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Attachment 5

National Recovery and Resilience Plan (NRRP)

Mission 4, Component C2, Investment 1.1: "Fund for the National Research Program and for Projects of National Interest (NRP)"

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RESTORE: REconstruct subsurface heterogeneities and quantify Sediment needs TO improve the REsilience of Venice saltmarshes

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Deliverable DL 5.3: Conference presentations

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Executive summary

The report details the conference presentations given during the first year of the RESTORE project.

Summary

1 INTRODUCTION

This report briefly details the communications given at scientific conferences and workshops in the framework of the RESTORE project, including information on the conference and the contributions presented.

2 EGU Annual meeting 2024

The EGU Annual meeting was held in Vienna from 14 to 19 April 2024.
Session GM9.5 - Land Subsidence: Quantifications, Projections, Impacts, and Mitigation in Natural and Urbanized Coastal Environments. Convener: Claudia Zoccarato | Co-conveners: Roberta Bonì, Makan Karegar, Manoochehr Shirzaei, Esther Stouthamer.

2.1 Rethinking the resilience of salt marshes to land subsidence and sea-level rise: The RESTORE project approach

Coastal transitional environments (CTE) are among the most productive ecosystems in the world, supporting various natural functions and providing important ecosystem services to human societies. Because of their low elevation, CTE are expected to be severely threatened by the accelerated sea-level rise (SLR) and their resilience will depend on the capability to keep pace with SLR. Recent field studies and modelling analyses suggest that Holocene events in terms of sedimentation rates and distribution of lithology could significantly influence the evolution and resilience of CTE with expected climate changes. Using the Venice Lagoon (Italy) as a case study, the RESTORE (i.e. REconstruct subsurface heterogeneities and quantify sediment needs TO improve the REsilience of Venice saltmarshes) project proposes a new multidisciplinary approach that combines geological conceptualizations, numerical modelling and vulnerability assessment to quantify the amount of sediment that CTE need to keep pace with the relative SLR. Specific attention is paid to the type of deposits and shallow subsurface architecture that play a key role in the process of land subsidence and autocompaction, i.e., the natural compaction caused by sediment self-weight. Specifically, the RESTORE workflow includes developing a detailed 3D reconstruction of the Holocene stratigraphic architecture and associated geomechanical properties, developing a numerical model that can simulate the evolution of elevations and natural subsidence over the Holocene, and developing a vulnerability assessment able to

highlight the areas of the lagoon most threatened by SLR. Expected results include the evaluation of quantitative data on the sediments needed to keep pace with IPCC projected sea-level rise and the production of vulnerability maps of tidal morphologies to different sea-level rise scenarios to assist policymakers in developing restoration, conservation, and mitigation plans.

3 LASII UNESCO ANNUAL MEETING 2024

The Scientific Meeting "Insight Best Practice of Management against Land Subsidence Disaster" during the LASII UNESCO ANNUAL MEETING was held in Jakarta from 23 to 25 July 2024.
The UNESCO Land Subsidence International Initiative summit in Jakarta was a great occasion to discuss the state-of-the-art mitigation and adaptation strategies to combat Land Subsidence and Sea Level Rise threatening Jakarta and similar places around the world.

3.1 Land subsidence in Italian coast: past and recent perspective

This presentation examines coastal subsidence in Italy, with a focus on Venice, demonstrating how ongoing advancements in monitoring methods contribute significantly to understanding the phenomenon. These developments offer essential tools for implementing effective management strategies to mitigate disasters caused by land subsidence.

4 SGI-SIMPs' Joint Conference 2024

The SGI-SIMPs' Joint Conference titled "Geology for a sustainable management of our Planet", held in Bari from 2 to 5 September 2024.

4.1 Autocompaction as a main driver of coastal depositional environments

Natural environments such as coastal wetlands, lowland river floodplains, and deltas are formed by sediment, transported by watercourses and the sea, and deposited over century to millennium timescales. These dynamic environments host vulnerable ecosystems with an essential role for biodiversity conservation, coastal protection and human activities. The body of these landforms consists of unconsolidated sediments with high porosity and compressibility. Consequently, they often experience significant compaction due to their own weight, that is, autocompaction, which creates an important feedback within the geomorphological evolution of the landform. This work aims to provide a comprehensive 4D

(i.e., 3D, 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. The novel NATSUB3D finite element model (Xotta et al., 2022) is used to simulate the evolution of two main case studies: the Mekong Delta in Vietnam (HIETE Project, funded by CaRiPaRo) and the salt-marshes of the Venice Lagoon in Italy (RESTORE Project, funded by PRIN PNRR 2022). To address the complexity of sedimentation-compaction history, we explored alternative methods for combining lithologic bore logs with sediment geochronological data. Through advanced interpolation techniques we derive delta-specific 3D sedimentation rate history that goes beyond the available spatial and temporal measurements. This new information, coupled with the geomechanical properties, forms the primary input to NATSUB3D. The simulator combines a 3D groundwater flow module with a 1D compressibility module to reproduce the Holocene delta evolution of a 3D domain using an adaptive finite-element mesh, properly simulating accretion and natural consolidation which govern the dynamic elevation evolution. The models are calibrated to match the present-day surface elevation and provide estimates of current natural compaction rates resulting from Holocene evolution. Furthermore, they can be used as tools to evaluate future compaction and consequent relative sea-level rise following ongoing sedimentation, sediment enhancing strategies, or sediment decrease following engineering intervention as the MoSE gate in the Venice Lagoon. The modeling procedure can be easily adapted to different deltaic/coastal environments with only minor modifications to accommodate site-specific data.

