Real-time ecohydrology

Vienna, 16 April 2015

Klement Tockner

Walter Bertoldi, Cliff Dahm, Stefan Krause, Jörg Lewandowski

www.igb-berlin.de
Real-time meteorology (e.g., radar)

Fotos: E. MASTELLER
30 miles long Hexagenia swarm at Lake Erie (time intervals: 4 min)

Fotos: E. MASTELLER

Research for the future of our freshwaters
Causes for resource pulses
(cf Young et al. 2008. Ecology)

- Climatic and environmental causes
- Temporal accumulation and release
- Spatial accumulation and release
- Outbreak population dynamics

(Tisza River: *Palingenia longicauda*

(Photo: C. Elpers)
A 3-D perspective of river corridors: Conceptual model of the airscape along a river corridor

Primary air flow:
- down valley (cold)
- up valley (warm)

Secondary flow:
- up slope (warm)
- down slope (cold)

Unidirectional primary flows can be formed by diurnal meteorological cycles.

Micro-structure of air flow:
effects of complex roughness distribution (water, sediments, vegetation)

Complex internal boundary layers, wakes, and mixing layers.
Quantifying air-plankton: Using a combination of radar, lidar, and microwave-radiometer

(6 August 2014; source: TROPOS, Leipzig)
The future:

Interactive robots in experimental biology
(Krause et al. 2012. TREE)
Temporary streams: Pulsed systems

(Photos: Alisha Steward, Brisbane)
Temporary streams: Pulsed systems

(From: Steward et al. 2011. Aquatic Sciences, 2012. FEE)
## Tagliamento: Release of material during (minor) first flush event

<table>
<thead>
<tr>
<th>Variable</th>
<th>Base Flow (n = 8)</th>
<th>Water Front (n = 4)</th>
</tr>
</thead>
<tbody>
<tr>
<td>SS (mg/l)</td>
<td>1.43 ± 1.19</td>
<td>4053 ± 1193</td>
</tr>
<tr>
<td>PP (µg/l)</td>
<td>5 ± 3</td>
<td>570 ± 111</td>
</tr>
<tr>
<td>TDP (µg/l)</td>
<td>11 ± 7</td>
<td>121 ± 209</td>
</tr>
<tr>
<td>DOC (mg/l)</td>
<td>1.2 ± 0.3</td>
<td>3.9 ± 1.2</td>
</tr>
<tr>
<td>POC (mg/l)</td>
<td>0.3 ± 0.1</td>
<td>77.7 ± 6.7</td>
</tr>
<tr>
<td>DOC/POC</td>
<td>4.3 ± 1.7</td>
<td>0.1 ± 0.0</td>
</tr>
<tr>
<td>NO$_3$-N (mg/l)</td>
<td>0.7 ± 0.0</td>
<td>2.1 ± 1.5</td>
</tr>
<tr>
<td>DON (mg/l)</td>
<td>0.2 ± 0.1</td>
<td>0.3 ± 0.2</td>
</tr>
</tbody>
</table>

(From: Larned et al. 2010. Freshwater Biology)
Las Conchas Fire – New Mexico (NM) 2011

• Was largest recorded NM fire
• High intensity forest fire

(New Mexico EPSCor)
Dissolved oxygen sags on the Rio Grande
(550 Bridge – August 16-22, 2011; discharge at Alameda & Central)

Dissolved Oxygen at Bernalillo Site and Rio Grande Discharge at USGS Alameda and Albuquerque Gages, 16 - 22 August 2011

NEW MEXICO EPSCOR
Lake Döllnsee (25 ha, max depth: 7.8 m)

3D-telemetry to trace fish in real time
(IGB, Department Biology & Ecology of Fishes)
One individual carp: Movement patterns during a 24 h cycle (From: C. Monk, IGB)
Integration high-temporal with high-spatial resolution data

Remote sensing

- deliver data of large areas in high spatial resolution,
- can help upscaling of local small-scale information,
- are faster than ground based technologies and
- allow measurements during time spans when remote areas are not accessible

(Photos: Terreno & Jörg Lewandowski)
Study site: Lake Arendsee

- Max. depth 49 m, mean depth 29 m, surface area 5.13 km$^2$
- Highly eutrophic (total phosphorus approx. 200 µg P L$^{-1}$)
- Located in north-eastern Germany

