

Supplementary materials for

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

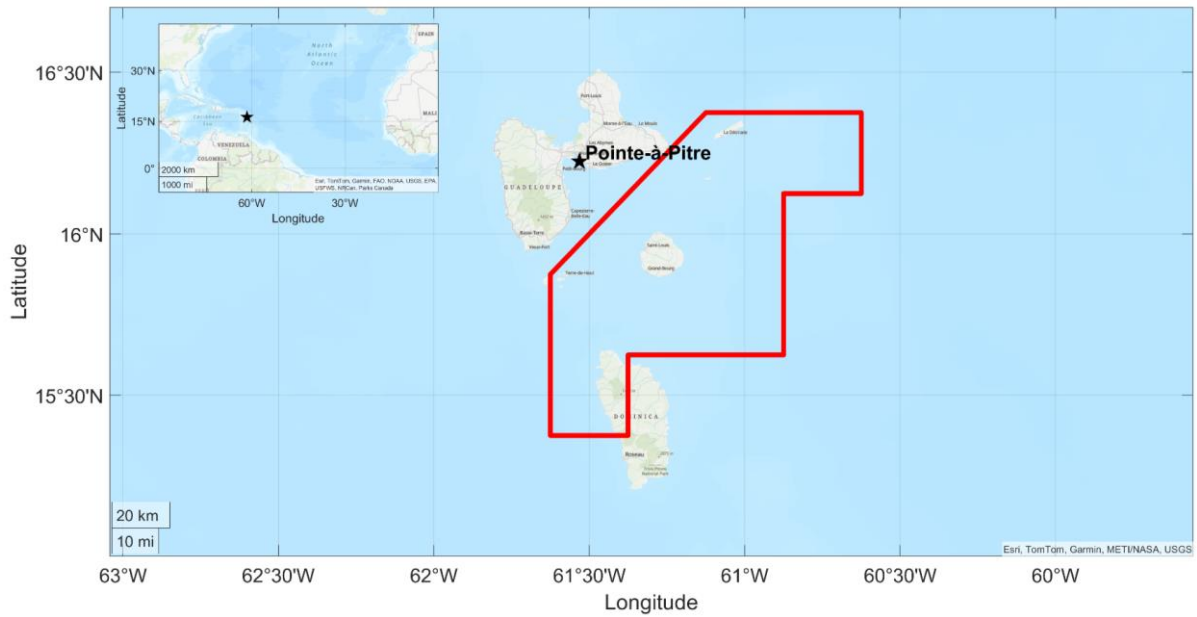
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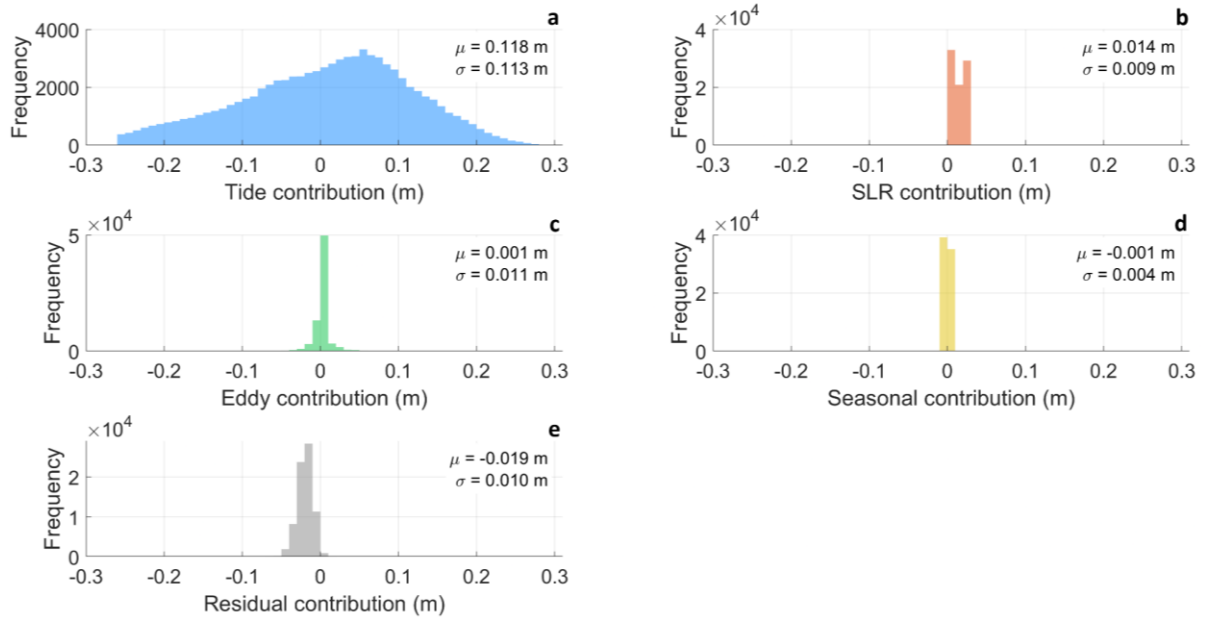
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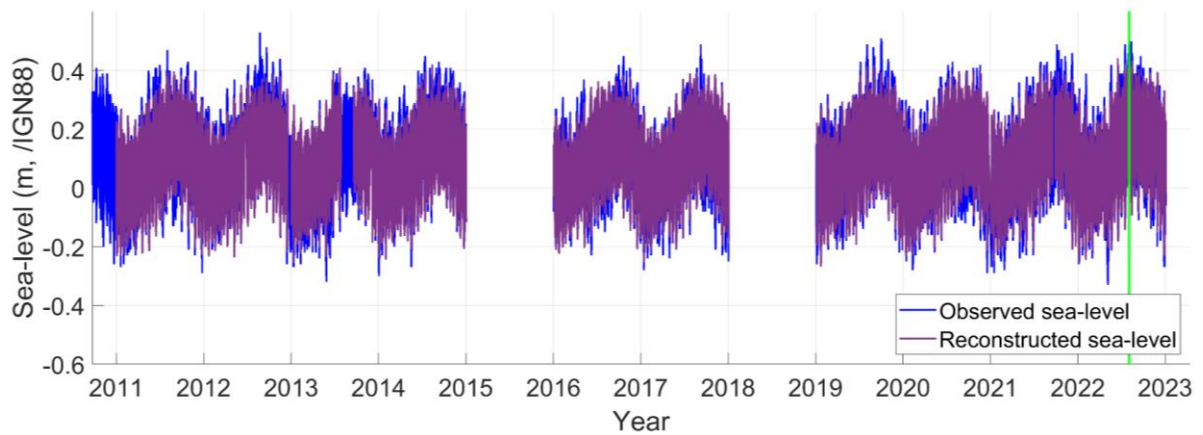
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Supplementary Fig. 1: Study area and eddy detection domain. Map of the Guadeloupe area showing the location of the Pointe-à-Pitre tide gauge (black symbol) and the spatial domain used to identify mesoscale eddies from satellite observations (red box). Only eddies intersecting this domain are considered in the reconstruction of coastal sea level. The domain is defined to capture oceanic structures whose influence on coastal sea level is expected to be significant based on their proximity to the coast (maximum 100 km away from Pointe-à-Pitre tide gauge). The inset shows the regional location of Guadeloupe within the tropical North Atlantic.



