Geophysical Journal International

Geophys. J. Int. (2022) **231,** 319–326
Advance Access publication 2022 May 23
GJI Geodynamics and Tectonics

https://doi.org/10.1093/gji/ggac192

Ongoing tectonic subsidence in the Lesser Antilles subduction zone

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Accepted 2022 May 19. Received 2022 May 16; in original form 2022 February 1

SUMMARY

Geological estimates of vertical motions in the central part of the Lesser Antilles show subsidence on timescales ranging from 125.000 to 100 yr, which has been interpreted to be caused by interseismic locking along the subduction megathrust. However, horizontal GNSS velocities show that the Lesser Antilles subduction interface is currently building up little to no elastic strain. Here, we present new present-day vertical velocities for the Lesser Antilles islands and explore the link between short- and long-term vertical motions and their underlying processes. We find a geodetic subsidence of the Lesser Antilles island arc at 1–2 mm yr^{-1}, consistent with the ∼100-yr trend derived from coral micro-atolls. Using elastic dislocation models, we show that a locked or partially locked subduction interface would produce uplift of the island arc, opposite to the observations, hence supporting a poorly coupled subduction. We propose that this long-term, margin-wide subsidence is controlled by slab dynamic processes, such as slab rollback. Such processes could also be responsible for the aseismic character of the subduction megathrust.

Key words: Seismic cycle; Dynamics: seismotectonics; Subduction zone processes.

1 INTRODUCTION

The accumulation of stress along locked subduction interfaces over timescales of tens to hundreds of years (i.e. short-term) leads to horizontal and vertical deformation of the overriding plate (e.g. Savage 1983; Chlieh *et al.* 2004). Interseismic locking results in landward horizontal motions in the (fore)arc and tectonic subsidence or uplift depending on the distance from the trench and the structure of the overriding plate (e.g. Wallace *et al.* 2012; Mouslopoulou *et al.* 2016). This interseismic deformation is typically assumed to be elastic, to be released by earthquakes along the subduction megathrust (i.e. co-seismic slip), as well as by post-seismic processes (i.e. afterslip and viscous relaxation; e.g. Avouac 2015; Hu *et al.* 2016). Monitoring the degree of locking along the subduction interface with geodetic measurements therefore provides information on its ability to generate large (M_w > 7.5) megathrust earthquakes (e.g. Loveless & Meade 2011; Avouac 2015).

In contrast to short-term interseismic deformation, convergence at subduction zones on timescales from ten thousand to several million years (i.e. long-term) leads to anelastic deformation of the overriding plate, resulting in processes such as mountain building (e.g. Armijo *et al.* 2015; Jolivet *et al.* 2020) or basal erosion or accretion (e.g. Heki 2004; Menant *et al.* 2020; Boucard *et al.* 2021). As a result, over timescales of tens to hundreds of years, plate convergence is not entirely accommodated by elastic, recoverable deformation, but part of it is converted into permanent strain. Understanding the interplay between such short- and long-term deformation patterns and how their underlying processes influence the seismogenic behaviour of subduction zones is fundamental for seismic hazard assessment in such contexts.

The Lesser Antilles subduction zone, which constitutes the eastern boundary of the Caribbean plate (Fig. 1), has not experienced any thrust events larger than M_w > 6.5 in the past 100 yr (Stein *et al.* 1983). Two large historical earthquakes in the 19th century (*M*7–8 in 1839 and *M*7.5–8.5 in 1843) have been interpreted by some as thrust events, but unequivocal evidence for this is missing (e.g. Bernard & Lambert 1988). Coastal stratigraphy records of the past 5000 yr reveal no tsunami deposits related to arc-wide, megathrust

