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Direct measurement of fault rupture from seismic dense arrays: method and application to the Alpine Fault, New Zealand

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A dense network of strong motion seismometers is being developed for the central South Island of New Zealand in order to investigate the complexities of the upper crustal rupture process and propagation of major seismogenic sources such as the Alpine Fault and strands of the Marlborough Fault System defining the South Island sector of the Australia-Pacific plate boundary zone. Dense array analysis allows one to measure directly fault rupture parameters such as the rupture direction, velocity, and fault rupture area. This study develops and applies dense array analysis to determine an optimal array for the Alpine Fault region.

The dense array analysis is based on the frequency-analysis MUSIC method (Multiple Signal Characterization) developed by Goldstein and Archuleta (1991). MUSIC was chosen for its ability to resolve seismic signals with low signal-to-noise ratios. Careful programming, thorough data pre-processing and an innovative optimal time window determination were essential in obtaining reliable results.

The proposed network is designed as a dense array comprising approximately 12 accelerographs utilising the University of Canterbury CUSP instrument. It will be deployed about 40km to the East of the East-dipping Alpine Fault in the central region of the South Island, with coverage extending across to the Alpine-Hope Fault junction. The search for an optimal network for the region is dependant significantly on optimal site locations, which because of the mountainous terrain provides a severe limitation.

In order to assess the efficiency of dense array analysis, synthetic data were generated for known rupture scenarios. The synthetic strong-motion records were computed us-

ing an empirical Green's function synthetic seismogram program EMPSYN (Hutchings, 1987). Comparison of computed rupture parameters with synthetic known inputs has proven that the technique is efficient in reproducing fault rupture scenarios. The analysis provides rupture velocities and directions consistent with input values. These results are an important outcome to validate dense array analysis performed on real data sets. A similar procedure is employed to design the Alpine Fault array. First, and optimum array location is found by trial and error using the synthetics-MUSIC combination; then an optimal configuration of the array is sought in the same fashion at that location.