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The Relationship between the Direction of the Diurnal Rainfall Migration and the Ambient Wind over the Southern Sumatra Island

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Introduction & Purpose

Sumatra Island is known as one of the regions where convective and rainfall activities are especially high (Fig. 1). Their diurnal cycle over the Sumatra Island has been reported by previous studies.

- Mori et al. (2004) looked into the diurnal cycle of rainfall over the Sumatra Island using TRMM satellite Precipitation Rader (PR) data and intensive in-situ observation.
- Sakurai et al. (2005) revealed the seasonal variations in the diurnal migration of cloud systems over the Sumatra Island making use of black body temperature data from GMS.

However, the seasonal variations of the diurnal propagation of rainfall and its migration mechanism remain not entirely clear although the diurnal rainfall cycles show clear seasonal contrasts there (Fig. 1).

The purpose of the present study is to elucidate the ***seasonal variations of diurnal rainfall cycle*** over the Southern Sumatra Island and to shed light on the climatological relationship between the ***diurnal rainfall migration and the ambient wind***.

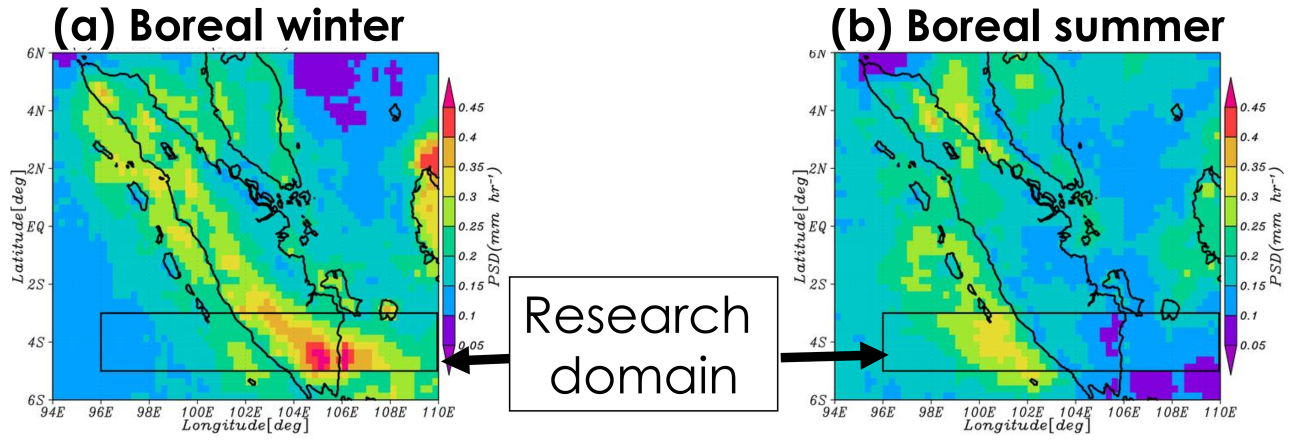

FIG.1: Distribution of the amplitude (mm/hr) of the diurnal harmonics using microwave-based rainfall data (TRMM 3B42) in the boreal winter (a) and boreal summer (b).

Data & Methodology

Precipitation Data (Jan.1998 – Dec.2012)

- TRMM 2A25 (TRMM 3G68-PR) of the orbital data are compiled into an hourly gridded product (0.25° × 0.25° spatial resolution).

Zonal Wind Data (Jan.1998 – Dec.2012)

- ERA-Interim of 6-hourly grids with the horizontal resolution of 0.75° × 0.75°. The 6 hourly wind is averaged to daily wind.

Composite Analysis

Using the values of the temporal-mean ($\bar{u}$ = 0.4 m/s) and standard deviation (σ = 3.8 m/s) of the time series, we identify 4 regimes and make a composite plot of diurnal rainfall variations in each regime (Fig. 2).

