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A hybrid EMD-AR model for the nonlinear and non-stationary wave forecast

Keywords: Wave forecast
Nonlinear and non-stationary
Autoregressive (AR) model
Empirical mode decomposition (EMD)
EMD-AR model

Short-term forecast of ocean waves

Engineering Applications

- Operation-related oceanic activities
- Offshore structure surviving condition monitoring

(e.g. Jain and Deo, 2007)

- Wave energy converter (e.g. Guang *et al*, 2012)

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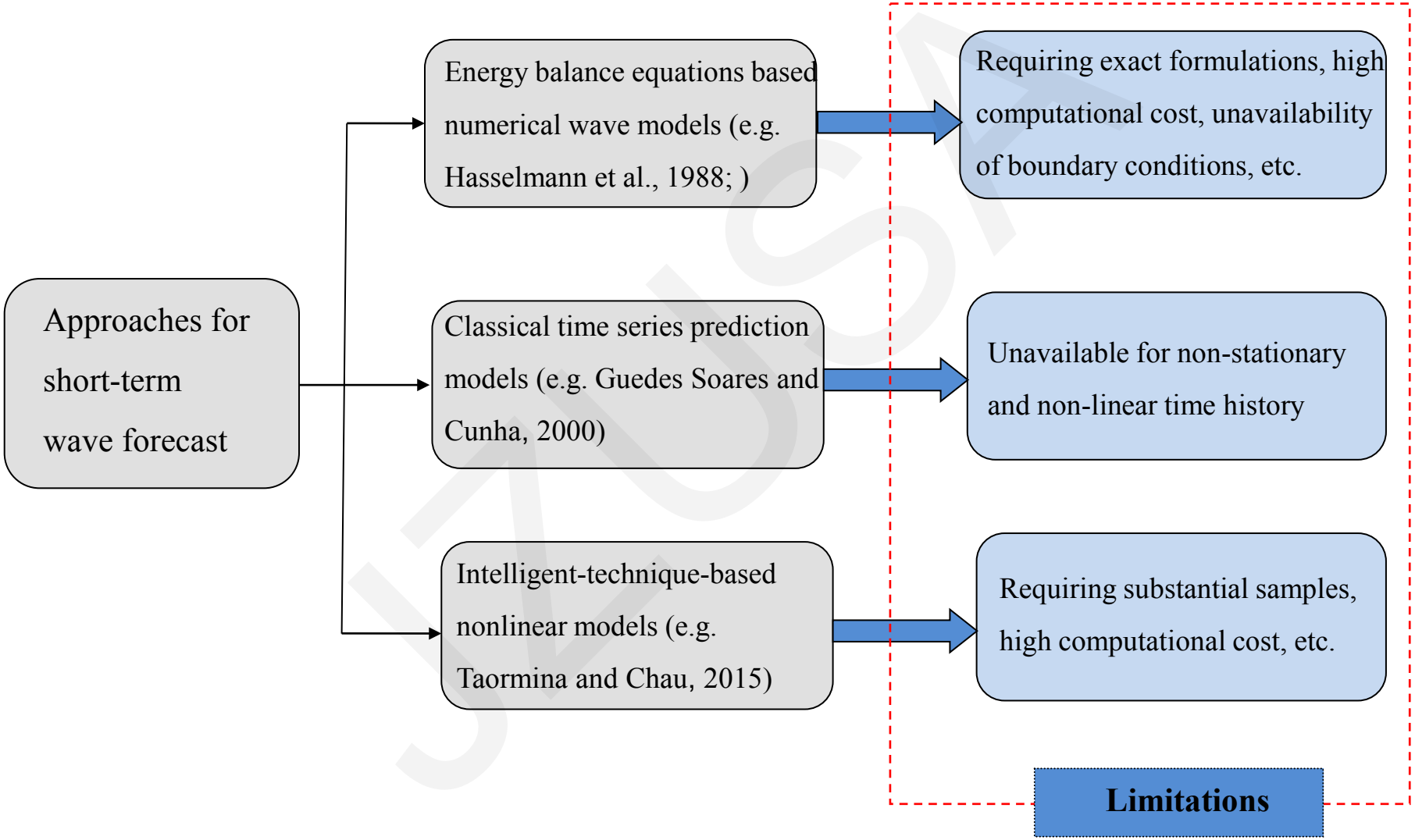
Approaches for short-term wave forecast



