Development of the Coupled Korean Integrated Model

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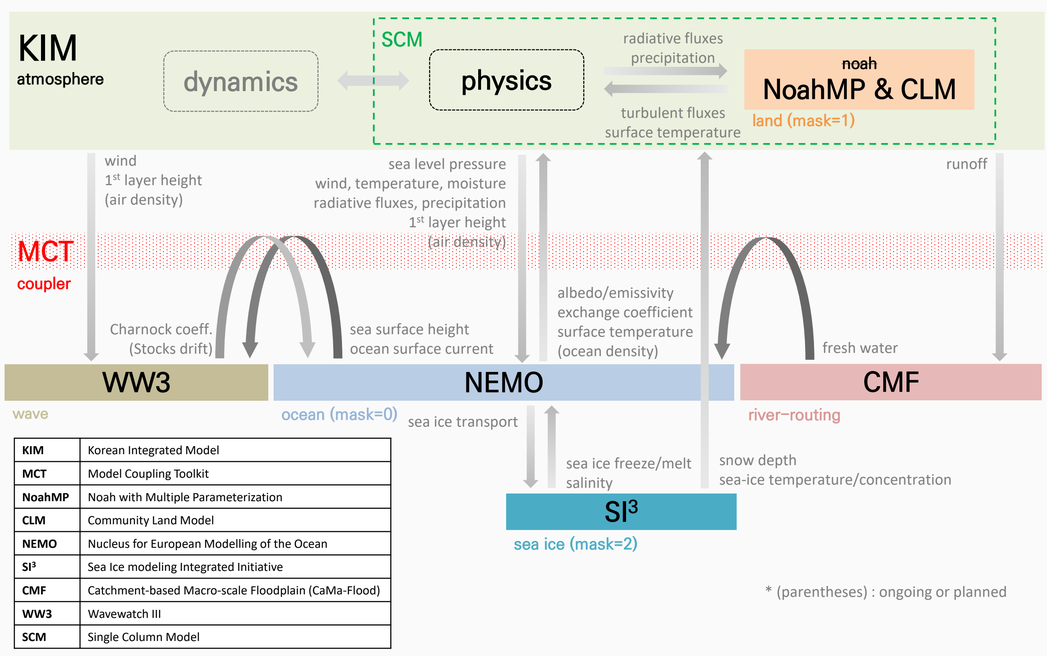
1 Background & Objectives

- The Korean Integrated Model (KIM) was developed for global weather forecasting at the first Phase (2011–2019) of the Korea Institute of Atmospheric Prediction Systems (KIAPS), and it has become the operational model of the Korea Meteorological Administration (KMA) since April 2020.
- It is necessary to better represent the physical process and interaction between the atmosphere and surface to improve the extended-range predictability beyond 2 weeks.
- To this end, the new KIAPS Phase 2 project (2021–2026) aims to advance the land surface model and to newly couple the ocean/sea-ice/wave/river-routing models to the operational KIM.

2 Coupled version of KIM

Framework structure



KIM	Korean Integrated Model
MCT	Model Coupling Toolkit
NoahMP	Noah with Multiple Parameterization
CLM	Community Land Model
NEMO	Nucleus for European Modelling of the Ocean
SI³	Sea Ice modeling Integrated Initiative
CMF	Catchment-based Macro-scale Floodplain (CaMa-Flood)
WW3	Wavewatch III
SCM	Single Column Model

