Hurricane Categories Depending on its Winds in Context of Warming Climate -Using Right-tail L Probability Distribution Function

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Introduce:

Along with globe warming the individual hurricane damage has increasingly been severe, sometimes, resultant destroy is than ever, even people influenced by super-hurricane disaster seems live in the shadow of apocalypse, super-hurricane generally is mainly characterized as violent winds (too much strong whirling wind or gusts), so here it may be supposed that hurricane winds(usually sustained winds in one minutes or ten minutes interval) is good index to represents strength and power of tropical cyclone, such as Saffir-Simpson hurricane wind scale, generally, from commonsensible scene , the more power of hurricane; the more stronger winds take places; but from professional and technical aspects, the fundamental and comprehensive mathematical tools should be ability and available to study those kind questions of categories for super tropical

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cyclone, Especially, at current trend of today hurricanes power has been increasing decade by decade（or year by year）, the new categories for super-hurricanes will be urgent for in adoption to globe warming and meet growing requirements to calibrate increasingly super-hurricane in tropical or subtropical cyclone-prone region, such as in today the Texas US; in the Louisiana US; in Florida US; in the Mississippi US; in the Alabama US; in Georgia US, in Fujian province China; in Guangdong province China; in Zhejiang province China, in Guangxi province China, in Vietnam; Thailand; Myanmar; Bangladesh; India and so on, in particular, using the intensified destructive winds the super-hurricane lead to, because hurricane violent wind often severely damaged infrastructure of some low-latitude and coastal cities today, such as Tropical Storm Hato did in Macao 23,Aug,2017, in Zhuhai of Guangdong province, for Hato, Hong Kong in five years shut down schools and financial markets, warned with the first Signal 10 typhoon.

Ideas:

Using how stronger wind of tropical cyclone or subtropical cyclone to give the category of strength of hurricane is one of many approaches to delineate What power of tropical cyclone is, at these points, obviously，the degree to whose mean of long term, the wind the hurricane will lead to, is important indicator of how much the hurricane has taken place, in other words, this degree is also in proportion to how much intensity (wind) the hurricane will bring to the area, or potential damage it will cause , at this time precisely speaking, the intensified wind the hurricane bring, the more stronger the hurricane is! here it is assumed that "stronger wind" event occurring is more than "weaker wind" event is for all wind-oriented events of any hurricane in future, same meaning, the distribution of the wind event of hurricane should be right-skewness distribution, and ‘weaker wind’ events is "scarce" but ‘ stronger wind’ events of hurricane is "often" ,even "abundant" and "plentiful", this means that right-distribution can suitable for the trend of the hurricane wind being growingly greater in future, In the other words, "below boundary" of wind of hurricane is near zero or limited value , however, its "up-boundary” will be approaching +∞ or unlimited, this is just main feature of right-skew distribution, Therefore, at this time, one the skew-distribution is needed to delineate the distribution of hurricane wind does and similarly using this distribution to categorize the strength of hurricane. Although, this right-skew distribution is required that it owns those ability to describe extreme wind velocity of hurricanes, such as, the wind of some one tropical cyclone is 1- times; 2-times...... 5-times; 6-times......10-times......of long term averaged value of all hurricanes historical wind, even 20-times....even 50-times....at so on, but here it is required at same time that its standard variable formation should be identical and stability or remain same in whole defining interval(-1,+∞) , and the boundary is limited in its “weaker wind” interval, however, the boundary is unlimited in its “intensified wind” interval, at this time, the theory of this right-skew distribution should be perfect , accurate; strict, even rigorous. Here it deserve stress, from extreme event (wind) perspective, although Normal Distribution(Gaussian Distribution) also somewhat have ability to delineate extreme precipitation, however, unfortunately Normal Distribution(Gaussian Distribution) is not skew-distribution but only symmetric distribution, its definition interval is from -∞to +∞ , so its standard variable should be different at two interval,(-∞, 0) and (0, + ∞) according to its boundary condition ,thus, symmetric feature and various standard variable formula of Normal Distribution(Gaussian Distribution) causes its interior ability for description to extreme wind, at least, not perfect and no accurate for discrimination of extreme wind, this is just that Normal Distribution(Gaussian Distribution) is often criticized by some scientist for its inefficient quality used to depict extreme events because of its symmetric and normal property and because extreme events generally is recognized to obey skew distribution,

In addition, it here is also worth of point out that although wind of hurricane in theory may be near to zero, in deed wind of hurricane generally is above 32m/s or 63 km/h (Saffir-Simpson hurricane scale), so it should be paid attention to that positive skew distribution gives broaden width in which extreme wind velocity can develop from its long term averaged value to + ∞ (unlimited), thus under of this condition, wind of hurricane more than 32m/s or 63 km/h can not impact the main quality that enable wind velocity vary from its mean point until to its + ∞ point or the unlimited biggest, just this point meets requirement of extreme unlimited biggest wind velocity for duration of studying extreme events of wind velocity for tropical or subtropical cyclone.

Theory and methods:

Wanli Wang right-skew L distribution function meets those basic requirements above,What property of approach being used to measure wind is key step to chose to its ability to describe to extreme wind event, here, it is recommended that wanli wang positive L probability distribution function may be suitable for category of the hurricane in term of wind it takes, wanli wang Positive-Skew L probability distribution function is also called right- tail or right- skew L distribution function, in fact , wanli Wang right-skew L distribution function is just combined wanli wang L standard (0,1) distribution function (symmetry) with Standard(0,1) Normal Distribution(Gaussian Distribution),also called as “Wang Wanli- Gaussian” Distribution”, and finally let Wang wanli right-skew L distribution function become asymmetry distribution and right-skew distribution. its intrinsic quality is that its interval is from -1 to + ∞ or "unlimited" ,here *x* indicates wind, it may be one minute sustained wind ; ten minute sustained wind etc, also several second maximum gusts , x_A indicates respective mean wind for long term and for historical data, therefore, standard random variable must be written as $(x-x_A)/x_A$ depending on boundary condition of the probability density function: f(-1) =0 or f(+∞) =0, both equal to zero , below, formula(1) is probability density function of wang wanli right-skew L distribution (Wang Wanli- Gaussian" Distribution).

