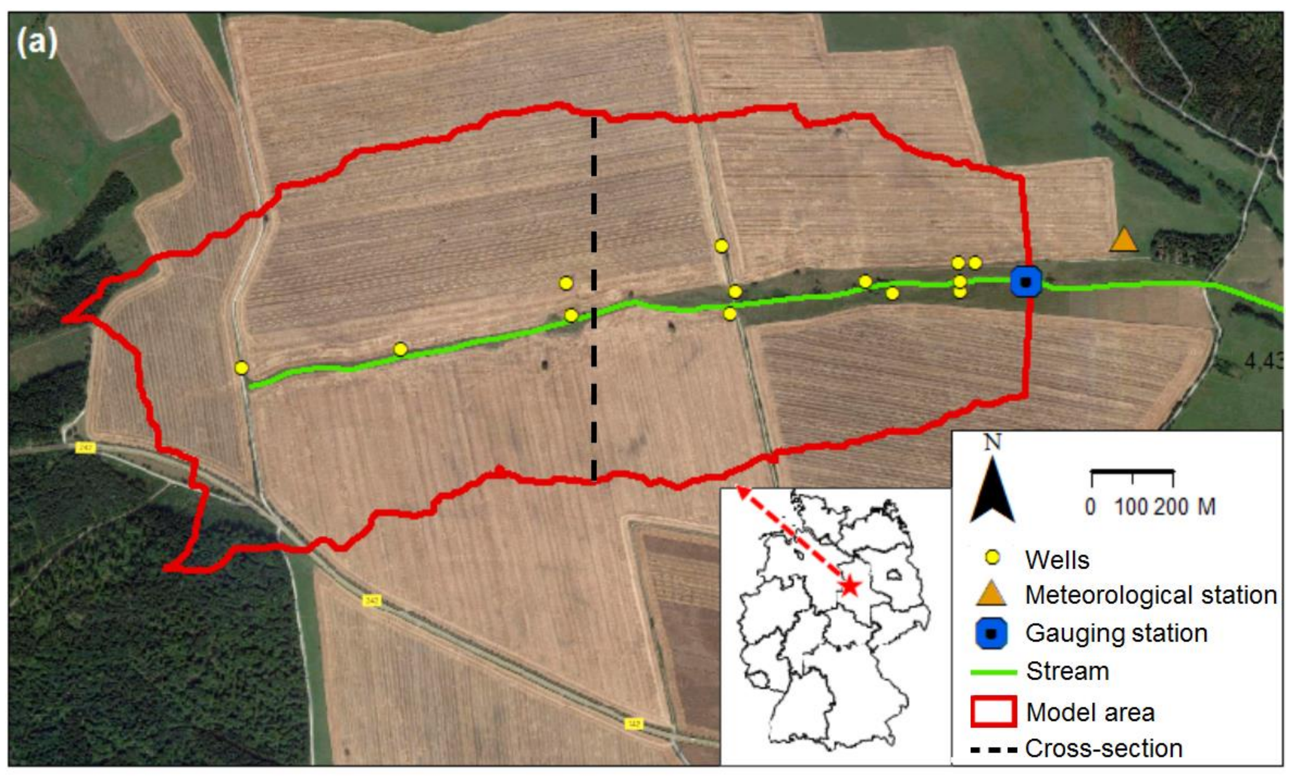
Investigating the dynamics of transit times and subsurface mixing of a small agricultural catchment using physically-based numerical model

