Supplementary Materials

1. SWAT-MAD model setup

Topography, land use, soil, and slope

The digital elevation model (DEM) of the basin, with a horizontal resolution of 30×30 m was downloaded from the U.S. Geological Survey (USGS) (https://viewer.nationalmap.gov/basic/) and used for estimation of basin terrain characteristics. The 2008 National Agricultural Statistics Service Cropland Data Layer (NASS CDL) (http://nassgeodata.gmu.edu/CropScape/), with a spatial resolution of 30×30 m, was used for land use distribution. The dominant agricultural land uses in the basin in 2008 were irrigated and dryland cotton (*Gossypium hirsutum* L.), which occupied ~12% and 18% of the entire basin area, respectively (Fig. 1). Approximately 41% and 21% of the basin areas were covered by range brush and range grass, respectively. Soil data were obtained from the Soil Survey Geographic Database (SSURGO) (Soil Survey Staff 2014). The study basin was classified into four slope groups: ≤ 1%, 1%-3%, 3%-5%, and > 5%.

Hydrologic response units (HRUs)

The HRU is the basic building block of the SWAT-MAD model, which consists of homogeneous land cover/land use, soil properties, and slope. SWAT-MAD calculations are performed at the HRU level and are then aggregated to the subbasin outlet, which is routed through the river system. For the HRU definition, thresholds of 5%, 5%, and 10% were used for land use, soil, and slope, respectively. The subbasins and HRUs identified for the study basin were 60 and 2160, respectively.

Climate data

Daily climate data were obtained from the National Oceanic and Atmospheric Administration-National Centers for Environmental Information (NOAA-NCEI) for the period from 1990 to 2009. Data from a total of seven weather stations, which were located either inside or within a closer distance of the Double Mountain Fork Brazos basin, were used in this study (Fig. 1). These weather stations were very well distributed spatially across the basin. The missing precipitation, maximum temperature, and minimum temperature data for a weather station were manually filled with the average value of the weather parameter for two adjacent weather stations (Ale et al. 2009).

Management practices of major land uses

The management related parameters for cotton were specified based on the locally followed practices. Spring tillage was implemented for cotton (Table 2). Approximately 138 and 69 kg N ha^{-1} was applied to the irrigated and dryland cotton, respectively. The SWAT model calculates the heat unit accumulation for cotton maturity using different climatic data inputs (seven weather stations in this study) depending on the cotton planting locations. Different geographical locations with different meteorological data inputs can reflect spatial variations. In addition, remote sensing images were used to identify irrigated subbasins. Subbasins that contain a large number of circular fields, which represent center pivot irrigated areas, were considered as irrigated subbasins. It was also made sure that the total extent of the irrigated cotton area was approximately 39% of the entire cotton-growing areas (61% of dryland cotton) in the watershed according to the USDA-NASS reports at the county level (NASS 2019). Auto-irrigation was therefore simulated in approximately 39% of cotton planting area in the watershed based on a newly developed management allowed depletion method.

The land uses of range grass and range brush were simulated as Southwestern U.S. range and honey mesquite, respectively. The most commonly adopted heavy continuous grazing management practices were simulated on the range grass (Park et al. 2017). The detailed management related parameters for the range grass were set up according to Park et al. (2017) SWAT study in Clear Creek watershed in north central Texas. Biomass of honey mesquite at the beginning of the simulation was assumed as 19.4 Mg ha^{-1} according to Whisenant and Burzlaff (1978).

2. Observed streamflow, irrigation, and cotton yield data

Observed monthly streamflow data recorded at Gages I and II for the time period from 1994 to 2009 were downloaded from the USGS National Water Information System (http://waterdata.usgs.gov/nwis/sw) and used for SWAT-MAD calibration and validation. The measured county-level irrigation and cotton yields at Lynn County in the Double Mountain Fork Brazos basin were used to provide auxiliary data to calibrate the SWAT-MAD model. Specifically, the county-level observed irrigation survey data in 2000, 2003, 2008, and 2013 (NASS-Irrigation and Water Management Survey 2020) for irrigated cotton and crop yield data (NASS 2019) for irrigated and dryland cotton from 1994 to 2009 at Lynn County (Fig. 1) were used for SWAT-MAD calibration.

3. SWAT-MAD model calibration, validation, and evaluation

The first four years (1990-1993) of SWAT-MAD simulations were used as the warmup period. The streamflow data were divided into two parts, and the data for the 1994-2001 and 2002-2009 periods were used for model calibration and validation, respectively. The SWAT-MAD model calibration was performed in three steps. First of all, the sensitive model parameters were identified by performing sensitivity analysis using the SWAT Calibration and Uncertainty Procedures (SWAT-CUP) (Abbaspour et al. 2007). In the second step, auto-calibration was performed using the SUFI-2 procedure in the SWAT-CUP. During this step, sensitive model parameters were adjusted within ±10% range to obtain calibrated parameters for the Double Mountain Fork Brazos basin. Finally, the calibrated parameters were slightly adjusted manually to achieve the best calibrated SWAT-MAD model for the basin. The model was initially calibrated against the observed streamflow data recorded at Gage I by adjusting the parameters in all subbasins that contributed streamflow to Gage I. The model was then validated against the remaining streamflow data recorded at Gage I. After achieving a satisfactory calibration of the model for Gage I, the model was calibrated against the streamflow data recorded at Gage II. To start with, the calibrated parameter values that were obtained from model calibration for Gage I were used in all subbasins between Gage I and Gage II, and later they were adjusted as needed to obtain a better match between the simulated and observed streamflow at Gage II. The model was finally validated based on the remaining streamflow data recorded at Gage II.

