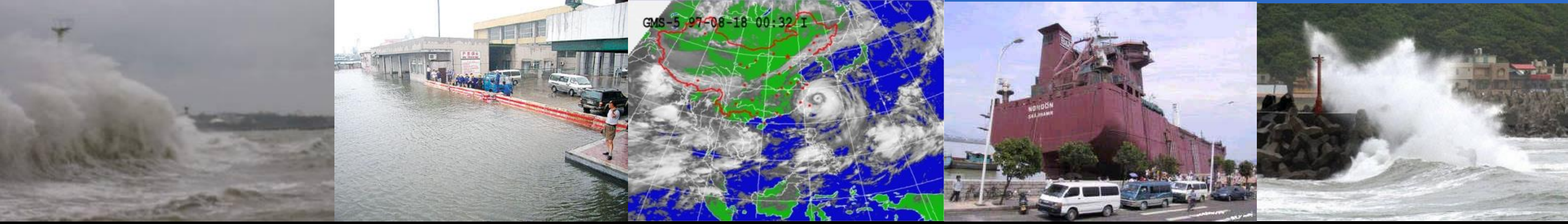

Statistical Analysis of storm surge hazard on China coast

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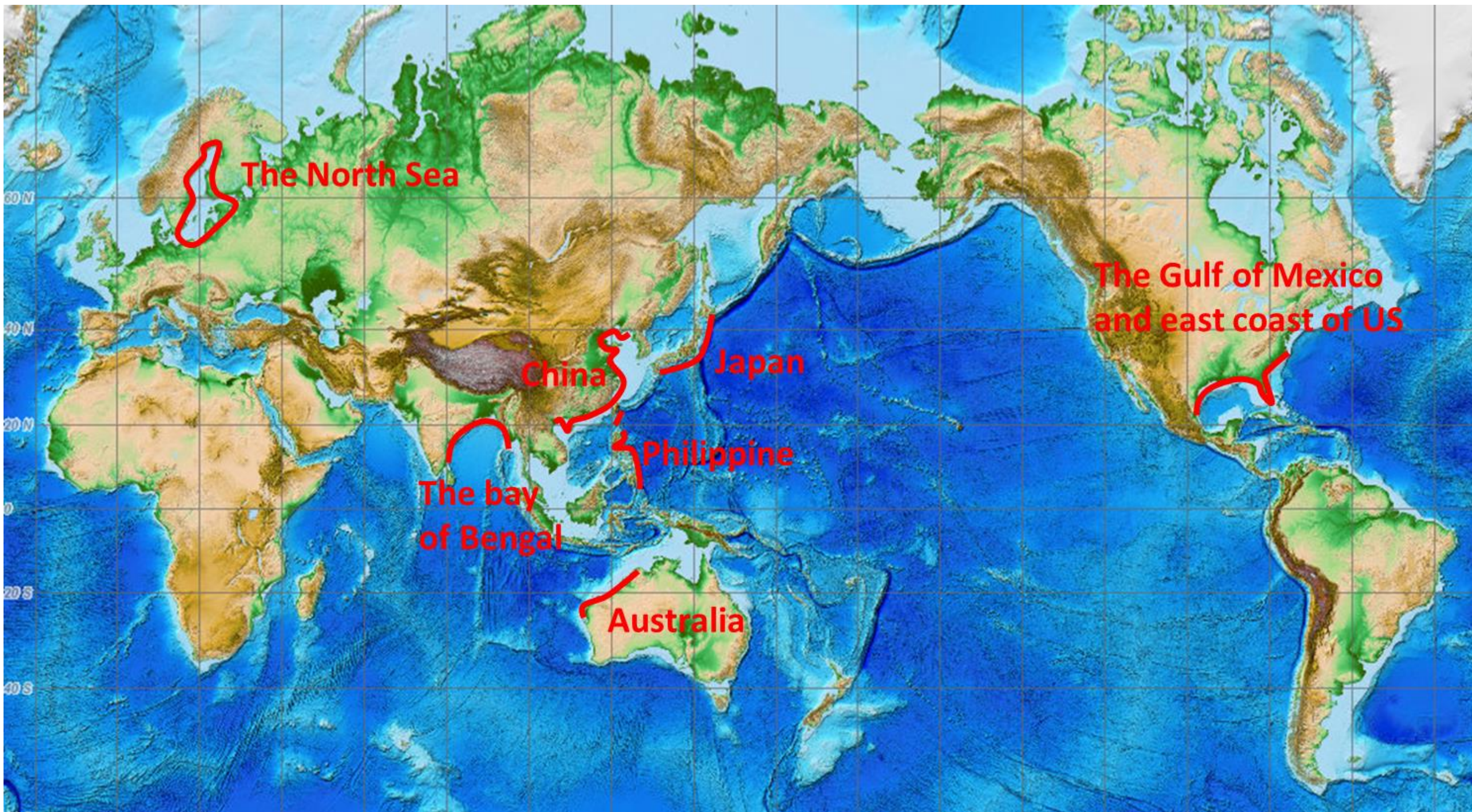
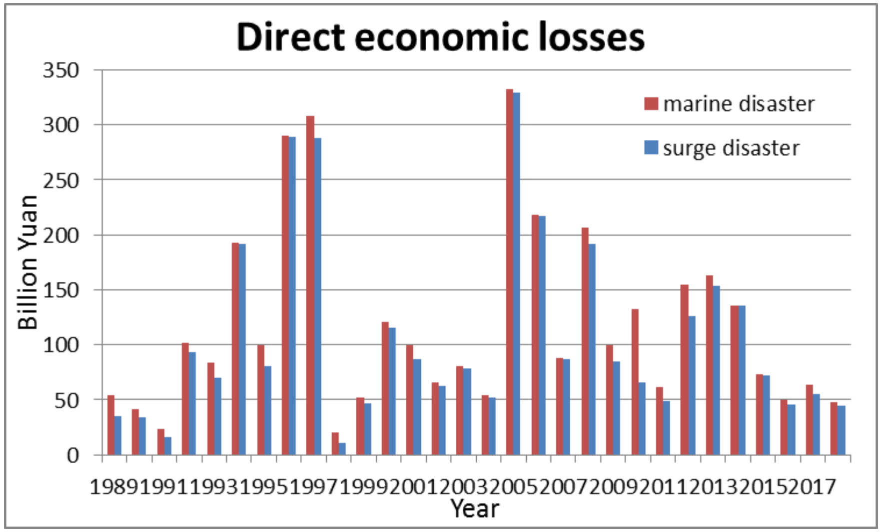
2019. 11 AUSTRALIA

