Multimodal fusion for sea level anomaly forecasting

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The accumulated remote sensing data of altimeters and scatterometers have provided a new opportunity to predict the ocean states and improve the knowledge in ocean/atmosphere exchanges. Few previous studies have focused on sea level anomaly (SLA) forecasting by deep learning for different modalities. For this paper, a novel multimodal fusion approach named MMFnet is used for SLA forecasting in the South China Sea (SCS). First, a grid forecasting network is trained by an improved Convolutional Long Short-Term Memory (ConvLSTM) network on daily multiple remote sensing data from 1993 to 2016. Then, an in-situ forecasting network is trained by an improved LSTM network, which is decomposed by the ensemble empirical mode decomposition (EEMD-LSTM), on real-time, in-situ and remote sensing data. Finally, the two single-modal networks are fused by an ocean data assimilation scheme. During the validation period from 2017 to 2019, the average RMSE of the MMFnet (single-modal ConvLSTM) is 4.03 cm (4.51 cm), the 15th day anomaly correlation coefficient is 0.78 (0.67), the performance of MMFnet is much higher than those of current state-of-the-art dynamical (HYCOM) and statistical (ConvLSTM, Persistence and Climatology) forecasting systems. Sensitivity experiments analysis indicates that, compared with a set of based single models, the MMFnet, which added CCMP SCAT products and OISST for SLA forecasting, has improve the period of validity over a week and can effectively produces 15-day SLA forecasting with reasonable accuracies. Take wind stress curl and SST anomaly as input data, the MMFnet has better forecasting ability for large-radius eddies in the open sea, and is able to produces accurately SLA forecasting with weak kinetic energy in shallow coastal regions, overcoming a weakness of single forecasting models. In an extension of the validation over the western Pacific Ocean, MMFnet can calculate the forecasting results in a few minutes, and we find good agreement in amplitude and distribution of SLA variability between MMFnet and other classical operational model products.

Keywords: multiple remote sensing, South China Sea, deep learning, convolutional LSTM, multimodal fusion