$$f_{L-Right}\left(\frac{x-x_A}{x_A}\right)\begin{cases} =\frac{1}{4}\ln\left(\frac{1}{\frac{x-x_A}{x_A}}\right)^2 & \left(-1\le\frac{x-x_A}{x_A}\le 0\right) \\ =\frac{1}{\sqrt{2\pi}}e^{-\frac{1}{2}\left(\frac{x-x_A}{x_A}\right)^2} & \left(0<\frac{x-x_A}{x_A}\le\infty\right) \end{cases}$$

(1)

Formula (2) is Right Skew L probability Distribution Function (RS-LPDF) of wang wanli L distribution (Wang Wanly- Gaussian" Distribution)

$$F_{L-Right}\left(\frac{x-x_A}{x_A}\right)\begin{cases} =\frac{1}{4}\left\{\left[\left(\frac{x-x_A}{x_A}\right)\ln\left(\frac{1}{\frac{x-x_A}{x_A}}\right)^2+2\left(\frac{x-x_A}{x_A}\right)\right]+2\right\} & \left(-1\le\frac{x-x_A}{x_A}\le 0\right) \\ =\Phi\left(\frac{x-x_A}{x_A}\right) \qquad \left(0<\frac{x-x_A}{x_A}\le\infty\right) \end{cases}$$

(2)

Here $F'_{L-Right}\left(\frac{x-x_A}{x_A}\right)=f_{L-Right}\left(\frac{x-x_A}{x_A}\right)$

At same time

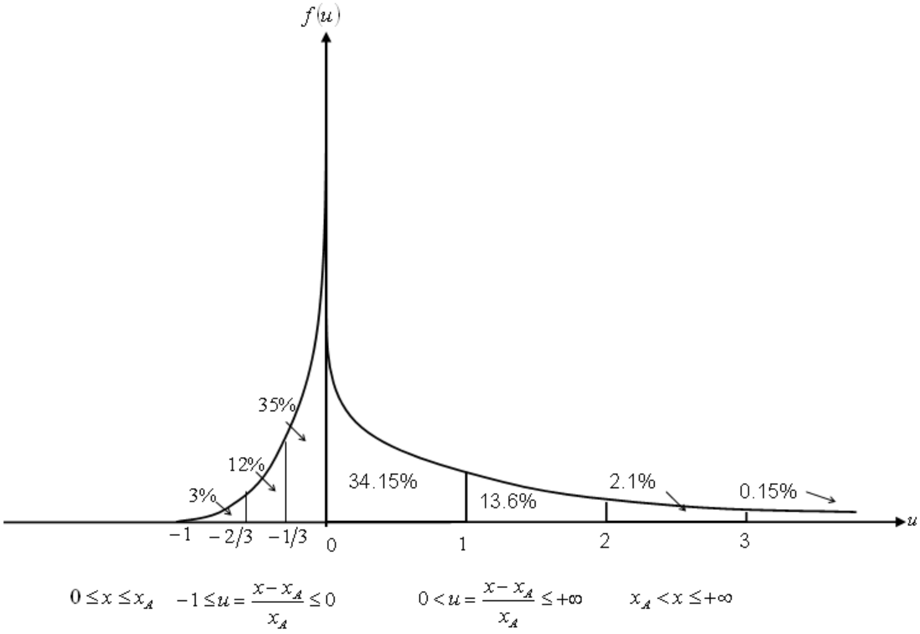
$$\Phi\left(\frac{x-x_A}{x_A}\right)=0.5+\frac{1}{\sqrt{2\pi}}.e^{-\frac{1}{2}\left(\frac{x-x_A}{x_A}\right)^2}\left\{\begin{aligned}&\frac{x-x_A}{x_A}+\frac{1}{3}\left(\frac{x-x_A}{x_A}\right)^3+\frac{1}{3\times 5}\left(\frac{x-x_A}{x_A}\right)^5\\&+\cdots+\frac{1}{(2n+1)\ !!}\left(\frac{x-x_A}{x_A}\right)^{2n+1}+\cdots\end{aligned}\right\}$$

(3)

In addition

$$\Phi\left[-\left(\frac{x-x_A}{x_A}\right)\right]=1-\Phi\left[\left(\frac{x-x_A}{x_A}\right)\right]$$

(4)



Here it should be noted that standard variable *u* must be $(x\text{-}x_A) / x_A$; obviously, standard variable is negative when *x* is less than its mean x_A ;standard variable is positive when *x* is more than its mean x_A : the standard variable is equal to zero when *x* is just its mean x_A; thus, standard variable is just -1 if *x* wind is zero (or wind is relatively more less than its mean), standard variable is also +∞ unlimited and biggest if *x* wind is +∞ (unlimited or biggest), finally, standard random variable fall into interval of -1 to + ∞ (positive unlimited) .

Another Problem:

Analysis above in fact, there is one problem which is related to minimum boundary of formula of right skew wanly Wang L distribution function, these are just that "below boundary of wind of hurricane is near zero or limited value", the sentence “below boundary of wind of hurricane is near zero” is very not perfect rather than the sentence “below boundary of wind of hurricane is limited value”, such as the table-1 below is Saffir-Simpson hurricane wind scale which is official and popular hurricane standard in US today, obviously, wind 17 m/s for 1-minute maximum sustained winds is lowest value of low boundary if Tropical storm is also be considered as initial degree of hurricane categories ;similarly, in table-2, which shows China Typhoon standard with wind strength , also indicates that minimum wind speed is 10.8 m/s, therefore, lowest boundary value for hurricane or typhoon should be set as 17 m/s or 10.8 m/s rather than zero(0) m/s like previous session, reasonably, standard real variable u must be necessarily changed and modified to adopt to requirements from this kind of demarcated(low boundary) asymmetric distribution, Actually, In the interval of (x_{min} , $+\infty$), standard real variable u is expressed as bellow through complicated process.

