Tropical Intraseasonal Variability in a 20-km Mesh MRI/JMA AGCM Incorporating a New Convective Scheme

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“Harerun” mascot of our agency

1. Introduction

Two 20-km AGCMs are used in the Japanese KAKUSHIN-3 project for the future projection of tropical depressions and extreme weathers. One is the MRI/JMA AGCM with the **Arakawa-Schubert-type** cumulus scheme. The other is the AGCM developed recently in this project, incorporating a new convective scheme developed by ***Yoshimura***, which is based on the **Tiedtke-type** scheme, but together with the cloud ensemble approach. The tropical intra-seasonal variability (ISV) in the simulations is investigated and compared with the observation utilizing a diagnostic tool developed by the CLIVAR MJO Working Group.

2. Experiment settings & new convective scheme

Resolution: TL959 (20-km) with 60 layers
Boundary condition: Observed monthly SST and sea ice concentration (HadISST)
Integrated period: 25 years (1979-2003)

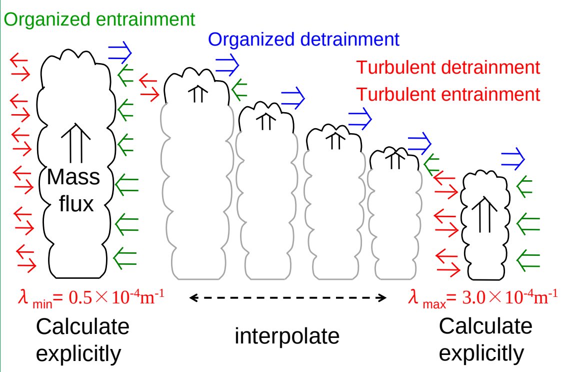

Fig.1 Schematic diagram for convective updraft in the **Yoshiumra cumulus scheme**.

- Convective updraft

Turbulent entrainment / detrainment
- Convective updrafts with λ_{min} and λ_{max} are calculated as detailed entraining and detraining plumes as in the **Tiedtke-type**.
- Multiple convective updrafts with different heights like the **AS-type** are represented by considering continuous convective updrafts between λ_{min} and λ_{max}.
- Magnitude of the convective updrafts are determined by a closure assumption based on **CAPE**.

Organized entrainment / detrainment
- Two kinds of organized entrainment are considered. One takes place near the level with the maximum moist static energy, in which updrafts originate. The other is nearly proportional to the grid-scale mass convergence.
- Organized detrainment is assumed to occur at the level with negative buoyancy.

- Convective downdraft
- Horizontal momentum transport

3. Mean states & 20-100day variance

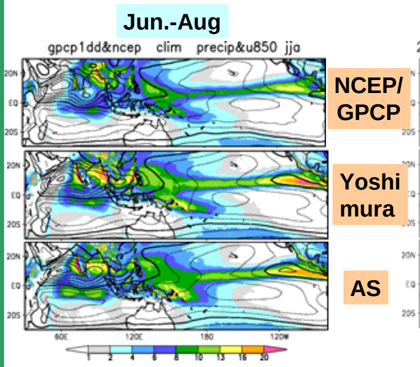

Fig. 2 June-August mean precipitation (shade) and 850hPa zonal wind (contour).

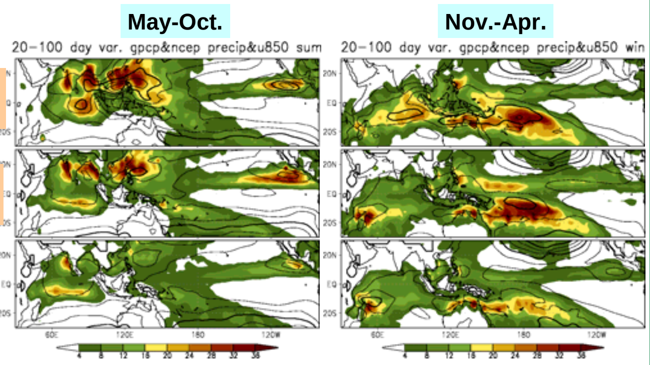

Fig. 3 Variance of 20-100-day filtered precipitation (shade) and 850hPa zonal wind (contour) in (left) May-Oct. and (right) Nov.-Apr.

Table 2 Skill score of mean fields from 1979 to 2003 using a metric suggested by Taylor (2001). Higher score is shaded. Asia: (40-160° E, 10° S-30° N), Tropics: (20° S-20° N, 0-360° E).