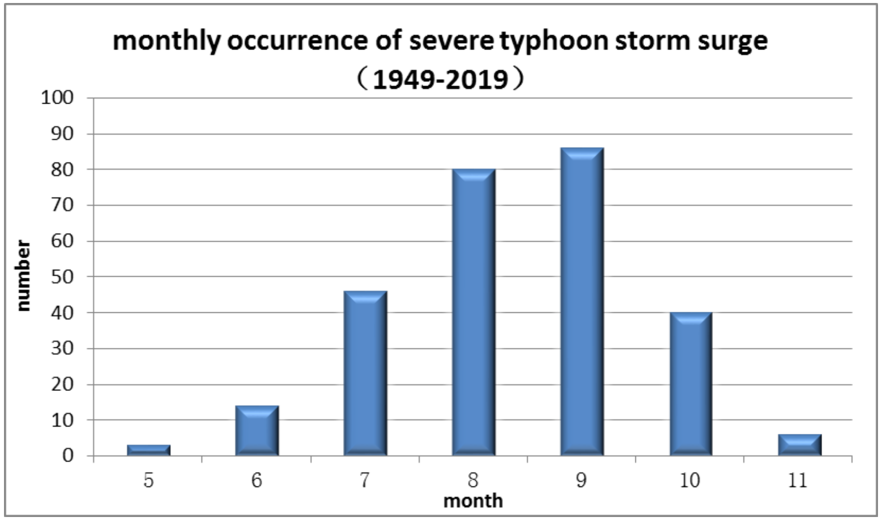
Overview

Chinese coast is one of the most vulnerable areas to storm surges in the world. The whole coast is affected by storm surges in every season.

