기상청
수치모델링센터

Impact of Aeolus HLOS winds in the Korean global model KIM

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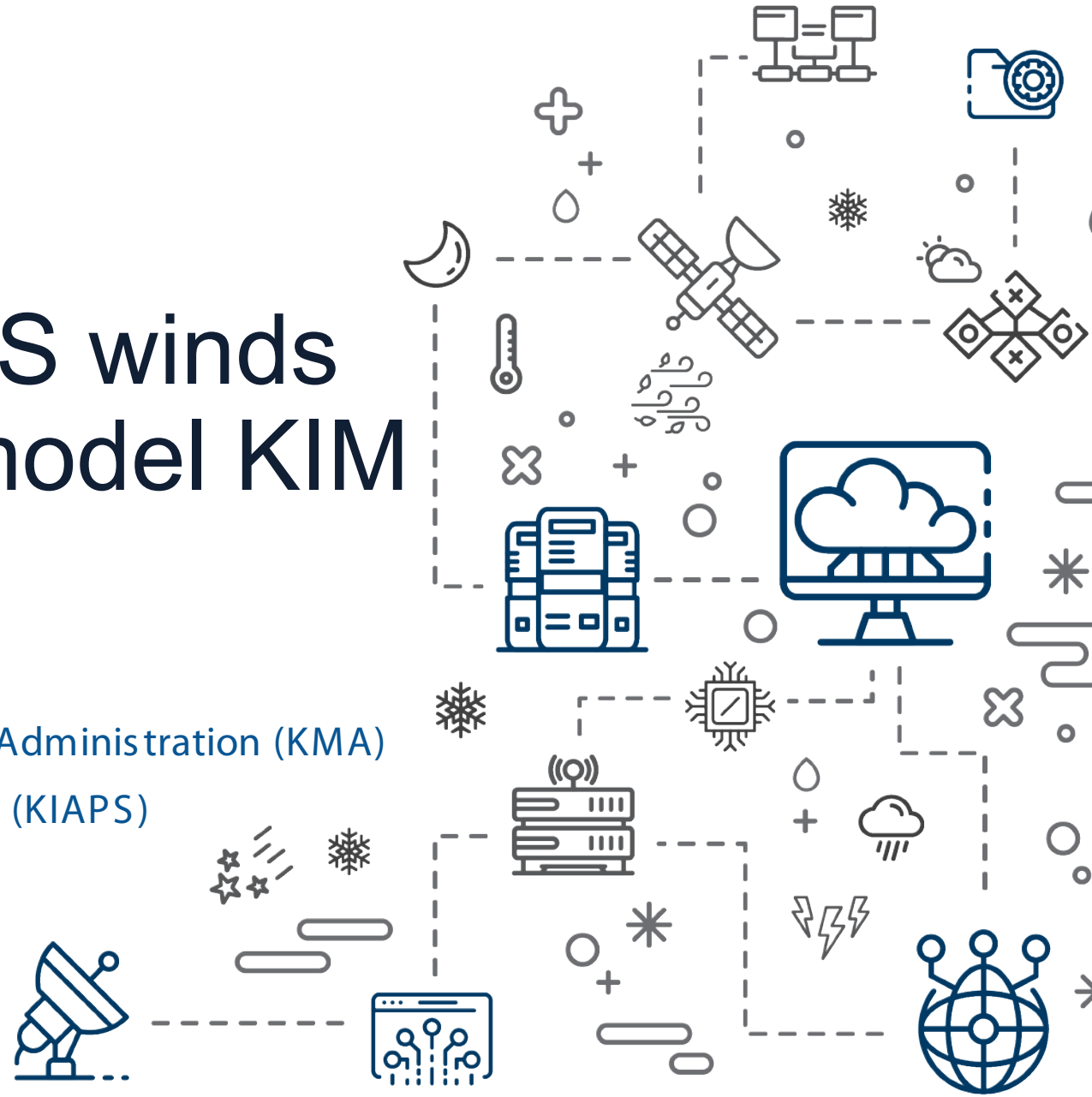

2021.12.3.

contents

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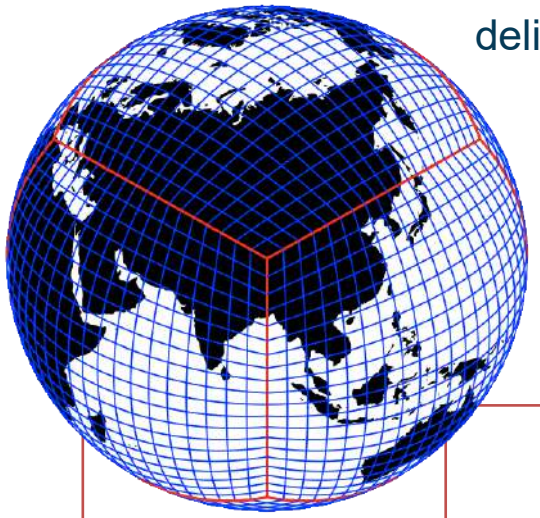
KIM, Korean global NWP model

The **Korea Institute of Atmospheric Prediction Systems** (**KIAPS**)
delivered the global NWP system to the Korea Meteorological Administration (KMA)

