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Length of Wave Records: A Numerical Model to Simulate Its Influence Upon Frequency Distribution of Wave Heights and Periods

Horacio A. Caruso† and Jorge L. Pousa‡

†Departamento de Hidráulica
Facultad de Ingeniería
Universidad Nacional de La Plata
La Plata, Argentina

‡Carrera del Investigador Científico (CONICET)
Laboratorio de Oceanografía Costera
Facultad de Ciencias Naturales y Museo
Universidad Nacional de La Plata
La Plata, Argentina

ABSTRACT

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An attempt is made to numerically simulate wind wave records. An algorithm is chosen to compute the characteristics of a large number of waves from assumed wind conditions. In this manner a simulated wave record may reach several centuries, from which frequencies of occurrence of wave heights and periods may be determined. This is considered a wave record of "infinite" length. Afterwards, a record of wind waves of "finite" length is simulated, reaching a few months or a few years only. The frequency of occurrence of wave characteristics shall be different from those of the record of infinite length, due to the limited length of the record. The influence of the length of wave records may then be estimated comparing the frequencies resulting from different lengths of wave records.

ADDITIONAL INDEX WORDS: *Wind waves, wave measuring, length of wave recording, method of Sverdrup-Munk-Bretschneider, wave frequency prediction.*

INTRODUCTION

How long should wind waves be measured? Is there any method to assure that a record of a particular length is sufficient to avoid large errors in the frequencies of occurrence of wind waves? How large are "large" errors? Should wind waves be measured indefinitely? Since this is not a reasonable question, limitations in time and budget always restrict the recording of waves, which are the statistical properties of meteorological events that need more attention, and which of these have more influence upon frequencies of waves? This work tries to provide a hint for the answer to these questions by means of a numerical model intended to simulate wind waves generated by random windspeeds, wind durations and fetches.

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Postal address of first author: Calle 43 N° 540, 1900-La Plata, Argentina.

METHOD OF ANALYSIS

The method of Sverdrup-Munk-Bretschneider, as suggested by the *Shore Protection Manual* (1984), gives expressions to compute wind wave characteristics gH/U^2 and gT/U in deep water as a function of gF/U^2 when they are limited by the length of the fetch F, and as a function of gt/U when they are limited by wind duration t. When the sea is considered fully developed (or arisen) the variables gH/U^2, gT/U and gt/U are given by constants. The aforementioned method is not very accurate but has been adopted herein because of its simplicity.

The symbols H and T denote, respectively, the spectrally based significant wave height and the period of the peak of the wave spectrum of waves produced by an adjusted windspeed U.

For a statistical analysis based on dimensionless variables, we will assume that we are in possession of a series of values,

$$(gF/U^2)_i,\ (gt/U)_i \qquad (i = 1, 2, 3, \ldots n) \qquad (1)$$

from which the following dimensionless wave characteristics may be forecast:

$$(gH/U^2)_i \quad \text{and} \quad (gT/U)_i \qquad (i = 1, 2, 3 \ldots n) \tag{2}$$

The different pairs of values of Eq. (1) are randomly generated within the ranges,

$$0 \le (gF/U^2)_i \le 20{,}000$$
$$0 \le (gt/U)_i \le 50{,}692 \tag{3}$$

and are assumed to represent fetches F_i, windspeeds U_i, and wind durations t_i, as if they had been measured in a real case.

The first part of the present work discusses uniform distributions of $(gF/U^2)_i$ and $(gt/U)_i$. Further, gaussian-type distributions will also be considered. It should be noted that these distributions may not be very realistic but are adopted for analytical convenience.

SIMPLIFYING ASSUMPTIONS

In order to simplify the statistical analysis, several assumptions have been made:

(a) The n events of Eq. (1) are assumed to be statistically independent.

(b) The time elapsed between wave generation and its arrival to the recording instrument is ignored.

(c) The method of the *Shore Protection Manual* (1984) is assumed to be applicable without any error.

(d) Wind direction is not considered.

(e) There are no seasonal variations of wind conditions.

(f) Due to the presence of a windspeed U in the denominators of all non-dimensional variables, it is necessary to assume that wind speed can be sufficiently small, but not zero.

