Hupsel Brook catchment, The Netherlands

Ype van der Velde (23-12-2011)

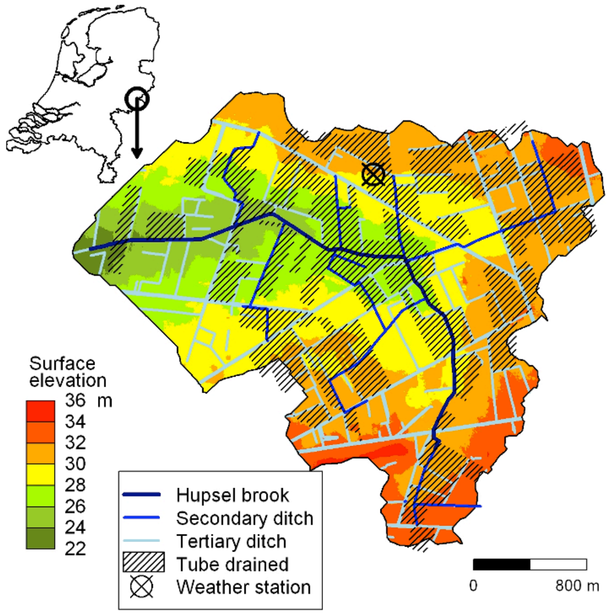

Figure 1: Map showing the location of the Hupsel brook catchment (Van der Velde et al.; 2009)

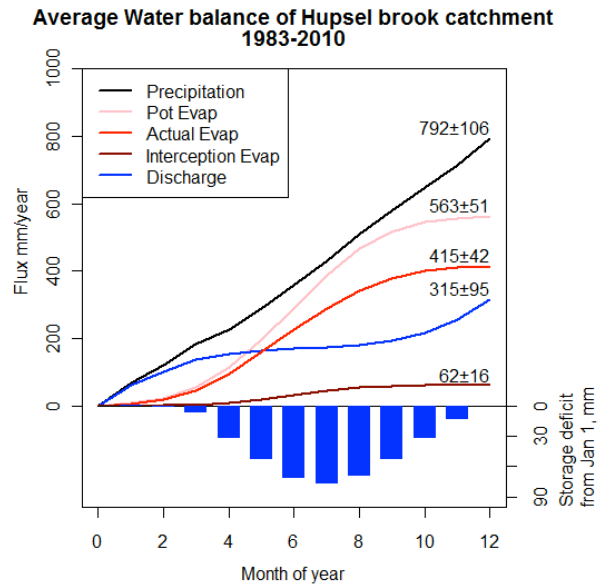

Figure 2: Average cumulative water balance of the Hupsel Brook catchment for period 1983-2010. Numbers indicate average yearly flux ± 1 standard deviation between years. This graph is based on results of Van der Velde et al; 2011.

Background Information

The Hupsel brook catchment is situated in the eastern part of the Netherlands (52°03' N; 6°38' E). It is a small catchment of 6.5 km^2 and has been the main Dutch hydrological research catchment since the 1960's. Although at the moment only a few hundred people live inside the Hupsel Brook catchment boundaries, the catchment has been severely impacted by human activities. Present landuse is dominated by intensive agriculture but extensive agriculture activity can be traced back until the earliest accounts of Hupsel (1327, barter of vegetables between farmers; 1627, Battle for Grolle when the army of Prince Frederik Hendrik stranded on the banks of the Hupsel brook). Given the long history of human habitation a natural reference landscape is impossible to define. However, because the catchment geology is characterized by a very thin sandy aquifer (1 to 20 m) overlaying an impermeable clay layer and little regional slope, the catchment still is and has always been very wet during winter conditions. Because of the risk for flooding within and downstream of the Hupsel brook catchment, the artificial drainage system has been modified many times in history. The last large scale redistribution of land among farmers and re-meandering of the Hupsel brook was only finished in 2011. Continuous drainage, large scale flattening of land and crushing of iron-ore layers to improve agricultural practices, mining of peat soils and clearing of forests are just some of the activities that have been ongoing during the past centuries and have severely impacted landscape and hydrology.

Main research and management problems
The main topic of research in the Hupsel Brook catchment has always been the effects of human activities on discharge and water quality. Several of the past and future management problems and scientific questions are listed below.

Management problems

- Optimal landscape design (drainage, landuse, soil) with respect to:
  - downstream flooding
  - local flooding
  - habitation
  - agriculture
  - surface water quality
  - biodiversity
  - tourism
- Quantifying impact of specific human activities on discharge, water quality and biodiversity
  - Building a new highway
  - Redistribution of land among farmers
  - Constructed meandering of the Hupsel Brook
  - Agricultural practice and landuse change
  - Sewage treatment
  - Climate change
- Optimizing agricultural practices
  - Positioning and usage of tube drains: Can farmers improve water quality by temporally raising and lowering of tube drain outlets
  - Finding and reducing hotspots of nutrients loads towards surface waters
  - Application of manure/fertilizer
  - What is sustainable agriculture?: the fine line between nutrient depletion of soils and leaching of nutrients towards surface waters.