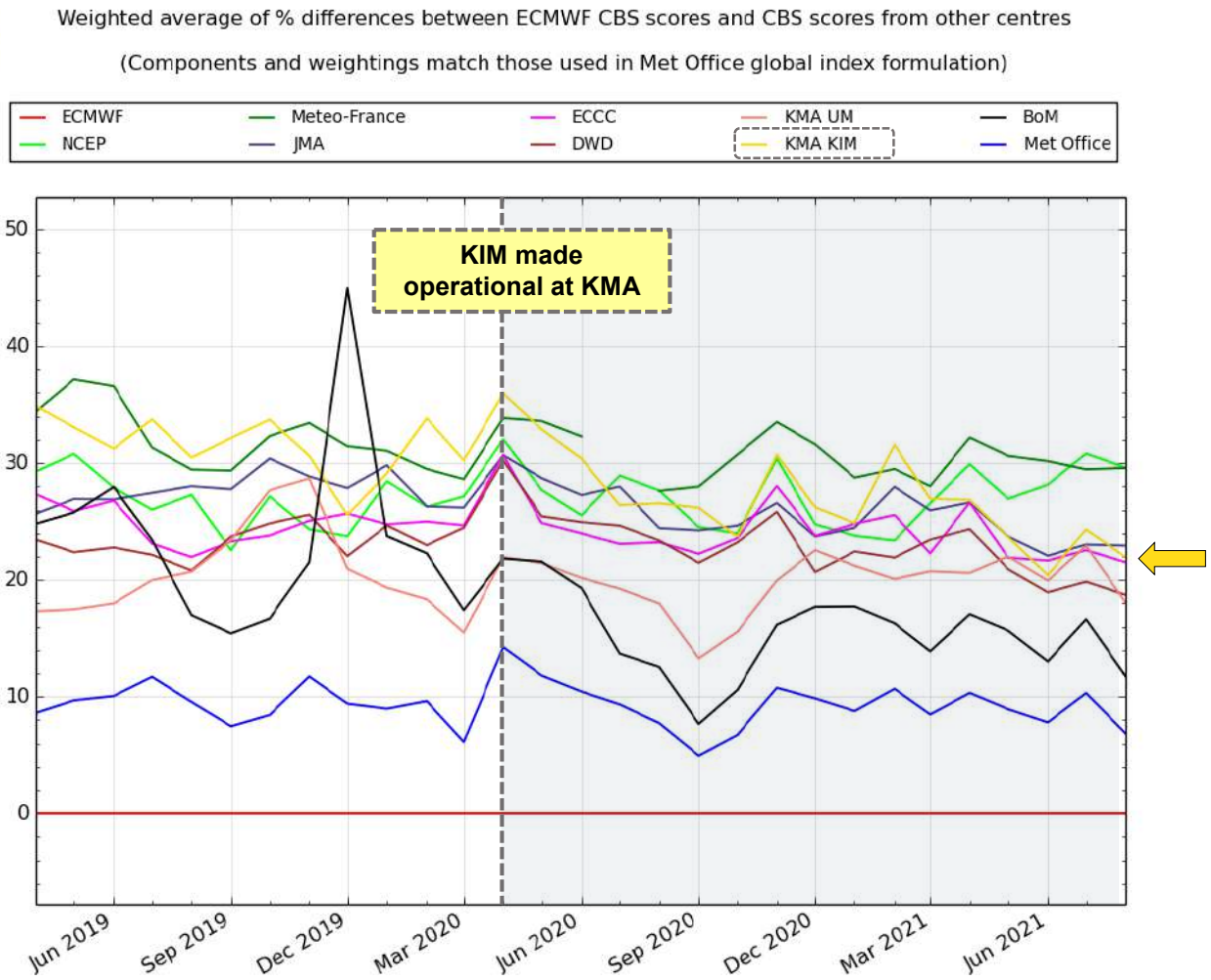


KIM: Korean Integrated Model
Cubed sphere grid structure global model
Horizontal resolution: NE360NP3 ~ 12km
Vertical resolution: 91 levels with 1 Pa top

	Dynamics	Physics
Numerical method	Spectral Element method	**RRTMG-K** (Baek 2017) **Noah LSM** (Koo et al. 2017) **Scale-aware PBL** (Shin & Hong 2015) **Scale-aware CPS** (KIAPS-SAS) (Han and Pan 2011, Kwon and Hong 2017) **Adjustment SCV** (Hong et al. 2013) **WSM5 MPS** (Hong et al. 2004) **Prognostic cloud** (Park et al. 2015)
Spherical grid	Cubed-sphere (Equi-angular gnomonic projection)	
Equation	Non-hydrostatic (Perturbation form)	
Temporal approximation	Split-explicit RK3, second-order for nonlinear equation	
Explicit spatial diffusion	6th order horizontal diffusion + divergence damping	

KMA has been operating UM and KIM in parallel since April 2020.

KIM performance



Plot produced using Met Office software, with permission

Weighted RMSE %age differences relative to ECMWF

$$\sum_{\text{component (c)}} \left(\frac{\text{RMSE} - \text{RMSE}_{\text{ECMWF}}}{\text{RMSE}_{\text{ECMWF}}} \right) \times w_c$$

