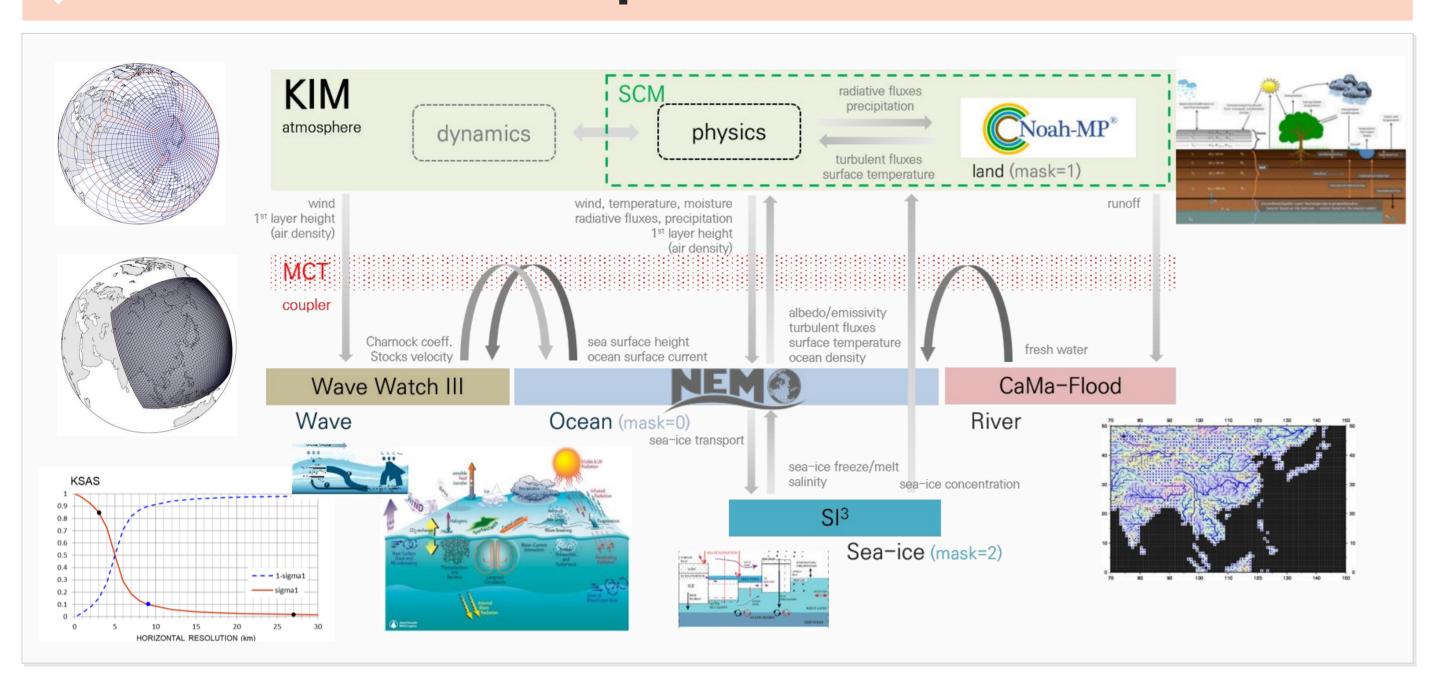# New Coupled Modeling System based on the Korean Integrated Model (KIM)

