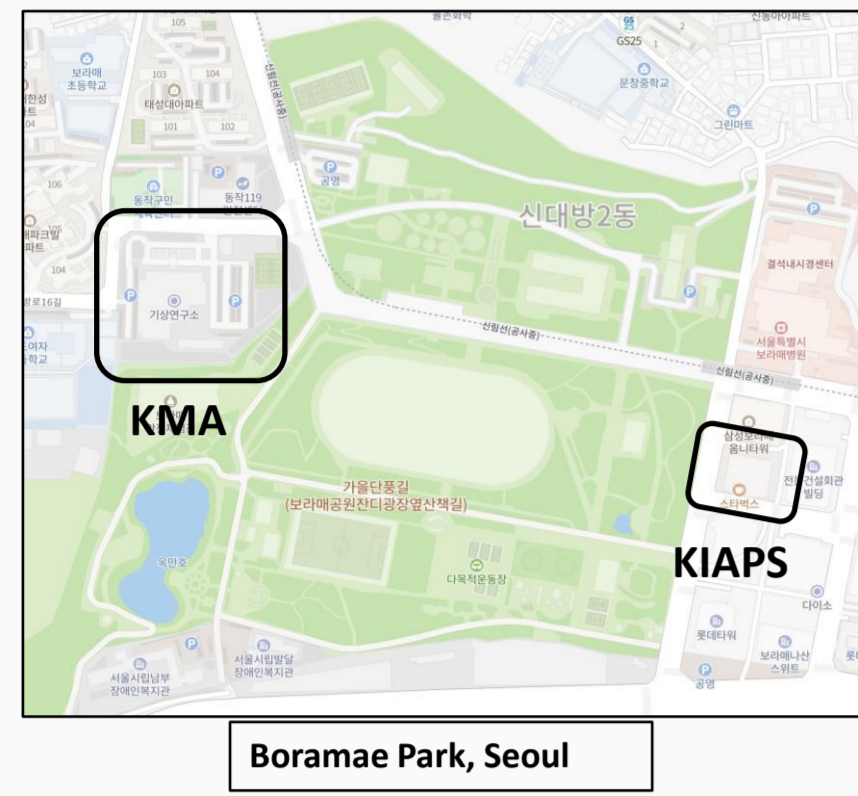
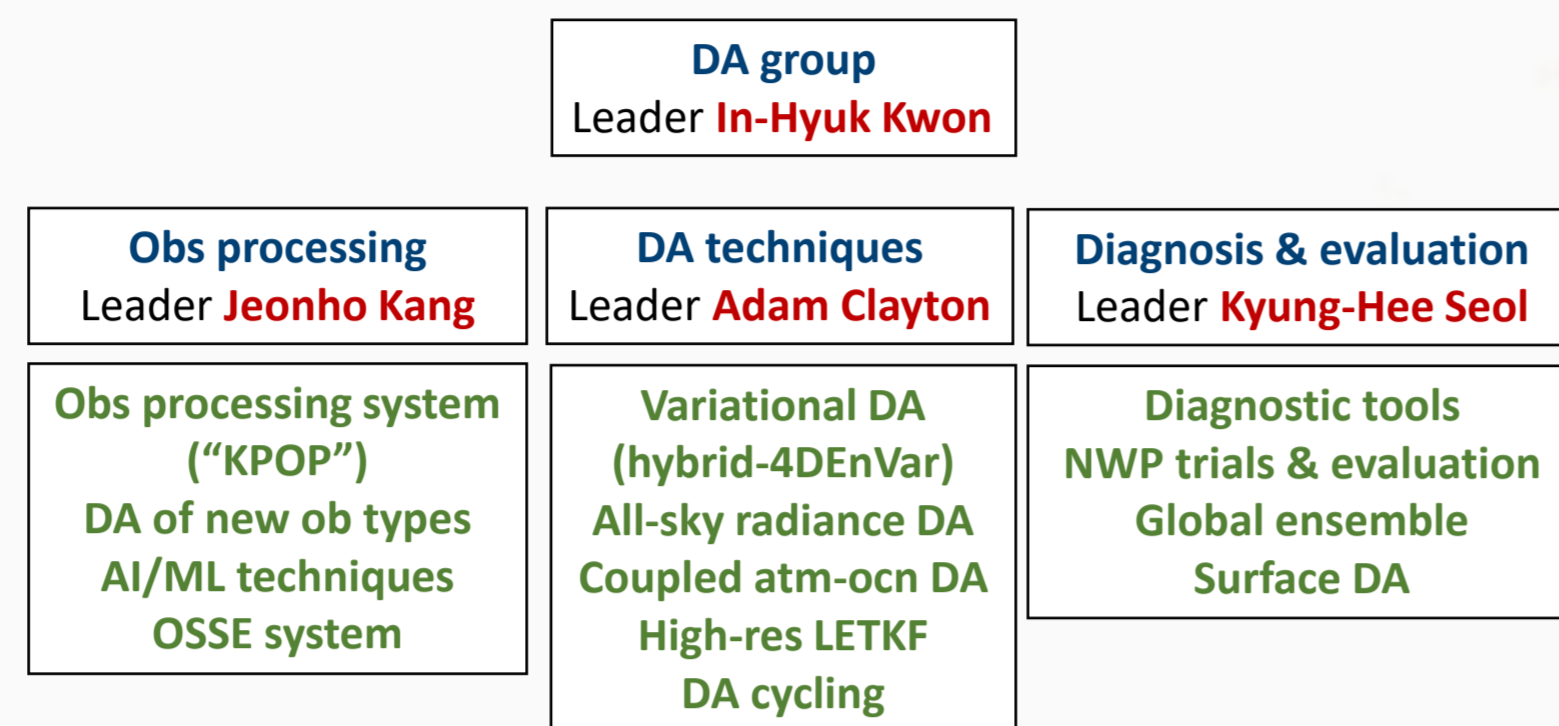


