Intense Precipitation Events in the Reanalysis Datasets

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INTRODUCTION

In these days, occurrence trends of extreme phenomena, particularly that of intense precipitation have been attracting much concern in association with the global warming. Many studies have been conducted based on both station data and model simulation on this issue.

In the study of intense precipitation, atmospheric reanalysis datasets would be useful to evaluate such trends over data sparse regions if reproducibility of precipitation in reanalyses is good because they provide not only precipitation but also other fields with spatially homogeneity and physical consistency for analysis of its background. Monthly precipitation reproduced in reanalyses show good performance in comparison with the GPCP data (Figure 1).

In this study, characteristics of precipitation reproduced in reanalyses, particularly inter-annual variations of precipitation amount and occurrence of intense precipitation events are compared with daily observed precipitation data, and are evaluated from the view point of reproducibility.

Recently, daily gridded precipitation datasets based on station data have been produced for the east Asian region by Xie, et al. (2006) and for India by the IMD (Rageevan, et al., 2006). In this analysis, such gridded products are used because they are considered to be more suitable for validation of model simulation results than individual station data from a viewpoint of representing wider spatial scales.

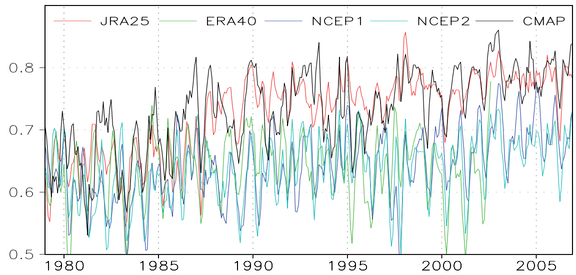

Figure 1. Spatial correlations of monthly precipitation with the GPCP over the globe (60S-60N). Three-months moving average is applied.

Data and Method

Three daily gridded precipitation datasets and four reanalysis datasets are used in this study. Their specifications are summarized in Table 1. Analysis period is 1979-2001 as the common period for all datasets.

Figure 2 shows the distribution of station used in the Chinese part of EA05 and IMD10. Originally EA05 covers the East Asia, but only Chinese region is used due to data quality problem. Figure 3 is the temporal changes of number of station used in the both datasets. The sudden decrease of number of station of EA05 in 1998 is due to lack of intense observation data around Yellow river basin after 1998. Except for those data, number of station used for China region in EA05 is nearly 600.

To examine intense precipitation events, precipitation classes are defined. Generally there are two ways for the classification, frequency base and total amount base. Here the latter is adopted following Fujibe, et al. (2005)

(Figure 4). We used normalized precipitation amount within the most intense class (class 10) as an index of intense precipitation events, and denoted it as NPC10 following Takahashi., et al. (2006). Normalization is done by dividing with one-tenth of totally accumulated precipitation on each grid.

Table 1. Specification of datasets used in this study

Symbol	Name	Data Period	Resolution of data used
EA05	East Asian Daily Precipitation Analysis V0409	1978.1-2003.7	0.5deg latlon
IMD10	High resolution daily gridded precipitation for the Indian region	1951-2004	1.0deg latlon
CPC10	Gridded daily precipitation by CPC	1948-2004	1.0deg latlon
JRA25	JMA-CRIPIE reanakysis	1979.1-current (JCDAS)	1.125deg Gaussian
ERA40	ECMWF 40year reanalysis	1958-2002.7	2.5deg latlon
NCEP1	NCEP-NCAR reanalysis	1948-current (CDAS1)	1.875deg Gaussian
NCEP2	NCEP-DOE reanalysis	1979-current (CDAS2)	1.875deg Gaussian
GPCP	GPCP Ver.2	1979-current	2.5deg latlon
CMAP	CMAP Standard	1979-current	2.5deg latlon

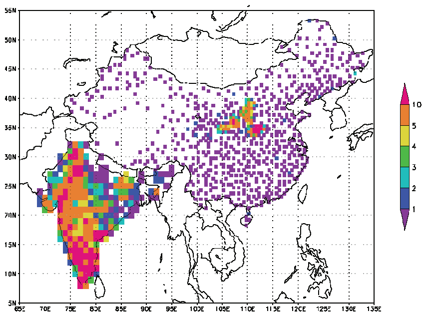

Figure 2. Density distribution of station used in EA05 (only China) and IMD10 on 1 Jan, 1979. The grid sizes are different in India and China.

