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# A NEW APPROACH TO ESTIMATION OF EFFECTIVE HEIGHT OF TOWERS ON MOUNTAIN TOPS FOR LIGHTNING INCIDENCE STUDIES: SENSITIVITY ANALYSIS

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## 1 SUMMARY

The total number of lightning strikes to the tower and also the percentage of lightning discharges initiated by the tower, called upward flashes, both increase with the height of the tower. It is believed that upward flashes can occur only when the tower height is 100 m or more. Similar increases in the total number of lightning strikes to the tower and in percentage of upward flashes are observed if the tower, even with height less than 100 m, is located on mountaintop. To account for these observations, towers on mountaintops are said to have an effective height that is often considerably larger than the physical height of the tower.

The earlier methods of evaluating effective height of towers on mountain tops were based on statistical observations of lightning strikes. In Pierce [1] it was based on the observed higher lightning incidence to the mountaintop towers compared to similar towers on the flat ground. In Eriksson's approach [2 – 4] it was based on the observed percentage of the upward flashes initiated from towers of different height. In this paper, it is shown that these earlier methods of evaluating effective height based on statistical observations yield different values compared to those predicted by engineering models of lightning attachment, such as that proposed by Rizk [5]. Specifically, Rizk's model predicts effective heights that less than those predicted by the Pierce and Eriksson methods, although the definitions of effective height in the three approaches are somewhat different from each other. We perform sensitivity analysis to evaluate the effect of uncertainties in model parameters that influence the effective height. Variations in the effective height as a function of model parameters, including the final quasi-stationary leader gradient, minimum positive streamer gradient, upward positive leader speed, and mountain base radius, are presented, with Gaisberg tower as the example.

It is shown that the effective height depends primarily on the structure height, mountain shape, and upward positive leader speed. When the tower height is less than 20% of the mountain height, the effective height is largely determined by the physical height of the tower and the mountain shape. The variation of mountain base radius can cause an uncertainty in effective height ranging from 100% to 300%. When the tower height is greater than 30% of the mountain height, the effective height is largely determined by mountain height, and variations of mountain base radius can cause a smaller uncertainty in effective height ranging from 20% to 65%. Variation of upward positive leader speed can cause an uncertainty of 30% in effective height, regardless of the ratio of the tower height and the mountain height. In conclusion, the effective height estimation based on Rizk-model method provides an alternative approach to evaluation of the effective height of towers on mountain tops. It can be employed to estimate the effective height for towers for which no lightning incidence data needed for the earlier methods are available.

The information given in this paper could be used in designing lightning protection of communication/transmission line towers and masts on mountain tops, even when no lightning incidence data to the tower is available.

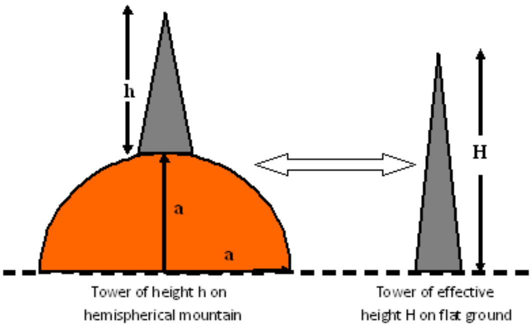


Fig. 1: The concept of effective height assuming a hemispherical mountain. The structure with height H on the flat ground will experience the same lightning incidence as the structure of height h on the mountain of height a.

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