Evaluation of the extended-range ensemble forecast experiments using the low-resolution KIM Hybrid 4D-EnVar system

Eun-Hee Lee(ehlee@kiaps.org), Eun-Hye Lee, Hye-Jin Park, and Keon-Hee Cho
Korea Institute of Atmospheric Prediction Systems(KIAPS), Seoul, Korea

1 Background

- Korea Institute of Atmospheric Prediction System (KIAPS) accomplished the first 9-year project (2011-2019) successfully, and Korean Integrated Model (KIM) began the operational global medium-range prediction in 2020. Now, in the second phase, one of missions is expanding the forecast length into the sub-seasonal range (~30 days) for the advantages in extreme weather prevention. To achieve this goal, coupling with ocean, sea-ice model and ensemble prediction system development are in progress.
- This study investigates the ensemble prediction capability simply using the current KIM system, in which the data assimilation, Hybrid 4d EnVAR using 50 ensembles, enables to produce prediction members easily. For the start-up, a low resolution prediction with a limited number of ensembles(4 & 13) is tested.
- The main objectives are to understand the extended range ensemble prediction using KIM-atmosphere and to accelerate the development processes of other components such as coupling, ensemble design, verification and diagnose tools, and so on.

2 KIM Low-resolution Prediction System (KLOS) & experimental set up

KLOS experiment (atmosphere only)	
Model	KIM version 3.6 Non-hydrostatic, spectral element over cubed-sphere grid Advanced physics package (Hong et al., 2018)
Resolution	100 km (ne045np3)
Vertical layer	91 layers
Data assimilation	Hybrid-4D EnVar * 4 vs 13 ens. prediction expanded ~32 days
Prediction period	Jan.-Feb. 2019 (spin-up 20 days), 00 UTC

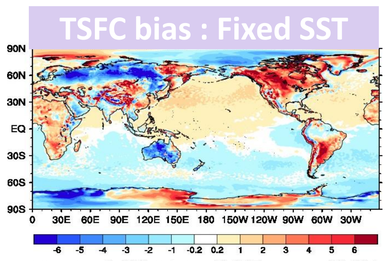
Ensemble perturbation method		
Initial Perturbation	Method	LETKF (50 members)
	Inflation	Additive inflation Relaxation to prior spread (RTPS) inflation
Initial surface uncertainty		Stochastically perturbed sea surface temperature (SSST)
Model uncertainty		Stochastic perturbation of physical tendency(SPPT) & dynamic tendency(STDT)

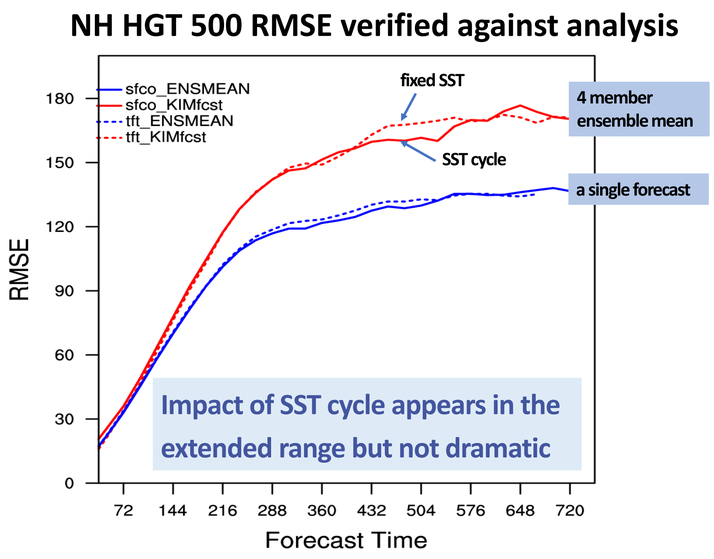
A first forecast cold-run is initialized by ERA5 reanalysis, and land/ocean condition is initialized for every forecast by GFS analysis and OSTIA SST/sea-ice.

3 Results

Impact of SST cycle

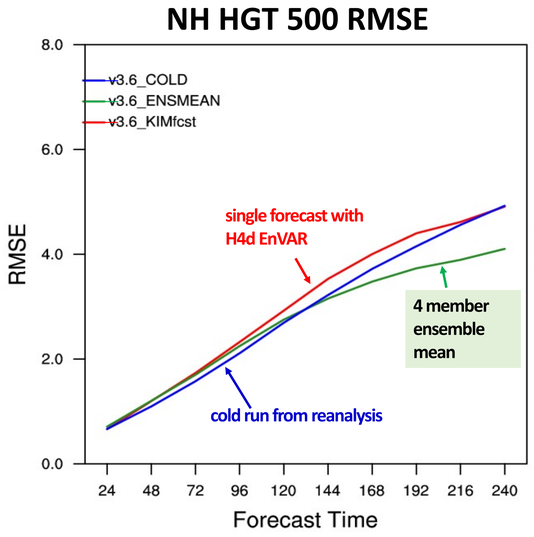
❖ Impact of SST is tested by 24h SST observation cycling in prediction

