Water Resources Research

Supporting Information for

Real-Time Monitoring and Postprocessing of Thermal Infrared Video Images for Sampling and Mapping Groundwater Discharge

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Introduction

The supporting information provides details on the hierarchical cluster analysis (HCA), the procedure of the presented method, a photograph of the equipment, a comparison between the RGB and thermal infrared (TIR) images, original data on the tentative minimum temperature of each frame, the relationship between the tentative and portable meter-derived temperatures, and fluctuations in the stream water temperature during the survey period.

Text S1: *Detailed method of hierarchical cluster analysis*

Q-mode hierarchical cluster analysis (HCA) was conducted to classify the stream and spring water samples into hydrochemically similar groups. The analysis was performed by using the EC, pH, and concentrations of all solute data. Although Güler et al. (2002) log-transformed the data to more closely correspond to a normal distribution, we did not conduct a log transformation because most of the chemical variables were originally normally distributed (Shapiro–Wilk test, $p > 0.05$). All variables were standardized by calculating their standard scores (z-scores) using their means and standard deviations. The Euclidean distance (euclidean method in dist function) and Ward's method (ward.D2 method in hclust function) were used for the similarity measurement and linkage, respectively. The number of groups was selected based on visual examination of the dendrogram at each site.

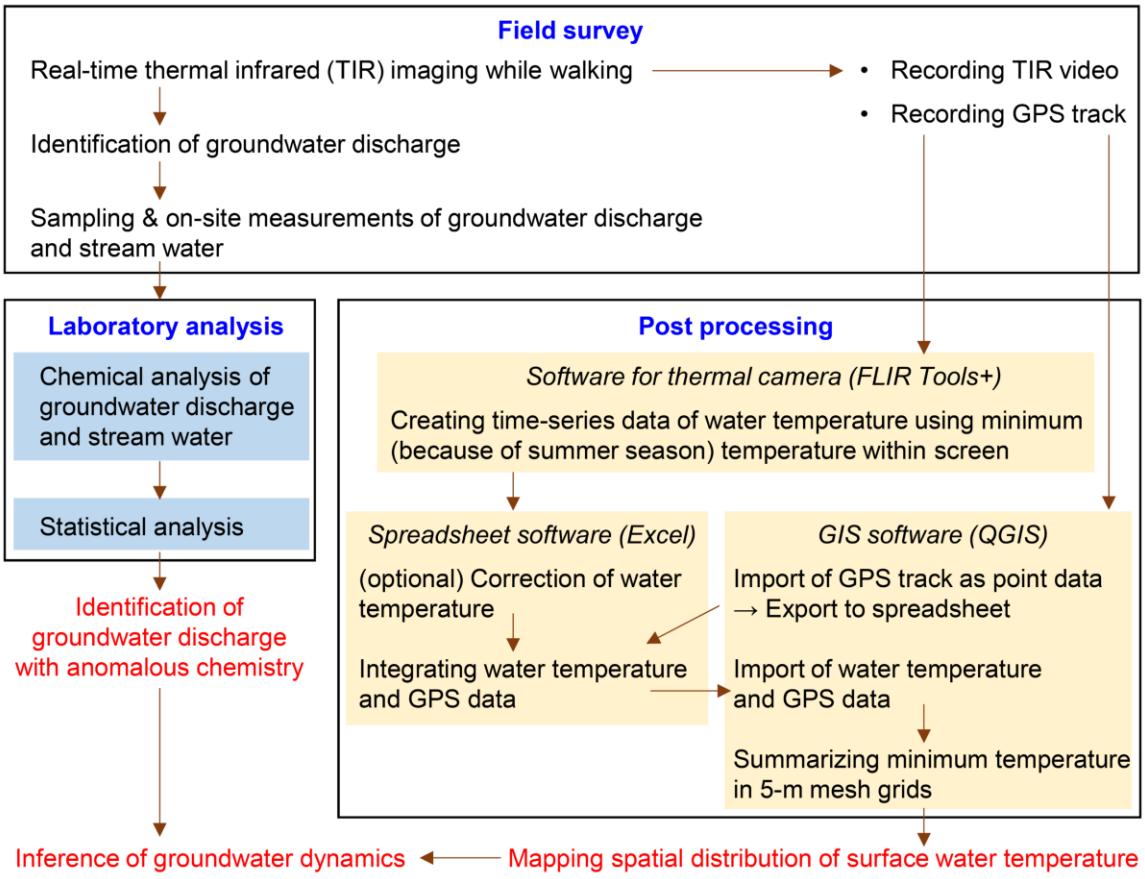

Figure S1. Procedure of the presented method.

