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Rémy Asselot

r.asselot@brgm.fr

BRGM

Rémi Thieblemont

BRGM

Deborah Idier

BRGM

Thibault Laigre

BRGM

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Mesoscale eddies contribution to nuisance flooding in the tropical island of Guadeloupe

Rémy Asselot^{1,*}, Rémi Thiéblemont², Déborah Idier² and Thibault Laigre³

¹BRGM - French Geological Survey, F-33600 Pessac, France

²BRGM - French Geological Survey, F-45060 Orléans, France

³BRGM - French Geological Survey, F-97404 Saint-Denis, France

*Corresponding author e-mail: r.asselot@brgm.fr

Abstract

Nuisance flooding occurring at high tide under calm weather conditions is increasing worldwide as sea level rises. From a coastal management perspective, there is a need to understand the causes, frequency of occurrence, and predictability of such events. Here we investigate a nuisance flooding event that affected Pointe-à-Pitre (Guadeloupe, Caribbean Sea) between July and August 2022. We develop a statistical reconstruction of coastal sea level that explicitly incorporates mesoscale eddy contributions. These contributions are derived from satellite observations using a Gaussian decay formulation linking eddy amplitude and its distance to the coastline. We identified a large anticyclonic eddy near Guadeloupe that modulated coastal sea level, with a maximum contribution of 10.44 cm on August 2nd, 2022. This contribution represented 27% of the observed daily maximum sea level, making the eddy the second most important contributor after the tide, which represented 59%. The eddy

contribution persisted over several days, indicating a delayed coastal adjustment to offshore conditions. Our results show that mesoscale eddies can increase coastal sea level, setting the stage for coastal flooding. More broadly, mesoscale eddies may represent a critical and previously underappreciated driver of present and future nuisance flooding events.

Keywords:

Sea level, mesoscale eddies, nuisance flooding, coastal risks

36 Introduction

37 Global mean sea level rise, reaching 3.94 mm yr⁻¹ over 2005–2023, is primarily driven
38 by land-ice melting, ocean thermal expansion and terrestrial water storage changes
39 (Zheng et al., 2026). This rate has not been linear: the rate of global sea level rise has
40 accelerated, even doubling between 1993 and 2023 (Hamlington et al., 2024). Sea
41 level rise (SLR) is expected to amplify flooding in low-lying areas during extreme
42 events, such as storms and cyclones, threatening coastal areas. Beyond these
43 extreme events, SLR is also expected to increase the frequency of nuisance flooding,
44 which occurs at high tide under calm weather conditions, without the influence of
45 storms, hurricanes or significant wave activity (Moftakhari et al., 2018). Although
46 nuisance floodings are individually non-catastrophic, they can disrupt daily life by
47 reducing the usability of roads (Jacobs et al., 2018; Moftakhari et al., 2017), damaging
48 port operations and subsurface infrastructure such as water drainage systems and
49 electrical utilities (Bosserelle et al., 2022). These impacts and their increased
50 frequency can lead to large economic losses (Hino et al., 2019). Beyond physical
51 damages, repeated nuisance floodings have also been shown to negatively affect
52 mental health (Fernandez et al., 2015; Law et al., 2025).

53 Nuisance flooding can be caused by a wide range of geophysical processes that affect
54 relative sea level. For instance, earthquakes can cause negative vertical ground
55 motion (subsidence), leading to the emergence of such flooding events (Ballu et al.,
56 2011; Jamero et al., 2017). Sea level rise itself can directly drive nuisance flooding, as
57 demonstrated by the October 2020 flooding in Cayenne, French Guiana (Thiéblemont
58 et al., 2023). Large-scale climate processes can also modulate coastal sea level and
59 thus influence nuisance flooding. Several studies along the U.S. Atlantic coast indicate

that a slowdown of the Atlantic Meridional Overturning Circulation and its upper branch, the Gulf Stream, can lead to elevated coastal sea levels and increased occurrence of nuisance flooding (Ezer et al., 2013; Ezer & Atkinson, 2014; Wdowinski et al., 2016). In addition, along the U.S. Pacific coast, the 2015–2016 El Niño-Southern Oscillation (ENSO) generated averaged sea level anomalies of up to 15 cm during the full El Niño phase, significantly enhancing flooding frequency in estuarine environments (Goodman et al., 2018).

Coastal communities worldwide are therefore increasingly exposed to nuisance flooding, yet the relative contribution of different processes remains insufficiently constrained, particularly in tropical island environments. In Pointe-à-Pitre (Guadeloupe), a major economic hub in the Caribbean, nuisance flooding already occurred occasionally and is expected to become chronic. Highly vulnerable sites are projected to be flooded up to half of the year by the late 21st century (Le Cozannet et al., 2021). A notable event occurred between mid-July and mid-August 2022, when flooding affected urban areas and critical infrastructure of Pointe-à-Pitre (Fig. 1). During this event, seawater repeatedly emerged through water drainage systems. The time window of this flooding event corresponds to high seasonal sea level anomalies (Torres & Tsimplis, 2012), which could partly explain this event. At a finer scale, a large anticyclonic eddy was present near Guadeloupe during this period, suggesting a potential role of mesoscale ocean dynamics in modulating coastal sea level.

Previous studies have demonstrated that mesoscale eddies can significantly influence coastal sea level. Firing & Merrifield (2004) showed that an anticyclonic eddy contributed to extreme sea levels in September 2003 in Honolulu, Hawaii. This

particular eddy coincided with high periods in both seasonal and decadal cycles. Consequently, this high sea level led to coastal flooding (Firing & Merrifield, 2004). In addition, Shinoda et al. (2023) reported recurrent sea level anomalies exceeding 15 cm in the Gulf of Mexico on a subseasonal scale (1-2 months) and the authors conclude that most of such anomalies are eddy-driven. Despite these findings, the contribution of mesoscale eddies to nuisance flooding remains poorly quantified, particularly in tropical island environments. There is currently no framework to integrate eddy-induced sea level anomalies into coastal sea level reconstructions and to assess their role relative to tides, long-term sea level rise, and other sources of variability.

Here, we address this gap by developing a statistical reconstruction of coastal sea level that explicitly incorporates the contribution of mesoscale eddies derived from satellite observations. We use the 2022 nuisance flooding event in Pointe-à-Pitre, as a case study (Fig. 1) to quantify the relative importance of eddies compared to other drivers of sea level variability and assess their role in modulating high sea level conditions. Guadeloupe is part of the Lesser Antilles (Supplementary Fig. 1), which is a region where eddies propagate, break and dissipate (Barabinot et al., 2025). Most of the eddies of the region are formed by the retroflexion of the North Brazil Current (NBC), generating current loops that are shed by the NBC (Barabinot et al., 2025). They propagate northwestward along the South American coast and can enter in the Gulf of Mexico (Andrade & Barton, 2000; Fratantoni et al., 1995; Huang et al., 2021) but the majority propagate towards the Lesser Antilles (Andrade & Barton, 2000; Barabinot et al., 2025; Fratantoni et al., 1995; Jochumsen et al., 2010). Our approach provides new insights into the mechanisms that could drive nuisance flooding and

highlights the need to account for mesoscale eddies in future coastal risk assessments in a changing climate.

