Long term hydrodynamics and sediment transport model under future climate change scenario

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Introduction: Since 2008 Syndial Spa performed several investigations and studies aimed to support sediment remediation decision making and environmental conditions assessment in the Pieve Vergonte SIN (Sito di Interesse Nazionale). As part of these activities, a detailed hydrodynamic and sediment transport model was developed to quantify the transport of sediment in the Toce River and the Pallanza Bay (Lake Maggiore) from 1982 to 2009. This model has also been used to simulate the sediment dynamic in Pallanza Bay in a long-term under the most extreme climate change scenarios for the years 2017 to 2050. The outcomes of this study are here presented.

Methods: Among the 3D Computational Fluid Dynamics codes available to model flow and transport in river and estuarine systems, EFDC (US Environmental Protection Agency) was selected for the implementation of this work because it is public domain, extendable, and has a thoroughly tested hydrodynamic solver. An extensive field campaign was carried out in 2009-2013 in the study site to achieve the characterization of water quality and sediment. Hydrodynamic measurements (velocity, temperature, turbidity, conductivity) and several SEDFlume cores were used for the model event based calibration (March 2009). Several geochronology cores were also collected to support the long term (1982-2009) calibration of the sediment deposition dynamics into the Bay. The EFDC model so developed was used to simulate future sediment dynamics into the Pallanza Bay. Three General Circulation Models (MIP-ESM ECHAM6, CCSM4 and EC-EARTH) covering the 2017-2050 future period were used as climate forcing scenarios for the distributed hydro-sedimentological models FEST-WB and ERODE. The EC-EARTH (RCP 8.5) and ECHAM6 (RCP 8.5) scenarios provided respectively the maximum and minimum flow and sediment load output. The FEST-WB/ERODE model output expressed in term of flow and total sediment load was used as boundary condition for the EFDC simulations.

Results: Overall modeling activity allowed to characterize future sediment dynamics in the Pallanza Bay in terms of distributed expected deposited sediment *(i)* cumulative thickness, *(ii)* annual average deposition rate and *(iii)* spatio-temporal deposition trends in the next 34 years. The two extreme climate change scenarios agreed reasonably with data provided by available geochronology cores. Given the model results, it is reasonable to expect that deposition rates under future climate change scenarios do not change drastically relative to historical values. The sediment deposition (“natural capping”) will continue even in the “worst scenario” (i.e. ECHAM6 RCP 8.5). Even if both scenarios result in higher or equal deposition rates compared to the hindcast 1982 to 2009 simulation, the point-by-point comparison between measured historical (1986-2009/2013) and projected deposition rate values at the geochronology core sites shows that projected values may be locally lower than the historical. However, there is no evidence of net sediment erosion in the shallow water portions of the Bay in agreement with previous studies.

Discussion: The good agreement between the hindcast model and data indicates that the model is producing valid results at the scales of interest for the findings in this study concerning the sediment deposition patterns and trends. The proposed scenarios provide an array of potential future deposition patterns that are reasonable under the expected evolution of climate within the next half century. However, given the uncertainties associated with any such projections, further monitoring and modelling of the system is recommended.