CERDA
Civil Engineering
Risk and Decision Analysis

DTU

Climate model-based probabilistic wind risk assessment under future climate

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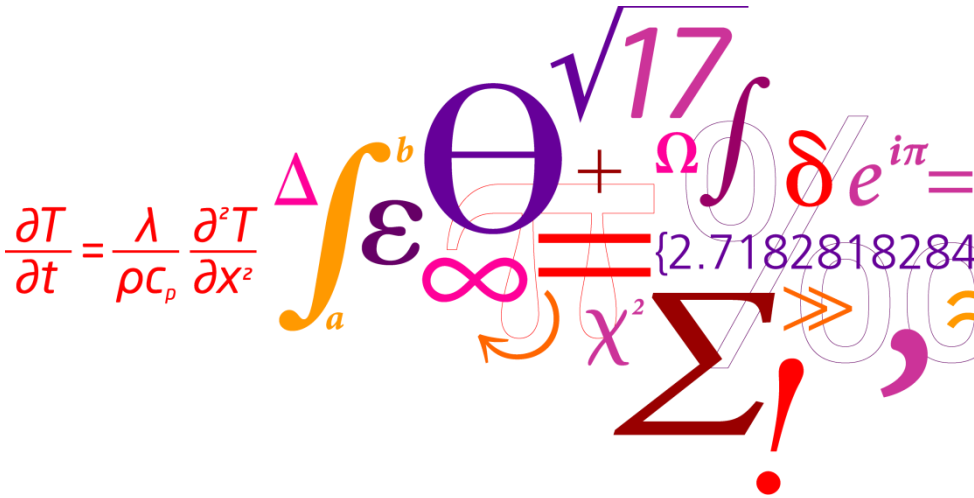
CERDA



DTU Civil Engineering
Department of Civil Engineering

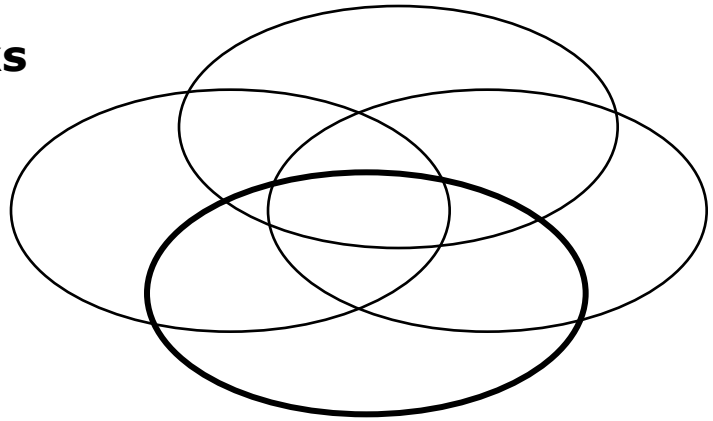
CERDA – Areas and current focuses

Structural reliability theory

- Bayesian networks
- Scaled probability integral

Natural hazard risks

- Wind hazard
- Wind vulnerability
- Flood vulnerability



Decision analysis

- Real-time decision optimization
- Reliability in economics
- Life safety

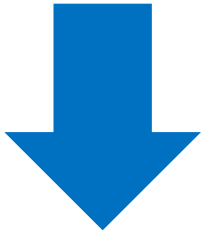
Climate change

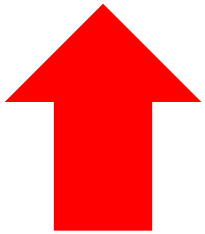
- Assessment
- Adaptation

Question to answer

Typhoon

Frequency vs. Intensity





Wind-induced residential building risk increases?

Inputs

Hazard modeling

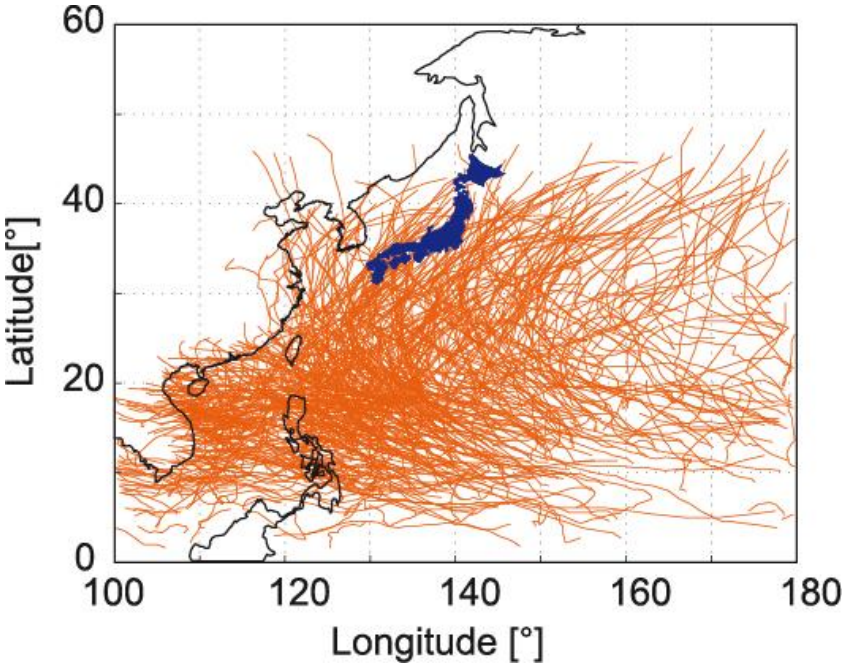
- AGCM simulation results within the KAKUSHIN program
- Probabilistic modeling methodology for typhoon events

Fragility modeling

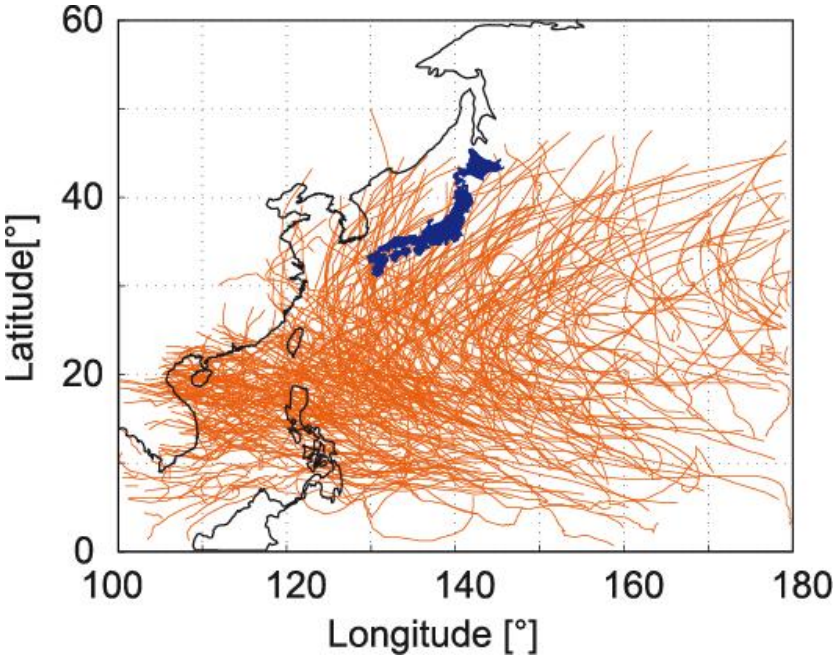
- Damage report for the typhoon Songda in 2004
- Wind field simulated with JMA-NHM and JMA-RANAL/JMA-RSM

