River temperature dynamics downstream of a shallow reservoir: process-based modelling to evaluate thermal mitigation strategies

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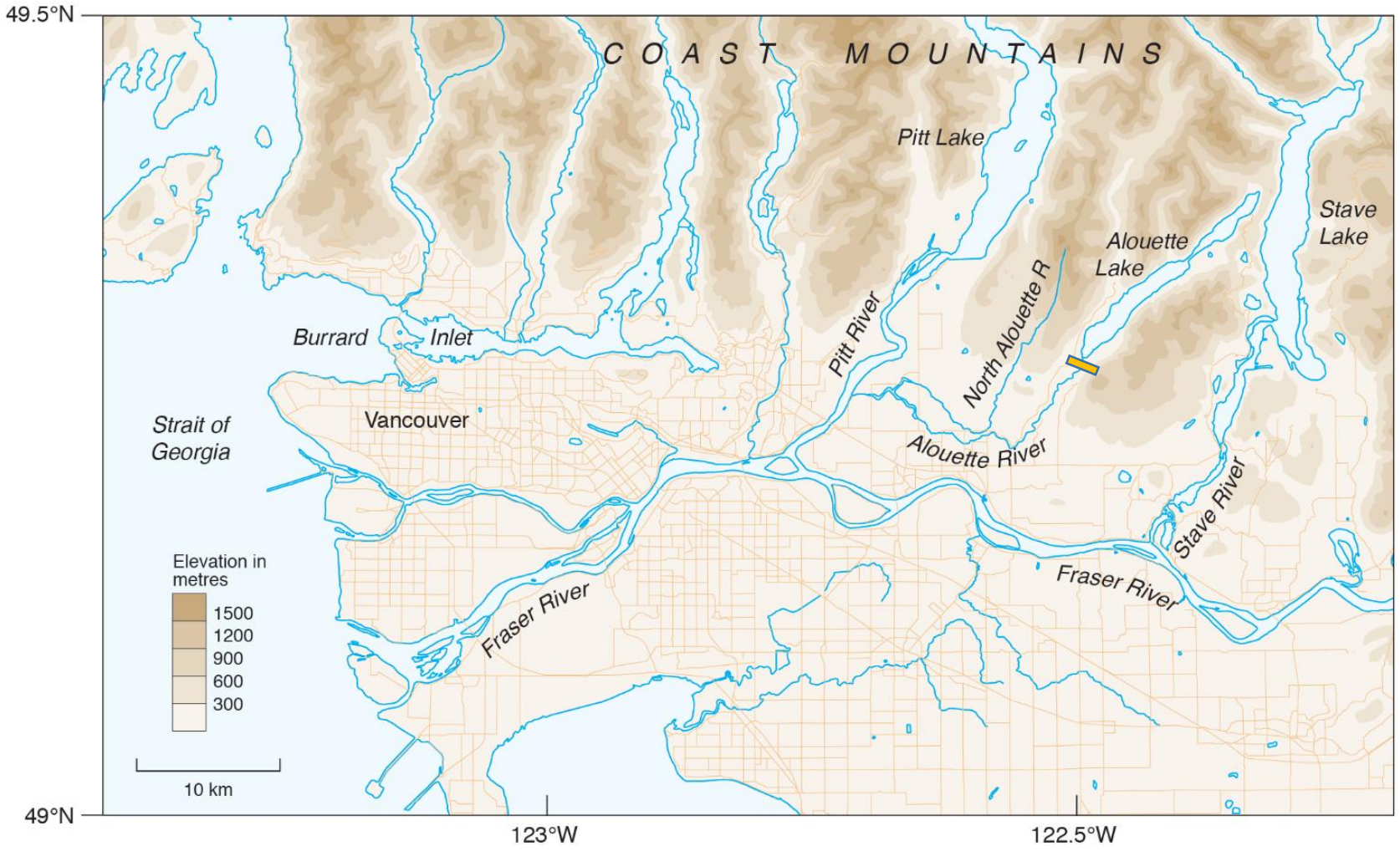
Field site

