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Impact of boundary conditions on RegCM4 20-year-long precipitation simulations over CORDEX-East Asia domain

Ju-Hee Park[1], Seok-Geun Oh[1], Myoung-Seok Suh[1]*, Hyun-Suk Kang[2]

[1]Dept. of Atmospheric Science, Kongju National University, Gounju, Korea

[2]Climate Research Laboratory, National Institute of Meteorological Research Korea Meteorological Administration, Seoul 156-720, Korea

*E-mail : sms416@kongju.ac.kr

1.Introduction

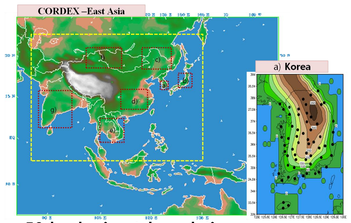
➢ The East Asian region where population and industrial facilities are concentrated can be more vulnerable to extreme climate events such as heat waves, tropical nights, droughts, and floods. Thus understanding and prediction of precipitation characteristics in this region are needed for the development of efficient adaptation strategies to future climate change.

➢ Regional Climate Model (RCM) is an one of the powerful tools in understanding and predicting the regional climate, especially for future detailed climate changes. However, simulation skills of most of RCMs are significantly dependent on geographic locations, seasons, variables, and boundary conditions (BC).

➢ CORDEX (COordinated Regional climate Downscaling Experiment) is a framework devoted to coordinate international efforts to produce improved generations of regional climate simulations.

➢ In this study, impacts of BC on the simulations skills of RegCM4 are investigated by using the 20-year (1989-2008) regional climate over CORDEX East Asia reproduced by using RegCM4 driven by ERA-Interim (ERA) and NCEP/DOE (R2), especially focused on the precipitation.

2. Data & Method



- 50-km horizontal resolution
- 197 (Lat) X 243 (Lon)

Vertical layers (top)	18 sigma layers (74 hPa)
Cumulus convection	MIT-Emanuel
Dynamic framework	Hydrostatic
Radiation	CCM3 package
PBL	Holtslag
LSM	NCAR CLM3.5
Lateral boundary data	ERA-Interim, NCEP/DOE2
Spectral nudging	Yes
Period	Jan. 1989. ~ Dec. 2008.

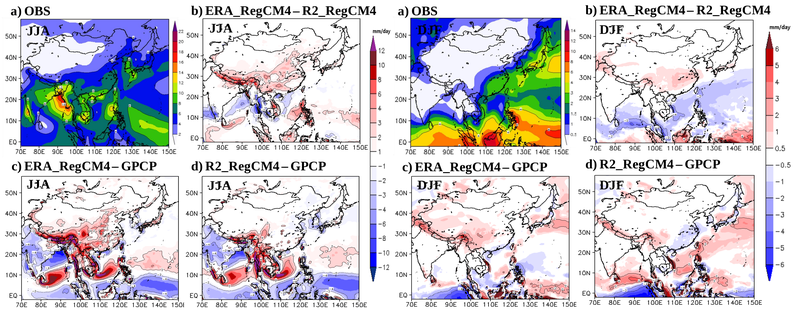
➢ The RegCM4 used in this work, is the updated version of RegCM3 in the prescription of SST, sea ice, and community land model coupling etc. (ICTP Portal, 2010).

➢ To produce a 20-year regional climate of RegCM4, two boundary conditions, ERA-Interim (ERA) and NCEP/DOE reanalysis 2 (R2) were used.

➢ For the validation of RegCM4 simulations, satellite-based global precipitation data (GPCP) and 59 stations precipitation data from KMA were used.