where $\sum_c w_c = 100$

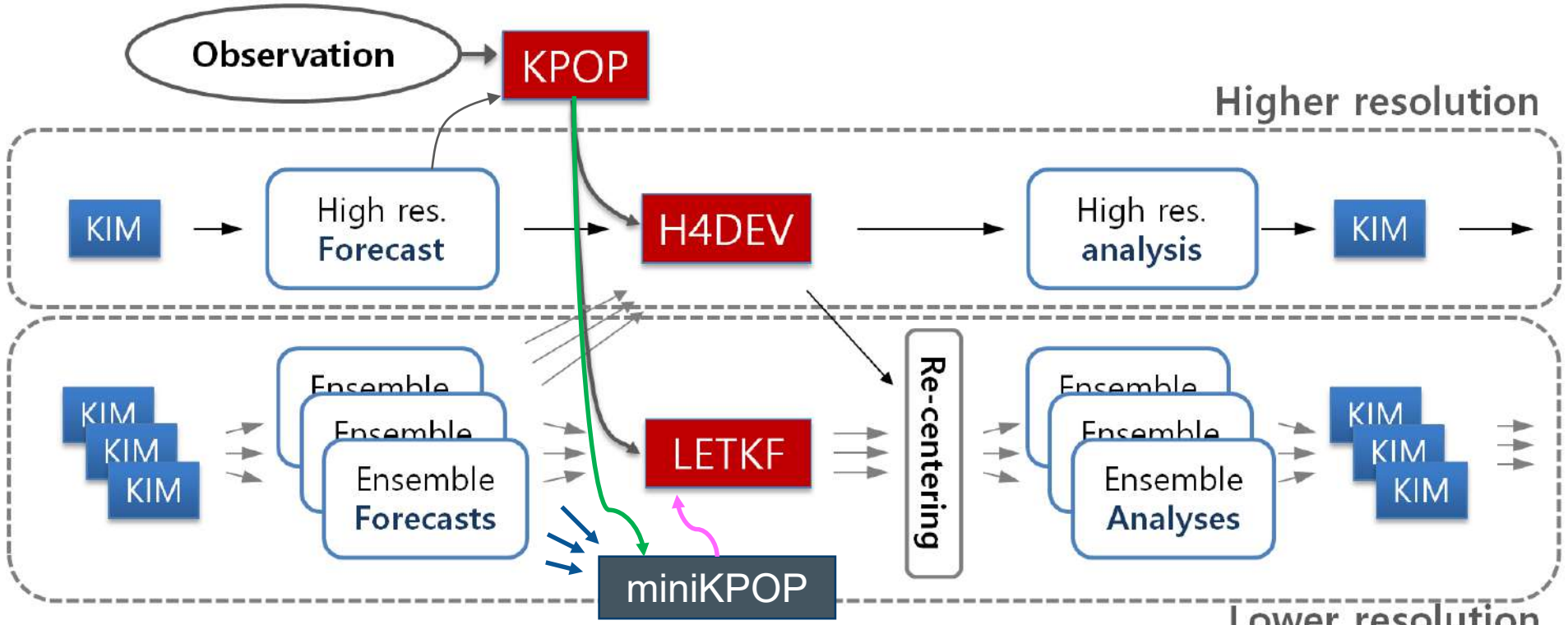
Component weights w_c

Area	Parameter	Forecast range				
		T+24	T+48	T+72	T+96	T+120
NH	PMSL	6.4	6.4	6.4	6.4	6.4
	500 hPa GPH	2.4	2.4	2.4	2.4	2.4
	250 hPa Wind	2.4	2.4	2.4	2.4	2.4
TR	850 hPa Wind	2.0	2.0	2.0	2.0	2.0
	250 hPa Wind	1.2	1.2	1.2	1.2	1.2
SH	PMSL	3.2	3.2	3.2	3.2	3.2
	500 hPa GPH	1.2	1.2	1.2	1.2	1.2
	250 hPa Wind	1.2	1.2	1.2	1.2	1.2

- Verification against own analyses
- 1.5° x 1.5° verification grid

Data assimilation of KIM, 4DEnVar

- KPOP : Observation Preprocessing
- H4DEV : Variational DA
- LETKF : Ensemble DA



KMA Operational

(KIM3.6a)

KIM (ne360np3 ~ 12 km)

Ensemble (ne144np3 ~ 32 km), 50 members

Analysis (ne090np3 ~ 50 km) → New KIM3.7 (ne144np3 ~ 32 km)

Static B : 0.7
Ensemble B: 0.3

Experiment setup

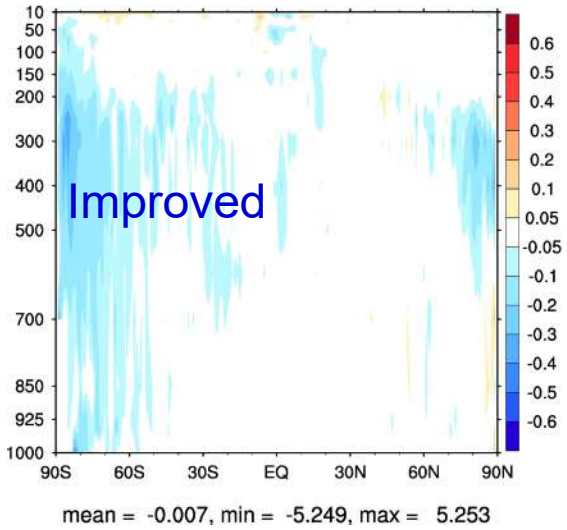
Items	Contents
Model	KIM3.7 (next candidate, Dec 2021) low resolution (ne180, 25 km)
DA	H4DEV(Hybrid 4D Ensemble Variational DA) (ne144, 32 km) Used data: sonde, surface, aircraft, scatwind, amsua, atms, mhs, mwhs2, amsr2, iasi, cris, csr(gk2a, himawari, msg), amv, gpsro
Execution period	Summer 1.5 mon (2020.06.15. ~ 07.31.)
Evaluation period	Summer 1 mon (2020.07.01. ~ 07.31)
CTL	without Aeolus
EXP	with Aeolus • Spatial thinning resolution = 300 km • Observation error inflation = 1.5 times • Mie in cloudy & Rayleigh in clear sky • Rejection: altitude below 1 km • Rejection: confidence flag 1

