Satellite Radiance Data Assimilation at KMA(Korea Meteorological Administration)

13p.02

Hyoung-Wook Chun[1], Na-Mi Lee[1] , Jiyoung Son[1], Young-Jun Cho[1], Chang-Hwan Kim[1], Eun-Hee KIM[1], Yong Hee Lee[1], Jeon-Ho Kang[2], Hyeyoung Kim[2], and Ahreum Lee[2]

[1]KMA, [2]KIAPS

Korea Meteorological Administration
Numerical Modeling Center

Contact: chunhw@korea.kr

Configuration of the global NWP system at KMA

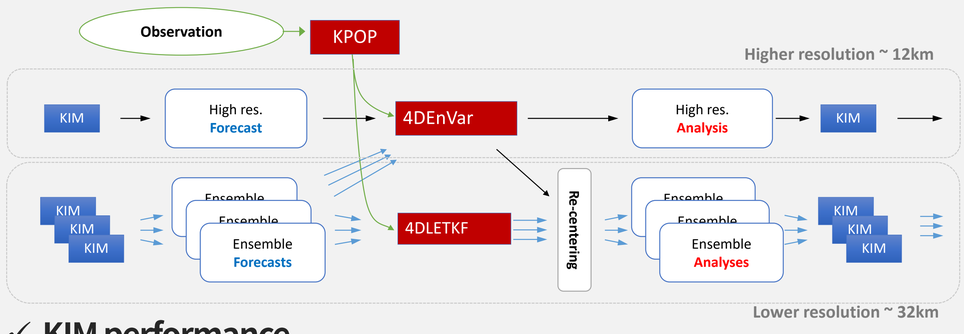
✓ **NWP: KIM(Korean Integrated Model)** launched April 2020

- Spatial resolution: ne360np3 ~ 12km, Cubed sphere grid system
- Vertical resolution: 91 levels, up to 0.01 hPa

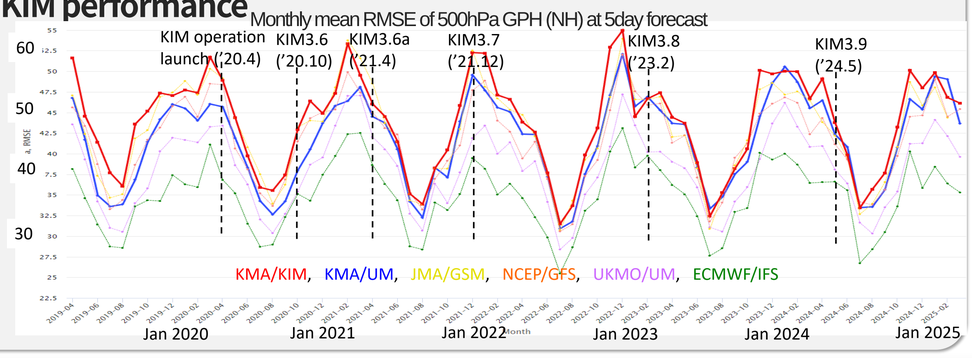
✓ **DA: Hybrid-4DEnVar**

- Incremental analysis resolution: ne144np3 ~ 32km
- 4 analyses per day with 6hour assimilation window
- Background error covariance is combination (Static : Ensemble = 3:7)
- Ensemble: **4D LETKF**, 50 members, ne144np3 ~ 32km
- **KPOP**: KIM Package for Observation Processing