Hazard modeling

Extracted typhoons

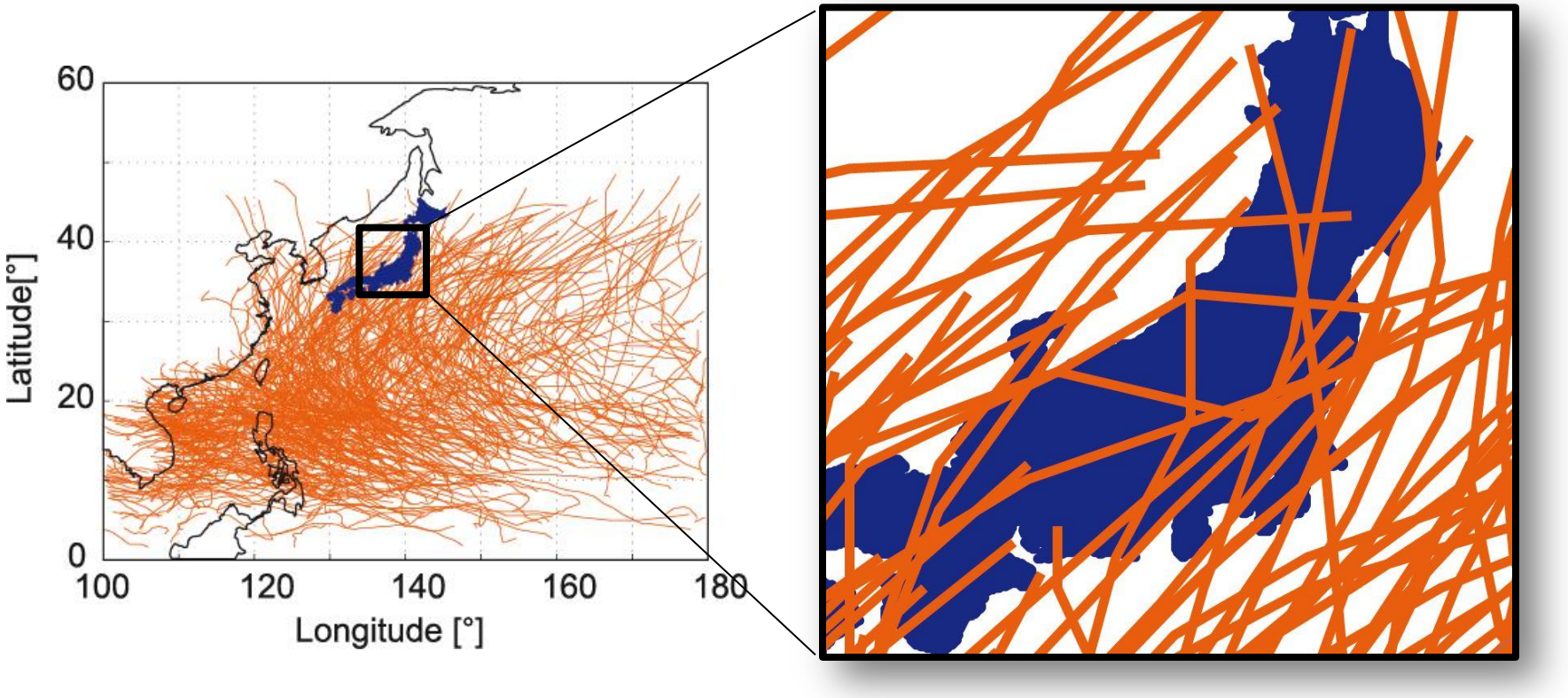


Current climate:1979-2003



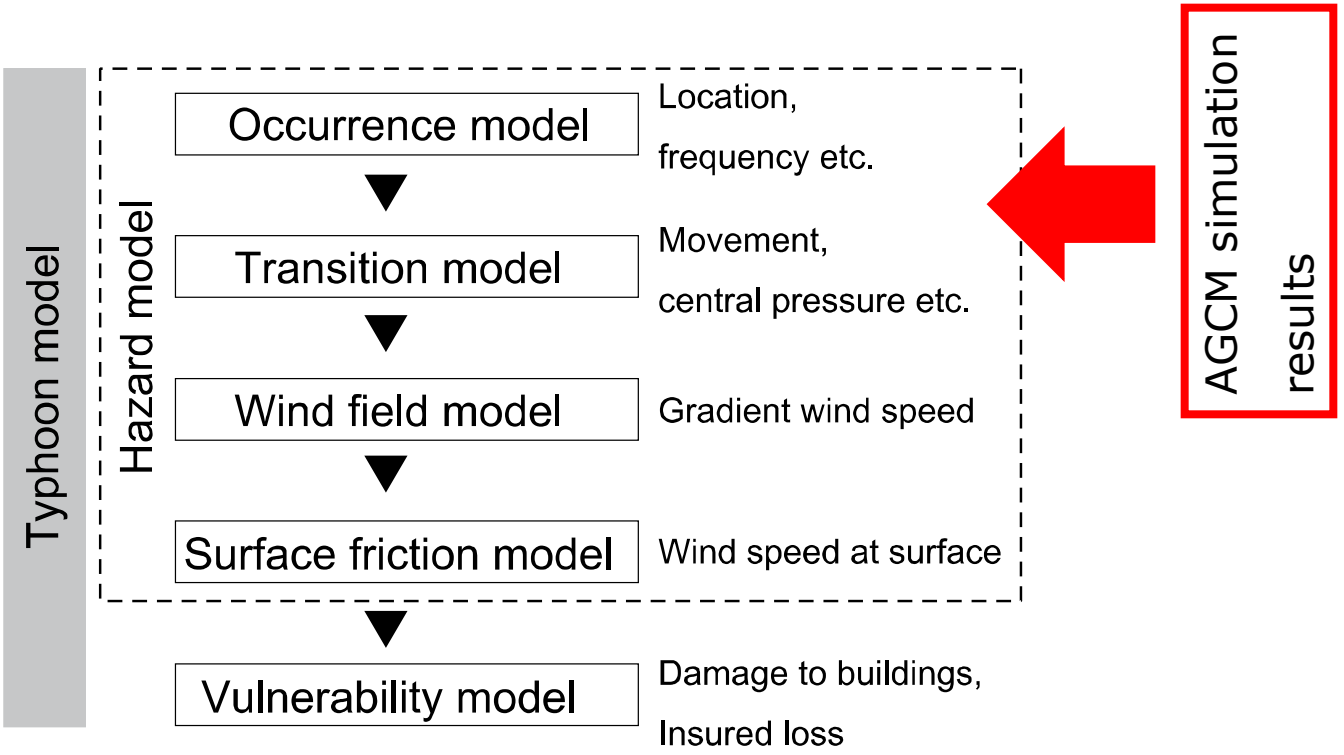
Projected future climate:2075-2099

Not enough typhoons for risk assessment…



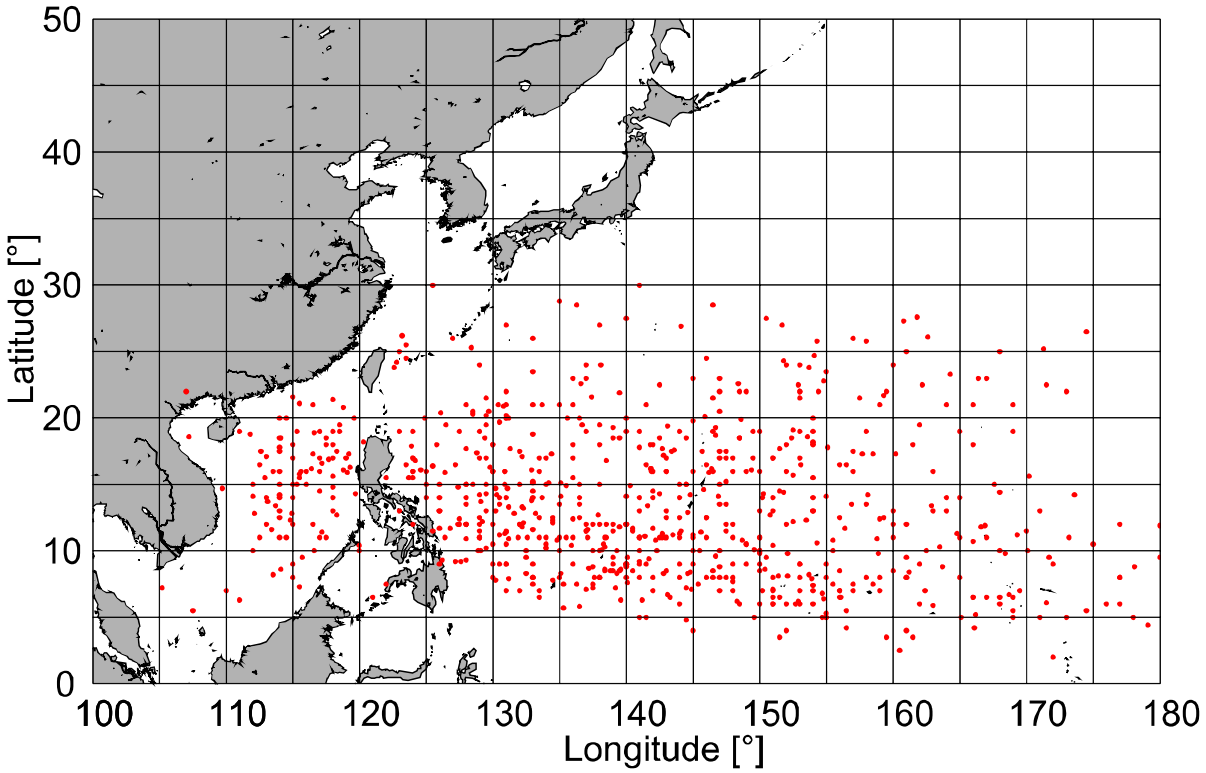
→Monte Carlo simulation with probabilistic typhoon model!