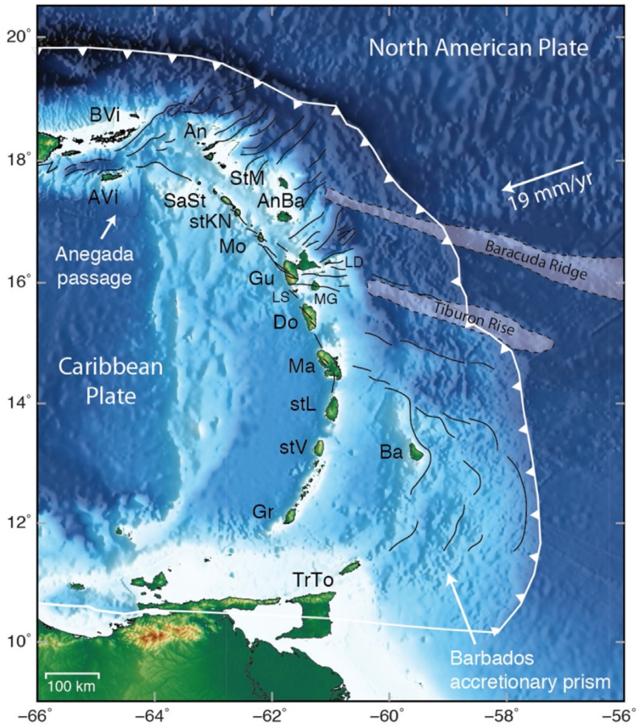

Figure 1. Seismotectonic setting of Lesser Antilles subduction zone. BVI, British Virgin Islands; AVI, American Virgin Islands; An, Anguilla; stM, Saint Martin; SaSt, Saba & Saint Eustatius; AnBa, Antigua & Barbuda; stKN, Saint Kitts & Nevis; Mo, Montserrat; Gu, Guadeloupe; LS, Les Saintes; MG, Marie Galante; LD, La Désirade; Do, Dominica; Ma, Martinique; stL, Saint Lucia; stV, Saint Vincent; Gr, Grenada; Ba, Barbados; TrTo, Trinidad & Tobago. Plate motion vector shows North America with respect to Caribbean from Symithe *et al.* (2015).

events, suggesting that such events either had a very low frequency or were absent during the Holocene (Paris *et al.* 2021). Caribbean-wide geodetic studies over the past decade all found low interseismic coupling of the subduction interface (Manaker *et al.* 2008; Symithe *et al.* 2015), a finding recently confirmed by a more detailed study focused on the Lesser Antilles (van Rijsingen *et al.* 2021). Their inversion of horizontal GNSS velocities and forward models show that the subduction interface is currently poorly coupled, with no re-locking of the proposed rupture areas of the 1839–1843 earthquakes. The active plate margin is thus apparently not building up elastic strain at a significant rate today. GNSS velocities typically cover the last few decades only, so expanding temporal coverage over one or several seismic cycles requires geological proxies such as coral data (e.g. Sieh *et al.* 2008; Philibosian *et al.* 2017).

Micro-atoll data collected in Martinique (Weil-Accardo *et al.* 2016) indicate tectonic subsidence at 1.3 ± 1.1 mm yr^{-1} since 1895, while estimates from reef terraces in Les Saintes (part of the archipelago of Guadeloupe, Fig. 1; Leclerc *et al.* 2014) and Martinique (Leclerc *et al.* 2015) indicate subsidence at 0.3–0.45 mm yr^{-1} over the past 125 ka. Recent micro-atoll results north of Martinique, covering ∼25–85 yr in the 20th century and encompassing the region between Marie Galante and Barbuda show subsidence at 0.3–8 mm yr^{-1} (Philibosian *et al.* 2022). Therefore, at least the central and northern parts of the Lesser Antilles arc have been experiencing tectonic subsidence over this time interval, an observation that has been related to temporal variations in friction of an overall locked plate interface or to the accumulation of coseismic deformation from megathrust earthquakes that would not be fully compensated by opposite interseismic uplift (Leclerc & Feuilet 2019). This interpretation is however inconsistent with the low interseismic coupling inferred from horizontal GNSS data covering the last few decades, which raises the question of how horizontal and vertical deformation of the Lesser Antilles (fore)arc are related over these timescales.

Here, we use data on vertical velocities from continuously operating GNSS stations in the Lesser Antilles to show that the island arc is currently experiencing margin-wide subsidence at 1–2 mm yr^{-1}, in agreement with observations from corals. We show such subsidence cannot be caused by the build-up of elastic strain during the interseismic period over a locked, or partially locked subduction interface. These results therefore suggest that the arc subsidence observed across several timescales (up to ∼20 yr for GNSS, 10s-100s yr for micro-atolls, 10^3–10^4 yr for marine terraces) is controlled by long-term lithosphere-scale processes.

2 OBSERVED VERTICAL MOTIONS

The GNSS data used in this study were processed as described in van Rijsingen *et al.* (2021), with longer time-series so as to cover the 1994–2020 time interval. The vertical velocities were computed using a least-squares fit of the data with a functional form that includes a linear trend, seasonal and semi-seasonal oscillations, and step functions at times when offsets are reported (equipment change or local earthquakes) or visually detected. We used the first-order Gauss–Markov extrapolation algorithm (Herring 2003; Reilinger *et al.* 2006) to obtain velocity uncertainties that account for time-correlated noise in the time-series.