$$u = \frac{(x - x_A)}{(x_A - x_{\min})} \quad (5)$$

$u = -1$, when $x = x_{\min}$

$u = 0$, when $x = x_A$

$u = +\infty$, when $x \to \infty$

Density function is changed as below for interval(x_{min} , $+\infty$)

$$f_{L-Right}\left(\frac{x - x_A}{x_A - x_{\min}}\right)\begin{cases} = \dfrac{1}{4}\ln\left(\dfrac{1}{\dfrac{x - x_A}{x_A - x_{\min}}}\right)^2 & \left(-1 \le \dfrac{x - x_A}{x_A - x_{\min}} \le 0\right) \\ = \dfrac{1}{\sqrt{2\pi}} e^{-\frac{1}{2}\left(\frac{x - x_A}{x_A - x_{\min}}\right)^2} & \left(0 < \dfrac{x - x_A}{x_A - x_{\min}} \le \infty\right) \end{cases}$$

(6)

Right Skew L probability Distribution Function (RS-LPDF) of wang wanli L distribution (Wang Wanly- Gaussian” Distribution) for the interval of (x_{min} , $+\infty$)

$$F_{L-Right}\left(\frac{x-x_A}{x_A-x_{\min}}\right)\begin{cases}=\frac{1}{4}\left\{\left[\left(\frac{x-x_A}{x_A-x_{\min}}\right)\ln\left(\frac{1}{\frac{x-x_A}{x_A-x_{\min}}}\right)^2+2\left(\frac{x-x_A}{x_A-x_{\min}}\right)\right]+2\right\} & \left(-1\le\frac{x-x_A}{x_A-x_{\min}}\le 0\right)\\ =\Phi\left(\frac{x-x_A}{x_A-x_{\min}}\right) & \left(0<\frac{x-x_A}{x_A-x_{\min}}\le\infty\right)\end{cases}$$

(7)

Here $F'_{L-Right}\left(\frac{x-x_A}{x_A-x_{\min}}\right)=f_{L-Right}\left(\frac{x-x_A}{x_A-x_{\min}}\right)$

At same time

$$\Phi\left(\frac{x-x_A}{x_A-x_{\min}}\right)=0.5+\frac{1}{\sqrt{2\pi}}.e^{-\frac{1}{2}\left(\frac{x-x_A}{x_A-x_{\min}}\right)^2}\left\{\begin{array}{l}\frac{x-x_A}{x_A-x_{\min}}+\frac{1}{3}\left(\frac{x-x_A}{x_A-x_{\min}}\right)^3+\frac{1}{3\times 5}\left(\frac{x-x_A}{x_A-x_{\min}}\right)^5\\ +\cdots+\frac{1}{(2n+1)\ !!}\left(\frac{x-x_A}{x_A-x_{\min}}\right)^{2n+1}+\cdots\end{array}\right\}$$

(8)

In addition

$$\Phi\left[-\left(\frac{x-x_A}{x_A-x_{\min}}\right)\right]=1-\Phi\left[\left(\frac{x-x_A}{x_A-x_{\min}}\right)\right]$$

(9)

Table-1 the winds in Saffir–Simpson scale

Saffir–Simpson scale				
Category	Wind speeds (for 1-minute maximum sustained winds)			
	m/s	knots (kn)	mph	km/h
Five	≥ 70 m/s	≥ 137 kn	≥ 157 mph	≥ 252 km/h
Four	58–70 m/s	113–136 kn	130–156 mph	209–251 km/h
Three	50–58 m/s	96–112 kn	111–129 mph	178–208 km/h
Two	43–49 m/s	83–95 kn	96–110 mph	154–177 km/h
One	33–42 m/s	64–82 kn	74–95 mph	119–153 km/h
Related classifications (for 1-minute maximum sustained winds)				
Tropical storm	18–32 m/s	34–63 kn	39–73 mph	63–118 km/h
Tropical depression	≤ 17 m/s	≤ 33 kn	≤ 38 mph	≤ 62 km/h

Table-2 the Winds in China Typhoon Scale

Categories	m/s	Maximum wind
……	……	……
Super Typhoon	≧ 51.0 m/s	≧ 16 degree
Severe Typhoon	41.5–50.9 m/s	14-15 degree
Typhoon	32.7–41.4 m/s	12-13 degree
Severe Tropical storm	24.5–32.6 m/s	10-11 degree
Tropical storm	17.2-24.4 m/s	8-9 degree
Tropical depression	10.8-17.1 m/s	6-7 degree

Consequences:

Multi-levels the categories of hurricane strength using Right Skew L probability Distribution Function (RS-LPDF), Using 1/3 (standard derivation of standard L probability distribution function) as "size of basic Step" , the Standard of hurricane strength is approximately classified as multi-grades, like table below, in the table,"–" signal presents individual hurricane wind is less than the hurricane averaged wind of long term; "+" signal presents individual hurricane wind is more than the hurricane averaged wind of long term.

Tab-3 multi-levels of hurricane strength in term of its sustained winds for Saffir–Simpson scale

u= $[(X-X_A)/(X_A–X_{min})]\%$	$(X- X_A)/(X_A-X_{min})$	Categories	Probabilities	X (wind speeds) m/s	Saffir –Simpson scale m/s	Words classification
+∞	+∞	+∞	→ 0			
……	……	……	……			
＞900	> 9.0	> + 15		>282.00		
800 ～ 900	8.00～9.0	+15		255.50-282.00		“Seventeen”
700 ～ 800	7.00～8.00	+14		229.00-255.50		“sixteen”
600 ～ 700	6.00～7.00	+13		202.50-229.00		“Fourteen”
500 ～ 600	5.00～ 6.00	+12	$0.0^{5}28$ %	176.00-202.50		“Thirteen”
400 ～ 500	4.00～5.00	+11	0.003 %	149.50-176.00		“Twelve”
300 ～ 400	3.00～4.00	+10	0.132 %	123.00-149.50		“Eleven”
267 ～ 300	2.67～3.00	+9	0.24 %	114.17-123.00		“Ten”
233 ～ 267	2.33～2.67	+8	0.61 %	105.33-114.17		“Nine”
200 ～ 233	2.00～2.33	+7	1.28 %	96.50-105.33		“Eight”
167 ～ 200	1.67～2.00	+6	2.47 %	87.67-96.50		“Seven”
133 ～ 167	1.33～1.67	+5	4.43 %	78.83- 87.67		“Six”
100 ～ 133	1.00～1.33	+4	6.69 %	70.00-78.83	＞70	“Five”
67 ～ 100	0.67～1.00	+3	9.27 %	61.17-70.00	58–70	“Four”
33 ～ 67	0.33～0.67	+2	11.93 %	52.33-61.17	50–58	“Three”
00 ～ 33	0.00～0.33	+1	12.93 %	43.50–52.33	43–49	“Two”
-33 ～ 00	-0.33～0.00	-1	34.79 %	34.67-43.50	33–42	“One”
-67 ～ -33	-0.67～-0.33	-2	12.12 %	25.83-34.67		“Severe Tropical storm”
-100 ～ -67	-1.00～-0.67	-3	3.08 %	17.00-25.83	18–32	“Tropical storm”