RMSE difference of wind speed

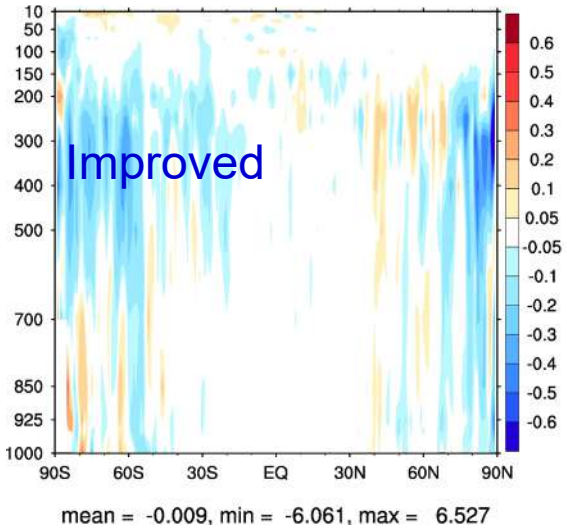
$RMSE_{exp} - RMSE_{ctl}$

RMSE is calculated against IFS analysis

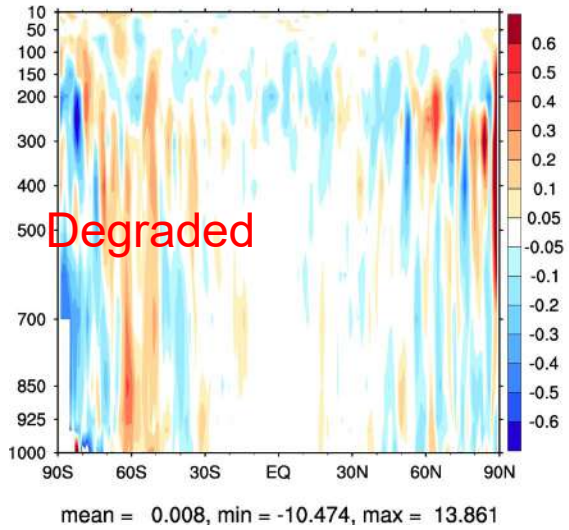
1 day forecast



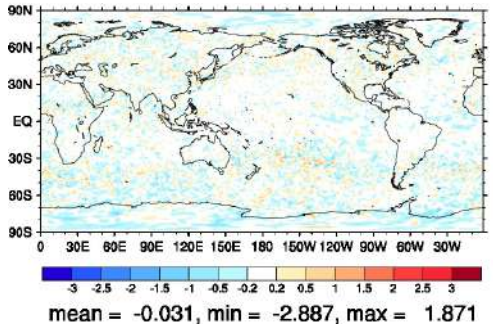
3 day forecast

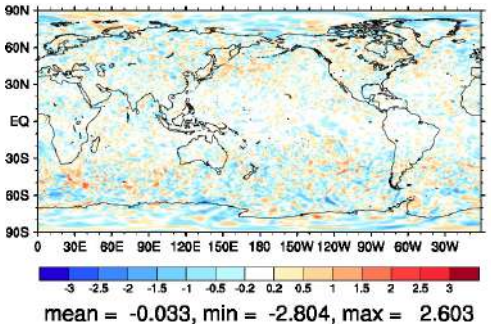


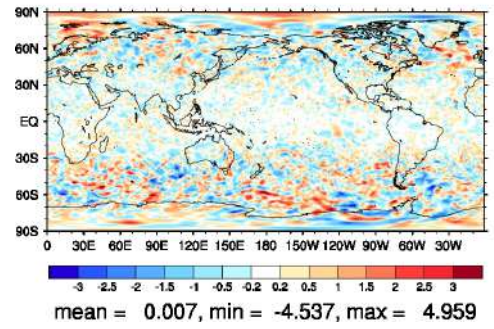
5 day forecast



500 hPa







Wind speed improved up to 3 days forecast in southern hemisphere.

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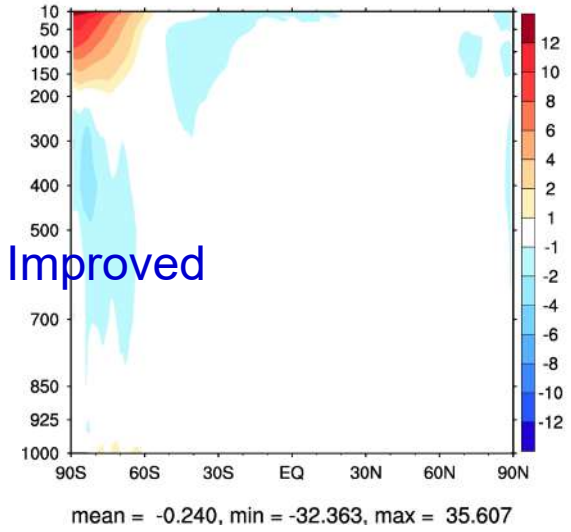
RMSE difference of geopotential

