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Modeling impacts of climate change and grazing effects on plant biomass and soil organic carbon in the Qinghai–Tibetan grasslands

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Table S1. Changes in livestock(million heads) in Qinghai province during the period from 1949 (data from Zhang (2011)) to 2015 (data from QPBS (2015)).

Livestock	**1949**	**1978**	**1980**	**1985**	**1990**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**
Yaks		4.97	4.87	5.16	5.39	5.51	5.09	5.24	5.01	4.43	4.22	3.94	3.78	3.91	4.01
Sheep and goats		16.45	16.13	13.28	16.08	16.48	16.35	16.77	16.66	15.70	16.01	16.39	16.40	16.42	16.76
Other large Animals		0.71	0.67	0.74	0.74	0.72	0.66	0.63	0.58	0.62	0.60	0.57	0.53	0.51	0.54
Total livestock	7.49	22.13	21.67	19.18	22.21	22.71	22.10	22.65	22.25	20.75	20.83	20.91	20.71	20.83	21.31
Livestock		**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**
Yaks		4.11	4.06	4.04	4.06	4.50	4.47	4.45	4.45	4.36	4.42	4.74	4.52	4.44	4.80
Sheep and goats		17.33	17.62	17.64	17.66	15.02	14.97	14.97	14.98	15.05	14.98	15.12	14.42	14.21	14.31
Other large Animals		0.52	0.50	0.49	0.47	0.36	0.41	0.39	0.36	0.36	0.36	0.34	0.33	0.32	0.32
Total livestock		21.95	22.18	22.17	22.19	19.88	19.85	19.81	19.78	19.77	19.76	20.21	19.27	18.97	19.42

Table S2. Livestock grazing intensity in each county in the study area.

County	Grazing Intensity		County	Grazing Intensity	
	Yak/Cattle (heads ha^{-1})	Sheep and Goats (heads ha^{-1})		Yak/Cattle (heads ha^{-1})	Sheep and Goats (heads ha^{-1})
Tianjun	0.04	0.32	**Banma**	0.29	0.32
Dulan	0.02	0.16	**Maqin**	0.24	0.27
Wulan	0.04	0.40	**Guinan**	0.24	1.39
Delinha	0.01	0.11	**Xinghai**	0.18	1.03
Geermu	0.01	0.05	**Guide**	0.18	1.03
Xisanzhen	0.03	0.23	**Tongde**	0.36	2.10
Qumalai	0.04	0.09	**Gonghe**	0.16	0.94
Nangqian	0.18	0.38	**Henan**	0.38	0.92
Zhiduo	0.02	0.05	**Zeku**	0.40	0.98
Chengduo	0.13	0.29	**Jianzha**	0.61	1.48
Zaduo	0.04	0.10	**Tongren**	0.29	0.69
Yushu	0.15	0.32	**Gangcha**	0.25	1.28
Maduo	0.05	0.06	**Haiyan**	0.24	1.20
Jiuzhi	0.20	0.22	**Qilian**	0.19	0.95
Dari	0.16	0.18	**Menyuan**	0.32	1.63
Gande	0.31	0.34			

The number of horses has decreased each year and at the end of 2014, the number of horses only accounted for 1.7% of the total number of grazing livestock. Therefore, we combined the data for horses and cattle to calculate the grazing intensity. The baseline grazing intensity was based on the grazing data from 2005, which was the highest in recent decades, and the grassland monitoring project also started in that year.

Table S3. Livestock grazing parameters employed in this study.

Parameters	Yak/Cattle	Sheep	Horse
Daily C intake (kg C head^{-1})	2.48[a]	0.50	4.01
Milk C fraction [0-1]	0.01	0.00	0.01
Meat C fraction [0-1]	0.05	0.04	0.05
Urine C fraction [0-1]	0.02	0.06	0.02
Dung C fraction [0-1]	0.44	0.42	0.44
Enteric CH_4 C fraction [0-1]	0.02	0.03	0.02
Respiration C fraction [0-1]	0.46	0.45	0.46
Milk N fraction [0-1]	0.00	0.00	0.00
Meat N fraction [0-1]	0.30	0.30	0.30
Urine N fraction [0-1]	0.35	0.49	0.35
Dung N fraction [0-1]	0.35	0.21	0.35

[a] Parameters derived from (Dong Quan min and quan, 2007; Xue Bai et al., 2004)

Table s4. Input values for the main grassland type parameters used in the DNDC model.

