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Comparison of JULES and a distributed recharge model

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Introduction

Within the Hydro-JULES project the BGS will be building a national groundwater model coupled to the JULES land surface model. BGS groundwater models are currently driven by recharge from the distributed recharge model ZOODRM (Mansour et al 2011), which is similar to that used by the Environment Agency (EA). Here, we compare the two for the River Eden (at Sheepmount) and the River Thames (at Kingston) during a dry (1995–1996) and a wet winter (2000–2001). We have used the BGS–EA national recharge model (Mansour et al. 2019) and the Centre for Ecology and Hydrology's national JULES model (Blyth et al. 1019, Martínez-de la Torre et al. 2019) for the comparison.

ZOODRM uses the modified EA–FAO method (Griffiths et al. 2006) to calculate evapotranspiration. Evapotranspiration is a function of potential evapotranspiration and the soil moisture deficit. Recharge and Runoff are generated only when the soil moisture deficit is zero, and a coefficient determines the fraction of each.

In JULES, evapotranspiration comprises bare soil evaporation, transpiration and canopy evaporation. Evapotranspiration is dependent on the radiation balance and soil heat fluxes.

Southern England catchment

Dry winter

Recharge is smoothed and delayed in JULES by the soil column (3 m), and is also ~ 90 mm less than in ZOODRM. ZOODRM matches surface runoff at the gauge better than JULES. ZOODRM predicts less evapotranspiration than JULES.

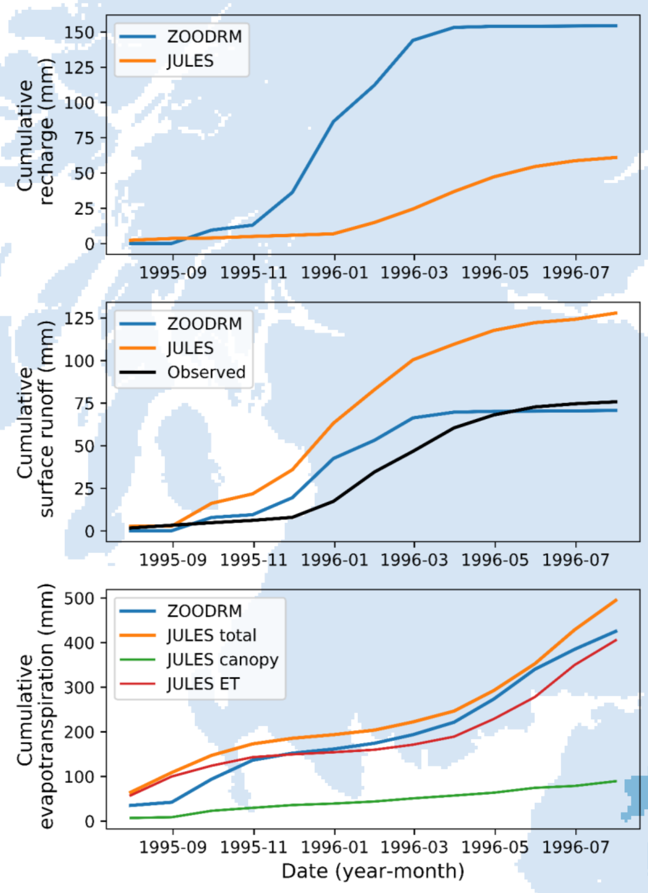

Fig 1. Cumulative recharge (top), surface runoff (middle) and evapotranspiration (bottom) calculated by ZOODRM vs JULES. Observed (middle) is separated surface runoff at the gauging station. ET, bare soil evaporation and transpiration.

Wet winter

Recharge is smoothed and delayed in JULES by the soil column, and is ~140 mm less than in ZOODRM. JULES matches surface runoff at the gauge better than ZOODRM. ZOODRM and JULES predict very similar evapotranspiration.

