Mapping and quantification of groundwater-surface water exchange along a headwater stream using Distributed Temperature Sensing:

First findings from the Wüstebach Catchment, Germany

8th Galileo Conference, A European vision for hydrological observations and experimentation
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Objectives

Investigate the spatial and temporal interconnection between surface- and groundwater in the Wüstebach Catchment

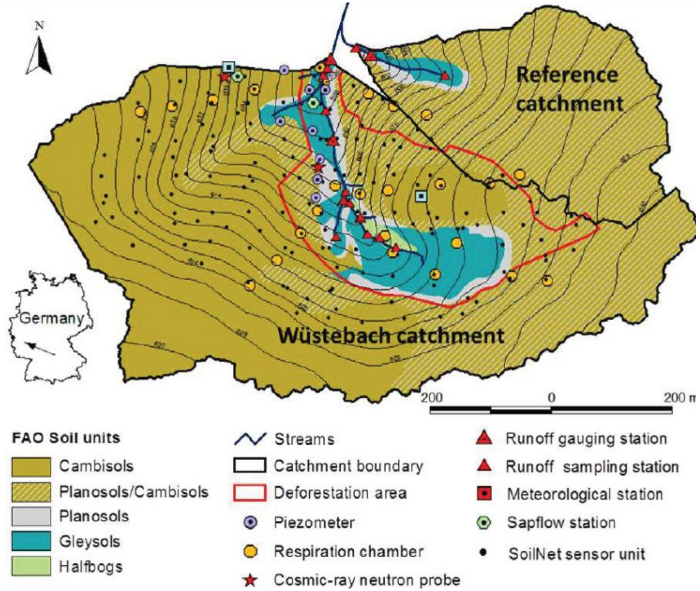
Quantifying the interaction between surface water and groundwater

Mapping of surface water and groundwater interconnection

Understanding the spatial and temporal variability of surface- and groundwater dynamics

The Wüstebach Catchment

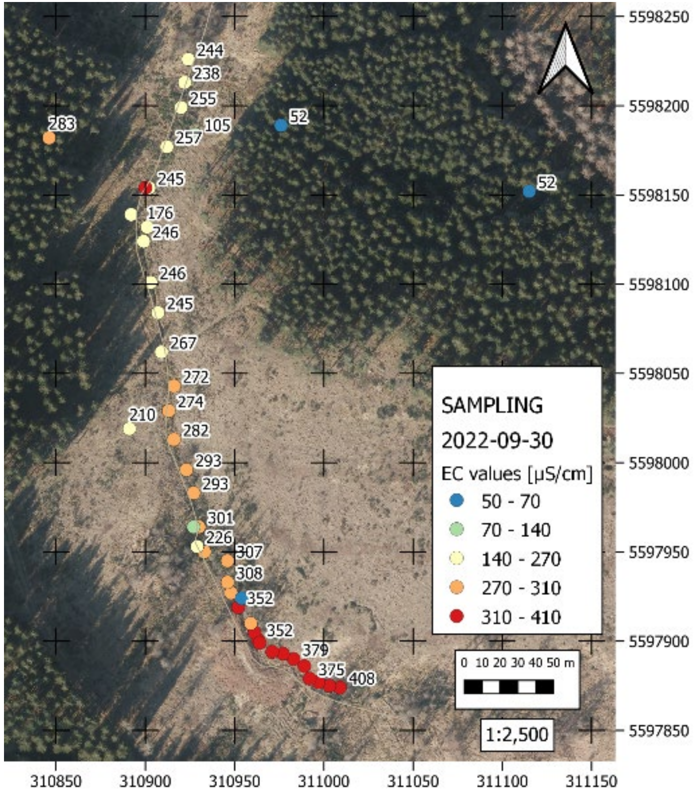
- Part of the **Eifel National Park**
- Covers an area of **38.5 ha**
- Mean altitude of about **610 m**
- Mean precipitation **1200 mm/a**
- Geology is dominated by **Devonian shale** covered by a **periglacial solifluction layer** of about 1–2 m
- Main soil texture is silty clay loam