1 KIAPS and the KIAPS DA group

KIAPS founded in 2011 to develop new operational forecasting systems for the Korea Meteorological Administration (KMA)



- 72 scientists and software engineers
- 30 DA scientists:



(Regular international recruitment)

2 Operational global NWP system

Korea Integrated Model (KIM)

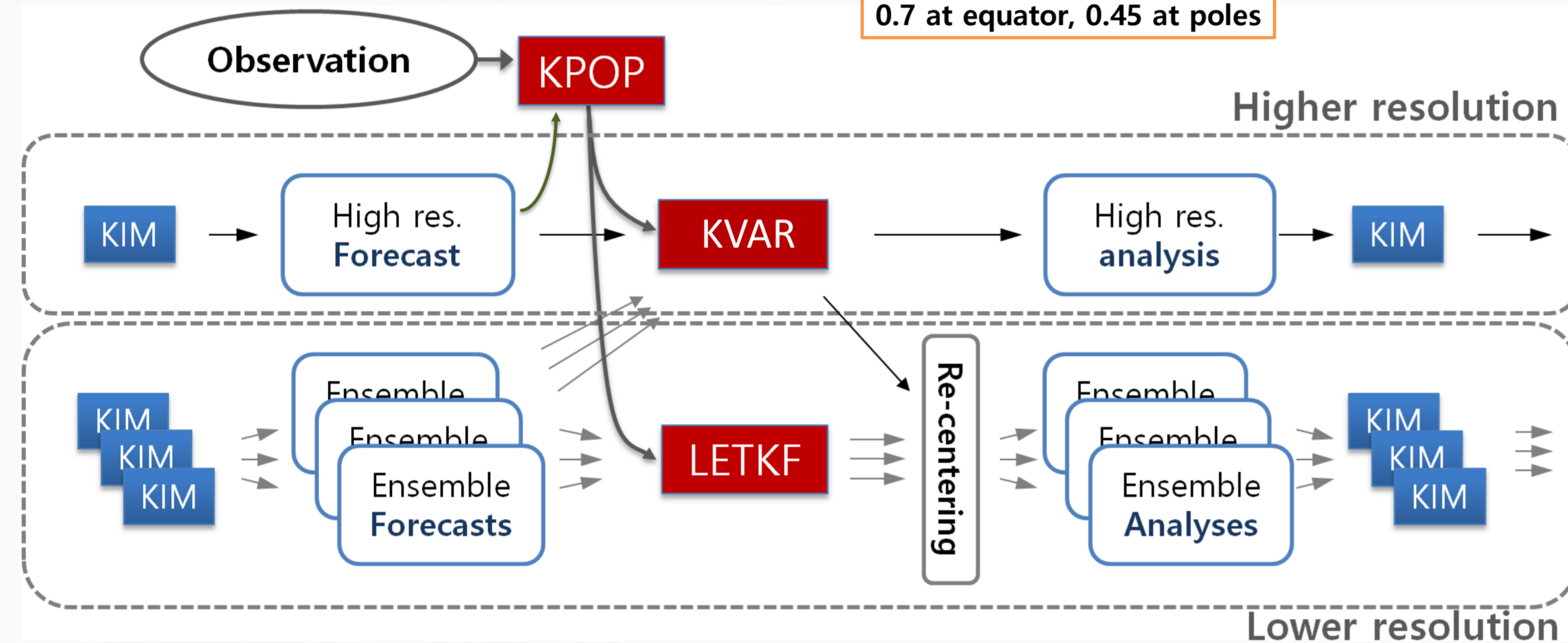
- Atmosphere – land model
- Cubed-sphere grid ; spectral-element method ; non-hydrostatic dynamics
- 91 levels ; 12 km deterministic grid ; 32 km ensemble grid