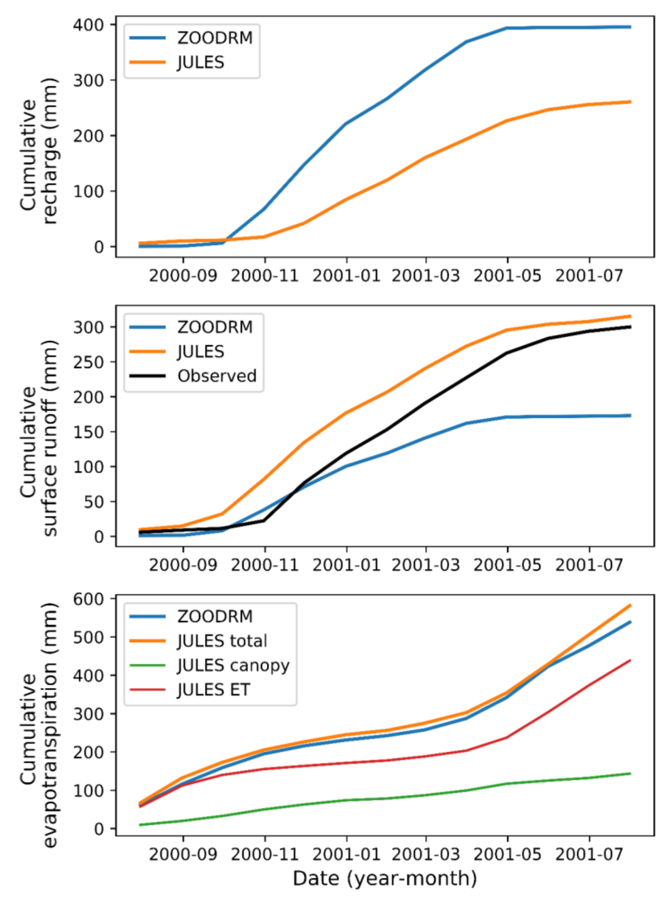

Fig 2. Cumulative recharge (top), surface runoff (middle) and evapotranspiration (bottom) calculated by ZOODRM vs JULES. Observed (middle) is separated surface runoff at the gauging station. ET, bare soil evaporation and transpiration.

Northern England catchment

Dry winter

Recharge is smoothed and delayed in JULES by the soil column, and is also ~ 140 mm less than in ZOODRM. ZOODRM matches surface runoff at the gauge better than JULES. ZOODRM predicts less evapotranspiration than JULES.

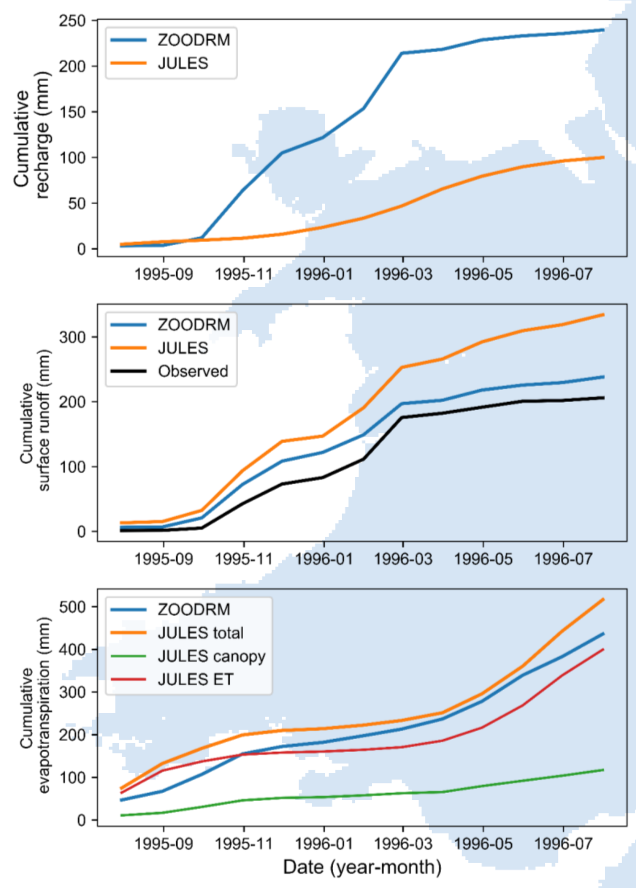

Fig 3. Cumulative recharge (top), surface runoff (middle) and evapotranspiration (bottom) calculated by ZOODRM vs JULES. Observed (middle) is separated surface runoff at the gauging station. ET, bare soil evaporation and transpiration.

