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Marsh margin retreat due to wind waves

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Salt-marsh ecosystems play a crucial role in the eco-geomorphological evolution of intertidal areas, acting as a fundamental buffer against the impacts of coastal storms, providing critical habitats for rare vegetation species and essential nursery areas for fishes and crustaceans. Recent observations of marsh degradation worldwide highlight the importance to improve our understanding of the chief processes responsible for their deterioration. The erosion of marsh boundaries produced by wind-wave impact on the marsh edge is generally agreed to be the most important process driving marsh degradation and disappearance. We have studied long-term changes of salt-marsh boundaries in the Venice Lagoon based on the analysis of sequential aerial photographs spanning a period of almost 50 years in connection with local wave dynamics described through a point wind-wave model. We find a positive correlation between the rates of marsh-boundary retreat, obtained from the sequence of aerial photographs, and the yearly average power density of the impacting wind waves, computed through the wave model. We then carry out a dimensional analysis of the problem which suggests a linear relationship between the eroded volume of marsh sediment and the average wave power density. The expression obtained from dimensional analysis interprets well the observational relationship between the annually eroded volume of marsh sediment and the computed power density of the impacting wind waves. The theoretical basis of the relationship derived from dimensional analysis and the observational support suggest the general applicability of the proposed relationship.