Analysis Of Debris Flow Behavior Considering Driftwood And Entrainment-Erosion

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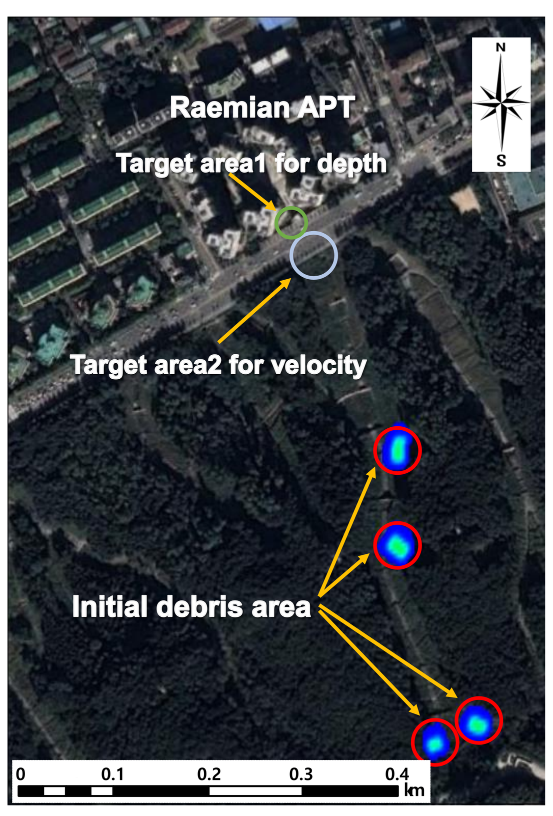
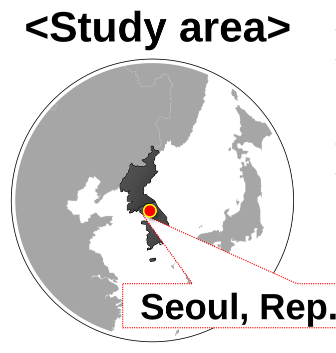
INTRODUCTION

- A numerical model for debris flow, considering driftwood and entrainment-erosion, was developed and applied to simulate the 2011 Mt. Umyeon landslide based on observed data.
- Initially, a driftwood dynamics model based on the particle method was integrated with the Nays2DFlood model to simulate the generation and behavior of driftwood, and an entrainment-erosion module was incorporated to replicate the erosion and volume increase behaviors of the debris flow.
- For the analysis of debris flow behavior, firstly, the Takahashi method of mixed concentration-transport-diffusion based ground shear stress and entrainment-erosion module was applied.
- Secondly, the ground shear stress method of the Voellmy-type mixture and the entrainment-erosion module by Frank et al. (2015) were implemented to compare and analyze the simulation results with the Takahashi method.

COMPUTATIONAL SETUP



<Study area>



- The study area is Mt. Umyeon in Seoul, South Korea, where there are 0.06 trees/m^2
- The simulation case, parameters, and modeling methods are as follows