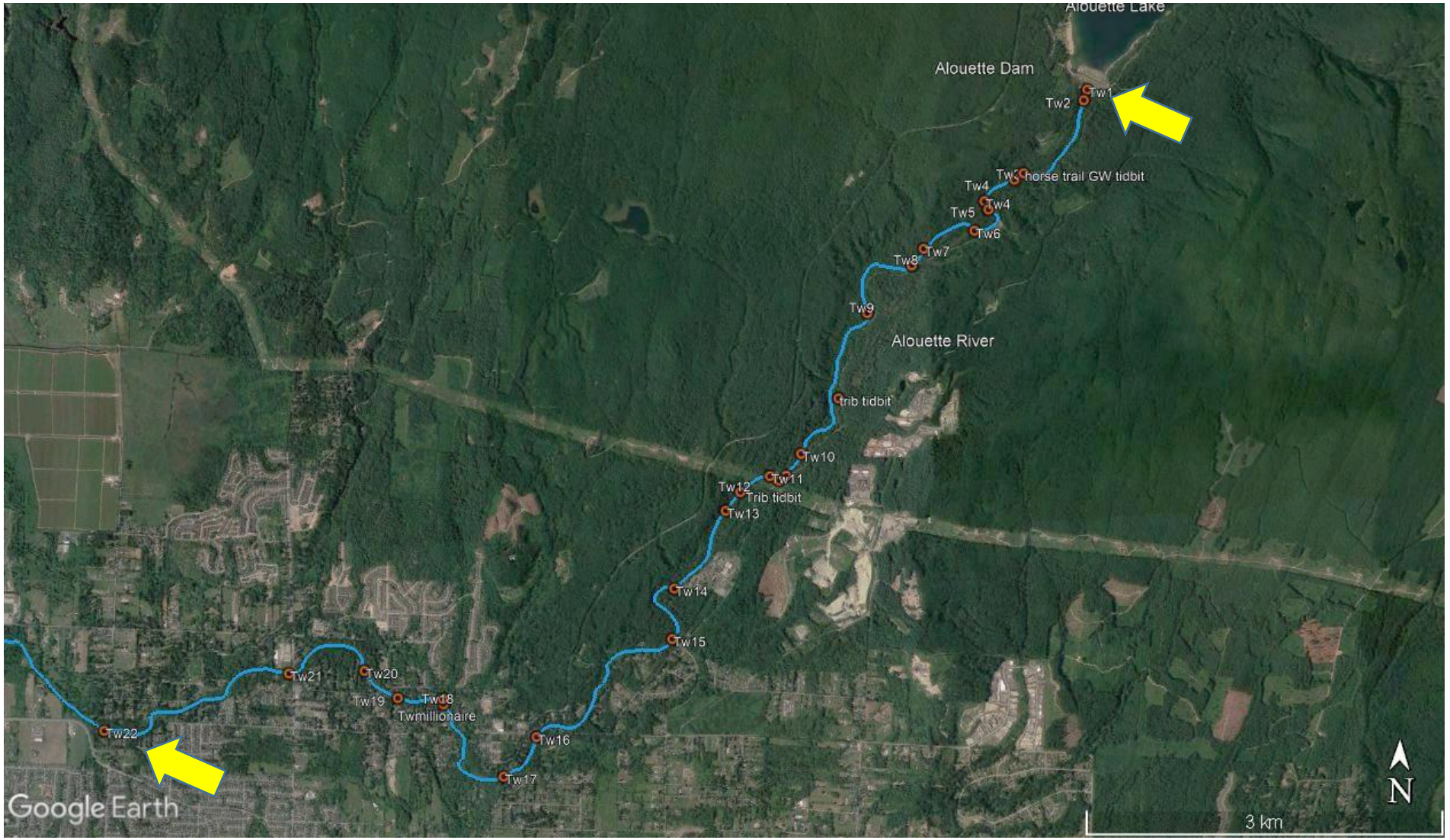


A control dam at Alouette Lake outlet diverts flow via a tunnel into Stave Lake for hydro-power production.

