DEVELOPMENT OF A REGIONAL MAP OF EXTREME WIND SPEEDS IN THE PHILIPPINES

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1. Introduction

The Philippines is prone to natural hazards like earthquakes and typhoons. As such a wind zone map is developed to help planners assess the levels of extreme wind speeds in the future for design purposes. Fig. 1 shows the recent wind zone map developed using 35 years of monthly maximum data (from 50 weather stations) using the Gumbel model. In this paper, recent and daily maximum wind speeds

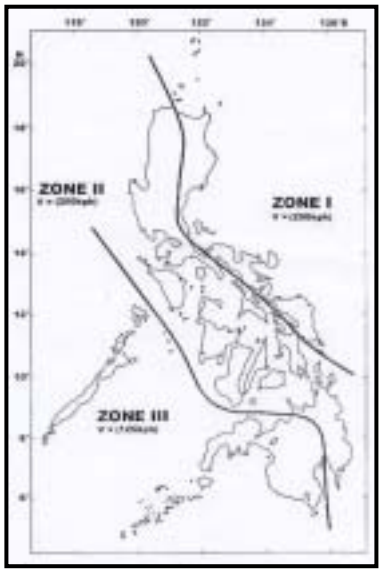

Fig. 1 Wind Zone Map of the Philippines

are utilized and the most appropriate extreme value model is selected to model extreme wind speeds in the Philippines.

2. Generalized Extreme Value Distribution

Usually the Generalized Extreme Value (GEV) distribution shown in eqn (2.1) is used to model annual maxima. The parameters of the GEV are μ, σ>0 and ξ.

$$G(x;\mu,\sigma,\xi) = \exp\left\{-\left[1+\xi\left(\frac{x-\mu}{\sigma}\right)\right]^{-\frac{1}{\xi}}\right\} \qquad (2.1)$$

The Gumbel Distribution (ξ= 0) is derived by taking the limit of eqn (2.1) as ξ→ 0 leading to

$$\underset{\xi \to 0}{G}(x;\mu,\sigma) = \exp\left\{-\exp\left(-\frac{x-\mu}{\sigma}\right)\right\}. \qquad (2.2)$$

The maximum likelihood principle is used to estimate the parameters in both distribution. The extreme quantiles of the annual maximum distribution are obtain from the following equation:

$$x_p = \begin{cases} \mu - \dfrac{\sigma}{\xi}\left[1-\{-\log(1-p)\}^{-\xi}\right], & \text{for } \xi \neq 0 \\ \mu - \sigma\log\{-\log(1-p)\}, & \text{for } \xi = 0 \end{cases} \qquad (2.3)$$

3. Results of GEV and Gumbel fitting

The parameters μ and σ are almost the same for both models, however for parameter ξ, it varies from station to station as shown in fig. 2. This means that there is overestimation and underestimation of extrapolated wind speeds especially at high levels as shown in fig. 3.

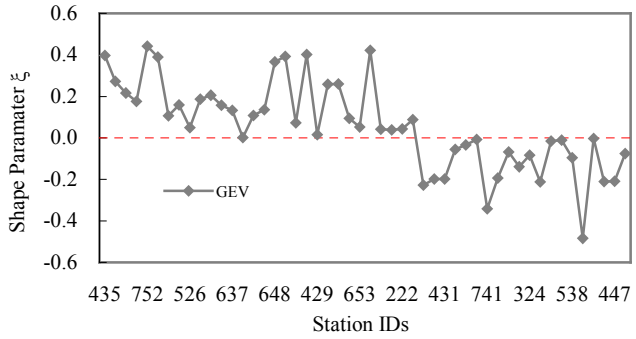

Fig. 2 Parameter ξ of GEV model for all stations

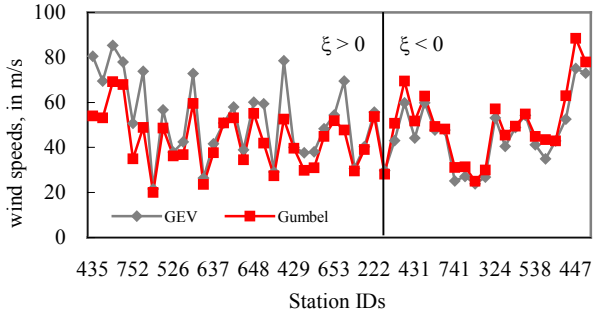

Fig. 3 Comparison of 50-year return wind speeds

Keywords: Generalized Extreme Value, Point Process, kriging, extreme wind speeds, wind zone map
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4. Point Process approach

The accuracy of the inference is improved by using point process approach for the daily wind data. Fig. 4 shows the exceedances of a threshold u in a time period [0,T] plotted with time as x-axis and location as y-axis.