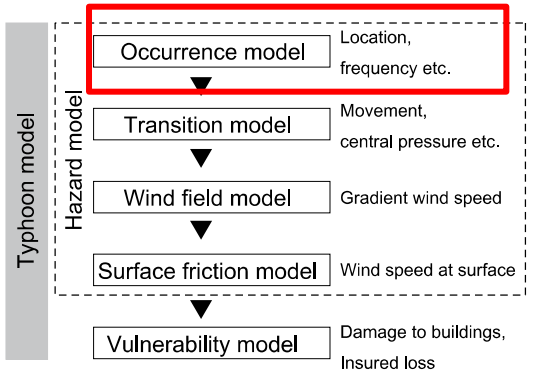
Probabilistic modeling of typhoon events

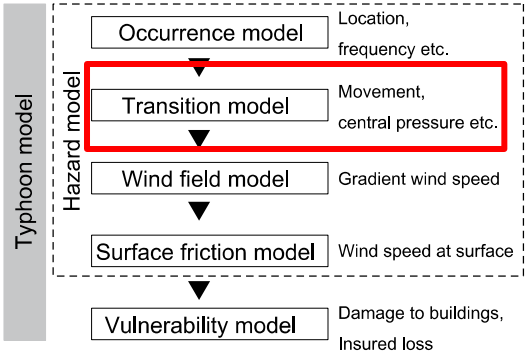


Occurrence model

- Re-sampling

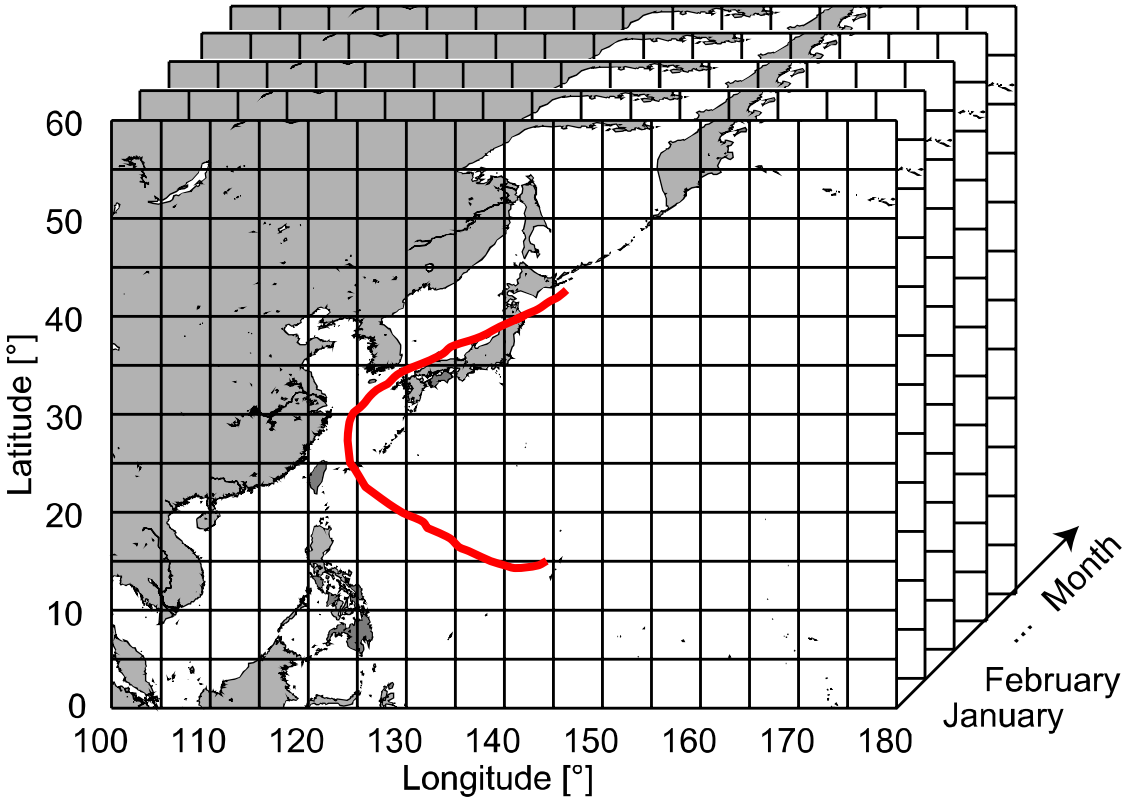






Transition model

- Temporary spatially inhomogeneous Markov model

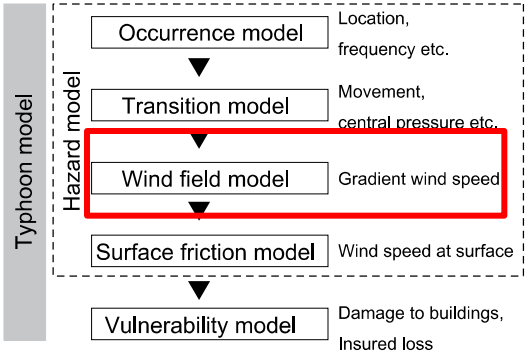


Model for each 5°x 5°grid and month.

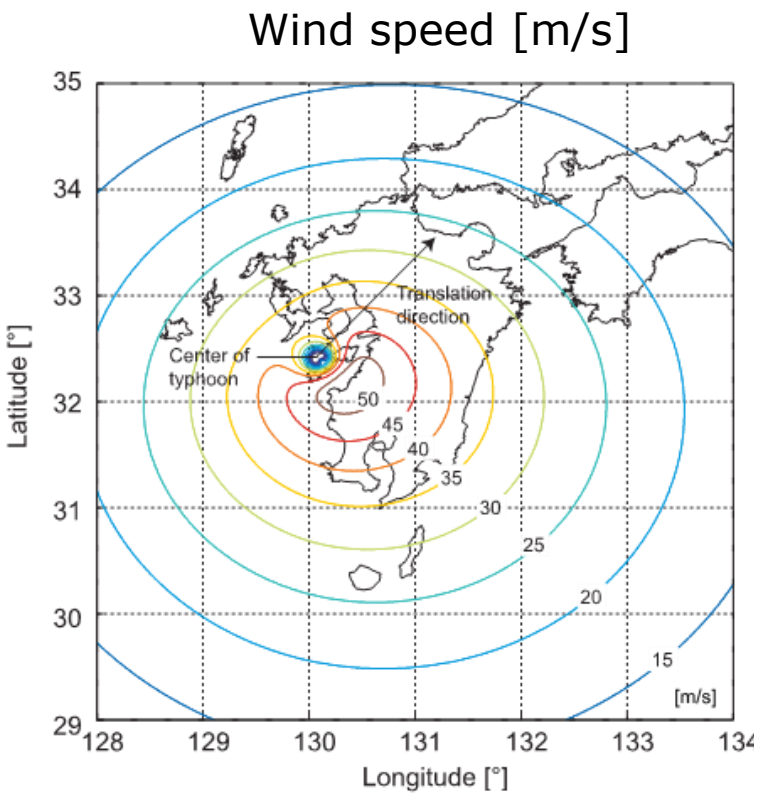
- Translation speed
- Translation angle
- Central pressure
- Radius of maximum wind speed