Science questions:

- From rainfall to discharge: quantifying water flows and corresponding water quality.
- From rainfall to discharge across centuries: Estimating the effects of human impact on hydrology
- Effects of local inundation/ponding on discharge and water balance
- Relations between landscape, waterbalance and wetlands
- Seasonal wetland dynamics
- Estimation of evapotranspiration
- Travel times of water within the catchment
- Predicting extreme discharge events: What catchment features matter under high discharge conditions (in-stream features such as weirs, vegetation and roads tunnels vs inundation of land and tube drainage)?
- The effects of wetlands on water quality (recent focus on dissolved and bound Phosphorus).
- In-stream water chemistry: loads and interactions across the periodic table

Possible end-users

Past research in The Hupsel brook catchment has been a rich source of knowledge on topics ranging from rainfall-runoff modeling and water quality assessment to quantifying evapotranspiration and soil classification. This research has found its way into national landscape/landuse surveys and outlooks, and national models for water quality assessments (Alterra, Delatres, TNO). By making the Hupsel Brook catchment part of the GWEN-Network we hope to improve international visibility of Hupsel Brook research and data. Especially, the GWEN-initiated renewed focus on human impact and wetland rehabilitation can be the new impulse that is needed to sustain research efforts in the near future. Because of the large data availability and the well constrained catchment boundaries, the Hupsel brook catchment has served and promises to serve an important role as benchmark-case study for many hydrological and hydro-chemical problems (For example see Fig. 3).

Site conditions

The Hupsel brook catchment has a semi-humid sea climate with an annual precipitation of 500 to 1100 mm and an annual estimated evaporation of 300 to 600 mm, leaving an estimated sum of runoff and recharge of 200 to 800 $mm \cdot year^{-1}$. (See Fig. 2)
Surface elevation ranges from 22 to 30 m above sea level (See Fig. 1). The soil texture class is mostly loamy sand with occasional layers of clay, peat and gravel of which the spatial extension is only marginally known (Wösten et al., 1985). A Miocene clay layer (20 -30 m thick, starting at 0.5 to 20 m below the soil surface) forms an impermeable boundary for the unconfined water flow. The surface of this clay layer is carved by Pleistocene glacier erosion.
The entire catchment is densely drained with 68 km of ditches and many tube drains. The main brook is canalized. Despite the extensive drainage system upto 10% of the area can be flooded under extreme circumstances (Brauer et al., 2011). Under summer condition only 0.01% of the landscape is inundated (only the downstream part of the main brook).

Monitoring and Data

The Hupsel brook catchment has been intensively monitored since 1960. However, until today no database exists for this catchment, and data have to be gathered from individual sources: KNMI, RIVM, TNO, WUR, Waterboard Rijn and Ijssel, personal databases of Ype van der Velde and Joachim Rozemeijer.
Hourly meteorological data has been measured inside the catchment by the KNMI since 1994. Also an air and rainwater quality station operated by the RIVM is located near the catchment. Discharge is measured since 1960 by waterboards and Wageningen University. A continuous record of groundwater level since 1974 (20 min interval) is available. Nutrient concentrations have been measured for the period 1985 until 2009 (see fig 3). Soil characterization has been done in the 1970's involving many hundreds of drillings and sounding (Wosten et al., 1985). Between 2007 and 2009 tube drainage, overland flow and groundwater have been measured at a single field site within the catchment (Van der Velde et al, 2011). These data are supplemented with groundwater level and soil moisture data throughout the field and water quality samples across the catchment.

