

# Track dependency of tropical cyclone risk

:Toward an impact forecasting



8 November 2017

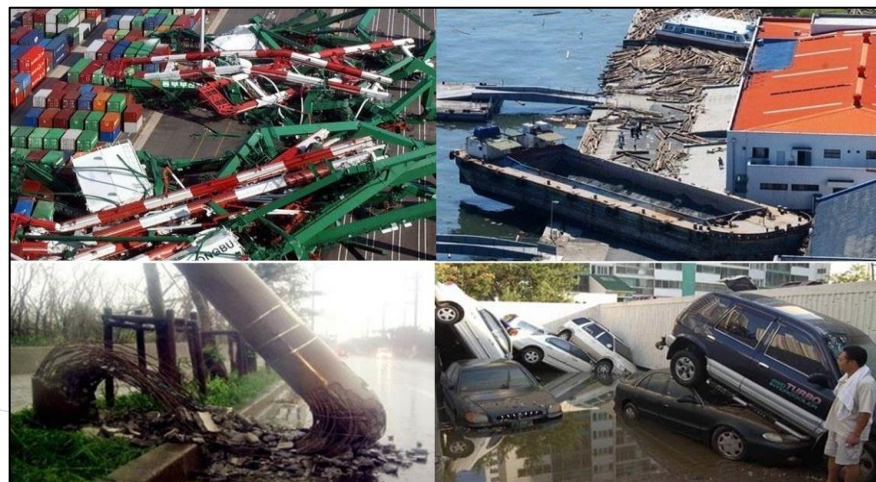
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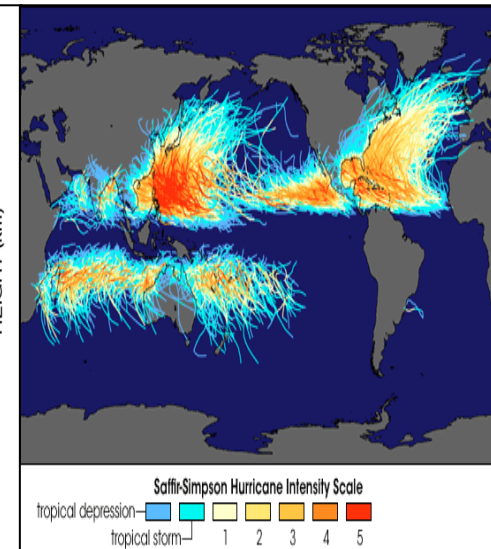
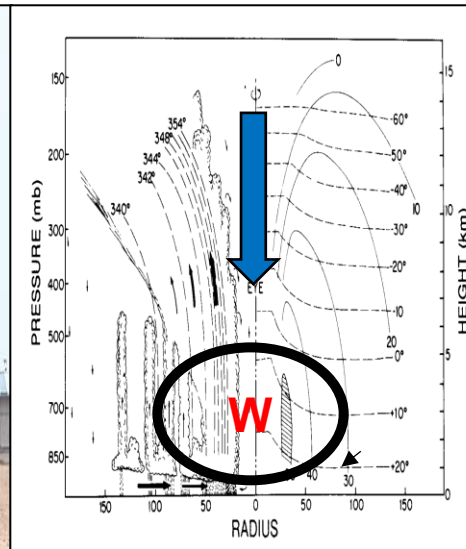
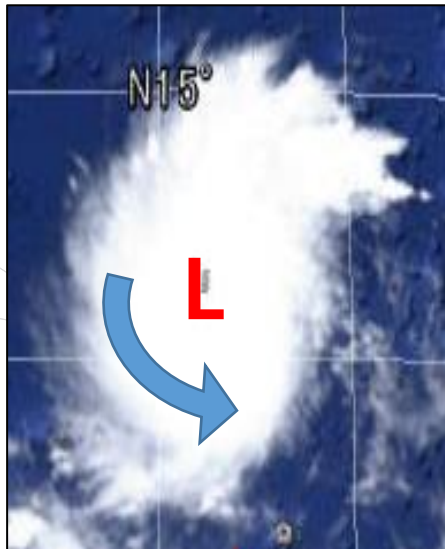
# General idea on tropical cyclone risk

- People think when tropical cyclone approaches South Korea, damage may occur every time.
  - I. People think that South Korea is not a huge country.
  - II. The size of the country is smaller than the average size of tropical cyclone.
- About one third of tropical cyclones did not incur damages.
  - I. The ratio of tropical cyclones undamaging varies by provinces.



