NUMERICAL EXPERIMENT FOR DRIFTWOOD DYNAMICS CONSIDERING ROOTWAD EFFECT AND WOOD COLLISION

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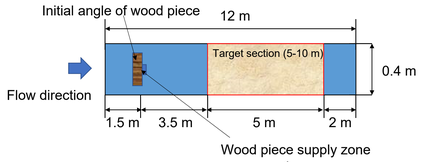
INTRODUCTION

- We carry out the flume experiments and numerical simulations to examine the effect of driftwood deposition patterns and bed deformation
- To quantify the bed deformation based on potential hydrodynamic changes by driftwood, we estimate non-dimensional stream power index (NDSPI) and bed relief index (BRI)
- We compared the simulations with experimental results
- This study shows useful data of interaction between the driftwood congestion and bed deformation
- This work can suggest the treatments for driftwood and bar formations in the numerical and experimental ways

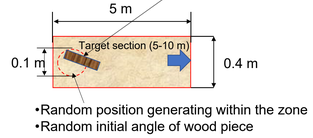
METHODOLOGY

Computational and experimental parameters	
Parameter	Value
Flow discharge	1.1 liter/s
Computational domain size (uniform rectangular grid shape)	5 m × 0.4 m
Bed slope	0.005 m/m
The resolution of gauged bed elevation (Δx and Δy)	0.001 m × 0.02 m
The resolution of computational grid length (Δx and Δy)	0.02 m × 0.02 m
Manning roughness coefficient	0.013 $sm^{-1/3}$
Uniform grain size	0.51 m/m
The total input number of driftwood pieces per case	200 (=100 rootwad + 100 no roowad)
Critical draft for wood motion (trunk particle)	0.0057 m
Critical draft for wood motion (root wad particle)	0.008 m
Static bed friction coefficient	0.5
Kinematic bed friction coefficient	0.2
Rolling bed friction coefficient	0.075
Eddy viscosity for zero equation	0.4
Time for experiment and simulation	40 min
Time interval for wood supply	5 s or 9 s
Range of initial angle of wood piece	0-360 [degrees]
Diameter of wood pieces generating zone	0.1 m
Poisson ratio	0.3
Young modulus	100000 psi
Time step of driftwood motion in simulation	0.00001 s
Time step of water flow & bed deformation in simulation	0.01 s

Flume domain



Computational domain

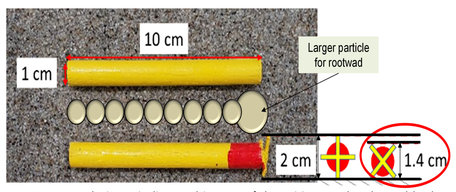


Conceptual collision model

$$\begin{cases} \mathbf{u}_p = \mathbf{u}_p + \Delta t \mathbf{F}, & \text{if } h > \text{CDM} \\ \mathbf{u}_p = \mathbf{u}_w, & \text{if } h \le \text{CDM} \end{cases}$$

Non-dimensional stream power index

$$\omega^* = \bar{q}\bar{S}\,[(S_s - 1) g d_m{}^3]^{-0.5},\ q = \bar{V} \times \bar{d}$$



Most wood pieces indicates this type of deposition on the channel bed

Experimental and simulation cases		
	Time interval of wood supply	Random parameter
Exp1	5 s	Absent
Exp2	9 s	Absent
Sim1	5 s	• Generating position of wood pieces within the supply zone • Initial angle of wood piece
Sim2	5 s	
Sim3	5 s	
Sim4	9 s	
Sim5	9 s	
Sim6	9 s	

REFERENCE

- Kang, T. and Kimura, I. (2018). Computational modeling for large wood dynamics with root wad and anisotropic bed friction in shallow flows. *Advances in Water Resources*, 121: 419-431.
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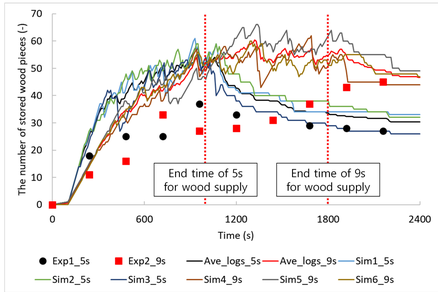
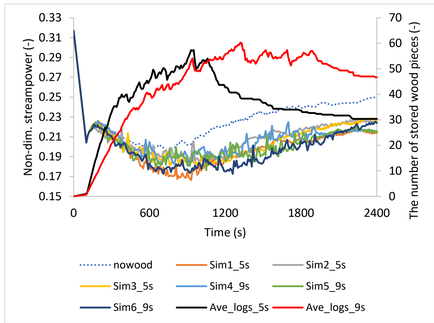
- Kang, T., Kimura, I. and Shimizu, Y. (2020). Numerical simulation of large wood deposition patterns and responses of bed morphology in a braided river using large wood dynamics model. *Earth Surf. Processes Landforms*, doi: 10.1002/esp.4789.
- Kimura, I. and Kitazono, K. (2019). Effects of the driftwood Richardson number and applicability of a 3D–2D model to heavy wood jamming around obstacles. *Environmental Fluid Mechanics*, doi.org/10.1007/s10652-019-09709-6.

