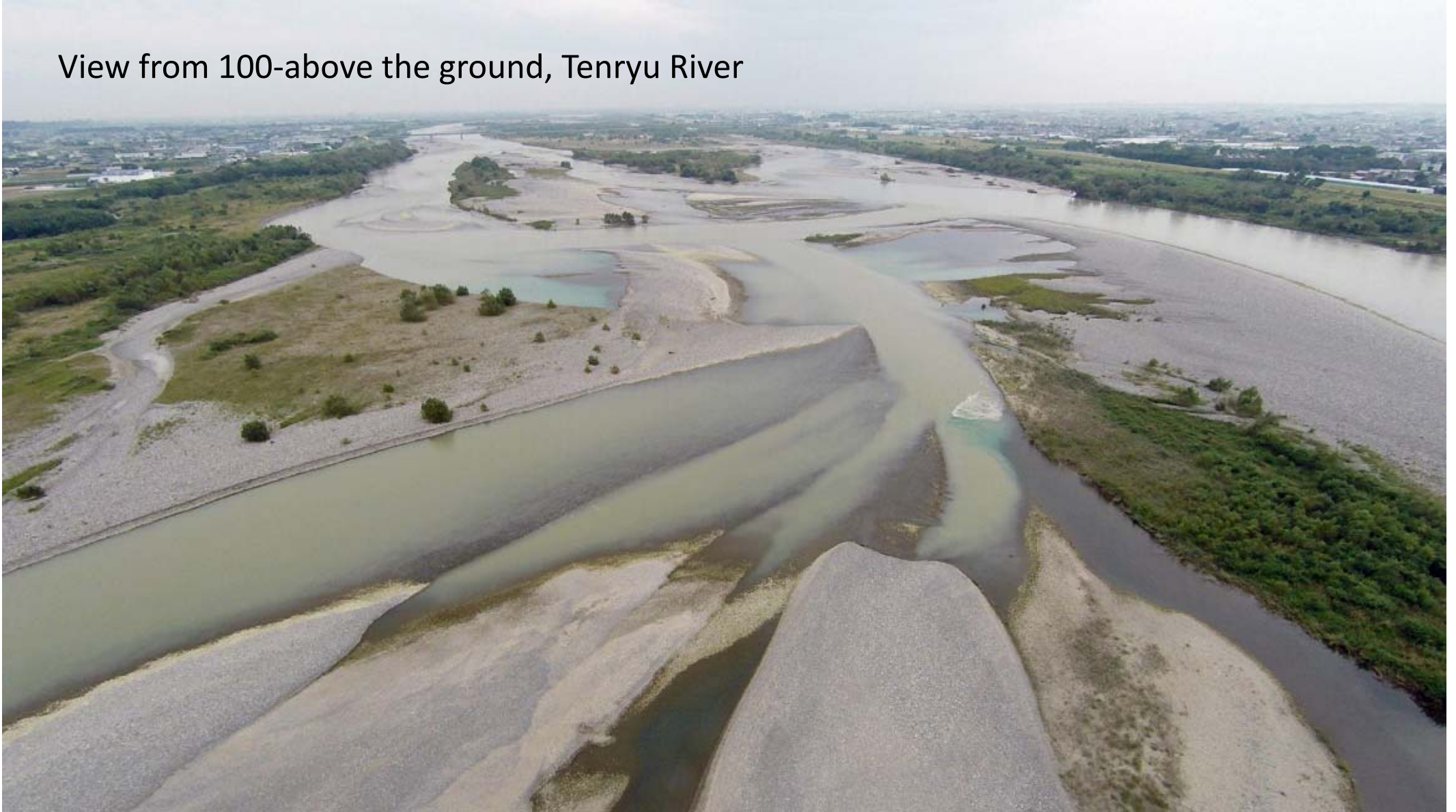


Evaluation of the ecosystem functions of gravel bars in rivers using drone

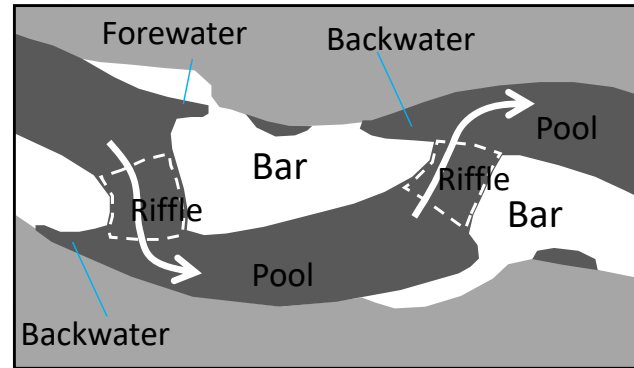
View from 100-above the ground, Tenryu River



Sohei Kobayashi (Disaster Prevention Research Institute, Kyoto University)¹

My study interests

Riverbed morphology, invertebrate community, their relationships



Sediment conditions and river ecosystem

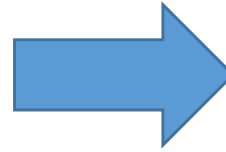
Natural rivers vs degraded rivers downstream of dam

Increase in sediment supply by dam removal, sediment bypassing, sluicing

My field study



4-5 years ago

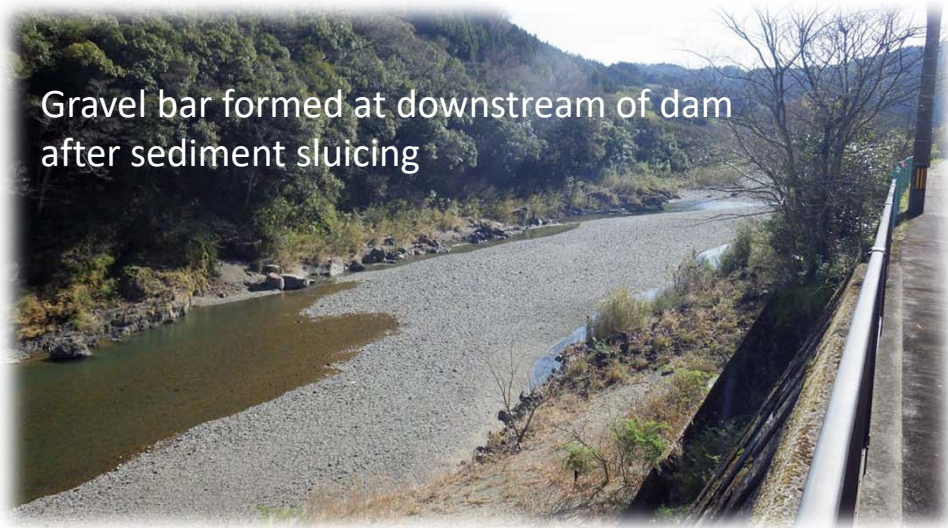


Drone, batteries, sd cards

Sampling net, white pan, sieve, forceps
ethanol, pH/EC meter, current meter, etc.

