Typhoon risk modeling for north west pacific

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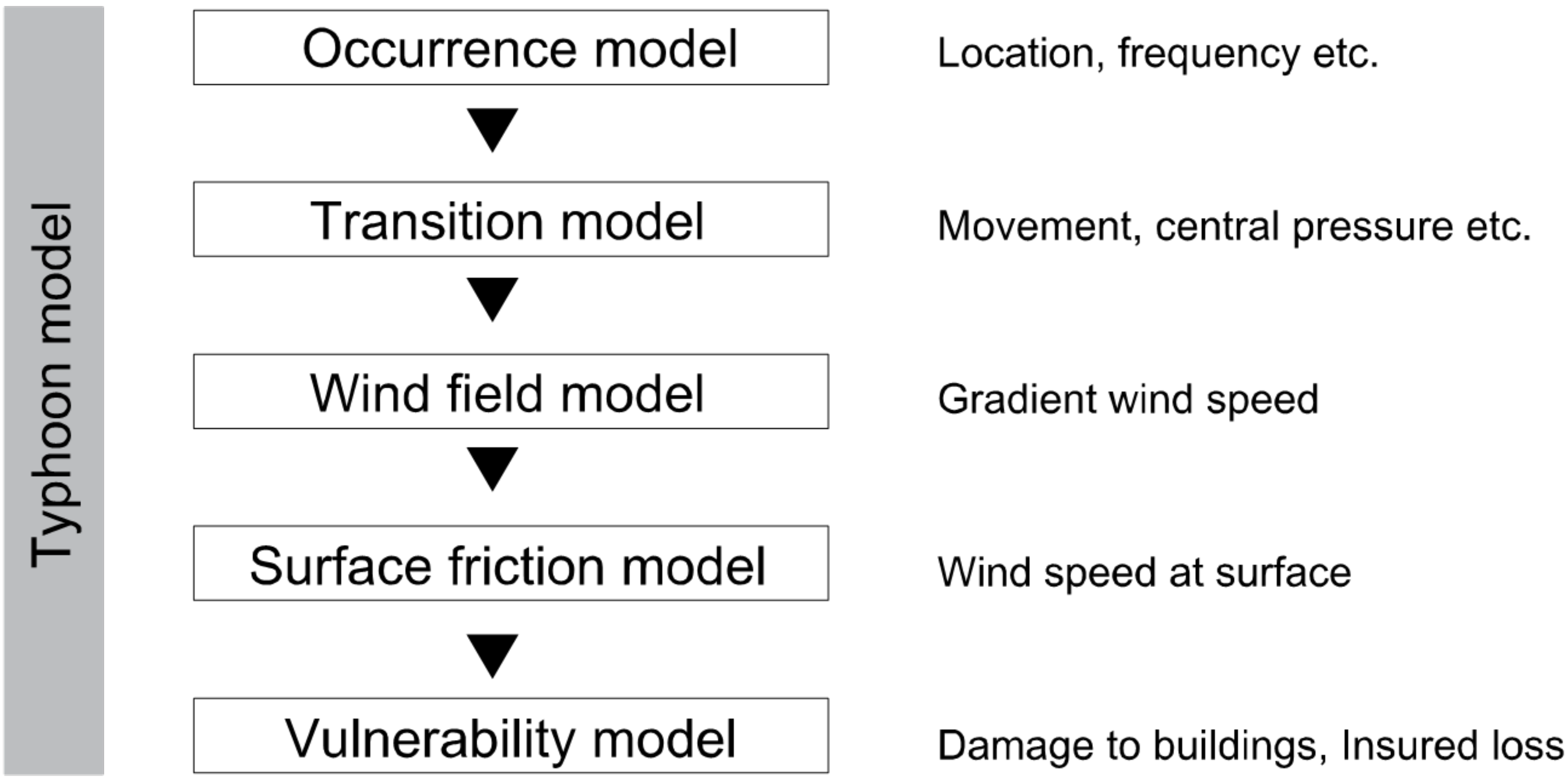
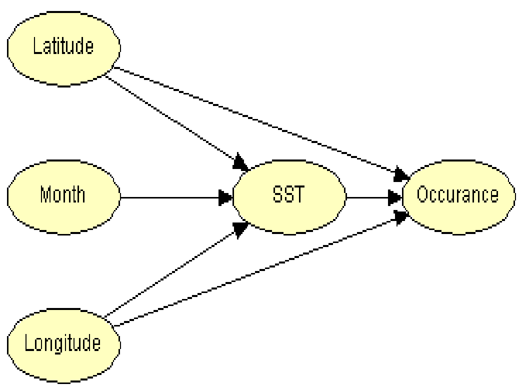
Typhoon model



