World Conference on Climate Change

World Conference on climate Change
October 24-26, 2016 Valencia, Spain

Susceptibility assessment of climate change-induced geo-disasters in Korea

2016. 10. 25

Moonhyeon Hong
Yonsei University

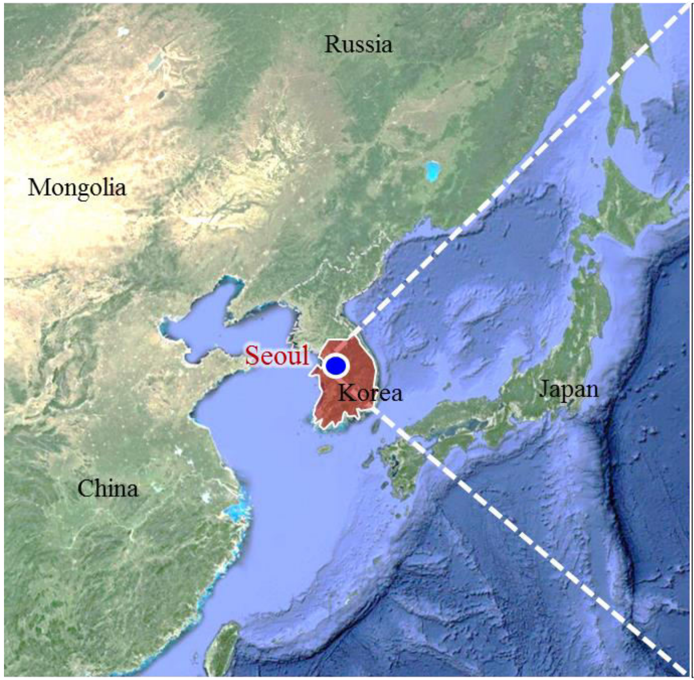
Sangseom Jeong
Junghwan Kim
Kwangwoo Lee

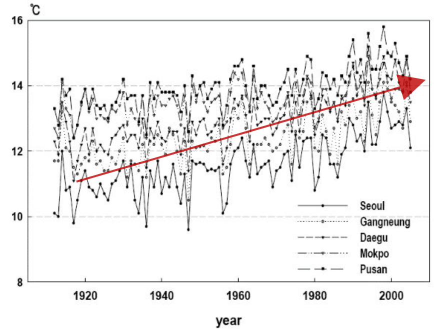
Contents

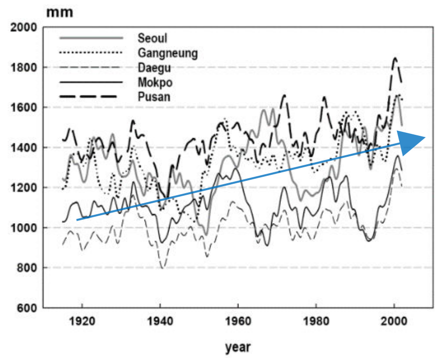
I Introduction

1. Climate change
2. Climate change-induced geo-disaster
3. Schematic diagram of study procedure

1 Climate change

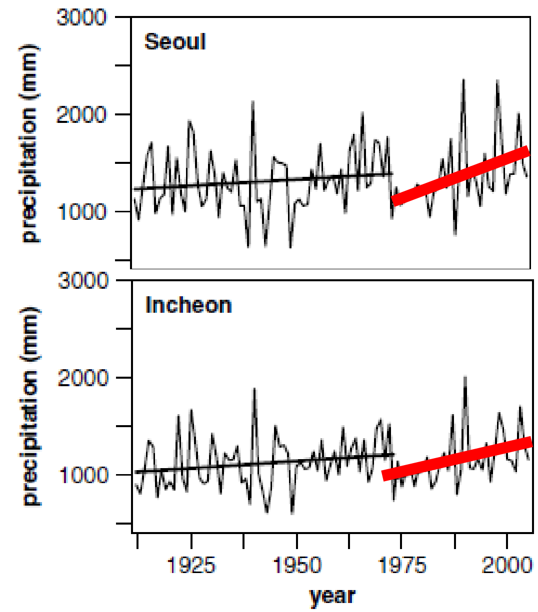






Warming

Rainfall increase



✓ *Climate change*

- More severe fluctuation in rainfall patterns

  (Rainfall intensity, frequency and quantity)

- Triggering the geo-disaster (landslide)

