Prediction of Tsunami Height and Arrival Time using Artificial Neural Network (ANN)

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BACKGROUND

The southern coast of Java is prone to tsunami attack as it directly faces towards an active subduction zone. A near-realtime tsunami prediction system which relies on linear tsunami propagation model can give the results in a few minutes. However, one large earthquake in the area might well generate a "near field" tsunami which arrives at the coasts within minutes. Therefore a fast AI system to enhance our tsunami early warning system (TEWS) is desirable.

Objective: to immediately predict tsunami height and arrival time using Artificial Neural Network (ANN) for a given earthquake magnitude and epicenter [CASE STUDY: SOUTHERN COAST OF JAVA]

METHODOLOGY

A feed-forward ANN with Levenberg-marquardt backpropagation algorithm is constructed (Figure 1.)

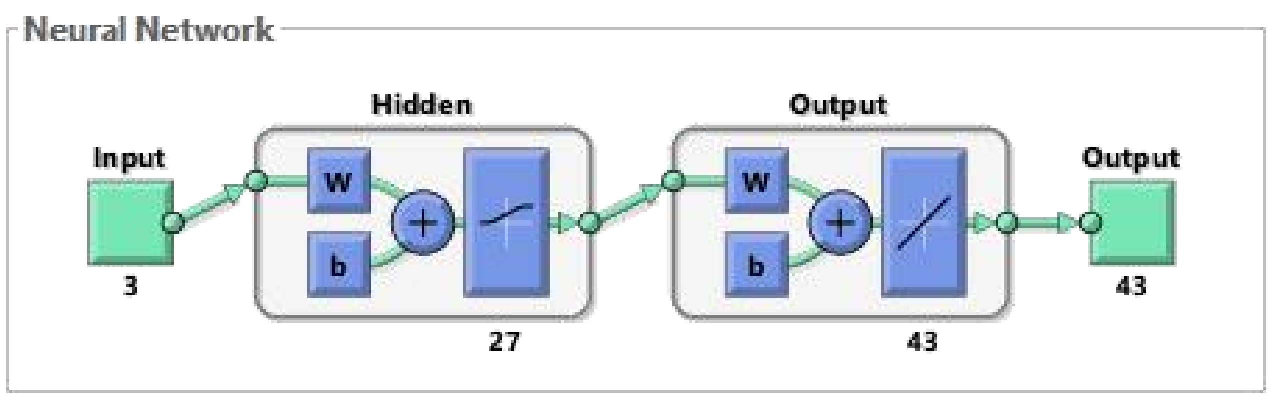

Figure 1. ANN topology consisting of 1 input layer, 1 hidden layer of 27 neurons, and 1 output layer

A set of data for the training of ANN was generated by modeling around 800 earthquake-tsunami scenarios (Fig 2).

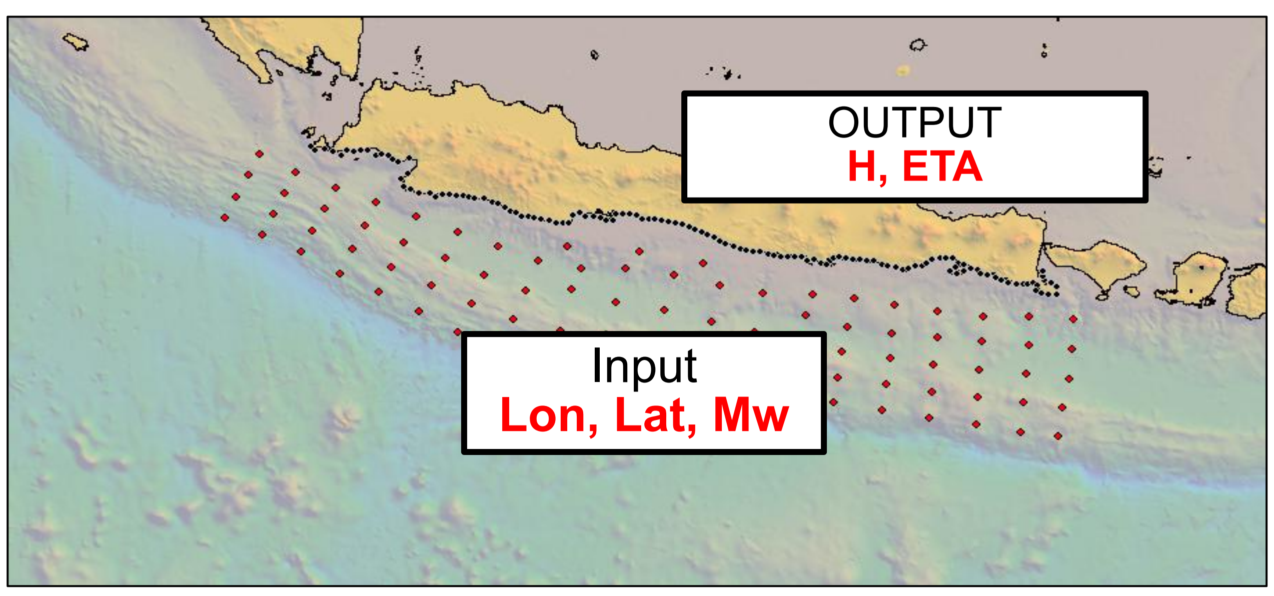

Figure 2. Area of study, showing locations of epicenter in the Indian Ocean and observation points along southern coast