COMPUTATIONAL AND EXPERIMENTAL RESULTS

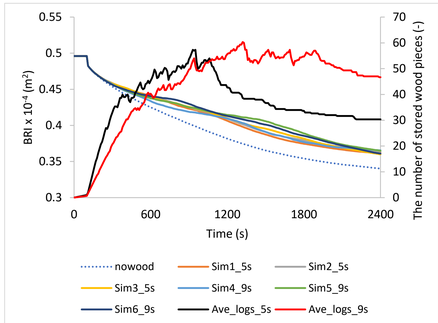
Time changes in the number of stored wood pieces



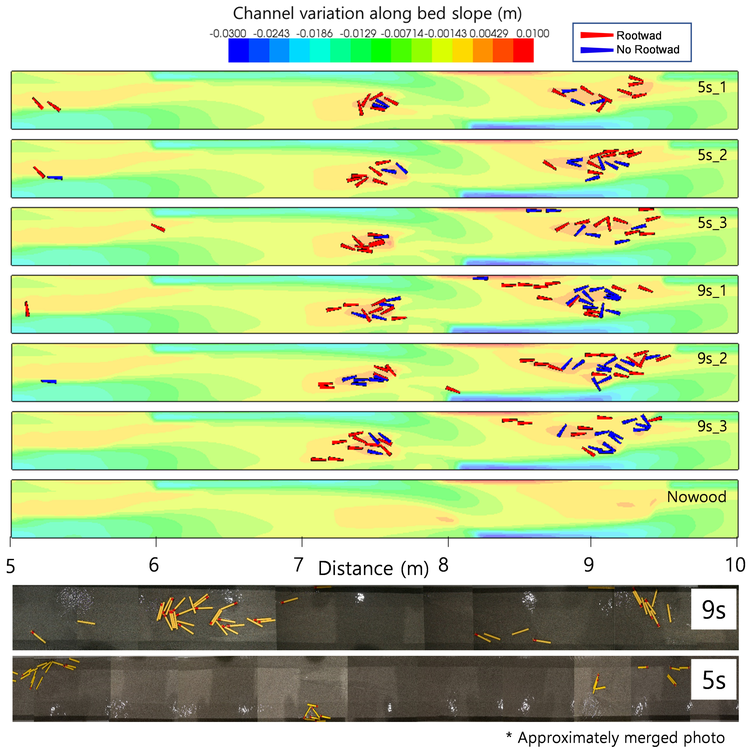
Time changes in NDSP



Time changes in BRI

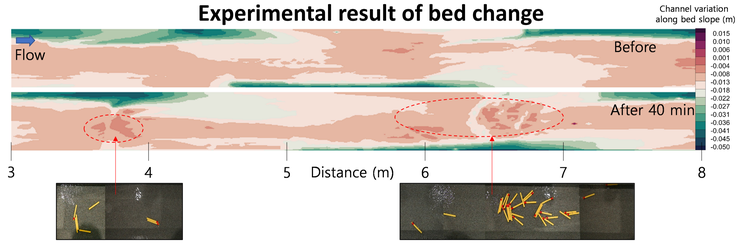


Simulation result of driftwood deposition patterns



* Approximately merged photo

Experimental result of bed change



CONCLUSION

- In the experiments (Exp1 and 2), the time interval of wood supply may affect the final number of stored wood pieces
- This is because the greater number of wood pieces allows more active collisions with floating motion
- The simulations (Sim1-6) also partially reproduced the number of stored wood pieces
- Along with the experimental results, NDSPI and BRI showed that the driftwood can influence bar formation through the local deformations on the channel bed
- Our results can be useful data to take account of the relationship between bed deformation and driftwood
- In particular, this study enhanced the understanding of the totally submerged channel bed, so it can be one of the important cases for driftwood study
- For more detailed discussions, such as the refinement of the wood collision model, we would additionally compare the experimental results with numerical model refinement in the future works

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