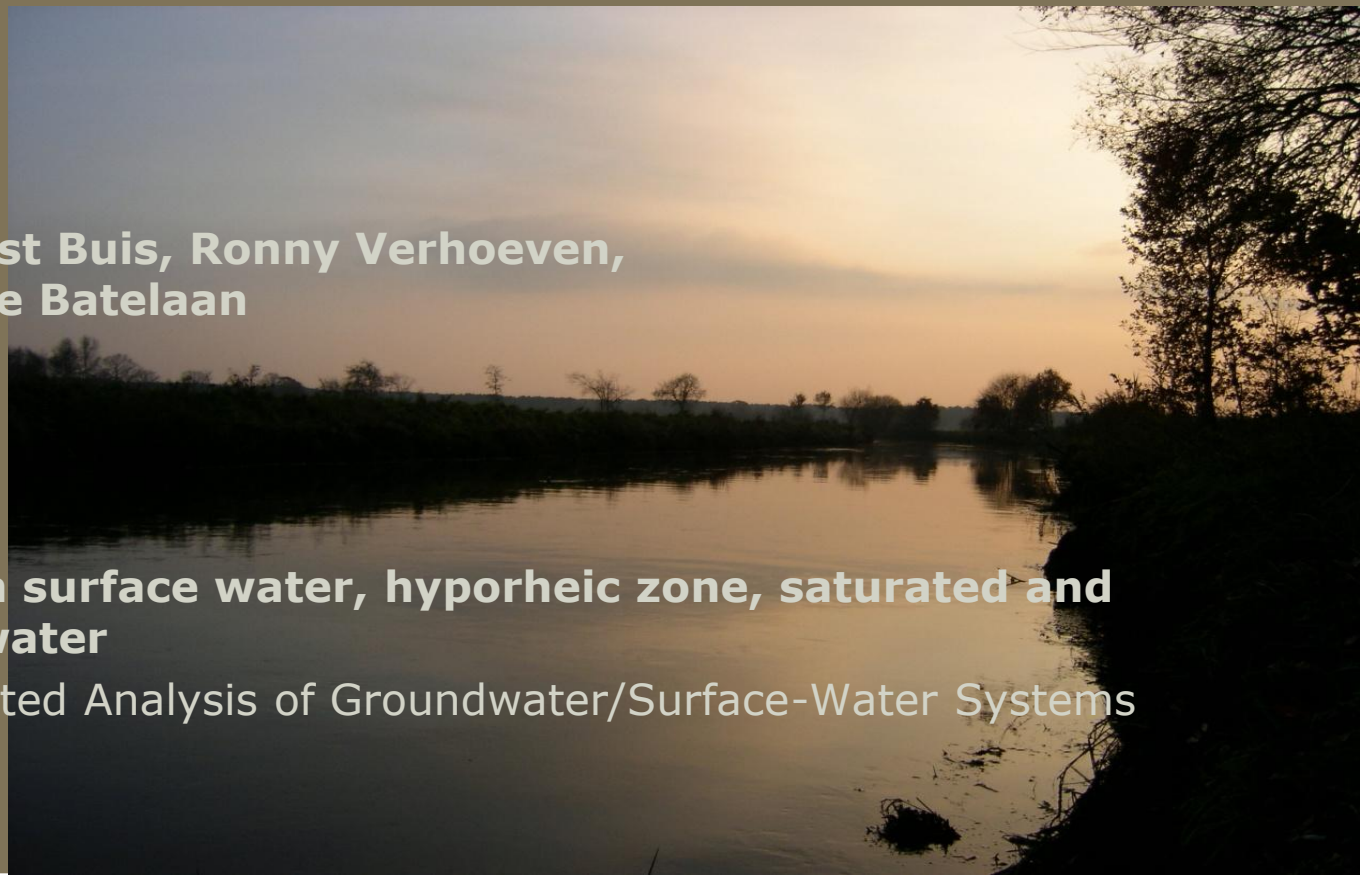
Groundwater-surface water interaction on a reach scale using a transient thermal mapping approach



Christian Anibas, Kerst Buis, Ronny Verhoeven, Patrik Meire and Okke Batelaan

HydroEco 2011
Vienna, Austria

Interactions between surface water, hyporheic zone, saturated and unsaturated groundwater
A New Focus on integrated Analysis of Groundwater/Surface-Water Systems

