Supplement of Hydrol. Earth Syst. Sci., 23, 4011–4032, 2019
https://doi.org/10.5194/hess-23-4011-2019-supplement

Hydrology and Earth System Sciences
Open Access

Supplement of

Benchmarking the predictive capability of hydrological models for river flow and flood peak predictions across over 1000 catchments in Great Britain

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Supplementary Information 1 – Plots looking at the relationship between catchment characteristics and model performance

The main body of the paper looked at the relationship between the catchment wetness index and runoff coefficient and model performance. These attributes were selected as they strongly related to model performance and explained differences between catchments. Here, we provide additional plots looking at the relationship between model performance and many different catchment characteristics to demonstrate how other catchment attributes impact model performance. These characteristics were either taken from the hydrometric register or calculated from the model input data timeseries (Centre for Ecology and Hydrology, 2016; Marsh and Hannaford, 2008a; Robinson et al., 2015a).

Figures S1 – S4 are scatter plots looking at the relationship between model performance (assessed using NSE, bias, error in standard deviation and correlation respectively) and different catchment attributes. Figures S5 onwards are plots looking at interactions between different catchment attributes and model performance.

Some links between catchment attributes and model performance can be seen from Figures S1-S4. Firstly, small catchments (<200km^2) tend to have more variable NSE scores (both high and low), whilst large catchments (>3000km^2) are easier to model. This is seen with all the decomposed metrics potentially indicating that daily data is not able to capture flow variation in small catchments. Secondly, baseflow dominated catchments (BFI > 0.7) are more likely to gain very low NSE values (although some high BFI catchments can be simulated well). Interestingly, BFI seems to have a relationship with error in the standard deviation, with baseflow dominated catchments the only catchments where the best simulations tend to overpredict variation. This could be due to groundwater dampening variation in flows. Thirdly, gauge elevation seems to cap overall model performance, with higher elevation gauges unable to achieve performance scores as high as low elevation gauges. Finally, it is surprising that urbanisation does not seem to decrease model performance.

From figures S5 onwards we can see that the worst performing catchments in terms of Nash-Sutcliffe efficiency are grouped being small catchments less than 120km^2, with elevations below 125m, mid to high BFIs (>0.5), low annual rain less than 1000mm and annual runoff values which differ from other catchments with similar annual rainfall totals. Poor NSE ~0.5 is achieved for wetter catchments (annual rain > 1200mm), which have relatively low annual runoff generally less than 900mm. Many have flow attenuation from reservoirs and lakes, and for these catchments correlation is poor.