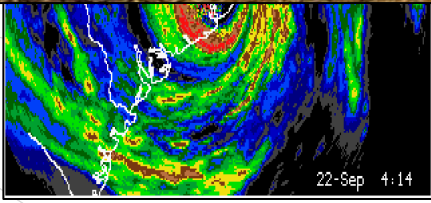
# Definition of tropical cyclone

- A weather system is characterized by
  - I. A low-pressure system which has cyclonic circulation with intense wind  
(maximum wind speed should exceed 17 m/s)
  - II. A warm-core structure due to a descending motion in the eye
  - III. Originating from the warm tropical oceans  
(SST  $\geq 26.5^{\circ}\text{C}$  &  $26^{\circ}\text{C}$  isotherm depth  $\geq 60$  m)



# Definition of tropical cyclone risk

- Tropical cyclone risk is a multiplication of the three factors: exposure, vulnerability and hazard.



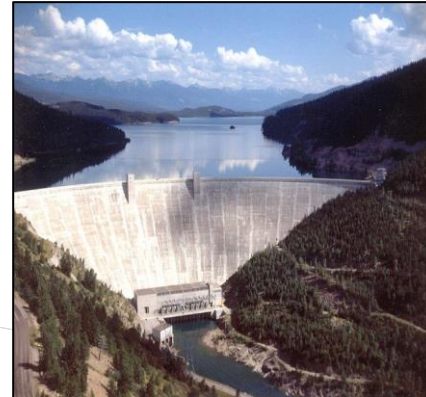
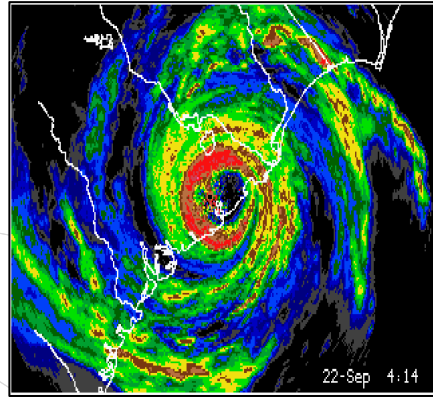
I.  
II  
II  
IV

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# Definition of tropical cyclone risk

- Why the risk equation should be expressed by a MULTIPLICATION of the three factors?
  - I. All of the factors generally well follow log-normal distributions. Hence, if we take log in both sides of the equation, we may use a multivariate linear regression method.
  - II. In risk concept, if one of the factors are zero, the risk should be zero. If we replace product ( $\times$ ) with plus ( $+$ ) in the equation, the damage can occur despite of nonexistence of tropical cyclones. This is impossible to occur in a real world.