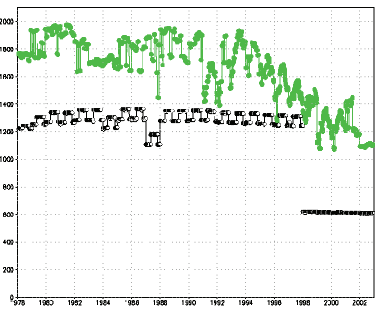

Figure 3. Temporal changes of total number of station. Green and black lines show total station number used in IMD10 and in Chinese part of EA05.

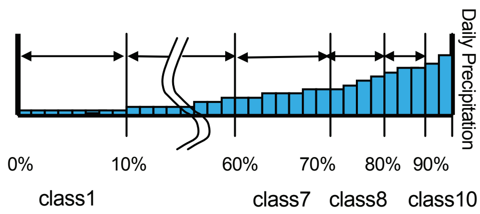

Figure 4. Definition of precipitation class based on totally accumulated precipitation for the whole period. Each class is defined so that the total amount within it is equal to one-tenth of the total sum.

Inter-annual variations of precipitation amount and NPC10

Analysis is done for several sub-regions shown in Figure 5 as well as whole China, the US, India.

Figures 6 and 7 show the interannual variation of precipitation amount and NPC10 respectively over India, China, US and Mexico. CMAP and GPCP data are also compared in precipitation amount. You can see all reanalysis datasets are reproducing the interannual variation in precipitation amount.

To evaluate the performance of each reanalysis dataset, correlation with observation in annual precipitation amount and NPC10, and the root-mean-square of difference between gridded observational data and reanalysis ones are calculated and summarized in Table 2.

This result shows that all reanalysis datasets reproduce precipitation activity as a whole in the inter-annual time scale although there are still differences in precipitation amount.

Moreover, for the intense precipitation index, NPC10, statistically significant correlations are obtained.

However, you should pay attention to India case in JRA-25 data. Interannual variation of precipitation amount looks good, but correlations for both north and south parts are very bad (Table 2 and Figure 8). As these situations are improved after 1988, it is considered due to the impact of incorporation of SSM/I data in 1987 on the precipitation behavior over the India.

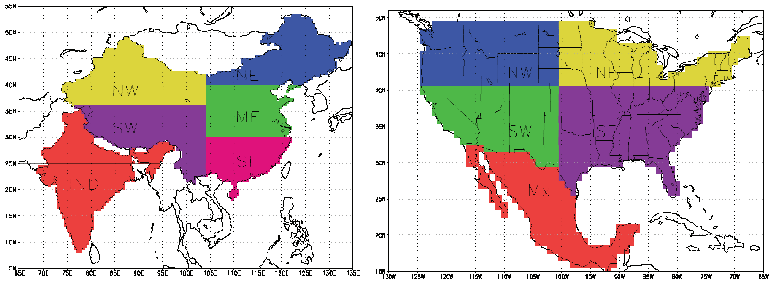

Figure 5. Analysis regions. China is partitioned with 36N, 40N, 30N in latitude and 104E in longitude. India is divided with 25N. The US is partitioned with 100E and 40N.

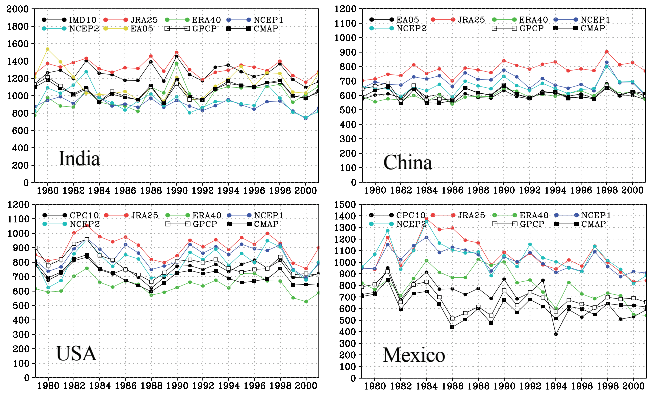

Figure 6. Interannual variations of annual precipitation amount.