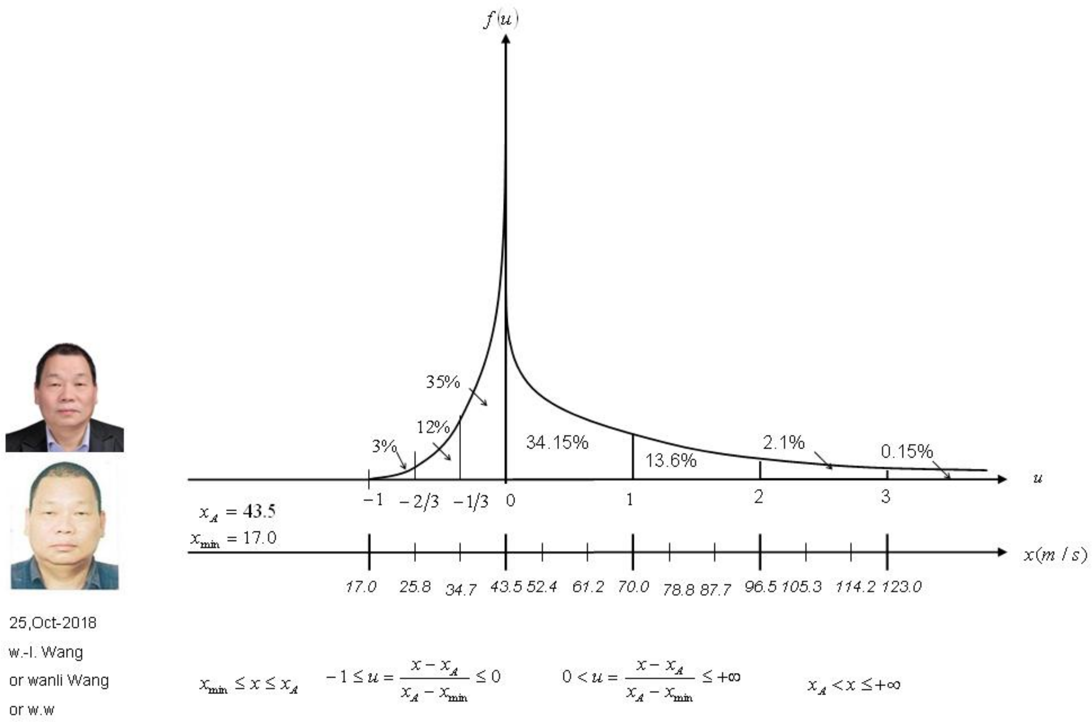


Fig-1 explanation for the hurricanes categories compared with Saffir–Simpson scale US

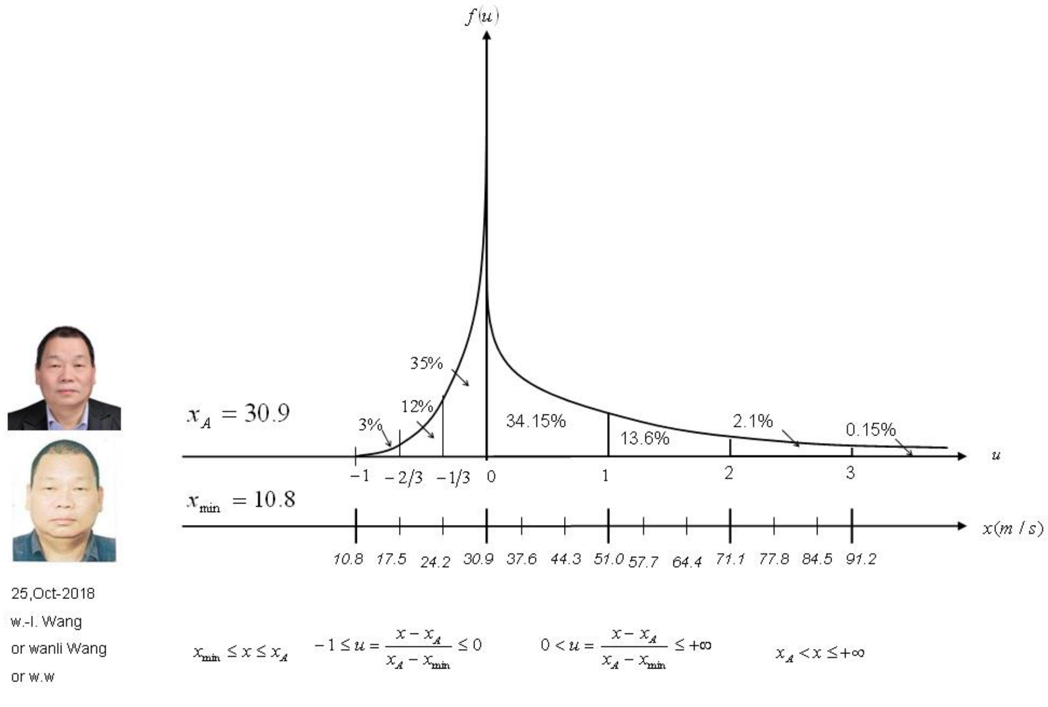


Fig-2 explanation for the hurricanes categories compared with China Typhoon scale