  Radiative transfer model: RTTOV v12.3



✓ **KIM performance**

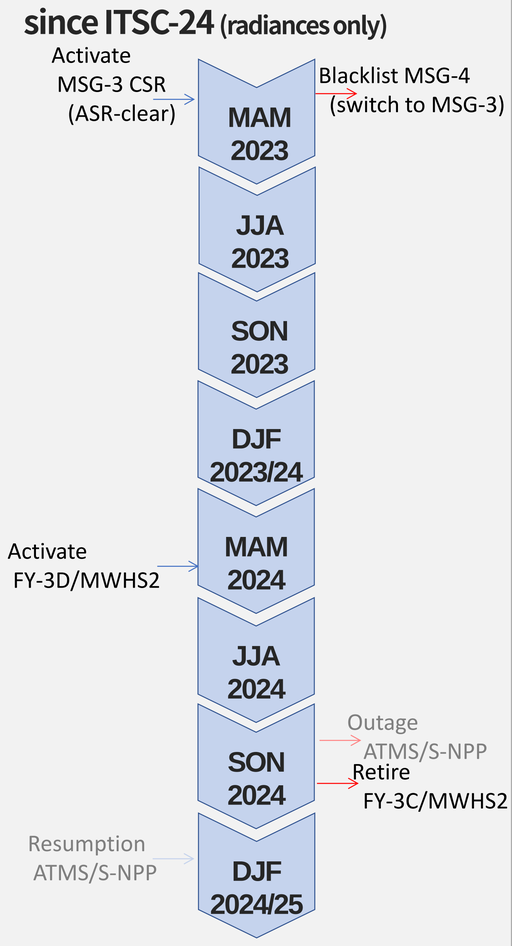


Current use of radiance instruments

A – Assimilated at 4DEnVar
E – Under evaluation
X – Failed/withdrawn
Changes since ITSC-24 are highlighted through orange shading

Satellite	MW Temperature sounder	MW Humidity sounder	MW Imager	IR broadband sounder or imager	IR hyperspectral sounder
NOAA-15	A	X			
NOAA-18	A	X			
NOAA-19	A	A			
NOAA-20	A	A			A
NOAA-21	E	E			E
S-NPP	A	A			X
MetOp-B	A	A			A
MetOp-C	A	A			A
FY-3C		X			
FY-3D		A			
GCOM-W1			A		
GPM			E		
MSG-2				A	
MSG-3				A	
Himawari-9				A	
GK-2A				A	
GOES-16				E	
GOES-18				E	
FY-4B					E

Timeline of main instrument changes since ITSC-24 (radiances only)



MW sounders and imagers

✓ **Main changes** [KIM3.9, May 2025]

- Adding MWHS-2/FY-3D
- ATMS ch8-15 over land
- VarBC update

✓ **Under developing**

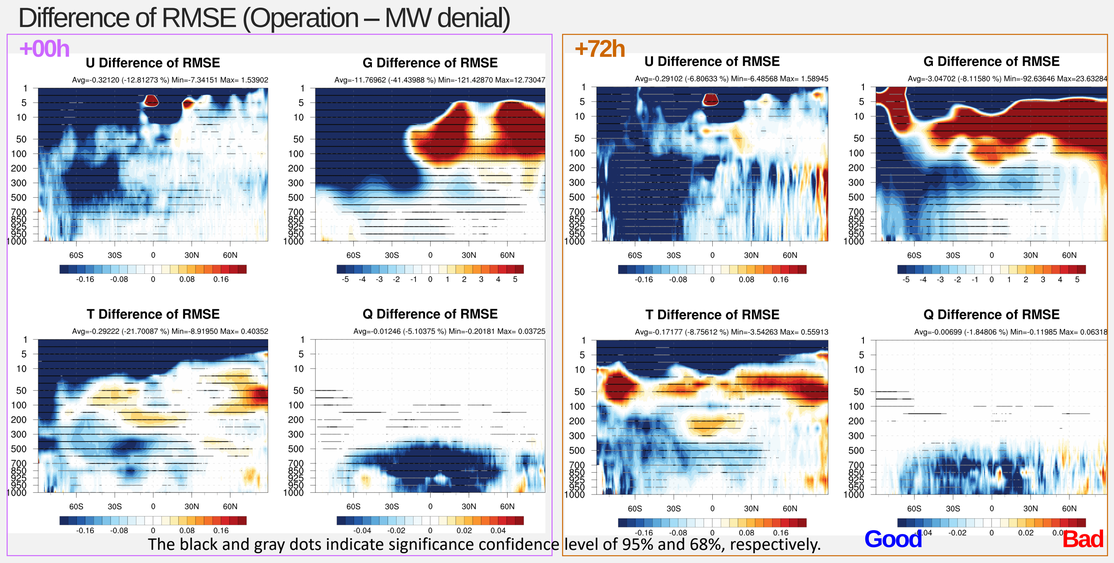
- ATMS using over land → 16p.01 (Hyeyoung Kim)
- All-sky assimilation, MW using over sea ice, Bias correction stabilizing