After achieving a satisfactory streamflow calibration, the model was further calibrated for county-level irrigation and cotton lint yields under both irrigated and dryland conditions. Finally, after achieving good irrigation and crop yield calibrations, the model performance in streamflow prediction was re-evaluated, and necessary minor adjustments were made to initially calibrated streamflow-related parameters. The identified sensitive parameters and the calibrated values for the streamflow, irrigation, and crop yield simulations are listed in Table S1. The SWAT-MAD model performance in streamflow prediction during calibration and validation periods was evaluated using three different statistical measures: *NSE* (Nash and Sutcliffe 1970), coefficient of determination (R^2) (Legates and McCabe 1999), and percent bias (*PBIAS*) (Gupta et al. 1999). The

NSE indicates how well the plot of observed vs. simulated values fits on the 1:1 line. It ranges from -∞ to 1, and the *NSE* values closer to 1 indicate the better model performance. The R^2 represents the proportion of total variance in the observed data that can be explained by the model. The R^2 ranges from 0 to 1 with higher values denoting better model performance. The *PBIAS* varies between -100 and ∞, with smaller absolute values closer to 0 indicating better agreement.

Table S1 Default and calibrated values of hydrologic and cotton growth parameters using the SWAT-MAD model in the Double Mountain Fork Brazos basin

No.	Parameter	Description	Default value	Calibrated value	Source
Hydrological parameters					
1	ESCO	Soil evaporation compensation factor	0.95	0.75 (Gage I) [#] 0.80 (Gage II) ξ	--
2	SOL_AWC	Available soil water capacity (mm H_2O mm^{-1} soil)	0.1-0.17	10%	--
3	CN2	Curve number for moisture condition II	39-84	-11% (Gage I) -10% (Gage II)	--
4	ALPHA_BF	Base flow recession constant	0.048	0.0765	--
5	GW_REVAP	Groundwater "revap" coefficient	0.02	0.08 (Gage I) 0.06 (Gage II)	--
Irrigated cotton parameters					
1	BIO_E	Biomass/energy ratio [(kg ha^{-1})/(MJ m^{-2})]	15	12.6	Sarkar et al. (2011)
2	BLAI	Max leaf area index (m^2 m^{-2})	4.0	4.8	Sarkar et al. (2011)
3	RDMX	Maximum rooting depth (m)	2.5	2.0	--
4	T_OPT	Optimal temperature for plant growth (°C)	30	27.5	Williams et al. (2015)
5	T_BASE	Min temperature for plant growth (°C)	15	12.5	Williams et al. (2015)
Dryland cotton parameters					
1	BIO_E	Biomass/energy ratio [(kg ha^{-1})/(MJ m^{-2})]	15	14.15	Sarkar et al. (2011)
2	BLAI	Max leaf area index (m^2 m^{-2})	4.0	4.7	Sarkar et al. (2011)
3	RDMX	Maximum rooting depth (m)	2.5	2.0	--
4	WSYF	Lower limit of harvest index [(kg ha^{-1})/(kg ha^{-1})]	0.3	0.35	--
5	T_OPT	Optimal temperature for plant growth (°C)	30	27.5	Williams et al. (2015)
6	T_BASE	Min temperature for plant growth (°C)	15	12.5	Williams et al. (2015)

[#] Parameter changed for all the subbasins that discharged to Gage I
ξ Parameter changed for the subbasins between Gage I and Gage II