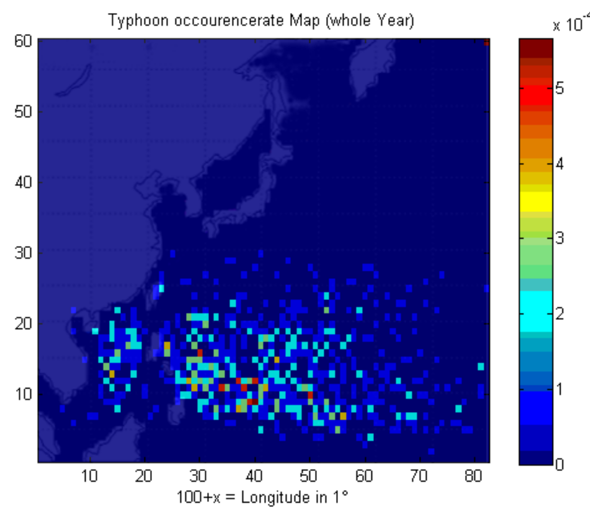
Occurrence model

- Number and locations of occurrence

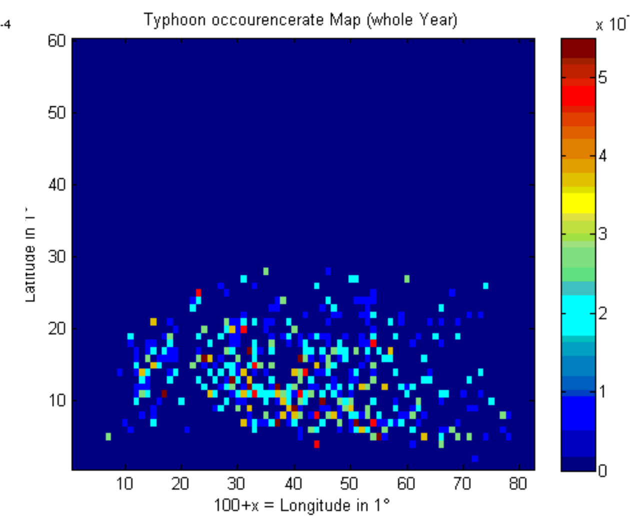
$$p\left(occurence \mid SST, Latitude, Longitude\right)$$



Structure of Bayesian network which represents occurrence model.



Spatial distribution of historical typhoon occurrences.



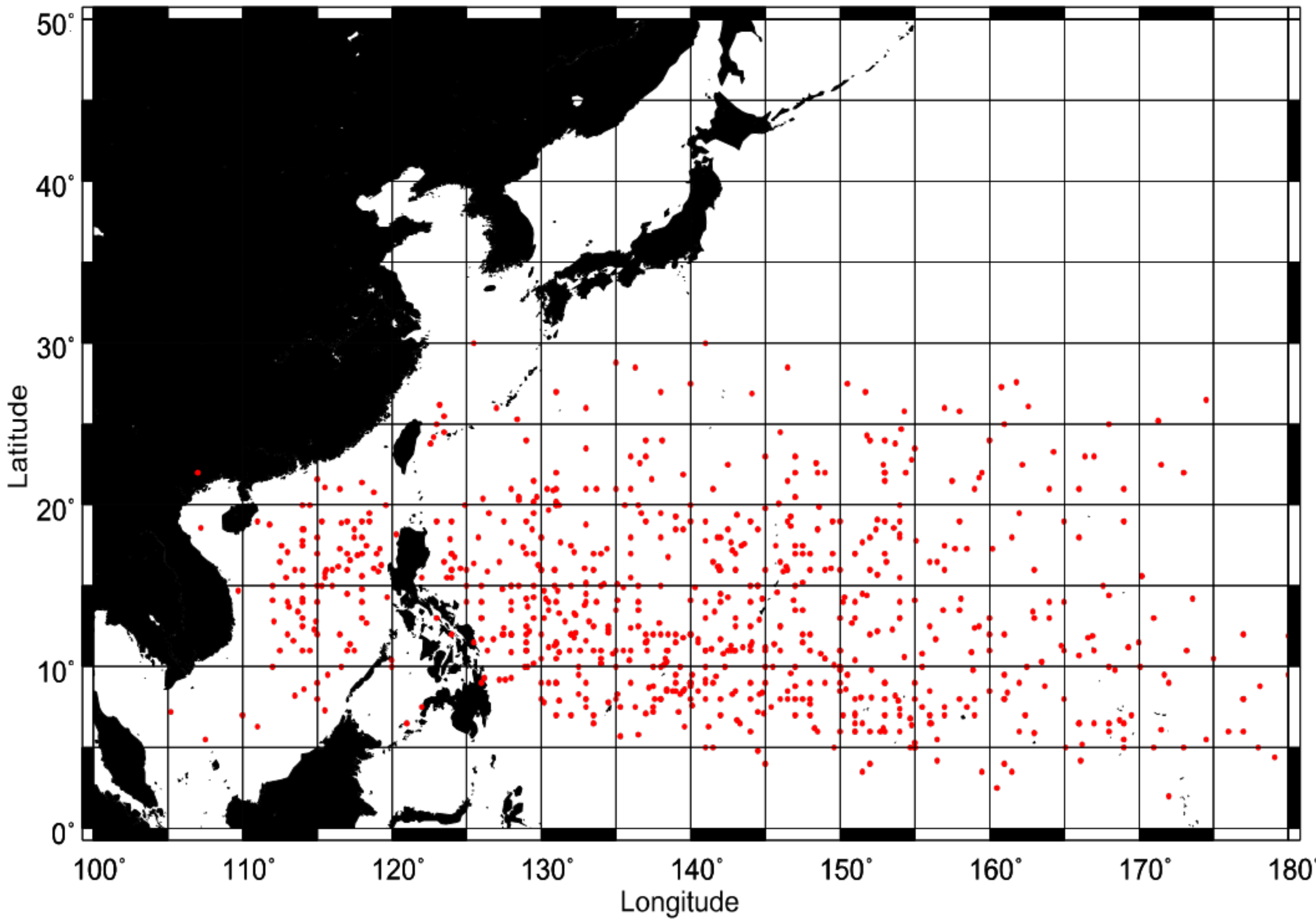
Spatial distribution of typhoon occurrences using the the model.