LENGTH OF WAVE RECORD

We shall assume a non-dimensional wave record as the sum

$$(gt/U)_{acc} = \sum_{i=1}^{n} (gt/U)_i \tag{4}$$

where the subscript acc means accumulated. This corresponds to a dimensional wave record length,

$$t_{acc} = \sum_{i=1}^{n} t_i \tag{5}$$

Windspeeds U_i are assumed to be randomly distributed over the range,

$$U_{min} \le U_i \le U_{max} \tag{6}$$

where min (max) stands for minimum (maximum). Mean windspeed is given by,

$$U_{mean} = (U_{min} + U_{max})/2 \tag{7}$$

The connection between t_{acc} and $(gt/U)_{acc}$, as shown in Appendix A, can be given by the expression,

$$t_{acc} = \Phi(U_{mean}/g)(gt/U)_{acc} \tag{8}$$

where the function Φ depends on the ratio U_{min}/U_{max} only, for the uniform random values of windspeeds U_i. For a gaussian-type distribution of U_i, the function Φ depends on U_{min}/U_{max} and $U_{mean}/U\sigma$, with $U\sigma$ denoting the standard deviation of the wind speed.

Wave Record of Infinite Length

The frequency of occurrence of dimensionless wave heights and periods, $(gH/U^2)_i$ and $(gT/U)_i$, will be denoted with the symbols $P_H(J)$ and $P_T(J)$, respectively, where J (from J = 1 to J = 10 in this paper) is the file where successful events are stored for different ranges of the previous variables.

It is evident that $P_H(J)$ and $P_T(J)$ will tend towards constant limits when wave length record, as given by Eq. (4), tends to infinity. Nevertheless, from a practical point of view, there will be a numerical value of $(gt/U)_{acc}$ for which the aforementioned frequencies will not be changed in a significant manner. It was found that a good compromise between computing time and precision of frequencies is found with,

$$(gt/U)_{acc} = 10^{10} \tag{9}$$

in which case it will be assumed that frequencies correspond to a wave record of "infinite" length. For typical values of wind duration and velocities, Eq. (9) would correspond to waves measured during several centuries. If $(gt/U)_{acc} = 2 \times 10^{10}$, maximum errors in the probability of occurrence of wave heights and periods, as defined later, do not reach 1%, an insignificant amount if compared with errors resulting from smaller values of $(gt/U)_{acc}$.

When the infinite wave record given by Eq. (9) is reached, both frequencies will be denoted with the symbols $P_{infH}(J)$ and $P_{infT}(J)$ for heights and periods, respectively.

Wave Record of Finite Length

When a wave record is limited to a length considerably smaller than Eq. (9), frequencies of oc-

Table 1. *Frequencies of wave heights.*

J	$P_{infH}(J)$	Frequencies $P_{finH}(J)$ for $(gt/U)_{acc} \times 10^{-6}$ = 1	2	4	8	16	32	64
1	0.056225*	0.1778	0.1398	0.1235	0.0926	0.0811	0.0738	0.0671
2	0.096487	0.2391	0.2125	0.1667	0.1567	0.1314	0.1196	0.1149
3	0.120434	0.2750	0.2471	0.2075	0.1949	0.1824	0.1551	0.1442
4	0.134871	0.3023	0.2469	0.2171	0.2006	0.1714	0.1606	0.1540
5	0.139881	0.2857	0.2530	0.2293	0.1993	0.1889	0.1673	0.1636
6	0.136301	0.3429	0.2597	0.2288	0.1986	0.1850	0.1628	0.1618
7	0.122682	0.3750	0.2442	0.1933	0.1827	0.1602	0.1590	0.1412
8	0.100518	0.2703	0.2133	0.1776	0.1623	0.1377	0.1297	0.1182
9	0.067529	0.1935	0.1757	0.1392	0.1270	0.1029	0.0876	0.0789
10	0.025073	0.1389	0.1096	0.0738	0.0526	0.0481	0.0408	0.0379

*See text regarding rounding off

currences of waves may be expected to change due to the fact that a smaller amount of data is taken into account. This limited wave record length will be considered as "finite" and the numerically recorded data will yield frequencies denoted with $P_{finH}(J)$ and $P_{finT}(J)$ for wave heights and periods, respectively. If this is the case, the use of Eq. (8) will correspond to waves being measured during weeks, months or years.

It is evident that the difference between $P_{infH}(J)$ and $P_{finH}(J)$ for wave heights will increase (in absolute value) when the wave record $(gt/U)_{acc}$ decreases. If the simplifying assumptions made herein are accepted as reasonable for a numerical model, these differences may be attributed to the length of the wave record. In the following paragraphs we propose a means to evaluate the influence of wave length record upon frequencies.

Typical results of the present work are displayed in Table 1 which shows, in the first column, the values of J where successful events for different ranges of wave heights are stored; the second column contains the frequencies of occurrence, $P_{infH}(J)$, of wave heights belonging to wave records of infinite length, those of Eq. (9). The value of n in Eq. (1) is a little over 2 million.

From the third to the ninth column, frequencies $P_{finH}(J)$ pertaining to wave records of finite length are presented; these lengths are in the headings of each column. Each of the frequencies $P_{finH}(J)$ are mean values of 500 independent numerical experiments. In order that a reader may reproduce the procedure in computing the errors (defined in the next section), all digits are kept in this table.

For the study of period frequencies, $P_{finT}(J)$ and $P_{infT}(J)$, a similar table was computed.

A predictable result is clearly evident in each of the rows of Table 1: as waves are recorded during longer periods of time, frequencies $P_{finH}(J)$ tend towards $P_{infH}(J)$.

DEFINITION OF ERRORS IN THE FREQUENCIES

From an engineering point of view the aforementioned differences may be evaluated with the following definitions of the errors that may appear when a wave record is not long enough:

$$\epsilon_H(J) = \left| \frac{P_{infH}(J) - P_{finH}(J)}{P_{infH}(J)} \right| \times 100 \quad (10)$$

$$\epsilon_T(J) = \left| \frac{P_{infT}(J) - P_{finT}(J)}{P_{infT}(J)} \right| \times 100 \quad (11)$$

The errors defined in Eq. (10) are presented in Table 2. A similar table was computed for the errors $\epsilon_T(J)$ of wave periods defined in Eq. (11). It should be recalled, as stated in a previous sec-

Table 2. *Errors in frequencies, defined in Eq. (10).*

J	Errors $\epsilon_H(J)$ in Heights for $(gt/U)_{acc} \times 10^{-6}$ = 1	2	4	8	16	32	64
1	216	149	120	65	49	32	21
2	148	120	73	62	38	24	19
3	128	105	72	62	51	29	20
4	124	83	61	49	32	20	15
5	104	90	64	42	35	20	17
6	152	91	68	47	36	25	19
7	206	99	68	49	31	30	18
8	169	112	77	62	37	29	20
9	187	160	106	88	52	30	18
10	454	337	194	110	92	63	51

Table 3. *Numerical results for maximum errors in the probabilities of wave heights and periods. Numbers in the second row identify the equations in the text.*

$(gt/U)_{acc} \times 10^{-6}$	ϵ_{maxH} (12)	ϵ_{maxT} (13)	ϵ_{maxH} (18)	ϵ_{maxT} (19)	ϵ_{maxH} (22)	ϵ_{maxT} (23)
1	454	583	1,309	1,071	36,133	387,515
2	337	392	810	917	18,481	205,671
4	194	273	482	634	72,976	104,071
8	110	181	331	402	37,132	52,981
16	92	154	188	260	18,876	26,314
32	63	76	163	229	9,350	13,181
64	51	53	101	160	4,597	6,556

See text regarding rounding off.

tion, that each of the errors in this table is the mean value of 500 numerical experiments. As it might well have been predicted from the theory of probabilities, it may be clearly seen in Table 2 that errors $\epsilon_H(J)$ decrease when waves are measured during longer periods of time, *i.e.*, when $(gt/U)_{acc}$ increases. Table 2 also shows another typical characteristic: a maximum error tends to occur at the tail of the distribution (J = 10 in Table 2) for a specific wave record length $(gt/U)_{acc}$. Our purpose is to focus our attention on the maximum error.

Maximum Errors in Frequencies

The greatest error ϵ_{maxH} in the frequencies of wave heights, found in the greatest or smallest wave heights (J = 10 or 1), and the greatest error ϵ_{maxT} in wave periods, found in the longest or shortest waves (J = 10 or 1), should give useful information for a project in which the most unfavorable conditions need to be forecast. This information is provided by Table 2 for heights, and a similar one for periods. In other words, ϵ_{maxH} and ϵ_{maxT} would give quantitative information on the errors that may be expected when a wave record is limited in time, since they are compared with waves recorded during an essentially infinite time.

The results upon which our analysis will be based are summarized in Table 3. It may be seen, as an example, that the maximum errors ϵ_H of the last row of Table 2 correspond to those in the first column of Table 3. It should be noted that this table contains a redundant number of digits; however, in the computations of the errors the constants are rounded off, as seen below.

