

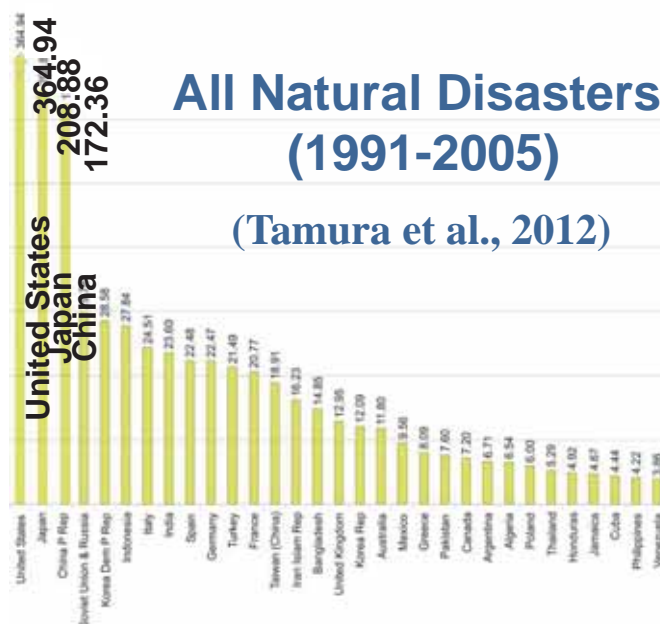
# An active multiple-fan wind tunnel proposal to meet the necessity of wind-related DRR in China

Shuyang Cao

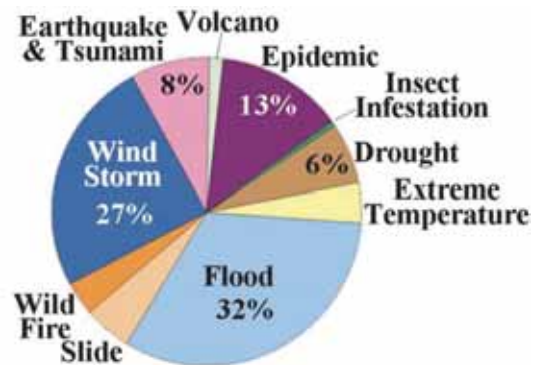


## Disaster statistics, UN/ISDR

Billion US\$



All Natural Disasters (1991-2005)  
(Tamura et al., 2012)



# Disasters in China

- *Diverse*
- *Regional*
- *Frequent*

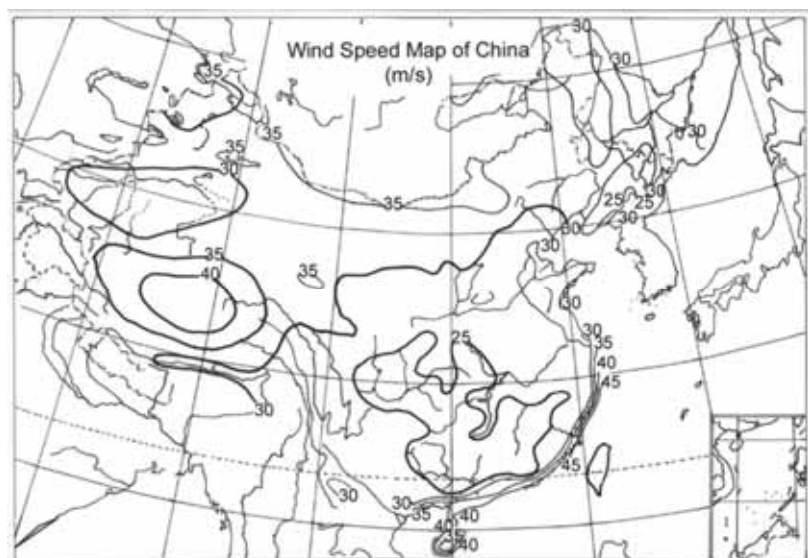
Flood                  Earthquake  
Drought                Windstorm  
Hail                    Snow  
Land slide              Wild fire  
Low temperature      .....

