

Supplementary material

Three-Dimensional Dynamic Variations of Ground/Air Surface Temperatures and Their Correlation with Large-Scale Circulation Indexes in Southwest China (1980–2019)

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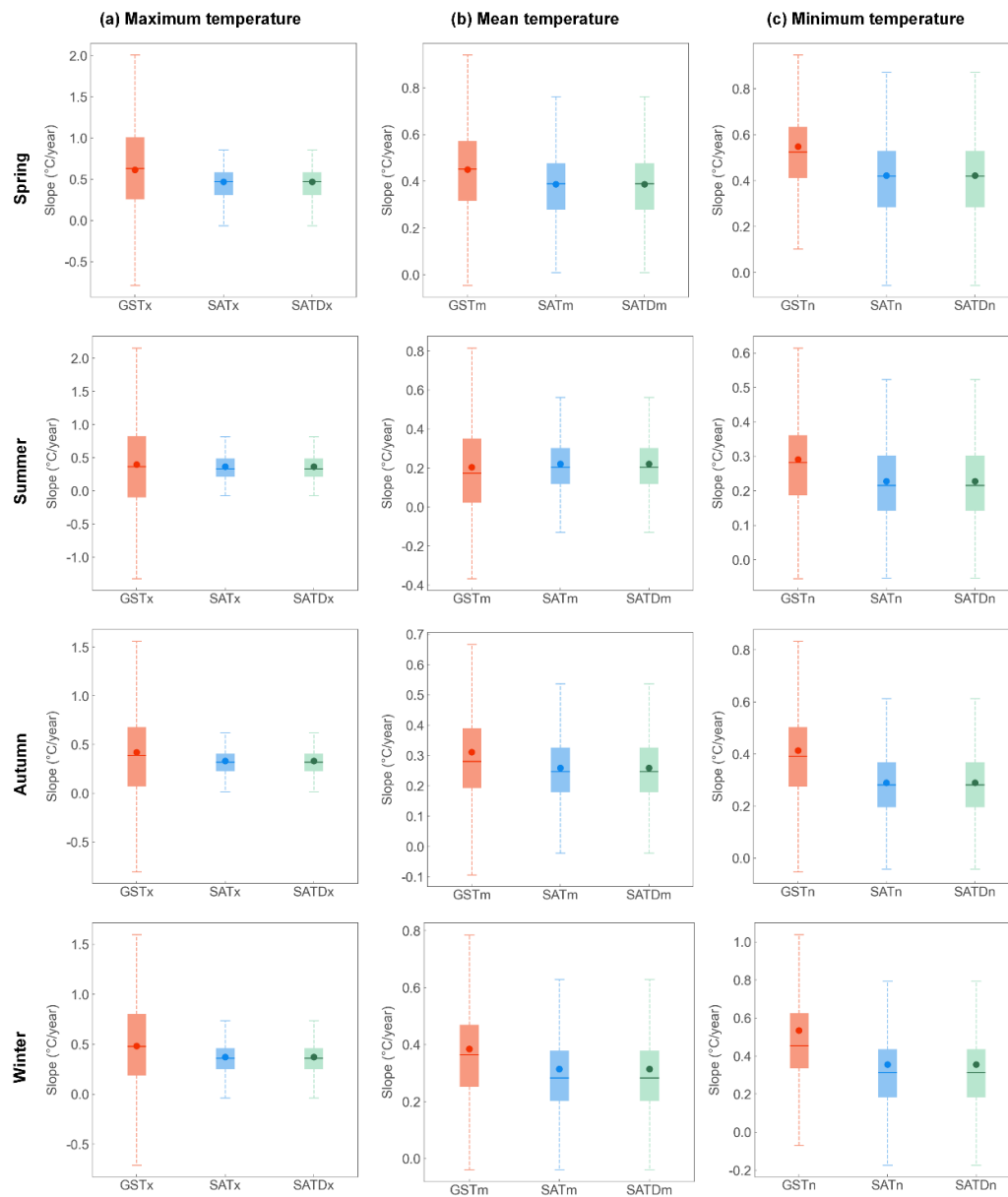


Figure S1. Box-and-whisker plots of trends in seasonal averaged GST-, SAT-, and SATD-related indexes 1980–2019 in Southwest China. In boxplot, horizontal line represents median, and circle represent average.