- Initial parameters:

  Translation speed and angle, central pressure

Occurence model

- Historical occurrence locations
  (Defined when the central pressure of a storm goes first time below 1000hPa)



Transition model

Estimation of the position of the typhoon at time step i+1 :

$$\Delta \ln V_i = a_1 + a_2 \ln V_i + a_3 \Phi_i + \varepsilon_V$$

$$\Delta \Phi_i = b_1 + b_2 V_i + b_3 \Phi_i + b_4 \Phi_{i-1} + \varepsilon_\Phi$$

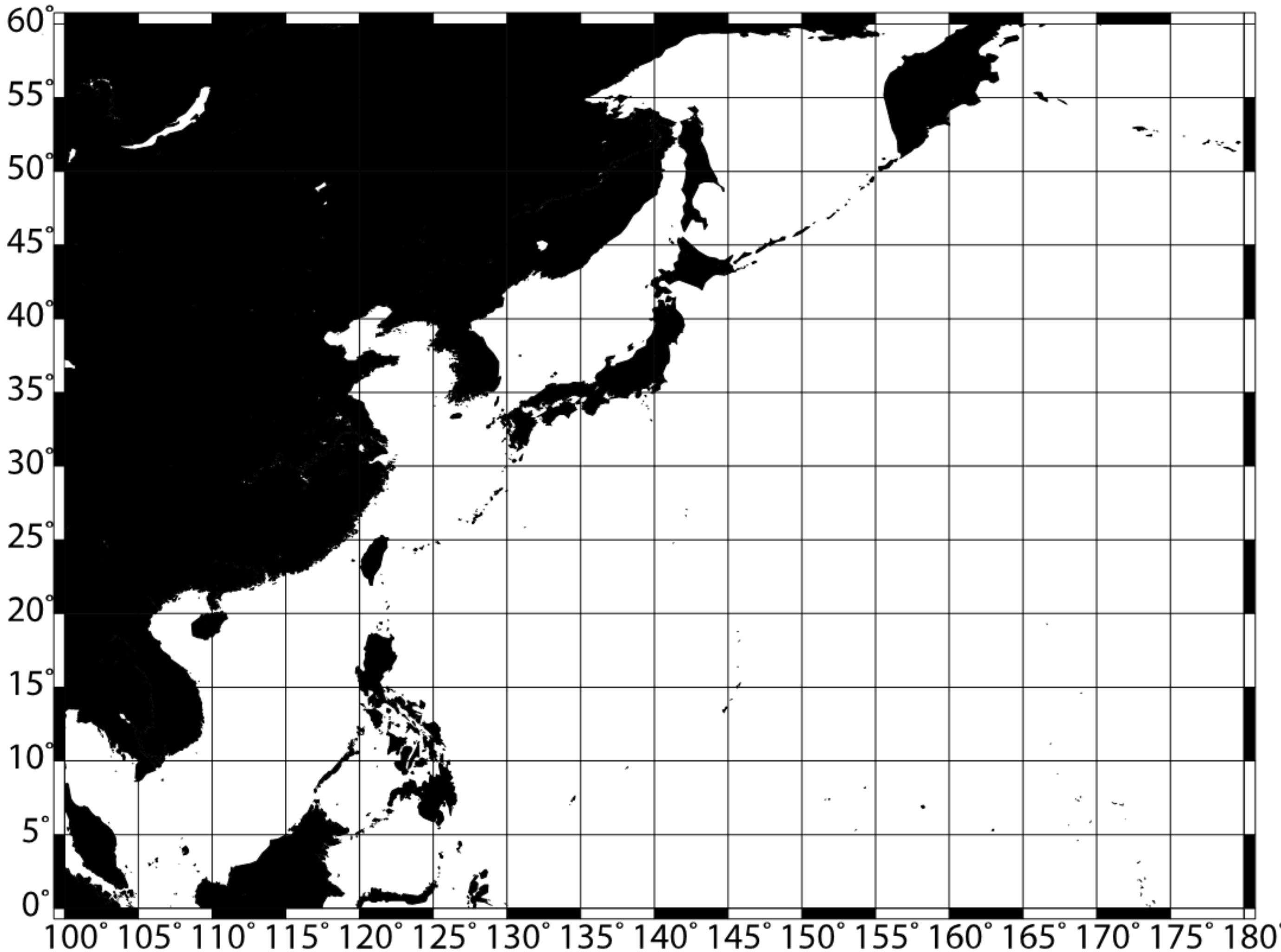
V_i = translation speed $[m/s]$ at time step i