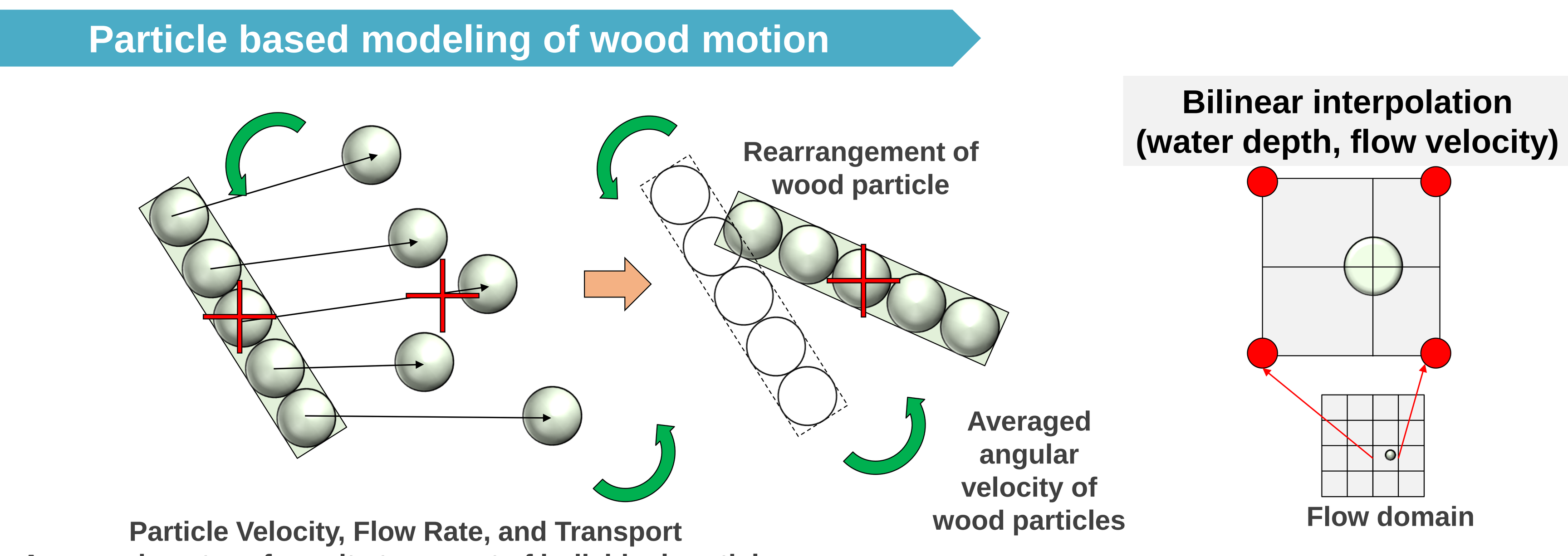
<Simulation case>

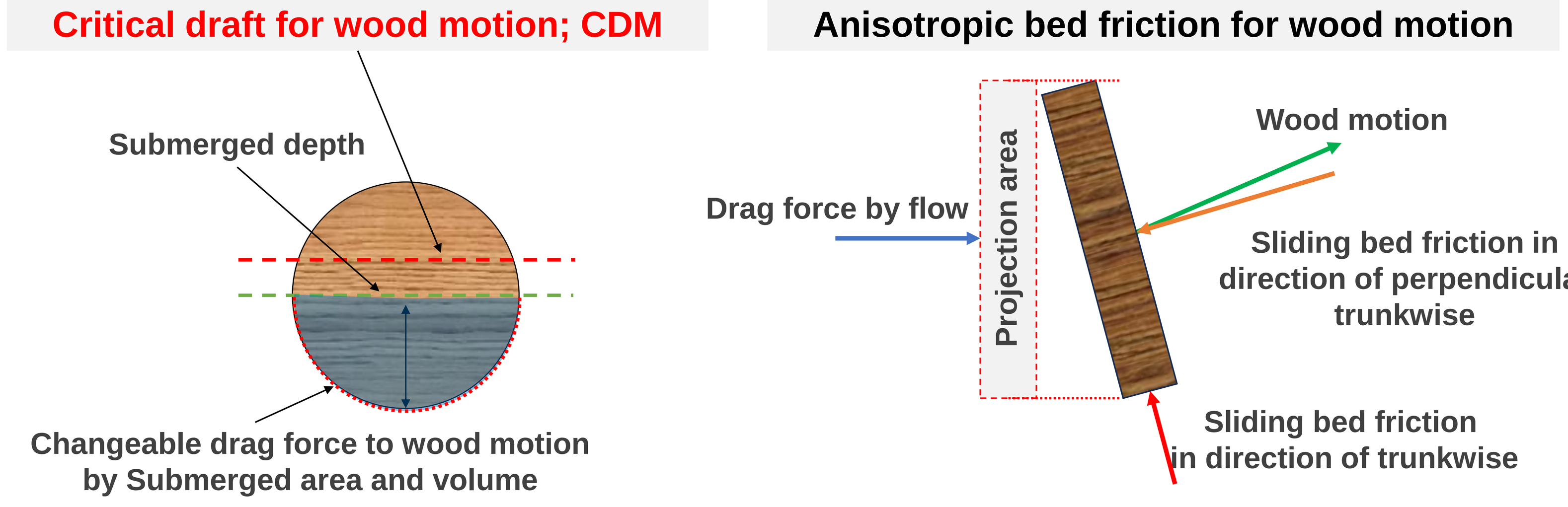
Run	Driftwood	Tree Density	Shear stress Eq.	Entrainment erosion
T-N	N	0	Manning, Takahashi (1991)	Takahashi (1991)
T-W	Y	0.06	Manning, Takahashi (1991)	Takahashi (1991)
T-W2	Y	0.12	Manning, Takahashi (1991)	Takahashi (1991)
T-W4	Y	0.24	Manning, Takahashi (1991)	Takahashi (1991)
V-N	N	0	Voellmy	Frank et al. (2015)
V-W	Y	0.06	Voellmy	Frank et al. (2015)
V-W2	Y	0.12	Voellmy	Frank et al. (2015)
V-W4	Y	0.24	Voellmy	Frank et al. (2015)