2 Climate change-induced geo-disaster

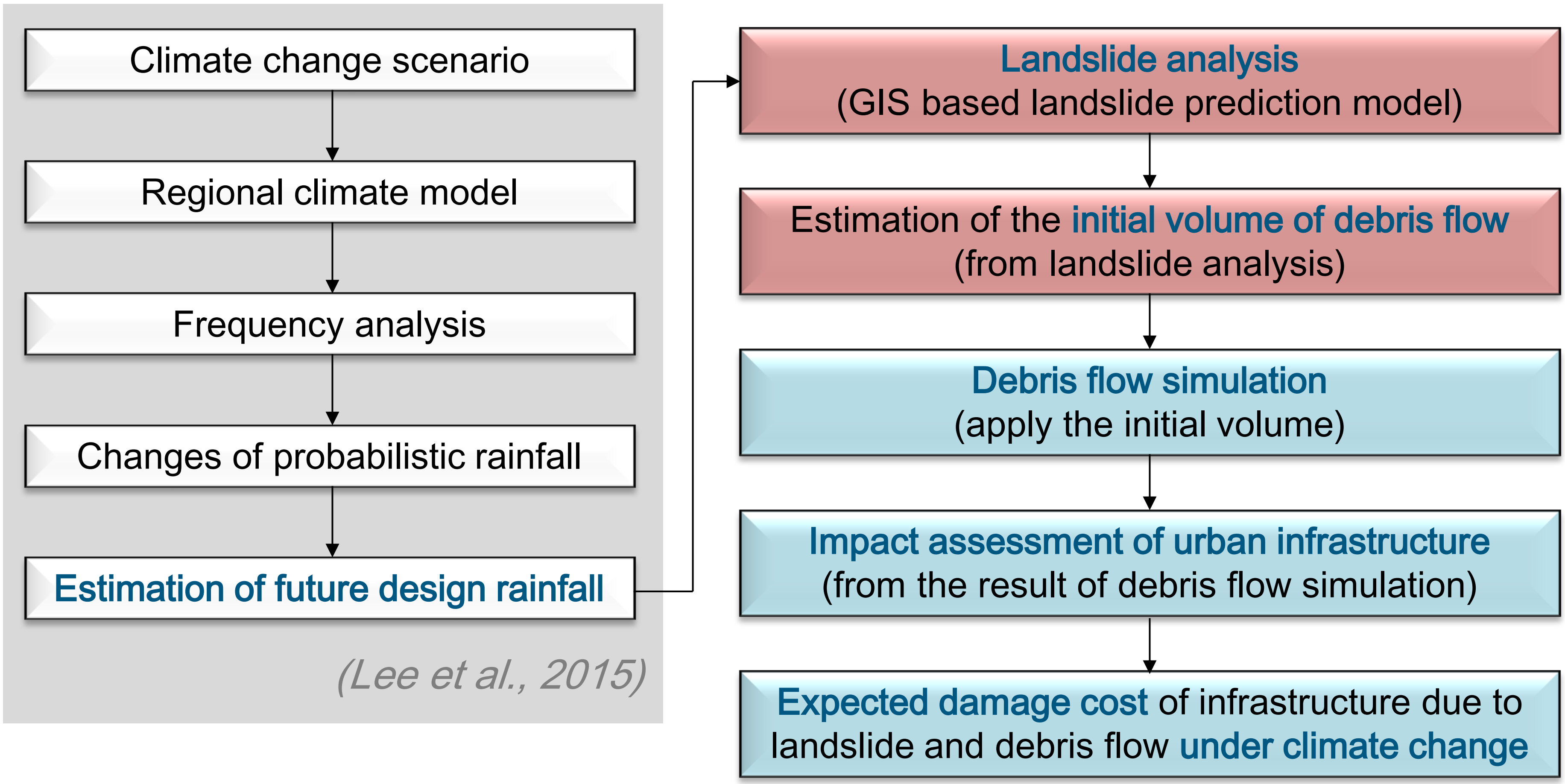
Backgrounds

- ✓ Global climate change is affecting regional weather patterns, rainfall trends, and their variability
- ✓ Extreme events like landslides related to geotechnical engineering are caused by climate change, particularly in Asia-Pacific Regions

Subject of analysis: landslides

- ✓ **One of the most critical disaster related geotechnical engineering**
- ✓ Extreme rainfall is main factor of landslides

