L-114-01-65

Taiwan - Japan Simulation Technology for Urban Flooding and River Hydraulics Sediment Transport Technology Workshop & iRIC training session

臺日「都會區淹水與河川水理輸砂模擬技術」交流講席會

Taiwan-Japan Simulation Technology for Urban Flooding and River Hydraulics Sediment Transport Technology Workshop (STW)

The world faces significant challenges in water resource management and disaster prevention, especially the research and application of urban flooding and river hydraulic sediment transport simulation technology, which has become a critical issue of concern for all countries. Taiwan and Japan, as island nations frequently affected by earthquakes and typhoons, rely heavily on their river systems for agriculture, urban development, and ecological conservation. Therefore, both countries aim to deepen exploration, strengthen collaboration, and enhance technical exchanges in this category through the Taiwan-Japan Simulation Technology for Urban Flooding and River Hydraulics Sediment Transport Technology Workshop.

Rivers are vital water sources and crucial areas for human life and productivity. However, rivers also serve as significant channels for natural disasters, especially floods and landslides, which often cause severe damage to people's lives and property. Therefore, establishing effective river warning systems and developing efficient simulation technologies are crucial for disaster prevention and mitigation and for protecting people's safety. Both Taiwan and Japan, being highly prone to earthquakes and typhoons, have strong needs and experience in urban flooding and river hydraulics sediment transport simulation technology. Currently, both countries have relatively well-developed hydraulic engineering and disaster prevention systems. However, in the face of extreme weather changes caused by climate change, we still need to continuously innovate and improve our technologies to cope with the new challenges. Through this workshop, both sides will explore the latest technological developments, research findings, and practical applications and exchange ideas on strengthening future cooperation to enhance disaster prevention capacity. This workshop will not only deepen both countries' understanding of urban flooding and river hydraulics sediment transport technology. Still, it will also play a stronger foundation for future cooperation between the two countries in disaster prevention, jointly addressing various challenges brought by global climate change. Furthermore, both countries possess rich resources and advantages in technologies and talents. Taiwan boasts many outstanding scientific talents and research institutions, while Japan is home to numerous world-renowned universities and research institutions. Through this exchange seminar, we can foster technological collaboration and innovation between the two countries, jointly advancing innovation and application in urban flooding and river hydraulics sediment transport simulation technology.

Therefore, this workshop is jointly organized by the Sinotech Foundation for Research & Development of Engineering Sciences & Technologies, the Ecological Engineering Research Center at National Taiwan University. The co-organizers include the Hydrotech Research Institute at National Taiwan University, the Department of Bioenvironmental Systems Engineering at National Taiwan University, the Department of Civil Engineering at National Taiwan University,the Department of Civil Engineering at National Chung Hsing University,Sinotech Engineering Consultants Co., Ltd., and Sinotech Engineering Consultants, Inc., the Sustainable Development Committee of the Chinese Institute of Civil and Hydraulic Engineering and the Water Resources Committee of the Chinese Institute of Civil and Hydraulic Engineering.

The Sinotech Foundation for Research & Development of Engineering Sciences & Technologies is dedicated to advancing domestic water resources and civil engineering technologies. In addition to actively collecting domestic literature on water resources and civil engineering, they also introduce advanced technologies from abroad. Therefore, through this workshop, we plan to invite academic institutions with extensive experience and professional knowledge, such as Hokkai Gakuen University, National Taiwan University, and National Chung Hsing University, to participate. Their contributions to hydrology, water resource management, and geographic information systems, as well as their participation, will facilitate technology sharing and knowledge exchange, driving continuous innovation and improvement in river simulation technology. This workshop will also strengthen cooperation between Taiwan and Japan, utilizing their extensive data resources to ensure the reliability and accuracy of urban flooding and river hydraulics sediment transport.

We also hope this workshop will offer an opportunity to promote cultural exchange and deepen friendship. Although Taiwan and Japan are geographically separated, their cultures, history, and values have much in common. Through this workshop, we can enhance our mutual understanding and friendship and jointly contribute to river basin management, adaptation, and disaster prevention research. The Taiwan-Japan Simulation Technology for Urban Flooding and River Hydraulics Sediment Transport Technology Workshop will help strengthen cooperation and exchange between the two countries in river basin management, adaptation, and disaster prevention, promote technological innovation and talent cultivation, as well as make meaningful contributions to the sustainable development of the region and the world.

臺日「都會區淹水與河川水理輸砂模擬技術」交流講席會

Simulation Technology for Urban Flooding and River Hydraulics Sediment Transport Workshop (STW)

Agenda

(Apr. 22nd 2025)

09:20~09:30	Registration
09:30~09:40	**Prof. Tsang-Jung Chang / Chairman Sheng-Bao Tseng** Taiwan-Japan Simulation Technology for Urban Flooding and River Hydraulics Sediment Transport Technology Workshop (STW) Open Ceremony
09:40~10:30	**Host : Prof. Tsang-Jung Chang / Speaker : Prof. Yasuyuki Shimizu** Towards Next-Generation Hydraulic Analysis – The Full Scope of iRIC Ver.4' s Latest Solvers
10:30~10:50	Tea break
10:50~11:05	**Host : Prof. Jihn-Sung Lai / Speaker : Chung-Kai Wang, Graduate student** Modeling Braided River Evolution and Lateral Alluvial Fan Interactions Using iRIC
11:05~11:20	**Host : Prof. Jihn-Sung Lai / Speaker : Yi-Jia Huang, Graduate student** Riverside intake impact under hydrological uncertainty
11:20~11:35	**Host : Prof. Jihn-Sung Lai / Speaker : Cheng-Chi Liu, Ph.D. student** SRH-2D and machine learning application on fluvial hydraulic and bridge scour prediction
11:40~12:00	**Prof. Tsang-Jung Chang** Comprehensive discussion

iRIC training session

13:30~14:30	**Host : Prof. Jihn-Sung Lai / Speaker : Prof. Yasuyuki Shimizu** Open ceremony & General Overview of the iRIC Software
14:30~14:40	Tea break
14:40~15:40	**Dr. Takaaki Abe** Basic sediment transport analysis and its utilization using iRIC-Nays2DH : Training session (1)
15:40~15:50	Tea break
15:50~16:50	**Dr. Takaaki Abe** Basic flood Analysis and its utilization using iRIC-Nays2D Flood : Training session (2)

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Towards Next-Generation Hydraulic Analysis – The Full Scope of iRIC Ver.4’s Latest Solvers…………………………………………………… 清水康行 Yasuyuki Shimizu

Modeling Braided River Evolution and Lateral Alluvial Fan Interactions Using iRIC……
……………………………………………………………… 王崇楷 Chung-Kai Wang

Riverside intake impact under hydrological uncertainty……………………………………
……………………………………………………………………… 黃翊嘉 Yi-Jia Huang

SRH-2D and machine learning application on fluvial hydraulic and bridge scour prediction……………………………………………………… 劉政其 Cheng-Chi Liu

清水康行 Yasuyuki Shimizu

Distinguished Professor, Department of Engineering,
Hokkai Gakuen University
北海學園大學工學部　特任教授

Towards Next-Generation Hydraulic Analysis–The Full Scope of iRIC Ver.4’ s Latest Solvers

- International River Interface Cooperative

  ・iRICis a free-to-use user interface and associated set of free solvers for simulating aquatic flow, sediment transport, riverbed deformation, and even ecosystem behaviors.

  ・The aim of iRICis not merely the development and dissemination of the software itself, but also to build an interface to facilitate international exchange among researchers and engineers through iRIC

  ・Version 1.0 was released in April 2010 → Marking its 15th anniversary this year.

- iRIC Solvers Lineup

- New Solvers in iRIC Version 4

  ・Cabernet2D
  Comprehensive Aquatic Basin Evaluation Tool for River Network

  ・Freebird3D
  Fully Responsive Engine for Evolution of Bathymetry and Improvement of River Design

  ・GELATO (Material Transportation Model)
  GEneralized LAgrangianTracking with Optimization

Towards Next-Generation Hydraulic Analysis – The Full Scope of iRIC Ver.4's Latest Solvers

Yasuyuki Shimizu

22 April 2025

iRIC

International River Interface Cooperative

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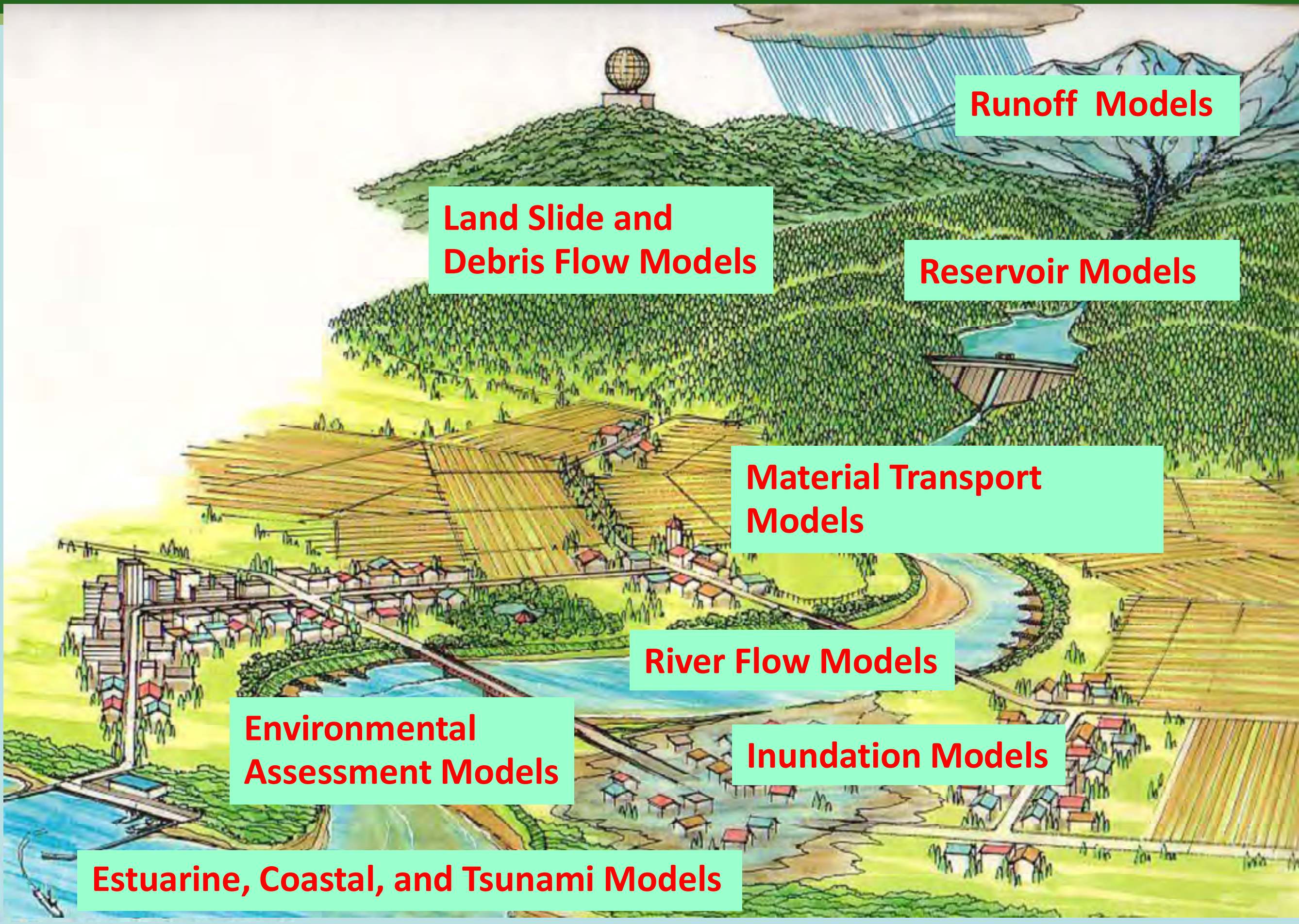
iRIC Solvers Lineup



iRIC Solvers Lineup

Solvers at the Time of iRIC Version 4 Release (June 2023

(1) Runoff Models → SRM(Lumped Model), RRI on iRIC(Distributed Model)

(2) River Flow Models → Nays1D+, CERI1D, Nays2DH, NaysMini, Nays2d+
FaSTMECH, SToRM, River2D, Mflow_02
Morpho2DH, Nays2DV, Nays3DV, NaysCube

(3) Inundation Models → Nays2dFlood(Geral Coordinates, Structured, Unsteady)

(4) Tsunami Model → ELIMO(2D Polar Coordinate Model)

(5) Environmental Assessment Models → DHABSIM(Fish Habitat Assessment)
EvaTrip_Pro(River Environment and River Characteristics Assessment)

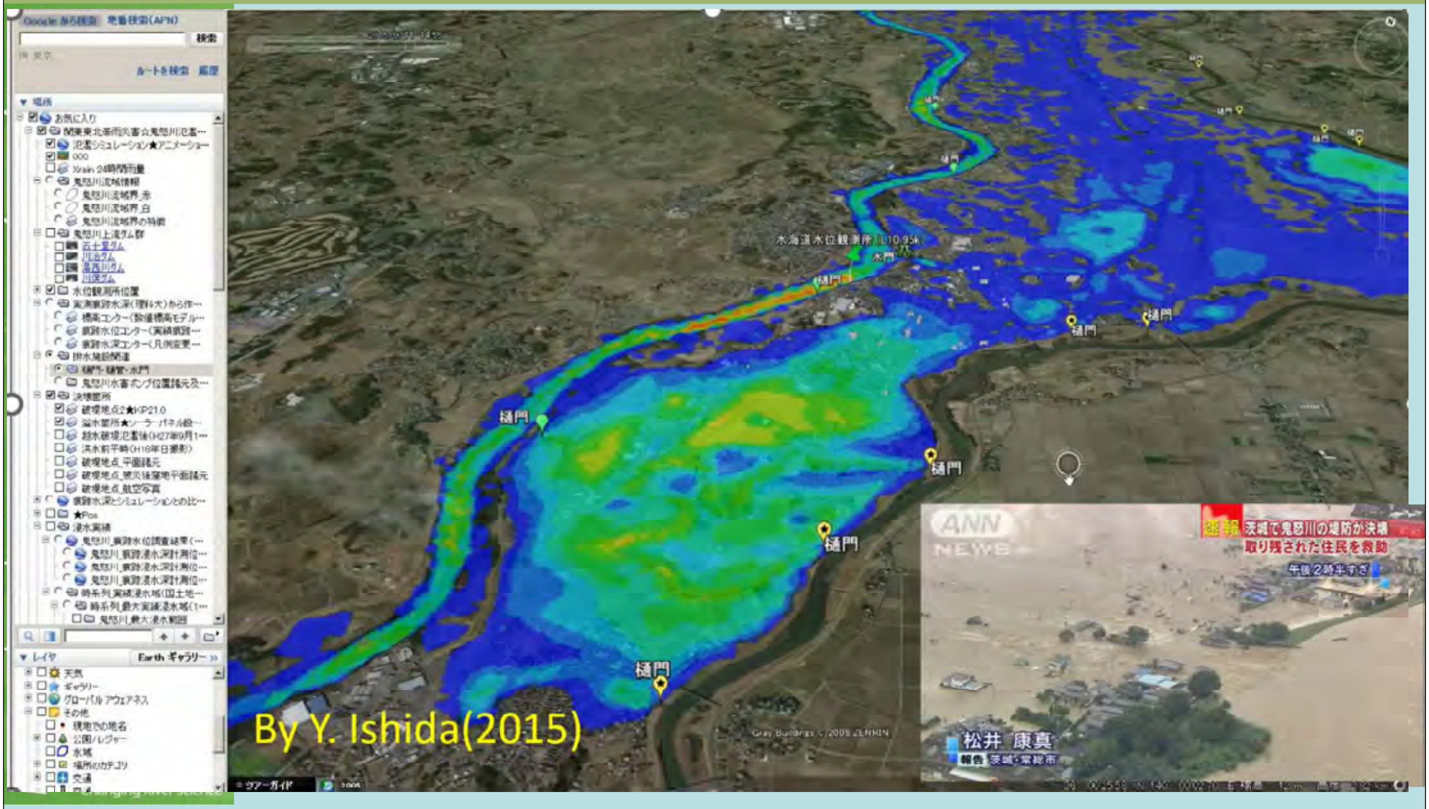
(6) Materical Transport Models → GELATO(Material Tracking), Nays2DW(Driftwood)

Open Source

Model Interaction

iRIC Software
Changing River Science

Kanto/Kinugawa River Major Flood (2015)



iRIC Software
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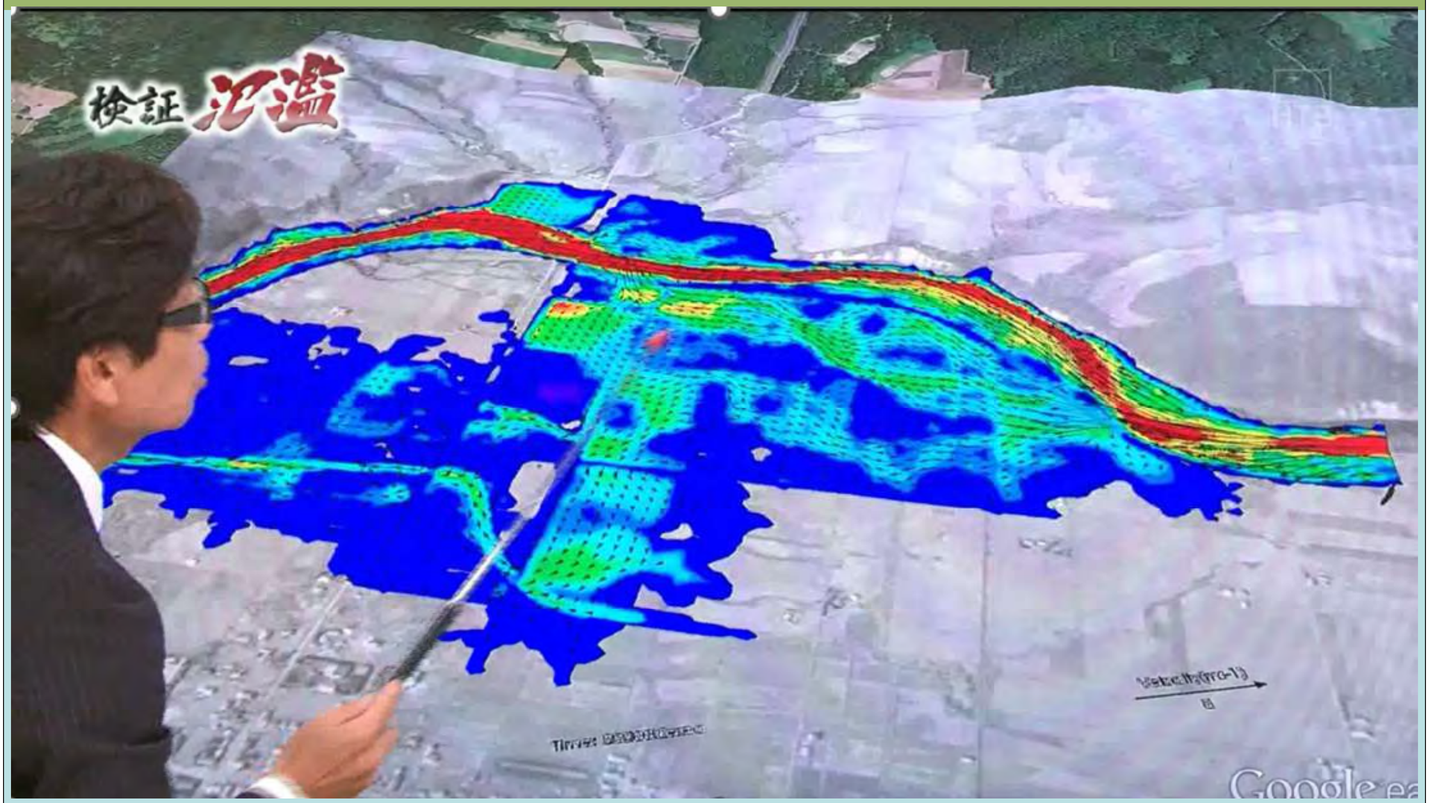

計算 石田さん

iRIC Software
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HTBイチオシスペシャル(2016年10月1日放送)

New Solvers in iRIC Version 4

You are the first witness!
The full picture of the new solver lineup...

iRIC Software
Changing River Science

New Solvers in iRIC Ver.4 (1)

Cabernet2D

Comprehensive Aquatic Basin Evaluation Tool for River Network

- Based on the 2D models Nays2dH and Nays2dFlood
- Supports confluences and bifurcations (unlimited number of tributaries and distributaries)
- Supports calculation of vegetation and tree group emergence, growth, resistance, and washout
- Breach simulation is possible
- Boundary conditions can be set on edges (e.g., impermeable structures)
- Bed deformation calculation (including vegetation succession at confluences and bifurcations)
- Floodplain simulation is also possible (culverts, drainage pumps, gates)
- Includes Gelato (material transport model)

New Solvers in iRIC Ver.4 (2)

Freebird3D

Fully Responsive Engine for Evolution of Bathymetry and Improvement of River Design

- 3D open channel flow model (based on Nays3dV)
- Non-hydrostatic model (hydrostatic model also selectable)
- Density flow simulation is supported
- Uses contravariant physical components for stable velocity calculation
- Supports subcritical flow, supercritical flow, mixed flow conditions, and hydraulic jumps
- Compatible with confluence and bifurcation points

iRIC Software
Changing River Science

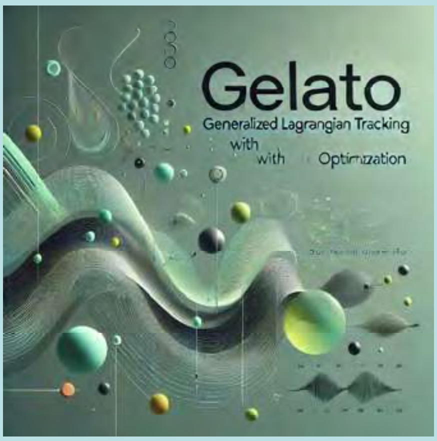
iRIC Software
Changing River Science

New Slovers in iRIC Ver.4 (3)

GELATO (Material Transportation Model)

GEneralized LAgrangian Tracking with Optimization

- Solver linkage function (transports substances using flow simulation results from solvers like Nays2D)
- Tracking of individual substances using a Lagrangian approach Dispersion effects can be considered using a random walk model
- Enhanced resolution through cloning
- Capable of tracking substances that move with the fluid (e.g., water quality components, oil, debris), as well as objects that move autonomously within the fluid (e.g., fish)



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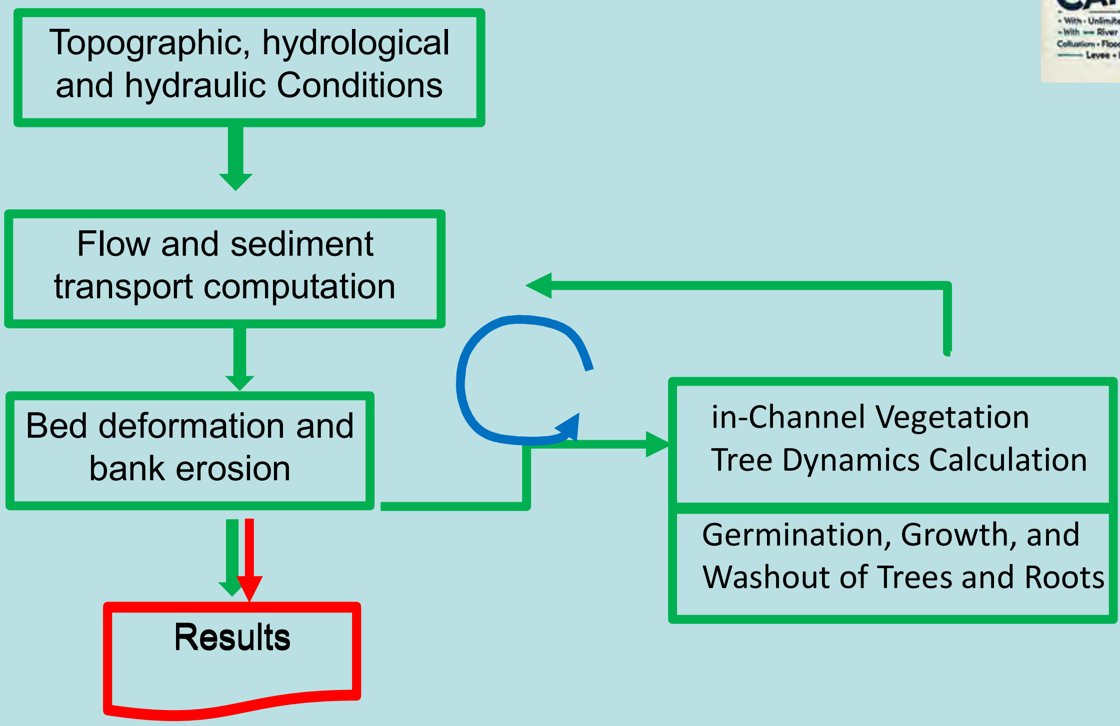
In-Channel Vegetation Model



Meandering and Bank Erosion(2016)

Bise River – Photographed on August 11, 2022

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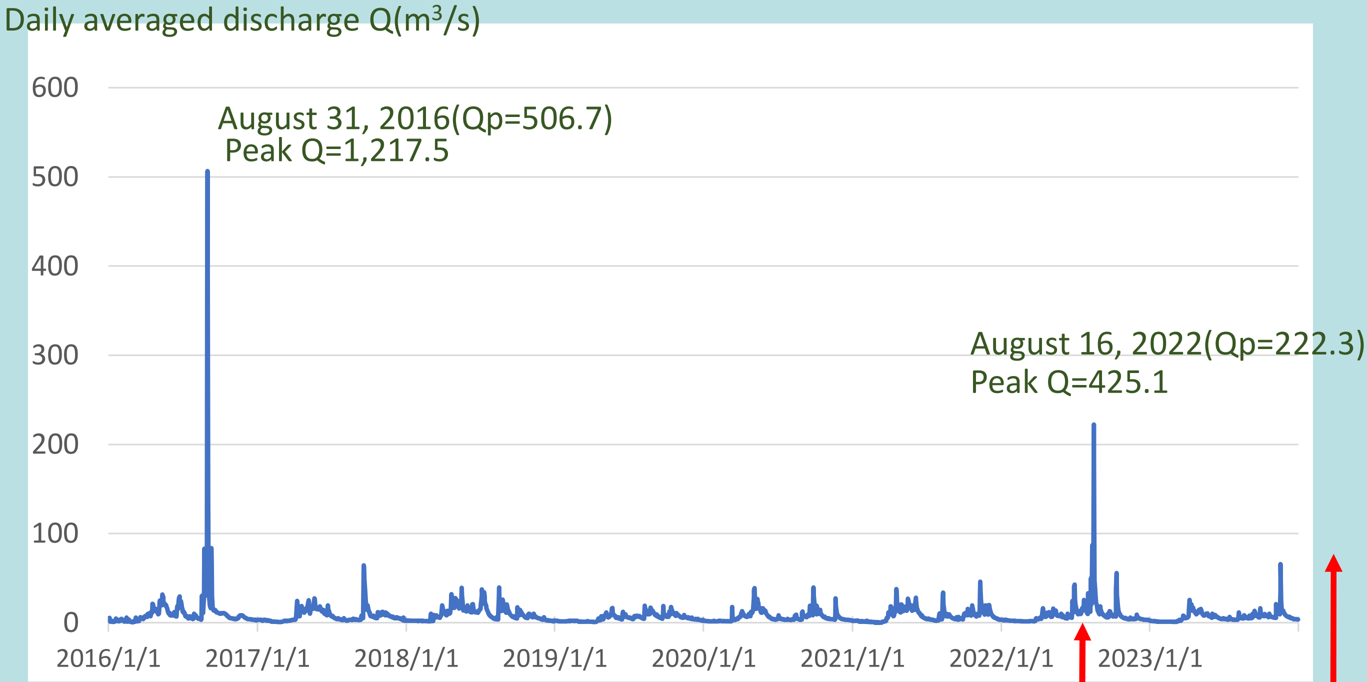
Photographed on June 27, 2024

iRIC Software
Changing River Science

Bisei River – Daily Discharge at Bisei Bridge
(Provided by Obihiro Development and Construction Department)



First Drone Photography
(Aug 11, 2022)

Second Drone
(June 6 2024)

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Aug 22, 2022(1st)

Jun 27, 2024(2nd)

Average tree length(m):

$V_l = V_{l\_max} \cdot \sigma$

Average root length(m):

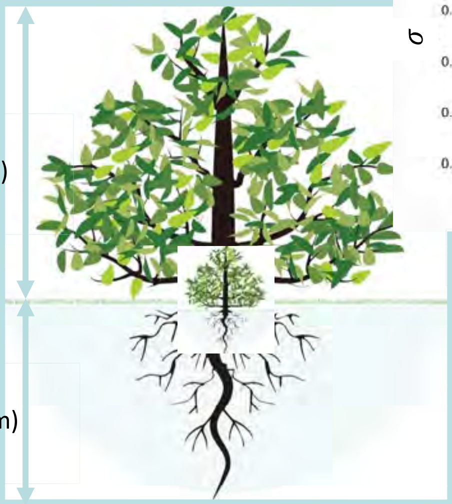
$R_l = R_{l\_max} \cdot \sigma$

Average root density(1/m):

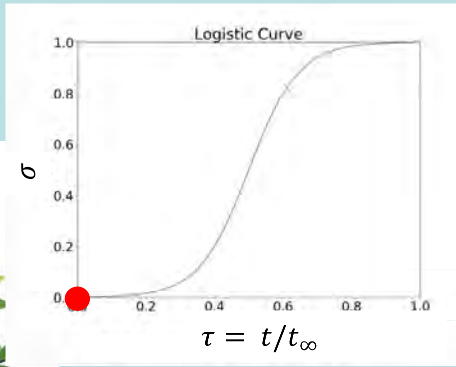
$a_s = a_{s\_max} \cdot \sigma$

$t = t_\infty \cdot \tau$

Averaged Tree length(m) : V_l

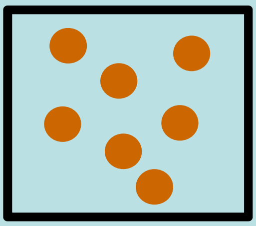


Averaged Root length(m) : R_l



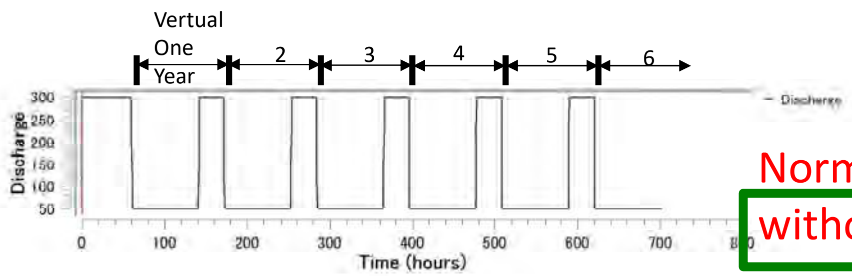
Logistic Curve ($\sigma_0 = 0.001$)

τ: nondimensional growth time
t: time,
t_∞: stulate time

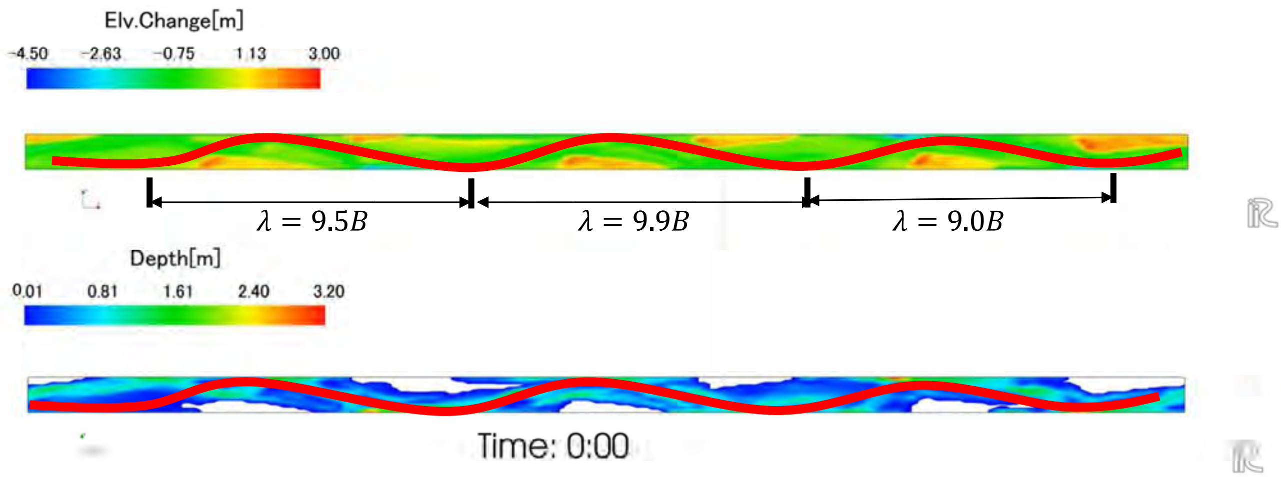


Averaged Tree density(1/m): a_s

Shimizu et al.(2000)
Nagata et al.(2016)
Dempo et al.(2022)



Normal Year Repetition without Trees



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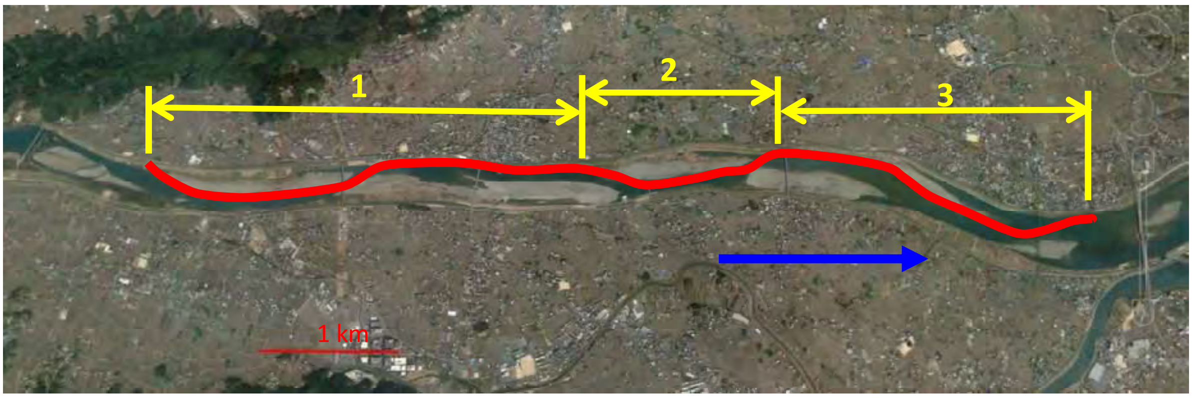
Naka River, Shikoku Island, Japan