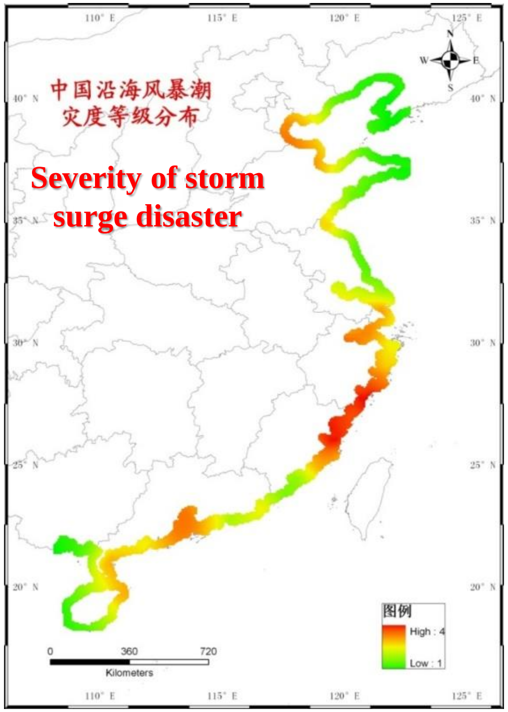


Overview





The direct economic loss caused by storm surge (including near shore waves) accounted for more than 90% of the total direct economic loss of marine disasters



Outline

Compound Poisson-Gumbel distribution

- Return values of storm surge at several stations

Threaten storm surge

- Return values of threaten storm surge

Compound Poisson-Gumbel distribution

Gumbel distribution:

$$G(x) = e^{-e^{-(x-\mu)/\alpha}}$$

Where μ is location parameter, and α is scale parameter

Poisson distribution:

$$P_k = e^{-\lambda} \frac{\lambda^k}{k!}$$

Where λ is the mean time between events

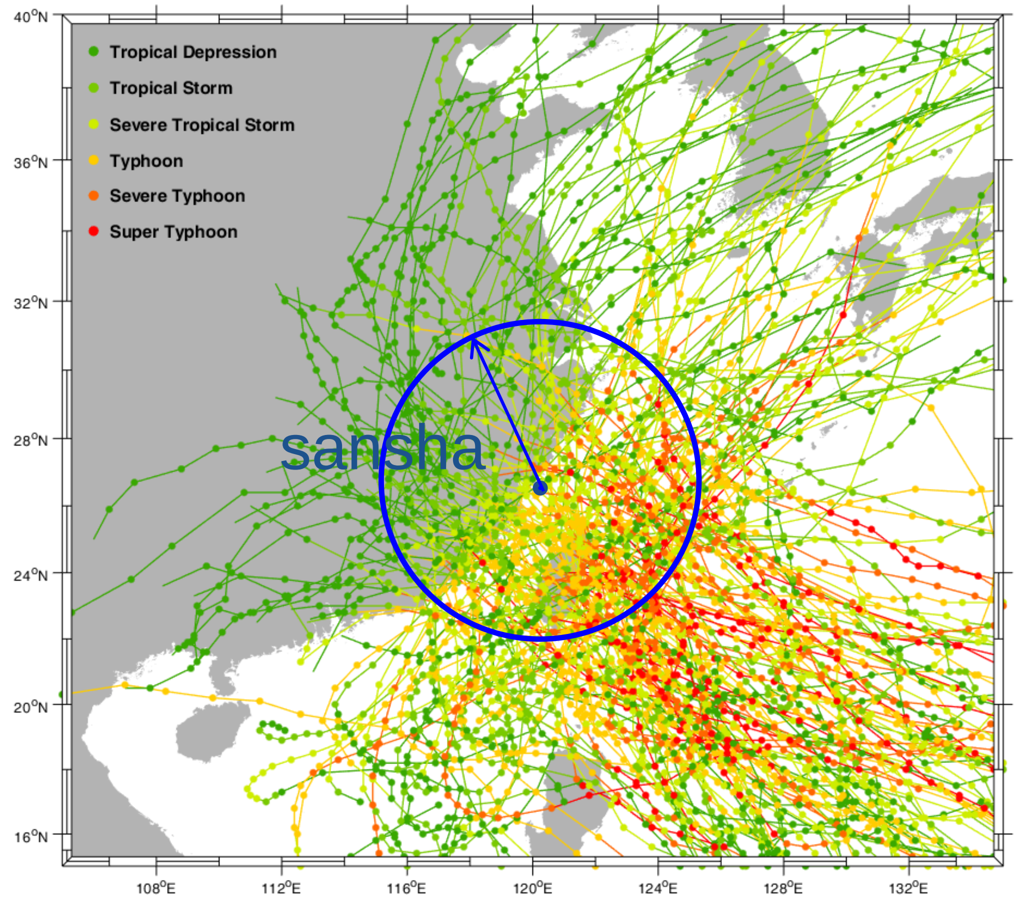
Compound distribution (Feller, 1957; Liu and Ma, 1980):

