APPLICATION OF EXTREME VALUE STATISTICS FOR MAXIMUM WIND SPEED FORECAST

BY

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APPLICATION OF EXTREME VALUE STATISTICS

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ABSTRACT

Different extreme value statistics are applied to forecast the maximum wind speed for Barstow, California, where no wind speed data is avaiable, using the maximum wind speed data for twelve stations around Barstow. The data for these twelve stations are analysed using Asymptotic Type I Distribution. The forecast obtained for these twelve stations are used to forecast the maximum wind speed for Barstow, using the Scalar, Linear and Gravity model and have been presented graphically. Monte Carlo simulation technique is developed to generate maximum wind speed data for twelve stations around Barstow and with the simulated data, forecast for Barstow is made. Kalman filtering technique is used to obtain optimal forecast of maximum wind speed for short return period (i.e., 20 Years) for twelve stations and forecast for Barstow is made by the Linear model.

Asymptotic Type I Distribution is widely accepted method for forecasting maximum wind speed. Results obtained from Monte Carlo simulation agrees favorably with the results obtained from Type I Distribution. For short term forecast The Kalman filter model provided better results.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

Chapter 1

INTRODUCTION

The objective of the present study is to apply different extreme value statistics to forecast the maximum wind speed with different return period and their associated probability for Barstow, California, where no maximum wind speed data for extended period is available. The maximum wind speed data from twelve stations around Barstow are utilized to forecast wind speed for Barstow. The data were obtained from National Atmospheric and Oceanic Adminstration. Wind speed is measured in a variety of units, whose interrelationship is given in Table (1.1). There is a qualitative scale of wind speed called Beaufort scale, which is given in Table (1.2).

Three main statistical techniques used are (i) Gumbel's extreme value statistics, (ii) Monte Carlo simulation technique, and (iii) Kalman filtering technique. However, some other types of statistical distributions, such as Log Pearson Type III distribution are discussed, and their applicability for wind speed forecast are checked by sample calulation.

Table 1.1 Conversion Factor for Wind Speed Units

Units	kont	m/sec	m.p.h.	km/hr	ft/sec
Knot	1.0	0.515	1.152	1.853	1.689
m/sec	1.943	1.0	2.237	3.600	3.281
m.p.h	0.868	0.477	1.0	1.609	1.467
km/hr	0.540	0.278	0.621	1.0	0.911
ft/sec	0.592	0.305	0.682	1.097	1.0

Left Column = Factor in body x Unit in top row.

Table 1.2 The Beaufort Wind Speed Scale

No	Beaufort Description	Speed	Land Effect
0	Clam	0-1	Smoke rises straight up
1	Light air	1-3	Direction shown by smoke drift
3	Light breeze	4-7	Wind felt on face; leaves rustle
4	Gentle Breeze	8-12	leaves in constant motion; wind extends light flag
5	Moderate breeze	13-18	Raises dust and loose paper; small brances move
6	Fresh breeze	19-24	Small trees' leaf began to sway
7	Strong breeze	25-31	Large branches in motion,whist-ling of telegraph wires
8	Moderate gale	32-38	Whole tree in motion; difficult to walk
9	Fresh gale	39-46	Breaks twigs off trees
10	Strong gale	47-54	Damage to vegetation & structure
11	Whole gale	55-63	Trees uprooted; vissible damage
12	Storm	64-75	Wide spread damage
13	Hurricane	<75	Severe damage

Gumbel [1] developed analytical solutions for different extreme value distributions. According to the limiting convergence form, Gumbel classified the three asymptotic forms as type I, II and III, and provided the convergence criteria for different distributions to the limiting forms. Gambel also developed the extremal probability paper for graphical representation of the extreme value distributions.

Ang and Tang [2] provided parameter estimation techniques for data analysis and forecasting for all three types of asymptotic distributions. They showed the relations between Asymptotic Type I, Type II and Type III distributions.

Wanielista [3] discussed in detail the Log Pearson Type III distribution, and provided the emperical equations for parameter estimation and forecasting of extreme value and their return period, using the Log Pearson Type III distribution.

Monte Carlo simulation technique is a process of replicating the real world situation, based on a set of assumptions and conceived models of reality. One of the main tasks in Monte Carlo simulation is the generation of random numbers. Aug and Tang [2] provided analytical

methods to generate random numbers from a particular probability distribution, required for Monte Carlo simulation.

The Kalman filter is a sequential estimation procedure for producing optimal estimates of the state vector of a linear dynamic system from noisy observations. Kalman filter is based on a recursive algotithm given by R. E. Kalman [4]. He assumed a state vector to be modeled as a time varying mean with additive noise. The mean of the vector was assumed to be a linear combination of known functions. The coefficients appearing in the linear combination were unknown. Under such assumptions, the state vector could be described as a linear systen. The Kalman filtering technique can be used to obtain optimal estimate of the state vector. One of the distinct advantages of the Kalman filter is that time varying coefficient can be permitted in the model.

Pike [5] developed a generalized method for using the Kalman filter in statistical forecasting. He had shown that the Kalman filter model could be regarded as a generalization of the least square model. The similarities and differences between the two models are discussed in his study.

Sallas and Harville [6] described in more detail the state space model of Kalman filter. The model is specified stage by stage, where the stages generally correspond to time points, at which the observations become available.

Suzuki, Miyata and Hongo [7] deseribed a technique for prediction of climatological extreme values and return period for small samples. For the prediction of extreme values, they proposed a method based on an approximation of conditional expectation, instead of calculating the definite integral involved and applied the Kalman filtering theory to predict the return period.

Sachs [8] and Thom [9] studied the initial distribution of maximum hourly wind speed from which annaual maximum wind speed data are tabulated and found to be exponentially distributed. It was also observed that the extreme values converged to asymptotic Type I distribution.

In chapter 2, three asymptotic distributions and their convergence criteria are studied. The extreme value from an initial distribution with an exponentially decaying tail, converge asymptotically to the Type I limiting form. For an initial variate that decays with