Non-stationarity in ship motions

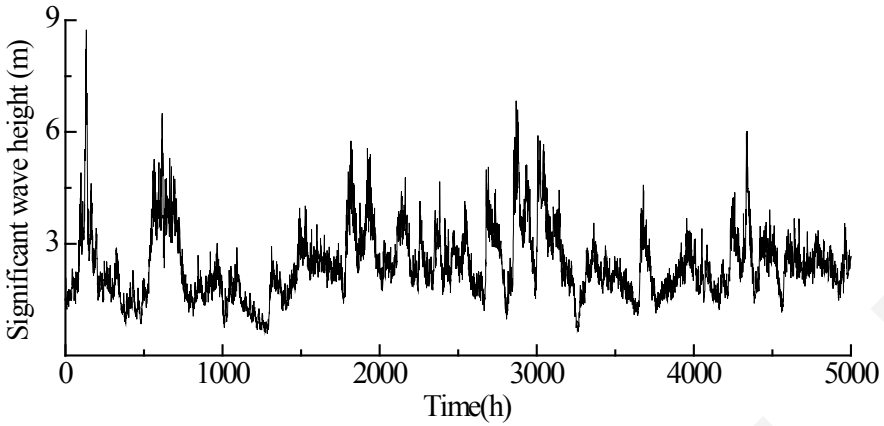


Fig.1 Measured significant wave height records by buoy No. 41053 that is located at the coast of San Juan, Puerto Rico (18° 28'27" N, 66° 5'57" W) and maintained by the National Data Buoy Center.

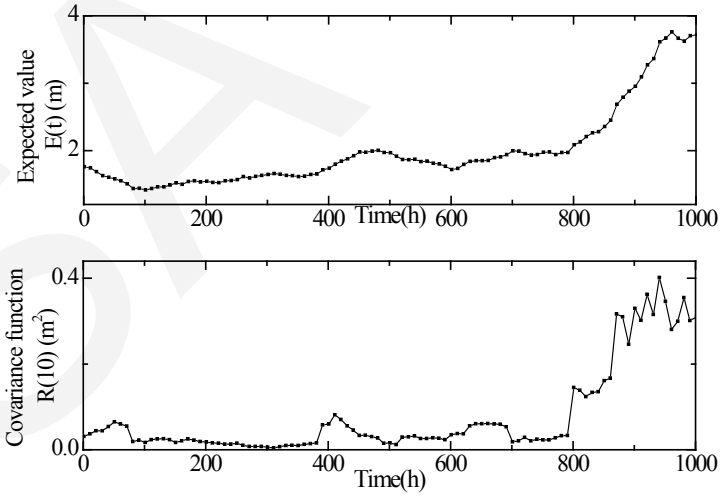


Fig.2 Expected value and covariance functions of the measured significant wave height records in Fig. 5.

Notable time varying expected value functions and covariance functions demonstrates the presence of non-stationarity in significant wave height data.

The proposed EMD-AR model

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Fig.3 Flowchart of the hybrid EMD-AR prediction model

