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Short Communication

Precipitation variability and trends over the Mekong Delta area of Vietnam

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Precipitation is a key characteristic of any watershed which plays a significant role in water planning and management. World Bank (2016) reported that Vietnam is among the top 5 countries most affected by droughts, floods and water scarcity due to the impacts of climate variability. MNRE (2016) reported that the annual and seasonal tendencies of precipitation and its big interannual variability in the Mekong Delta of Vietnam create drought, water scarcity, unusually heavy rainfall and seriously affected the agricultural production activities. They predicted that the frequency of droughts variabilities and unseasonal precipitation will increase in 2020s year. Lee and Dang (2018) showed that the spatial distribution tends to increase with main scales including moderate and severe droughts in the Mekong Delta area. Daksiya *et al.* (2017) studied annual and seasonal rainfall for a Southeast Asian region under current and future climate conditions. Waghaye *et al.* (2018) applied Mann-Kendal and Sen slope estimate to analysis trends and change point detection in annual and monsoon rainfall over Andhra Pradesh and Telangana, India.

The purpose of the study is to evaluate the variability of precipitation in the Mekong Delta of Vietnam using Mann-Kendall test and Sen slope estimate. Mekong River delta is located at 8°34'-11°10'N and 104°25'-106°48'E and is known as one of two large rice warehouses in Vietnam next to the Red River Delta (Vu *et al.* 2018). The climate of the study area is dominated by tropical monsoon climate with two major monsoon seasons namely northeast and southwest which alternately blow throughout the year.

For this study, 13 stations (Table 1) having sufficiently long period (1984-2015) were selected and data were collected from the Southern Regional Hydro-meteorological Center of Vietnam. There is large spatial variability in precipitation over Mekong Delta region. The mean annual precipitation varies between 1364 mm at Chau Doc in north to 2394 mm at Ca Mau in south (Table 1). The 85 percent of mean annual precipitation is concentrated in the wet season (May to October) which varies between 1127 mm to 2108 mm across the locations. During dry season (November to April) about 100 to 286 mm precipitation are received.

The daily precipitation data were converted to monthly, seasonal and annual totals. Wet season is considered from May to October, and dry season is considered from November to April. The non-parametric Mann-Kendall test and Sen's slope estimator were applied to detect the trends its slope. The advantage of Mann-Kendall test is that it is a non-parametric test and does not need to provide the input data series to be normally distributed (Yue *et al.* 2002). Both Mann-Kendall test and Sen's slope estimator are applied to detect the changes of precipitation characteristics with confidence level of 95 per cent. At the 95 per cent significance level, the null hypothesis of no trend is rejected if $|Z_S| > 1.96$.

Variability in precipitation characteristics

Precipitation characteristics across the study area show that on the annual precipitation scale, a slightly downward trend is found in the western coastal provinces with an average decrease varies from Zs = -0.075 at Soc Trang station to Zs = -0.216 at Can Tho station. Meanwhile, slightly increasing trend was recorded in the eastern coastal provinces with an average increase ranging from Zs = 0.078 at Kien Giang station to Zs = 1.624 at Tien Giang station.

During wet season the non-negligible decreasing trend was found in coastal provinces with values varying from Zs = -0.208 at Ca Mau to Zs = -1.674 at Can Tho. Seven out 13 stations of eastern coastal provinces recorded slightly increasing trend with values varies from Zs = 0.125 to 1.035.

Dry season precipitation showed an increasing trend at 85 per cent of the stations. Slightly increasing trend occurred at An Giang, Dong Thap, Vinh Long, Can Tho, Ben Tre, Tra Vinh, Soc Trang, Bac Lieu and Kieng Giang with Zs value varying from 0.193 to 1.379 while a significant upward trend was found at Long An (Zs = 2.078), Hau Giang (Zs = 2.218) and Tien Giang stations with Zs = 2.988. Only Ca

Table 1. Mean annual rainfall, wet season rainfall and dry season rainfall at gauge stations

Station	Annual rainfall (mm)	Wet season (mm)	Dry season (mm)	Longitude (E)	Latitude (N)
Chau Doc	1364	1127	147	105°08'09	10°33'24
Can Tho	1580	1472	108	105°33'20	10°08'16
Hau Giang	1852	1677	175	105°38'28	09°45'33
Tien Giang	1448	1347	101	106°20'37	10°22'36
Cao Lanh	1473	1336	137	105°37'58	10°27'21
Vinh Long	1489	1370	119	105°57'32	10°14'41
Soc Trang	1908	1762	146	105°58'26	09°36'13
Bac Lieu	1895	1706	189	105°45'22	09°34'40
Rach Gia	2105	1960	145	105°12'01	09°54'23
Ca Mau	2394	2108	286	105°07'35	09°10'15
Cang Long	1543	1273	270	106°20'04	09°57'04
Ba Tri	1527	1425	102	106°24'44	10°19'53
Moc Hoa	1632	1485	147	106°10'35	10°54'26

Table 2: Statistical tests of precipitationcharacteristicsduring period 1984-2015

Station	Annual precipitation			Wet season precipitation			Dry season precipitation		
	Z_S	p-value	β	Z_S	p-value	β	Z_S	p-value	β
Kien Giang	0.078	0.469	-0.002	-1.332	0.091	-0.007	1.325	0.092	0.000
Ca Mau	-0.107	0.458	-0.003	-0.208	0.418	-0.005	-1.025	0.15	-0.0013
Bac Lieu	0.821	0.206	0.000	0.274	0.392	-0.003	1.562	0.059	0.000
Soc Trang	-0.075	0.470	-0.001	-1.566	0.058	-0.007	1.385	0.083	0.000
Tra Vinh	0.913	0.181	0.000	0.125	0.450	-0.003	1.733	0.041	0.000
Ben Tre	1.038	0.150	0.000	0.585	0.279	-0.002	1.739	0.041	0.000
Can Tho	-0.216	0.414	-0.001	-1.674	0.047	-0.006	0.751	0.226	0.000
Hau Giang	0.996	0.160	0.000	0.378	0.353	-0.003	2.218	0.013	0.000
Vinh Long	1.080	0.140	0.000	0.649	0.258	-0.002	1.702	0.044	0.000
Tien Giang	1.624	0.052	0.000	1.035	0.150	-0.001	2.988	0.001	0.000
Dong Thap	0.913	0.181	0.000	0.125	0.450	-0.003	1.593	0.055	0.000
Long An	0.437	0.331	-0.001	-0.598	0.275	-0.005	2.078	0.018	0.000
An Giang	-0.002	0.499	-0.001	-0.860	0.195	-0.004	0.193	0.423	-0.0001

Mau station recorded slightly decrease in dry seasonal precipitation with approximate value Zs = -1.025.

The spatial and temporal distribution of precipitation characteristics analysed for the period 1984-2015 for Mekong Delta of Vietnam revealed that the annual and wet seasonal precipitation showed increasing trend in most of the provinces of study area. There was a slight upward trend of annual precipitation in 9 out of 13 provinces. The wet seasonal precipitation showed down trend in seven out of 13 stations belonging to eastern, western coastal provinces and an inland province. The dry seasonal precipitation also recorded a slight upward at 9 out of 13 provinces.

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