Supplementary material

1.1 Model Evaluation Methods

The synthetic time series generated by SDSM is compared with the observed data using, in addition to the basic statistical methods included in SDSM, the coefficient of determination (R^2), Root Mean Square Error (RMSE), and Mean bias (Mbias) (Cohen Liechti et al., 2012; Daren Harmel and Smith, 2007; Moazami et al., 2013). R^2 (Eq. 1) is used to evaluate the accuracy of the model in synthesizing the observed data.

$$R^2 = \frac{\sum_{i=1}^{N}(X_i-\bar{X})\,(Y_i-\bar{Y})}{\sqrt{\sum_{i=1}^{N}(X_i-\bar{X})^2\ \sum_{i=1}^{N}(Y_i-\bar{Y})^2}} \quad (1)$$

RMSE (Eq. 2) is an indicator of goodness of fit and shows the differences between synthesized and observed data (Legates and McCabe, 1999); the presence of over- or underestimation is described by Mbias (Eq. 3).

$$\mathrm{RMSE} = \sqrt{\frac{\sum_{i=1}^{N}(X_i-Y_i)^2}{N}} \quad (2)$$

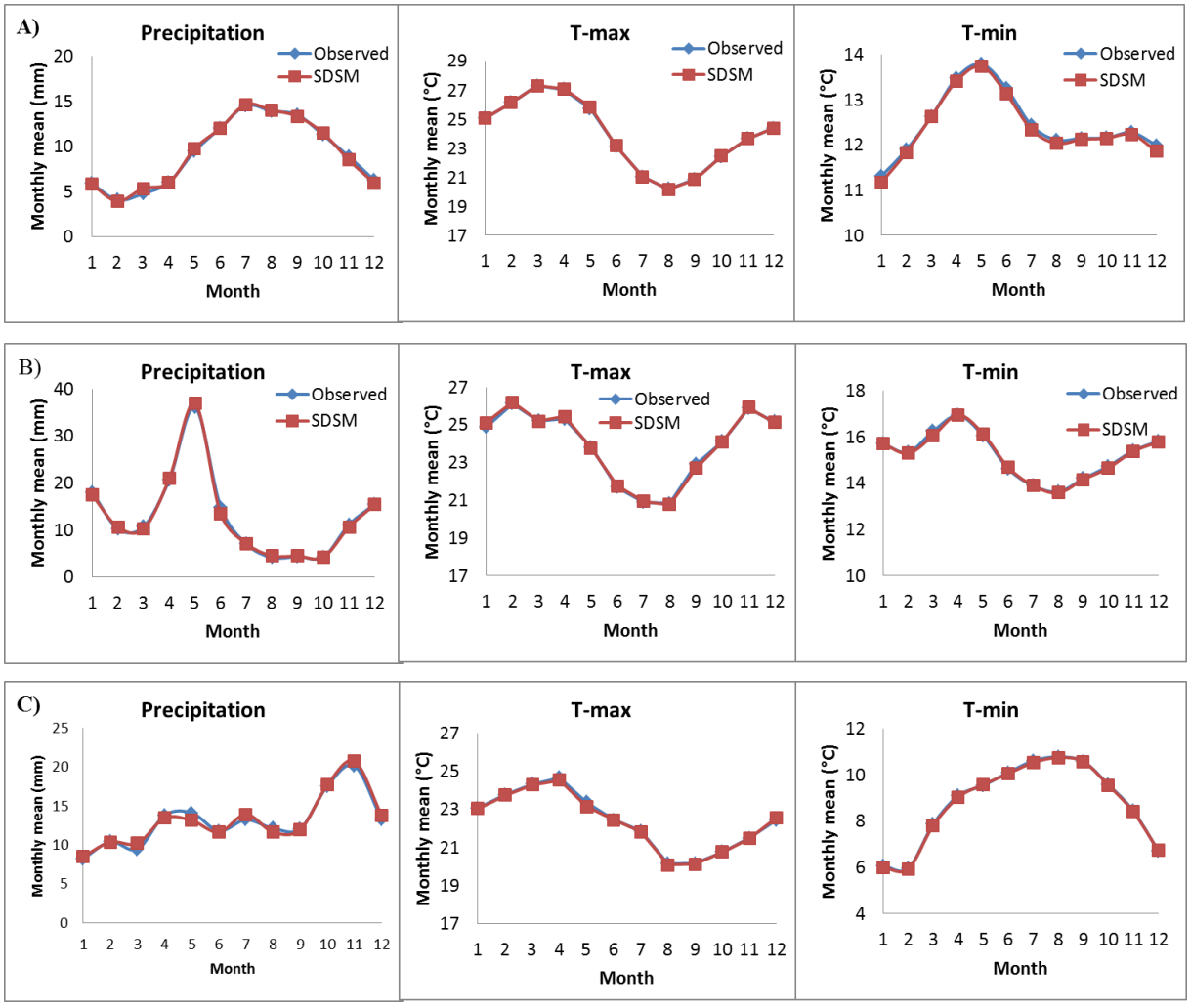
$$Mbias = \frac{\sum_{i=1}^{N}(Y_i-X_i)}{N} \quad (3)$$

