Characteristics and interannual variations of East Asian summer monsoon simulated by Korean Integrated Model

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1 Background

- The Korea Institute of Atmospheric Prediction Systems (KIAPS) developed a new global numerical weather prediction system for the medium-range forecast, Korean Integrated Model (KIM) and it began operation in 2020 at the Korea Meteorological Administration. The new project of KIAPS aims to extend the forecast length to 30 days.
- To accomplish stable long-term prediction performance, it is need to diagnose systematic errors and to understand error sources of KIM.
- In this study, KIM is simulated through integrations of a seasonal time scale for 20 years with low horizontal resolution by 100 km and evaluated systematic errors and characteristics of East Asian summer monsoon (EASM).

2 Experimental setup & Materials

Experimental set up : KIM3.7.01

- Resolution : NE045NP3 (~100km), L91
- Initial data : ERA5 analysis data
- Surface cycle : SST and sea-ice cycling for every 24h using ERA5 data
- Forecast period : 4 months forecast from May to August
  during 2001~2020 (First one month is spin up period)
- Ensemble : 5 members (24h interval from 1st to 5th May)

- **Observational proxies** of atmospheric variables : ERA5 reanalysis, precipitation : GPCP, and SST : OISST monthly data

Table 1. Definition of EASM indices

EASM Index	category	Definition	Reference
WNPMI (Western North Pacific Monson Index)	shear vorticity of zonal wind	U850 (5~15˚N, 100~130˚E) - U850 (20~30˚N, 110~140˚E)	Wang and Fan (1999)
EAMI (East Asian Monsoon Index)	meridional position of East Asian summer monsoon	V850 (20~30˚N, 110~140˚E) - V850 (30~40˚N, 110~140˚E)	Wang et al. (2001)

3 Results

20-year averaged seasonal bias

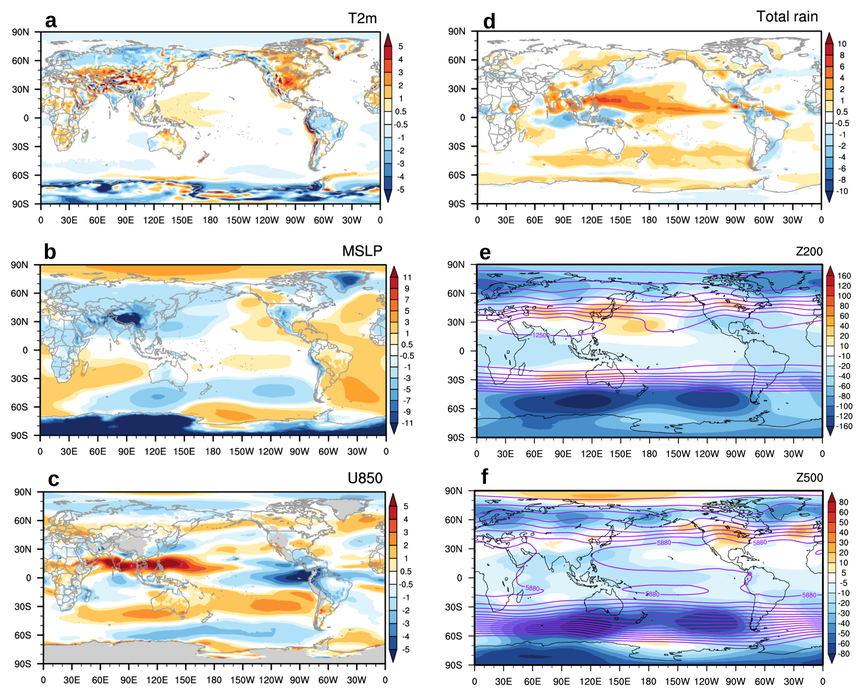


Figure 1. The difference between KIM and ERA5 / GPCP in JJA for (a) T2m, (b) MSLP, (c) U850, (d) Precipitation, (e) Z200 and (f) Z500. The contours indicate bias and the purple line is climatology of ERA5.

