Supplemental Material

I. Streamflow Drought Analysis (Section 2.2)

The Distributed Hydrology Soil Vegetation Model (DHSVM; Wigmosta et al. 1994) is a spatially distributed watershed model that employs full mass and energy balance to simulate key hydrological processes. As applied in the Delaware Bay Estuary, DHSVM was configured at a 90-m spatial resolution and ran on a 3-hourly timestep. The model was driven by the Weather Research and Forecasting (WRF) downscaled Fifth Generation European Centre for Medium-Range Weather Forecasts (ECMWF) Atmospheric Reanalysis (ERA5), spanning from 1980 to 2020. Simulations from the initial two-year spin-up period was excluded from our analysis. The performance of DHSVM in replicating historical flow regimes was assessed at both daily and monthly scales (see Figure S1 and Table S1 in the supplemental). Overall, the DHSVM streamflow agreed well with the observations obtained from six United States Geological Survey (USGS) gauges located along the Delaware River mainstem, which have long-term available data. The Kling-Gupta Efficiency (KGE; Gupta et al. 2009) of daily streamflow ranges from 0.61 to 0.73. The physics of DHSVM are extensively documented in previous studies (e.g., Wigmosta et al. 1994, Sun et al. 2015, Perkins et al. 2019). For development and application of DHSVM in the Delaware River basin, the readers are referred to Deb et al. (2023) and Sun et al. (2024).

The drought condition was determined using the Standardized Streamflow Index (SSI), calculated as the standard normal deviate associated with the percentile of accumulated runoff over a given period (e.g., 3-6 months). Here, the SSI were derived using a nonparametric approach as described in Hao et al. (2014) using a 3-month sliding window. Specifically, the 3-month SSI compares the streamflow over a specific 3-month period in a given year with the streamflow marginal probability distribution for the same 3-month period across all years (i.e., 1982-2020). In this method, the marginal probability distribution of streamflow is computed using the empirical Gringorten plotting position. Drought conditions are classified based on the SSI values according to the U.S. Drought Monitor categories ranging from D0 to D4. D0 indicates abnormally dry condition (SSI between -0.50 and -0.79), D1 moderate drought (SSI between -0.80 and -1.29), D2 severe drought (SSI between -1.3 and -1.59) , D3 extreme drought (SSI between -1.6 and -1.99) and D4 exceptional drought (SSI < -2.00).

The worst drought was defined by the longest duration of the lowest SSI at -2.2. In Trenton, the worst drought began in July 1993, lasting three months with an SSI of -2.2. In Schuylkill, the worst drought started in November 2001 with an SSI of -2.2 for five consecutive months.

