Blue Carbon storage in tidal channel networks deposits

(Proposer: Prof. M. Ghinassi, Prof. A. D'Alpaos)

Branching and meandering networks of tidal channels are prevalent in low-lying coastal areas affected by tides. These networks play a pivotal role in mediating tide propagation, thereby influencing changes in local mean sea level and controlling the fluxes of nutrients, sediments, and particulate matter within the tidal wetlands they drain. These interconnected channel networks and wetland systems also provide a wide array of ecosystem functions and services, including the storage of significant quantities of blue carbon, offering substantial potential for nature-based climate mitigation.

Recent studies have depicted eco-morphodynamic processes leading to the trapping of organic matter in salt marshes, underscoring their crucial role in storing large amounts of blue carbon in coastal sedimentary successions. Despite these advancements, there remains a significant knowledge gap regarding the carbon storage capacity of tidal channel. Therefore, it is crucial to understand the eco-morphodynamic processes governing the formation and evolution of these channel networks, along with their capacity to store blue carbon in deposits they generate over their lifespan.

Fig. 1- Tidal channels of the Northern Venice Lagoon (Italy)

This project will focus on tidal channel networks within the Venice Lagoon (Fig. 1), in Italy, and will employ an integrated approach combining sedimentological and geomorphological analyses to address three primary research questions:

1) *How do tidal channel networks form?*

2) *What is the blue carbon storage capacity of tidal channels and how does this capacity covary with channel size?*

3) *How do geomorphological properties of network (e.g., channel size and density, frequency of piracy and meander cutoffs) impact their blue carbon storage capability?*

To address these research questions, the PhD student will investigate selected tidal channel networks across various areas of the Venice Lagoon. Morphometric characteristics of the networks will be analyzed using remote sensing data and in situ topographic surveys. Meander bend characteristics of different channels will be assessed, including channel aspect ratio, sinuosity, amplitude, wavelength, asymmetry, and lateral migration rate, based on analyses of aerial and satellite images. Sedimentary cores will be extracted from point bar deposits formed by channel bends of varying sizes within the network hierarchy, spanning from 0.3-0.5 m wide creeks to 30-40 m wide channels. These cores will enable the reconstruction of 3D bar geometry/volume and the characterization of related sedimentary facies distribution to classify different bar types in relation to their position within the network. Organic matter and organic carbon content of different types of bars will be measured using Loss-on-Ignition and Elemental Analysis techniques. Stable isotope analysis ($\delta 13C$ and $\delta 15N$) will help differentiate between autochthonous and allochthonous sources of organic carbon. Sedimentary cores will be recovered from marshes drained by the selected networks to reconstruct the depositional history of the network development area.

Application of the above-mentioned techniques will allow addressing the three research questions as follows:
1) *How do tidal channel networks form*? The relationship between the geometry of tidal creek point bars and the stratigraphy of deposits where the network was cut will enable defining the depositional environments (e.g., salt marsh or tidal flat) where the bar originated, providing a basis to develop a model for the origin of tidal creeks and related networks.
2) *What is the blue carbon storage capacity of tidal channels and how does this capacity covary with channel size*? Measurement of organic matter and organic carbon content in point bars formed by channels of different sizes/order will depict how blue carbon is variably stored within the network as a function of the channel hierarchy. Stable isotope analysis will contribute to understanding the autochthonous or allochthonous origin of organic carbon stored in bar deposits.
3) *Can different morphologies and styles of tidal network evolution impact its blue carbon storage capability?* The relationship between the morphometry/temporal evolution of networks and the carbon storage capability of related channels will allow us to define network configurations and morphodynamics that are more effective for blue carbon storage.

Results from this project will provide insights into the formation, blue carbon storage capacity, and evolution of tidal channel networks, contributing to a better understanding of the bio-geomorphological and sedimentological processes in coastal wetland systems and the pathways of blue carbon fluxes.

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Possible Collaborations: University of Southampton (UK); Massachusetts Institute of Technology (USA)