			Precip		U850	V850	U200
			GPCP	CMAP	NCEP	NCEP	NCEP
Asia	JJA	*Yoshimura*	0.904	0.930	0.985	0.965	0.989
		AS	0.89	0.884	0.984	0.964	0.979
Tropics	JJA	*Yoshimura*	0.918	0.958	0.985	0.938	0.996
		AS	0.925	0.948	0.975	0.919	0.992
Tropics	DJF	*Yoshimura*	0.934	0.958	0.966	0.907	0.991
		AS	0.921	0.942	0.966	0.894	0.983

The Yoshimura scheme model improves climatology over all seasons, especially in precipitation distribution over the Asian monsoon region in boreal summer (**Fig.2** and **Table 1**).

The Intraseasonal variability in the Yoshimura scheme model is much stronger than that in the AS-type model and close to observation except over the equatorial eastern Indian Ocean (**Fig.3**).

4. Eastward propagation (November-April)

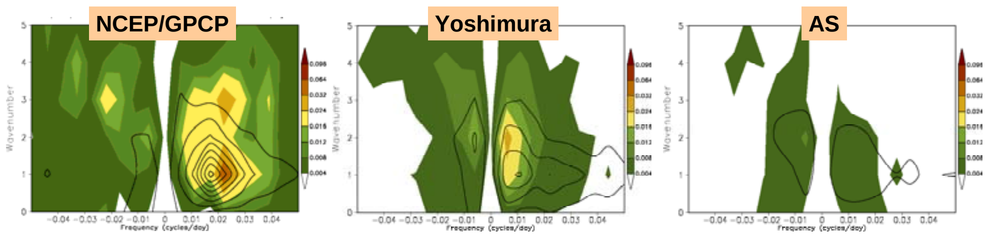

Fig. 4 Wavenumber-Frequency spectra of 10° N-10° S averaged precipitation (shade) and 850hPa zonal wind (contour).

The Yoshimura scheme model improves the space-time power spectra in the MJO band compared to the AS-type model. However, the spectral power in the MJO band is still weaker than the observation, and the simulated power is distributed more on the time periods longer than 90 days (**Fig.4**).

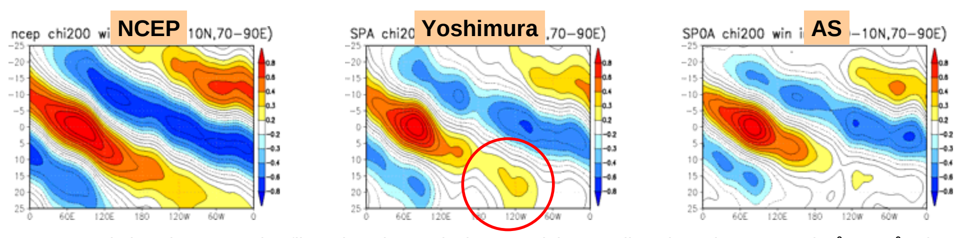

Fig. 5 Lag correlations in 20-100-day filtered 200hPa velocity potential anomalies along the equator (10° S-10° N). Reference point is the equatorial Indian Ocean (10° S-10° N, 70-90° E.)

In the 200hPa velocity potential field, the Yoshimura scheme model holds clear signals until over east of the date line and has longer frequency (∼40 days/1cycle) than those in the AS-type model (**Fig.5**).

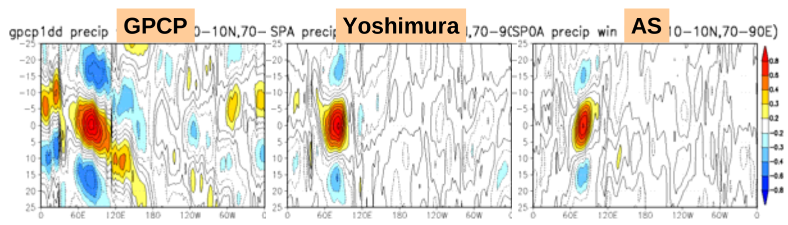

Fig. 6 Same as Fig.5 except for precipitation

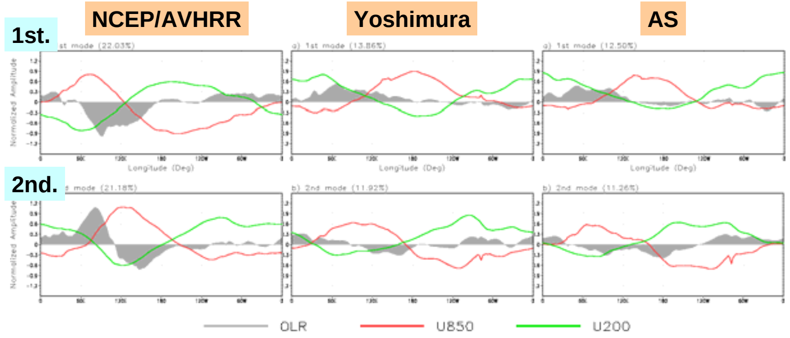

Fig. 7 The first two CEOF modes of 20-100-day 15N-15S averaged 850hPa and 200hPa zonal wind and OLR. CEOF analysis is conducted using all season data.