3 Schematic diagram of study procedure

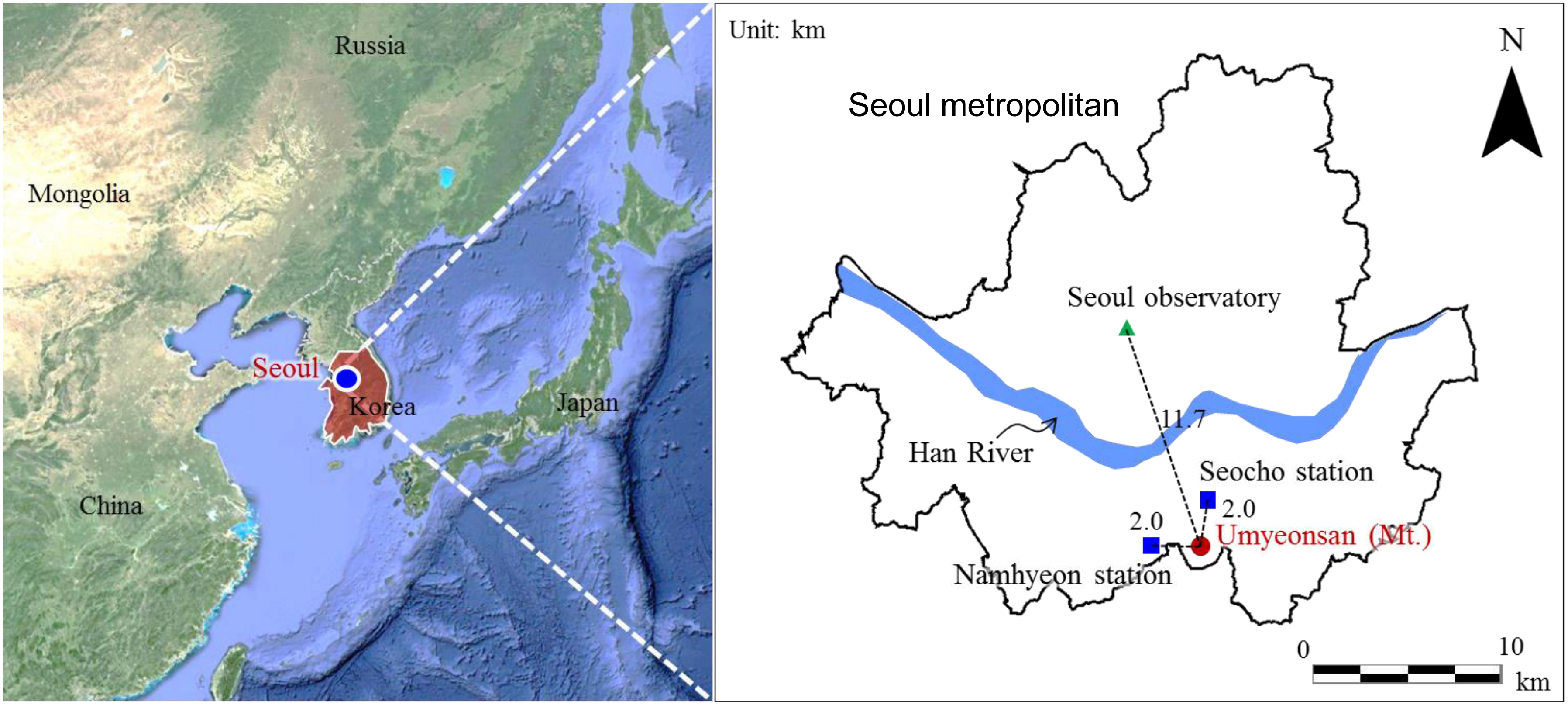


Ⅱ A case study on landslides

1. Study area: Umyeonsan (MT.)
2. Prediction model for landslide analysis
3. Analytical model for the debris flow

1 Study area

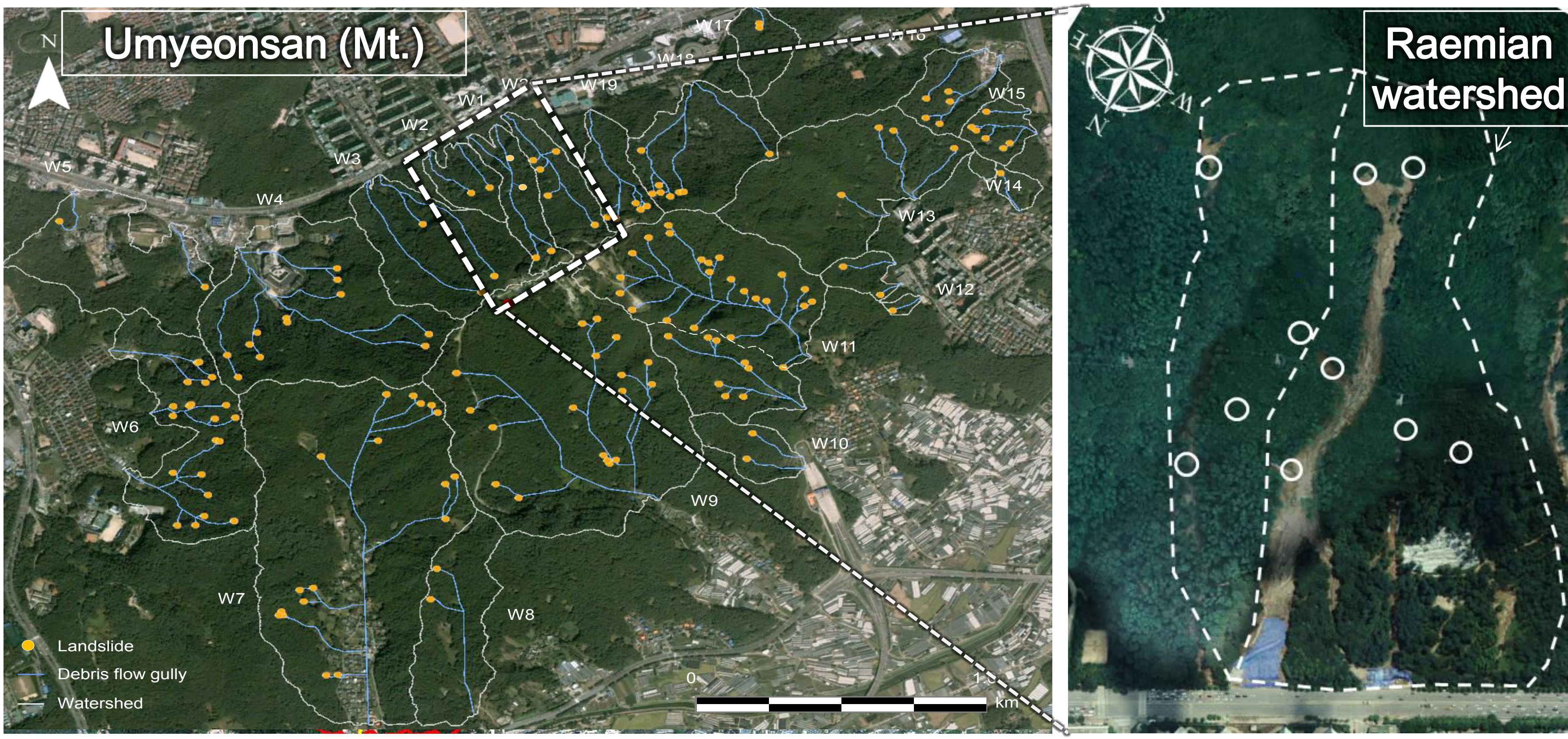
Umyeonsan (Mt.) landslide in July 2011



- ✓ Umyeonsan(Mt.) is located in **south-east of Seoul**
- ✓ **151 landslides** and **33 debris flows** occurred in 20 watersheds
- ✓ The accumulated rainfall of **24-h was 424.5 mm**.

(Jeong et al., 2015)

Study area: Raemian watershed, Umyeonsan (Mt.)



(Jeong et al., 2015)

2 Prediction model for landslide analysis