Flow is released via a spillway (spring) and a low-level outlet in summer (below).

Summer flow releases at the dam are ~ 3 m^3s^{-1}.

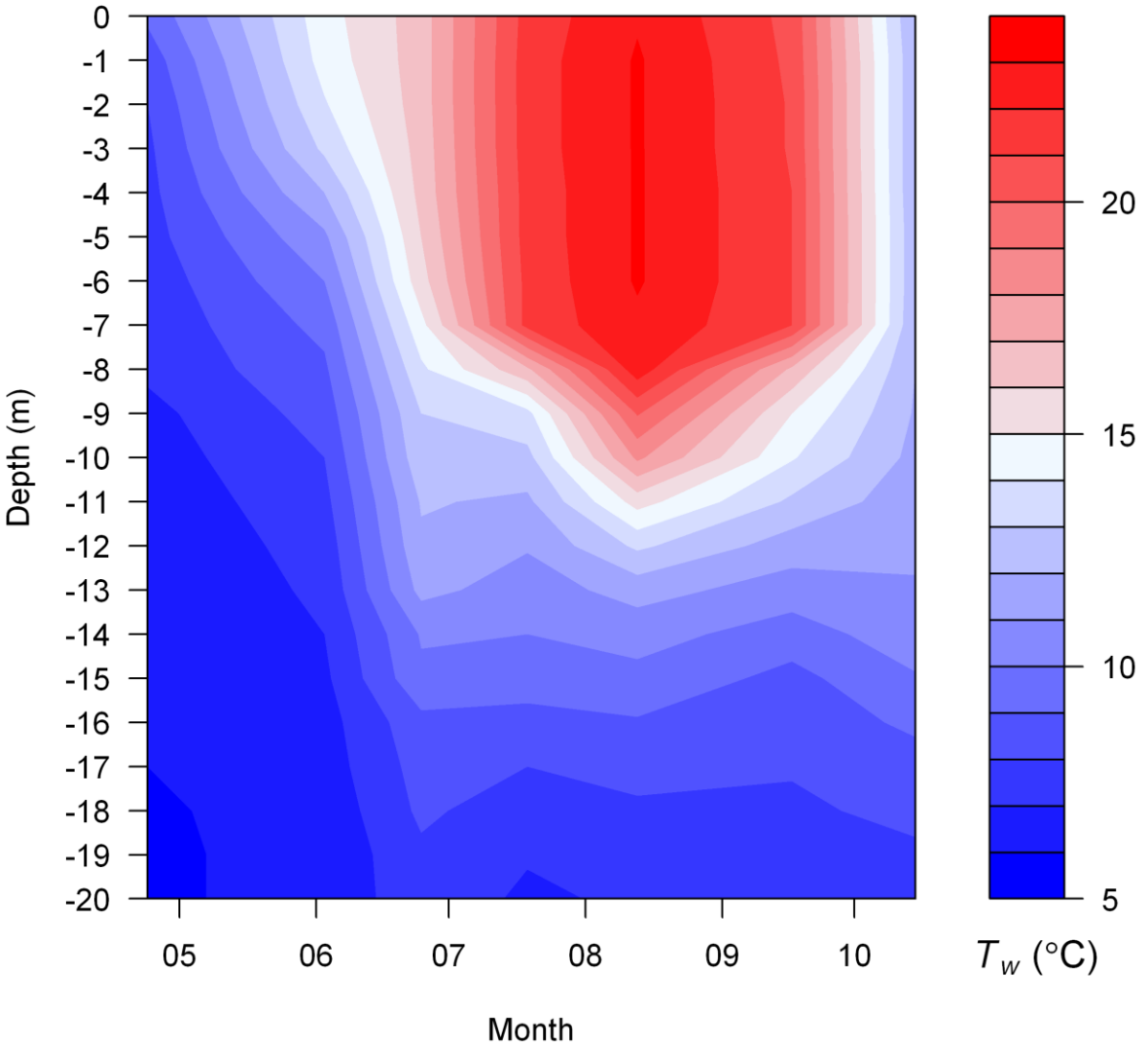
Study reach with temperature sensors



The study domain extended from T_{w1} (below dam outlet) to T_{w22}, ~15 km downstream of dam.