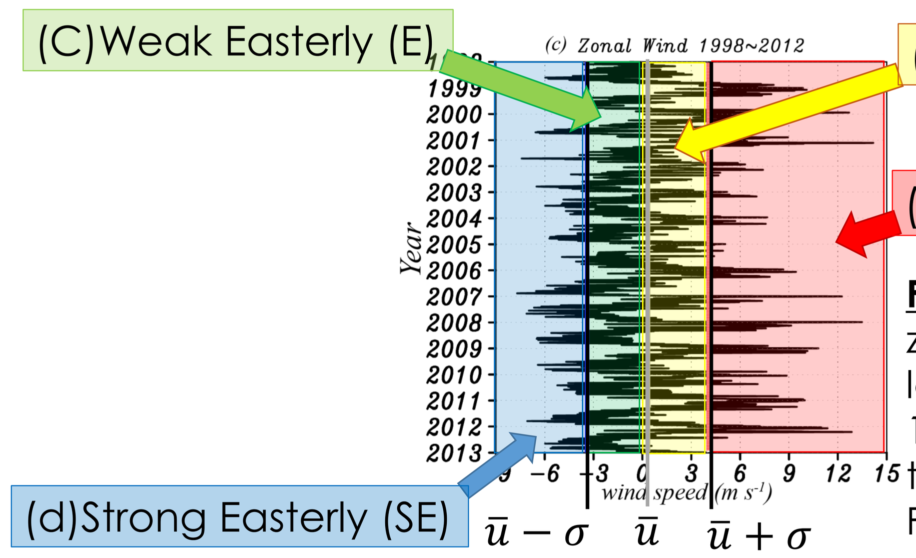

FIG.2: Time series of the zonal wind averaged for lower troposphere (from 1000 hPa to 500 hPa) over the rectangular domain in Fig. 1.

