3-D ELASTIC AND VISCOELASTIC STRIKE-SLIP FAULT BENCHMARKS

May 2, 2008 – David Sandwell and Bridget Smith-Konter

3-D elastic half-space (Okada) benchmark

Benchmark comparisons between the Maxwell code (infinite plate thickness) of Smith and Sandwell [2006] (herein referred to as S&S model) with results from an Okada half space formulation coded by Yuri Fialko and implemented in Matlab in a program called Synthetic Interferogram Calculator (SIC). The model consists of a 200 km long right-lateral strike-slip fault that has uniform slip of one between the surface and 15 km or 30 km depth.

Results from these benchmark comparisons can be found in separate directories in the attached tar file: the two Okada models are stored in directories okada_15 and okada_30; two maxwell models are stored in directories maxwell_15 and maxwell_30. The Matlab script compare_okada.m differences the two models for all three components. Figures 1, 2, and 3 below illustrate these differences. Residuals are small away from the fault but large near the fault. These differences occur because in the S&S model, the fault has a finite thickness of 2 km so the model can be generated on a 1 km grid. In addition, the ends of the fault in the S&S model are cosine tapered over two grid cells. The cell size of the S&S model is easily reduced to 500 m (or smaller) when necessary.

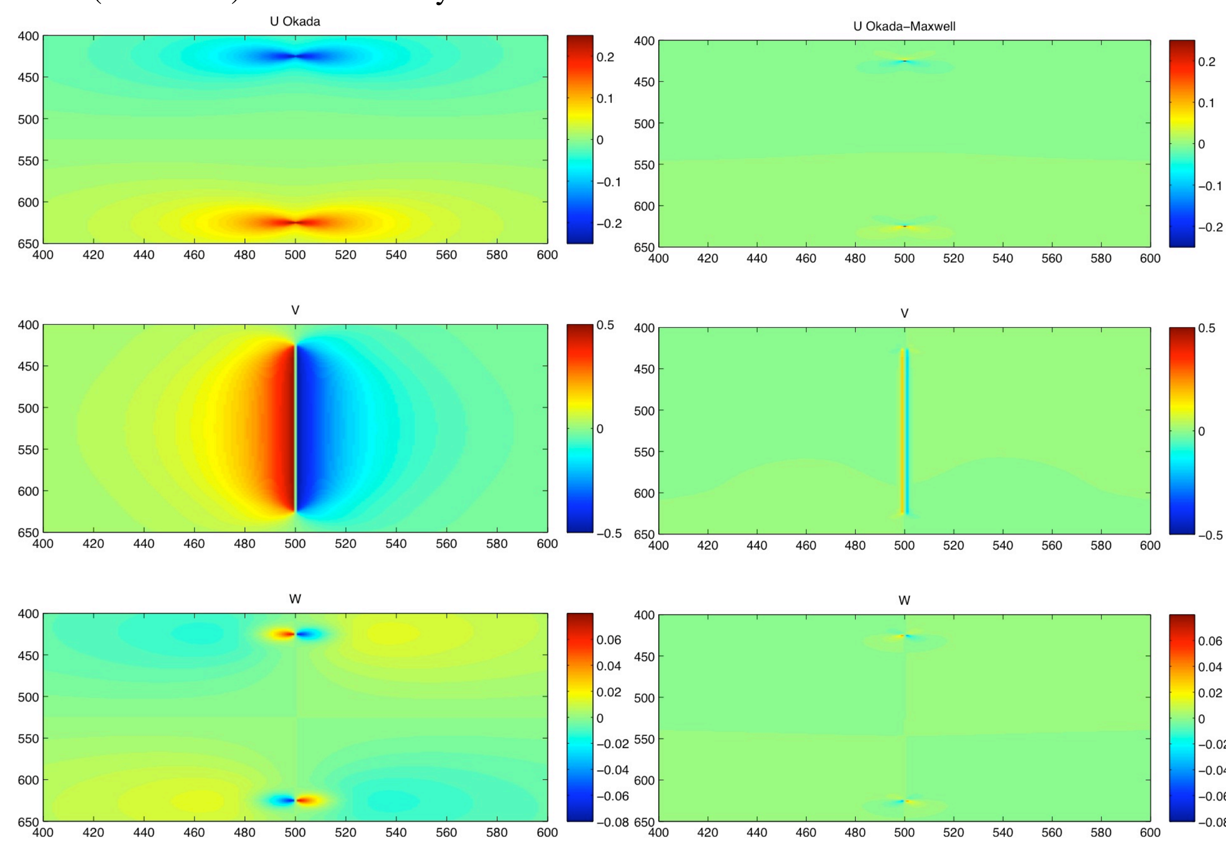

Figure 1. (left) Three components of deformation (U = across-fault, V = along-fault, W = vertical) for a 200-km long 15-km deep right-lateral strike-slip fault in an elastic half-space, calculated by analytic Okada model. Displacement results are in mm. **(right)** Differences between the analytic Okada calculation and the finite-thickness fault approximation of the S&S model.

