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Direct measurement of fault rupture from seismic dense arrays: 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. The proposed network is designed as a dense array comprising approximately 12 accelerographs. 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.

In order to assess the efficiency of dense array analysis, synthetic data were generated for a known magnitude 8 earthquake scenario. The synthetic strong-motion records were computed using the AXITRA code developped by O Coutant. Data were filtered beween 1 and 2 Hz and aligned with respect to the time of the first wave arrival at the central station. The dense array analysis is based on the frequency-analysis MUSIC method (Multiple Signal Characterization) developed by Goldstein and Archuleta (1991). Careful programming, thorough data pre-processing and an innovative optimal time window determination were essential in obtaining reliable results. Dense array analysis of this case study shows direction, velocity and propagation of the rupture front on the fault plane that are consistent with known input values. These results are an important outcome to validate dense array analysis performed on real data sets. Finally, since it does not need any assumption on the fault rupture model, dense array analysis should be applied as a complementary method to waveform inversion for source mechanic studies.