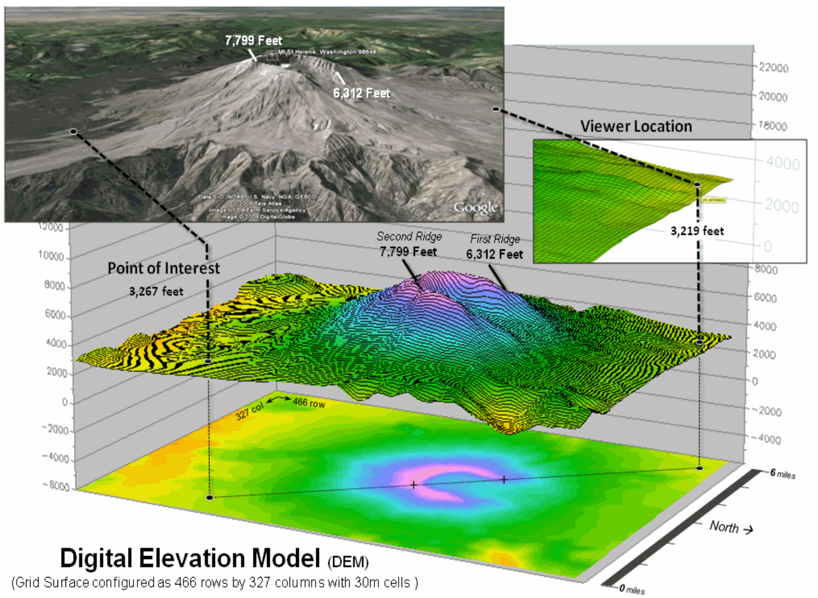
"Prediction model for rainfall-induced landslide based on 3D spatial data"

Background

- Considering rainfall intensity, duration and real-time rainfall
- Predicting the rainfall infiltration-groundwater flow from landslide mechanism
- Reflecting topography, hydrology, spatial characteristics
- Initial volume of debris flow based on regional scale hazard map (by applying future design rainfall)

2 Prediction model for landslide analysis

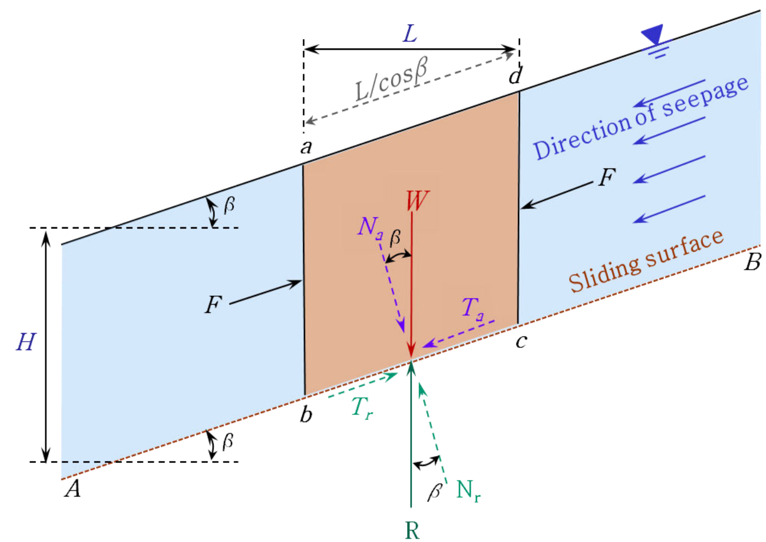
3D GIS data



Digital Elevation Model (DEM)
(Grid Surface configured as 466 rows by 327 columns with 30m cells)

