POSTER

The Spatial Characteristics of Afternoon Lightning in Weak-Synoptic Forcing Weathers over a Subtropical Monsoon Island

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Abstract

Taiwan, located at western Pacific coastal region, is a mountainous island bisected by the Tropic of Cancer and has 300-km north-south stretch of the Central Mountain Range (CMR) with more than 50 peaks above 3,000 m. The hot and humid weather patterns in warm season provide plentiful conditions for lightning strikes over this island. In this study, the lightning data (2007 to 2009) from Total Lightning Detection System (TLDS) operated by Tai-Power Company was analyzed in the afternoon period (12 to 18 LST) under weak synoptic forcing weather conditions. TLDS is formed by seven Vaisala VHF/LF detection sites surrounding Taiwan started from 2004.

Total 248 afternoon thunderstorm (TS_a) cases were selected in this study by the evolutionary characteristics of inter/intra cloud (IC) lightning during May to October in 2008 to 2009. The IC lightning distribution of these cases showed that there are four hot spots along the western slope of CMR, and the spots were defined as the division N, NC, C, and S (Fig. 1a and 1b). The cloud-to-ground (CG) lightning distribution of these cases showed in Fig. 1c. The 30-m resolution of land digital topography is used in Fig. 1 to diagnose the detailed geographic characteristics of different lightning types. These hot spots locate at the downstream of urban cites and have wider land (ground level below 500m) area (Fig. 1d). Relatively, rare lightning happened on the eastern slope of CMR where it faces to the open Pacific Ocean and has smaller valley land area.

On the other hand, topography adjustment could be another possible reason to explain why IC lightning can concentrate in certain regions, so the weather charts (wind field only) for the cases with normalized IC lightning number of times above 0.9 in one specific division were composited (Fig. 2). The number of cases for IC lightning concentration degree above 0.9 in division N, NC_C, and S are 20, 13, and 43, respectively. The composited analysis suggested that the southwesterly flow at lower level and south-southwesterly flow at middle level may favor for afternoon IC lightning to concentrate at division N when subtropical high elongates along NE-SW direction at NW Pacific Ocean. On the contrary, low and mid-level weak northeasterly flow associated with cyclonic circulation in Philippine Sea could be the favorable environment for IC lightning concentrating at division S. Moreover, there was a

mass of IC lightning happened in the division NC_C while low and mid-level southeasterly flow prevailed.

Besides the climatological summary, two case studies were conducted by WRF in this study. Lightning appeared from north to south along the western slope of CMR and concentrated at central Taiwan on 15 August 2008 and 15 September 2009 respectively (Fig. 3, column left). The WRF was initialized by the GFS data obtained from NCAR. Table 1 shows the parameters used in the simulations. Generally speaking, the distribution of simulated rainfall (Fig. 3, middle column) resemble the observation (Fig. 3, right column) in space but occurred slightly late (not shown) in both simulations.

Generally, CG lightning begins after some number of IC lightning have occurred. It implies that the IC lightning could be more significant to trace the evolution in early stage of convection than CG. Based on the preliminary results in this study, some other issues are worthy for further investigating:

- Why and how can the airflow with a specific direction favor the convection at a specific position by the modulation of CMR? How important the mechanism of local circulation is if it exists in the CMR's modulation process?
- Why the total numbers of total lightning in one TS_a case can vary from one hundred to over thirty thousand times? The possible thermal factors affecting the convection's strength are necessary to be thoroughly examined.
- A method calculating the leading time need to be developed before the predictability of afternoon thunderstorm achieves to an acceptable level.
- Before the launch of regular cloud-seeding in the season of afternoon convection, one has to understand where the early stage of convection occurred frequently.