<Simulation parameter>

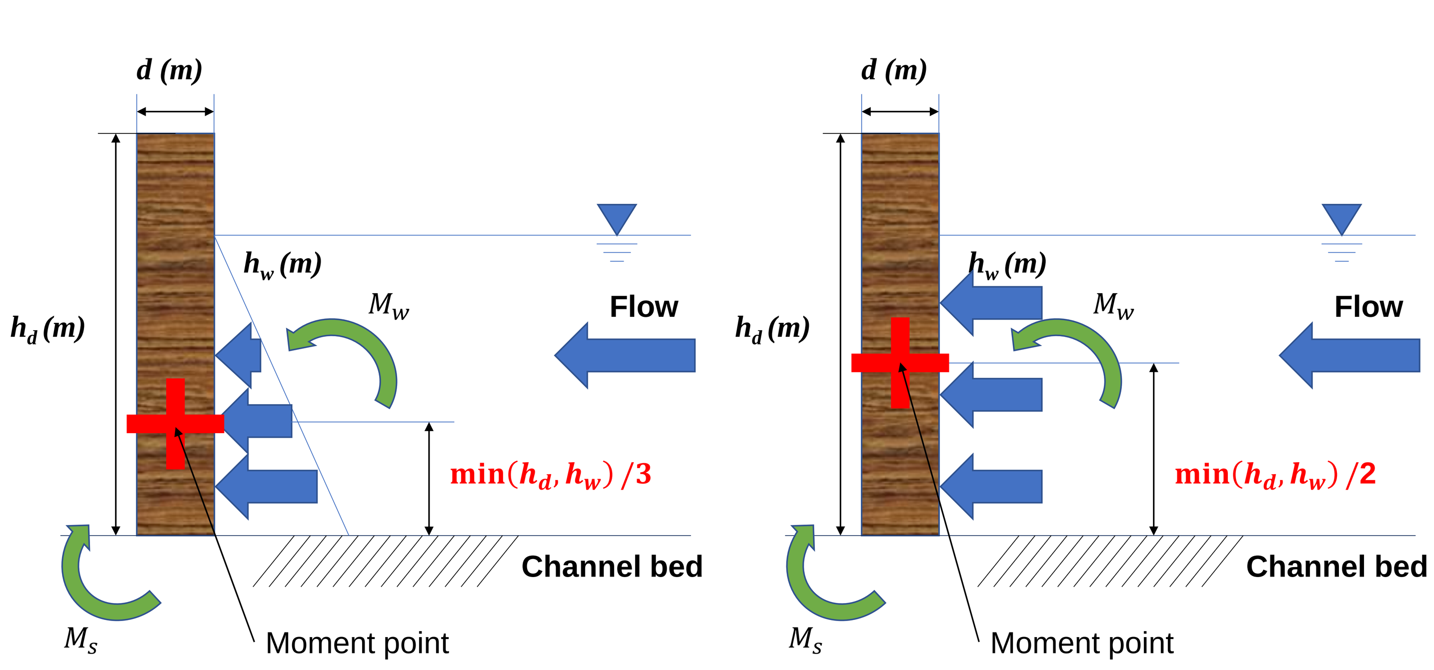
Parameter	Value (Unit)	Parameter	Value (Unit)
Flow condition		Turbulence model	Zero equation
Advection of concentration	Upwind	Advection of flow	TVD-MUSCL
Computational domain	0.6 (width) × 0.8 (length) (km^2)	Uniform grid size	3 × 3 (m^2)
Density of sediment mixture	2,000 (kg/m^3)	Initial debris volume	4,250 m^3
Wood profile		Density of forest	0.06(trees/m^2)
Density of wood	800 (kg/m^3)	Mean stem length	10.3 (m)
Static friction Coef. Of driftwood	0.7	Mean stem diameter	0.28 (m)
Rolling friction Coef. Of driftwood	0.2	Critical bending stress of wood deformation	10 MPa
Kinematic friction Coef. of driftwood	0.4	Critical bending stress of wood breaking	45Mpa
Voellmy-Frank et al. (2015)		**Takahashi method**	
Coluomb friction Coef.	0.1	Angle of repose	30°
Shear stress for entrainment erosion	1 Kpa	Manning roughness Coef.	0.05 (s/m$^{1/3}$)
Coef. of turbulence shear stress	3,000 (m/s^2)	Concentration of Min. sediment mixture	0.4
Coef. of shear stress for entrainment erosion	0.3 (N/s)	Concentration of Max. sediment mixture	0.55
Erosion rate for Frank et al.(2015)	0.08 (m/s)	Erosion ratio for Takahashi Eq.	0.001
Deposition rate for Frank et al.(2015)	0.01 (m/s)	Deposition ratio for Takahashi Eq.	0.01