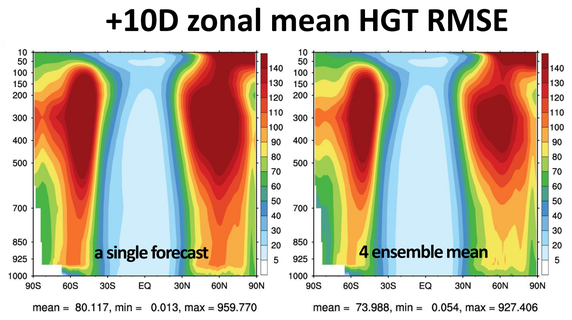




Ensemble mean vs single forecast

❖ Ensemble mean forecast accuracy compared with single forecasts.

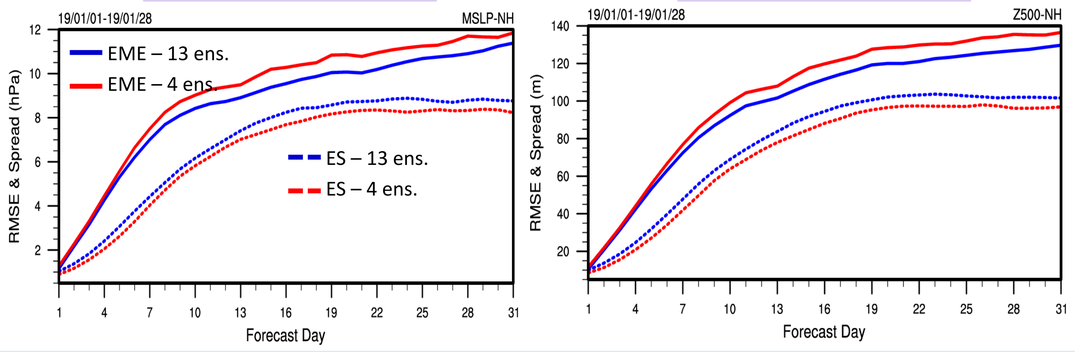




4 Ens. mean prediction accuracy is superior to not only a single member but also the cold-run from reanalysis after +6D forecast

Ensemble size & spread-skill relationship

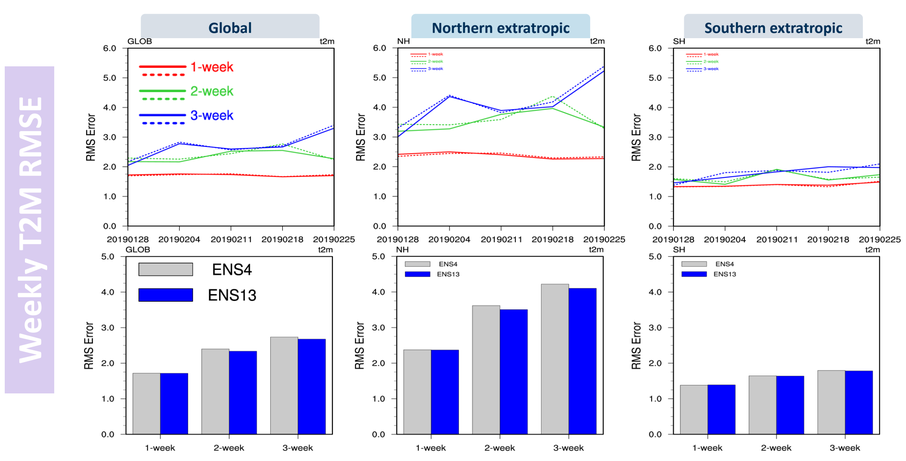
❖ 4 & 13 members ensemble forecast: RMSE and spread



Ensemble size increase improves forecast accuracy significantly throughout the forecast range. However, EME(Ensemble Mean Error) - ES(Ensemble spread) relation shows that current KLOS system does not address model uncertainty well over all forecast ranges

Weekly forecast verification

A preliminary weekly deterministic forecast verification system is developed
- 4 or 13 members per day X 7 days used for a week forecast
- ERA5 used for both observation and forecast climatology



* Without hindcast, model climatology is considered to be the same with observation

4 Summary

- KLOS is a test set-up for developing the KIM extended range forecast system, and results show capability of KIM ensemble prediction.
- Ocean coupling and data assimilation is a must but a surface cycle test shows the marginal impact in overall accuracy in 30-day forecast.
- The ensemble size increase is the effective way to improve skill but considerable improvement to address the model uncertainty is required.
- This experiment is performed only for a short period and evaluation is quite limited. Further research will support soon.

「ECMWF workshop on model uncertainty, 9–12 May 2022, ECMWF