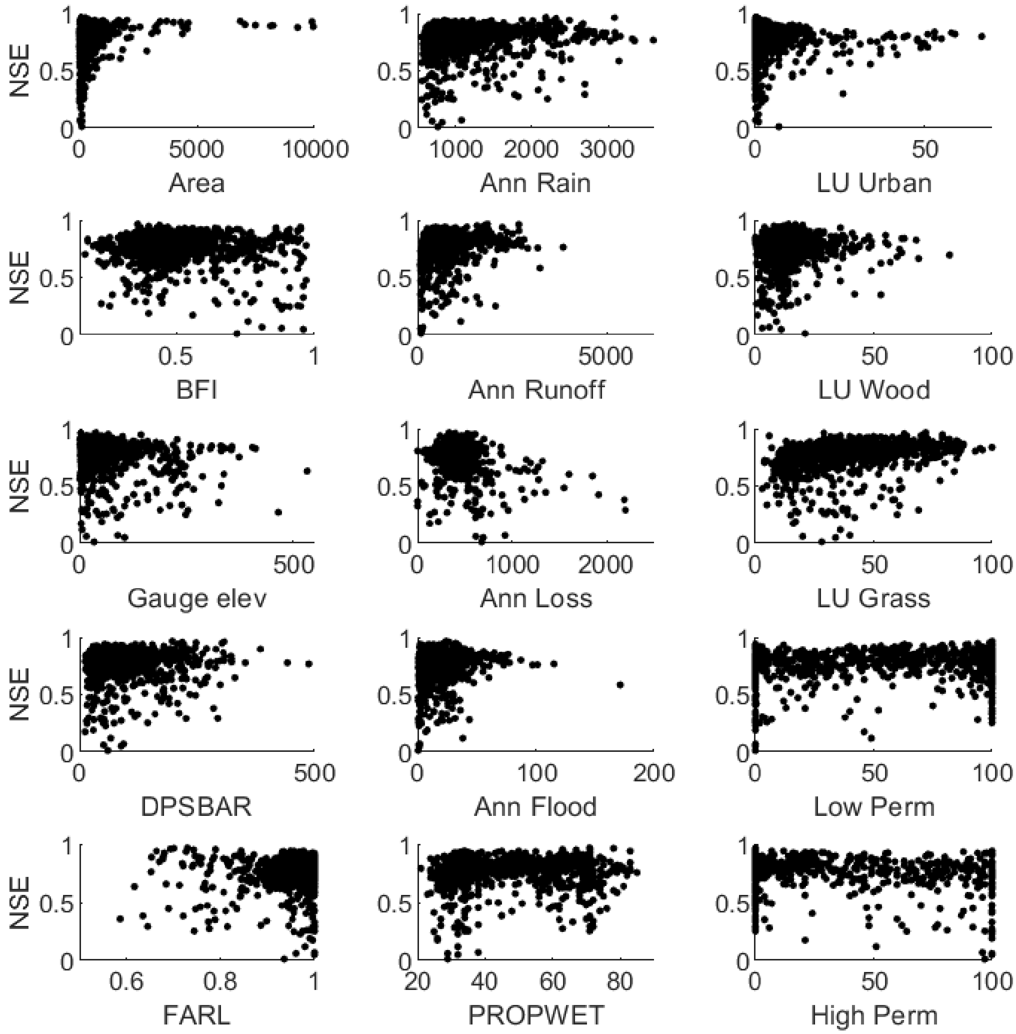

Figure S1: Relationship between NSE and a selection of 15 catchment descriptor variables. Column 1 gives general catchment attributes from the hydrometric register (Marsh and Hannaford, 2008). These are catchment area (km^2), Baseflow index (BFI), Gauge elevation (m above sea level), mean drainage path slope (DPSBAR) which indicates overall catchment steepness in metres per kilometre, and flood attenuation by reservoirs and lakes (FARL) where values close to 1 indicate the absence of flow attenuation and values below 0.8 indicate a substantial influence. Column 2 gives hydroclimatic attributes calculated from our data, and proportion catchment is wet (PROPWET) from the hydrometric register. Annual Loss is Rainfall-Runoff, whilst Annual flood is the Median Annual maximum flood peak, and all are reported in mm. Column 3 gives land-use and bedrock permeability descriptors (%), also from the UK hydrometric register.