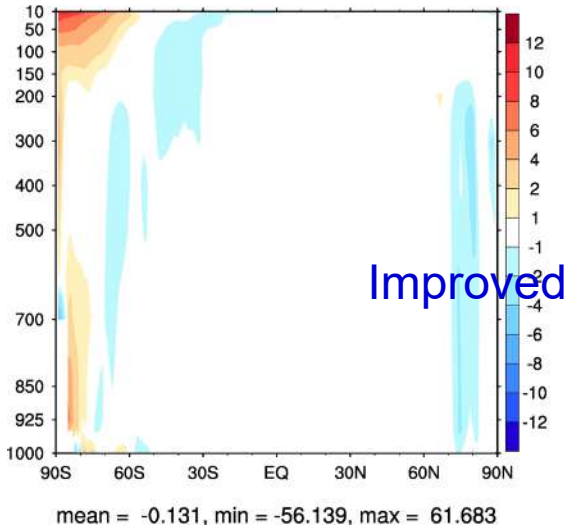
$RMSE_{exp} - RMSE_{ctl}$

RMSE is calculated against IFS analysis

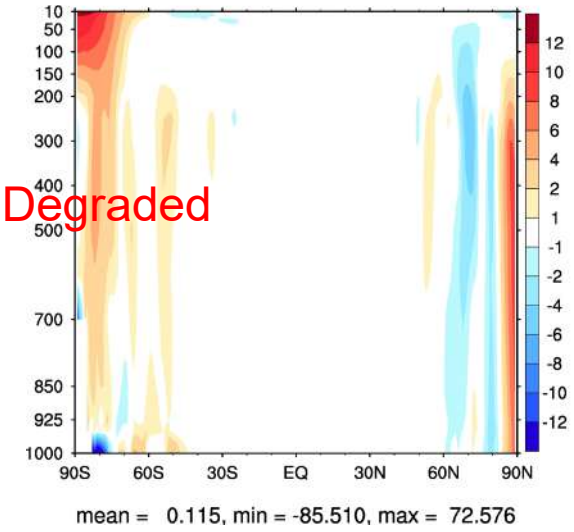
1 day forecast



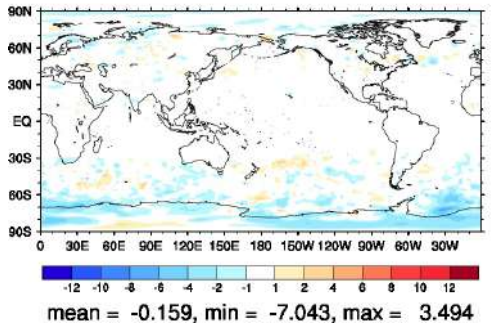
3 day forecast

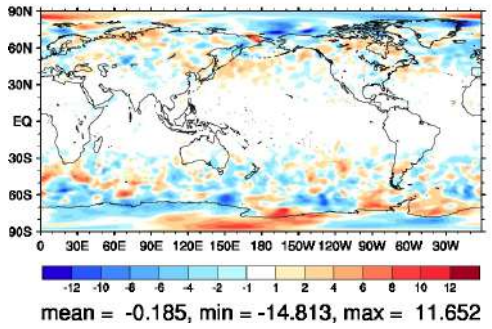


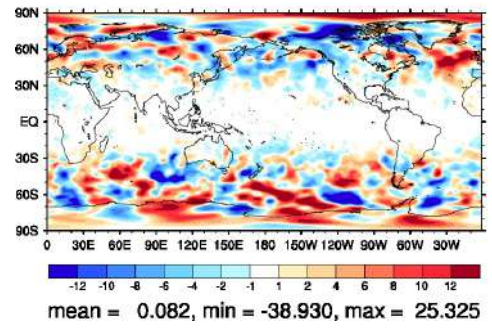
5 day forecast



500 hPa







Geopotential improved up to 3 days forecast

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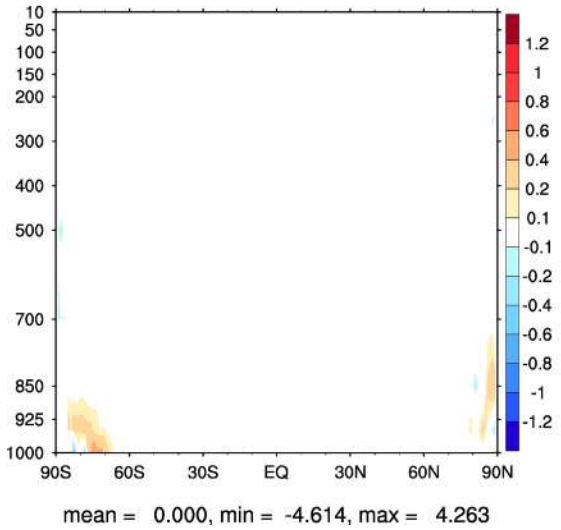
RMSE difference of temperature