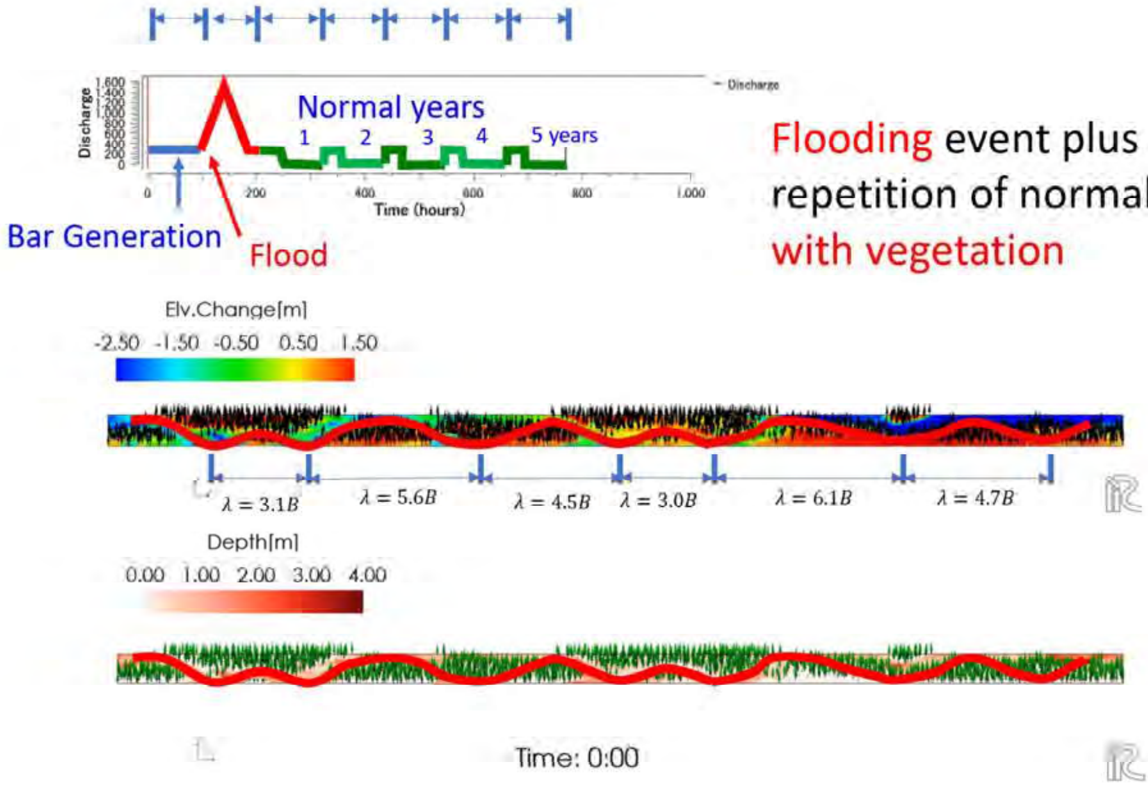


#	Width B(m)	Wave length λ (m)	λ/B
1	312	3,398	10.9
2	279	2,467	8.8
3	301	3,940	13.1

Average $\frac{\lambda}{B}$ = 10.9

$\frac{\lambda}{B}$ = 7-15 (JSCE 1973)

Within a range



Flooding event plus repetition of normal years with vegetation

Bar Characteristics in the Bisei River

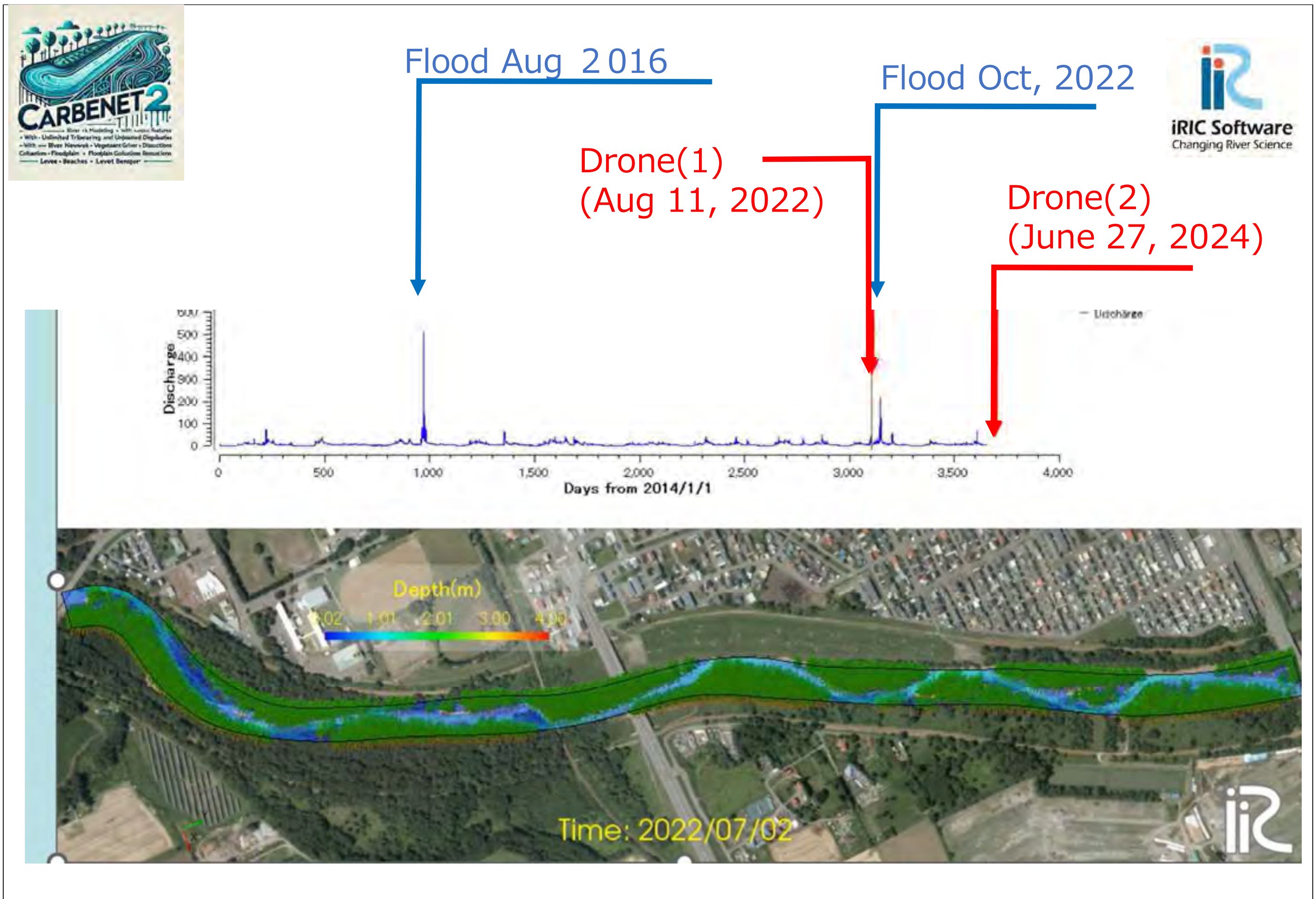
Bar Number	Channel width B (m)	Wavelength λ (m)	λ/B
1	59	239	4.1
2	62	238	3.8
3	68	185	2.7

Average values

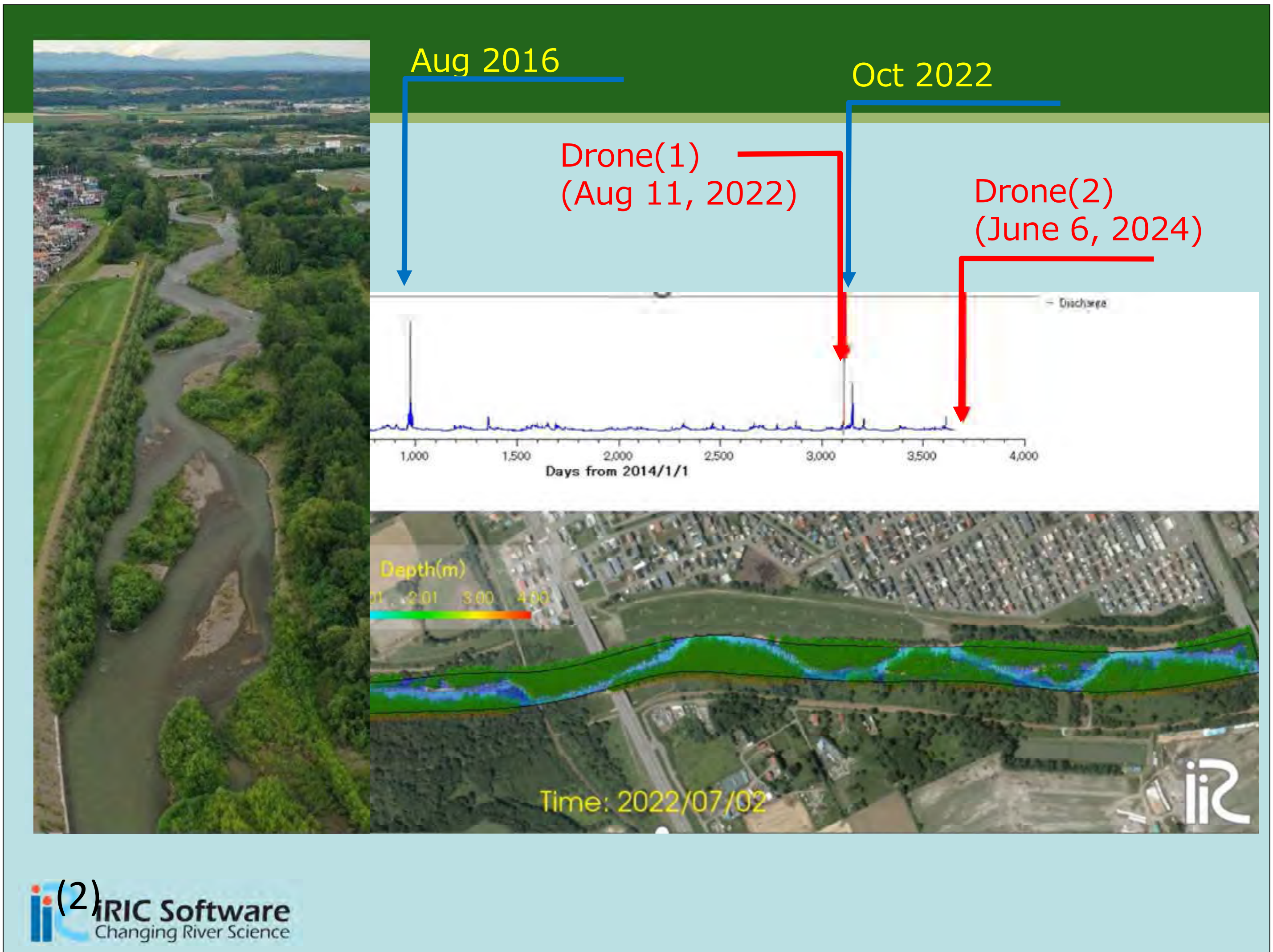
$$\frac{\lambda}{B} = 3.5$$

Much shorter than Japanese typical alternate bar rivers

$$\frac{\lambda}{B} = 7\text{-}15 \text{ (JSCE 1973)}$$


Flood Aug 2016
Flood Oct, 2022
Drone(1)
(Aug 11, 2022)
Drone(2)
(June 27, 2024)
iRIC Software
Changing River Science
Discharge
Days from 2014/1/1
Depth(m)
Time: 2022/07/02

(0)


Aug 2016
Oct 2022
Drone(1)
(Aug 11, 2022)
Drone(2)
(June 6, 2024)
Discharge
Days from 2014/1/1
Depth(m)
Time: 2022/07/02
iRIC Software
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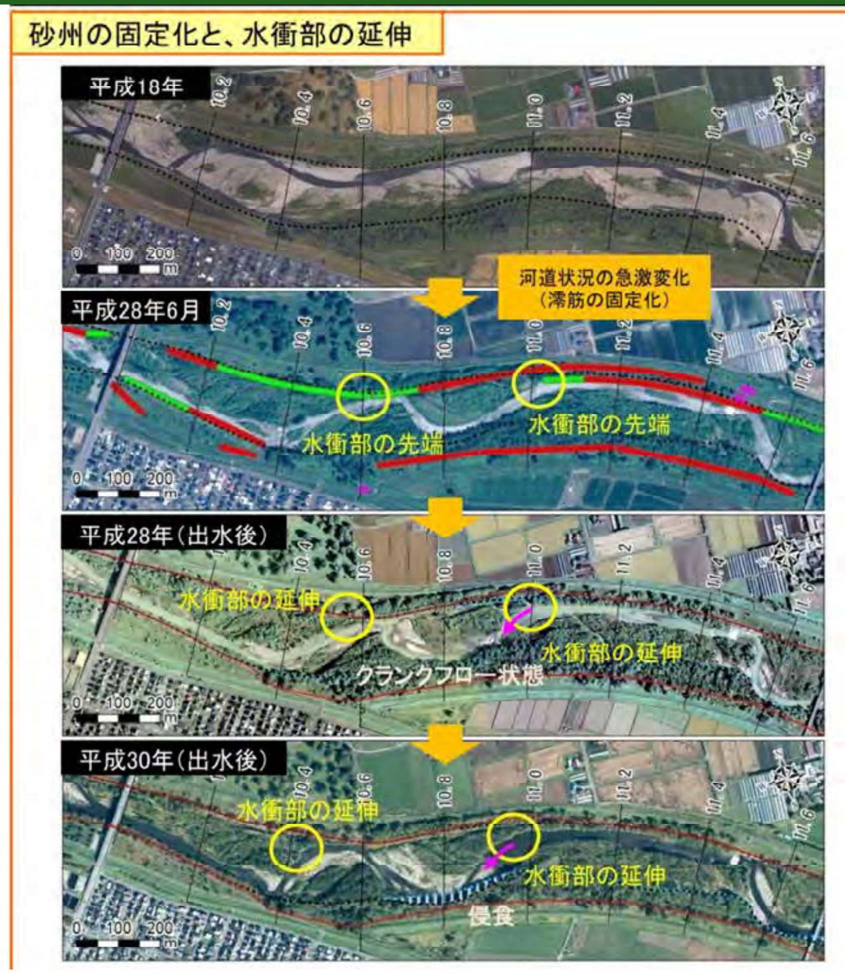
(2)

Afforestation of the Chubetsu River

Stabilization of Sandbars and Extension of Erosion-Prone Areas (Water Attack Zones)



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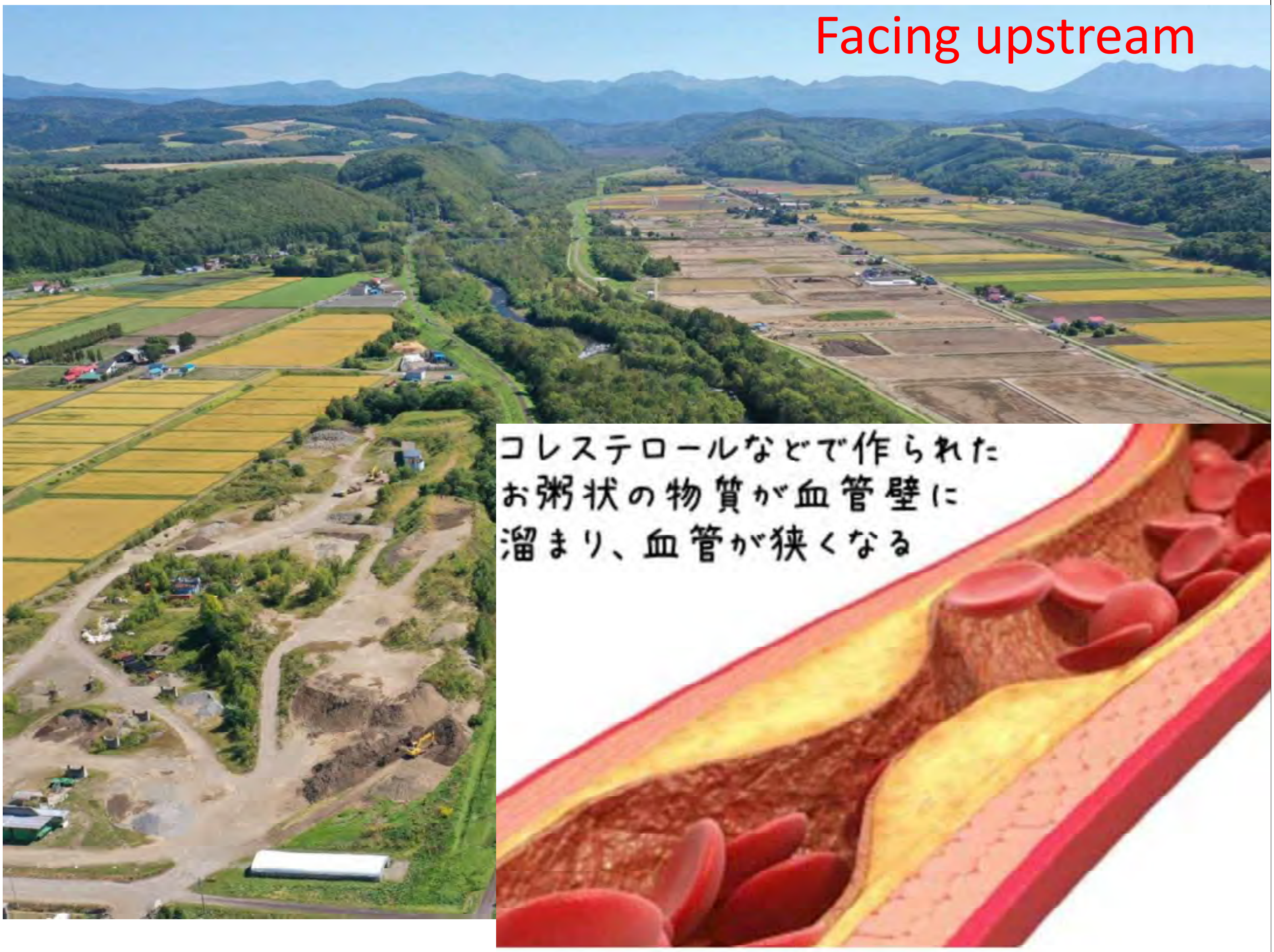
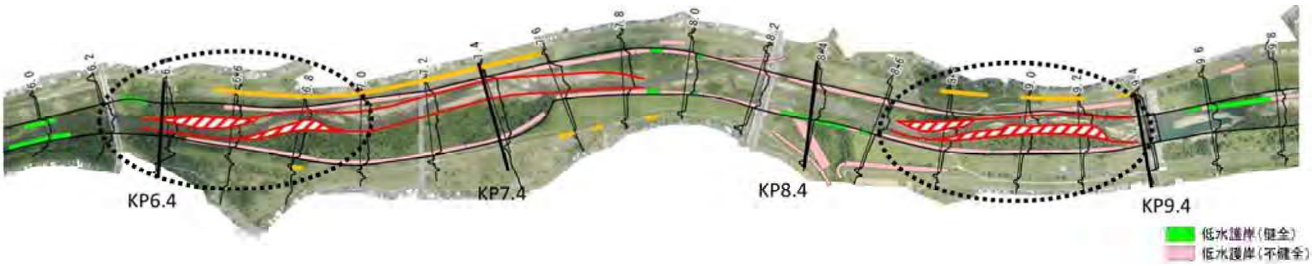
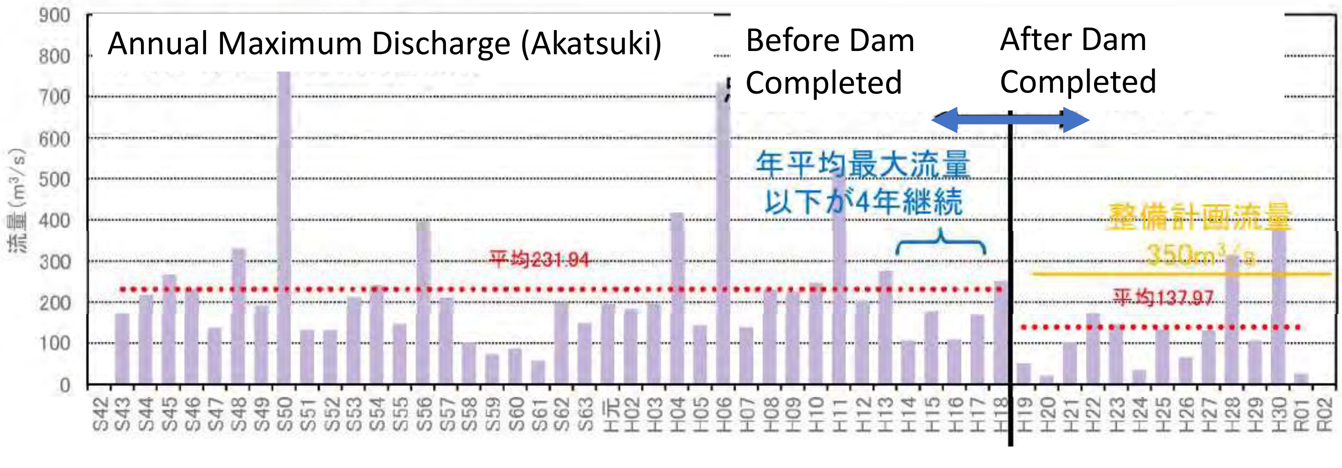
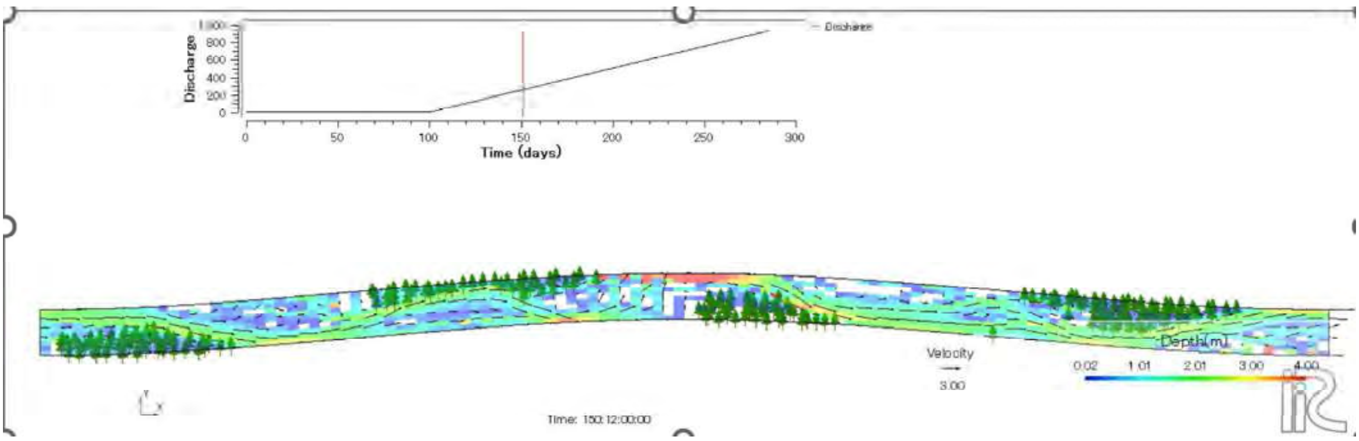
Photographed on September 9, 2024 – Near Higashikawa Town, Facing Downstream



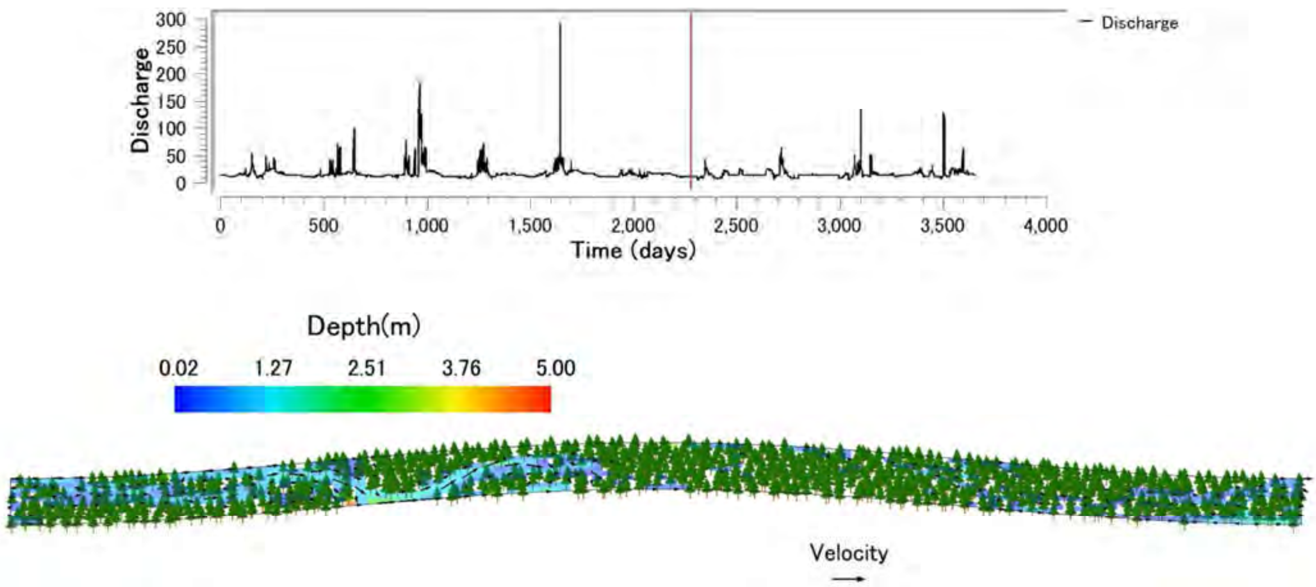


KP 6.4-9.4, dm=50mm, Width B=100m
Bar Wave Length =2.5km, Slope i=1/200



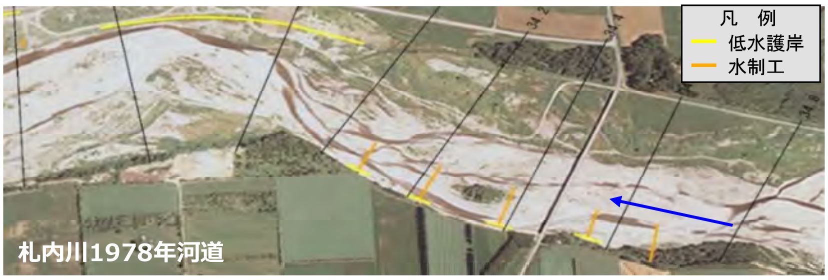


KP 6.4-9.4   dm=50mm B=100m L=2.5km   i=1/200

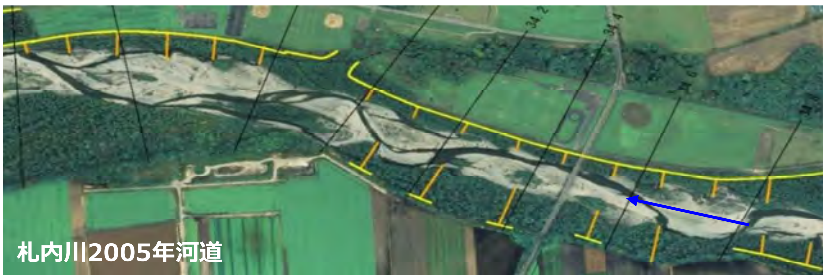


Satsunai River[Sasaki and Sumitomo(2024)]

p.32



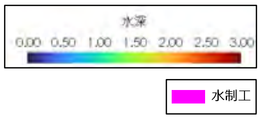
Before Dam Constraction
Groin Spacing
600m

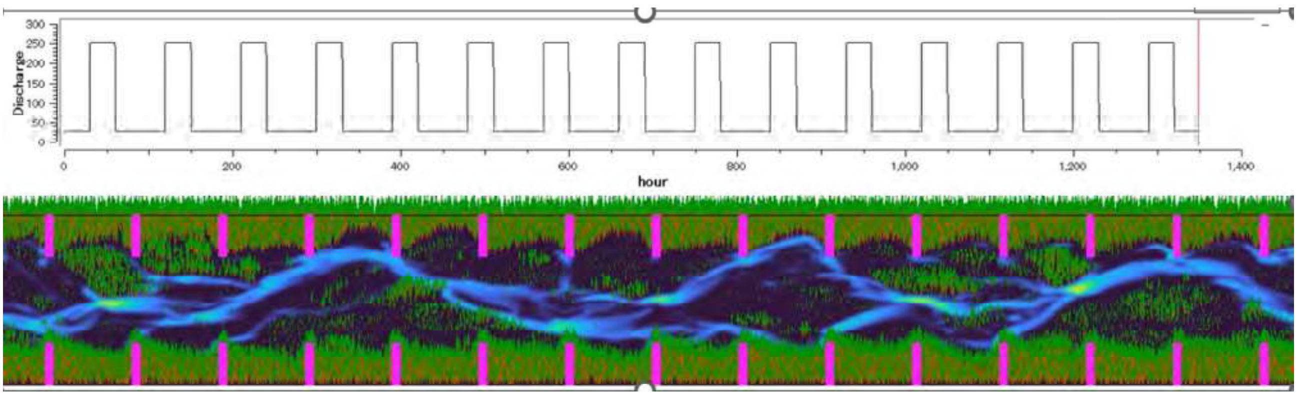


Just after Dam Completion in 1998
Groin Spacimg 200m

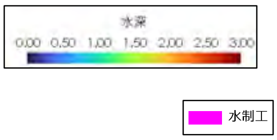
After Dam Completion
Groin Spacing
200m

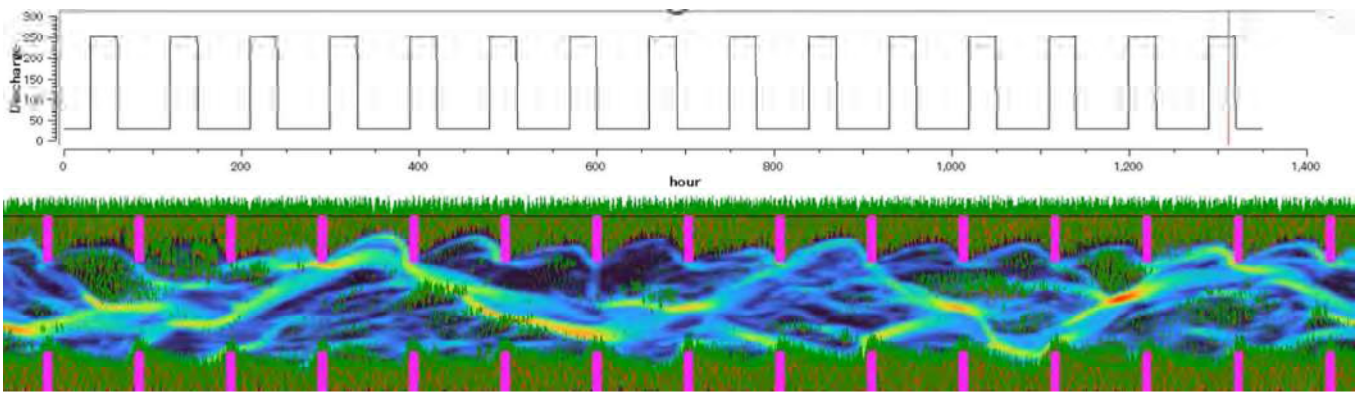
Before Dam Completion Qp=250m^3/s
Groin Spacing 600m



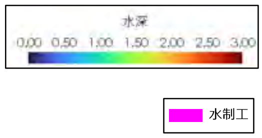


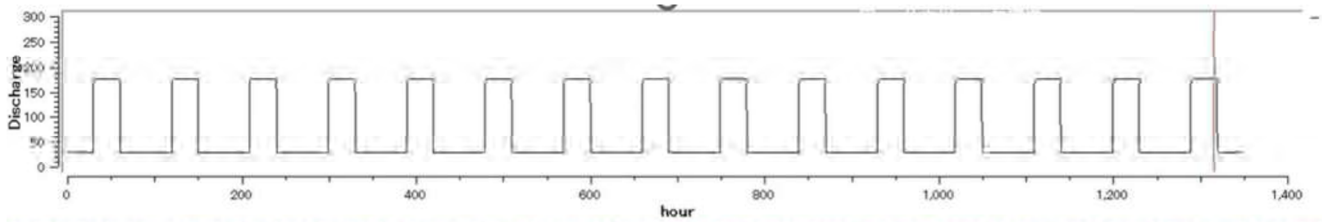
Before Dam Completion Qp=250m^3/s
Groin Spacing 200m

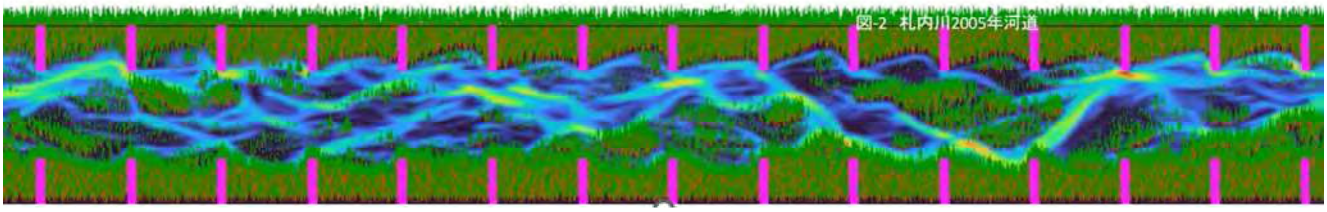




After Dam Completion Qp=180m^3/s
Groin Spacing 200m

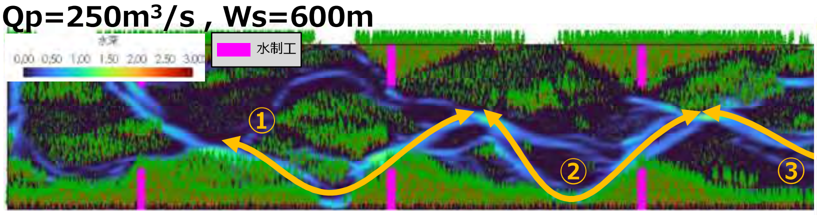






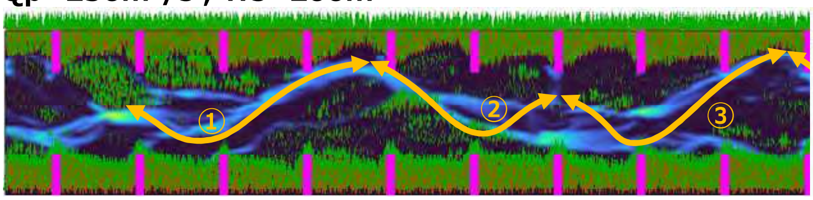
Simulation Results

Qp=250m^3/s , Ws=600m



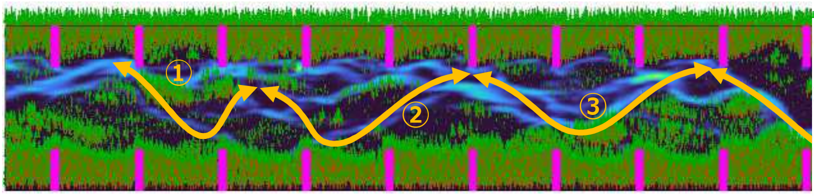
Before Dam Completion

Qp=250m^3/s , Ws=200m



Before Dam Completion

Qp=180m^3/s , Ws=200m



After Dam Completion

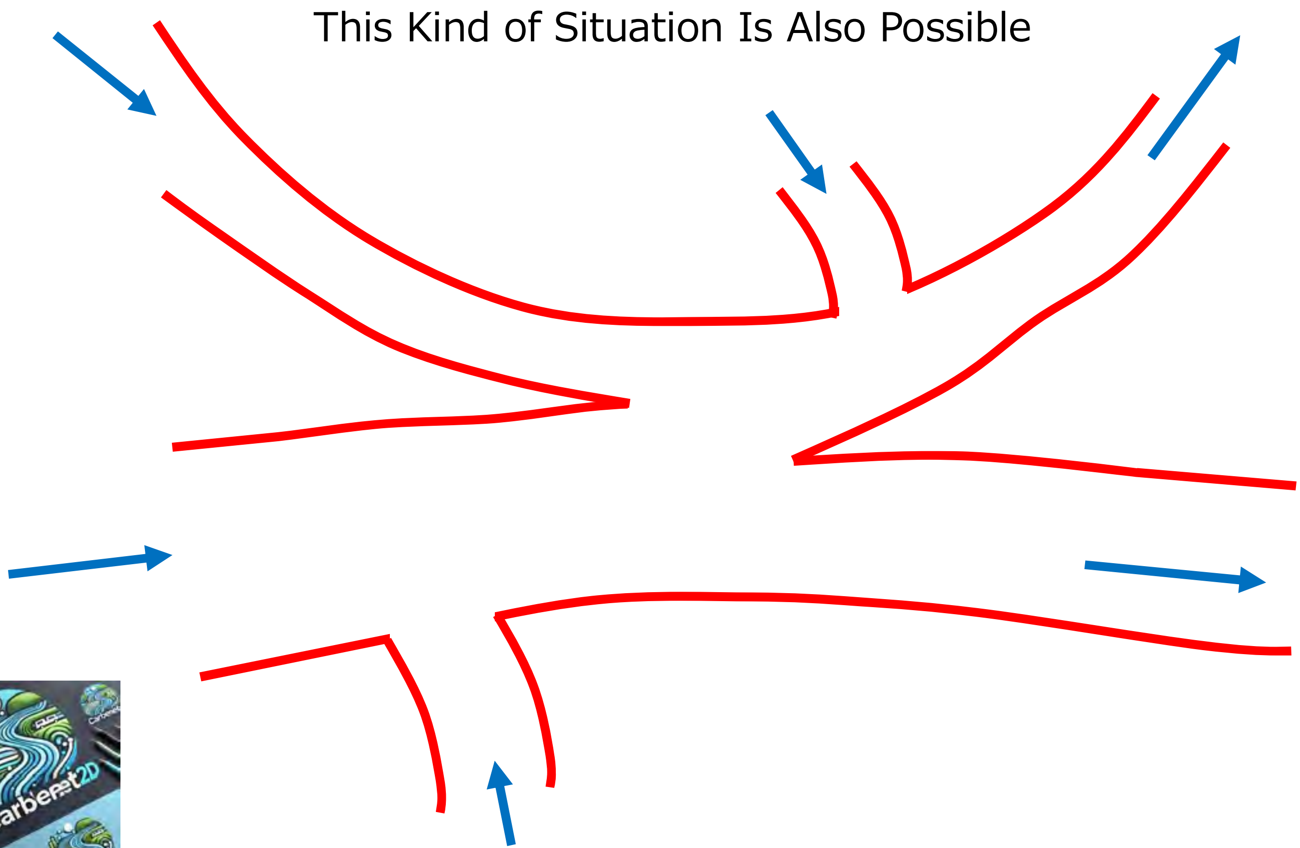
Flow＋Sediment＋
Bed deformation＋Sabd Bar ＋Groin

