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REMOTE SENSING DATA ASSIMILATION IN WATER QUALITY NUMERICAL MODEL OF EAGLE CREEK RESERVOIR USING ENSEMBLE KALMAN FILTER METHOD

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INTRODUCTION

Numerical models are used as effective tools for simulating complex processes in aquatic systems, such as hydrodynamic and water quality processes [1, 2]. The accuracy of the model is reliant on the multiple model parameters and variables which need to be calibrated and regularly updated to reproduce changing conditions accurately. Different sources of observations such as remote sensing data or in-situ monitoring technologies can improve the model accuracy by providing benefits of individual monitoring technology within the model updating process. Remote sensing technology can provide the spatially dense surface temperature of water body, while in-situ technology is able to prepare more frequent time interval data along the depth. Hence, a framework is required to find the relationships between the remote sensing and in-situ measurements, especially if they are used together. Moreover, a data assimilation approach is needed to incorporate spatially continuous remote sensing temperature observations and spatially discrete in-situ observations to change initial conditions of the numerical model. Although several studies have used remote sensing and in-situ observations to assimilate water temperature, it is unclear of whether updating temperature based on remote sensing observations would improve the model's prediction of temperature with respect to in-situ observation [1, 4, 5]. This study explores a direct observer data assimilation method to overcome the challenge of using data from heterogeneous sources for improving the model performance. The main goal of this study is to adjust the water column temperature using surface temperature and present an ensemble Kalman filter data assimilation framework that combines three-dimensional finite difference numerical model with multiple sources of observations to simulate water column temperature in Eagle Creek Reservoir (ECR) in central Indiana.

METHODOLOGY

The Eagle Creek Reservoir (ECR) is one of the main sources of drinking water for the city of Indianapolis, in Indiana, USA. It was constructed about 16 km northwest of Indianapolis in

1967 and was initially used for flood mitigation. The average depth of the reservoir is 5.7 m and the normal pool surface area is about 5.1 km^2.

A simple physically based model considering a 27-yr record of measurements developed by Piccolroaz et al. (2013) was used to find the relationship between the skin temperature and air temperature [3]. They considered the air temperature as the only input for the model and predicted the temperature of the lake superficial layer. Remote sensing measurements are available for August 7th, August 23rd, September 24th, and October 10th of 2008 while in-situ temperatures have been collected for different days (August 14th , August 20th, August 27th, September 3th, September 16th, and September 30th). The model proposed by Piccolroaz et al. (2013) was employed to relate the remote sensing and in-situ measurements. First, the lake skin temperature was calculated using the air temperature for the period that observations are available (August 7th to end of October) and then remote sensing observations were used to validate the results. In the next step, the predicted skin temperatures for the dates that in-situ observations are available were compared to in-situ observations to estimate the relationship between the remote sensing and in-situ measurements. To compare the measurements, the reservoir was divided to four representative physical regions (Regions A, B, C and D) which provided means to create a time series of in-situ observations at a specific region.

Finally, an ensemble Kalman filter data assimilation framework was presented from the initial condition to the last observation time to incorporate the Environmental Fluid Dynamics Code (EFDC) model with adjusted remote sensing temperatures to simulate water column temperature.

PRELIMINARY RESULTS:

Figure 1 shows the predicted skin temperature and air temperature from August 7th to the end of October. Results show that there is a satisfactory match between the model and the observed data. Comparing the predicted skin temperatures with the in-situ measurements indicated that the bulk temperatures are on average 3.3 ºC warmer than the superficial layer at 16:00 (local time). This trend was applied to remote sensing measurements to adjust the temperature. Figure 2 compares the in-situ measurements, remotely derived and adjusted skin temperatures for region B.

Finally, a remote sensing data assimilation process was set up using the adjusted skin temperatures. The future results include how a model updated via assimilation of adjusted remotely sensed observations of temperature would perform with respect to in-situ observations of temperature.

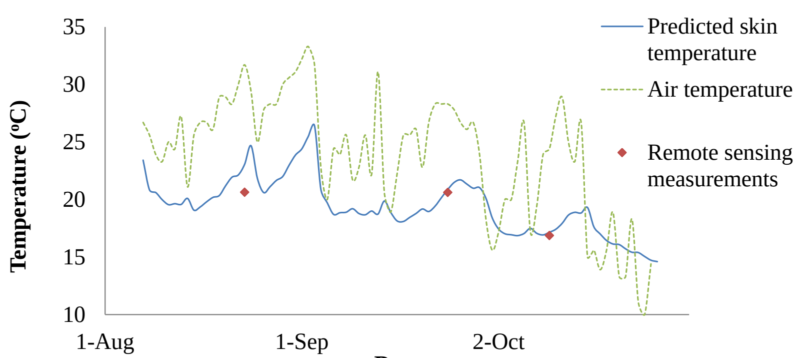

Figure 1: Comparison between air temperature, predicted skin temperature and remote sensing measurements for August 7th to October 31st, 2008

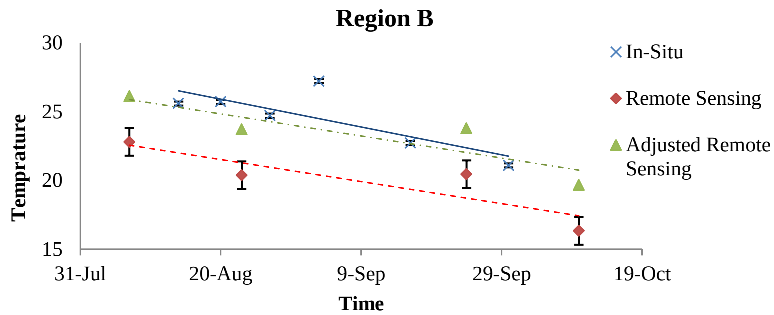

Figure 2: Comparison between in-situ measurements, remotely derived and adjusted skin temperatures for region B

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