Particle based modeling of wood motion





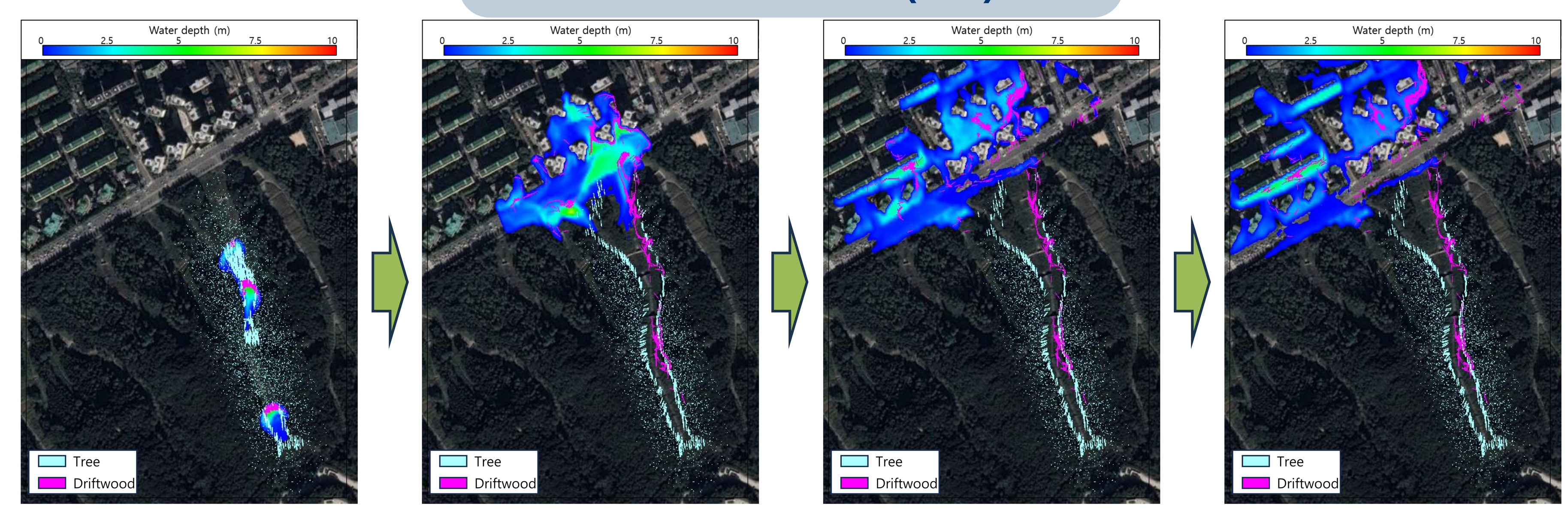
<Driftwood modelling>



<Driftwood generation by external force>

SIMULATION RESULT

Takahashi method (T-W)