$$\mathrm{F(x)} = \sum P_k [G(x)]^k = e^{-\lambda[1-e^{-e^{-(x-\mu)/\alpha}}]}$$

Compound Poisson-Gumbel distribution

Year	Typhoon occurrence	Year	Typhoon occurrence
1980	5	2000	6
1981	5	2001	6
1982	3	2002	3
1983	2	2003	5
1984	2	2004	5
1985	4	2005	6
1986	4	2006	6
1987	3	2007	4
1988	2	2008	4
1989	7	2009	2
1990	7	2010	5
1991	3	2011	4
1992	3	2012	4
1993	0	2013	6
1994	7	2014	3
1995	4	2015	5
1996	3	2016	4
1997	2	2017	5
1998	6	2018	7
1999	3	2019	6

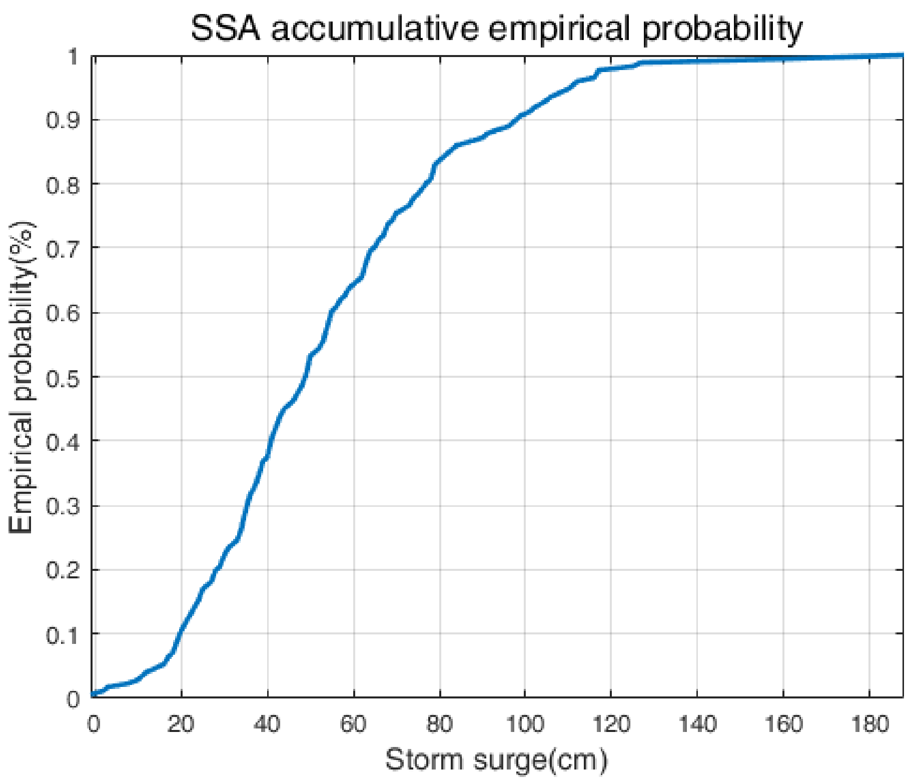
1980-2019:171 typhoon



Compound Poisson-Gumbel distribution

Sorted out the consequent storm surge events

Chose the maxima surge values within every event



Maximum:188cm

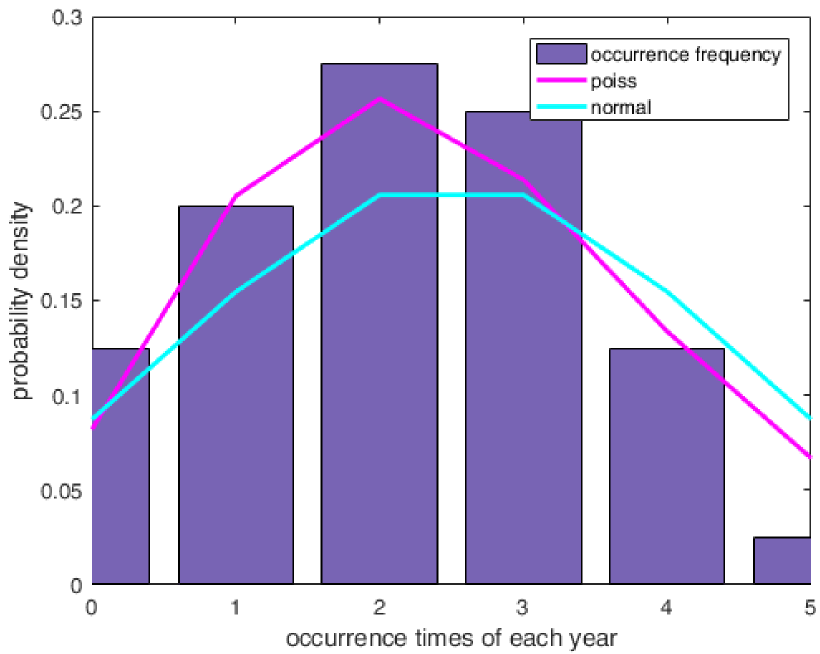
Minimum：1cm

Median：50cm

POT events：85

Compound Poisson-Gumbel distribution

Goodness-of-fit-test



Pearson chi-square test

$$\chi^2 = \sum_{i=0}^{k} \frac{(f_i - nP_i)^2}{nP_i} \quad (i = 0,1 \ldots 5)$$

Storm surge k	Occurrence number n	Theoretical probability p	χ^2
0	5	0.0821	0.896667
1	8	0.2052	0.005271
2	11	0.2565	0.053372
3	10	0.2138	0.245171
4	5	0.1336	0.022144
5	1	0.0668	1.046251
total			2.268877

