Temporal and spatial analysis of lightning and precipitation over South Korea during the summer monsoon season

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Introduction

The goal of this study is to investigate the variations in the spatial and temporal patterns of lightning activity over the Koran Peninsula in relation to precipitation during the summer monsoon months during two synoptically different years and to develop a better understanding of these two meteorological phenomena. In this paper we present the results of an analysis of lightning activity and associated monsoon rainfall over Korea.

This information will be of use in understanding the role of lightning in the monsoon rain band over Korea and this improved understanding could eventually result in enhanced skills for predicting convective rainfall in similar situations.

Data

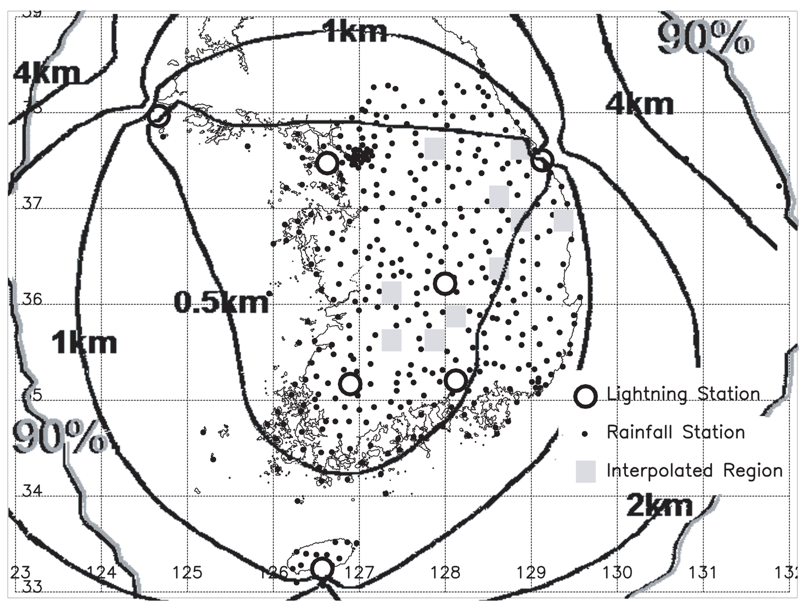

Fig. 1 Observation stations with lightning detection-efficiency an system accuracy.

The lightning data used in this study were collected from a lightning detection network installed by the Korean Meteorological Administration (KMA) (open circle in Fig. 1).

The network consists of seven IMPACT ESP (IMProved Accuracy from Combined Technology Enhanced Sensitivity and Performance) sensors mainly for detecting cloud-to-ground lightning with seventeen LDARII sensors for cloud-to-cloud lightning.

The efficiency of detection and position accuracy were obtained by combining TOA (Time of Arrival) and MDF (Magnetic Direction Finding) technology in IMPACT ESP sensor, and the time was motivated by GPS. For the accurate detection of lightning events, three IMPACT sensors are needed. The sensors automatically detect over 90% of all cloud-to-ground lightning that occurs within a nominal detectable distance of less than 1km as shown in Fig. 1.

