Geophysical Research Abstracts
Vol. 14, EGU2012-11257, 2012
EGU General Assembly 2012

Inter-annual variability of stream temperature, micro-climate and heat exchange dynamics: a comparison of forest and moorland environments

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Riparian woodland is recognised as important in moderating stream temperature variability and offers potential to mitigate thermal extremes under a warming climate. Previous research on the heat exchanges determining water column temperature has been often short-term, or seasonally-constrained, with the few long term year-round studies limited to a maximum of two years. This paper addresses these research gaps by comparing inter-annual variability in stream temperature, micro-climate and heat exchange dynamics between stream reaches of contrasting riparian landuse. Automatic weather stations (AWS) were installed in semi-natural woodland and moorland (no trees) reaches of the Girnock Burn, an upland tributary of the Aberdeenshire Dee. Data were collected across all seasons over seven calendar years. This research yields, for the first time, a long-term perspective on temporal differences in river heat exchange processes associated with riparian landuse under a range of hydroclimatological conditions. Results indicate that the presence of a riparian canopy has a persistent effect year-to-year in reducing mean and maximum daily water column temperature under a variety of hydrological and meteorological conditions. Woodland and moorland reaches display similar inter-annual variability in daily water column temperature range during spring and early summer, but in mid-summer and autumn woodland inter-annual variability is reduced greatly compared with moorland. Higher inter-annual variability (indicated by standard deviations) in spring and early summer water temperature ranges at both sites are attributed to increasing day length and solar radiation receipt, which a developing forest canopy at the woodland site is not able to mitigate. Once the full riparian canopy, hence maximum shading potential, is established (mid-summer) inter-annual variability in woodland temperature range is reduced greatly. The magnitude of woodland water temperature range is greater in spring and early summer than mid-summer and autumn, which causes the annual cycle of temperature range to have a peak skewed persistently towards spring; to our knowledge this has not been shown in the existing literature. This research provides new understanding of the year-to-year variability in riparian forest canopy effects that moderate stream temperature under varying hydroclimatological conditions and so yields a more robust process basis for modelling impact of changes in forest practice on river thermal dynamics.