Table 1. Model description of two case simulations

domain	D01	D02	D03
grid points	300×200	196×196	208×226
resolution	30-km	10-km	3.33-km
vertical levels	27		
governing equations	hydrostatic	non-hydrostatic	
microphysics	WSM6		
PBL	YSU		
cumulus	KF		
land	Unified Noah land-surface		

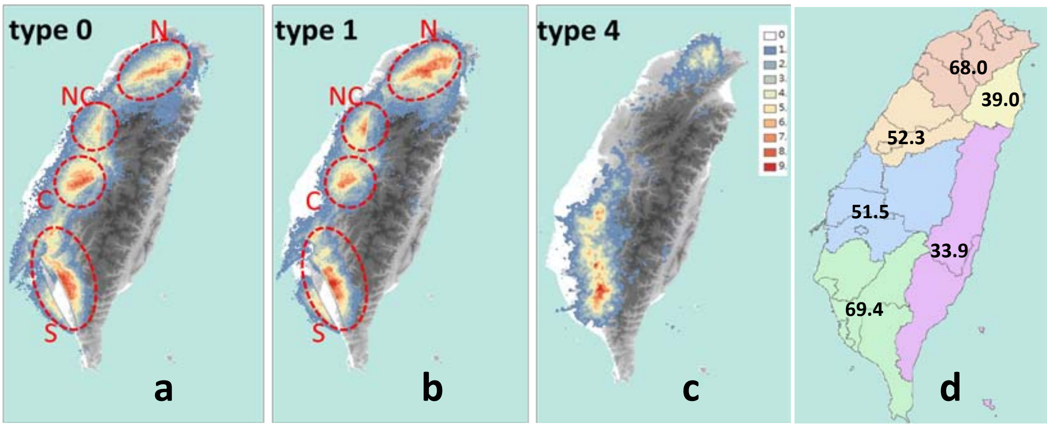

Fig. 1. The distribution of (a) type 0 (the position of single IC), (b) type 1 (the start of consecutive IC), and (c) type 4 (CG) of total lightning. (d) The proportion of ground level lower than 500 m at every division.