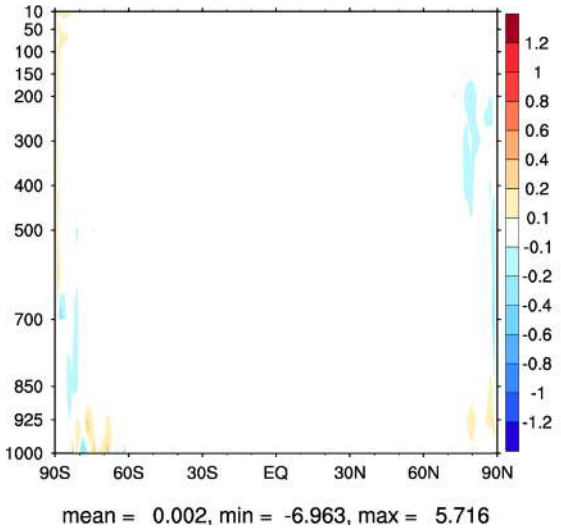
$RMSE_{exp} - RMSE_{ctl}$

RMSE is calculated against IFS analysis

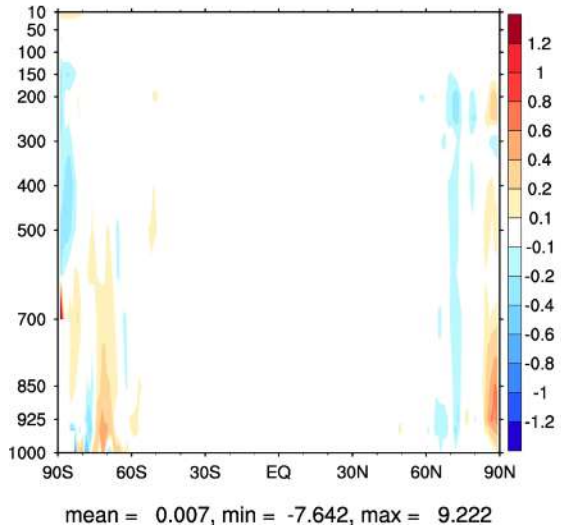
1 day forecast



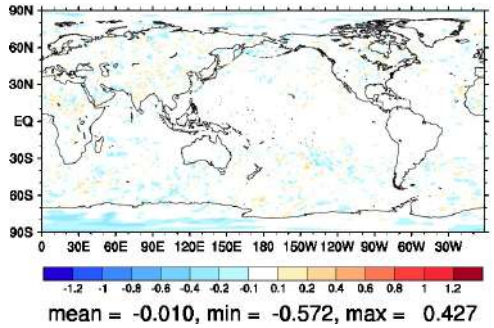
3 day forecast

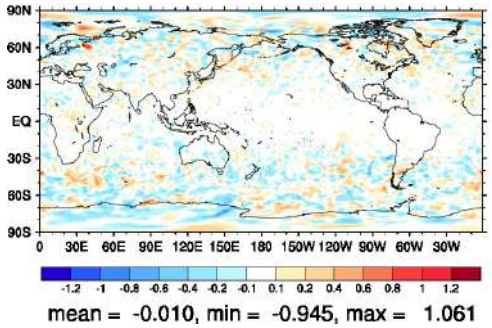


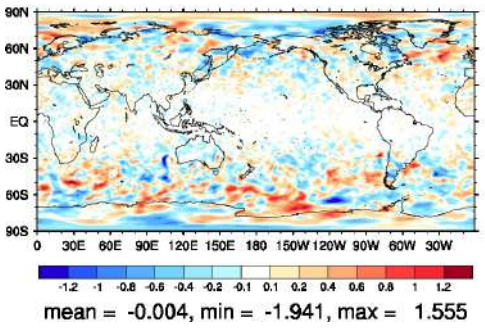
5 day forecast



500 hPa







Temperature looks neutral.

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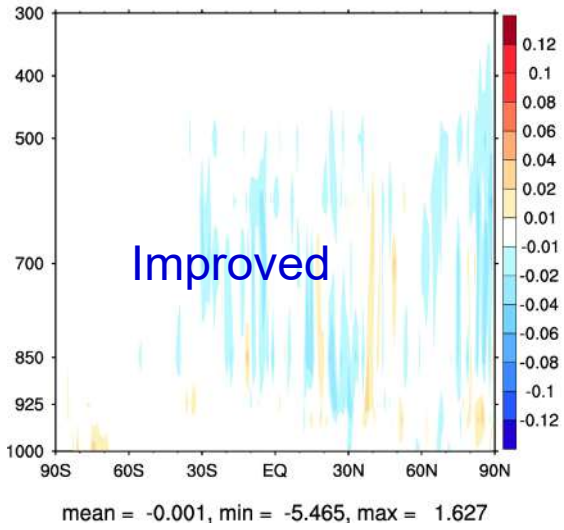
RMSE difference of humidity