02.05.2011

FWO VLAANDEREN
Fonds Wetenschappelijk Onderzoek
Research Foundation – Flanders

G.0306.04

Vrije Universiteit Brussel

Goals & Motivation

Goals

- Estimation of GW-SW exchange on a local and reach scale
- Applying a numerical transient heat transport model

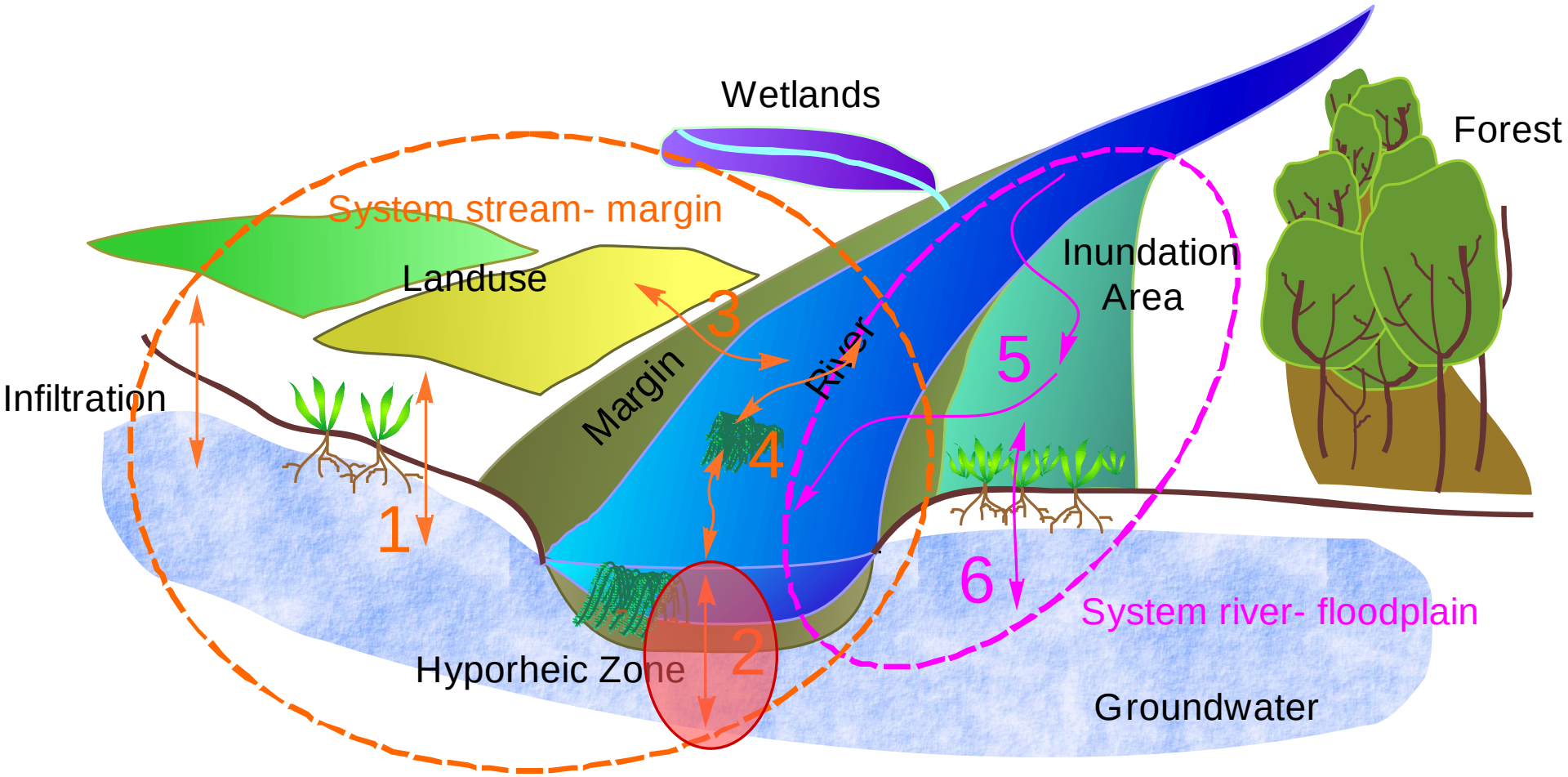
Hypothesis

- Temporal resolution
- Using all available thermal data
- Quality of fit

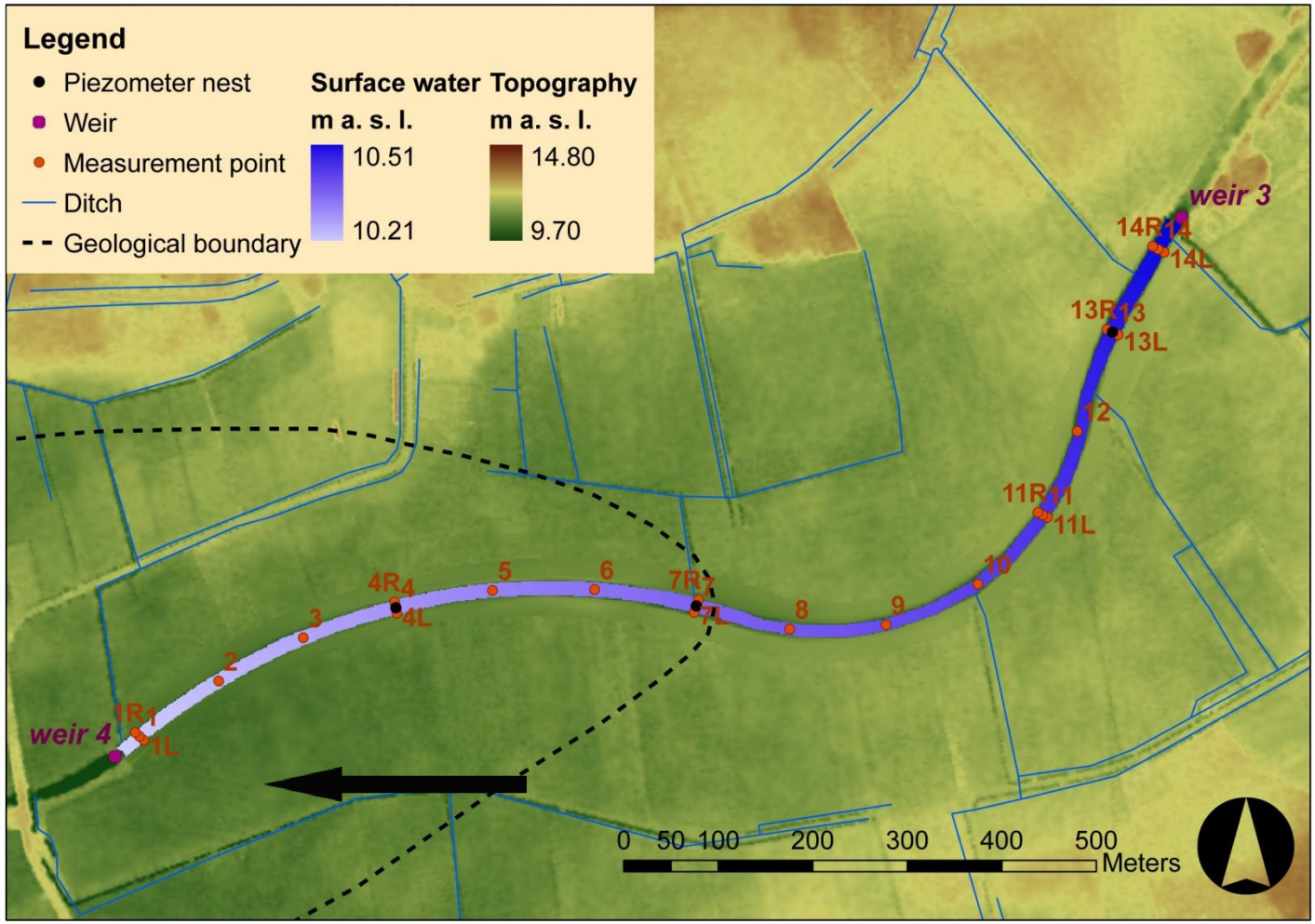
Aa River, Belgium

- Modified river channel
- Length: 1425 m
- Average depth: 1.1 m
- Average width: 14.0 m
- Average discharge: 1.9 m^3/s
- Inclination: 0.5 ‰
- Riverbed: fine sand
- Aquifer: sand, sand- loam 80 m thickness

