WP4

Forecast numerical modeling for coastal extreme weather and flooding risk management

Activity 4.4

Set up of high resolution coastal dispersion model close to river outlet

D4.4.2 Evolution maps and quantitative indicators of sediment transport and dispersion released in the vicinity of coastal areas and river outlets using FLOWAdria

PROJECT AND ACTIVITY DETAILS

Project Acronym	AdriaMORE
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Activity	4.4
Activity Title	Set up of high resolution coastal dispersion model close to river outlet
Work Package	WP4: Forecast numerical modeling for coastal extreme weather and flooding risk management
Executive Summary	Deliverable D4.4.2 includes basic results of numerical simulations of flow and sediment transport evolution in the coastal area surrounding the Pescara River outlet.
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0. Introduction

The coastal flow and transport model here discussed was built up upon the open source code Delft3D (http://oss.deltares.nl/web/opendelft3d), a modelling package which consists of several modules to compute amongst other the flow (FLOW), and the morphology (MOR, included in FLOW) in coastal waters. The FLOW module solves the depth-averaged or 3D shallow water equations on a rectilinear or curvilinear grid. The system of equations consists of the horizontal momentum equations, the continuity equation, the transport equation, and a turbulence closure model. The vertical momentum equation is reduced to the hydrostatic pressure relation as vertical accelerations are assumed to be small compared to gravitational acceleration and are not taken into account. Under the so-called "shallow water assumption" the vertical momentum equation reduces to the hydrostatic pressure equation. Under this assumption vertical accelerations due to buoyancy effects or sudden variations in the bottom topography are assumed negligible compared to gravitational acceleration and are not taken into account. For more technical details about the coastal flow model see D4.4.3. In the following, basic results about velocity and density field evolution as well as sediment concentration around the Pescara River outlet area are introduced and discussed. The morphology of the Pescara harbor (i.e. the breakwater dam) refers to the long-standing configuration before the ongoing restructuring works started. Response of the hydrodynamical system to the dam modification will matter of next studies and applications.

1. Pescara River case study

We use the FLOW and MOR modules to solve the depth-averaged on a rectilinear, uniform grid composed by 1502 x 568 squared cells with $\Delta x = \Delta y = 6$ m.
The domain is composed by one closed boundary with no slip condition and 3 open boundaries to which the zero water level condition and the no reflection are imposed. We considered one layer along the vertical direction. We adopt an incremental time step for the hydrodynamic computation within the range 0.01-1 min. Horizontal background eddy viscosity and diffusivity are set equal to 1 m^2/s and 1 m^2/s respectively. The sea water salinity is set to 31 ppt, while the river flow is composed by fresh water, having a density of 1000 kg/m^3.
The update expression of the TRANSPOR2004 formula (Van Rijn, 2007a, b) is used to calculate the bedload and suspended sediment transport. Bed shear stress calculation is based on the Van Rijn (2007a) roughness predictor. Sediment was assumed to be sandy with a D50 equal to 2 mm, and a sediment density equal to 2600 kg/m^3. Initially, it is uniformly arranged over all the domain bottom, composing a 5 m thick mobile bed. The initial sediment concentration is set to zero. Otherwise, the

Pescara river plume is characterized by a sediment concentration which depend on the considered flow rates. Average monthly outflow rates at Pescara River mouth (Fig. 1) are available thanks to CETEMPS Hydrologic Modelling Group. Bathymetry and artificial obstacles characterizing the domain around the Pescara River outlet are reported in Fig. 2. We analyzed two different outflow conditions: the average annual flow rate (i.e. 25.4 m^3/s) with a sediment concentration of 0.1 kg/m^3 (see Fig. 3), and the average monthly flow rate (i.e. 35.5 m^3/s) with a sediment concentration of 0.225 kg/m^3 (see Fig. 4). For each case we show the evolution of the density and velocity field and the depth averaged sediment concentration for successive time steps.