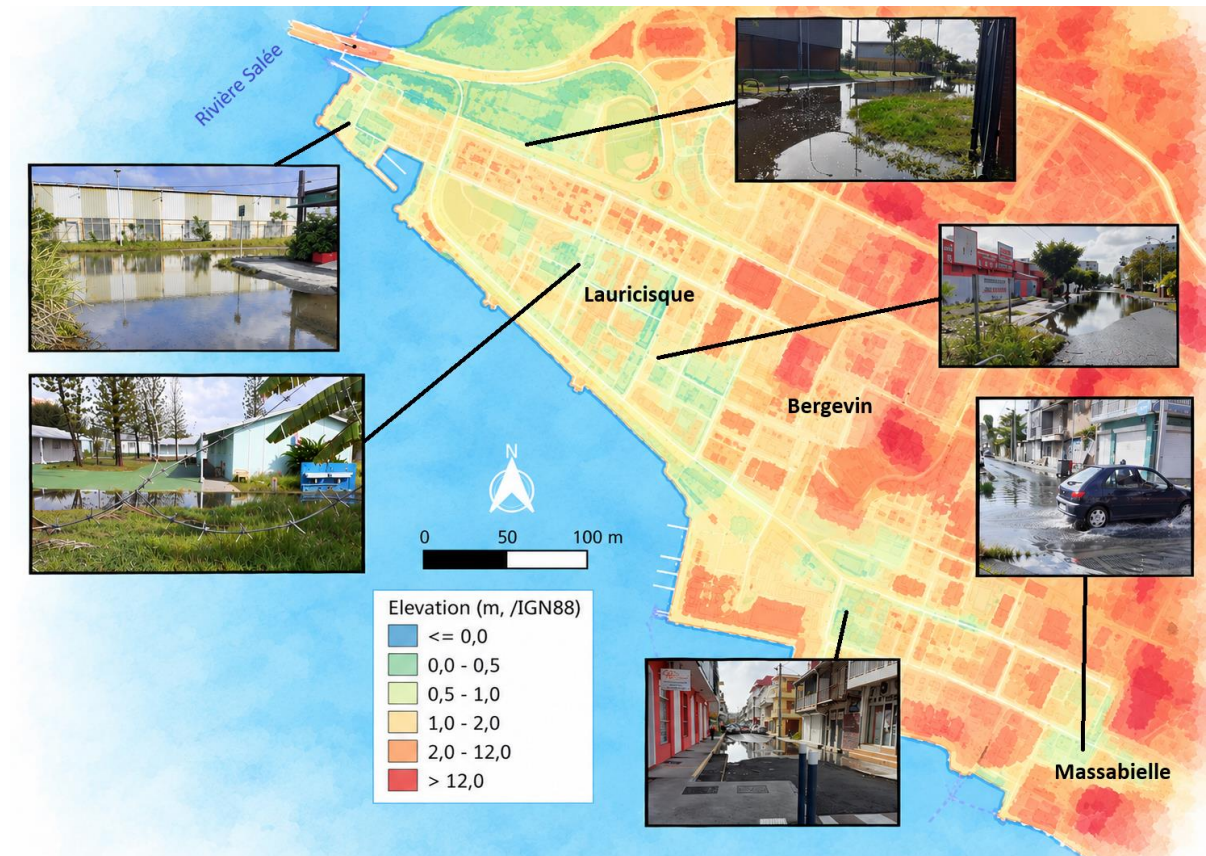


Fig. 1: Observations of the nuisance flooding event that took place between late-July and early-August 2022. The observations took place on August 2nd, 2022 between 08:30 and 09:00 UTC-04:00. The background colors indicate the elevation (m, /IGN88). The topography is derived from the IGN's LidarHD 2024 product. Photos were taken by Claire Meillarec (Cap Excellence).

Results

Reconstructed sea level evaluation

Our sea level reconstruction combines five components contributing to coastal sea level variability (see Methods): tide, long-term SLR, eddy-induced variability, seasonal

residuals, and non-seasonal residuals. The first four components are treated deterministically, whereas the non-seasonal residuals are modeled probabilistically following the approach of Dusek et al. (2022). This probabilistic framework generates an ensemble of 100 sea level members by randomly sampling the non-seasonal residuals. The reconstructed sea level is defined as the ensemble mean. Eddy locations are derived from the autonomous eddy identification scheme of Faghmous et al., (2015), which is based on satellite data. The eddy-induced sea level variability is parameterized as a Gaussian decay function of eddy amplitude and distance to the coastline. The reconstructed sea level has an hourly temporal resolution and is compared against recorded sea level at Pointe-à-Pitre tide gauge (16.2244°N, 61.5315°W).

Because we are interested in nuisance flooding occurring under calm weather conditions, we removed periods influenced by storms and atmospheric cyclones from the observed sea level dataset (see Methods). Over the whole study period (January 2011 to December 2022), the observed sea level ranges from a minimum of -0.33 m (expressed within the IGN88, a legal French national vertical datum) recorded on May 3rd, 2022 at 15:00 UTC, to a maximum of 0.51 m (/IGN88) recorded on September 29th, 2019 at 20:00 UTC (Supplementary Fig. 3). The mean tidal range is 0.21 m, with weak modulation by the spring–neap cycle (0.22 m during spring tides and 0.20 m during neap tides). Maximum tidal range reaches 0.43 m.

The reconstructed sea levels show good agreement with observations over the full study period (Supplementary Fig. 3). The mean bias is $2 \cdot 10^{-4}$ mm, indicating no systematic over- or underestimation. The root mean square error (RMSE) is 0.041 m, which remains small relative to the overall sea level variability. The coefficient of

determination is high ($R^2 = 0.89$, $p\text{-value} < 0.001$) and indicates that approximately 89% of the observed variance is explained by the reconstruction (Fig. 2a). The reconstructed and observed deciles are in close agreement from the first to the ninth decile, following the 1:1 relationship (Fig. 2b). However, the tenth decile is underestimated by 7.2 cm, indicating a slight underestimation of our reconstruction for the highest sea levels. Overall, these results demonstrate that the reconstruction accurately captures most of sea level variability, while slightly underestimating the highest sea levels encountered under calm weather conditions.

When examining the hourly contributions of the different components to the reconstructed sea level, tidal variability exhibits the largest range of amplitudes, reflecting its dominant role in short-term coastal sea level fluctuations (Supplementary Fig. 2). Its maximum contribution to sea level is 20 cm. However, the remaining components also display non-negligible contributions. The long-term trend introduces a persistent increase in sea level over the study period and its maximum contribution, at the end of the period, was ~3 cm. The maximum contribution of the non-seasonal residual component was also ~2 cm. The contribution of the seasonal residual component is smaller, with a maximum value of 0.4 cm. The eddy component had a maximum contribution of ~10 cm. Although these four components are generally smaller than the tidal signal, their amplitudes are sufficiently large to substantially modify coastal sea level. The distribution of the components demonstrates that none of the five components can be considered negligible, as each contributes to the coastal sea level variability (Supplementary Fig. 2). Their combined effects ultimately determine whether coastal sea level remains below or exceeds flooding thresholds.

The nuisance flooding event was observed on August 2nd, 2022 therefore we conducted an additional analysis covering the period from July 28th, 2022 to August 2nd, 2022, which is referred to as the “nuisance flooding period” hereinafter (Fig. 2c). This period represents a period where the satellite data required to estimate eddy contributions are complete. Before and after this period, daily satellite data are missing. During the nuisance flooding period, the maximum observed sea level value reached 0.49 m (/IGN88) on August 2nd, 2022 at 23:00 UTC. For the exact same date, our reconstructed sea level gives a value of 0.42 m (/IGN88). During this particular period (July 28th to August 2nd), the coefficient of determination is $R^2 = 0.94$ (p-value < 0.001) and the RMSE is 0.04 m, which remains small (one-fifth) compared to the mean tidal range.

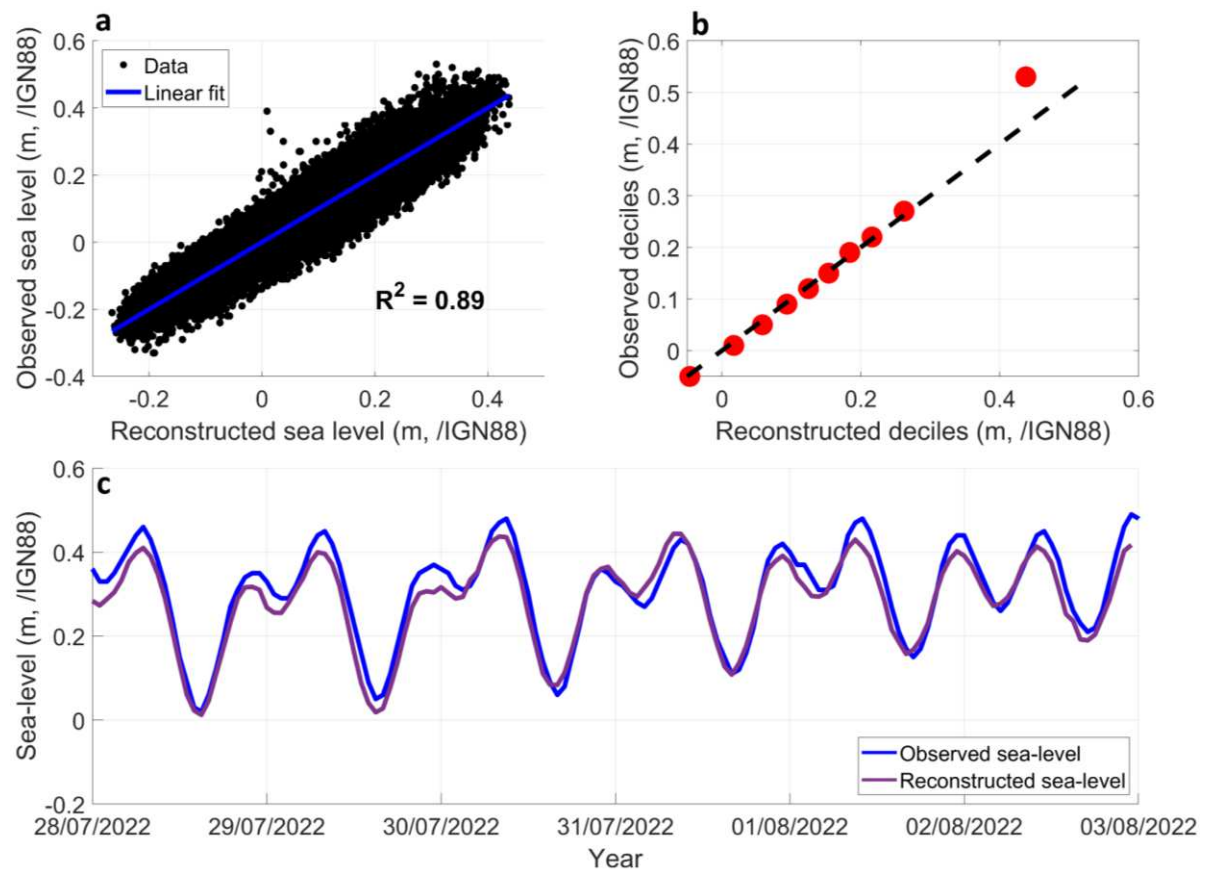


Fig. 2: Comparison between the observed (m, /IGN88) and reconstructed (m, /IGN88) sea level at Pointe-à-Pitre tide gauge (16.2244°N, 61.5315°W). a, Scatter plot of observed

versus reconstructed sea level over the whole study period (2011-2022). The blue curve represents the linear regression model. **b**, Scatter plot of observed versus reconstructed sea level deciles for the whole study period. The dashed black curve represents the 1:1 curve. **c**, Time series of observed (blue curve) and 100-members average reconstructed (purple curve) sea level between July 28th, 2022 and August 2nd, 2022.