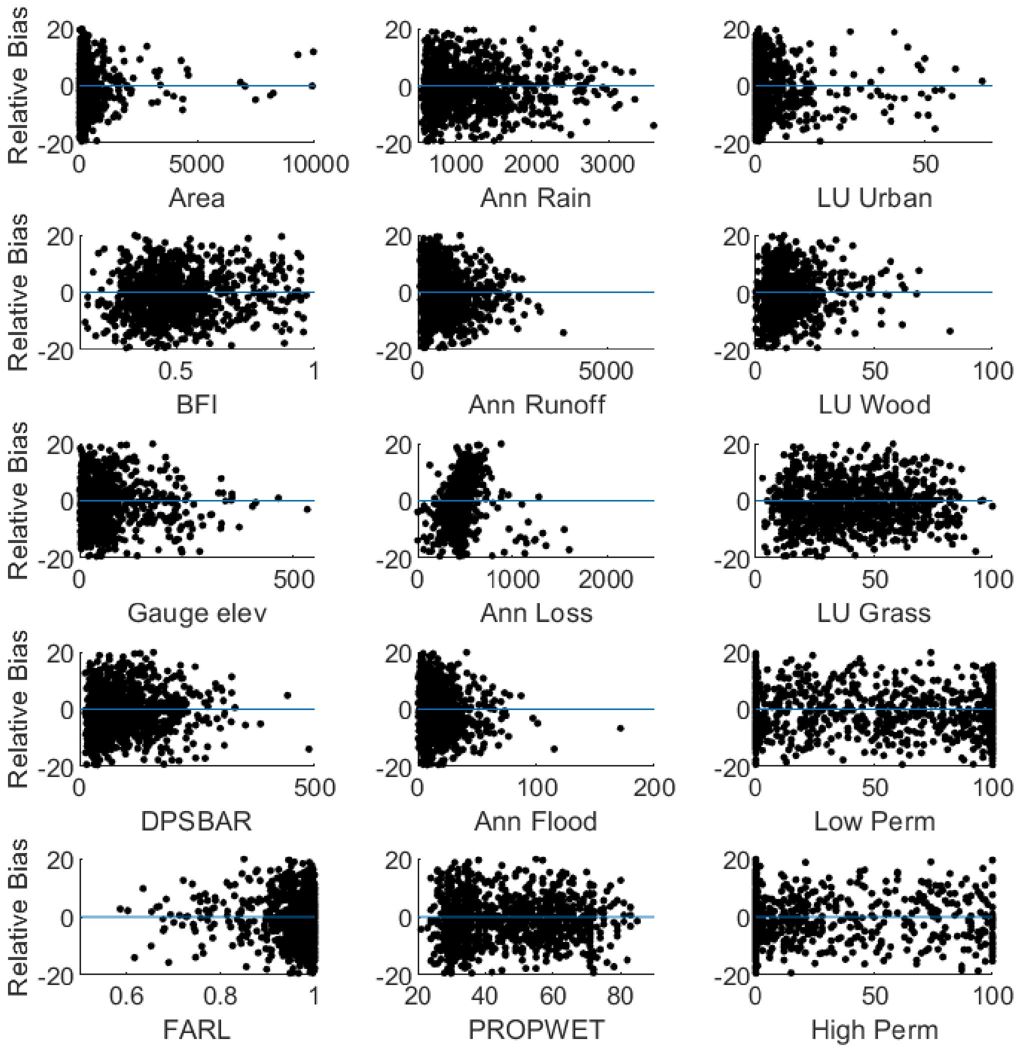

Figure S2: Relationship between bias and a selection of 15 catchment descriptor variables, as in Figure S1.

