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Comparative study of thermal infrared imaging and fibre-optic distributed temperature sensing for detecting lacustrine groundwater discharge: a mesocosm experiment

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Detecting lacustrine groundwater discharge (LGD) still remains a challenge. The buoyancy of groundwater during winter and early spring can be used for identification of groundwater up-welling related hotspots on surface water by TIR imaging (TIR). TIR has been successfully used to image and fast screen relatively large surface areas of coastal zones, lakes, reservoirs and large rivers for groundwater contributions. Still, quantitative interpretations of groundwater fluxes are hampered by the lack of understanding how the groundwater up-welling signal propagates from the sediment-water interface through the water column to the water-air interface and what perturbations and signal losses occur along this pathway. In the present study, groundwater discharge to a surface water body was simulated in a mesocosm experiment. Under winter conditions water of 14° C to 16°C was discharged at the bottom of a 10x2.8 m mesocosm where surface water varied from 4°C –7.4°C. Four layers (20, 40, 60 and 80 cm above the sediment) of the 81 cm deep mesocosm were equipped with fibre-optic distributed temperature sensing (FO-DTS) for tracing thermal patterns in the mesocosm and TIR imaging was deployed to monitor temperature pattern at the water surface in order to: (1) analyze the propagation of the temperature signal through the water column by FO-DTS and (2) characterize the spatial distribution of groundwater upwelling at the pond surface by FO-DTS and TIR. Different LGD rates were simulated in order to establish the minimum rate of GW upwelling that can be reliably detected at the water surface by TIR imaging. The experiments also allow us to benchmark scale dependencies and adequacy of both methods, FO-DTS and TIR. They also reveal that weather conditions can have important impacts on the detection of LGD at surface water-atmosphere interfaces at larger scales.