Eddy identification and contribution during the nuisance flooding event

To identify eddy locations and characteristics, we use the autonomous eddy identification scheme of Faghmous et al. (2015), which is based on satellite data (see Methods). During the nuisance flooding period, we identified an anticyclonic eddy that passes close to the Guadeloupe island (Fig. 3). This eddy exhibited a mean sea surface height anomaly (amplitude) of 11.93 cm, an average surface area of 11,100 km², and a mean geostrophic velocity of 5.70 m s⁻¹ during this period. On August 2nd, 2022, when nuisance flooding was observed, the eddy reached a maximal amplitude of 12.13 cm (Fig. 3c). On that day, its center was located only ~66 km away from the Pointe-à-Pitre tide gauge.

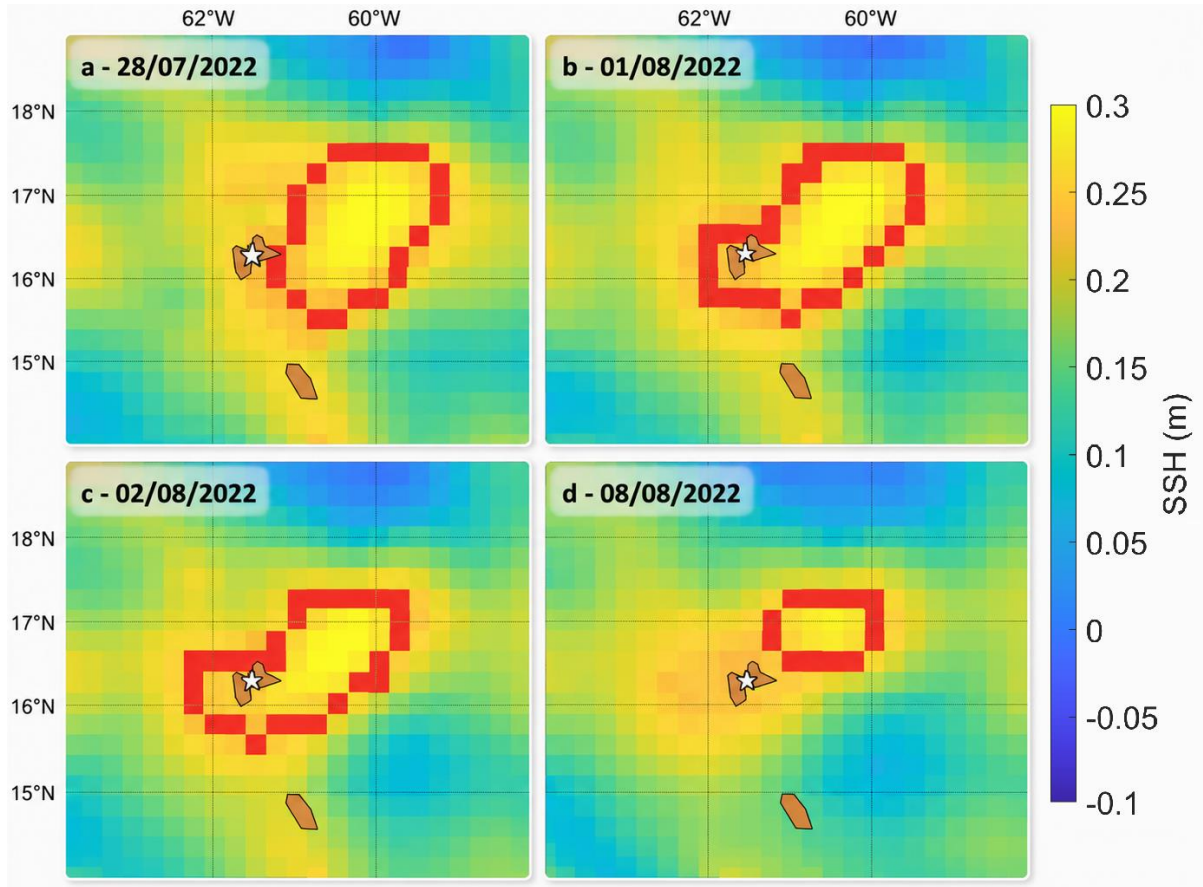


Fig. 3: Anticyclonic eddy position for a, July 28th, 2022. b, August 1st, 2022. c, August 2nd, 2022. d, August 8th, 2022. The red contours indicate the anticyclonic eddy position. The background colors represent the sea surface height (m) derived from satellite data. The white star shows the location of the Pointe-à-Pitre tide gauge.

Eddy contribution to sea level variation at Pointe-à-Pitre tide gauge is parameterized as a Gaussian decay. This contribution depends on the amplitude of the eddy, its radius and the distance between the eddy center and the tide gauge (see Methods). For a given day, a single eddy contribution can be either negative or positive. An anticyclonic eddy has a positive contribution indicating that it increases coastal sea level. In contrast, a cyclonic eddy has a negative contribution indicating that it decreases coastal sea level. During the nuisance flooding period, at the tide gauge, eddy contribution always exceeded 4.50 cm and its averaged contribution was 8.14

cm (Fig. 4a). The maximum eddy contribution occurred on August 2nd, 2022, when flooding was documented (Fig. 1), and reached a value of 10.44 cm (Fig. 4a). These results indicate that the anticyclonic eddy identified previously (Fig. 3) has a large positive contribution to sea level variability.

Because the tidal signal includes both high and low water phases, the tidal contribution was expressed as an anomaly relative to its temporal mean to isolate the positive contribution of high tides to flooding (Fig. 4b). Seasonal and non-seasonal residuals, as well as eddies are already expressed as anomalies. Sea level rise is expressed as a deviation from a reference state (January 1st, 2011). During the nuisance flooding period (July 28th, 2022 to August 2nd, 2022), tidal oscillations remained the dominant contributor to reconstructed sea level. The maximum and 95th percentile of positive tidal contribution relative to mean sea level is 20.16 cm and 19.16 cm, respectively (Fig. 4b). The eddy contribution increased progressively from 6.52 cm on July 28th, 2022 to 10.44 cm on August 2nd, 2022 as the anticyclonic eddy approached Guadeloupe. Unlike the tidal signal, which oscillates predominantly over semi-diurnal timescales, the eddy contribution evolved smoothly over several days, producing a sustained elevation of the sea level.

During the nuisance flooding period, the mean contribution of tides accounted for 42.9% of the mean reconstructed sea level. For the same period, the mean contribution of mesoscale eddies represented 38.4%, underscoring its nearly equivalent role to that of the tide (Fig. 4c). By comparison, the long-term sea level rise (SLR) contributed for 13.2%, while seasonal and non-seasonal residual components remained below or equal to 5% for this period, respectively. These results indicate that

mesoscale eddies can play an important role in coastal sea level over multi-day timescales. More importantly, the large relative eddy contribution that can occur punctually, on top of moderate tide is likely to generate nuisance flooding.

When focussing on nuisance flooding events, the daily maximum sea level (DMSL) is a key information. Performing a similar analysis as above but focusing on the contributions to DMSL, we find that the tide remains the dominant contributor during the nuisance flooding period (Fig. 4d). Its contribution fluctuates between 55% and 70% of the reconstructed DMSL. The relative contribution of eddies increased from 16% at the beginning of the nuisance flooding period to 33% on August 2nd, 2022, highlighting their increasing importance in the daily maximum sea level as the anticyclonic eddy approaches the coast. The long-term trend contributed approximately 8.5%. Seasonal residuals contributed less than 1% while non-seasonal residuals contribution fluctuates between 6% and 1%. Although tide remains the primary driver of daily maximum sea level, mesoscale eddies can provide a substantial (one-third) additional contribution during nuisance flooding events.