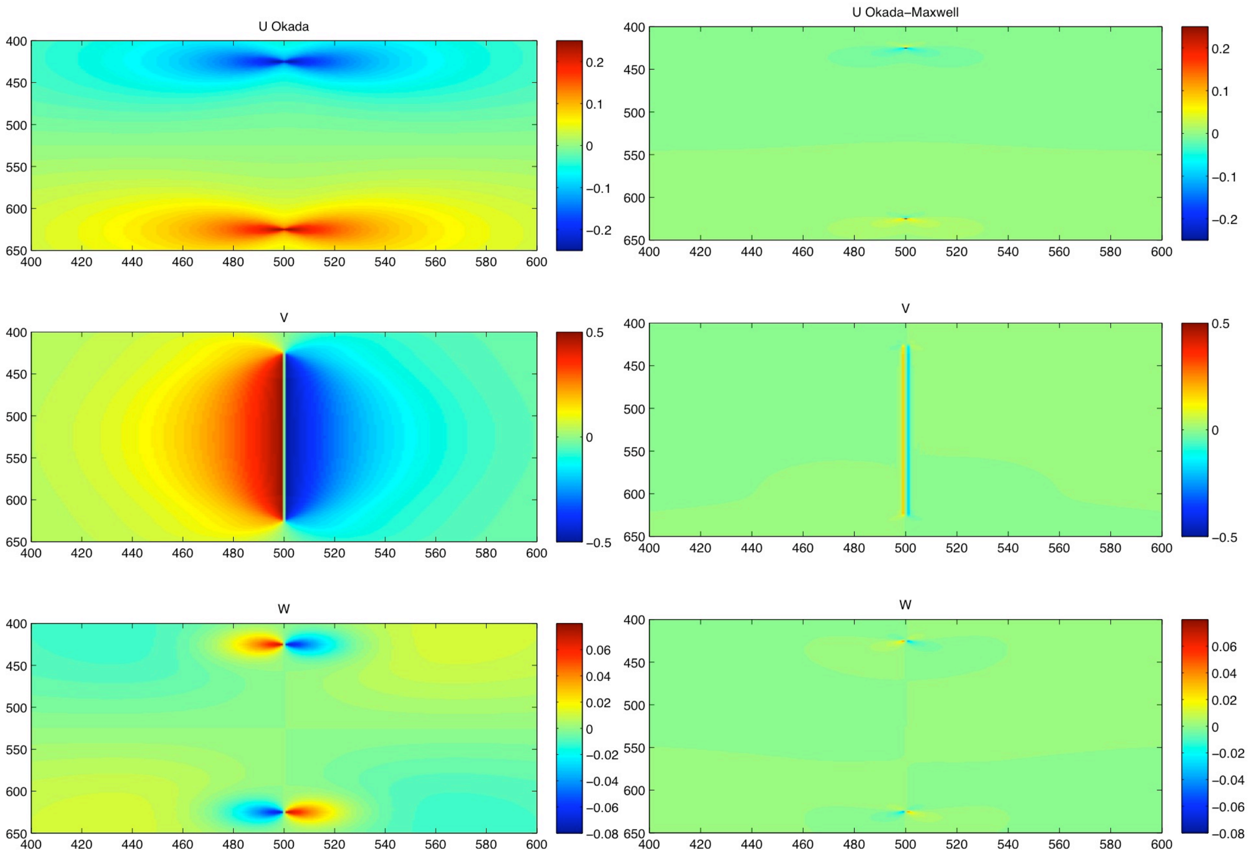

Figure 2. (left) Three components of deformation (same as Figure 1) for a 200-km long 30-km deep strike-slip fault in an elastic half-space, as calculated by the analytic Okada model. **(right)** Differences between the analytic Okada calculation and the finite-thickness fault approximation of the S&S model.

