River-aquifer relationship at the Maggia

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1 Introduction

The river-aquifer connection in braided gravel bed rivers is strong and the p*hreatophytes* on the river bar*,* which take up most of the water from the capillary fringe right above the groundwater table, are likely to be influenced by the river-aquifer dynamics. The connection between river and aquifer is dependent on the properties of the riverbed, which usually acts as retarding layer of stream stage variations. Being exposed to the erosion/deposition processes, the riverbed properties are expected to show signs of transience.

This work aims to clarify

1) the presence, magnitude and potential variability of the semi-impervious riverbed, and
2) the role of groundwater table as a predictor for stomatal conductance of phreatophytes positioned on the river bar

in the river Maggia in Moghegno.

2 Method overview

The effect of the semi-impervious riverbed was first estimated with a numerical model that uses the convolution theorem to calibrate the retardation-factor *a* of the semi-impervious riverbed as a function of the river stage and an analytical response-function, which depends on the retardation factor *a*.

$$h_{gw}(x,t) = \int_0^t \frac{dH_r(t)}{dt} \cdot h_{resp}(x,a,t-\tau)d\tau$$

$$a = \frac{K_{aquifer} \cdot d_{riverbed}}{K_{riverbed}} [m]$$

K denotes the hydraulic conductivity and *d* the thickness.

In a second approach, the first 30 hours of recession after floods in the river and the groundwater were analyzed and compared. The recession rates were estimated by fitting an exponential decay to the respective stages by use of equations in figure 3.

The stomatal conductance measurements were compared to the current local and regional meteorological variables and to the current groundwater level.

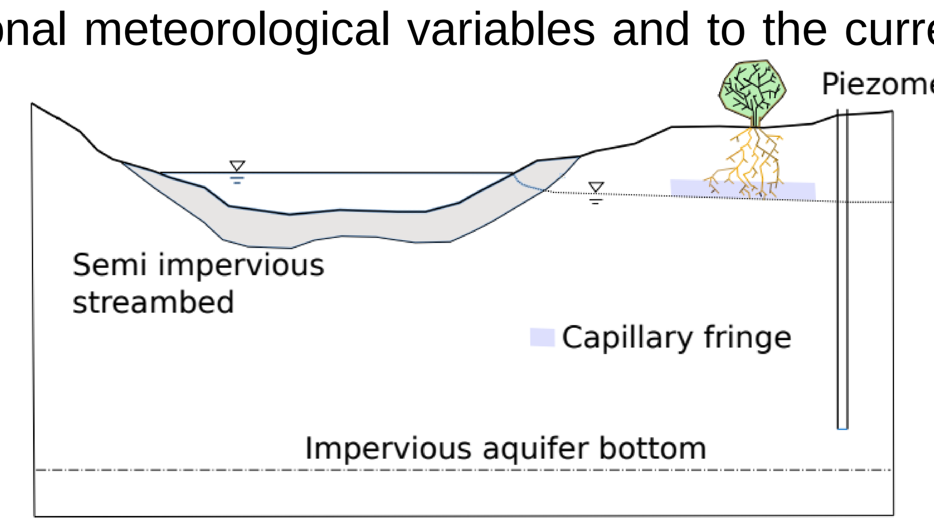

Fig. 1. Conceptual sketch of the river-aquifer relationship at the Maggia. On one hand, the groundwater level is influenced by the river and the properties of the semi-impervious riverbed. On the other hand, the water uptake of the phreatophytes occurs mostly in the capillary fringe, which lies directly above the variable groundwater table.

3 Materials and Data

Parameter	Measured/ Modeled	Period	Measurement-device/ Data origin
Temperature *T* [°C]	Measured	Summer 2019	*Sensirion* SHT31
Relative humidity *RH* [-]	Measured	Summer 2019	*Sensirion* SHT31
Stomatal cond. g_s [mmol H_2O m^{-2} s^{-1}]	Measured	Summer 2019	*Meter* SC-1 Leaf Porometer
Groundwater stage H_{gw} [m]	Measured	2001-2006, 2018-2019	unknown pressure tube *Keller* DCX-22
River stage H_r [m]	Modeled, Measured	2001-2006, 2018- 2019	BASEMENT software, *Keller* DCX-22

Tab. 1. Data origin and period. Measurements in summer 2019 were done periodically. The modeled H_r is based on measurements in Lodano 3.3 km upstream of Moghegno. *T* and *RH* were used to calculate vapor pressure deficit (*vpd*).

Fig. 2. Measurement of stomatal conductance of a leaf of *salix eleagnos* on the riverbank in Moghegno. Per plant (3 *salix eleagnos,* 1 *populus nigra,* 1 *alnus incana*) 5 leafs were marked and measured on 10 days between July and October 2019.

4 Results and discussion

Streambed retardation and recession rates

The calibration of the *a*-factor can be differentiated in two situations.