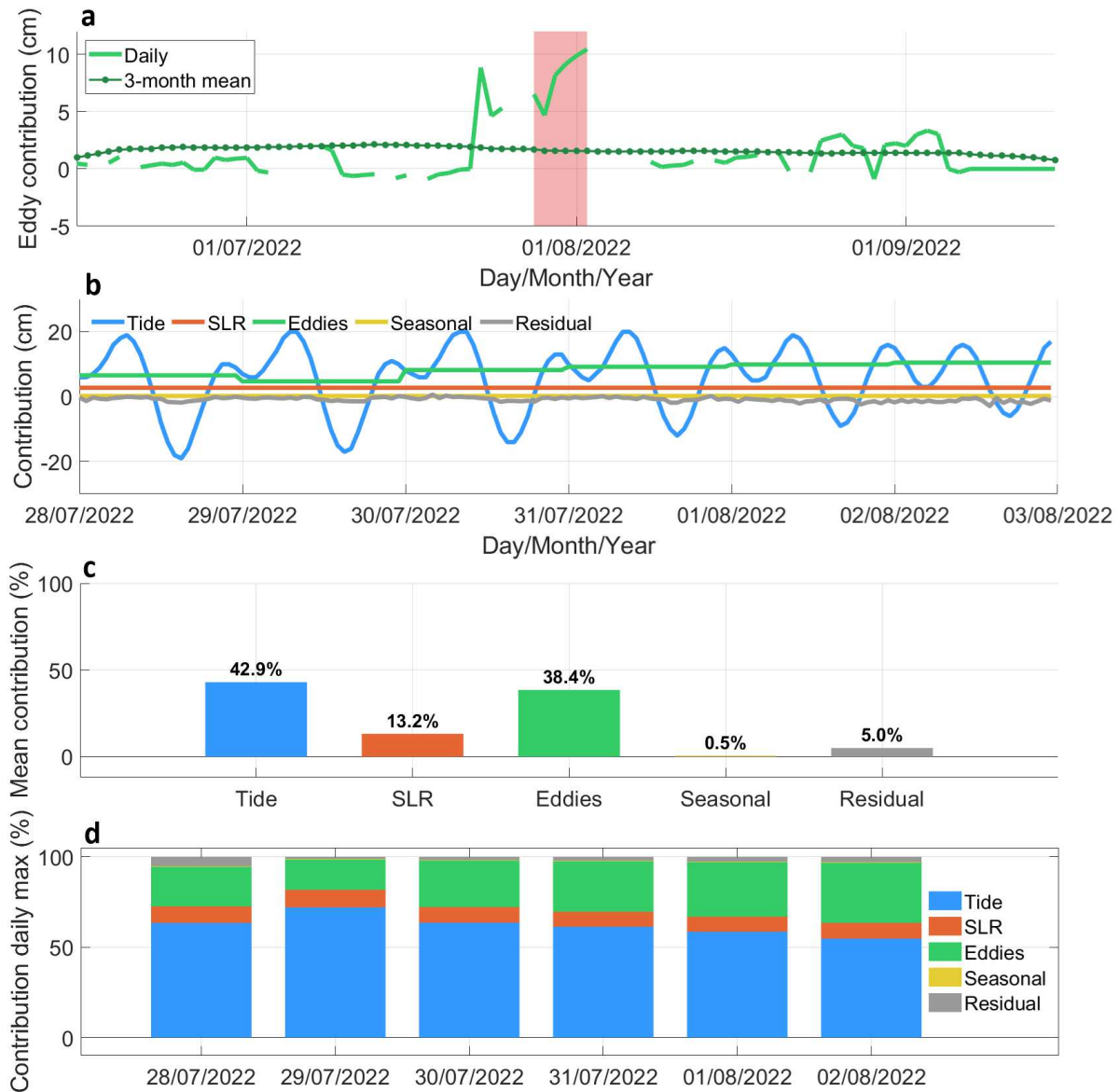


Fig. 4: Component contributions to sea level variability over the nuisance flooding period. **a**, Eddy contribution to sea level (cm). The light green curve represents the daily contribution while the dark green curve with circles shows the 3-month moving mean. The red box represents the nuisance flooding period. **b**, Contribution of the five components used for sea level reconstruction over the nuisance flooding period (cm). **c**, Mean hourly contribution of the five components relative to the mean reconstructed sea level over the nuisance flooding period (%). **d**, Contribution of each component relative to the reconstructed daily maximum sea level (%). Each contribution is taken at the exact time of the daily maximum sea level. SLR = sea level rise.

Eddy contribution to sea level variability

Over the whole study period (January 1st, 2011 to December 31st, 2022), the eddy contribution exceeded 5 cm (99th percentile) for only 97 days, representing 1% of the whole study period (Fig. 5a). Eddy contributions to sea level exceeding 8 cm (99.9th percentile) occurred during the study period (Fig. 5c), with particularly large contributions in 2015 and 2022. This threshold, exceeded for 11 days, represents 0.1% of the whole study period. The maximum (anticyclonic) eddy contribution occurred on August 2nd, 2022 and reached a value of 10.44 cm, exceeding all previous recorded events by more than 1 cm (Fig. 5c). Cyclonic eddies, having a negative contribution, reach a maximum contribution of -7.65 cm on June 17th, 2019. On May 3rd 2022, a cyclonic eddy contribution of -3.82 cm was identified, coinciding with the lowest observed sea level over the entire study period. The 3-month moving mean oscillates around zero (mean value of 0.13 cm), indicating that positive and negative eddy contributions largely compensate over seasonal to interannual timescales (Fig. 5a). Nevertheless, several periods of enhanced positive eddy contribution are evident, notably in 2014–2015 and in mid-2022. The largest positive anomaly of the 3-month moving mean eddy signal occurred on July 13th, 2022 with a maximum value of 2.12 cm.

The eddy contribution is marked by a seasonal cycle (Fig. 5b). When anticyclonic and cyclonic eddies are considered together, the mean contribution remains near zero or slightly negative from January to May. It rises sharply in June and July, peaking at 6.8 mm in August. This rapid increase and the persistently high values during summer in Guadeloupe are driven by the anticyclonic contribution. This anticyclonic contribution exceeds 12.5 mm throughout June, July, and August, and reaches a maximum of 16.9 mm in June. In contrast, the cyclonic contribution reaches its second-lowest value of

the seasonal cycle in August, at -4.3 mm. Overall, the total eddy contribution declines progressively during autumn, turning negative again by late autumn and winter. This climatological seasonal evolution suggests that mesoscale eddies are most likely to enhance coastal sea level during the summer months in Guadeloupe. Considering all eddies, the seasonal peak-to-peak amplitude reaches 8.9 mm while the anticyclonic and cyclonic seasonal peak-to-peak amplitudes are 15.1 mm and 10.5 mm, respectively.

To further investigate the role of eddies, we compared their contribution to the tidal contribution (Fig. 5d). Although tides dominate the coastal sea level variability in our study area, eddies can become a significant contributor when they pass near the coast. Because of their episodic nature, the averaged relative contribution of eddies compared to tide anomalies is modest, reaching only 1.5% over the 2011–2022 period. However, this average masks important short-term variability. The 95th percentile reaches 14.8%, and during the nuisance flooding period (red points on Fig. 5d), the relative contribution always exceeds 23%. It approached a maximum of 90% on August 2nd, 2022 at 23:00 UTC, i.e. a contribution very close to the one of the tide (Fig. 5d). Notably, both anticyclonic and cyclonic eddies contribute to these elevated values, with cyclonic eddies amplifying the negative anomalies and anticyclonic eddies reinforcing the positive ones. The 2022 flooding event was thus characterized not only by a large absolute eddy anomaly, but also by an unusually large contribution relative to the dominant tidal forcing. This result underscores that eddies, while episodic, can play a decisive role during extreme sea level events.