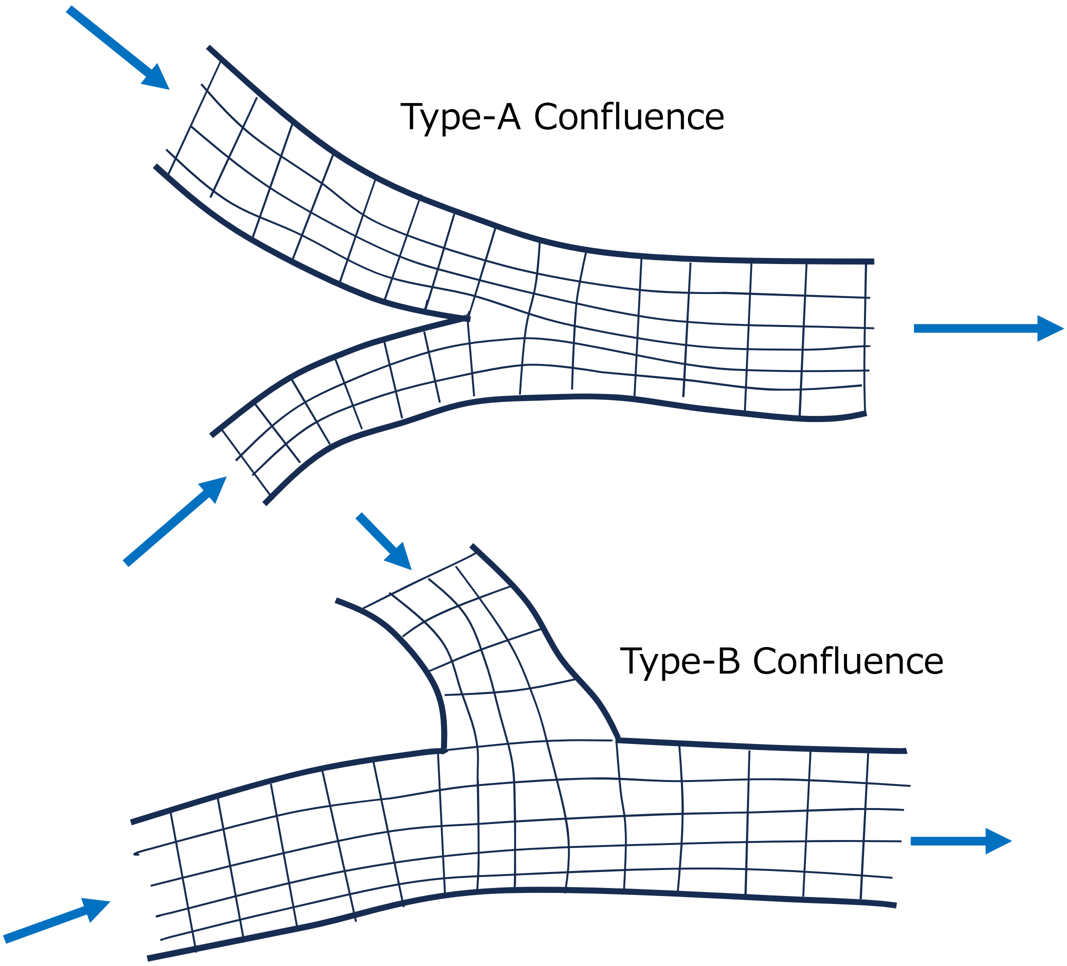
＋Vegetation (Emergence, Growth and Washout)

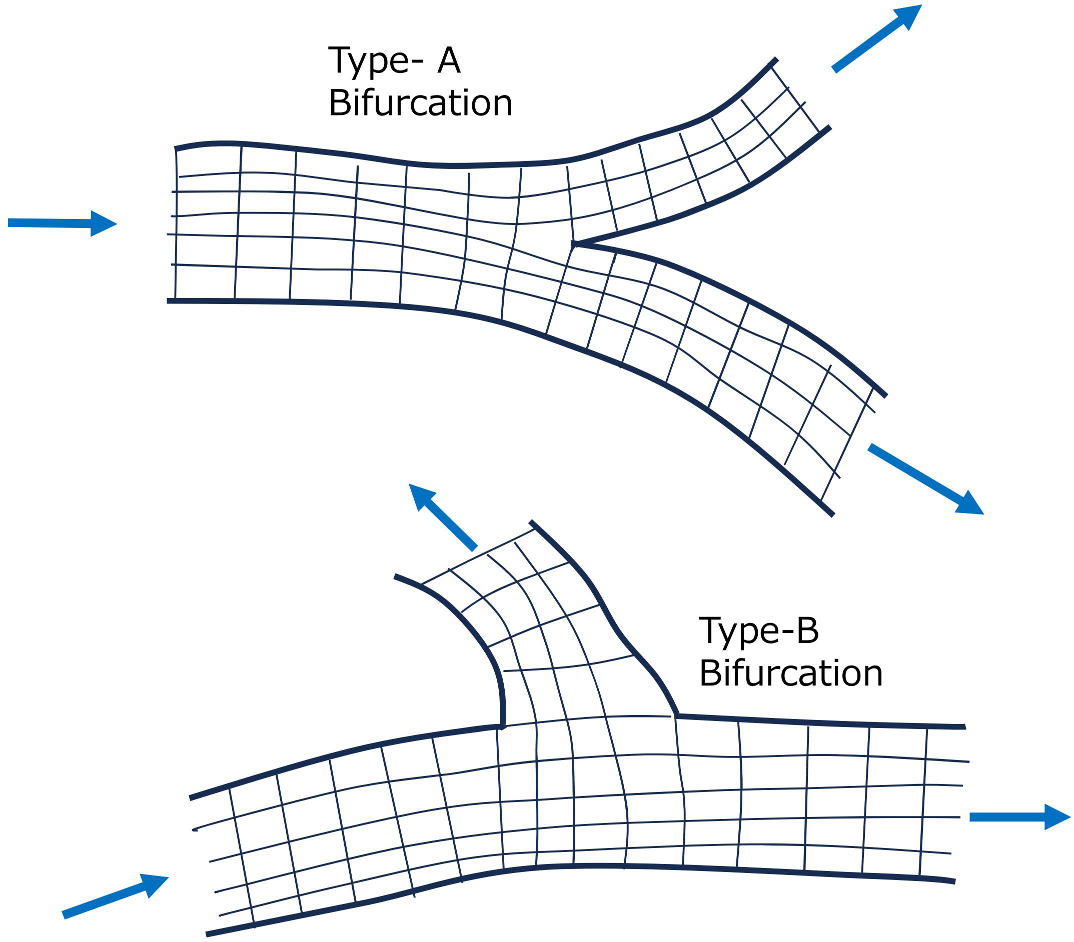
Nasy2dH

Cabernet2d

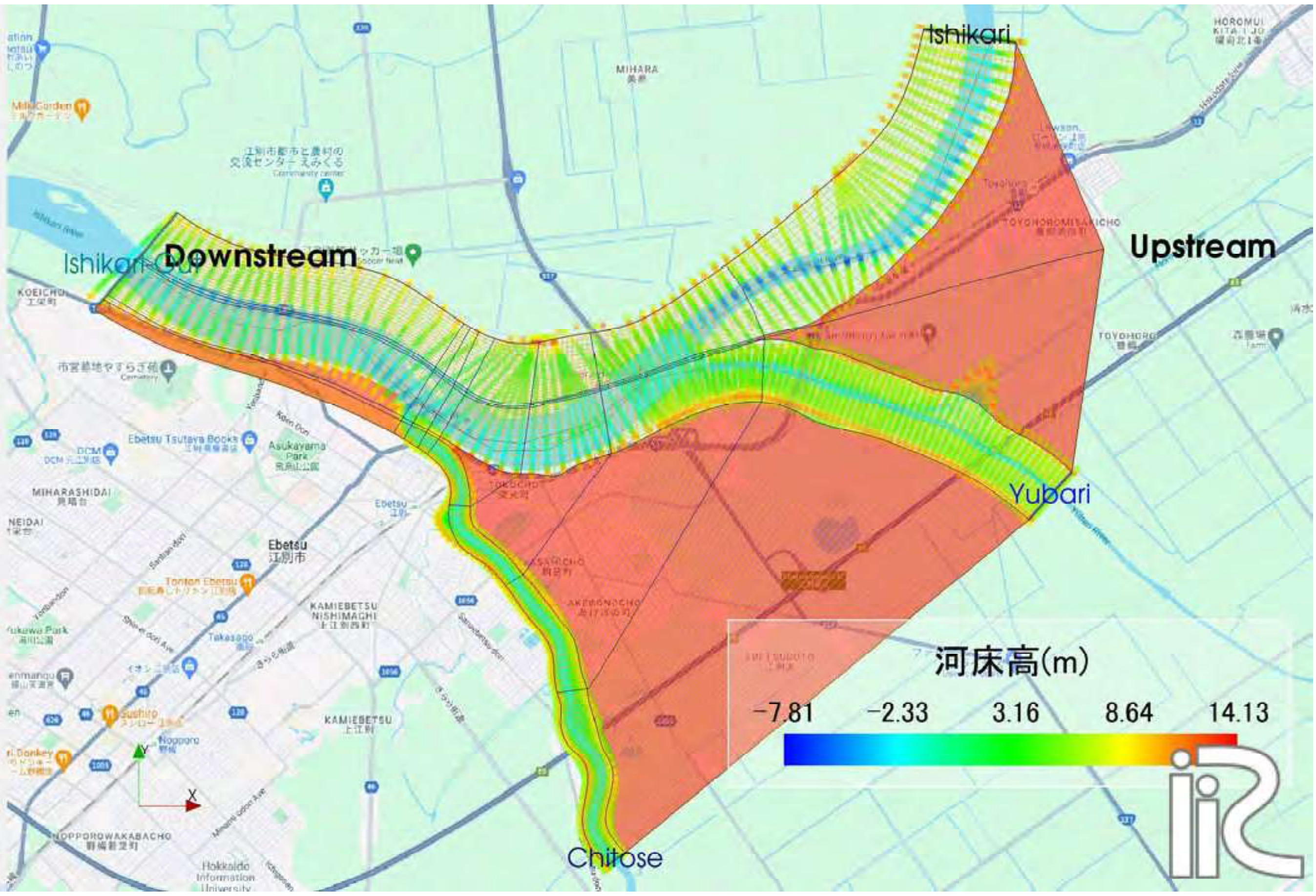
Unsteady 2D Flow Simulation Including Confluences and Bifurcations Using Cabernet2D

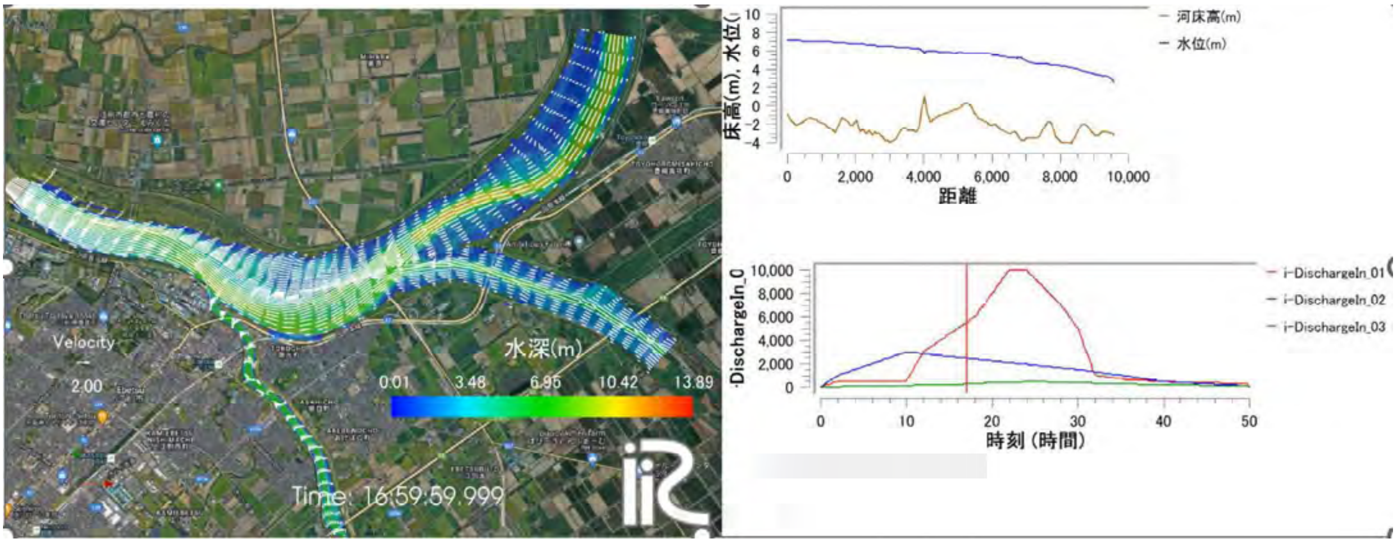


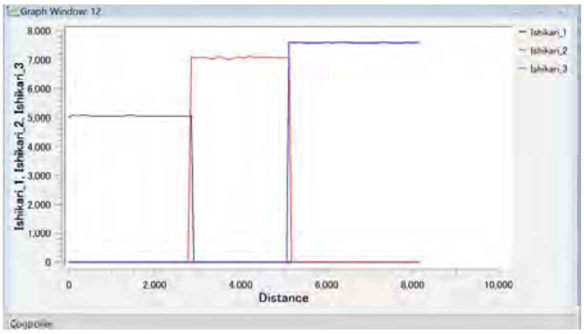




Yubari River and Chitose River Confluence in Ishikari River





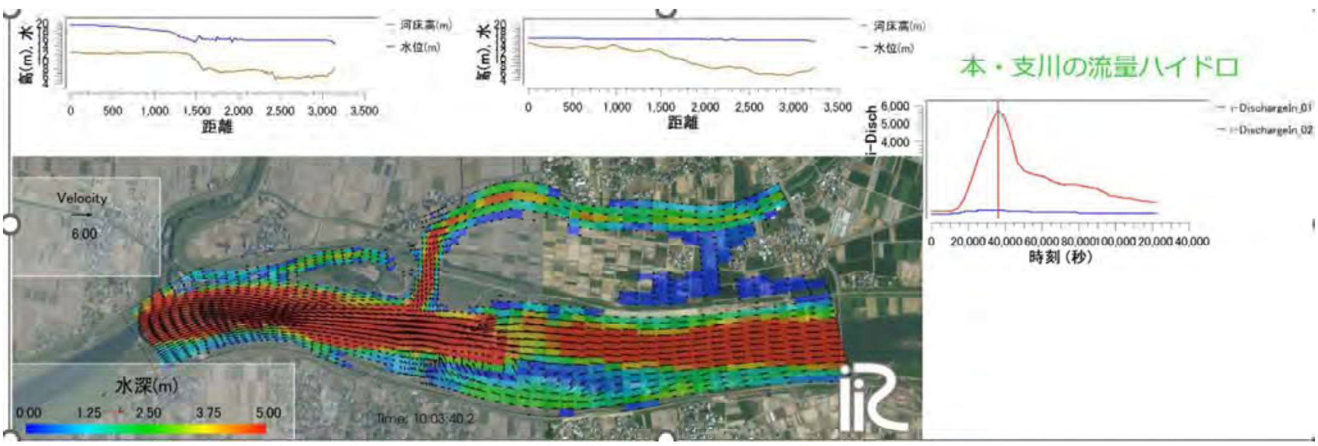


Longitudinal Profile of the Discharge Along the Main Channel

Confluence of the Katsura River in the Chikugo River

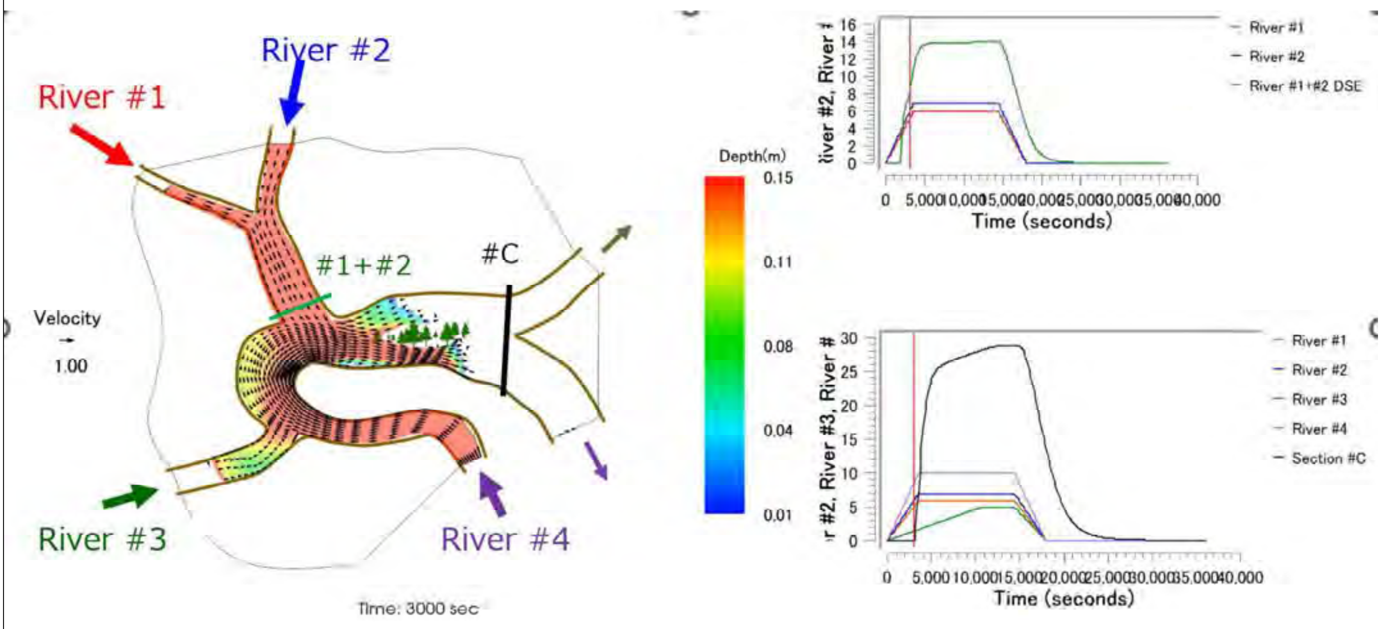
本川に沿った水位河床縦断

支川に沿った水位河床縦断



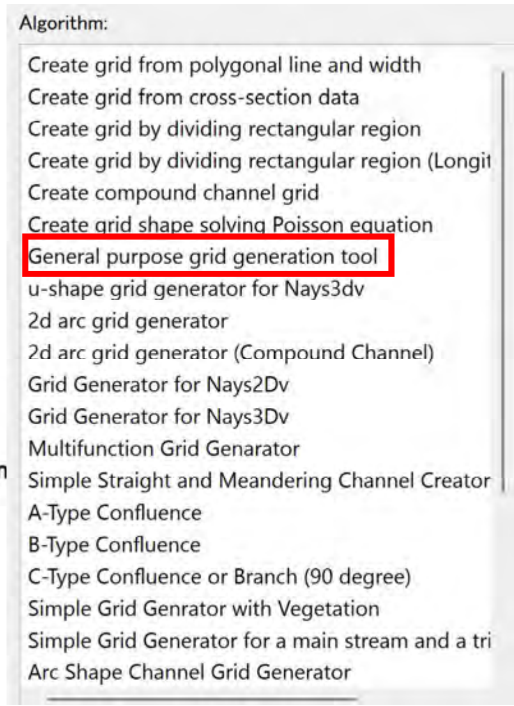
by Yasuda et al.(2024)

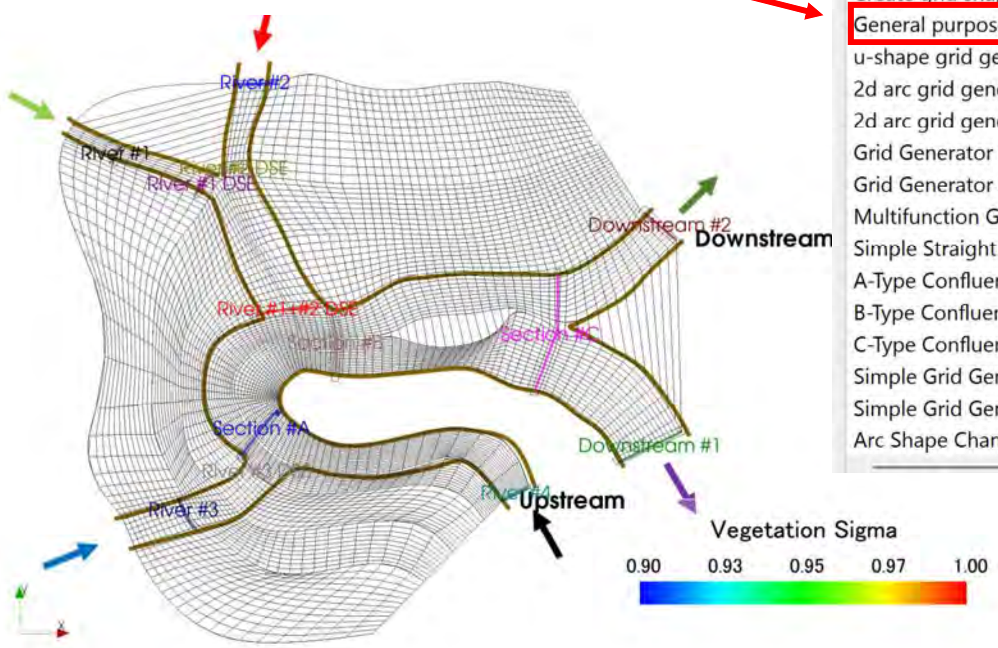
Complex River Network



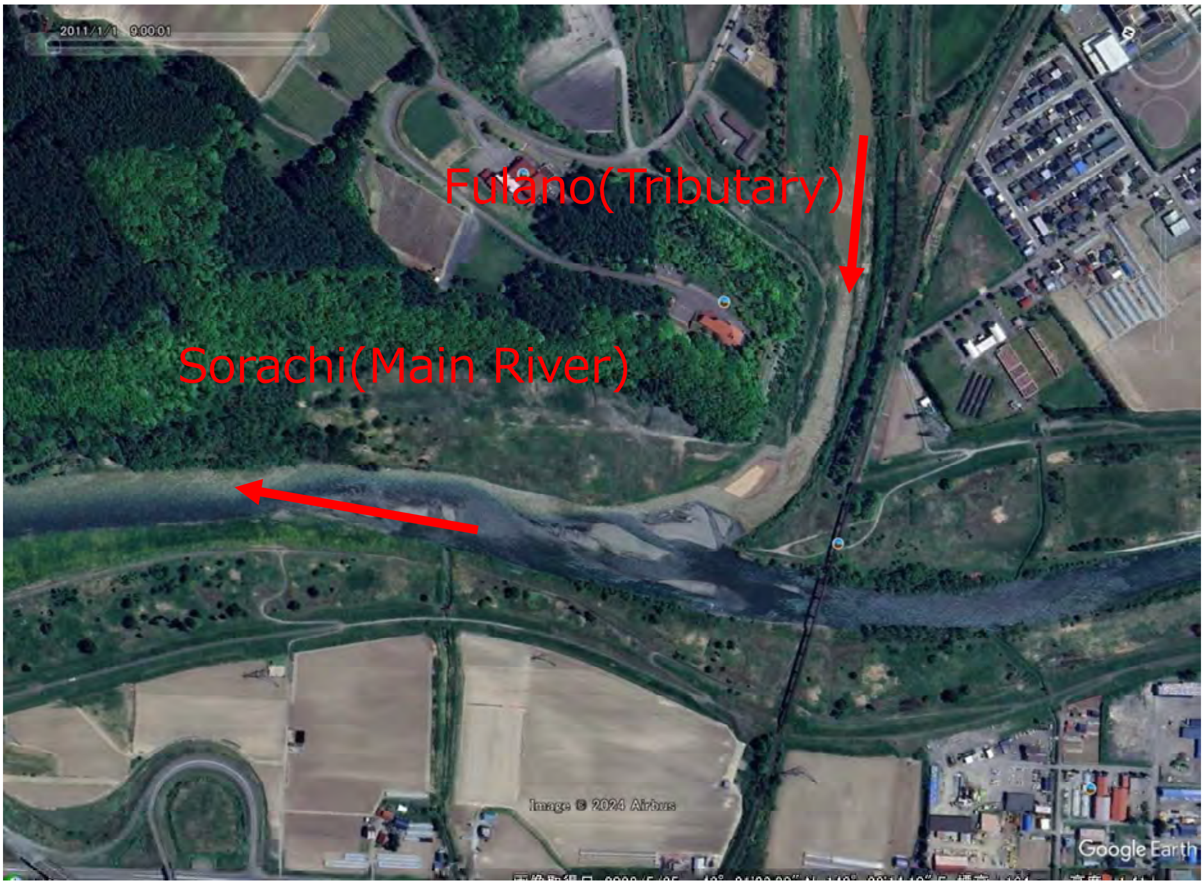
It is possible to display the discharge at any cross-section.

Even complex grid creation can be easily done with the [General Purpose Grid Generation Tool].

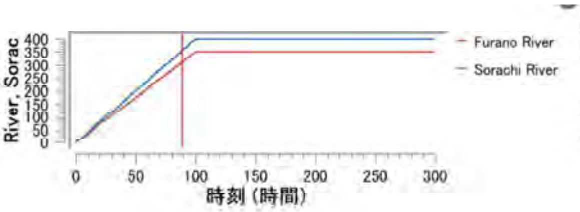




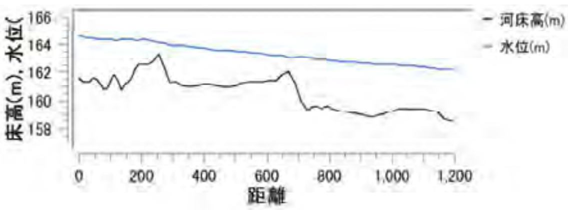
Sediment Deposition Problem at Confluence Point

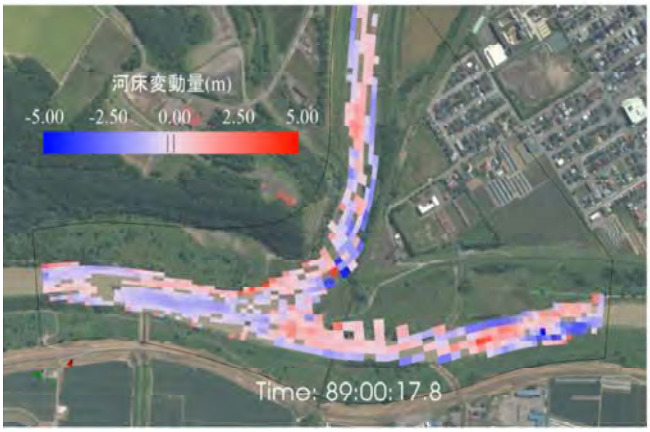


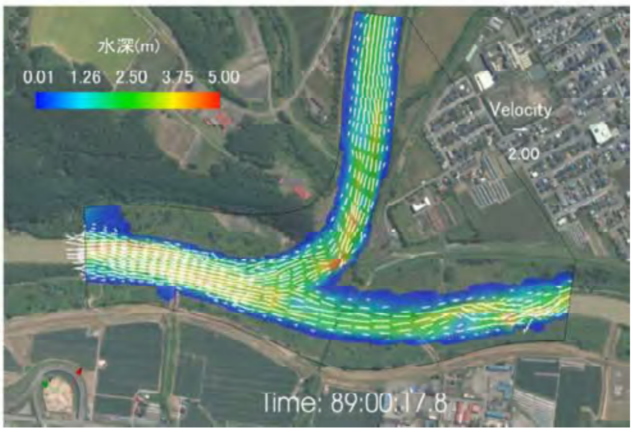
Time Change of Discharge
in Main Channel and Triburtary



Longitudinal Bed and Surface Profile

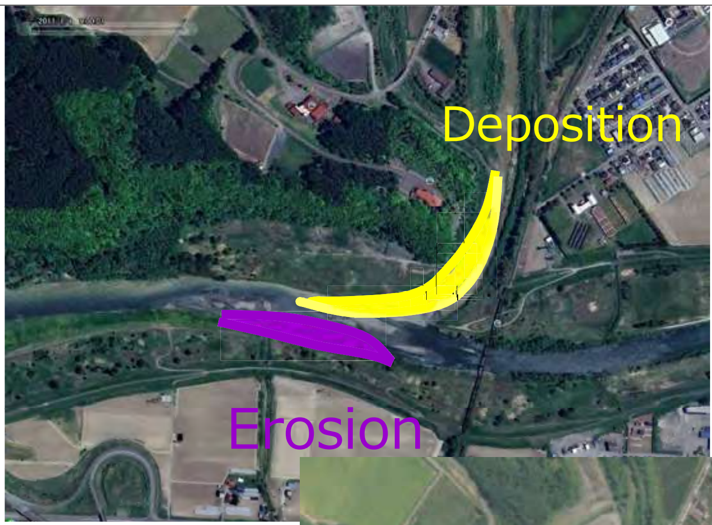






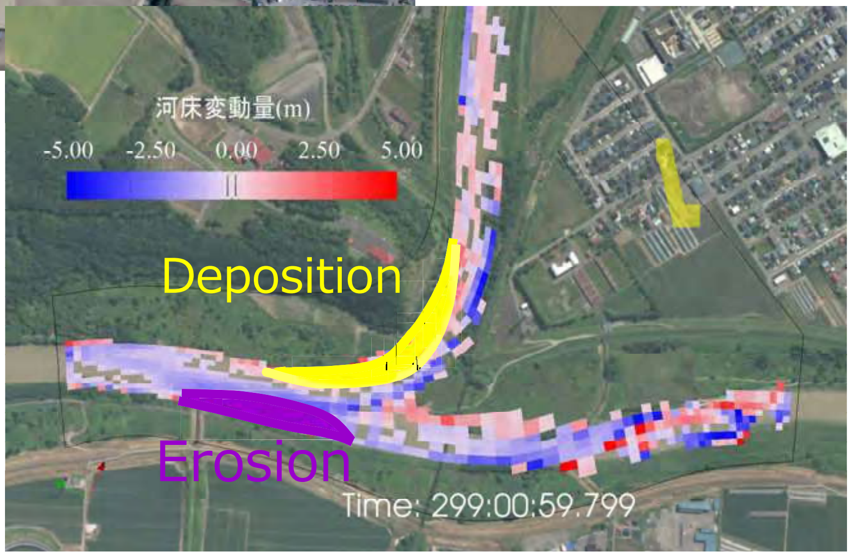
Bed deformation contour

Velocity vectors and depth contour

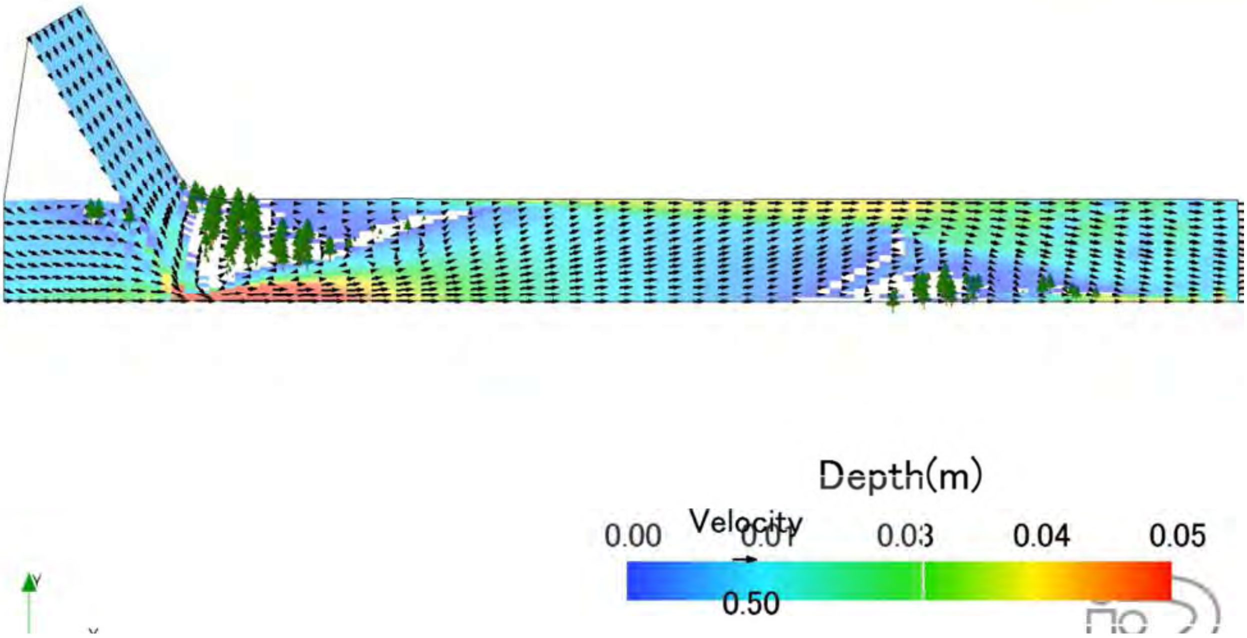


Actual River

Simulated



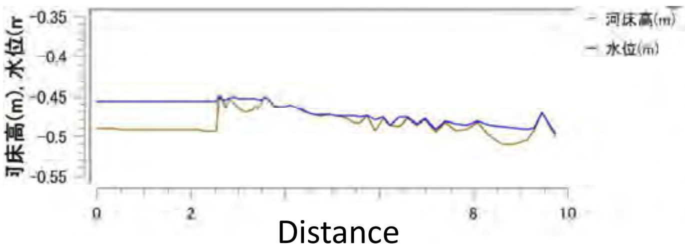
Simulation Example of Sediment Deposition and Vegetation Growth at a River Confluence



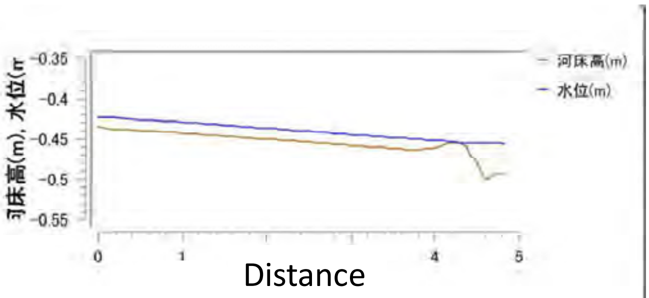
Confluence of the Akatani River and Chikugo River

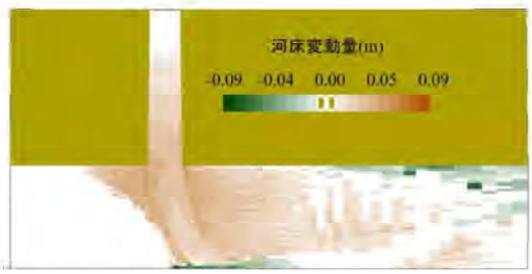
Sediment-Producing Tributary Joins the Main River at a Right Angle

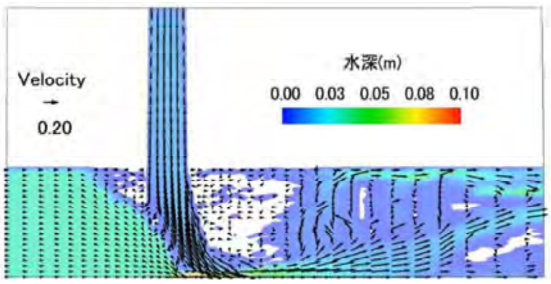
Along the main channel



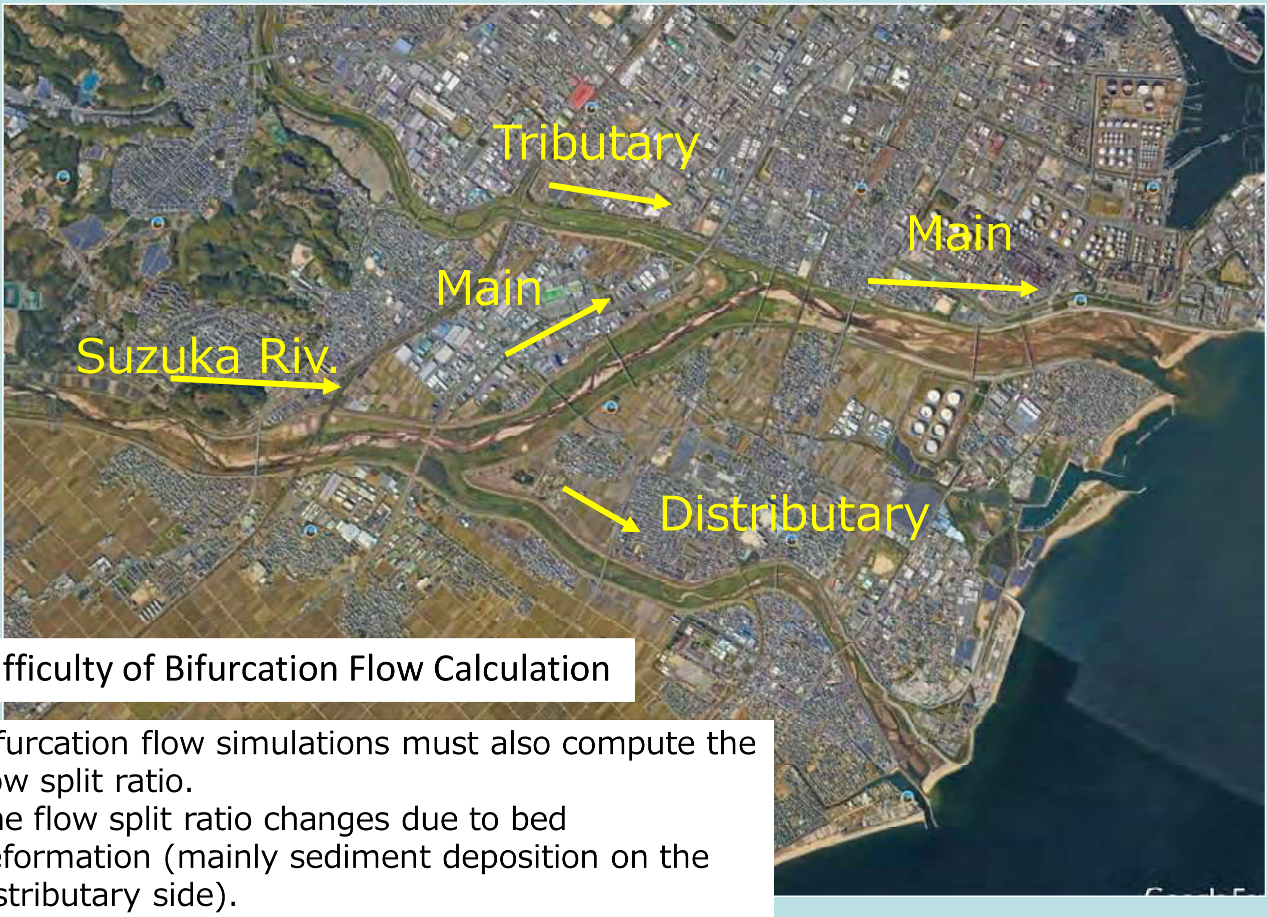
Along the tributaryy





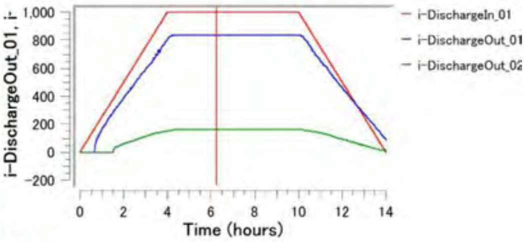


With Cabernet2D, it is also possible to simulate bifurcation points, which was not feasible with Nays2DH. Suduka River in Mie Prefecture



Difficulty of Bifurcation Flow Calculation

1. Bifurcation flow simulations must also compute the flow split ratio.
2. The flow split ratio changes due to bed deformation (mainly sediment deposition on the distributary side).