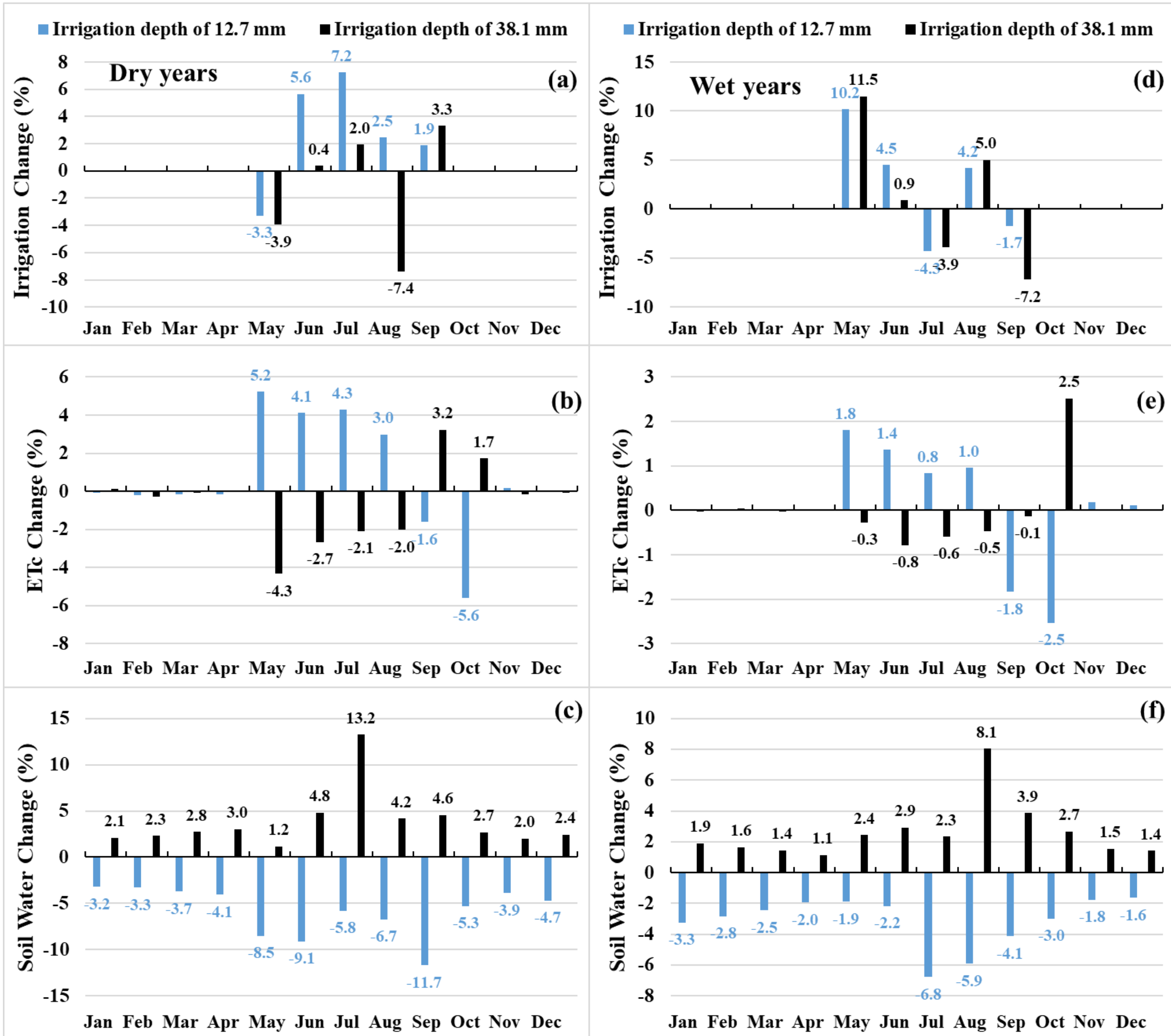

Figure S1. Change percentages of average monthly irrigation, crop evapotranspiration (ET_c), and soil water content under dry and wet years using different irrigation application depths relative to the baseline irrigation depth in the irrigated cotton HRUs in the Double Mountain Fork Brazos basin.

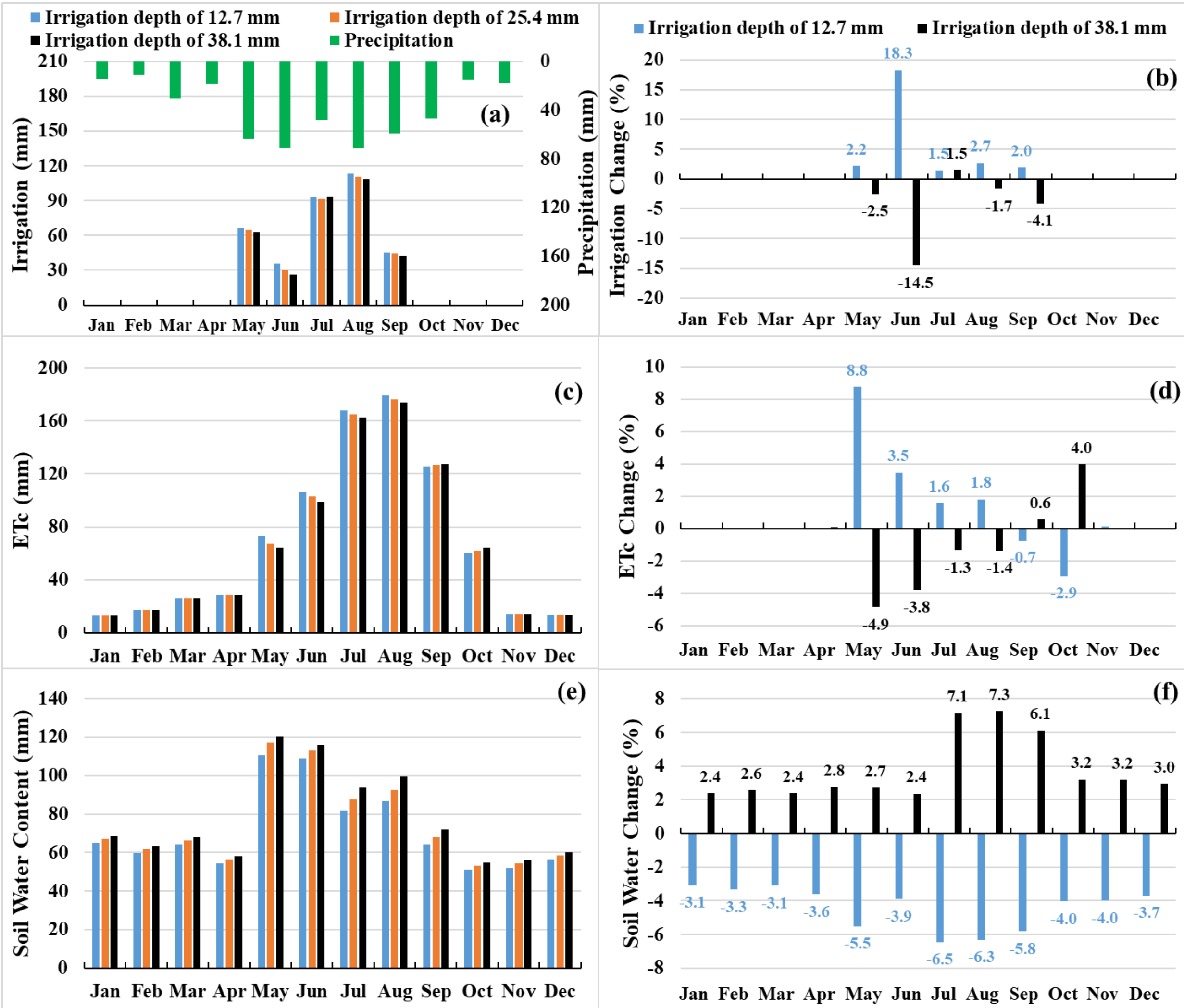

Figure S2. Comparison of average monthly irrigation, crop evapotranspiration (ET_c), and soil water content under normal years using different irrigation application depths in the irrigated cotton HRUs in the Double Mountain Fork Brazos basin.