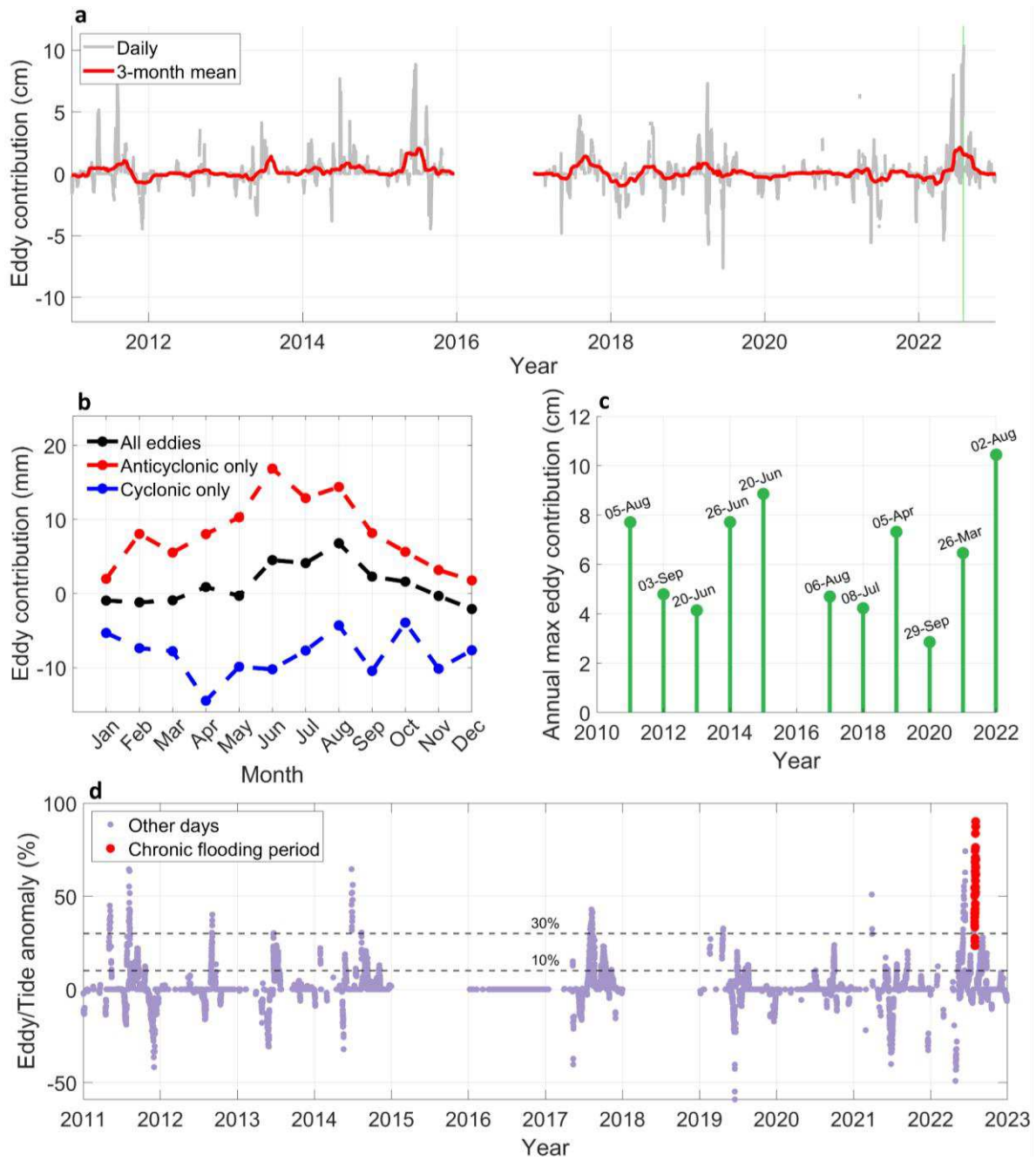


Fig. 5: Eddy contribution (cm) to sea level variability over the whole study period. a, Time series of eddy contributions (cm). The grey curve represents the daily contribution while the red curve shows the 3-month moving mean. The green line represents the nuisance flooding period (July 28th, 2022 and August 2nd, 2022). **b,** Climatological seasonal cycle of eddy contribution (mm) over the 2011-2022 period. **c,** Annual maximum eddy contribution (cm) between 2011 and 2022. **d,** Relative contribution of mesoscale eddies to the tidal anomaly contribution (%) over the 2011–2022 study period. Because nuisance flooding occurs during

high-water conditions, only data with a tidal contribution exceeding the 80th percentile of the tidal anomaly (0.10 m) was retained. Red symbols highlight the nuisance flooding event of late July to early August 2022.

Together, these results indicate that mesoscale eddies contribute to coastal sea level across a broad range of temporal scales. While their contribution is episodic (5-6 days), anticyclonic eddies can play a decisive role during extreme sea level events, giving positive contributions exceeding 10 cm. These contributions occur preferentially during summer in Guadeloupe and can amplify coastal water levels during high tides. The nuisance flooding event of late July–early August 2022 represents the most extreme case observed over the 2011–2022 period, during which the eddy contribution reached both its largest absolute magnitude (10.44 cm) and its largest relative contribution to the tidal signal. It highlights the potential for mesoscale eddies to act as a major driver of extreme coastal sea levels under calm weather conditions.

Discussion

This study provides evidence that mesoscale eddies can influence coastal sea level and contribute to nuisance flooding in the tropical island of Guadeloupe. Using a statistical sea level reconstruction that incorporates an eddy contribution term, we investigated the nuisance flooding event of late July to early August 2022. We quantify the magnitude of eddy-induced sea level anomalies relative to other drivers, including tides, long-term sea level rise, and residual variability. Over the 2011–2022 study period, the largest eddy contribution occurred on August 2nd, 2022, reaching 10.44 cm. On that day, the observed daily maximum sea level reached 0.49 m (/IGN88). Referenced to the mean sea level of 2011, this value equals 0.39 m (/MSL). According to our Gaussian decay formulation, when a large anticyclonic eddy is located close to

the coastline, its contribution to coastal sea level can represent up to 27% of the observed daily maximum sea level referenced to 2011 mean sea level. This result highlights that mesoscale eddies may constitute a significant component of high coastal water levels, even under calm weather conditions. For comparison, the maximum tidal contribution on the same day was 29 cm, corresponding to 59% of the observed daily maximum sea level at Pointe-à-Pitre tide gauge. These results seem to imply that eddies can set the stage for the coastal ocean by raising the background sea level onto which tidal oscillations are superimposed. As a result, even moderate tidal peaks can lead to flooding when combined with a large positive eddy contribution.

Our results further demonstrate that eddy-induced sea level variability occurs on multi-day timescales rather than as an instantaneous response. As the eddy approaches the coast, its contribution progressively increases owing to the reduced distance between the eddy center and the coast. In contrast, the contribution decreases smoothly as the eddy weakens or propagates away from the coast. This temporal evolution is a consequence of the Gaussian decay formulation, which parameterizes the coastal influence of mesoscale eddies as a function of both eddy amplitude and distance to the coastline.

The eddy contribution formulation assumes that mesoscale eddies induce sea level anomalies through steric effects associated with their density structure (Stewart, 2008). The Gaussian decay formulation reflects the spatial structure of eddies, with maximum influence at the eddy core and decreasing impact with distance, scaled by the eddy radius. This approach provides a first-order representation of the attenuation of offshore sea level anomalies as they propagate toward the coast, implicitly accounting for processes such as Rossby wave propagation in the open ocean and

coastal adjustment through Kelvin waves. However, this formulation does not explicitly resolve the wave dynamics, coastal geometry, bathymetric effects, anisotropic propagation or time lags. In addition, it assumes a linear superposition of eddy contributions. As such, it should be interpreted as a simplified representation of the influence of mesoscale eddy on coastal sea level, and thus we cannot ensure that we capture the full signal of the eddy contribution.

To our knowledge, Mitchum (1995) was the first one to question the role of eddies on coastal sea level. The author relates 90-day oscillations of sea level at Wake Island (western Pacific) to Rossby waves associated with eddies. Later, Firing & Merrifield (2004) investigated the contribution of mesoscale eddies on coastal sea level. The authors demonstrated that the high sea level observed in Honolulu, Hawaii in late September 2003 partly resulted from an anticyclonic eddy of ~15 cm peak amplitude. They also suggested that eddy contribution on sea level can exceed the contribution of sea level rise and seasonal variability. Our findings are consistent with this statement because, during the nuisance flooding period, eddy contribution on sea level is higher than sea level rise and seasonal residuals. Previous studies indicate that extreme coastal events associated with anticyclonic eddies could last on the order of weeks (Firing & Merrifield, 2004) or months (Shinoda et al., 2023). Rather than weeks or months, our results demonstrate that extreme coastal events caused by an eddy could last several days. These discrepancies in timescales between studies might come from the different study locations, undergoing different eddy regimes. However, we cannot rule out the possibility that the shorter timescales found within this study compared to previous ones come from the underestimation of the eddy lifetime in our eddy detection methodology.

In terms of magnitude, we found a maximum eddy contribution to coastal sea level of 10.44 cm during the nuisance flooding event, a magnitude comparable to values previously reported in the Gulf of Mexico (Shinoda et al., 2023) and in Hawaii (Firing & Merrifield, 2004). This contribution can generate coastal sea level anomalies of the same order as major climate processes. For example, along the U.S. Pacific coast, the 2015–2016 ENSO event produced positive coastal sea level anomalies ranging from 4 to 15 cm (Goodman et al., 2018). This climate process can even generate anomalies exceeding 20 cm on interannual timescales (Hamlington et al., 2015). Similarly, large river discharge events can raise coastal sea level by approximately ~10 cm (Piecuch et al., 2018). Our results therefore place mesoscale eddies among the major contributors to coastal sea level variability capable of modulating flooding hazards. Unlike basin-scale climate modes that operate over seasonal to interannual timescales, mesoscale eddies evolve over days to weeks and can locally amplify sea level in a transient manner.