**No.1** : *Climate-related*



## Strong wind climates

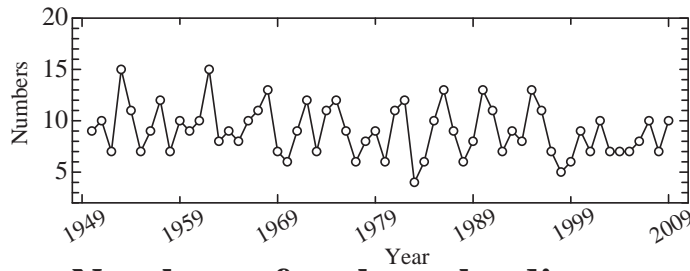
*Monsoons*  
*Frontal depressions*  
*Typhoons*  
*Tornadoes*  
*Devils*  
*Gravity winds*  
.....



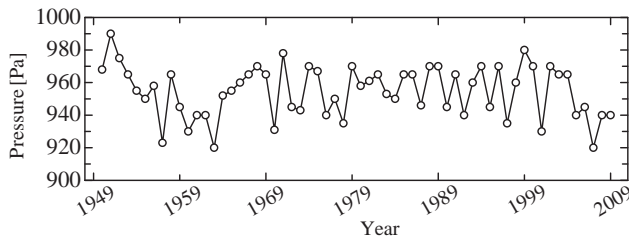
**Wind speed map of China**  
*(Based on Metrological data)*