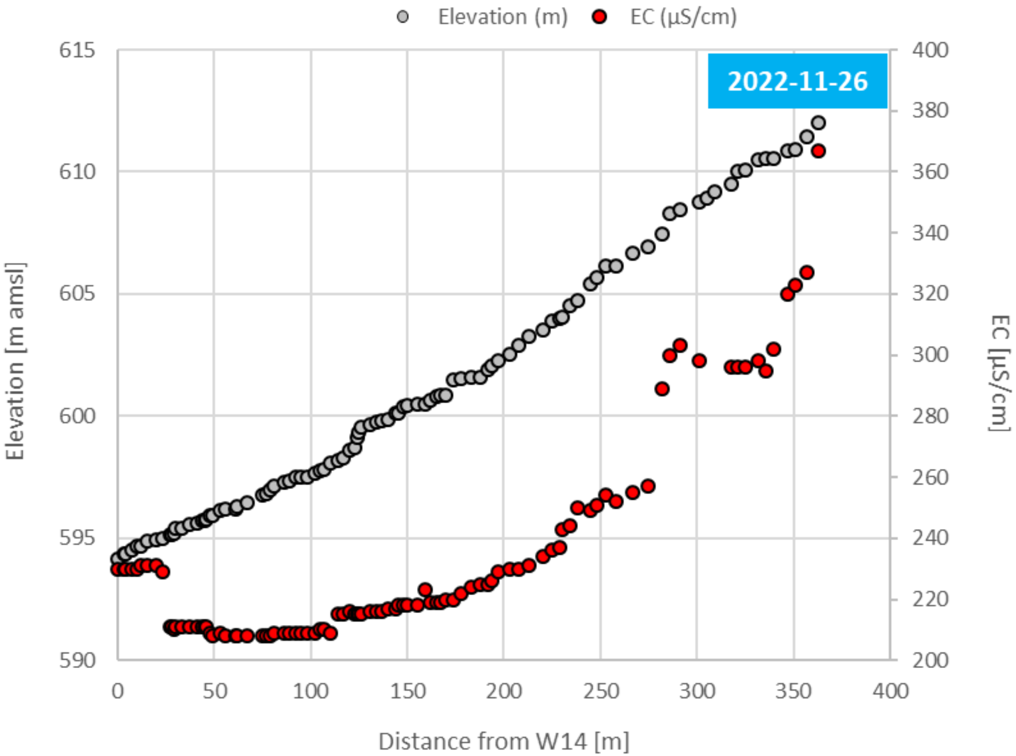


Bogena, H., et al. (2018), doi: 10.2136/vzj2018.03.0055.

TERENO
TERRESTRIAL ENVIRONMENTAL OBSERVATORIES

Distribution of Electrical Conductivity





High variability of EC values along the stream and tributaries ranging from 50 - 400 µS/cm

DTS - Distributed Temperature Sensing

DTS: Ultima XT DTS - 8ch 10 km range, 25 cm sampling

Cable: Tacticcal FOC, 4 MM, OM3, 6.0 mm, 300 m

Installation on 2022-10-26 with 15 minutes sampling interval

Installation of fiber optic cable at W14 (2022-10-29)

Ultima XT DTS setup at W14 (2022-10-29)