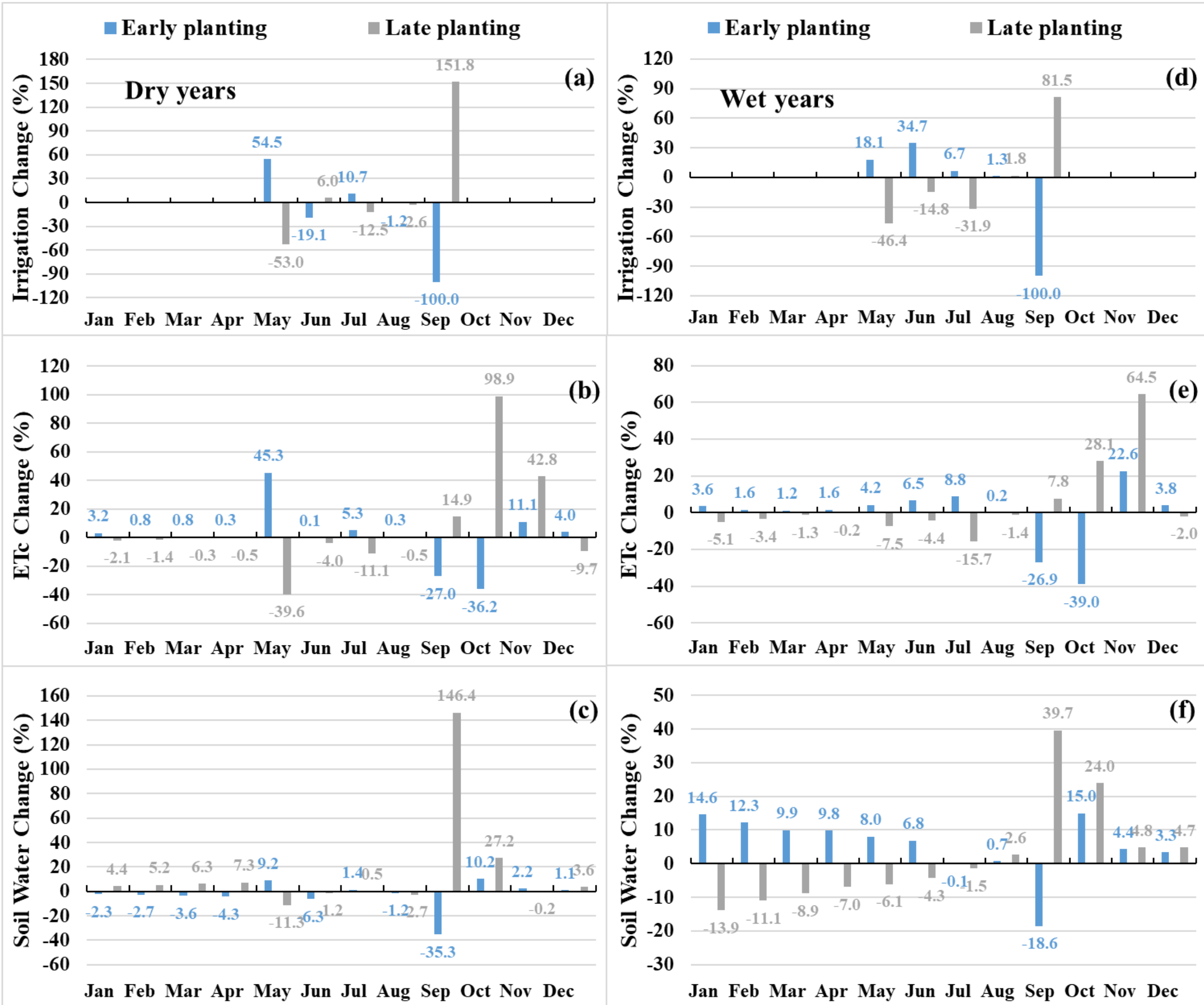

Figure S3. Change percentages of average monthly irrigation, crop evapotranspiration (ET_c), and soil water content under dry and wet years using various planting dates relative to the baseline planting date in the irrigated cotton HRUs in the Double Mountain Fork Brazos basin.

