Groundwater as the dominant control process to model recession and baseflow phases in lowland catchments

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Outline

• Groundwater processes in lowlands
• Representation of recession and low flow
• Groundwater module in SWAT
• Extension of the groundwater module
• Modelled discharge
• Conclusion
• Perspectives
Groundwater processes in lowlands

- Shallow groundwater tables
- Strong interaction between groundwater and river
- Winter: high discharge
- Summer: distinct low flows
- Groundwater as the main contributor to discharge

von Pape 2002
Schmalz 2011
SWAT application in lowlands

Kielstau catchment (UNESCO Ecohydrological Demonstration Site)

- 50 km²
- Shallow groundwater tables
- Flat topography
- Interaction between river and groundwater
- High fraction of agricultural land use
SWAT application in lowlands

Problems in simulating recession

| discharge [m³/s] |
|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|
|                 | simulated       | observed        | NSE: 0.62       |                 |                 |                 |

![Graph showing simulated and observed discharge with NSE value 0.62]
SWAT application in lowlands

Flow duration curve: detection of underestimation in low flow segment

![Graph showing the flow duration curve with observed and simulated data, indicating PBIAS values of 22.5 and -52.0 respectively.](image)
Groundwater module of SWAT

- One single active shallow aquifer to describe groundwater contribution to channel
- Inactive deep aquifer to describe groundwater not contributing to channel

(Pfannerstill et al., under review)
Extension of the conceptual structure for the groundwater module
Extended groundwater module of SWAT$_{3S}$

- **SWAT**: groundwater main contributor to channel

- Improvement of low flow by groundwater driven baseflow
Extended groundwater module of SWAT$_{3S}$

- **SWAT**: groundwater main contributor to channel
- **Improvement of low flow by groundwater driven baseflow**
Extended groundwater module of SWAT$_{3S}$

- Groundwater processes are strongly nonlinear

- Emphasizing nonlinearity with multiple groundwater storages

- Splitting one single aquifer into a fast and a slow reacting aquifer
Groundwater module of SWAT$_{3S}$

- Two active shallow aquifers for a fast and a slow groundwater contribution to the channel

- Two recession constants for independent control of slow and fast shallow aquifer

(Pfannerstill et al., under review)
SWAT$_{3S}$ application

Improved simulation of recession and low flow

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<td>simulated</td>
<td>observed</td>
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NSE: 0.64
Flow duration curve: improved discharge reproduction in low flow segment

PBIAS: 6.3

PBIAS: 7.0
SWAT$_{3S}$ performs much better in low flow (PBIAS 7.0 vs. -52.0) and in mid flow segment (PBIAS 6.3 vs. 22.5)
Comparison: SWAT and SWAT$_{3S}$

- Same overall groundwater contribution
- SWAT$_{3S}$: groundwater contribution split into fast and slow component
Comparison: SWAT and SWAT$_{3S}$
Conclusion

- Groundwater contribution as dominant control process for low flows in lowland catchments

- Splitting of shallow aquifer into fast and slow reacting aquifer emphasizes nonlinearity

- Improvement of recession (PBIAS 6.3 vs. 22.5) and low flow (PBIAS 7.0 vs. -52.0) reproduction
Perspectives

• Application of SWAT$_{3S}$ in other lowland catchments

• Consideration of heterogeneous groundwater characteristics (modular application SWAT$_{3S}$)

• Test in large catchments
Thank you!

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