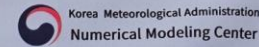


Verification of a Regional Ensemble Wave Model in Summer 2024

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Introduction and Description

- Objective: To evaluate the performance of the KIM-EWW3 ensemble wave model, developed to quantify the uncertainty of a deterministic KIM-RWW3 wave model (KIM: Korea Integrated Model).
- Model specification:
 - Ensemble Members: 26 (1 control run+ 25 perturbed members)
 - Forecast Period: 120 hours (5 days)
 - Domain: East Asia (refer to map)
- Input Data:
 - Wind forcing: 10m wind fields from KIM-GENS (26 members)
 - Boundary Conditions: Global wave model (KIM-GWW3)

Specification	Ensemble Model Regional Ensemble Wave Model (KIM-EWW3)	Deterministic Model Regional Wave Model (KIM-RWW3)
Base	WAVEWATCH III ver6.07	WAVEWATCH III ver6.07
Model domain	115°E - 150°E, 20°N - 50°N	115°E - 150°E, 20°N - 50°N
Resolution (Grid)	1/12° × 1/12° (421 × 361)	1/30° × 1/30° (1051 × 901)
Boundary conditions	Global Wave Model (KIM-GWW3)	Global Wave Model (KIM-GWW3)
Wind forcing	10m Wind (26 members) from Global Ensemble Model (KIM-GENS)	10m Wind from Global Model(KIM-Global)

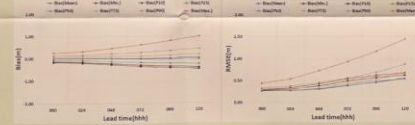
<Model Domain and Verification Buoy Locations>



Verification of Model

- Verification Description:
 - Verification Period: July to September 2024
 - Verification Buoys: 32 (refer to map)
 - Verification methods for Significant Wave Height (SWH)
 - Percentile verification: Bias, RMSE for each percentiles
 - Deterministic verification: Bias, RMSE (comparison with KIM-RWW3)
 - Probabilistic verification: ROC (Receiver Operating Characteristic), Brier score
- Results: Percentile verification
 - The ensemble mean and 50th percentile member shows the lowest Bias and RMSE.

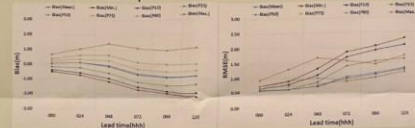
<Bias and RMSE for percentiles and ensemble mean>



Forecast time (hours)	RMSE of Percentiles (unit: m)							
	Min.	P10	P25	P50	Mean	P75	P90	Max.
24	0.34	0.31	0.28	0.28	0.28	0.32	0.38	0.54
48	0.43	0.38	0.33	0.31	0.31	0.37	0.46	0.73
72	0.54	0.49	0.42	0.39	0.39	0.44	0.56	0.93
96	0.62	0.57	0.48	0.45	0.46	0.53	0.69	1.16
120	0.67	0.62	0.54	0.54	0.55	0.66	0.87	1.44

- For the observed SWH > 3m, the 75th percentile member shows the best performance.

<Bias and RMSE of percentiles and ensemble mean for SWH > 3m>



- Results: Deterministic verification
 - Comparison of KIM-EWW3 (ensemble mean) and KIM-RWW3 for overall and high wave (SWH > 3m) conditions.

Conclusions

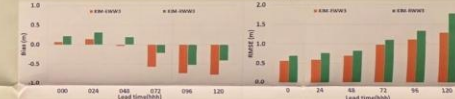
- Conclusions
 - At the 72-hour forecast, KIM-EWW3 significantly outperformed KIM-RWW3 in RMSE, with improvements of 4.9% for overall SWH and 11.7% for high waves.
 - For high wave conditions during summer 2024, the 75th percentile member proved to be the most effective predictor.
 - Probabilistic scores at 72 hours (ROC: 0.93, Brier Score: 0.08) confirm the reliable probabilistic forecasting capability of KIM-EWW3.
 - Based on this comprehensive evaluation, KIM-EWW3 is expected to enhance the accuracy of operational wave forecasting.
 - The model's ability to provide probabilistic information, such as EPSgrams and ensemble spread, offers valuable guidance for wave forecasters.

※ This research was supported by the Korea Meteorological Administration (KMA) under the

<Bias and RMSE of KIM-EWW3 vs. KIM-RWW3 (All SWH)>



<Bias and RMSE of KIM-EWW3 vs. KIM-RWW3 (High Wave Conditions, SWH > 3m)>



- Overall SWH :
 - Bias: KIM-EWW3 shows a lower bias up to 96-hour forecast lead time. (e.g., at 72hr: KIM-EWW3 0.07m, KIM-RWW3 0.04m)
 - RMSE: KIM-EWW3 shows a lower RMSE throughout the entire forecast period. (e.g., at 72hr: KIM-EWW3 0.39m, KIM-RWW3 0.41m)
- High Wave conditions (SWH > 3m):
 - RMSE: The RMSE improvement of KIM-EWW3 is particularly notable under high wave conditions (e.g., 72hr: KIM-EWW3 0.98m, KIM-RWW3 1.11m)

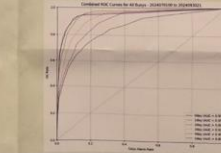
Results: Probabilistic Verification

- Event Threshold: SWH exceeding the observed mean by +1σ
- KIM-EWW3 demonstrates stable and reliable probabilistic performance, which slightly degrades with longer forecast lead times.

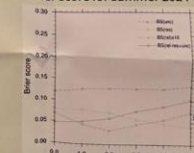
※ AUC: Area Under Curve

Forecast hour	0	24	48	72	96	120
ROC score (AUC)	0.95	0.95	0.95	0.93	0.90	0.85
Brier score	0.05	0.06	0.07	0.08	0.09	0.10

<ROC curve for summer 2024>



<Brier score for summer 2024>



※ rel: reliability
res: resolution
unc: uncertainty

<Probabilistic information>