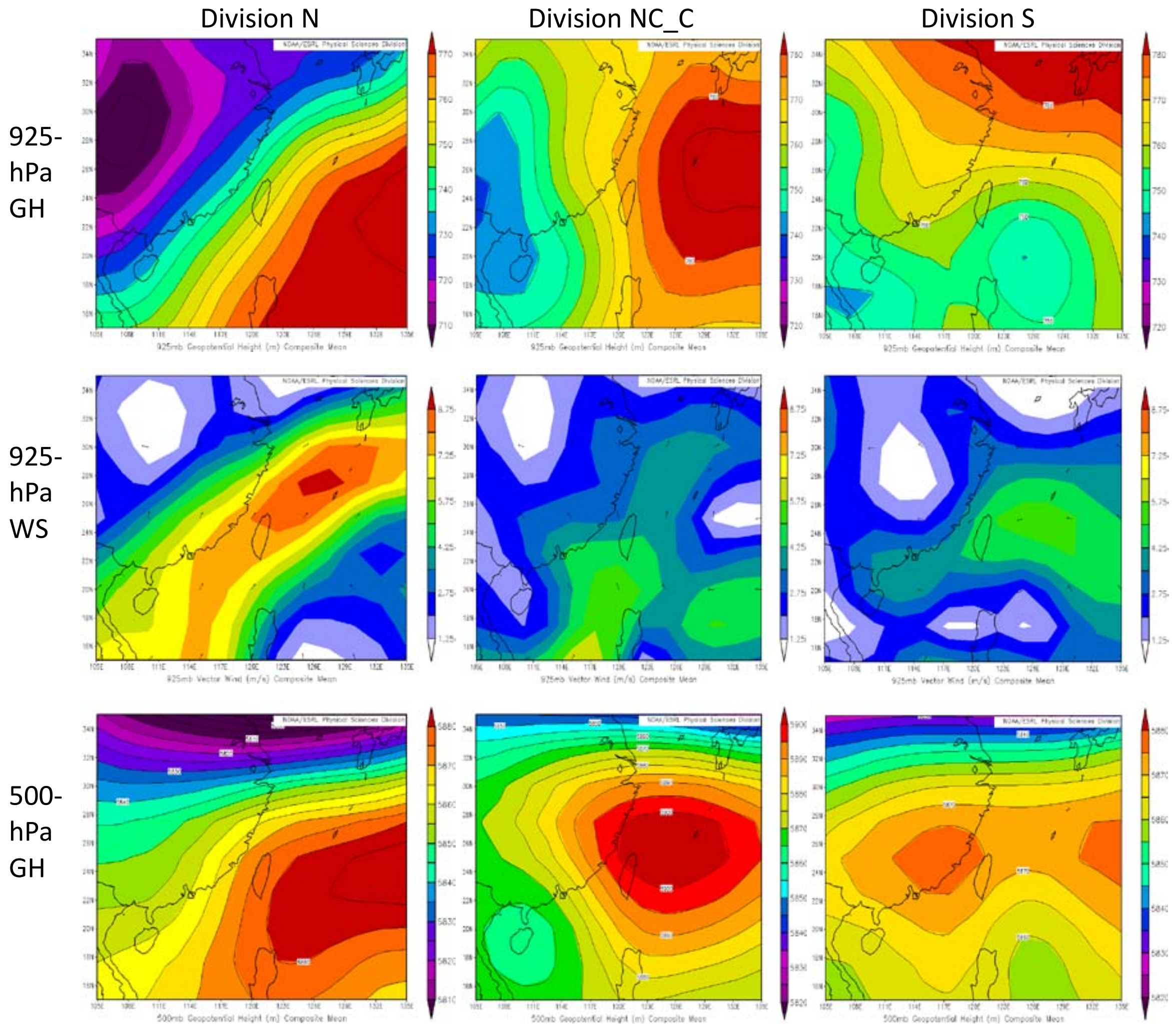

Fig. 2. The composited synoptic patterns of afternoon IC lightning concentration at Division N (left column), NC_C (middle column), and S (right column). Upper, middle, and lower row show the weather charts of 925-hPa geopotential height (m), 925-hPa wind speed (m s^{-1}), and 500-hPa geopotential height (m).

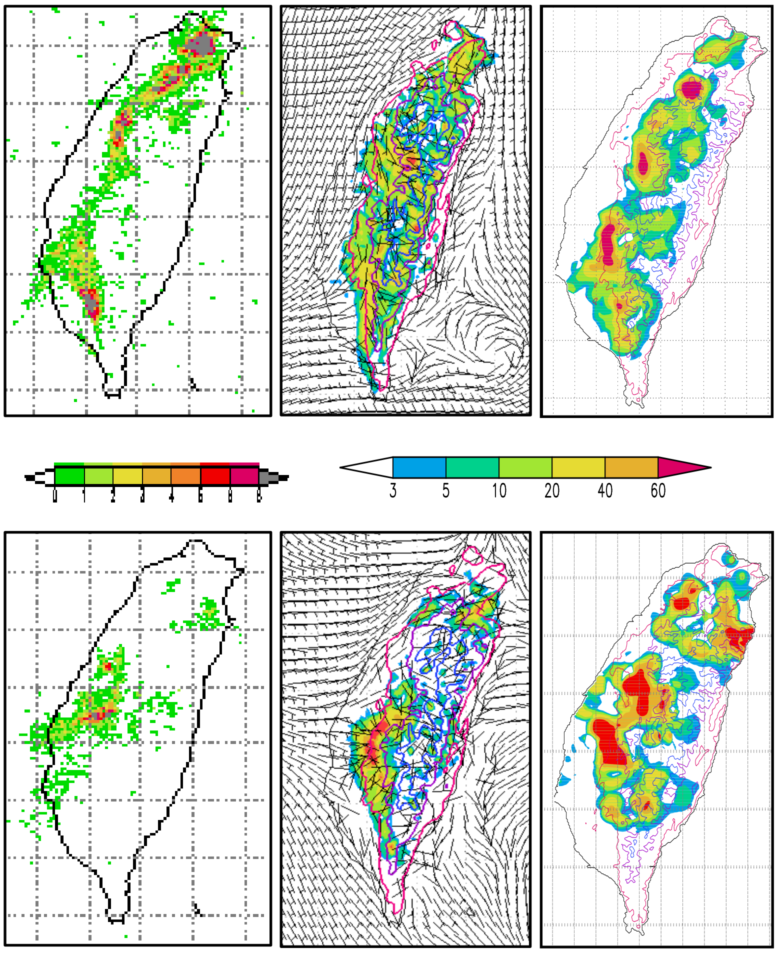

Fig. 3. The afternoon lightning distribution (left column), simulated rainfall (middle column, mm) and wind (m s^{-1}), and observed rainfall (right column, mm) of 15 August 2008 (upper row) and 15 September 2009 (lower row). The time window is from 12 to 18 LST for left column, from 12 to 20 LST for middle column, and from 15 to 20 LST for right column.