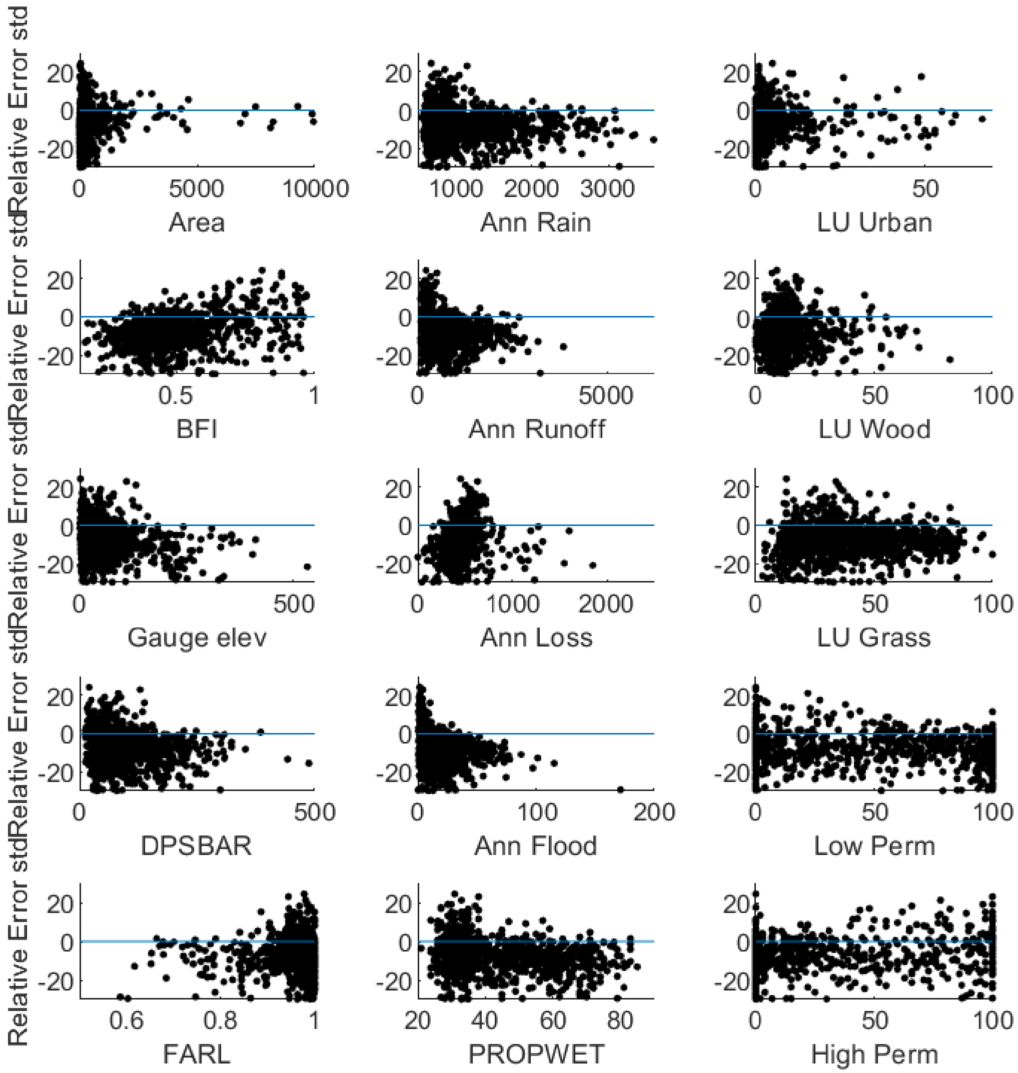

Figure S3: Relationship between error in standard deviation and a selection of 15 catchment descriptor variables, as in Figure S1.

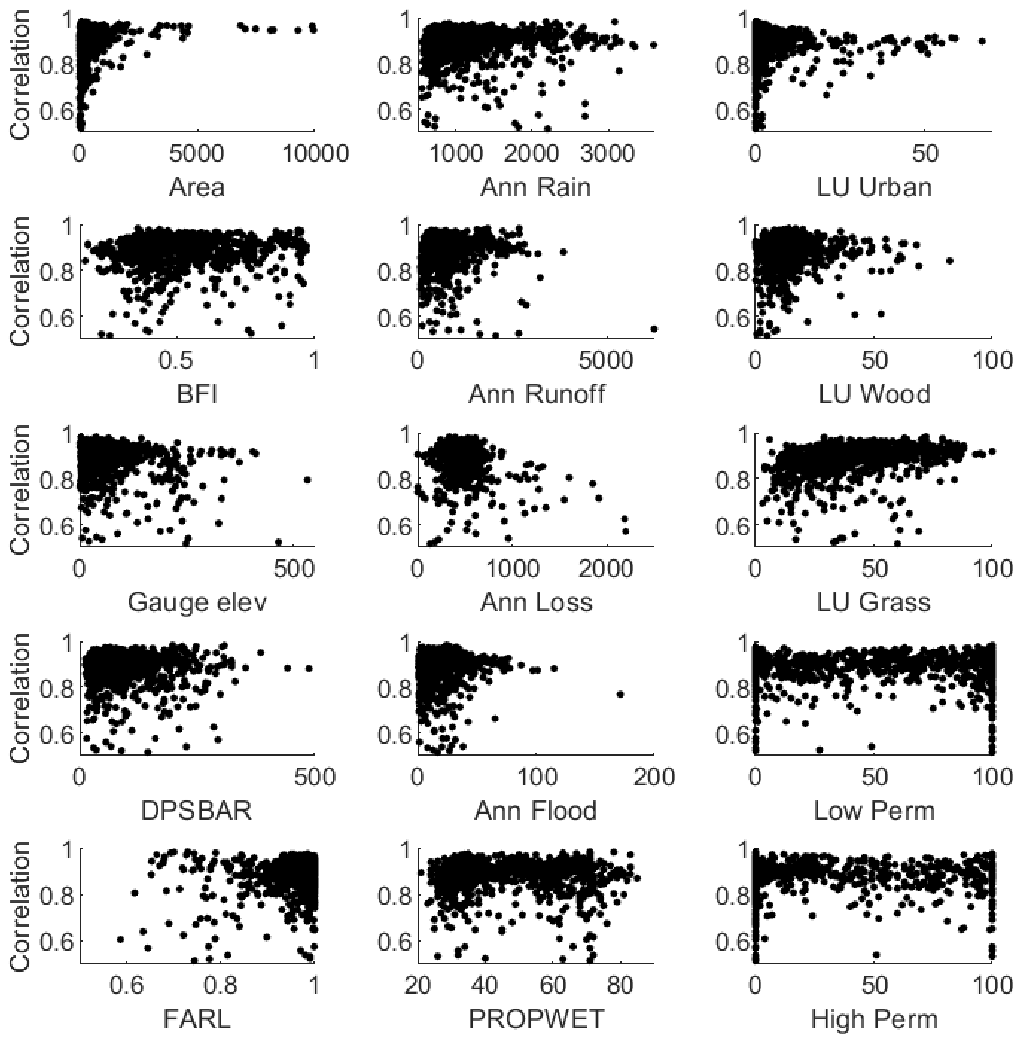

Figure S4: Relationship between correlation and a selection of 15 catchment descriptor variables, as in Figure S1.