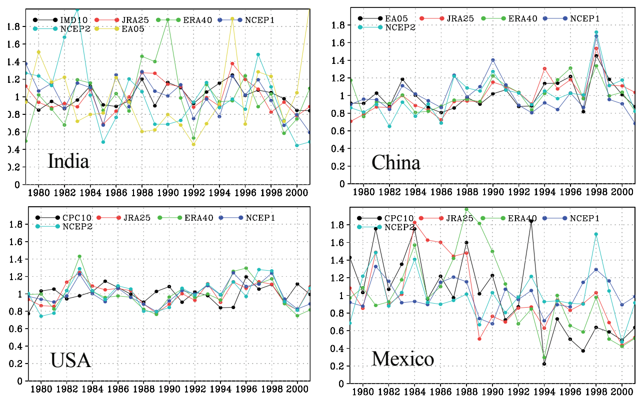

Figure 7. Interannual variations of NPC10.

Table 2. Correlation and RMS of difference between gridded observation and reanalysis precipitation.

		India IMD10	India North	India South	88-04 North	88-04 South	China EA05	China NW	China SW	China NE	China ME	China SE	USA CPC1	USA NW	USA SW	USA NE	USA SE	Mexico
JRA25	COR-Precip	**0.78**	0.31	0.12	0.77	0.70	**0.76**	**0.81**	**0.69**	0.91	0.67	0.81	0.70	**0.85**	0.67	0.71	0.57	0.65
	RMS-Precip	**72.9**	132.0	167.2	82.5	84.1	180.9	32.9	371.1	55.3	77.6	456.9	158.3	100.7	140.5	52.9	282.3	358.1
	COR-NPC10	**0.60**	**0.46**	0.14	-0.41	-0.48	**0.79**	**0.70**	0.44	**0.94**	0.56	**0.74**	0.36	0.77	**0.57**	0.31	0.57	0.59
ERA40	COR-Precip	0.69	0.31	**0.75**			0.66	0.64	0.63	**0.95**	0.71	0.62	**0.82**	0.80	0.74	0.79	0.74	0.71
	RMS-Precip	206.7	**126.9**	329.4			**20.3**	16.2	306.1	**20.2**	133.3	308.5	106.0	41.2	57.7	125.3	221.4	127.1
	COR-NPC10	0.41	0.35	0.17			0.68	0.53	0.23	0.83	**0.63**	0.68	0.49	**0.82**	0.46	0.42	0.64	**0.60**
NCEP1	COR-Precip	0.77	**0.67**	0.49	0.64	0.62	0.68	**0.82**	0.26	0.85	0.79	0.48	0.79	0.83	**0.76**	0.75	0.68	**0.75**
	RMS-Precip	277.5	385.6	199.4	384.1	231.0	231.5	89.9	488.1	164.7	102.9	384.1	96.7	113.7	**43.9**	62.6	203.8	319.9
	COR-NPC10	0.39	0.35	-0.26	0.51	0.05	0.49	0.48	0.15	0.72	0.48	0.36	**0.64**	0.83	0.55	**0.52**	**0.66**	0.18
NCEP2	COR-Precip	0.59	0.61	0.33	0.62	0.63	0.72	0.74	0.64	0.78	0.74	0.76	0.74	0.85	0.73	0.74	0.65	0.69
	RMS-Precip	185.2	473.4	183.1	453.0	124.7	172.2	22.4	546.4	98.3	60.9	274.0	71.3	106.7	46.7	50.9	127.8	341.7
	COR-NPC10	0.05	0.33	-0.25	0.25	0.12	0.61	0.63	0.33	0.53	0.53	0.65	0.46	0.66	0.38	0.31	0.55	0.36
EA05	COR-Precip	0.26	0.31	0.30														
	RMS-Precip	168.3	248.9	152.1														
	COR-NPC10	-0.14	0.14	-0.25														
GPCP	COR-Precip	0.56	0.32	0.64	0.56	0.83	0.63	0.73	0.50	0.88	**0.90**	0.81	0.70	0.82	0.70	0.81	0.82	0.54
	RMS-Precip	205.8	418.6	**91.2**	**398.3**	**86.6**	27.0	**12.4**	**0.7**	50.9	**28.3**	**73.9**	54.1	**35.6**	46.9	116.5	59.3	**96.7**
CMAP	COR-Precip	0.66	0.40	0.75	0.64	0.87	0.61	0.80	0.59	0.82	0.88	**0.81**	0.72	0.84	0.73	**0.84**	**0.84**	0.50
	RMS-Precip	200.6	341.7	116.2	308.5	110.5	25.1	23.8	83.0	21.1	46.8	126.7	**46.8**	53.4	53.0	**35.8**	**52.6**	115.2

*Bold indicates the best score and grey color shows its significance of correlation at 99% confidence level.