Wind field model

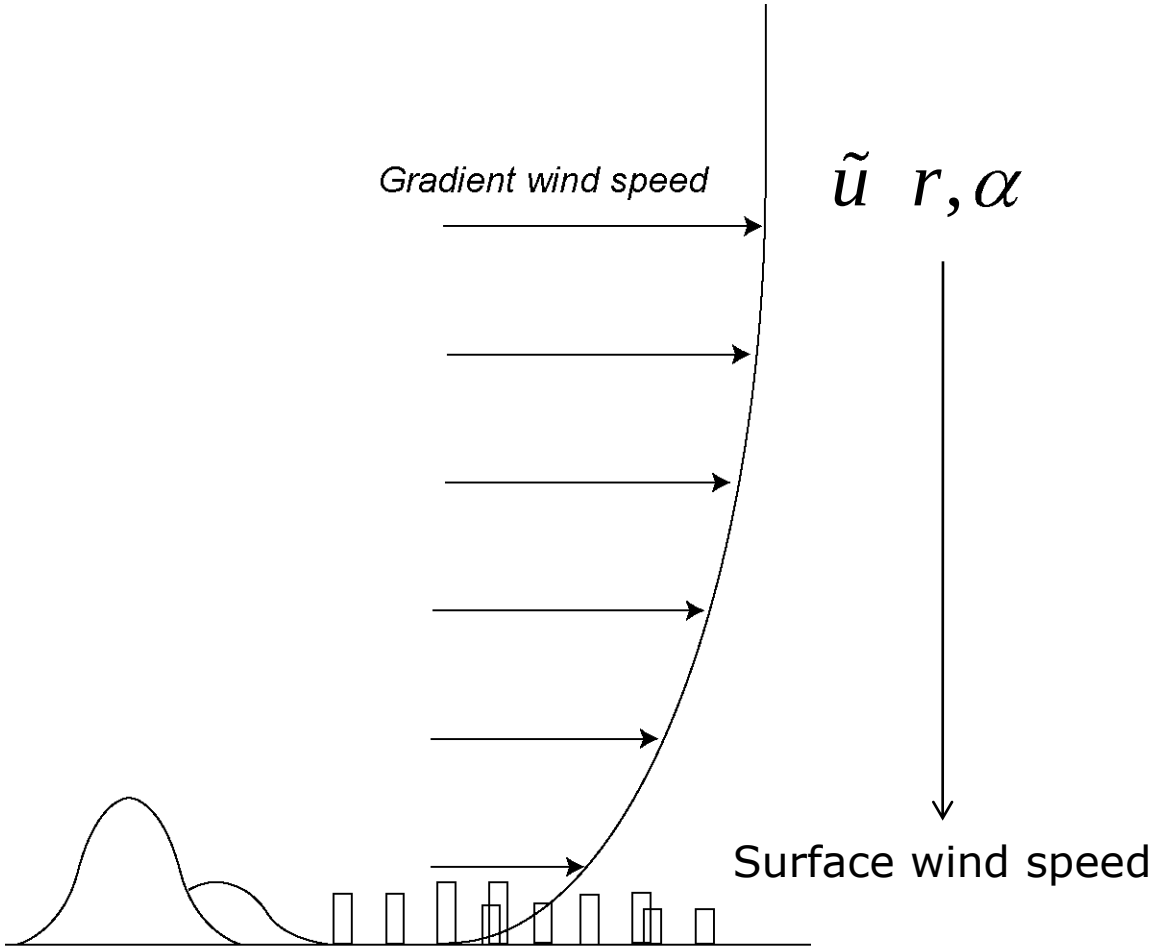
- Wind field at gradient height

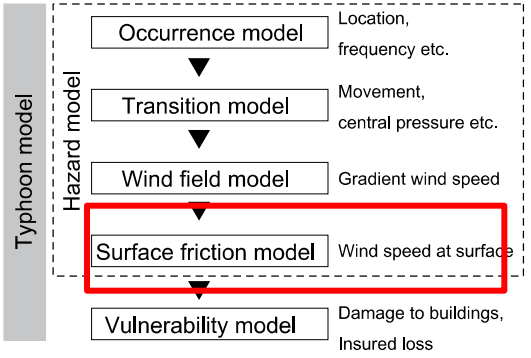


Given
- Central pressure
- Translation speed/angle
- Radius of maximum wind speed