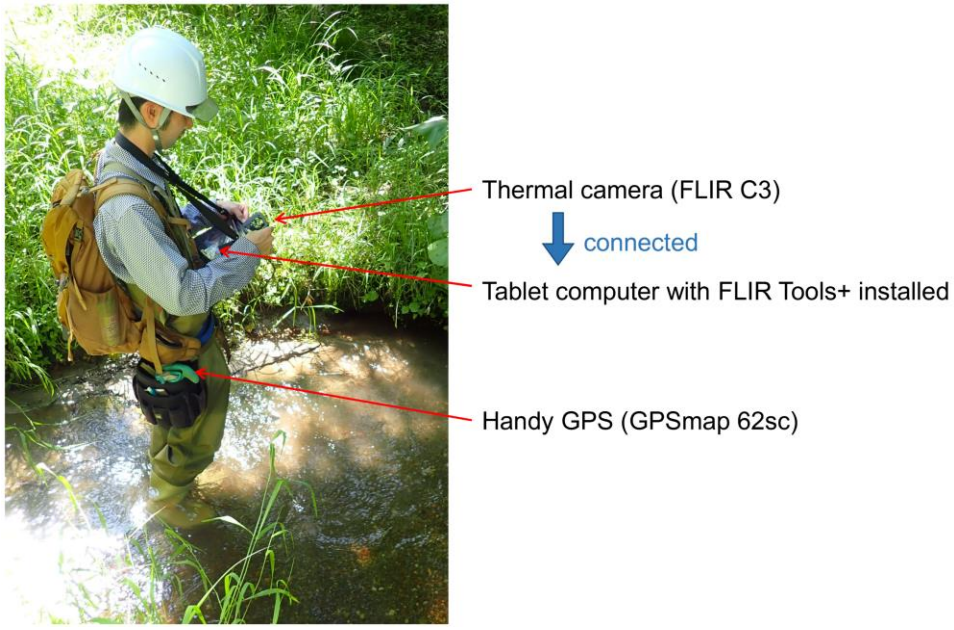

Figure S2. Photograph of the equipment used in the survey.

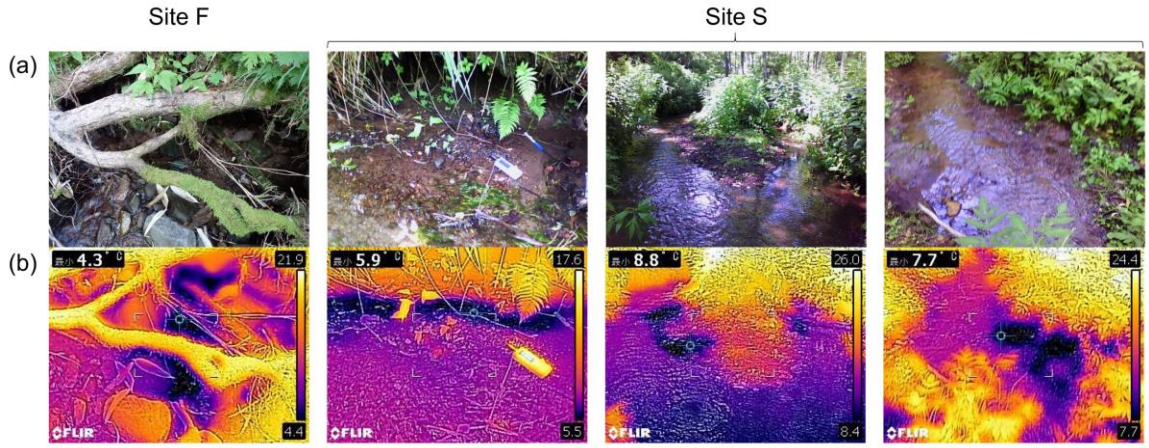

Figure S3. (a) RGB and (b) TIR images of the stream.