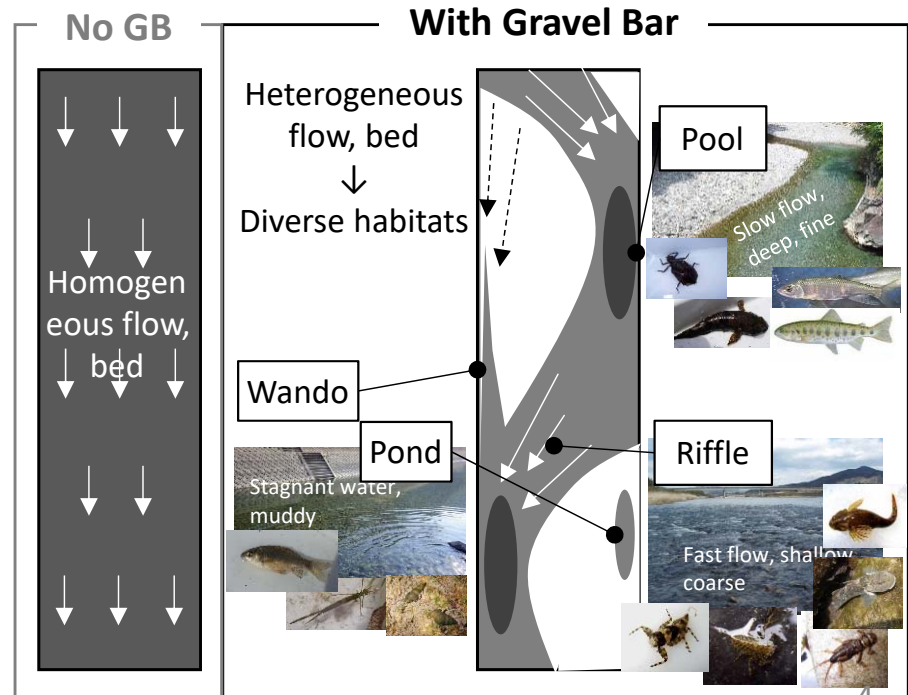
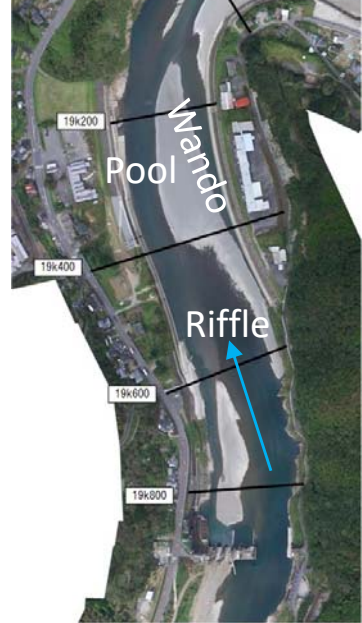
Sampling net, white pan, sieve, forceps
ethanol, pH/EC meter, current meter, etc.

Gravel bars: basis of habitat diversity within reaches



**Without GB
(before dam removal)**

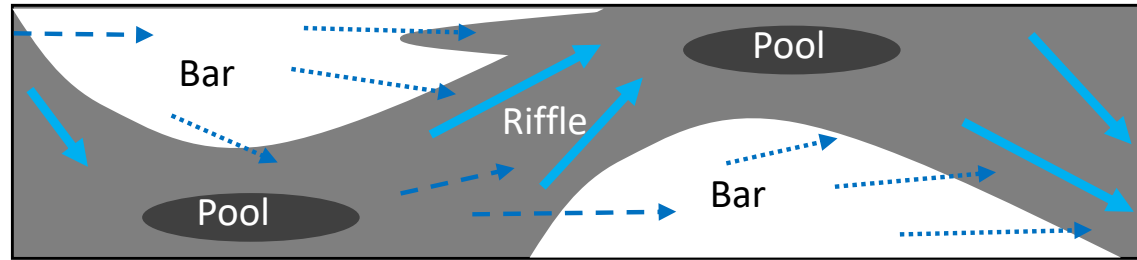
**With GB
(after dam removal)**



Gravel bars: places of water filtration

Exchanges of water between surface and subsurface (hyporheic) at bars

Surface flow →
Subsurface flow (hyporheic) - - -> Down-welling
 · · · · ·> Up-welling

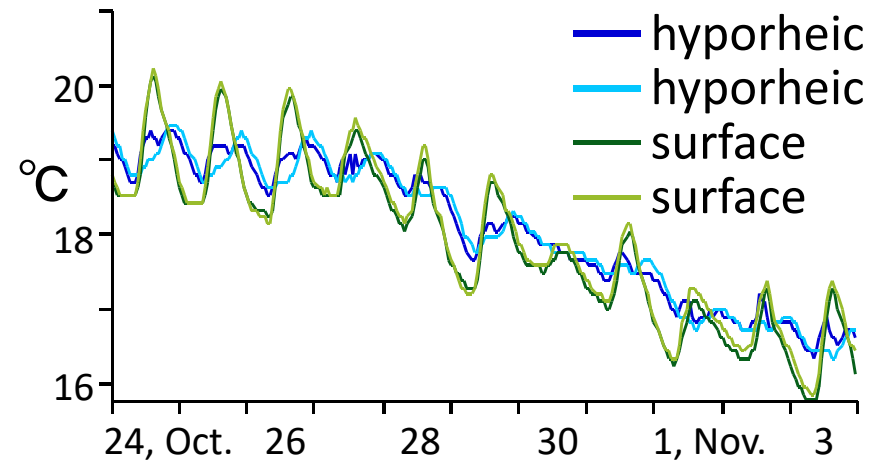
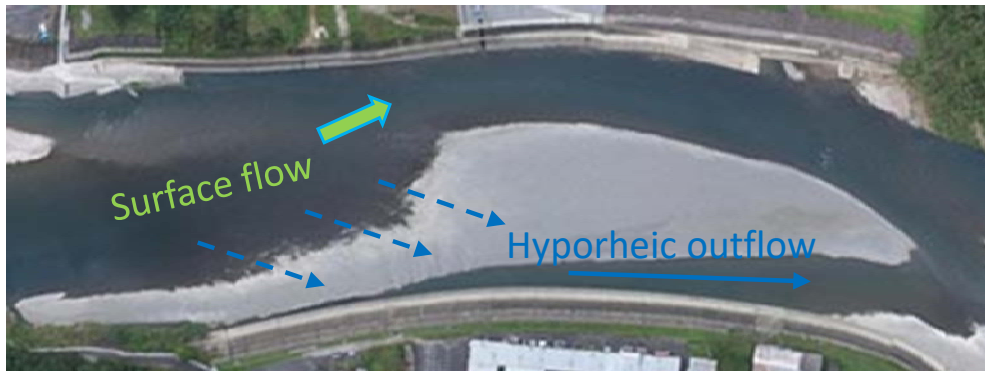


By the filtering process bars contribute to reduce turbidity in the downstream direction.

Gravel bars: creation of thermal heterogeneity

Temperature change is usually smaller for hyporheic than surface water, which cause local difference in temperature within reaches.

Hyporheic outflow act as nursery for fish juvenile and refugia for insect/fish during hot summer/cold winter.



Fish seek and stay cool places during hot periods (daytime of summer).



A large number of juvenile fish in hyporheic outflow

Drone as a helpful tool to monitor gravel bars

The spatial scale of bars are 100 – 1000 m in many rivers.



It takes an hour or a whole day to walk around and determine places for survey.



Single flight (10-20 min) is enough to overview the bar

In addition, many physical data of bars can be obtained from drone photos

Orthoimage map and DEM

Take drone photos with camera facing vertically down and a high overlap between two consecutive images.
A commercial software automatically creates orthomosaic image and DEM.

