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SOME CALCULATED RESULTS ON STATISTIC CHARACTERISTICS OF METEOROLOGICAL-HYDRODYNAMICAL PROCESSES IN THE WATERS OF NORTHERN BINH THUAN PROVINCE

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ABSTRACT The determination of happening probability of extremal parameters of meteorological - hydrodynamical processes plays a very important role not only in coastal planning but also in engineering practice. In the present time, there are a lot of extremal probability distribution functions being applied for meteorological and hydrodynamical processes, among them, Weibull and Fisher - Typpett functions are the most suitable functions for determining the extreme probability with long-term statistics. In this paper, we try to use these functions for calculating statistic wind parameters such as: extremal wind speed related to rare probability and their return period in Binh Thuan seawater area based on observed wind data series during 10 years (1985 – 1995) of Phu Quy Meteorological Station. Some main results, discussion and their applied ability in meteorological - hydrodynamical processes are also presented.

MOT SO KET QUA TÍNH TOAN CAC ÑAC TRÖNG THONG KE KHÍ TÖÔNG – THUY ÑONG LÖC KHU VÖC BIEN BAC BÌNH THUAN

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TOM TAT Viec xac ñònh cac xac xuat xuat hien cac thong so cöc trò cua cac qua trình khí töông, thuy van, ñong löc ñong mot vai tro rat quan trong trong viec quy hoach phat trien kinh te xa hoi ñôi ven bô va sö dung trong thöc tien cho cac cong trình ven bien. Hien nay co kha nhieu cac phöông phap ñe tính toan cac ham phan bo xac suat cöc trò. Qua cac tai lieu tong ket va ñanh gia (cua cac tac gia trong va ngoai nöôc) thì viec sö dung cac ham phan bo xac xuat dang Weibull va cac ham dang Fisher la thích hôp nhat cho cac ñac tröng thong ke chu ky dai trong khí töông thuy van bien. Trong bai bao nay chung toi sö dung cac ham phan bo xac xuat tren ñe tính toan cac ñac tröng cöc trò cua gio co xac xuat hiem töông öng vôi cac chu ky lap khac nhau cua khu vöc bien Bac Bình Thuan tren cô sô chuoi so lieu gio 10 nam (1985-1995), quan trac tai tram khí töông Phu Quy. Mot so ket qua chính, cac van ñe can thao luan va kha nang ap dung cac ket qua nghien cöu tren ñöôc trình bay chi tiet trong bai bao nay.

I. INTRODUCTION

The determination of climate - meteorological regime and related statistic parameters plays an important role in studies of hydrodynamic processes. They allow to assess a part of reasons resulting in coastal erosion – deposition processes and are also important input materials for validation and calibration parameters of numerical modeling. The extreme statistic meteorological characteristics related to rare probabilities that happen in 2, 5, 10 years and longer... also have got practical mean in coastal building engineering when determining the design parameters.

In present time, some statistic distribution functions are used for calculation of extreme parameters related to rare probability such as Raleigh, Pearson I, III, Weibull, Fisher-Typpett (F-T) in which the distribution functions of Weibull and F-T are more effective. In this paper, the authors try to use these functions for calculation of maximum wind speed related to rare probability in the waters of northern region of Binh Thuan province. Some main results, discussion and their applied ability in meteorological-hydrodynamic processes are also presented.

II. MATERIALS AND CALCULATING METHODS

Applying the 10 years series of wind observation data (from 1985 to 1995) in Phu Quy Meteorological Station, we try to calculate the statistic parameters of wind in northern region of Binh Thuan province. Wind data including both module (error: ± 0.5 m/s) and direction (N, NE, E, SE, S, SW, W, NW) were observed in main observation (1h, 7h, 13h, 19h). Due to technical trouble, data in some periods were lacked (in Jan, Feb, and March of 1991). The total observed data were 14,609. In statistical calculation of meteorological - hydrodynamical processes, a lot of different statistic distribution functions are used. The collection of suitable function depends on numerous data and physical characteristics of studied object. Based on summarized results of foreign authors (Leenknecht, Szuwalski and Sherlock 1992; Goda 1988; Goda 1990; Mathiese et al. 1994...) some used distribution functions are listed as following:

Table 1: The used distribution functions and application ability in meteorological – hydrodynamical studies (x, α: parameters of Rayleigh function)