Wet winter

Recharge is smoothed and delayed in JULES by the soil column, and is ~200 mm less than in ZOODRM. ZOODRM matches surface runoff at the gauge better than JULES. ZOODRM and JULES predict very similar evapotranspiration.

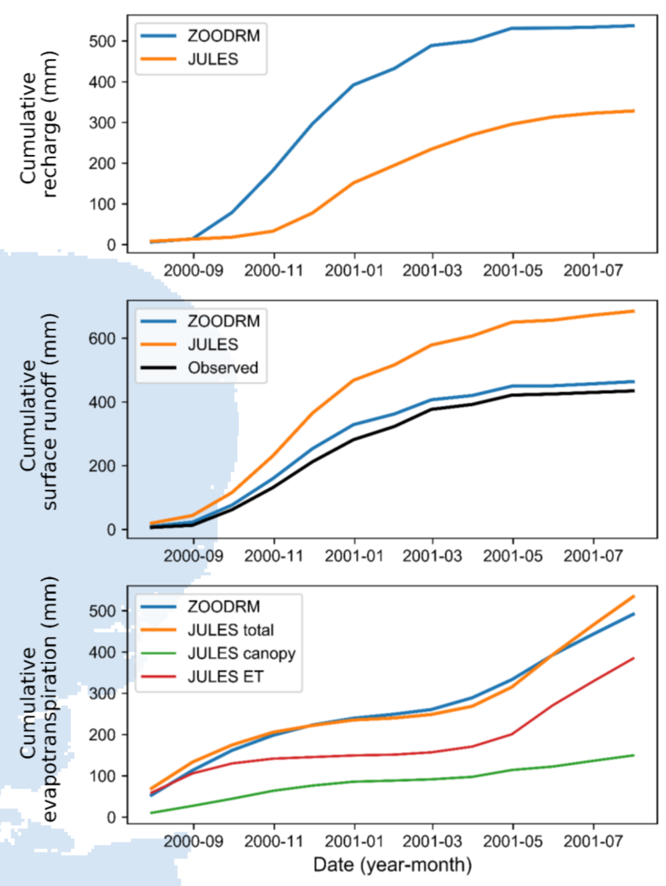

Fig 4. Cumulative recharge (top), surface runoff (middle) and evapotranspiration (bottom) calculated by ZOODRM vs JULES. Observed (middle) is separated surface runoff at the gauging station. ET, bare soil evaporation and transpiration.

Summary

The modified EA–FA0 method in ZOODRM (Griffiths et al. 2006) produces similar evapotranspiration to JULES, although in dry years it predicts lower evapotranspiration. The soil column in JULES provides storage, which delays and smooths the recharge signal. ZOODRM predicts significantly more recharge and less surface runoff than JULES. ZOODRM matches the surface runoff determined by baseflow separation (Gustard et al. 1992) more closely than JULES, which is expected because the runoff coefficients in ZOODRM were calibrated based on baseflow separation. It is interesting that during the winter of 2000-2001, when groundwater flooding occurred in the Chalk aquifer, JULES matches the observed surface runoff more closely than ZOODRM.

References

Blyth, E., Martínez-de la Torre, A. & Robinson, E. 2019. Trends in evaporation and its drivers in Great Britain: 1961 to 2015. *Progress in Physical Geography: Earth and Environment*

Griffiths, J., Young, A.R. & Keller, V. 2006. Model scheme for representing rainfall interception and soil moisture. Environment Agency Environment Agency R&D Project W6-101 Continuous Estimation of RiverFlows (CERF).UK.

Gustard, A., Bullock, A. & Dixon, J.M. 1992. Low Flow Estimation in the United Kingdom. Institute of Hydrology Report No.682108.

Mansour, M.M., Barkwith, A. & Hughes, A.G. 2011. A simple overland flow calculation method for distributed groundwater recharge models. *Hydrological Processes*, 25(22). 3462-3471.

Mansour, M.M., Wang, L., Whiteman, M. & Hughes, A.G. 2018. Estimation of spatially distributed groundwater potential recharge for the United Kingdom. *QJEGH* 51(2). 247-263.

Martinez-de la Torre, A., Blyth, E.M. & Weedon, G.P. 2019. Using observed river flow data to improve the hydrological functioning of the JULES land surface model (vn4. 3) used for regional coupled modelling in Great Britain (UKC2). *GMD* 12. 765-784.

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