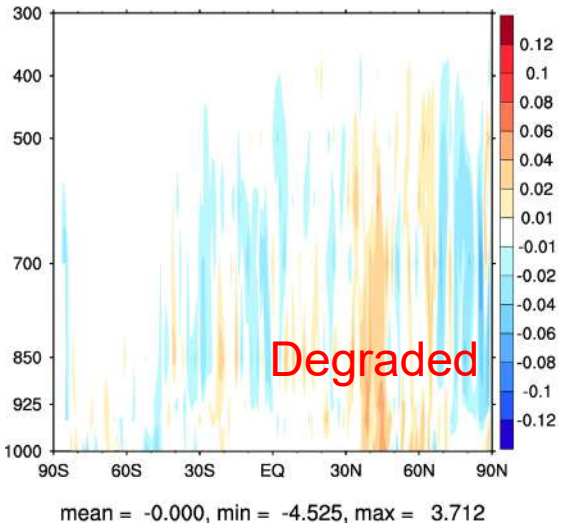
$RMSE_{exp} - RMSE_{ctl}$

RMSE is calculated against IFS analysis

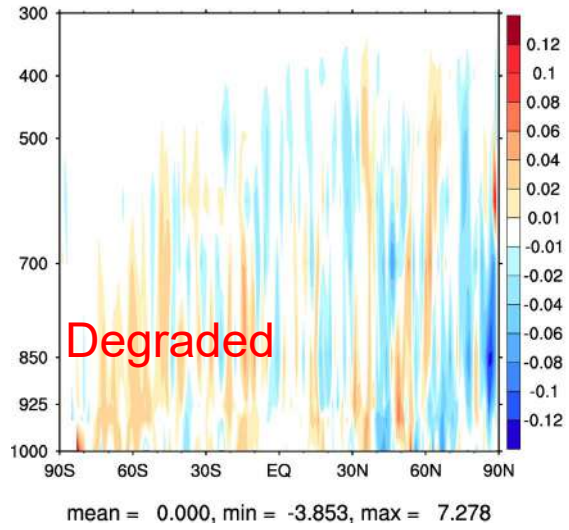
1 day forecast



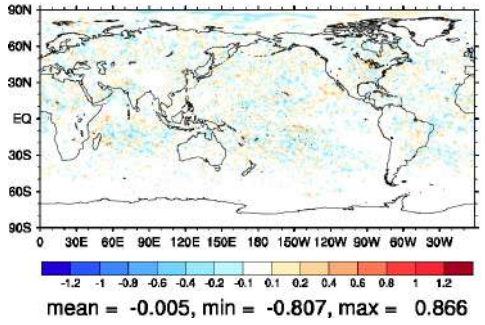
3 day forecast

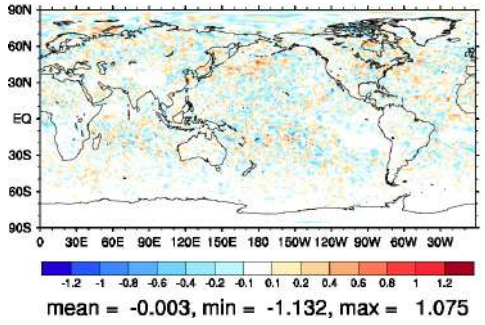


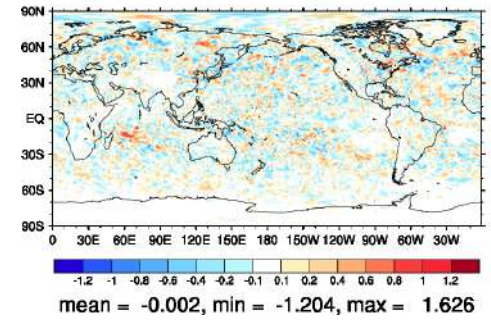
5 day forecast



700 hPa







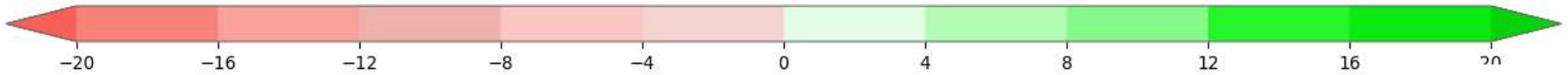
Humidity improved in early forecast.

Improvement ratio of forecast

$(RMSE_{ctl} - RMSE_{exp})/RMSE_{ctl}$

RMSE is calculated against IFS analysis

		Southern Hemisphere						Tropics						Northern Hemisphere					
	fcst time (hr)	00	24	48	72	96	120	00	24	48	72	96	120	00	24	48	72	96	120
Humidity	s700hPa	0.48	1.25	1.45	0.41	0.04	0.09	0.27	0.49	0.53	0.37	0.11	-0.01	0.12	0.14	0.27	-0.12	0.83	0.4
Wind Speed	w250hPa	2.13	2.02	2.43	1.72	0.63	-0.5	0.69	0.36	0.17	-0.01	0.29	0.96	0.59	0.33	0.4	0.12	-0.05	0.13
	w500hPa	2.83	2.03	1.91	1.16	0.15	-0.55	2.47	1.48	0.69	0.87	0.59	0.12	0.47	0.15	0.34	0.52	0.75	0.33
	w850hPa	1.37	1.35	1.04	0.05	-0.54	-0.49	1.32	0.36	0.44	0.2	-0.59	-0.49	0.34	0.4	0.22	0.31	0.53	0.49
Geopotential	z250hPa	7.52	5.21	3.26	2.47	0.57	-0.88	1.38	2.92	2.03	1.81	2.33	2.23	2.73	1.47	0.64	0.03	1.51	0.55
	z500hPa	4.21	3.57	2.57	1.32	-0.3	-1.0	-1.18	1.03	1.27	0.61	-0.63	0.57	0.79	1.31	0.62	1.01	2.82	0.75
	z850hPa	-0.29	0.76	1.36	-0.17	-1.05	-0.53	-1.57	2.2	0.34	0.24	-1.54	-0.53	0.73	1.18	0.19	1.12	2.51	0.33
Temperature	t250hPa	1.78	1.82	1.54	1.74	0.28	-0.2	1.73	1.4	1.39	1.0	0.86	1.28	0.88	0.87	0.87	1.08	1.41	1.06
	t500hPa	3.2	2.2	1.78	1.54	0.64	-0.15	1.81	0.74	0.0	0.24	0.28	0.69	1.51	0.87	0.64	0.21	0.71	0.55
	t850hPa	-0.39	-0.15	-0.2	0.28	-0.32	-0.33	1.17	0.34	0.04	-0.11	-0.4	-0.33	0.57	0.32	0.33	-0.03	0.54	0.44