Minami and Yoshitake(2024)

土木学会論文集B1(水工学) Vol.69, No.4, I_985-I_990, 2013.

河川分流点周辺の流れと河床変動特性に関する研究

CHARACTERISTICS OF FLOW AND BED VARIATION IN A DIVERSION OF A RIVER

重枝未玲[1]・秋山壽一郎[2]・坂本 洋[3]・新谷恭平[4]
Mirei SHIGE-EDA, Juichiro AKIYAMA, Hiroshi SAKAMOTO and Kyouhei SHINTA

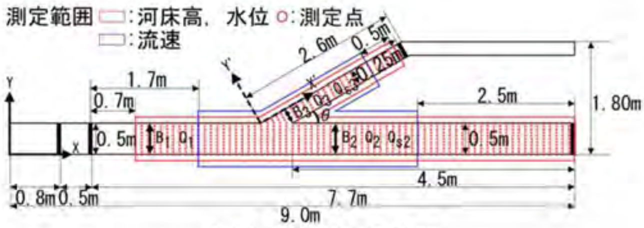
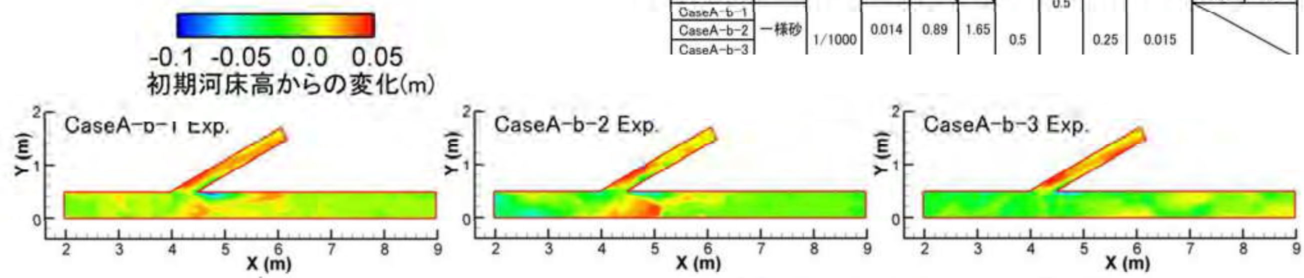


図-1 実験装置の概要

表-1 実験条件

Case名	河床	I	n	D(mm)	s	B_1(m)	B_2(m)	B_3(m)	Q_1(m^3/s)	本川水面形 分流前	本川水面形 分流後
CaseA-a-1	固定床	1/1000	0.01			0.5	0.5	0.25	0.015	M1	M1
CaseA-a-2										M2	M1
CaseA-a-3										M2	M2
CaseA-b-1	一様砂		0.014	0.89	1.65						
CaseA-b-2											
CaseA-b-3											



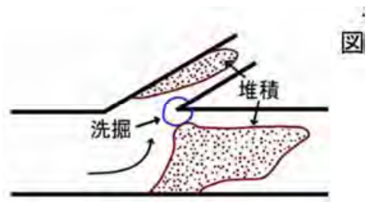


図-6 分流点の洗掘と堆積パターン

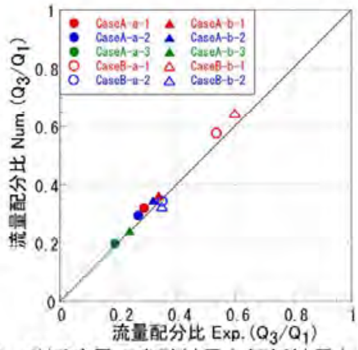
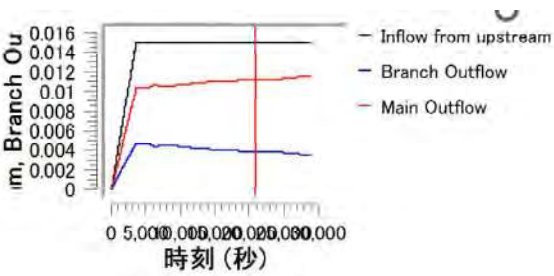
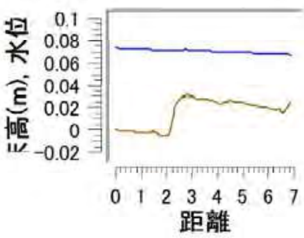
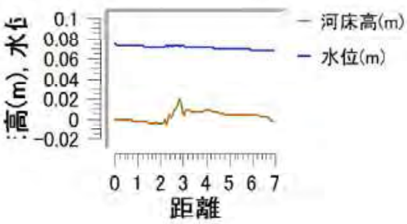
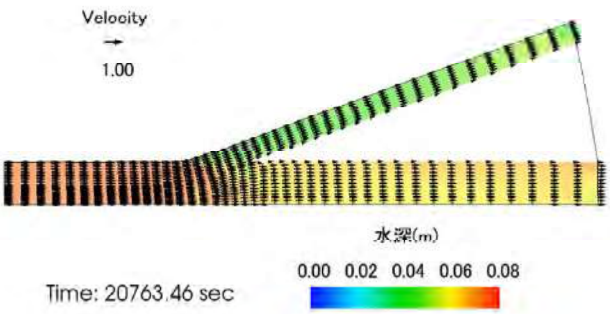


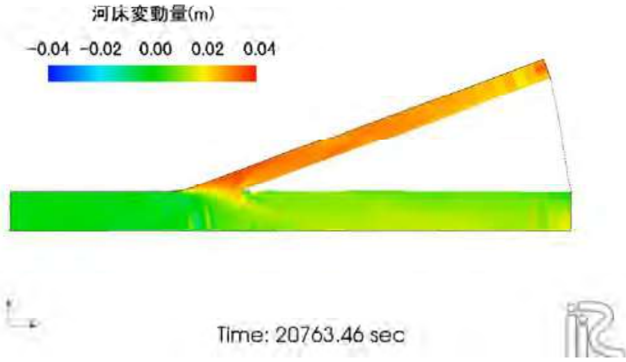
図-10 分派流量の実験結果と解析結果との比較



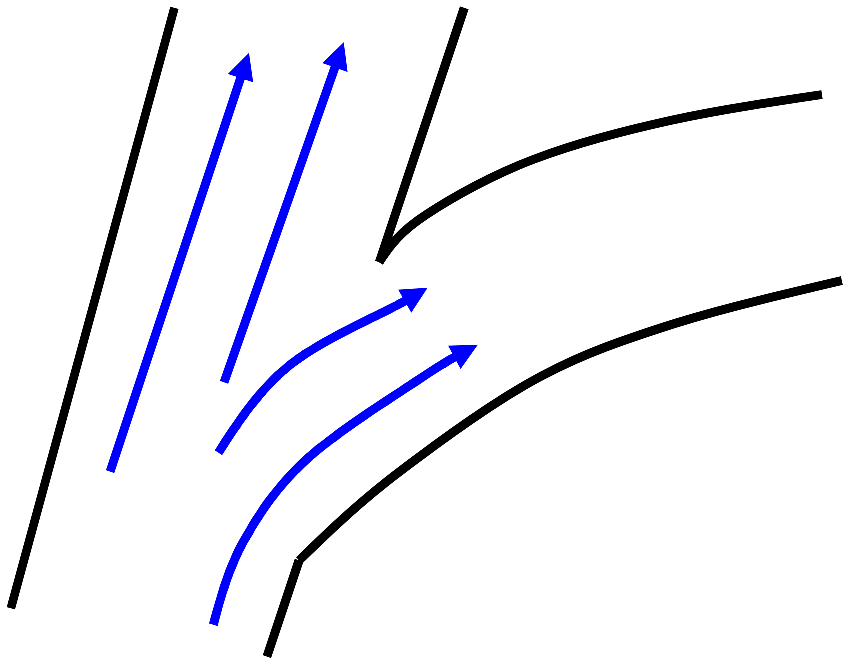








Why does sediment tend to flow more into the distributary and accumulate there in the first place?



When Streamlines Curve...

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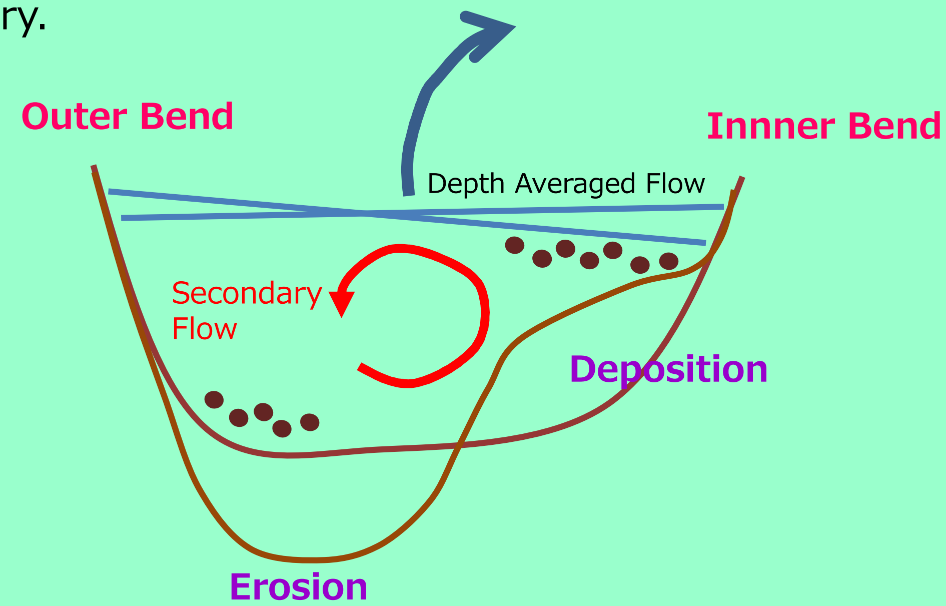
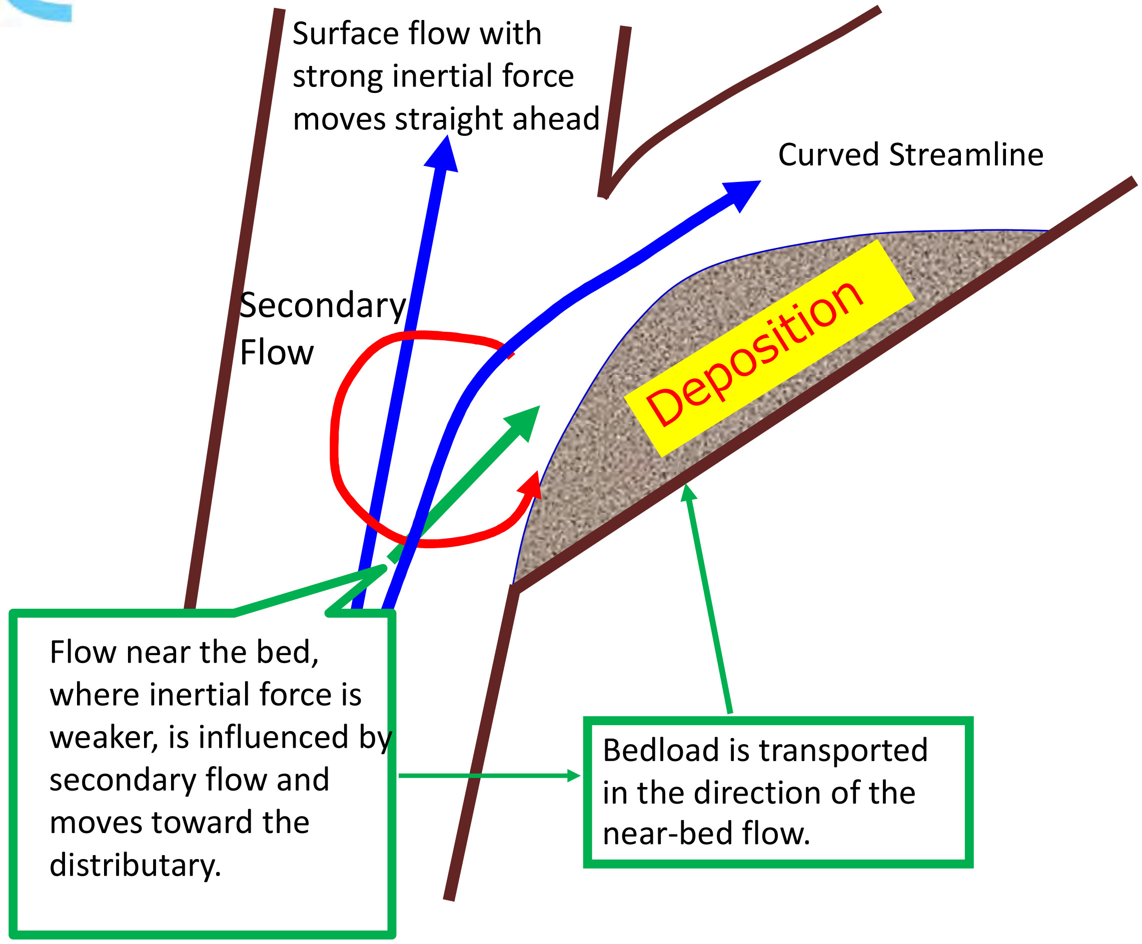
River Interface Corporative
iRIC

Due to centrifugal force, secondary flow occurs, and near the bed, flow tends to move from the outer to the inner bank. As a result, sediment on the outer side of the curve is transported toward the inner side. At bifurcation points, more sediment from the main channel tends to be transported into the distributary.





Levee Breach Experiments[Shimada et al.(2012)]

写真- 19　予備実験（正面越流）の状況

表- 7　実験条件

堤体・水路形状					通水流量（目標）	実験実施日
土質	高さ	天端幅	法勾配	水路幅		
砂礫	2.5m	2m	1:2	30m	20m^3/s	2008年8月

写真- 20　実験状況

Experimental Results (Grabd Shape)

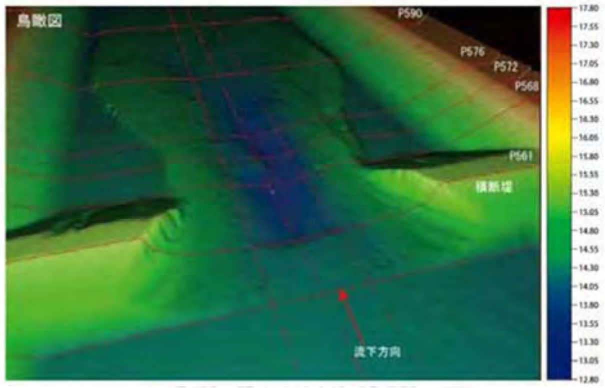
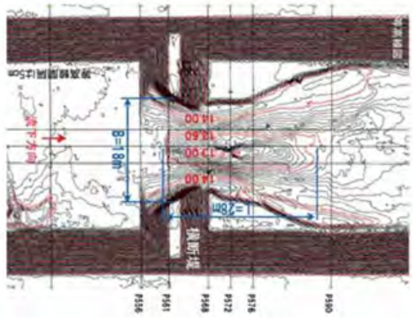
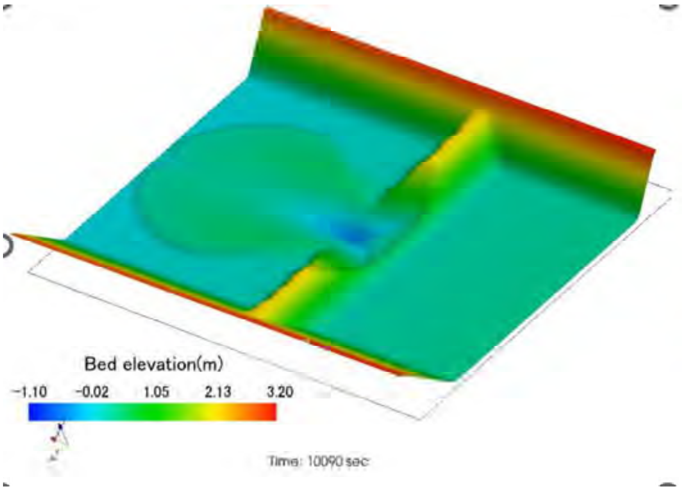
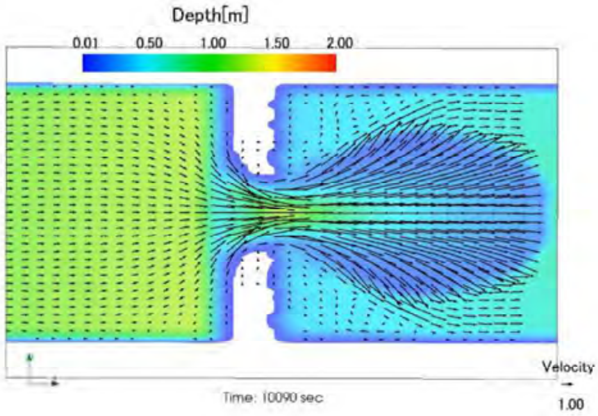


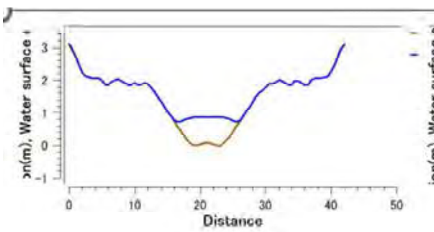
図- 38 通水終了後の地形形状

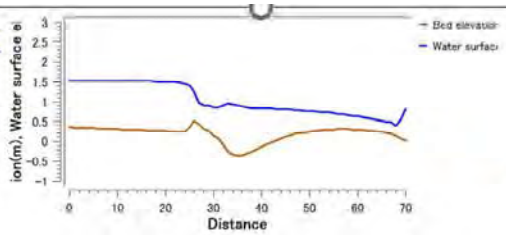


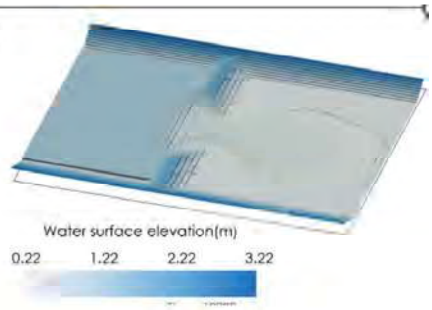


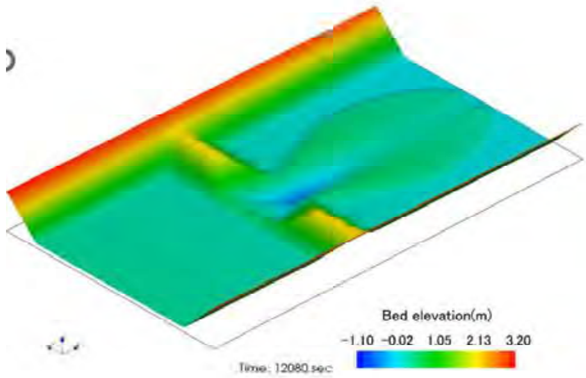


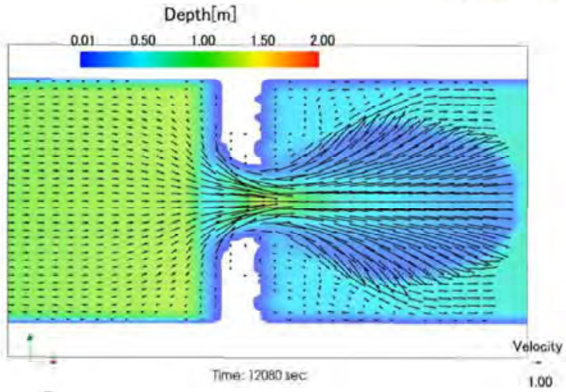
Computational Results(Bed Configuration and Depth)



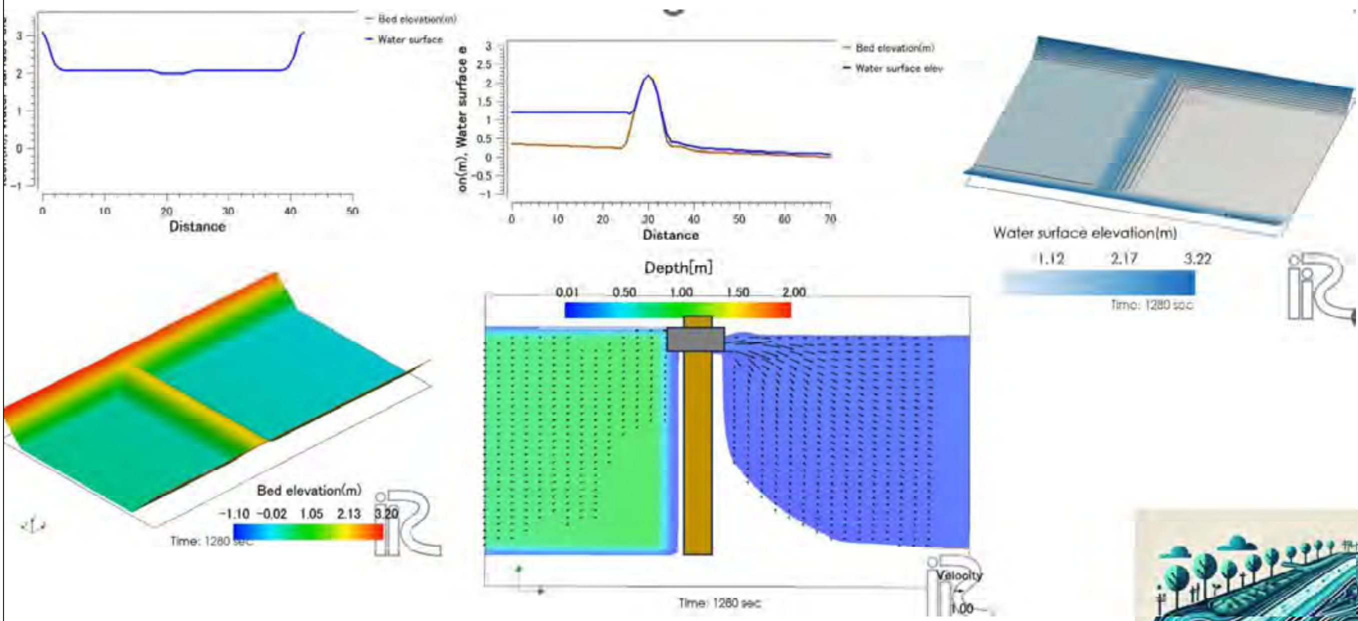






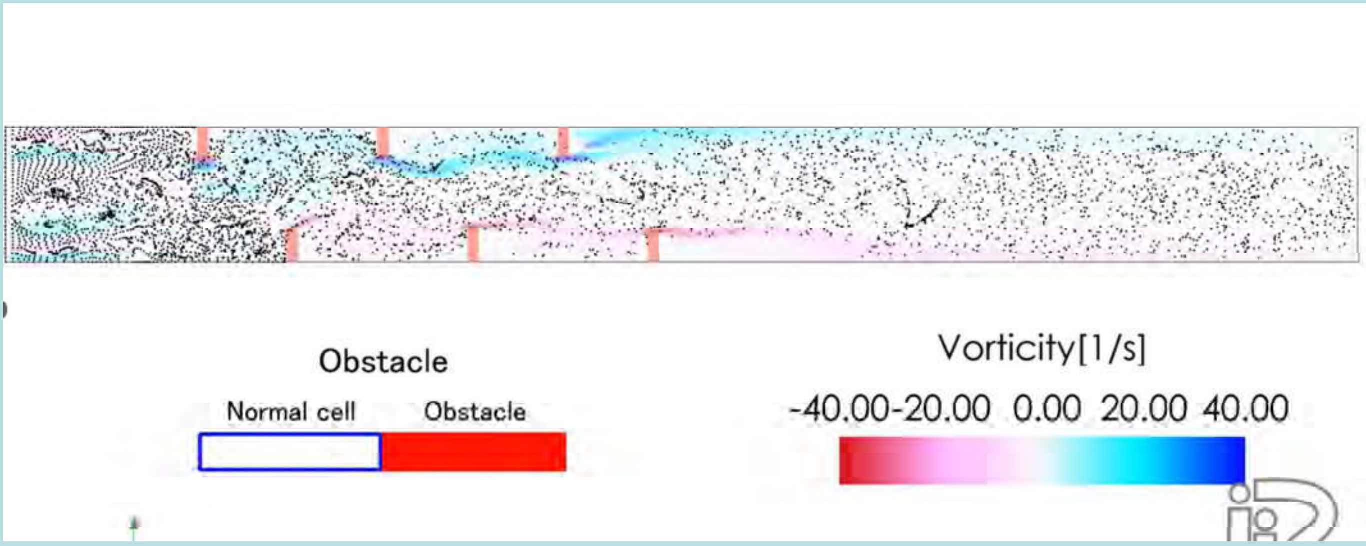


Box culverts, sluice gates, flap gates,
and pumps can also be simulated.

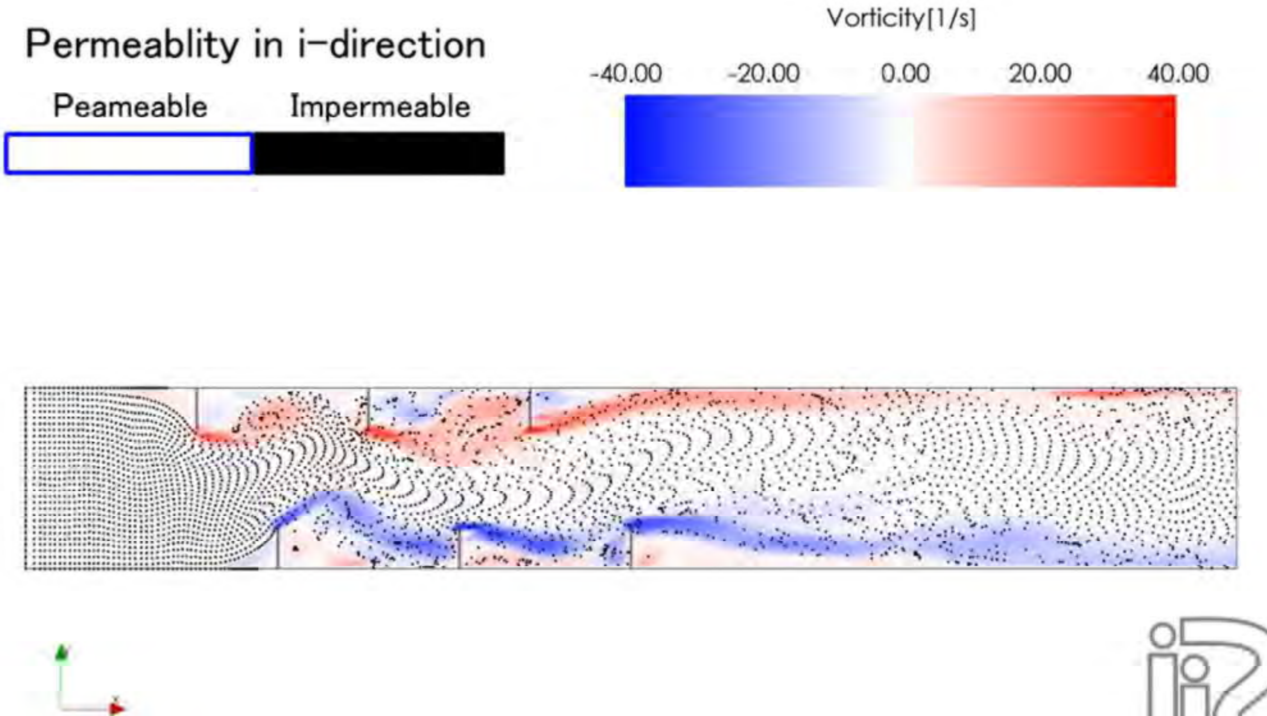


New Feature of Cabernet2D:
Boundary Conditions on Edges

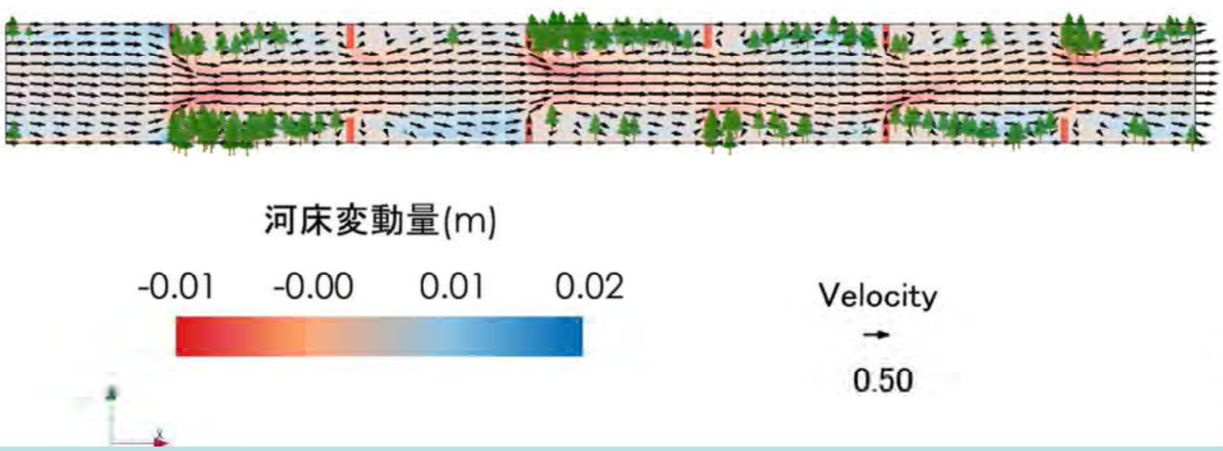
In Nays2dH and Nays2dFlood, obstacles could only be defined using cells. Therefore, the minimum thickness of a groin (spur dike) had to be at least the size of a cell.(The function to assign boundary conditions using edges (lines) was implemented in iRIC Version 4.)



iRIC Software
Changing River Science



Simulating and visualizing tree growth between groins can now be done with ease!