**Risk = Hazard  $\times$  Sensitivity  $\times$  Exposure**



# Motivation

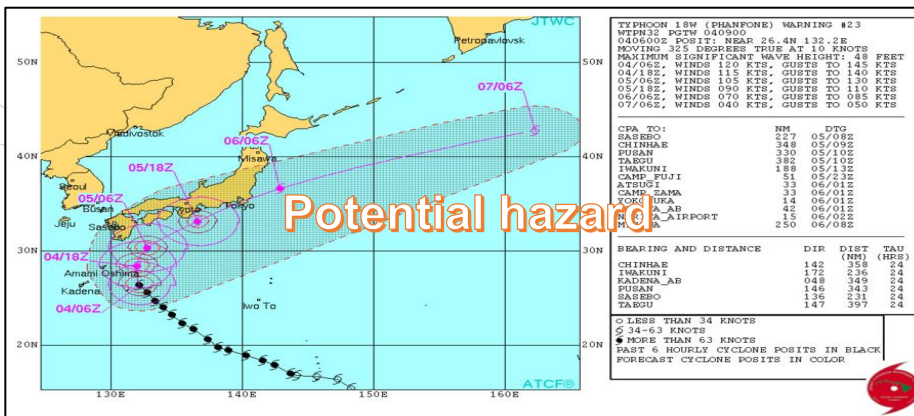
- Concepts of potential and active hazards

- I. Potential hazard: maximum wind speed of tropical cyclone

- The potential hazard follows tropical cyclone's migration
    - It is widely used in research community of tropical cyclone risk due to its convenience of usage.

- II. Active hazard: Wind speed and rainfall measured at a fixed weather station

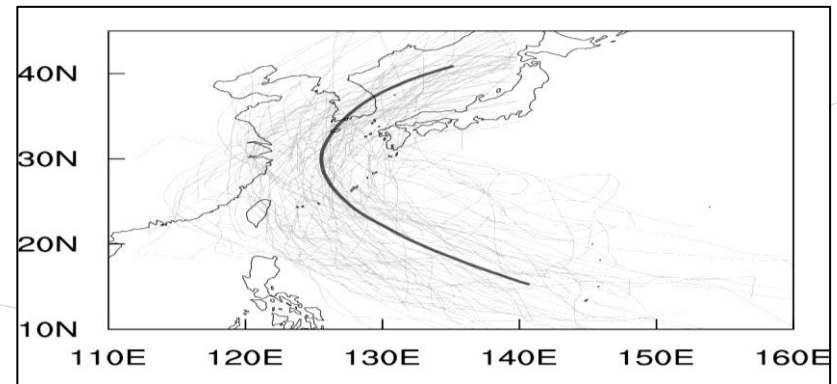
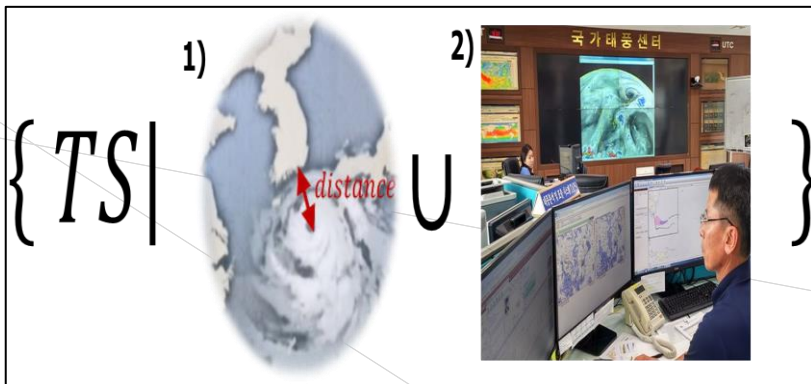
- For risk calculation, the active hazard is more appropriate, but its usage is difficult in forecasting.
    - Track information may supplement the risk calculation when using potential hazard. (Track likely affect tropical cyclone risk)



# Data and methods

- Tropical cyclones affecting South Korea are selected when they meet one of the following criteria.
  - I. Tropical cyclones of which max wind speeds exceed  $17 \text{ m s}^{-1}$  & Tropical cyclones entering the line of 300 km apart from the coast of Korea
  - II. Tropical cyclones recorded in the Typhoon White book as tropical cyclone influenced Korea