In tropical islands such as Guadeloupe, an increase in sea level of 5–10 cm is expected to occur between 2030 and 2050 (IPCC, 2022) and could double the frequency of coastal flooding (Vitousek et al., 2017). The nuisance flooding event of late July to early August 2022 therefore provides a valuable insight for the near-future coastal conditions that tropical islands may increasingly experience. Our results highlight that mesoscale eddies, although often neglected in coastal hazard assessments, can temporarily raise coastal sea level by amounts comparable to several decades of projected mean sea level rise. Consequently, future coastal flooding projections and adaptation strategies should account not only for tides, storm surges and long-term sea level rise but also for offshore mesoscale ocean dynamics. Nevertheless, important uncertainties remain. In particular, eddy detection from

satellite altimetry is currently limited by the spatial resolution of available products (~1/4° resolution, corresponding to ~25 km at the Equator), which may underestimate the size, amplitude, lifetime, or coastal influence of smaller and short-lived eddies. Eddies are chaotic features that are not explicitly resolved by current climate projections. Consequently, how mesoscale eddy activity and its coastal impacts may evolve under future climate scenarios remains largely unknown. Future high-resolution satellite missions and coastal ocean observing systems will likely improve the detection and characterization of mesoscale and submesoscale structures near coastlines. Integrating these observations with dynamical coastal models could provide a more physically explicit representation of eddy-coast interactions and improve forecasts of nuisance flooding in vulnerable tropical regions.

Methods

Tide gauge data

This study relies on hourly validated observations of total water level recorded at the Pointe-à-Pitre tide gauge (16.2244°N, 61.5315°W) between January 1st, 2011 and December 31st, 2022. These data are provided by the French National Hydrographic Office (SHOM) and are publicly available through their data portal (<https://data.shom.fr/>, last access: July 17th, 2026). The total water level results from several processes, including, among others, tide, storm surges, and other phenomena inducing mean sea level variations. In this study, we focus on nuisance flooding occurring under calm weather conditions. Therefore, periods influenced by storms and atmospheric cyclonic activity were removed from the observed sea level dataset. Using the IBTrACS dataset (Knapp et al., 2010), we identified 50 storms or atmospheric cyclone events, resulting in the exclusion of a total of 137 days (1.57% of

our hourly sea level time series) between January 2011 and December 2022. To ensure a robust estimation of sea level variability, only years with a minimum data coverage of 90% were retained. In practice, all years met this criterion. Total water level observations are referenced to IGN88, an official French national vertical datum.

Sea level reconstruction

Our sea-level reconstruction combines five distinct components of sea level variability:

1. Tidal prediction provided by the SHOM ($\eta_{tide}(t)$)
2. Long-term sea level rise derived from the tide gauge ($\eta_{SLR}(t)$)
3. Eddy contribution estimated from satellite data ($\eta_{eddies}(t)$)
4. Seasonal residual signal derived from the tide gauge ($\eta_{resi-season}(t)$)
5. Non-seasonal residual variability from the tide gauge ($\eta_{resi-non-season}(t)$)

The reconstructed sea level is expressed as (Eq. 1):

$$\eta_{recon}(t) = \eta_{tide}(t) + \eta_{SLR}(t) + \eta_{eddies}(t) + \eta_{resi-season}(t) + \eta_{resi-non-season}(t) \quad (1)$$

where t denotes time at hourly resolution and η_{recon} is the reconstructed sea level (m). Each term on the right-hand side corresponds to the components (1–5) described above, all expressed in meters. All components are treated deterministically, except for the non-seasonal residual term $\eta_{resi-non-season}(t)$, which is modeled probabilistically using a Gaussian distribution. Each component is described in detail in the following subsections.

Predicted tide. Tidal predictions at Pointe-à-Pitre tide gauge ($\eta_{tide}(t)$ in Eq. 1) are provided by the SHOM. These predictions are computed using the MAS tidal software (Simon, 2013), which is the operational tool used for official tidal forecasts in areas

under French jurisdiction. MAS applies a least-squares harmonic analysis (Codiga, 2011; Pawlowicz et al., 2002) to solve the tidal equation, estimating the amplitude and phase of each tidal constituent at the site of interest.

Sea level rise. The long-term sea level trend ($\eta_{SLR}(t)$ in Eq. 1) is estimated using a quadratic fit over the tide gauge observations to tackle acceleration in sea level rise over the 2011–2022 period. This approach allows the estimation of a time-varying trend, defined as the first derivative of the fitted polynomial. The mean trend during this period is $2.36 \pm 0.12 \text{ mm yr}^{-1}$ ($t = 20.48$, $p\text{-value} < 0.001$) and the acceleration is estimated to be $0.41 \pm 0.04 \text{ mm yr}^{-2}$ ($t = 10.37$, $p\text{-value} < 0.001$). This acceleration indicates that the rate of sea level rise has increased over the study period, rising from $-2.21 \pm 0.49 \text{ mm yr}^{-1}$ in 2011 to $6.87 \pm 0.49 \text{ mm yr}^{-1}$ in 2022. The statistical significance of the quadratic term is supported by the t-statistic, indicating that the acceleration term is significantly different from zero. Uncertainties on the trends are computed by propagating the errors associated with the quadratic and linear coefficients, while accounting for their covariance. This ensures a consistent estimation of the confidence intervals for the time-varying trend. However, caution is required when interpreting these results, as the relatively short duration of the time series may lead to an overestimation of long-term changes due to low-frequency variability. Vertical land motion is implicitly included in this component because this trend is estimated from the tide gauge observations.

Eddies detection algorithm. To detect eddies in our region of interest, we run the autonomous eddy identification scheme of Faghmous et al., (2015). This algorithm monitors mesoscale ocean eddy activity in global sea level anomaly (SLA) dataset.

We used the Copernicus Climate Change (C3S) sea level product as input for the eddy detection algorithm. This product is the Data Unification and Altimeter Combination System (DUACS) version DT2024 reprocessed delayed-time altimeter sea level products. Compared to the previous version, the vDT2024 version includes new input L2P altimeter standards (Kocha et al., 2023) while tide corrections occurred through the tidal atlas FES2022b (Carrere et al., 2022). The SLA dataset integrates daily data from up to eight satellites and is projected onto a Cartesian grid with a resolution of $1/4^\circ$ covering the global ocean. The eddies identification scheme (Faghmous et al., 2015) is based on the assumption that each eddy is characterized by a single extremum, defined as a grid cell whose SLA is higher or lower than its 24 neighbors in a 5×5 grid. The eddy boundary is then determined by identifying the largest closed contour that preserves this single-extremum constraint within the eddy interior. To track eddies over time, each feature identified at time t is compared with features detected at time $t+1$ within a predefined search space. When two features at time t and $t+1$ are associated, their spatial proximity and size are evaluated to ensure physical consistency between successive detections. This method is subject to two main sources of uncertainty. First, the use of a geometric eddy definition, rather than a physical one, introduces uncertainty in the delineation of eddy boundaries, which may not fully correspond to the underlying physical structure. Second, the single-extremum constraint may prevent the detection of small or closely spaced features, which can merge or cancel out in the detection process. Despite these limitations, the eddy identification algorithm achieves a success detection rate of 96.4% (Faghmous et al., 2015), supporting its robustness for large-scale applications.

Eddie's contribution to sea level. Mesoscale eddies can contribute to sea level (Firing & Merrifield, 2004) and their contribution is estimated for the Pointe-à-Pitre tide gauge. These estimations come from the daily eddy detection products (Faghmous et al., 2015) derived from satellite altimetry. For each day, all eddies intersecting a predefined spatial domain (Supplementary Fig. 1) surrounding Pointe-à-Pitre are identified. An eddy is considered to influence the sea level at Pointe-à-Pitre tide gauge if at least one of its pixels lies within the selected spatial domain. The sea level contribution of each eddy is parameterized as a Gaussian decay function (Eq. 2):

$$\eta_{eddy} = \alpha A \exp\left(-\frac{d^2}{\beta R^2}\right) \quad (2)$$

where A is the eddy amplitude (m), d is the distance between the eddy center and the tide gauge (km) and R is the eddy radius (km). The parameters α and β are empirical scaling coefficients set to 1 in this study (see supporting information for a sensitivity analysis of these coefficients). Daily eddy contributions are obtained by summing the contributions of all eddies present on a given day. Anticyclonic and cyclonic eddies are treated separately, with cyclonic contributions ($\eta_{eddy(j)}(t)$ in Eq. 3) assigned to a negative sign to reflect their decrease in sea level while anticyclonic contributions ($\eta_{eddy(i)}(t)$ in Eq. 3) assigned a positive sign to indicate their increase in sea level. The total eddy-induced sea level anomaly is therefore expressed as the sum of all individual eddies of a given day (Eq. 3):

$$\eta_{eddies}(t) = \sum_{i \in anti} \eta_{eddy(i)}(t) + \sum_{j \in cycl} \eta_{eddy(j)}(t) \quad (3)$$

where t denotes time at daily resolution, η_{eddies} is the total eddy contribution (m), $\eta_{eddy(i)}$ represents the contribution from anticyclonic eddies (m) and $\eta_{eddy(j)}$ is the contribution from cyclonic eddies (m). This approach provides a first-order estimate of the influence of mesoscale eddies on coastal sea level. It neglects potential interactions between eddies and large-scale circulation or bathymetric effects.