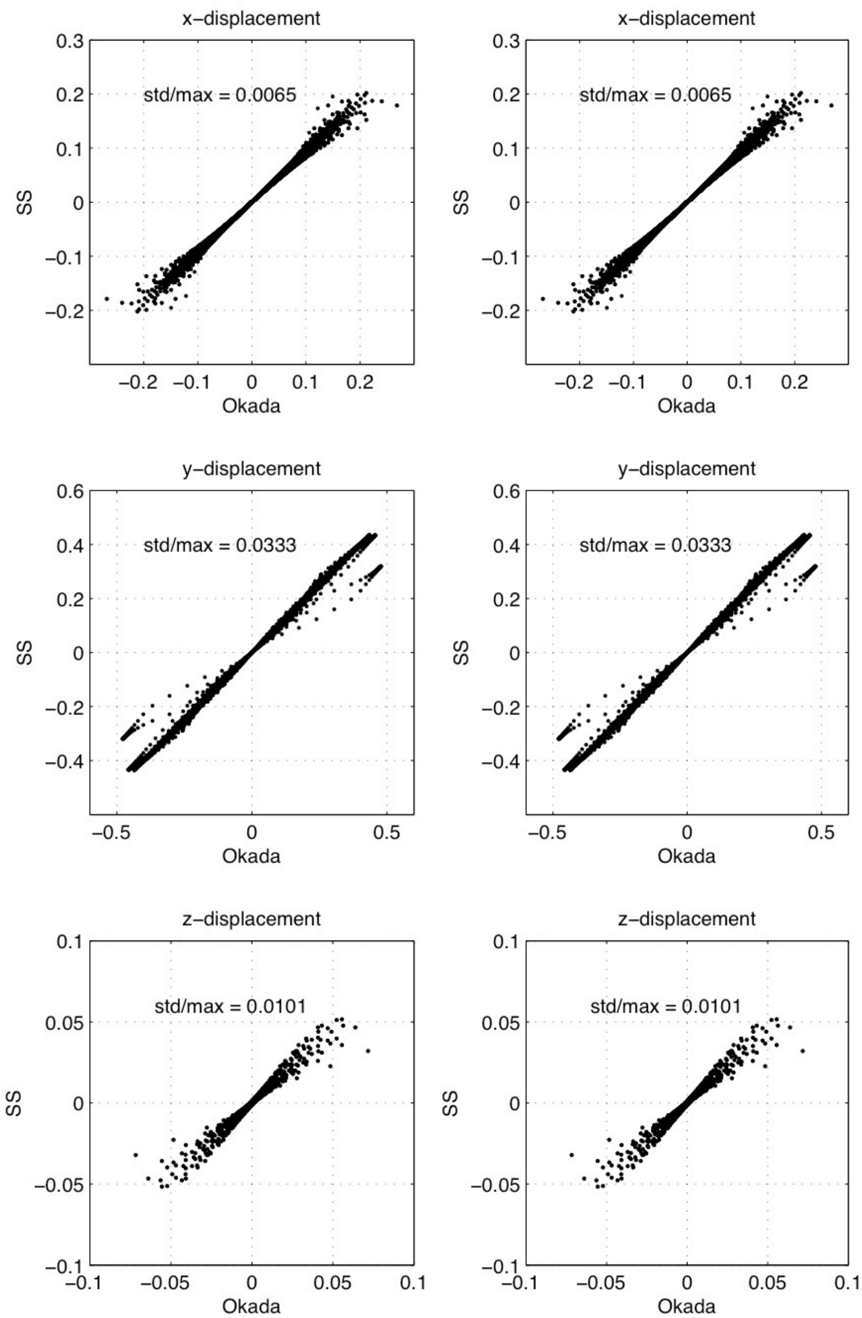

Figure 3. Point-wise comparison of the three components of deformation from the Okada model versus S&S model, where x-displacement is in the across-fault (U) direction, y-displacement is in the along-fault (V) direction, and z-displacement is vertical (W). **(left)** 15-km deep fault, **(right)** 30-km deep fault. The standard deviation of the differences between the two models normalized by the maximum positive excursion (std/max) is shown for each case. Deviations for the *y*-component (along-fault) are largest because of the finite thickness fault used in the S&S model.

3-D elastic plate overlying a viscoelastic half-space benchmark

Benchmark comparisons between the Maxwell code (viscoelastic version) of Smith and Sandwell [2006] (herein referred to as S&S model) and viscoelastic code developed by Kaj Johnson. The following benchmarks reflect results for the viscoelastic component of post-earthquake displacement only and do not include the larger coseismic deformation due to the strike-slip fault in the half-space. In both cases, the benchmark model consists of a 30-km thick plate over a fluid half space (μ = 0, time = infinity).

Figures 4 (S&S) & 5 (K. Johnson) illustrate the resulting displacements for 200-km long fault that is 15 km deep (left) and 30 km deep (right). Figure 6 demonstrates the resulting differences of these two approaches. Figures 7 & 8 demonstrate a side-by-side comparison of the vertical components of both models.