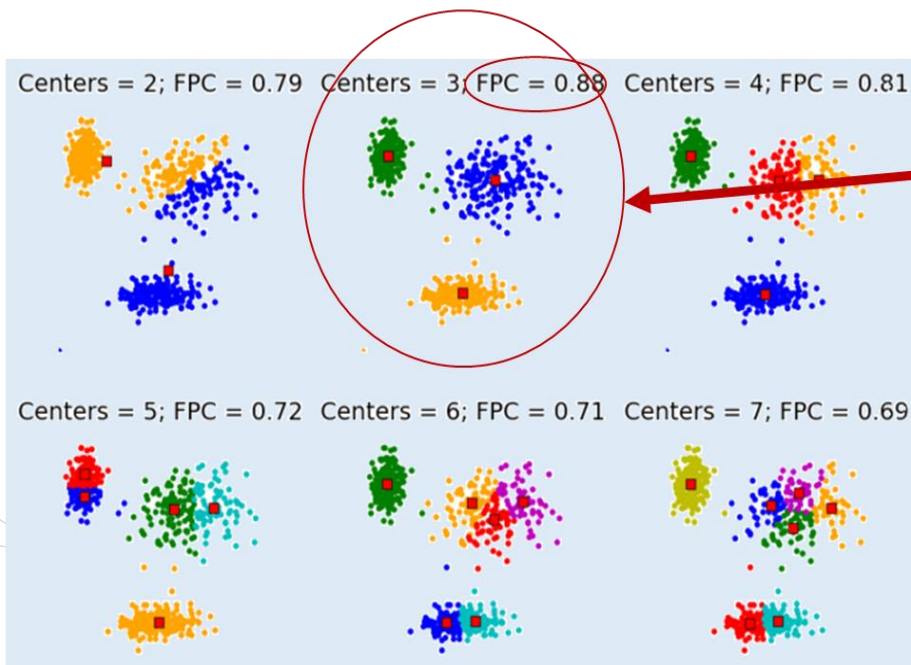
**Total 85 tropical cyclones are selected for 1979–2010**



# Data and methods

- **Fuzzy c-means clustering**

- Fuzzy c-means is utilized in order to categorize track patterns of 85 Korea – influenced TCs
- Fuzzy c-means is a method of clustering which allows one piece of data to belong to two or more clusters (degree of membership) which is **frequently used in pattern recognition**



- **Optimum cluster number** is decided by five objective indexes including Fuzzy Partition Coefficient (FPC)

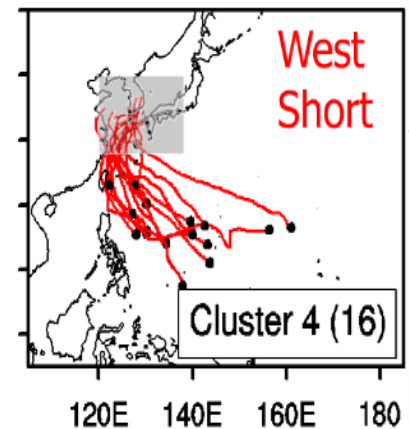
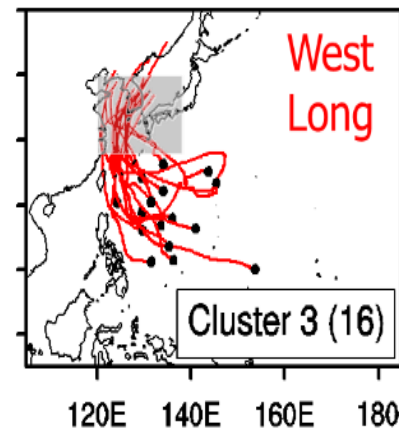
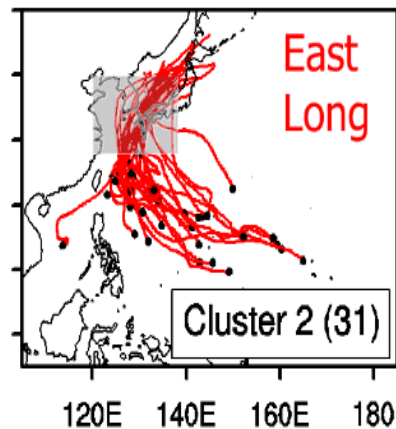
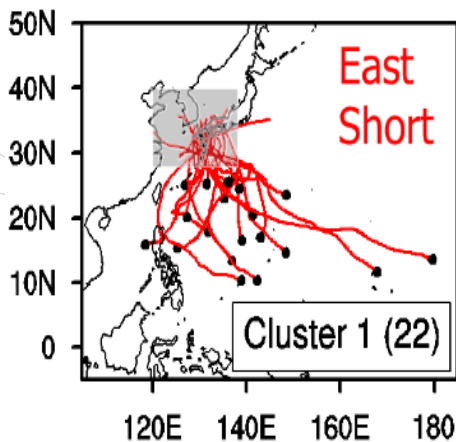
$$J = \sum_{i=1}^C \sum_{k=1}^K (\mu_{ik})^m \|x_k - c_i\|^2 \quad 7/15$$

