**Supplementary Material**

**Assessment of the effectiveness of a multi-site stochastic weather generator on hydrological modelling in the Red Deer River watershed, Canada**

C. Dai and X.S. Qin

**Table S1.** Data used for the SWAT model configuration.

|  |  |  |  |
| --- | --- | --- | --- |
| Data | Purpose | Characteristic | Source |
| DEM | Subbasin delineation | Resolution of 90 × 90 m; data rang of [578, 3,231] m referring to Figure 1. | NASA Shuttle Radar Topographic Mission (SRTM) project ([Jarvis *et al.* 2008](#_ENREF_4)) |
| Land use data | HRU definition | Resolution of 400 × 400 m; seven categories reclassified for matching SWAT land use database | USGS Global Land Cover Characterization (GLCC) database ([Brown *et al.* 1999](#_ENREF_1)) |
| Soil data | HRU definition | 1: 5000 thousand scale; nine soil types; two-layer physical property was estimated based on SPAW tool b | Food and Agriculture Organization of the United Nations (FAO) ([Nachtergaele *et al.* 2009](#_ENREF_5)) |
| Precipitation data | Meteorological forcing | Four stations, as shown in Table 1 and Figure 1 | Government of Canada (http://climate.weather.gc.ca) |
| Other meteorological data a | Meteorological forcing | 36-year data from 1979 to 2014; data are available at 0.3 degree resolution | National Centers for Environmental Prediction’s Climate Forecast System Reanalysis (CFSR) ([Dile and Srinivasan 2014](#_ENREF_2)) |
| Streamflow data | Calibration and validation | Daily monitoring data from 1979 to 2005 for the streamflow gauging station (05CK004) at the estuary of Red Deer River (Figure 1) | Environment Canada (http://www.ec.gc.ca/rhc-wsc) |

Notes: a Other meteorological data includes air temperature, relative humidity, wind speed and solar radiation; b SPAW (soil-plant-air-water) tool can be used to simulate soil water tension, conductivity and water holding capability, which can be downloaded from https://www.ars.usda.gov ([Saxton *et al.* 2006](#_ENREF_6))

**Table S2.** Description of the selected parameters for the SWAT model.

|  |  |  |  |
| --- | --- | --- | --- |
| Hydrological process | Parameter | File extension | Description a |
| Snow | SFTMP | Sub | Snow fall temperature (ºC) |
| SMTMP | Sub | Snowfall melt base temperature (ºC) |
| SMFMX | Sub | Maximum melt rate for snow during the year (mm/ºC-d) |
| SMFMN | Sub | Minimum melt rate for snow during the year (mm/ºC-d) |
| TIMP | Sub | Snow pack temperature lag factor |
| Groundwater | ALPHA\_BF | gw | Base flow alpha factor (d) |
| REVAPMN | gw | Threshold depth of water in the shallow aquifer for re-evaporation to occur (mm) |
| GW\_DELAY | gw | Groundwater delay time (days) |
| GW\_REVAP | gw | Groundwater re-evaporation coefficient |
| GWQMN | gw | Threshold depth of water in the shallow aquifer required for return flow to occur (mm) |
| RCHRG\_DP | gw | Deep aquifer percolation fraction |
| Soil | SOL\_AWC | sol | Available water capacity |
| SOL\_K | sol | Soil conductivity (mm/h) |
| Evaporation | EPCO | hru | Plant evaporation compensation factor |
| ESCO | hru | Soil evaporation compensation factor |
| Interflow | OV\_N | hru | Manning’s *n* for overland flow |
| SLSUBBSN | hru | Average slope length (m) |
| Runoff | CN2 | mgt | SCS runoff curve number for moisture condition II |
| Stream | CH\_N2 | rte | Manning’s *n* for the main channel |
| CH\_K2 | rte | Effective hydraulic conductivity in the main channel (mm/h) |

Note: a the description of such parameters referred to [Faramarzi *et al.* (2015](#_ENREF_3)).

G:\Papers\B7p-16# Stochastic weather generator for flow response assessment\Computation\figure_2_statis rainfall and calulate the correlation of stations\plotMonthAveragePcp.tif G:\Papers\B7p-16# Stochastic weather generator for flow response assessment\Computation\figure_2_statis rainfall and calulate the correlation of stations\plotCorrelationByDistance.tif

**Figure S1.** The statistical characteristic of the climate stations: (a) the multi-year average monthly precipitation amount and (b) the annual inter-station spatial correlation.



G:\Papers\B7p-16# Stochastic weather generator for flow response assessment\Computation\stochastic weather generator\comparison_(timeSeries)\coninuityRation_forStatistics(d).tif

**Figure S2.** Scatterplots of (a) mean, (b) standard deviation, (c) maximum daily, and (d) continuity ratio of the observed *vs* generated precipitation series for all seasons and station pairs.

F:\Papers\B7p-16# Stochastic weather generator for flow response assessment\Response\caculation\comparison_for_pdf\station1.tif

**Figure S3.** Fitting performance of monthly precipitation amount using different distributions at the Oyen Cappon station.

F:\Papers\B7p-16# Stochastic weather generator for flow response assessment\Response\caculation\comparison_for_pdf\station2.tif

**Figure S4.** Fitting performance of monthly precipitation amount using different distributions at the Brooks North station.

F:\Papers\B7p-16# Stochastic weather generator for flow response assessment\Response\caculation\comparison_for_pdf\station3.tif

**Figure S5.** Fitting performance of monthly precipitation amount using different distributions at the Drumheller Andrew station.

