Development of an impact assessment model of water environment near river mouse by using coupled river discharge and ocean circulation model

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Abstract In order to assess the impact on water environment near river mouse, a coupled river discharge and ocean circulation model is developed. A distributed Hydrological River Basin Environment Assessment Model (Hydro-BEAM) and RIAM ocean circulation model (RIAMOM) are used. These two models are connected at the river mouse through the boundary conditions of river outflow. This flood-surge coupling model is applied to the river basin of Arakawa, Edogawa, Tamagawa and Sagamigawa rivers and Tokyo Bay, where Tokyo metropolitan area exists. Case studies for typhoon are simulated and the model results are verified with the observation of river current, ocean current, sea surface temperature and salinity. A result from case study simulation shows that fresh waters from river outflow are distributed in the north-west part of Tokyo Bay.

Keywords assessment of water environment; Hydro-BEAM; ocean circulation model; coupling model; Tokyo Bay

INTRODUCTION

It is necessary to evaluate the simultaneous risk of flood and surge, because there is a possibility that the flood and the surge occur at the same time by an increase of heavy rain and an increase of the power of typhoon in the future by global warming. And it is also worried that global warming gives various impacts on not only the natural disasters but also the water environment of river basin and near shore region.

In 1986, typhoon numbered T8610 passed across the east coast of Japanese islands. T8610 has made a heavy rain fall in Kanto and the Tohoku region, and caused the flood disasters of several rivers in east Japan. Total rainfall amount of Sendai exceeded 400 mm, and the daily rainfall record has not been still broken. Fig. 1 shows the true colour image of LANDSAT-5 satellite around the north part of Tokyo Bay on 6/Aug/1986 after the T8610 passage. Sediment discharges from Arakawa and Tamagawa rivers are clearly seen. Sediment discharge has an important role on the preservation of shoreline. So it is necessary to understand the discharge mechanism and quantitative estimation.

Another important role of river discharge is the nutrient inputs to the ocean. The nutrient influences the water quality and the fishery in the bay such as the red tide and so on. It is exported by the circulation of the current of Tokyo Bay. The ocean circulation is affected by wind, temperature, solar radiation, salinity and tide, therefore a numerical modelling of ocean circulation is needed to understand its mechanisms.

An impact assessment model of water environment near river mouse by using coupled river discharge and ocean circulation model is developed in order to evaluate water and material cycle. The purposes of the model are the both sides of flood hazard prevention and water environment management around the river mouse region. In this paper, the model development, the case study for Tokyo Bay and the verification of result are described.

Fig. 1 Sediment discharge into Tokyo Bay after typhoon T8610 passage.

MODEL DESCRIPTION

A coupled river discharge and ocean circulation model was developed. A distributed Hydrological River Basin Environment Assessment Model (Hydro-BEAM) and RIAM ocean circulation model (RIAMOM) are used.

Hydro-BEAM is a physical based distributed hydrological model developed by Kojiri (2006) for the purpose of to predict the hydrological impact in the regional scale. This model is a cell concentrate type rainfall runoff model. Each cell is divided into two pairs of rectangular hill slopes and one river channel (Fig. 2). The surface flow, subsurface flow from A layer and channel flow are calculated by the kinematic wave model. The groundwater flow from B and C layer are calculated by the storage function model. The deeper seepage and long-term ground water storage are considered in D layer. The land use categories are forest, grass land, urban, paddy field and water. The channel network is calculated by 50 m mesh DEM data provided by GSI (Geospatial Information Authority of Japan). Meteorological observed data of precipitation, temperature and radiation are used as input data.

Fig. 2 Basic cell structure of Hydro-BEAM.

RIAMOM is developed by Lee and Yoon (1994), which is used as an operational three dimensional ocean circulation model of Japan Sea. RIAMOM is a fully three dimensional primitive equation model. Basic equations are equation of motion, continuity equation, hydrostatic approximation and conservation of tracer elements. Prognostic variables are three components of current (u, v, w), pressure (geopotential height of sea surface), temperature, salinity and concentration of tracer. Upper boundary conditions of sea surface are given as sea surface stress and heat flux by using meteorological model outputs (JMA GPV). Bottom friction is given. Lateral boundary conditions are given as tidal change and coarse ocean circulation model outputs at open sea boundary. As a coarse ocean circulation model, we used JCOPE model by JAMSTEC. Model region covers Tokyo Bay and Sagami Bay of south east coast of Japan, and three nested regions are used. The most fine mesh region covers Tokyo Bay and its mesh interval is 280 m and 66 vertical layers are used.

Hydro-BEAM and RIAMOM are coupled at the river mouse as boundary conditions of current, temperature and salinity. On the river mouse mesh, ocean current is replaced by the river discharge, and the salinity is replaced by zero as fresh water. Hydro-BEAM does not calculate temperature, so sea temperature of river mouse is replaced by surrounding temperature.

RESULTS AND DISCUSSION

Calculation by Hydro-BEAM is applied to Tonegawa, Arakawa, Edogawa, Tamagawa and Sagamigawa river basins. RIAMOM calculation is performed for the case of 26/Sep/2006, when ship observation by Tokyo Marine Science and Technology University was carried out. Model results are verified by using three dimensional observed data of temperature, salinity and current.

Fig. 3 shows a snap shot of RIAMOM output of sea surface (2 m depth) at 12 UTC on 26/Sep/2006. Salinity distribution is indicated as colour shade, and blue colour shows fresh water. Current is indicated as arrows, and its length corresponds to current velocity. River discharge impact is shown as fresh water distribution. River water spreads into the north part of Tokyo Bay, but its area is limited near river mouse comparing with T8610 case (Fig. 1). In the case of T8610, daily rainfall amount at Tokyo (Ootemachi observation) was 185 mm/day, and it exceeded 200 mm/day in

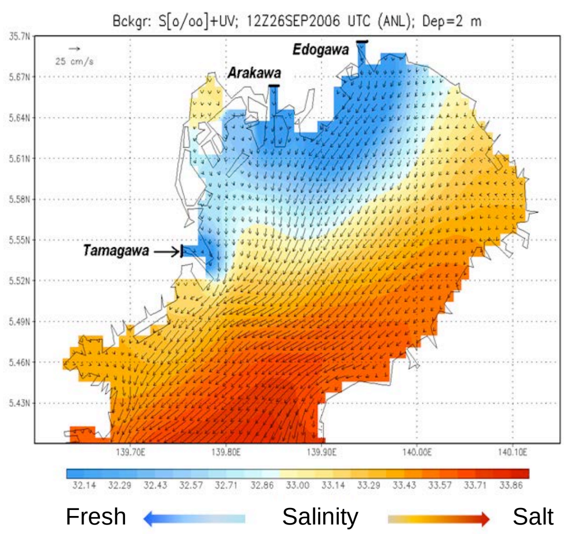

Fig. 3 Salinity and current distribution at 12 UTC on 26/Sep/2006.

upper reach basin. On the other hand, daily rainfall amount at 26/Sep/2006 was only 69 mm/day. The difference of rainfall amount causes the river discharge difference, so that the fresh water distribution is affected by the river discharge.

By this case study, the impact of river discharge on the ocean circulation is able to be calculated. Verification of model and application to sediment discharge or salinitation etc. are the future problems.

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