Parameters	**Mountain meadow subclass**	**Alpine steppe**	**Lowland saline meadow subtype**	**Alpine meadow subtype**	**Alpine swamp meadow subtype**	**Alpine desert**	**Desert soil subclass**
Maximum biomass production (kg C ha^{-1} $year^{-1}$)[a]	1157	798	879	2786	3586	1441	672
Grain fraction of biomass[b]	0.04	0.03	0.03	0.02	0.02	0.01	0.01
Leaf and stem fraction of biomass[b]	0.40	0.40	0.42	0.60	0.40	0.11	0.28
Root fraction of biomass[b]	0.56	0.57	0.55	0.38	0.58	0.88	0.71
C/N ratio of grain[c]	34	31	31	34	33	26	25
C/N ratio of leaf and stem[c]	33	30	30	32	31	22	24
C/N ratio of root[c]	40	48	22	59	58	25	19
Water requirement[c] (kg water kg^{-1} dry matter)	200	200	200	200	200	200	200
Max height (m)[a]	0.5	0.6	0.5	0.4	0.4	0.5	1
TDD[d]	1000	1500	1000	1500	1500	1000	1000
N fixation index[d]	1.5	1.5	1.5	1.5	1.5	1.5	1.5

[a]Parameters derived from field observations; [b] parameters derived from (ji et al., 1995); [c]parameters derived from(cai et al., 2007; li et al., 2016; lin et al., 2014); [d]parameters derived from the default values in the DNDC model.

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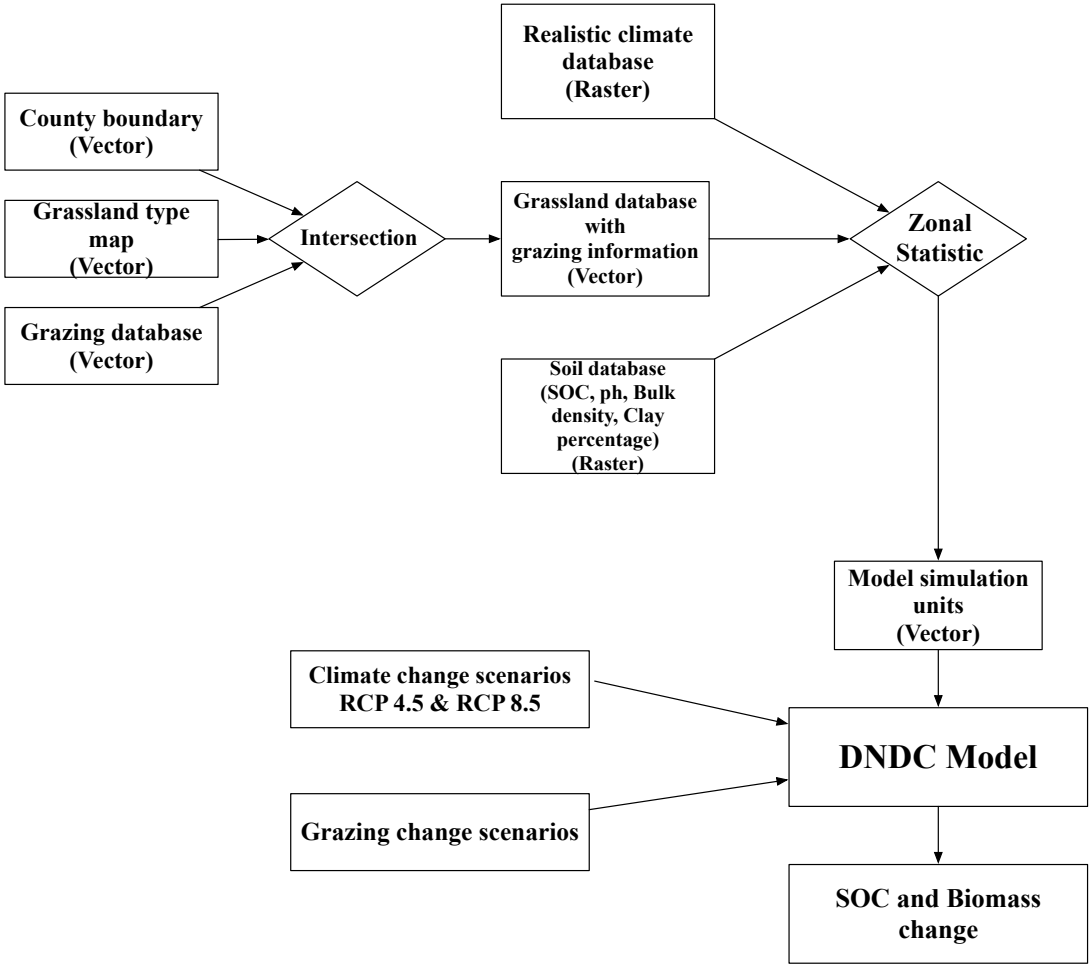

Fig. S1. The flowchart of model data preparation and simulation. The vector and raster inside the brackets indicate the input data format, and the intersection and zonal statistic inside the rhombus indicate the ArcGIS algorithm applied to process the data.