Vertical motions at the 53 GNSS stations with at least 3 yr of continuous data (Fig. 2a) show a general pattern of subsidence of the Lesser Antilles, while islands at the edges of the subduction (i.e. the Virgin Islands in the north and Trinidad in the south) show uplift. The islands of Guadeloupe and Martinique, for which station density is highest, show subsidence rates from 0 ± 0.3 to 3.8 ± 0.9 mm/yr (Fig. 2b), in good agreement with a recent study by Sakic *et al.* (2020) who found similar vertical velocities from two independent geodetic solutions (Supporting Information Fig. S1 and Table S3). The variability likely results from variations in time-series duration amongst GNSS stations and between solutions. We therefore use the time-series duration to calculate a weighted average for each island (Fig. 2c; Supporting Information) and find a homogeneous pattern of subsidence at 1–2 mm yr^{-1} along the arc, with an overall average rate of 1.1 ± 0.6 mm yr^{-1}. This subsidence is in agreement with observations from micro-atolls in Martinique over the past 125 yr (i.e. 1.3 ± 1.1 mm yr^{-1}; Weil-Accardo *et al.* 2016), and has an amplitude similar to that observed at other subduction zones where subsidence is also currently observed (e.g. Vannucchi *et al.* 2013).

The subsidence derived from micro-atolls has been interpreted as the result of interseismic locking of the subduction interface or co-seismic displacements during megathrust earthquakes (Leclerc *et al.* 2015; Weil-Accardo *et al.* 2016; Philibosian *et al.* 2022). However, the agreement between the ‘geological’ subsidence and the ‘geodetic’ one, while the subduction interface currently has very low interseismic coupling (i.e. a coupling coefficient ≤0.2 in the 0–65 km depth range; van Rijsingen *et al.* 2021), is an indication that subsidence does not result from processes related to the elastic earthquake deformation cycle. In the following, we therefore calculate how much vertical deformation one should expect from