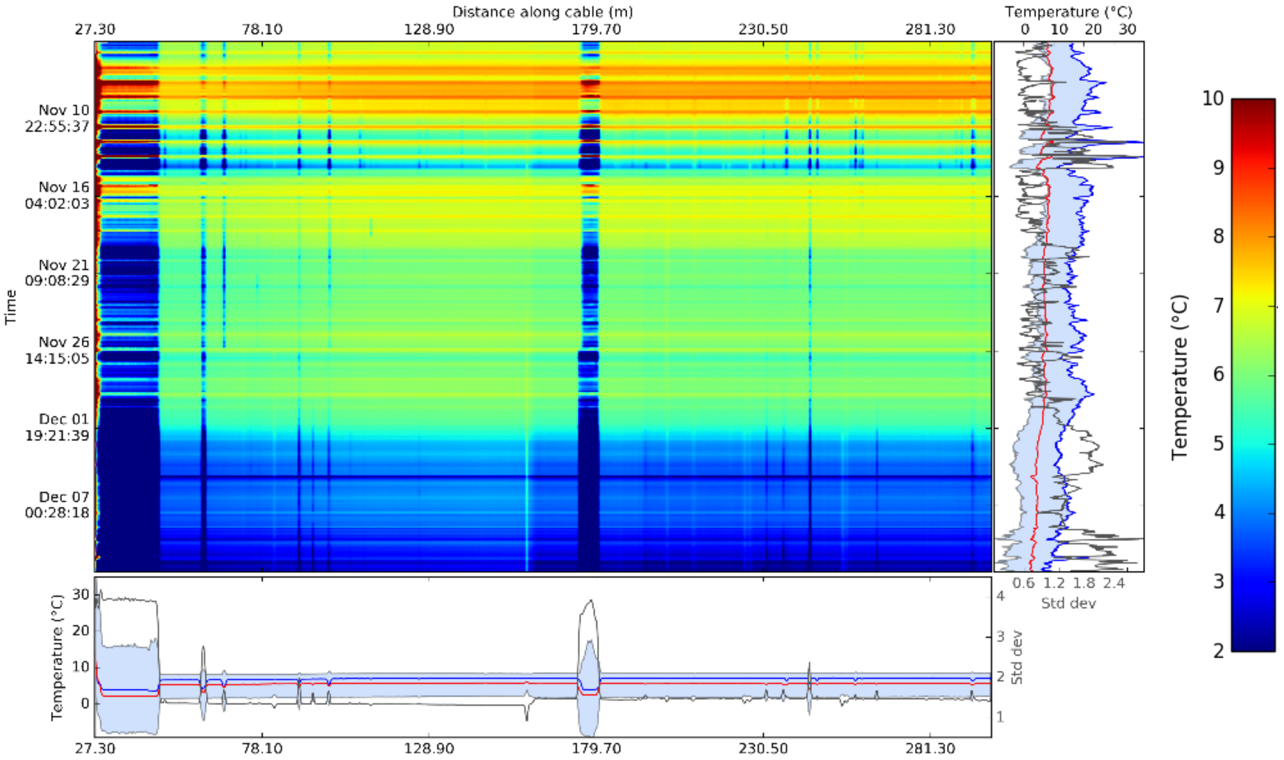
Splicing the fiber optic cable at W6 (2022-11-05)

Ultima XT DTS setup next to W14 (2022-12-11)