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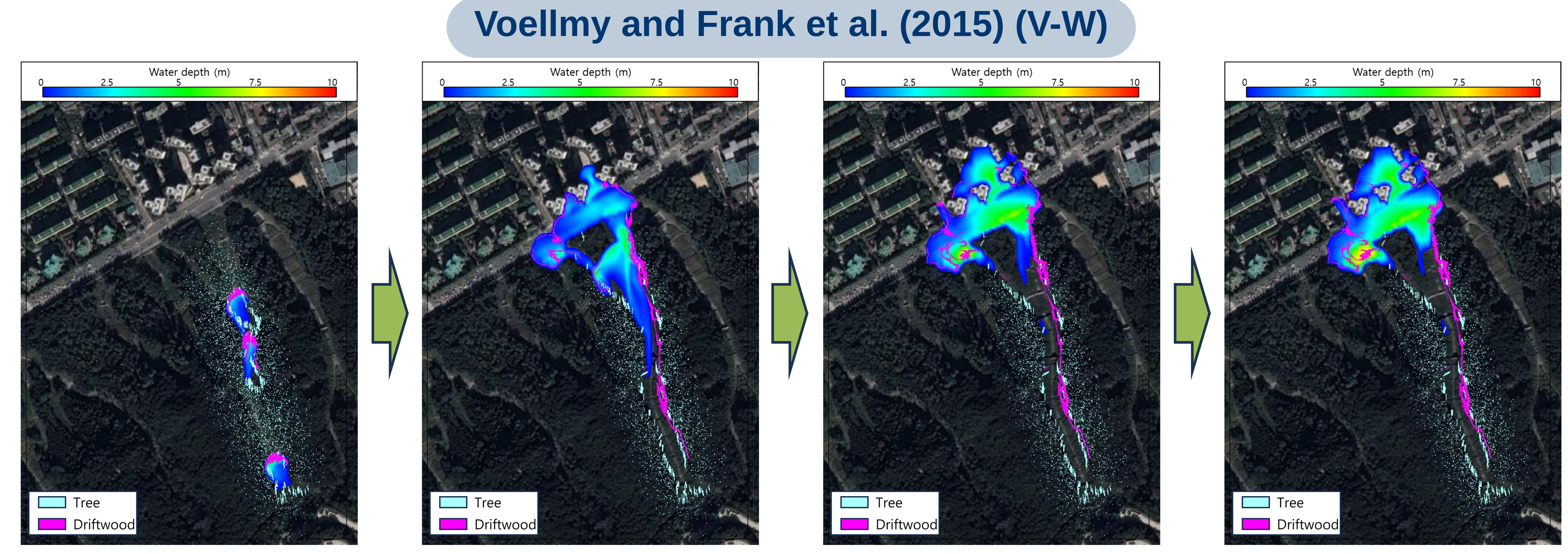
Voellmy and Frank et al. (2015) (V-W)



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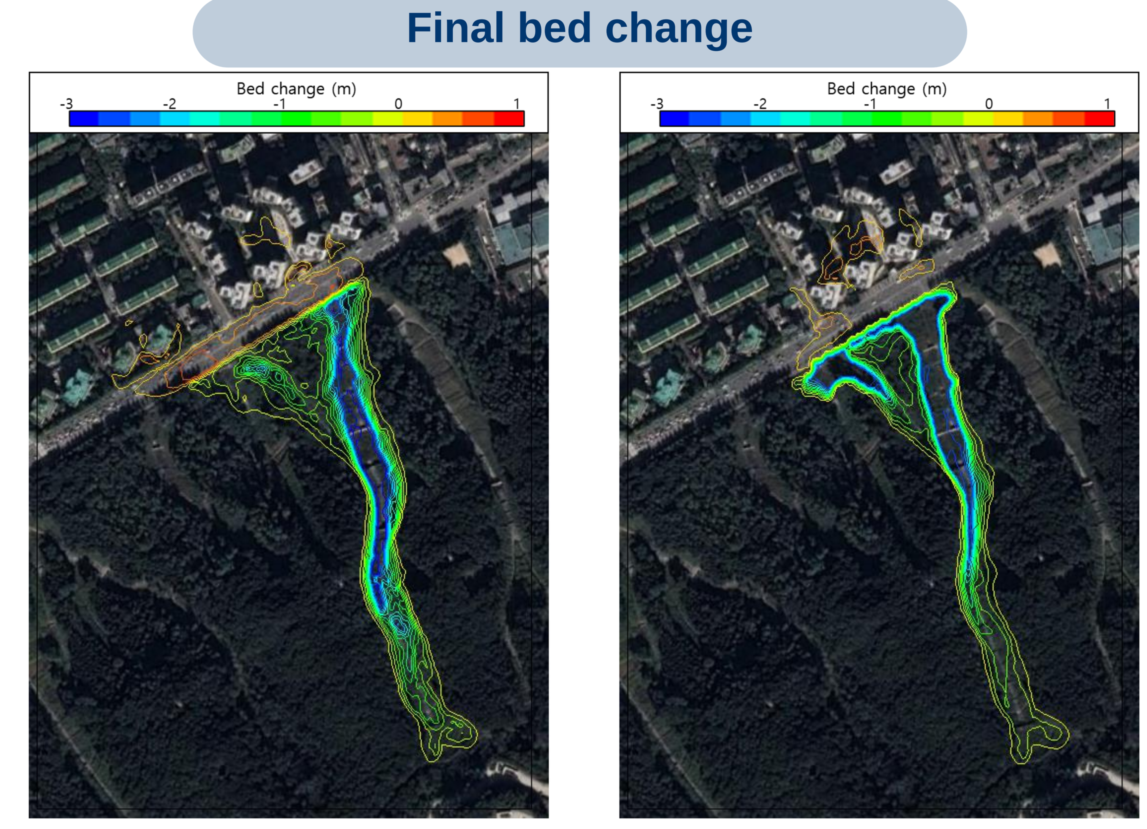
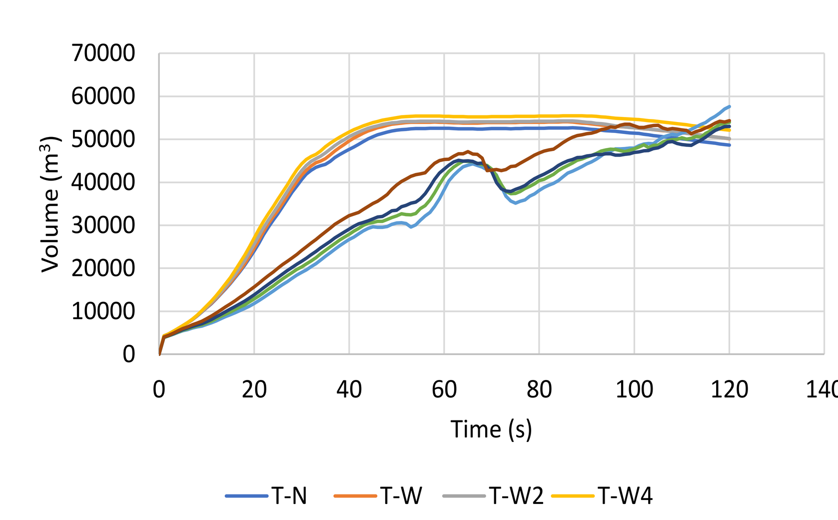
Final bed change