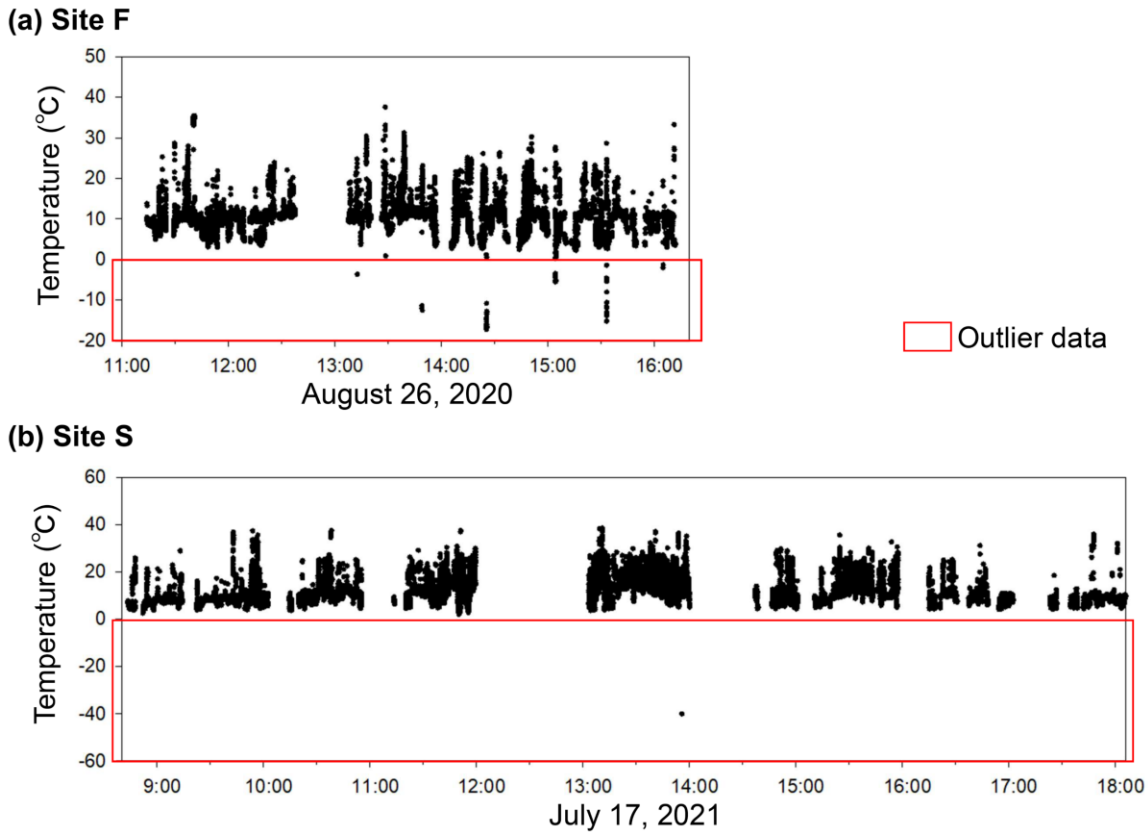

Figure S4. Original data on the tentative minimum temperature of each frame recorded at (a) Site F and (b) Site S.

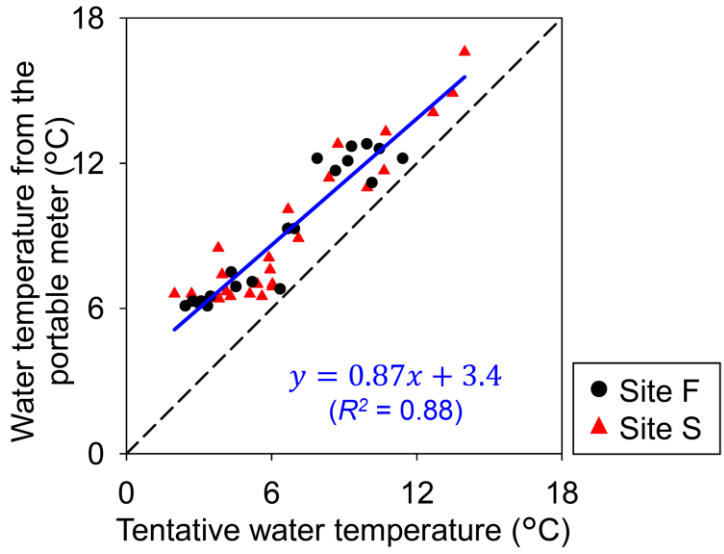

Figure S5. Relationship between the tentative water temperature from TIR videos and water temperature measured by a portable meter.

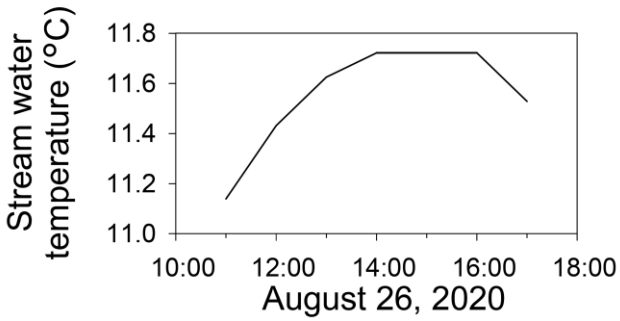

Figure S6. Fluctuations in the stream water temperature during the survey period at Site F.