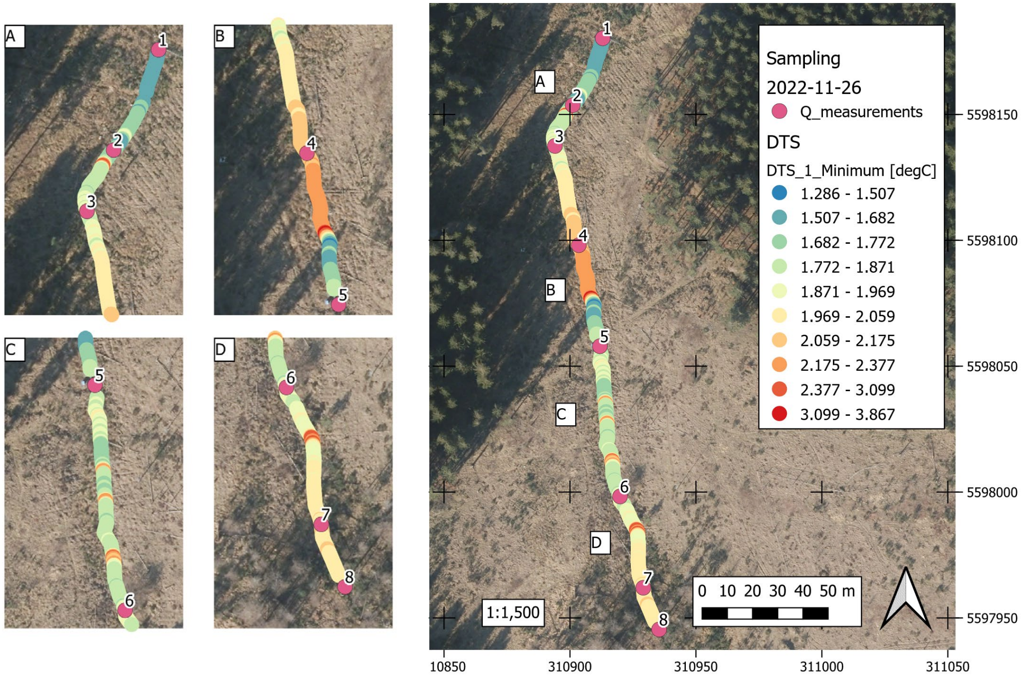
DTS - Distributed Temperature Sensing

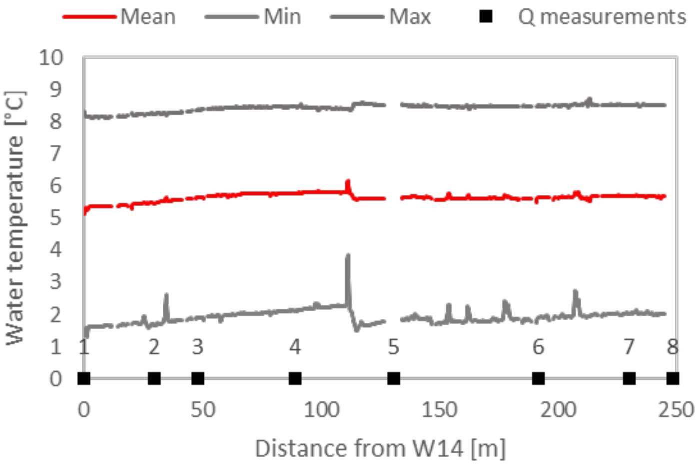
DTS data from 2022-10-26 until 2022-12-11 in a waterfall plot. Raw data is not corrected for distance offset and cable exposure to the atmosphere.

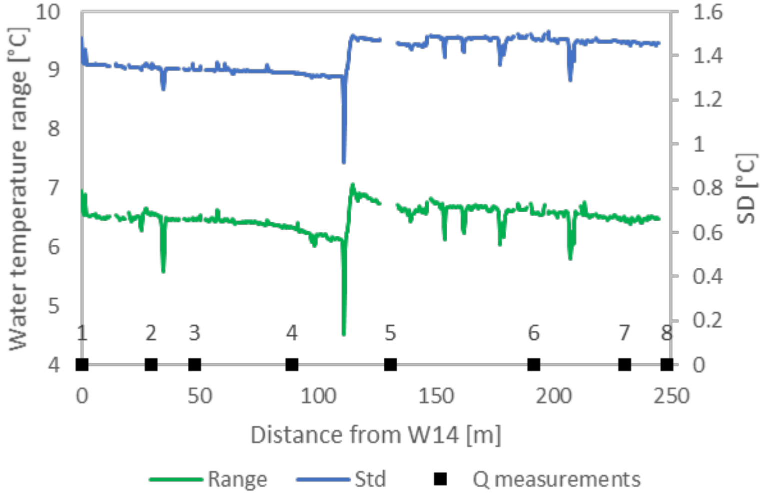
e.g. dark blue areas between 27 m and 48 m and around 179 m are exposed to the atmosphere.