Train the ANN using the input-output data pairs
Input : earthquake magnitude M, longitude (Lon) & latitude (Lat).
Output: tsunami height (m) & arrival time (min) at locations along southern Java coasts.

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RESULTS

A). ANN TRAINING

The dataset used for the ANN training (results from 810 modeling scenarios) is divided into 3 categories: training, validation, and in-training test (testing the networks during training period).

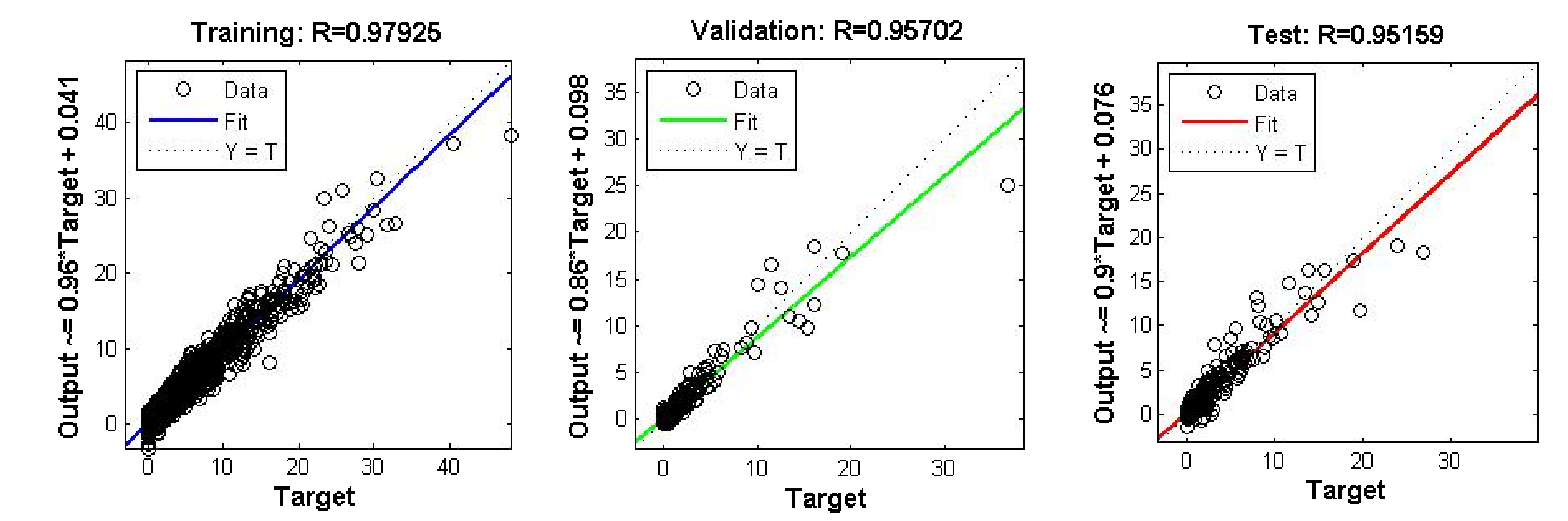

Figure 3. The correlation coefficients for the model results and the ANN-predicted results

A). ANN TESTING WITH NEW INPUT

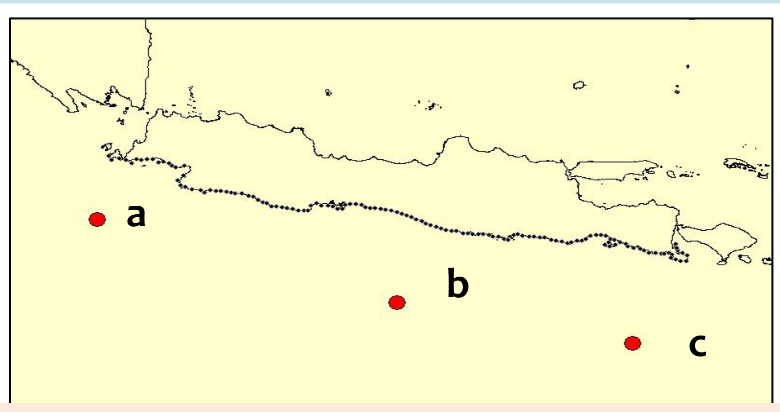

Figure 4. Location of tsunami sources (a, b, c)

The ANN is tested with 3 new cases of earthquake events (Mw=8). The predicted results from ANN (Hmax and ETA at observed locations along the southern Java coast) are compared with results from TUNAMI linear model output.