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

Introduction

Study site: catchment Schäfertal



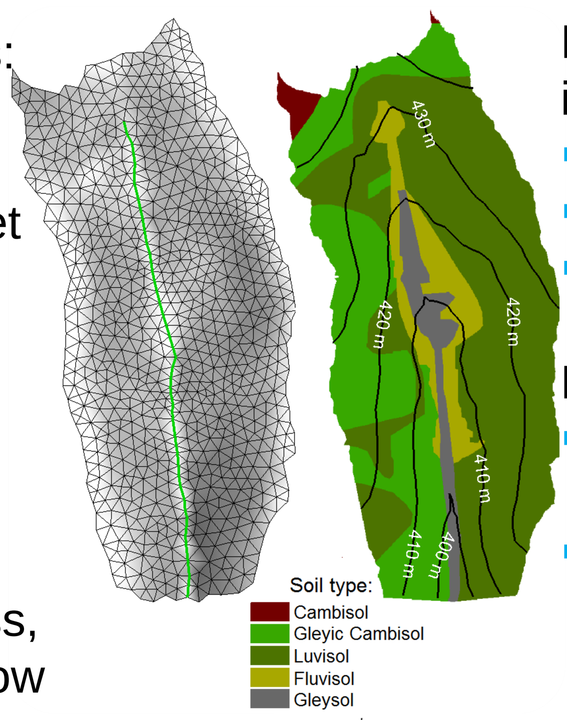
- Area: ~ 1.4 km2
- Agriculture
- P = ~ 610 mm/yr
- ET = ~ 450 mm/yr
- Q = ~ 160 mm/yr
- Meteorological station, gauging station, wells, etc
- Intensive records since 1996

Method

Flow modelling:

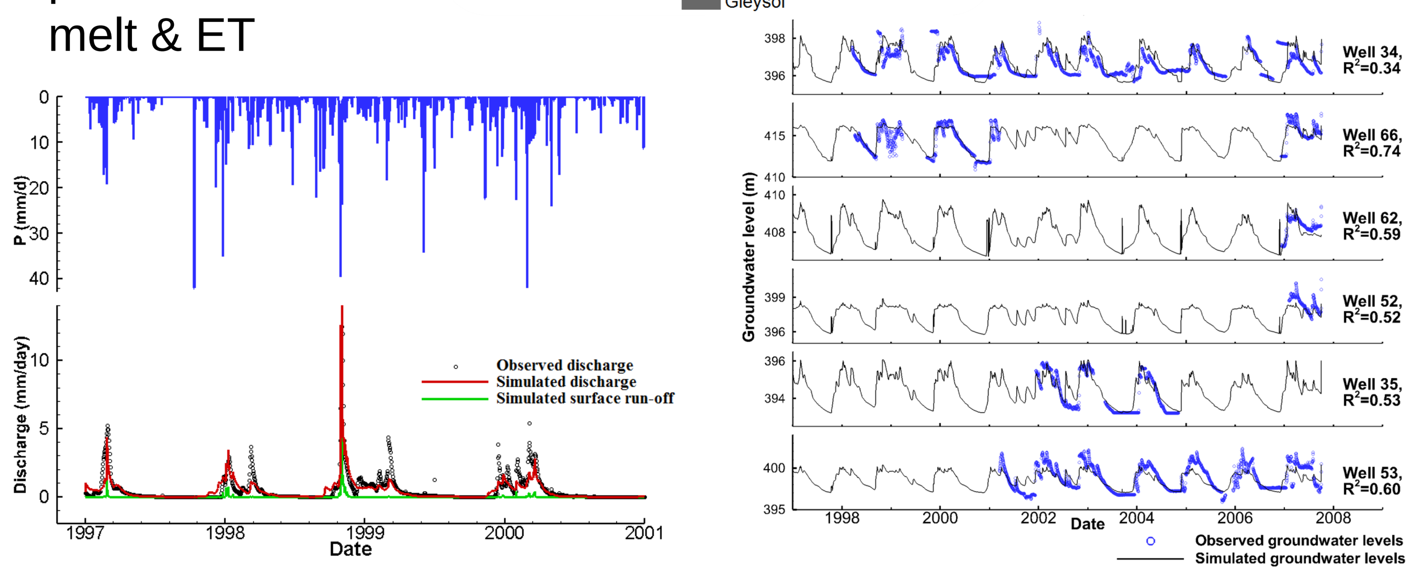
Boundary conditions:
- Daily P(t), $ET_p(t)$
- Daily T(t)
- Critical depth outlet

Calibration:
- For Q, water level, using PEST
- 54 optimized parameters: K, porosity, roughness, parameters of snow melt & ET