- To minimize objective function ( $J$ ), which is composed of distance from the cluster center & degree of membership in the cluster)

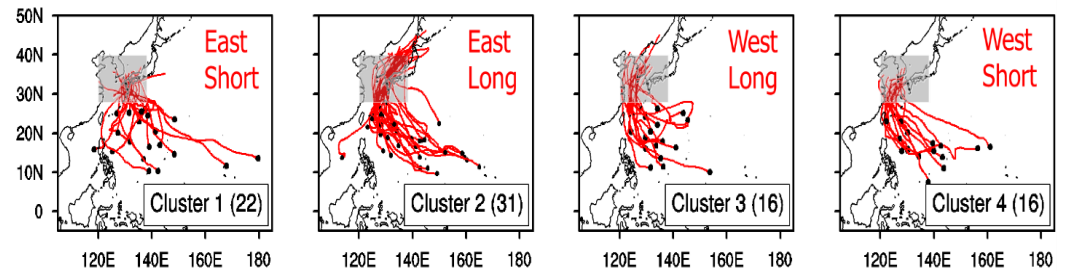


# Results

- The four track patterns are characterized by their entering location and length.
  - I. East-short, east-long, west-long, and west-short
  - II. In order of occurrence frequency, it is east-long, east-short, west-long, and west-short.
  - III. There is less chance to approach south Korea from its west with sustaining intensity due to East China continent, which can weaken tropical cyclone via larger friction and less moisture there.