- KIM shows a warm bias in the northern mid-latitudes and a cold bias in high-latitude Eurasia and polar regions (Fig 1a). MSLP of KIM is underestimated in the Eurasian continent and Western North Pacific and overestimated in the Arctic region (Fig 1b).
- KIM overestimates Indian precipitation due to strengthening of the tropospheric low-level Somali jet and underestimates East Asian precipitation because of cyclonic bias in East Asia and weakening of southerly wind over the East Asia (Fig 1c & 1d).
- The simulation of North Pacific and Tibetan high pressure in KIM is shifted eastward relative to the ERA5 (Fig 1e & 1f).

Correlation between SST & precipitation

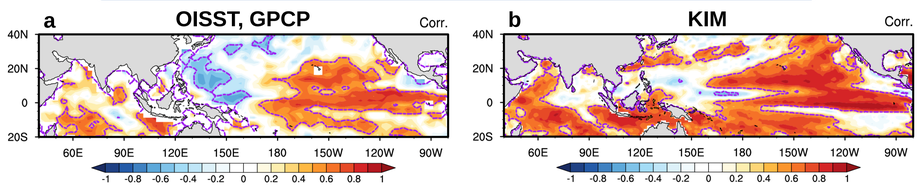


Figure 2. Seasonal correlation between SST and precipitation during 2001~2020 for (a) OISST and GPCP, (b) SST and precipitation in KIM. The contours denote the correlation coefficients significant at the 95% confidence level.

- Compared to relationship between OISST and GPCP, KIM has no correlation over the Western North Pacific where air-sea interaction is important. In seasonal systematic bias of KIM, precipitation is overestimated in the Western North Pacific. It fails to reproduce the relationship of air-sea interaction and could be improved through the coupled atmosphere-ocean model (Zhu and Shukla, 2013).

Interannual variability of EASM

◆ EASM indices & Correlation between individual EASM indices and 850hPa wind vector and precipitation field

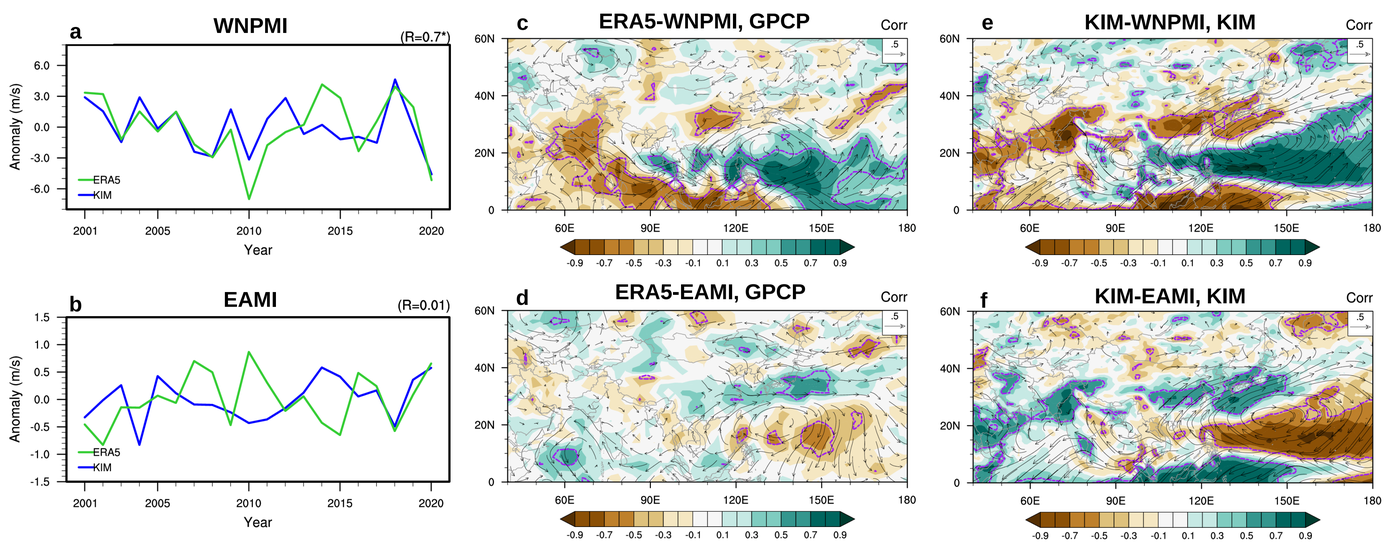
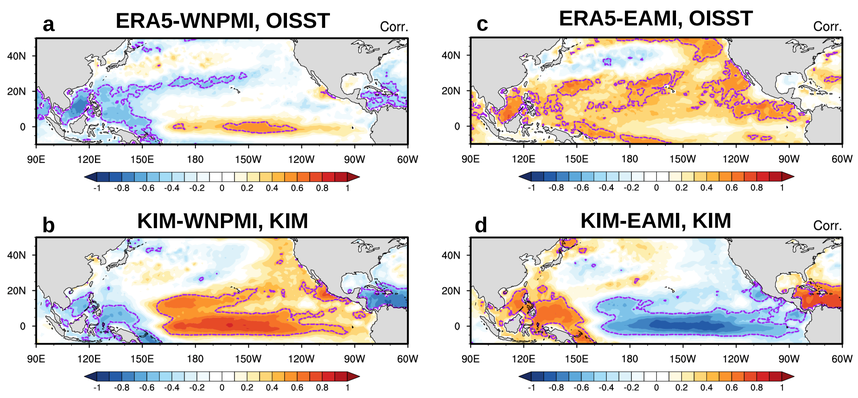


