Geophysical Research Abstracts, Vol. 8, 06245, 2006
SRef-ID: 1607-7962/gra/EGU06-A-06245
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The Hawaiian plume: what do geophysical observables tell us?

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The Hawaiian islands are the best-known example of intraplate volcanism produced by an upwelling mantle plume. This talk reviews recent progress in the direct modeling of the surface geophysical signatures produced by the Hawaiian plume, using 3D dynamical plume-lithosphere interaction (PLI) models. I begin by describing a method for inferring poorly known parameters of the Hawaiian plume via inversion of scaling laws obtained from PLI models. One striking result of this method is that the plume's buoyancy flux is 2-3 times smaller than previous estimates based solely on the size of the swell. I turn next to the geoid/topography ratio (GTR) of the swell, concerning which a conflict has long existed between values estimated from filtered gravity and bathymetry data (GTR $\approx 0.004 - 0.005$) and those predicted by PLI models (GTR ≈ 0.008). The paradox is resolved by an extended PLI model that includes the flexural effects of volcanic loading, which suggests that the low values inferred from observations are artefacts of incomplete filtering of (shallowly compensated) flexural topography. A third application of PLI models is to understand the complex variation of the eruption rate of Hawaiian volcanoes with time. PLI models outfitted with a melting parameterization predict that melting continues 500-600 km downstream from the hotspot, which may explain the occurence of late-stage 'post-erosional' lavas. Finally, I discuss the application of PLI models to calculate directly the distribution of olivine lattice preferred orientation (LPO) and seismic anisotropy within the flow. The results of such calculations may have important implications for the interpretation of data from ocean-bottom seismometer arrays.