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Playing with Edges: The Influence of Arbitrary Definitions on Hotspot–LLSVP Correlations

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Correlating surface hotspot volcanism with sharply defined edges of Large Low Shear Velocity Provinces (LLSVPs) is a common yet potentially oversimplified approach in mantle geodynamics. Such direct radial projections ignore the lateral displacement of plume conduits observed in seismic tomographic imaging, which suggests that purely vertical transport through the mantle is not guaranteed. Furthermore, many studies merge the African and Pacific LLSVPs, despite evidence that their correlation with hotspots differs significantly. These oversimplifications can lead to misinterpretations of plume-lithosphere interactions, the interaction between mantle plumes and the ambient ”mantle wind”, and mantle flow dynamics in general. Here, we systematically investigate how varied criteria can alter the inferred hotspot– LLSVP edge relationship. We separately analyze African and Pacific LLSVPs using: multiple tomography models, horizontal-gradient based definitions of edges, different vote-map methodologies, and distinct plume geometry assumptions–from perfectly vertical “spokes” to randomly deflected trajectories. We also apply the Back-and-Forth Nudging (BFN) method applied to time-reversed thermal convection, initialized with a present-day seismic–geodynamic–mineral physics model (Glisovic & Forte, 2016), to provide a geodynamically consistent assessment of the relationship between present-day hotspot locations and their source regions in the deep lower mantle. This independent geodynamic assessment clarifies how arbitrary choices concerning the interpretation of hotspots and LLSVP edges may lead to biased or skewed deep-plume reconstructions. Our results reveal that adjustments in hotspot catalogs, or the decision to combine the two main LLSVPs rather than regard each as dynamically distinct, can yield important differences in the significance attributed to sharply defined LLSVP edges. These findings underscore that commonly cited correlations between hotspot locations and LLSVP boundaries hinge on assumptions that vary considerably across the literature. Recognizing and rigorously defining input parameters–particularly the separate treatment of the African and Pacific LLSVPs and the inclusion of realistic lateral plume deflection–proves essential for robust interpretations of deep Earth structure. This highlights the need for standardized methodologies and careful parameter choices to avoid overstating the importance of LLSVP edges in shaping plume pathways.