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Unraveling brackish groundwater - surface water interaction in an agricultural field using direct measurements at the field scale

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Understanding the interaction between groundwater and surface water is important for a myriad of reasons, including flow forecasting, nutrient transport, and water allocation for agriculture and other water users. This understanding is especially important in deep polder areas in the Netherlands, where brackish groundwater seepage (upward flowing regional groundwater) results in a significant salt load to surface water, and may damage crops if salts reach the rootzone in dry summers.

Research on groundwater - surface water interaction historically focused on relatively pristine headwater catchments, only recently shifting somewhat to agricultural catchments. The latter pose specific research challenges, as agricultural activities and active water management can have a significant influence on hydrology. A brackish seepage flux, with a different density as precipitation, may significantly influence flow paths to surface water. Research on this specific topic is, however, lacking. We therefore investigated the interaction between groundwater and surface water in an agricultural catchment with a significant brackish seepage flux. In addition, we investigated the effects of intake of fresh water during periods of precipitation deficits, a common management strategy in lowland regions.

We instrumented an agricultural ditch to enable direct, 15 min interval measurements of water fluxes and salinity to both agricultural drains and the ditch separately. These measurements are supported by piezometer nests, soil moisture sensors, temperature sensors, geophysics and a meteorological tower. Measurements focused on the summer period and were taken during two measurement periods: May 2012 - November 2012, and April 2013 - October 2013.

Our measurements allowed for a direct, high-frequency separation of hydrological flow routes on this agricultural field between flow to agricultural drains and the ditch. The salinity of seepage water allowed for a relatively easy separation of the time-varying contribution of seepage and precipitation to the separate agricultural drain and ditch hydrographs. We observed a quick response of drain flow and a more damped ditch response. Drain salinities decreased during discharge events, the salinity of ditch exfiltration showed a more complicated response. Infiltration during periods of precipitation deficits resulted in a significant rise in groundwater levels both near the ditch and in the field. The combination of direct flow measurements and the availability of a suitable tracer proved valuable in investigating the interaction between groundwater and surface water in an agricultural field.