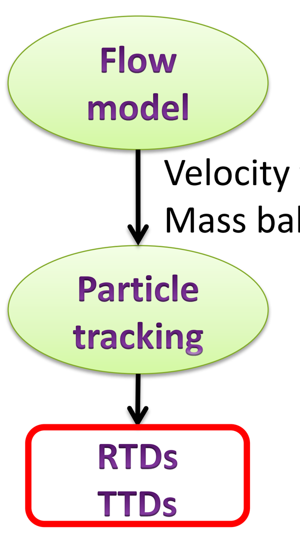


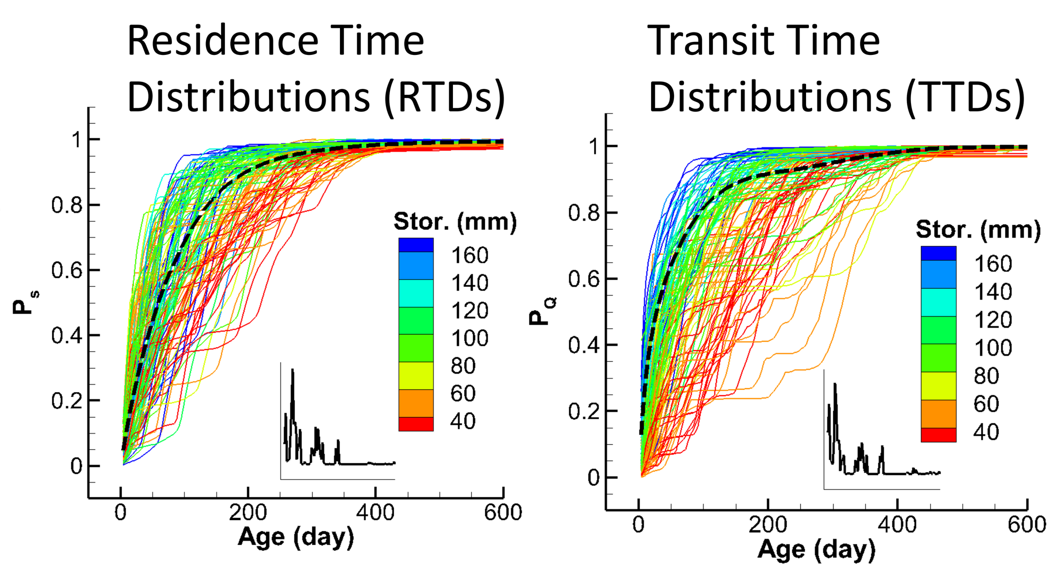
HydroGeoSphere integeral modelling:
- 3D Subsurface
- 2D Surface
- 1D Channel