Where X_i and Y_i are the observed and simulated data of the ith event and N is the number of events.

1.2 Model performance

The performance of SDSM in reproducing the observed daily precipitation, T-max, and T-min in Ethiopia, Kenya, and Tanzania was evaluated for each station based on multiple statistics (e.g., mean, variance, percentiles and extremes). An explanatory example is given in Fig. 3 for three stations in Ethiopia, Kenya, and Tanzania. The example is used to show the model accuracy in each country. In Nekemt-Ethiopia (SF. 1a) the model showed higher accuracy in synthesizing T-max compared to T-min and precipitation. The baseline average (1961-1990) monthly R^2 in this station are greater than 0.99 and 98 for T-max and T-min and precipitation, respectively. Similarly, in Eldort-International (Kenya, SF. 1b) and Arusha (Tanzania, SF. 1c)

stations, the model shows higher performance in reproducing the average monthly precipitation, T-max, and T-min with an R^2 of greater than 0.95. In general, in all the 214 stations a similar method of evaluation is used and the model showed high accuracy during the calibration (1961-1990) and validation (1991-2005) period with an R^2 of higher than 0.95 and 0.8 for T-max and T-min and precipitation, respectively. Compared to T-max and T-min, the process of selecting the best fit predictors is much more difficult in the case of precipitation.



SF. 1: Overview of the average monthly and model data over selected stations (see text) of Ethiopia (a), Kenya (b), and Tanzania (c) for the period of 1961-1990.

Supplementary tables and figures

ST. 1: List of the CMIP5 GCMs used in this study (adapted from, http://climate-scenarios.canada.ca). The required RCPs (RCP2.6, RCP4.5, and RCP8.5) are present in each model.

No	Model name	Historical	RCP2.6	RCP4.5	RCP8.5
1	BNU-ESM	yes	yes	yes	Yes
2	CCSM4	yes	yes	yes	Yes
3	CESM1-CAM5	yes	yes	yes	Yes
4	CESM1-WACCM	yes	yes	yes	Yes
5	CNRM-CM5	yes	yes	yes	Yes
6	CSIRO-Mk3-6-0	yes	yes	yes	Yes
7	CanESM2	yes	yes	yes	Yes
8	EC-EARTH	yes	yes	yes	Yes
9	FGOALS-g2	yes	yes	yes	Yes
10	FIO-ESM	yes	yes	yes	Yes
11	GFDL-CM3	yes	yes	yes	Yes
12	GFDL-ESM2G	yes	yes	yes	Yes
13	GFDL-ESM2M	yes	yes	yes	Yes
14	GISS-E2-H	yes	yes	yes	Yes
15	GISS-E2-R	yes	yes	yes	Yes
16	HadGEM2-AO	yes	yes	yes	Yes
17	HadGEM2-ES	yes	yes	yes	Yes
18	IPSL-CM5A-LR	yes	yes	yes	Yes
19	IPSL-CM5A-MR	yes	yes	yes	Yes
20	MIROC-ESM	yes	yes	yes	Yes
21	MIROC-ESM-CHEM	yes	yes	yes	Yes
22	MIROC5	yes	yes	yes	Yes
23	MPI-ESM-LR	yes	yes	yes	Yes
24	MPI-ESM-MR	yes	yes	yes	Yes
25	MRI-CGCM3	yes	yes	yes	Yes
26	NorESM1-M	yes	yes	yes	Yes
27	NorESM1-ME	yes	yes	yes	Yes
28	bcc-csm1-1	yes	yes	yes	Yes
29	bcc-csm1-1-m	yes	yes	yes	Yes

ST. 2: Regional average anomalies of annual T-max in Ethiopia, Kenya, and Tanzania under RCP2.6, RCP4.5, and RCP8.5 for the period of the 2020s, 2050s, and 2080s based on projections from SDSM, CanESM2, and GCMs.