Detailed field measurements (shade, above-stream met., bed temperature) were used to parameterize the model in place of calibration.

Thermal structure of the reservoir

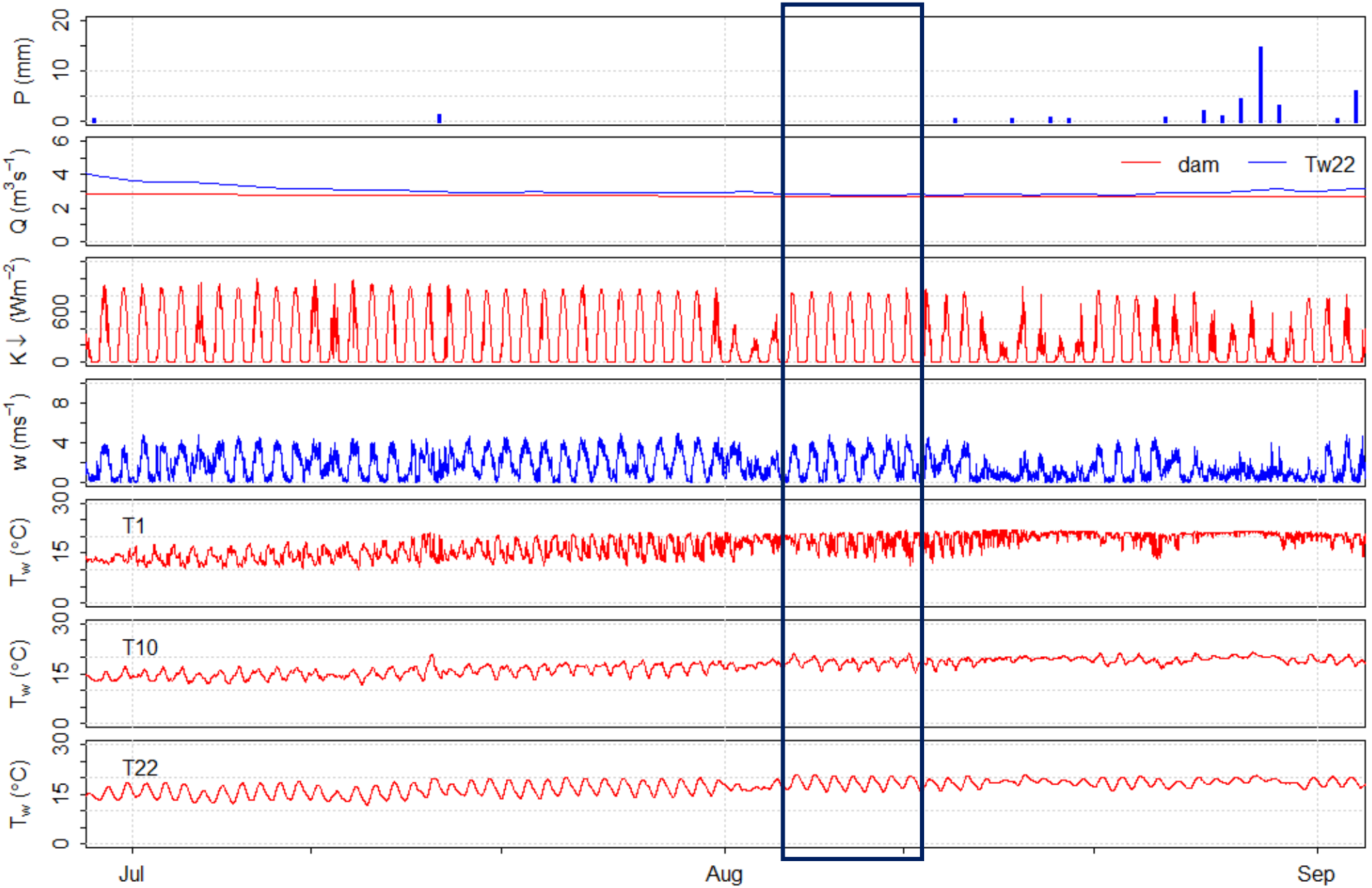


Stratified conditions dominated July through September 2013.