Trends

Figure 9 shows horizontal distribution of linear trends of annual precipitation amount and NPC10 with IMD10 and JRA-25 data for 1988-2004. This period is taken to avoid the impact by SSM/I data introduction. Figure 9 (a) and (b) show that reanalysis datasets reproduce well linear trends of precipitation amount over India. But comparing figure 8 (c) and (d), reproduction of NPC10 trends is difficult.

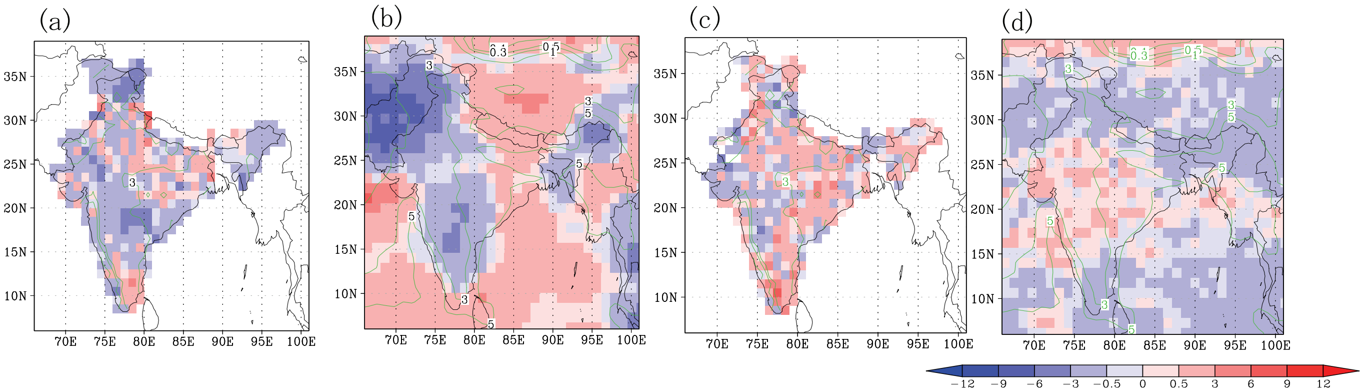

Figure 9. Horizontal distributions of linear trends of annual precipitation and NPC10 of IMD10 and JRA-25 for 1988-2004. (a) IMD10-Precipitation (b) JRA25-Precipitation (c) IMD10-NPC10 (d) JRA25-NPC10

Concluding Remarks

In this study, reproducibility of precipitation in reanalysis datasets is examined with interanual variation of its total amount and the defined index for intense precipitation events, NPC10. Due to availability of observational gridded precipitation data, analysis regions are limited to India, China, the US and Mexico.

As a whole, every reanalysis reproduces well the interannual variations in precipitation amount although total amount itself has still some difference from observation.

Over the India, correlation in JRA-25 becomes worse if the target area is divided into the north and south parts although correlation is good for the whole India (Table 2). This is due to the influence of SSM/I data incorporation in JRA-25. This is confirmed by better correlation for 1988-2004.

As for NPC10, the reproducibility is lower than that of the total amount of precipitation, but the interannual variations are reproduced to some degree. Generally the reproducibility in NPC10 tends to be better in higher latitude.

These results suggest the possibility of utilization of reanalysis data in the evaluation of extreme precipitation event occurrence. Further investigation is needed for other regions.

REFERENCES

Fujibe, F., N. Yamazaki, M. Katsuyama and K. Kobayashi, 2005: The Increasing Trend of Intense Precipitation in Japan Based on Four-hourly Data for a Hundred Years, SOLA, **1**, 41-44

Higgins,R.W., Y. Chen and A. V. Douglas, 1999: Interannual Variability of the North American Warm Season Precipitation Regime, J.Climate, **12**, 653-680

Rageevan,M., J. Bhate, J. D. Kale and B. Lal, 2006: High resolution daily gridded rainfall data for the Indian region: Analysis of break and active monsoon spell, Current Science, **91**, 296-306

Takahashi,K., N. Yamazaki and H. Kamahori, 2006: Trends of Heavy Precipitation Events in Global Observation and Reanalysis Datasets, SOLA, **2**, 96-99

Xie, P., A. Yatagai, M. Chen, T. Hayasaka, Y. Fukushima, C. Liu and Y. Song, 2007: A Gauge-Based Analysis of Daily Precipitation over East Asia. *J. Hydrometeor.,* **8**, 607-627