- Topography: Slope, slope direction
- Hydrology : Precipitation data
- Spatial data : Soil and forestry

Physical Model



- Geotechnology: Unsaturated soil
- Infiltration : Modified G-A Model
- Failure model : Infinite slope model

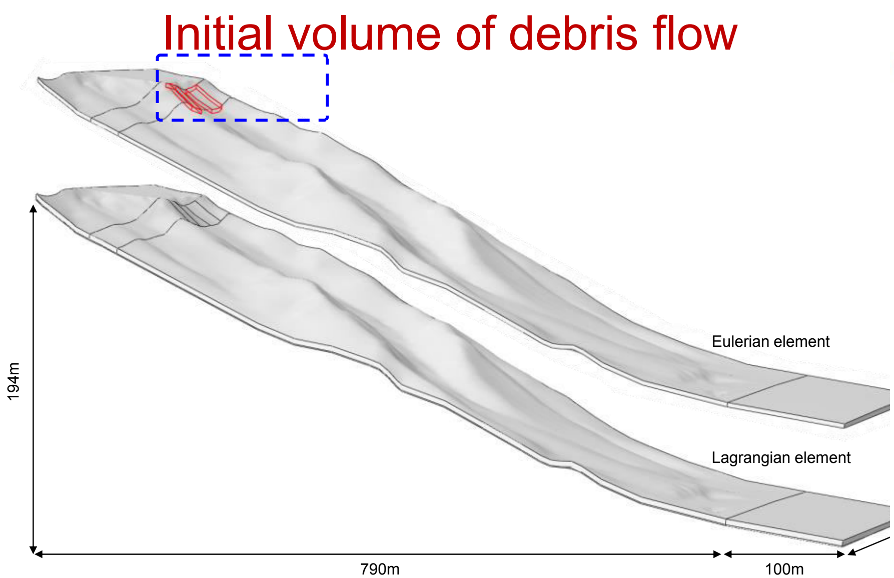
(Kim et al., 2014)

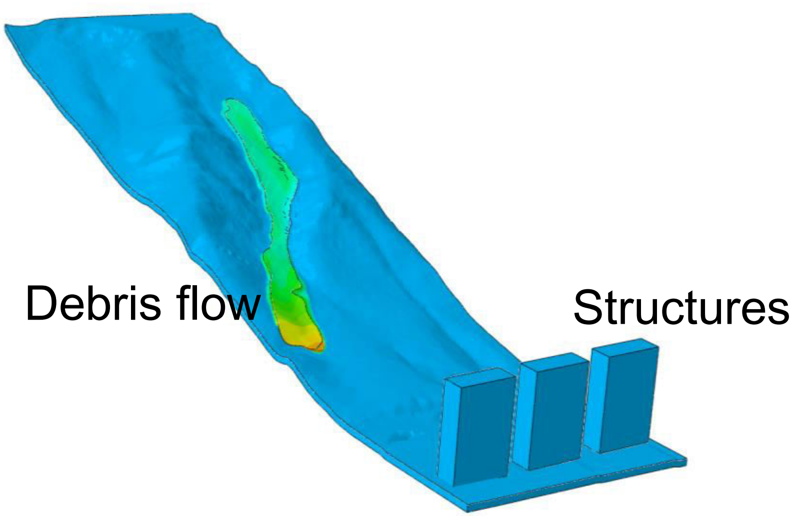
3 Analytical model for the debris flow

Debris flow model with erosion and entrainment of soil

- ✓ Simulation of debris flow based on Coupled Eulerian-Lagrangian (CEL) method
- ✓ Considering the erosion and entrainment of soil layer by debris flow

(Lee et al., 2016)