New Solvers in iRIC Ver.4 (2)

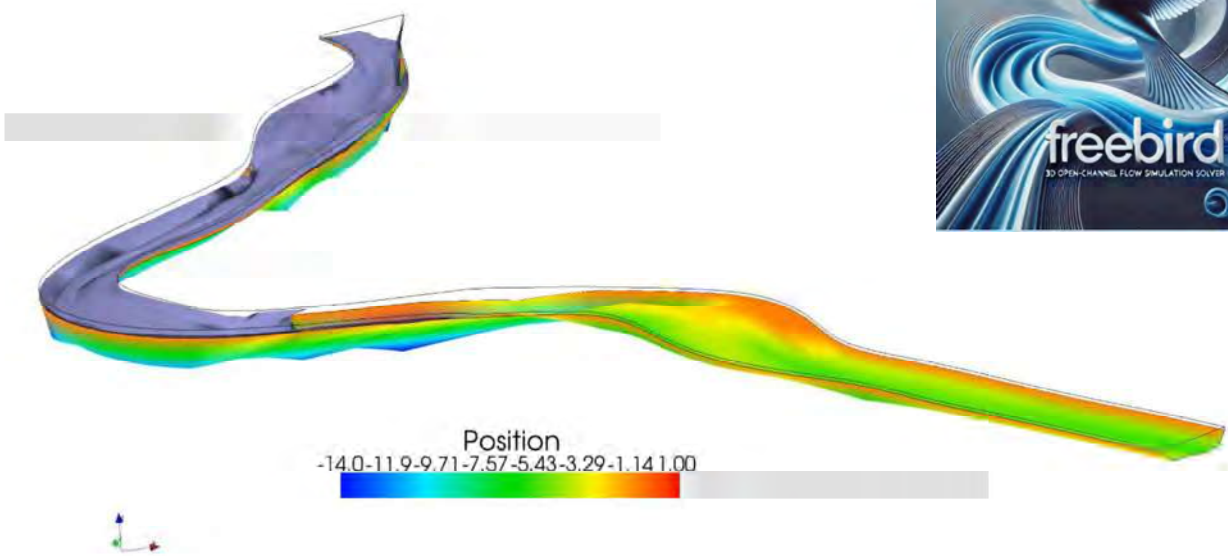
Freebird3D

Fully Responsive Engine for Evolution of Bathymetry and Improvement of River Design

- 3D open channel flow model (based on Nays3dV)
- Non-hydrostatic model (hydrostatic model also selectable)
- Density flow simulation is supported
- Uses contravariant physical components for stable velocity calculation
- Supports subcritical flow, supercritical flow, mixed flow conditions, and hydraulic jumps
- Compatible with confluence and bifurcation points

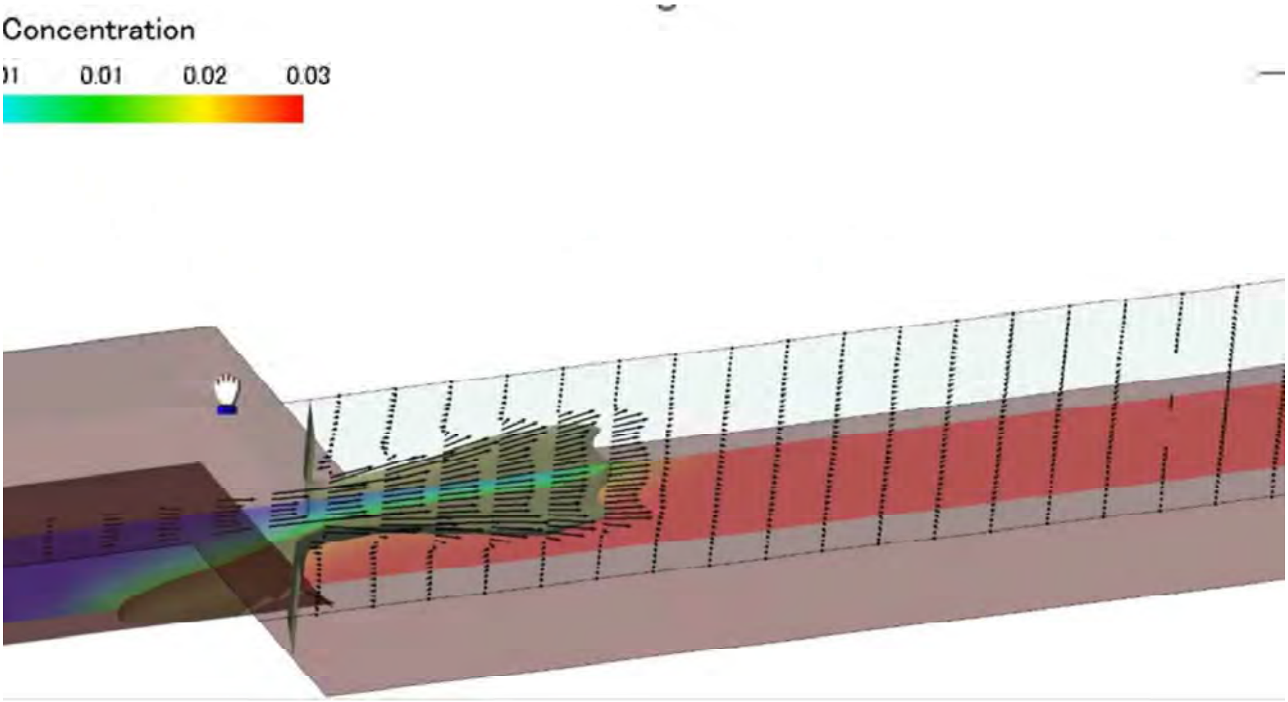
iRIC Software
Changing River Science

Example of Saline Wedge Simulation in the Ishikari River

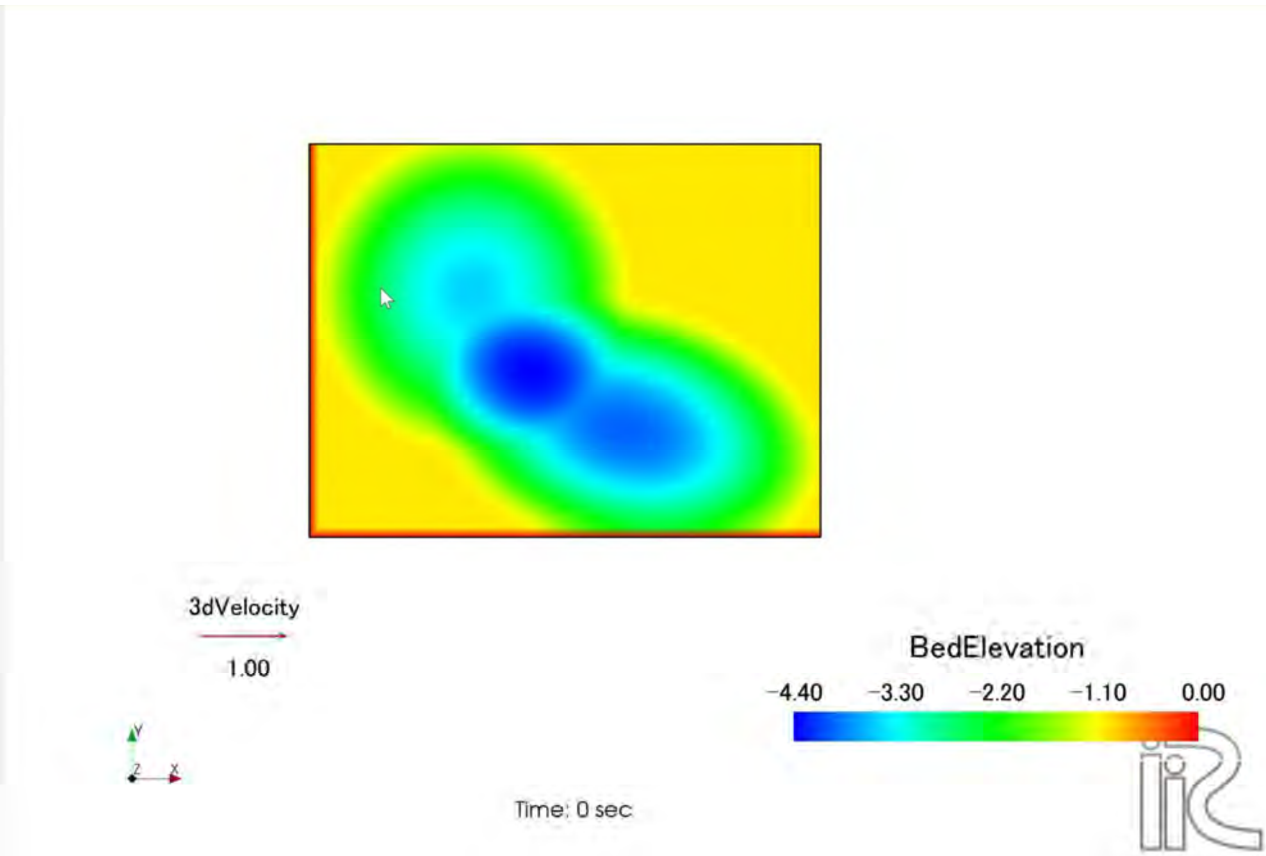


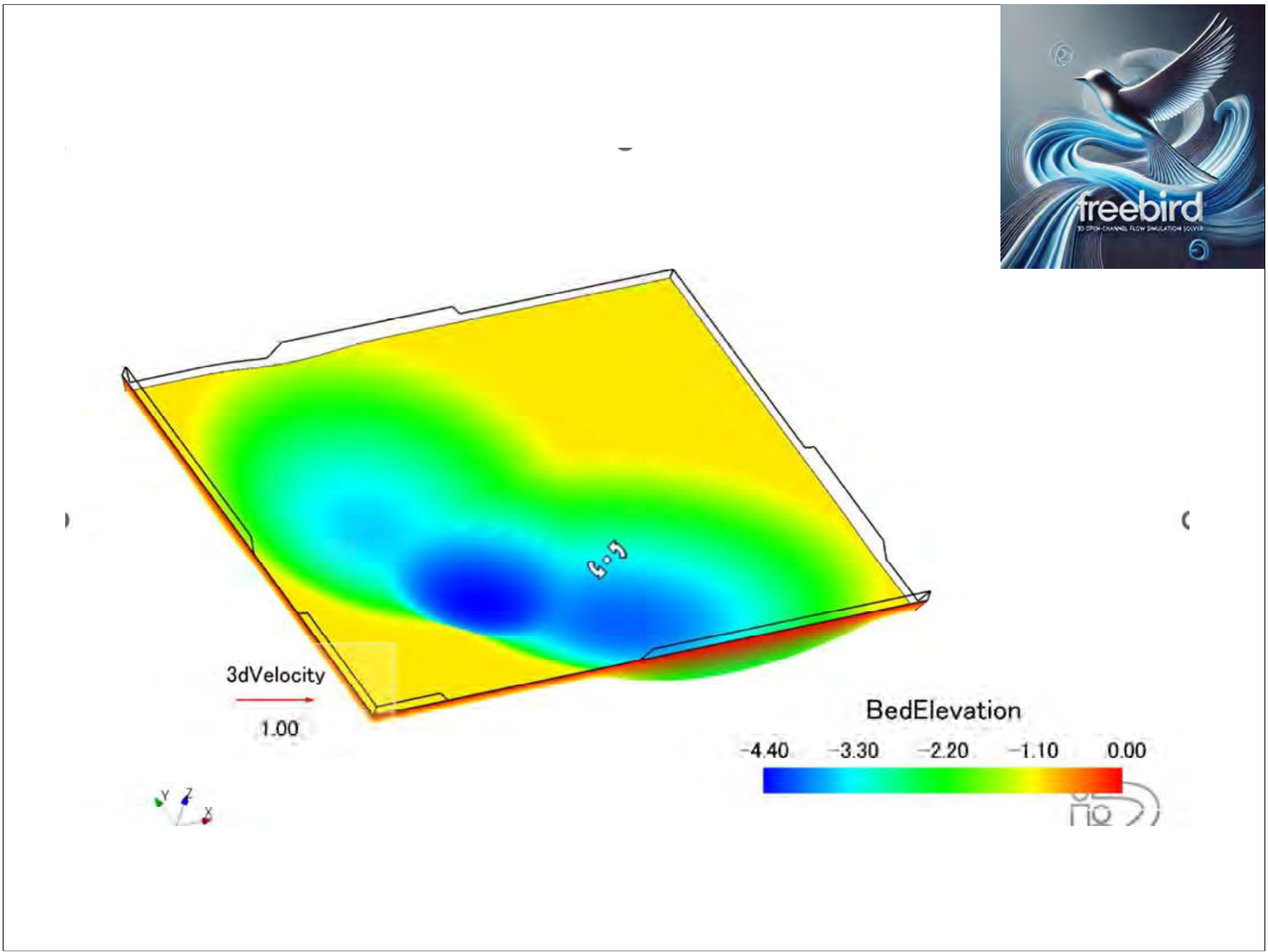
FREEBIRD:

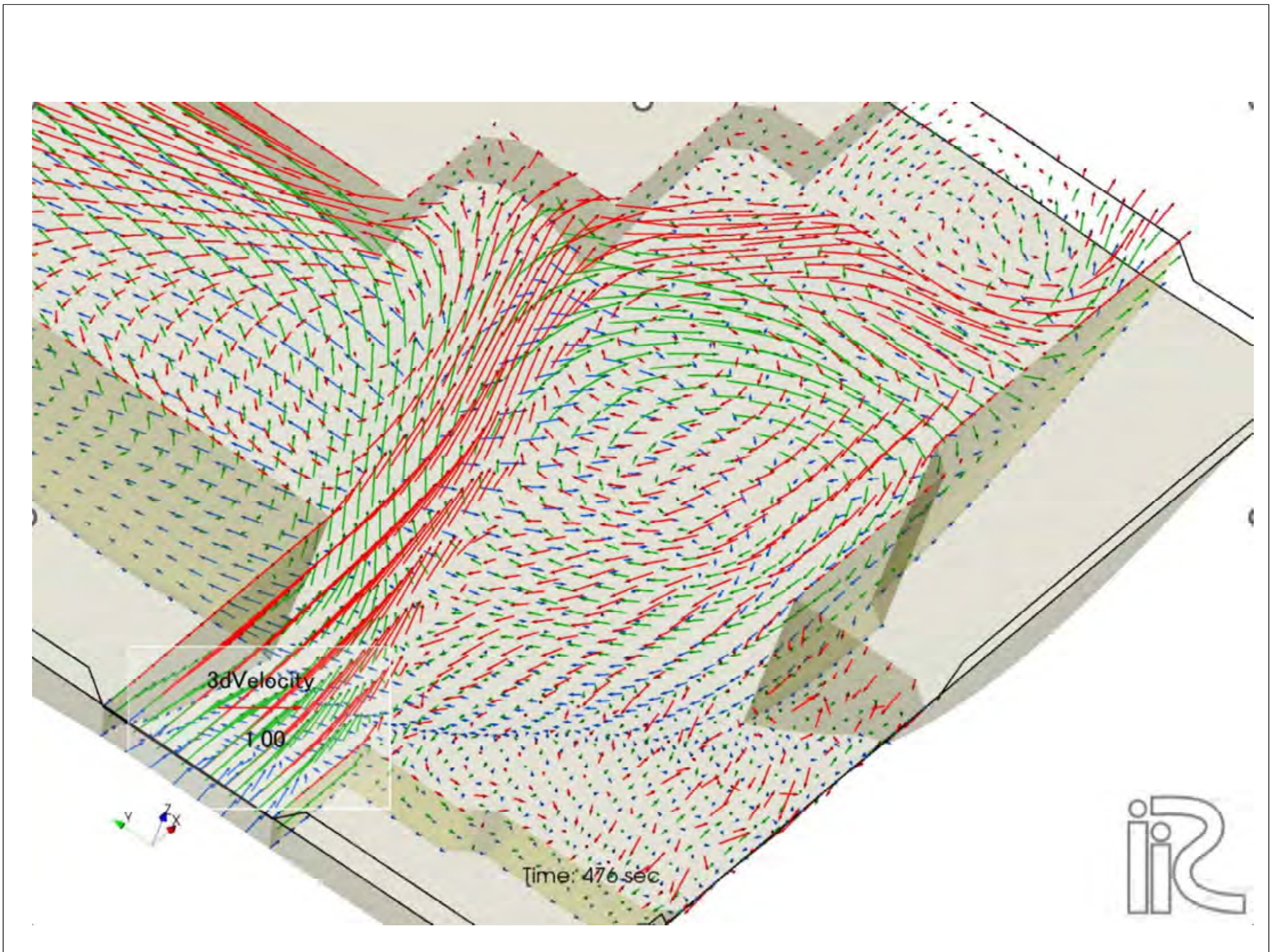
Fully-3D River Engine with Evolution of Bathymetry for Improvement of River Design



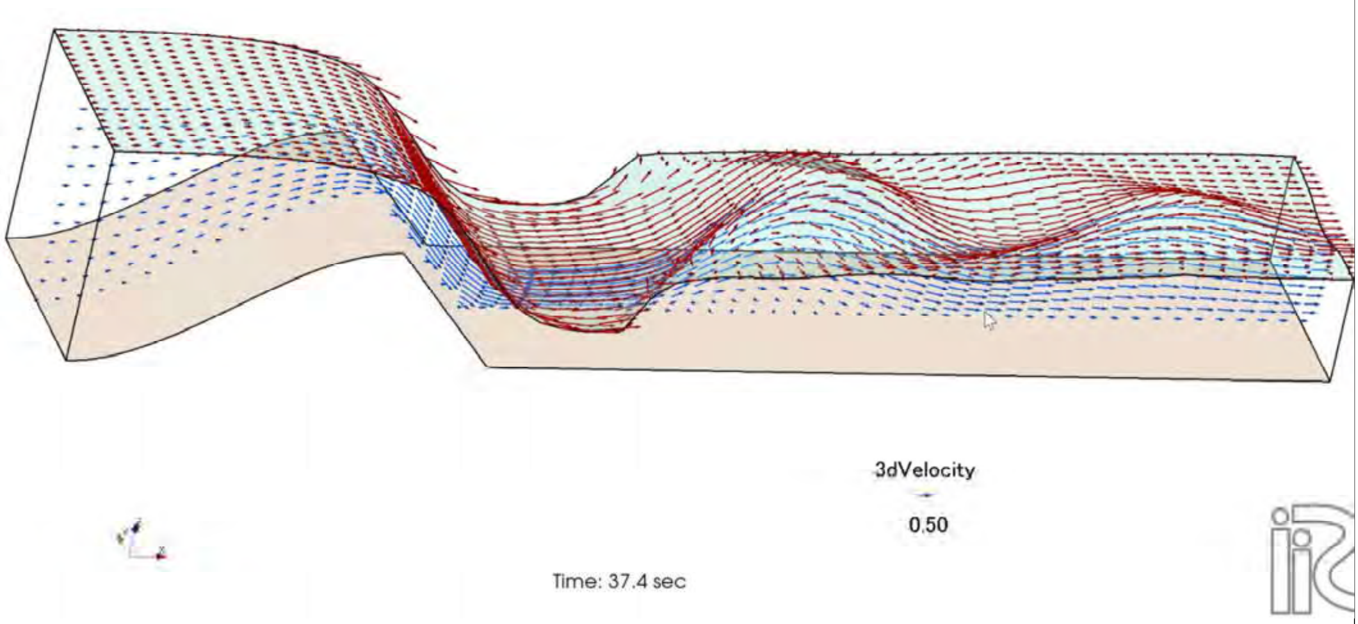
Complex Riverbed Topography

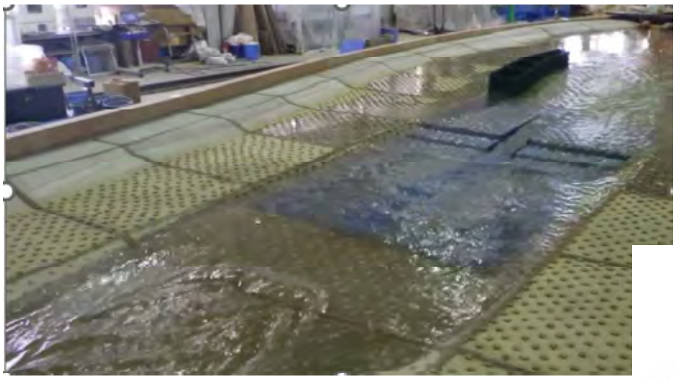



freebird
3D OPEN-CHANNEL FLOW SIMULATION SOLVER
3dVelocity
1.00
BedElevation
-4.40
-3.30
-2.20
-1.10
0.00

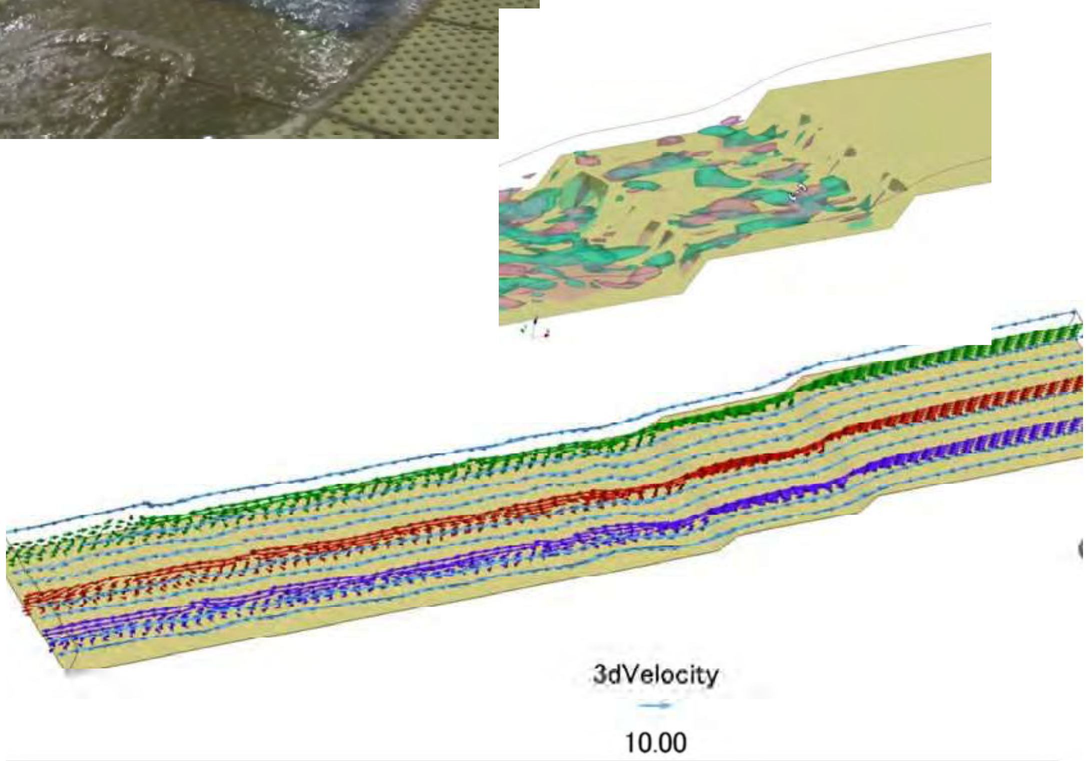

3dVelocity
1.00
Time: 476 sec

FREEBIRD





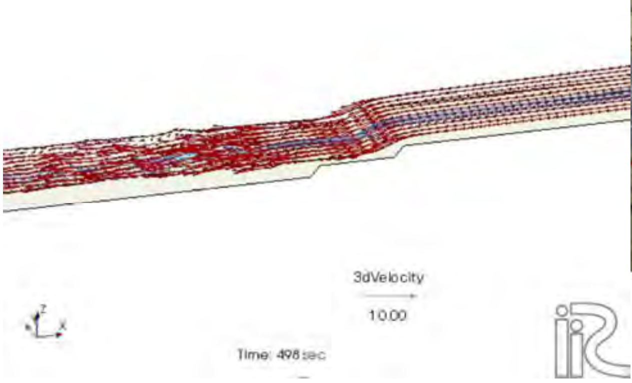
濱木ら(2024)

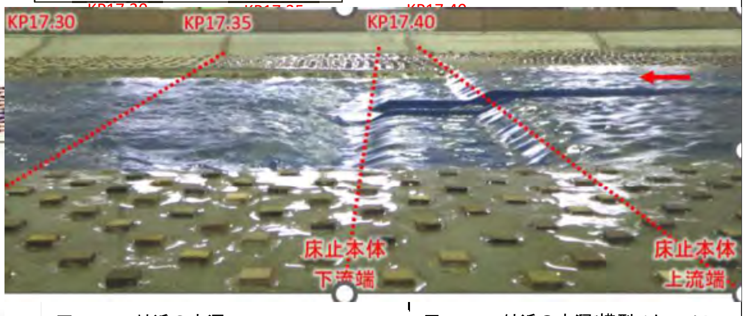


Reproduction of Hydraulic Jump Location Using Freebird (3D)

- In the 3D analysis, the overflow depth tends to be slightly smaller, and a distinct hydraulic jump like that observed in experiments is less likely to occur. However, the overall water surface profile, water depth, and hydraulic jump location generally match well.

C1-1：平均年最大流量

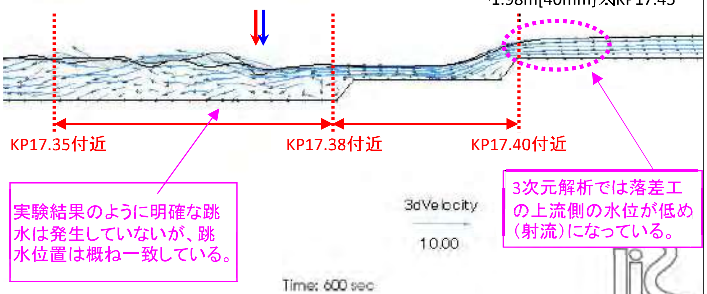




■KP17.35付近の水深
数値解析：hs=2.58m[52mm]
模型実験：hs=2.55m[51mm]

■跳水位置：実験↓
計算↓

■KP17.40付近の水深[模型スケール]
限界水深：hc=1.38m[28mm]
数値解析：hs=0.98m[20mm]※KP17.40
～1.65m[33mm]※KP17.43
模型実験：hs=1.76m[35mm]※KP17.40
～1.98m[40mm]※KP17.45



※数値解析による跳水位置は水面変動が大きい箇所を抽出

項目	計算条件
河道形状	KP17.33～KP17.43の100m区間 ※KP17.39とKP17.40にdz1.3mの落差（合計2.6mの落差）
平面形状	流下方向：201格子（約0.5m間隔） 横断方向：21格子（約0.5m間隔）
粗度係数	相当粗度ks=0.1m　※Roughness Size(Grain Size)(m) ※マニングストリックラー型でn=0.0284（護床工と同等）
下流水位	35.03m C1-1：480m3/sに対応するKP17.3地点水位
流量	5.05m3/s/m C1-1：480m3/sに対応する低水路内の単位幅流量
その他	渦粘性係数　※Eddy Viscosity 一定

Vertical Drop Stracture and Fishway on the Toyohira River (Sapporo City)

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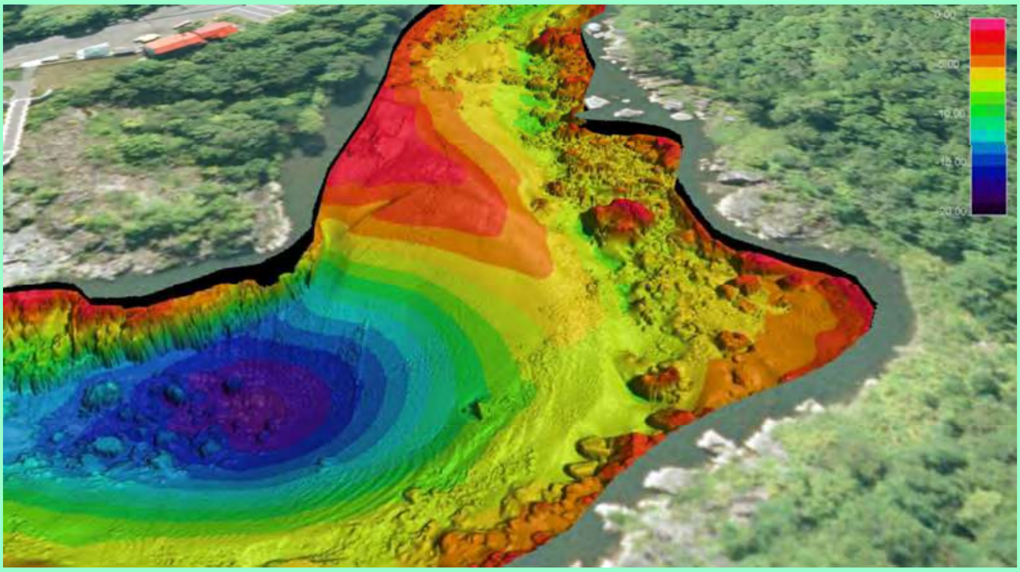
Rapid Expansion Area of the Ishikari River
(Photographed on March 1, 2018)



Survey Results Using Multibeam, in 2011.
(Asahikawa Development and Construction Department)

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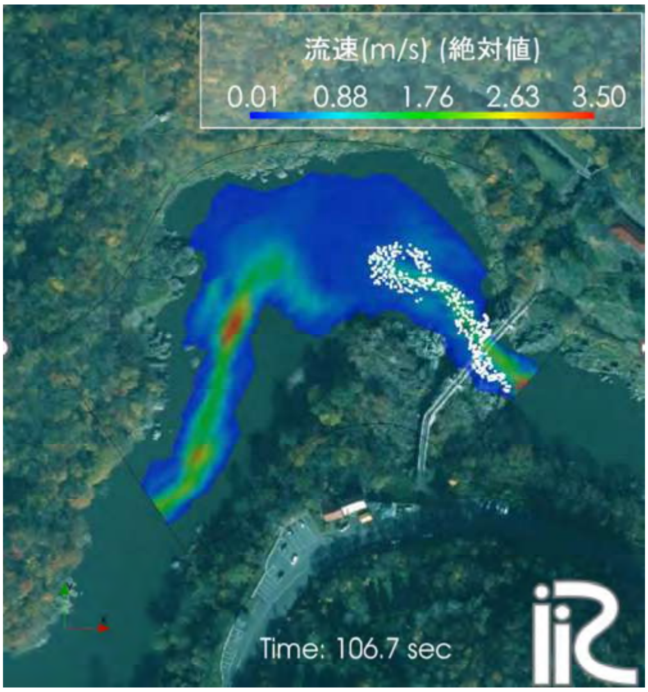
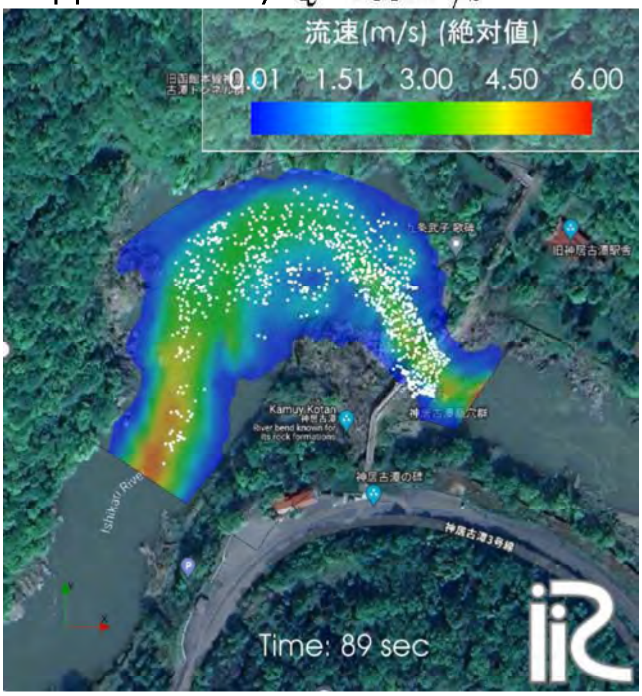
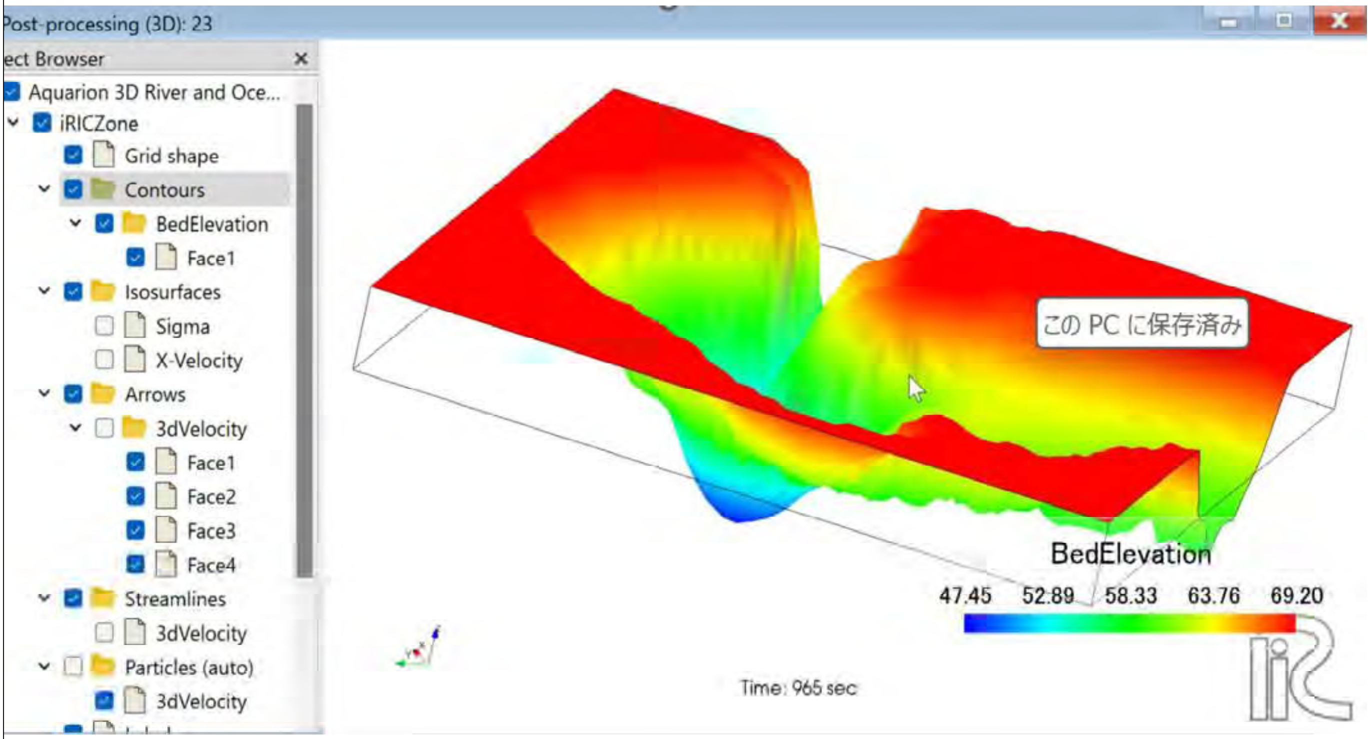
February 27, 2018 – During Aerial Circle Photography Simulation Assuming a Discharge of $Q\!=\!60\mathrm{m}^3/\mathrm{s}$



April 19, 2024 – Simulation Assuming a Discharge of Approximately $Q\!=\!465\mathrm{m}^3/\mathrm{s}$



What Happens in 3D?