# Typhoon statistics

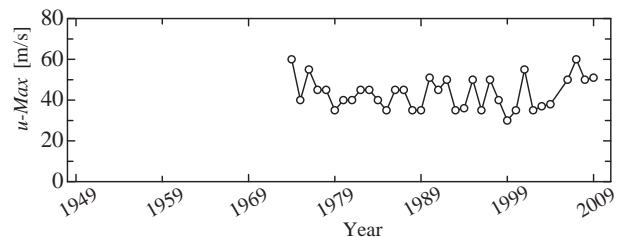
CMA  
Statistics



Numbers of typhoon landing



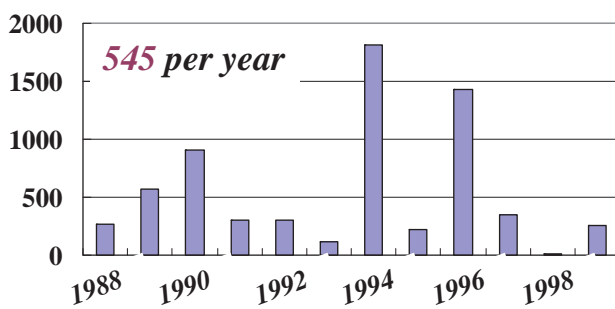
Min. centre pressure after landing



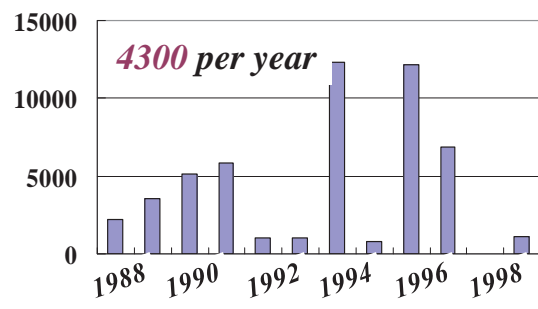
Max. gust wind speed

# Typhoon damage

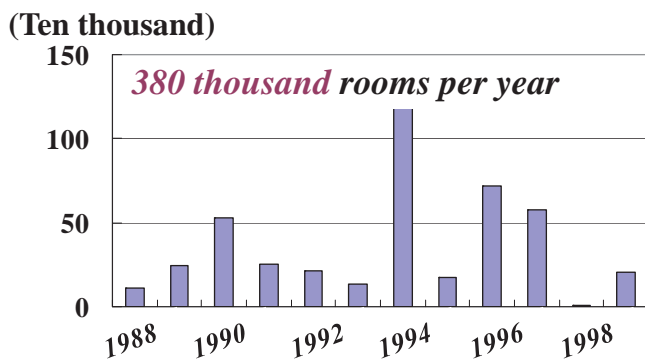
CMA  
Statistics



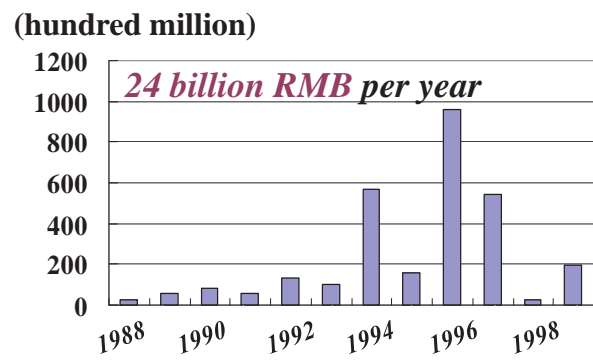
Number of death



Number of injury



Number of collapsed house



Economy loss

# Typhoon-related damages

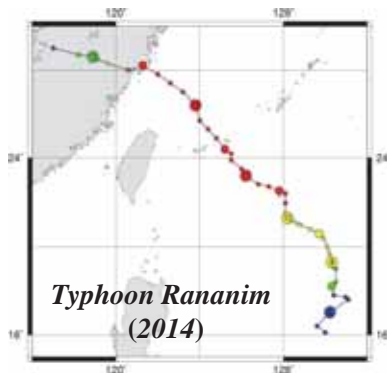
CMA  
Statistics



**No.7503 (Henan): Flood (1060.3mm in 24 hours).  
Several ten thousand people died; 5.6 million rooms collapsed.**

**No. 7314 (Hainan): Gust wind 60m/s.  
The city was almost destroyed. 903 people died, 5800 people injured;  
200 thousand rooms collapsed.**

## An example of typhoon damage



### Causes of deaths

Cause	Deaths
Building collapse	109
Debris flow	28
Strong wind	9
Flooding	12
Collapse of tele. Poles, etc.	5
Others	1
<b>Total</b>	<b>164</b>



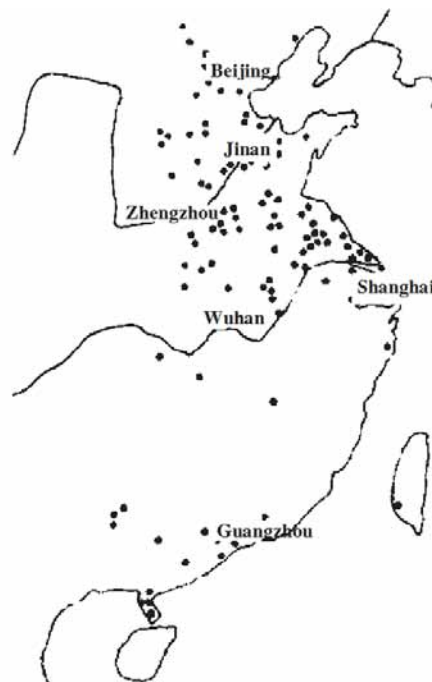
### Decreasing numbers of deaths

Typhoon	195606	199416	199713	200413
Deaths	4925	1126	236	164

# Tornado in China

*Golden and Snow (1991)* **About 10 to 100 tornadoes per year**

*Zheng and Xie (2010)*



1980-1993

## An example of tornado damage

**2013.3.19**

*The length of squall line is  
over 1000Km*

*Super cells*

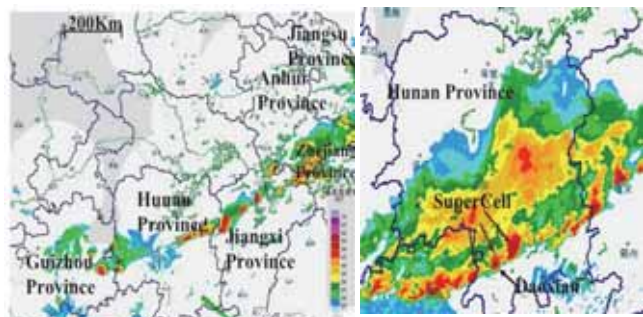
*At Daoxian*

*Gust wind speed: 31m/s*

*Duration: 5 minutes*

*(3 died, 30 was injured)*

*Radar echo*



# Hailstone damage

- ✓ *About 1000 hailstone events occur in China annually  
400 (1977), 2150 (1987)*
- ✓ *Most frequently happened natural disaster*
- ✓ *10% of disaster economy loss*