DTS - Minimum temperature



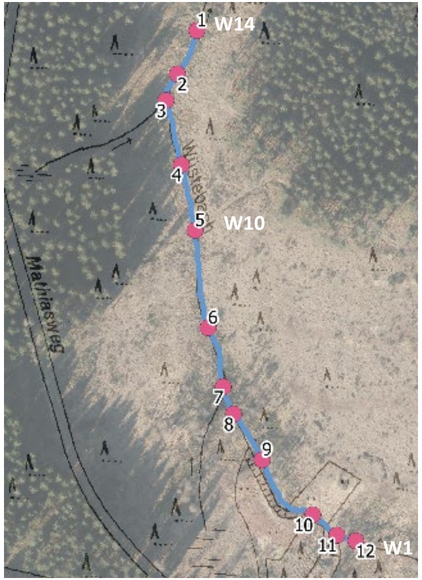


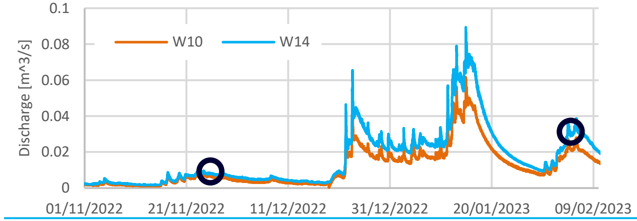


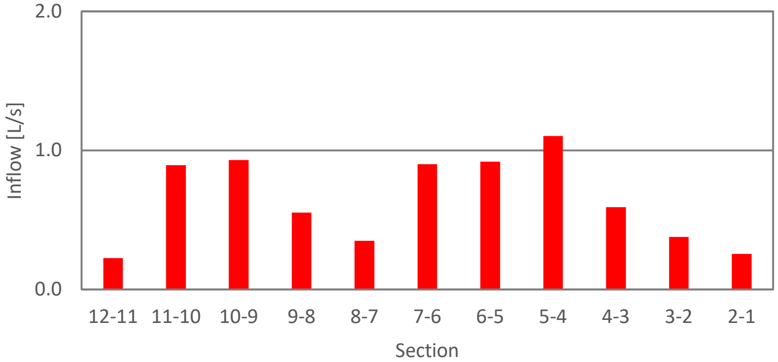
2022-10-26 to 2022-12-11

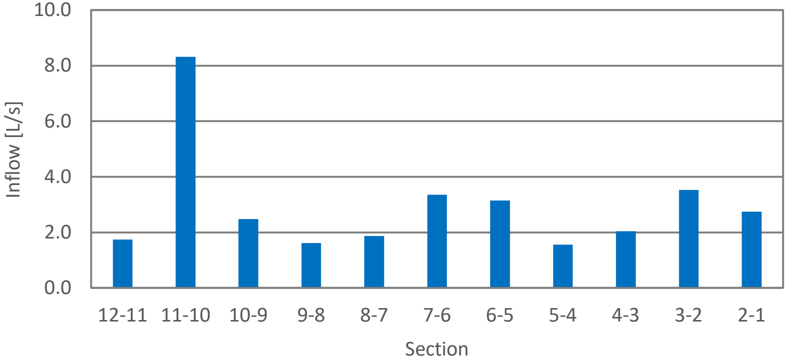
$\Delta T_{min} = 2.6°C$

Discharge measurements – Total inflow [L/s]