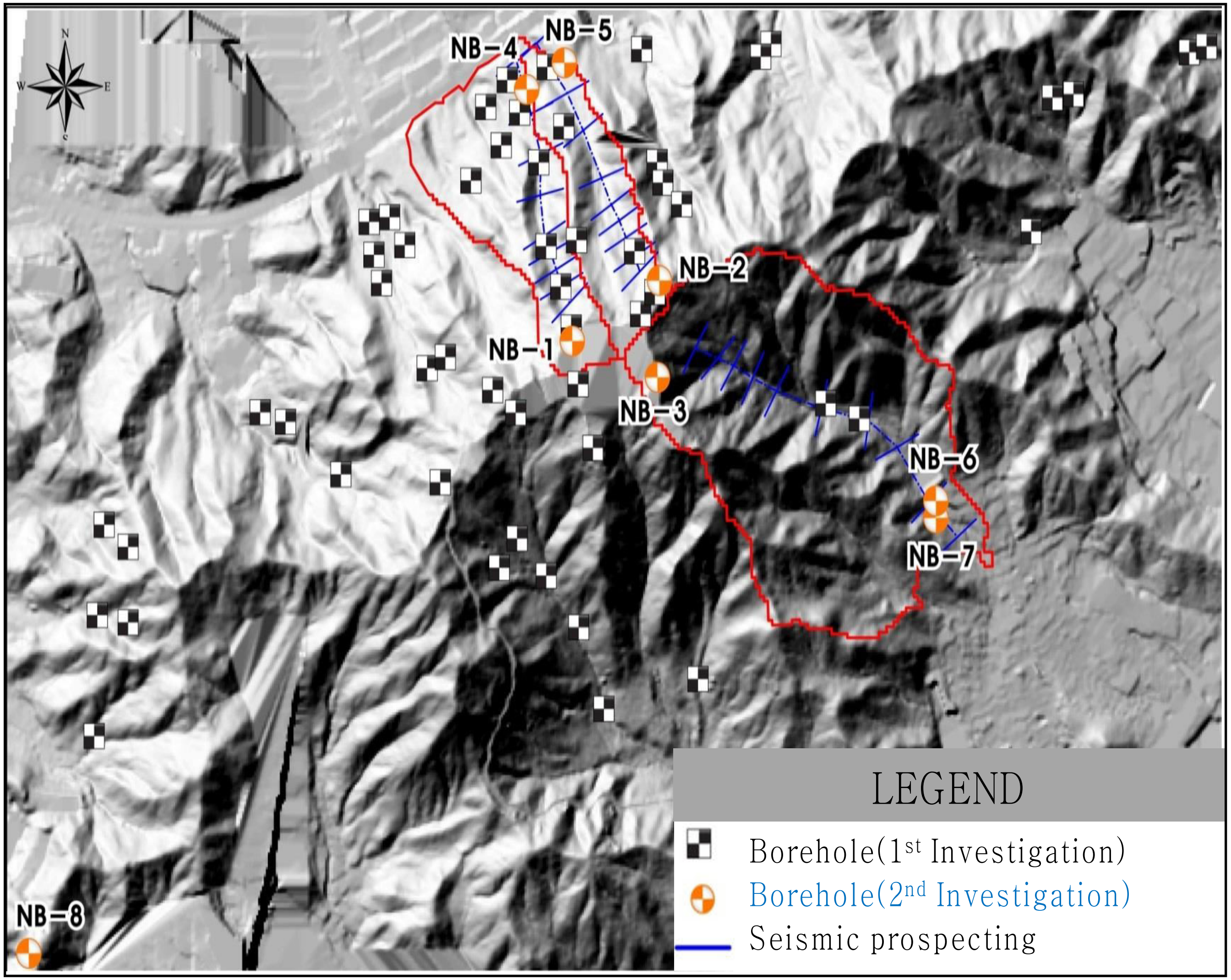




Ⅲ Susceptibility assessment of landslide

1. Site investigation and input parameters
2. Applied future design rainfall
3. Result of landslide analysis
4. Debris flow simulation

Site investigation



- Seismic Prospecting
- In-Situ Permeability
- SWCC
- Borehole Shear Test
- Direct Shear Test
- SPT

Input parameters: soil properties and depth

❖ Soil Property

Parameters	Values	Description
Hydraulic conductivity, k_s	8×10^{-4} cm/s (28.8 mm/h)	In-situ permeability test
Initial water contents, θ_i	28.0–32.0 (30.0) %	SWCC test
Water-content deficit, $\Delta\theta$	0.20	SWCC test
Wetting front suction head, ψ_f	830 mm	SWCC test
Soil cohesion, C'_s	10.2–12.8 (11.0) kPa	Direct shear test, borehole shear test
Soil friction angle, φ'	22.4–26.6 (26.5)°	Direct shear test, borehole shear test
Total unit weight of soil, γ_t	17.0–18.5 (18.0) kN/m^3	Laboratory test of density
Additional shear strength by roots of tree, C'_r	1.0 kPa	Suggested by Norris (2008)
Uniform load by tree, q_0	0.253 kPa	Suggested by KFRI (2006)

(Kim et al., 2014)

❖ Soil Depth

- **Raemian watershed :** 4.0~10.0 m

2 Applied future design rainfall

Future design rainfall based on climate change scenario

✓ Future period: S0 (1971-2000), S1 (2011-2040), S2 (2041-2070), S3 (2071-2100)

✓ Applied rainfall: 100-year return periods, 24-hour duration

Applied rainfall intensity

- S0 (1971-2000): 18.16 mm/hr
- S1 (2011-2040): 24.71 mm/hr
- S2 (2041-2070): 26.65 mm/hr
- S3 (2071-2100): 32.53 mm/hr