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1 Background

- The Korean Integrated Model (KIM) was developed for global numerical weather prediction and has been operational in real-time since April 2020.
- To expand its capabilities from deterministic medium-range weather forecast to probabilistic sub-seasonal to seasonal prediction, the Korea Institute of Atmospheric Prediction Systems (KIAPS) is developing a new coupled modeling system by advancing the land surface processes and coupling the ocean, sea ice, wave, and river-routing models, along with the further development in ensemble forecast and coupled data assimilation.
- This presentation will provide an overview, evaluation result, and future plan of the KIM-based coupled modeling system.
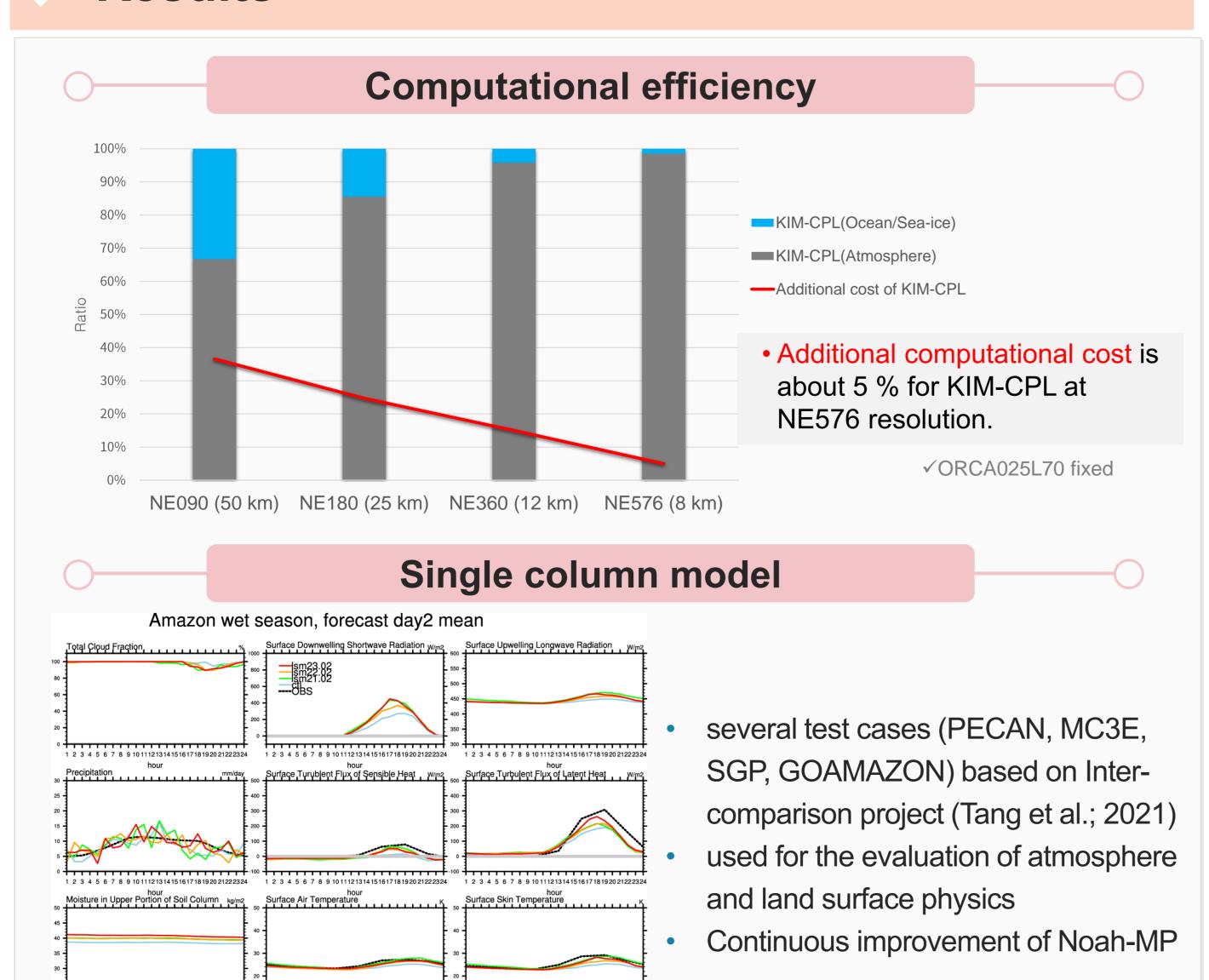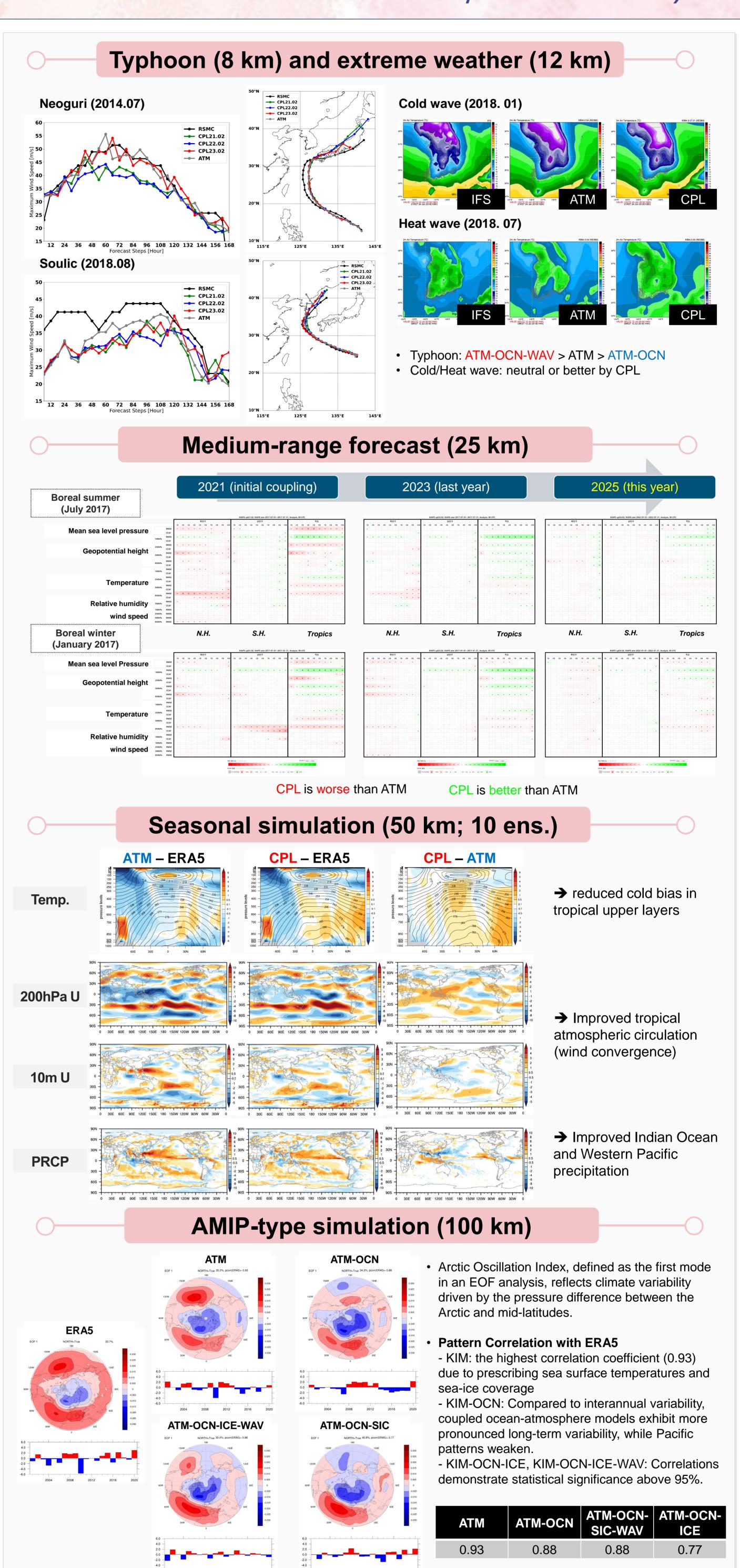
2 Framework of coupled KIM