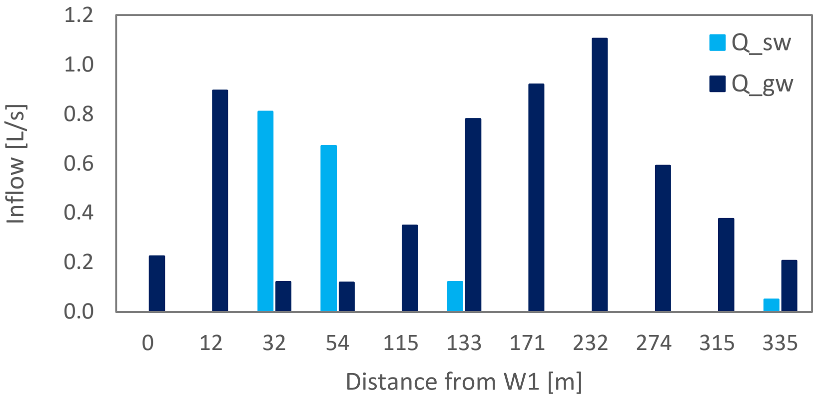


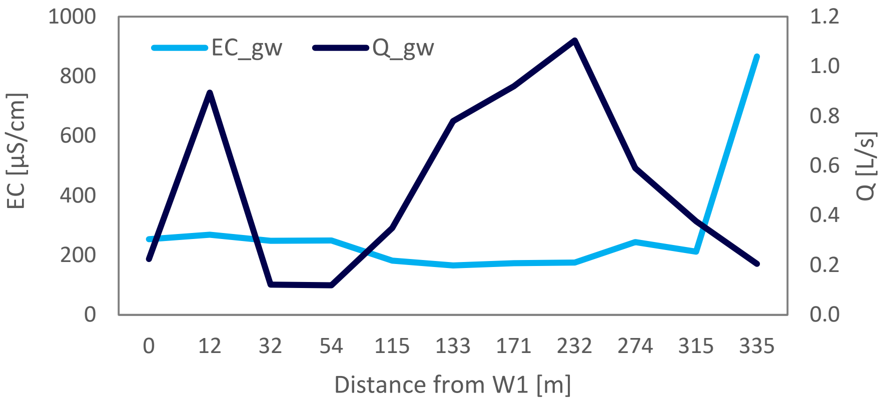


Mass balance calculations

$$Q_T \cdot C_T = Q_{sw} \cdot C_{sw} + Q_{gw} \cdot C_{gw}$$

2022-11-26	Unit	#12	#11	#10	#09	#08	#07	#06	#05	#04	#03	#02	#01
Location	m	0	12	32	54	115	133	171	232	274	315	335	363
Q	L/s	0.5	0.96	2.13	3.35	4.08	4.54	5.72	6.93	8.38	9.15	9.65	9.98
EC	µS/cm	367	332	297	295	251	244	225	216	209	212	212	231
Q_sw	L/s		0.00	0.00	0.81	0.67	0.00	0.12	0.00	0.00	0.00	0.00	0.05
EC_sw	µS/cm		0	0	298	83.5	0	66.4	0	0	0	0	404
Q_gw	L/s		0.22	0.89	0.12	0.12	0.35	0.78	0.92	1.10	0.59	0.38	0.21
EC_gw	µS/cm		254	269	248	250	182	166	173	176	244	212	866





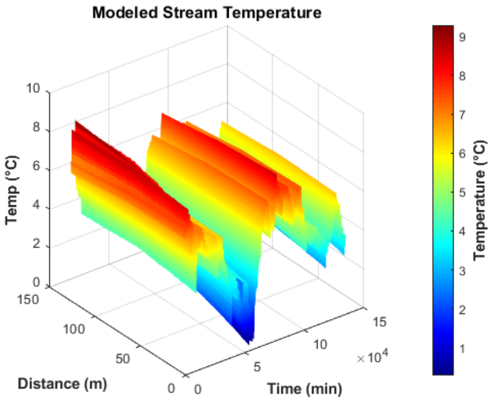
Temperature modelling - HFLUX

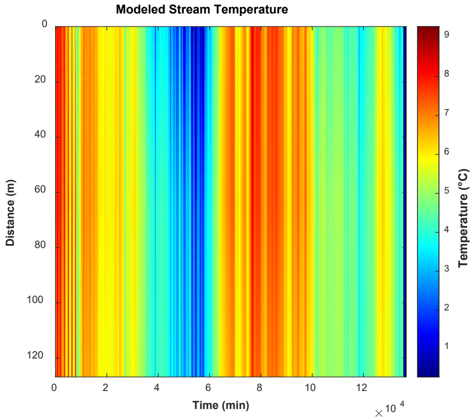
HFLUX Stream Temperature Solver Version 3.1 (2019)

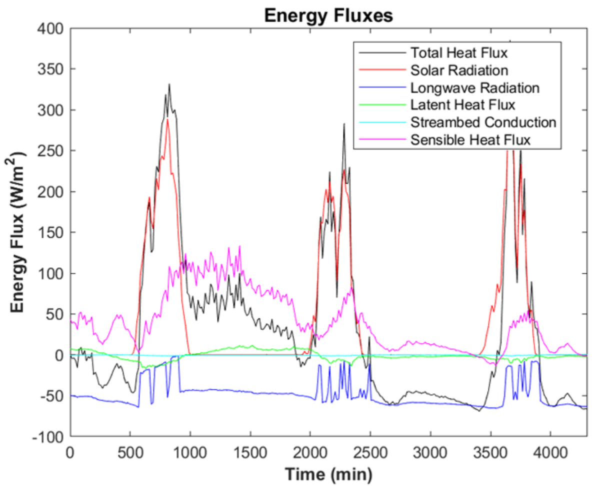
Anne Marie Glose, Laura K. Lautz, and Emily Baker, Syracuse University, USA