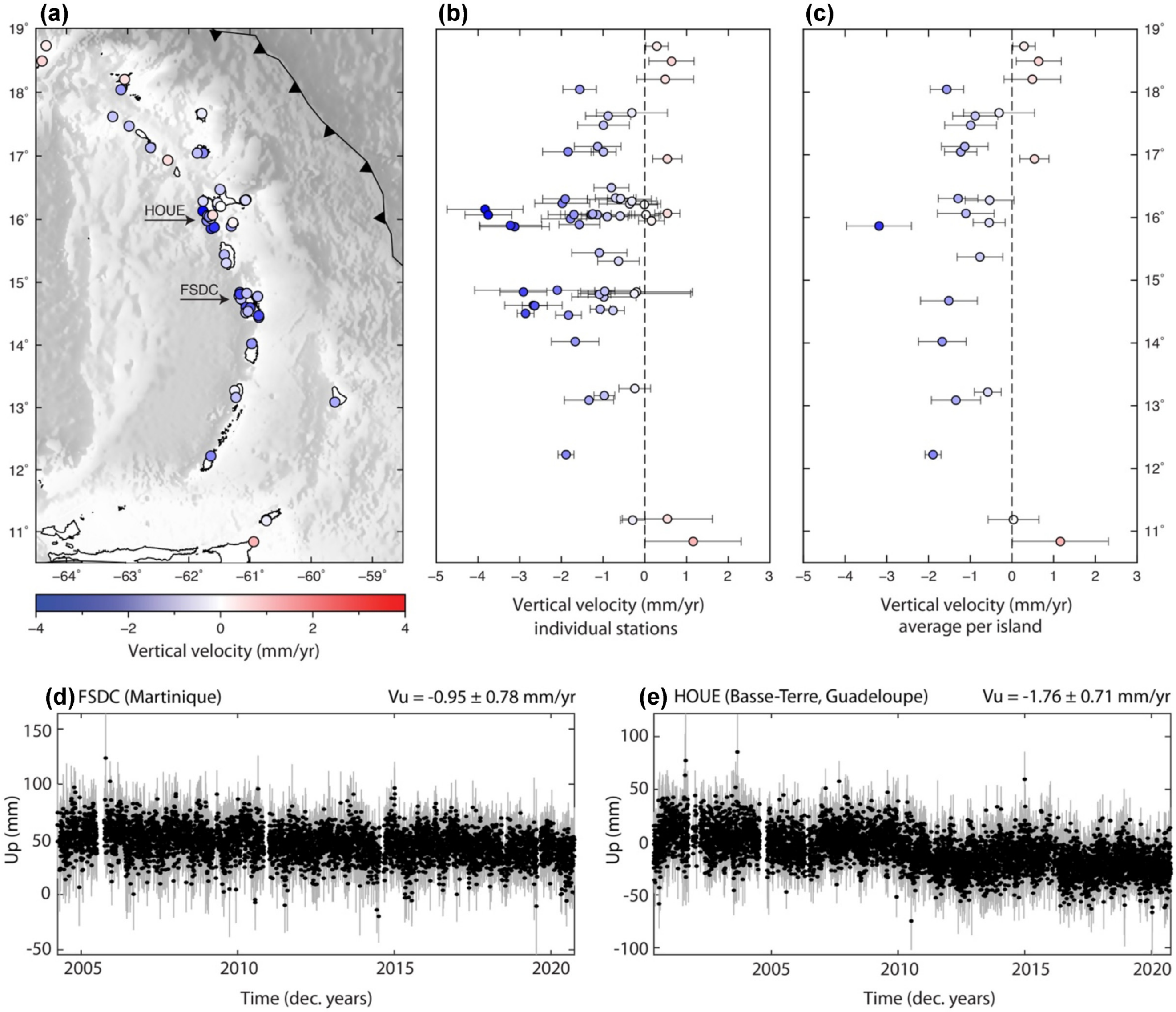

Figure 2. Vertical tectonic motions of the Lesser Antilles islands. (a) Vertical velocity of GNSS stations in map view. (b) Vertical velocities (horizontal axis) ordered by latitude (vertical axis). (c) Average velocity per island, calculated as a weighted average based on the time-series length. (d) Time-series of the vertical component of GNSS station FSDC (Martinique). (e) Time-series of the vertical component of GNSS station HOUE (Basse-Terre, Guadeloupe).

interseismic loading along the plate interface using forward models with various interseismic locking depths.

We use the model setup of van Rijsingen *et al.* (2021), which uses the Slab2 geometry (Hayes *et al.* 2018) and a layered semi-infinite elastic medium (Zhu & Rivera 2002) based on Schlaphorst *et al.* (2018). We test six different scenarios of homogeneous full or partial interplate locking, using downdip limits of the seismogenic zone at 20, 40 and 65 km (Fig. 3 and Supporting Information Fig. S2, respectively). Using these locking patterns, we calculate predicted vertical velocities at the locations of GNSS stations along the arc. As can be observed in Fig 3(a), a shallow locking down to 20 km does not result in significant vertical motion at most of the islands, a consequence of their large distance to the locked portion of the subduction interface. Increasing the downdip limit of the locked interface to 40 km (Fig 3b) results in uplift of most islands at rates of 1–2 mm yr^{-1} for the full locking scenario. Only some islands in the south, such as Saint Vincent, the Grenadines and Grenada, where the slab dip is shallower and the arc is thus located further away from the trench, do not show uplift or subsidence. The third scenario, a homogeneously locked interface down to 65 km depth (Fig 3c), as proposed by Bie *et al.* (2020), is a deep end-member compared to the global range (51 ± 9 km; Heuret *et al.* 2011). This model shows subsidence at the islands located above the coupled area (i.e. from south to north: Tobago, Barbados, Basse-Terre, La Désirade, Antigua, Barbuda, Anguilla, and Saint Martin) and uplift at 0.2 to 1.3 mm yr^{-1} further west along the present-day volcanic arc (Figs 3c). We find results similar to those described above when performing the forward model calculations for an alternative slab geometry (Bie *et al.* 2020), which becomes steeper at larger depths compared to the Slab2 model (Supporting Information Fig. S3). Forward models in which we explore a smoother transition from the coupled to the non-coupled region at depth (Supporting Information Fig. S4) similarly predict uplift at almost all islands, as do models with deep locking (Supporting Information Fig. S5).

From these forward model experiments we can draw two conclusions. First, deep or intermediate interseismic locking of the plate

