Reply to "Shear-wave splitting to test mantle deformation models around Hawaii" by Vinnik et al.

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[1] Observations of teleseismic shear-wave splitting from station H2O reported in the Comment from *Vinnik et al.* [2003, hereinafter referred to as VMGDS] show a quite different orientation of the fast azimuth from that we obtained in *Walker et al.* [2001, hereafter referred to as WBK]. We found that azimuth orientations at H2O and JOHN were incorrectly labeled in the waveform headers residing at the archive center. After correcting for this, we recovered a similar station estimate as VMGDS. Additional new events suggest no evidence for two-layer anisotropy beneath either of these stations, despite there being evidence for two-layer anisotropy beneath KIP on Oahu (upper layer parallel to neighboring fracture zone, lower layer parallel to plate motion). A simple pattern of anisotropy emerges in the north-central Pacific that is generally consistent with body-wave and surface-wave anisotropy studies.

[2] VMGDS found a single-layer-anisotropy station estimate fast azimuth $\phi = 102° \pm 13.3°$ and delay time $dt = 1.0 \pm 0.4$ s, which is different from the estimate in WBK ($\phi = 42° \pm 4°$ and $dt = 1.3 \pm 0.2$ s). We investigated the horizontal-component azimuth orientations in the data sets downloaded from the data archive centers and used in WBK for both stations H2O and JOHN. We discovered that most of these azimuths were incorrect. The correct orientations of the horizontal components are HH1 = 258.5°/HH2 = 348.5° for H2O, and BH1 = 75°/BH2 = 165° for JOHN. Due to strict space restrictions, a detailed description of the problem and our analysis is included as supporting material[1]. We conclude that in chronological order for station H2O, the splitting results for the first five events reported in WBK are incorrect, while the sixth event was correct. For JOHN, the two splitting measurements analyzed in WBK are incorrect.

[3] After correcting the azimuths reported in the headers, we reanalyzed all the reported events for H2O and JOHN in WBK using the apparent splitting method of *Silver and Chan* [1991] implemented in an algorithm developed by George Helffrich and revised by Paul Silver, and then stacking the events using the method of *Wolfe and Silver* [1998] implemented in our own code. In addition, we found and analyzed new events for both stations[1]. The new results are: H2O = 103 ± 4°/1.4 ± 0.1 s and JOHN = 103 ± 5°/1.1 ± 0.2 s (Figure 1). Thus anisotropy beneath H2O and JOHN is still very similar, but now is subparallel with the orientation of the plane of Pacific plate motion relative to a fixed hotspot reference frame (~120°; Figure 2) [*Gripp and Gordon*, 1990]. This contradicts our earlier reported station estimates and lithospheric anisotropy interpretation for H2O and JOHN. The revised estimates suggest that anisotropy at H2O and JOHN is related to plate motion.

[4] Our new measurements and station estimates[1] are in agreement with those reported in VMGDS, except that our station estimates have smaller error bars. There are two possible reasons for these smaller error bars: (1) the larger number of events used here, and (2) the difference in the analytical techniques. Included as supporting material due to space restrictions[1], we address the second possibility, but only focus on statistical aspects of the techniques because the splitting results themselves are in agreement.

[5] The corrected data in Figure 2 suggest that mantle anisotropy both around Hawaii and at great distances from it is located in the asthenosphere and perhaps lowermost lithosphere. These fast azimuths are roughly consistent with those predicted from a 3D global surface-wave study [*Montagner and Guillot*, 2000], but the delay times sensed by shear-wave splitting are stronger than those predicted by the surface-wave study. These studies together suggest that the dominant "reference" upper-mantle anisotropy in the north-central Pacific appears to be a result of simple shear between the plate and asthenosphere, an interpretation that also explains some splitting data in the south Pacific [*Farra and Vinnik*, 1994, *Wolfe and Silver*, 1998, *Russo and Okal*, 1998], but not necessarily in the western Pacific where fast directions are apparently 80° [*Farra and Vinnik*, 1994], a deviation of 40° from absolute plate motion. The revisions to our previous station estimates for H2O and JOHN do not change our preferred interpretation of mantle anisotropy around Hawaii, where it may be perturbed by (1) the plume as suggested by the good fit of the station estimates around Hawaii to the flowlines from a parabolic asthenospheric flow model (Figure 2), and (2) the Molokai fracture zone near station KIP, a station that requires a two-layer anisotropy model to explain the many observations of teleseismic shear-wave splitting recorded there.

[1] Supporting material is available at ftp://agu.org, directory "apend" (Username = "anonymous," Password = "guest"); subdirectories in the FTP site are arranged by paper number. See also http://www.agu.org/pubs/esupp_about.html.

