Figure S1: Sub-basin discretization for HBV model (left, Huiskes 2016) and SPHY(right). HBV model used 134 sub basins to calibrate the model whereas, SPHY model was calibrated at 7 sub basins. The major sub-basin in the model are delineated at the same location.
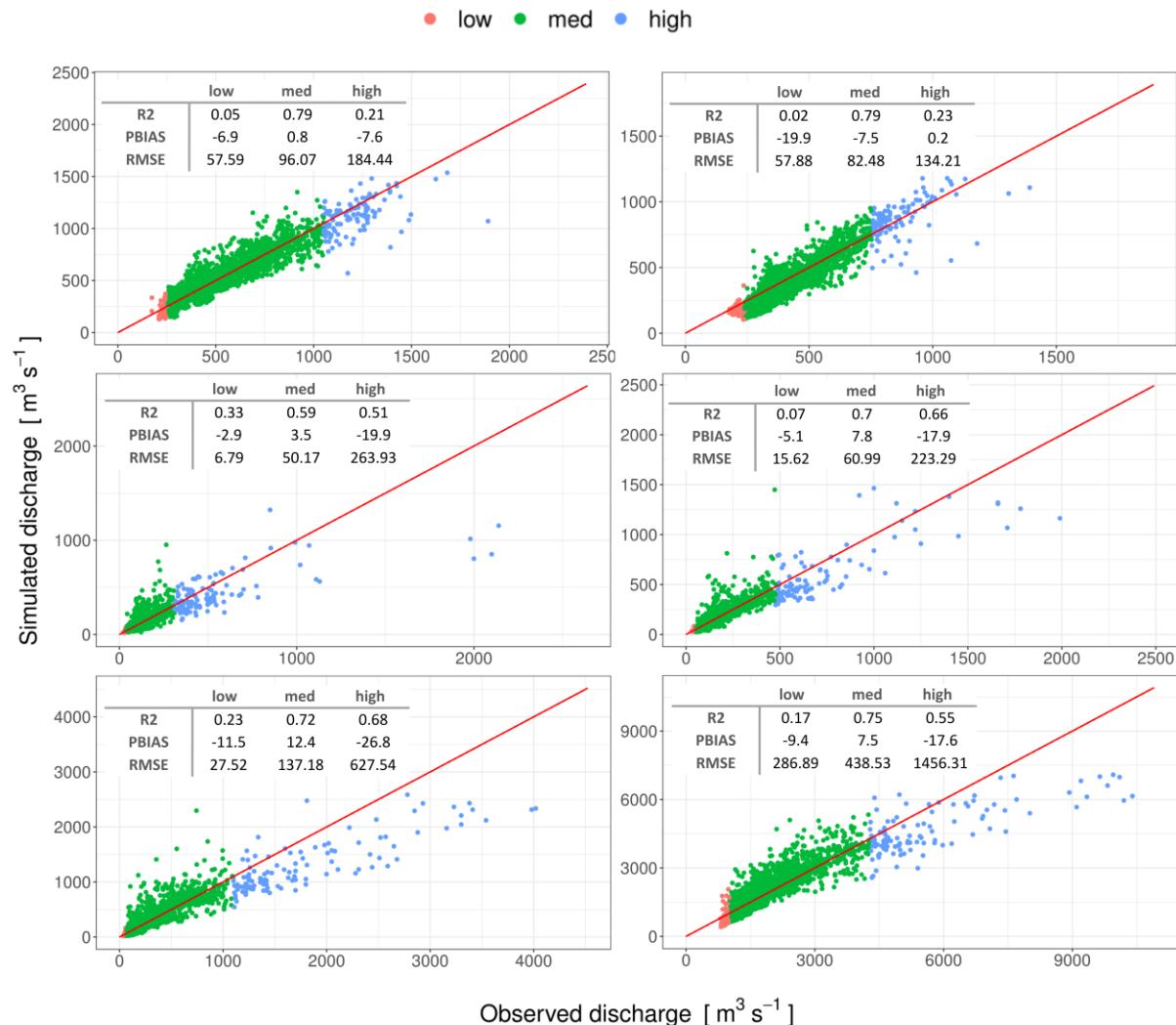
Figure S2. Observed versus modeled daily streamflow at (a) Untersiggenthal (b) Reckingen (c) Rockenau, (d) Frankfurt (e) Cochem and (f) Andernach for SPHY model. Colours indicate three ranges based on observed percentiles: "low" (<5%, red), "med" (5-95%, green) and "high" (>95%, blue). The solid red line represents the 1:1 slope. The tables on the figure represent the performance statistics coefficient of determination (R2), percent bias (PBIAS, %) and root mean square error (RMSE, m3/s) for three ranges of quantiles.