✓ **Impact of MW radiances on KIM forecasting**

- MW radiances: AMSUA, MHS, ATMS, AMSR2, MWHS2 vs. denial experiment
- Verification period: 1– 31 July, 2022
- Improvement rate of RMSE against ECMWF analysis [%]

		Globe						North Hemisphere						Tropics						South Hemisphere						North Pole						South Pole					
		0	24	48	72	96	120	0	24	48	72	96	120	0	24	48	72	96	120	0	24	48	72	96	120	0	24	48	72	96	120	0	24	48	72	96	120
Q	700hPa	8.71	5.53	3.73	2.74	2.05	1.50	5.13	2.74	1.36	1.27	0.78	0.11	10.85	7.13	4.98	3.42	2.52	2.10	10.17	6.36	5.22	4.36	3.96	3.18	3.47	1.23	0.79	0.24	0.65	-0.83	6.44	4.59	4.26	3.79	3.69	3.70
WS	250hPa	5.10	4.92	4.79	3.96	3.28	3.01	2.79	2.87	2.83	0.39	0.51	1.02	2.34	2.11	1.93	2.05	2.90	3.74	9.73	9.60	8.52	7.87	5.61	4.27	3.94	3.49	3.29	-1.89	-1.26	-0.99	10.35	12.68	8.79	7.53	4.27	4.50
WS	500hPa	5.85	5.56	5.13	4.78	3.65	2.74	3.23	2.44	1.93	1.04	0.95	0.57	4.59	3.41	2.95	2.63	2.86	2.53	8.32	8.28	7.31	6.77	4.81	3.62	2.52	2.54	1.86	0.03	-0.35	-1.26	6.86	6.52	6.38	5.38	4.38	2.84
WS	850hPa	2.76	3.17	3.45	3.30	2.90	2.48	1.15	0.77	1.18	0.85	0.77	0.76	2.31	1.78	2.05	2.08	2.56	2.12	4.50	5.99	5.58	5.10	4.04	3.43	0.91	0.32	1.10	0.88	0.68	-1.24	4.40	5.46	4.76	3.99	2.93	3.18
GPH	250hPa	31.25	21.21	13.36	9.30	6.05	4.16	14.33	13.26	8.78	4.79	1.53	-1.06	24.91	28.19	25.12	17.86	13.02	9.67	43.83	23.14	13.73	10.85	7.90	6.48	15.70	11.26	6.65	0.91	-2.73	-4.75	41.18	24.93	15.27	11.85	10.03	9.49
GPH	500hPa	22.71	18.66	12.92	10.05	7.14	5.16	21.78	13.68	9.51	5.26	1.97	-1.33	22.05	28.63	25.87	23.46	18.48	14.80	23.40	17.89	12.41	10.73	8.37	6.86	16.72	10.32	5.43	2.23	-2.18	-5.00	17.62	15.08	11.03	9.73	9.34	8.95
GPH	850hPa	5.98	7.55	7.01	7.88	6.26	4.93	2.50	0.18	0.16	0.85	0.45	-1.07	5.30	3.09	3.05	8.22	4.48	6.63	7.63	11.96	9.94	9.97	8.08	6.59	3.57	2.20	1.54	1.72	-1.73	-5.48	4.40	12.05	9.04	9.52	9.03	9.04
T	250hPa	1.91	0.24	1.82	1.89	1.84	1.69	3.32	1.81	1.62	0.25	0.10	0.75	-14.50	-16.53	-13.27	-12.42	-10.04	-8.26	7.61	7.15	7.64	7.10	5.63	3.97	5.97	4.68	3.12	0.89	-0.65	0.09	9.60	10.60	8.39	6.04	5.24	4.39
T	500hPa	12.94	10.99	9.02	6.98	4.91	3.59	2.44	6.36	6.08	4.43	1.99	0.27	18.39	15.35	13.29	10.99	8.51	7.57	15.61	10.80	8.60	7.03	5.52	4.53	-3.44	2.25	3.20	1.26	-1.41	-2.77	9.89	10.89	7.85	6.85	6.28	5.25
T	850hPa	7.02	4.85	3.62	3.45	3.03	2.83	2.56	2.45	1.47	1.46	0.50	0.04	10.78	7.36	5.46	4.18	3.76	3.82	6.57	4.28	3.75	4.35	4.29	4.22	-3.58	-1.49	-0.40	-0.66	-1.93	-3.44	4.89	4.66	5.18	5.63	4.85	6.24

- Difference of RMSE (Operation – MW denial)



- The impact of MW on KIM forecasting is mostly positive except for 10~300 hPa temperature and geopotential height.