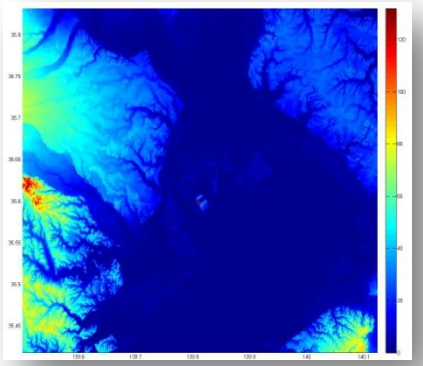
Surface friction model



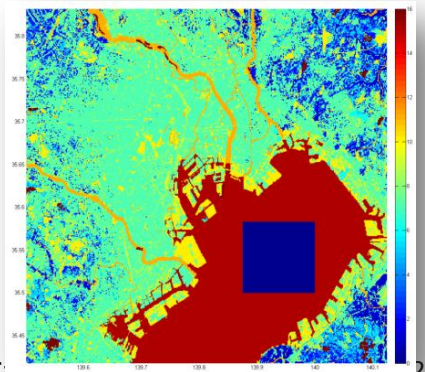


Considering

- Topography

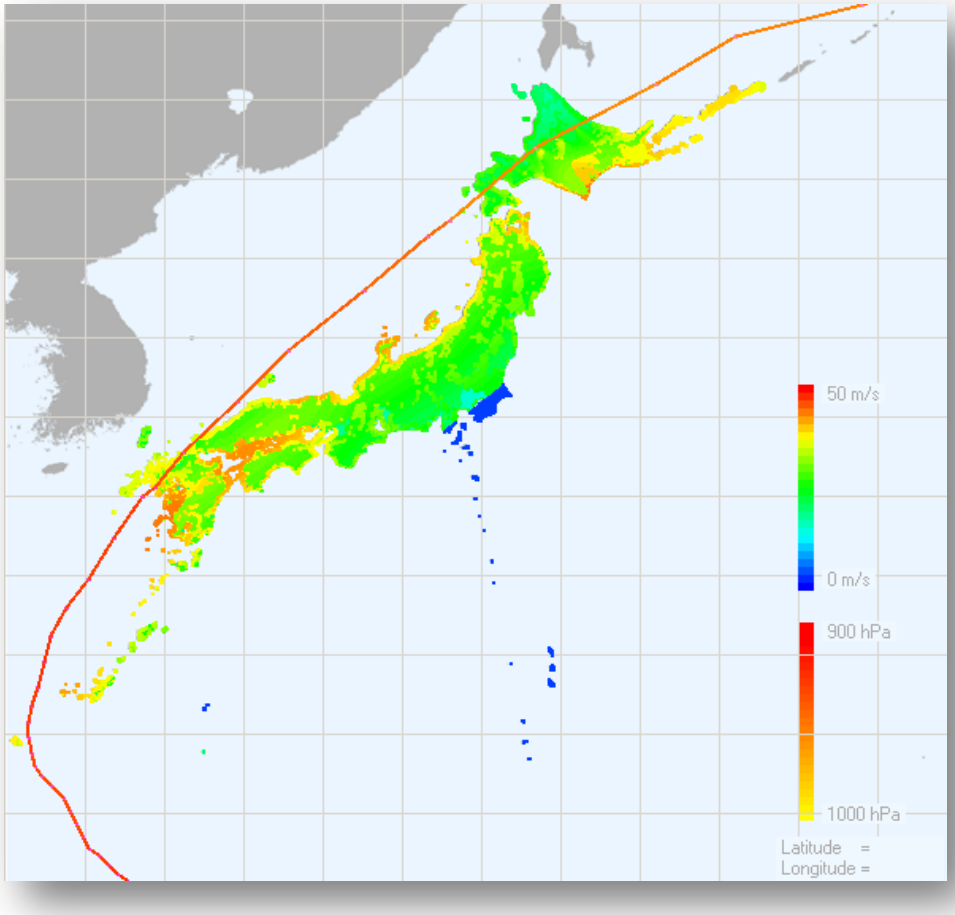


- Land use

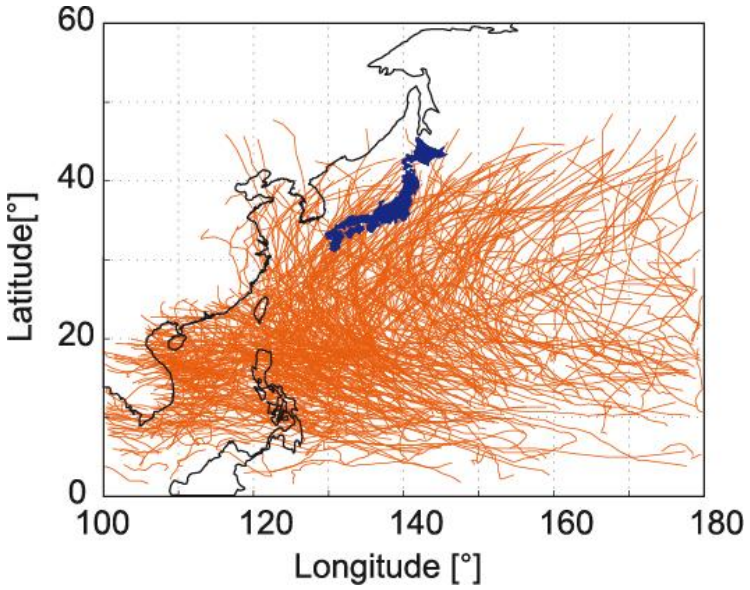


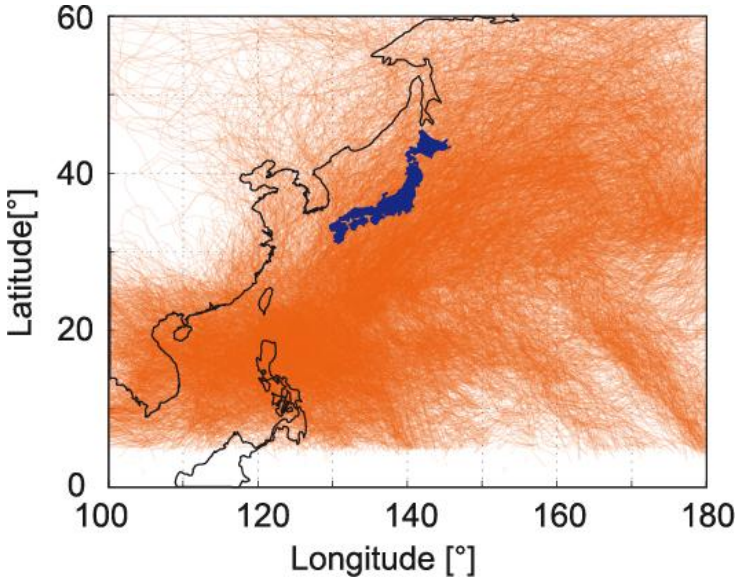
Simulated surface wind speed

- Maximum wind speeds during a typhoon event



Monte Carlo simulation





AGCM simulation

25 years

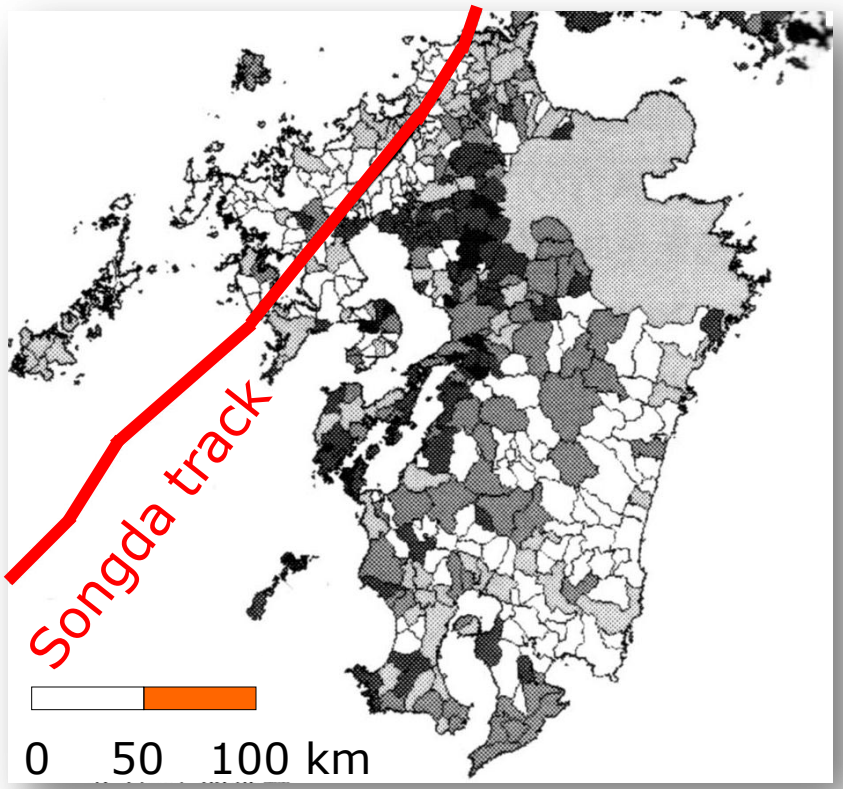
Monte Carlo simulation

25000 times of 1-year

x1000!!

Fragility modeling

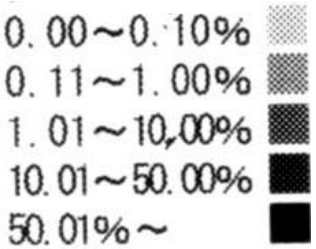
Reported damage ratio of residential buildings



Kyushu island in Japan

$$\frac{(\#\text{ of damaged buildings})}{(\#\text{ of total buildings})}$$

Damage ratio

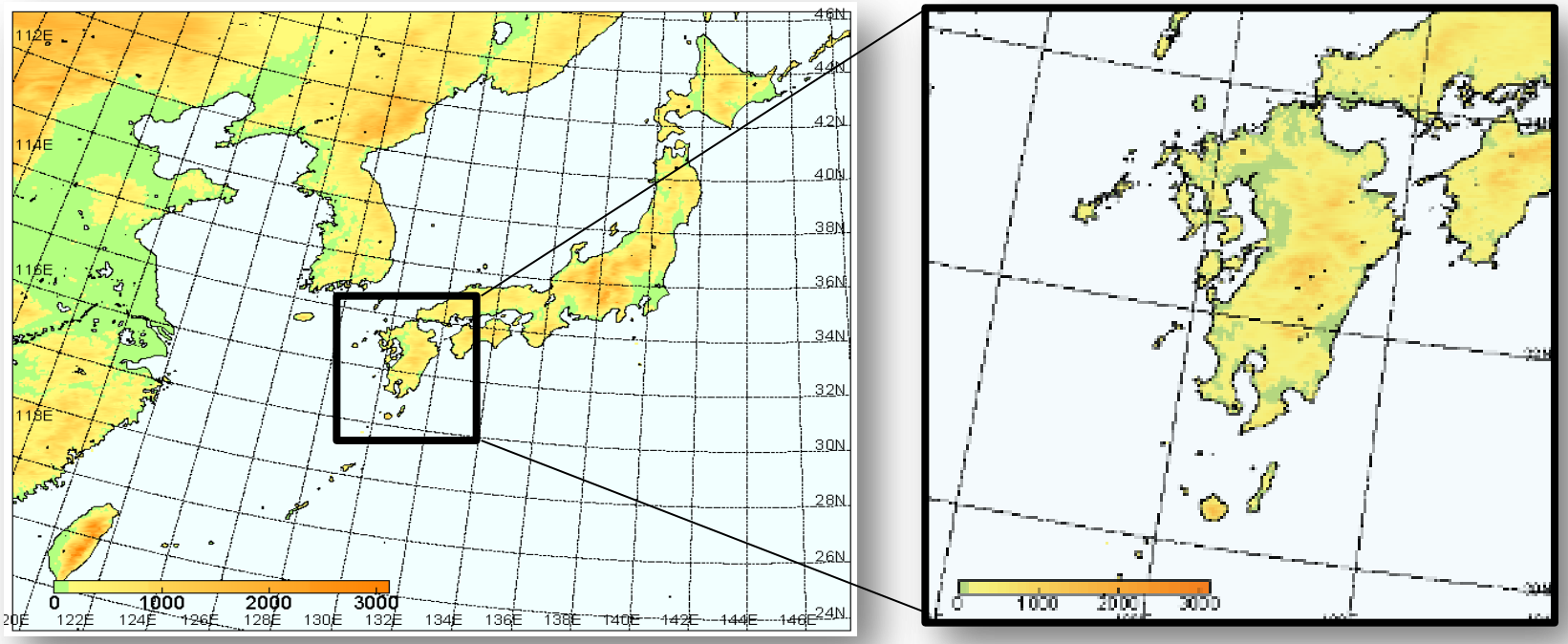


(Degree of damage is not differentiated.)

Tomokiyo et al. (2009)

Computation of wind field by Songda

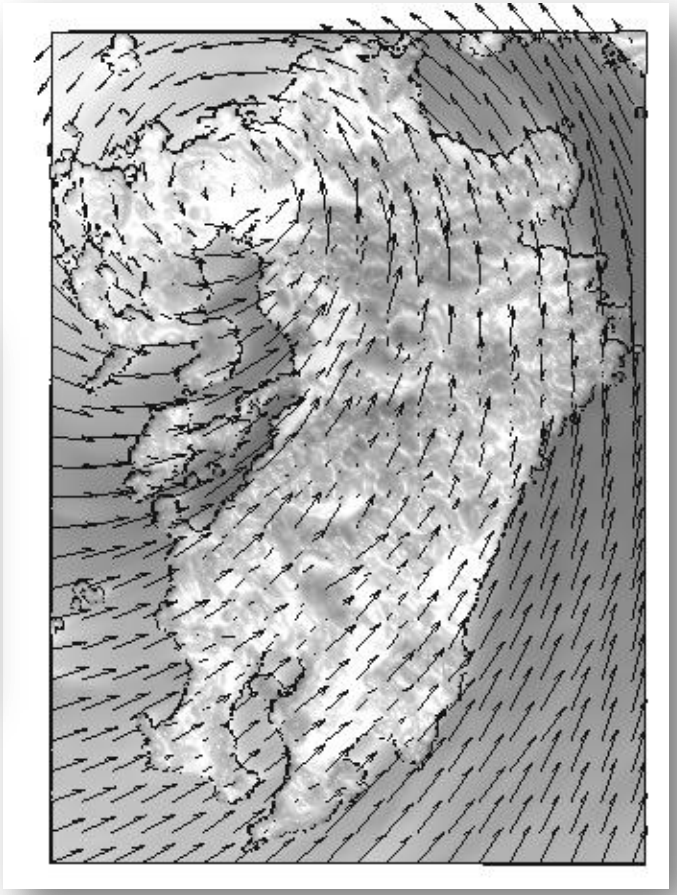
- Japanese 25-year Reanalysis (JRA-25)
- JMA Non Hydrostatic Mesoscale Model (JMA-NHM)