Parameters	Representation function
Short term	
+Water elevation	Gaussian
+ Wave height	Rayleigh : $x = H$; $\alpha = 1/H^2_{rms}$
+ Wave period	Rayleigh : $x = T^2$; $\alpha = 1/T^4$
+ Run-up	Rayleigh
Long term	
+ Extreme wind	FT-1
+ Hs	Weibull: A = standard division of Hs; B = minimum of Hs; k=1
+ Tp	Weibull: B = minimum of Hs; Auk estimated from observed data
Extreme of Hs	FT-1; Weibull
Sea level	Log- Pearson – III

In the case of the calculation of the wind extreme in Binh Thuan, we try to use some distribution functions such as Pearson III, Weibull, F-T-1.

The Pearson III functions are usually applied in hydraulic studies. They are represented in complex function by mean of momentum parameter (Cv: standard deviation σ^2 and asymmetry Cs ==μ_3* C_v^3):

$$P(v)=P_o \cdot e^{\frac{-2v}{CsCv}} \left[1+\frac{2v.Cs}{Cv\left(4-C_s^2\right)}\right]^{\frac{2(4-C_s^2)}{C_s^2}}$$

In practical application, some authors simplified by using some base parameters as V_{max}, Cv, Cs and application of mathematical schema Crisk – Menken for looking through wind speed corresponding to the happened probability.

where:

$$\bar{v}_{max} = \frac{\sum_{i=1}^{n} v_{max}}{N} \; ; \; Cv = \sqrt{\frac{\sum_{i=1}^{n}(v_i-\bar{v})^2}{n}} \; ;$$

$$Cs = \frac{\sum_{i=1}^{n}(v_i-\bar{v})^3}{n.\sigma_x^3}$$

The distribution function F-T- 1 is represented as the following:

$$U_N = \overline{U_m} + 0.78^* \sigma_m [\ln(12\ T_N) - 0.577]$$

where:

- U_N: Wind speed with repeated period N years.
- $\overline{U_m}$: Average value of maximum speed in each month
- σ_m: Standard deviation of maximum speed in each month
- T_N: Repeated period

The distribution function Weibull is represented as the following:

$$F_w(v) = \left(\frac{k}{c}\right)\left(\frac{v}{c}\right)^{k-1} \exp\left[-\left(\frac{v}{c}\right)^k\right] \qquad (1)$$

where:

- $F_w(v)$: Happened probability of speed according to wind speed scale
- v: Wind speed in m/s
- k, c: Parameters that need to be found

In present time, there are many methods for finding c and k /1 /, /2 /, but method of linear regression function is more common. From formula (1), finding the regression function according to parameters c, k and F_W (v) in form:

$$k\ln(v) - k\ln(c) = \ln(-\ln[1-F(v)]) \qquad (2)$$

Suppose that:

$X = \ln(v)$ and $Y = \ln(-\ln\left[1-F(v)\right])$

$Y = AX + B$

where:

A = k and B = -kln(c) (or c = exp (-B/A))

Thus, the program of maximum speed calculation is performed by the following steps:

- Classification of wind speed probability in wind speed scale (for determining v_i,$f(v)_i$)
- Finding X_i , Y_i according to v_i , $f(v)_i$ and calculating A and B by passing function of Y = AX + B
- Finding c and k from A and B
- From building Weibull function, we easily determine the extreme speed according to rare probability.

III. RESULTS AND DISCUSSION

1. Calculation of statistic parameters by Pearson III function

From observed data (10 years) in Phu Quy Station, we found average and extreme wind speeds in months (Tables 2 and 3).

Table 2: Probability of wind direction and speed in months in Binh Thuan region (1985 – 1995)