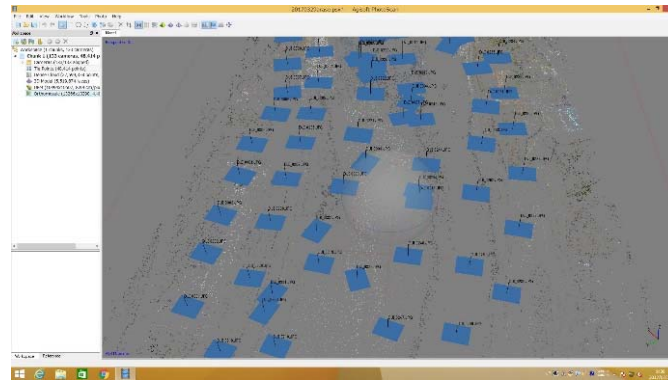
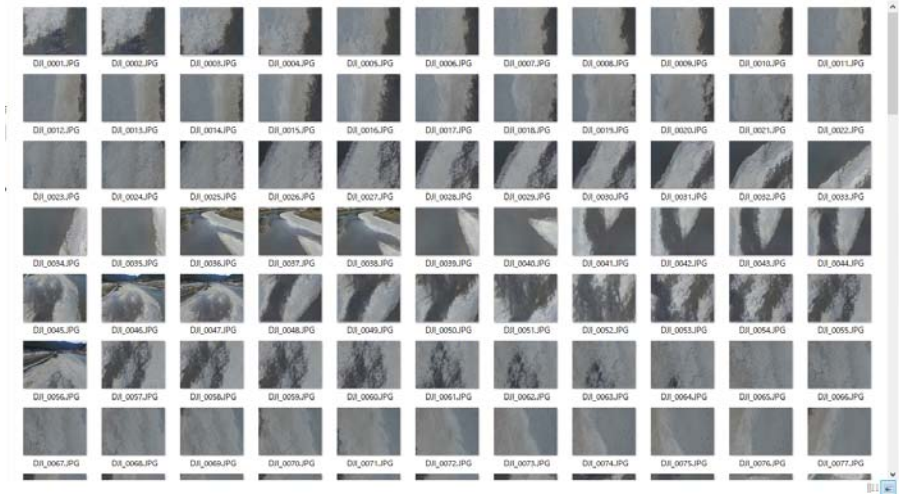
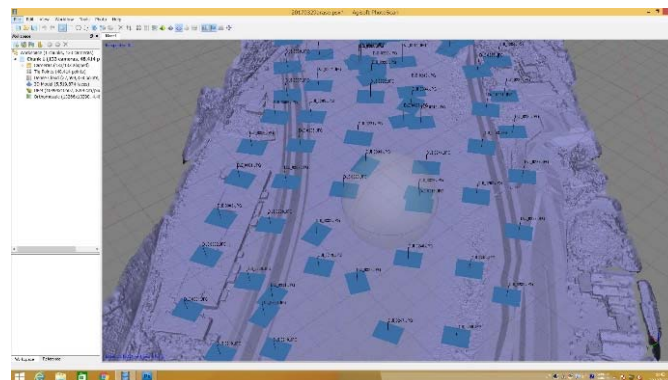


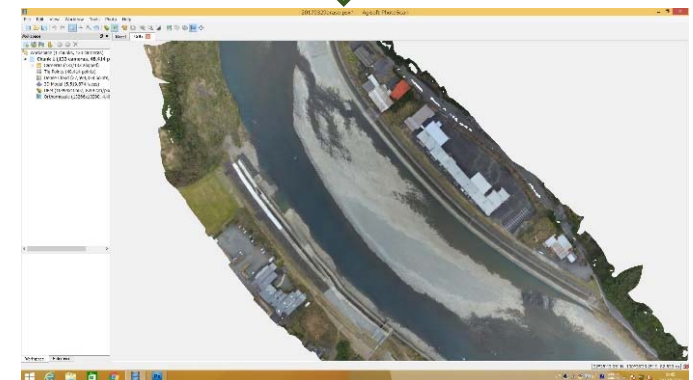
Photo alignment and detecting tie points



Building dense point cloud



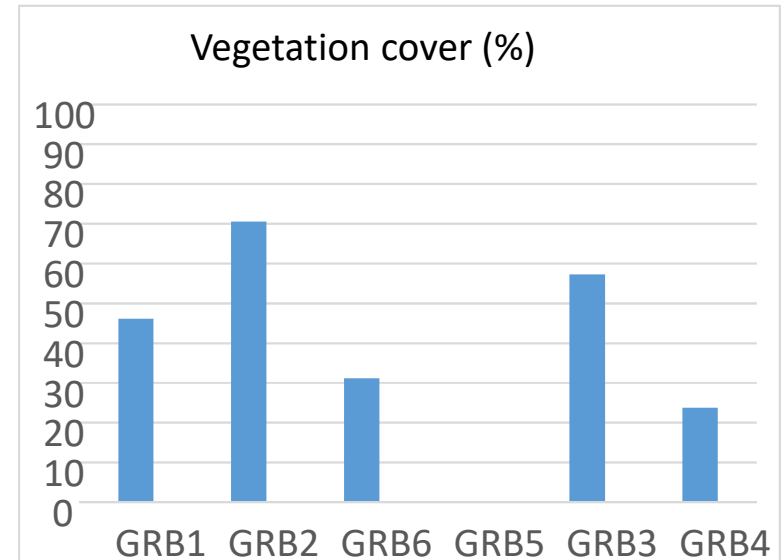
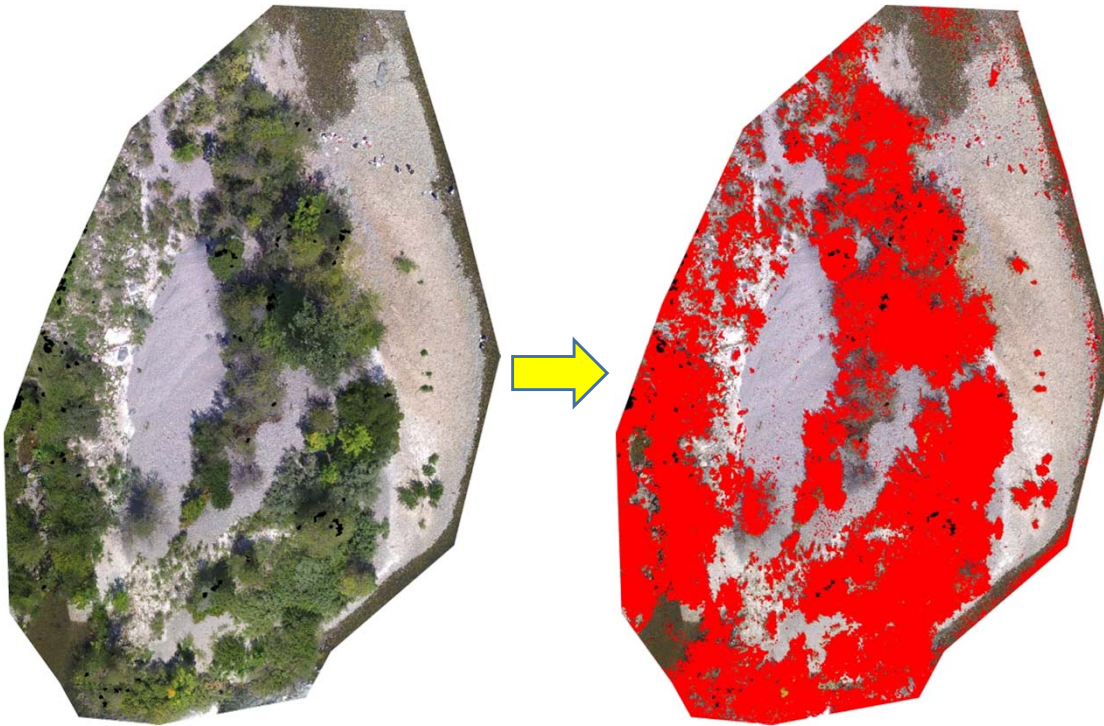
Building 3D polygonal mesh model



