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Novel methods for identifying and quantifying hyporheic exchange fluxes using Fibre Bragg Grating sensor arrays

John Arkwright[1], **Eddie W Banks**[1,2], Margaret Shanafield[1,2], and Anthony Papageorgiou[1]
[1]College of Science and Engineering, Flinders University, Adelaide, Australia
[2]National Centre for Groundwater Research and Training, Flinders University, Adelaide, Australia

Most streambed heat tracer studies use vertical, ambient temperature profiles and a 1D analytical solution of the heat diffusion–advection equation to estimate hyporheic exchange fluxes (HEF). This approach has limited capacity in complex flow settings, which has led to the successful development of active heat pulse sensing to investigate the dynamic 3D flow fields in the near subsurface and to quantify HEF. At the scale of the hyporheic zone very small water level fluctuations drive changes in the hydraulic gradients across streambed bedform structures. Generally, hydraulic head gradients are measured with pressure sensors deployed in shallow monitoring wells, but such devices do not have the required vertical spatial resolution and precision to accurately evaluate these processes. New and novel research developed by the biomedical community for in-vivo medical devices can now be used in the geosciences field to measure temperature and pressure at a much higher spatial and temporal resolution to overcome these challenges. As part of this research we have developed a fibre optic, active heat pulse and pressure sensing instrument (formed from Fibre Bragg Grating sensor arrays) to determine small hydraulic gradients in the subsurface and to quantify the exchange fluxes. The instrument was tested in a controlled laboratory environment and in the field. Combining point-scale measurements from this novel instrument with near surface geophysical data and other hydrological observations (i.e. measurements with fibre optic distributed temperature sensing) can be used to upscale some of the key physical exchange processes to the stream reach and river scale.