Results: time history comparison

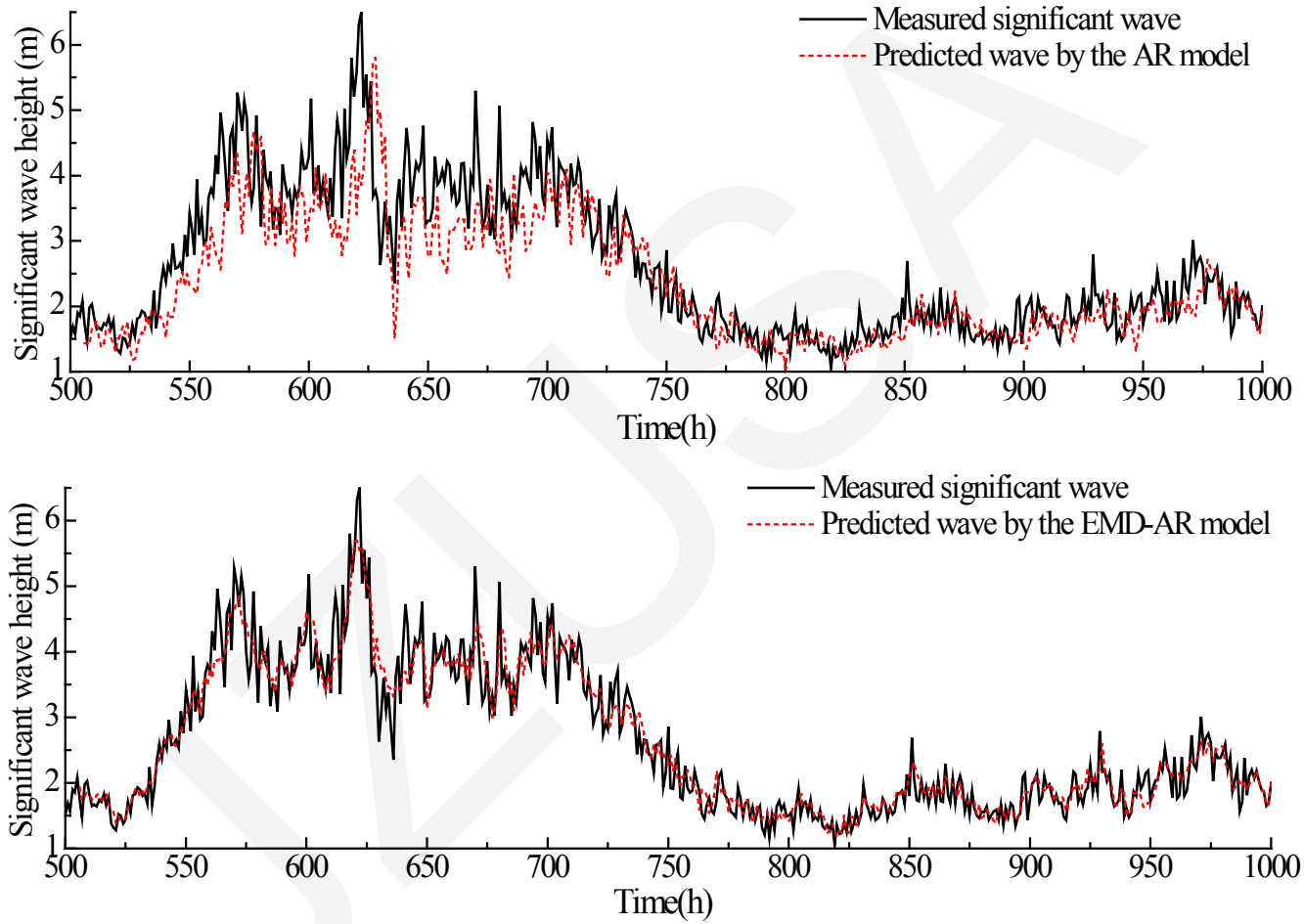

Fig.4 6-h forecast of significant wave by the AR and EMD-AR models. The wave height time history was measured by buoy No. 41053 located at the coast of San Juan, Puerto Rico (18° 28'27" N, 66° 5'57" W)