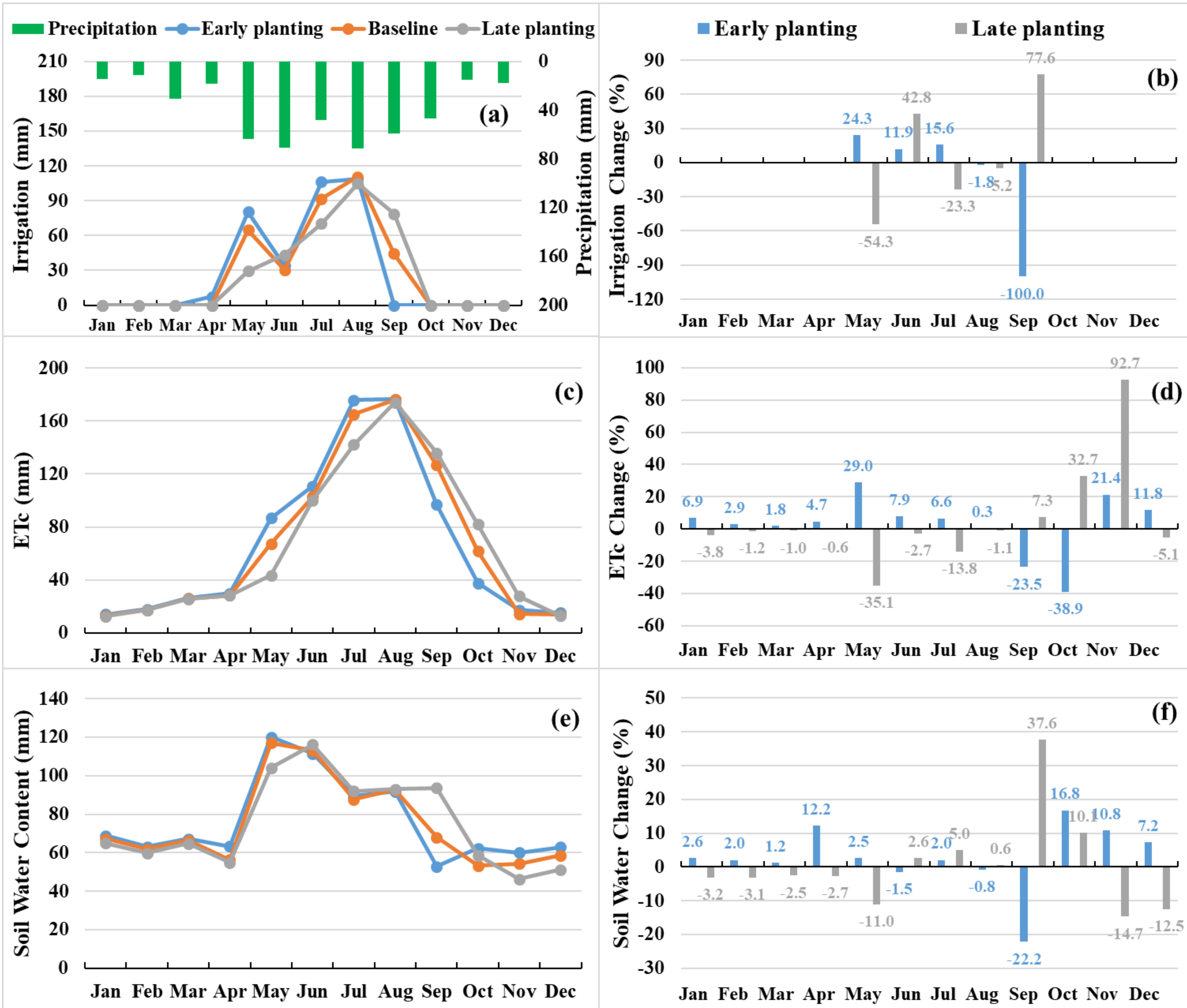

Figure S4. Comparison of average monthly irrigation, crop evapotranspiration (ET_c), and soil water content under normal years using various planting dates in the irrigated cotton HRUs in the Double Mountain Fork Brazos basin.

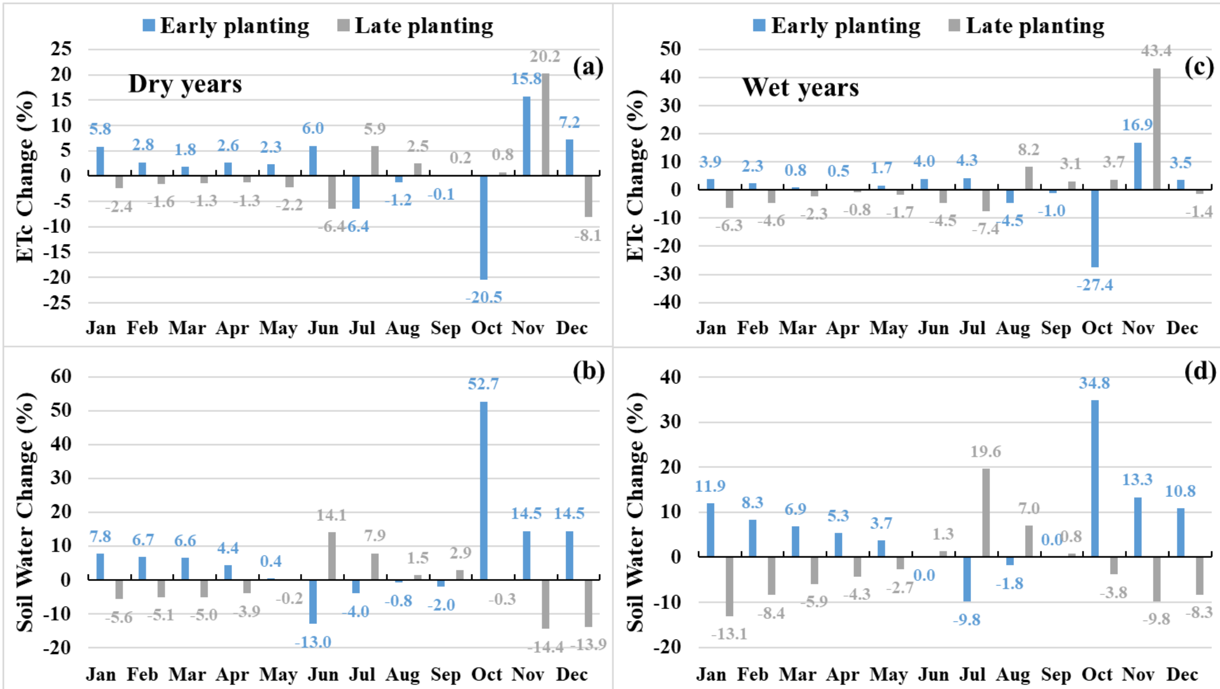

Figure S5. Change percentages of average monthly crop evapotranspiration (ET_c) and soil water content under dry and wet years using various planting dates relative to the baseline periods in the dryland cotton HRUs in the Double Mountain Fork Brazos basin.