The thermocline occurred at 8 to 10 m below the surface.

Deepest thermocline position occurred in August

Hydrometeorological overview - 2013

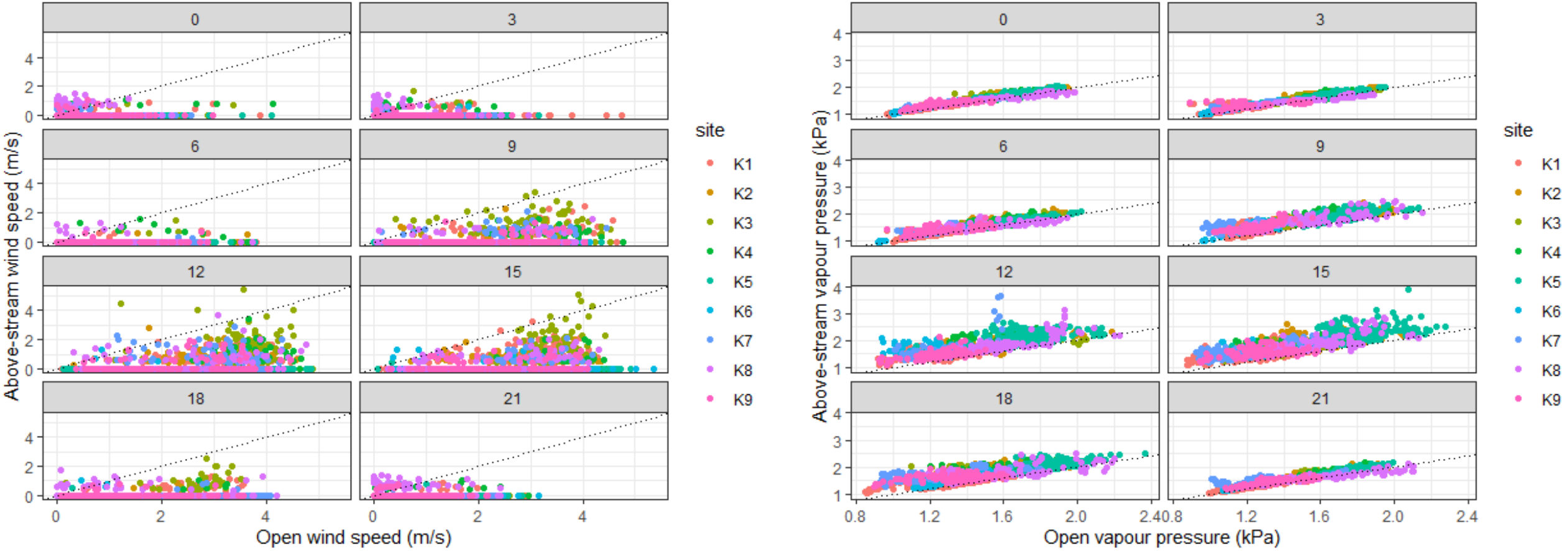


Maximum weekly maximum temperature (MWMT) occurred Aug. 3 to Aug. 10 at T_{w22}.

Met. data collected at open site (top of dam).