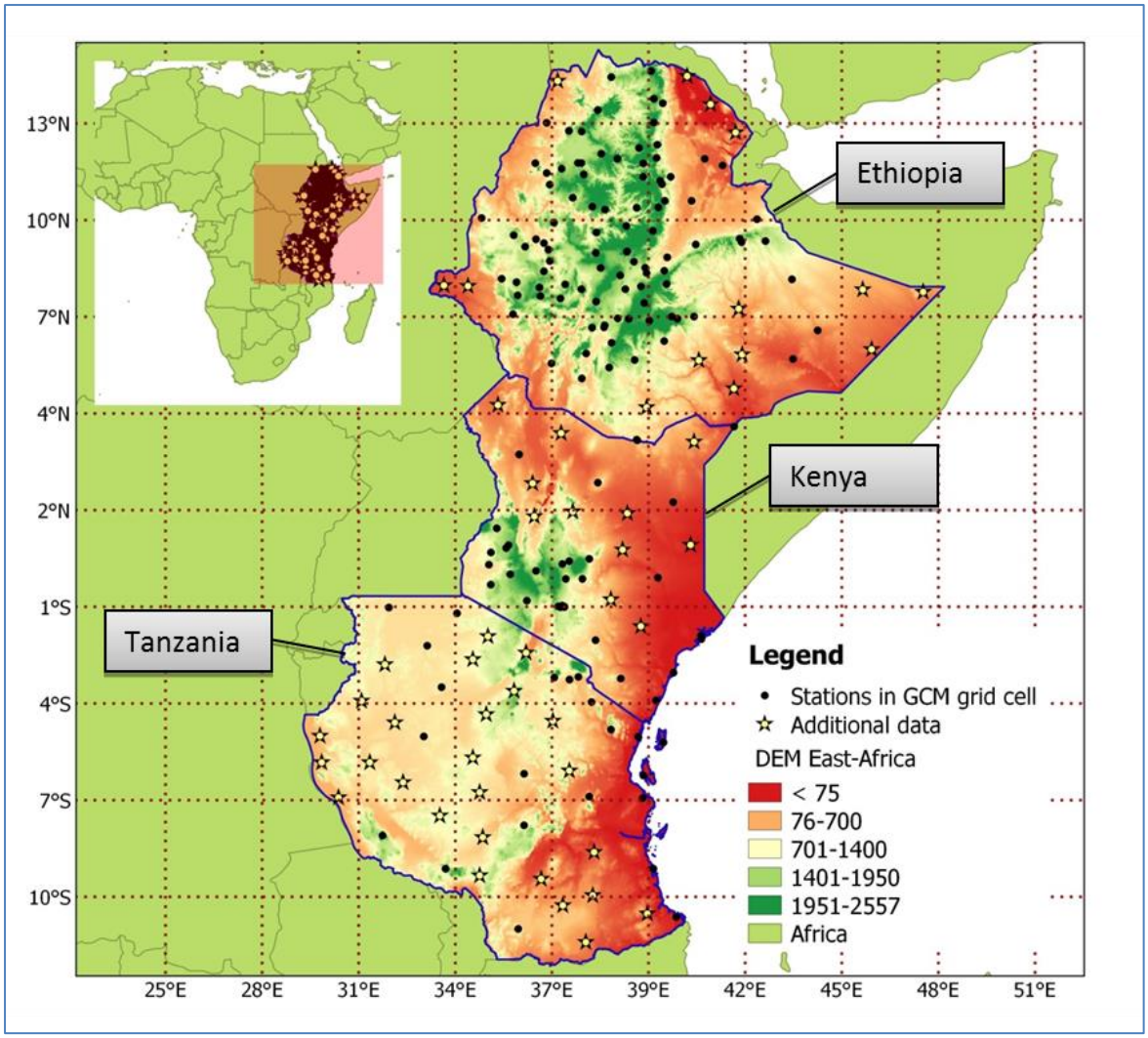
Region	Model	2020s			2050s			2080s		
		Rcp2.6	Rcp4.5	Rcp8.5	Rcp2.6	Rcp4.5	Rcp8.5	Rcp2.6	Rcp4.5	Rcp8.5
Ethiopia	SDSM	0.24	0.24	0.25	0.31	0.36	0.49	0.29	0.42	0.73
	CanESM2	1.18	1.05	1.31	1.51	1.78	2.59	1.57	2.16	4.04
	GCMs	1.1±0.22	1.48±0.21	1.49±0.25	1.16±0.31	1.92±0.37	2.34±0.51	1.24±0.39	2.56±0.52	4.08±0.88
Kenya	SDSM	0.41	0.43	0.43	0.50	0.57	0.76	0.47	0.66	1.10
	CanESM2	0.94	0.87	1.12	1.18	1.47	2.12	1.22	1.57	3.38
	GCMs	1.0±0.21	1.32±0.21	1.32±0.26	1.07±0.33	1.77±0.35	2.15±0.45	1.16±0.36	2.37±0.50	3.80±0.69
Tanzania	SDSM	0.15	0.16	0.17	0.20	0.21	0.29	0.18	0.23	0.41
	CanESM2	1.50	1.16	1.53	2.07	1.95	2.89	2.13	2.29	4.63
	GCMs	1.15±0.21	1.51±0.2	1.50±0.24	1.21±0.36	2.01±0.32	2.42±0.44	1.31±0.44	2.68±0.40	4.35±0.69