Results

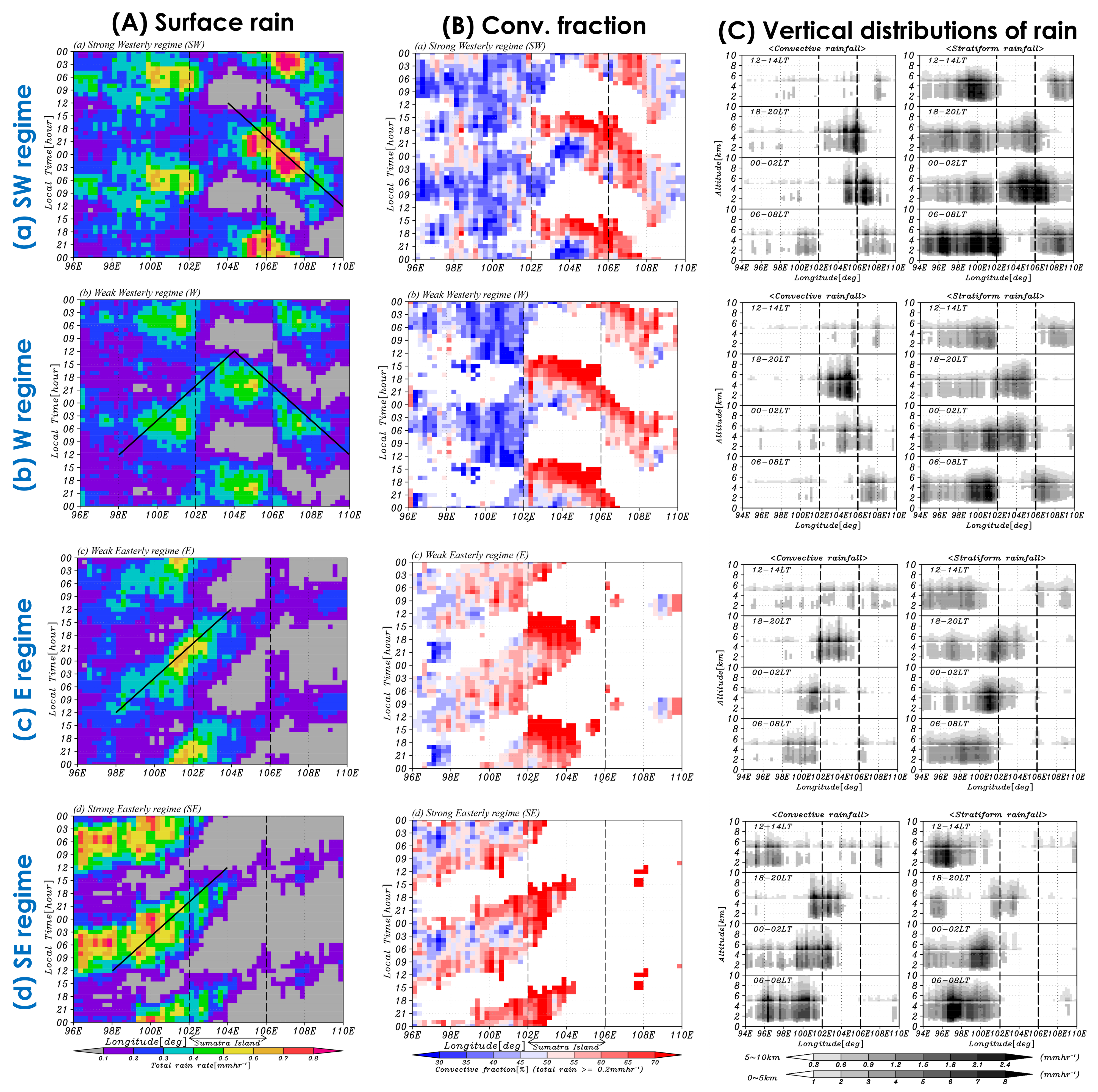

FIG.3: Time-longitude cross sections of (A) the composite surface rain-rate (left panel) and (B) the convective rain fraction to the total precipitation (center panel) from TRMM 2A25 in (a) strong westerly (SW) regime, (b)weak westerly (W) regime, (c) weak easterly (E) regime, and (d) strong easterly (SE) regime. The area between two dashed lines from 102° E-106° E corresponds the land region. In the A panels, one or two solid line indicates subjectively estimated migration speed of 8 m/s. The area with the surface rain rates 0.2 mm/hr is blanked out in the (B) panel.

(C)The sequence of the vertical distributions of the convective (right small frame) and stratiform rain (left small frame) in (a) SW, (b) W, (c) E, and (d) SE regimes (right panel). The area between the two dashed lines at 102° E and 106° E corresponds to the land region.

Discussion

We quantitatively compare the propagation speed with the zonal wind speed in this section using the result of Figs. 3 and Fig. 4.

(a) SW regime

The wind speed (~8 m/s) from 800 hPa to 600 hPa (Fig. 4a) matches the migration speed (~8 m/s) of the convective rainfall system (Fig. 3A, 3B and 3C –a).

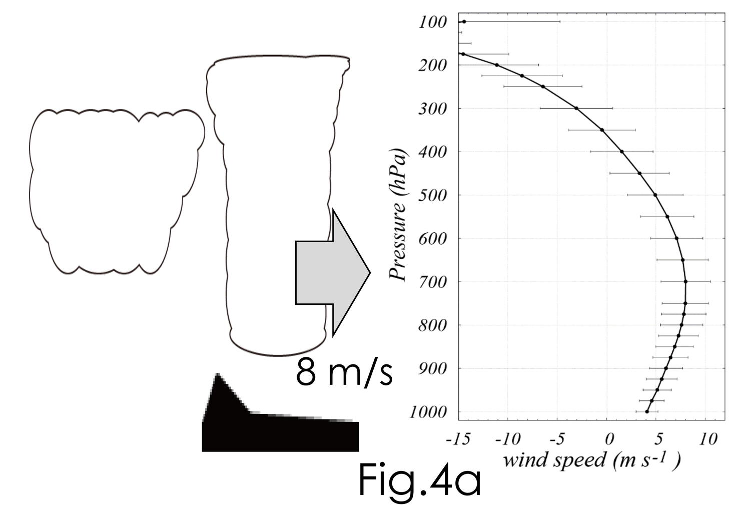

Fig.4a

(b) W regime

The eastward migration speed (~5 m/s) of convective rainfall system (Fig. 3A, 3B and 3C -b) is slightly faster than the wind speed (~0-4 m/s) in the lower troposphere (Fig. 4b).

On the other hand, the westward migration speed of stratiform rainfall (~4 m/s) agrees with the composite wind speed (~3-6 m/s) for 400 – 250 hPa level.

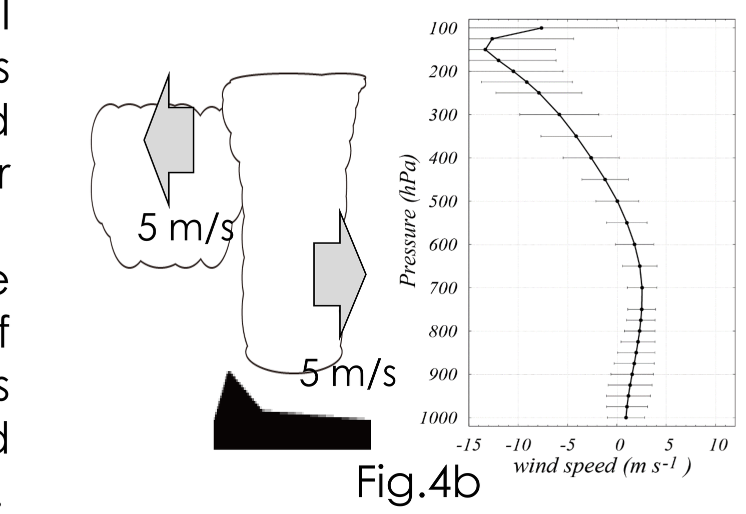

Fig.4b

(c) E regime

The speed of the composite zonal wind (less than 4 m/s) in the lower level (Fig. 4c) is much slower than migration speed (~8 m/s: Fig. 3A, 3B and 3C -c). The migration speed corresponds to the zonal wind speed (~6-9 m/s) for 400 – 250 hPa level (Fig. 4c).