Airborne thermal infrared (TIR) measurements

- TIR data collected on 22 March 2012 from 10:59 to 11:03 h
- Airborne mission with a Cessna 207T
- TIR camera VarioCam HR, head 600, 640 x 480 pixels, f 30 mm
- Installed on a stabilized platform GSM 3000 together with an inertial navigation system (IGI Aerocontrol)
- Very low lens distortion and the stabilized platform made it possible to mosaic the data rapidly with a common imaging program (Gimp)
Airborne thermal infrared (TIR) to detect LGD

(LGD = lacustrine groundwater discharge)

Determination of groundwater-borne phosphorus loads

Usually separate determination of seepage volume and nutrient concentration in the approaching groundwater (multiplication)

- **Groundwater observation well**
- **Near-surface piezometers**
- **Private groundwater extraction well**

**Phosphorus concentration**
- 0 - 100 μg l⁻¹
- 100 - 200 μg l⁻¹
- 200 - 500 μg l⁻¹
- 500 - 1000 μg l⁻¹
- > 1000 μg l⁻¹

**Groundwater exfiltration rate**
- 0 - 20 l m⁻² d⁻¹
- 20 - 40 l m⁻² d⁻¹
- 40 - 60 l m⁻² d⁻¹
- 60 - 80 l m⁻² d⁻¹
- > 80 l m⁻² d⁻¹

<table>
<thead>
<tr>
<th>Input path</th>
<th>Water [10⁶ m³ yr⁻¹]</th>
<th>P Input [kg yr⁻¹]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Groundwater</td>
<td>1.27</td>
<td>1,000</td>
</tr>
<tr>
<td>Wet and dry deposition</td>
<td>—</td>
<td>300</td>
</tr>
<tr>
<td>Precipitation</td>
<td>3.02</td>
<td>—</td>
</tr>
<tr>
<td>Surface inflow</td>
<td>2.39</td>
<td>180</td>
</tr>
<tr>
<td>Water flow</td>
<td>—</td>
<td>200</td>
</tr>
</tbody>
</table>

Subsurface catchment of Lake Arendsee

Surface inflow (% of the overall surface inflow in March 2011)
Monitoring bio-geomorphic processes in real time

(Photo: W. Bertoldi, Univ. Trento)
Effects of a seasonal flow pulse (from Bertoldi et al.)

Is it possible to predict eco-geomorphological effects from flood magnitude?

RI 2 yrs = 280 cm

27 April 2013 – 14.00

NO WOOD!
Effects of a seasonal flow pulse

28 April 2013 – 07.00
Effects of a seasonal flow pulse

28 April 2013 – 08.00
Effects of a seasonal flow pulse

28 April 2013 – 09.00
Effects of a seasonal flow pulse

28 April 2013 – 10.00
Effects of a seasonal flow pulse

28 April 2013 – 11.00
Effects of a seasonal flow pulse

28 April 2013 – 12.00

[Graph showing hydrometric level over time]
Effects of a seasonal flow pulse

28 April 2013 – 13.00
Effects of a seasonal flow pulse

28 April 2013 – 14.00
Effects of a seasonal flow pulse

28 April 2013 – 15.00
Effects of a seasonal flow pulse

28 April 2013 – 16.00
Effects of a seasonal flow pulse

28 April 2013 – 17.00
Effects of a seasonal flow pulse

29 April 2013 – 07.00
Wood erosion and deposition

Up to 40% of the trees were deposited on the nearest downstream bar

- position of island edge on 18/12/2009

(A) 18/12/2009 16.00
(B) 26/12/2009 16.00
(C) 15/01/2010 16.00
Wood erosion and deposition

Most wood deposited as single logs during the decreasing phase of the flood
Wood erosion and deposition

Recent improvements in wood monitoring

→ McVicar et al. 2009, 2012 → video tracking
→ Fixed monitoring section on the Ain River (H. Piègay, CNRS Lyon)

→ Possibility to link wood production and deposition
→ Monitoring when and where wood is deposited

Bertoldi et al. 2013 Wood recruitment and retention: the fate of eroded trees on a braided river explored using a combination of field and remotely-sensed data sources. Geomorphology, 180-181, 146-155
Real-time ecohydrology

**Improve** the capability to quantify the transfer and transformation of organisms and material

**Detect** thresholds, monitor rapid alterations, and provide early warning signals

**Understand** the effects of critical periods (e.g. pulse events)

**Link** hydrogeomorphic, ecological, biological, and social processes across spatio-temporal scales
Thank you for your attention!

Vienna, 16 April 2015


www.igb-berlin.de