In addition, the categories for the Winds in China Typhoon Scale to reference to Table-4

Tab-4 multi-levels of hurricane strength in term of its sustained winds for China Typhoon Scale

$u=[(X-X_A)/(X_A-X_{Min})]\%$	$(X-X_A)/(X_A-X_{Min})$	Categories	Probabilities	X(wind speeds)	Traditional China Typhoon Scale	Words classification
+∞	+∞	+∞	→ 0			
……	……	……	……			
＞900	> 9.0	> + 15		>211.80m/s		
800 ～ 900	8.00～9.0	+15		191.70m/s-211.80m/s		Super Extreme-III
700 ～ 800	7.00～8.00	+14		171.60m/s-191.70m/s		Super Extreme- II
600 ～ 700	6.00～7.00	+13		151.50m/s-171.60m/s		Super Extreme- I
500 ～ 600	5.00～ 6.00	+12	$0.0^{5}28$ %	131.40m/s-151.50m/s		Severe Extreme-III
400 ～ 500	4.00～5.00	+11	0.003 %	111.30m/s-131.40m/s		Severe Extreme- II
300 ～ 400	3.00～4.00	+10	0.132 %	91.20m/s-111.30m/s		Severe Extreme- I
267 ～ 300	2.67～3.00	+9	0.24 %	84.50m/s-91.20m/s		Extreme - VI
233 ～ 267	2.33～2.67	+8	0.61 %	77.80m/s-84.50m/s		Extreme - V
200 ～ 233	2.00～2.33	+7	1.28 %	71.10m/s-77.80m/s		Extreme - IV
167 ～ 200	1.67～2.00	+6	2.47 %	64.40m/s-71.10m/s		Extreme - III
133 ～ 167	1.33～1.67	+5	4.43 %	57.70m/s- 64.40m/s		Extreme - II
100 ～ 133	1.00～1.33	+4	6.69 %	51.00m/s-57.70m/s		Extreme - I
67 ～ 100	0.67～1.00	+3	9.27 %	44.30m/s-51.00m/s	≧ 51.0 m/s	Super Typhoon
33 ～ 67	0.33～0.67	+2	11.93 %	37.60m/s-44.30m/s	41.5–50.9 m/s	Severe Typhoon
00 ～ 33	0.00～0.33	+1	12.93 %	30.90m/s -37.60.m/s	32.7–41.4 m/s	Typhoon
-33 ～ 00	-0.33～0.00	-1	34.79 %	24.20m/s -30.90m/s	24.5–32.6 m/s	Severe tropical storm
-67 ～ -33	-0.67～-0.33	-2	12.12 %	17.50m/s -24.20m/s	17.2-24.4 m/s	Tropical storm
-100 ～ -67	-1.00～-0.67	-3	3.08 %	10.80m/s-17.50m/s	10.8-17.1 m/s	Tropical Depression

A little Discussion:

It is found that new hurricanes categories derived from “wanli Wang”right-tail L probability distribution function is very near close to “Saffir–Simpson scale” or new typhoon categories of “wanli Wang”right-tail L probability distribution function is also very similar to traditional China typhoon scale , analysis from Fig-1,Fig-2, Table-3 and Table-4,in detail, for example, in table-3, all interval the wind speeds X is less than long term averaged value X_A(43.5m/s), in the interval of (17.00m/s- 43.50m/s), more interesting , new categories have three classes : “tropical storm”(17.00-25.83m/s); “severe tropical storm”(25.83-34.67m/s) and “one scale hurricane”(34.67-43.50m/s). However, “Saffir–Simpson scale” have two classes: “tropical storm”(18-32m/s) which almost and nearly encompasses “Tropical storm” and “severe tropical storm” of new categories (17.00-25.83m/s) interval and (25.83-34.67m/s), due to long term averaged value X_A may be supposed as 43.5m/s or so , therefore, 34.67m/s is negative point of “standard deviation”; as well as 52.33m/s is Pseudo-positive point of “standard deviation” because This point (52.33m/s) corresponds to standard variable u just being equal to 1/3, thus from negative “standard deviation” point (34.67m/s) to Pseudo-positive point of “standard deviation” point(52.33m/s), in other words, there exists the probabilities of (12.93%+34.79%=47.72%) in the interval(34.67, 52.33m/s), this probability means that “One and two “hurricane occurring probabilities approximately reaches 47.72, and 4-5 number “One and two “hurricane can happens out of 10 hurricanes ; meanwhile, Real-positive point of “standard deviation” is 70m/s because the point(70 m/s) just corresponds to standard variable u just being equal 1, then, thus from negative “standard deviation” point (34.67m/s) to Real-positive point of “standard deviation” point(70.00m/s), naturally, there exists the probabilities of (12.93%+34.79%+11.93+9.27%=68.92%) in the interval(34.67, 70.00m/s),of courses, hurricane less than “one” and tropical storm occurring probabilities only reaches 15.2%(12.12%+3.08%) in the space(17.00, 34.67),finally, results is summarized as that “big probabilities’ events ” is from “one” to “four” scales whose probabilities in theory is 68.92% , but “five” scale hurricane only is zero-1(6.69%) unite out of 10 number hurricanes ; “six” scale hurricane only is zero-0.5 (4.43%) unite out of 10 number hurricanes ; “seven” scale hurricane only is zero-0.3 (2.47%) unite out of 10 number hurricanes ; “eight” scale hurricane only is zero-0.2 (1.28%) unite out of 10 number hurricanes ; “nine” scale hurricane only is zero-0.1 (0.61%) unite out of 10 number hurricanes ; strikingly contrast, in the “Saffir–Simpson scale”, “Five” scale occurring probability is near to 15.87%，new categories is obviously easy to calibrate and measure growing and increasing trend of hurricanes strength or power once hurricanes intensities increase in future in context of globe warming and if total those varies of more than four scale hurricanes simply will be grouped only and alone one of five category, if so, this such deal very is not art and elaboration, so “Saffir–Simpson scale”, is necessitated be improved and developed beyond over or more than five scale(including five scale)(>70m/s) in detail ,and to make “Saffir–Simpson scale” more sensitive to subtle varies of hurricanes wind speeds in future, new hurricanes categories deduced from wanli Wang L right-tail probability distribution function just meet those requirement and challenges above, therefore , using wanli Wang L right-tail probability distribution function, the all space more than five scale (including five) have been theoretically categorized and the rest also keeps very closer to “Saffir–Simpson scale” well.

Appendix:

Table of right skew standard L probability distribution function, here standard variable formula $u = (x-x_A) / (x_A- x_{min})$, *in the formula,* x indicates real random variable (wind of Individual hurricane studied), x_A indicates long term averaged value of hurricane wind, x_{min} is minimum wind as well as low boundary value.

Table -4 right skew standard L probability distribution function-author-wanli wang-20-march-2017

u	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09	***u***
-1.00	*0.000000*										-1.00
-0.9	$0.0^{2}25878$	$0.0^{2}20886$	$0.0^{2}16445$	$0.0^{2}12546$	$0.0^{3}91856$	$0.0^{3}63569$	$0.0^{3}40544$	$0.0^{3}22728$	$0.0^{3}10067$	$0.0^{4}25084$	-0.9
-0.8	*0.010743*	$0.0^{2}96580$	$0.0^{2}86351$	$0.0^{2}76732$	$0.0^{2}67716$	$0.0^{2}59295$	$0.0^{2}51462$	$0.0^{2}44210$	$0.0^{2}37533$	$0.0^{2}31425$	-0.8
-0.7	*0.025164*	*0.023416*	*0.021739*	*0.020131*	*0.018591*	*0.017119*	*0.015714*	*0.014375*	*0.013100*	*0.011890*	-0.7
-0.6	*0.046752*	*0.044240*	*0.041809*	*0.039459*	*0.037188*	*0.034996*	*0.032880*	*0.030840*	*0.028875*	*0.026983*	-0.6
-0.5	*0.076713*	*0.073297*	*0.069979*	*0.066757*	*0.063630*	*0.060595*	*0.057651*	*0.054796*	*0.052029*	*0.049348*	-0.5
-0.4	*0.116742*	*0.112222*	*0.107825*	*0.103546*	*0.099384*	*0.095336*	*0.091398*	*0.087570*	*0.083847*	*0.080229*	-0.4
-0.3	*0.169404*	*0.163467*	*0.157691*	*0.152071*	*0.146602*	*0.141281*	*0.136103*	*0.131063*	*0.126159*	*0.121386*	-0.3
-0.2	*0.239056*	*0.231132*	*0.223446*	*0.215987*	*0.208746*	*0.201713*	*0.194880*	*0.188240*	*0.181785*	*0.175508*	-0.2
-0.1	*0.334871*	*0.323600*	*0.312784*	*0.302386*	*0.292372*	*0.282716*	*0.273394*	*0.264384*	*0.255668*	*0.247231*	-0.1
-0.0	*0.500000*	*0.471974*	*0.450880*	*0.432402*	*0.415623*	*0.400107*	*0.385598*	*0.371926*	*0.358971*	*0.346642*	-0.0
0.0	*0.5000*	*0.5040*	*0.5080*	*0.5120*	*0.5160*	*0.5199*	*0.5239*	*0.5279*	*0.5319*	*0.5359*	0.0
0.1	*0.5398*	*0.5438*	*0.5478*	*0.5517*	*0.5557*	*0.5596*	*0.5636*	*0.5675*	*0.5714*	*0.5753*	0.1
0.2	*0.5793*	*0.5832*	*0.5871*	*0.5910*	*0.5948*	*0.5987*	*0.6026*	*0.6064*	*0.6103*	*0.6141*	0.2
0.3	*0.6179*	*0.6217*	*0.6255*	*0.6293*	*0.6331*	*0.6368*	*0.6406*	*0.6443*	*0.6480*	*0.6517*	0.3
0.4	*0.6554*	*0.6591*	*0.6628*	*0.6664*	*0.6700*	*0.6736*	*0.6772*	*0.6808*	*0.6844*	*0.6879*	0.4
0.5	*0.6915*	*0.6950*	*0.6985*	*0.7019*	*0.7054*	*0.7088*	*0.7123*	*0.7157*	*0.7190*	*0.7224*	0.5
0.6	*0.7257*	*0.7291*	*0.7324*	*0.7357*	*0.7389*	*0.7422*	*0.7454*	*0.7486*	*0.7517*	*0.7549*	0.6
0.7	*0.7580*	*0.7611*	*0.7642*	*0.7673*	*0.7703*	*0.7734*	*0.7764*	*0.7794*	*0.7823*	*0.7852*	0.7
0.8	*0.7881*	*0.7910*	*0.7939*	*0.7967*	*0.7995*	*0.8023*	*0.8051*	*0.8078*	*0.8106*	*0.8133*	0.8
0.9	*0.8159*	*0.8186*	*0.8212*	*0.8238*	*0.8264*	*0.8289*	*0.8315*	*0.8340*	*0.8365*	*0.8389*	0.9
1.0	*0.8413*	*0.8438*	*0.8461*	*0.8485*	*0.8508*	*0.8531*	*0.8554*	*0.8577*	*0.8599*	*0.8621*	1.0
1.1	*0.8643*	*0.8665*	*0.8686*	*0.8708*	*0.8729*	*0.8749*	*0.8770*	*0.8790*	*0.8810*	*0.8830*	1.1
1.2	*0.8849*	*0.8869*	*0.8888*	*0.8907*	*0.8925*	*0.8944*	*0.8962*	*0.8980*	*0.8997*	*0.90147*	1.2
1.3	*0.90320*	*0.90490*	*0.90658*	*0.90824*	*0.90988*	*0.91149*	*0.91309*	*0.91466*	*0.91621*	*0.91774*	1.3
1.4	*0.91924*	*0.92073*	*0.92220*	*0.92364*	*0.92507*	*0.92647*	*0.92785*	*0.92922*	*0.93056*	*0.93189*	1.4
1.5	*0.93319*	*0.93448*	*0.93574*	*0.93699*	*0.93822*	*0.93943*	*0.94062*	*0.94179*	*0.94295*	*0.94408*	1.5
1.6	*0.94520*	*0.94630*	*0.94738*	*0.94845*	*0.94950*	*0.95053*	*0.95154*	*0.95254*	*0.95352*	*0.95449*	1.6
1.7	*0.95543*	*0.95637*	*0.95728*	*0.95818*	*0.95907*	*0.95994*	*0.96080*	*0.96164*	*0.96246*	*0.96327*	1.7
1.8	*0.96407*	*0.96485*	*0.96562*	*0.96638*	*0.96712*	*0.96784*	*0.96856*	*0.96926*	*0.96995*	*0.97062*	1.8
1.9	*0.97128*	*0.97193*	*0.97257*	*0.97320*	*0.97381*	*0.97441*	*0.97500*	*0.97558*	*0.97615*	*0.97670*	1.9

2.0	*0.97925*	*0.97778*	*0.97831*	*0.97882*	*0.97932*	*0.97982*	*0.98030*	*0.98077*	*0.98124*	*0.98169*	2.0
2.1	*0.98214*	*0.98257*	*0.98300*	*0.98341*	*0.98382*	*0.98422*	*0.98461*	*0.98500*	*0.98537*	*0.98574*	2.1
2.2	*0.98610*	*0.98645*	*0.98679*	*0.98713*	*0.98745*	*0.98778*	*0.98809*	*0.98840*	*0.98870*	*0.98899*	2.2
2.3	*0.98928*	*0.98956*	*0.98983*	$0.9^{2}0097$	$0.9^{2}0358$	$0.9^{2}0613$	$0.9^{2}0863$	$0.9^{2}1106$	$0.9^{2}1344$	$0.9^{2}1576$	2.3
2.4	$0.9^{2}1802$	$0.9^{2}2014$	$0.9^{2}2240$	$0.9^{2}2451$	$0.9^{2}2656$	$0.9^{2}2857$	$0.9^{2}3053$	$0.9^{2}3244$	$0.9^{2}3431$	$0.9^{2}3613$	2.4
2.5	$0.9^{2}3790$	$0.9^{2}3963$	$0.9^{2}4132$	$0.9^{2}4297$	$0.9^{2}4457$	$0.9^{2}4614$	$0.9^{2}4766$	$0.9^{2}4915$	$0.9^{2}5060$	$0.9^{2}5201$	2.5
2.6	$0.9^{2}5339$	$0.9^{2}5473$	$0.9^{2}5604$	$0.9^{2}5731$	$0.9^{2}5855$	$0.9^{2}5975$	$0.9^{2}6093$	$0.9^{2}6207$	$0.9^{2}6319$	$0.9^{2}6427$	2.6
2.7	$0.9^{2}6533$	$0.9^{2}6636$	$0.9^{2}6736$	$0.9^{2}6833$	$0.9^{2}6928$	$0.9^{2}7020$	$0.9^{2}7110$	$0.9^{2}7197$	$0.9^{2}7282$	$0.9^{2}7365$	2.7
2.8	$0.9^{2}7445$	$0.9^{2}7523$	$0.9^{2}7599$	$0.9^{2}7673$	$0.9^{2}7744$	$0.9^{2}7814$	$0.9^{2}7882$	$0.9^{2}7948$	$0.9^{2}8012$	$0.9^{2}8074$	2.8
2.9	$0.9^{2}8134$	$0.9^{2}8193$	$0.9^{2}8250$	$0.9^{2}8305$	$0.9^{2}8359$	$0.9^{2}8411$	$0.9^{2}8462$	$0.9^{2}8511$	$0.9^{2}8559$	$0.9^{2}8605$	2.9
3.0	$0.9^{2}8650$	$0.9^{2}8694$	$0.9^{2}8736$	$0.9^{2}8777$	$0.9^{2}8817$	$0.9^{2}8856$	$0.9^{2}8893$	$0.9^{2}8930$	$0.9^{2}8965$	$0.9^{2}8999$	3.0
3.1	$0.9^{3}0324$	$0.9^{3}0646$	$0.9^{3}0957$	$0.9^{3}1260$	$0.9^{3}1553$	$0.9^{3}1836$	$0.9^{3}2112$	$0.9^{3}2378$	$0.9^{3}2636$	$0.9^{3}2886$	3.1
3.2	$0.9^{3}3129$	$0.9^{3}3363$	$0.9^{3}3590$	$0.9^{3}3810$	$0.9^{3}4024$	$0.9^{3}4230$	$0.9^{3}4429$	$0.9^{3}4623$	$0.9^{3}4810$	$0.9^{3}4991$	3.2
3.3	$0.9^{3}5166$	$0.9^{3}5335$	$0.9^{3}5499$	$0.9^{3}5658$	$0.9^{3}5811$	$0.9^{3}5959$	$0.9^{3}6103$	$0.9^{3}6242$	$0.9^{3}6376$	$0.9^{3}6505$	3.3
3.4	$0.9^{3}6631$	$0.9^{3}6752$	$0.9^{3}6869$	$0.9^{3}6982$	$0.9^{3}7091$	$0.9^{3}7197$	$0.9^{3}7299$	$0.9^{3}7398$	$0.9^{3}7493$	$0.9^{3}7585$	3.4
3.5	$0.9^{3}7674$	$0.9^{3}7759$	$0.9^{3}7842$	$0.9^{3}7922$	$0.9^{3}7999$	$0.9^{3}8074$	$0.9^{3}8146$	$0.9^{3}8215$	$0.9^{3}8282$	$0.9^{3}8347$	3.5
3.6	$0.9^{3}8409$	$0.9^{3}8469$	$0.9^{3}8527$	$0.9^{3}8583$	$0.9^{3}8637$	$0.9^{3}8689$	$0.9^{3}8739$	$0.9^{3}8787$	$0.9^{3}8834$	$0.9^{3}8879$	3.6
3.7	$0.9^{3}8922$	$0.9^{3}8964$	$0.9^{4}0039$	$0.9^{4}0426$	$0.9^{4}0799$	$0.9^{4}1158$	$0.9^{4}1504$	$0.9^{4}1838$	$0.9^{4}2159$	$0.9^{4}2468$	3.7
3.8	$0.9^{4}2765$	$0.9^{4}3052$	$0.9^{4}3327$	$0.9^{4}3593$	$0.9^{4}3848$	$0.9^{4}4094$	$0.9^{4}4331$	$0.9^{4}4558$	$0.9^{4}4777$	$0.9^{4}4988$	3.8
3.9	$0.9^{4}5190$	$0.9^{4}5385$	$0.9^{4}5573$	$0.9^{4}5753$	$0.9^{4}5926$	$0.9^{4}6092$	$0.9^{4}6253$	$0.9^{4}6406$	$0.9^{4}6554$	$0.9^{4}6696$	3.9
4.0	$0.9^{4}6833$	$0.9^{4}6964$	$0.9^{4}7090$	$0.9^{4}7211$	$0.9^{4}7327$	$0.9^{4}7439$	$0.9^{4}7546$	$0.9^{4}7649$	$0.9^{4}7748$	$0.9^{4}7843$	4.0
4.1	$0.9^{4}7934$	$0.9^{4}8022$	$0.9^{4}8106$	$0.9^{4}8186$	$0.9^{4}8263$	$0.9^{4}8338$	$0.9^{4}8409$	$0.9^{4}8477$	$0.9^{4}8542$	$0.9^{4}8605$	4.1
4.2	$0.9^{4}8665$	$0.9^{4}8723$	$0.9^{4}8778$	$0.9^{4}8832$	$0.9^{4}8882$	$0.9^{4}8931$	$0.9^{4}8978$	$0.9^{5}0226$	$0.9^{5}0655$	$0.9^{5}1066$	4.2
4.3	$0.9^{5}1460$	$0.9^{5}1837$	$0.9^{5}2199$	$0.9^{5}2545$	$0.9^{5}2876$	$0.9^{5}3193$	$0.9^{5}3497$	$0.9^{5}3788$	$0.9^{5}4066$	$0.9^{5}4332$	4.3
4.4	$0.9^{5}4587$	$0.9^{5}4831$	$0.9^{5}5065$	$0.9^{5}5288$	$0.9^{5}5502$	$0.9^{5}5706$	$0.9^{5}5902$	$0.9^{5}6089$	$0.9^{5}6268$	$0.9^{5}6439$	4.4
4.5	$0.9^{5}6602$	$0.9^{5}6759$	$0.9^{5}6908$	$0.9^{5}7051$	$0.9^{5}7187$	$0.9^{5}7318$	$0.9^{5}7442$	$0.9^{5}7561$	$0.9^{5}7675$	$0.9^{5}7784$	4.5
4.6	$0.9^{5}7888$	$0.9^{5}7987$	$0.9^{5}8081$	$0.9^{5}8172$	$0.9^{5}8258$	$0.9^{5}8340$	$0.9^{5}8419$	$0.9^{5}8494$	$0.9^{5}8566$	$0.9^{5}8634$	4.6
4.7	$0.9^{5}8699$	$0.9^{5}8761$	$0.9^{5}8821$	$0.9^{5}8877$	$0.9^{5}8931$	$0.9^{5}8983$	$0.9^{6}0320$	$0.9^{6}0789$	$0.9^{6}1235$	$0.9^{6}1661$	4.7
4.8	$0.9^{6}2067$	$0.9^{6}2453$	$0.9^{6}2822$	$0.9^{6}3173$	$0.9^{6}3508$	$0.9^{6}3827$	$0.9^{6}4131$	$0.9^{6}4420$	$0.9^{6}4696$	$0.9^{6}4958$	4.8
4.9	$0.9^{6}5208$	$0.9^{6}5446$	$0.9^{6}5673$	$0.9^{6}5889$	$0.9^{6}6094$	$0.9^{6}6289$	$0.9^{6}6475$	$0.9^{6}6652$	$0.9^{6}6821$	$0.9^{6}6981$	4.9
5.0	$0.9^{6}7133$	$0.9^{6}8302$	$0.9^{7}0036$	$0.9^{7}4210$	$0.9^{7}6668$	$0.9^{7}8101$	$0.9^{7}8928$	$0.9^{8}4010$	$0.9^{8}6684$	$0.9^{8}8192$	5.0
6.0	$0.9^{9}0136$										6.0
……	……	……	……	……	……	……	……	……	……	……	……
$+\infty$	*1.00000*										
u	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09	***u***