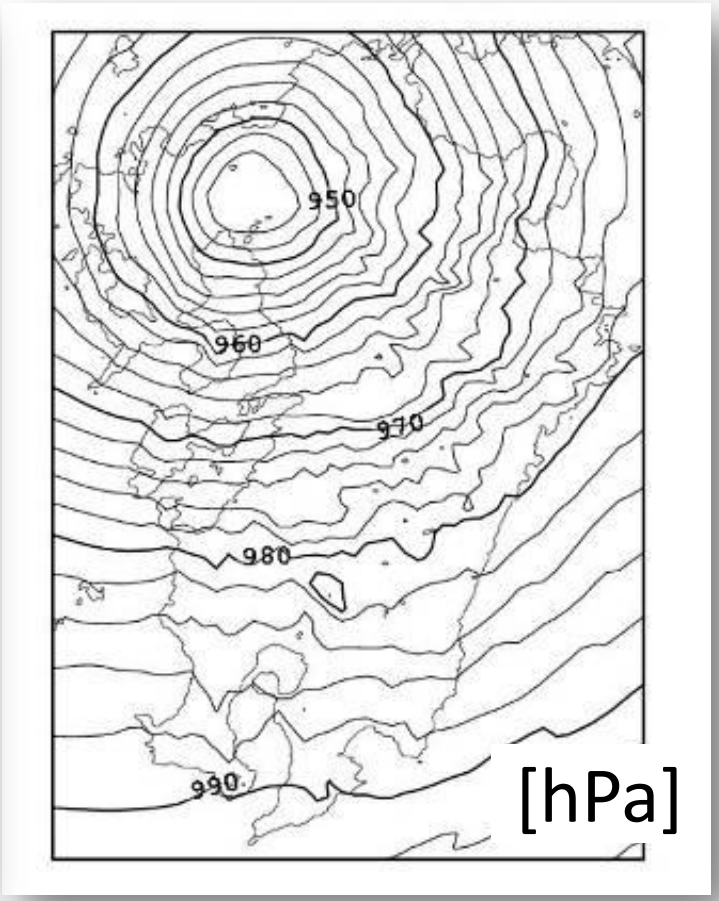
Large scale 5km mesh

Small scale 1km mesh

Computed wind field and pressure fields

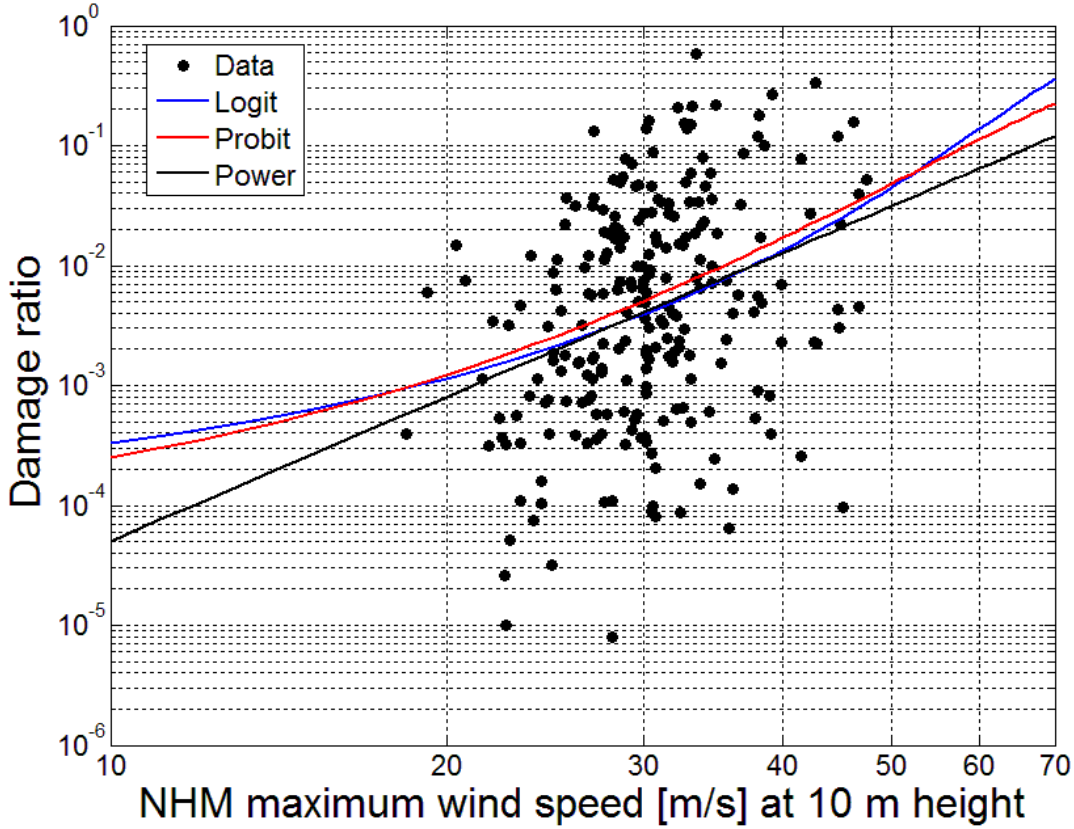


Wind speed/direction

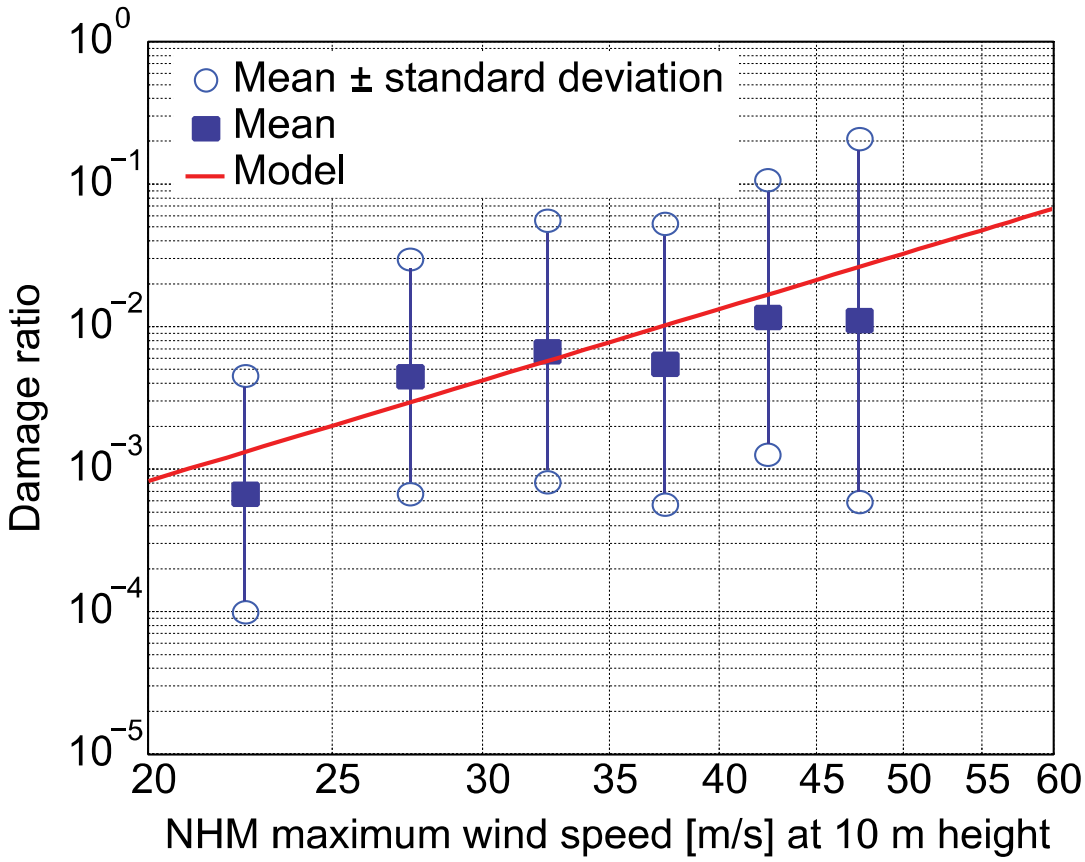


Sea level pressure

Combining these

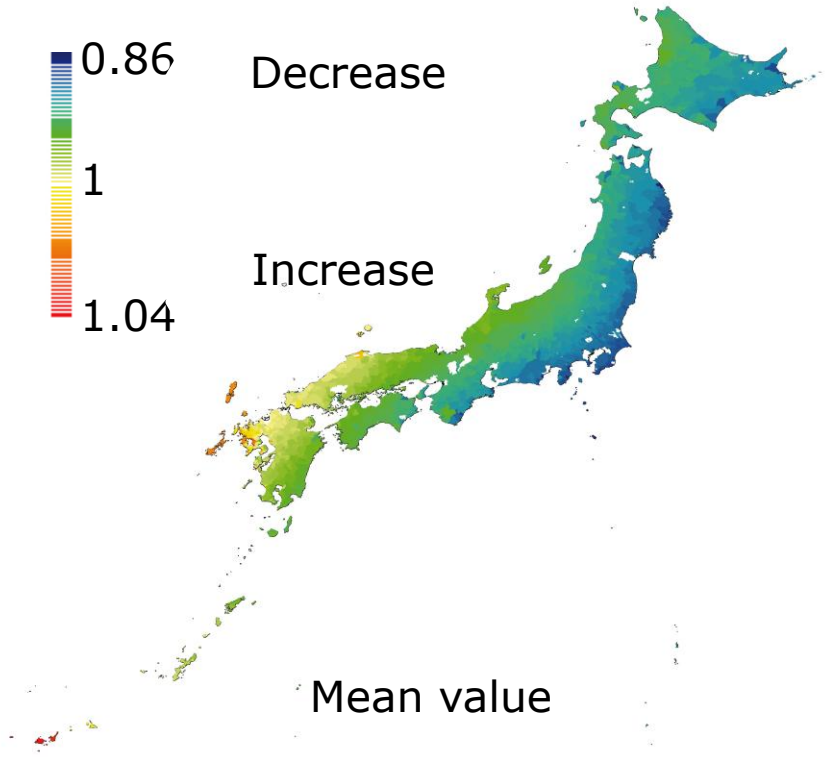


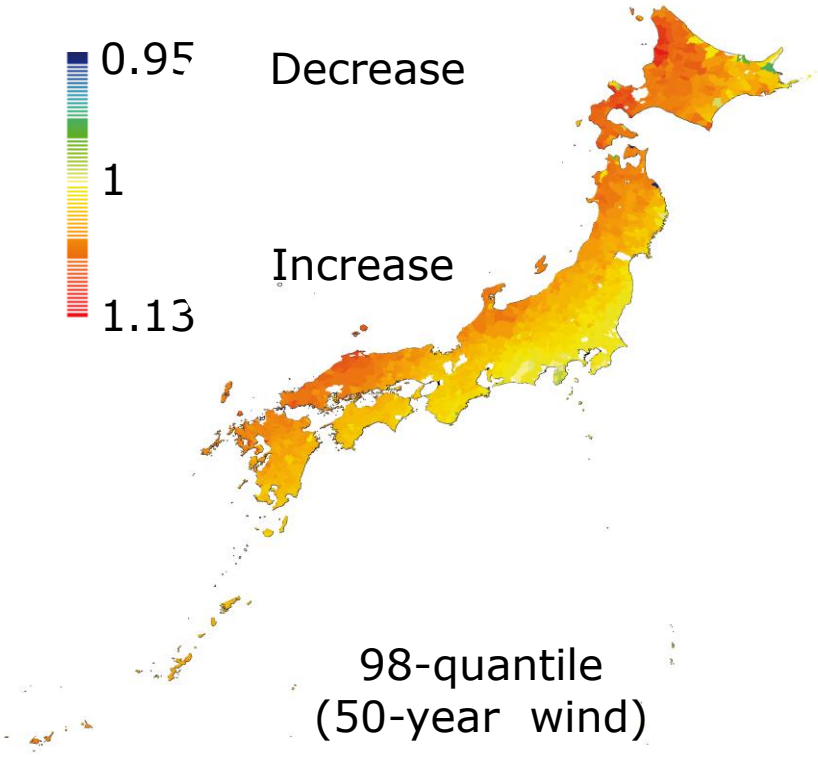
Fragility model