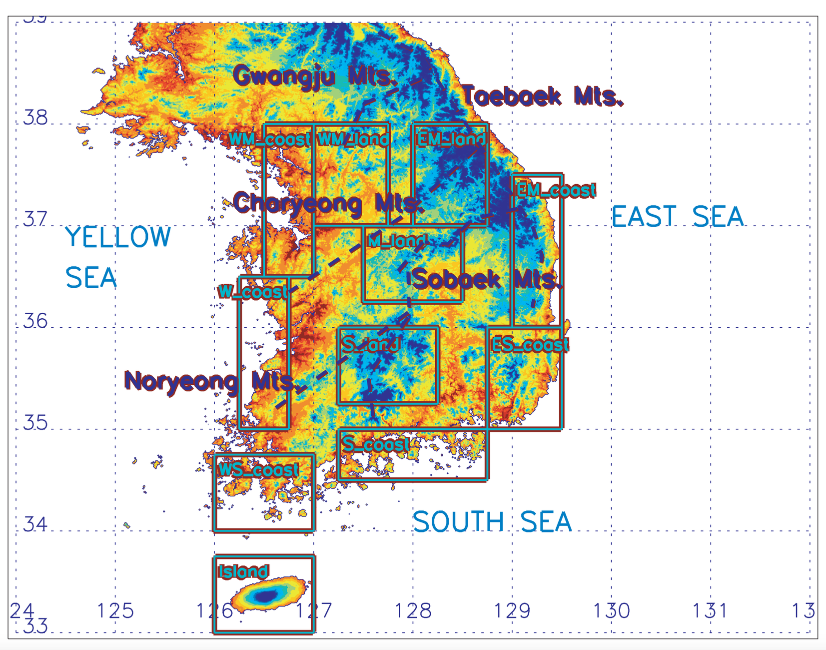

Fig. 2 Topography of Korea, Moutain ranges are noted with thick dashed lines, rectanges are to analyze the spatial variation in CG flash counts and precipitation.

The average annual precipitation over South Korea is about 1000 to 1800 mm and about 50 to 60% of the annual precipitation occurs during the summer monsoon season. Before describing precipitation or lightning, it is necessary to be acquainted with the physical features of South Korea (Fig. 2).