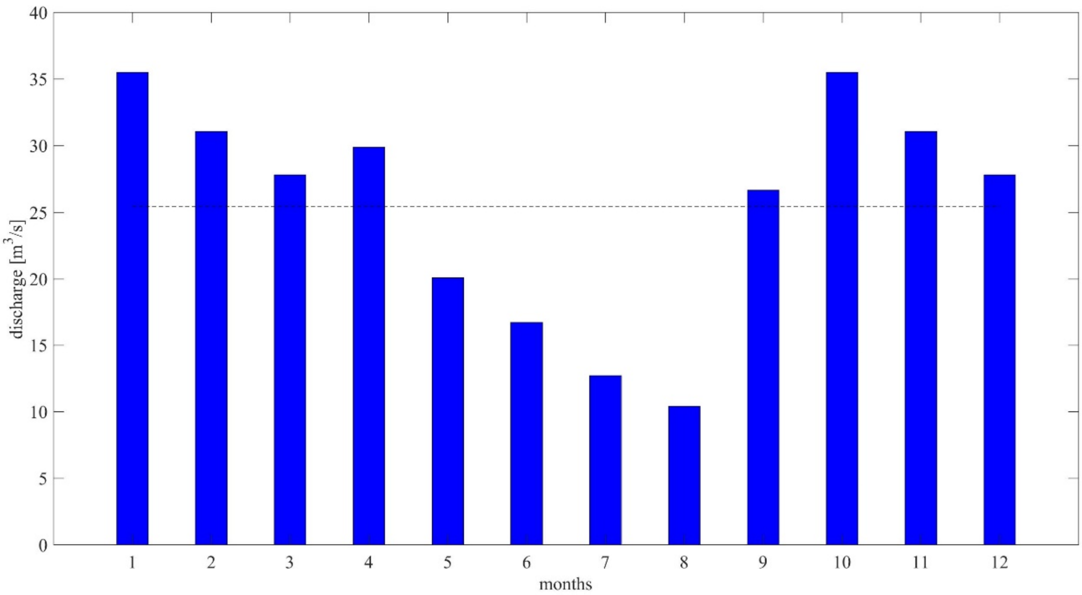

Figure 1. Average monthly flow rate evaluated for 10 years. The dashed line indicates the average annual flow rate for the same period (data provided by CETEMPS, Hydrology Modelling Group).

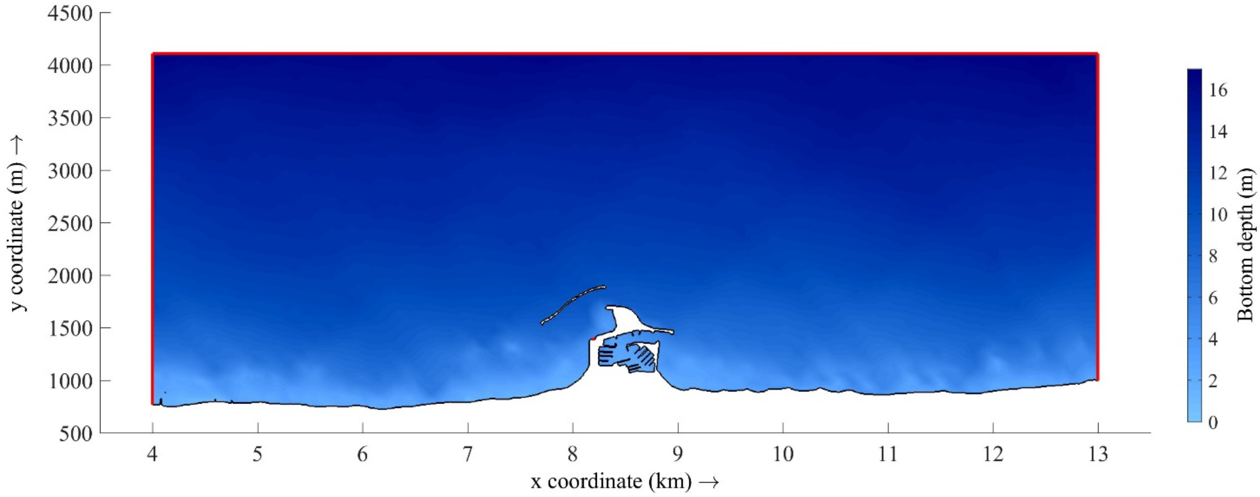

Figure 2. Domain bathymetry. The black line indicates the closed boundaries while the red lines represent the open boundaries.

