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Icing Event Occurrence in Quebec: Statistical Analysis of Field Data

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ABSTRACT

The objective of this study is to analyze the distribution of the annual number of atmospheric icing events and ice deposit residency periods in the province of Quebec. These distributions are important for the improvement of theoretical icing models and, especially, for a reliable prediction of combined wind-on-ice loads on overhead transmission line conductors. Statistical analysis is performed on the data base of the Hydro-Quebec Passive Ice Meter (PIM) measurement program initiated in 1974. The studied data records from 150 icing measurement sites in Quebec led to the conclusion that the best fitting for annual frequency of icing events is the negative binomial discrete distribution. The ice residency period is best fitted by Weibull's two-parameter distribution.

INTRODUCTION

Atmospheric icing is one of the most important factors to consider in reliability based overhead transmission line design and operation. A brief review of the enormous quantity of special literature on the subject shows the increasing need for sufficient and reliable statistical data for improving the prediction of climatic loads on structures. During the last two or three decades, regardless of the considerable amount of time and costs involved, long term and wide scale icing measurement programs have been started in several countries across North America, Europe and Asia (Eliasson and Thorsteins, 1996; Ghiocel and Lungu, 1975; Laflamme and Périard, 1996;. Raison et al., 1996; Hiroshi et al., 1996). In Quebec, since 1974, Hydro-Quebec has established a network of 150 PIMs throughout the province, within a grid dimension of about 50 km (Laflamme and Périard, 1996). In fact, during the 21-year existence of this PIM network, about 180 measurement stations were installed, but several of them were suppressed for various reasons, and the data coming from these is not pertinent for the present study. The preliminary analyses of this unique measurement program are now used for creating a detailed Atlas of freezing rain maps covering various icing parameters: annual maximum values of ice thickness, freezing rain frequencies and persistence of ice deposits in the St-Lawrence valley (Laflamme and Périard, 1996).

The main objective of this study is to make a statistical analysis of the distributions of the annual number of atmospheric icing events and ice deposit residency periods in the province of Quebec. Knowledge of these distributions is important for the improvement of theoretical icing models and, especially, for a reliable prediction of combined wind-on-ice design loads on overhead transmission line conductors. In a second paper submitted to ISOPE-98, the authors have used computer performed Monte Carlo simulations to assess an event-based estimation of wind speed accompanying ice events, V_{ice}, (Savadjiev and Farzaneh, 1998). It was found that the predicted values of V_{ice} depend greatly on the annual number of icing events and ice residency periods. A realistic validation of this probabilistic model must be based only on reliable meteorological field data. Although the data-base recorded from Hydro-Quebec's PIM network concerns only freezing rain, its statistical analysis may be pertinent for transmission lines in various regions like the St-Lawrence valley, where this phenomenon is more important than in-cloud icing or wet snow.

Recently, a statistical analysis of the same climatic data was made with the purpose of estimating combined wind and ice loads on telecommunication towers (Elfashny et al.,1996). Although useful for some punctual in space structures such as telecommunication towers, this statistical analysis does not take into account the effect of the length of transmission lines over large areas. The data from each measurement site is processed separately, which reduces the sample size to 10-100 studied events, and hence reduces considerably the statistical reliability of predicted parameters, particularly for maximum extreme value analyses. Indeed, to avoid the same disadvantage (Laflamme and Périard, 1996) pooled together the maximum values of three neighbouring stations to produce coherent extreme value distributions.

For the purposes of this study, the statistical data for the annual number of icing events and ice residency periods are processed for all stations pooled together. This is in accordance with the unification of the climatic conditions in Quebec, made for design purposes (Ghannoum, 1993).