CHAPTER 10

Conclusions

Our analysis of the spatio-temporal variability of lightning activity and its correlations with convective activity in the atmosphere and topography and landform in the region of South/Southeast Asia for the period of 1995-2005 leads to the following conclusions:

1. The area of investigation displays a large diversity in lightning activity in both space and time. For example, the areas of Northwest and Northeast India, foothills of the Himalayas, peninsula of Indo-China experience very high flash rates in some seasons. In contrast, some areas on the Tibetan Plateau, Northwest of India, over seas, experience very low flash rates in other seasons. However, the area as a whole shows a seasonal variation of the monthly-averaged flash rate with a maximum in May and a minimum in January. This general trend of variation remains almost unchanged when the area is divided in two equal areas along the longitude of 90°E. The seasonal and diurnal variations of average flash rate in different regions identified on the basis of some dominant meteorological / topographical / landform basis, show large diversity as discussed in Chapter-2. For example, seasonal variations of average flash rate are single periodic in all regions at an average altitude of ~ 2700 m or above and are double periodic in all regions of < 2700 m altitude. Diurnal variations of average flash rate are single periodic in the regions of Tibetan Plateau and peninsulas, double periodic in all other regions over land and do not show any definite trend over sea regions. While single periodicity in average flash rate can be associated with convective activity due to solar heating of land surface, double periodicity can be associated with interactions of convective activities due to solar heating, topography and progress of monsoon through this area.

2. Very good correlation of the average flash rate with surface temperature, shows that convective activity due to solar heating of land is important in all
regions in tropics. The same is true for the CAPE except in the
mountainous regions of Himalayan foothills and northeast where transfer of
sensible heat flux perhaps does not efficiently contribute to the vertical
convective activity of the atmosphere. In high altitude regions, mean values
of CAPE are low but mean values of flash /CAPE are high. Reverse is the
trend in the low-altitude regions except in the dry environment of the desert.
The reverse trend is clearly visible also in all the three sea regions.

(3) Optical radiance and, therefore, the lightning discharge energy is directly
related to CAPE and inversely related to the altitude of the region. The
storm energy could be released earlier by occurrence of a lightning
discharge in shallow thunderstorms forming over high altitude regions. In
contrast, the lightning discharges occurring in tall clouds forming over
tropical seas, are very energetic due to larger charge-storing capacity of
such clouds.

(4) Seasonal and diurnal variations of average flash rate in the TP region on
Tibetan Plateau can be taken as 'de facto standard' curves for the effect of
solar radiation on the average flash rate.

(5) The flash per CAPE values are one to two orders of magnitude higher in
dry environments (e.g. in the ID, NW, HF, and TP regions) than in moist
environments (e.g., in the NE, SC, CI, PI and IP regions) over land and two
to four orders of magnitude higher in moist environments (e.g. the AS, BB
and CS regions) over sea. So, the same change in the CAPE can lead to
more change in number of flashes in moist than in dry environments.

(6) Distribution of lightning activity in and around the Himalayan foothills
illustrate a good example of the interaction of monsoon and topography
with the lightning activity. Development and the spatio-temporal variability
of high flash rates in the region of Himalayan foothills effectively
demonstrate that the Himalayan range confines this interaction to the
altitudes less than ~ 2700 m and to the south of the Himalayas. Moreover,
this interaction propagates from the East to West as the monsoon current
propagates westward from the mouth of the Bay of Bengal.

(7) Flash rates are low, both over the Tibetan Plateau and over all the three
seas. However, the shallow clouds over the Tibetan Plateau frequently
release their electrical energy in the low-energy flashes, presumably
because of the proximity of charge centers in the cloud. On the contrary, deep convective clouds over tropical oceans have larger charge-storing capacity and thus produce high-energy flashes with comparatively much higher values of flash per CAPE.

(8) The lightning activity data obtained from space on much larger scales of space and time support some conclusions reached from the surface observations such as (i) The first lightning discharge does not occur unless the cloud has grown to a depth of 3 to 4 km, (ii) Presence of both precipitation and convective activity are necessary but not sufficient conditions for lightning to occur, (iii) Warm clouds can exhibit lightning and, (iv) The clouds in which only ice-phase exists, are weakly electrified.

(9) The values of flash rate over peninsular regions (IP and PI) is 2.6 to 33 times of those over sea regions (AS, BB, CS). Though this contrast is seen throughout the year it is more dominant in pre-monsoon and post-monsoon seasons and is confined from the afternoon to midnight hours.

(10) Influence of the diurnal cycle in solar heating of sea surface is not sufficient to cause a significant change in flash rate on diurnal scale. But change in solar heating of sea surface on seasonal scale can significantly change the flash rate on seasonal scale.

(11) In case of the 1997-98 ENSO, the number of flashes, average flash rate and number of flash days increase by about 100%, 64% and 12%, respectively, during the El Nino period and decrease by 29%, 31% and 10%, respectively, during the La Nina period as compared to the corresponding normal periods in 1998-99. Similarly, in case of the 2002-2003 El Nino, increases of about 114%, and 39% are obtained for the number of flashes and flash rate, respectively, during the El Nino period in 2002 as compared to the corresponding normal period in 2003. The phenomenon of El Nino and La Nina are more effective in changing the lightning activity in the region of Southeast Asia than in the region of South Asia.

(12) Inspite of breakdown of the El Nino-ISMRF relationship in the 1997-98 ENSO event, the El Nino-lightning relationship maintains its normal trend, indicating that lightning activity is more sensitive to convective activity than to the precipitation in thunderclouds.
(13) A comparison of seasonal, intra-annual, and inter-annual variations in electrical activity over three islands of different area but located in similar synoptic conditions in the South Bay of Bengal shows that the 10-year monthly means of flash density and flash rate mostly increase with the area of island even on a monthly scale. Annual means of flash rate do not show any significant change over a period of 10 years. Further, the conclusion of theoretical models that the strengthening of updraft causes the increase in flash rate in a storm, is upheld in our study.