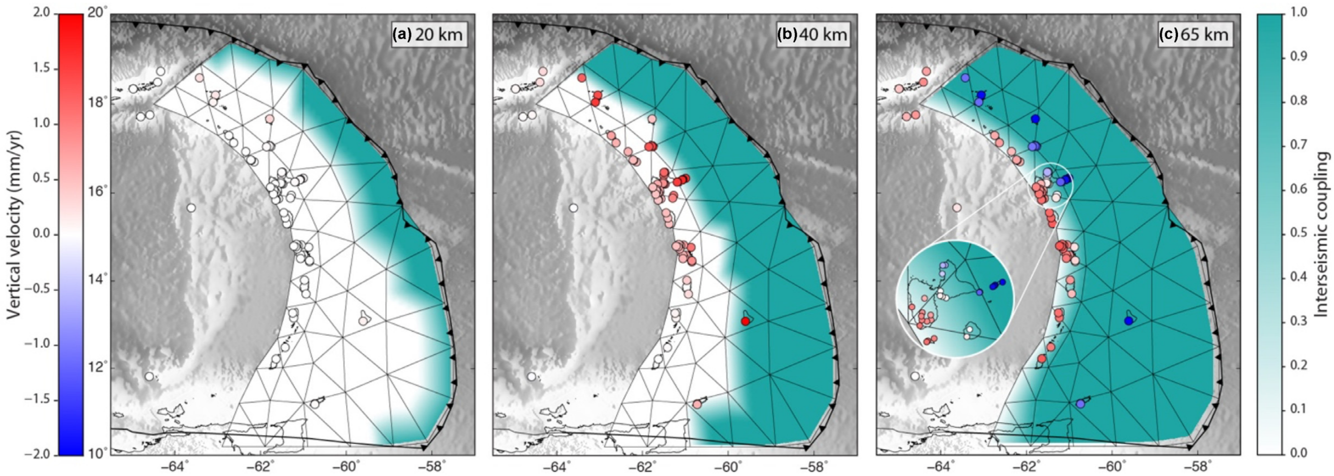

Figure 3. Predicted vertical motions for three scenarios of interseismic coupling: a downdip locking limit of 20 km (a), 40 km (b) and 65 km (c). The inset in panel (c) shows the transition from predicted subsidence to uplift from NE to SW for the Guadeloupe Archipelago. Supporting Information Fig. S2 shows these models with partial (i.e. 50 per cent) instead of full locking for these three depth ranges.

interface would result in present-day uplift of the islands at rates that would be detectable by GNSS (Fig. 3), whereas geodetic and micro-atoll observations both show subsidence in the 1–2 mm yr^{-1} range (Fig. 2a). This is an additional argument in favour of a largely uncoupled Lesser Antilles subduction interface, consistent with the low (<0.2) interseismic coupling found using horizontal geodetic velocities only (van Rijsingen *et al.* 2021). Second, as the three locking scenarios tested here contradict the observation of present-day subsidence of the entire Lesser Antilles arc, we infer that such subsidence is not the result of seismic cycle-related processes but rather of longer-term tectonics, which will be discussed below.

3 LONG-TERM SUBSIDENCE ALONG THE ENTIRE MARGIN

The comparison of subsidence in the Lesser Antilles over a range of timescales shows a long-term subsidence trend, though the rate derived from reef terraces over 125 kyr is smaller than the more recent observations from micro-atolls and GNSS (i.e. <0.5 versus 1–2 mm yr^{-1}, respectively; Fig. 4). Although within uncertainties, this difference could indicate an increase in the overall subsidence rate since the last hundreds of thousands of years, as suggested by Leclerc & Feuillet (2019). Variations in long-term subsidence rates have been observed in the geological record as well (e.g. Cornée *et al.* 2021) and may result from time-dependent variations of the incoming slab properties (e.g. in terms of roughness or buoyancy). Another hypothesis to explain the short- versus long-term difference is that the current short-term subsidence rate represents a snapshot in time, while longer-term estimates average out variations in subsidence rate on short timescales and may thus appear lower. This would assume that, over time intervals other than the Present-day, subsidence rate was lower than at present.

As the general subsidence of the Lesser Antilles cannot be attributed to interseismic locking of the subduction megathrust, one must consider that longer-term processes are at play. For instance, crustal faulting and volcano-related deformation (e.g. magmatic chamber cooling or loading of volcanic edifices) may contribute to the overall subsidence, although it is unlikely that these processes explain the 1–2 mm yr^{-1} subsidence that would affect the entire arc. Variations in vertical motion between islands could be attributed to either intra-arc crustal faulting (Feuillet *et al.* 2011) or to the subduction of oceanic ridges that may temporarily and locally affect vertical motion of the arc. This may be the case for La Désirade (a small island part of the Guadeloupe Archipelago; Fig. 1) that has undergone substantial uplift starting in the Calabrian (∼1.48 Ma), followed by a decrease to negligible rates since 122 ka, possibly due to the transient influence of the subducting Tiburon ridge (Fig. 4; Léticée *et al.* 2019). Although such local processes may contribute to the overall subsidence pattern, the subsidence signal we observe affects the entire arc and is thus best explained by a regional process rather than by the sum of local phenomena.

To understand the apparent long-term, margin-wide subsidence of the Lesser Antilles, we now consider the geodynamic and tectonic context of the region. Since the late Eocene (∼38 Ma), two main extensional phases affected the Northern Lesser Antilles (NLA), first in a trench-parallel direction, followed by trench-perpendicular extension that appears to be still active today (e.g. Boucard *et al.* 2021). The trench-parallel extension most likely occurred in response to collision of the Bahamas Bank with the Northeastern Caribbean Plate in late Paleocene-early Eocene times (∼56 Ma), which caused a major plate reorganization, followed by progressive bending of the Lesser Antilles trench into its current convex geometry (Cornée *et al.* 2021). The arc-perpendicular V-shaped basins that formed in response to this are currently sealed and cross-cut by transverse faults that accommodate ongoing arc-perpendicular extension since the mid-Miocene (Boucard *et al.* 2021). This second phase of extension is chronologically consistent with subsidence in the NLA forearc and the intra-arc Kalinago basin (0.34 mm yr^{-1}; Boucard *et al.* 2021; Cornée *et al.* 2021), as well as subsidence in the central part of the arc (offshore Guadeloupe; De Min *et al.* 2015). Recent estimates of NW–SE extension based on polygonal fault orientations indicate that the NLA backarc is submitted to similar processes as the arc and forearc (Gay *et al.* 2021). Estimates of backarc extension show a change from EW to SSE–NNW towards the south, while post-mid-Miocene subsidence is observed there as well, with increasing rates towards the southernmost part of the margin since Late Miocene (i.e. 0.02–0.12 mm yr^{-1}; Garrocq *et al.* 2021). While it remains difficult to reconcile some of these kinematic differences between the northern- and southern Lesser Antilles, tectonic subsidence for the more recent times (Fig. 4), including the present, is