Generation of orthomosaic and DEM

Vegetation cover

If there is a sufficient contrast in color or brightness, area of different cover types can be evaluated by a free image software

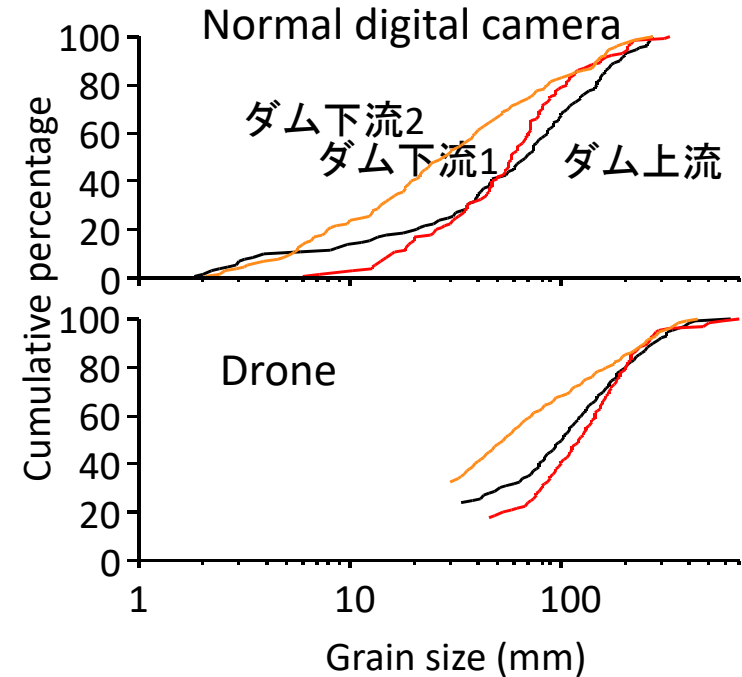
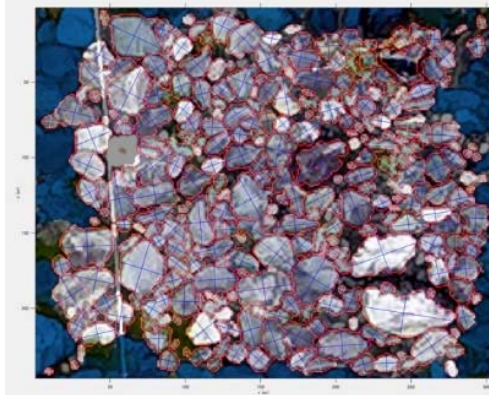


ImageJ (color threshold, count pixel)

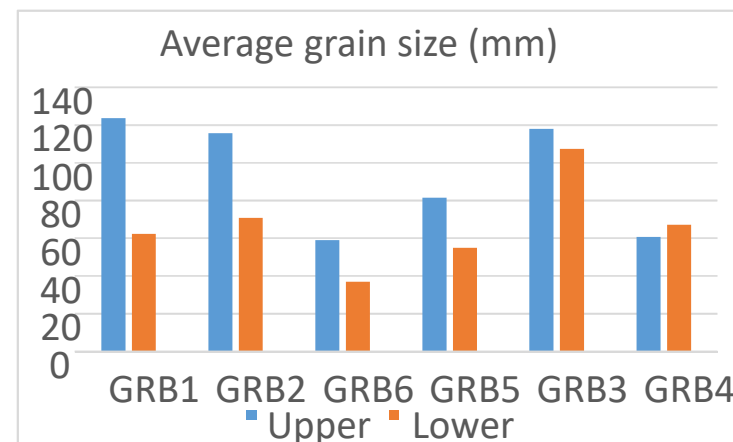
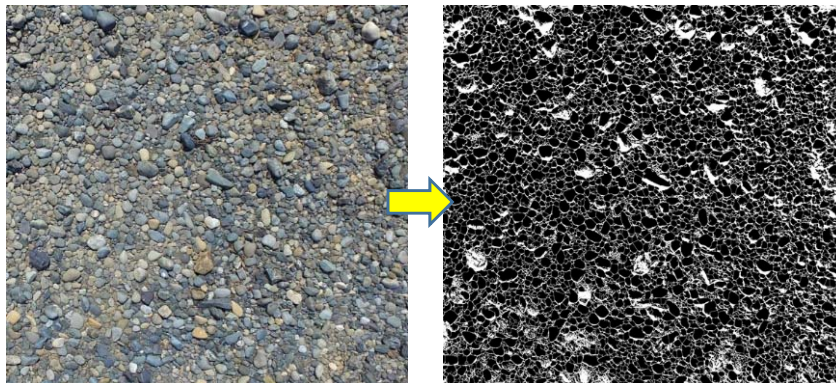
Bed particle size

If you are interested in bed materials size larger than a few centimeter, a free software can also automatically define particle and measure size.

Using Basegrain

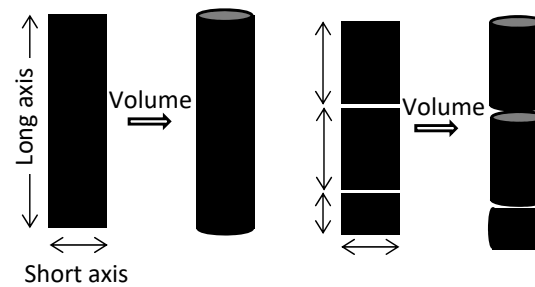
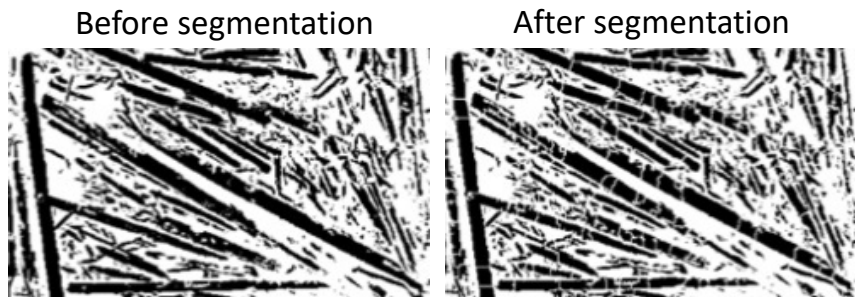


Using ImageJ



Drift wood volume on the surface of bed

You can sometimes estimate volume of LWD from the image.



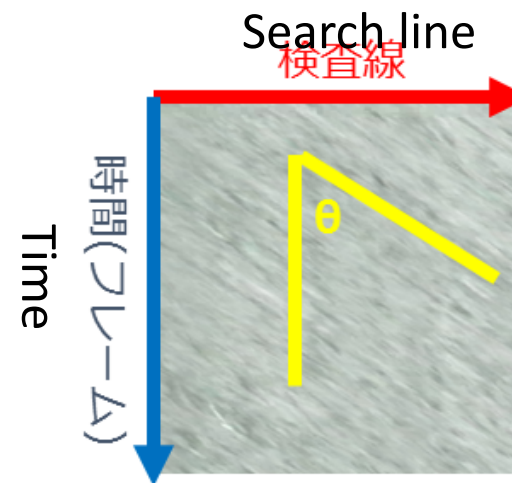
Velocity of flow surface from video



STIV (space for time velocimetry)