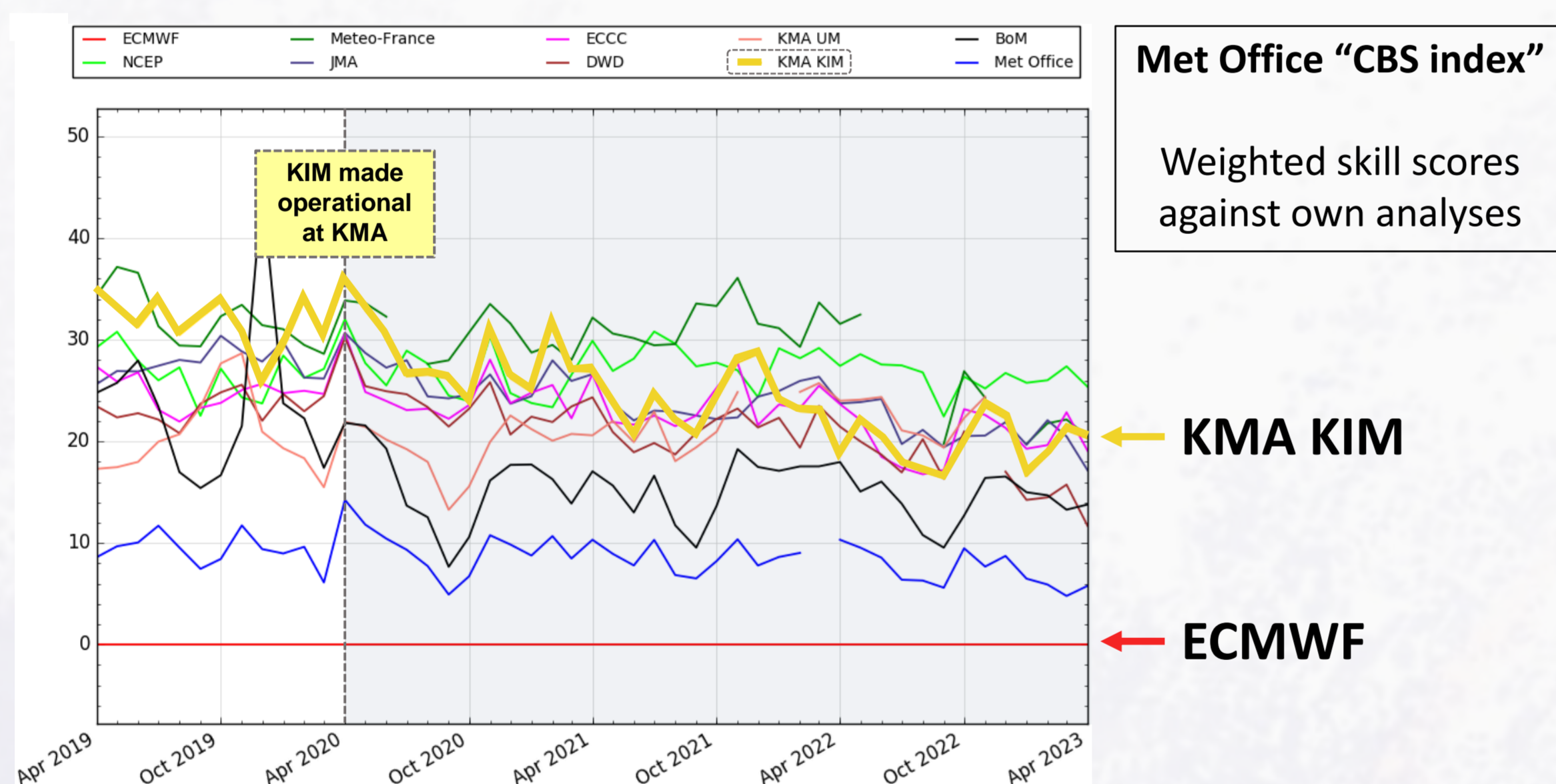
DA system

- Ensemble DA: 50-member LETKF
- Deterministic DA: Hybrid-4DEnVar (KVAR)

Ensemble B fraction:
0.7 at equator, 0.45 at poles



Performance



3 Ongoing development of hybrid-4DEnVar

1. Improvements to observation operator formulation:

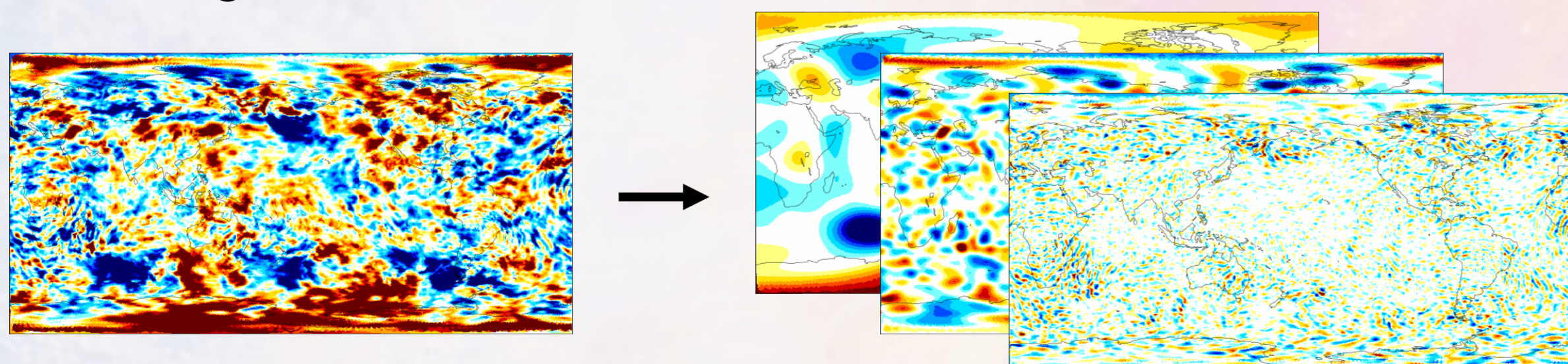
Ideally: $\mathbf{y} = \mathbf{H}(\mathbf{x}^g) + \mathbf{H}\delta\mathbf{w}$ Currently: $\mathbf{y} = \mathbf{H}(\mathbf{w}^g) + \mathbf{H}\delta\mathbf{w}$

model grid
(12 km)

analysis grid
(32 km)