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

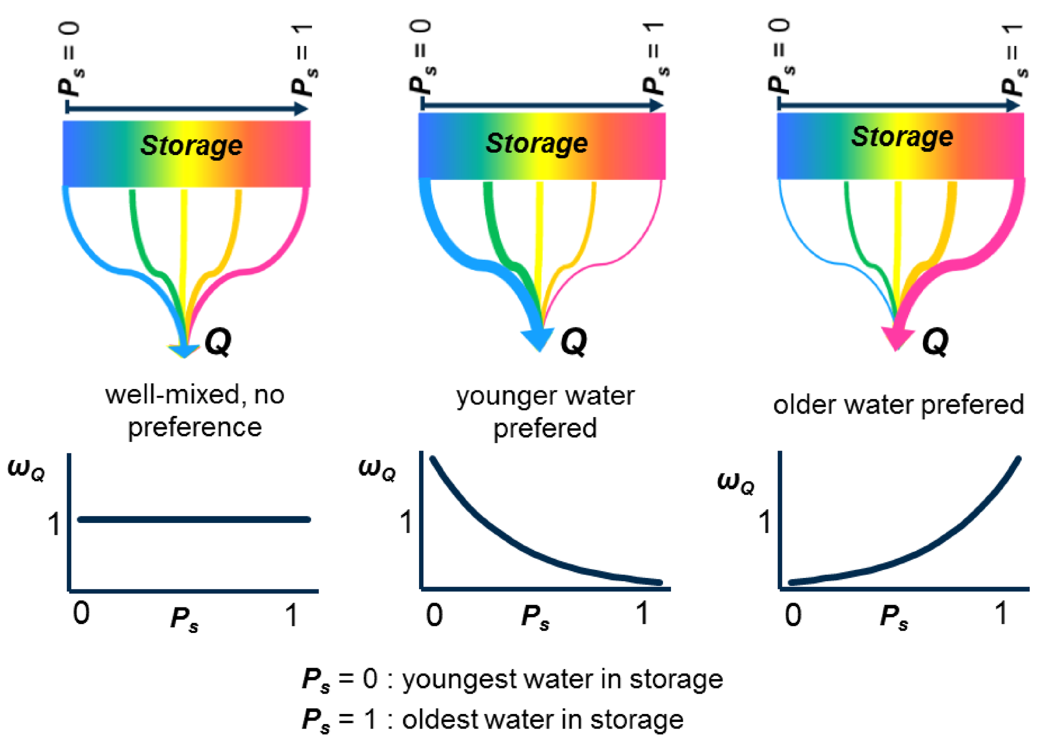


RTDs, TTDs computing:





fractoinal StorAge Selection (fSAS) functions ω_Q

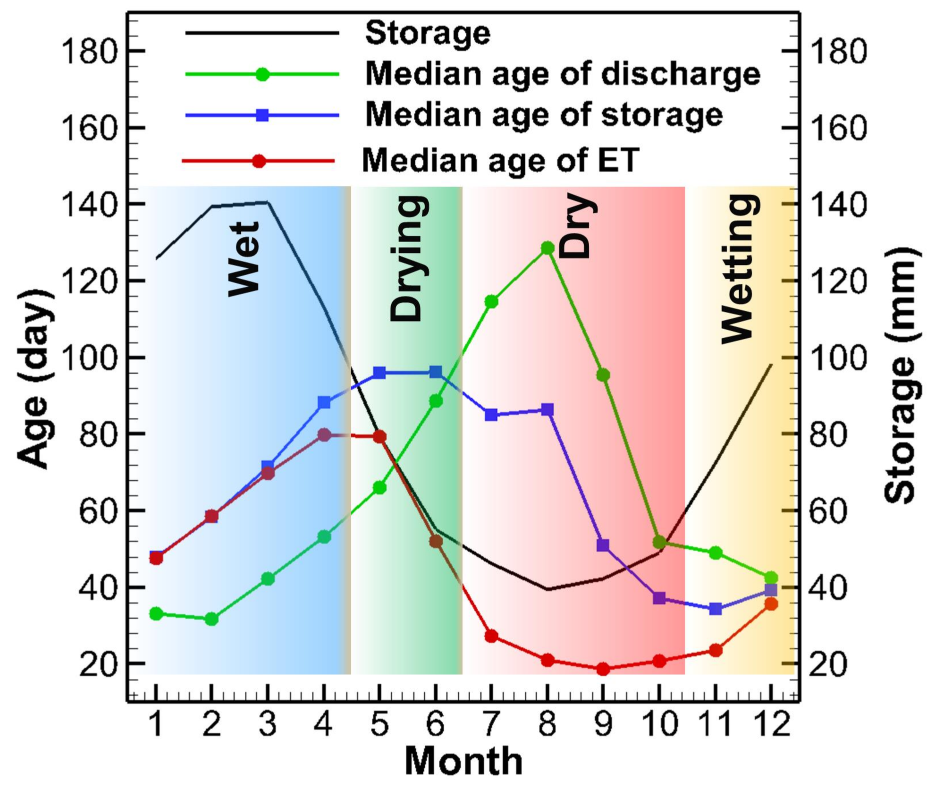


$$\omega_Q(Ps, t) = \frac{TTDs}{RTDs}$$

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

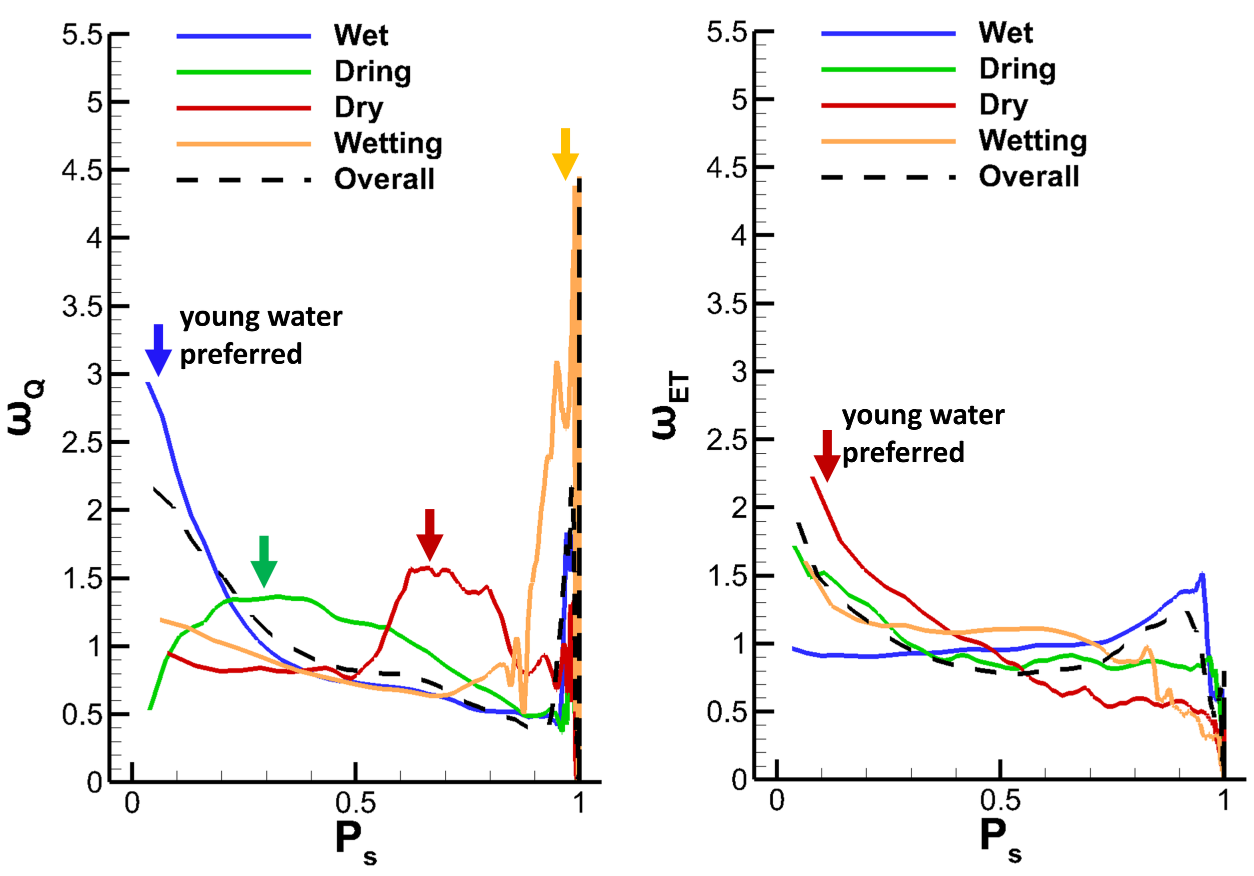
Results

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

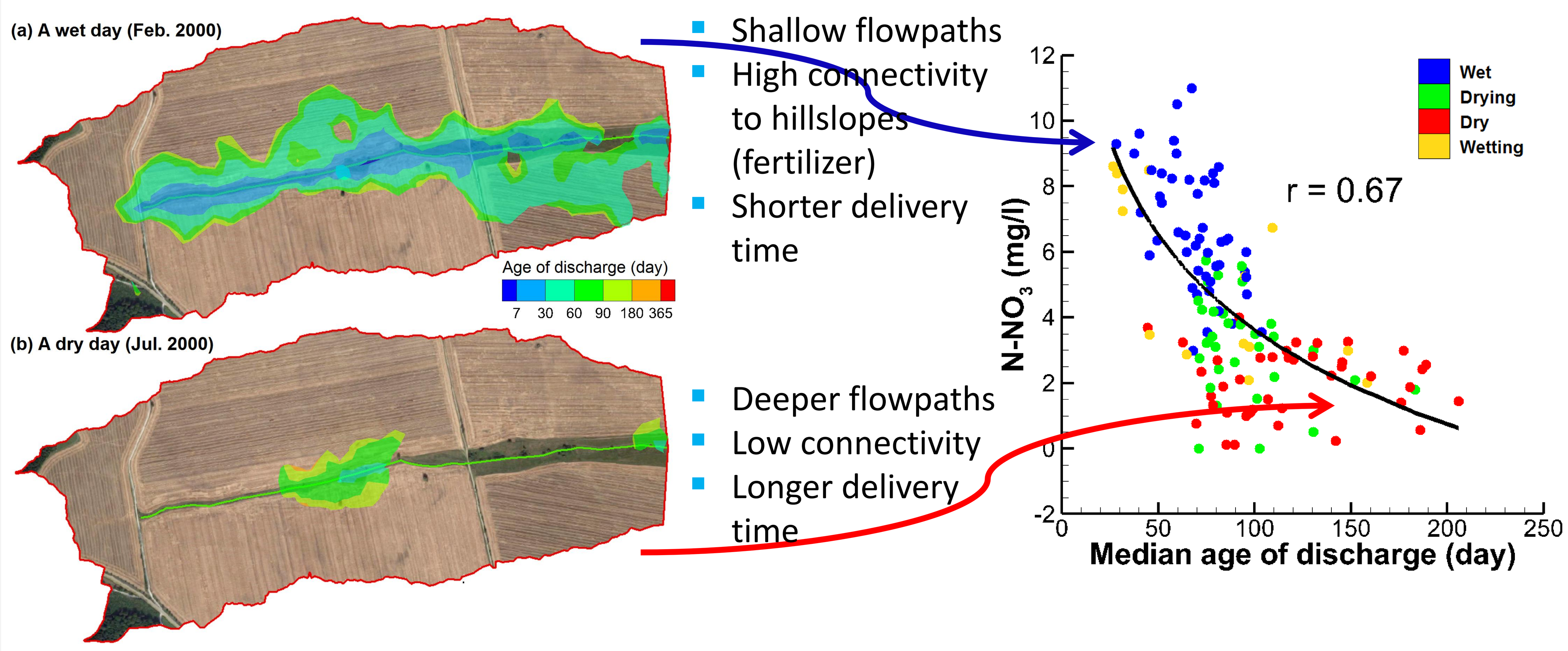


SAS functions indicate a seasonal shift in selection preferences