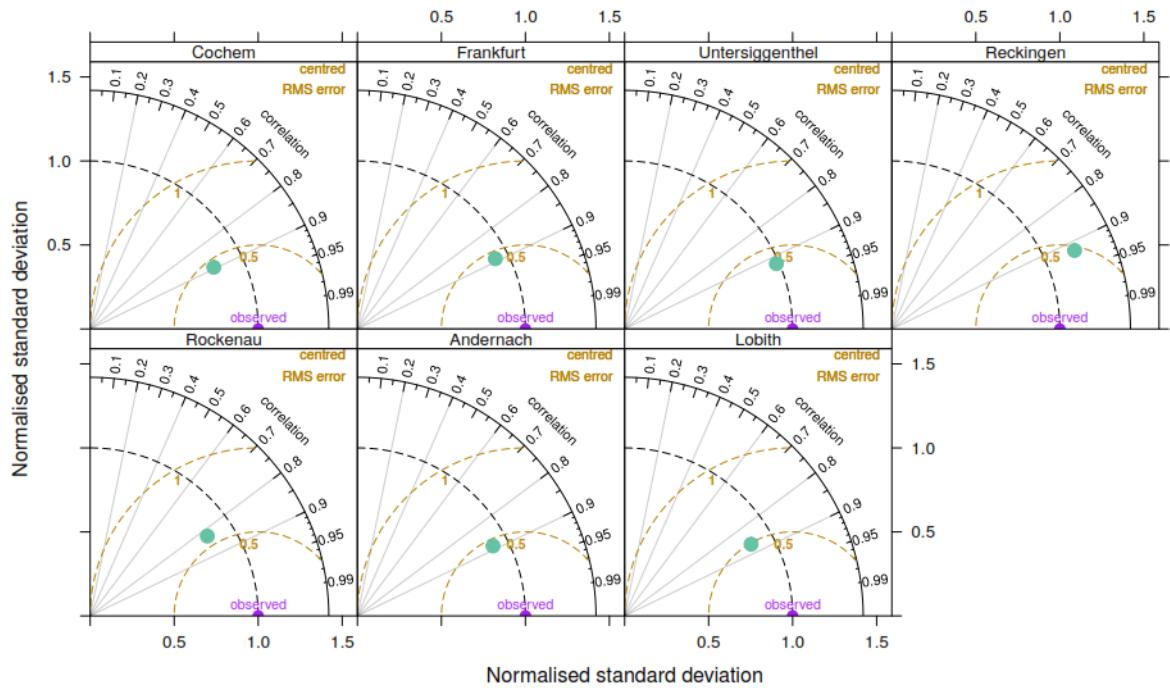
Figure S3. Taylor diagram at different locations for SPHY model. The axis represents the normalized standard deviation (sd). The purple triangle represents the observed and the green dot represents the simulated discharge respectively. These statistics compared here are correlation coefficient (R), sd and root-mean-square error. The plot is made using "TaylorDiagram" function from "open air" R package (Carslaw and Ropkins 2012).
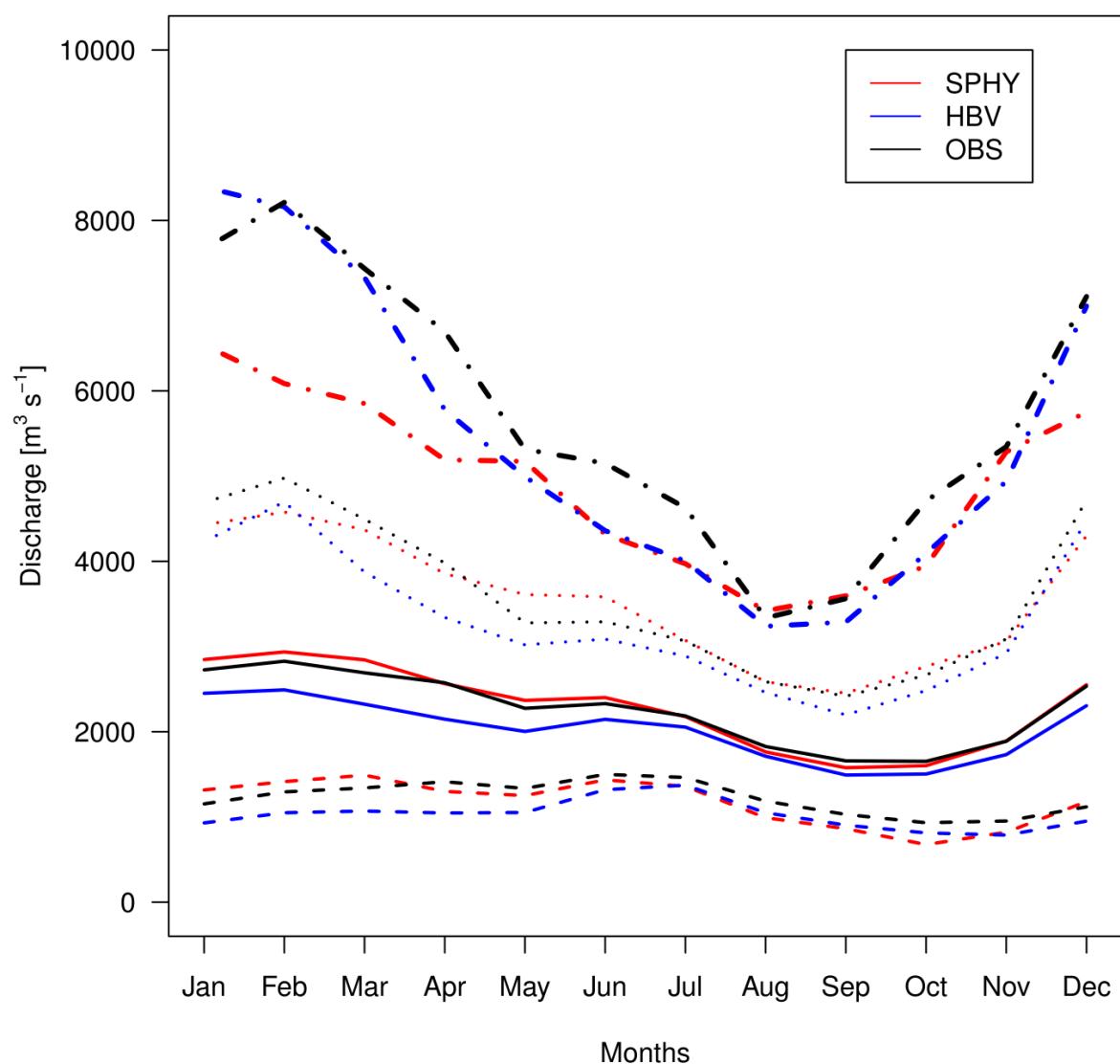
Figure S4: Seasonal cycle for the SPHY (red), HBV (blue) and Observations (black) for 1951-2000. The different line types indicate the 10th quantile (dash line), mean (solid line), 90th quantile (dotted line) and 99th quantile (dot dash line).
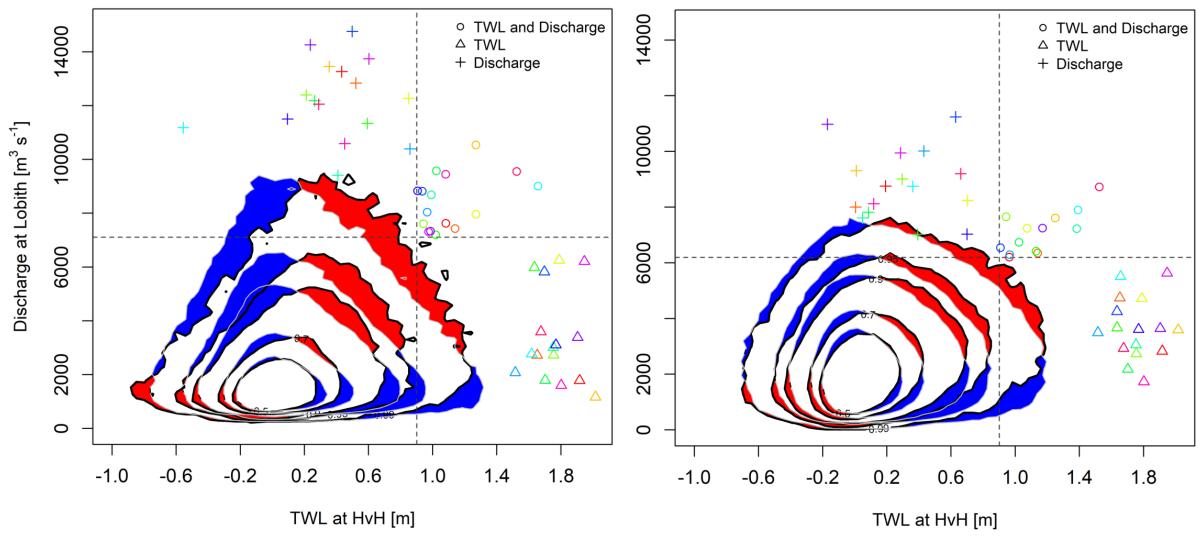
Figure S5: 2d-density estimate for total water level at HVH and discharge at Lobith (6-day lagged) for winter six months period (left-HBV and right-SPHY). The contours show various percentiles of the distribution (50th,70th ,90th ,95th and 99th). Shading is used to contrast density estimates from direct model output and randomized (shuffled) data, where correlations have been artificially removed. Red/blue shading indicates regions where model data is more/less populated than the shuffled data. The thin dashed lines show the 99% quantiles of each variable. The colored points correspond to the highest surge (Δ), discharge (+) and compound events (o) for individual ensemble members.

References

Carslaw D and Ropkins K 2012 openair - An R package for air quality data analysis *Environ. Model. Softw.* **27**–**28** 52–61

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