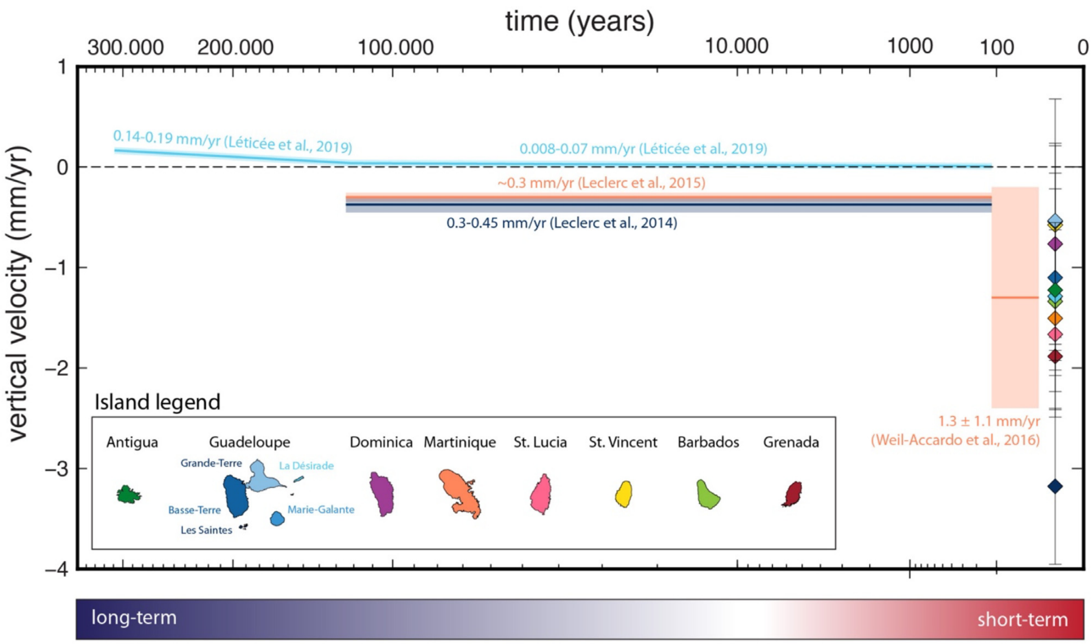

Figure 4. Overview of vertical tectonic motions on different time-scales, ranging from several tens of years (right) to hundreds of thousands of years (left) and colour-coded per island. Diamond symbols indicate the weighted average velocities for all islands (modern geodesy; this study), while lines indicate estimates from micro-atoll data (Weil-Accardo *et al.* 2016) and reef terraces (Leclerc *et al.* 2014, 2015; Léticée *et al.* 2019). The annotations from the literature have been written as positive values for readability, but indicate subsidence.

consistent with the post-mid-Miocene extension documented geologically and could be its on-going continuation.

In terms of processes, Boucard *et al.* (2021) argue that tectonic erosion is responsible for the forearc subsidence, as well as for the westward migration of the NLA arc in the early Miocene. Assuming such a mechanism could play a role in the north, where the incoming plate is relatively rough, the 7-km-thick pile of trench sediments in the south would likely overcome any material lost by tectonic erosion (De Min *et al.* 2015). This contrast in incoming plate properties may result in along-arc variability of the subsidence rate, though we do not observe this in the GNSS data. This signal may simply be hidden in the noise of the GNSS-derived vertical velocities. Alternately, an independent process, which remains to be identified, may be responsible for the subsidence in the south, producing similar rates as in the north. We argue that it is more likely that a larger-scale process is responsible for the margin-wide subsidence, while other processes such as tectonic erosion or intra-arc faulting may also be acting at a local scale. Here we propose that both the observed trench-perpendicular extension and the ongoing margin-wide subsidence are controlled by slab dynamics, possibly driven by slab rollback.