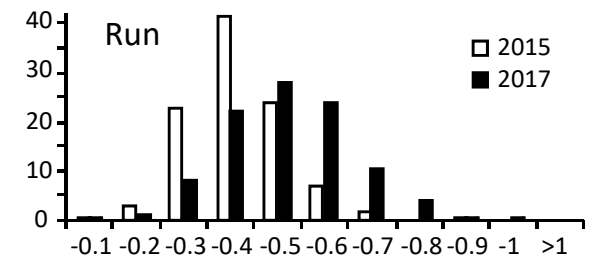
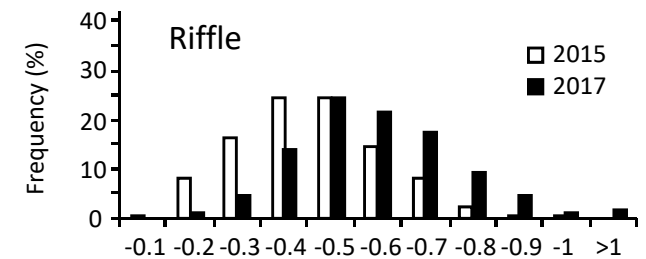
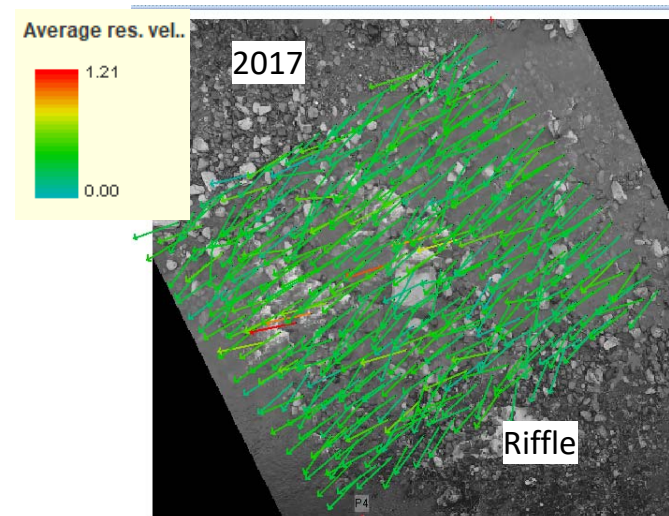
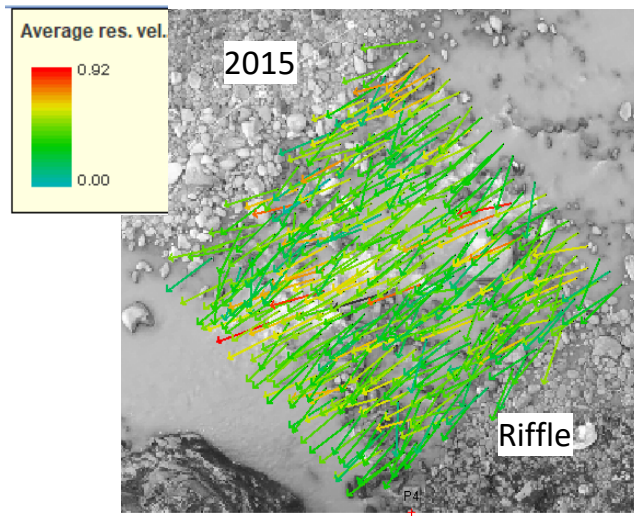
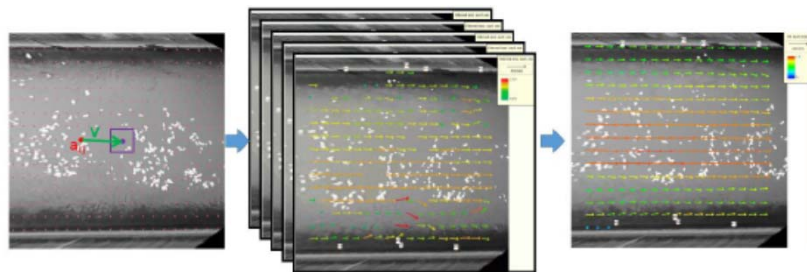
A commercial software



Velocity of flow surface from video

LSPIV (large-scale particle image velocimetry)

Free (Fudaa-LSPIV) and commercial software are available



Flow velocity (m/s)

Flow discharge

Flow velocity and water depth are needed to calculate discharge (m^3/s).
Water depth is still difficult to obtain from drone photo.

Non-expensive fishfinder sonar can be used for depth measurement.

Deeper: record gps and depth (from 0.3-0.6 to 80 m)



https://deepersonar.com/jp/ja_jp/home-jp

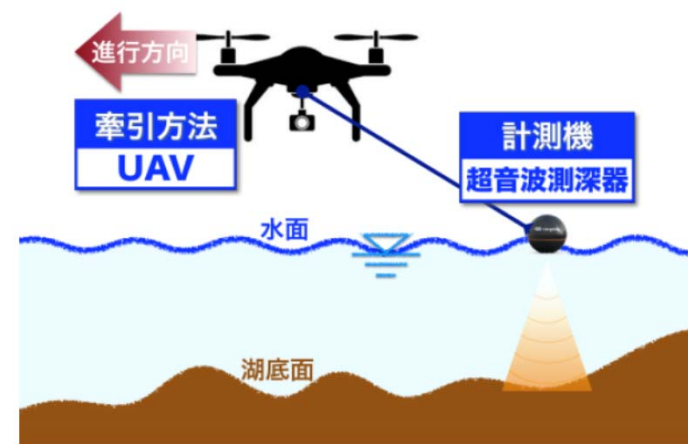
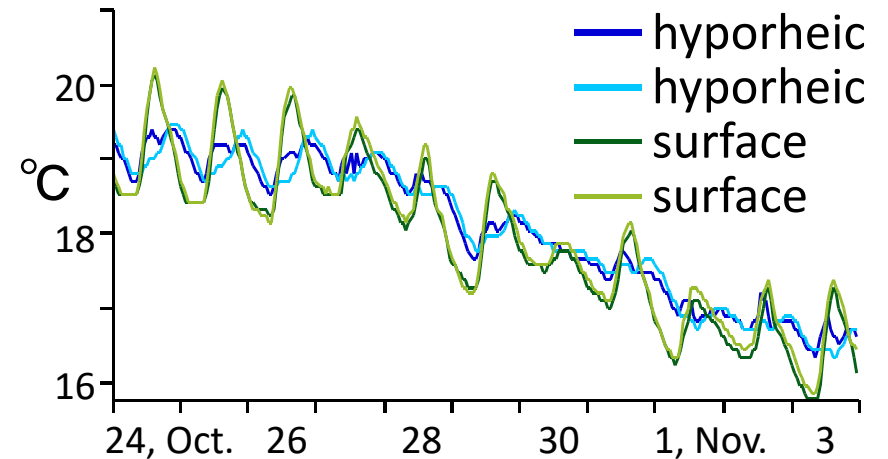
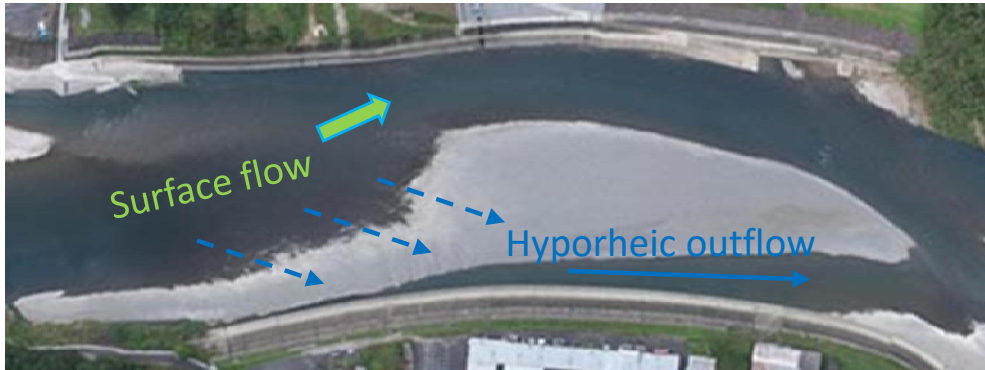