Eastward propagation of convection signals from the Indian Ocean to the western Pacific is not clear in either model (**Fig.6**). Both models show weak coupling among convection and zonal winds and low explained variances by each EOF (**Fig.7**).

5. Northward propagation in Asia (May-October)

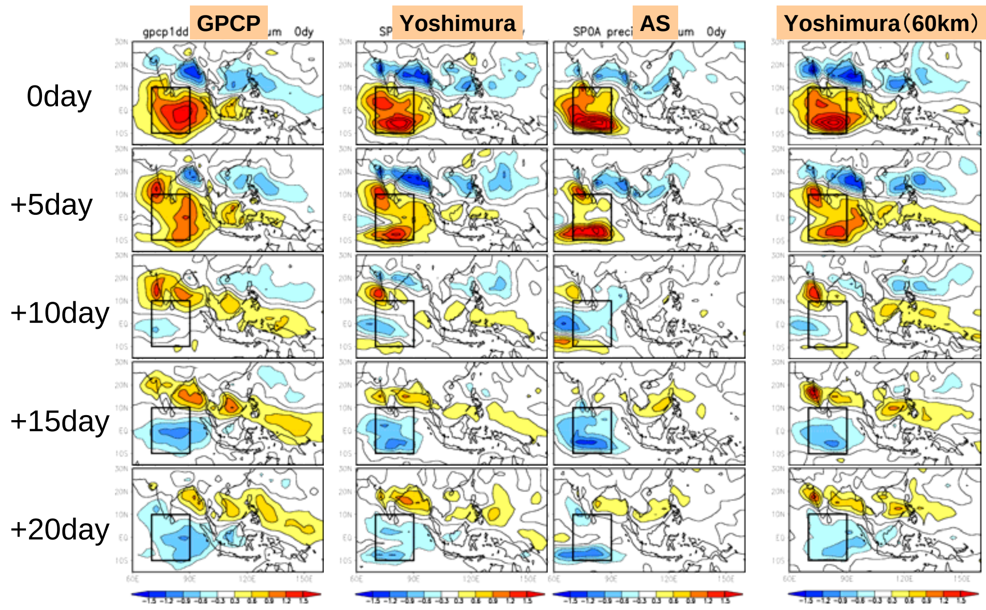

Fig. 8 Lag regression coefficient in 20-100-day filtered precipitation. Reference area is the equatorial Indian Ocean (10° S-10° N and 70-90° E.)

Fig. 8 shows that the Yoshimura scheme model can realistically simulate northward propagation of intraseasonal precipitation anomalies from the equator with the northwest to southeast tilted band. On the other hand, in the AS-type model those features aren’t produced. The northward propagation of the convection signal can also be found in lower resolution model experiments (60km and 180km).

6. Summary

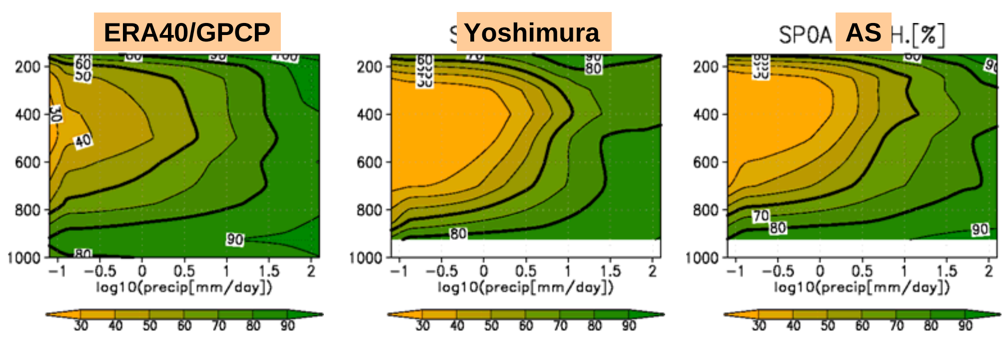

Fig. 9 Composite vertical profile of relative humidity binned by daily average rain rate from the Indian Ocean to the central Pacific (15° S-15° N, 50-180° E). The 60% and 80% contours are darkened for clarity.

The 20km mesh MRI/JMA AGCM incorporating the Yohimura scheme can simulate the intraseasonal variability with amplitude close to observations (**Fig.3**) and the northward ISV propagation with the tilted rain band over southeast Asia (**Fig.7**). Improvement of dry bias in the mid- to lower troposphere for heavy rain rates (**Fig.9**) may lead to those realistic simulations.

However, the simulated eastward propagation along the equator by the new model is still less realistic. Further analysis and model improvements are necessary.

Acknowledgements

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