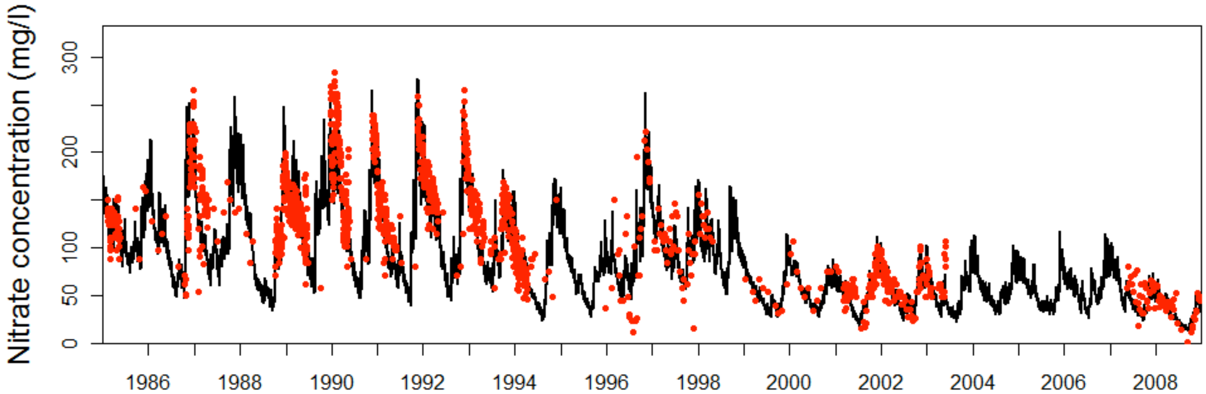

Fig 3 Measured and modeled nitrate concentrations in the Hupsel Brook. Data is based on Van der Velde et al., 2011.

Publications

- Van der Velde, Y., J.C. Rozemeijer, G.H. De Rooij, F.C. Van Geer, and H.P. Broers (2010), Field-scale measurements for separation of catchment discharge into flow route contributions, Vadosezone journal 9, 25-35.
- Van der Velde, Y., G.H. De Rooij and P.J.J.F. Torfs (2009), Catchment-scale non-linear groundwater-surface water interactions in densely drained lowland catchments, Hydrol. Earth Syst. Sci. 13, 1867-1885.
- Van der Velde, Y., G.H. de Rooij, J.C. Rozemeijer, F.C. van Geer and H.P. Broers (2010), The nitrate response of a lowland catchment: on the relation between stream concentration and travel time distribution dynamics, Water Resources Research 46, W11534, doi:10.1029/2010WR009105.
- Van der Velde, Y., J.C. Rozemeijer, G.H. de Rooij, F.C. van Geer and P.J.J.F. Torfs, and P.G.B. de Louw (2011), Improving catchment discharge predictions by inferring flow route contributions from a nested-scale monitoring and model setup, Hydrol. Earth Syst. Sci. 15, 913-930.
- Rozemeijer, J.C., Y. Van der Velde, F.C. Van Geer, G.H. De Rooij, P.J.J.F. Torfs, and H.P. Broers (2010), Improving load estimates for NO3 and P in surface waters by characterizing the concentration response to rainfall events, Environ. Sci. Technol. 44, 6305-6312.
- Rozemeijer, J.C., Y. Van der Velde, H. De Jonge, F.C. Van Geer, H.P. Broers, M.P.F. Bierkens (2010), Application and evaluation of a new passive sampler for measuring average solute concentrations in a catchment-scale water quality monitoring study, Environ. Sci. Technol., 44, 1353-1359.
- Rozemeijer, J.C., Y. van der Velde, R.G. McLaren, F.C. van Geer, H.P. Broers, and M.F.P Bierkens (2010), Using field scale measurements of flow route contributions to improve integrated model representations of dynamic groundwater-surface water interactions, Water Resources Research 46, W11537, doi:10.1029/2010WR009155.
- Rozemeijer, J.C., Y. van der Velde, F.C. van Geer, H.P. Broers, M.F.P Bierkens (2010), Direct quantification of the tile drain and groundwater flow route contributions to surface water contamination: from field-scale concentration patterns in groundwater to catchment-scale surface water quality, Environmental Pollution 158, 3571-3579.
- Brauer, C.C., A. J. Teuling, A. Overeem, Y. van der Velde, P. Hazenberg, P. M. M. Warmerdam, and R. Uijlenhoet (2011), Soil buffer limits flash flood response to extraordinary rainfall in a Dutch lowland catchment, Hydrol. Earth Syst. Sci. 15, 1991-2005
- Ernst, L.F., 1978. Drainage of undulating sandy soils with high groundwater tables. J. hydrol., 39, 1-30.
- Hopmans, J.W., and J.N.M. Stricker, 1989. Stochastic analysis of soil water regime in a watershed. J. Hydrol., 105, 57-84.

- Kraijenhoff van de Leur, D.A, 1962. A study of non-steady groundwater flow.II. De Ingenieur 74, 285-292
- Van den Eerthwegh, G.A.P.H., 2002. Water and nutrient budgets at field and regional scale. Travel times of drainage water and nutrient loads to surface water. Wageningen Universiteit, Wageningen.
- Van Ommen, H.C., R. Dijksma, J.M.H. Hendrickx, L.W. Dekker, J. Hulshof and M. Van Den Heuvel, 1989. Experimental assessment of preferential flow paths in a field soil. Journal of Hydrology 105, 253-262.
- Wösten, J.H.M., J. Bouma, and G.H. Stoffelsen, 1985. Use of soil survey data for regional soil water simulation models. Soil Science Society of America Journal, 49, 1238-1244.
- H. Stricker and W. Brutseart, 1978. Actual evapotranspiration over a summer period in the "Hupsel catchment". Journal of Hydrology, 39, 139-157