図-4 UAVとDeeperを組み合わせた計測方法の模式図

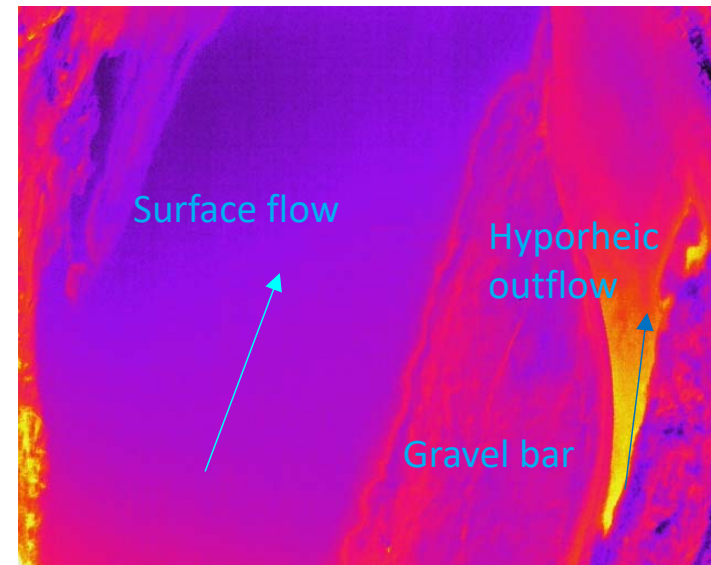
Okada et al., 2018
River Engineering Symposium

Detection of hyporheic outflow by thermography

Because of the temperature difference, hyporheic outflow can be detected by using drone with infrared camera, thermography.

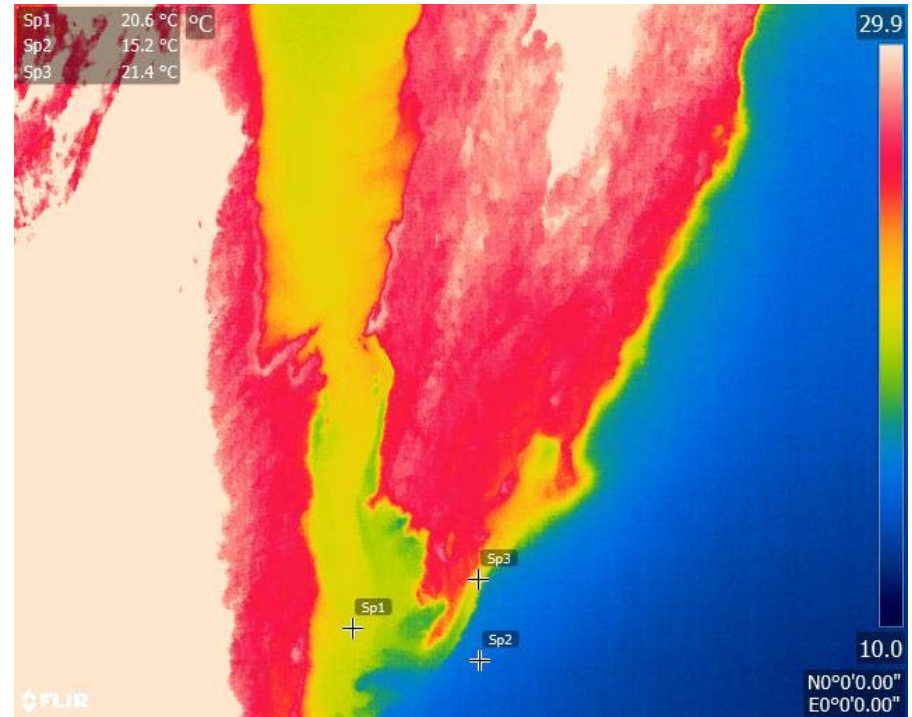
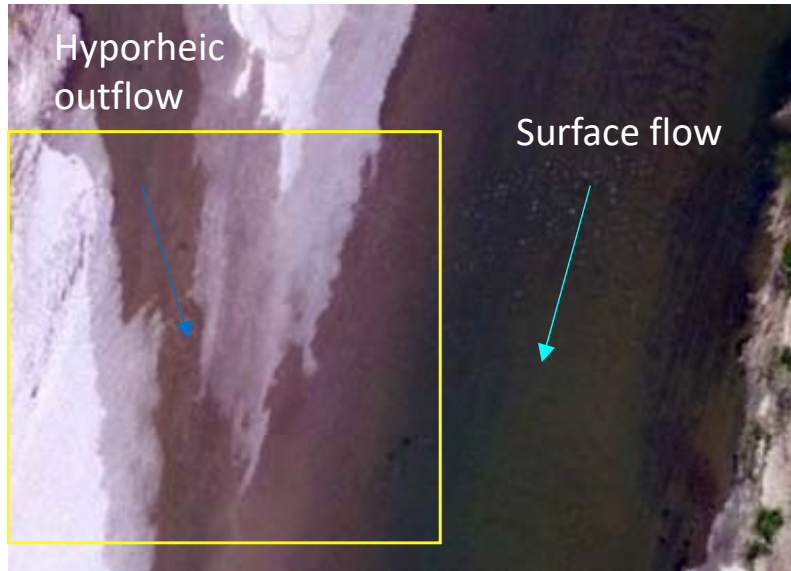


Infrared camera is usually used for detecting animals or electric problems of facilities.