2. Improvements to use of ensemble data:

- Introducing waveband localization



- Introducing use of time-lagged and time-shifted ensemble data

3. Unifying static covariances with ensemble-based covariances:

"NMC method" samples → KIM ensemble samples

4. Improvements to assimilation of "all-sky" satellite radiances

5. Software refactoring and performance improvements

4 Future DA systems

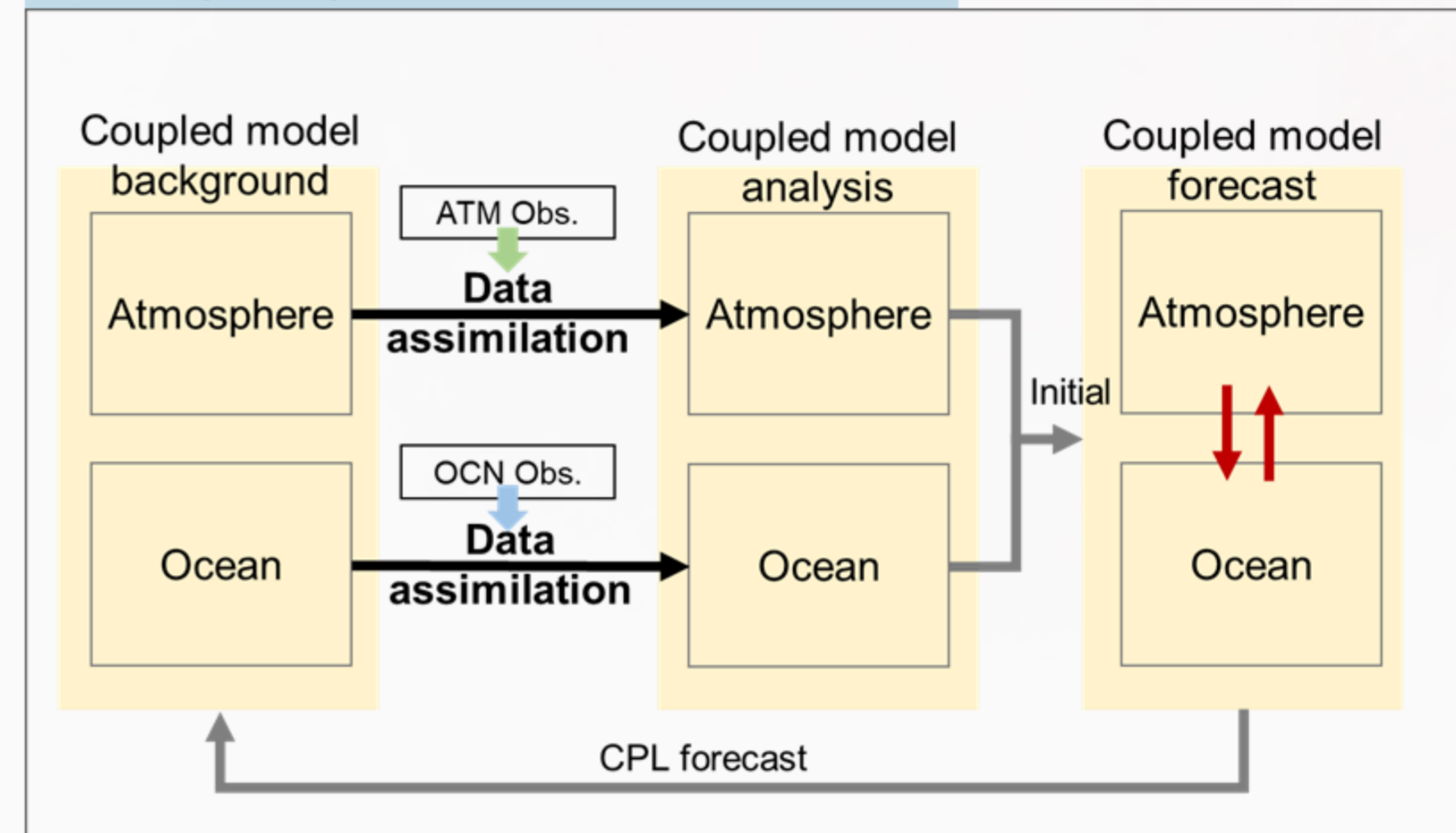
Weakly-coupled atmosphere-ocean DA

Target: Earth System NWP system, aimed at skillful forecasting out to T+30 days

Model: KIM-CES (KIM - Coupled Earth System), including NEMO ocean.