Exchange processes in river ecosystems



Measurements



'T-stick' measurements

32 measurement points

14 longitudinal points

6 transects

Bimonthly measurement campaigns

Relevance of Temperature

Hydrology

- Flux estimates
- Hydraulic conductivity
- Energy balances
- Heat pumps
- Geothermal resources

Ecology

- Growth and decay rates
- Reaction rates
- Extent and composition of active zones
- Effects of climate change

Transport of water and heat

Advection

$$k\frac{\partial^2 T}{\partial z^2} - v_z c_w \rho_w \frac{\partial T}{\partial z} = c\rho\frac{\partial T}{\partial t}$$

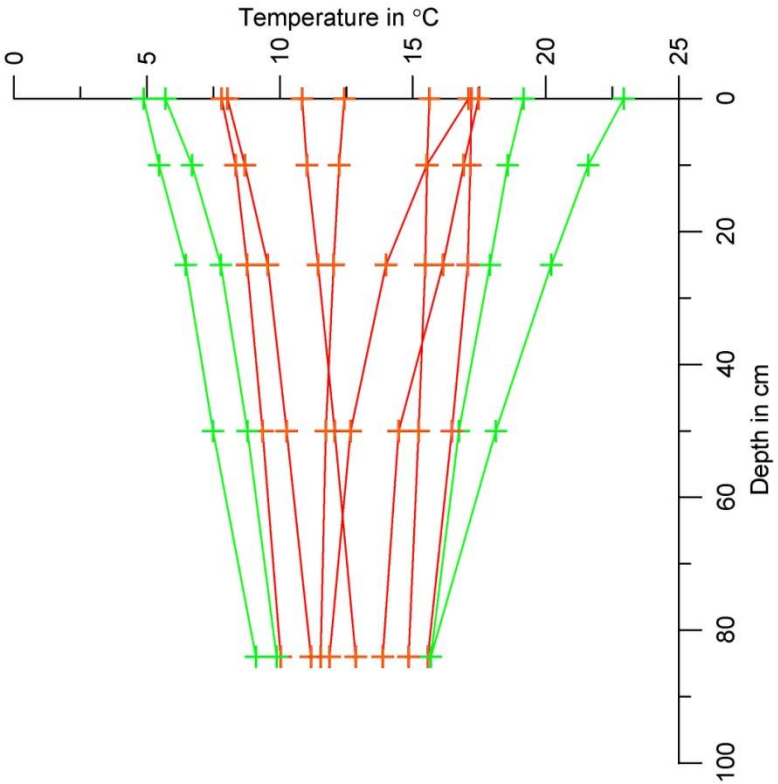
Conduction

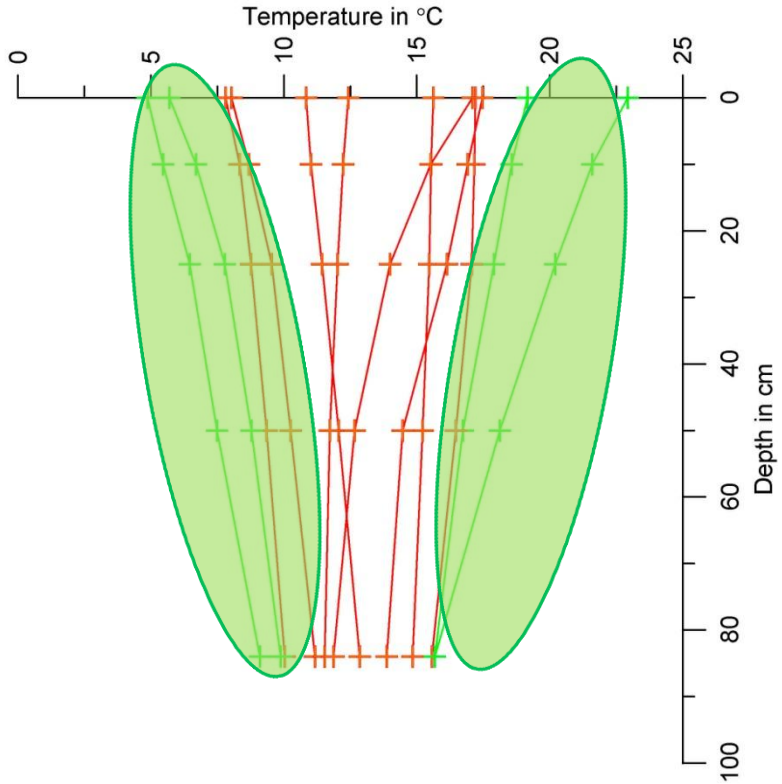
Steady state: $\frac{\partial T}{\partial t} = 0$

k: Thermal conductivity;
T: Temperature;
c: Specific heat capacity;
ρ: Density;
v_z: Vertical flux;