3 Configuration of surface models

KIM-CPL		LSM		OCN	SIC	WAV	RIV
Model		Noah-MP		NEMO	SI³	WaveWatch III	CaMa-Flood
Ver. current	4.0.1	4.2 → 4.4	5.0		4.0	7.13	4.0.0 (4.1)
Ver. origin	LIS	WRF	GitHub	-	-	-	-
Ver. latest		5.0			5.0 beta	7.14	4.2
Coupler		-			MCT-based		
Initial data		ERA5		ORAS5 (GODAPS)	ERA5/GIOMAS PIOMAS(N.H.)	-	-
Exchange frequency		every time step (same with KIM)		1h (fixed; same with radiation)			
Grid system		cubed-sphere (same with KIM)		tripolar		(regular) lat-lon	unit-catchment
Resolution		100~6 km (NE045~768L91; same with KIM)		25 km (eORCA025L70; fixed)		50 km (fixed)	25 km (fixed)

4 Results

Computational efficiency

- KIM-CPL(Ocean/Sea-ice)
- KIM-CPL(Atmosphere)
- Additional cost of KIM-CPL

- **Additional computational cost** is about 5 % for KIM-CPL at NE576 resolution.

✓ORCA025L70 fixed

Single column model

Amazon wet season, forecast day2 mean

- several test cases (PECAN, MC3E, SGP, GOAMAZON) based on Inter-comparison project (Tang et al.; 2021)
- used for the evaluation of atmosphere and land surface physics
- Continuous improvement of Noah-MP

Typhoon (8 km) and extreme weather (12 km)

Neoguri (2014.07)

Soulic (2018.08)

Cold wave (2018. 01)

Heat wave (2018. 07)

- Typhoon: ATM-OCN-WAV > ATM > ATM-OCN
- Cold/Heat wave: neutral or better by CPL

Medium-range forecast (25 km)

| Boreal summer (July 2017) | 2021 (initial coupling) | 2023 (last year) | 2025 (this year) |

Mean sea level pressure / Geopotential height / Temperature / Relative humidity / wind speed

Boreal winter (January 2017)

Mean sea level Pressure / Geopotential height / Temperature / Relative humidity / wind speed

N.H. / S.H. / Tropics

CPL is **worse** than ATM   CPL is **better** than ATM

Seasonal simulation (50 km; 10 ens.)

ATM – ERA5 / CPL – ERA5 / CPL – ATM

- Temp.
- 200hPa U
- 10m U
- PRCP

→ reduced cold bias in tropical upper layers

→ Improved tropical atmospheric circulation (wind convergence)

→ Improved Indian Ocean and Western Pacific precipitation

AMIP-type simulation (100 km)

ATM / ATM-OCN / ERA5 / ATM-OCN-ICE-WAV / ATM-OCN-SIC

- Arctic Oscillation Index, defined as the first mode in an EOF analysis, reflects climate variability driven by the pressure difference between the Arctic and mid-latitudes.
- **Pattern Correlation with ERA5**
  - KIM: the highest correlation coefficient (0.93) due to prescribing sea surface temperatures and sea-ice coverage
  - KIM-OCN: Compared to interannual variability, coupled ocean-atmosphere models exhibit more pronounced long-term variability, while Pacific patterns weaken.
  - KIM-OCN-ICE, KIM-OCN-ICE-WAV: Correlations demonstrate statistical significance above 95%.

ATM	ATM-OCN	ATM-OCN-SIC-WAV	ATM-OCN-ICE
0.93	0.88	0.88	0.77

5 Summary and future plan

KIM coupled modeling system

- has been newly developed by coupling the state-of-the art surface model.
- is being updated and provides deterministic forecast skill comparable to that of the operational KIM, along with better performance on long-term simulations.
- shows potential to help improve medium- and long-term forecasting performance.

In the future, we will

- adopt more sophisticated physics/model (lake, …) and realistic data (LAI, …).
- employ (weakly) coupled data assimilation system by utilizing LIS and NEMO-VAR .
- deeply evaluate on sub-seasonal (MJO, …) to decadal (ENSO, …) prediction.