Methods of modeling the energy fluxes of low land rivers including the shading effect of river geometry and riparian vegetation

Heidelinde Trimmel[1], Philipp Weihs[1], Herbert Formayer[1] Gerda Holzapfel[2], Hans Peter Rauch[2], Florian Dossi[3], Wolfram Graf[3], Patrick Leitner[3], Andreas Melcher[3]

University of Natural Resources and Life Science, 1190 Vienna, Austria:
[1] Institute of Meteorology,
[2] Institute of Soil Bioengineering and Landscape Construction
[3] Institute of Hydrobiology and Aquatic Ecosystem Management

University of Natural Resources and Applied Life Sciences, Vienna
Department of Water, Atmosphere and Environment
Institute of Meteorology (BOKU-Met)

powered by klima+ energie fonds

The poster presents the preliminary results from the ACRP project: „Potential of riparian vegetation to mitigate effects of climate change on biological assemblages of small and medium sized running waters" (BIO-CLIC) 04/2012 – 03/2015

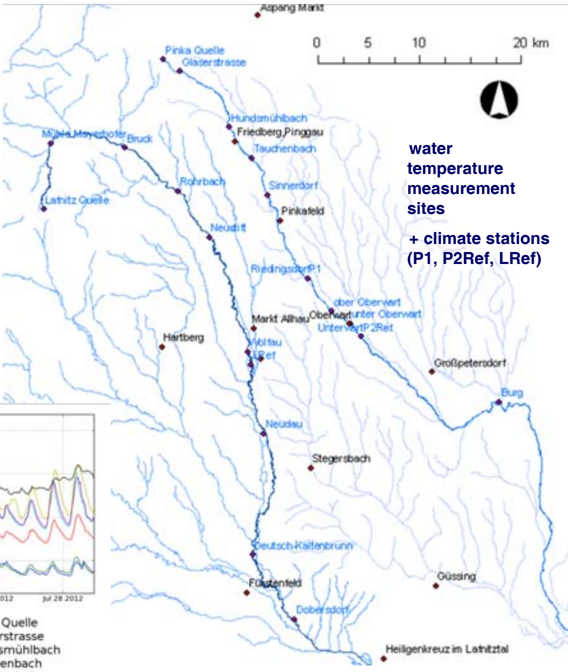
Introduction:

Low land rivers are especially vulnerable to climate change effects because of their low water current, high aquatic surface area in relation to water-depth and their reduced shading by riparian vegetation caused by high river width. The water temperature regime can surpass critical values under future climate scenarios and therefore cause a significant change in the habitat quality and availability for various benthic invertebrates and fish species.

Riparian areas with vegetation can provide direct shading of water bodies and thus can contribute to avoid the corresponding increase of water temperature. Riparian vegetation may decrease evaporation and increase the relative air humidity, which contributes to reduced water temperature but large woody debris also helps to provide very important niches for terrestrial and aquatic stages of riverine organisms.

The project BIO-CLIC focuses on the potential of riparian vegetation to mitigate effects of climate change on biological assemblages of small and medium sized running waters namely the Lafnitz and Pinka. The course of the two rivers is 100km (Pinka) and 113km(Lafnitz) from their source to their mouth into the river Raab.

Five workgroups are involved (Vegetation, Benthos, Fish, Radiation, Climate). This poster presents the aspect of Workgroup Radiation.



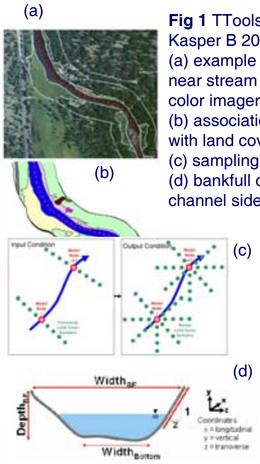


Fig 1 TTools input (Boyd M and Kasper B 2002):
(a) example of polygon mapping of near stream land cover from aerial color imagery
(b) association land cover polygons with land cover types
(c) sampling of land cover
(d) bankfull channel geometry – channel side slope 'z'

geodata input:
*river center
*left and right bank lines
*DEM
*riparian vegetation distribution (height, density, overhang)

TTools

> aspect and gradient of river
> 3d position of shading elements
(vegetation densities and topography)

1)morphology data of zones:
*bottom width
*channel angle
*Mannings n
*substrate information
(horizontal bed conductivity, bed particle size)

2)Tools results

3)hourly data at nodes:
*global radiation
*air temperature
*air humidity
*windspeed
*water temperature
*river discharge

