Embedding compaction processes in long-term evolution of the Venice Lagoon. A 2D analysis on representative vertical sections

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The spatiotemporal evolution of transitional landforms, such as river deltas and coastal lagoons, is intrinsically linked to sediment accumulation and (auto)compaction. These two natural processes significantly affect their thickening and surface elevation with respect to the mean sea level. As new sediments accumulate on the top surface, the underlying soil is compacted under gravitational load over time. This work aims to provide a comprehensive 3D (i.e., 2D in space, including time) perspective to address this issue, incorporating data interpretation techniques and novel numerical modeling tools that account for the dynamic interplay of sedimentation and compaction. Advanced simulators, based on finite element or virtual element approaches are used to simulate the evolution over the Holocene of a few exemplificative sections of the Venice Lagoon, Italy. The complexity of sedimentation-compaction history is explored by combining 2D seismic lines, lithologic borehole logs, and sediment geochronological data. This information, coupled with the geomechanical properties of lagoon deposits derived from field and laboratory testing, forms the primary input to the simulators. The simulators combine a 2D groundwater flow module with a 1D compressibility module to reproduce the Holocene evolution of the domain using adaptive meshes, properly simulating accretion and natural consolidation, which govern the dynamic thickening and elevation evolution. The models are calibrated to match the present-day lagoon topography/bathymetry, and provide estimates of current natural compaction rates resulting from Holocene evolution. Furthermore, they can be used as tools to evaluate future land subsidence and quantify the sedimentation needed to maintain saltmarshes at their present elevation relative to a rising mean sea level driven by climate change. This work is part of the RESTORE (REconstruct subsurface heterogeneities and quantify sediment needs TO improve the REsilience of Venice saltmarshes) research program, a PRIN 2022 PNRR Project funded by the European Union – NextGenerationEU.