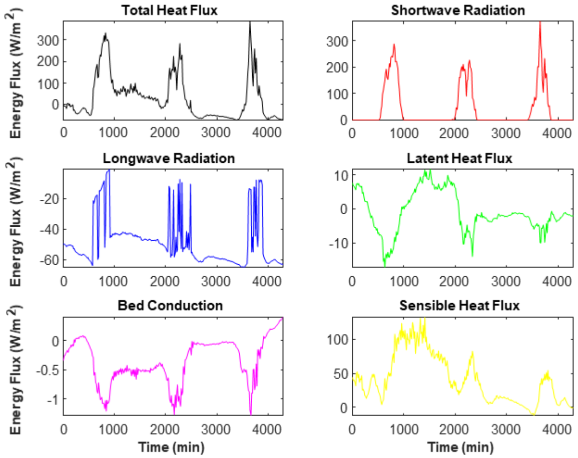
<u>Main input data:</u>

- Water temperatures along the stream reach (DTS measurements)
- Discharge at the upstream and downstream boundary
- Stream reach conditions
- Solar radiation, air temperature, relative humidity, wind speed



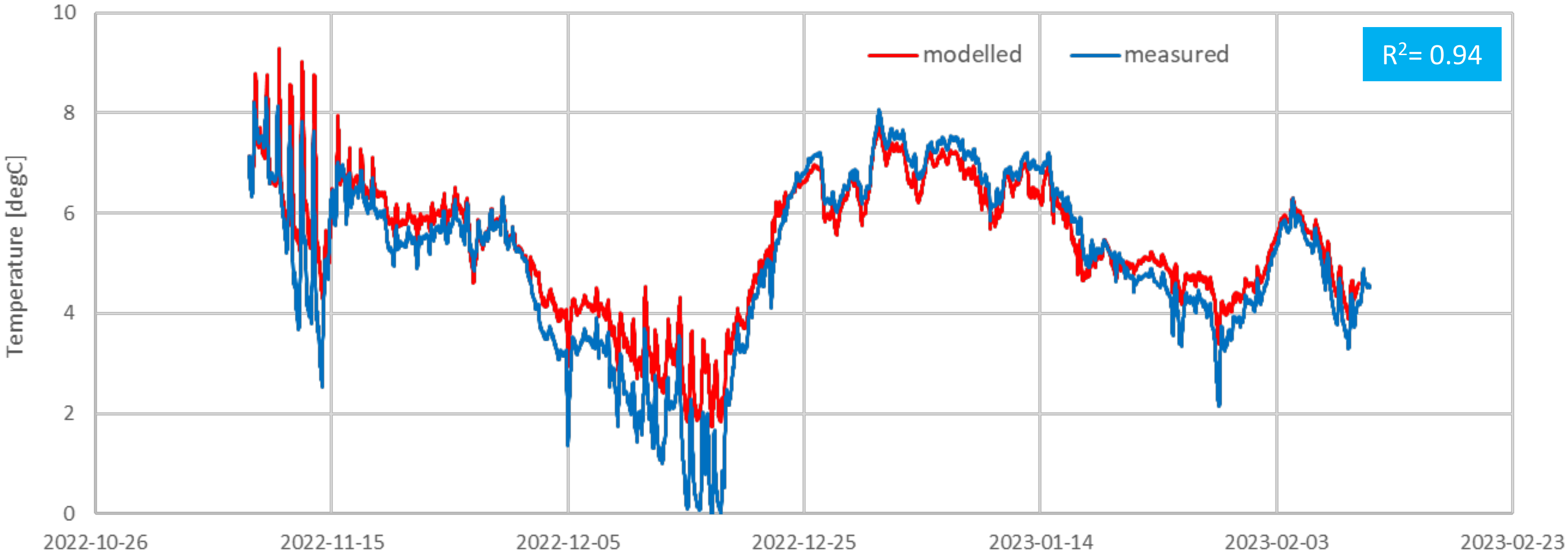






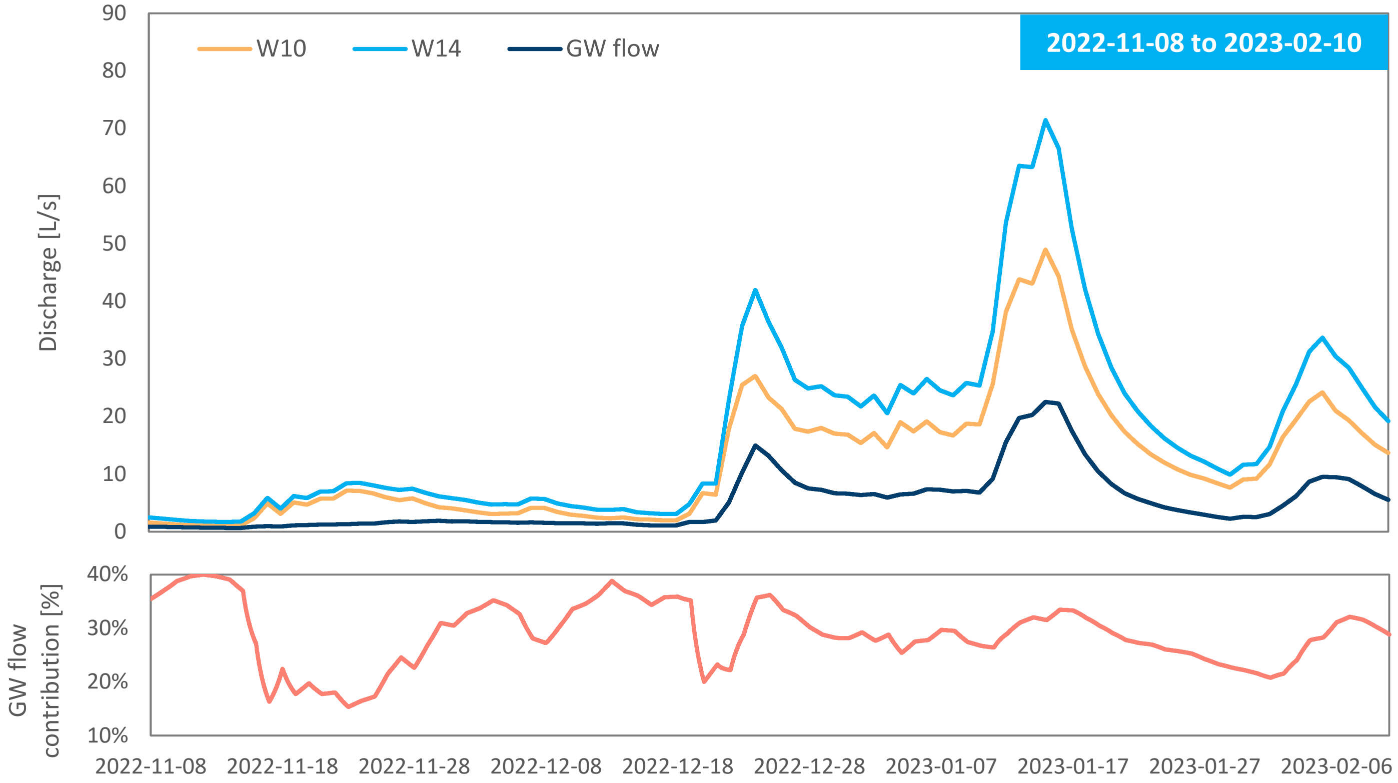
2022-11-08 to 2023-02-10

HFLUX – Temperature at W14; 126 m



2022-11-08 to 2023-02-10

HFLUX – Groundwater contribution



GW contribution:

Average = 29%
Minimum = 15%
Maximum = 40%

Conclusions

- The **DTS** installation helped in the **identification of hotspots** of groundwater exfiltration.

- The high EC values in the stream (200-400 µS/cm) cannot be justified by the inflow from the shallow periglacial drift cover layer (200-275 µS/cm) alone and therefore there should be a **contribution from a deeper, more mineralised aquifer system** of lower water temperature.

- The combination of **DTS measurements and HFLUX modelling** allowed the **continuous quantification of surface- and groundwater fluxes**.




Thank you

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