The Lesser Antilles subduction zone experienced eastward slab rollback and subsequent arc migration since ∼59 Ma, while the latest migration of the volcanic arc occurred westward (e.g. Allen *et al.* 2019). Folding of the slab at depth, when it reaches the mantle transition zone, could produce episodic trench migration, with phases of retreat and advance (e.g. Schellart *et al.* 2007). Changes in slab buoyancy could tune such migration as well, for example when a sharp transition in ocean-floor age subducts, causing a temporary change in slab pull. A decrease in slab pull due to such a buoyancy change has been proposed for the westward jump of the volcanic arc in the Lesser Antilles (Braszus *et al.* 2021). The trench-perpendicular extension and margin-wide subsidence that have been observed since mid-Miocene may indicate that the Lesser Antilles subduction is currently progressing towards a stage of trench retreat again. Slab dynamic processes could also be responsible for the aseismic character of the subduction megathrust by tuning the subduction interface stress state, with an overall reduction in normal stress (Beall *et al.* 2021).

4 IMPLICATIONS FOR OTHER SUBDUCTION ZONES

In this work we show that present-day, margin-wide subsidence of the Lesser Antilles arc does not result from earthquake cycle deformation, but is probably part of the ongoing extension and related subsidence observed over geological timescales (10^4–10^6 yr). The low interseismic coupling of the subduction interface makes the region unique as it allows us to observe longer-term and permanent deformation patterns that would otherwise be partially masked by elastic deformation related to the build-up and release of stresses along the megathrust (e.g. Menant *et al.* 2020). Several studies have shown how short-term deformation is partly converted into permanent strain, often related to uplift in the forearc as observed in Chile, for instance (Mouslopoulou *et al.* 2016; Jolivet *et al.* 2020). Our work suggests that interseismic strain does not need to be the main driver of such permanent deformation, and that in the Lesser Antilles, other underlying processes related to subduction dynamics must be involved. Along the South American margin, Martinod *et al.* (2016) explain periods of forearc subsidence and uplift by an increase or decrease in convergence velocity, respectively. Regalla *et al.* (2013) find a temporal correlation between forearc subsidence, upper plate extension and backarc spreading in northeastern Japan during the Miocene. These processes are observed on a regional scale (>500 km), suggesting that they are governed by processes operating at lithospheric scale (e.g. downward flexure of the slab due to changes in slab buoyancy) rather than by local processes such as basal tectonic erosion. Present-day observations of geodetic subsidence in the NE Japan forearc that cannot be explained by predictions from a backslip model have previously been interpreted as a result of tectonic erosion as well (e.g. Heki 2004), but could also result from a change in slab dynamics.

Models of lithospheric-scale tectonic subsidence or uplift rates at subduction volcanic arcs involve overlapping processes that are not easy to entangle. For instance, Menant *et al.* (2020) use thermo-mechanical simulations to show that transient stripping of sediments at the base of the forearc crust can lead to alternating uplift/subsidence sequences with vertical rates reaching 0.5–1 mm yr^{-1}, values that are consistent with the observations reported here. This process may contribute to the arc-wide subsidence of the Lesser Antilles arc, but would likely act differently in the northern and southern parts of the subduction, where incoming sediment thickness differs significantly. Another mechanism may involve the long-term dynamics of the subducting slab reported in the Lesser Antilles (Allen *et al.* 2019), as analogue and numerical models indeed show that this process affects surface topography. For instance, Chen *et al.* (2017) show that a depression forms during the slab sinking phase due to slab suction. Although this depression disappears during slab rollback, its development would involve discernable subsidence rates as its final depth is on the order of a fraction of the trench depth. Slab rollback models also show extension in the upper plate (e.g. Xue *et al.* 2022) leading to the formation of crustal-scale normal faults which may lead to discernable subsidence as well (e.g. Sternai *et al.* 2014). In that case, arc subsidence rates could show significant along-arc variations, which does not appear to be the case in the Lesser Antilles from the data set presented here. Slab rollback also comes with negative dynamic topography, with amplitudes that are comparable to observed topographic variations (∼thousands of metres) in both numerical and analogue models (e.g. Husson 2006; Xue *et al.* 2022). Finally, mantle flow at the scale of lithospheric plates may also contribute to long-term vertical motions of subduction arcs. For instance, Chen *et al.* (2021) show that the westward flow of mantle material from the Galapagos plume through the Panama subduction slab window underneath the Caribbean plate to induces a tilting of the Caribbean plate, resulting in 100s of meters of negative dynamic topography at the Lesser Antilles arc. Although dynamic topography models do not provide, to our knowledge, vertical motion rates that could be directly compared to our observations, the fact that they predict a signal comparable to observed long-term vertical deformation indicates that they also contribute to current vertical rates at subduction volcanic arcs.