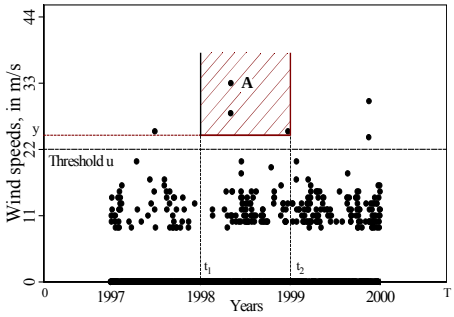

Fig. 4 Sample daily maximum wind speeds from a weather station

For a suitably high threshold u, the expected number of excess values within set A = $(t_1,t_2) \times (y, \infty)$ follow a Poisson process with intensity function

$$\Lambda(A) = (t_2 - t_1)\left(1 + \xi \frac{y-u}{\sigma}\right)^{-\frac{1}{\xi}}. \qquad (4.1)$$

Eq. (4.1) can be modified so that the parameters (μ,σ,ξ) correspond to the GEV distribution of the annual maxima. The point process likelihood is written as

$$L = \exp\left\{-n_y\left[1+\xi\frac{u-\mu}{\sigma}\right]^{-1/\xi}\right\}\prod_{i=1}^{N(A)}\frac{1}{\sigma}\left[1+\xi\frac{y_i-\mu}{\sigma}\right]^{-\frac{(1+\xi)}{\xi}} \qquad (4.2)$$

Again the maximum likelihood principle is used to estimate the parameters of the point process approach.

5. Results of Point Process approach fitting

The estimates of ξ for each station using GEV and point process approach are shown in fig. 5 below.

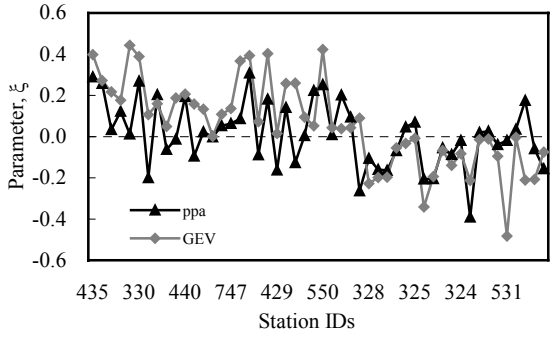

Fig. 5 Parameter ξ for GEV and point process approach

Figure 6 shows the reduction in the standard errors in the parameter estimate for ξ in the point process approach. Based on these results, we conclude that the results of the point process are better than the GEV and Gumbel models.

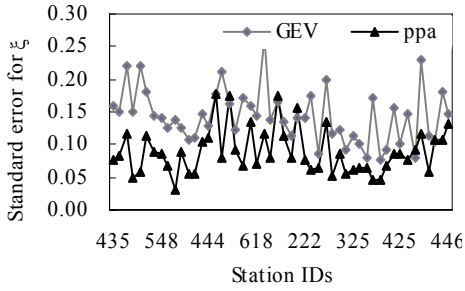

Fig. 5 Standard errors of ξ for GEV and point process approach

6. Regional Wind Zone Map

The regional wind zone map with annual exceedance probability of 0.02 is shown in Fig. 7 below.

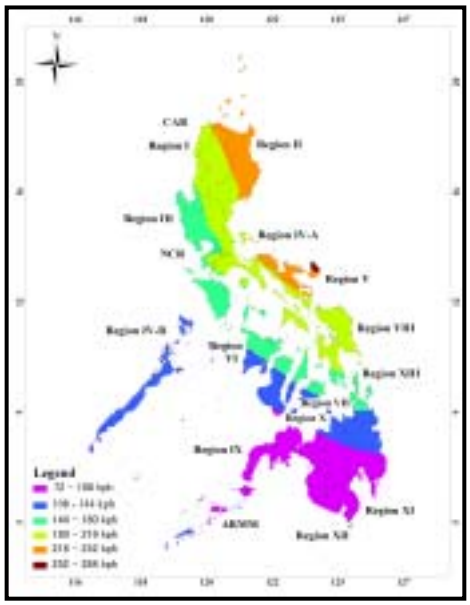

Fig. 7 Regional wind zone map

7. Summary and Conclusion

A regional wind zone map (6 zones) were developed using extrapolated 50-year return winds speeds from the point process approach. Kriging interpolation method of ArcView Geostatistical Analyst was used to develop the map.

8. References

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