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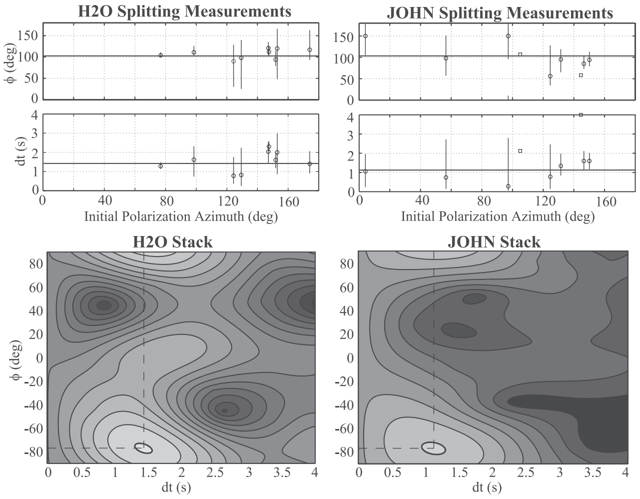

Figure 1. Corrected apparent splitting measurements as a function of initial polarization azimuth for stations H2O and JOHN. Circles represent constrained measurements, and vertical lines are the associated 2σ bars. Squares indicate null measurements. Both stations have measurements that are consistent with a single-layer anisotropy model with a horizontal fast axis. As such, we stack the measurements following the method of *Wolfe and Silver* [1998], and find that both station estimates are almost identical within errors (the 95% confidence contour is bold).

[6] **Acknowledgments.** We thank L. Vinnik, J.-P. Montagner, N. Girardin, I. Dricker, and J. Saul for inspiring us to reexamine our shear-wave splitting results for H2O, and consequently JOHN. We also thank F. Duennebier, T. Storm, and V. Peyton for their efforts in helping to resolve the correct horizontal-component azimuth orientations. Finally, we would like to thank the IRIS Data Management Center for providing access to the GSN waveform data, and the Advanced National Seismic System for use of their online earthquake-catalog search engine.

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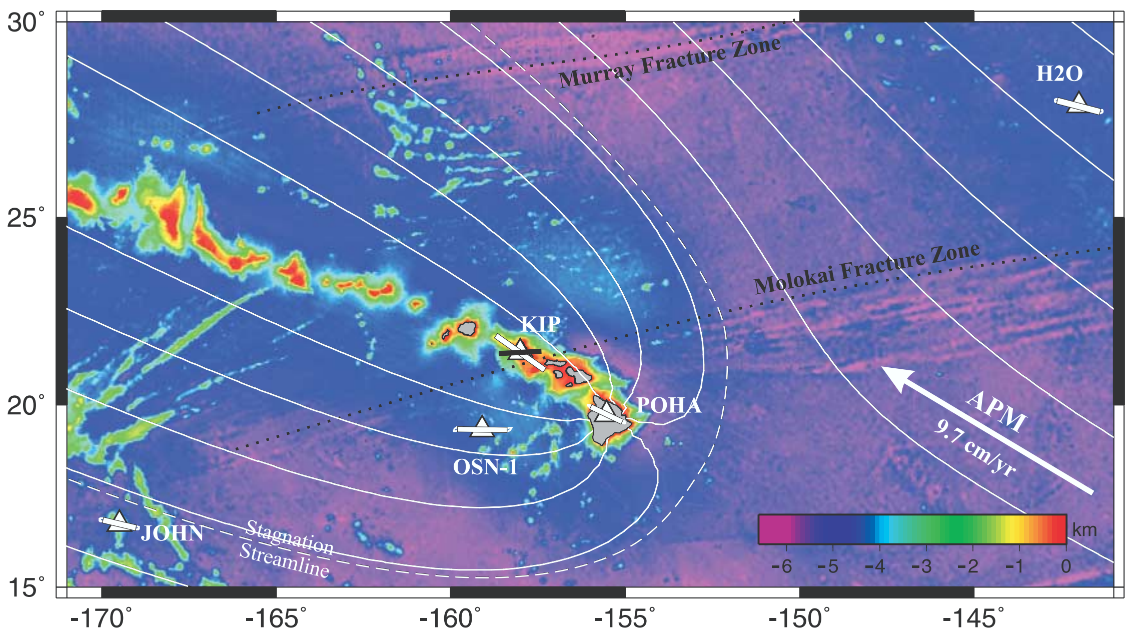

Figure 2. Map of Hawaii and surrounding region showing our corrected shear-wave splitting station estimates for H2O and JOHN. Triangles indicate stations analyzed in *Walker et al.* [2001]. All estimates are plotted as lines with their shade depending on their interpretation (filled = asthenospheric, open = lithospheric), their orientation parallel to fast polarization direction, and length proportional to delay time. 95% confidence regions are plotted at ends of vectors for the single-layer models. The best-fitting parabolic flow model is overlaid. Note the good fit with the fast polarization directions at all stations.