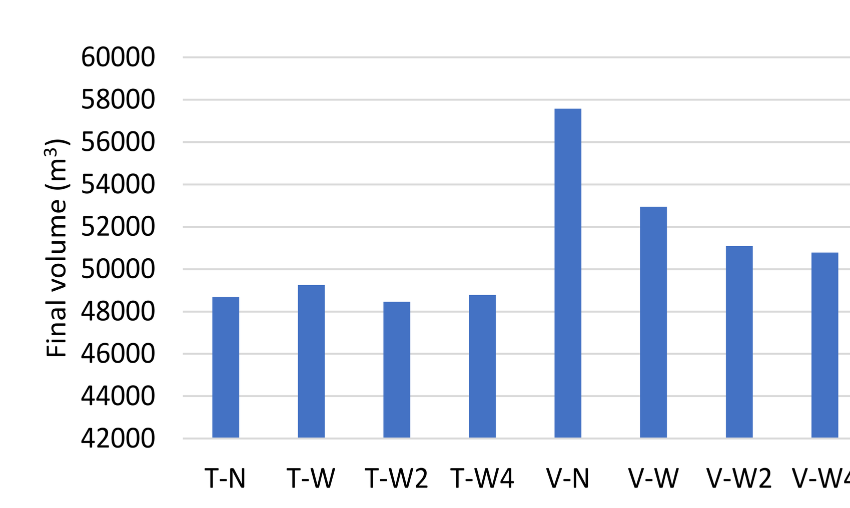
<T-W> <V-W>

<Final result of simulation cases>

Run	Final volume of debris flow (m^3)	Max. velocity of inflow (m/s)	Max. depth of impact depth (m)
Obs.	42,500	28.00	10.00
T-N	48,677	15.14	5.96
T-W	49,256	20.32	6.98
T-W2	48,455	17.99	7.95
T-W4	48,783	15.57	7.11
V-N	57,582	11.71	6.09
V-W	52,949	11.69	5.95
V-W2	51,096	13.03	6.01
V-W4	50,786	13.96	6.97



<Time changes in volume of debris flow>



<Final volume of debris flow>

CONCLUSION

- Based on the two methods, the simulation results were deemed to accurately reproduce the impact depth, impact velocity, and final volume of the debris flow that caused damage to the Raemian APT during the Mt. Umyeon landslide
- However, it was indicated that the Takahashi method resulted in a wider inundation area of the debris flow
- The results of this study are expected to be utilized as part of establishing debris flow mitigation strategies by predicting the occurrence of debris flows caused by the uncertainties of rainfall due to climate change in advance

REFERENCES

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