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Future salt intrusion climate scenarios: the case of the Po river

Giorgia Verri[1], Sahameddin Mahmoudi Kurdistani[1], Nadia Pinardi[2], Giovanni Coppini[1], Andrea Valentini[3], and Dario Conte[1]

[1]Euro-Mediterranean Center on Climate Change Foundation (CMCC), Lecce, Italy
[2]Department of Physics and Astronomy, University of Bologna, Bologna, Italy
[3]Arpa Emilia-Romagna, Hydro-Meteo-Climate Service (Arpae-SIMC), Bologna, Italy

A 2-layer Estuary Box Model, named CMCC EBM (Verri et al., 2020), has been devised by the CMCC Foundation to offer a proper representation of the estuarine overturning circulation and mixing processes in a coupled modelling framework with hydrology models and ocean models. The regional to global ocean models reaching the mesoscale cannot solve the estuarine dynamics because they cannot represent the estuary geometry due to their low resolution. Thus, the idea of an estuary box model that gives reasonable values of water volume flux and salinity at the river mouth, which in turn affects the ocean dynamics.

A further development of the model equations (Verri et al. 2021, under revision) considers the estuary length, i.e. the length of the salt wedge intrusion, as a model unknown which depends on the competition between the riverine freshwater and the salt ocean water.

The physical core of the model consists of two conservation equations for volume flux and salt flux both averaged over the diurnal tidal cycle. Moreover, two non-dimensional equations based on the Buckingham theorem have been conceived to provide the estuary length and the along-estuary eddy diffusivity (Verri et al., under revision) as time-variable parameters instead of assuming they are static as most box models do.

The input fields required by the CMCC EBM are the river runoff at the estuary head and the ocean inflow at the river mouth in terms of both barotropic tidal inflow through the water column and baroclinic inflow at the bottom. The estuary width and depth at the river mouth are the only tunable parameters of the CMCC EBM.

The model capability to estimate the length of the salt wedge intrusion has been tested and validated. The Po di Goro branch of the Po delta system has been selected as case study. It is representative of the river-dominated estuaries in a micro-tidal sea, the so called “salt wedge estuaries”, with a multiannual average of the salt wedge intrusion around 15 km according to the ArpaE monitoring campaigns.

Overall the high statistical performance, the short computation time and the minimal calibration encourage to use the CMCC EBM in coupled mode with mesoscale ocean models to produce more realistic operational forecasts and climate scenarios.

In the framework of the Operandum H2020 project (https://www.operandum-project.eu), the CMCC EBM has been used to provided historical simulations (1981-2010 time window) and mid-term scenarios (2021-2050 time window under RCP 8.5) of both the salt wedge length and the salinity at the Po di Goro mouth. The final aim is to design and develop a site-specific nature-based solution which may address the pressing issue of the salinization of the inland waters. The CMCC EBM results clearly showed a stronger intrusion of saltier ocean water in the middle term. The average, the minimum and the maximum values of salinity at the river mouth provided by the model projections are assumed as reference values to investigate the behaviour of two halophyte species which have been selected to reduce the saline intrusion problem because of their high salinity absorption capacity.