HeatSource

>effective shade, sky openness along the river
>total heat flux (solar and long wave radiation, evaporation, convection, soil heat flux in river bed)
>water temperature along the river

Fig 2 Overview of the TTools – HeatSource Workflow

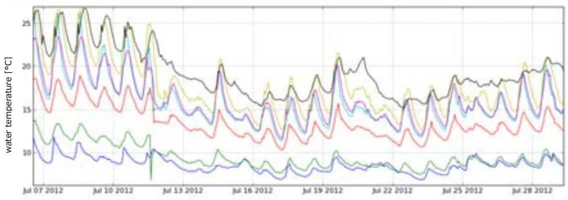


Fig 3 Water temperature [°C] **from the source** of the river Pinka (16) **to the lower course** village Burg (25) during July 2012

Methods

Measurements + Data Collection

Along the river continuous measurements of global radiation, air temperature, air humidity, wind and water temperature are performed which together with flow measurement data from longtime local stations, will be used as input data for the simulation.

The vegetation along the river will be classified in different zones of fixed vegetation height, density and overhang. Using this input and a digital elevation model (DEM) of the surrounding terrain the reduced sky view influencing the river surface can be sampled (Fig 1).

Additionally information about the river width, slope angle and substrate distribution along the river is collected.

Modelling

Using all gathered data the water temperature and energy fluxes along the river using the GIS based program TTools (Boyd M and Kasper B 2002) and the model HeatSource (Analytical methods for dynamic open channel heat and mass transfer: Methodology for heat source model Version 7.0, Boyd M and Kasper B 2003) are calculated (Fig 1 + 2).

First measurement results

The measurements of the first year show a strong longitudinal differentiation in water temperature (Fig 3 + 4) which are strongly influenced by the distance of the source to the mouth but also there are changes which are caused by the changing riparian influence.

In Fig 5 four consecutive water temperature measurements along the Lafnitz are shown. According to aerial photographs the sections between them seem to differ in vegetation and topographic shade, which will be further analyzed by the group Vegetation.

Between site I and II (7km) there is only a low shading level which results in +0.58° mean water temperature in August 2012.

Between site II and III (35km) there is more riparian vegetation. There is a warming +1.04°C due to the long distance, but the extremes are reduced, the standard deviation reduced from 1 to 0.36. Between site III and IV (27km) again the river is more exposed to solar radiation. The mean water temperature increases + 0.96°C and also the standard deviation increases again up to 0.59.

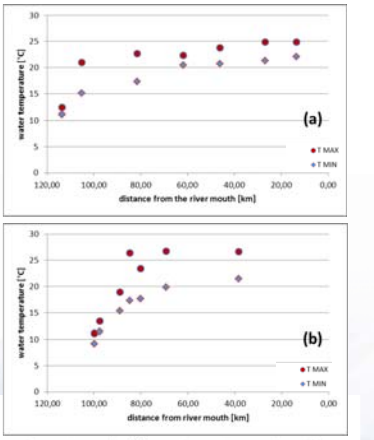


Fig 4 **minimum and maximum** water temperature [°C] on the river Lafnitz (a) and Pinka (b) **according to their distance from the river mouth** measured on the 8th of July 2012.

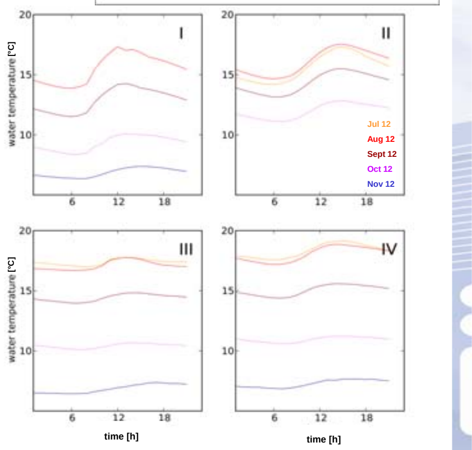


Fig 5 mean diurnal cycles at 4 different sites downstream the Lafnitz (I:Rohrbach, II: Neustift, III: Neudau, IV:Deutsch-Kaltenbrunn) for July to November 2012

University of Natural Resources and Applied Life Sciences, Vienna, Department of Water, Atmosphere and Environment, Institute of Meteorology
Peter Jordan Strasse 82, A-1190 Vienna, Austria, Tel.: +43 699 1130 1873, email: heidelinde.trimmel@boku.ac.at