Hazard assessment

- Change of annual maximum wind speed statistics





The answer

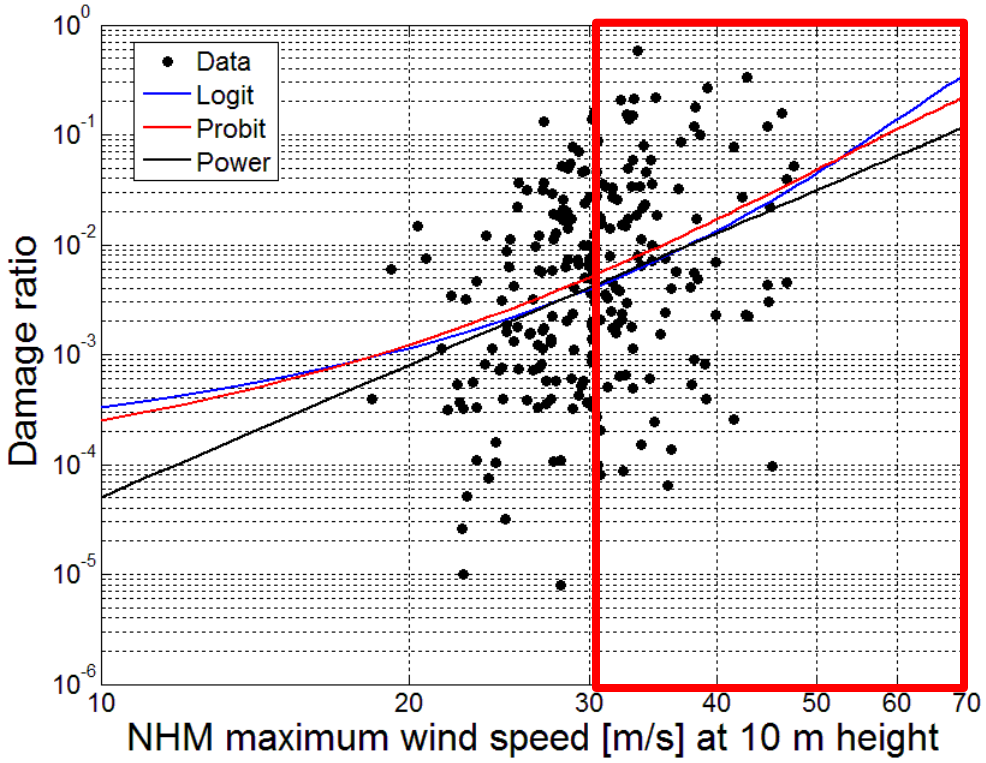
$$\frac{\text{(Projected future climate)}}{\text{(Current climate)}} = 0.87^{*}$$

* Simple average over 2249 locations in Japan

Are you happy?

Research agenda

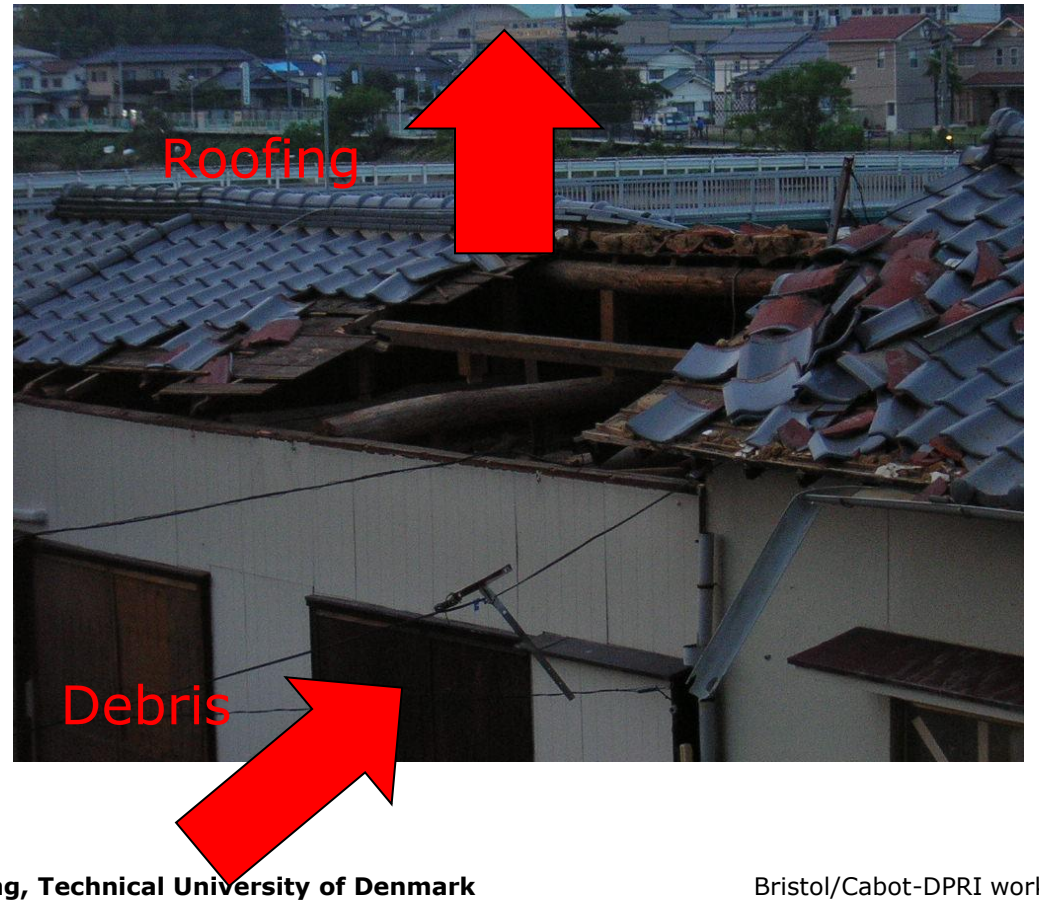
(1) Improved fragility/vulnerability model