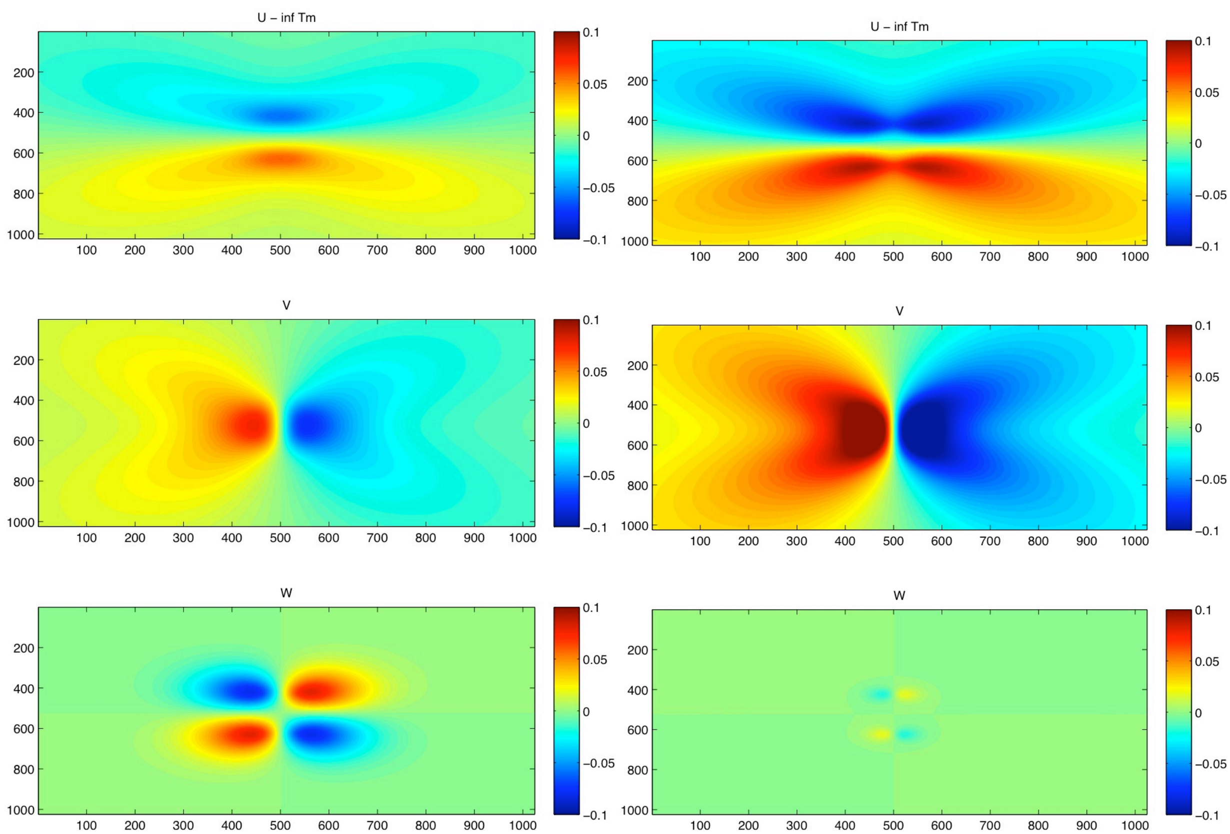

Figure 4. Post-earthquake deformation at infinite time for **(left)** 15-km deep right-lateral strike-slip fault and **(right)** 30-km deep fault (U = across-fault, V = along-fault, W = vertical). Displacement results are show in mm.

