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Integrating structure-from-motion photogrammetry and process-based river temperature modelling for improved characterisation of riparian shading

Stephen Dugdale (1), David Hannah (1), and Iain Malcolm (2)

(1) School of Geography, Earth and Environmental Sciences, University of Birmingham, Edgbaston, Birmingham, UK, (2) Marine Scotland Science, Freshwater Fisheries Laboratory, Faskally, Pitlochry, UK

Climate change will increase river temperature globally, with potential consequences for cold water-adapted organisms such as salmonids. In regions with reduced forest cover, elevated river temperatures are often associated with a lack of bankside shading. River managers have therefore increasingly adopted riparian tree planting as a strategy for reducing river temperature extremes. However, there is a general lack of information regarding how tree shading and other landscape and environmental controls interact to influence stream temperature heterogeneity. Further research is therefore needed to better understand the context in which riparian planting will produce optimal stream temperature outcomes. In order to fill this knowledge gap, researchers have increasingly used river temperature models to gain detailed insights into the key controls on river temperature. Many process-based models are capable of simulating the impact of riparian tree cover on radiative fluxes and are therefore well-suited for elucidating the impacts of tree shading on stream temperature. However, data on riparian tree heights necessary to parameterise such models can often be difficult to obtain, especially in remote or data-poor regions. There is therefore a need to develop simple, cost-effective methodologies for the provision of riparian tree height inputs to stream temperature models.

In this paper, we document a novel methodology using structure-from-motion (SfM) photogrammetry to simulate the effects of tree shading on river temperature within a process-based model. SfM was applied to imagery acquired from a small unmanned aerial system (sUAS) and used to map riparian tree heights in Glen Girnock, an upland catchment draining into the Aberdeenshire Dee, Scotland. This data was subsequently used to parametrise a process-based stream temperature model of a 2.1 km reach of the Girnock Burn. Initial results show that SfM is able to approximate true riparian tree heights with a good degree of accuracy ($R2 = 0.91$). Temperature predictions from the model incorporating these SfM-derived tree heights are considerably better (RMSE $\approx$ 0.6 – 0.8) than a ‘null’ tree heights model (RMSE $\approx$ 1.1 – 1.8). Our findings reveal that SfM is an effective tool for characterising riparian shading and highlight the utility of sUAS for improving river temperature modelling efforts. It is hoped that the results of this study will contribute to improvements in riparian tree planting strategies with a view to improving the resilience of river ecosystems threatened by climate change.