# Results



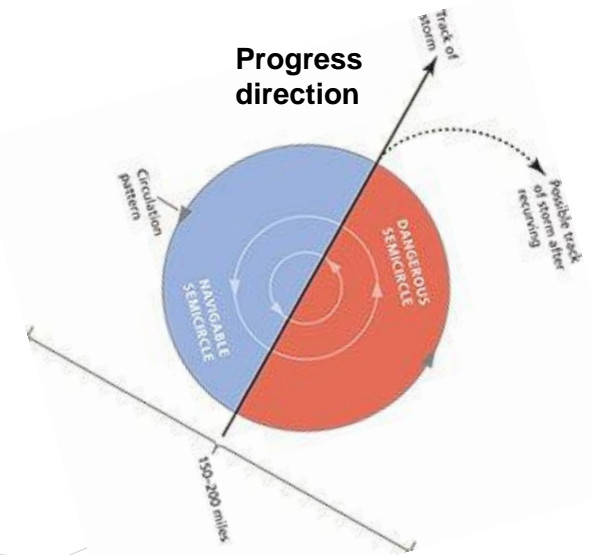
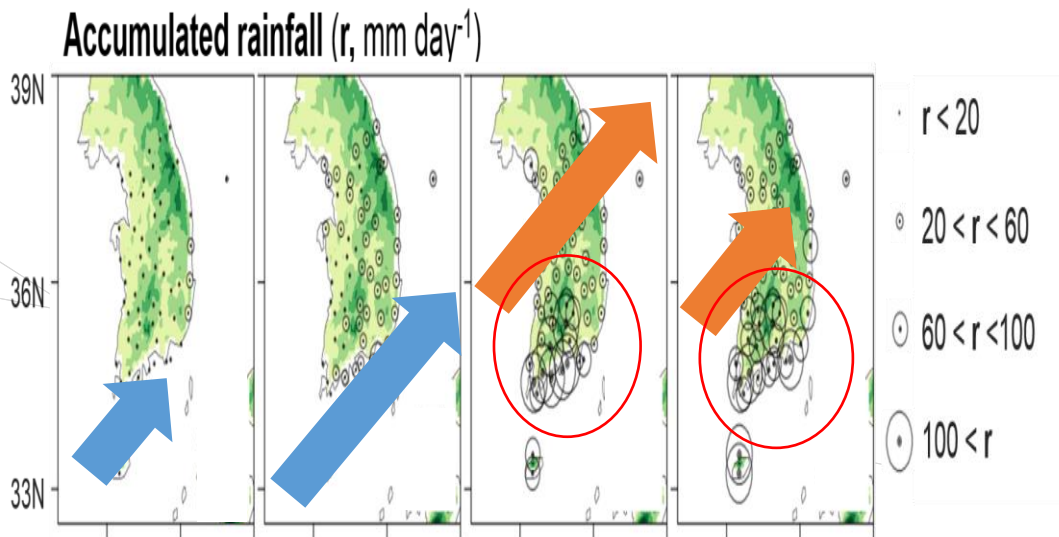
- In order of potential hazard, it is east-long, west-long, west-short, and east-short.
  - I. If we rely on only potential hazard, east-long pattern should incur the largest damage.
  - II. In order of damage, it is west-short, west-long, east-long, and east-short, which is same as that of active hazard.
  - III. In correlation with damage, active hazard is higher.

Risk elements	Magnitude rank
Potential hazard	East-long > West-long > West-short > East-short
Active hazard	<b>West-short &gt; West-long ≥ East-long &gt; East-short</b>
Damage	<b>West-short &gt; West-long &gt; East-long &gt;&gt; East-short</b>