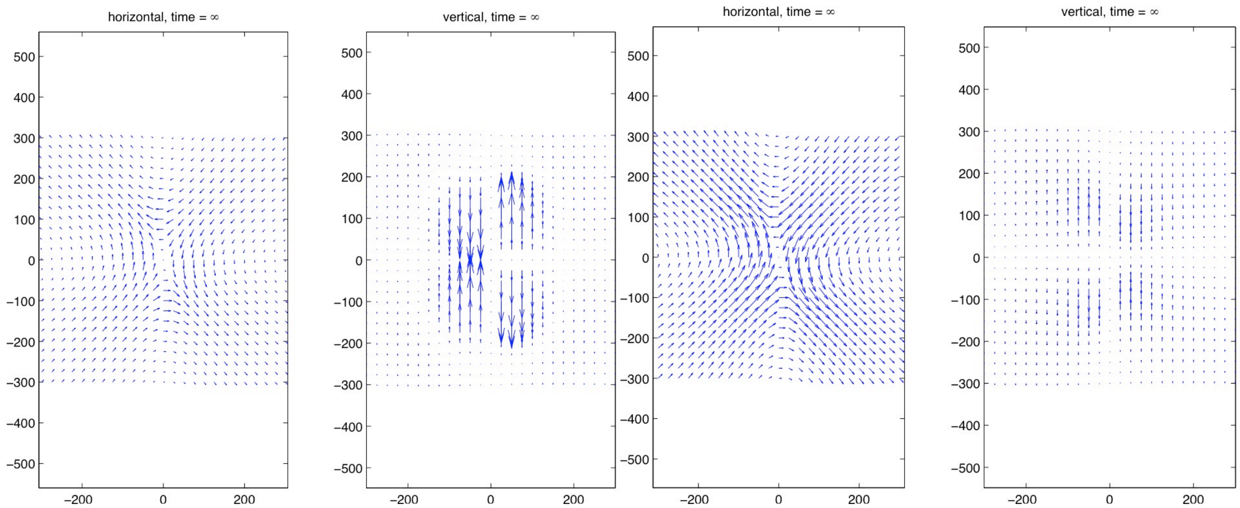

Figure 5. Post-earthquake deformation vectors at infinite time for 15-km deep right-lateral strike-slip fault (**left**, horizontal and vertical) and 30-km deep fault (**right**, horizontal and vertical). Results provided by Kaj Johnson.