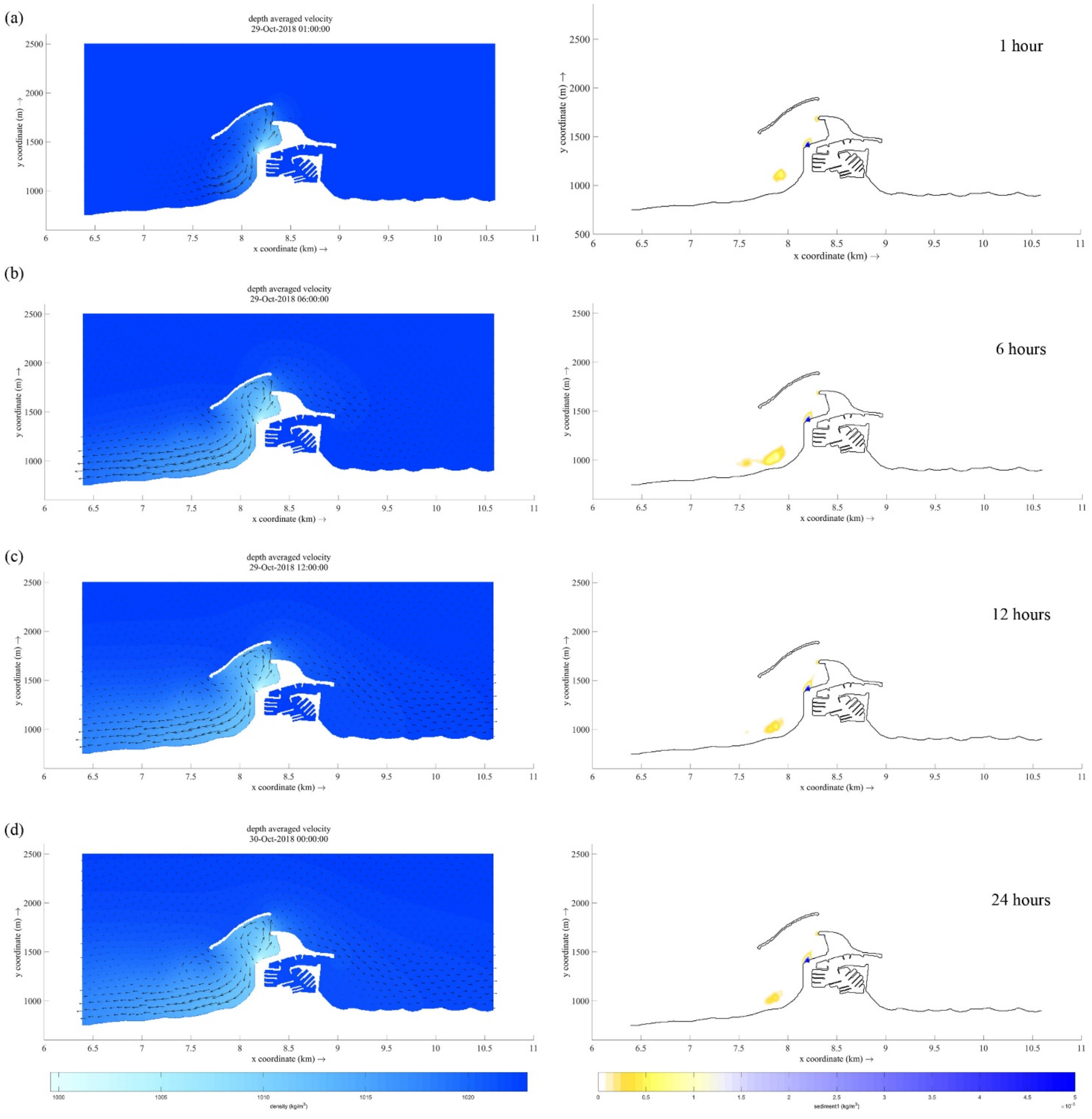

Figure 3. Density and velocity field (on the left) and averaged sediment concentration (on the right) for successive times: (a) 1 hour, (b) 6 hours, (c) 12 hours and (d) 24 hours. The river discharge is the annual average flow rate (i.e. 25.4 m^3/s). The sediment concentration is 0.1 kg/m^3.

