Summary of Session 2.3:
Simulation and observations of complex interacting fault systems

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Earthquakes do not occur in isolation from one another, but they and the faults upon which they occur form a complex web of interacting elements. The objective of Session 2.3 was to explore the means by which earthquakes and faults interact and how this effects the dynamics of earthquake occurrence and the resulting space-time patterns of seismicity. We explored three main topics during this session:

- **Long/short range interactions versus long/short range correlations in interacting fault systems** – many simulation models of the earthquake process show highly complex behavior even though they include only nearest-neighbor interactions among the model elements. However, observations of earthquake triggering suggest interactions at distances far greater than an earthquake rupture length. Are long range interactions necessary to model the earthquake process, or can the observed long range correlations be modelled with only short range interactions?
- **Application of frictional relationships to stress transfer and dynamic triggering** – early attempts to model earthquake and fault interactions assumed a simple Coulomb failure criteria for stress transfer. However, laboratory derived frictional relationships show that the failure strength on fault surfaces can be highly dependent upon their loading history. This topic will explore the application of these frictional relationships to the triggering/shadowing of future earthquake occurrence.
- **Dependence of spatio-temporal seismicity patterns upon the structure of interacting fault systems** – natural fault systems show a high degree of heterogeneity in their structure, ranging from fairly simple systems with only one or a few active faults to complex regions with many active faults of different orientation and sense of slip. Active faults also come in a hierarchy of different sizes. How does this complexity effect the dynamics of regional scale fault interaction?

No conclusions - only questions!

- **Long-range correlations are not the same as long-range interactions** –

if earthquake fault system is in or near a critical state, one can have long-range correlations even if interactions are only short range.

- **Many questions about stress transfer** – including "How well do Coulomb stress transfer calculations describe enhanced/depressed activity?" and "How well does the Coulomb Failure Function (CFF) capture the physics?". It was noted that the focal mechanisms of activity presumed to be triggered by Coulomb stress transfer are not always consistent with the model. Questions were also raised regarding how much CFF was dependent upon the coefficient of friction and what was the influence of viscoelastic stress transfer. The general feeling of the group appeared to be that while Coulomb stress transfer had some predictive power in terms of the location of triggered seismicity, it does not do a good of explaining the timing of triggered events.
- **What is a seismicity pattern?** – the raw data used to infer the dynamics of fault interaction is the seismicity produced by the faults themselves. But how do we quantify the spatial and temporal patterns seen in real data? And then how do we relate these patterns to the underlying physical variables?

Recommendation

While not many answers were found to the questions above, it has become clear that the addition of numerical simulation research to the arsenal of tools used to study the earthquake process will greatly expand our ability to explore these issues (Figure 1). In particular, numerical experimentation is essential for understanding how processes observed at one scale relate to and influence processes at other scales; e.g., how friction relationships observed at the laboratory scale relate to observed regional scale seismicity patterns. Theoretical concepts (e.g., those regarding the influence of disorder) can be implemented in numerical models and allow us to educate our scientific intuition as to what role they may play in the observed process.

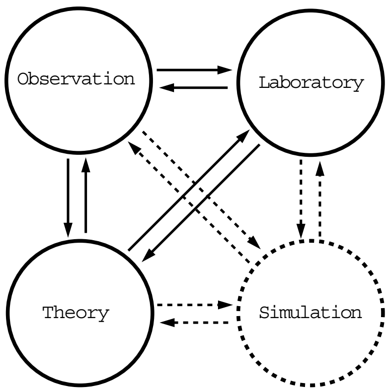

Figure 1: Historically, advances from either new observations, laboratory experimentation, or in theoretical concepts have a positive feedback that stimulates new advances in other areas. We recommend that numerical simulation be included as a fourth "leg" of this research structure.