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Effects of subduction and slab gaps on mantle flow beneath the Lesser Antilles based on observations of seismic anisotropy

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Subduction is a key process in the formation of continental crust. However, the interaction of the mantle with the subducting slab is not fully understood and varies between subduction zones. The flow geometry and stress patterns influence seismic anisotropy; since anisotropic layers lead to variations in the speed of seismic waves as a function of the direction of wave propagation, mantle flow can be constrained by investigating the structure of these anisotropic layers.

In this study we investigate seismic anisotropy in the eastern Greater and the Lesser Antilles along a subduction environment, including the crust and the upper mantle as regions of interest. We use a combination of teleseismic and local events recorded at three-component broadband seismic stations on every major island in the area to observe and distinguish between anisotropy in the crust, the mantle wedge and the sub-slab mantle.

Local event delay times (0.21 ± 0.12s) do not increase with depth, indicating a crustal origin and an isotropic mantle wedge. Teleseismic delay times are larger (1.34 ± 0.47s), indicating sub-slab anisotropy. The results suggest trench-parallel mantle flow, with the exception of trench-perpendicular alignment in narrow regions east of Puerto Rico and south of Martinique, suggesting mantle flow through gaps in the slab. This agrees with the continuous northward mantle flow that is caused by the subducting slab proposed by previous studies of that region.

We were able to identify a pattern previously unseen by other studies; on St. Lucia a trench-perpendicular trend also indicated by the stations around can be observed. This pattern can be explained by a mantle flow through a gap induced by the subduction of the boundary zone between the North and South American plates. This feature has been proposed for that area using tomographic modelling (van Benthem et al., 2013). It is based on previous results by Wadge & Shepherd (1984), who observed a vertical gap in the Wadati-Benioff zone at that location using a seismicity catalogue from local seismic networks. This work strengthens the argument for that location to be the plate boundary between the North and South American plates.