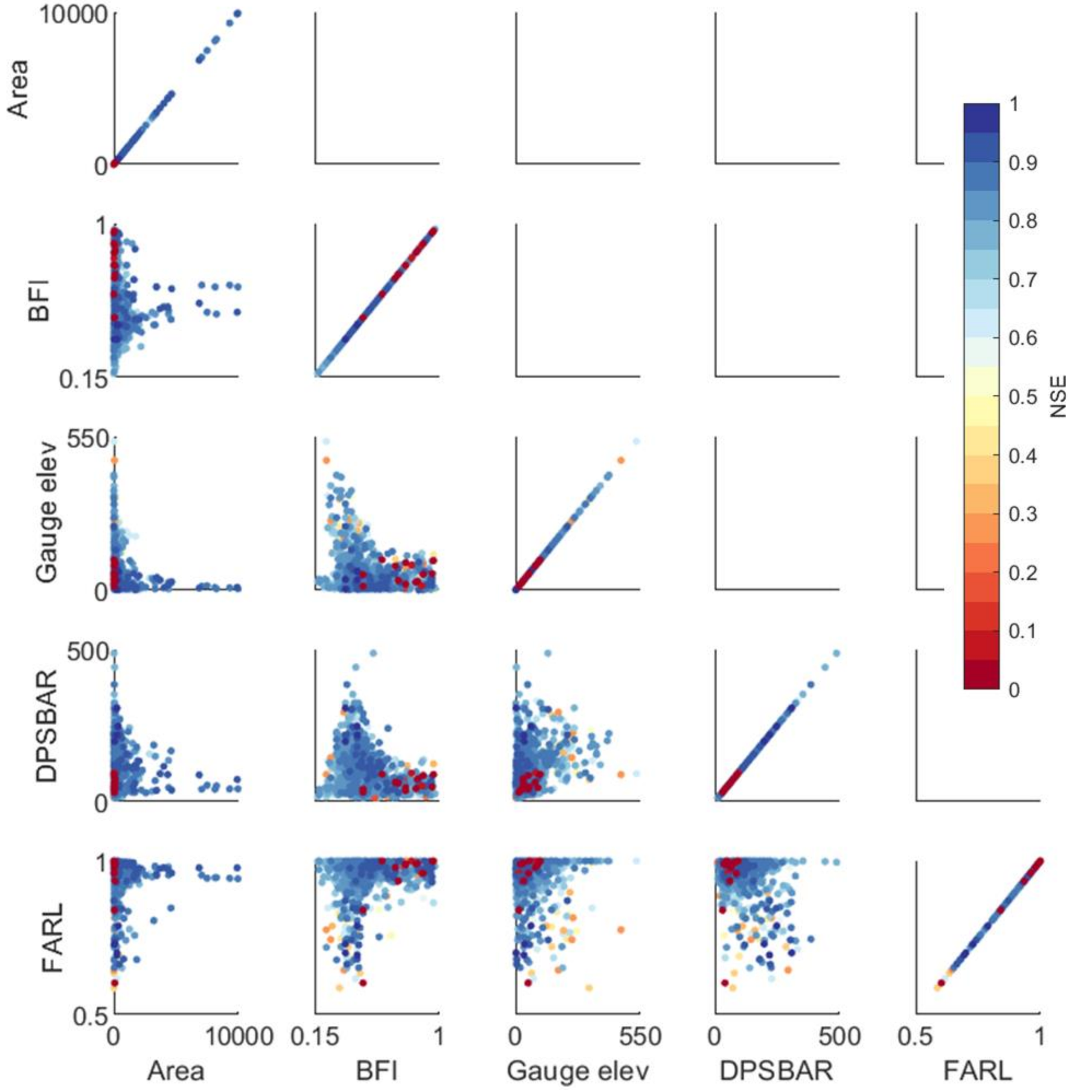

Figure S5: Relationship between general catchment characteristics, coloured by model ensemble NSE score for that catchment. Column 1 gives general catchment attributes from the hydrometric register (Marsh and Hannaford, 2008). These are catchment area (km^2), Baseflow index (BFI), Gauge elevation (m above sea level), mean drainage path slope (DPSBAR) which indicates overall catchment steepness in metres per kilometre, and flood attenuation by reservoirs and lakes (FARL) where values close to 1 indicate the absence of flow attenuation and values below 0.8 indicate a substantial influence. Column 2 gives hydroclimatic attributes calculated from our data, and proportion catchment is wet (PROPWET) from the hydrometric register. Annual Loss is Rainfall-Runoff, whilst Annual flood is the Median Annual maximum flood peak, and all are reported in mm. Column 3 gives land-use and bedrock permeability descriptors (%), also from the UK hydrometric register.

