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Improving Run Time in Three-Dimensional Reservoir Hydrodynamics and Water Quality Modeling

IMPROVING RUN TIME IN THREE-DIMENSIONAL RESERVOIR HYDRODYNAMICS AND WATER QUALITY MODELING

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Kranji Reservoir (1°25'N, 103°43'E) is a small and shallow tropical reservoir (surface area of about 300 hectares and mean depth of about 5 m, see Fig. 1A) located in Singapore which experiences episodes of eutrophication. As part of management efforts for the reservoir, we have applied the Estuary Lake and Coastal Ocean Model-Computational Aquatic Ecosystem Dynamics Model (ELCOM-CAEDYM) which is an integrated three-dimensional hydrodynamic-ecological model developed by the Centre for Water Research, University of Western Australia (Hodges *et al.*, 2000; Romero *et al.*, 2004). An ELCOM-CAEDYM model was set up to model water quality in Kranji reservoir, specifically studying dissolved oxygen (DO), major nutrients and total chlorophyll-a concentrations.

ELCOM-CAEDYM is a complex model and proper model calibration and validation is not a trivial task. Furthermore, calibrating three dimensional hydrodynamics and water quality models is time intensive. Although the Kranji Reservoir model is relatively small (155 × 87 × 21 cells in the model), model run-time is nevertheless prohibitive, taking approximately 19 hrs for full one-year simulation (time step = 120 seconds), when running on a single desktop computer (CPU speed of 3.06 GHz). Hence, the objective of the current study was to leverage on high-performance computing techniques by parallelizing the execution of the ELCOM-CAEDYM model automatically on multiple computing nodes, which can potentially be achieved for example on a cloud computing platform. In this way speedups in model simulations can be achieved where hundreds of simulations with different parameter settings can be run at the same time. To our knowledge, few studies on such a scale have been attempted.

We have conducted a global sensitivity analysis using the Monte-Carlo technique described in Raychaudhuri (2008) to identify the most influential CAEDYM model parameters for the prediction of total chlorophyll-a concentration in Kranji Reservoir. The values of the model parameters were assumed to be uniformly distributed and chosen from ranges suggested in the literature using the Latin Hypercube Sample (LHS) method to generate the randomly chosen model parameters. In total, 100 different parameters sets were created using random combinations of 18 parameters found in CAEDYM. The simulations were then run on a cluster consisting of 10 computing nodes, each consisting 8 CPU cores running at 3.06 GHz. Preliminary analysis of model run-time, based on the usage of 20 cores in the cluster, showed that it took approximately 5 days to complete 100 one-year simulations, equivalent to an average of about 1.0 hr for a single run. This is in contrast to about 19 hours for a single simulation running on one core. Thus, improvements in model run time of approximately 20 times was achieved suggesting that

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additional reductions in run time can potentially be obtained when implemented in full scale on the cloud platform. The simulations of total chlorophyll-a concentrations at various locations in Kranji Reservoir were analyzed to evaluate model parameter sensitivity. Chi-square goodness of fit test was performed and results showed that the simulated total chlorophyll-a concentrations followed a gamma distribution (see Fig. 1b). This study also found that the most influential parameter in CAEDYM is the minimum internal phosphorus concentration (IPmin). We are currently proceeding with further model sensitivity and uncertainty analyses.

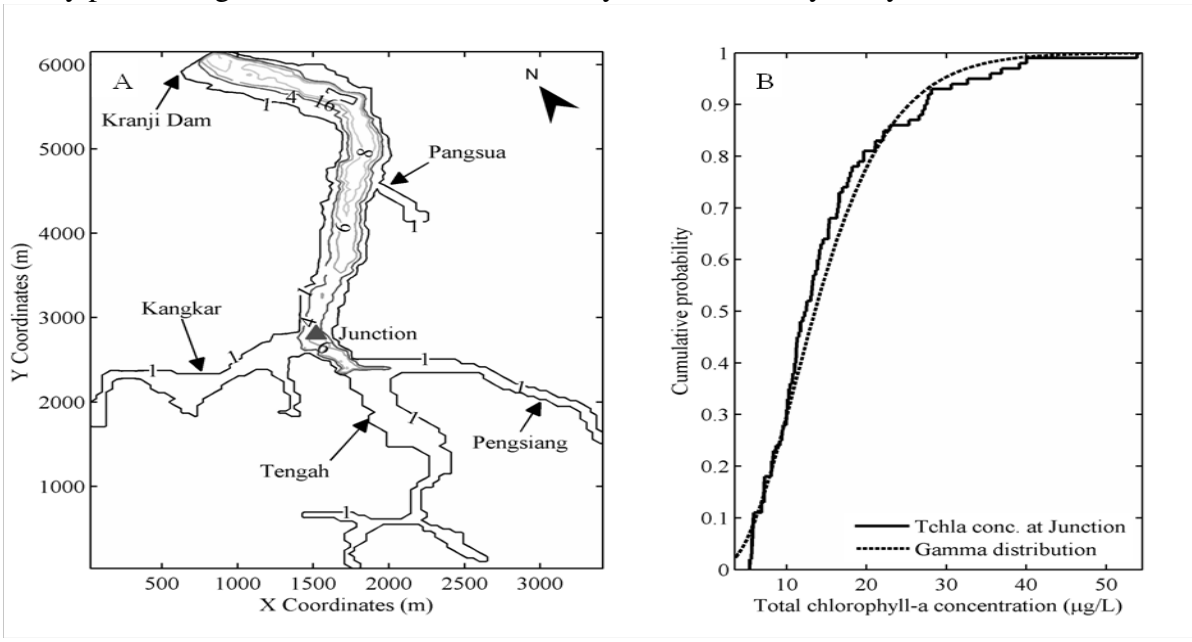

Figure 1 (a) Contour map of Kranji reservoir showing the Kranji Dam, the four tributaries and the location of Junction. (b). Cumulative probability distribution of the output total chlorophyll-a concentration at Junction simulated by 100 model runs and the comparison with gamma distribution.

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