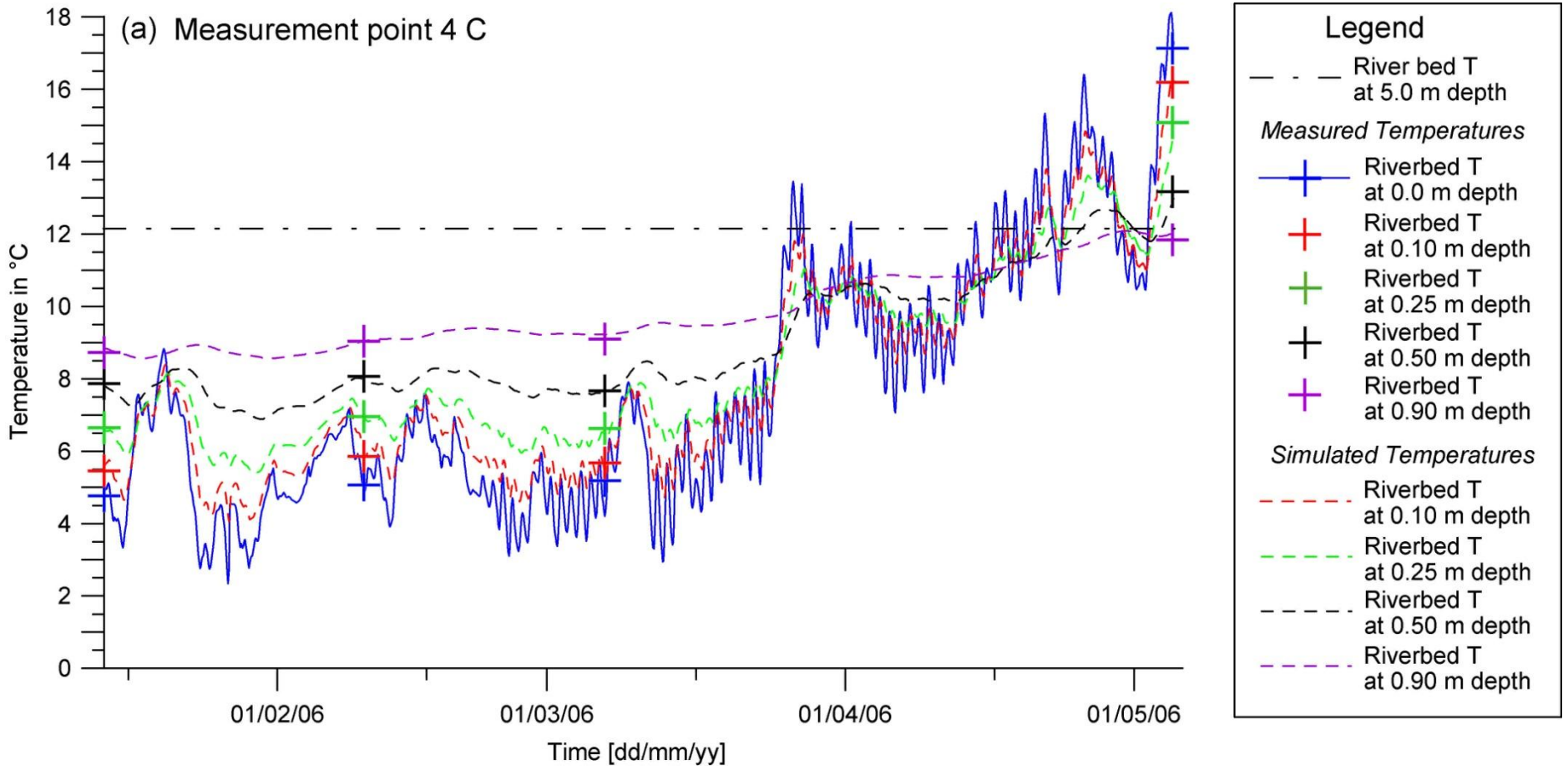
(Suzuki, 1960; Stallmann, 1965)