(Lee et al., 2015)

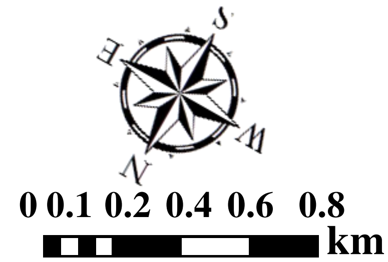
3 Result of landslide analysis

Safety factor

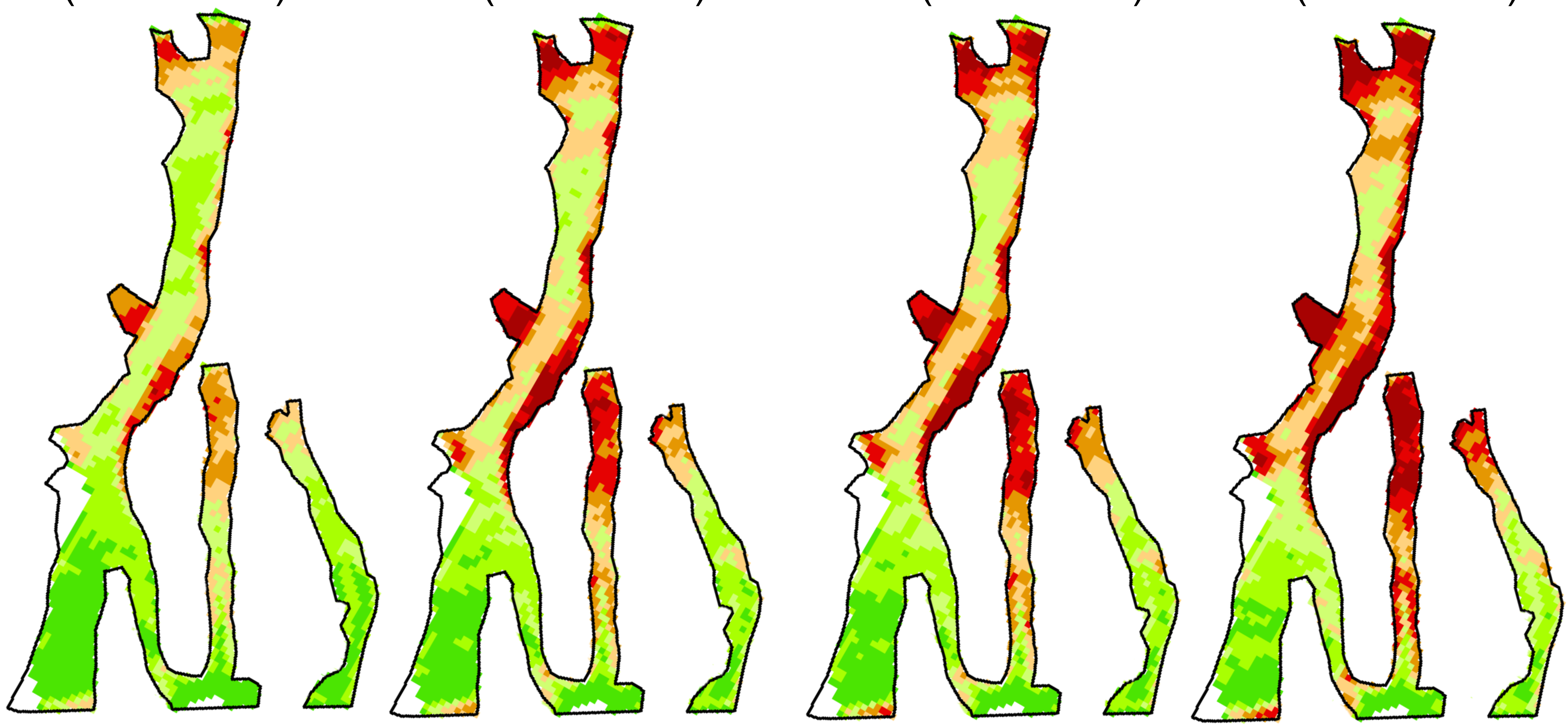
- 0 – 0.8
- 0.8 – 1.0
- 1.0 – 1.2
- 1.2 – 1.5
- 1.5 – 2.0
- 2.0 – 3.0
- 3.0 – 5.0