Φ_i = translation angle [°] at time step i

Best track data was used to establish for each month and for each 5° by 5° grid the coefficients

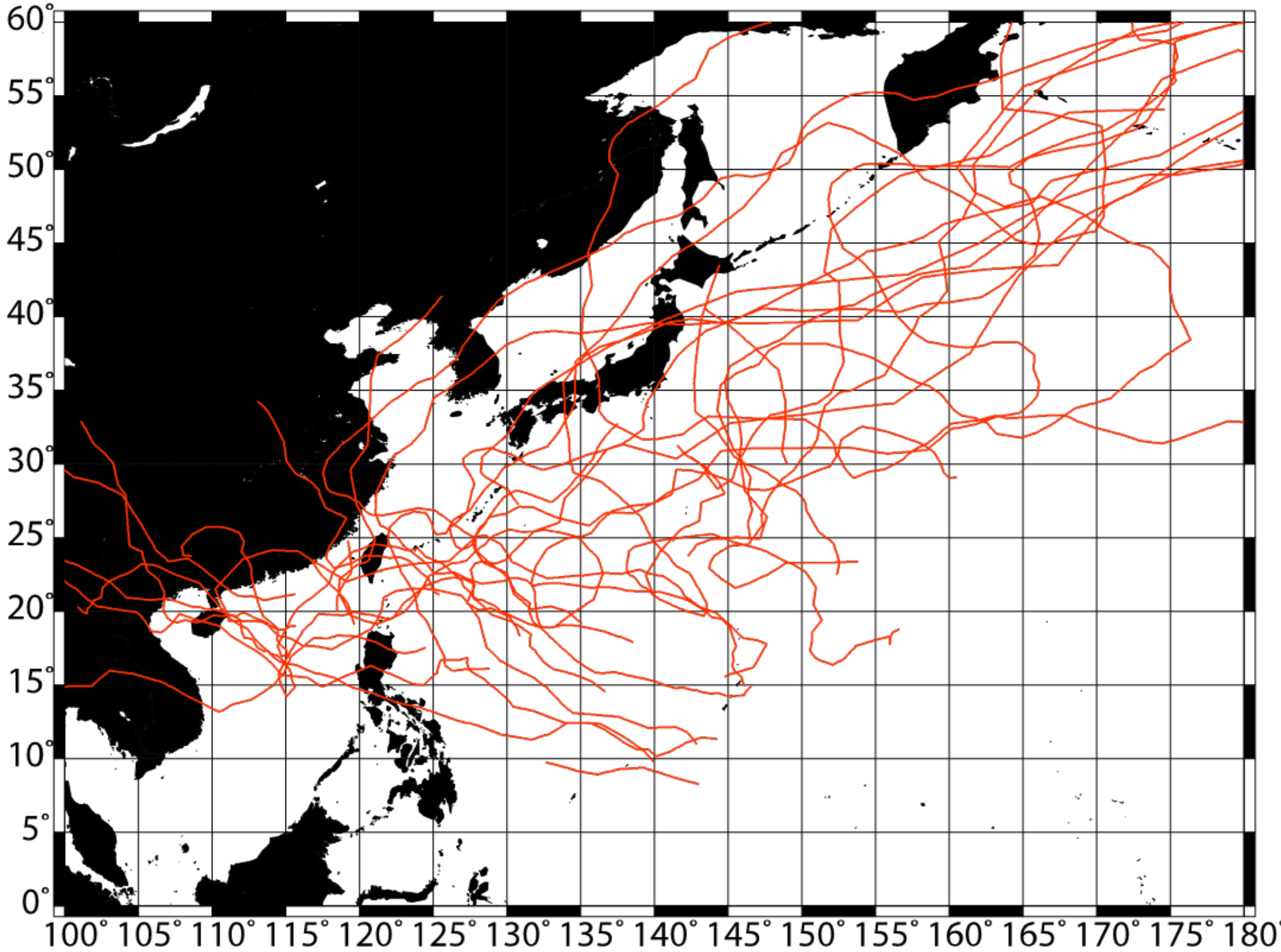
Transition model

Map of the north west pacific



Transition model

Map of the north west pacific with 30 tracks (August)



Transition model (Pressure)

The central pressure at time step i+1 is estimated from:

At sea:

$$P_{i+1} = c_1 + c_2 P_i + c_3 P_{i-1} + c_4 P_{i-2} + c_5 T_i + c_6 \Delta T_i + \varepsilon_P$$

$P_i =$ Central pressure $[hPa]$ at time step i

$T_i =$ Sea surface temperature [°] at time step i

Transition model (Pressure)

The central pressure at time step i+1 is estimated from:

At land (filling model):

$$\Delta P_t = \Delta P_0 \cdot \exp\left(-\left(d_1 + d_2 \Delta P_o\right) t\right)$$

ΔP_t = Peripheral pressure (1013 hPa) - central pressure at time t [h] after landfall