Results

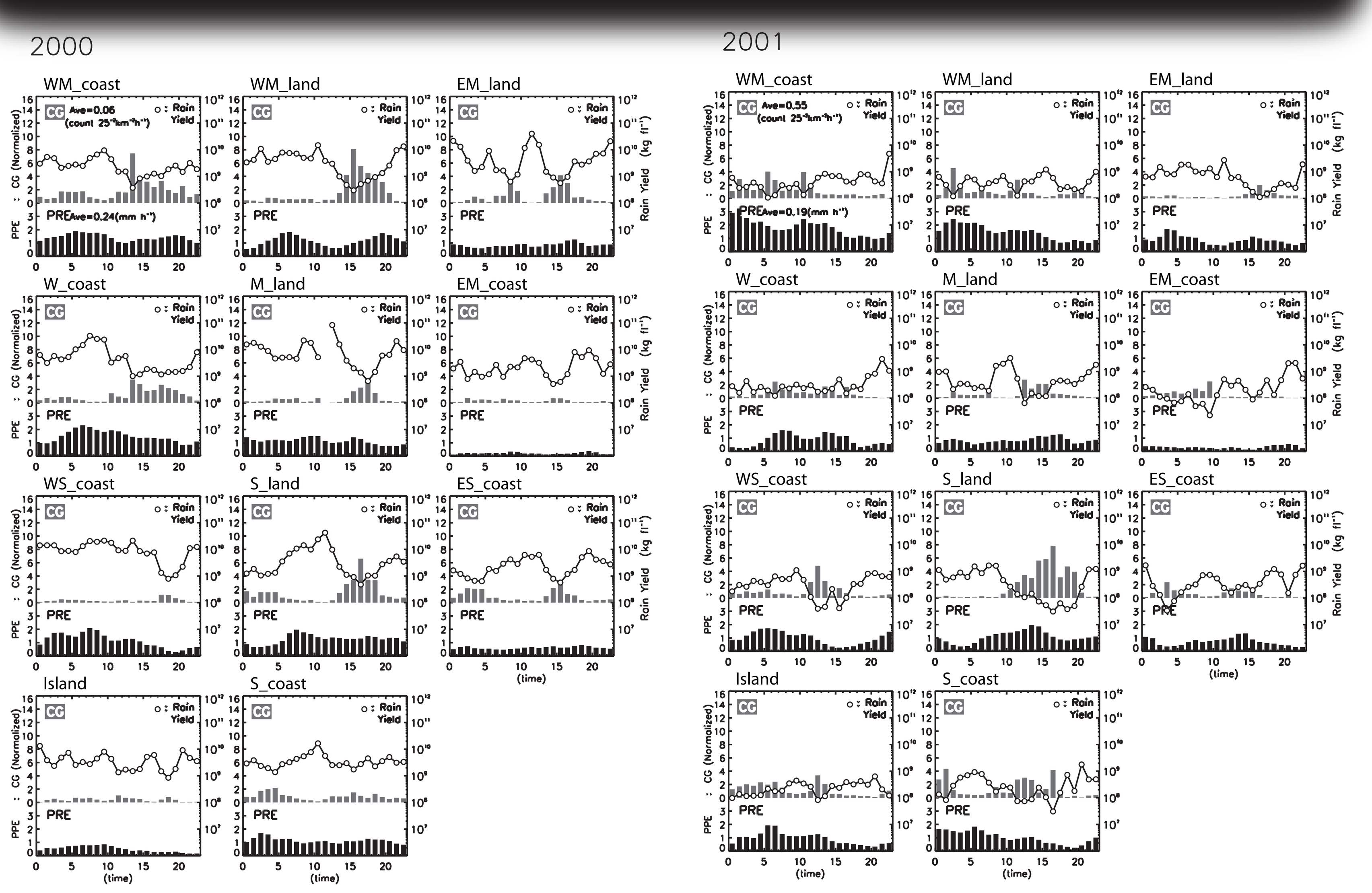

Fig. 3 Time evolution of precipitation, CG flash counts and rain-yields for nine areas marked in Fig. 2 during 2000 and 2001.

The most distinctive difference compared to 2000 is that the afternoon peaks of lightning are seen only in the southern land (S_land) during the year 2001. After noon peaks of lightning of other regions (WM_coast, WM_land, EM_land), are not so prominent during the year 2001 compared to 2000. The afternoon peaks of precipitation and lightning are predominant over the southern inland (S_land) might be due to the effect of local orography. However, in the south coast (S_coast) and 'Island' there are no noticeable peaks and the diurnal variation remains constant for all the afternoon peaks of the neighboring southland.

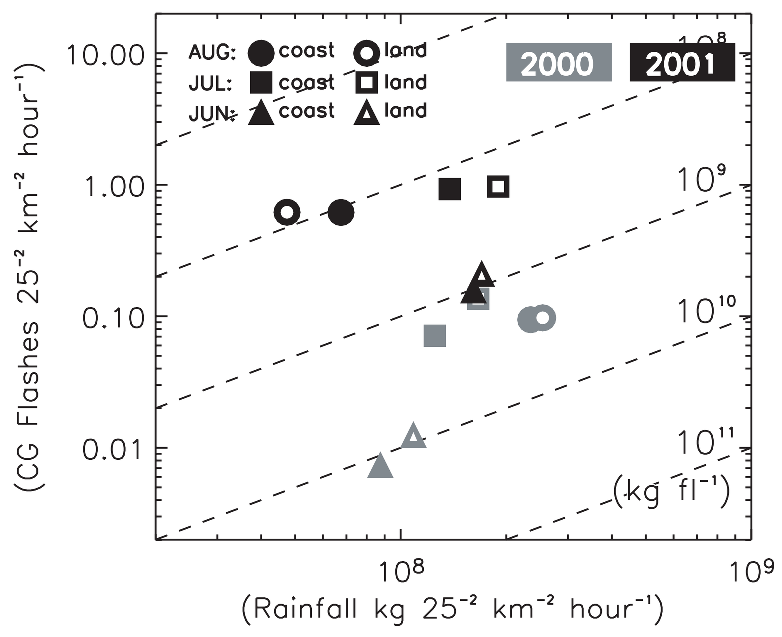

Fig. 4 Monthly averages of precipitation and CG flash counts for coastal and land regions for each month. Dashed line shows rain-yield value.

