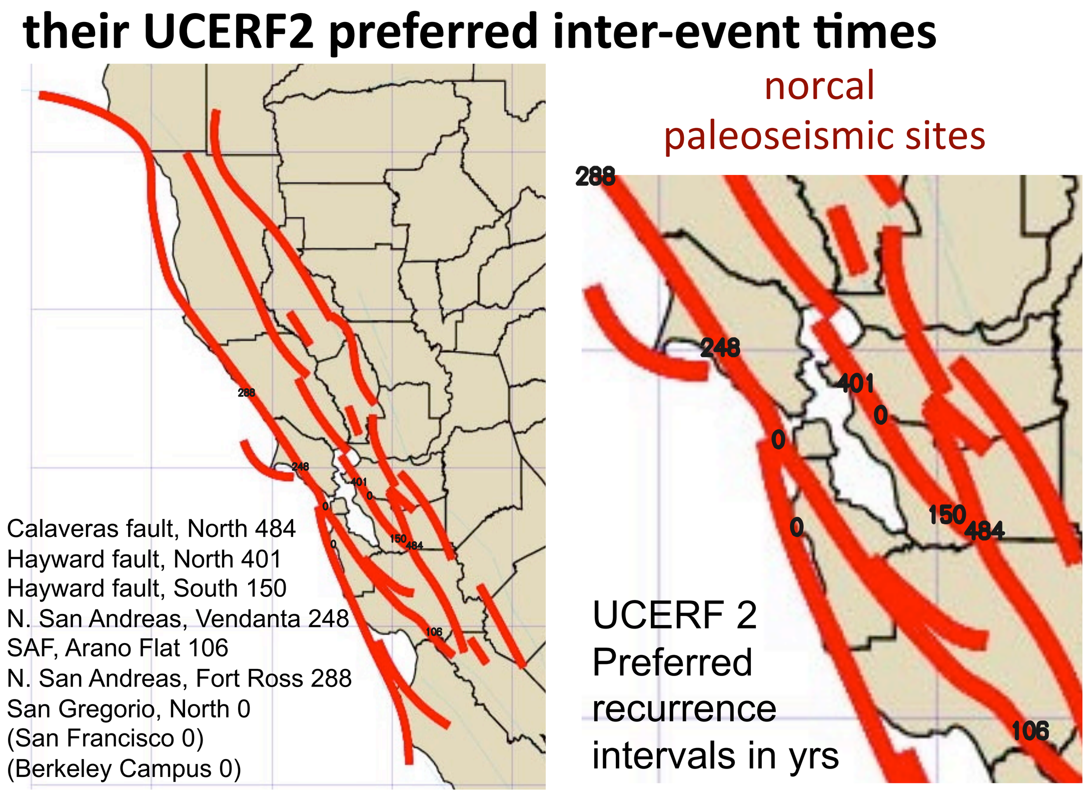
1. Abstract

Earthquake simulators are computer programs that simulate long sequences of earthquakes. If such simulators could be shown to produce synthetic earthquake histories that are good approximations to actual earthquake histories they could be of great value in helping to anticipate the probabilities of future earthquakes and so could play an important role in helping to make public policy decisions. Consequently it is important to discover how realistic are the earthquake histories that result from these simulators. One way to do this is to compare their behavior with the limited knowledge we have from the instrumental, historic, and paleoseismic records of past earthquakes. Another, but slow process for large events, is to use them to make predictions about future earthquake occurrence and to evaluate how well the predictions match what occurs. A final approach is to compare the results of many varied earthquake simulators to determine the extent to which the results depend on the details of the approaches and assumptions made by each simulator.