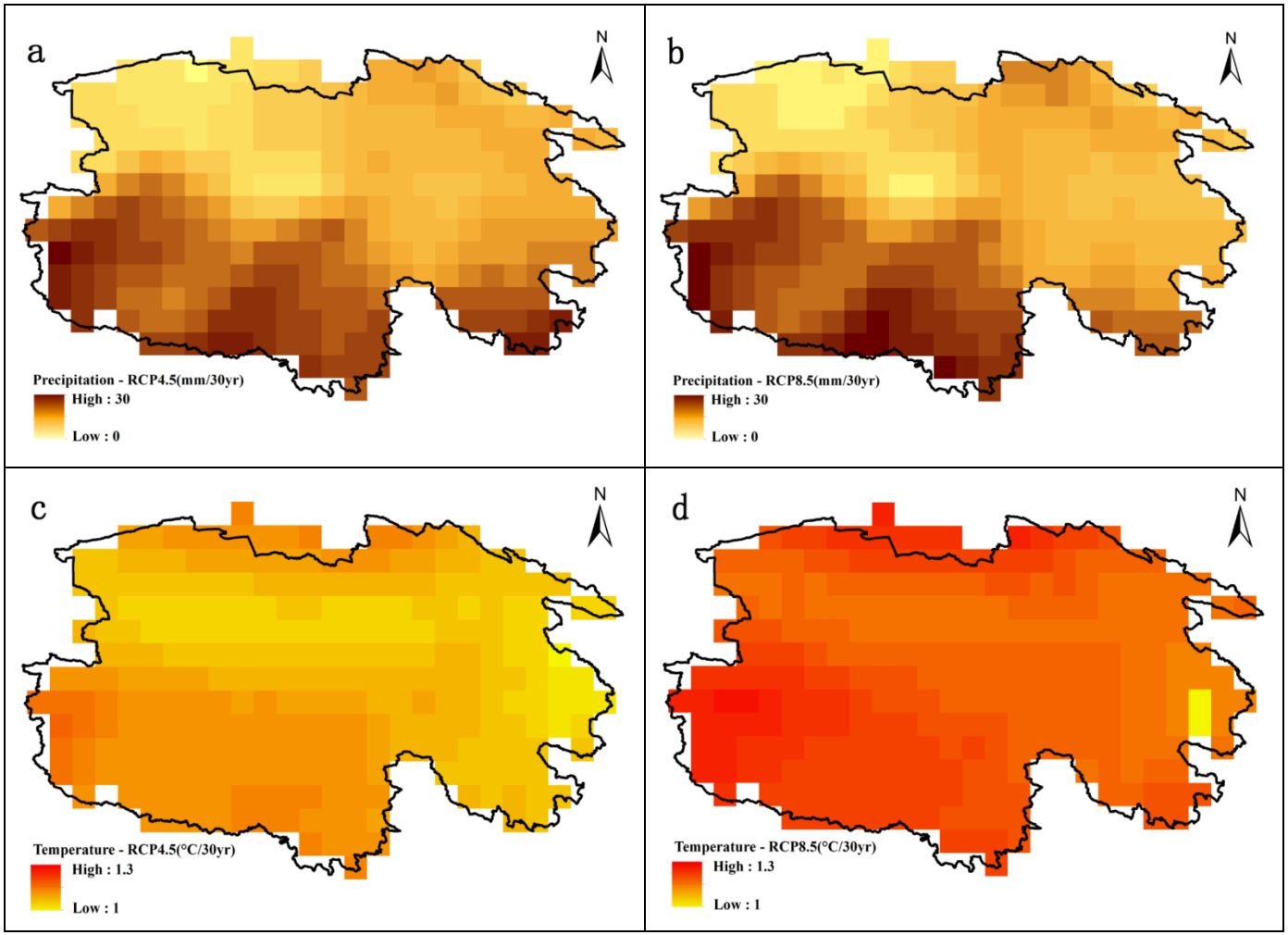

Fig. S2. Spatial distributions of precipitation and changes in temperature under the RCP4.5 (a, c) and RCP 8.5 (b, d) climate change scenarios up to 2044.