Heat transport model

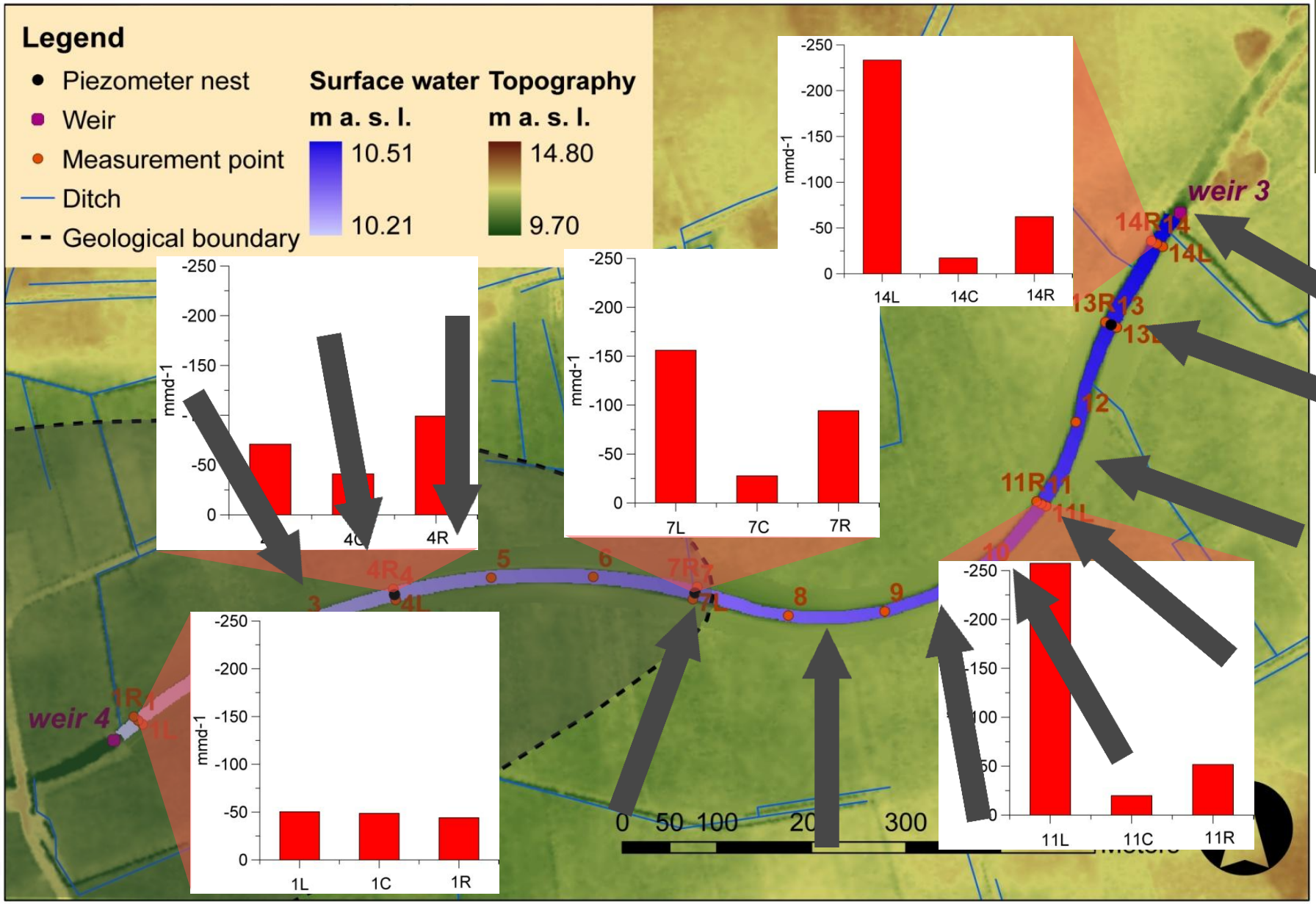




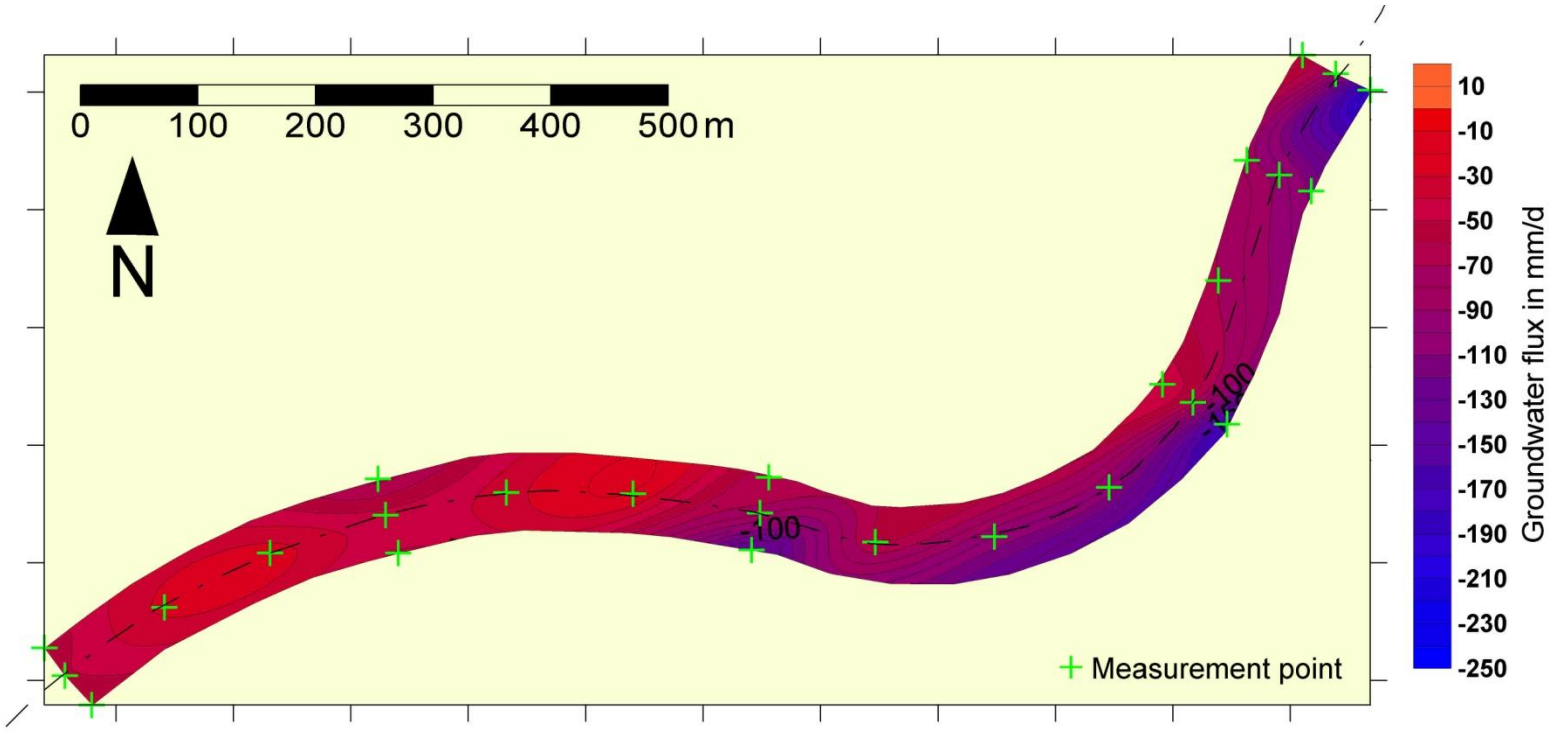
Transient thermal model



Christian Anibas
canibas@vub.ac.be


Legend
Piezometer nest
Weir
Measurement point
Ditch
Geological boundary
Surface water
m a. s. l.
10.51
10.21
Topography
m a. s. l.
14.80
9.70
weir 3
weir 4
14R
14
14L
13R
13
13L
12
11R
11
11L
10
9
8
7R
7
7L
6
5
4R
4
4L
3
1R
1
1L
mmd-1
-250
-200
-150
-100
-50
0
14L
14C
14R
7L
7C
7R
4C
4R
1L
1C
1R
11L
11C
11R
0
50
100
200
300