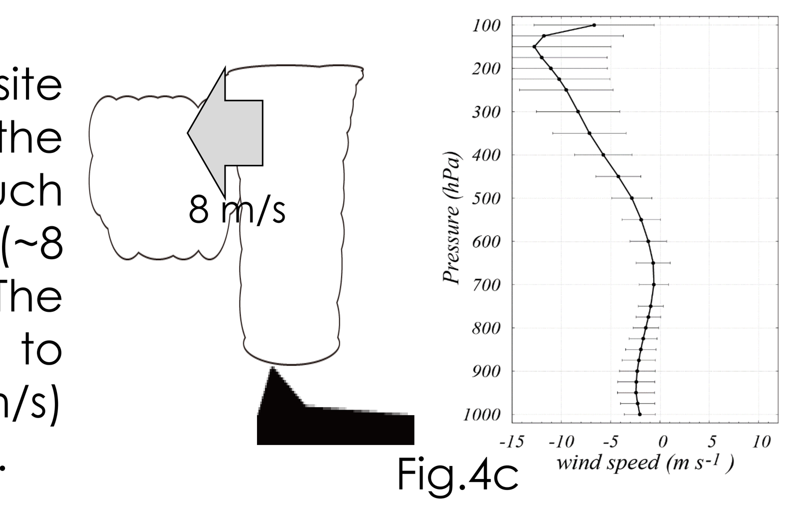

Fig.4c

(d) SE regime

The westward propagation speed (~8-12 m/s) of rainfall system (Fig. 3A, 3B and 3C -d) exceeds that of the composite zonal wind in the lower troposphere (less than 6 m/s) and better agrees with that in the mid-upper troposphere (Fig. 4d).

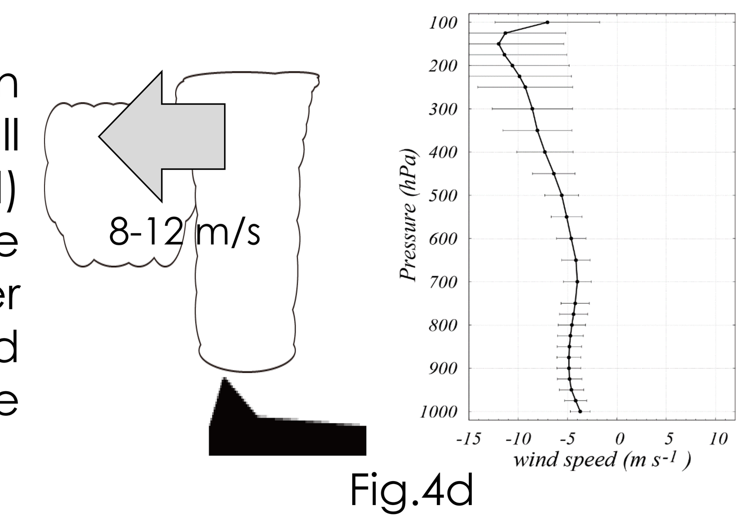

Fig.4d

FIG.4: Comparison between the estimated migration speed (left: schematic pic.) and vertical profiles of the zonal wind (right) averaged over the rectangular domain of Fig. 1 for (a) SW, (b) W, (c) E, and (d) SE regimes. Error bars indicate one standard deviation at each level.

Summary

The present study investigates the ***climatological relationship between the direction of the diurnal migration of rainfall and the ambient wind*** and its mechanism over the Southern Sumatra Island using long-term data (15-yr) from TRMM-PR satellite observation and re-analysis.

Based on these results, *the **direction and speed of the rainfall system migration appear to be generally consistent with ambient zonal wind***. Although same features have been reported by the previous studies (e.g. Mori et al. 2004; Sakurai et al. 2005; 2009), it is the first to report the propagation direction of diurnal rainfall system through ***all the seasons*** over the Sumatra Island.

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