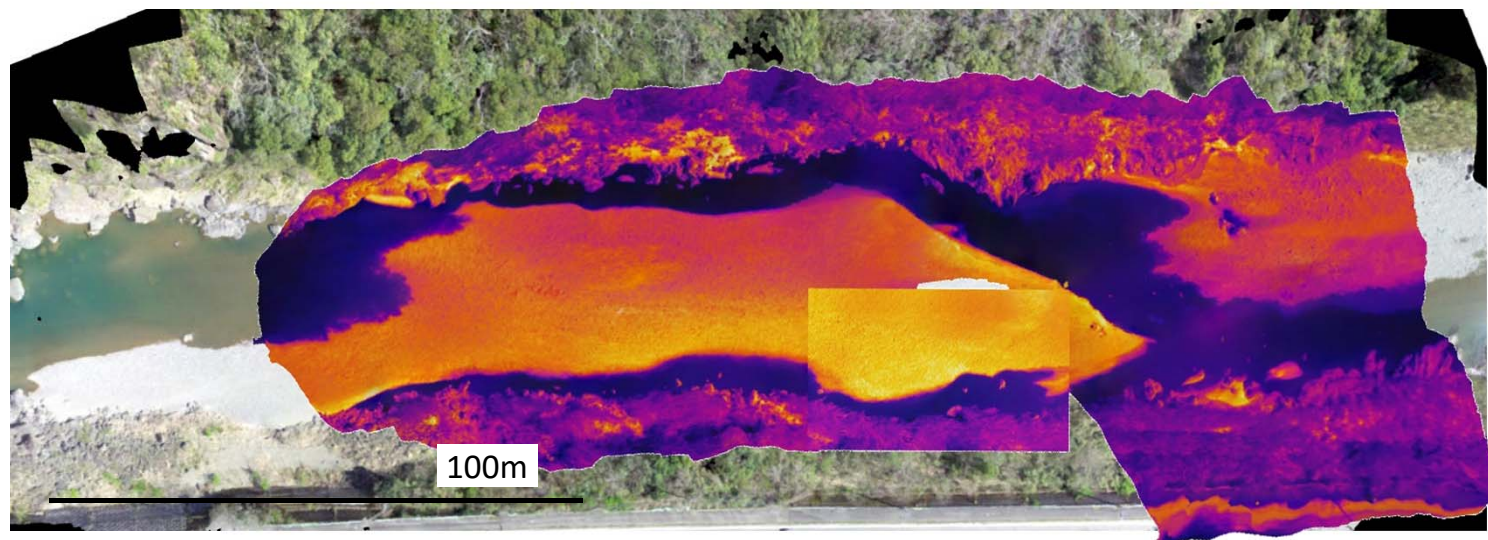
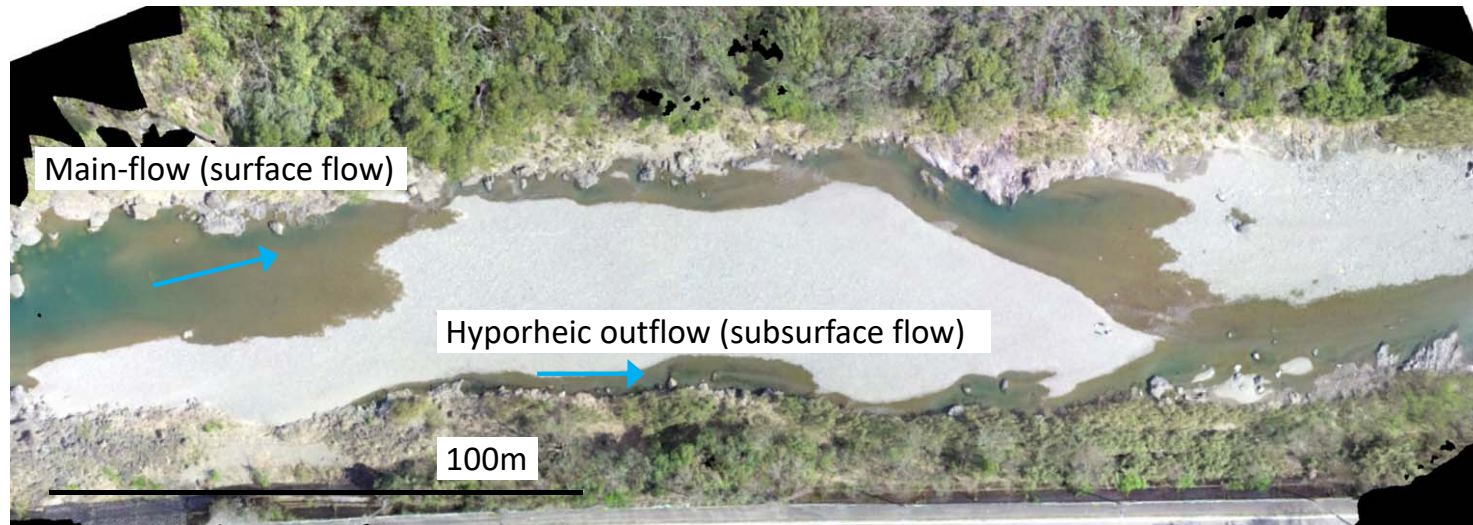
Temperature difference of $>0.3-0.5^{\circ}\text{C}$ can be detected visually.

Source of temperature variation: surface/subsurface/groundwater and midflow/edge (heated by sunlight, or cooled by air)

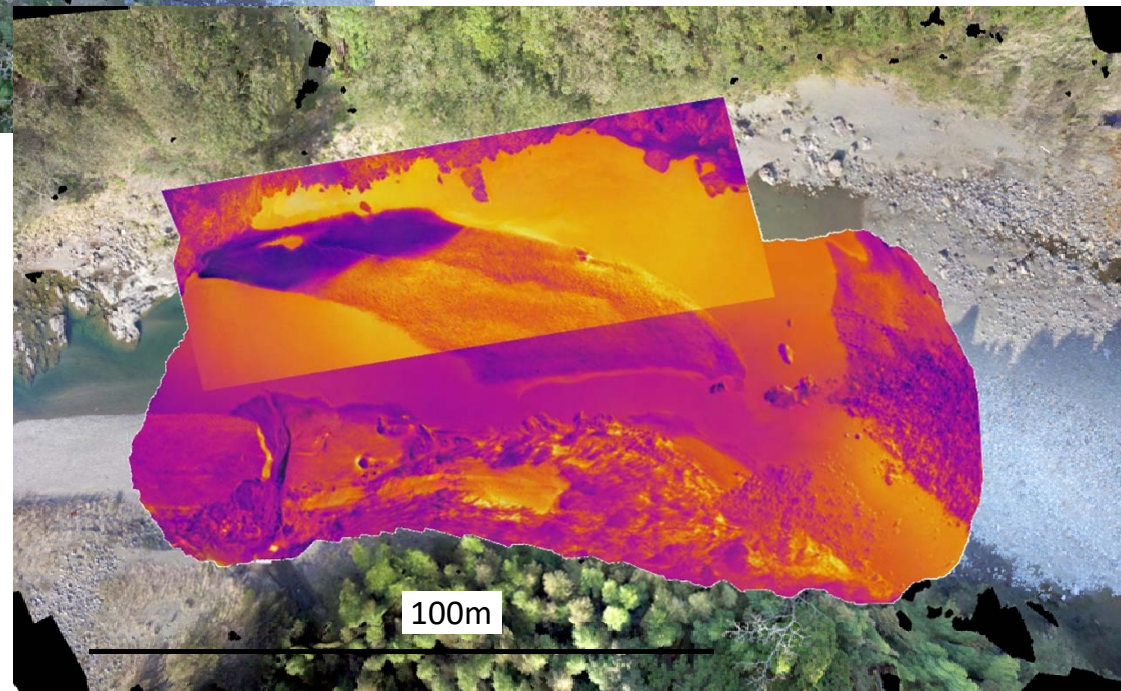
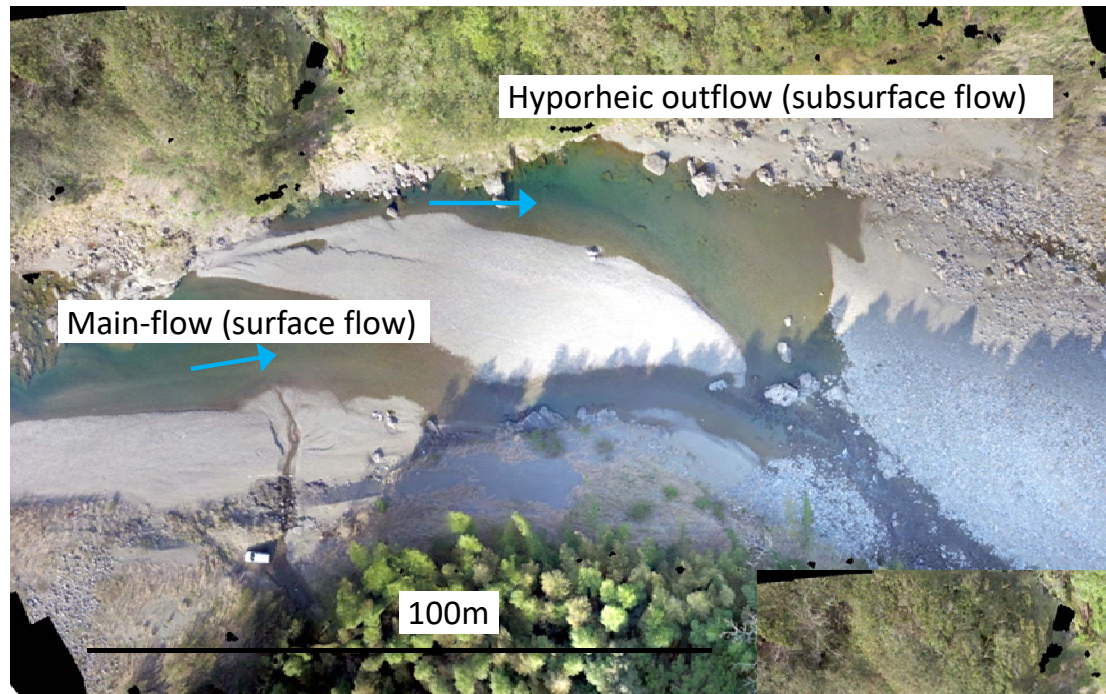