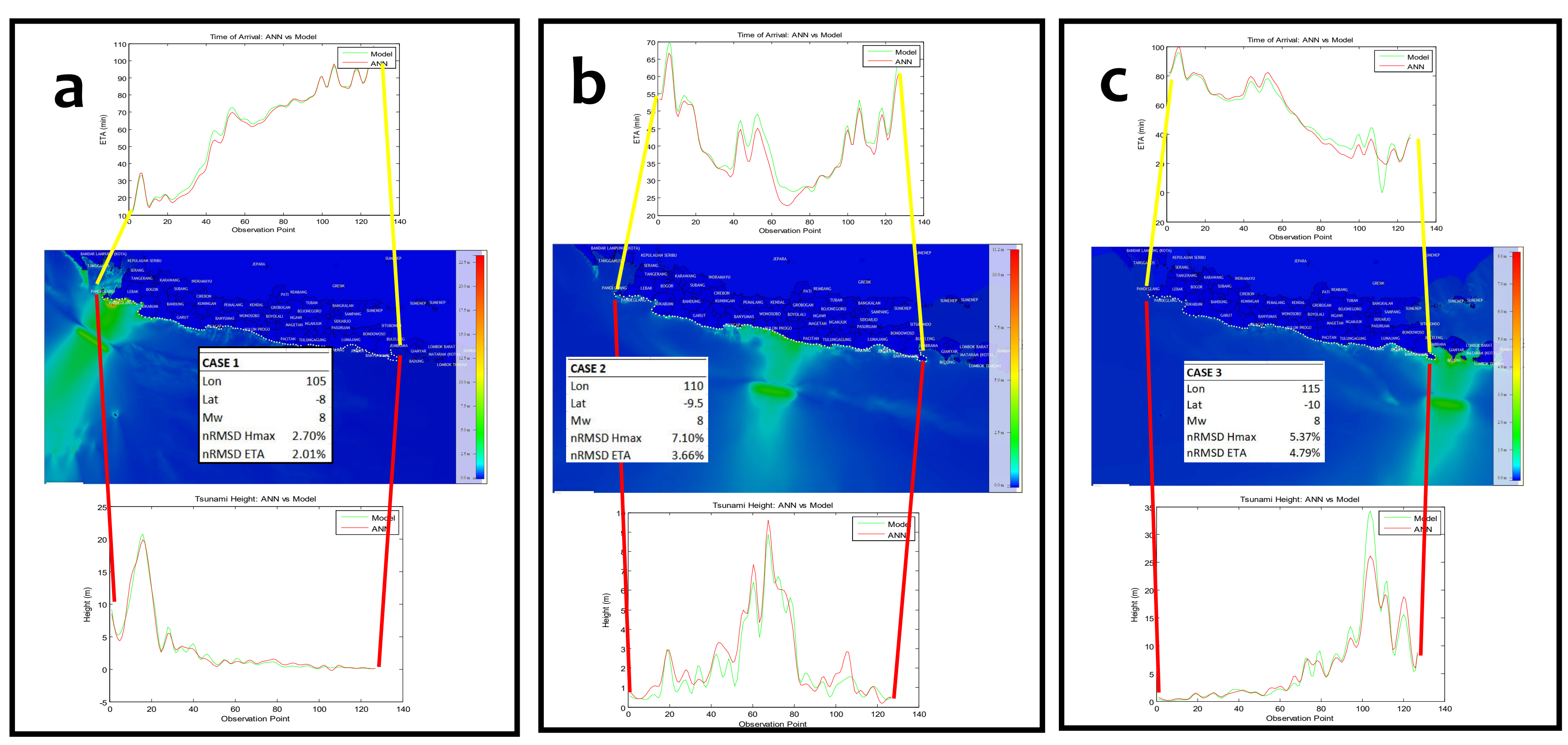

Figure 5. Comparison of sea surface height (Hmax) and estimated time of arrival (ETA) between ANN and TUNAMI model for 3 new cases

CONCLUSIONS & OUTLOOK

- In the training process, the error calculated for training, validation, and test are 2.2%, 4.3%, and 4.8% respectively.
- With the new cases, good agreement is obtained between ANN and TUNAMI model, where differences in Hmax (tsunami height) and ETA (arrival time) for all 3 cases lies in the range of 2 to 7 %.
- ANN can be very useful for tsunami near-realtime predictions, considering it's fast processing time if compared to tsunami modeling.
- Accuracies may be improved if the region is divided into several subregions e.g. West, Central and East Java, and each region has its own ANN.
- NRT predictions using AI, especially ANN may also be applied for other regions such as western coast of Sumatera, owing to similar tectonic patterns with southern Java.