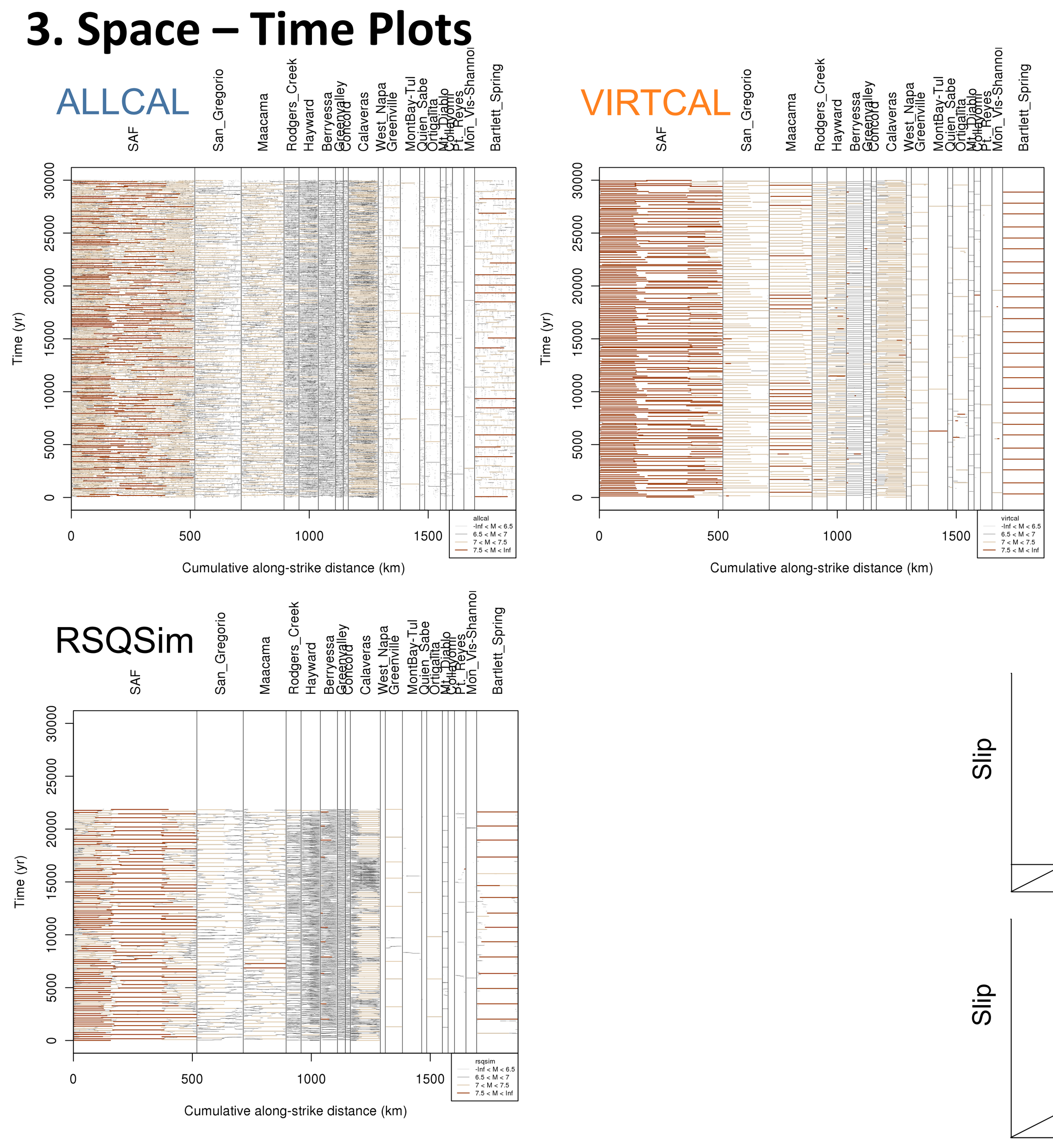
Five independently developed simulators, capable of running simulations on complicated geometries containing multiple faults, are in use by some of the authors of this abstract. Although similar in their overall purpose and design, these simulators differ from one another widely in their details in many important ways. They require as input for each fault element a value for the average slip rate as well as a value for friction parameters or stress reduction due to slip. They share the use of the boundary element method to compute stress transfer between elements. None use dynamic stress transfer by seismic waves, although some make approximations to the effects of true elastodynamics. A notable difference is the assumption different simulators make about the constitutive properties of the faults.