Simulation by FREEBIRD

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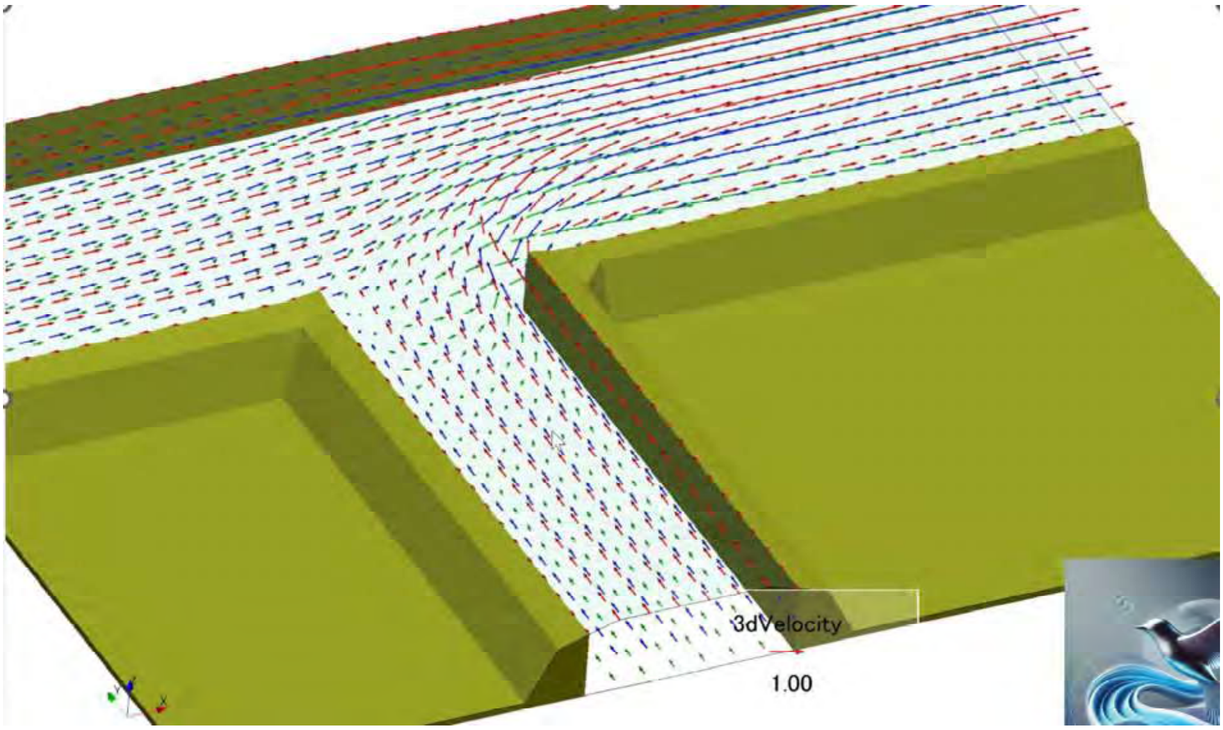
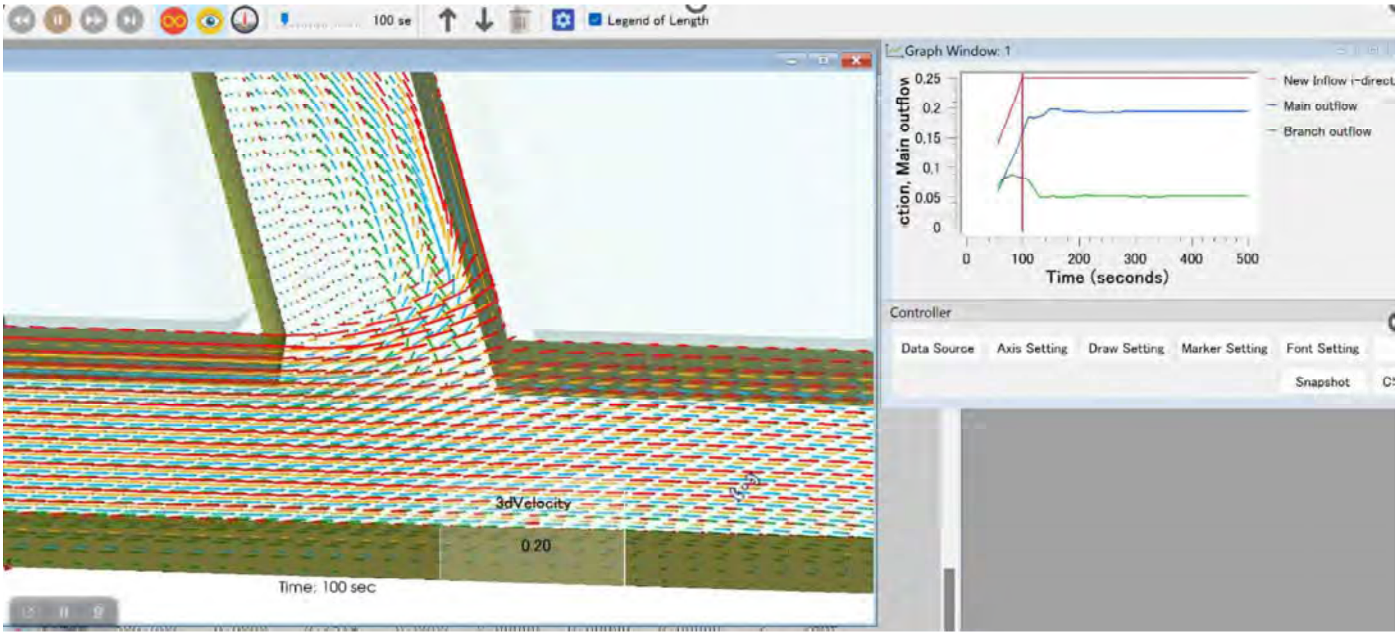
Simulation of Confluences and Bifurcations in Freebird (3D





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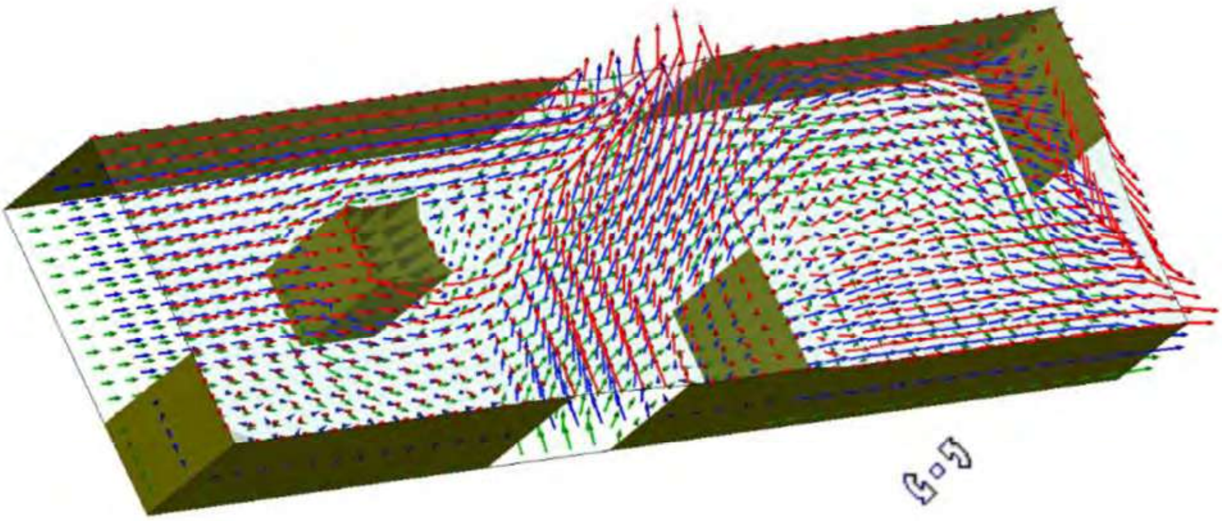
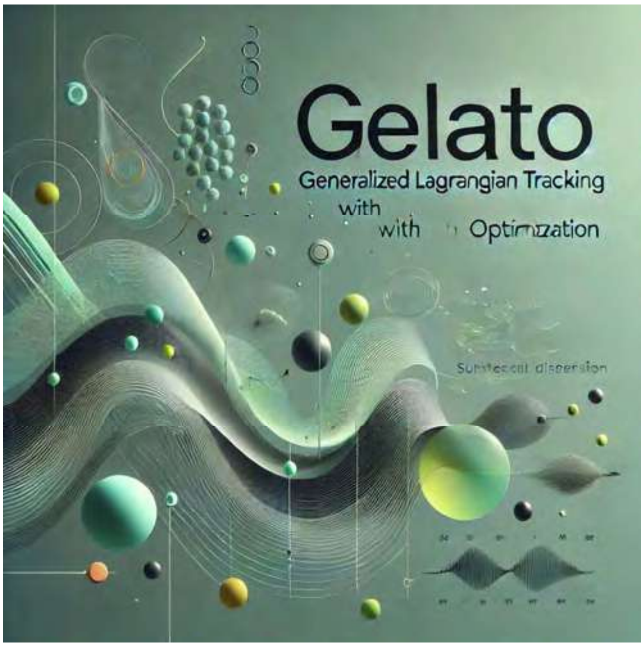


Multifunctional Material Transport Model GELATO

GEneralized LAgrangian Tracking with Optimization



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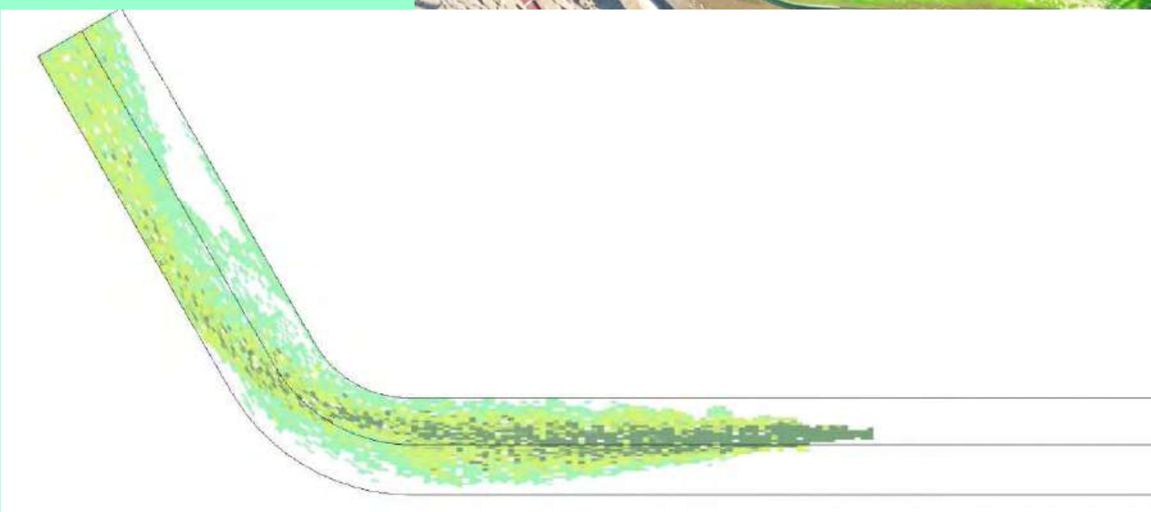

Example:
Dispersion
of floating
contaminant

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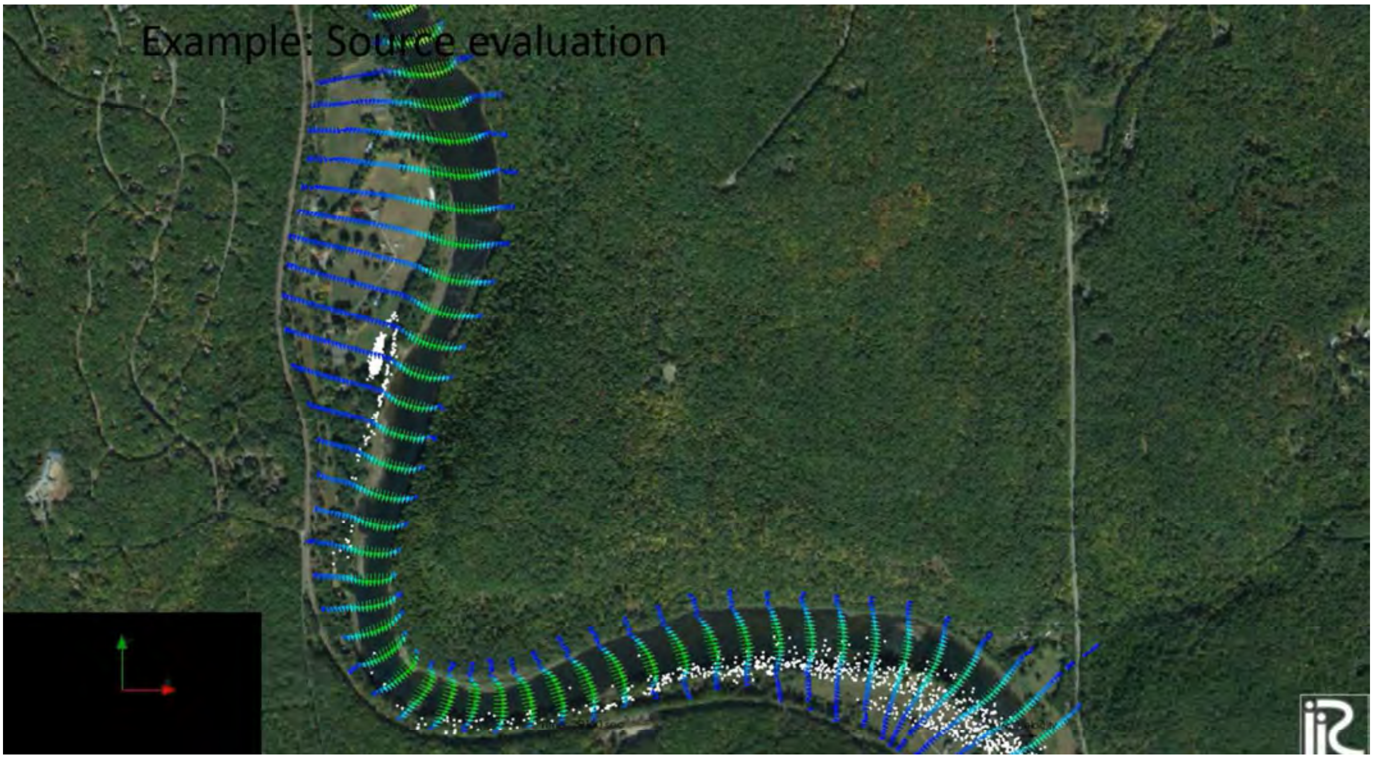
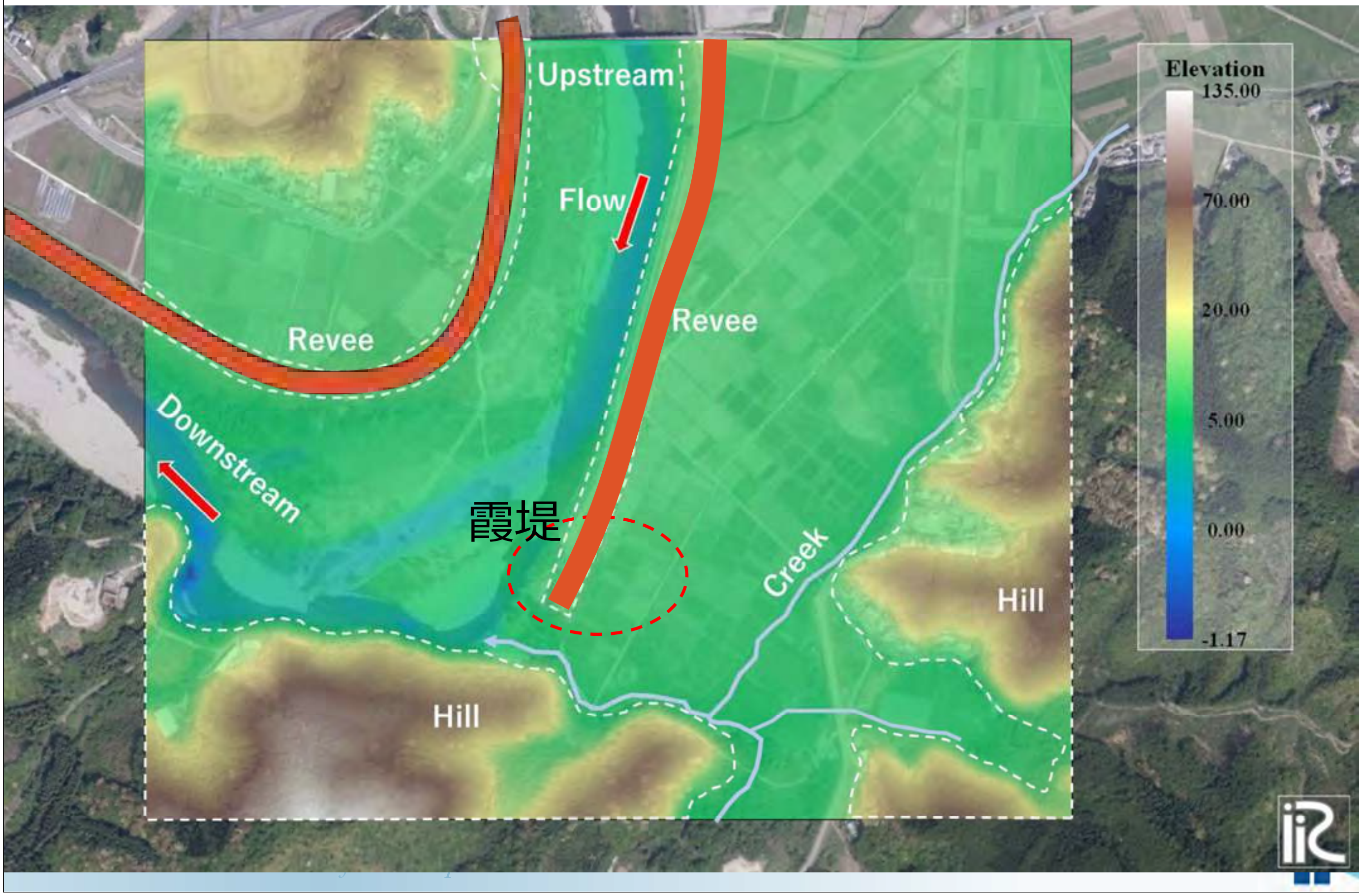
Example: Source evaluation

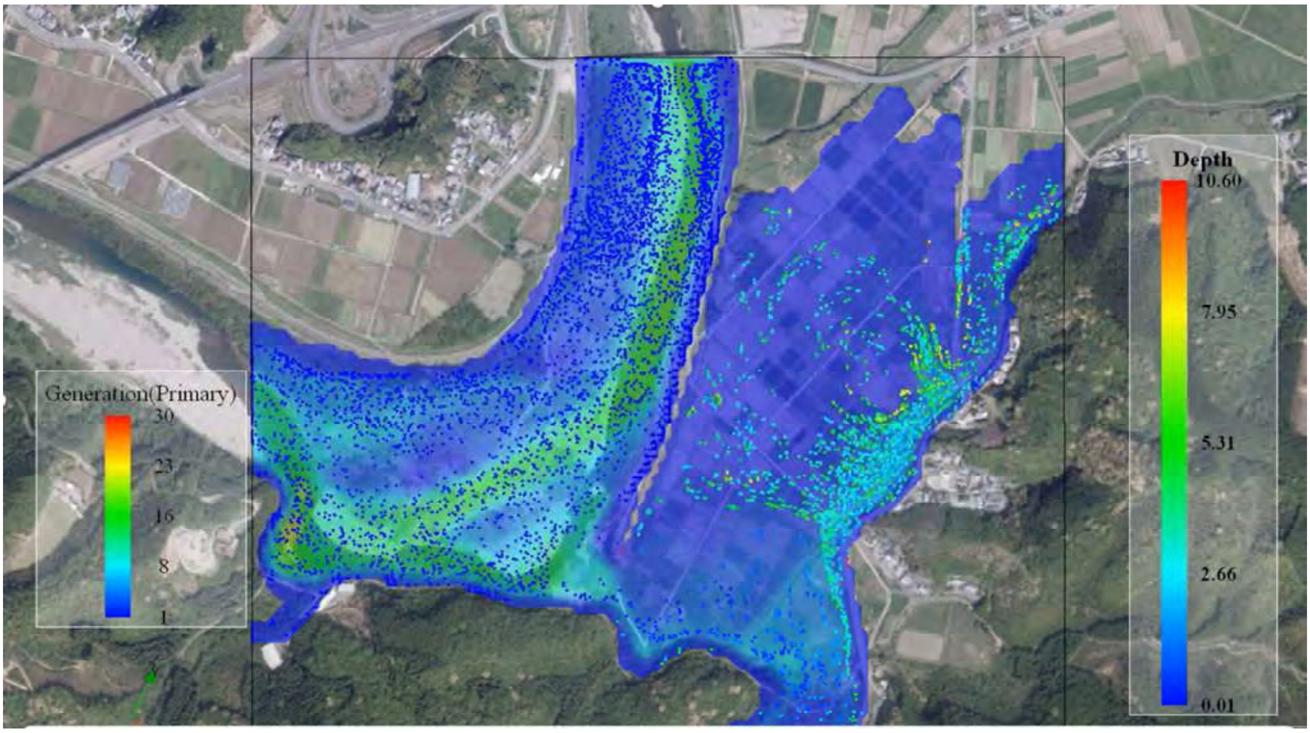


Application Example at a Kasumi-Tei Levee on the Kitagawa River, Miyazaki Prefecture [Asahi & Hoshino (2023)]



The Problem of Large Amounts of Woody Debris (Goso)

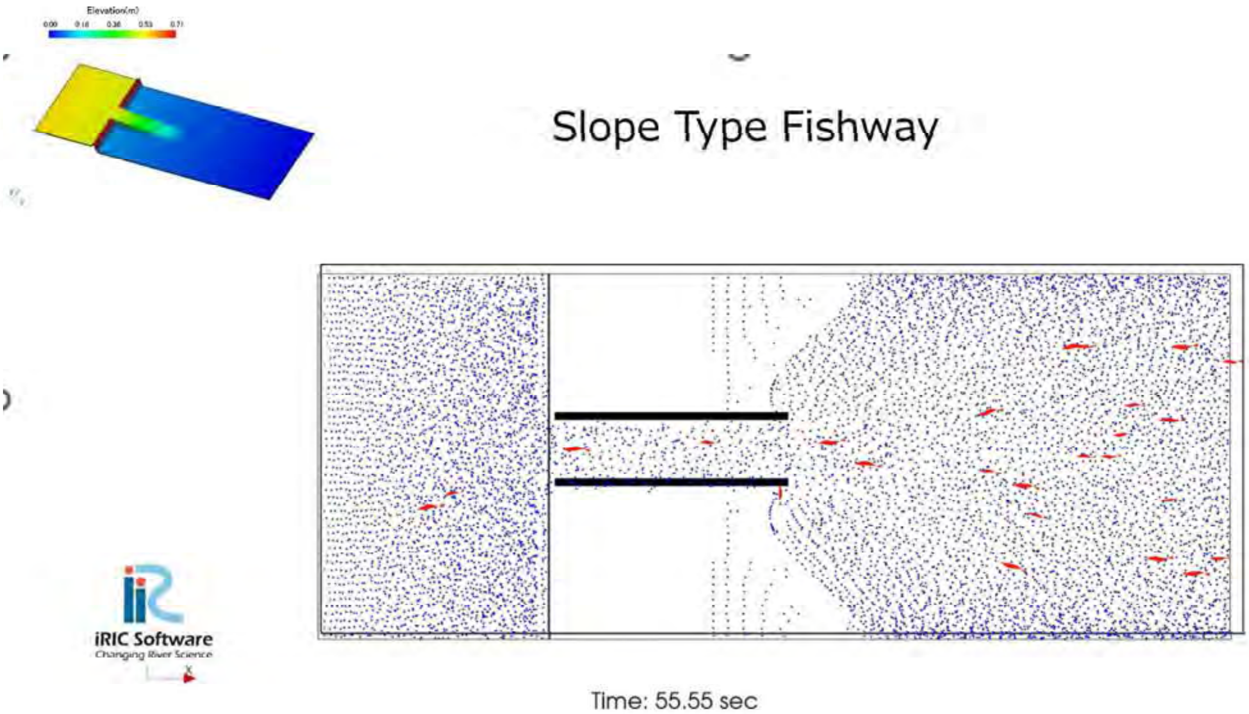
Normal Tracer Tracking



Example of Fish Behavior Tracking Simulation Using GELATO [Hamaki et al. (2024)]

Bed Protection Work and a Fishway on the Toyohira River (Sapporo City)

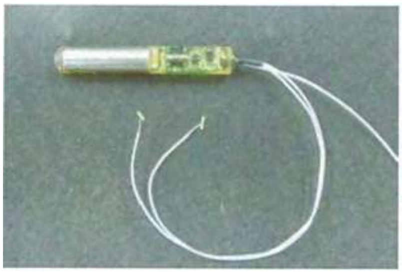
出水時


Elevation(m)
0.00
0.36
0.53
Slope Type Fishway
iRIC Software
Changing River Science
Time: 55.55 sec

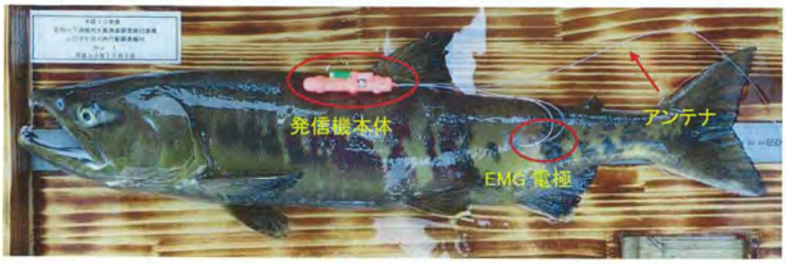
Overview of Fish Survey (Biotelemetry Study)

➢ 調査概要（2018/10/3～5、2018/10/9～11）
・調査区間…5号床止下流～8号床止上流
・調査個体数…5尾(1回目)、6尾(2回目)

・バイオテレメトリー手法を用い、各供試魚にEMG発信機を装着して遡上経路を追跡
・ EMG発信機により供試魚の河川内の位置および遊泳速度を把握
　※EMG値…赤筋に流れる微電流を感知し、0~50の相対値に換算された値
　　　　　既往調査で得られた相関式から遊泳速度に変換可能



EMG発信機



発信機を装着した供試魚

※ H30河川横断工作物に係わる魚類調査(公益社団法人北海道栽培漁業振興公社)

Fish Survey Results (Biotelemetry Survey)

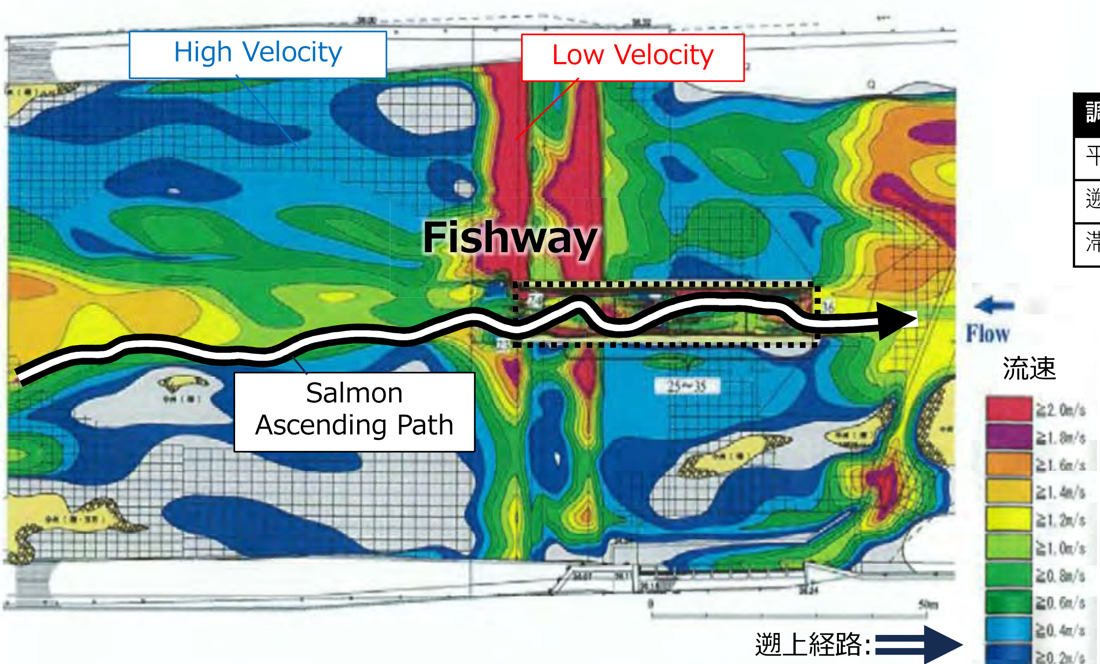


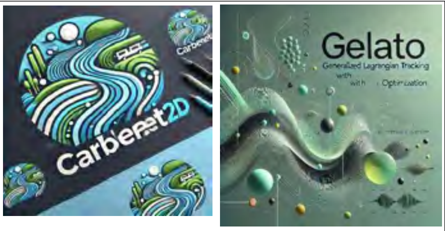
図　No.1の遡上経路および流況調査図

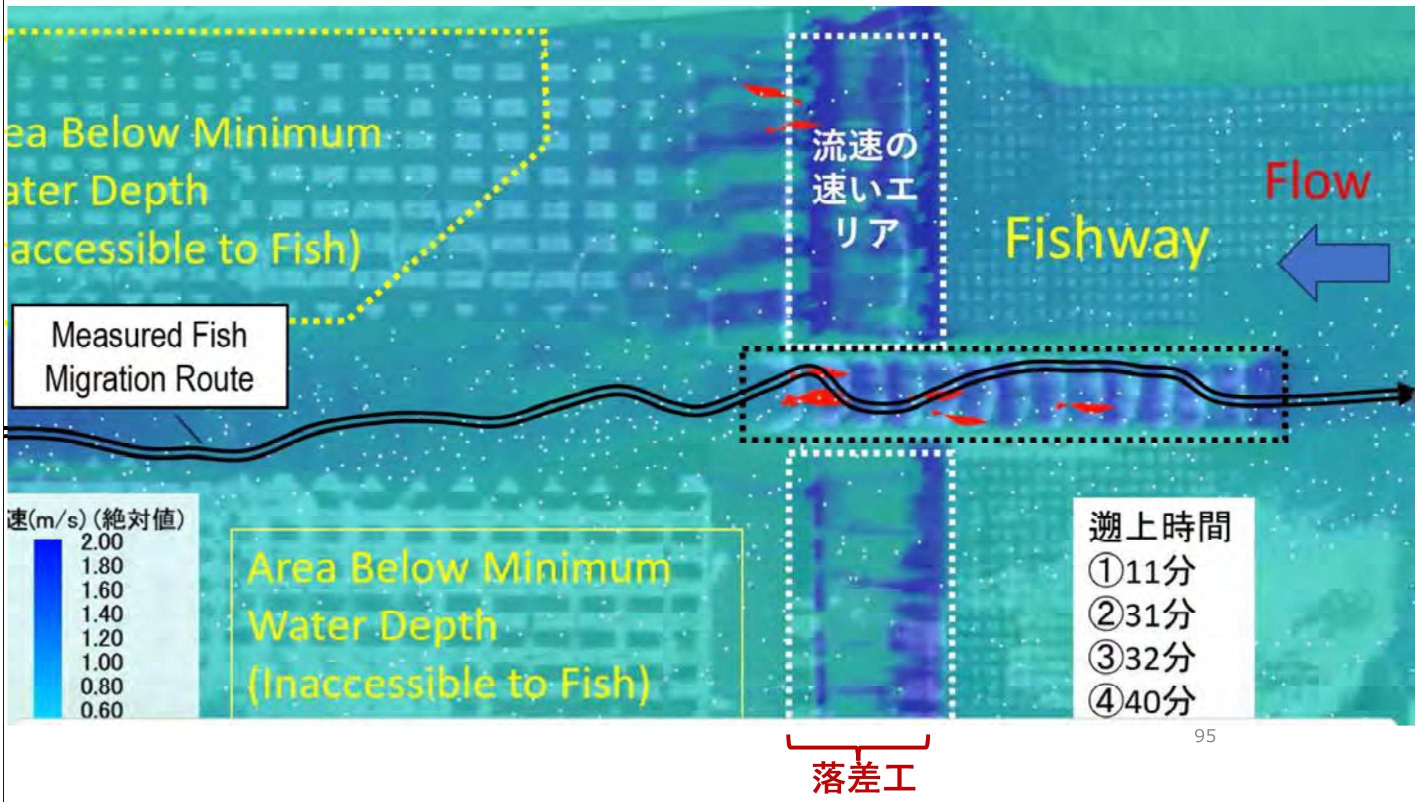
調査結果	No.1
平均遊泳速度	0.6m/s
遡上時の遊泳速度	2.0m/s
滞在時間	41min

(Hokkaido Stock Enhancement Promotion Corporation, Public Interest Incorporated Association)

Upstream Migration Simulation [Hamaki et al. (2024)]

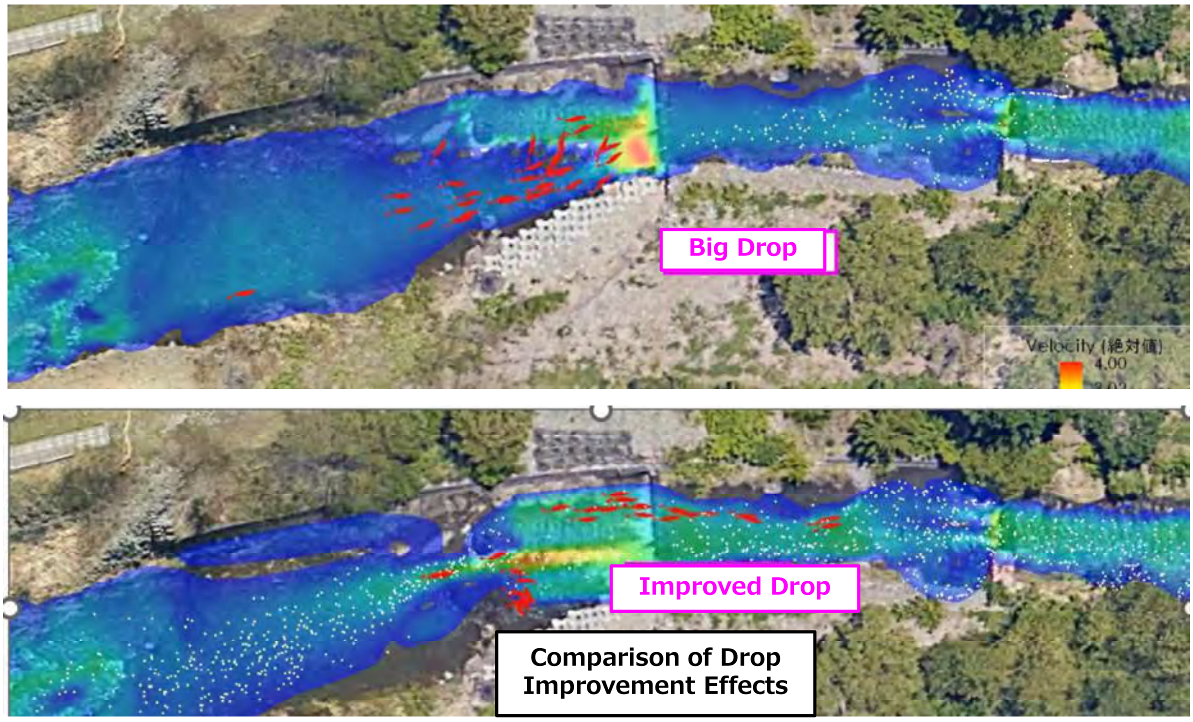
- When comparing upstream migration paths, the simulated results closely matched the observed data, successfully reproducing the behavior of fish selecting the fishway rather than locations with large drops.





Application Examples

By accumulating case studies and improving accuracy in the future, it is expected to be utilized as a method for evaluating the upstream migration performance of fishways before and after renovation.



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Thank you for your attention

王崇楷 Chung Kai Wang

Master Student, Department of Hydraulic and Ocean Engineering,
National Cheng Kung University, Tainan, Taiwan
國立成功大學水利及海洋工程學系 碩士生

Modeling Braided River Evolution and Lateral Alluvial Fan Interactions Using iRIC

Felix Chung Kai Wang [1], Steven Yueh Jen Lai [2],

[2] Associate Professor, Department of Hydraulic and Ocean Engineering, National Cheng Kung University, Tainan, Taiwan

[2] Deputy Director, Disaster Prevention Education Center (DPEC), National Cheng Kung University, Tainan, Taiwan

This study employs the Nays2DH module in iRIC to investigate the morphological adaptation mechanisms of braided channels influenced by lateral alluvial fans of varying dimensions. The research focuses on two key parameters: the inflow-to-sediment discharge ratio (Q_w/Q_s) and the ratio of alluvial fan radius to channel width (r/B). The numerical simulation of flow patterns is consistent with experimental observations, validating the reliability of the Nays2DH module for river morphodynamics. Quantitative comparisons reveal that the active braiding intensity (BI_A) is proportional to Q_w/Q_s but inversely proportional to the main channel recovery time (t_r). Furthermore, when lateral alluvial fans occupy the main channel, the flows cause erosion on the opposite bank, with erosion intensity proportional to both Q_w/Q_s and r/B. Both simulation and experimental results demonstrate that dimensionless stream power (ω^*) is proportional to BI_A, consistent with findings of previous large-scale physical experiments on braided channels. Through two-dimensional hydraulic modeling and physical experiments, we have gained new insights into the morphological adaptation mechanisms of braided channels affected by lateral alluvial fans. The research findings provide practical recommendations for river management, particularly regarding reinforcement of bank protection opposite to alluvial fans and prevention of flood-prone areas caused by upstream deposition on alluvial fans.