Supplementary Fig. 2: Distribution of the different components modelled in our sea level reconstruction (m). **a**, Tide contribution. **b**, SLR contribution. **c**, Eddy contribution. **d**, Seasonal cycle contribution. **e**, Non-seasonal residuals contribution. Note that the y-axis are different between panels.

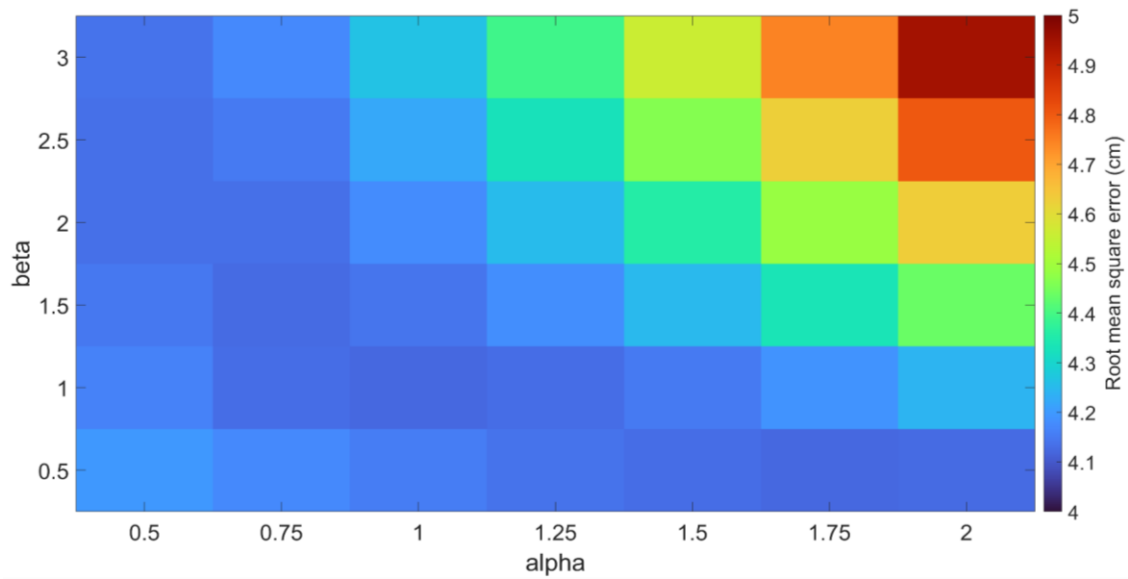


Supplementary Fig. 3: Sea level evolution between 2011 and 2022. The blue curve represents the observed sea level while the purple curve indicates the 100-members averaged reconstructed sea level. The green line represents the nuisance flooding period.