It is clear that convective precipitation was stronger in 2001 than in 2000. Compared between land and coastal values, large differences were not found. This suggests that the averaged pattern of precipitation and CG flashes between the land and coast do not make large differences over South Korea at least during 2000 and 2001. However, it should not be concluded that there is no local influence of other factors for each land and coastal region in the Korean Peninsula. The spatial variation in CG flash counts is analyzed in the next figure.

The spatial pattern of precipitation and lightning distribution during June 2001 is similar to that of July 2000. However, the maximum time of lightning activity is quite opposite from each other. The southern peaks are dominant in the afternoon and mid land peaks in the nighttime. These patterns are carried over to the next month and the maximum time of flash counts between south east and middle west areas are clearly confronted in July 2001.

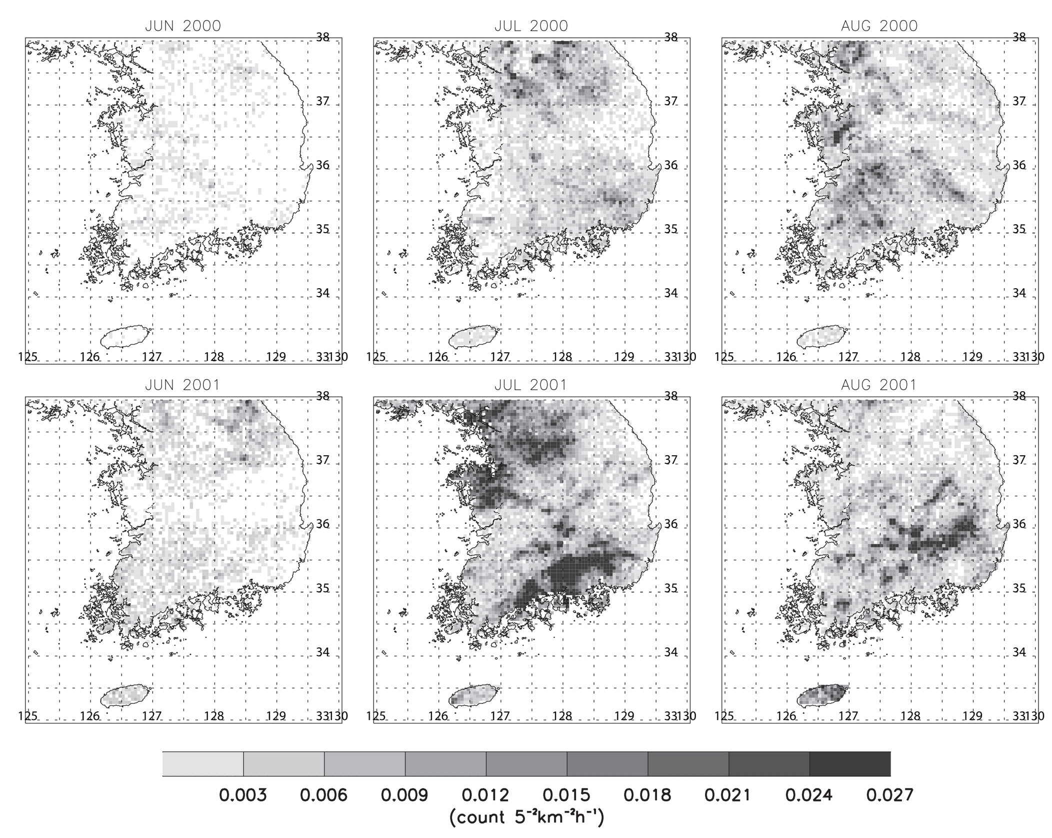

Fig. 5 Spatial distribution of precipitation in 2000 (top) and 2001 (bottom) during the summer monsoon seasons.