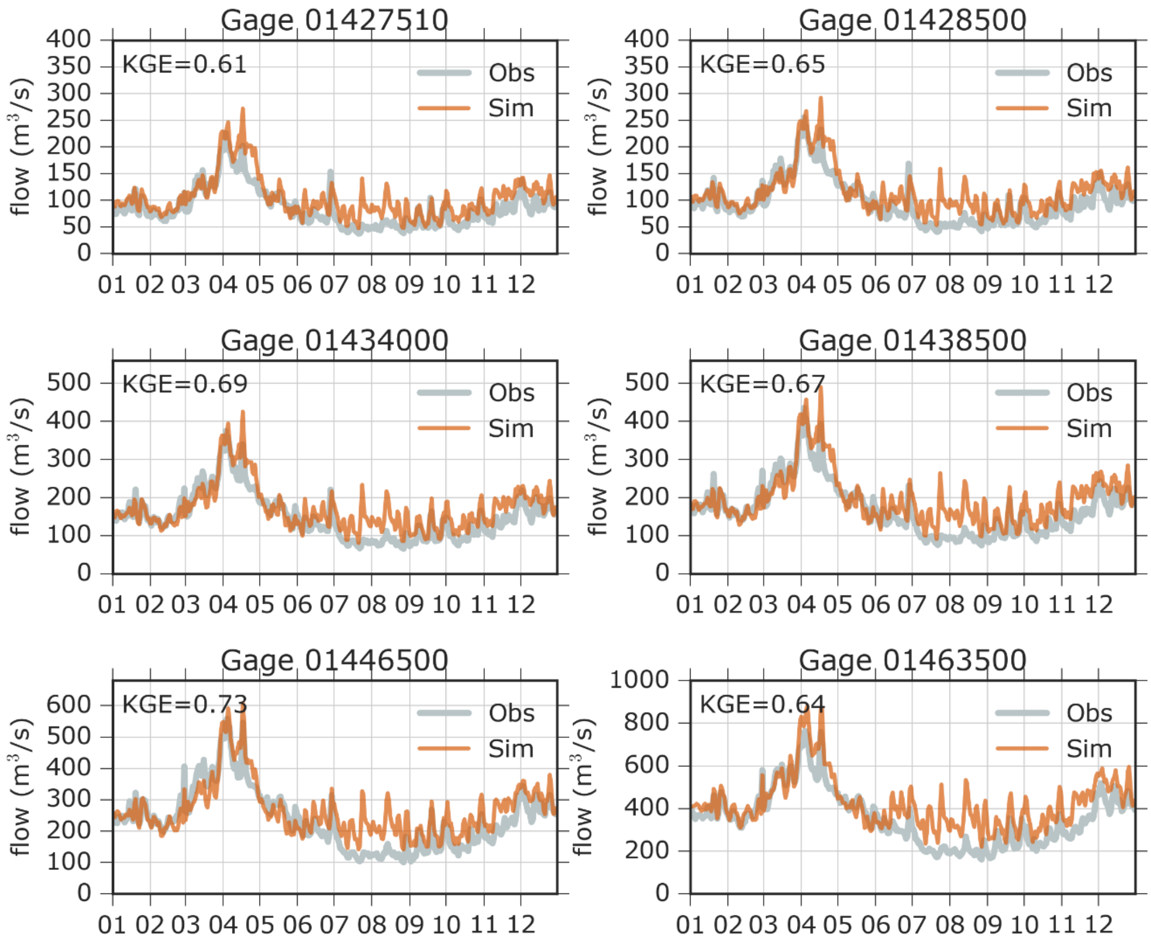


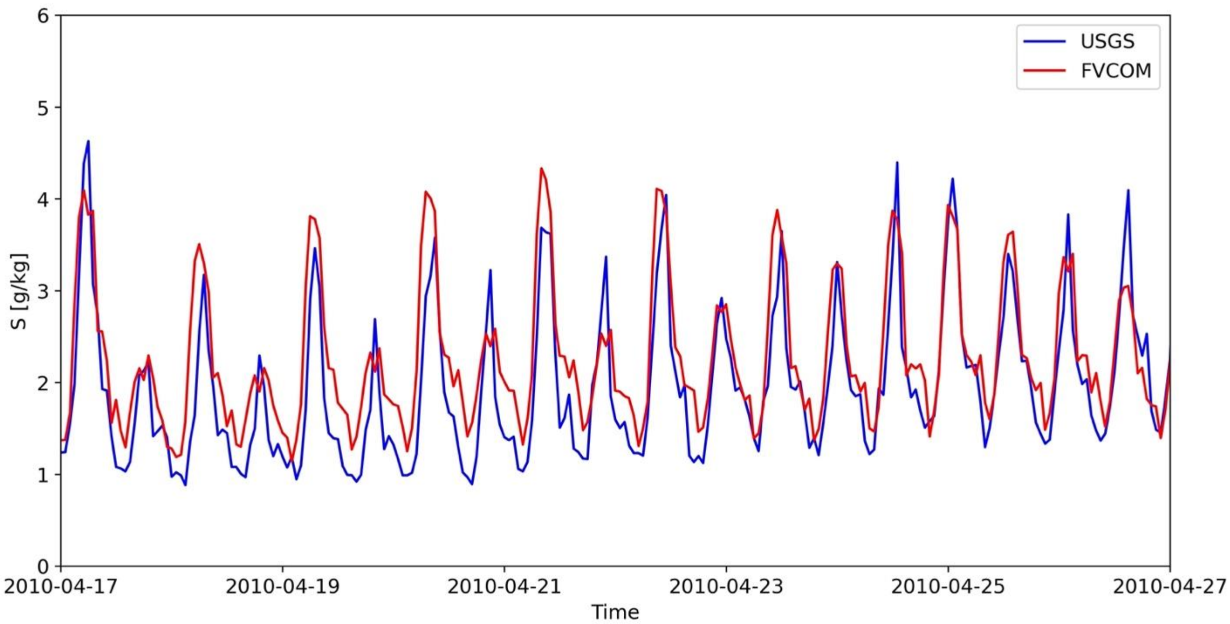
Figure S1. Comparison of mean daily flow between DHSVM simulations and USGS flow records at six gage locations along the Delaware River. Mean daily flow was calculated for each day of the year by averaging flows on the same day across all years from 1982–2020 for all basins.

Table S1. USGS gages used for evaluating simulated daily streamflow.

Gage ID	Latitude	Longitude	Drainage Area (sq mi)	KGE
01427510	41.757	-75.057	1820	0.61
01428500	41.509	-74.986	2020	0.65
01434000	41.371	-74.698	3076	0.69
01438500	41.309	-74.795	3480	0.67
01446500	40.826	-75.083	4535	0.73
01463500	40.222	-74.778	6780	0.64

II. Model Description and Configuration

The comparison between modeled and observed salinity at Reedy Island Jetty, DE (USGS 1482800) is shown in Figure S2.



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