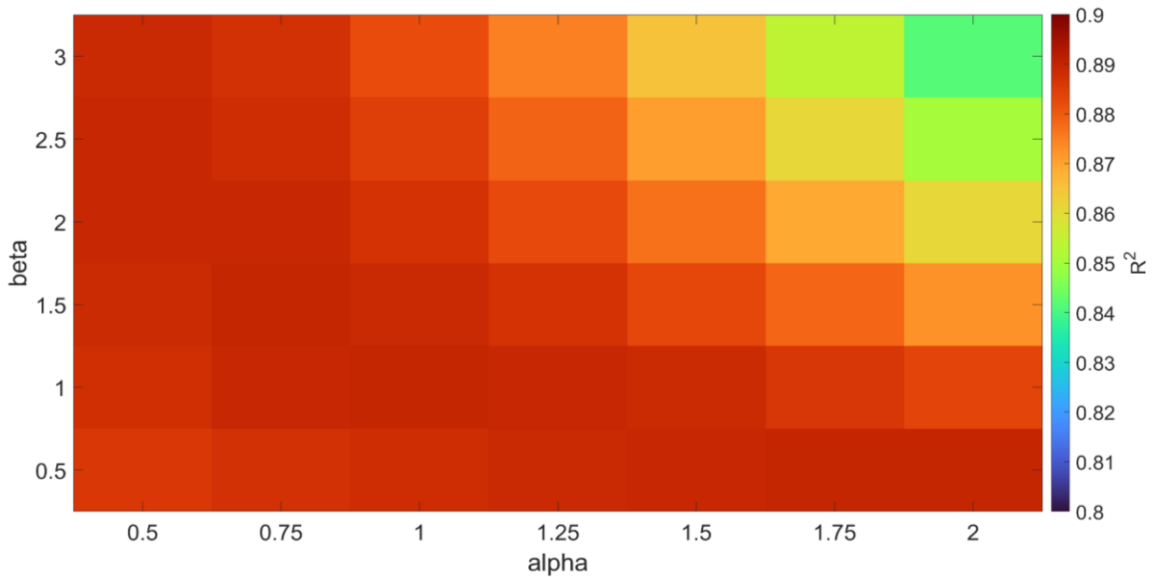
Sensitivity analysis of the empirical scaling coefficients α and β

To assess the sensitivity of the eddy contribution to the empirical scaling coefficients of the Gaussian decay model, we performed a sensitivity analysis over the coefficients α and β in Eq. 2. The parameter α controls the amplitude scaling of the eddy contribution, while β modulates the spatial decay of the signal with distance from the eddy center. For α we explored values ranging from 0.5 to 2.0 (step 0.25) and for β we explored a range of values from 0.5 to 3.0 (step 0.5). For each parameter pair we computed the sea level reconstruction (including only tide, long-term sea level rise and eddy contributions). The reconstruction performance was evaluated against Pointe-à-Pitre tide gauge observations using the root mean square error (RMSE) and the coefficient of determination (R^2). The resulting RMSE and R^2 values were stored in a two-dimensional parameter space, allowing identification of the optimal parameter combination minimizing RMSE. The robustness of the reconstruction with respect to α and β was assessed by examining the variability of RMSE across the parameter space, which provides an estimate of the uncertainty associated with the empirical formulation.

RMSE increases while R^2 decreases as both α and β increase, indicating that high α and β degrade the sea level reconstruction (Supplementary Figs. 3 and 4). Both heatmaps show that reconstruction performance is relatively stable across a broad range of α and β , but with an optimum at $\alpha = 1$ and $\beta = 1$ (RMSE = 4.1 cm and $R^2 = 0.89$).



Supplementary Fig. 4: Root means square error (RMSE) of the two-dimensional α and β parameter space. Blue color indicates a lower RMSE while red color indicates a higher RMSE. The lowest RMSE of 4.1 cm is for the couple $\alpha = 1$ and $\beta = 1$.



Supplementary Fig. 5: Coefficient of determination (R^2) of the two-dimensional α and β parameter space. Blue color indicates a lower R^2 while red color indicates a higher R^2 . The highest R^2 of 0.89 is for the couple $\alpha = 1$ and $\beta = 1$.