- MW Issues

#	Location	Description	Future work
1	Tropics @ 300~100 hPa	Temperature performance degradation from the early to the late forecast period	Bias correction
2	Arctic lower-level	Temperature error gradually increases as the forecast progresses, leading to deterioration across all variables.	Expand MW data usage in seaice
3	Overall @ 50 hPa	Temperature and geopotential height after 3day forecast	Bias correction

IR sounders and imagers

✓ **Main changes**[KIM3.9, May 2025]

- VarBC update

✓ **Under developing**

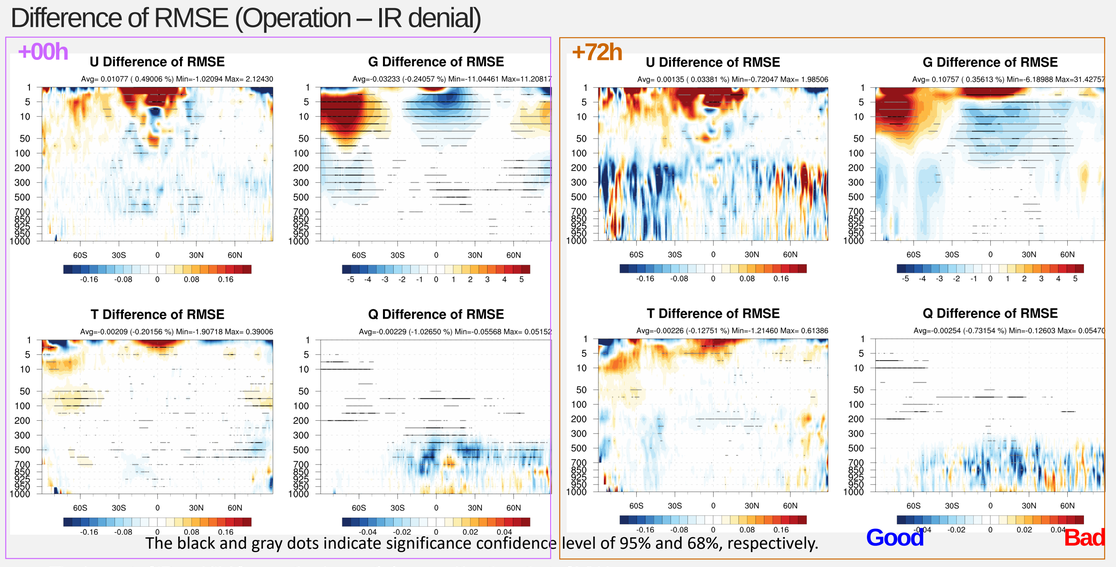
- Assimilation of CSR from GOES → 2p.06 (Ahreum Lee)
- Forecast impact of Simulated GeoHIS based on KIM-OSSE → 4.02 (Young-Jun Cho)
- Diagnostics of CrIS preprocessing system → 9p.04 (Na-Mi Lee)
- Optimize thinning, blacklisting, bias correction, and observation error

✓ **Impact of IR radiances on KIM forecasting**

- IR radiances: IASI, CrIS, CSR of geos (GK2A, MSG, Himawari) vs. denial experiment
- Verification period: 1– 31 July, 2022
- Improvement rate of RMSE against ECMWF analysis [%]