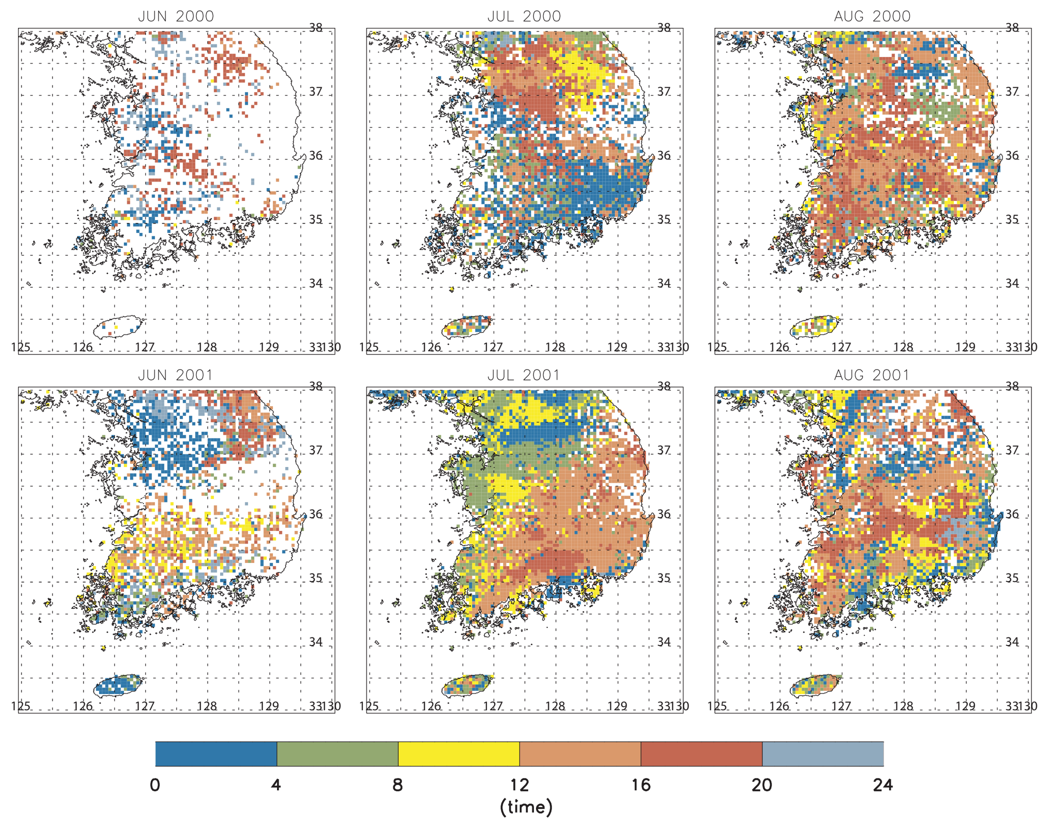

Fig. 6 Spatial distribution of the maximum time for flash counts in 2000 (top) and 2001 (bottom) duringthe summer monsoon seasons.

The southern peaks of flash counts seem to be brought by the topography. The maximum lightning activity in the middle west is mainly due to the abundant moist air associated with the westerly and southwesterly flows in the lower part of the air causing highly unstable parcels and the development of mesoscale convective systems (MCSs).

Conclusion

The amount of rainfall and the area of coverage can both vary by orders of magnitude, and the location of the convection may differ considerably from one month to the next. Several factors are supposed to be responsible for the monthly fluctuations. Distinct temporal and spatial patterns of the convection would be expected to develop under certain synoptic regimes. Therefore the timing, intensity, and motion of see breeze convergence zones and their attendant convection are probably dependent on the synoptic scale flow. Surface features such as water conservation areas, and the coastal configuration also play varying roles in the generation, maintenance and monthly decay of circulation on the peninsular and local scales. These factors, in combination with the synoptic and regional-scale flow, may provide the necessary mechanism to account for the observed large month-to-month variability in convective patterns. We have shown that there are important differences in the principal meteorological factors and types of convective patterns. This study was successful in identifying the principal factors responsible for the development of lightning and precipitation in the South Korean Peninsula and the strong relationship between observed convective patterns and precipitation with variations in the large-scale flow.

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