ΔP_0 = Peripheral pressure (1013 hPa) - central pressure at landfall

Wind field model

Pressure field (Schloemer):

$$p(r) = p_C + \Delta p \cdot \exp\left(-\frac{r_M}{r}\right)$$

r_M = Radius of maximum wind speed

r = Distance

$p(r)$ = Pressure at distance r

p_C = Central pressure

Δp = Peripheral pressure (1013 hPa) - central pressure

Wind field model

Wind field:

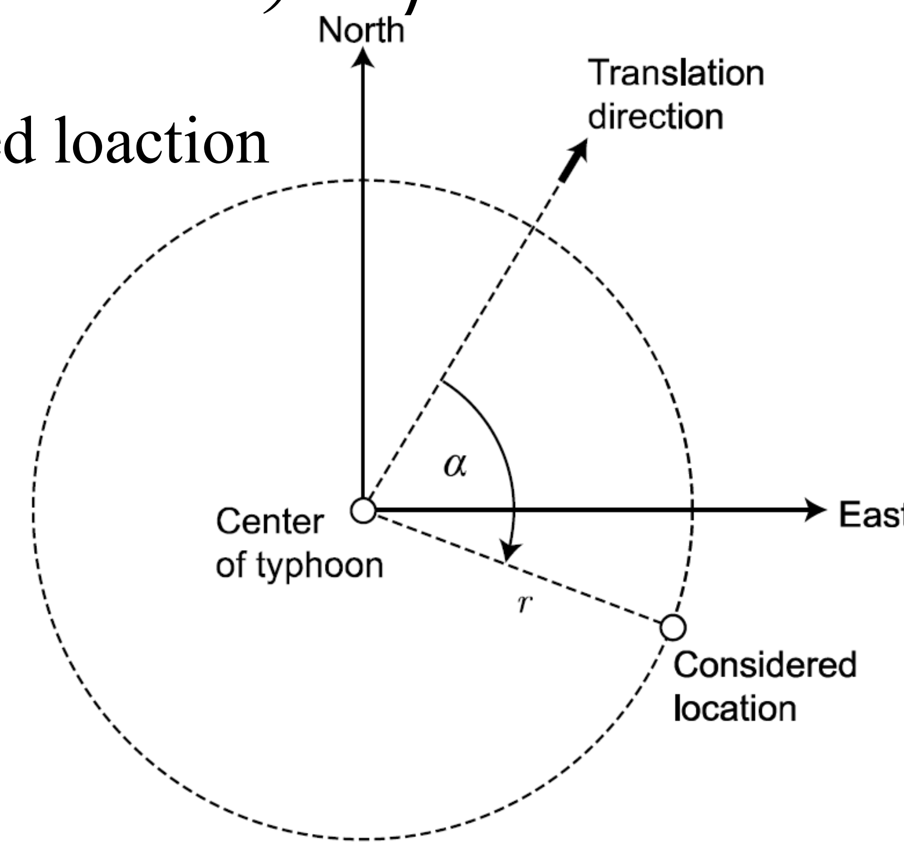
$$\tilde{u}(r,\alpha) = \frac{V \sin\alpha - fr}{2} + \sqrt{\left(\frac{V \sin\alpha - fr}{2}\right)^2 + \frac{r}{\rho}\frac{\partial p(r)}{\partial r}}$$