3. Results

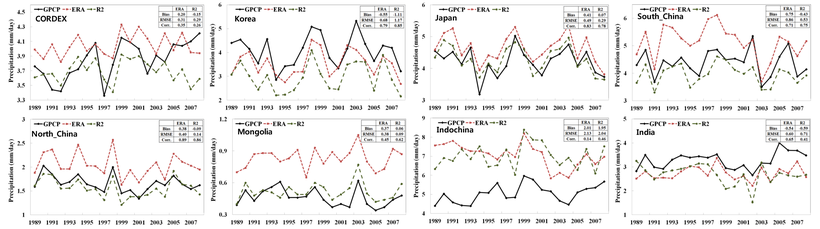
◆ Spatial distribution of precipitation



✓ In general, RegCM4 overestimates precipitation over mid-latitude land areas including southern areas of China, while precipitation over the Korean peninsula and India are significantly underestimated, irrespective of the boundary conditions.

✓ RegCM4 driven by ERA produces more precipitation than that of RegCM4 driven by R2, especially in the central land area of the model domain.

◆ Inter-annual variation (IAV) of precipitation

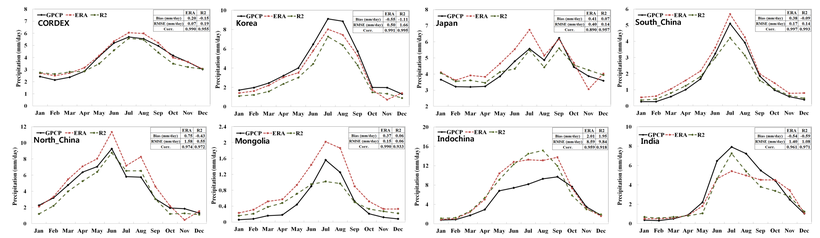


✓ Skills of RegCM4 for the IAV of Precip. are impacted by the BCs without regard to regions.

✓ The skills of RegCM4 over Japan, China, and Mongolia are better when driven by R2 than ERA.

✓ In general, RegCM4 underestimates the inter-annual variability of precipitation irrespective of the regions and BCs.

◆ Seasonal variation (SV) of precipitation



✓ In general, the RegCM4 successfully simulates seasonal variation of precipitation in most of the regions, although the amplitudes of seasonal variation are not well captured.

✓ And the skills of RegCM4 for the SV of precipitation are also impacted by BCs, including the amplitude and phase of seasonal march of precipitation.

✓ The RegCM4 using ERA better simulates the SV of precipitation than those of RegCM4 using R2.

◆ Statistical validation over CORDEX-East Asia domain

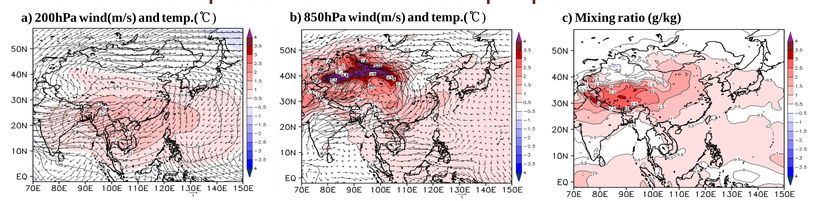
Statistical valid.	Combination	Season				
		Annual	Spring	Summer	Autumn	Winter
Bias	ERA	0.20	0.23	0.31	0.03	0.22
	R2	-0.15	-0.05	-0.27	-0.05	0.28
RMSE	ERA	4.04	3.56	5.21	4.33	3.04
	R2	3.79	3.31	5.00	3.81	3.02
Spatial corr.	ERA	0.56	0.58	0.49	0.52	0.67
	R2	0.54	0.51	0.48	0.53	0.63

✓ In general, RegCM4 using ERA shows a better performance than those using R2.

✓ RegCM4 using ERA shows high RMSE because of excessive overestimation.

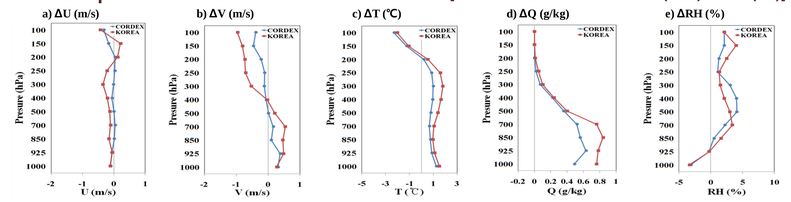
✓ Skills of RegCM4 for precipitation are better during winter than summer.