1) *a* = 0 [m], when the river stage shows major fluctuations and a strong groundwater response occurs. In this case, the semi-impervious riverbed is not existent ($d_{riverbed}$ = 0).
2) *a* >> 0 [m], when there is low flow with minimal river stage fluctuations and the groundwater response is numerically not captured by the model.

The recession rates after floods in the river and the groundwater showed a relationship, which indicates that the connection between river and aquifer is indeed very high.

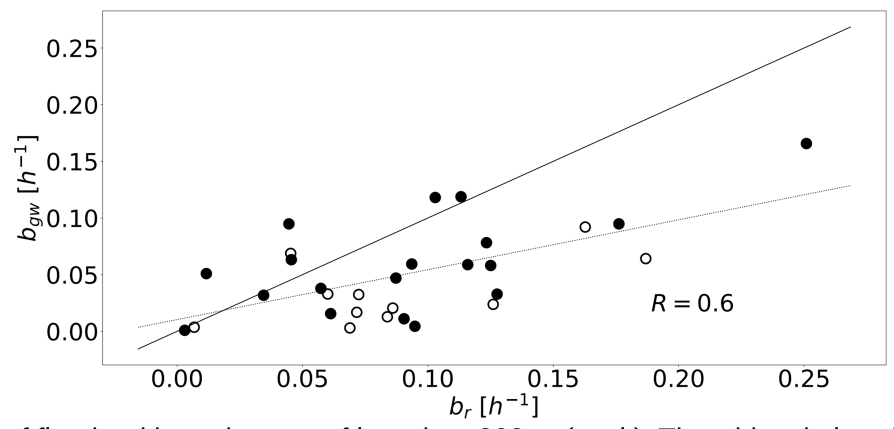

Fig. 3. Recession rates of floods with peak stage of less than 308 m (a.s.l.). The white circles show floods whose previous flood had a peak stage greater than 308 m (a.s.l). The occurrence of a previous larger flood leads to on average slower recession rate in the groundwater. This is a consequence of more water infiltrating into the aquifer due to the increased hydraulic conductivity of the riverbed which is caused by eroding force of the previous flood.
A stage of 308 m (a.s.l.) corresponds to a flood with a return period of roughly 1 year.

Stomatal conductance

The g_s measurements confirmed the sensitivity of the stomatal opening towards vapor pressure deficit. However, the relationship between g_s and *vpd* is influenced by H_{gw}, as can be seen in figure 4.

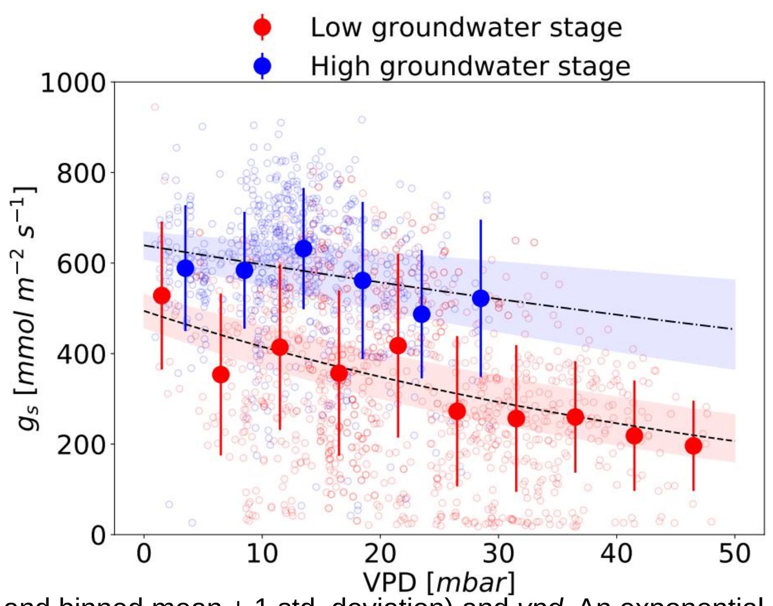

Fig. 4. g_s measurements (raw data and binned mean ± 1 std. deviation) and *vpd*. An exponential decay model was fit to the data. The 95%-confidence intervals do not overlap, which undermines the difference in plant transpiration between high and low H_{gw}.

5 Conclusion

In particular, our analysis showed the following:

1) The riverbed of the Maggia allows a strong interaction between river and aquifer. Conceptually, this means that the *a*-factor is low.
2) The numerical model is not able to detect potential transience of the riverbed properties. The analysis of the recession rates, however, suggests a decrease of the *a*-factor after bigger floods due to erosion of the fine sediments that "clog" the riverbed.
3) The measurements of g_s gathered field evidence of the role of H_{gw} in the plant's control of the stomatal opening. At low H_{gw} situations, the relationship between g_s and meteorological parameters is different compared to high H_{gw} situations. Transpiration is therefore dependent on H_{gw}, which in turn depends on H_r and the *a*-factor.

6 References

1. Guillaume Gianni et al., Rapid identication of transience in streambed conductance by inversion of floodwave responses. Water Resources Research, 2016.
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