The simplest functions that may be fitted to express the maximum errors in the prediction of wave frequencies, together with the square of the correlation coefficient r^2, have the following forms:

$$\epsilon_{maxH} = 8.55 \times 10^5 \times (gt/U)_{acc}^{-0.55} \qquad (r^2 = 0.98) \qquad (12)$$

and

$$\epsilon_{maxT} = 1.56 \times 10^6/(gt/U)_{acc}^{\ 0.57} \qquad (r = 0.99) \qquad (13)$$

If Eq. (8) is used in the above two equations, and t_{acc} is expressed in years,

$$\epsilon_{maxH} = 64.21 \times (gt_{acc}/\Phi U_{mean})^{\ 0.55} \qquad (14)$$

and

$$\epsilon_{maxT} = 82.95 \times (gt_{acc}/\Phi U_{mean})^{\ 0.57} \qquad (15)$$

The exponents in the above equations show that, if wave records are increased twice, maximum errors decrease by a factor of approximately 1.5, because $(1/2)^{\ 0.55} \simeq (1/2)^{\ 0.57} \simeq 1.5$.

Gaussian-Type Distributions

In previous paragraphs we have been dealing with uniform distributions of fetches $(gF/U^2)_i$ and durations $(gt/U)_i$. With the purpose of comparing results between different wind conditions, we will assume now that non-dimensional data Eq. (1) follow gaussian-type frequency distributions, defined by their mean values (subscript m) and standard deviations (subscript σ).

As a first example we have tried the following constants for the gaussian distribution:

$$(gF/U^2)_m = 10{,}000 \quad \text{and} \quad (gF/U^2)_\sigma = 5{,}000 \qquad (16)$$

$$(gt/U)_m = 25{,}346 \quad \text{and} \quad (gt/U)_\sigma = 12{,}673 \qquad (17)$$

Following the same procedures described for the uniform distribution, the statistical analysis lead to the following equations:

$$\epsilon_{maxH} = 5.50 \times 10^{6} \times (gt/U)_{acc}^{\ 0.61}$$

$$(r^2 = 0.99) \qquad (18)$$

and

$$\epsilon_{maxT} = 9.08 \times 10^{5} \times (gt/U)_{acc}^{\ 0.48}$$

$$(r^2 = 0.98) \qquad (19)$$

The incorporation of Eq. (8) into Eq. (18) and Eq. (19) lead to expressions of maximum errors similar to Eq. (14) and Eq. (15).

A further decrease in the standard deviation of data about the same mean values of Eq. (16) and Eq. (17),

$$(gF/U^2)_m = 10{,}000 \qquad \text{and}$$

$$(gF/U^2)_\sigma = 2{,}500 \qquad (20)$$

$$(gt/U)_m = 25{,}346 \qquad \text{and}$$

$$(gt/U)_\sigma = 6{,}337 \qquad (21)$$

yield the following equations:

$$\epsilon_{maxH} = 2.81 \times 10^{11} \times (gt/U)_{acc}^{\ 1}$$
$$(r^2 = 1.00) \qquad (22)$$

and

$$\epsilon_{maxT} = 3.24 \times 10^{11} \times (gt/U)_{acc}^{\ 1}$$
$$(r^2 = 1.00) \qquad (23)$$

The use of Eq. (8) into Eq. (22) and Eq. (23) yields the maximum errors of the form similar to Eq. (14) and Eq. (15).

The observation of the final results given by the maximum errors ϵ_{maxH} and ϵ_{maxT} clearly show the strong influence of decreasing the standard deviation upon the maximum errors expressed in Eqs. (12), (13), (18), (19), (22) and (23). There is also an increase in the negative exponent of the variable $(gt/U)_{acc}$ towards -1. This would indicate that if the time during which waves are measured is doubled, then the maximum errors in the prediction of wave frequencies are reduced in half.

Examples of Application

Let us assume, for $g = 9.81$ m/sec^2 the following wind characteristics:

$$U_{min} = 0.2 \text{ knots} = 0.1 \text{ m/sec}$$

$$U_{max} = 40 \text{ knots} = 20.6 \text{ m/sec}$$

$$U_{mean} = 20 \text{ knots} = 10.3 \text{ m/sec}$$

$$U_{min}/U_{max} = 0.2/40 = 0.005 \qquad (24)$$

Example 1

Windspeeds are uniformly distributed between U_{min} and U_{max}. Consequently, from Eq. (A-1) in Appendix A, $\Phi(U_{min}/U_{max}) = \Phi(0.005) = 0.374$. From Eq. (14) and Eq. (15) the following table may be computed:

$t_{acc(years)}$	0.25	0.5	1	1.5	2	2.5
ϵ_{maxH}	82	56	38	31	26	23
ϵ_{maxT}	107	72	49	39	33	29

A wave record as short as three months may have maximum errors of the order of 100% for wave heights and periods. It may also be seen what has already been pointed out: if a wave record of six months is increased to one year, the maximum errors are decreased by a factor of $56/38 \simeq 72/49 \simeq 1.5$.