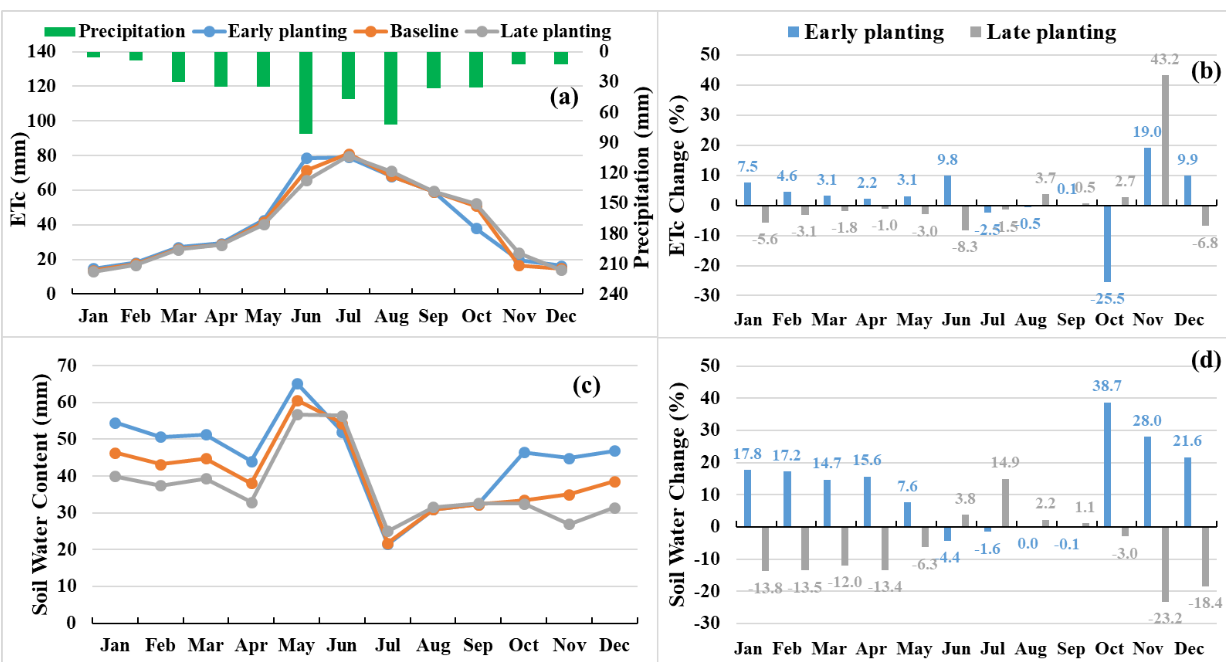

Figure S6. Comparison of average monthly crop evapotranspiration (ET_c) and soil water content under normal years using various planting dates in the dryland cotton HRUs in the Double Mountain Fork Brazos basin.