$\tilde{u}(r,\alpha) =$ Wind speed at considered loaction

$V =$ Translation speed

$f =$ Coriolis parameter

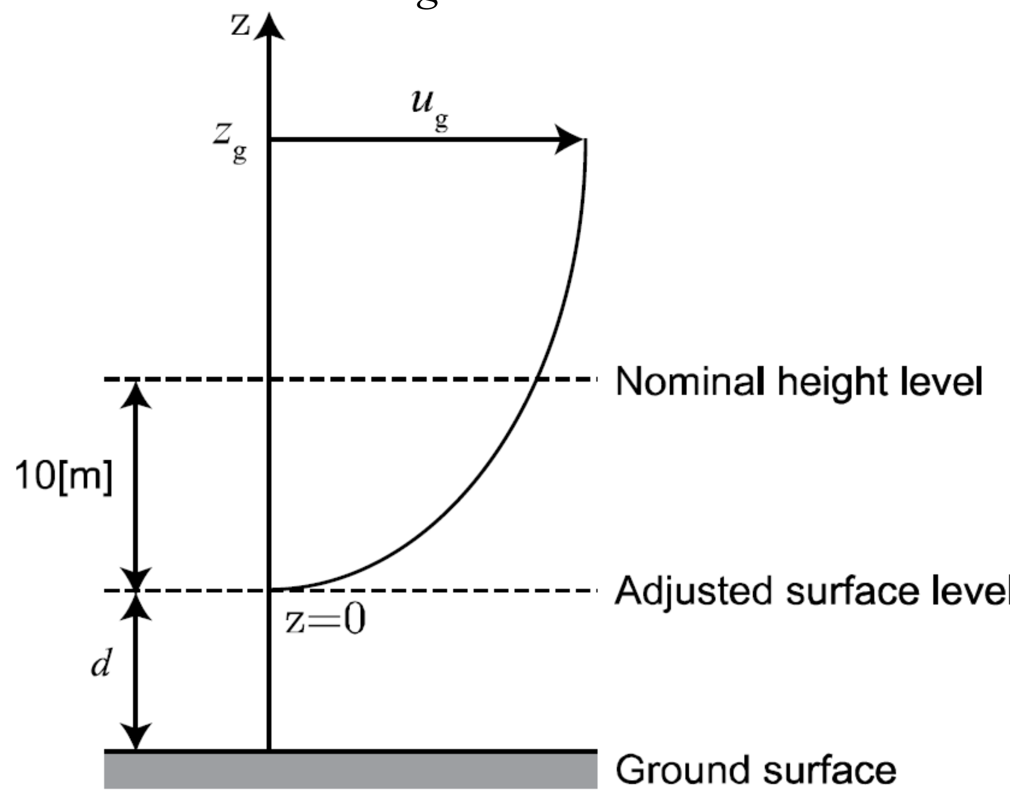
$\rho =$ Air density



Surface friction model

Converting wind speed at gradient u_g height to wind speed at surface $u(z)$

$$u(z) = u_g \left(\frac{z}{z_g} \right)^{\alpha}$$

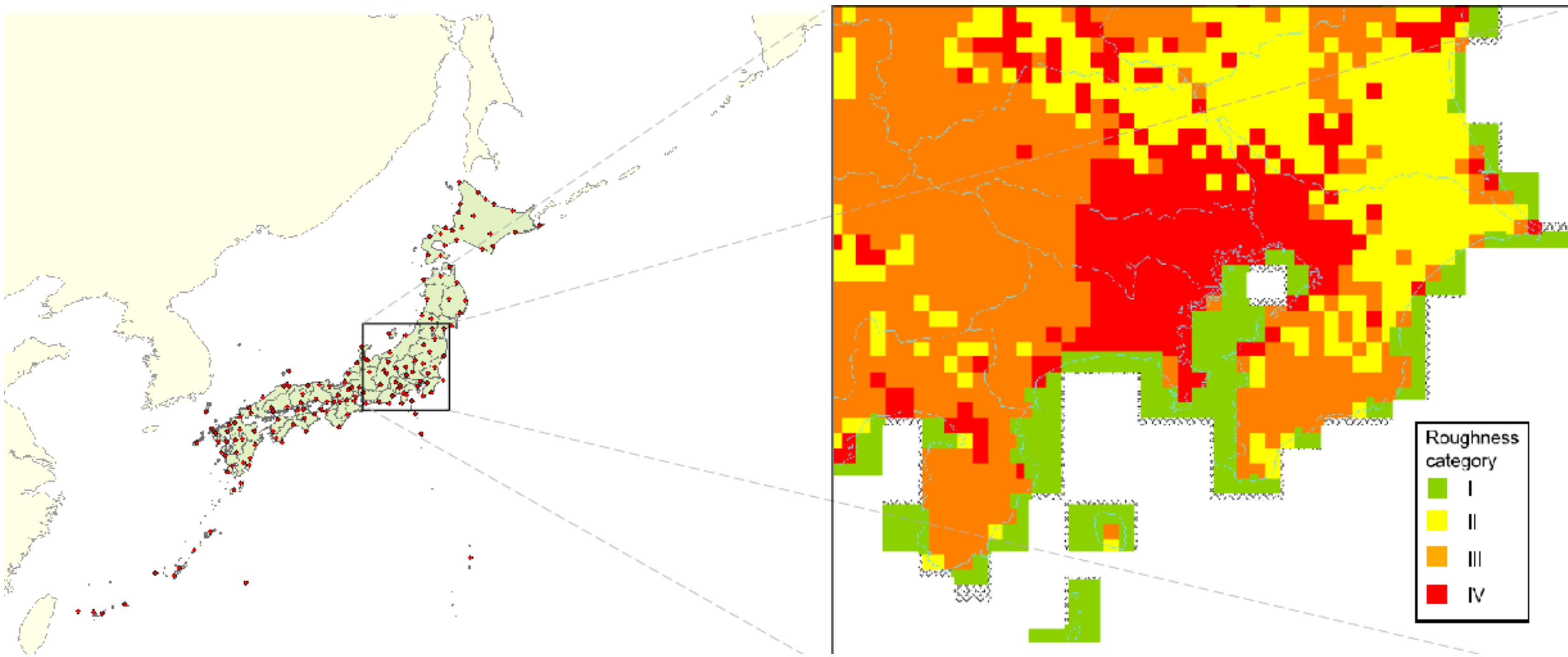