Example 2

Let us assume now that the non-dimensional durations and fetches of a gaussian-type, as given by Eq. (16) and Eq. (17), are specified by $U\sigma = U_{mean} = 20$ knots. Then, $U_{mean}/U\sigma = 1$, and, from Eq. (A-2) or Table A in Appendix A,

$$\Phi(U_{min}/U_{max}, U_{mean}/U\sigma) = \Phi(0.005,1) = 0.441$$

The use of Eqs. (18) and (19) with Eq. (8) result in the following table:

$t_{acc(years)}$	1	2	3	4	5	10
ϵ_{maxH}	92	60	47	39	34	22
ϵ_{maxT}	158	113	93	81	73	52

It may be seen, for example, that for a wave record of 1 year, the maximum error in the prediction of the probabilities of wave heights, ϵ_{maxH}, increases from 38% (Example 1) to 92% (Example 2) when wind conditions producing waves change from uniform to a gaussian-type, respectively. It may also be seen that by increasing wave records twice, errors are decreased by a factor of about 1.5, since $(1/2)^{\ 0.61} \simeq (1/2)^{\ 0.48} \simeq 1.5$.

Example 3

A further decrease of the standard deviation of wind speeds about its mean value, with $U_\sigma = 5$ knots and $U_{mean} = 20$ knots, gives $U_{mean}/U_\sigma = 4$. Thus, with the same conditions of Eq. (16) and Eq. (17), and with the same values of maximum and minimum wind speeds, $U_{min}/U_{max} = 0.2/40 = 0.005$, from Appendix A,

$$\Phi(U_{min}/U_{max}, U_{mean}/U_\sigma) = \Phi(0.005,4) = 0.924$$

A table with the same t_{acc} as in the previous example is shown below,

$t_{acc(years)}$	1	2	3	4	5	10
ϵ_{maxH}	144	94	74	62	54	35
ϵ_{maxT}	225	161	133	116	104	75

The consequence of a narrow spread of windspeeds from $U_\sigma = 20$ knots (Example 2), to $U_\sigma = 5$ knots (Example 3), increases the errors in heights from 92% to 144%, for a record of one year.

Example 4

We will consider here wind conditions given by Eq. (20) and Eq. (21), with $U_\sigma = 20$ knots. As in Example 2, $U_{mean}/U_\sigma = 1$, $U_{min}/U_{max} = 0.005$ and $\Phi(0.005,1) = 0.441$. The following table shows the computed results for this example:

$t_{acc(years)}$	5	10	20	40	50
ϵ_{maxH}	823	412	206	137	82
ϵ_{maxT}	949	475	237	158	95

The strong influence of the standard deviation of wind conditions as given by the pair of Eqs. (16) and (17), as compared with the pair of Eqs. (20) and (21), for a wave record of 5 years, may be observed from the tables of Examples 2 and 4: the maximum errors increase from 34% to 823% for wave heights.

A similar situation happens when wave periods are compared, also for 5 years of wave recording. The maximum errors increase from 73% (Example 2) to 949% (Example 4).

CONCLUSIONS

A numerical model based upon the method of Sverdrup-Munk-Bretschneider, as suggested by the *Shore Protection Manual* (1984), has been used to generate a large number of wind waves. A wave record may thus reach such a length that wave frequencies of occurrence of wave heights and periods will not change significantly.

If the wave record length, given by a duration t_{acc}, is then numerically shortened, these frequencies shall be altered. Through some simplifying assumptions, the changes in frequencies may be attributed only to the length of wave record. Then the errors in the prediction of frequencies will vary with the time during which waves are recorded. From mean values of a relatively large amount of numerical simulations (500 in the present work), the maximum errors in the frequency of occurrence of wave heights, ϵ_{maxH}, and the maximum errors in wave periods, ϵ_{maxT}, may be found.