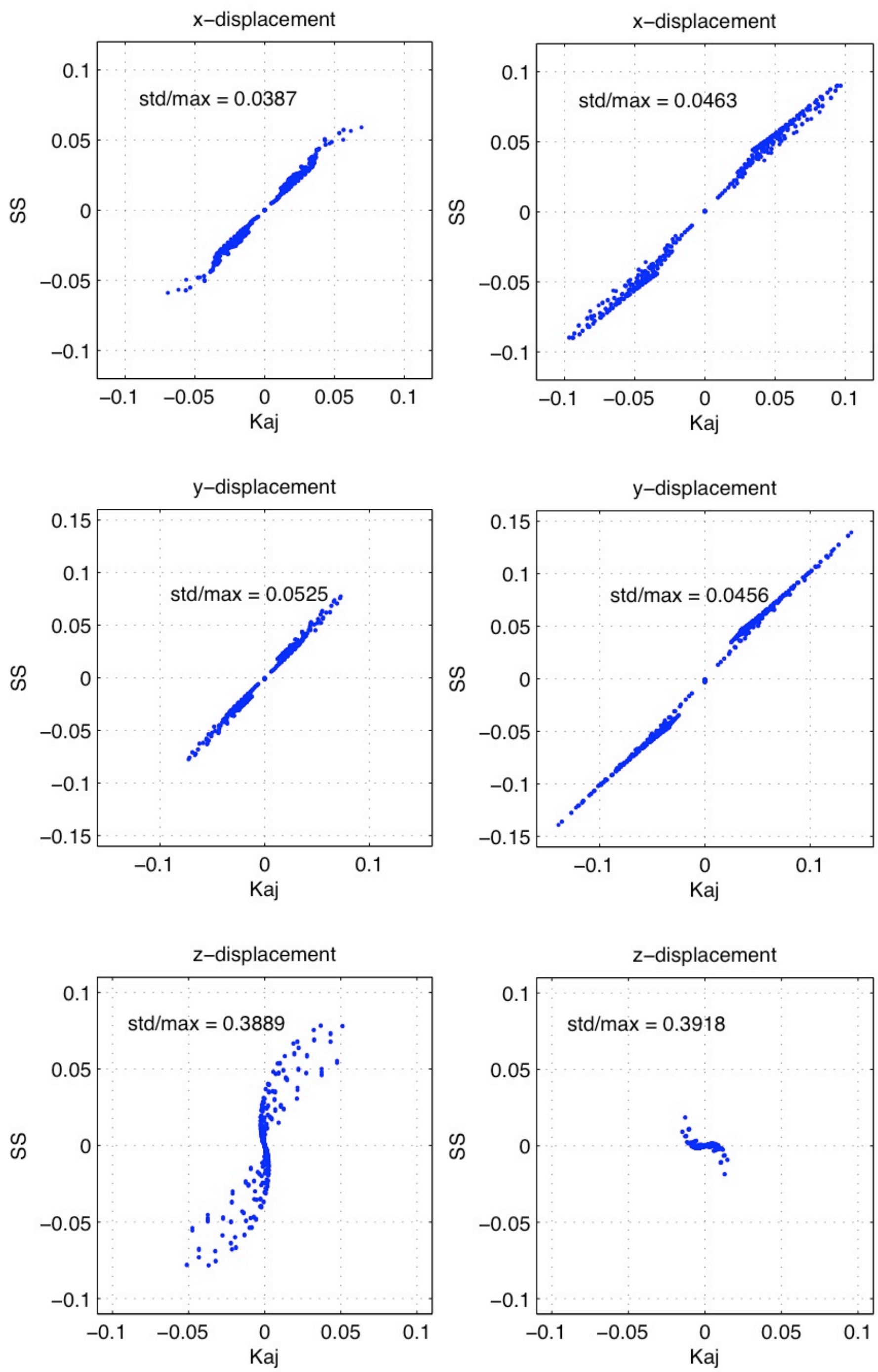

Figure 6. Point-wise comparisons between vector displacements provided by Kaj Johnson (horizontal axis, Figure 5) and the S&S model (vertical axis, Figure 4). **(left)** 15-km deep fault. **(right)** 30-km deep fault. There is excellent agreement between the two approaches for the horizontal (*x, y*) component (4-5%) but considerable disagreement in the vertical (z).