Degraded with Aeolus

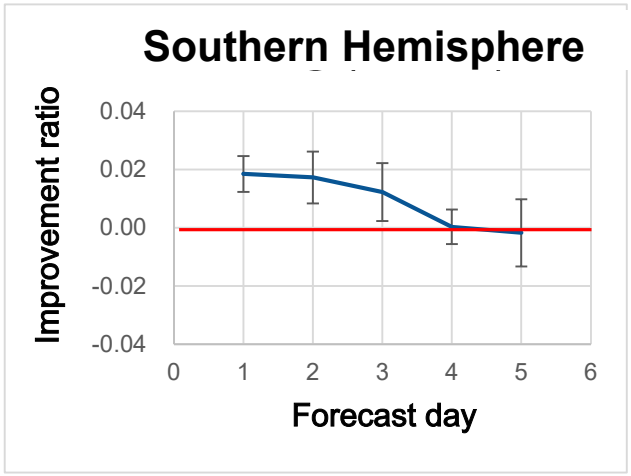
Improved with Aeolus

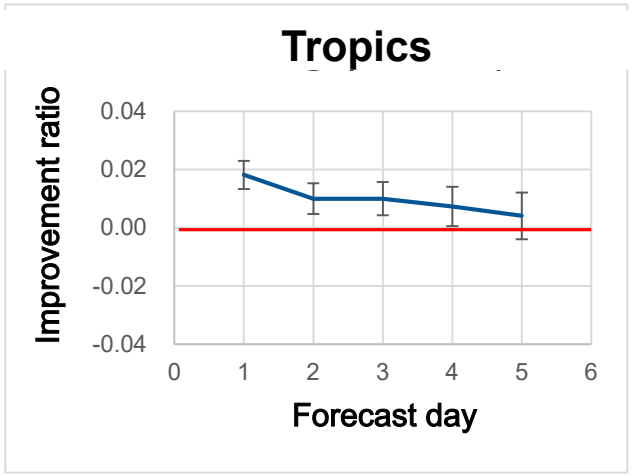
Improvement ratio of forecast

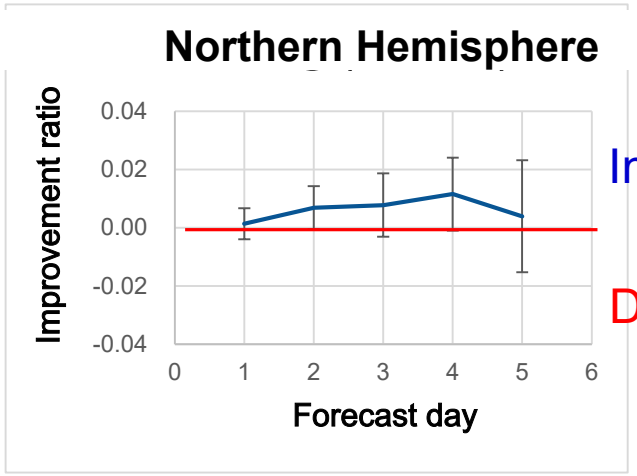
$(RMSE_{ctl} - RMSE_{exp})/RMSE_{ctl}$

RMSE is calculated against IFS analysis

Zonal wind 500hPa



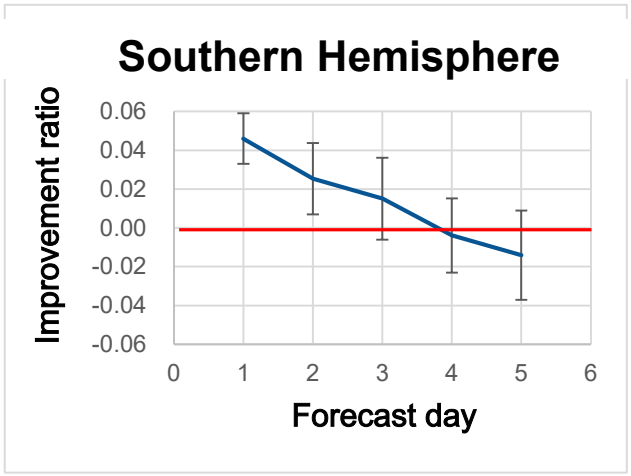


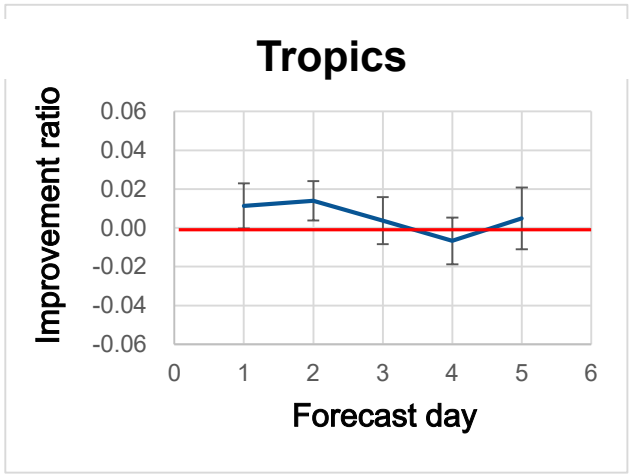


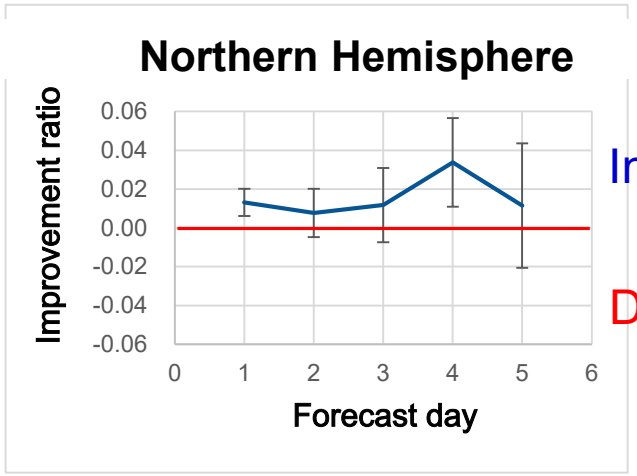
Improved

Degraded

Geopotential 500hPa







Improved

Degraded

Vertical bar indicate 95% confidence interval

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Summary

- We have assessed the forecast impacts of assimilating Aeolus wind data in the Korean global NWP model (KIM) system.
- Assimilation of Aeolus gives a globally significant benefits for 1~2% reduction of the winds RMSE in Southern Hemisphere and tropics up to 3 days forecast.
- In the Southern Hemisphere, Aeolus gives a large improvement in initial field of the geopotential height, but the positive impact can not be last up to 4 days forecast.
- In the Northern Hemisphere, the improvement of the initial field is smaller than in Southern Hemisphere, but the positive effect persists up to 4 days forecast.

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Thank you!!