Results：scatter diagram comparison

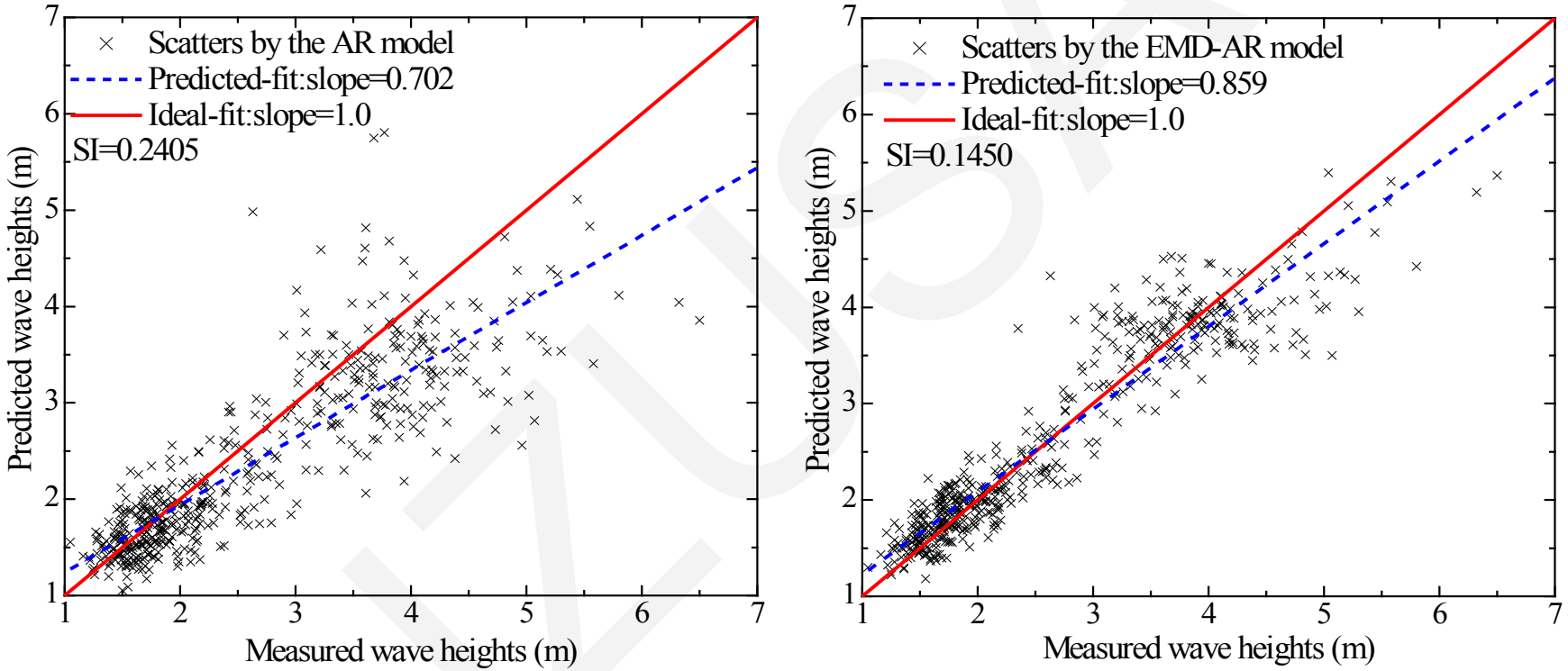

Fig. 5 Scatter diagrams of observations and 6-h predictions as shown in Fig. 4

Results：error measures comparison

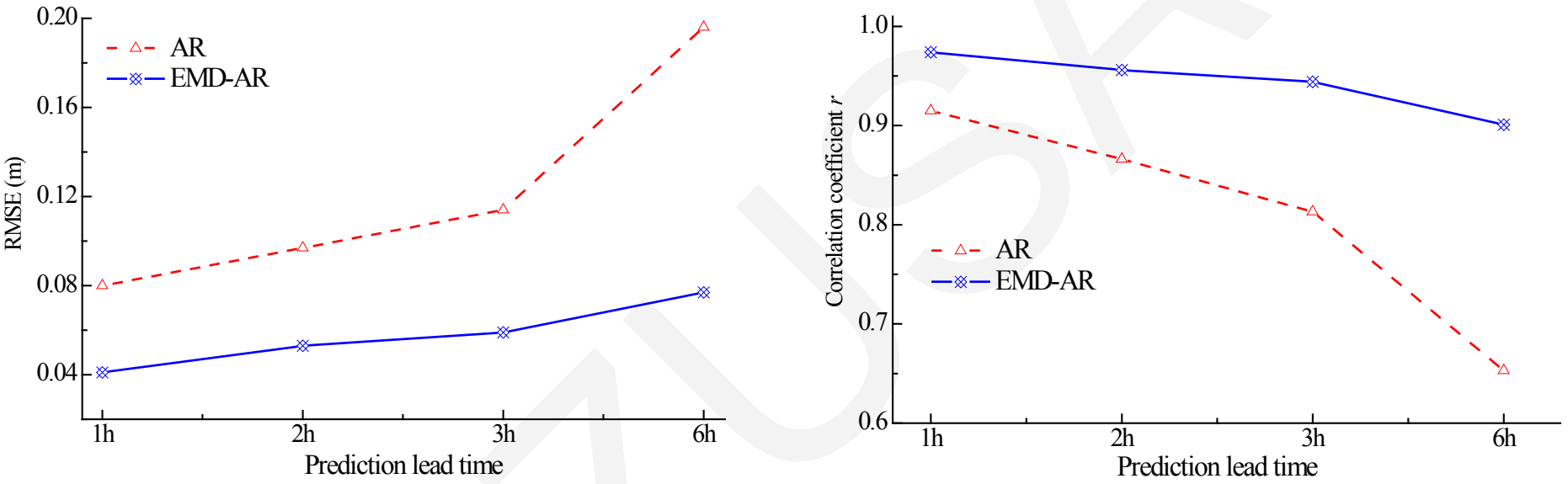

Fig.6 Prediction error measures of the AR and EMD-AR models in various lead times. Where the wave height time history measured by buoy No. 41053 was used.

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Conclusions

- The nonlinearity leads to spatial offsets in the predicted results while the non-stationarity results in obvious shifts between in predicted and measured wave heights.

- The EMD technique is effective in handling nonlinear and non-stationarity ocean wave whereas the conventional AR model suffers difficulty.

- Comparative analysis of the AR and EMD-AR models highlights the superiority of the proposed method providing forecasts.

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