		Globe						North Hemisphere						Tropics						South Hemisphere						North Pole						South Pole					
		0	24	48	72	96	120	0	24	48	72	96	120	0	24	48	72	96	120	0	24	48	72	96	120	0	24	48	72	96	120	0	24	48	72	96	120
Q	700hPa	1.19	1.06	1.22	1.10	0.68	0.53	1.32	1.17	1.11	0.93	0.22	0.33	1.08	1.06	1.44	1.41	1.10	0.66	1.14	0.71	0.64	0.53	0.71	0.67	2.44	1.32	1.33	0.52	0.30	1.15	0.43	-0.58	-0.14	-0.23	1.97	1.38
WS	250hPa	0.80	1.11	0.67	0.99	0.91	0.71	1.34	1.37	0.90	0.13	0.91	0.81	0.39	0.72	0.49	0.82	0.40	0.26	0.74	1.31	0.61	1.89	1.15	0.82	2.19	2.39	0.89	-0.95	0.22	-1.87	0.48	0.00	-0.11	1.86	0.84	1.25
WS	500hPa	1.40	0.75	0.54	0.90	1.28	1.25	1.74	1.22	0.80	0.22	0.94	1.02	1.19	0.62	0.84	0.98	0.93	0.28	1.32	0.56	0.32	1.18	1.51	1.53	1.68	1.79	0.70	-0.03	1.12	0.45	0.73	-0.73	-0.51	0.93	1.43	1.41
WS	850hPa	0.40	0.44	0.61	0.74	1.12	0.88	0.51	0.28	0.79	0.55	0.93	1.25	0.30	0.12	0.68	0.77	0.63	0.51	0.38	0.81	0.46	0.85	1.35	0.81	0.30	-0.09	0.72	0.19	2.12	0.90	0.53	0.22	-0.64	-0.16	0.67	0.91
GPH	250hPa	3.95	2.52	1.40	2.30	2.16	1.86	2.94	2.83	1.30	1.19	0.90	0.23	3.16	4.17	3.14	1.52	1.46	1.88	5.40	1.59	1.33	3.07	2.92	2.64	9.71	4.58	1.05	-1.07	-1.64	-2.67	9.92	1.33	0.71	1.92	2.42	2.37
GPH	500hPa	3.26	-0.50	0.07	2.03	2.18	1.89	0.62	-0.51	0.39	0.88	1.37	1.65	2.95	-2.81	-3.54	-2.67	-2.63	-1.00	4.74	0.05	0.41	2.70	2.66	2.06	2.49	1.20	0.36	0.42	0.40	0.25	6.66	-0.08	-0.14	1.71	2.36	1.83
GPH	850hPa	0.83	0.13	0.87	2.21	1.77	1.92	2.59	0.14	0.99	1.02	2.20	3.11	0.61	0.43	2.29	3.10	-0.11	0.93	0.15	0.00	0.65	2.60	1.82	1.65	3.65	0.07	0.45	1.22	3.17	2.75	-0.23	-0.74	-0.67	1.13	1.76	1.70
T	250hPa	0.81	0.94	1.20	1.29	1.38	1.06	1.75	1.18	0.81	0.17	0.21	-0.16	-1.59	0.56	2.21	2.54	3.64	3.53	1.27	0.99	1.14	1.96	1.90	1.61	3.71	2.59	0.89	0.07	0.53	-0.27	2.02	0.01	-0.21	0.37	1.19	-1.18
T	500hPa	2.00	0.80	0.32	1.06	0.99	1.00	3.98	1.43	0.54	0.87	-0.14	-0.80	1.91	0.07	-0.13	-0.19	-0.42	-0.15	0.19	0.79	0.42	1.57	1.77	1.92	8.02	2.93	0.94	0.15	-1.06	-3.02	-1.59	0.13	-1.09	0.71	1.33	0.60
T	850hPa	1.09	0.83	0.57	0.65	0.66	1.03	0.35	0.69	0.40	0.47	0.16	0.91	2.18	1.30	1.13	0.59	0.23	0.61	0.73	0.56	0.33	0.84	1.16	1.27	-0.58	-0.14	-0.15	-0.20	0.07	0.49	0.62	0.31	0.19	0.49	0.87	0.98

- Difference of RMSE (Operation – IR denial)



- The impact of IR on KIM forecasting is mostly less positive than that of MW.
- IR helps offset the negative impacts of MW, particularly by improving upper-level in the tropics

- IR Issues

#	Location	Description	Future work
1	Overall	The impact is weak	Optimization needed: Thinning interval, Increase in the number of utilized channels, Reduction of observation errors
2	Model top level	Negative impact on all variables	Expand the use of upper-level sensitive channels (currently only used below 50 hPa)

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