ST. 3**.** Regional average anomalies of annual T-min in Ethiopia, Kenya, and Tanzania under RCP2.6, RCP4.5, and RCP8.5 for the period of the 2020s, 2050s, and 2080s based on projections from SDSM, CanESM2, and GCMs.

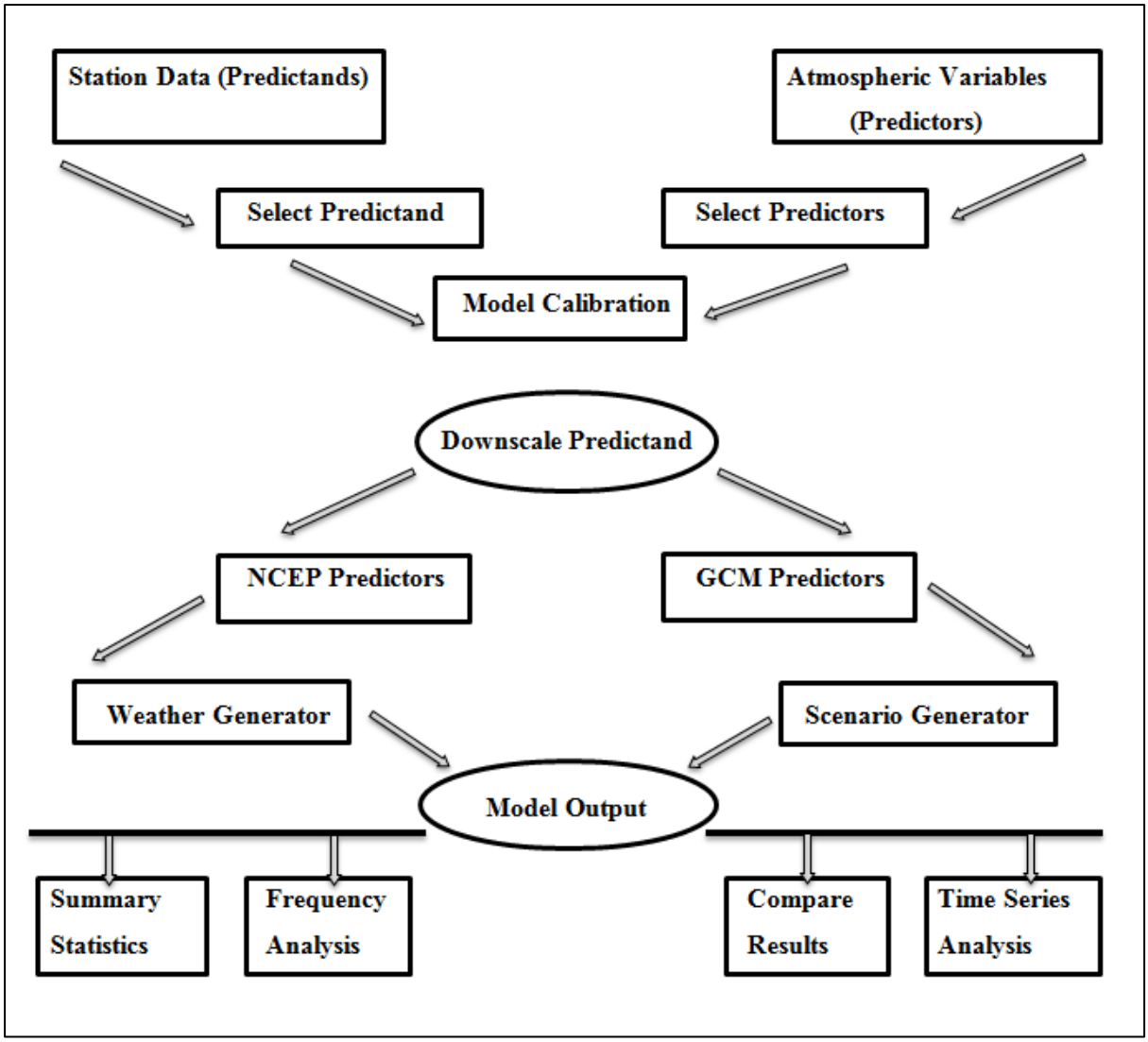
Region	Model	2020s			2050s			2080s		
		Rcp2.6	Rcp4.5	Rcp8.5	Rcp2.6	Rcp4.5	Rcp8.5	Rcp2.6	Rcp4.5	Rcp8.5
Ethiopia	SDSM	0.23	0.24	0.26	0.32	0.37	0.49	0.29	0.42	0.74
	CanESM2	1.92	1.85	2.11	2.39	2.87	3.88	2.41	3.37	5.86
	GCMs	1.37±0.40	1.80±0.36	1.81±0.39	1.40±0.53	2.28±0.60	2.75±0.76	1.51±0.73	3.05±0.74	4.83±1.22
Kenya	SDSM	0.44	0.46	0.48	0.60	0.70	0.89	0.56	0.81	1.37
	CanESM2	1.62	1.57	1.78	2.02	2.47	3.31	2.05	2.89	5.01
	GCMs	1.28±0.34	1.65±0.34	1.67±0.36	1.29±0.45	2.10±0.55	2.53±0.66	1.44±0.59	2.91±0.68	4.60±1.01
Tanzania	SDSM	0.30	0.31	0.33	0.41	0.47	0.61	0.38	0.54	0.95
	CanESM2	1.66	1.56	1.81	2.13	2.47	3.38	2.13	2.9	5.20
	GCMs	1.23±0.24	1.56±0.26	1.54±0.25	1.26±0.31	2.06±0.42	2.48±0.48	1.39±0.39	2.81±0.53	4.52±0.78