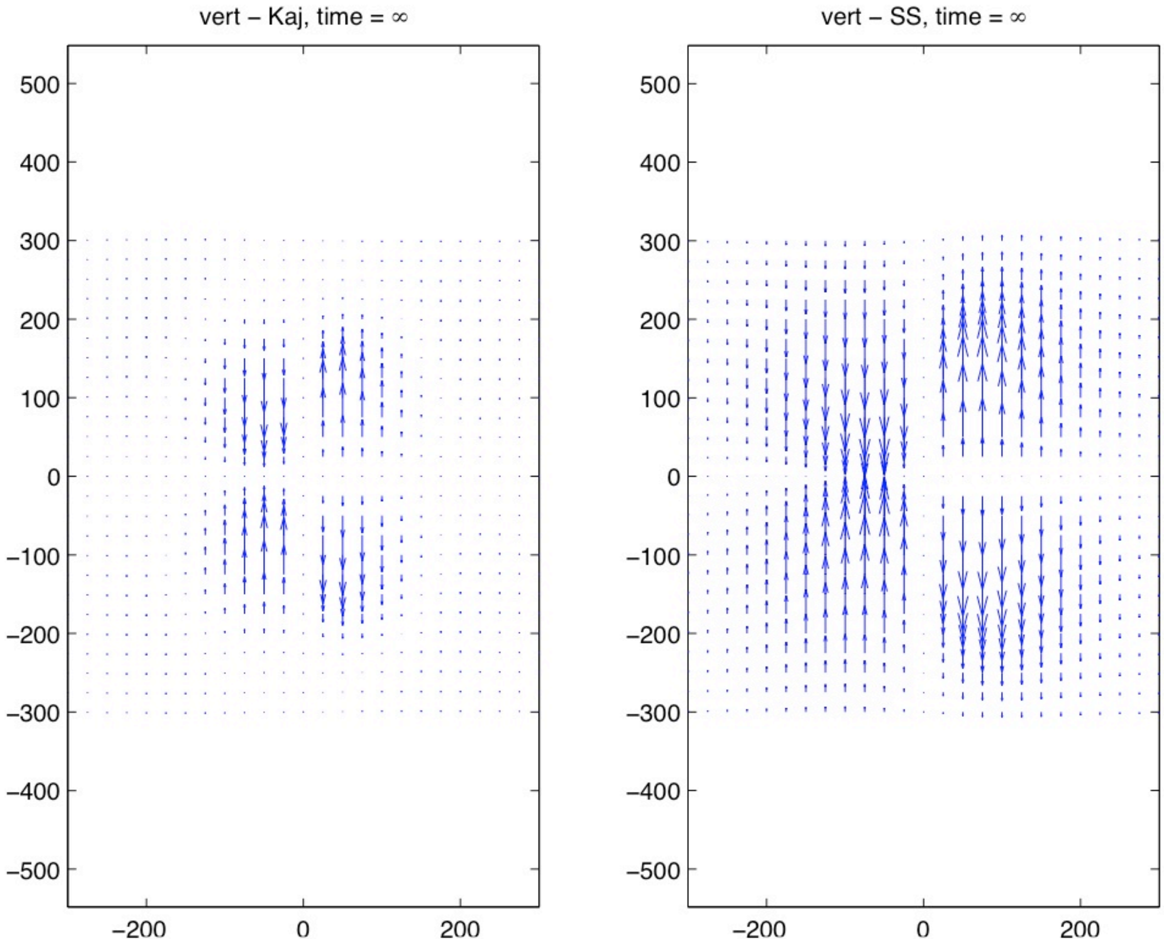

Figure 7. Vertical post-earthquake deformation vectors for 15-km fault reflecting side-by-side comparison of two models. **(left)** Kaj model, **(right)** S&S model. Th main difference in the vertical is at distances greater than 150 km from the fault where the Kaj model goes to zero more rapidly than the S&S model.

