Multi-component Seismic in Rough Terrain: an example from Wyoming Green River basin
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Summary
The results of a test indicate that single sensor three component receivers provide better data than groups of geophones in rough terrain. The images from the 3C data have better resolution and better imaging of dipping reflectors. Arguably, the benefits of the 3C data are much more significant than the small increase in random noise (wind noise) that we observe on the single sensor data.

Introduction
Imaging targets under rough terrain like the mid continent overthrust belt in the USA, is a challenge. Recent advances in acquisition technology include single sensors and multi-component systems. To test the applicability of such systems in rough terrain we acquired and processed a 2D line in the Green River Basin, south west Wyoming. A similar test was conducted in the Canadian Foothills (Behr, 2005) just before our test in Wyoming.

Terrain
The survey was conducted over the Darby thrust fault (Figure 1). The elevation along the line is 2200-2500 m. At the center of the line the elevation varies 200 m vertically over a horizontal distance of 400 m (26° slope).

Acquisition
The data were recorded along an 8.8 km line. The source was 5 kg Pentolite at 18 m hole depth, with 50 m shot interval. Data from both conventional geophones in groups and from three component single sensors of type digital sensor unit (DSU) were recorded. The receiver interval was 50 m for the geophone groups and 25 m for the DSUs. To reduce the effect of inter-array statics, the geophone array size was smaller in the steep segments.

Processing
The processing sequence included tomographic refraction statics, multi-component polarization filters with an SVD based method (Meersman and Kendall, 2005; Jin and Ronen, 2005), coherent and random noise attenuation, surface consistent deconvolution, two iterations of velocity analysis and residual statics and prestack migration. The unstacked data are shown in Figures 2-4. The trace interval
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prestack is 50 m for the geophones and 25 m for the DSUs. Note the improved spatial and vertical resolution of the DSU data and the Ground Roll attenuation with the Adaptive Polarization Filter (APF). Unlike dip filters, which depend on spatial sampling, the APFs are a station-by-station process. This was a 2D test but challenge is really in 3D and in 3D spatial sampling in the cross receiver-line direction is a problem which is very much mitigated by the APF, if and only if multi-component data are acquired. The stacked images, after PreStack Time Migration (PSTM) are shown in Figures 5-6. The trace interval post stack is 25 m for the geophones and 12.5 m for the DSUs. Note the improved imaging of the dipping reflectors under the ridge (where the terrain was rough) and also the improved vertical resolution of the DSU data. Arguably, the somewhat increased noise level of the single sensors DSU data seems to be a small price to pay for the improved imaging and resolution.

We compared various receiver types and group types in rough terrain. The 3C data provide better resolution and better imaging of dipping reflectors.

References
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Figure 5: Image produced from the conventional geophone (groups of 12) data.
Figure 6: Image produced from the multi-component single sensors (DSU) data.