$$\chi^2 < \chi_5^2(0.05) = 11.07$$

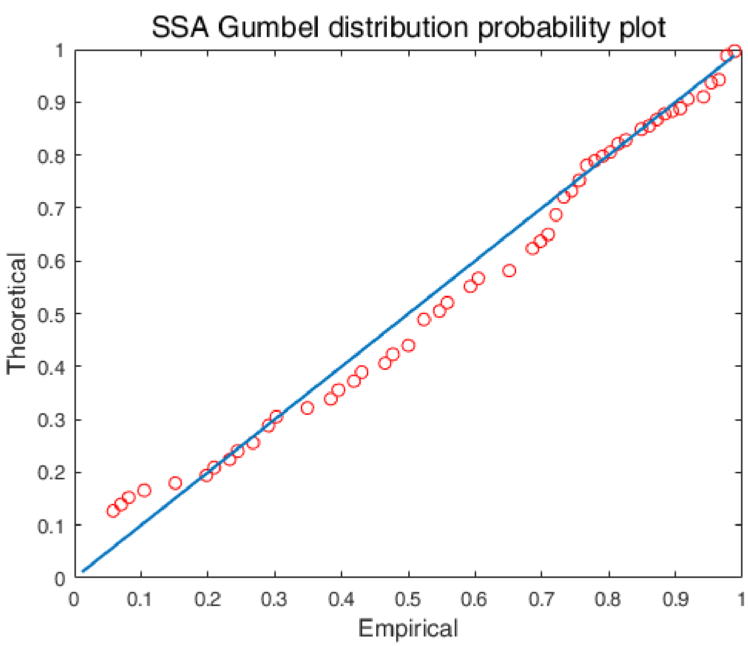
Compound Poisson-Gumbel distribution

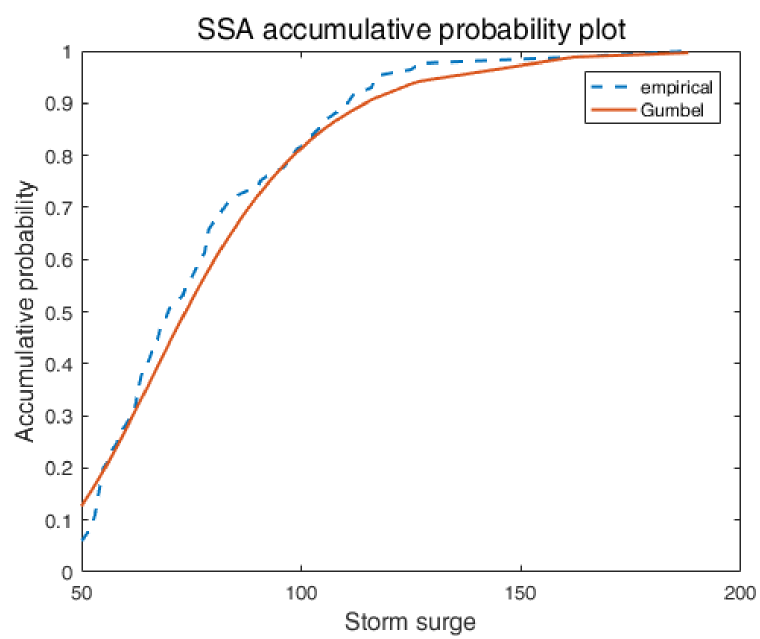
Goodness-of-fit-test

K-S(Kolmogorov-Smirnov) test

$$D = \max|F_n(x) - F_0(x)|$$

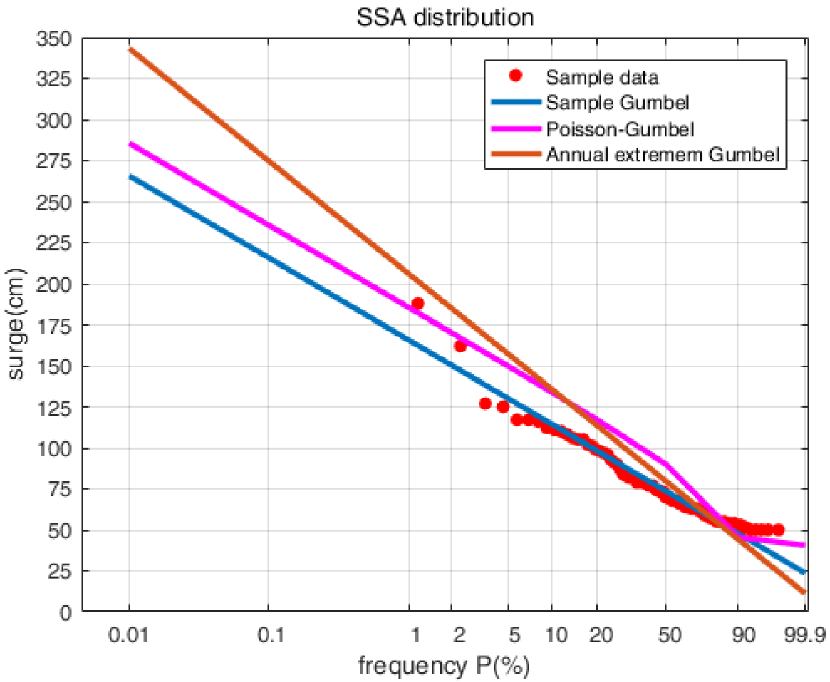
$$D = 0.077571 < D_{85}(0.05) = 0.1475$$





