Loss of Geomorphic Diversity in Flood-Regulated Shallow Tidal Embayments

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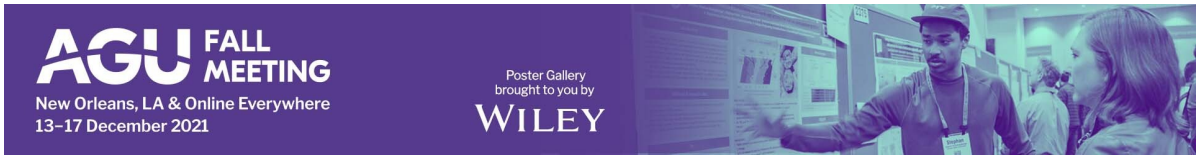
PRESENTED AT:



MOTIVATIONS

- **Storm-surge barriers** are **increasingly adopted** to protect coastal cities worldwide, threatened by rising sea levels.
- Storm-surge barriers may importantly modify the propagation of tides and surges.
- However, their **effects on sediment transport** in shallow tidal embayments are **poorly investigated**.

SETTING & METHODS

- Application to the **Venice Lagoon**, Italy: microtidal, sediment-starved back-barrier lagoon protected by storm-surge barriers, known as Mo.S.E. system, since October 2020
- **2-D finite-element model** to reproduce tide (Defina, 2000 (https://agupubs.onlinelibrary.wiley.com/doi/abs/10.1029/2000WR900167)), wind waves (Carniello et al., 2011 (https://www.sciencedirect.com/science/article/pii/S0272771411000035)), sediment transport (Carniello et al., 2012 (https://www.sciencedirect.com/science/article/pii/S0272771412000893)), and barrier closures (Mel et al., 2020 (https://www.sciencedirect.com/science/article/pii/S0272771421003978))
- Comparison between **regulated** (barrier ON) and **non-regulated** (barrier OFF) **scenarios** of the first 15 barrier operations (October 2020 – January 2021).
  Detailed comparison: 3 and 15 October 2020

EFFECTS: HYDRODYNAMICS

- Water levels below the safety threshold
- Strong north-easterly Bora **wind** on 15 October 2020 **influences water levels** within the lagoon

- In the regulated scenario, water level reduction is between 30 and 70 cm
- Lowered water levels **reduce salt-marsh flooding** and, hence, sedimentation

EFFECTS: MORPHODYNAMICS

Difference between regulated and non-regulated scenarios.

Positive value (red) = increase with barrier closed

- Wind waves on reduced water levels can **enhance bottom shear stress** (BSS), increasing erosion
- Consequently, **suspended sediment concentration** (SSC) **increases**
- At event time scale, flood-regulation can increase BSS and SSC

SEDIMENT BUDGET

- Sediment export towards the sea is temporarily reduced (grey line),
- Erosion of tidal flats does not change at a longer time scale (light blue line),
- Important reduction of salt-marsh sedimentation (green line),
- Increased sedimentation within channels (dark blue line).

CONCLUSIONS

Flood-regulation in the Venice Lagoon:

- Can enhance erosion (BSS) and resuspension (SSC) events,
- Promote channel infilling,
- Reduce salt-marsh sedimentation (Tognin et al., 2021 (https://www.nature.com/articles/s41561-021-00853-7)),

Promoting the **loss of geomorphic diversity.**

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ABSTRACT

Conventional engineering measures, such as surge barriers and mobile floodgates, are being adopted in many coastal cities worldwide, threatened by the increasing flooding hazard due to rising sea levels. Famous examples include London, the Netherlands, New Orleans, St. Petersburg and Venice. However, the question of how flood regulation affects the morphodynamic evolution of shallow tidal embayments still lingers. Storm-surge barriers may importantly modify the propagation of tides, surges and wind waves, changing sediment transport and, thus, the morphological evolution of regulated tidal environments, in particular in sediment-starved systems.

Combining field data and numerical modelling, we investigate the effect of the Mo.S.E. storm-surge barriers, designed to protect Venice from flooding, on the morphodynamic evolution of the Venice lagoon. Artificial reduction of water levels within the lagoon affects the interaction between tide propagation and wind waves, increasing sediment resuspension on tidal flats. Resuspended sediment hardly accumulates on salt marshes, contributing to their vertical accretion and offsetting the negative effect of relative sea-level rise, owing to the reduction of marsh flooding determined by reduced water levels. Although barrier closures temporarily reduce the sediment export toward the open sea, this does not point to preserve the characteristic lagoonal morphology, hindering salt-marsh accumulation and promoting tidal-flat deepening and channel infilling.

We conclude that the operations of flood barriers can promote a significant loss of geomorphological diversity, which will critically impact the ecosystem services provided by the shallow tidal environments they are meant to protect, thus increasing the costs related to their conservation and restoration.