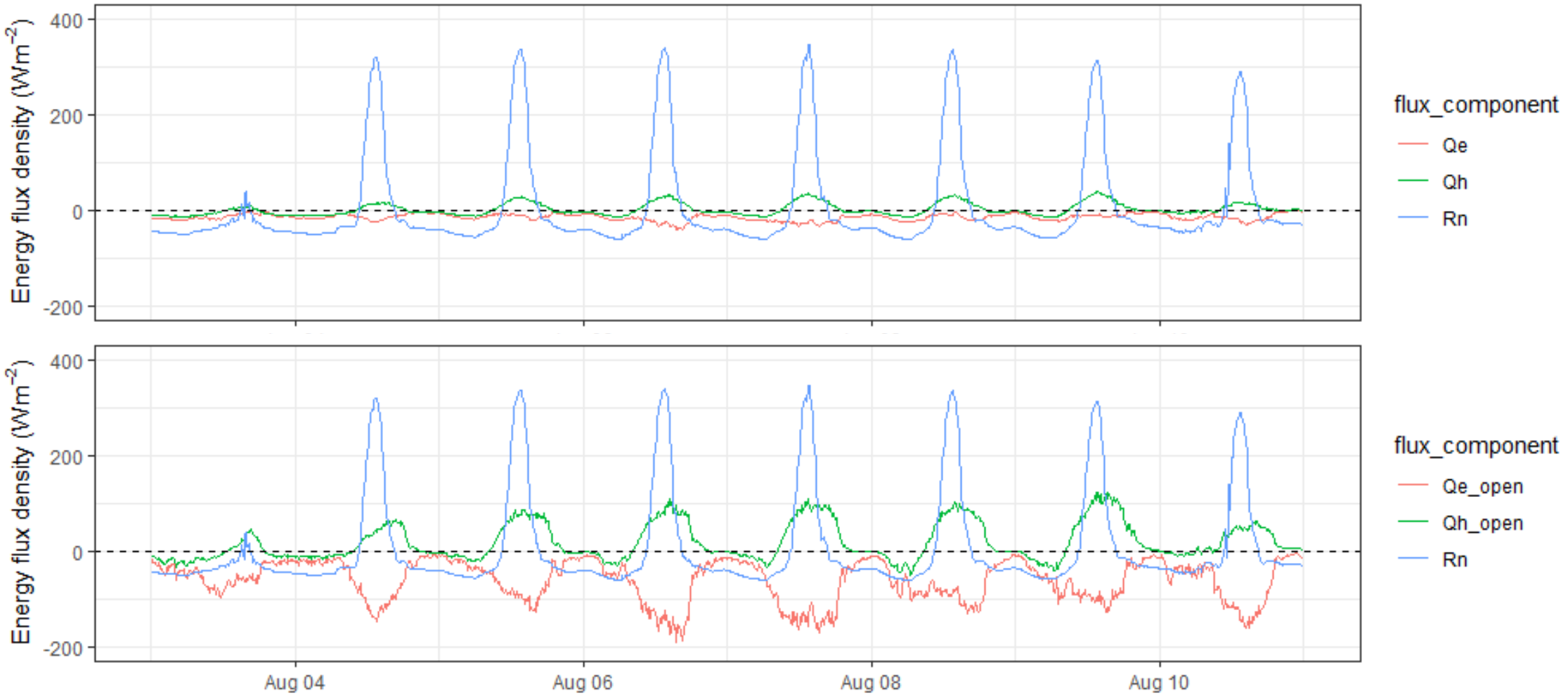
Note semi-diel seiching signal in T_w for most of July and early August.