**Correlation with damage: Active hazards (~0.75) >> Potential hazards (~0.25)**

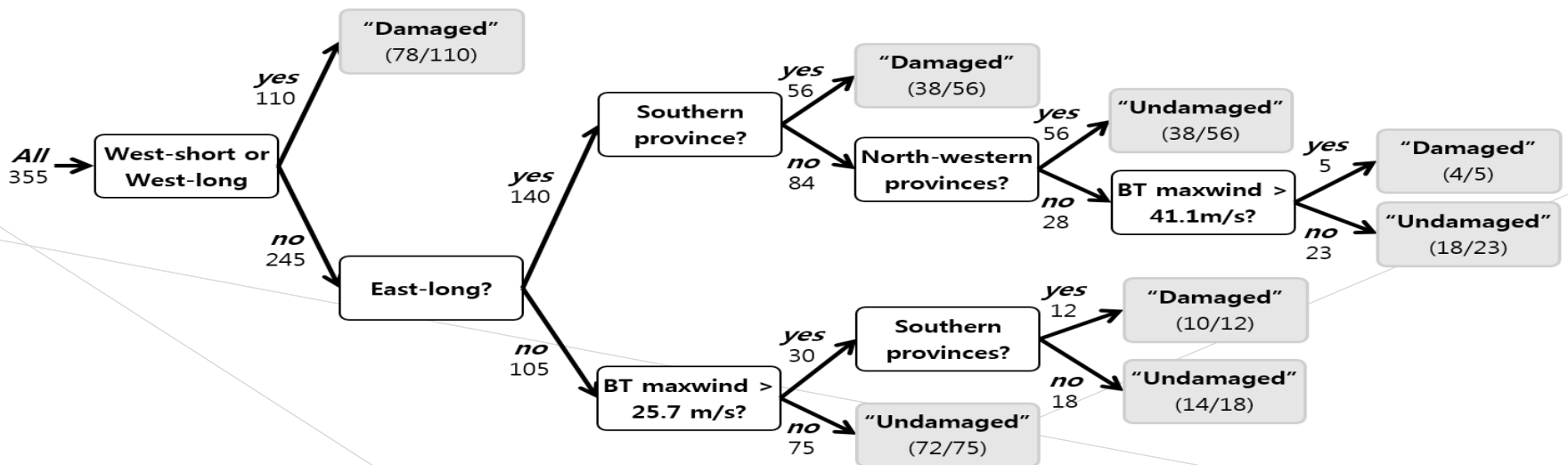
# Results

- How track differs active hazards from potential hazards?
  - I. West-type cyclones can stay longer over Korea.  
East-type patterns just pass by Korea while west-type ones penetrate Korea.
  - II. in west-type patterns, larger area can be exposed by dangerous semicircle



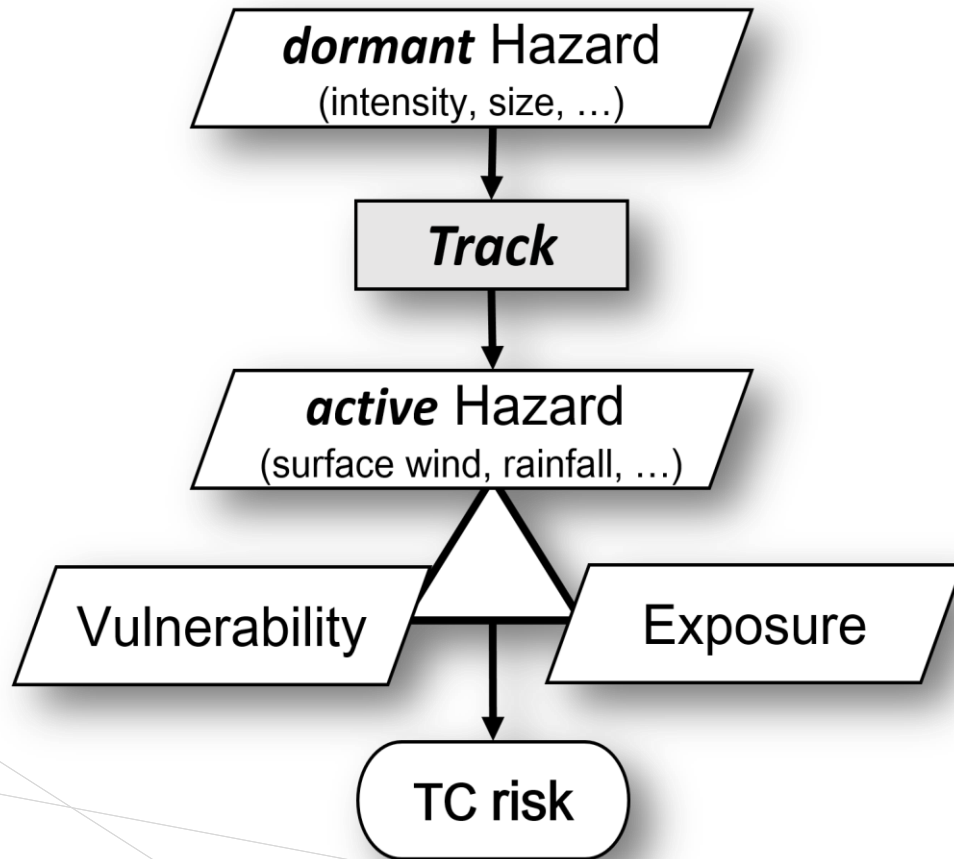
# Results

- According to the decision tree analysis, track is the most important in determining tropical cyclone risk.
  - I. 100% of track information was used to judge damaging or non-damaging cases while 48% and 37% of province and maximum wind information were used, respectively.
  - II. This implies that track information is a primary factor to determine damage occurrence.