Initial volume of debris flow

- S0 : 546 m^3
- S1 : 4,330 m^3
- S2 : 5,301 m^3
- S3 : 7,463 m^3

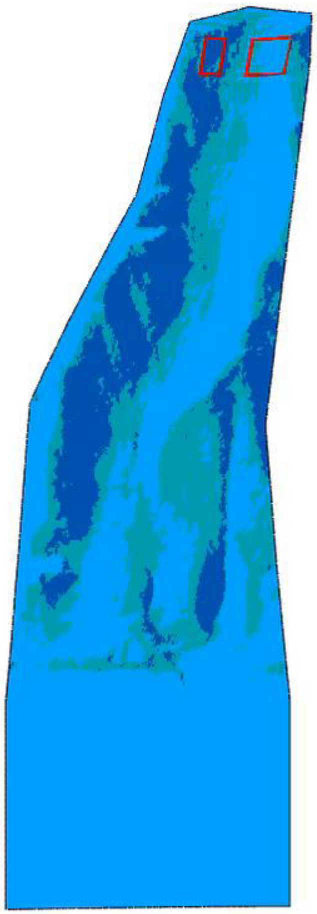


S0 (1971-2000) S1 (2011-2040) S2 (2041-2070) S3 (2071-2100)

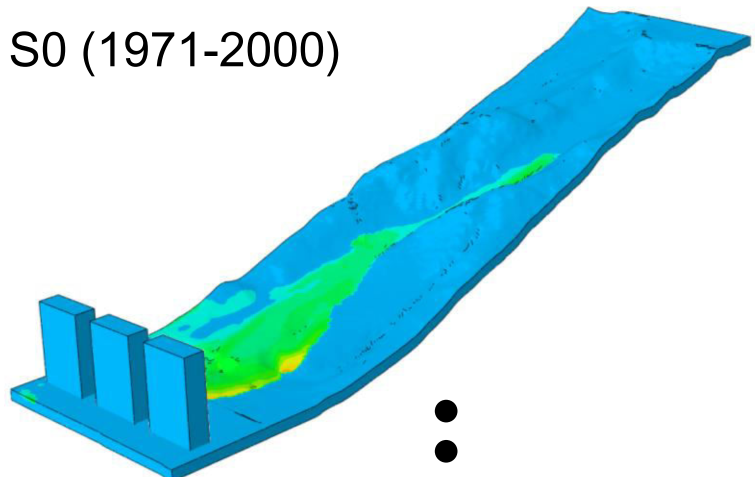


4 Debris flow simulation

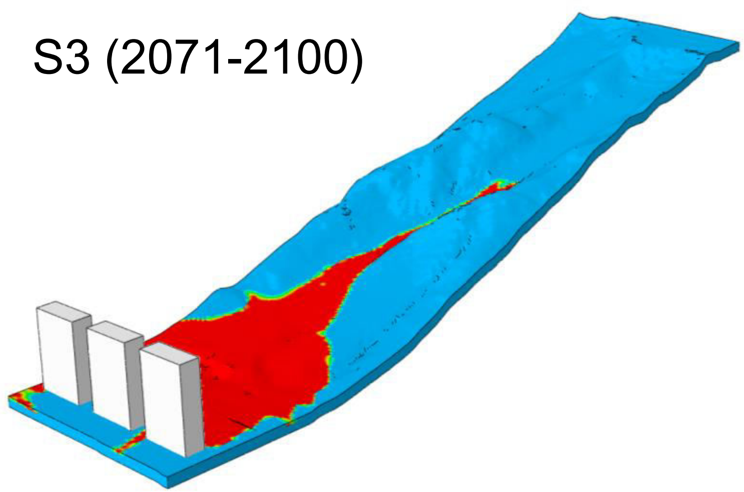
Impact assessment of urban infrastructure (from the result of debris flow simulation)



S0 (1971-2000)



S3 (2071-2100)



Damaged area and height

- S0 : 7,802 m^2, 0.5 - 1 m
- S1 : 61,874 m^3, 1 – 1.5 m
- S2 : 75,749 m^2, 1 – 1.8 m
- S3 : 106,643 m^3, 1.5 - 2 m

Expected damage cost

- S0 : € 395,672.5
- S1 : € 4,465,180.91
- S2 : € 6,549,371.71
- S3 : € 10,227,664.08

Summary

Period for analysis (yr)	Applied rainfall intensity (mm/hr)	Initial volume of debris flow (m^3)	Damaged areas (m^2)	Damaged heights (m)	Expected damage costs (€)
S0 (1971-2000)	18.16	546	7,802	0.5-1.0	395,673
S1 (2011-2040)	24.71	4,330	61,874	1.0-1.5	4,465,181
S2 (2041-2070)	26.65	5,301	75,749	1.0-1.8	6,549,372
S3 (2071-2100)	32.53	7,463	106,643	1.5-2.0	10,227,664

IV Conclusions

Conclusions

- By using some ewll=designed model and climate scenario, we conducted the susceptibility assessment of landslides for a case study of mountain Umyeonsan, estimating the impacts and the expected costs of infrasturctures due to landslides and debris flow under climate change.
- From the results of this study, we can conclude that the climate change-induced geo-disasters like landslides or debris flow will be increased, and the damage of infrastructures due to the geo-disasters will be increased.
- The result of these study can be useful information for early warning system of landslides and debris flows.

Thank You

http://www.git4cc.com

World Conference on
Climate Change