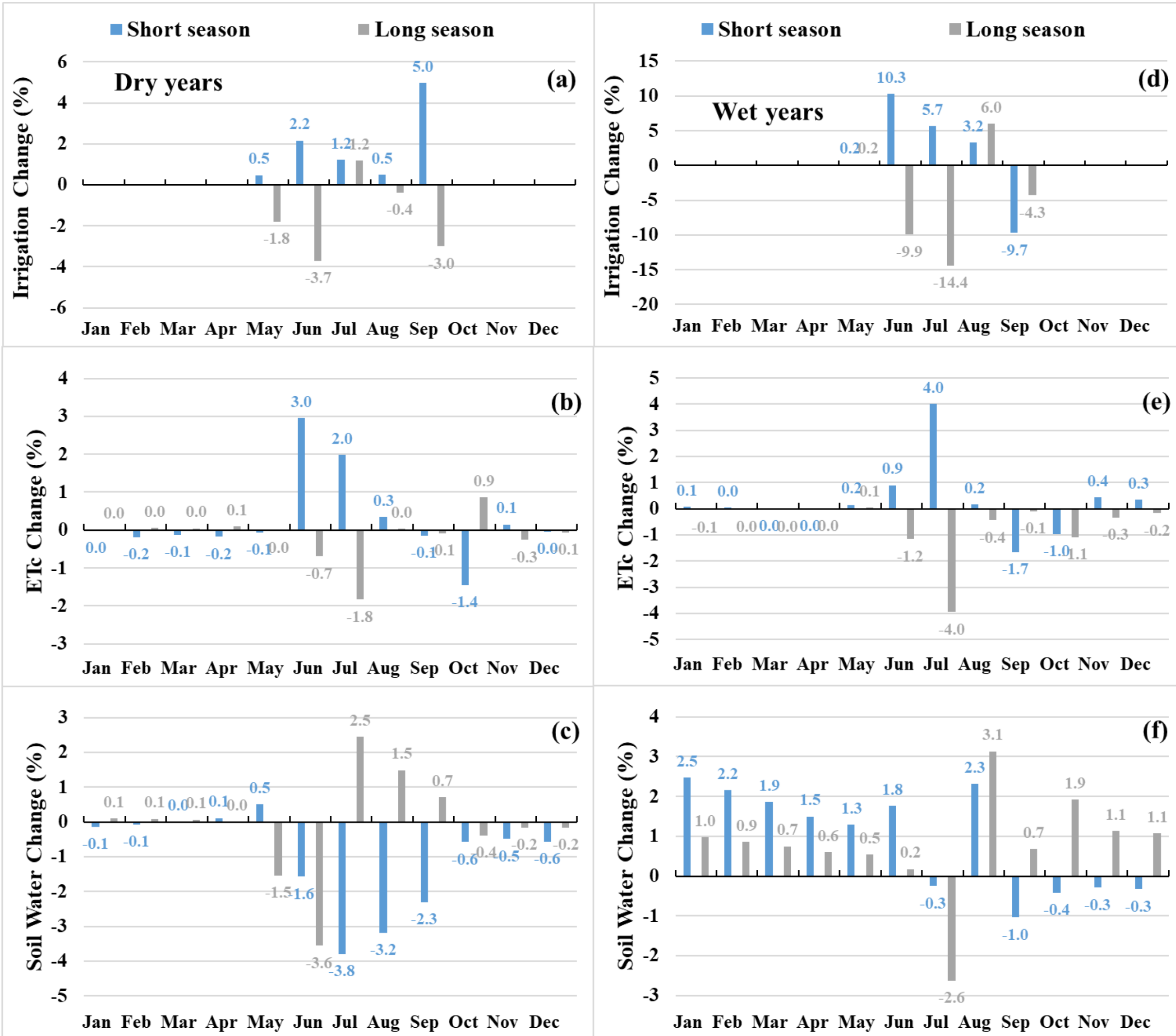

Figure S7. Change percentages of average monthly irrigation, crop evapotranspiration (ET_c), and soil water content under dry and wet years using diverse maturity cultivars relative to the baseline cultivar in the irrigated cotton HRUs in the Double Mountain Fork Brazos basin.

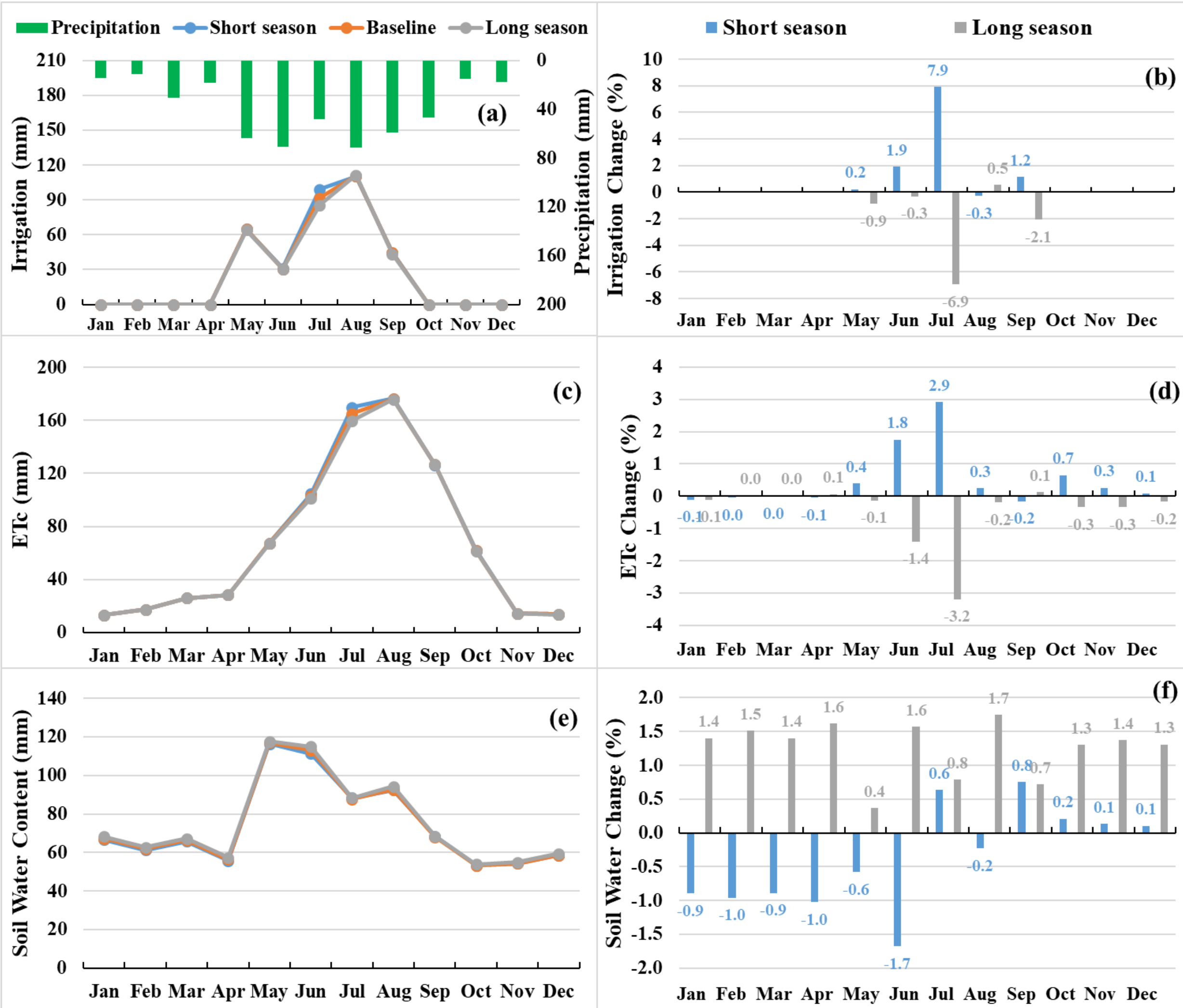

Figure S8. Comparison of average monthly irrigation, crop evapotranspiration (ET_c), and soil water content under normal years using diverse maturity cultivars in the irrigated cotton HRUs in the Double Mountain Fork Brazos basin.