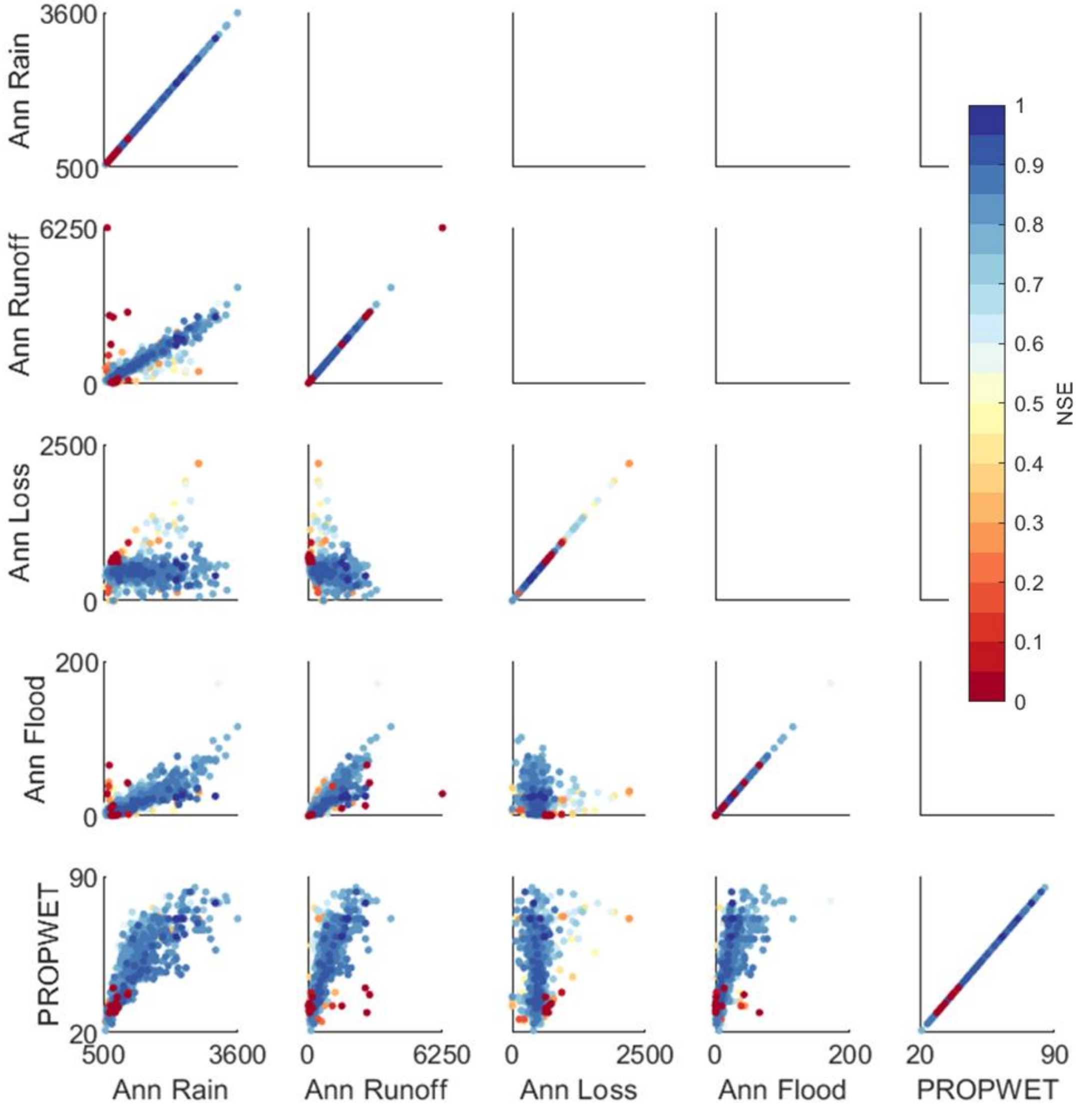

Figure S6. Same as figure S5, but this time looking at hydroclimatic catchment descriptors. Annual rainfall (mm), annual runoff (mm), annual loss (mm) and mean annual maximum flood (mm), were all calculated from the model input data used in this study. PROPWET is a measure of the percentage of time soils are wet, as calculated by the UK hydrometric register (Marsh and Hannaford, 2008).