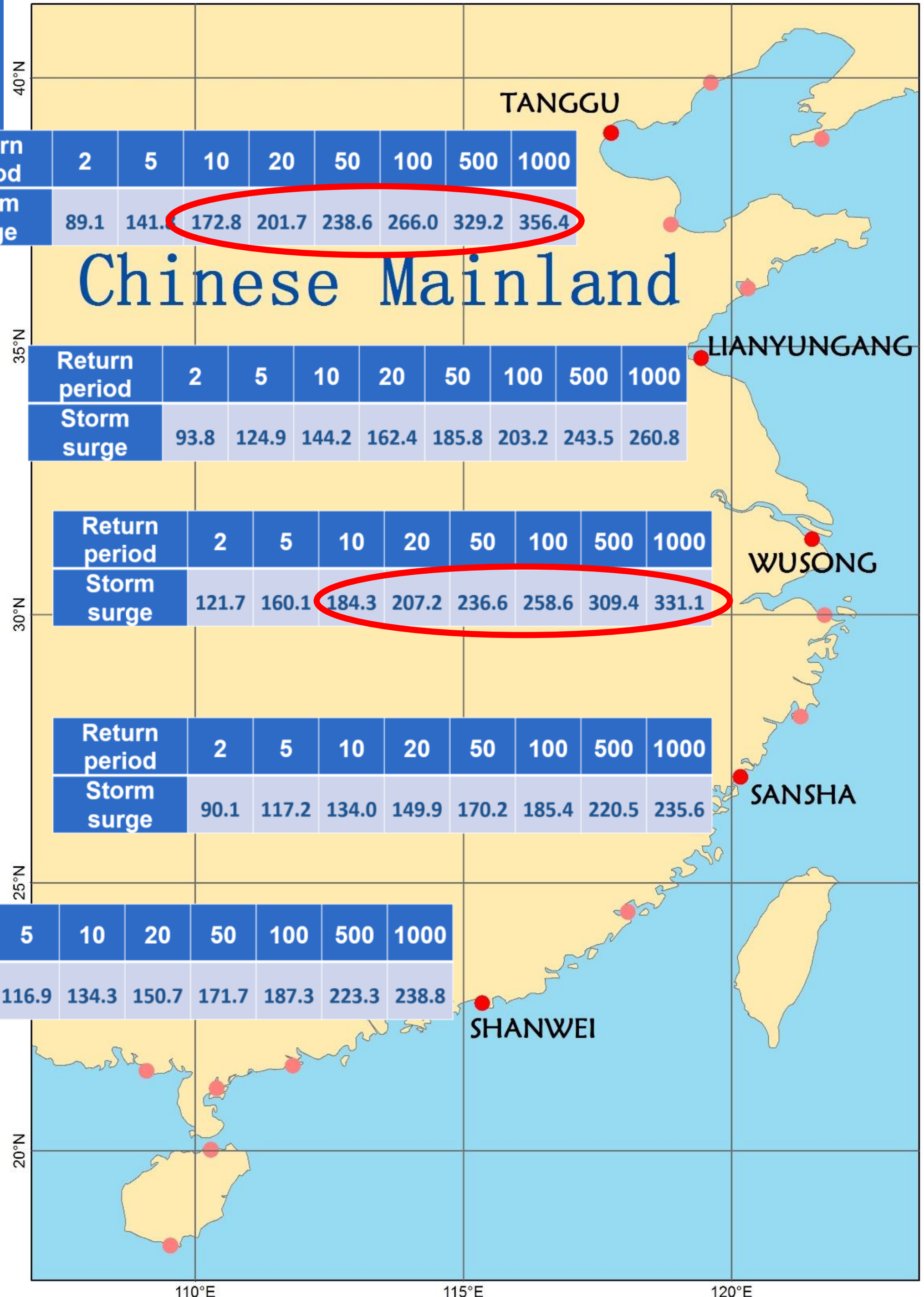
Compound Poisson-Gumbel distribution

Return period	2	5	10	20	50	100	500	1000	10000
Gumbel	79.8	113.6	135.9	157.4	185.1	205.9	254.0	274.7	343.3
Poisson-Gumbel	90.1	117.2	134.0	149.9	170.2	185.4	220.5	235.6	285.6



- the compound distribution performs superior when fitting for the high values
- annual extreme Gumbel distribution has steep slope

nbel



Return period	2	5	10	20	50	100	500	1000
Storm surge	89.1	141.8	172.8	201.7	238.6	266.0	329.2	356.4

Return period	2	5	10	20	50	100	500	1000
Storm surge	93.8	124.9	144.2	162.4	185.8	203.2	243.5	260.8

Return period	2	5	10	20	50	100	500	1000
Storm surge	121.7	160.1	184.3	207.2	236.6	258.6	309.4	331.1

Return period	2	5	10	20	50	100	500	1000
Storm surge	90.1	117.2	134.0	149.9	170.2	185.4	220.5	235.6

Return period	2	5	10	20	50	100	500	1000
Storm surge	88.4	116.9	134.3	150.7	171.7	187.3	223.3	238.8