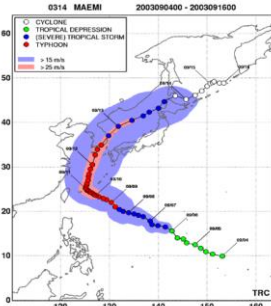
# Summary and future plan

## Conceptualization

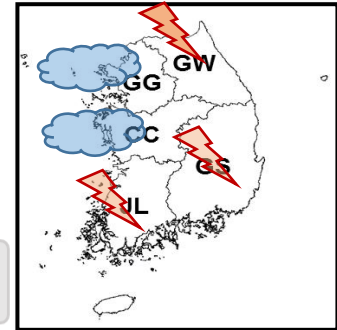
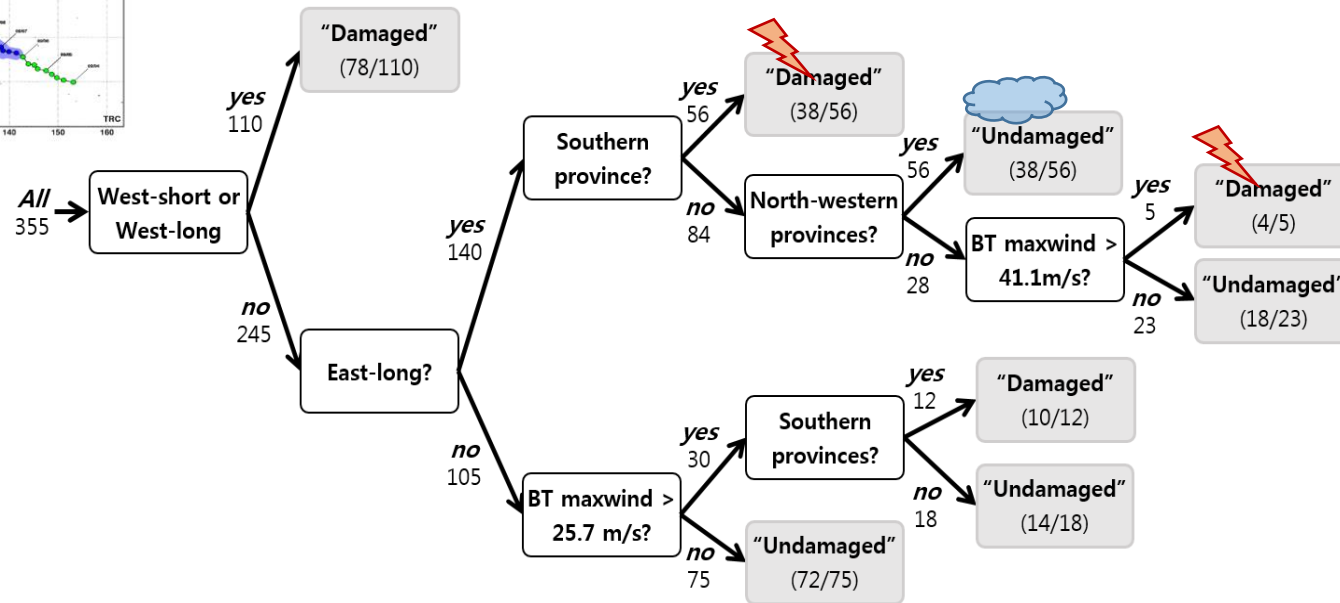


- High track-dependency is because track is responsible for the realization of active hazard by controlling multiple factors.
  - I. Influence duration
  - II. Relative position of dangerous/navigable semicircles
- It may be helpful to consider track together with potential hazard

# Summary and future plan



Maemi: 45 m/s



- We are developing a forecasting model on tropical cyclone risk based on the relationship shown in the decision tree analysis.
- The risk model may help a decision making related with disaster prevention.



**Thank you**