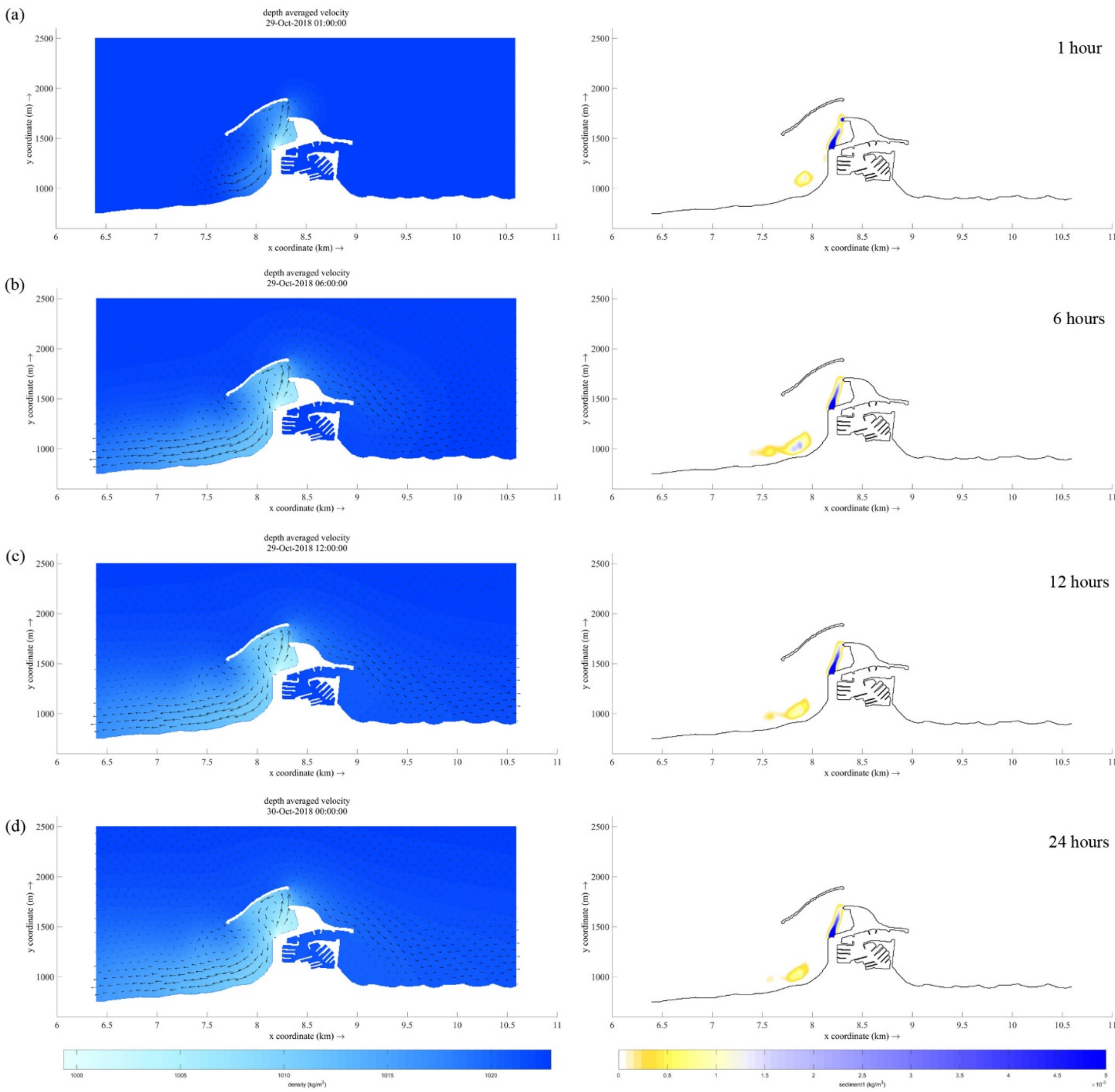

Figure 4. Density and velocity field (on the left) and averaged sediment concentration (on the right) for successive times: (a) 1 hour, (b) 6 hours, (c) 12 hours and (d) 24 hours. The river discharge is the maximum among the average monthly flow rates (i.e. 35.5 m^3/s). The sediment concentration is 0.225 kg/m^3.

Some remarks about the last two figures:

a) The characteristic time of the simulations turns out to be of the order of 1-2 days. This means that the effects of the river outflow on the surrounding domain become visible just after time intervals of some hours;
b) Water density is affected by the river output preferentially northward (left with respect to the harbor). This occurs mainly for the reflecting action of the dam (former structure);
c) Sediment concentration, too, appears to have a significant impact along the northern coastline (about one km from the river mouth), with a slight dependence on the sediment mass;
d) The response of the system, in terms of both marine currents and sediment transport, will be evaluated also in relation to the structural change of the harbor in future studies;
e) These preliminary results show the potentiality of the modelling device in terms of useful quantities and indicators that can be computed through numerical simulations for more detailed applications.

2. References

Van Rijn L.C., 2007a. Unified view of sediment transport by currents and waves. I: Initiation of motion, bed roughness, and bed-load transport. Journal of Hydraulic EngineeringASCE 133 (6): 649-667.

Van Rijn L.C., 2007b. Unified view of sediment transport by currents and waves. II: Suspended transport. Journal of Hydraulic Engineering-ASCE 133 (6): 668-689.