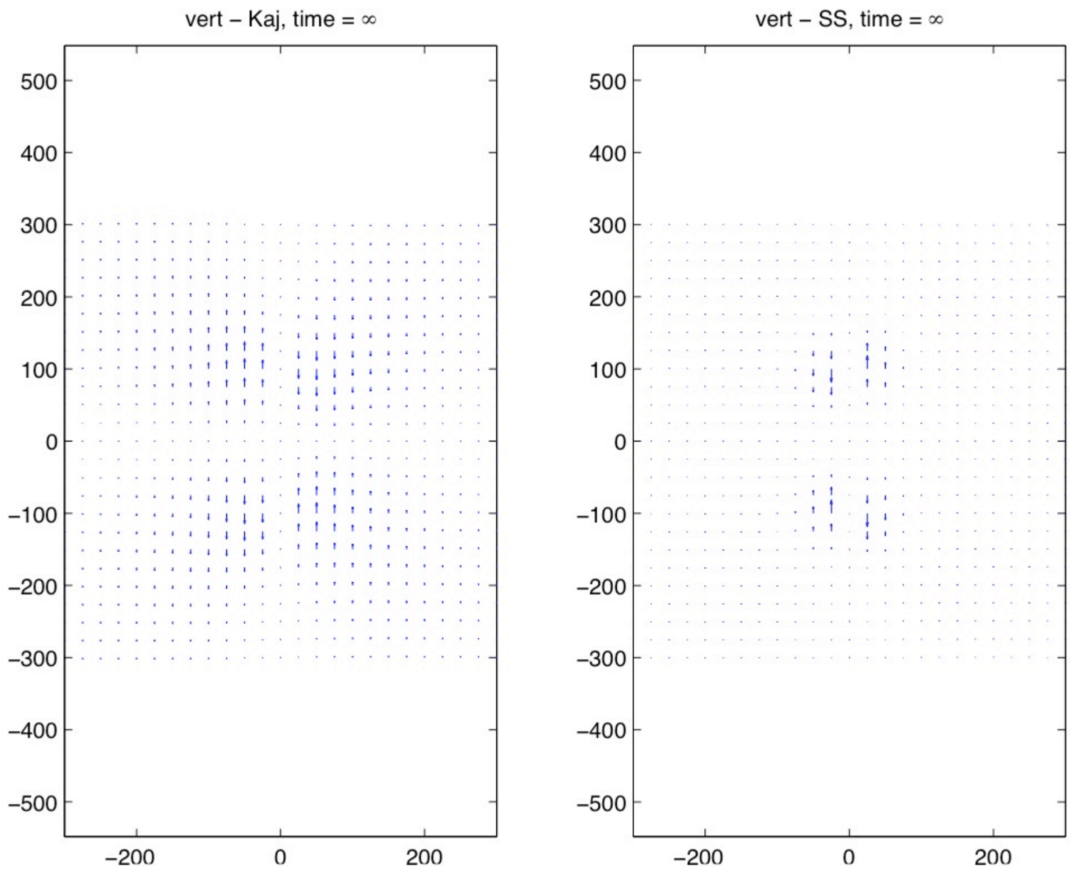

Figure 8. Vertical post-earthquake deformation vectors for 30-km fault reflecting side-by-side comparison of two models. **(left)** Kaj model, **(right)** S&S model. Both models have very small residual vertical deformation, with the S&S smaller than the Kaj model and of opposite sign.