Design wind speed: around 30-35m/s in main Japanese islands

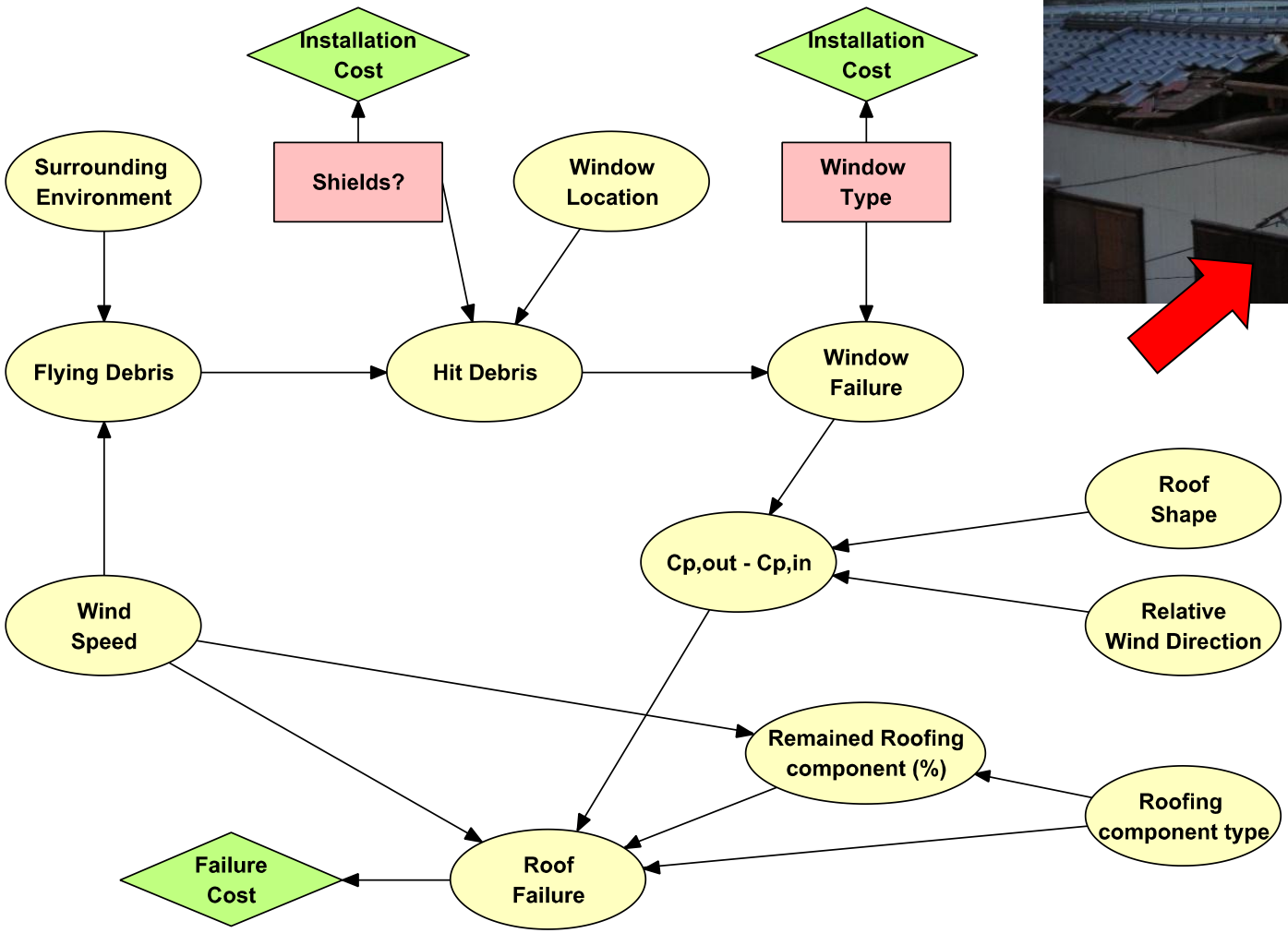
Research agenda

- A failure mode



Research agenda

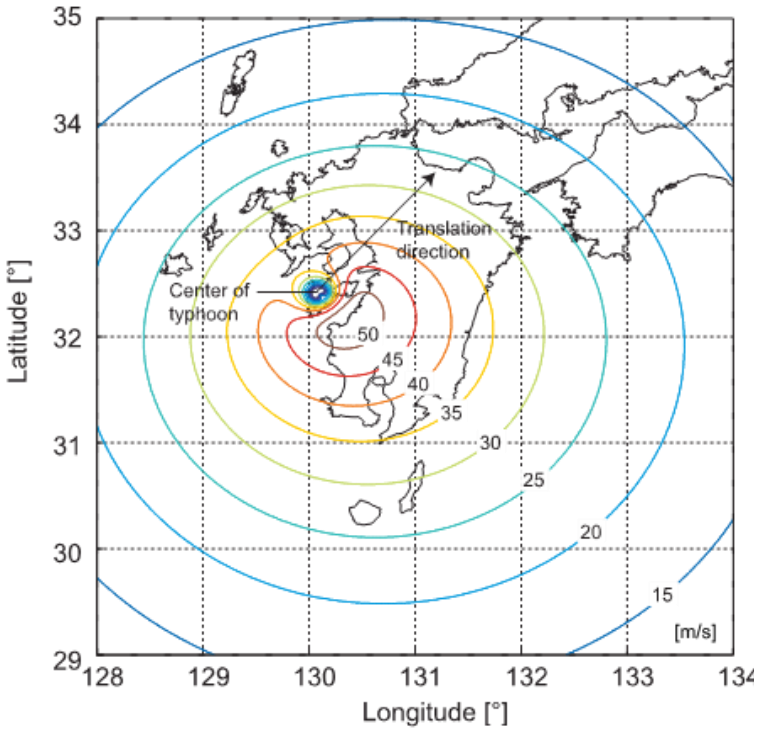
- Hybrid (statistical + engineering) approach

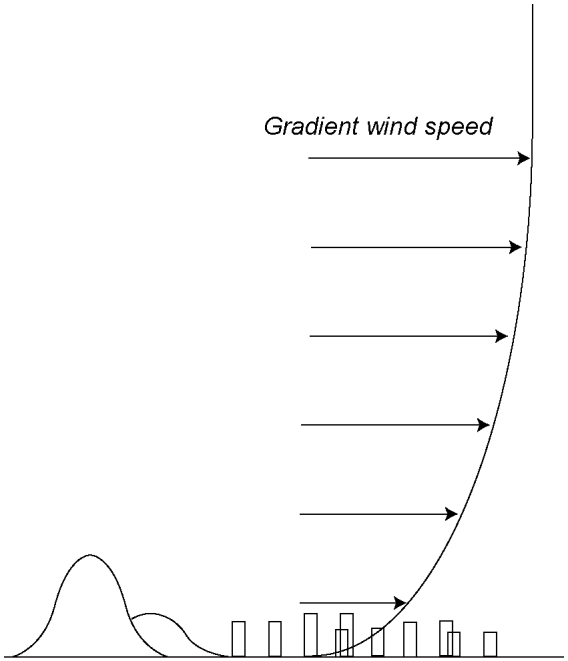


Research agenda

(1) Improved fragility/vulnerability model

(2) Improved wind field model





Thank you for your attention!