The earthquake simulator comparison project is designed to allow comparisons among the simulators and between the simulators and past earthquake history. The project uses sets of increasingly detailed realistic fault geometries and slip rates taken from California, excluding the Cascadia subduction zone. In order to make as close comparisons between the simulators as possible we have developed shared data formats for both input and output and a growing set of tools that can be used to make statistical comparisons between the simulator outputs. To date all five simulators have run a Northern California fault model and are in various stages of working on an All California fault model. The plan in the near future is to run them on the UCERF2 fault model. As will be shown, initial comparisons show significant differences among the simulators and some differences from observed earthquake statistics. However, it is too early in the process to infer too much from these preliminary results. For example, the differences in how each simulator treats fault friction means that they may each need to use values for the assumed stress drops that are better tuned to their approach than are the common values used in the first comparison.

2. Faults used with paleoseismic sites and their UCERF2 preferred inter-event times



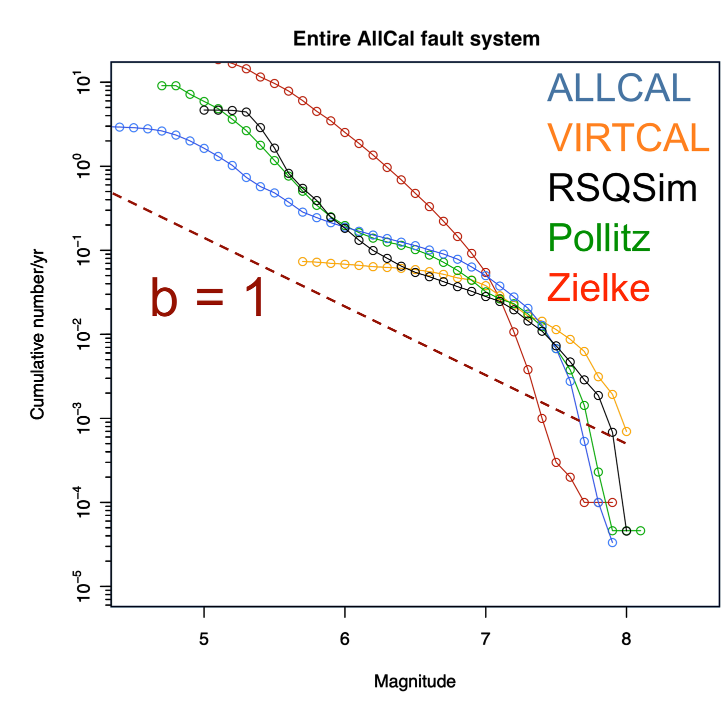
3. Space – Time Plots



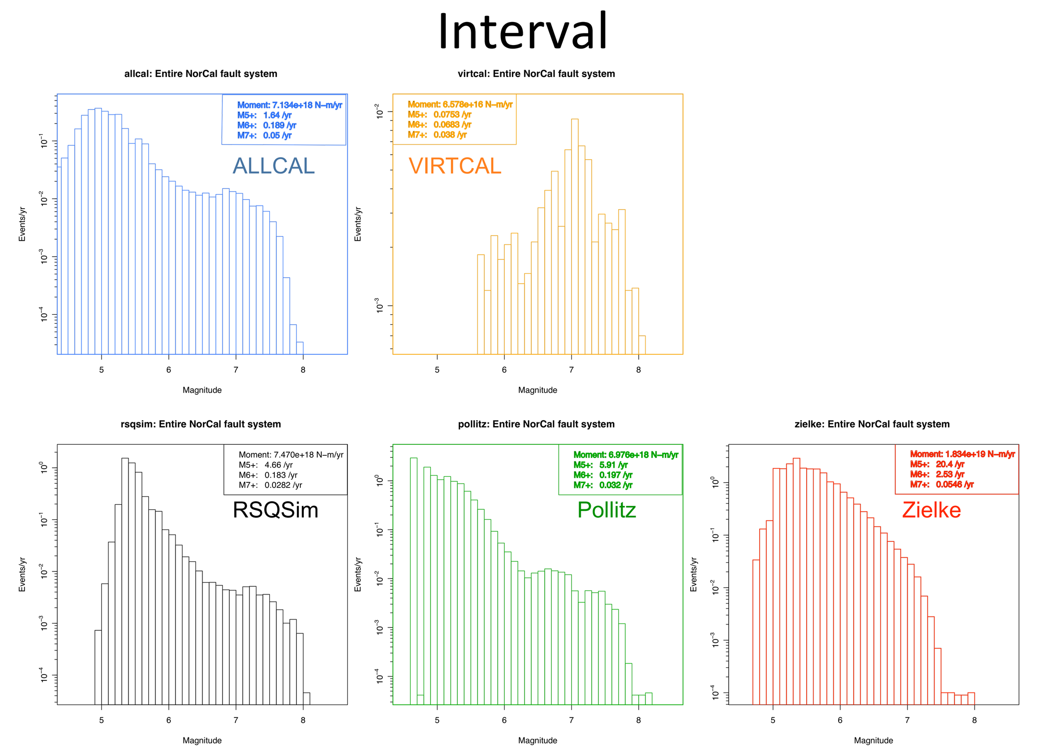
4. Frequency Magnitude Distributions