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

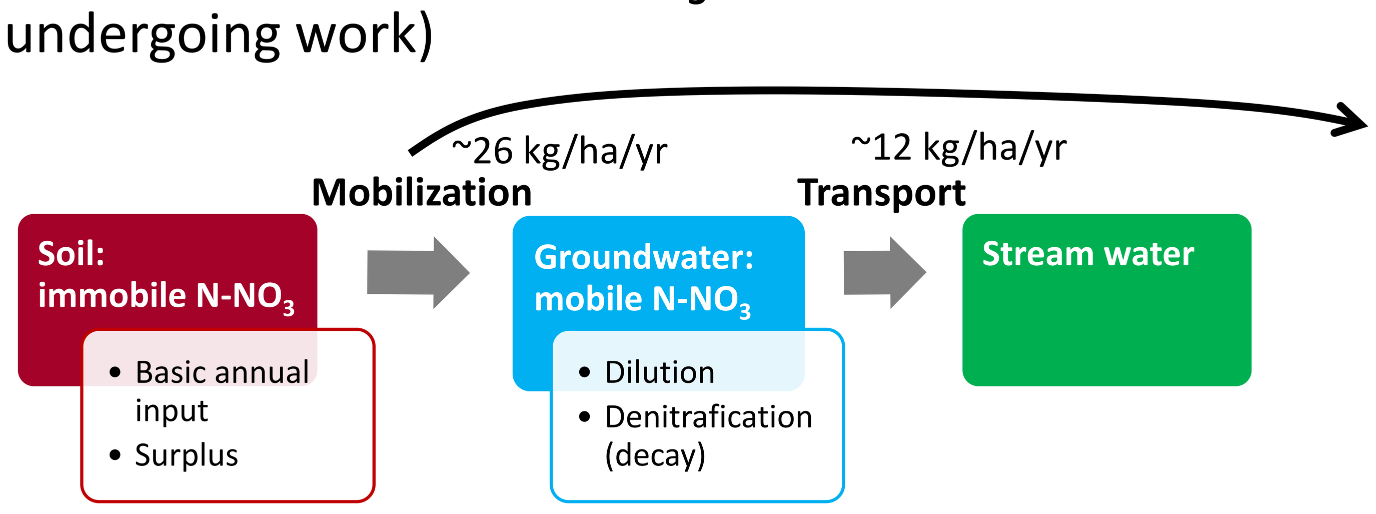
$N\text{-}NO_3$ export patterns

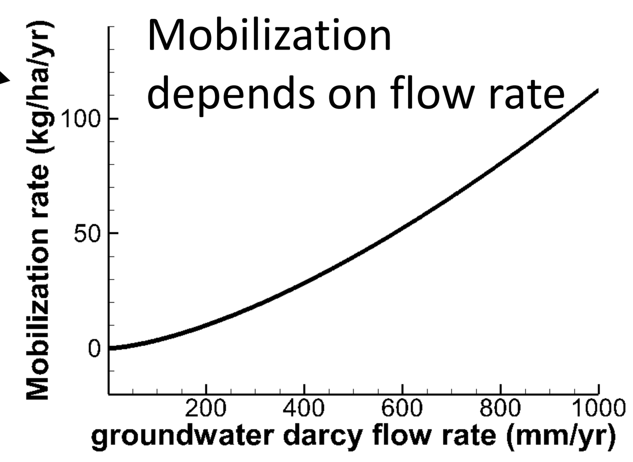


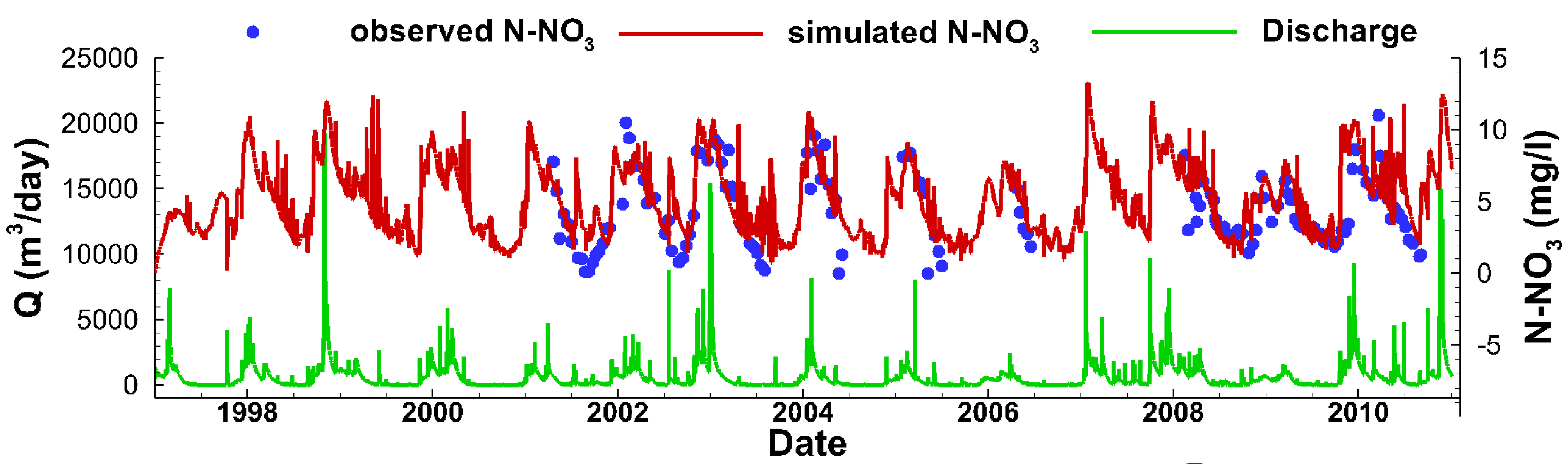
- Shallow flowpaths
- High connectivity to hillslopes (fertilizer)
- Shorter delivery time

- Deeper flowpaths
- Low connectivity
- Longer delivery time

An approach to model $N\text{-}NO_3$ export (undergoing work)







References:

van der Velde, Y., Torfs, P. J. J. F., van der Zee, S. E. A. T. M., & Uijlenhoet, R. (2012). Quantifying catchment-scale mixing and its effect on time-varying travel time distributions. Water Resources Research, 48, W06536.

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