Results

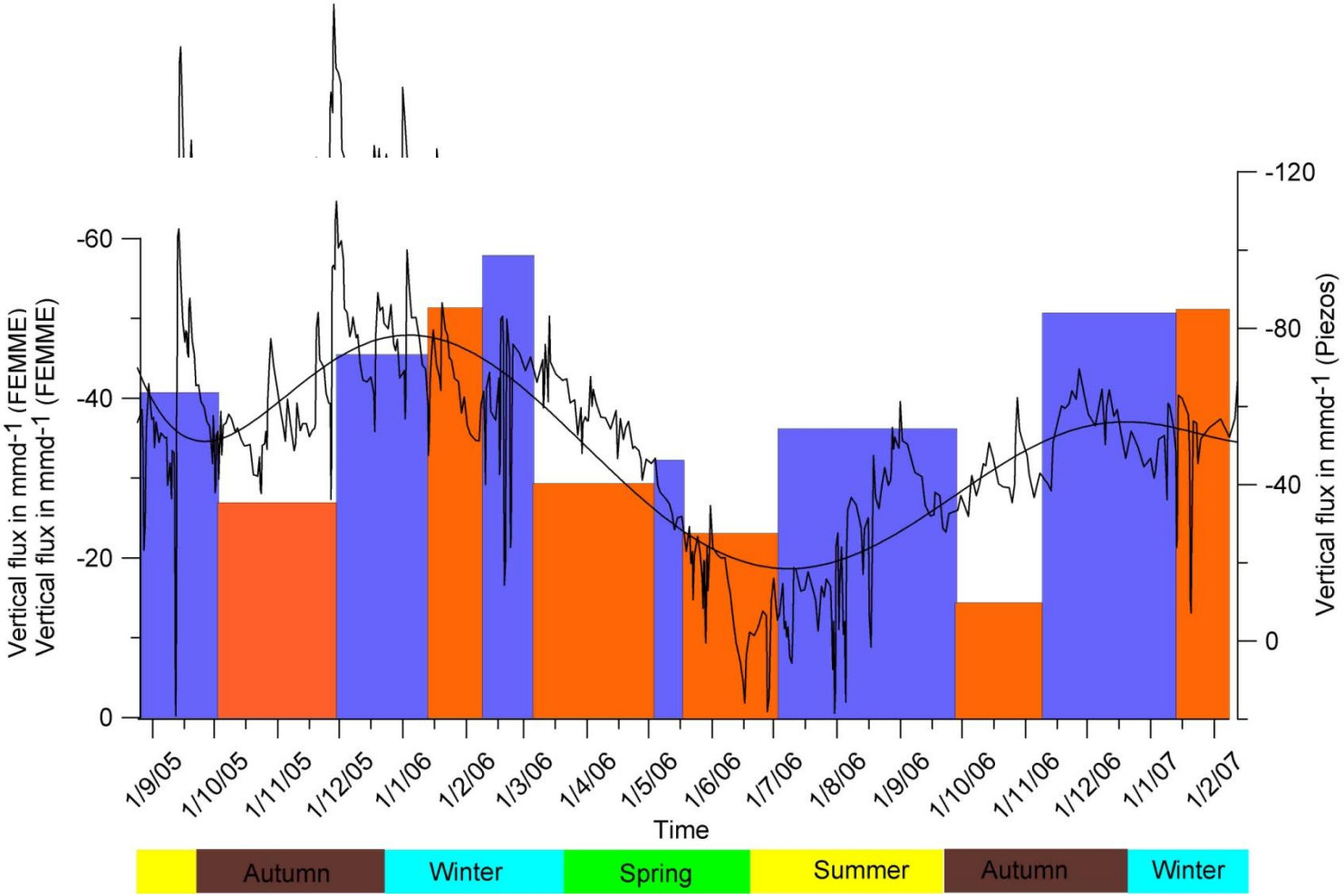


Interpolation – Reach scale

- 26.08.2005-10.02.2006: v_z=-65 mmd^{-1}
- 09.09.2006-09.02.2007: v_z=-60 mmd^{-1}

Results

Temporal Resolution



Christian Anibas
canibas@vub.ac.be

Conclusions

- Interpretation on floodplain or sub catchment scale
  - Topography
  - Geology
  - Morphology
  - Bathymetry
- Combination of field methods
- Multidisciplinary approach
- Complementary for groundwater models

Future research

- Collection of long term data sets
- Concentration on specific field locations
- Modified field instrumentation
- New modeling tools
- 2D Models