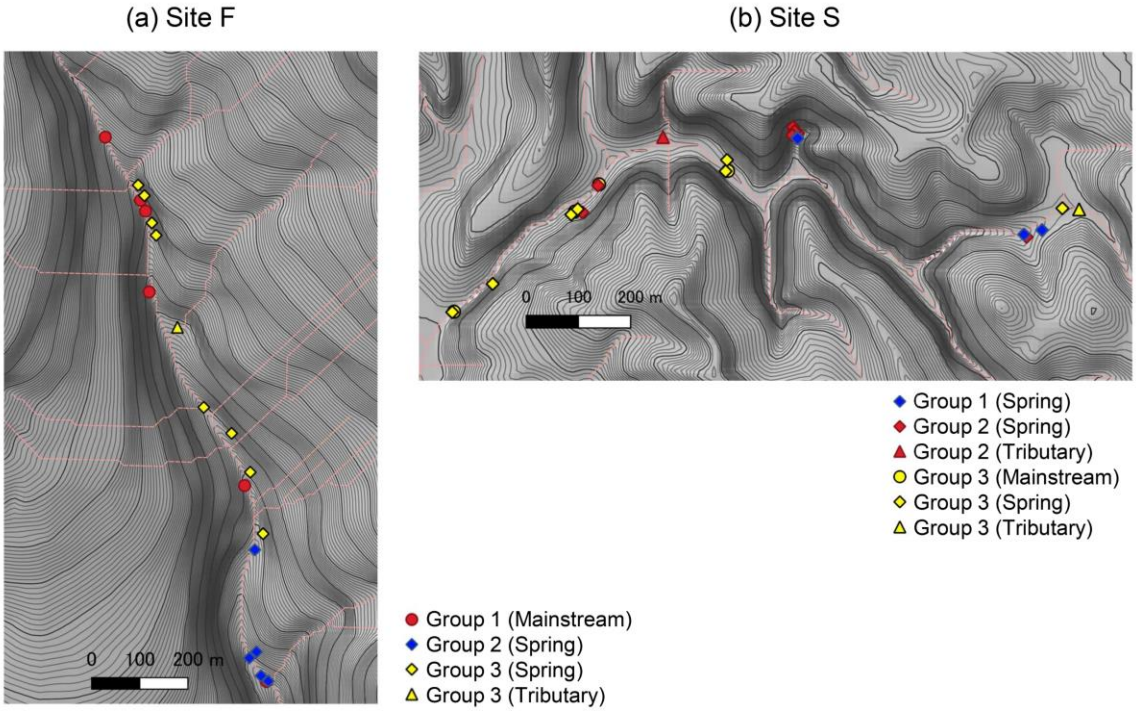

Figure S7. Sampling locations of each group at (a) Site F and (b) Site S.

Table S1. Specifications and parameters of the TIR camera.

Specifications	
Camera model	FLIR C3
Resolution for TIR images	80 × 60 pixels
Field of view	41° × 31°
Instantaneous field of view	11 mrad
Thermal sensitivity	<0.10°C
Frame rate when TIR video is recorded by USB connection	~3 Hz
Parameters	
Water emissivity	0.97
Distance to object	1 m
Reflected temperature	20°C
Atmospheric temperature	20°C
External optical temperature	20°C
External optical transmittivity	1
Relative humidity	50%

Table S2. Mean water chemistry of the stream and spring samples in groups determined from HCA.

Group	EC (µS/cm)	pH	Solute concentrations (µmol/L)							
			Na^+	K^+	Mg^{2+}	Ca^{2+}	Cl^-	NO_3^-	SO_4^{2-}	PO_4^{3-}
Site F										
1	54.9 a	7.40 a	136 a	23 a	44 a	119 a	46 a	7 a	20 a	-
2	69.2 b	6.71 b	167 b	28 b	58 b	163 b	53 b	4 b	27 b	-
3	66.6 b	7.36 a	160 b	22 a	55 b	145 c	54 b	7 a	25 b	-
Site S										
1	168.5 a	6.62 a	417 a	58 a	162 a	423 a	235 a	100 a	28 a	0.99 a
2	70.3 b	7.06 b	256 b	41 b	51 b	137 b	78 b	19 b	20 b	0.78 a
3	117.1 c	7.10 b	335 c	48 c	106 c	270 c	139 c	64 c	18 b	0.98 a

Values not sharing the same letter are significantly different (Tukey-Kramer, $p < 0.05$).

Table S3. Mean water temperature and elevation of spring samples in groups determined from HCA.

Group	Water temperature (°C)		Elevation (m)
	From portable meter	From TIR video	
Site F			
2	7.46	7.38	752.20
3	7.29	7.68	809.49
Site S			
1	6.78	7.04	85.64
2	10.71	10.46	78.47
3	6.89	7.46	71.03