Threaten storm surge

low storm surge + low astronomical tide

high storm surge + low astronomical tide

low storm surge + high astronomical tide

high storm surge + high astronomical tide

Threaten storm surge

$$\mathrm{TSS} = \frac{S * \lambda + \Delta T_{over} * (1 - \lambda)}{\lambda}$$

$$\Delta T_{over} = T_{storm} - T_{warn}$$

S: storm surge

λ: weight coefficient

T_{storm}: storm tide

T_{warn}: warning tide

Threaten storm surge

Return water values

Local elevation

Seawall height

Disk firmness

Social economy

Seawall slop and wave runup

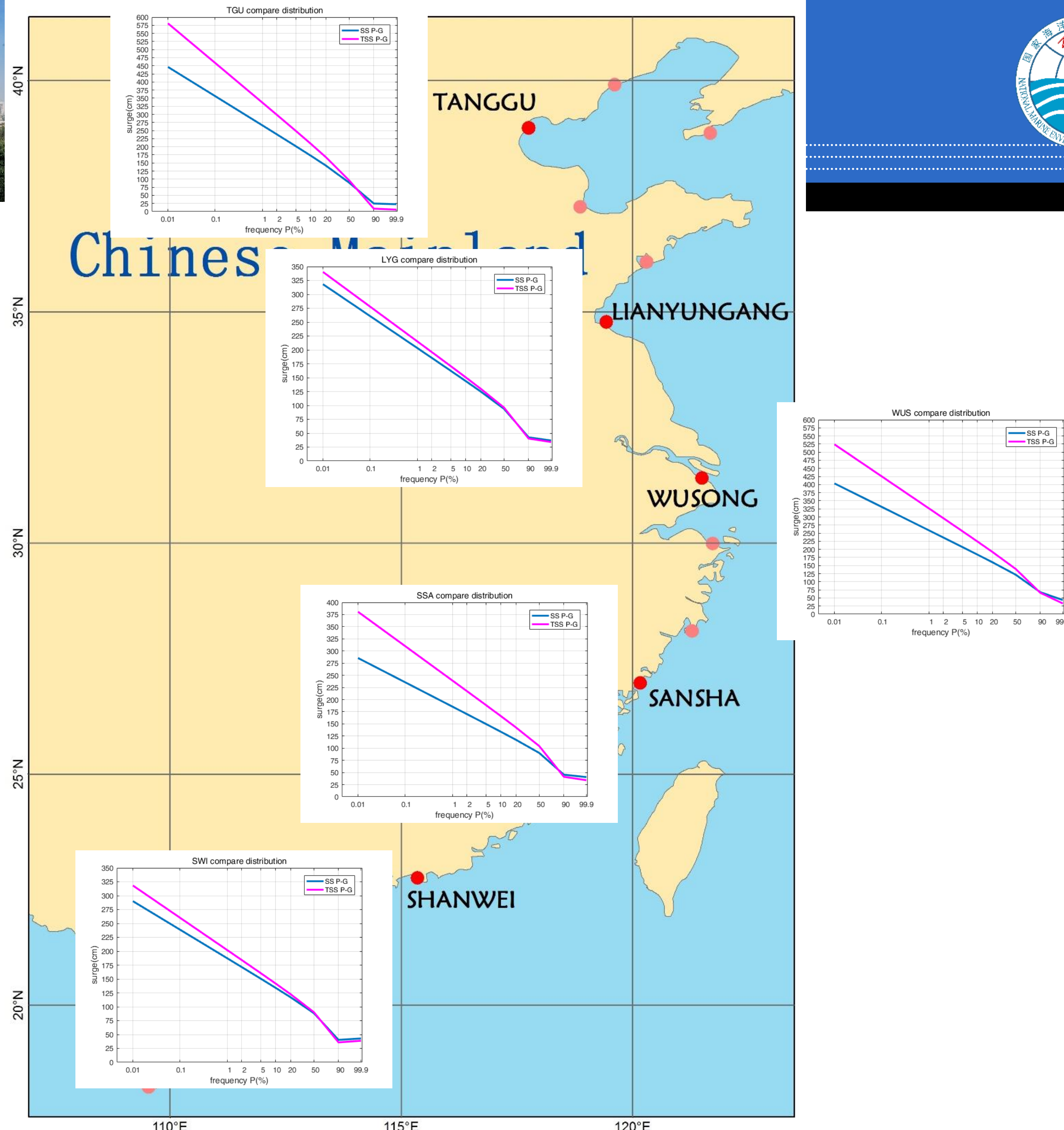
……

China has already issued all warning water levels for more than 200 coastal sections of the country.

Threaten storm surge

Storm surge	Storm tide	Warning tide	TSS
150cm	300cm	400cm	150cm
150cm	450cm	400cm	183cm

$\lambda = 0.6$



TANGGU
LIANYUNGANG
WUSONG
SANSHA
SHANWEI
Chinese Mainland
40°N
35°N
30°N
25°N
20°N
110°E
115°E
120°E
TGU compare distribution
LYG compare distribution
WUS compare distribution
SSA compare distribution
SWI compare distribution
SS P-G
TSS P-G
surge(cm)
frequency P(%)
0.01
0.1
1
2
5
10
20
50
90
99.9

Summary

- ✓ Utilization of a discrete distribution compounding a peaks-over-threshold “conditional” distribution is a satisfactory manner to take advantage of as much valid data as possible。
- ✓ Use Poisson-Gumbel compound distribution to fit typhoon storm surge records of several gauges along Chinese coast for the period of 1980-2019. And return surge values retrieved for further analysis.
- ✓ In order to reflect the possible hazard of storm surge, developed a threaten storm surge which considering the storm high tide。
- ✓ From the Poisson-Gumbel distribution， return values of threaten storm surge retrieved as well for further analysis。

Thanks !

谢谢