Investigating the dynamics of transit times and subsurface mixing of a small agricultural catchment using physically-based numerical model

J. Yang, I. Heidbüchel, A. Musolff, F. Reinstorf, J. H. Fleckenstein | Helmholtz Centre for Environmental Research GmbH - UFZ

Introduction

Study site: catchment Schäfertal

- Area: ~1.4 km²
- Agriculture
- P = ~610 mm/yr
- ET = ~450 mm/yr
- Q = ~160 mm/yr
- Meteorological station, gauging station, wells, etc
- Intensive records since 1996

Method

Flow modelling:
- Boundary conditions:
  - Daily P(t), ET_p(t)
  - Daily T(t)
  - Critical depth outlet
- Calibration:
  - For Q, water level, using PEST
  - 54 optimized parameters: K, porosity, roughness, parameters of snow melt & ET

HydroGeoSphere integral modelling:
- 3D Subsurface
- 2D Surface
- 1D Channel

Properties:
- 10 zones for subsurf. property
- 7 zones for surface & ET → land use

RTDs, TTDs computing:
- Residence Time Distributions (RTDs)
- Transit Time Distributions (TTDs)

fractional StorAge Selection (fSAS) functions \( \omega_Q \)

\( \omega_{\text{P}_0} \), \( \Omega = \frac{\text{TTDs}}{\text{RTDs}} \)

SAS function describes which fraction of the storage is preferentially sampled by discharge (i.e. mixing)

Results

Age dynamics

- Strong seasonal fluctuations in age of Storage, Discharge and ET.
- Discharge younger than storage in the wet and the drying periods
- ET younger than Storage

Dynamics of Discharge/ET selection preferences

SAS functions indicate a seasonal shift in selection preferences
- For discharge:
  - Preference for young water in wet period, preference shift gradually to older water as the catchment transitions into the drying, dry and wetting periods.
- Dominated by wet period
- For ET:
  - Strong preference for young water in dry period. Approaching uniform selection in wet period.
  - Dominated by drying period

N-NO\textsubscript{3} export patterns

An approach to model N-NO\textsubscript{3} export (undergoing work)

References:
