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Crustal structure of the Lesser and Leeward Antilles forearcs inferred from satellite Vertical Gravity Gradients

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The characterization of the crustal structure of the plates involved in a subduction system is a crucial step towards the understanding of potentially associated geohazards. Despite the low current seismic activity in the Lesser and Leeward Antilles (compared with other subduction zones), several historical M>7 earthquakes have been registered in both regions. In the Lesser Antilles, the oceanic floor of the North and South American plates subducts beneath the Caribbean plate. In contrast, in the Leeward Antilles, the Caribbean plate subducts under the continental South American plate. In regions where the seismic records do not extend far back in time, or where the frequency of such large earthquakes is low, alternative indirect methods for delimiting seismogenic zones may be applied. In those cases, it would be valuable to characterize in detail the regional continental-oceanic boundary and the backstop edge location. The tectonic history of the Lesser Antilles includes a variety of allochthonous slightly or high buoyant fragments, which have been either subducted or accreted to the backstop, and which can influence the spatial seismicity patterns. Moreover, previous studies suggest that the north central region of the Lesser Antilles forearc is composed of two different crustal units: an inner and an outer forearc domains, characterized by high and low seismic velocity gradients, respectively. Such crustal domains interact spatially with the down-going plate, for example, acting as backstops. Nevertheless, the seismic experiments carried out in the Lesser Antilles have focused only on a relatively narrow region; thus, much of the structure of the currently active volcanic arc remains poorly constrained.

Taking advantage of the high spatial resolution and homogeneous coverage of satellite gravity and altimetry data, we propose a new methodology for the characterization of the oceanic crust. We use the residuals between the observed Vertical Gravity Gradients (VGG) of the EIGEN-6C4 dataset, and the modelled VGG obtained from a-priory 3D lithospheric density distributions. The VGG are especially sensitive to high-density contrasts in the upper crust; therefore, the high resolution ($\lambda \approx$18 km) of EIGEN-6C4 allowed us to identify not only the edges of crustal bodies present in the study area, but also the continental-oceanic boundary. Especially, our results suggest the existence of an anomalous buoyant body (of $\approx$31 x 10^3 km^2) in the oceanic crust of the South American plate, offshore Dominique and Martinique Islands, which is buried under the thick sedimentary layer (10 – 16 km) of the Barbados Accretionary Prism. This body seems to act as a boundary between two different clusters of seismicity, and is most likely related with a fragment of a volcanic arc that migrated from the Atlantic Ocean. Additionally, we identified more broadly distributed high and low-density bodies along the Lesser and Leeward Antilles forearcs, which may act as backstops of the subduction zone, and therefore, can be tested as the up-dip limit of the seismogenic zones in these systems. Thanks to the global coverage of the combined gravity dataset, our methodology could be used in other marine environments, were data availability is limited.