Geophysical Research Abstracts, Vol. 7, 09310, 2005
SRef-ID: 1607-7962/gra/EGU05-A-09310

Modeling the Transport Time Scales for the Venice Lagoon

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Lagoons and semi-enclosed basins are commonly subject to intensive anthropogenic inputs that modify both the trophic state and the health of the whole ecosystem. The intrinsic cleaning capacity of these environments is deeply influenced by the advection and diffusion processes, that transport the lagoon water masses to the open sea where they are mixed with the sea water. The transport time scales of the lagoon basin give an idea of the efficiency of this physical cleaning process and their determination is thus of major interest in the environmental management of the lagoon basins. If the tide is the main forcing for the water circulation, such as in the Venice Lagoon case, the cleaning capacity of the basin is influenced by the characteristic of the tidal exchange. In this situation, the flushing mechanism is produced through repeated exchange of the intertidal water volume between the embayment (the Venice Lagoon) and the receiving water body (the Adriatic Sea). Water entering the embayment on flood tide fills the intertidal volume until high water is reached. This new water mixes with the existing water in the embayment and as the tide falls the intertidal volume of water, discharges out of the embayment on the ebb tide. Some fraction of the discharged water is lost by exchange and mixing within the receiving water body the remainder returns to the embayment on the subsequent flow. Not all the water entering on the incoming tide is then 'new water'. Therefore, the tidal flushing and the cleaning capacity depend not only on the tidal range and the basin geometry but also on the effluent water that returns on the subsequent flood tide, the so called return flow as defined by Sanford, et al., (1992). Hence, in order to investigate the cleaning capacity of the Venice lagoon the influence of the return flow on the basin flushing dynamic has to be taken into account. In this work the renewal capacity of the Venice Lagoon has been investigated with a 2D hydrodynamic model, already implemented in the Venice lagoon (Umgiesser et al., 1995, Umgiesser, 2000, Umgiesser et al., 2004, Cucco and Umgiesser, 2004, Soli-

doro, et al., 2003). Using the finite element method, the model solves the circulation pattern of both the lagoon basin and the Adriatic Sea induced by different meteomarine forcings. Wind and tidal forcing have been prescribed in the model to obtain three different idealized scenarios. For each simulation, the residence time and the transport time of the lagoon water inside the basin have been computed. These can be considered as the most representative time scales of the transport processes that occur in the lagoon. To compute the water residence time, an eulerian approach has been followed (Takeoka, 1984a, b). A passive tracer subject to transport and diffusion processes has been released inside the lagoon. Solving the decay of the tracer concentration for the whole area, the residence time is computed. It represents a time scale for the renewal capacity of the fluid volume. The results for the various scenarios have then been compared with each other. The importance of the various forcings on the renewal capacity of the basin has been investigated. Furthermore, the influence of the return flow on the lagoon residence times has been quantified by means of a numerical experiment (Cucco and Umgiesser, 2005). . The transport times of the lagoon water masses have been computed by means of a lagrangian technique. A big amount of particles have been released inside the lagoon and the time spent by each particle inside the basin has been recorder. For each forcing scenario, the results obatined from the computation of the two trasnport time scales have been compared one each other. This analysis reveals that the spatial distribution of the two time scales are correlated in a direct way, when the trasport process is dominated by the diffusion (tide forcing scenario), on the other hand they are correlated in a inverse way, when the transport process is advective (tide and wind forcing scenario). Furthermore, the spatial distribution of the two transport time scales have been analysed in order to define a parameter able to detect the areas inside the basin that are characterised by a strong trapping capacity.

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