5 CONCLUSIONS

Vertical velocities from continuously operating GNSS stations in the Lesser Antilles show a regional subsidence of the island arc at 1–2 mm yr^{-1}. Such short-term signal fits the longer-term pattern of geological subsidence observed since at least 125 ka, as well as data from coral microatolls from Martinique to Barbuda over the past ∼100 yr. We show that this subsidence, which extends beyond the islands of Martinique and Guadeloupe, is a margin-wide feature with similar rates in the north and south Lesser Antilles. Using elastic dislocation models, we show that a locked or partially locked subduction interface would produce uplift of the island arc, opposite to the observations, hence supporting a poorly coupled subduction. The recent (125 ka to present) subsidence is consistent with the post-mid-Miocene extension documented geologically, though variations in rates may have occurred over time. That this subsidence concerns the entire arc, in spite of lateral variations of the properties of the subducting oceanic plate, suggests that it is controlled by long-term processes related to slab dynamics, such as slab rollback.

ACKNOWLEDGMENTS

We thank Roland Bürgmann and Jeff Freymueller for their constructive reviews, as well as Serge Lallemand and Boris Marcaillou for helpful discussions. EvR and GNSS campaigns were supported through the FEDER European Community program within the Interreg Caraïbes 'PREST' project and EC and RJ acknowledge support from the Institut Universitaire de France. This project has received funding from the European Research Council (ERC) under the European Union's Horizon 2020 - Research and Innovation Framework Programme (Grant Agreement 758210, Geo4D project).

AUTHOR CONTRIBUTION

EMvR, EC and RJ designed the study and contributed to the data analysis and interpretation of the results. EC, JBdC, RR, GAR and SS have contributed to data collection and processing. All authors contributed to the manuscript.

DATA AVAILABILITY

This work uses data services provided by the UNAVCO Facility with support from the U.S. National Science Foundation (NSF) and National Aeronautics and Space Administration (NASA) under NSF Cooperative Agreement EAR-073 5156. Permanent and episodic GNSS within the OVSG, OVSM and SRC footprint in the Lesser Antilles have been funded by CNRS-INSU-ACI programs originally, then through three FEDER European Community programs (CPER-PO and Interreg IV and V Caraïbe projects) co-funded by the French Ministry of Research, the French Ministry of Environment, the Guadeloupe Regional Council, and the IPGP. The vertical GNSS velocities presented in this work are included in the supporting information; data are also openly available from the IGS (http://www.igs.org/), UNAVCO (www.unavco.org), and IPGP data centre (http://volobsis.ipgp.fr/) archives.

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SUPPORTING INFORMATION

Supplementary data are available at *GJI* online.

Figure S1. A comparison with a previous analysis of vertical velocities limited to the island of Martinique and Guadeloupe (Sakic *et al.* 2020). Velocities for all three solutions are shown per station, ordered by latitude with highest latitudes towards the top (a). Panels on the right show comparisons between different solutions (b–d) where the dashed line indicates the diagonal on which velocities would plot if they are equal in magnitude between solutions. The comparison with the two solutions of Sakic *et al.* (2020) shows a good agreement with the one presented here, with subsidence at most common sites at rates that are consistent within uncertainties. Differences between our solution and those of Sakic *et al.* (2020) likely stem from the duration of the time-series used (longer in our analysis), the fact that they use a PPP approach versus a network strategy, as well as a different implementation of the ITRF14 reference frame.

Figure S2. Predicted vertical motions for three scenarios of partial (i.e. 50 per cent) interseismic coupling down to 20 km (a), 40 km (b) and 65 km (c).

Figure S3. Predicted vertical motions for three scenarios of interseismic coupling, using the slab geometry by Bie *et al.* (2020). Panels indicate a downdip locking limit of 20 km (a), 40 km (b) and 65 km (c).

Figure S4. Predicted vertical motions for three scenarios of a smoother transition from fully coupled to uncoupled at depth, over a depth range of (a) 30–50 km, (b) 45–65 km or (c) 50–70 km. A refined mesh is used with respect to the original mesh (Fig. 3).

Figure S5. Predicted vertical motions for deep locking (30–65 km) along the Slab2 (a and c) and the Bie *et al.* (2020) geometry (c and d). A cross-section is drawn through Guadeloupe, showing predicted vertical velocities as a function of distance from the trench (panel a for Slab2 and panel b for Bie *et al.* 2020). The dashed vertical lines indicate where the profile crosses Guadeloupe.

Figures S6–S58. Time-series for all 53 stations used in this study (East, North and Up components)**.** The raw time-series (corrected for offsets only) are shown (left-hand panels), as well as the residuals to the model fit, which include slope, offsets and annual and semi-annual patterns (middle and right-hand panels). The residuals show the difference between the raw, uncorrected time-series and the model and thus provide a quantification of the quality-of-fit to the model.

Table S1. Vertical GNSS data.

Table S2. Average velocities per island.

Table S3. Comparison velocities with Sakic *et al.* (2020, https://doi.org/10.1007/1345_2020_101).

Text S1. Calculation weighted average GNSS velocities.

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