F:\Papers\B7p-16# Stochastic weather generator for flow response assessment\Response\caculation\comparison_for_pdf\station4.tif

**Figure S6.** Fitting performance of monthly precipitation amount using different distributions at the Sundre Garrington station.

F:\Papers\B7p-16# Stochastic weather generator for flow response assessment\Response\caculation\comparison_for_mean_max_std\MeanSeason_forStatistics(a).tifF:\Papers\B7p-16# Stochastic weather generator for flow response assessment\Response\caculation\comparison_for_mean_max_std\StdSeason_forStatistics(b).tifF:\Papers\B7p-16# Stochastic weather generator for flow response assessment\Response\caculation\comparison_for_mean_max_std\MaxSeason_forStatistics(c).tif

**Figure S7.** Scatterplots of (a) mean, (b) standard deviation, and (c) maximum daily of the observed *vs* generated precipitation series by WGEN using different distributions for all seasons and station pairs.

G:\Papers\B7p-16# Stochastic weather generator for flow response assessment\Computation\stochastic weather generator\comparison_search_process\searchOcc1.tifG:\Papers\B7p-16# Stochastic weather generator for flow response assessment\Computation\stochastic weather generator\comparison_search_process\searchAmount (1b).tifG:\Papers\B7p-16# Stochastic weather generator for flow response assessment\Computation\stochastic weather generator\comparison_search_process\searchOcc (2c).tif G:\Papers\B7p-16# Stochastic weather generator for flow response assessment\Computation\stochastic weather generator\comparison_search_process\searchAmount (2d).tif

G:\Papers\B7p-16# Stochastic weather generator for flow response assessment\Computation\stochastic weather generator\comparison_search_process\searchOcc (4e).tif G:\Papers\B7p-16# Stochastic weather generator for flow response assessment\Computation\stochastic weather generator\comparison_search_process\searchAmount (4f).tifG:\Papers\B7p-16# Stochastic weather generator for flow response assessment\Computation\stochastic weather generator\comparison_search_process\searchOcc (5g).tifG:\Papers\B7p-16# Stochastic weather generator for flow response assessment\Computation\stochastic weather generator\comparison_search_process\searchAmount (5h).tif

**Figure S8.** Left: search processes of MBAF *vs* (a) MGA1, (c) MGA2, (e) MGA4, and (g) MGA5 for generating the precipitation occurrence. Right: search processes of MBAF *vs* (b) MGA1, (d) MGA2, (f) MGA4, (h) MGA5 for generating the precipitation amount.

F:\Papers\B7p-16# Stochastic weather generator for flow response assessment\Response_round2\flow_response\pdf_PIII\fiting_pdf (a).tifF:\Papers\B7p-16# Stochastic weather generator for flow response assessment\Response_round2\flow_response\pdf_PIII\fiting_pdf (b).tif

F:\Papers\B7p-16# Stochastic weather generator for flow response assessment\Response_round2\flow_response\pdf_PIII\fiting_pdf (c).tifF:\Papers\B7p-16# Stochastic weather generator for flow response assessment\Response_round2\flow_response\pdf_PIII\fiting_pdf (d).tif

**Figure S9.** Probability distribution fitting for the annual maximum flows simulated by SWAT using (a) observed, (b) WGEN-generated, (c) MBFA-generated and (d) MGA3-generated precipitation series. Note: the benchmark is frequency distribution.

F:\Papers\B7p-16# Stochastic weather generator for flow response assessment\Response_round2\flow_response\cdf_PIII\fiting_cdf (a).tifF:\Papers\B7p-16# Stochastic weather generator for flow response assessment\Response_round2\flow_response\cdf_PIII\fiting_cdf (b).tif

F:\Papers\B7p-16# Stochastic weather generator for flow response assessment\Response_round2\flow_response\cdf_PIII\fiting_cdf (c).tifF:\Papers\B7p-16# Stochastic weather generator for flow response assessment\Response_round2\flow_response\cdf_PIII\fiting_cdf (d).tif

**Figure S10.** Cumulative distribution fitting for the annual maximum flows simulated by SWAT using (a) observed, (b) WGEN-generated, (c) MBFA-generated and (d) MGA3-generated precipitation series. Note: the benchmark is empirical distribution.

**References**

Brown, J. F.*, et al.*, 1999. The global land-gover gharacteristics database: The users' perspective. *Photogrammetric Engineering and Remote Sensing,* 65(9), 1069-1074.

Dile, Y. T. and Srinivasan, R., 2014. Evaluation of CFSR climate data for hydrologic prediction in data-scarce watersheds: an application in the Blue Nile River Basin. *Journal of the American Water Resources Association,* 50(5), 1226-1241.

Faramarzi, M.*, et al.*, 2015. Setting up a hydrological model of Alberta: Data discrimination analyses prior to calibration. *Environmental Modelling & Software,* 74, 48-65.

Jarvis, A.*, et al.*, 2008. Hole-filled SRTM for the globe Version 4. *available from the CGIAR-CSI SRTM 90m Database (*[*http://srtm.csi.cgiar.org)*](http://srtm.csi.cgiar.org)).

Nachtergaele, F.*, et al.*, 2009. Harmonized world soil database. *Wageningen: ISRIC (*[*http://www.fao.org/land-water/en/)*](http://www.fao.org/land-water/en/)).

Saxton, K. E., Willey, P. H. and Rawls, W. J., Field and pond hydrologic analyses with the SPAW model. ed. *2006 ASAE Annual Meeting*, 2006, 1.