ST. 4: Regional average annual precipitation anomalies (mm) in Ethiopia, Kenya, and Tanzania in the 2020s, 2050s, and 2080s under RCP2.6, RCP4.5, and RCP8.5 based on projections from SDSM, CanESM2, and GCMs.

Region	Model	2020s				2050s		2080s		
		Rcp2.6	Rcp4.5	Rcp8.5	Rcp2.6	Rcp4.5	Rcp8.5	Rcp2.6	Rcp4.5	Rcp8.5
Ethiopia	SDSM	50.9	40.6	59.3	84.0	92.2	145.4	70.2	121.3	322.3
	CanESM2	141.01	118.71	133.88	177.89	179.66	240.01	179.37	204.06	377.98
	GCMs	43.3±59.2	18.6±59.9	36.1±59.1	43.4±73.8	26.7±80.1	60.4±92.8	44.5±78.2	29.1±82.8	112.3±112.5
Kenya	SDSM	72.2	66.4	98.2	144.7	162.0	245.1	129.7	215.5	465.5
	CanESM2	157.96	137.20	147.54	211.25	206.18	271.75	204.63	248.32	404.94
	GCMs	49.7±67	40.5±68.6	49.4±70.4	55.0±93.5	67.0±94.7	98.4±115.8	56.7±85.8	86.9±100.4	86.9±143.5
Tanzania	SDSM	13. 7	24.2	37.3	49.6	82.8	123.2	37.4	119.5	248.0
	CanESM2	168.61	161.78	153.96	179.62	231.52	288.76	184.40	266.94	376.17
	GCMs	33.9±74.8	28.1±79.8	36.6±75.5	29.7±94.37	46.2±112.0	75.0±125.8	29.4±88.5	62.5±122.7	125.7±170.6



SF. 1: Location Map of meteorological stations in a GCM grid box and elevation (DEM) map of the study area (Ethiopia, Kenya, and Tanzania).



SF. 2: General structure and selected components of SDSM version 4.2, modified from Wilby and Dawson (2007).

References

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