MedGU 10–13 NOV. 2025 ATHENS, GREECE | MEDITERRANEAN GEOSCIENCES UNION 5TH ANNUAL MEETING

Hellenic Republic National and Kapodistrian University of Athens | Host Institution
Scopus | Scopus-Indexed Proceedings

Natural land subsidence in the marshlands of the Venice Lagoon: monitoring by InSAR and modelling by NATSUB3D

Urooj Qayyum [1], Marta Cosma [2], Cristina Da Lio [2], Sandra Donnici [2], Annamaria Mazzia [1], Selena Baldan [1], Claudia Zoccarato [1], Massimiliano Ferronato[1], Luigi Tosi [2], Pietro Teatini [1]

[1] Dipartimento di Ingegneria Civile, Edile e Ambientale, Università di Padova
[2] CNR-IGG, Padova
urooj.qayyum@studenti.unipd.it

Abstract :

Natural land subsidence, primarily driven by the auto-compaction of Holocene sediments, is a key process shaping coastal lagoon morphology. In the Venice Lagoon, Italy, subsidence significantly influences salt marsh elevation and stability under rising sea levels. This study provides a comprehensive 3D perspective (i.e., 2D in space over time) to address the subsidence issue, incorporating InSAR outcomes with field characterization and advanced numerical modeling tools that capture the dynamic interplay of auto-compaction and sedimentation.

Simulations are performed using the advanced simulator NATSUB3D based on deforming finite elements to reconstruct the Holocene evolution of representative sections of the Venice Lagoon. The complexity of sedimentation-compaction history is explored through the integration of 2D seismic lines, lithologic borehole logs, geochronological data, and historical maps. This dataset, combined with the geomechanical properties of lagoon deposits derived from field and laboratory testing, forms the primary input to the models. The simulator couples a 3D groundwater flow module with a 1D compressibility module, employing adaptive meshes to simulate accretion and natural consolidation processes, which govern dynamic thickening and elevation change. The model is calibrated against present-day lagoon bathymetry and the recent InSAR

outcomes obtained in the area, allowing to estimate the current natural compaction rates resulting from Holocene evolution.

Results reveal that natural auto-compaction alone accounts for a significant fraction of vertical land movement, particularly in the fine-grained deposits of the lagoon. Subsidence rates vary spatially depending on lithological heterogeneity together with sediment age and loading history.

These findings demonstrate that, even in the absence of groundwater extraction and long-term tectonic activity, natural consolidation of Holocene units can induce substantial elevation changes that leafing to significant morphological changes. The implications are critical for predicting future landscape trajectories and evaluating the sedimentation required to maintain saltmarsh elevation relative to rising mean sea levels under climate change.

This research underscores the importance of incorporating natural land subsidence into coastal evolution models and restoration planning. The study is part of the RESTORE project, funded by the European Union – NextGenerationEU under PRIN 2022 – PNRR.

Keywords: Land Subsidence, Auto-compaction, Numerical Modeling, InSAR, Venice Lagoon salt marshes

Advances into the Evolution of Venice Lagoon's Subsurface from Late Pleistocene to Holocene

Marta Cosma[1], Cristina Da Lio[1], Sandra Donnici[1], Luca Baradello[2], Massimo Zecchin[2], Luigi Tosi[1]

[1] Institute of Geosciences and Earth Resources, National Research Council of Italy, Padova 35127, Italy
[2] Istituto Nazionale di Oceanografia e di Geofisica Sperimentale – OGS, Sgonico, Italy

marta.cosma@igg.cnr.it

Abstract.

The Holocene evolution of the Venice Lagoon, the largest brackish basin in the Mediterranean, reflects a complex interplay of fluvial, tidal, wave, and marine processes, modulated by relative sea-level change, sediment supply, subsidence, and anthropogenic modification. Despite extensive investigations, the lagoon's subsurface architecture has remained only partially resolved owing to its size (~550 km²) and the inherent challenges of surveying shallow-water and wetland environments.

Within the RESTORE project, we integrated broad and wide-ranging datasets gathered over the past 30 years, including sediment core analysis, very-high-resolution seismic profiles, and radiocarbon data, to develop an unprecedented reconstruction of the late Pleistocene–Holocene stratigraphy. Facies analysis identified a range of depositional environments—from alluvial and palustrine to lagoonal, deltaic, estuarine, and shallow marine—while seismostratigraphic interpretation revealed three key bounding surfaces (S1–S3) and three corresponding Holocene units (H1–H3). Notably, the Holocene succession displays a high spatial variability in thickness, ranging from less than 2 m along the central–northern inner lagoon margin to more than 20 m in the offshore and southern sectors. The distribution of the three seismostratigraphic units exhibits pronounced lateral and vertical heterogeneity, reflecting the complex interaction of autogenic and allogenic controls during the Holocene.

Marine transgression initially affected the southern sector, while deltaic–palustrine conditions persisted in the central–northern lagoon. As lagoonal environments expanded northward, a delta system developed in the south. The final phase resulted in the establishment of the modern lagoonal configuration, subsequently modified by centuries of human intervention.

This reconstruction offers new insights into the spatial–temporal variability of Holocene evolution in the Venice Lagoon, highlighting how stratigraphic heterogeneity shapes present morphology and informs predictions of future responses to sea-level rise, subsidence, and sediment budget shifts.

This research was carried out within the RESTORE project (PRIN2022PNRR), funded by Next Generation EU, Mission 4, Component 1, Investment 1.1, CUP B53D23033630001.

Keywords: Venice lagoon, coastal environment, marine transgression, high-resolution seismic, Holocene evolution