Geophysical Research Abstracts
Vol. 14, EGU2012-13432, 2012
EGU General Assembly 2012

Sub-seasonal river heat flux partitioning in an alpine, glacierized basin

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In the alpine zone climate-cryosphere interactions are particularly important as seasonal dynamics in snow- and glacier-melt regulate river flow and stream water temperature. Shifts in the timing, magnitude and duration of meltwater production are predicted in response to a warming climate, which has potential to alter thermal regimes of glacier fed rivers. Current knowledge of the deterministic processes controlling alpine stream temperature dynamics is very limited. To address the research gap, this paper aims to undertake detailed hydro-meteorological investigation of the energy budget processes driving water column thermal dynamics from a glacier fed stream in the French Pyrenees over two summer melt seasons.

During both summers, the heat budget was strongly positive with the majority of energy exchanged at the air - water interface. On average, net radiation was the largest heat source ($\sim$80% of total flux). Sensible heat transfer, latent heat and fluid friction were also significant heat sources. However, the latent heat flux displayed the most inter-annual variability; during 2010 (2011) it contributed to 5.2% (0.03%) of the total heat budget. This was due to windier, dryer conditions prevailing in 2011 which balanced out early season condensation gains with evaporative losses. Energy exchanges at the channel - river bed interface comprised <1% of the heat budget. However, >20% of all energy losses occurred at this interface, only latent heat transfer contributed more to total energy loss.

Daily total energy fluxes were analysed to characterise sub-seasonal dynamics. Small declines in net radiation receipt and total energy available to the water column were observed as the melt season progressed. While both the sensible heat flux and bed heat flux displayed no clear patterns. Interestingly latent heat was an energy balance component in terms of heat gains and losses, showing a seasonal shift from source to sink over the melt season. This shift was driven by the retreating snowline which created changes in the thermal and humidity gradients at the air-water interface.

These findings highlight the importance of considering a meltwater generation component in future heat budget models and suggests that exchanges at the river bed could be neglected when applying such models to alpine river basins.