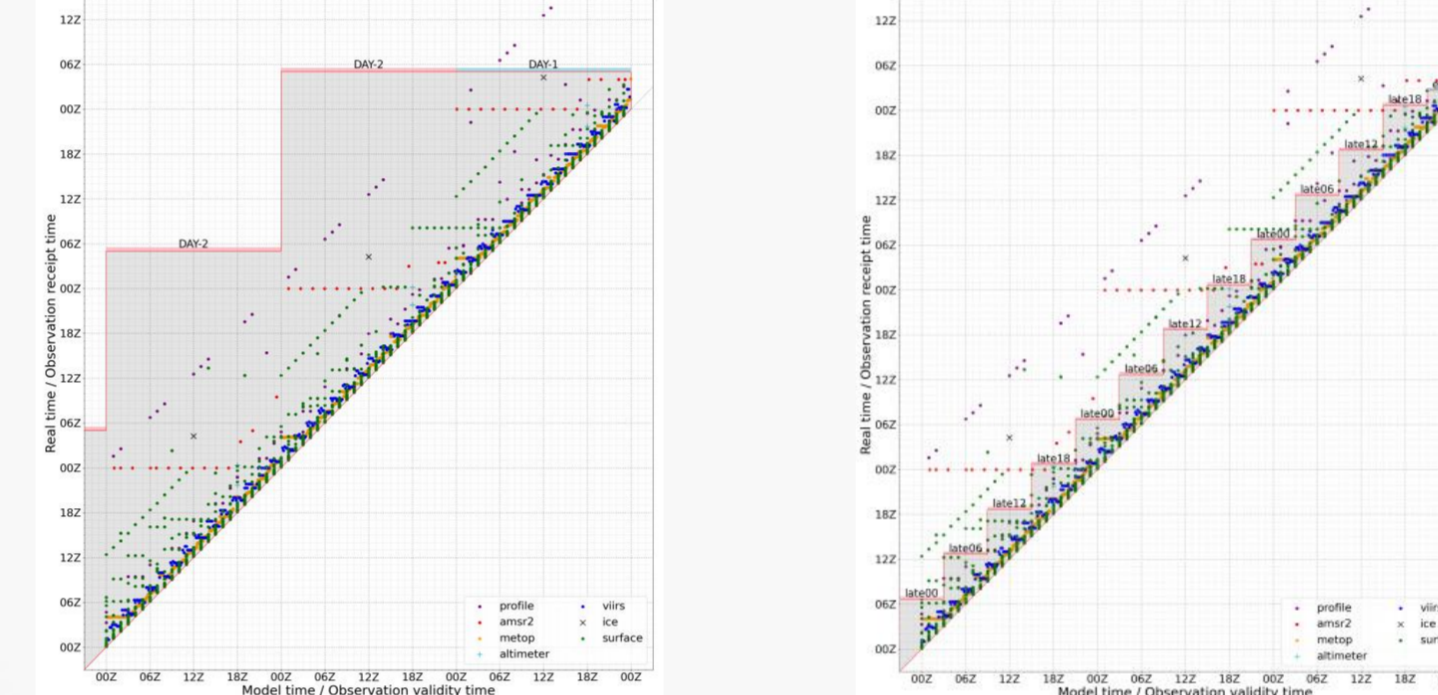
- DA:
- Weakly-coupled atmosphere-ocean DA
 - 6-hourly cycling with 6-hour DA windows (like the UK Met Office)
 - NEMOVAR 3DVar-FGAT system for the NEMO component, adapted from an ocean-only DA system with 24-hour cycles.

Weakly Coupled DA



Issue: Earlier ocean cutoff times will reduce number of usable observations:

Ocean-only DA cutoff times → Atmospheric DA-like cutoff times



Usable observations

Initial solution: Add "catch-up" cycles with later observation cutoff times

Status: Initial NWP suites almost complete. Cycling experiments to start shortly.