# Wind-sensitive structures

## *Constructed*

Shanghai WFC	492m
Shanghai Tower	632m
Shanghai Oriental Tower	468m
Canton TV Tower	610m
Sutong Bridge	1088m
Xihoumen Bridge	1650m

## *On construction*

Z15 Tower in Beijing	528m
PingAn in Shenzhen	600m
Sky City in Changsha	838m
Qiongzhou Bay Crossing Project (cable-stayed bridge)	twin 1500m

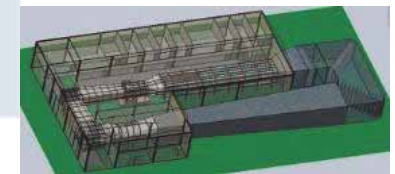
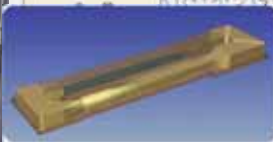
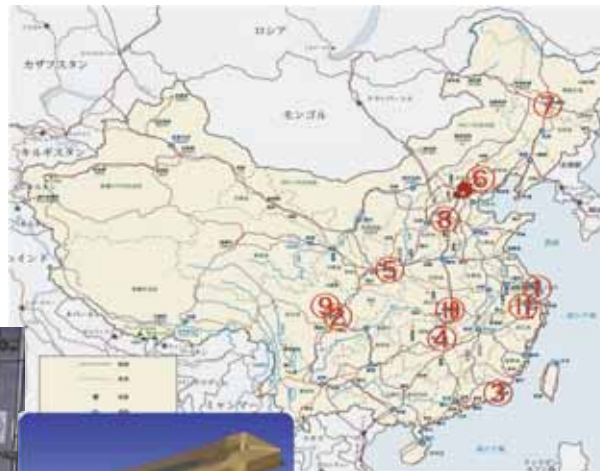


# Wind tunnel boom in China

50 boundary layer wind tunnels until 2013  
more than 30 tunnels built after 2000



(4 meters in width)



# Wind tunnels at TJU



JT-1 (1.8m × 1.8m × 12m, 1-30m/s)



JT-2 (3.0m × 2.5m × 15m , 2-68m/s )



JT-3 (15.0m × 2.0m × 14m, 1-17.6m/s)



JT-4 (0.8m × 0.8m × 5m)

# Special wind tunnels at TJU



**JT-5**

**Max speed: 6-12m/s**  
**Diameter of the core: 100-200mm**  
**Diameter of the tunnel: 1500mm**  
**Inflow height: 300-700mm**  
**Movable Distance: 2.8m**  
**Max translational speed: 0.4m/s**



**JT-6 (B1.5m × H1.8m × L10m)**  
**(12 × 10 individually-controlled fans)**

**Max mean speed: 18m/s**  
**Velocity fluctuation:**

$$u(t) = U_0 + U_m \sin(2 \times \pi \times f \times t)$$

**Max  $f=6\text{Hz}$  when  $U_0=12\text{m/s}$ ,  $U_m=4\text{m/s}$**   
*(expected)*

# Improvement from the tunnel at Miyazaki U.

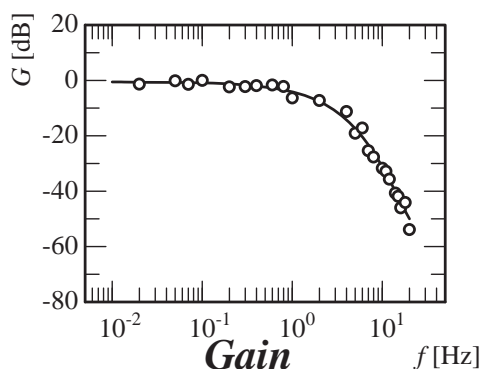


**WT at Miyazaki U.**



**The fan is customized to improve the aerodynamic performance.**

*The performance of the WT is under investigation*





# ***A large-scale WT proposal***

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## ***A personal proposal***

***The multiple-fan WT is a guide tunnel for a large scale WT to be constructed at TJU***

**H: 10m   L: 40m   B: 30m+30m**

**Speed: 2-60m/s**

***Hybrid use (laminar and turbulent flows)***

***Multi hazards (wind, rain, fire, hail...)***

***Multidisciplinary***



**Thank You for Your  
Attention**

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**Contact:  
shuyang@tongji.edu.cn**