$$\alpha = 0.27 + 0.09 \log z_0 + 0.018(\log z_0)^2 + 0.0016(\log z_0)^3$$

$z_0 =$ rougness lenght

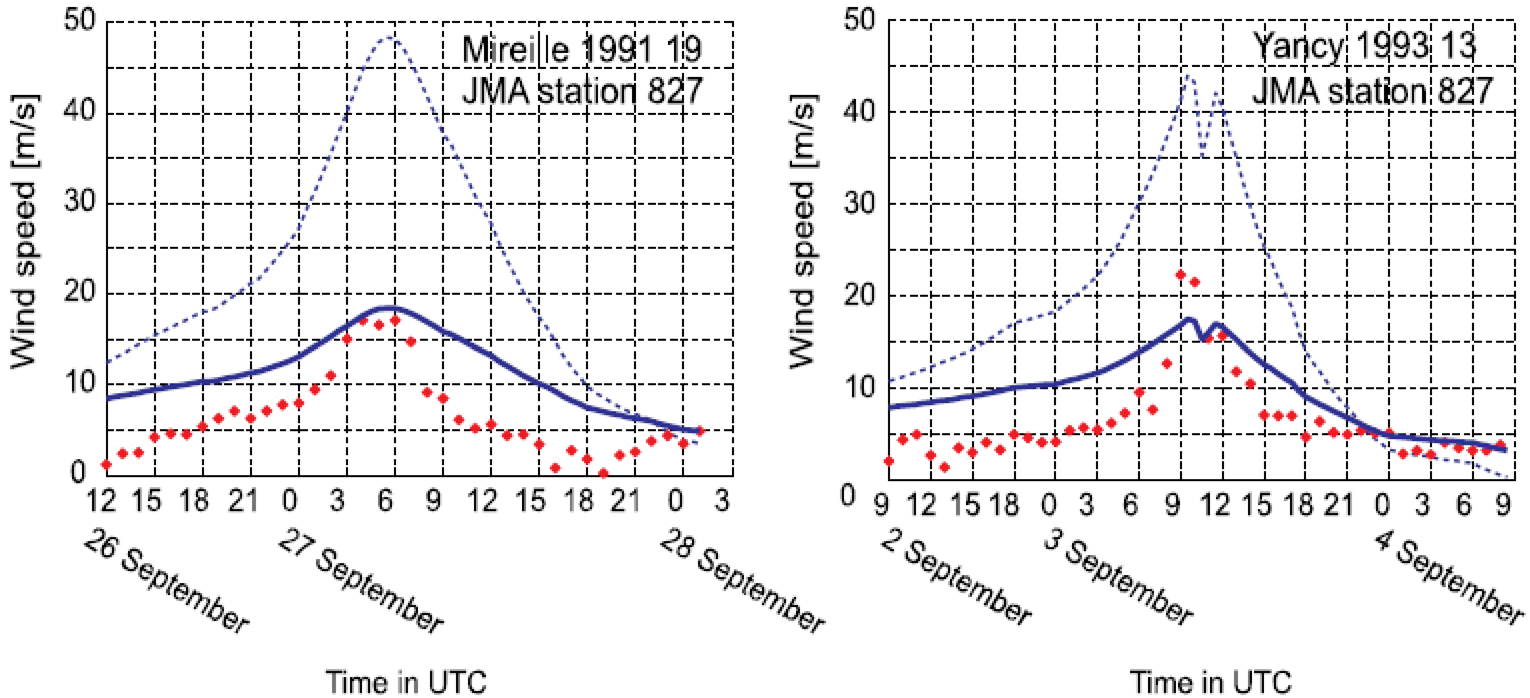
Surface friction model

Identification of the rougness leght z_0



Roughness category	Terrain type	Roughness length [m]
I	Very flat terrain	0.003
II	Open terrain (grassland, few trees)	0.03
III	Suburban terrain (buildings, 3-5 [m])	0.3
IV	Dense urban (buildings, 10-30 [m])	3