Above-stream meteorology



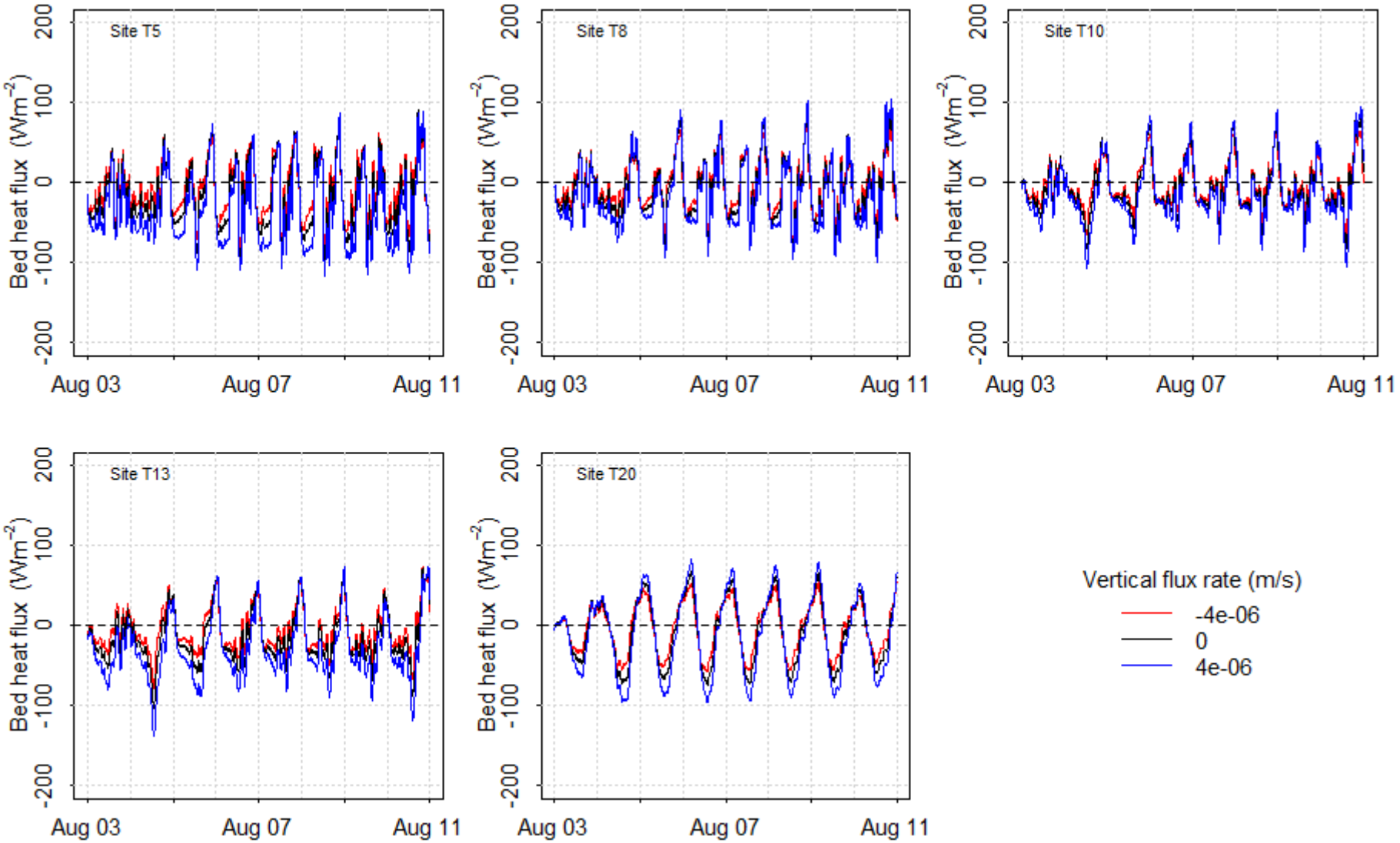
Above-stream conditions at nine sites were generally more calm, more humid and slightly cooler than open-site values, with relations that varied based on hour of day (shown in strip label). Examples for wind speed and vapour pressure are shown above. Vapour pressure was filtered to remove values affected by over-heating during calm conditions.

Site-scale surface energy exchanges – logger T_{w10}



Above-stream net radiation (R_n) was computed from geometric models supported by field surveys and open-site solar radiation. Q_h and Q_e were computed using the Penman wind function; the graphs compare fluxes using adjusted (top) and unadjusted (bottom) meteorological data.

Diagnostic modelling of bed heat flux



Bed heat flux was modelled using field measurements of bed and stream temperature as BCs.

The range of vertical water fluxes was based on field measurements of vertical hydraulic gradients and piezometer slug tests.

These simulations are for a single set of bed thermal properties.