Seasonal residual signal. The seasonal residual ($\eta_{resi-season}(t)$ in Eq. 1) to sea level is estimated from the residual signal after removing the tidal ($\eta_{tide}(t)$), long-term trend ($\eta_{SLR}(t)$), and eddy-induced ($\eta_{eddies}(t)$) components from the observed sea level. First, using a least-squares regression, a linear trend is removed from the residual time series to isolate the seasonal variability. Second, the detrended residuals are then used to compute a monthly climatology, defined as the mean sea level anomaly for each calendar month over the 2011–2022 period. To determine the seasonal patterns, the monthly climatology is further averaged into four seasons, corresponding to January–February–March, April–May–June, July–August–September, and October–November–December. Since the eddy contribution already contains part of the seasonal variability, directly adding the residual seasonal signal would lead to double counting. To prevent this, in a third step, the climatological seasonal cycle estimated from the eddy contribution is removed from the residual seasonal signal. The corrected residual seasonal anomaly is then incorporated into the reconstructed sea level as a time-dependent correction based on the season.

Non-seasonal residual variability. The non-seasonal residual component ($\eta_{resi-non-season}(t)$ in Eq. 1) is defined as the difference between the observed sea level and the reconstructed signal including tide ($\eta_{tide}(t)$), long-term trend ($\eta_{SLR}(t)$), eddies ($\eta_{eddies}(t)$),

568 and seasonal ($\eta_{\text{resi-season}}(t)$) contributions. This residual therefore represents variability
569 not captured by the other components of the reconstruction, including processes such
570 as storm surges, inverse barometer effects, coastal trapped waves, wave setup, etc.
571 To characterize the statistical distribution of the non-seasonal residuals, we adopt the
572 probabilistic method of Dusek et al. (2022). For each time step, non-seasonal residuals
573 are classified according to their month and their reconstructed sea level decile (here
574 reconstructed sea level corresponds to the deterministic reconstruction including only
575 tides, long-term trend, eddies, and seasonal contributions). For each combination of
576 month and reconstructed sea level decile (here, the reconstructed signal only accounts
577 for tide, long-term sea level trend, eddies contribution and seasonal residuals), the
578 mean and standard deviation of the residuals are computed. This two-dimensional
579 binning allows the non-seasonal residual variability to depend both on monthly
580 conditions and on the sea level state. Bins containing less than 100 observations are
581 excluded to ensure statistical robustness. Within each month–decile bin, the residuals
582 are assumed to follow a Gaussian distribution. This Gaussian distribution is assumed
583 because we focus on frequently occurring conditions, for which the central part of the
584 distribution is well approximated by a normal distribution (Dusek et al., 2022), although
585 deviations may occur in the tails. Based on this Gaussian distribution, an ensemble of
586 100 members is generated to represent the stochastic variability of the non-seasonal
587 residuals. For each time step, residual values are randomly sampled from the
588 Gaussian distribution defined by the corresponding bin-specific mean and standard
589 deviation, and added to the deterministic reconstruction. This framework allows the
590 estimation of ensemble-based uncertainty bounds and produces an ensemble of 100
591 possible sea-level realizations. The overall reconstructed sea level is then computed
592 as the average of the 100 members.

593

594 **Data availability.** Tide gauge data can be accessed and downloaded on the SHOM
595 platform (<https://data.shom.fr>). The Ssalto/Duacs altimeter products were produced
596 and distributed by the Copernicus Marine and Environment Monitoring Service
597 (<http://marine.copernicus.eu>) and can be accessed on their platform
598 (<https://cds.climate.copernicus.eu/>).

599

600 **Code availability.** The Matlab code used for the reconstruction is available from the
601 corresponding author upon request.

602 **References**

603

604 Andrade, C. A., & Barton, E. D. (2000). Eddy development and motion in the
605 Caribbean Sea. *Journal of Geophysical Research: Oceans*, 105(C11), 26191-26201.
606 <https://doi.org/10.1029/2000JC000300>

607 Ballu, V., Bouin, M.-N., Siméoni, P., Crawford, W. C., Calmant, S., Boré, J.-M., Kanas,
608 T., & Pelletier, B. (2011). Comparing the role of absolute sea-level rise and vertical
609 tectonic motions in coastal flooding, Torres Islands (Vanuatu). *Proceedings of the*
610 *National Academy of Sciences*, 108(32), 13019-13022.
611 <https://doi.org/10.1073/pnas.1102842108>

612 Barabinot, Y., Speich, S., Carton, X., L'Hégaret, P., Subirade, C., Laxenaire, R., &
613 Karstensen, J. (2025). Mesoscale dynamics and transport in the North Brazil Current
614 as revealed by the EUREC4A-OA experiment. *Ocean Science*, 21(5), 1849-1872.
615 <https://doi.org/10.5194/os-21-1849-2025>

616 Bosserelle, A. L., Morgan, L. K., & Hughes, M. W. (2022). Groundwater Rise and
 617 Associated Flooding in Coastal Settlements Due To Sea-Level Rise : A Review of
 618 Processes and Methods. *Earth's Future*, 10(7), e2021EF002580.
 619 <https://doi.org/10.1029/2021EF002580>
 620 Carrere, L., Lyard, F., Cancet, M., Allain, D., Dabat, M.-L., Fouchet, E., Sahuc, E.,
 621 Faugere, Y., Dibarboure, G., & Picot, N. (2022). *A new barotropic tide model for global*
 622 *ocean : FES2022*. <https://doi.org/10.24400/527896/A03-2022.3287>
 623 Codiga, D. L. (2011). *Unified Tidal Analysis and Prediction Using the UTide Matlab*
 624 *Functions* (p. 59) [Technical report]. Graduate School of Oceanography, University of
 625 Rhode Island, Narragansett.
 626 Dusek, G., Sweet, W. V., Widlansky, M. J., Thompson, P. R., & Marra, J. J. (2022). A
 627 novel statistical approach to predict seasonal high tide flooding. *Frontiers in Marine*
 628 *Science*, 9, 1073792. <https://doi.org/10.3389/fmars.2022.1073792>
 629 Ezer, T., & Atkinson, L. P. (2014). Accelerated flooding along the U.S. East Coast : On
 630 the impact of sea-level rise, tides, storms, the Gulf Stream, and the North Atlantic
 631 Oscillations. *Earth's Future*, 2(8), 362-382. <https://doi.org/10.1002/2014EF000252>
 632 Ezer, T., Atkinson, L. P., Corlett, W. B., & Blanco, J. L. (2013). Gulf Stream's induced
 633 sea level rise and variability along the U.S. mid-Atlantic coast. *Journal of Geophysical*
 634 *Research: Oceans*, 118(2), 685-697. <https://doi.org/10.1002/jgrc.20091>
 635 Faghmous, J. H., Frenger, I., Yao, Y., Warmka, R., Lindell, A., & Kumar, V. (2015). A
 636 daily global mesoscale ocean eddy dataset from satellite altimetry. *Scientific Data*,
 637 2(1), 150028. <https://doi.org/10.1038/sdata.2015.28>
 638 Fernandez, A., Black, J., Jones, M., Wilson, L., Salvador-Carulla, L., Astell-Burt, T., &
 639 Black, D. (2015). Flooding and Mental Health : A Systematic Mapping Review. *PLOS*
 640 *ONE*, 10(4), e0119929. <https://doi.org/10.1371/journal.pone.0119929>

641 Firing, Y. L., & Merrifield, M. A. (2004). Extreme sea level events at Hawaii : Influence
 642 of mesoscale eddies. *Geophysical Research Letters*, 31(24), 2004GL021539.
 643 <https://doi.org/10.1029/2004GL021539>

644 Fratantoni, D. M., Johns, W. E., & Townsend, T. L. (1995). Rings of the North Brazil
 645 Current: Their structure and behavior inferred from observations and a numerical
 646 simulation. *Journal of Geophysical Research: Oceans*, 100(C6), 10633-10654.
 647 <https://doi.org/10.1029/95JC00925>

648 Goodman, A. C., Thorne, K. M., Buffington, K. J., Freeman, C. M., & Janousek, C. N.
 649 (2018). El Niño Increases High-Tide Flooding in Tidal Wetlands Along the U.S. Pacific
 650 Coast. *Journal of Geophysical Research: Biogeosciences*, 123(10), 3162-3177.
 651 <https://doi.org/10.1029/2018JG004677>