4a. Entire N CA Fault System

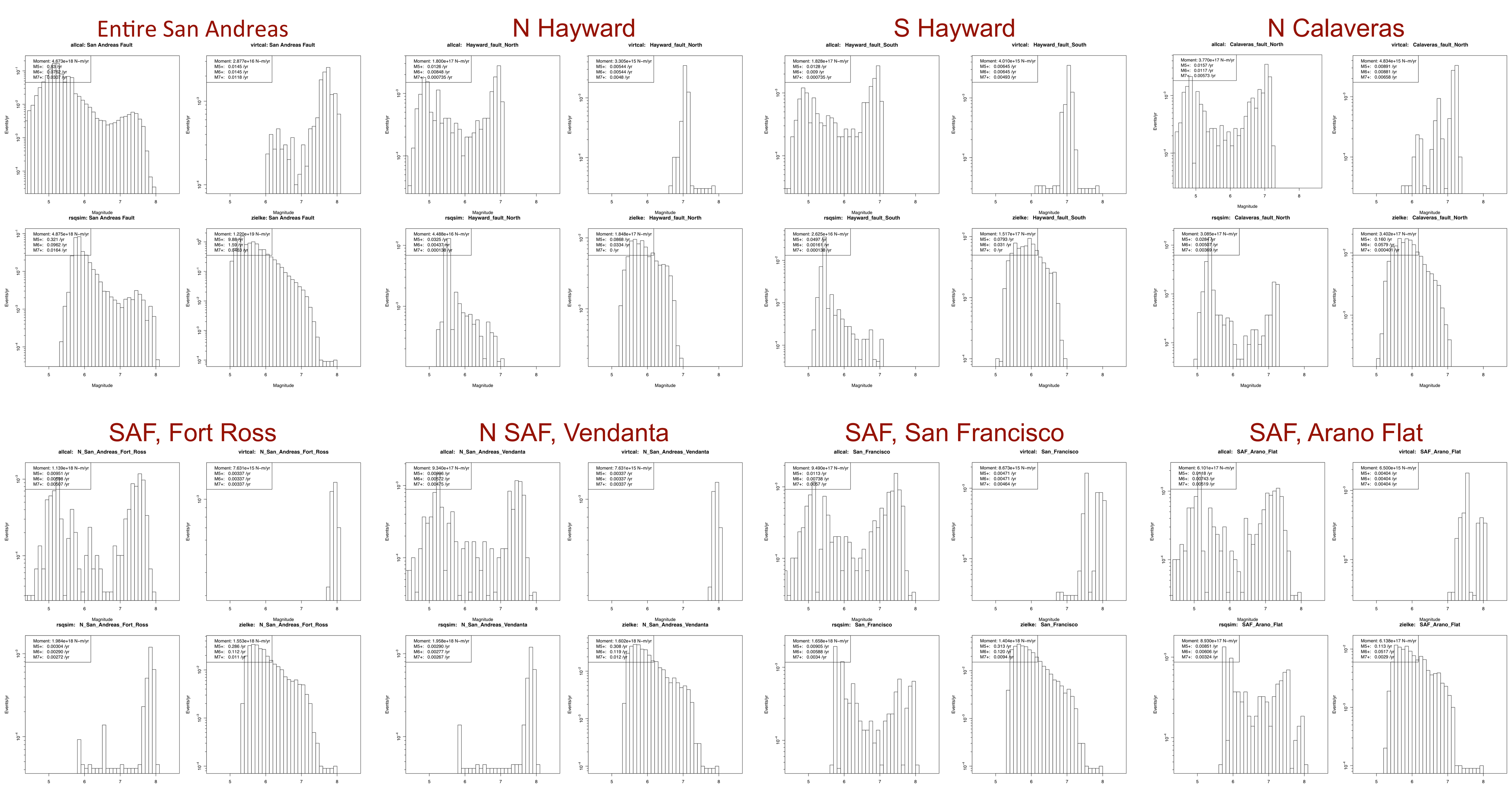
Cumulative



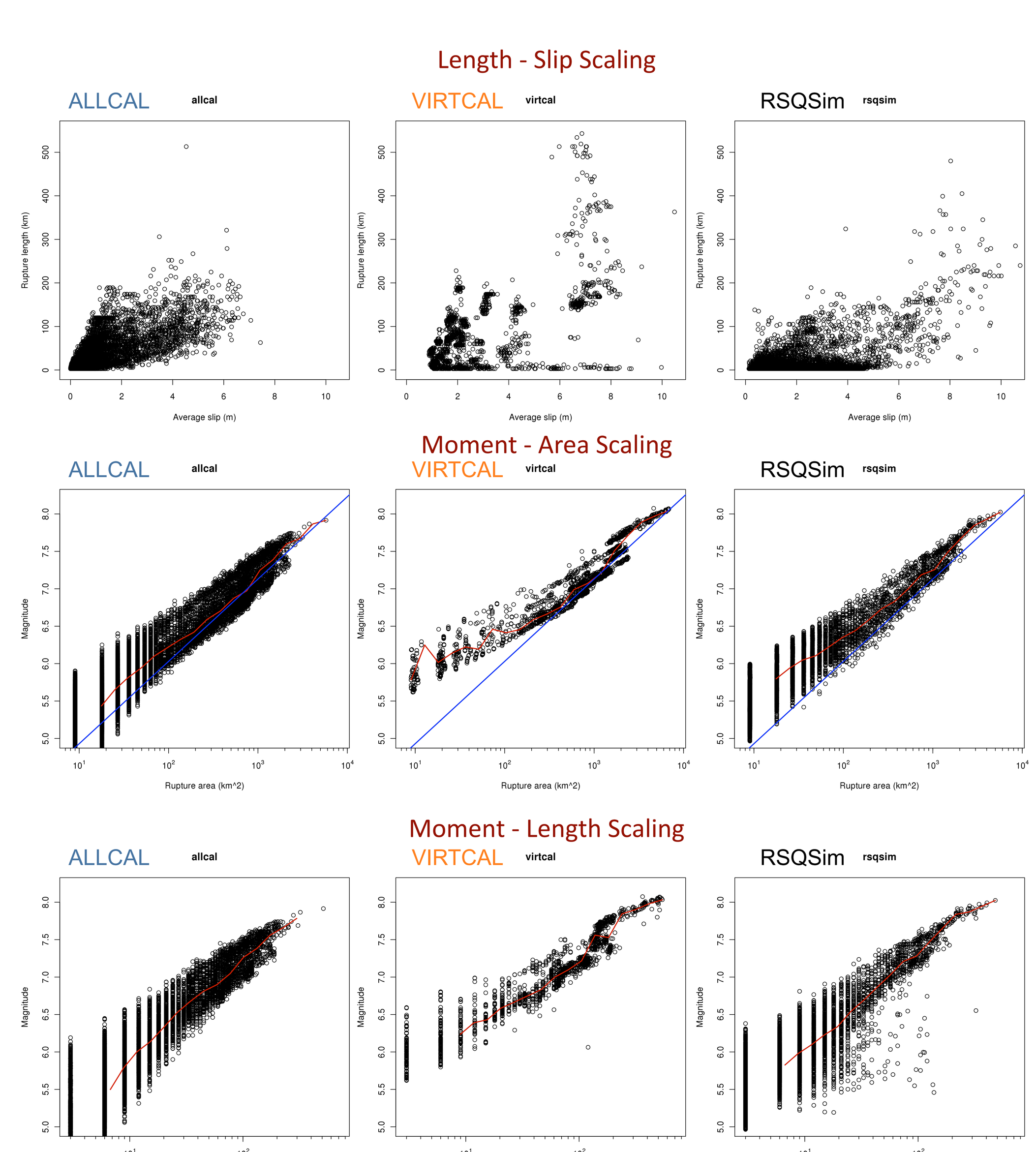
Interval



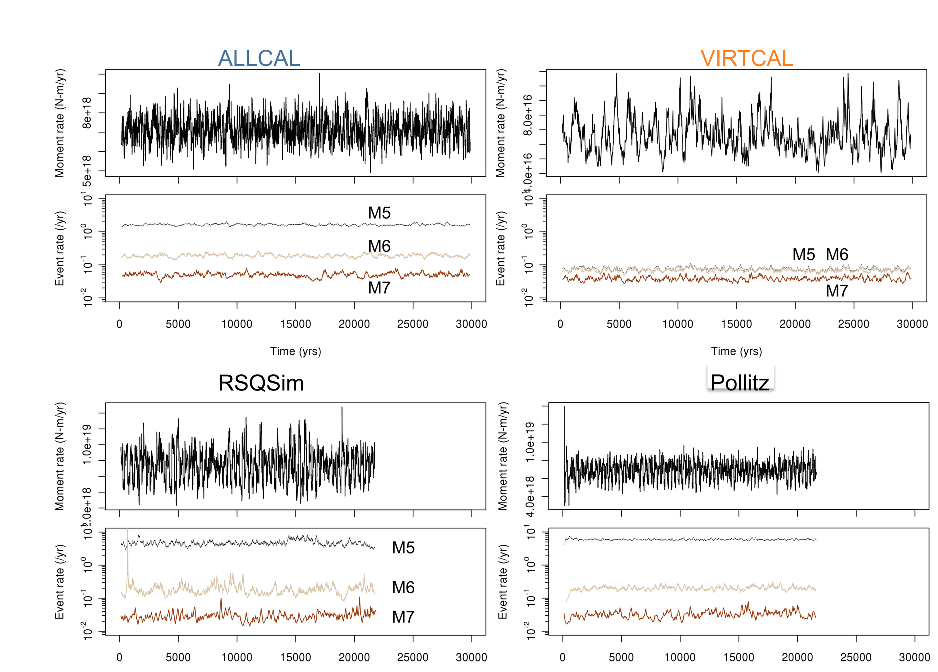
4b. Individual Fault or Paleoseismic Sites Interval Frequency Magnitude Distributions

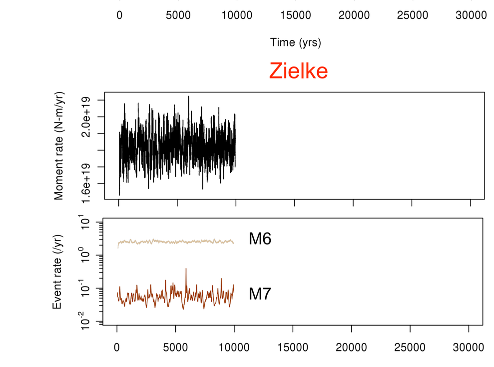


5. Scaling relations



6. Moment and event rates





For all simulators, hundreds of years can be found in which the rates differ from other similar periods.

7. Time vs. slip predictability