* (parentheses) : ongoing or planned

Model description

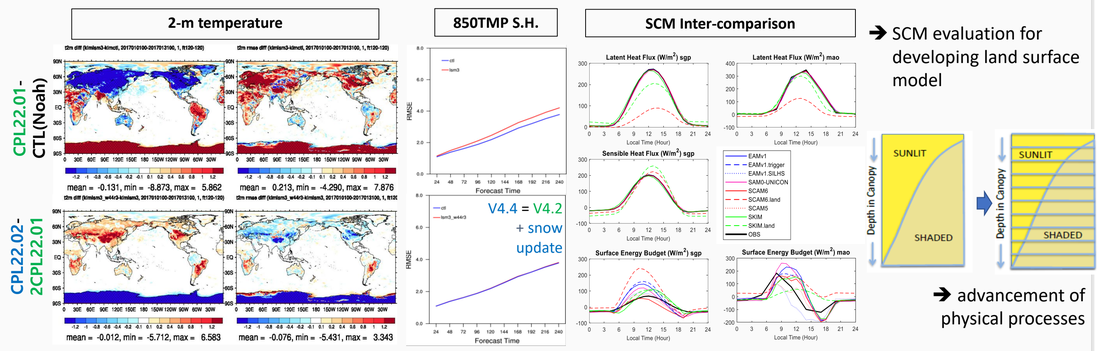
		LSM			OCN	SIC	WAV	RIV	SCM
Model		NoahMP		CLM	NEMO	SI3	WW3	CMF	Single column in KIM framework
Version	**current**	4.0.1	4.2 → 4.4	5.0	4.0		7.13	4.0.0	
	origin	LIS	WRF	CTSM	-		-	-	
	latest	4.4			4.2.0		7.14	4.0.1	
Coupler		-			MCT				-
Compile option		-	-	LSM_CLM	--ocn		--wav	--riv	-
Usage		lsm_flag=2	lsm_flag=3	lsm_flag=4	ocn_comp	nn_ice=2	wav_comp	riv_comp LN_RNF	run_flag=3
Initial data		ERA5			ORAS5	ERA5 PIOMAS GIOMAS	-	-	DCP project (SGP/ Amazon)
Exchange freq.		every time step (same with KIM)			1h (same with radiation)			24h	1h
Grid system		cubed-sphere (same with KIM)			tripolar		(regular) lat-lon		point
Resolution		NE045-NE360 (same with KIM)			25km (fixed)				100 km

Development process

	CPL-22.01 (August 2022)	CPL-22.02 (October 2022)	CPL-23.01 (March 2023)	Under development
make_sfci	- Sea-ice Initialization		- Ocean/sea-ice initial data	
LSM3	**[Initial coupling; NoahMP]**	- upgrade to **V4.4** no canopy heat storage - CWPVT=0.18 for EBLFOREST - fixed snow albedo over glacier	- enhanced wind speed - soil color from CLM - lai/sai from CLM	- advancement in surface emissivity - thermal roughness length
LSM4			**[Initial coupling; CLM]**	
OCN	**[Initial coupling; NEMO]** - consistent exch. coeff. - consistent z0t - skin temperature para.	- bug fix in downward longwave flux - reference height is equal to first model layer		- ocean albedo parameterization
SIC	**[Initial coupling; SI3]** - salinity from 5.3 to 4 - skin temperature para. - maximum snow albedo - correction of snow unit		- salinity parameterization	
WAV		**[Initial coupling; WW3]** - coupled to KIM-NEMO - reference height is equal to first model layer		- advancement in Langmuir circulation
RIV		**[Initial coupling; CMF]** - coupled to KIM-NEMO		
physics package	- radiation-code refactory - hourly update of clim. - unit from mm to m	- constant consistency - icec from 0.5 to 0.15 for sea-ice mask		

3 Impact of coupled model

Land surface model



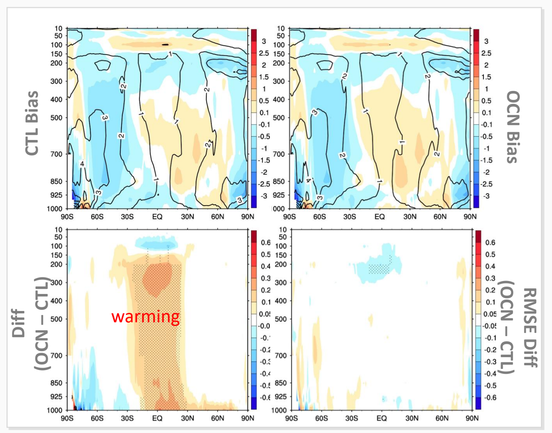
→ SCM evaluation for developing land surface model

→ advancement of physical processes

→ Please see the poster “The impact of Land Surface Models change in the KIM” for further detail.

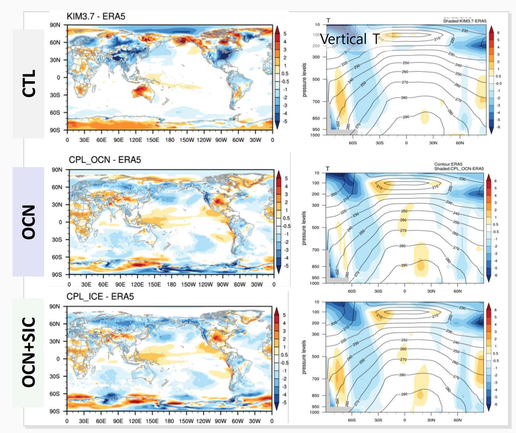
ocean/sea-ice models

Medium-range forecast (Jul 2017)



