Improvement of Hydrodynamic Models of Shallow Water Bodies Using
Combined Eulerian and Lagrangian Observations

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Introduction and Objectives

Intermittently Closed and Open Lakes or Lagoons (ICOLLS) are a subcategory of estuaries that exhibit limited exchange with the ocean and river flows. [1]

This study focuses on improving hydrodynamic modelling in shallow water estuaries using GPS tracked Lagrangian drifter data. The inclusion of drifter data will improve hydrodynamic models, which are commonly used to assess and manage risks of flooding, sediment transport, and pollutants.

Traditionally, Eulerian hydrodynamic models used in shallow water systems are calibrated using observations from fixed instruments. With the recent availability of inexpensive GPS tracked drifters that can be deployed in shallow estuaries [2], a higher density of data can be collected to improve the confidence in the hydrodynamic model outputs.

The numerical model [3] is set up for an ICOLL in South East Queensland (Currimundi Lake). This model will be calibrated and validated using both Lagrangian and Eulerian data. The effectiveness of assimilated Lagrangian drifter data on improving the prediction of velocity and water heights in the ICOLL is investigated. The calibrated numerical model will further be used for modelling advection-dispersion of potential contamination, sediment transport, and flood modelling within the ICOLL.

Study Site

Currimundi Lake is a coastal lagoon (ICOLL) located on Queensland's Sunshine Coast in Eastern Australia (Figure 1). The surrounding area has high recreational, environmental, social, and economic values.

Conceptual Model

Input the model parameters
Hydrodynamic model
Sub-model for a certain period of time
Source: model observed data
Pareto model observed data
Calibration
Do calibration and observed data model value is yes

Data Assimilation

The typical set-up is a "twin experiment" [4], in which two different DA (Data Assimilation) methods including spatial temporal averaging and Ensemble Kaiman Filtering are assessed in estimating the true state of the system. We use the DELT3D hydrodynamic modelling system to demonstrate how the above algorithms can be used to improve the predicted water level and velocity.

Results

• The effectiveness of Lagrangian drifters to improving hydrodynamic models of estuaries is being investigated. For the initial analysis, the Lagrangian dataset are compared with fixed-velocity measurements [5] in close proximity and the result showed that they captured similar flow fluctuation. Therefore as an extension, Lagrangian drifter could be used to provide additional information not covered by the fixed devices (Figure 3).

• These drifter data can be assimilated into the DELT3D hydrodynamic models to investigate the effects of the Lagrangian data on model improvement.

Conclusion

Discussion

• Two experiment were carried out over a three-day period, 12-15 September 2017 using ADCP (Acoustic Doppler Current Proflle) and a 5-hour period, on 12 September 2017 using LR (Low Resolution) drifters.

• The velocity is relatively low throughout the lake with typical values of 0.001 – 0.004 m/s during the closed entrance.

• In general when the entrance is "closed" or "nearly-closed", only ocean tides higher than MHWN (Mean High Water Neaps) have any significant impact on the lake. The low and high tide in the lake for the duration of the study was 0.31m and 1.68m respectively. Figure 2 shows the map velocity at high tide for both closed and open mouth condition.

• Following an entrance opening the lake responds by establishing a tidal flow with water levels being elevated above that of the closed condition.

• Assuming that velocities are so low unless there is either a flood or an entrance breakthrough due to a major opening. It is suggested that more such events be monitored to provide a more robust validation of the Delt3D model under varying entrance characteristics.

Reference