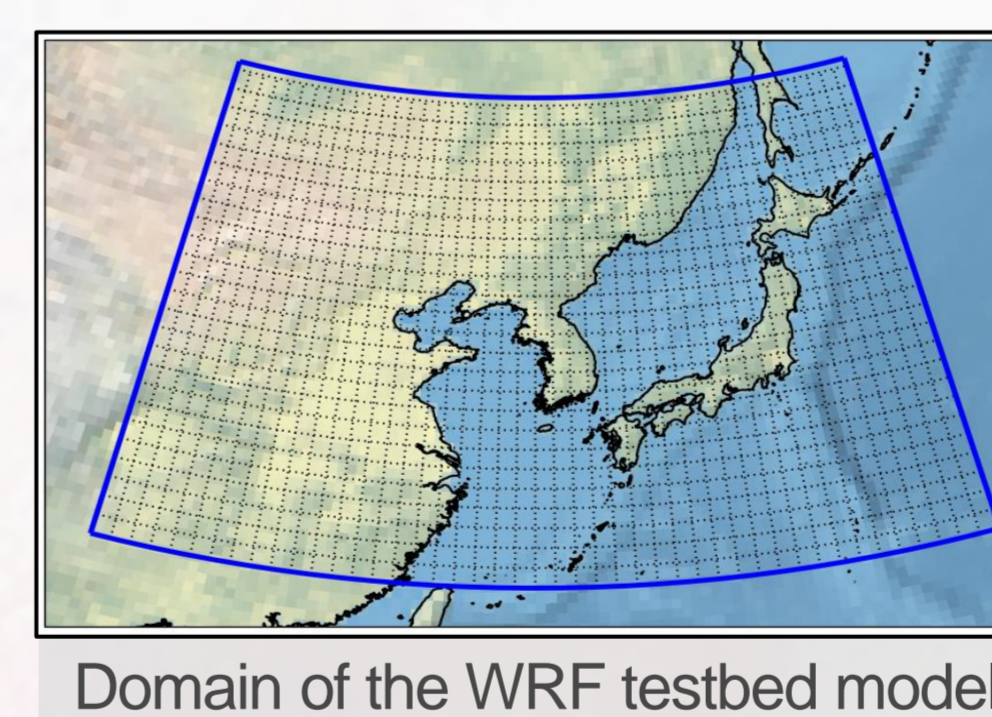
High-resolution LETKF

Target: High-resolution forecasting system for East Asia

Final model: KIM-LAM (limited-area version of KIM, currently under development)

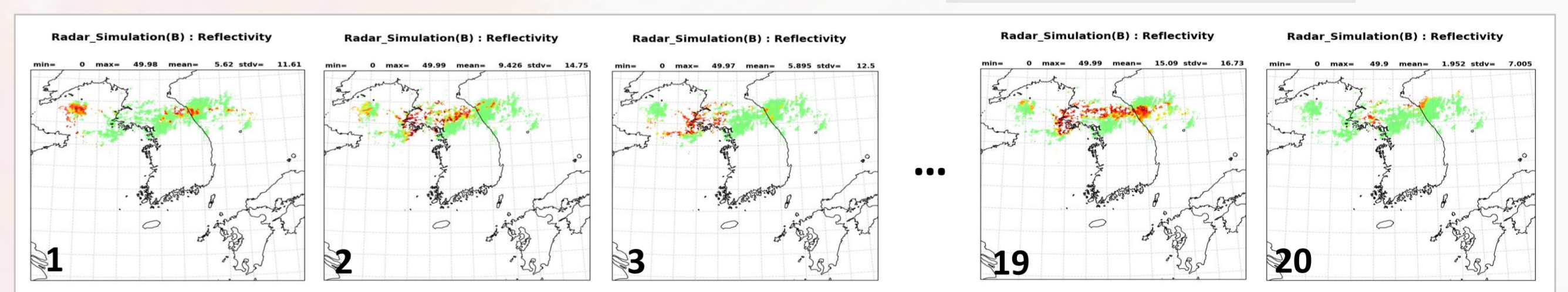
"Testbed" model: "KIM-meso" – 3 km WRF, with KIM-like physics.

- DA:
- 20-member LETKF
 - Direct assimilation of gridded Korean radar reflectivity observations
 - Simulated reflectivities calculated using WDM7 reflectivity operator:
 $dBZ = 10 \times \log(Ze_{rain} + Ze_{snow} + Ze_{grupei} + Ze_{hail})$



Observation Type	Variables provided by KPOP	
Conventional	Sonde	T, U, V, Q
	Surface	T, Q, RH, U, V, Ps
	Aircraft	T, U, V
Satellite-based wind	AMV	U, V
	SCATWIND	U, V
Microwave Radiance	AMSUA	TB
	MHS	TB
	ATMS	TB
	MWHS2	TB
	AMSR2	TB
Infrared Radiance	IASI	TB
	CSRK2A	TB
Radio Occultation	GPSRO	BA

Core set of observations



Simulated radar reflectivities for individual ensemble members

Status: System mostly complete. Cycling experiments to start shortly.

5 Summary

- The operational KIM NWP system is giving world-class performance, despite clear weaknesses in our hybrid-4DEnVar system. (Section 3)
Addressing these weaknesses is a major focus.
- Development of coupled and high-resolution NWP now moving from the "system building" stage to the scientific analysis stage.