Surface friction model



Reproduced wind speeds at gradient height

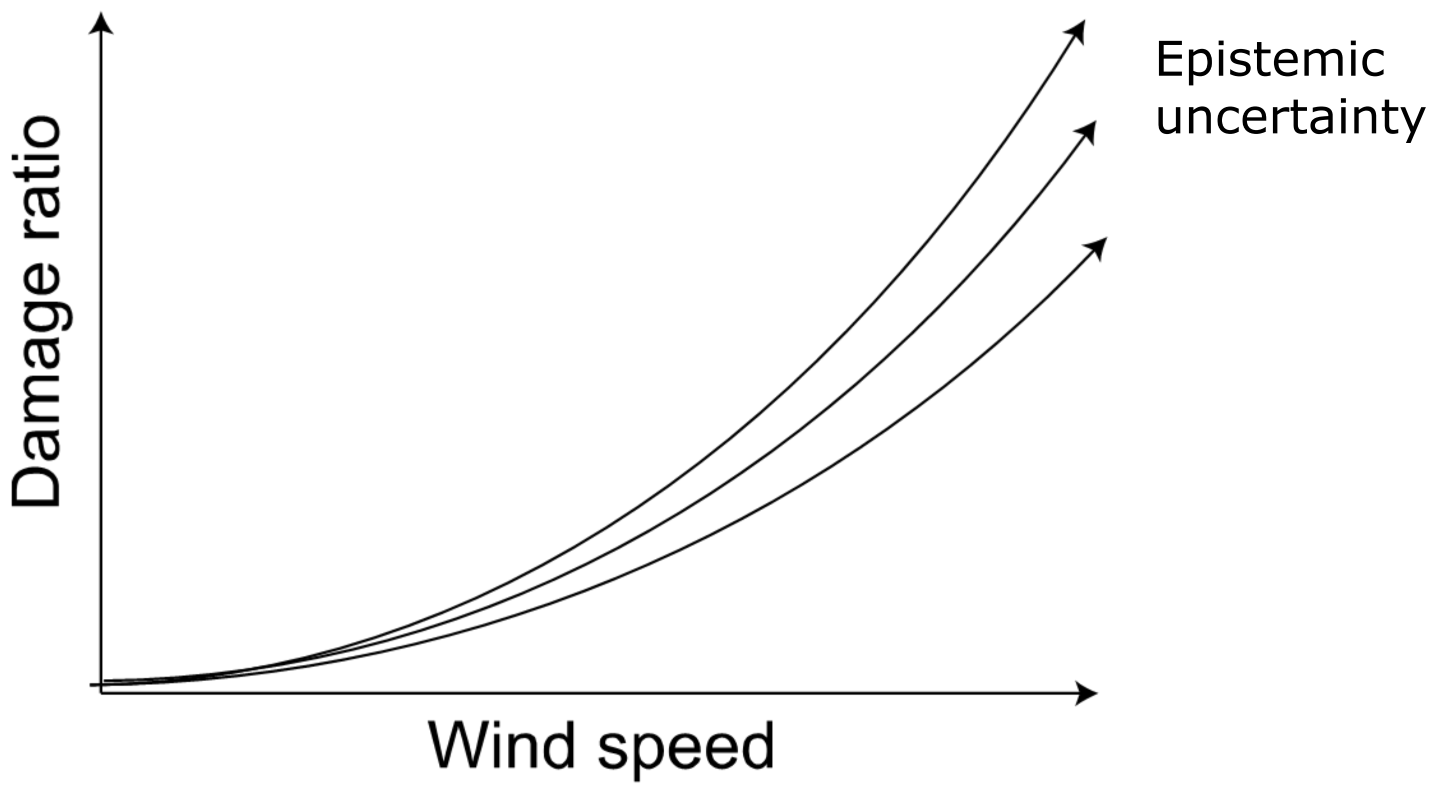
Reproduced wind speeds converted at the height of the location of the measurement device at each station

Observed wind speeds

Vulnerability model

Relation between wind speed and damage

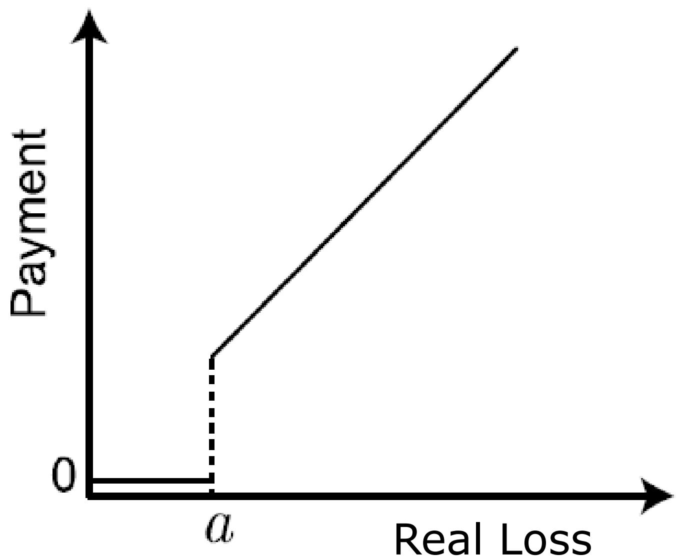
- Combining loss data from insurance companies with reproduced wind speed from historical data

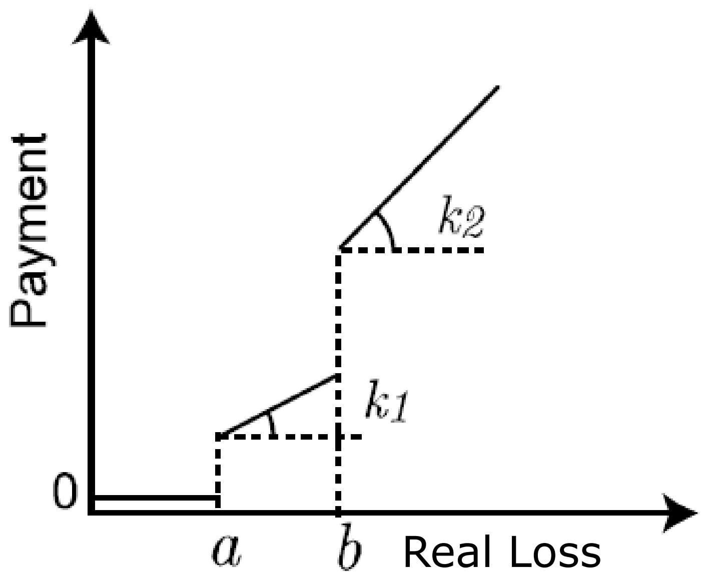


Vulnerability model

Risk assessment for portfolios losses

- Transform real loss to insurance payment





Application for portfolio risk assessment

Disaggregation of portfolios