Summary of Session 5:

Assimilation of geodetic data and seismic activity data into simulation models

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Some of the primary questions in understanding earthquakes are; how does the earth respond to earthquakes, how is stress transferred or propagated, how does this behavior change with time, and how are these changes manifested in the surface deformation and seismicity.? These problems are complicated because the earthquake cycle occurs on timescales of hundreds to hundreds of thousands of years, therefore our sampling interval is quite small compared to the earthquake cycle – particularly the cycle of the entire interacting fault system. It is further complicated due to a nonlinear behavior of the crust and mantle. These two problems make direct inversion of data difficult to impossible. It is therefore necessary to assimilate the data into models that simulate the complete earthquake cycle.

In this session, four presentations were made to discuss data assimilation issues. Donnellan et al. presented an integrated study of geodetic and geological data in the Los Angels area where active shortening is observed. They considered a long-term uplift of San Gabriel Mountains to estimate a slip rate of the Sierra Madre fault and attributed the remaining shortening to an unknown buried fault, which is connected to the Sierra Madre fault at the Decollemont. In simulations of earthquake cycle, it is important not only to explain modern geodetic data but also to satisfy long-term geological constraints. They presented a way of compiling multi-disciplinary data for earthquake simulation, which shall be very useful for everywhere.

Sagiya et al. presented a new geodetic inversion technique to estimate a whole slip history during earthquake cycles using surface deformation data. In their technique, viscoelastic response of the earth is taken into account and the estimated slip history is to be provided for the simulation of earthquake cycles. A unique point of the inversion is that all the coseismic, postseismic, and interseismic slip distributions are estimated simultaneously. Slip history on the fault is an important kinematic constraint on simulations of earthquake cycles. However, the problem is that available deformation data are insufficient to cover the whole earthquake cycle.

Parker presented a poster discussing ongoing analysis efforts for continuous GPS data from SCIGN network in Southern California. An example of Hector Mine earthquake was

a very good demonstration showing importance and effectiveness of the continuous GPS network in studying earthquakes. He is trying a principal component analysis to pick up meaningful deformation pattern from GPS time series data. Massiveness of continuous GPS data is a serious problem in Japan, too, and pattern extraction methods are definitely needed. He also presented preliminary result of finite element modeling, which will be very important and has many problems not only scientifically but also technically.

Finally, Verbytskyj and Verbythkyj presented an interesting result of data assimilation in Ukraine. They are trying to predict energy flow and number of earthquakes in the tectonically active Transcarpathians based on various geophysical data. They have tested several statistical models and found that inclusion of more kinds of data improved predictability of the model. Probably combination of their statistical model with physics-based simulations will be the next step.

Presentations in this session showed that assimilation of geodetic data is becoming feasible. However, seismicity data are still difficult to handle. Unfortunately, the seismicity data assimilation was not discussed enough in this workshop although there were related presentations in another session. As Professor Aki mentioned, it is quite important to control the simulation model with observation data. In addition, not only geodetic data but also seismicity and other data should be assimilated. Therefore assimilation of seismicity data and combination of different types of data will be key topics in the future workshops. As for the geodetic data, since it comes to a feasible stage, effectiveness and efficiency of the data processing, and combination with simulation codes will be main issues to be discussed. Finally, the author would like to point out that well-organized database system is crucial to successful data assimilation. Collaborations with database specialists are to be considered in the future.