Temperature at forecast day 5 against the IFS analysis

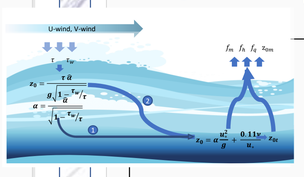
Seasonal prediction (JJA2017)



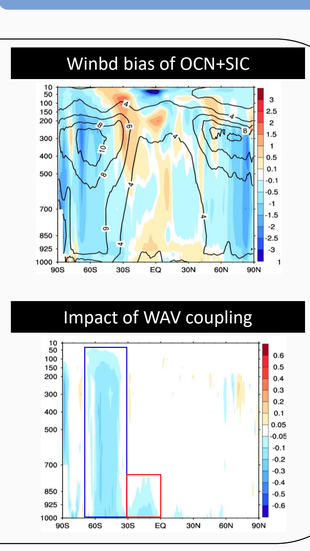
Bias of (left) 2-m and (right) vertical temperature

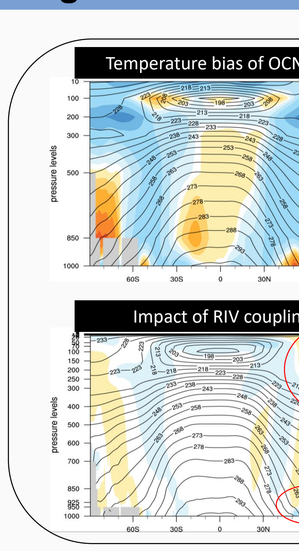
→ Please see the poster “Atmosphere-Ocean Coupling in the KIM” for further detail.

wave/river-routing models

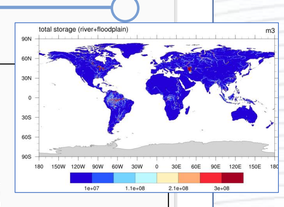


Enhanced surface drag over region with strong ocean current

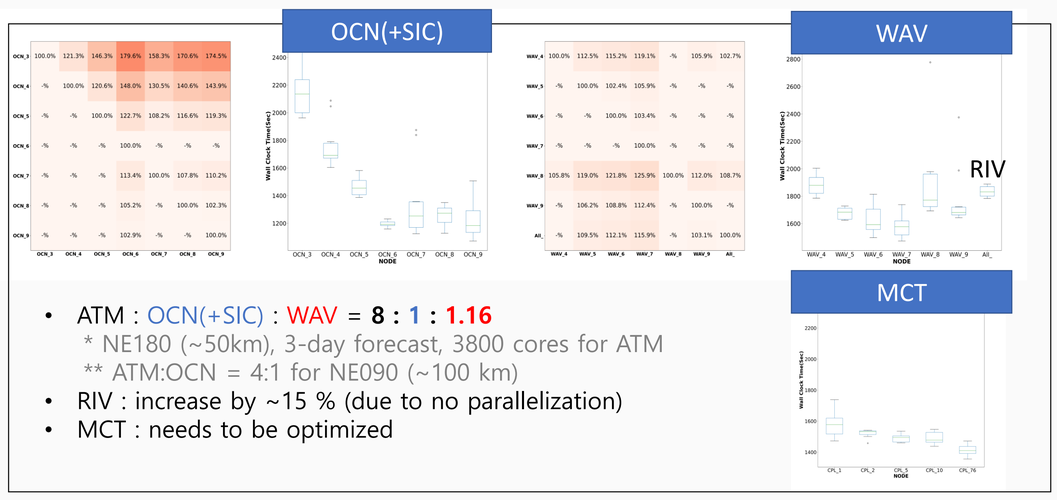




Improvement in temperature over polar region



Computational cost



- ATM : OCN(+SIC) : WAV = **8 : 1 : 1.16**
  * NE180 (~50km), 3-day forecast, 3800 cores for ATM
  ** ATM:OCN = 4:1 for NE090 (~100 km)
- RIV : increase by ~15 % (due to no parallelization)
- MCT : needs to be optimized

4 Conclusions

- The coupled version of KIM was successfully developed for the first stage (2020–2022) of the KIAPS Phase 2 project.
- In the future, we are going to
  - advance the physical processes of coupled models
  - optimize the computational efficiency in coupling process
  - evaluate on the extended- and long-term time scales (e.g. S2S, interannual)
  - adopt atmosphere-surface (weakly) coupled data assimilation
  - ultimately replace the operational KIM with its coupled version in 2026.

「6th WGNE workshop on systematic errors in weather and climate models」 ECMWF, Reading, October 31 to November 4, 2022