Modeling Braided River Evolution and Lateral Alluvial Fan Interactions Using iRIC

Presenter: Felix Chung Kai Wang
Adviser: Steven Yueh Jen Lai

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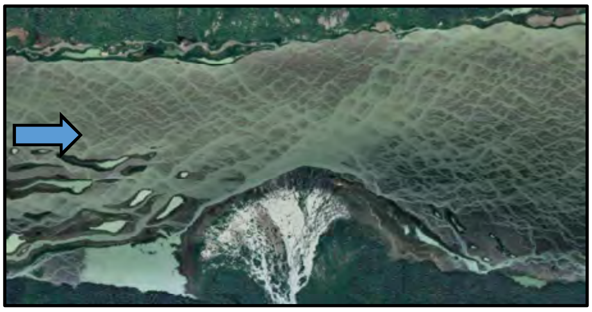
Introduction > Experiment > iRIC > Discussion > Conclusion

- Rivers can be morphologically classified into three types : straight, meandering, and **braided rivers**
- **Lateral alluvial fans** can lead to river channel constriction, resulting in bottleneck sections that alter channel morphology and flow patterns



Upstream of Kenibuna Lake, Alaska

Laonong River - Yusui Tributary

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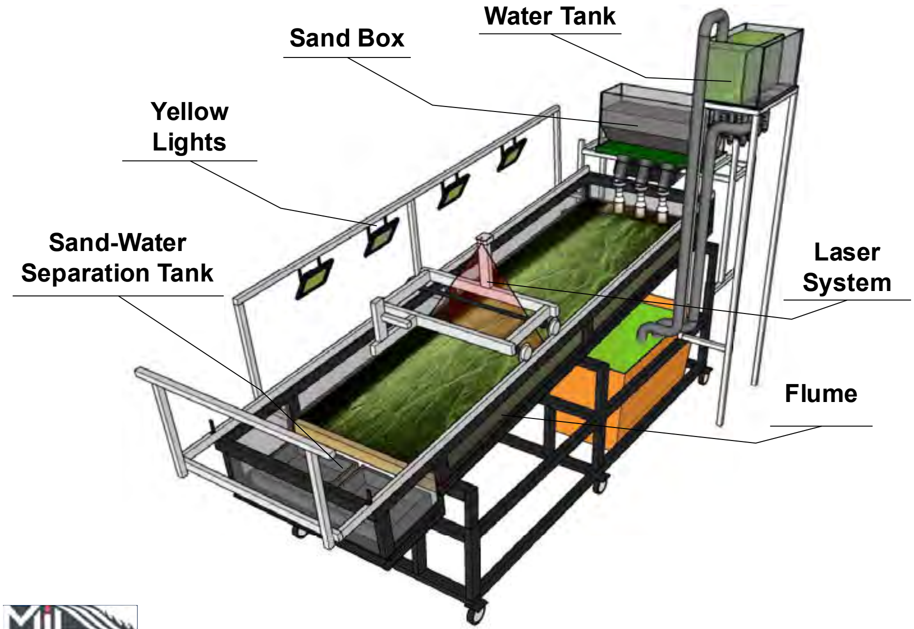
Introduction | Experiment | iRIC | Discussion | Conclusion



Basic Flume Setup Parameters

- Length : 3.8m
- Width : 1.2m
- Depth : 0.3m
- Bed slope : 4 degrees
- Median grain size(d_{50}) : 0.41mm

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Introduction | Experiment | iRIC | Discussion | Conclusion

r: fan radius
B: channel width

NO.	*Real run*	*r/B*	*Slope(degree)*	*$Q_w(cm^3/s)$*	*$Q_s(cm^3/s)$*	*Q_w/Q_s*
A1	Run-09	25%	4	55.38	0.91	60.89
A2	Run-08	50%	4	54.73	0.91	60.17
A3	Run-10	75%	4	55.80	0.91	61.35
B1	Run-05	25%	4	82.17	0.91	90.34
B2	Run-07	50%	4	82.20	0.91	90.37
B3	Run-06	75%	4	82.78	0.91	91.01

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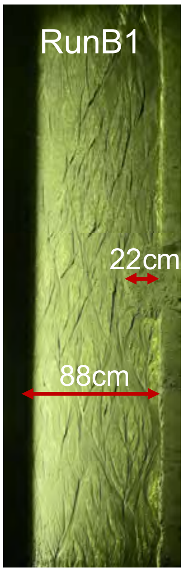
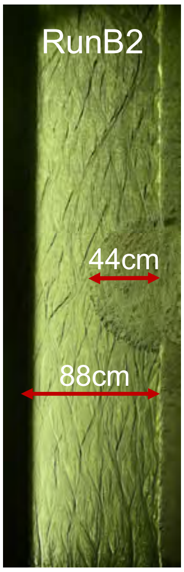
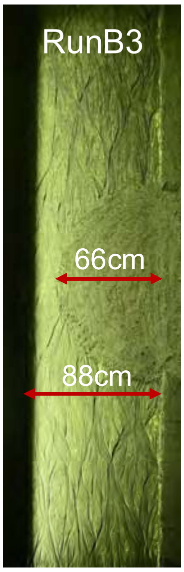
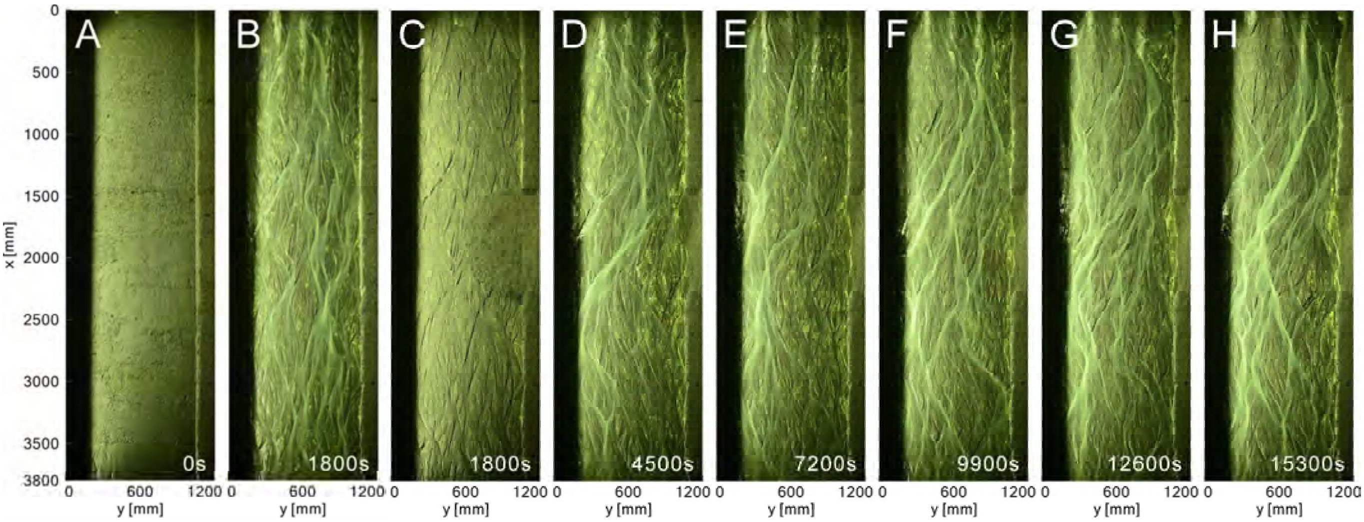
r/B	25%	50%	75%
			

Introduction | Experiment | iRIC | Discussion | Conclusion

B2

RunB2-Orthophoto



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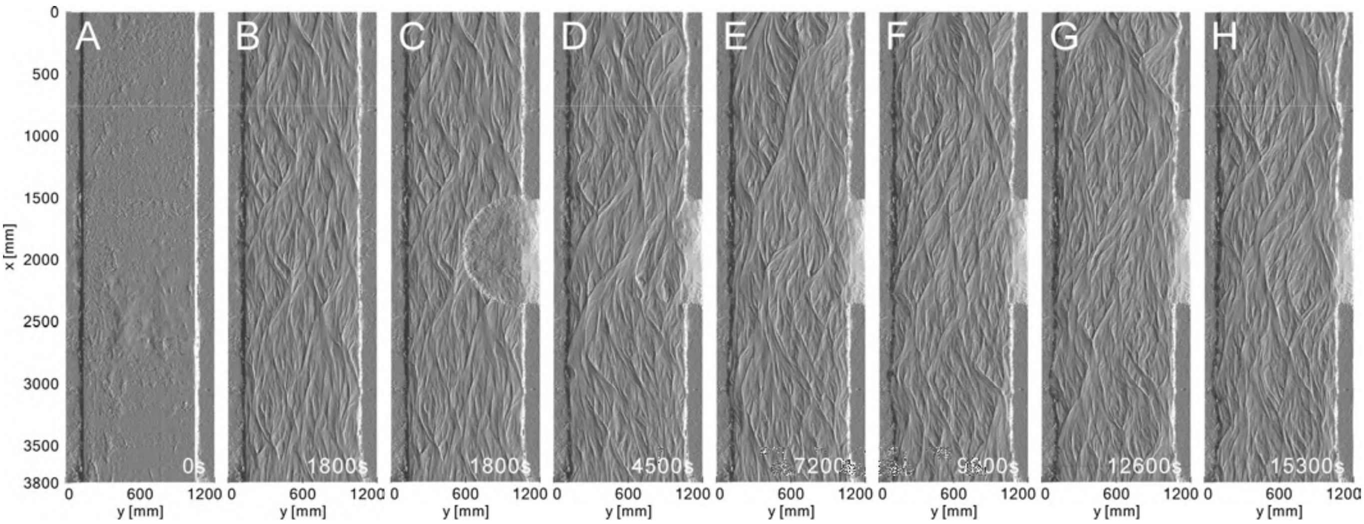
RunB2-DTM Hillshade



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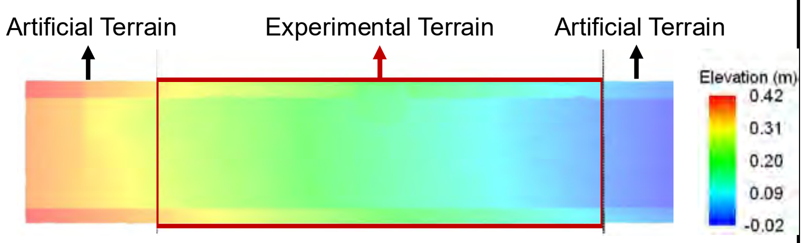


Basic Simulation Parameters

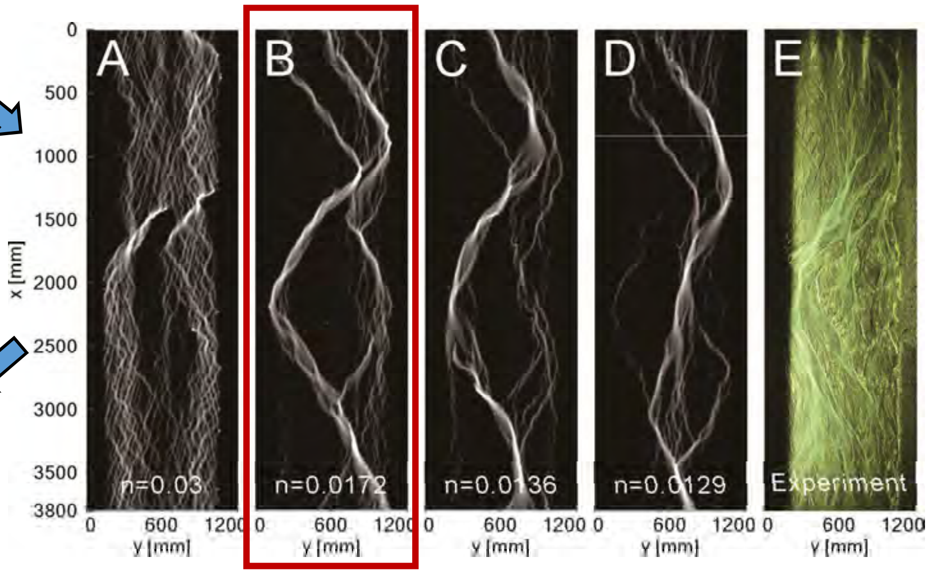
- Grid Size : *10*10mm²*
- Total Physical Time : *3.75hr*
- Total Computational Time : *200hr*
- Bedload Formula : *Ashida and Michiue*
- Suspended Load Formula : *Itakura and Kishi*

Sensitivity Analysis Manning's n

Author(Year)	Empirical Manning's Formula (d_{50} in mm)	n
Stricker (1923)	$n = 0.015d_{50}^{1/6}$	0.0129
Meyer-Peter and Muller (1948)	$n = 0.0122d_{90}^{1/6}$	0.0116
Handerson (1966)	$n = 0.0131d_{50}^{1/6}$	0.0113
Anderson (1970)	$n = 0.0152d_{50}^{1/6}$	0.0131
Garde and Raju (1976)	$n = 0.015d_{50}^{1/6}$	0.0129
Bray (1979)	$n = 0.0171d_{50}^{0.179}$	0.0146
	$n = 0.0164d_{90}^{0.16}$	0.0156
Subramanya (1982)	$n = 0.0149d_{50}^{1/6}$	0.0129
Rice (1998)	$n = 0.029S^{0.147}d_{50}^{0.147}$	0.0172
	Average	0.0136

Sensitivity Analysis Manning's n t=4500s

	RunA3	
n	0.03	0.0172
	0.0136	0.0129



Final Selection

Base on flow performance

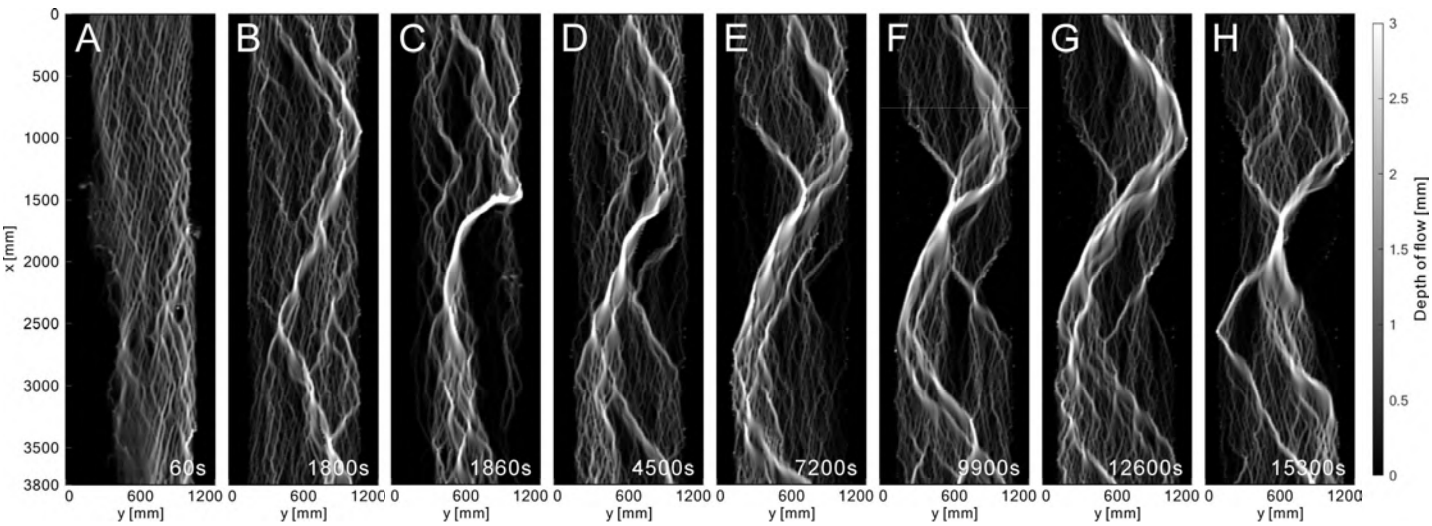
n=0.0172

n = 0.0172

Total Time = 15300s

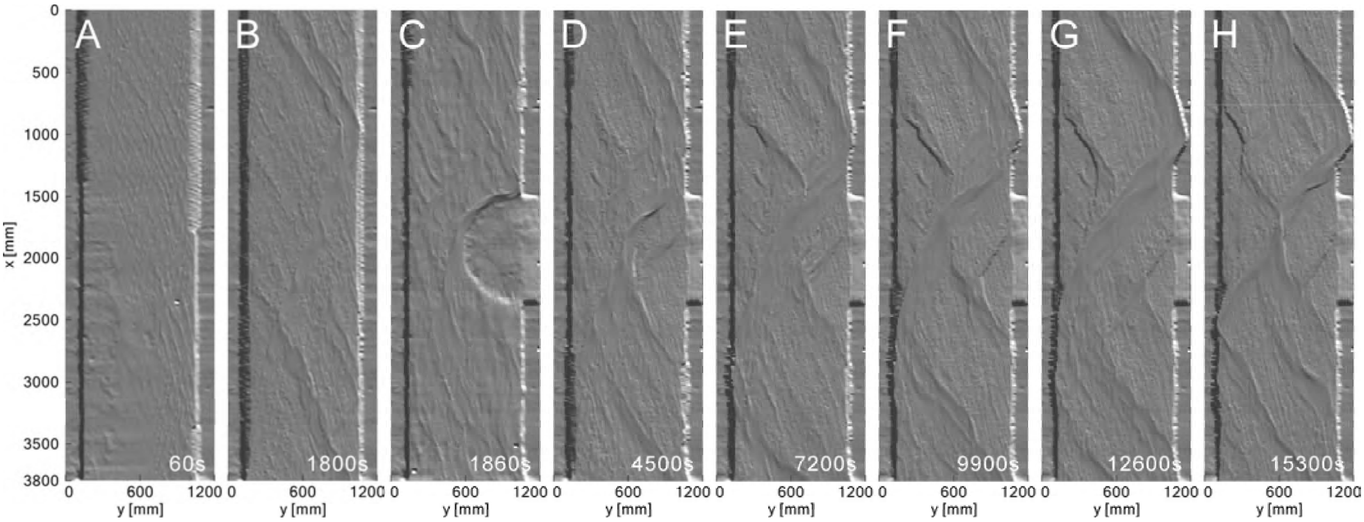
Grid Size = 10*10mm

RunB2 (iRIC)-Flow Depth

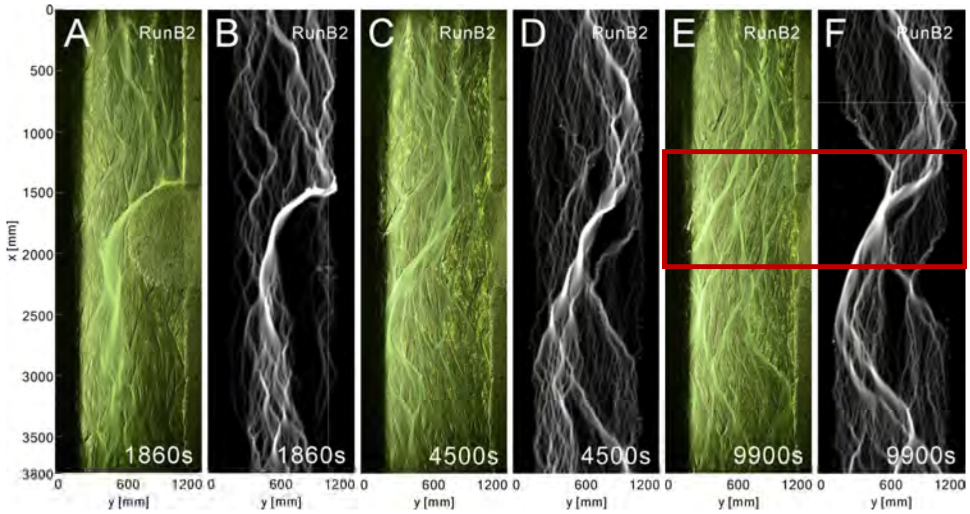


n = 0.0172
Total Time = 15300s
Grid Size = 10*10mm

RunB2 (iRIC)-DTM Hillshade



Comparison of Flow Morphology between the Experiment and the iRIC Simulation

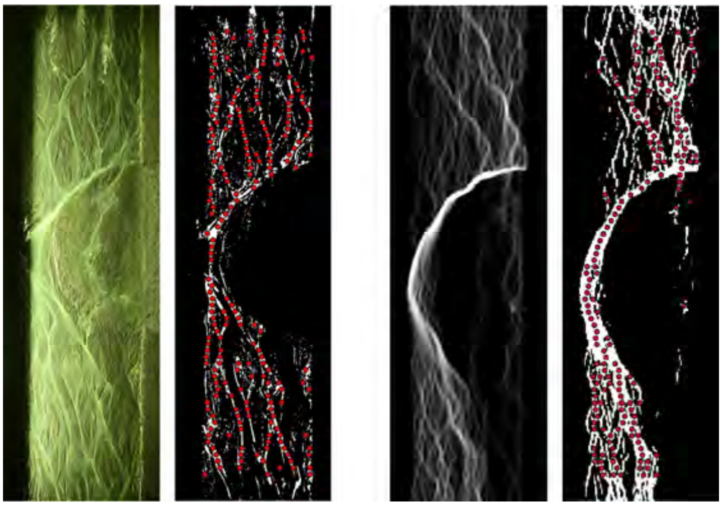


Comparison of BI_A between the Experiment and the iRIC Simulation

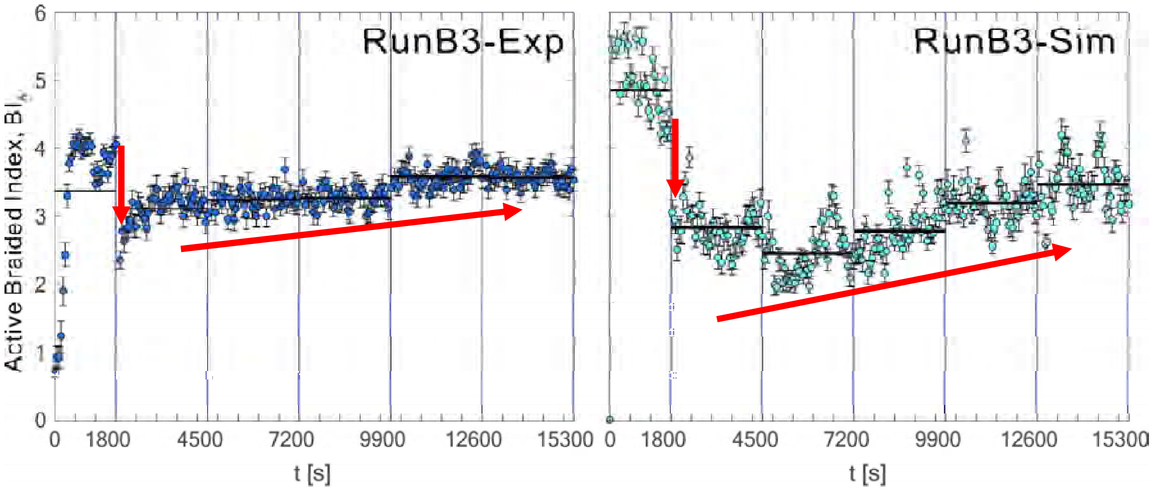
BI_A

Activity Braiding Index

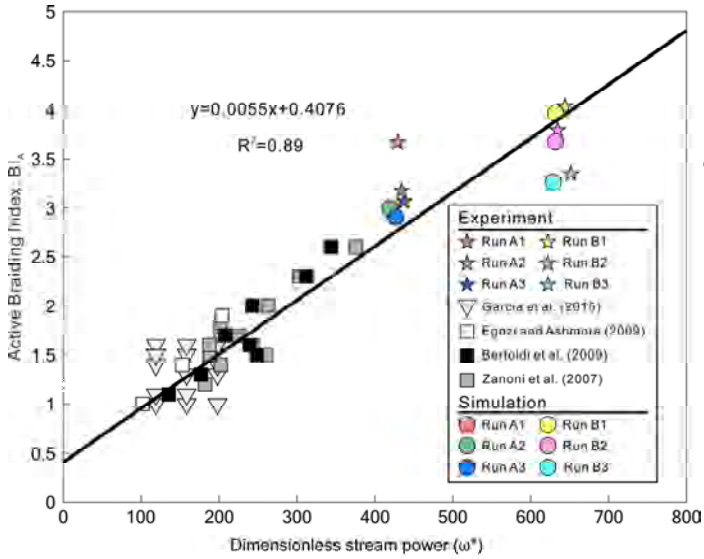
counting the number of channels with bedload transport across a cross section over time.



Comparison of BI_A between the Experiment and the iRIC Simulation



Comparison of ω*–BI_A Relationship between the Experiment and the iRIC Simulation



ω*, Dimensionless stream power

$$\omega^* = \frac{(\rho_{in} - \rho_a)QS}{\rho_{in} w_s d_s^2}$$

Lai et al. (2017)

1. The iRIC simulation reproduced braided flow patterns. After adding the lateral alluvial fan, it also captured flow convergence and deflection caused by fan-induced obstruction.
2. BI_A values successfully extracted from the iRIC simulation results show a consistent trend with the experimental results, supporting the model's ability to represent braided river dynamics.
3. Results from the experiment, simulation, and previous studies consistently indicate that ω* is proportional to BI_A.


Thank you for
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黃翊嘉 Yi-Jia Huang

Master's Student, Department of Civil Engineering, National Chung Hsing University
國立中興大學土木工程學系　碩士生

Riverside intake impact under hydrological uncertainty

Fong-Zuo Lee [1], and Yi-Jia Huang [2]
[1] Assistant Professor, Department of Civil Engineering, National Chung Hsing University

The increasing variability in hydrological conditions due to climate change, human interventions, and natural processes poses significant challenges to the design and operation of riverbank intake systems. These systems, vital for water supply, agriculture, and industrial processes, are becoming increasingly vulnerable to fluctuations in river flow, sediment load, and water quality.

Hydrological uncertainty manifests in altered precipitation patterns, extreme weather events, and seasonal variability, affecting river discharge and sediment transport. These changes can alter river morphology and water quality, reducing intake withdrawal capacity. Sediment deposition can clog intake systems or decrease withdrawal discharge, while high-flow events may cause potential damage to infrastructure. Furthermore, unpredictable shifts in water quality, such as increased turbidity or contamination, exacerbate operational risks and necessitate advanced treatment technologies.

This study employs the SRH-2D model to simulate concentration differences at the Niaozueitan intake and variations in bed sediment deposition along the river and right banks upstream of the intake under two flow conditions: Q2 and Q20 return periods. The concentration changes observed before and after the water intake location under Q2 and Q20 scenarios indicate that the intake process effectively reduces sediment accumulation. Under Q2 conditions, the peak concentration (approximately 4,500 ppm) shows a slight decrease, followed by a gradual downward trend. In contrast, Q20 conditions begin with a significantly higher initial concentration (approximately 25,000 ppm), and the peak concentration decreases notably after the water intake location, demonstrating a more pronounced reduction effect. Both scenarios exhibit a gradual decline in concentration over time, although Q20 shows a slower decay rate, reflecting its higher sediment accumulation levels.

Riverside intake impact under hydrological uncertainty

Presenter:黃翊嘉(Yi-Jia Huang)
Advisor:李豐佐(Fong-Zuo Lee)

Contents

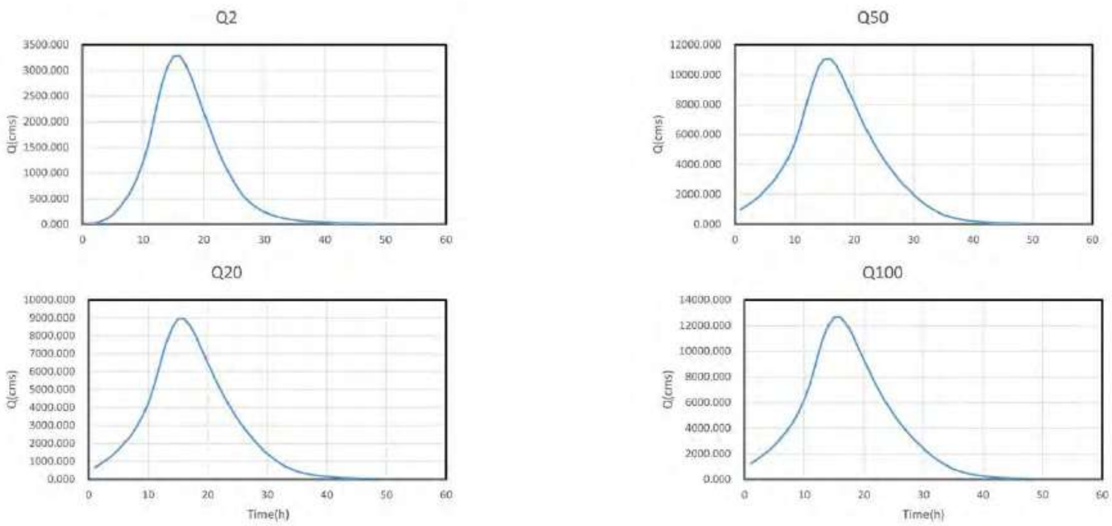
- Research Area
- Research Methods
- Comparison
- Research Results
- Conclusion

Research Area

Niaozuitan Artificial Lake

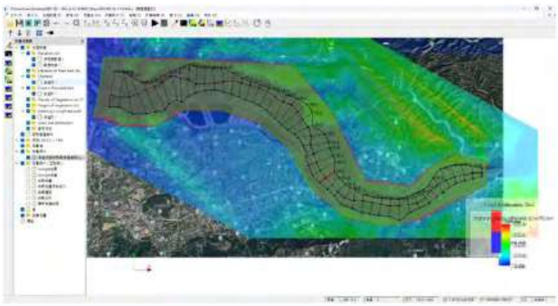
Item	Data
Location	Caotun Township, Nantou County, near Wu River and National Highway No. 6
Project Approval	2015
Construction Start	August 2019
Completion	2023
Total Capacity	17 million cubic meters
Effective Capacity	14.5 million cubic meters
Catchment Area	1,031.9 square kilometers
Lake Surface Area	Approximately 128 hectares
Daily Water Supply	250,000 tons (40,000 tons for Caotun, 210,000 tons for Changhua)
Reduction in Groundwater Extraction	About 62 million tons per year
Number of Lake Zones	6 (A', A, B, C, D, E, F)
Main Functions	Stabilizing water supply, reducing land subsidence
Surrounding Facilities	Cycling paths, observation decks, pavilions, ecological park

Research Data



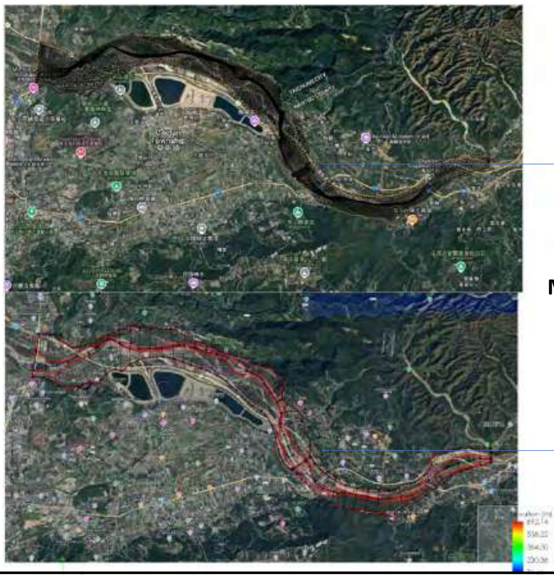
Research Methods

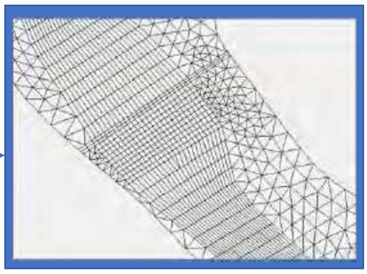
SRH-2D



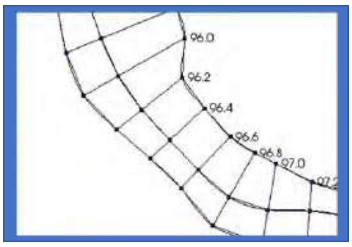
iRic-2D

Comparison



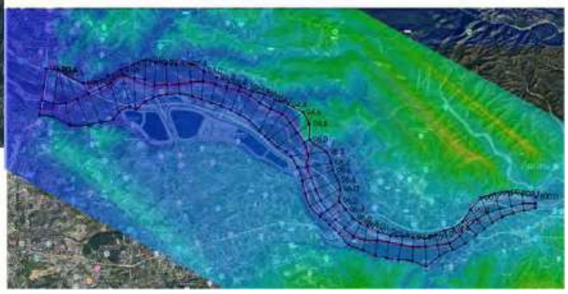


Mesh generator

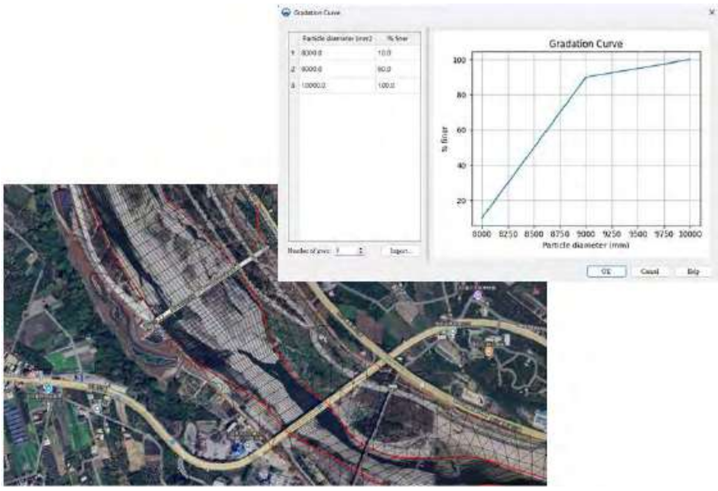


Comparison

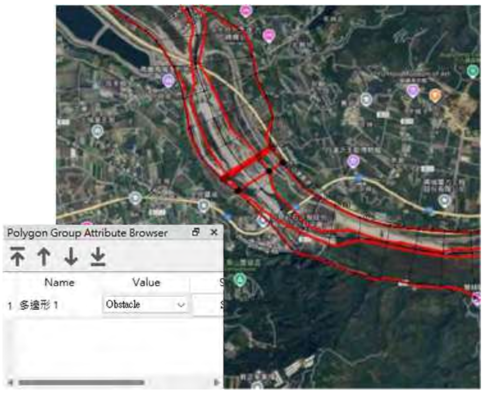
EDM 20*20m



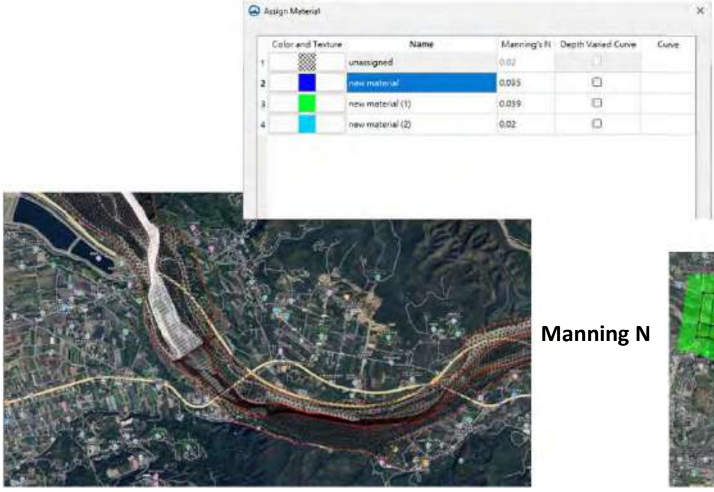
Comparison



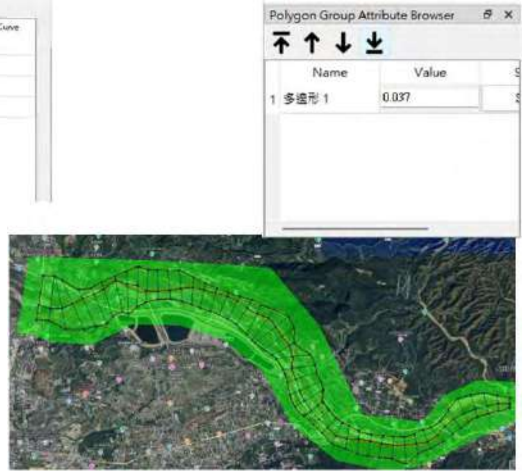
obstacle



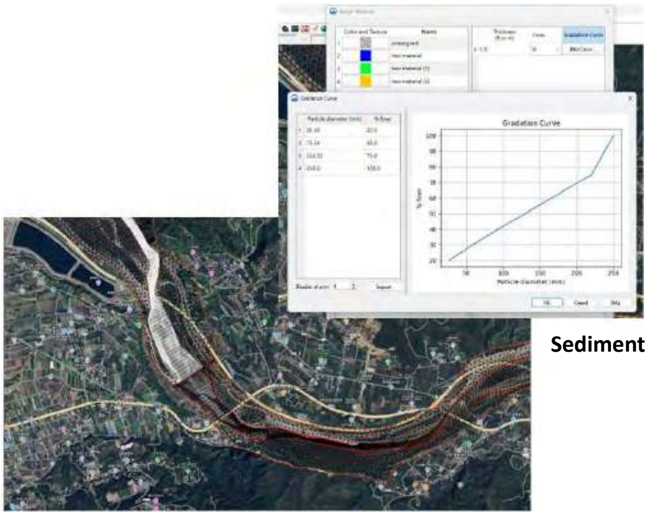
Comparison



Manning N



Comparison



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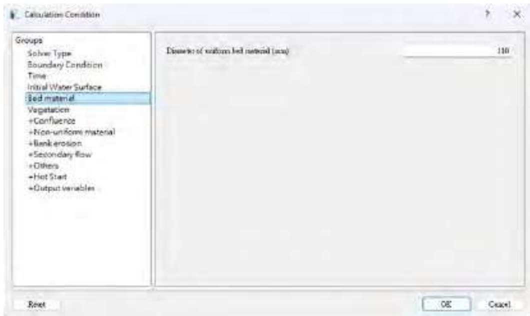