- The difference in temperature between surface and subsurface changes by time of the day .
- You cannot detect hyporheic outflow if it flows under surface flow.
- You need good camera stabilizer and tilt (angle control) to keep camera vertically down and get good resolution images.

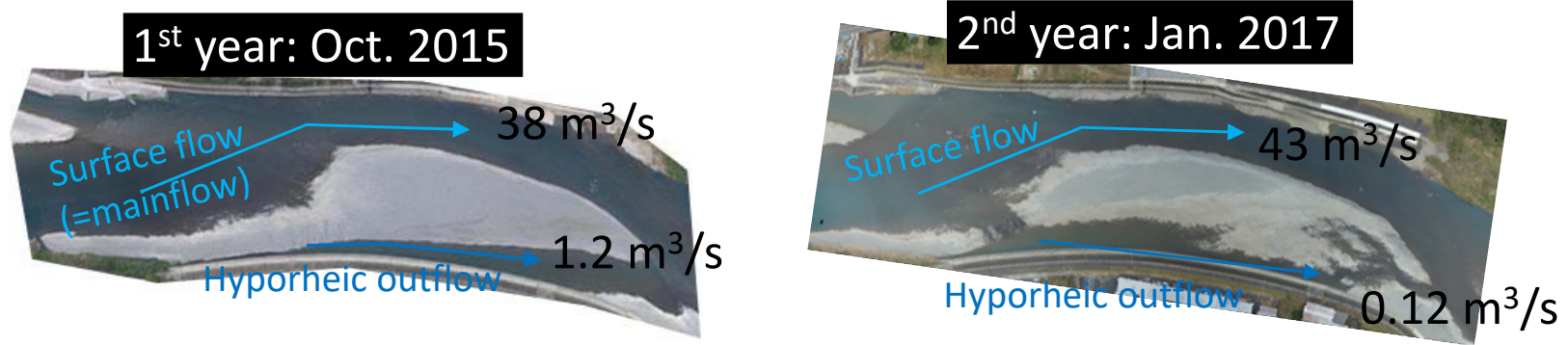
Can you detect hyporheic outflow?



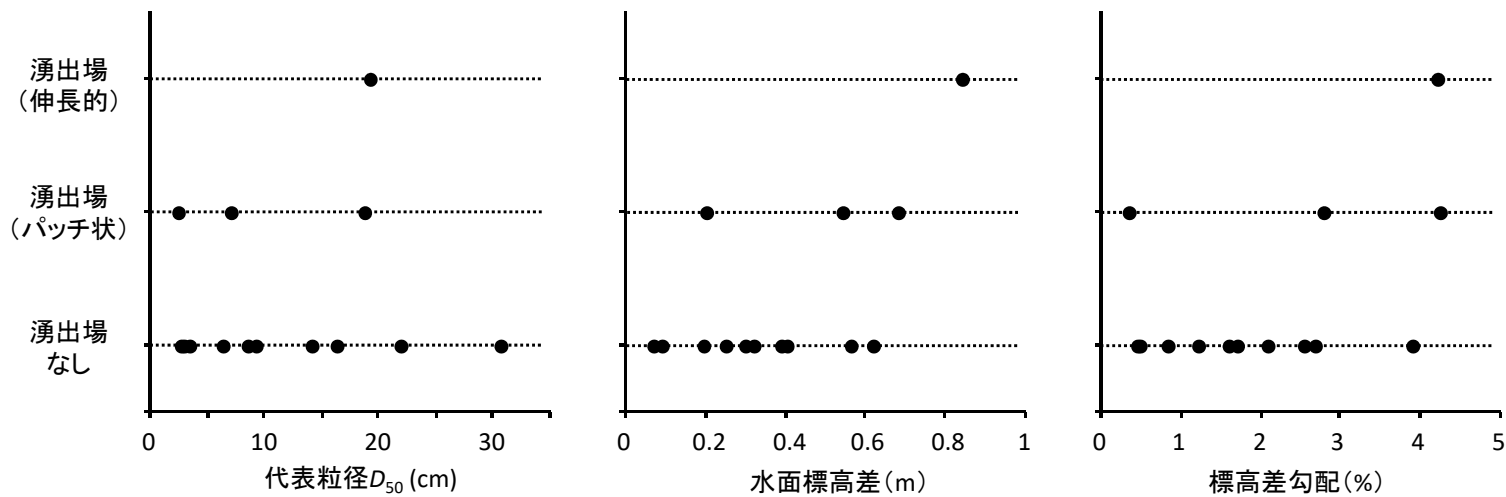
Can you detect hyporheic outflow?



The purpose is to show what kind of gravel bar has high filtering potential



Hyporheic exchange potential



Bar characteristics

Kobayashi et al. 2017
River engineering symposium

Various thermography drones are available,



Phantom 4

※初めてのの方は、取り付けに時間がかかる場合があります。

FOR PRIVATE

標準可視光カメラのみ

FOR BUSINESS

赤外線カメラと標準カメラのツインカメラ

工具不要!
取付け
数分

簡単

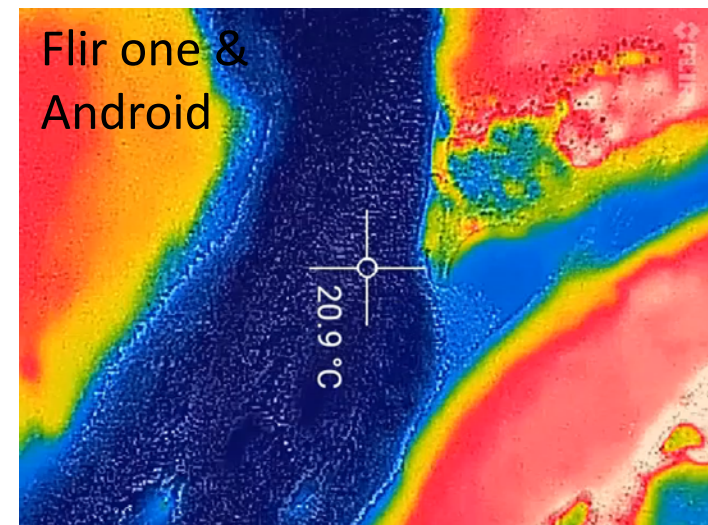
取外し
数分

Phantom 3



but are probably still very expensive.

What I tried at first



Summary

- Spatial scale of gravel bars (100m-1km, reach scale) is suited to use drones.
- Powerful software and free software for analyzing river environment are increasing.
- Gravel bars are the basis of habitat diversity and hyporheic exchange of water.
- Hyporheic outflow around bars can be detected by drones with infrared camera.

Thank you