5 CMWR 2024 Meeting

The 'Conference on Computational Methods in Water Resources' (CMWR 2024) was held in Tucson, Arizona from 30 September to 3 October 2024.

5.1 A novel and efficient mortar strategy for multi-physics multi-domain simulations in subsurface applications

Accurate modeling of subsurface engineering applications often requires the simulation of multiple physical processes simultaneously occurring in different parts of the domain. An effective approach may rely on decomposing the overall domain into subdomains, where only the physical processes of major interest are actually simulated, each one with the most effective computational grid and discretization method. To this aim, it is necessary to equip the multi-physics simulator with appropriate mesh-gluing algorithms, which can handle non-conforming subdomains with hanging nodes and intersecting interfaces. The mortar method

is an effective technique for enforcing the continuity in a weak sense of a scalar or vector variable field across interfaces by introducing integrals of basis and test functions defined on different meshes. However, the exact numerical evaluation of mortar integrals for arbitrary 3D grids can be a very challenging task, involving the use of complex computational geometry tools. In this work, we introduce a novel approach with the aim at simplifying the implementation and computational effort required by the mortar method, while preserving its accuracy. The idea is based on developing an approximate quadrature algorithm that replaces standard geometric projections with mesh-free interpolations using radial basis functions. The proposed strategy turns out to be particularly effective as the number of quadrature points increases. Benchmark results show that the proposed method maintains the accuracy and convergence properties of the classical mortar method at a lower cost, also in complex 3D geometries. Numerical experiments dealing with multi-physics and multi-domain simulations in groundwater multi-aquifer systems and coastal transitional environments are presented to support the effectiveness of the proposed approach.

5.2 GReS: A novel multi-physics multi-domain computational tool for geomechanical simulations

It is very well-known that the prediction of the geomechanics plays a crucial role for a proper management of underground resources, involving multiple physical processes, such as fluid flow, poromechanics, fault activation, thermal flow, and chemical reactions, that can take place simultaneously with multiple time and space scales. Despite a lot of work has been already done for the analysis and simulation of individual subsurface processes, research is still very active in the attempt of coupling geomechanics with other relevant phenomena at the proper scale, from both a numerical and a physical point of view. GReS is a novel open-source modular platform, specifically designed with the aim at contributing to the development and prototyping of numerical algorithms for fully coupled multi-physics multi domain geomechanical applications. The idea is to partition the overall computational domain into possibly non-conforming subdomains where different physics and discretization schemes can be used. The code is based on a high-level programming platform (MATLAB) that should lower the entry barrier for new users and developers, as well as the effort for implementing and testing innovative numerical algorithms. Moreover, the modular structure of the code encourages contributions from different developers at variable levels, from the implementation of new physics and discretization schemes to specific algorithms to accelerate the linear and non-linear solver. Despite being primarily conceived as a prototyping platform,

GReS wraps low-level advanced linear algebra packages to combine simplicity with fair efficiency. In the present communication, we will introduce the GReS concept and its current development state, including advances to the mortar algorithm used to transfer the information among nonconforming subdomains with independent meshes. Basic benchmarks will be presented to show the current code's potentials, along with some ideas for future developments.

6 First West African International Workshop On Coastal Land Subsidence

The "First West African International Workshop On Coastal Land Subsidence" was held in Accra, Ghana from 4th to 8th November 2024.

The first West African Regional Workshop on Coastal Land Subsidence aimed to build a community of interest on land subsidence in the region. Coastal subsidence poses a significant threat to coastal communities and ecosystems in Africa. The workshop brought together the community of interest, local and international experts and policy makers who shared their knowledge and experiences and initiated regional discussions on land subsidence. The workshop addressed the latest research findings, shared insights and developed joint strategies to mitigate impacts and ensure sustainable coastal management for future generations. Specifically, the approach and the activities of RESTORE project were presented as an example of multidisciplinary approach which combines a detailed 3D reconstruction of the Holocene stratigraphic architecture, which properly accounts for vulnerability assessment of lagoon morphologies to RSLR.

The workshop comprised three academic days, one day with a field trip to the Volta Delta and one day with an open discussion to formulate recommendations for the public and private sector on how to better address the political, environmental, economic and social challenges of coastal development.

6.1 Revisiting The Impact of Relative Sea-Level Rise on The Venice Lagoon (Italy)

The notoriety of subsidence in Venice has been known worldwide since the 1960s when a catastrophic tidal wave flooded a large part of the city. Since then, much has been done to defend Venice from the effects of land subsidence and global sea-level rise.

The regulation of groundwater exploitation, the raising of the city floor, the construction of mobile gates at the inlets, and other works have meant that today most of the city

is protected from flooding. While there continues to be great concern about the fate of Venice at the end of the century given the SLR projections, attention has now shifted to the impact of the relative sea-level rise on the lagoon's environment. Accelerated global sea-level rise and land subsidence are seriously threatening the diversity of tidal morphologies that, due to their geomorphological heterogeneity and high biodiversity, support some of the most valuable ecosystem services and have made the Venice lagoon a distinctive landscape. It is therefore important to revisit the concept of the impact of relative sea-level rise on Venice and its lagoon, taking into account the vulnerability of tidal morphologies. This work provides a retrospective overview of land subsidence in Venice and then proposes a new concept of the vulnerability of lagoon morphology to relative sea-level rise.

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