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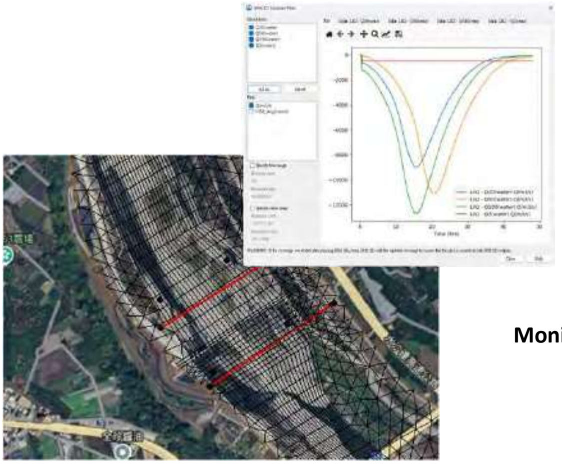
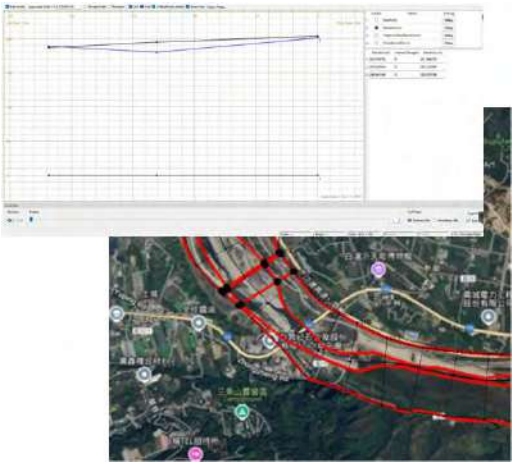
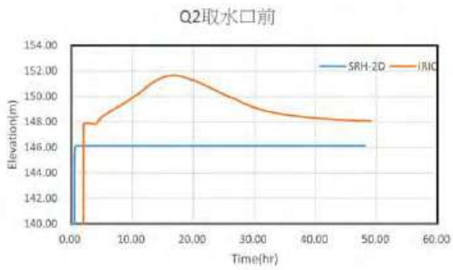
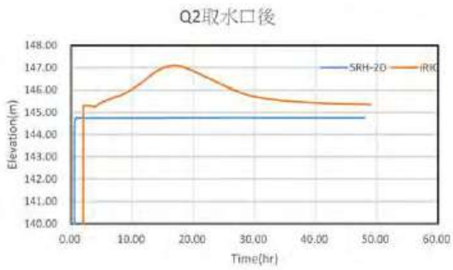


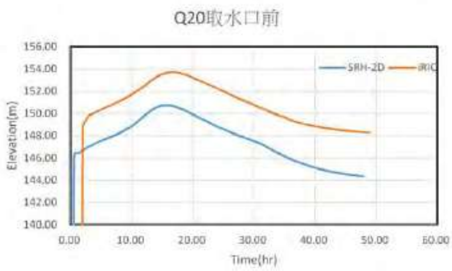
Monitor

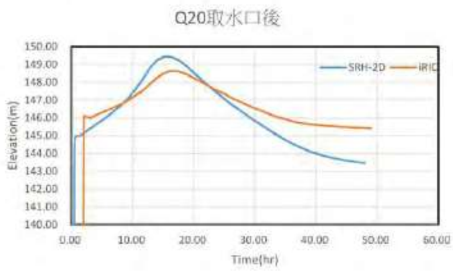


Research Results

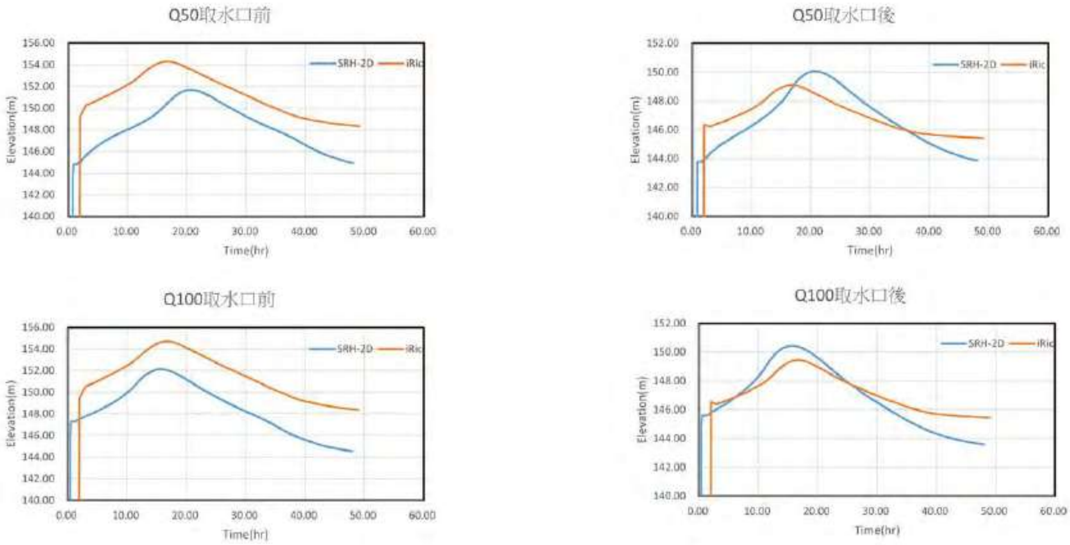








Research Results



Conclusion

- Both SRH-2D and iRIC are powerful tools for modeling riverbank water withdraw.
- SRH-2D is more suitable when advanced sediment modeling is required.
- Due to limitations in mesh refinement—especially when using the cross-section method—iRIC is more suitable for shorter and less meandering river sections.

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SRH-2D and machine learning application on fluvial hydraulic and bridge scour prediction

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[3] Assistant Professor, Department of Civil Engineering, National Chung Hsing University
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In recent years, extreme climate events have increased in frequency and intensity, causing significant threats to river and bridge structural safety. Accurate prediction of fluvial hydraulic changes and bridge scour has become crucial in hydraulic disaster prevention research. This study aims to investigate watershed hydraulic hazards under climate change conditions by combining the two-dimensional sediment transport numerical model (Sedimentation and River Hydraulics – Two-Dimension, SRH-2D) with the Long Short-Term Memory (LSTM) recurrent neural network, an artificial intelligence (AI) approach, for predicting river hydraulics and bridge scour. The study area focuses on a segment of the Zhuoshui River in central Taiwan, where the Mingzhu Bridge is located. The 0601 heavy rainfall event in 2017 was initially adopted as the baseline flood scenario. The SRH-2D numerical model was used to simulate this event, generating temporal-spatial data series such as upstream discharge, downstream water levels, and mesh water depths required for AI model training, thereby constructing the training dataset for the LSTM model. The input layer of the LSTM model incorporates three characteristic parameters: upstream discharge, downstream water depth, and time steps. The output layer predicts future water depth variations at each mesh node along the river channel over the subsequent hours. The simulation results demonstrated that the LSTM model shows good convergence and stability, achieving a mean absolute error (MAE) in predicted water depths of less than 0.2 meters. This indicates that the established LSTM model provides an effective predictive capability for water depth variations.

To enhance the accuracy of the AI model, additional historical typhoon events from 2015 to 2017, including Typhoons Soudelor, Dujuan, Nepartak, and Megi, as well as designed flood scenarios for return periods of 1.1, 2, 10, and 100 years (Q1.1, Q2, Q10, Q100), were included as additional training and test data for the LSTM model. The model was applied to the P4 pier location of Mingzhu Bridge and further validated using the 2015 Typhoon Dujuan and 2016 Typhoon Megi events for water depth and velocity predictions. Validation results indicated a high consistency between LSTM-predicted water depths and velocities and SRH-2D simulation results, confirming the effectiveness of the AI model in real-time river hydraulic predictions. In the future, this research will focus on expanding the training dataset with mobile-bed simulation parameters, such as bed shear stress, sediment concentration, and scour depth, to improve AI models' predictive accuracy and reliability in hydraulic sediment transport simulations. This study demonstrates the potential of integrating the SRH-2D and LSTM models for predicting fluvial hydraulics and bridge scour risks. The LSTM model effectively learns hydrological time-series variations and spatial distribution characteristics, enabling rapid predictions of river hydraulics and bridge-scouring processes. Integrating real-time monitoring data with early warning systems in the future would contribute to developing hydraulic modeling support systems and disaster alert applications for bridge areas in rivers. The results of this study have practical value for river management and bridge safety. They can be a reference for river-bridge risk management and real-time disaster warning systems.

SRH-2D and Machine Learning Application on Fluvial Hydraulic and Bridge Scour Prediction

Cheng-Chi Liu[1], Wen-Yi Chang[2], Fong-Zuo Lee[3], and Jihn-Sung Lai 4

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Reporter: Cheng-Chi Liu
2025/04/22

Figure source: https://upload.wikimedia.org/

Introduction: Background

◆ Bridge and Embankment Safety under Extreme Weather

- Bridge and embankment damage risk is rising due to climate-driven extreme floods.
- In recent years, extreme climate events have increased in frequency and intensity, causing significant threats to river, bridge and embankment safety.
- Accurate prediction of fluvial hydraulic changes, bridge pier scour, and embankment overflow, is a key challenge for flood disaster prevention research.

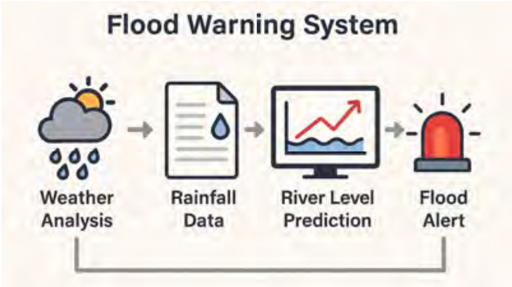
Floodwaters from the rising Zhuoshui River submerged the downstream road and threatened the bridge foundation.

The right embankment downstream of Mingzhu Bridge on the Zhuoshui River was damaged during heavy floods.

Introduction: Motivation

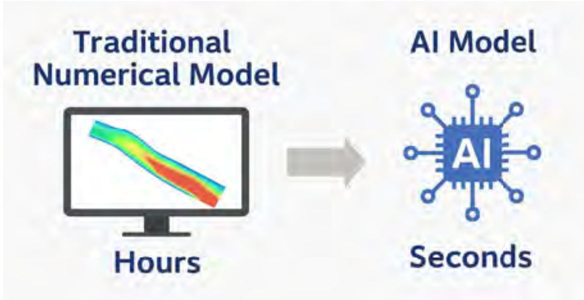
◆ Current Limitations

- Flood warning systems often use 1D models to quickly predict river water levels.
- However, 2D hydraulic models are too slow for real-time prediction of river flow patterns, bridge pier scour and embankment overflow.
- This makes it difficult to assess detailed flood risks during extreme events.



flood warning system

- If we could use AI model to replace these slow simulations?



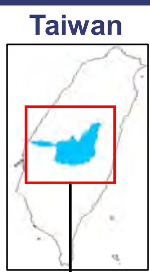
◆ AI model as a Potential Solution

- AI models can significantly reduce computation time — from hours to seconds.
- With AI, we can estimate 2D hydraulic fields much faster and predict pier scour and bank overflow.
- This approach shows strong potential for real-time disaster warning applications.

Introduction: Study Area

◆ Zhuoshui River basin

- The Jiji Barrage plays a key role in water resource management in the Zhuoshui River basin. It improves water supply efficiency to better fulfill various water demands.
- Mingju Bridge is the first bridge downstream of the Jiji Barrage. When a flood occurs, its piers are the first to face strong flow impact.

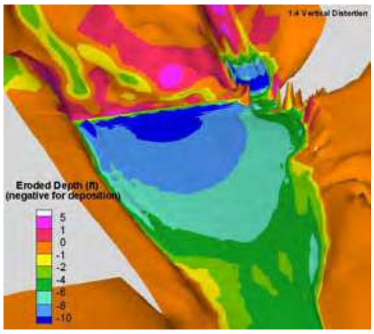


Methodology: Hydraulic Numerical Model

BUREAU OF RECLAMATION

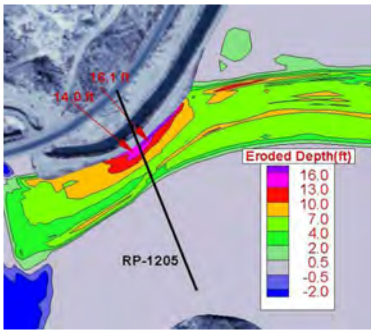
◆ **Sedimentation and River Hydraulics - Two-Dimensional**

- SRH-2D is a numerical model designed to simulate 2D hydraulic and sediment transport processes in river basins.
- SRH-2D predicts bed changes by tracking non-equilibrium sediment transport for suspended, mixed, and bed loads, It also handles granular, erodible rock, non-erodible beds, and bank erosion.



◆ **Key Equations**

- **Fix-Bed Simulation**: it uses mass conservation and momentum equations for hydraulic simulation, simulates hydrodynamics without considering sediment transport and bed changes.
- **Mobile-Bed Simulation**: it uses non-equilibrium sediment transport equations for mobile-bed simulation, simulates both hydrodynamics and sediment transport, allowing for bed changes in river or reservoir, analyzes bed erosion (沖刷), deposition (淤積) and sediment transport processes.

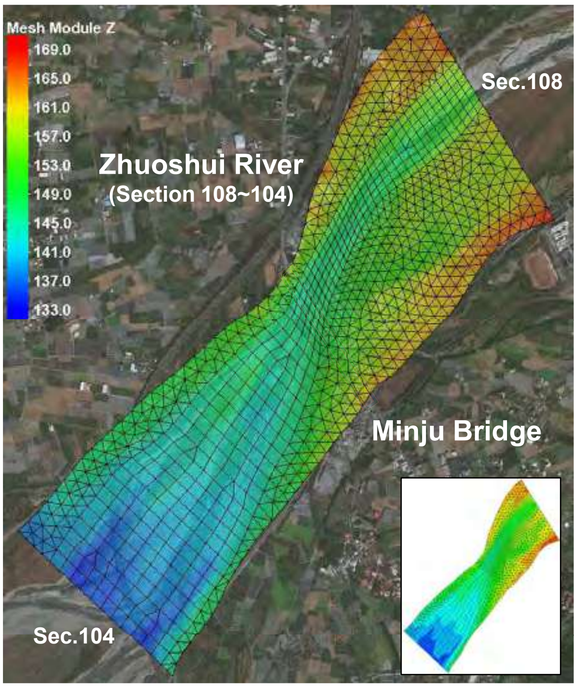


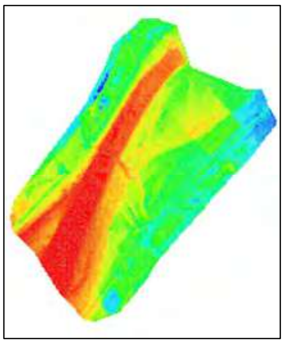
Source: U.S. Bureau of Reclamation, 2020

Methodology: SRH-2D model establishing

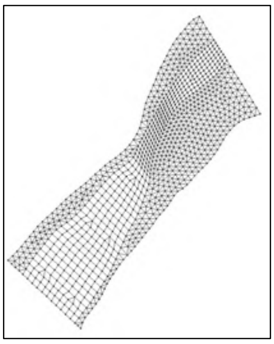
◆ **Process**

- Software and data used: used the SMS software (Surface-water Modeling System, V.13.0) to import the DEM data of Zhuoshui River (Section 108~104) and establish the 2D model mesh file for SRH-2D.
- **Data processing**: the DEM data was converted into scatter points for further analysis after formatting.
- **2D mesh construction**: a two-dimensional mesh and numerical terrain of model was established based on the DEM data range.

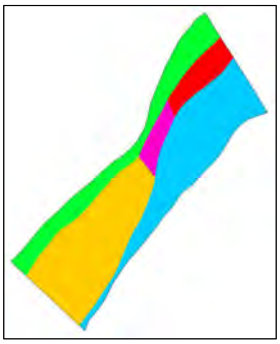




Digital elevation model (DEM)



Mesh generation



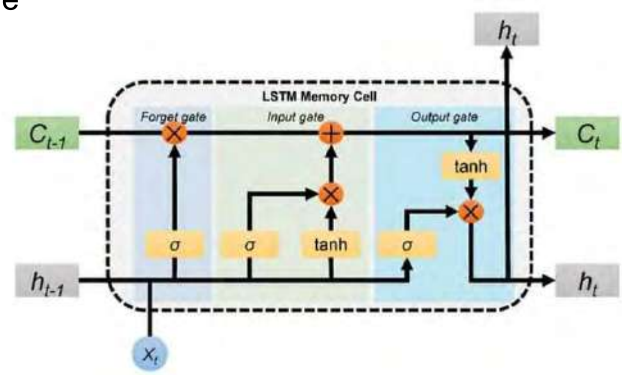
Manning's value distribution

Topography of 2D model

Methodology: AI model

◆ Long Short-term Memory (LSTM)

- LSTM is a special type of neural network for time series prediction.
- It can remember past information over long periods.
- It uses three gates:
  - → Input gate – learns new info
  - → Forget gate – decides what to ignore
  - → Output gate – passes useful info forward



Internal Mechanism of LSTM: Forget, Input, and Output Gates

◆ Why LSTM?

- LSTM is designed for time series prediction.
- It can remember long-term patterns in data, even with delays.
- This makes it suitable for predicting changes in river flow, water levels, or flow velocity over time.

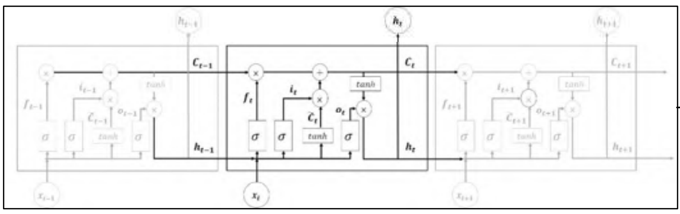
Methodology: LSTM model establishing

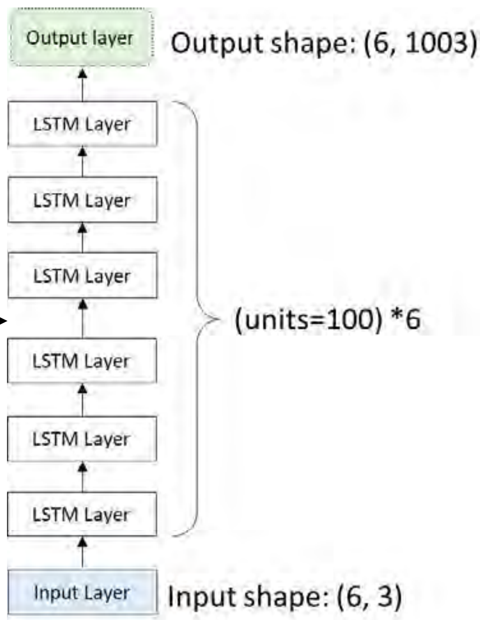
◆ Objective

- Use AI model (LSTM) to predict water depth at all mesh nodes.
- Input features: upstream inflow, downstream water elevation, and time step.

◆ Deep Learning Model (Keras / Tensorflow, python)

- Input shape: (Time steps, Number of features) = (6, 3)
- Output shape: (Time steps, Number of mesh nodes) = (6,1003)
- Middle Layer: 6 stacked LSTM layers (100 units each)
- This setup helps the model learn both temporal and spatial patterns.

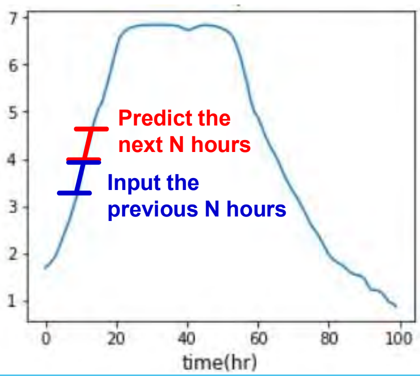


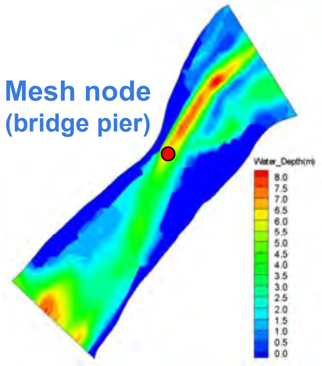


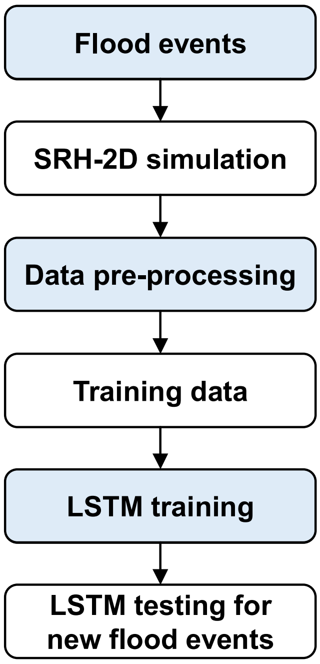
Methodology: LSTM Workflow

◆ Process

- LSTM is used to simulate flood-related water depth at all mesh nodes, such as areas near bridge piers or river bank.
- The model uses the previous N hours of upstream inflow and downstream water elevation as input, and predicts the next N hours of water depth.
- The right-side flowchart summarizes the complete workflow from flood events to LSTM training and testing.
- LSTM can quickly predict future flood conditions at each mesh node.





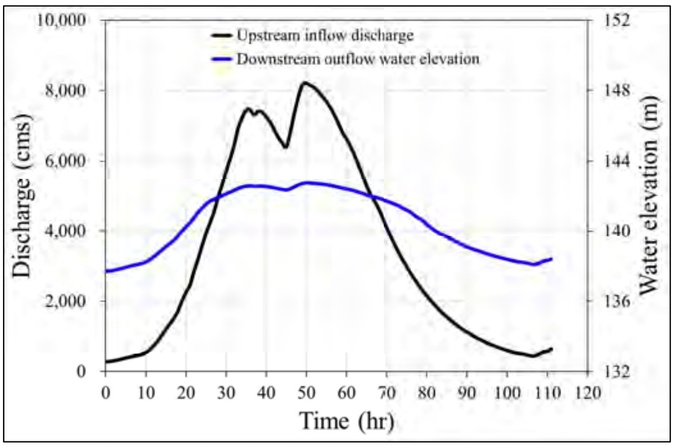


Flowchart: LSTM model

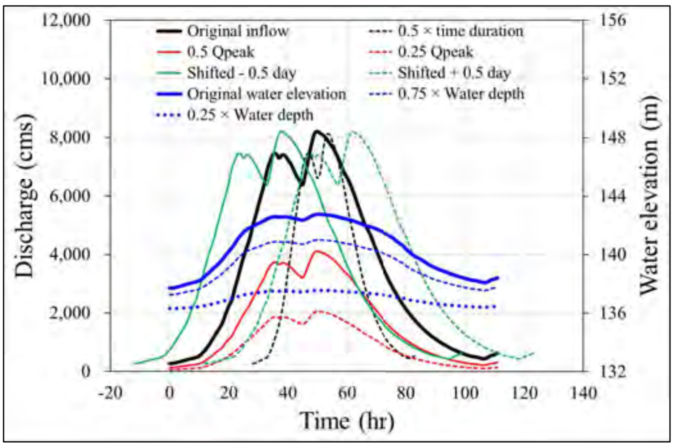
Training Data Preparation

◆ Training Data Expansion

- 0601 Heavy rainfall event in 2017 was used as the baseline case.
- Additional hydrographs were created by modifying upstream peak inflow (Q_{peak}), duration (shift time), and downstream water depth.
- This helps the model learn from more diverse flood scenarios.



Hydrograph baseline (0601 rainfall event in 2017)

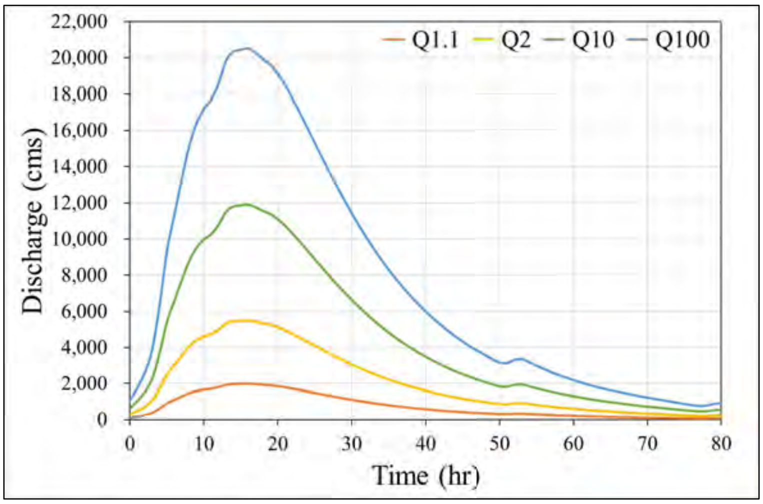


Hydrograph Variations for Data Expansion

Training Data Preparation

◆ Training Data Collection

- These hydrographs represent various flood magnitudes and shapes for training.
- This helps improve the model's generalization across different flood scenarios.

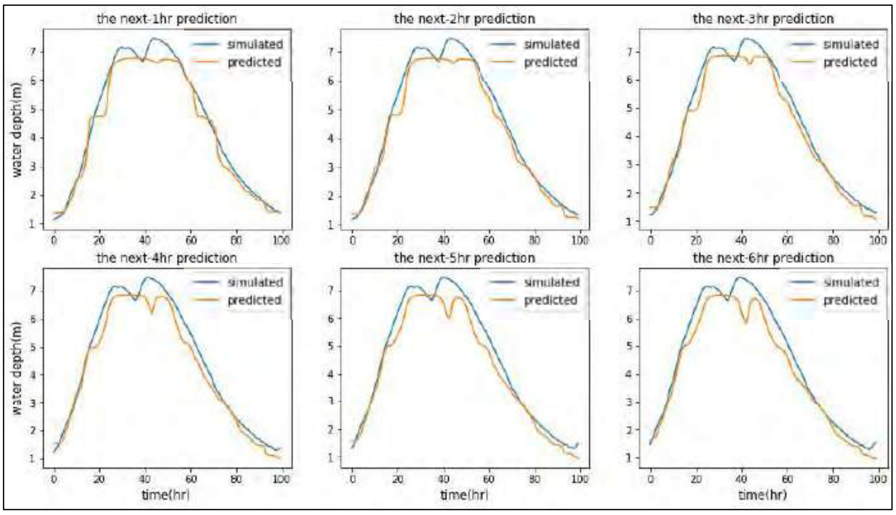


Flood Hydrographs by Return Period

Testing Results: Water depth

◆ LSTM Model Testing

- LSTM prediction water depth results that compared with SRH-2D simulation results.
- Using the previous 6 hours of input to predict the next 6 hours, just like a sliding window with sequence-to-sequence output.



Water Depth Prediction: 1–6 Hour Time Step

- MSE and MAE values indicate good accuracy for short-term water depth prediction.

Time step	1hr	2hr	3hr
MSE	0.29	0.29	0.28
MAE	0.17	0.17	0.17
Time step	4hr	5hr	6hr
MSE	0.30	0.32	0.33
MAE	0.18	0.19	0.20

MSE and MAE of Water Depth for Different Time Step

Simulation Results: 2D distribution

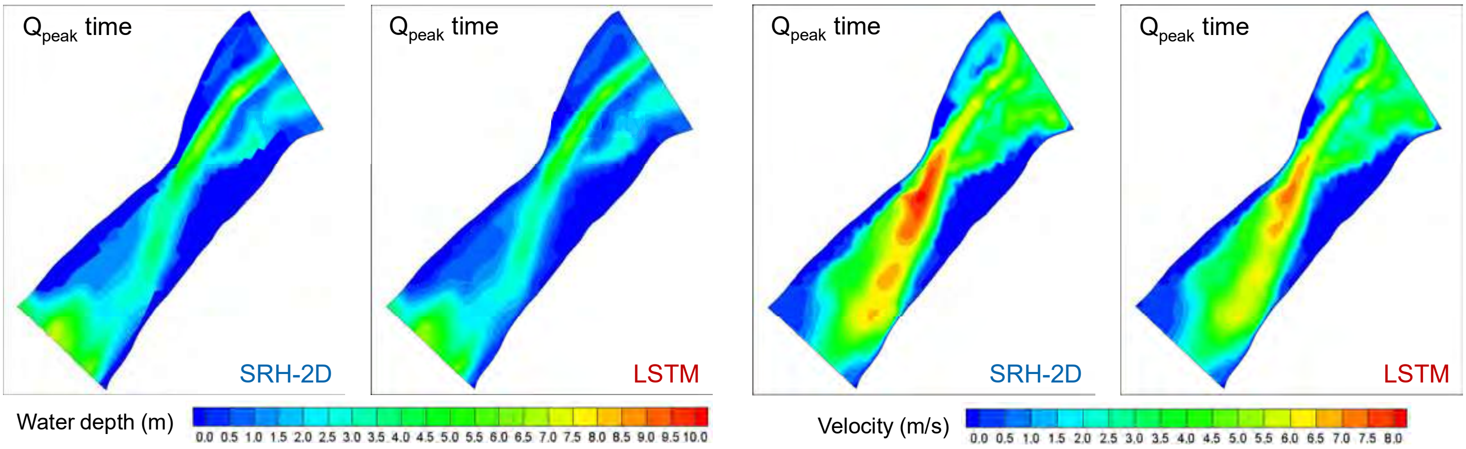
◆ 2-D distribution Comparison

- Compared 2D simulation results from SRH-2D and LSTM at the peak inflow time of Typhoon Dujuan (2015).
- LSTM model only takes about 1 minutes to compute, compared to 90 minutes for SRH-2D model.
- The 2D distribution of water depth and velocity simulated by LSTM model is similar to that of SRH-2D.

- This shows that LSTM can accurately simulate hydraulic processes, but with much faster computation.

Hydrological Process (80 hours)

Time / Model	SRH-2D	LSTM
Computer Time	90 min	1 min



Summary

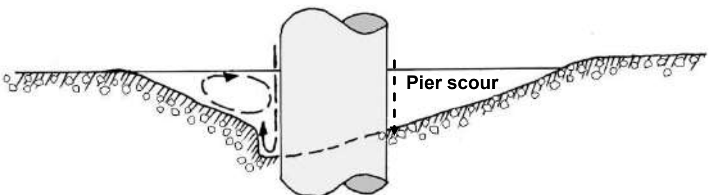
◆ Conclusion

- LSTM model can simulate hydrological process at all mesh nodes with much faster computation than SRH-2D.
- The 2D simulation results of LSTM model are similar to SRH-2D in terms of water depth and flow velocity.

◆ Potential Application

- LSTM shows strong potential for real-time prediction of bridge pier scour and bank erosion under extreme floods.
- Pier scouring depth (Total pier scour)
  = General Scour + Constriction scour + Local Scour

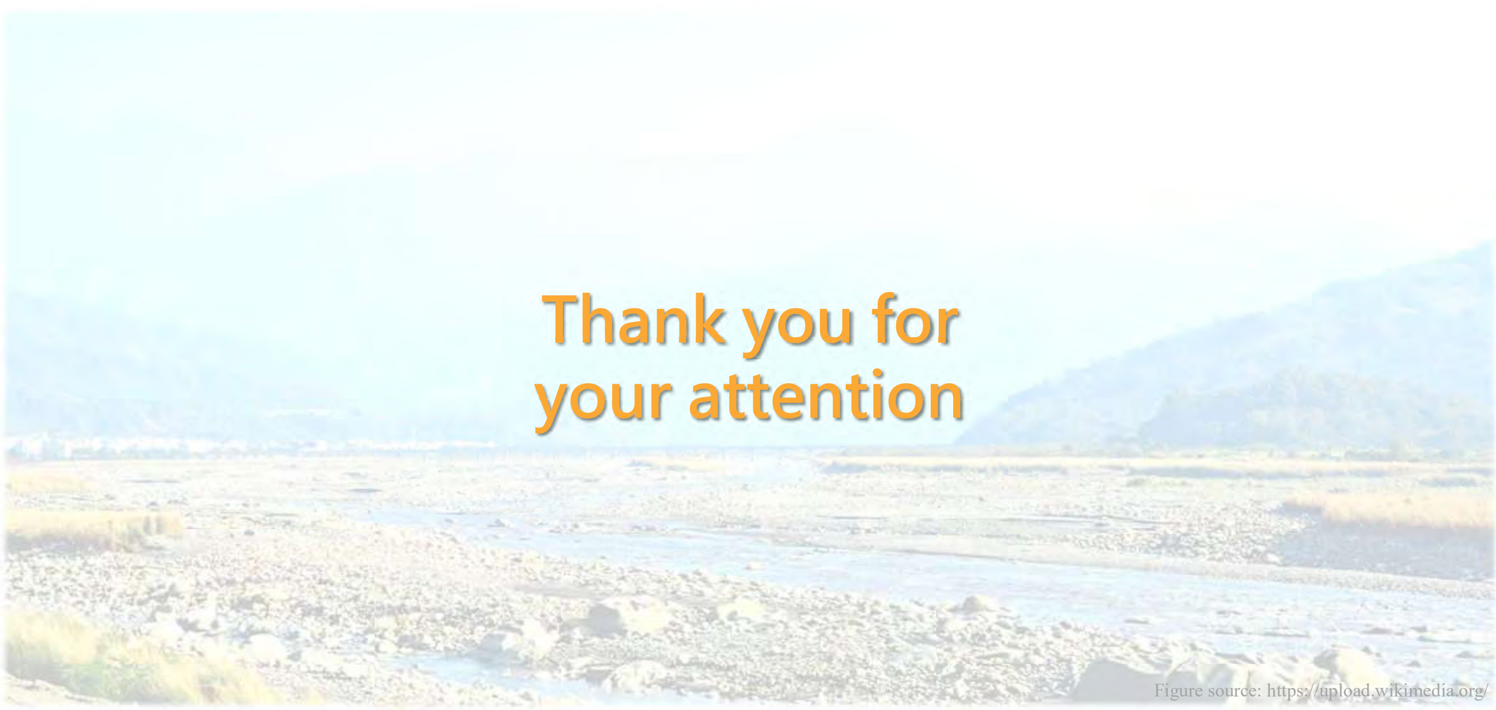
  General Scour: Simulated by model
  Constriction scour, Local Scour: Estimated by empirical formulas



Bridge Pier Scour

◆ Future Work

- Modify the type of input data to get good mobile-bed simulated results, such as d_{50}, erosion & deposition, and sediment concentration to improve prediction accuracy of model.
- Develop other AI models (e.g. GRU, MLP) for river hydraulic prediction, and their performance will be compared with the LSTM model.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