Integrated modelling of ecohydrological processes along ephemeral rivers
Sven Arnold, Sabine Attinger, Karin Frank, and Anke Hildebrandt

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Problem Definition … Kuiseb River

- Transpiration
- Q ~ 55 Mm³/a
- Q ~ 5 Mm³/a
- Local ground water recharge
- Regional ground water flow

Kuiseb River and its water flow components.
Problem Definition ... Kuiseb River

Research Questions
How do different types of water storages influence the ecosystem?
What mechanisms stabilize the system?
Motivation

State of the art
Ecology: qualitative/probabilistic models with no memory in hydrology
Hydrology: Sink or source term „transpiration“ does not depend on ecological dynamics

Our approach
Ecology: Flood has short- and long-term memory (Hurst-Effect)
Hydrology: Quantitative water flux with dynamic feedbacks to ecosystem dynamics
Model

<table>
<thead>
<tr>
<th>Motivation</th>
<th>Model</th>
<th>Input</th>
<th>First Results</th>
<th>Summary</th>
</tr>
</thead>
<tbody>
<tr>
<td>Green Biomass</td>
<td>Leaves – high turnover, seasonality</td>
<td>G … green biomass(^a) [t/ha]</td>
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<tr>
<td>Reserve Biomass</td>
<td>Stem, Main Roots – slow turnover</td>
<td>R … reserve biomass(^a) [t/ha]</td>
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Ecohydrological Interface
### Motivation

### Model

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<tr>
<th>Species</th>
<th>Transpiration $[g(H_2O)/g(G)*hr]$</th>
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<td>Acacia sp.</td>
<td>1.03&lt;sup&gt;a&lt;/sup&gt;</td>
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<sup>a</sup> Bate and Walker 1993. Water relations of the vegetation along the Kuiseb River, Namibia. Madoqua, 18(2), 85-91.
Conceptual Water Balance Model

Motivation

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Summary

Evaporation (E)

Inflow (I)

Recharge (R)

Pumping (P)

Lateral Flow (L)

Storage Level (S)

Vertical Flow (V)

Outflow (O)

Graphic: C. Külls
Motivation

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Transpiration

![Graph showing transpiration rate vs. G(t) [t/ha]](image-url)
Input

Floodregime simulated by autoregressive approach (FARIMA) (Fractionally Differenced Autoregressive Integrated Moving Average)

“In contrast to using traditional ARIMA models, this approach allows the modeling of both short- and long-term persistence that are present in many hydrologic long-memory processes.”

Wet and drought periods
Extraordinarily high and low floods

→ Joseph Effect\textsuperscript{a}
→ Noah Effect\textsuperscript{a}

\textsuperscript{a} Mandelbrot and Wallis, 1968 and 1969
First Results ... without interspecies competition

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How do different types of water storage influence the ecosystem?
Increasing storage capacity leads to:
(1) Increase of mean reserve biomass
(2) Decrease of variability of reserve biomass

Which factors influence system stability?
Water storage (buffering mechanism)
Species composition (presence of Tamarix sp. leads to co-existence and decreased biomass variability)
Thank you!
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