◆ Reasons for the impacts of BC on the simulated precipitation



✓ RegCM4 using ERA simulates higher temperature than those using R2, especially in the central region of the model domain. This strengthens the low pressure, mixing ratio, Somlia jet and the southwesterly wind over the East Asian region at the lower troposphere. As a result, more precipitation is reproduced in the central part of the model domain, including the East Asian region.

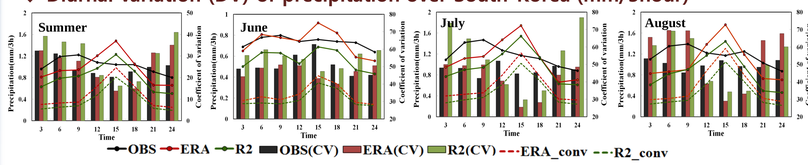
◆ Vertical profiles of the simulation differences [simulated climate variables (ERA) – SCV(R2)]



✓ The RegCM4 using ERA simulates stronger southerly (northerly) wind at the lower (upper) troposphere than those using R2. Also, the RegCM4 using ERA simulates the low to mid-troposphere layers to be warmer and moister than that using R2.

✓ The RegCM4 using ERA generates more favorable atmospheric conditions for the precipitation by simulation of more warm-humid (cold) in lower (upper) layers than those R2.

◆ Diurnal variation (DV) of precipitation over South-Korea (mm/3hour)

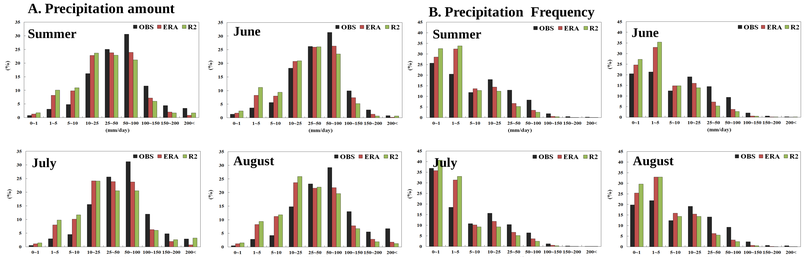


✓ Summer precip. over South-Korea shows two peaks in the early morning and late afternoon.

✓ RegCM4 underestimates the early morning peak but overestimates the late afternoon peak.

✓ RegCM4 shows a poor skill in the simulating of DV characteristics of precip. irrespective of BCs.

◆ Precipitation amount and frequency according to the intensity over South-Korea



✓ The RegCM4 oversimulates the light precipitation but undersimulates the heavy precipitation compared to the observation regardless of the boundary condition.

✓ This results indicate that RegCM4 can hardly estimate the extreme precipitation events, such as heavy rainfall and flash floods. This can be partly related to the coarse horizontal resolution (50 km).

4. Summary

➢ The impacts of BC on the simulation skills of RegCM4 for precipitation are significant in the spatial distribution, temporal variation (inter-annual/seasonal/diurnal variations) and precipitation characteristics (amount and frequency).

➢ In general, the RegCM4 using ERA simulates more precipitation and shows a better performance especially in the central land area of the model domain than those using R2.

➢ The RegCM4 using ERA generates more favorable atmospheric conditions for the precipitation through the simulating of the lower (upper) troposphere warm-humid (cold and dry) than those by R2.

➢ The strong underestimation of summer precipitation can be partly related to the low spatial resolution (50km) because the summer precipitation over South Korea caused by the meso-scale convective systems imbedded in the Changma front and sometimes typhoons.

➢ Regardless of BCs, RegCM4 shows a relatively poor skill in the simulation of precipitation, especially heavy precipitation. Therefore, improvement of BC and physical processes that affect precipitation are needed for the better projection of future climate changes, including precipitation.

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