Months		I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
Calm		0.4	8.5	17.6	19.7	21.8	6.2	3.6	5.1	16.1	14.2	4.7	0.8
N	Prob	11.8	9.2	4.6	2.0	1.0	0.3	0.2	0.1	1.8	4.9	10.3	12.4
	Speed	8.0	5.1	3.6	3.4	1.7	2.2	2.0	1.7	2.9	3.7	4.6	7.1
NE	Prob	87.0	74.8	58.6	38.8	12.8	1.9	0.6	0.2	6.7	44.6	77.4	85.8
	Speed	7.0	5.8	5.0	5.1	2.9	2.8	1.4	2.5	2.7	4.0	6.7	6.8
E	Prob	0.1	4.1	9.0	11.9	8.6	1.0	0.2	0.2	3.0	4.1	1.9	0.4
	Speed	2.8	3.0	2.7	2.7	2.2	2.6	1.2	2.0	1.9	2.4	5.0	3.0
SE	Prob	0.1	0.8	3.0	5.0	3.8	0.6	0.3	0.4	0.4	0.8	0.4	0
	Speed	1.0	2.4	2.0	1.8	1.6	2.0	2.2	2.2	1.6	2.2	2.3	0
S	Prob	0.3	1.5	3.7	12.1	9.1	3.1	2.1	1.1	2.4	2.4	0.8	0.2
	Speed	2.0	1.7	2.0	2.0	2.4	2.5	3.1	3.7	2.1	2.6	3.5	1.3
SW	Prob	0.1	0.9	2.0	8.2	27.3	39.6	46.5	40.4	28.0	10.0	1.5	0.1
	Speed	3.5	1.7	2.2	2.9	3.9	5.6	5.8	7.5	5.1	3.9	5.6	2.0
W	Prob	0.2	0.2	0.8	1.7	14.8	45.6	45.9	52.1	39.7	16.9	2.6	0.1
	Speed	3.0	1.8	2.3	3.0	4.5	6.6	6.1	8.2	5.5	4.5	7.9	12.0
NW	Prob	0	0	0.4	0.6	0.8	1.7	0.6	0.4	1.9	2.1	0.4	0.2
	Speed	0	0	2.3	1.5	2.9	3.9	4.3	3.9	3.1	3.0	4.7	1.5

Table 2 shows that: in the water region of Binh Thuan province, in the NE monsoon (Nov., Dec., Jan., Feb.), the NE direction is usually predominant and reaches probability of 75 – 85 %, wind speed in this direction reaches 6.5 – 7 m/s. In the SW monsoon (Jun., Jul., Aug.), popular direction is SW and W with probability of 45 – 50%, wind speed in this period is 7.5 – 8m/s. In transition periods, the wind speed is too small and calm with high probability (from 15–20 %). Beside the average parameter, we had calculated (25, 50, 100... years) by the function of Pearson III.

Table 3: The statistic characteristics of maximum speed (m/s) according to different probabilities (1%, 5%, 10%, 15%, 20%, 30%) on meteorology at Phu Quy Station by application of Pearson II function

N^o	Month	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Years
	$\bar{v}_{max}$	15.5	15.1	14.2	12.5	13.3	16.4	16.2	18.5	14.8	15.3	18.2	17.1	22.7
	Cv	0.21	0.12	0.12	0.1	0.28	0.2	0.21	0.25	0.2	0.24	0.31	0.18	0.22
	Cs	0.15	0.29	1.09	-0.29	-0.03	1.25	1.17	0.15	0.71	1.42	2.47	1.18	1.07
	P (%)	VmaxP	VmaxP	VmaxP	VmaxP	VmaxP	VmaxP	VmaxP	VmaxP	VmaxP	VmaxP	VmaxP	VmaxP	VmaxP
1	1.0	23.4	19.8	19.3	15.3	21.8	26.6	26.9	29.7	23.3	27.2	40.0	26.6	43.8
2	5.0	21.0	18.3	17.3	14.6	19.4	22.5	22.6	26.3	20.3	22.2	29.4	22.8	32.3
3	10.0	19.7	17.5	16.4	14.2	18.0	20.6	20.7	24.5	18.8	20.1	25.2	21.1	29.5
4	15.0	18.9	17.0	15.8	13.9	17.1	19.5	19.5	23.3	17.9	18.7	22.8	20.1	27.8
5	20.0	18.2	16.6	15.4	13.7	16.4	18.7	18.7	22.3	17.2	17.8	21.1	19.3	26.5
6	30.0	17.2	16.0	14.8	13.3	15.2	17.4	17.4	20.8	16.1	16.4	18.9	18.1	24.6

- $\bar{v}_{max}$: Average value of maximum speed in each month
- Cv: Standard deviation
- Cs: Asymmetry parameter
- VmaxP: Maximum parameter according to P % (1%, 5%, 10%, 15%, 20%, 30%)

Table 4: Probability of P (n % - N years happened n times) corresponding to different repeated periods