Figure 3. The timeseries of (a) WNPMI and (b) EAMI of ensemble mean of KIM (blue) and ERA5 (green). Correlation map between summer precipitation (shaded), horizontal winds at 850hPa (vector) and individual EASM indices during 2001~2020 for (c) GPCP and WNPMI of ERA5 and (e) precipitation and WNPMI in KIM. (d) Same as (c) but EAMI of ERA5. (f) Same as (e) but EAMI of KIM. The contours indicate the correlation coefficients significant at the 95% confidence level.

- The WNPMI of KIM simulates interannual variability well and captures that of ERA5 with a correlation coefficient of about 0.7 at the 95% significance level (Fig 3a).
- In KIM, the correlation between WNPMI and precipitation is overall stronger than ERA5 and there is no correlation efficient as much as ERA5 in the eastern Indian ocean (Fig 3c & 3e).
- Due to the limitation of simulating the meridional wind in KIM, there is no correlation between the EAMI of KIM and the EAMI of ERA5 (Fig 3b).
- In KIM, the correlation between EAMI and precipitation is similar to Fig 3e in the opposite pattern, rather than ERA5. The relationship between WNPMI and EAMI of KIM has a correlation of 0.85, which is greater than that of ERA5.

◆ Correlation between individual EASM indices and seasonal SST



- In KIM, the positive correlation between WNPMI and SST is stronger than ERA5 in tropical central Pacific (Fig 4a & 4b).
- Unlike positive correlation over subtropical North Pacific in the ERA5, the relationship between EAMI and SST in KIM indicates the opposite pattern of Fig 4b.

Figure 4. Seasonal (JJA) correlation map between SST and individual EASM indices during 2001~2020 for (a) OISST and WNPMI of ERA5. (b) Same as (a) but SST and WNPMI of KIM. (c) Same as (a) but EAMI of ERA5. (d) Same as (b) but EAMI of KIM. The contours denote the correlation coefficients significant at the 95% confidence level.

4 Summary

- In this study, the simulation characteristics of KIM are investigated focused on systematic errors and East Asian summer monsoon through seasonal simulation for multi years.
- KIM captures well interannual variations of WNPNI and relationship between WNPMI and SST, despite North Pacific high pressure was underestimated and shifted toward the east. However, KIM poorly simulates variability of EAMI and its relationship with SST, unlike the correlation between EAMI and SST in the ERA5.
- Additionally, it is necessary to confirm whether East Asian summer monsoon is well simulated through the improvement of relationship between SST and precipitation in the coupled atmosphere-ocean model.

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