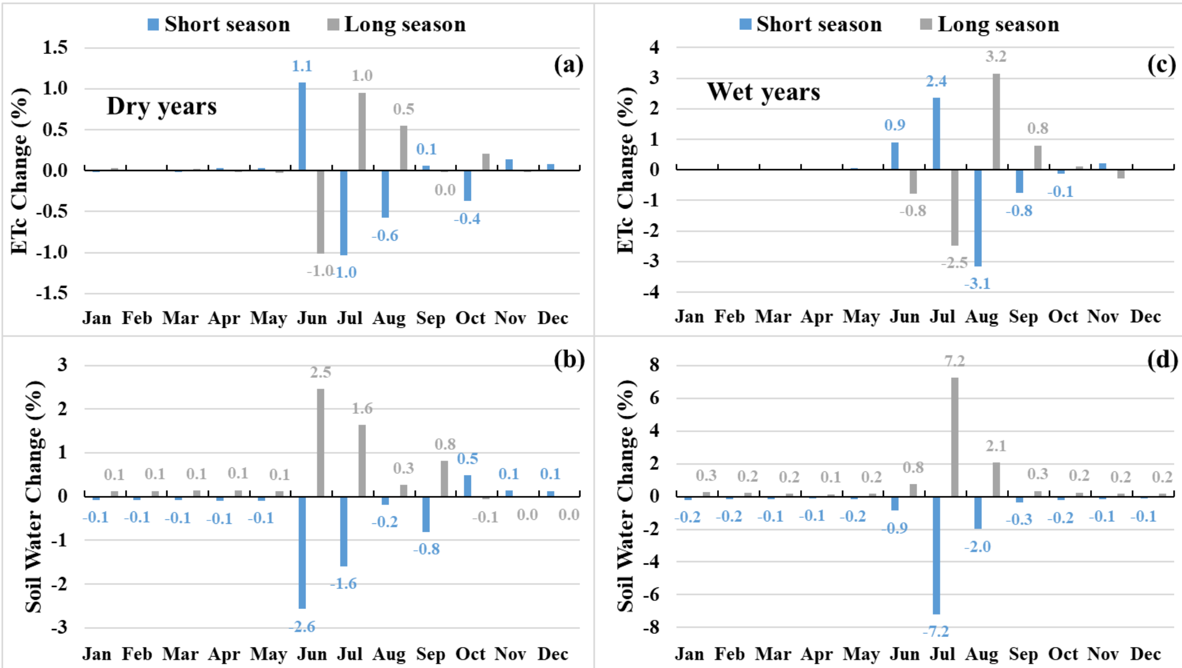

Figure S9. Change percentages of average monthly crop evapotranspiration (ET_c) and soil water content under dry and wet years using diverse maturity cultivars relative to the baseline cultivar in the dryland cotton HRUs in the Double Mountain Fork Brazos basin.

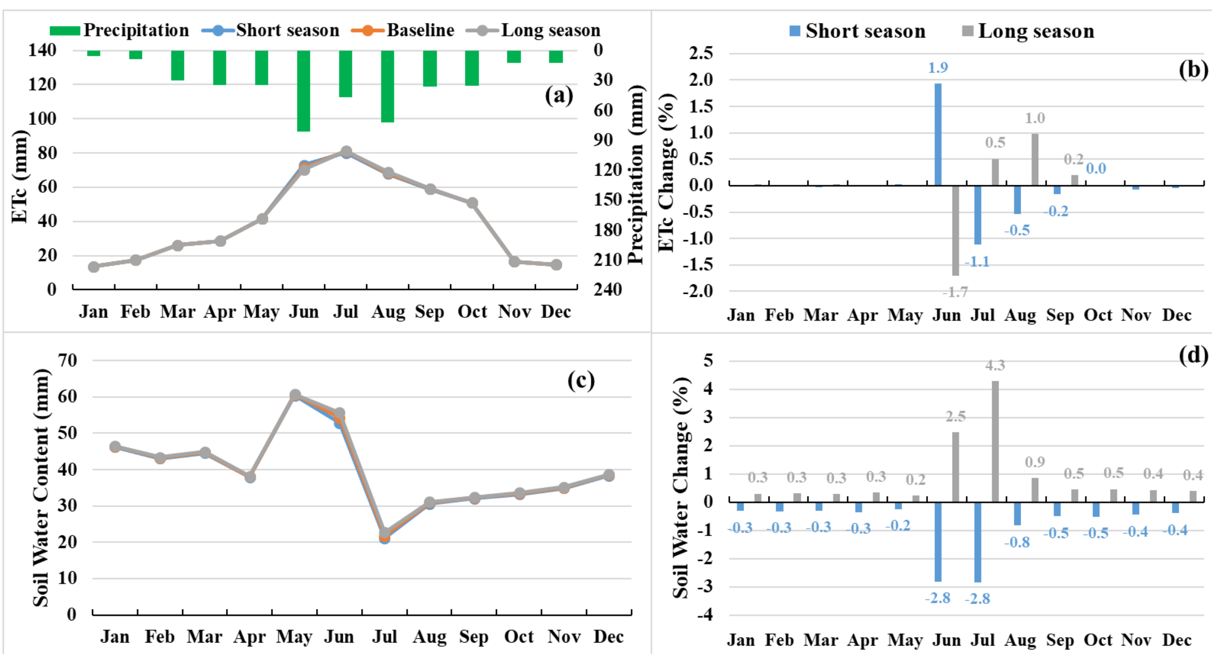

Figure S10. Comparison of average monthly crop evapotranspiration (ET_c) and soil water content under normal years using diverse maturity cultivars in the dryland cotton HRUs in the Double Mountain Fork Brazos basin.

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