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下界右尾L分布函数与气候变暖下飓风台风等级（英文）

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尽管有许多质疑和批评,但萨菲尔-辛普森飓风等级至今仍然是美国官方和当下流行的使用标准，它分成：热带风暴（tropical-storm）;飓风一级；飓风二级；飓风三级；飓风四级；飓风五级；共六级，但17米/秒（一分钟或十分钟持续性平均风速）以下归为热带低压，不列入这六级，大于70米/秒（不等于，定义同前）上不封顶为飓风五级。中国目前使用的台风标准：热带低压（起于10.2米/秒）；热带风暴；强热带风暴；台风；强台风；超强台风（大于51米/秒），也是共六级。一些学者，如王万里（2009年），认为随着全球变暖单个台风强度可能呈现增强趋势,可是萨菲尔-辛普森飓风等级和中国台风等级对五级飓风(含五级）以上和超强台风（含超强台风）以上统统划分为单一等级，这显然不利于监测这档内飓风(71米/秒以上)或台风（51米/秒以上)的强度细微变化，为此，飓风五级和超强台风为适应气候变化的需要应该作更进一步的分级细化。右尾L概率分布函数在理论上适合这样的挑战（新的分级细化需求）。

关键词：概率分布函数；飓风台风等级；气候变化；均方根；大概率事件；小概率事件


简介：
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