The statistical properties of wind conditions are defined with the mean $(gt/U)_{mean}$ and $(gF/U^2)_{mean}$, and the standard deviation $(gt/U)_\sigma$ and $(gF/U^2)_\sigma$ for a gaussian-type frequency distribution. Uniformly distributed conditions may be seen as having a large standard deviation of the aforementioned non-dimensional variables. Windspeeds are also assumed to have the mean and the standard deviation, U_{mean} and U_σ, respectively, with a range from U_{min} to U_{max}, and a mean value, $U_{mean} = (U_{min} + U_{max})/2$.

It is found that, if the spreads of $(gF/U^2)_\sigma$ and $(gt/U)_\sigma$ are relatively high, then the errors in the prediction of wave heights and wave periods are very low even for wave records of a few years only. On the other hand, the narrow spreads of gF/U^2 and gt/U about their mean values result in large errors, ϵ_{maxH} and ϵ_{maxT}, even for wave records lasting many years, because of wave occurrences in the tail of the narrow distribution.

Finally, it should be stated that the present statistical analysis yields qualitative as well as quantitative results. However, due to the highly simplifying assumptions on which it is based, a more realistic analysis will be required to obtain more quantitatively reliable results.

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APPENDIX A

In connection with Eq. (8), through the use of Eq. (4) and Eq. (5), it can be stated that,

$$\sum_{i=1}^{n} t_i = \Phi U_{mean} \sum_{i=1}^{n} (t/U)_i$$

from where,

$$\Phi = \frac{n}{U_{mean} \sum_{i=1}^{n} (1/U)_i}$$

since, because of the independence of the variables t and U,

$$\sum_{i=1}^{n} (t/U)_i = \frac{1}{n} \sum_{i=1}^{n} t_i \sum_{i=1}^{n} (1/U)_i$$

If the number n tends to infinity the integration of the expresssion for Φ gives,

$$\Phi(U_{min}/U_{max}) = 2\frac{U_{min}/U_{max} - 1}{U_{min}/U_{max} + 1}\frac{1}{\ln(U_{min}/U_{max})} \quad \text{(A-1)}$$

for uniform distrubution of windspeeds U_i. In particular, $\Phi(0.005) = 0.374$. The above equation has the following limits:

$$\lim_{x \to 0} \Phi(X) = 0 \qquad \text{and} \qquad \lim_{x \to 1} \Phi(X) = 1$$

If windspeeds are normally distributed from U_{min} to U_{max}, with a mean value U_{mean} and a standard deviation U_σ, the integration for the function Φ gives,

$$\Phi(U_{min}/U_{max}, U_{mean}/U_\sigma) = \frac{1}{U_{mean}}\frac{I_1}{I_2} \quad \text{(A-2)}$$

where,

$$I_1 = \int_{U_{min}}^{U_{max}} f(U)\, dU, \qquad I_2 = \int_{U_{min}}^{U_{max}} \frac{f(U)}{U}\, dU$$

and,

$$f(U) = \frac{1}{\sqrt{2\pi}\, U_\sigma} \exp\left[-\frac{1}{2}\left(\frac{U - U_{mean}}{U_\sigma}\right)^2\right]$$

is the normal distribution function. Equation (A-2) tends towards Eq. (A-1) when U_{mean}/U_σ tends to zero.

Numerical integration of Eq. (A-2) gives the following results, for $U_{min}/U_{max} = 0.005$:

Table A *Results of the numerical integration of equation (A-2)*

U_{mean}/U_σ	$\Phi(0.005, U_{mean}/U_\sigma)$
10	0.990
8	0.984
6	0.970
5	0.956
4	0.924
3	0.831
2	0.624
1	0.441
0.5	0.396
0.25	0.386
0	0.374

□ RESUMEN □

Se trata de simular numéricamente el registro de olas. Se elige un algoritmo para calcular las características de las olas a partir de condiciones específicas del viento, y luego se generan datos en cantidades generosas. De esta forma se puede llegar a un registro de olas que podría abarcar varios siglos de duración y del cual se pueden determinar las frecuencias de ocurrencia de alturas y períodos de olas. Este registro de olas se considerará como de longitud "infinita". Posteriormente se simula uno que cubra solamente unos pocos meses o años, registro que se considerará como de longitud "finita". La frecuencia de ocurrencia de alturas y períodos de olas será diferente de aquella obtenida con el registro de longitud infinita debido a lo restringido de la información. De esta manera se podrá determinar la influencia de la longitud de registro comparando las frecuencias de ocurrencia provenientes de una cantidad infinita de información con aquellas que resultan de una cantidad limitada de datos.