Advancing Indonesia's Operational Coupled Ocean Forecasting System through Ensemble Data Assimilation: Initial Results from InaCAWO

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Abstract

The Indonesian Maritime Continent is characterized by strong atmosphere–ocean interactions, complex coastlines, narrow straits, and highly variable ocean circulation. These conditions make marine prediction particularly challenging and require an integrated forecasting system that can represent interactions between the atmosphere, ocean, and waves

BMKG has developed the Indonesian Coupled Atmosphere–Wave–Ocean model, InaCAWO, which integrates WRF, ROMS, and SWAN through the Model Coupling Toolkit. The system has been designed to support operational marine forecasting in Indonesia. The current development focuses on improving forecast accuracy through data assimilation and ensemble forecasting.

This study presents the first implementation of ROMS–DART ensemble data assimilation within the InaCAWO framework. An 80-member ROMS ensemble was combined with multiple ocean observations collected during 2–10 October 2025. The observations included SVP drifter sea surface temperature and currents, ARVOR float temperature and salinity profiles, HF Radar total and radial surface currents, CMEMS Level-3S satellite SST, and near-real-time satellite sea surface height. After quality control and merging, 44,423 observations from 10 observation types were used in the assimilation experiment.

Initial results show clear improvements in the analyzed ocean state. Assimilation of HF Radar radial velocity reduced surface-current RMSE from 0.293 to 0.170 m s^{-1}, corresponding to an error reduction of approximately 42%. Independent verification using a deep-ocean float showed that temperature-profile RMSE decreased from 1.99°C to 1.64°C, with improved representation of the thermocline. Satellite SST assimilation reduced the mean observation-space bias from +0.37°C to −0.01°C, while SSH assimilation reduced the mean bias from +15.55 cm to −0.60 cm. Temperature increments also extended to several hundred meters below the surface, demonstrating that ensemble covariance can propagate observational information into the subsurface ocean. Evaluation for model accuracy uses the ocean and atmospheric parameters is about 80%.