652 Hamlington, B. D., Bellas-Manley, A., Willis, J. K., Fournier, S., Vinogradova, N.,
 653 Nerem, R. S., Piecuch, C. G., Thompson, P. R., & Kopp, R. (2024). The rate of global
 654 sea level rise doubled during the past three decades. *Communications Earth &*
 655 *Environment*, 5(1), 601. <https://doi.org/10.1038/s43247-024-01761-5>

656 Hamlington, B. D., Leben, R. R., Kim, K. -Y., Nerem, R. S., Atkinson, L. P., &
 657 Thompson, P. R. (2015). The effect of the El Niño-Southern Oscillation on U.S.
 658 regional and coastal sea level. *Journal of Geophysical Research: Oceans*, 120(6),
 659 3970-3986. <https://doi.org/10.1002/2014JC010602>

660 Hino, M., Belanger, S. T., Field, C. B., Davies, A. R., & Mach, K. J. (2019). High-tide
 661 flooding disrupts local economic activity. *Science Advances*, 5(2), eaau2736.
 662 <https://doi.org/10.1126/sciadv.aau2736>

663 Huang, M., Liang, X., Zhu, Y., Liu, Y., & Weisberg, R. H. (2021). Eddies Connect the
 664 Tropical Atlantic Ocean and the Gulf of Mexico. *Geophysical Research Letters*, 48(4),
 665 e2020GL091277. <https://doi.org/10.1029/2020GL091277>

666 IPCC. (2022). *The Ocean and Cryosphere in a Changing Climate : Special Report of*
 667 *the Intergovernmental Panel on Climate Change* (1^{re} éd.). Cambridge University
 668 Press. <https://doi.org/10.1017/9781009157964>
 669 Jacobs, J. M., Cattaneo, L. R., Sweet, W., & Mansfield, T. (2018). Recent and Future
 670 Outlooks for Nuisance Flooding Impacts on Roadways on the U.S. East Coast.
 671 *Transportation Research Record: Journal of the Transportation Research Board*,
 672 2672(2), 1-10. <https://doi.org/10.1177/0361198118756366>
 673 Jamero, Ma. L., Onuki, M., Esteban, M., Billones-Sensano, X. K., Tan, N., Nellas, A.,
 674 Takagi, H., Thao, N. D., & Valenzuela, V. P. (2017). Small-island communities in the
 675 Philippines prefer local measures to relocation in response to sea-level rise. *Nature*
 676 *Climate Change*, 7(8), 581-586. <https://doi.org/10.1038/nclimate3344>
 677 Jochumsen, K., Rhein, M., Hüttl-Kabus, S., & Böning, C. W. (2010). On the
 678 propagation and decay of North Brazil Current rings. *Journal of Geophysical*
 679 *Research: Oceans*, 115(C10), 2009JC006042.
 680 <https://doi.org/10.1029/2009JC006042>
 681 Knapp, K. R., Kruk, M. C., Levinson, D. H., Diamond, H. J., & Neumann, C. J. (2010).
 682 The International Best Track Archive for Climate Stewardship (IBTrACS): Unifying
 683 Tropical Cyclone Data. *Bulletin of the American Meteorological Society*, 91(3),
 684 363-376. <https://doi.org/10.1175/2009BAMS2755.1>
 685 Kocha, C., Lievin, marine, Pageot, yann, Rubin, clemence, Philipps, sabine,
 686 Dibarboure, gerald, Denis, isabelino, Guinle, thierry, & Nogueira Ioddo, carolina.
 687 (2023). *30 years of sea level anomaly reprocessed to improve climate and mesoscale*
 688 *satellite data record*. <https://doi.org/10.24400/527896/A03-2023.3804>

689 Law, S., Marinova, T., Ewins, L., & Marks, E. (2025). Understanding the psychological
690 impact of flooding on older adults : A scoping review. *Annals of the New York Academy*
691 *of Sciences*, 1548(1), 99-115. <https://doi.org/10.1111/nyas.15356>

692 Le Cozannet, G., Idier, D., De Michele, M., Legendre, Y., Moisan, M., Pedreros, R.,
693 Thiéblemont, R., Spada, G., Raucoules, D., & De La Torre, Y. (2021). Timescales of
694 emergence of chronic flooding in the major economic center of Guadeloupe. *Natural*
695 *Hazards and Earth System Sciences*, 21(2), 703-722. [https://doi.org/10.5194/nhess-](https://doi.org/10.5194/nhess-21-703-2021)
696 21-703-2021

697 Mitchum, G. T. (1995). The source of 90-day oscillations at Wake Island. *Journal of*
698 *Geophysical Research: Oceans*, 100(C2), 2459-2475.
699 <https://doi.org/10.1029/94JC02923>

700 Moftakhari, H. R., AghaKouchak, A., Sanders, B. F., Allaire, M., & Matthew, R. A.
701 (2018). What Is Nuisance Flooding? Defining and Monitoring an Emerging Challenge.
702 *Water Resources Research*, 54(7), 4218-4227.
703 <https://doi.org/10.1029/2018WR022828>

704 Moftakhari, H. R., AghaKouchak, A., Sanders, B. F., Matthew, R. A., & Mazdiyasni, O.
705 (2017). Translating Uncertain Sea Level Projections Into Infrastructure Impacts Using
706 a Bayesian Framework. *Geophysical Research Letters*, 44(23).
707 <https://doi.org/10.1002/2017GL076116>

708 Pawlowicz, R., Beardsley, B., & Lentz, S. (2002). Classical tidal harmonic analysis
709 including error estimates in MATLAB using T_TIDE. *Computers & Geosciences*, 28(8),
710 929-937. [https://doi.org/10.1016/S0098-3004\(02\)00013-4](https://doi.org/10.1016/S0098-3004(02)00013-4)

711 Piecuch, C. G., Bittermann, K., Kemp, A. C., Ponte, R. M., Little, C. M., Engelhart, S.
712 E., & Lentz, S. J. (2018). River-discharge effects on United States Atlantic and Gulf

713 coast sea-level changes. *Proceedings of the National Academy of Sciences*, 115(30),
714 7729-7734. <https://doi.org/10.1073/pnas.1805428115>

715 Shinoda, T., Tissot, P., & Reisinger, A. (2023). Influence of Loop Current and eddy
716 shedding on subseasonal sea level variability along the western Gulf Coast. *Frontiers*
717 *in Marine Science*, 9, 1049550. <https://doi.org/10.3389/fmars.2022.1049550>

718 Simon, B. (2013). *Coastal Tides* (Paris, France). [https://iho.int/iho_pubs/CB/C-33/C-](https://iho.int/iho_pubs/CB/C-33/C-33_maree_simon_en.pdf)
719 [33_maree_simon_en.pdf](https://iho.int/iho_pubs/CB/C-33/C-33_maree_simon_en.pdf)

720 Stewart, R. H. (2008). *Introduction to physical oceanography* (Department of
721 Oceanography, Texas A&M University).

722 Thiéblemont, R., Le Cozannet, G., D'Anna, M., Idier, D., Belmadani, A., Slangen, A.
723 B. A., & Longueville, F. (2023). Chronic flooding events due to sea-level rise in French
724 Guiana. *Scientific Reports*, 13(1), 21695. [https://doi.org/10.1038/s41598-023-48807-](https://doi.org/10.1038/s41598-023-48807-w)
725 [w](https://doi.org/10.1038/s41598-023-48807-w)

726 Torres, R. R., & Tsimplis, M. N. (2012). Seasonal sea level cycle in the Caribbean
727 Sea. *Journal of Geophysical Research: Oceans*, 117(C7), 2012JC008159.
728 <https://doi.org/10.1029/2012JC008159>

729 Vitousek, S., Barnard, P. L., Fletcher, C. H., Frazer, N., Erikson, L., & Storlazzi, C. D.
730 (2017). Doubling of coastal flooding frequency within decades due to sea-level rise.
731 *Scientific Reports*, 7(1), 1399. <https://doi.org/10.1038/s41598-017-01362-7>

732 Wdowinski, S., Bray, R., Kirtman, B. P., & Wu, Z. (2016). Increasing flooding hazard
733 in coastal communities due to rising sea level : Case study of Miami Beach, Florida.
734 *Ocean & Coastal Management*, 126, 1-8.
735 <https://doi.org/10.1016/j.ocecoaman.2016.03.002>

736 Zheng, H., Cheng, L., Dangendorf, S., Meyssignac, B., Barnoud, A., Trenberth, K. E.,
737 Fasullo, J. T., & Abraham, J. (2026). Improved closure of the global mean sea level

738 budget from observational advances since 1960. *Science Advances*, 12(21),
739 eaea0652. <https://doi.org/10.1126/sciadv.aea0652>

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748

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750 of the study. R.A. conducted the data analysis with inputs from R.T., D.I. and T.L. R.A.
751 drafted the first version of the manuscript. All co-authors read and reviewed the paper
752 and all co-authors agreed on the final version of the paper.

753

754 **Competing interests.** The authors declare no competing interests

755

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