Development of Biwa-3D to predict water quality in lakes and estuaries, and its application for other lakes & estuaries.

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Abstract. This study introduces the comprehensive development procedure of Biwa-3D and its application for several lakes. Water temperature and dissolved oxygen in Lake Biwa has been numerically simulated using Biwa-3D with 250m horizontal grid spacing. Calculated temperatures were compared with field observation results by Lake Biwa Environmental Research Institute (LBERI), and showed agreement, especially in horizontal direction. The model outputs for dissolved oxygen concentration initially showed earlier decrease compared to the field observation results, which has been modified throughout adjusting vertical mixing procedures during stratified and non-stratified seasons. The model also showed non-uniform distribution in the east-west section, which observation cannot support due to the lack of sampling stations. Seasonal changes in Chlorophyll-a concentration is also simulated and compared with field observation data. Application of the model into different lakes, including Lake Tahoe, is introduced with relevant agreement to field observation dataset.
Keywords: Biwa-3D, temperature, dissolved oxygen.

1. INTRODUCTION

Lake Biwa, as the biggest lake in Japan, suffers water quality degradation induced by urbanization in catchment areas. There are also concerns about the decrease of dissolved oxygen concentration in the future, induced by insufficient vertical mixing during the winter, caused by atmospheric temperature increase during the mixing period. Similar concerns are raised in Lake Tahoe in the USA, where decrease in dissolved oxygen, due to the reduction of vertical mixing, is reported. To predict water quality change associated with vertical mixing, appropriate models with relevant hydrodynamics and ecological models should be developed. The models can support monitoring activity by; (1) interpolating monitoring results where no data is available, (2) predicting important positions of monitoring before launching activities and (3) supporting satellite based water quality observation.

2. ECOLOGICAL MODEL & CALCULATION

Two species of nutrients (N, P: inorganic nitrogen and inorganic phosphorus), three groups of phytoplankton (M1, M2, M3: diatom, blue-green algae and the other phytoplankton), zooplankton (Z), detritus (D) and dissolved organics (C), are assumed to be the main components in ecosystems of lakes and reservoirs. Therefore, they are included in the Biwa-3D model variables. Dissolved oxygen (DO) is also included in the model as an important component that strongly affects the transformation mechanisms. The ecological components of Biwa-3D can be classified into; (A) biochemical transport modules which enable us to calculate mass and scalar transport, and (B) water quality production term modules, which include all of the above ecological modeling. In this study, Lake Biwa calculations were performed for the year 2002, using AMeDAS meteorological datasets as input data, and compared with field observation datasets obtained by LBERI. For Lake Tahoe, meteorological datasets obtained by UC Davis Tahoe Environmental Research Center for the year 2011 were used. For both calculations, initial vertical profiles of lake water temperature and other associated parameters were assumed to be the same as the observed data by both institutes.

Figure 1 Vertical profile of temperature(a) and dissolved oxygen(b): Observed(lower) and Calculated(upper)

Figure 2(a) Vertical profile of (a)temperature and (b) Dissolved Oxygen: Observed(upper) and Calculated(lower)

Figure 3 Comparison between field observation (left) and calculation result of Chlophyll-a concentration

3. RESULTS AND DISCUSSIONS

Figure 1(a)(b) illustrates vertical profile of temperature and dissolved oxygen(DO) concentrations by the model, compared with field observations by LBERI for the year 2002. Figure 2(a)(b) illustrates vertical profile of temperature and DO for Lake Tahoe in the year 2011, compared with field observation by TERC. Through optimization of parameter sets for each lake basin, the general trend agreed with observation results. Figure 3 illustrates a comparison between field observation and calculation results of Chlorophyll-a concentration for May 2002. The second peak can be found in the calculation results, representing higher temperature and nutrients in eastern part of the north basin, which could not be observed in the observation results. This may be due to the lack of monitoring points in that region.

Further applications of the model are being made for Lake Toba of Indonesia with the collaboration of LIPI.

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