N=100 years	N = 50 years	N=20 years	N = 15 years	N = 10 years	N = 05 years
1	0.5	0.2	0.15	0.1	0.05
5	2.5	1	0.75	0.5	0.25
10	5	2	1.5	1	0.5
15	7.5	3	2.25	1.5	0.75
20	10	4	3	2	1
30	15	6	4.5	3	1.5

Thus, with repeated period of 10 years, maximum speed corresponding to probability of 1% reaches 29.4 cm/s, and with repeated period of 100 years, maximum speed of 1% reaches over 40.0 cm/s and happened in November. These results show that: in 10 years, the calculation of maximum speed is suitable (29.4 m/s compared to 31 m/s of true value), but when extrapolating the maximum speed is too high (over 40 m/s) and exceeds the true condition.

2. Application of F-T-1 for determining the maximum speed according to rare probability

From formula of distribution function F-T-1:

$$U_N = \overline{U_m} + 0.78 * \sigma_m [\ln (12T_N) - 0.577]$$

Based on observed wind data of Phu Quy Station, we have:

$\overline{U_m}$ = 12.846; σ_m = 3.07; T_N = 10

U_{10} = 22.92 m/s; U_{25} = 25.12 m/s

U_{50} = 26.78 m/s; U_{100} = 28.44 m/s

3. Application of Weibull for determining the maximum speed according to rare probability

Based on procedure presented above, we find the parameters c and k:

c = 4.75 ; k = 1.34

and maximum speed according to different repeated periods:

- Maximum speed happening in 10 years/ one time: v = 30.4 m/s
- Maximum speed happening in 25 years/ one time: v = 30.4 m/s
- Maximum speed happening in 50 years/ one time: v = 34.2 m/s
- Maximum speed happening in 100 years/ one time: v = 36.7 m/s

Some calculated results are presented in table 5 and figure 1.

Thus, the function of Pearson III gives too high calculated value, the function F-T-1 gives too low value, and Weibull function gives average value and suitable with the true condition.

Table 5: The calculated parameters of Weibull function from observed data of Phu Quy Station

Vi	fi	p (vi)	F (vi)	x	y	Fw(v)
0.5	2815	19.29933	0.192993	0	-1.5398	12.56278
1.5	1547	10.60606	0.299054	0.693147	-1.03472	15.39798
2.5	603	4.134101	0.340395	1.098612	-0.8768	14.81911
3.5	1787	12.25147	0.46291	1.386294	-0.47548	13.04352
4.5	693	4.751131	0.510421	1.609438	-0.33658	10.88775
5.5	988	6.773619	0.578157	1.791759	-0.1472	8.752688
6.5	2022	13.86261	0.716783	1.94591	0.232335	6.833064
7.5	1161	7.959687	0.79638	2.079442	0.464677	5.207114
8.5	857	5.875497	0.855135	2.197225	0.658532	3.886881
9.5	1105	7.575758	0.930893	2.302585	0.982862	2.849186
10.5	8	0.054847	0.931441	2.397895	0.98584	2.054856
11.5	817	5.601261	0.987454	2.484907	1.476668	1.460258
12.5	3	0.020568	0.987659	2.564949	1.480436	1.023732
13.5	113	0.774715	0.995407	2.639057	1.683269	0.708728
14.5	0	0	0.995407	2.70805	1.683269	0.48492
15.5	61	0.418209	0.999589	2.772589	2.053618	0.328144
16.5	0	0	0.999589	2.833213	2.053618	0.21975
17.5	1	0.006856	0.999657	2.890372	2.076735	0.145711
18.5	0	0	0.999657	2.944439	2.076735	0.09571
19.5	2	0.013712	0.999794	2.995732	2.138795	0.062304
20.5	0	0	0.999794	3.044522	2.138795	0.040208
21.5	0	0	0.999794	3.091042	2.138795	0.025734
22.5	0	0	0.999794	3.135494	2.138795	0.016339
23.5	0	0	0.999794	3.178054	2.138795	0.010295
24.5	0	0	0.999794	3.218876	2.138795	0.006438
25.5	1	0.006856	0.999863	3.258097	2.185452	0.003997
26.5	0	0	0.999863	3.295837	2.185452	0.002464
27.5	1	0.006856	0.999931	3.332205	2.260493	0.001509
28.5	0	0	0.999931	3.367296	2.260493	0.000918
29.5	0	0	0.999931	3.401197	2.260493	0.000555
30.5	1	0.006856	1	3.433987	2.260493	0.000333

where:

- Vi: wind speed in m/s
- Fi: the counted data number in each wind speed interval

- P(vi): happened probability in each wind speed interval
- $F_w(v)$: accumulated happened probability of speed according to wind speed scale
- x,y: the data series of dependent variables of regression function for determining the parameters c and k
- k, c: parameters need to be found

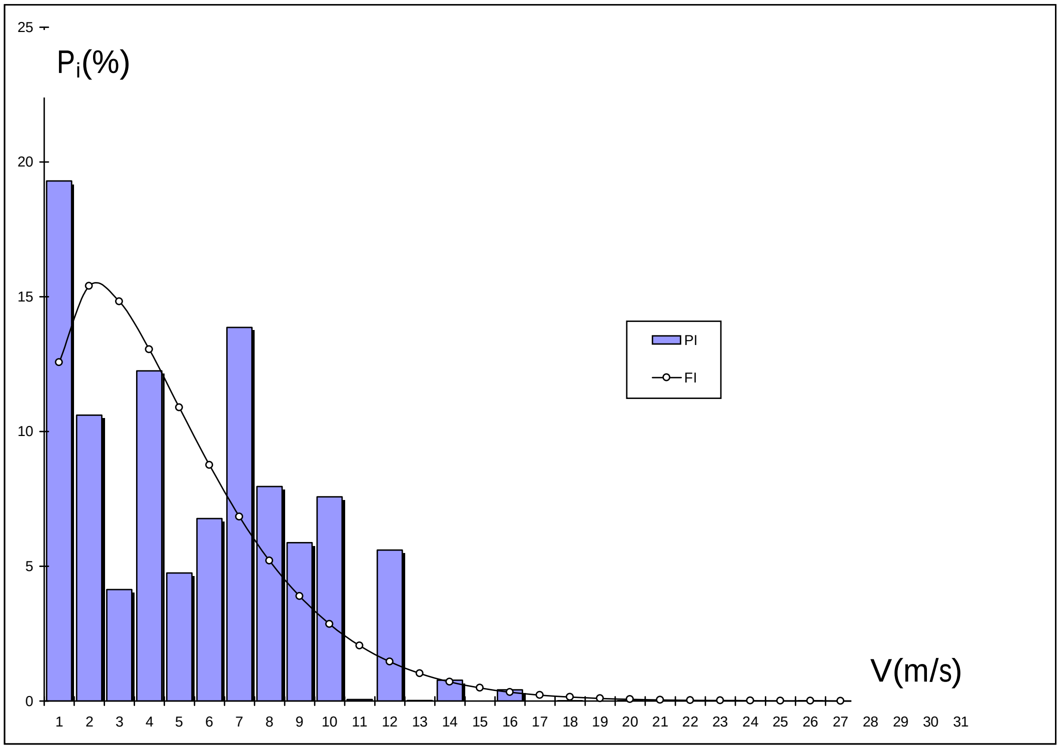

Fig. 1: Plot of happened probability (Pi) and curve of probability distribution Weibull (Fi) of wind speed at Phu Quy Station (from data of 1985 – 1995)

IV. CONCLUSION

The calculated results show that:

- Function of Pearson III gives too high-calculated value of maximum speed (> 43.8 m/s) compared to true condition. But for finding average parameters, the application of this function is very good.
- Function F-T- 1 is very simple, but it gives results that are too low compared to true condition (U10 = 22.92 m/s), in the case of Phu Quy data, it is impossible. In our opinion, function F-T-1 has not yet applied for determination of maximum speed in Vietnamese conditions because of the following reasons:
  - Observation time in meteorological station is too scattered (3h/one time), in other countries, observation time can reach to 10 min./one time).
  - Data series of meteorology aren't long enough.

This method can be applied in station with automatic equipment and long time data series (> 10 years).

- Function of Weibull gives better results even in case of observation time of 3h/one time. This result can be applied for designing purpose and provides input data for numerical modeling (the calibration and validation parameters).

- Function of Weibull is applied not only for calculation of wind speed but also for finding directly wave parameters such as height, period, run-up. But, in concrete conditions in Vietnam in present time, in almost cases, the measuring equipments have not yet been satisfied (for collection of long time series data and automatic data with high accuracy).

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