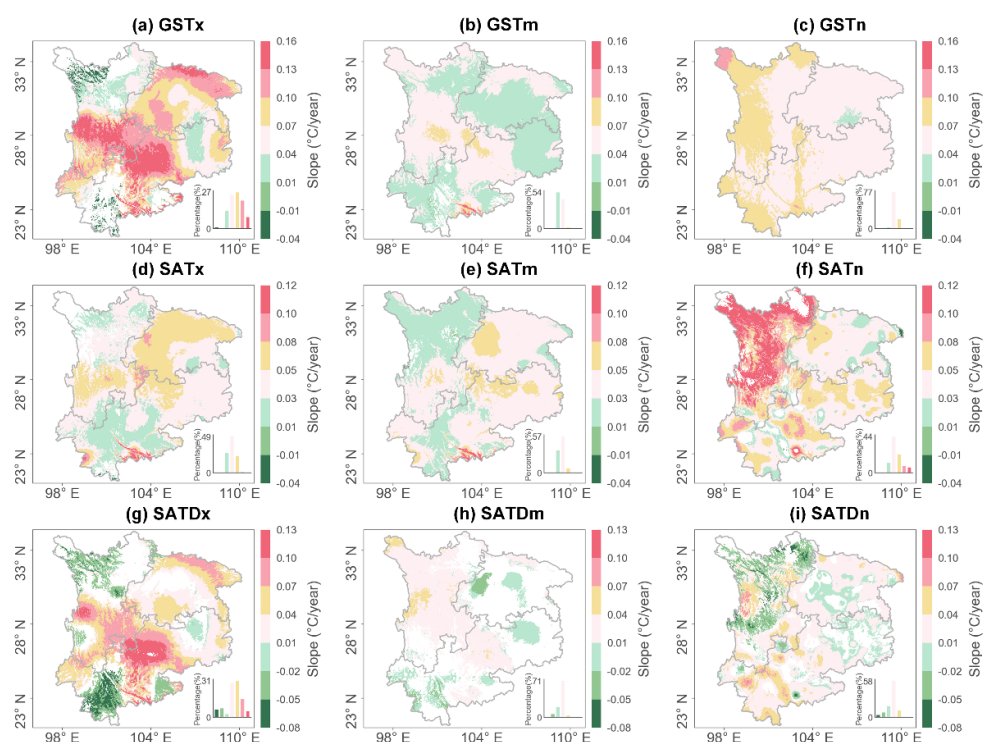


Figure S2. Significant variation rate of spring averaged GST-, SAT-, and SATD-related indexes for each pixel during 1980 to 2019 in Southwest China.(Significance test by MMK trend mehod at the 0.05 confidence level).

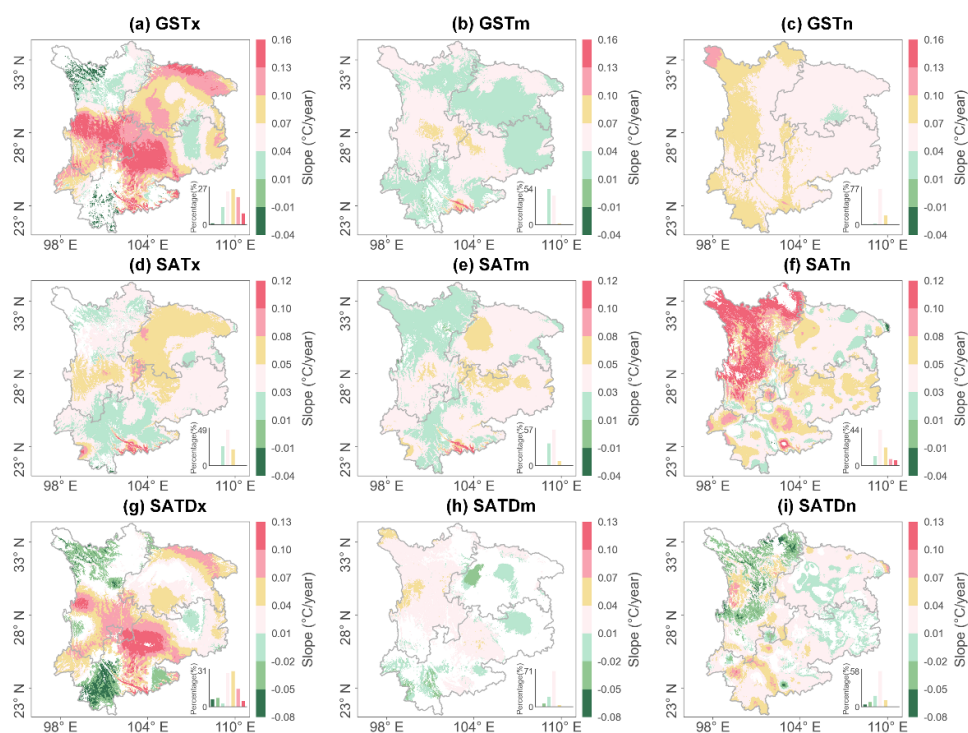


Figure S3. Significant variation rate of summer averaged GST-, SAT-, and SATD-related indexes for each pixel during 1980 to 2019 in Southwest China.(Significance test by MMK trend mehod at the 0.05 confidence level).

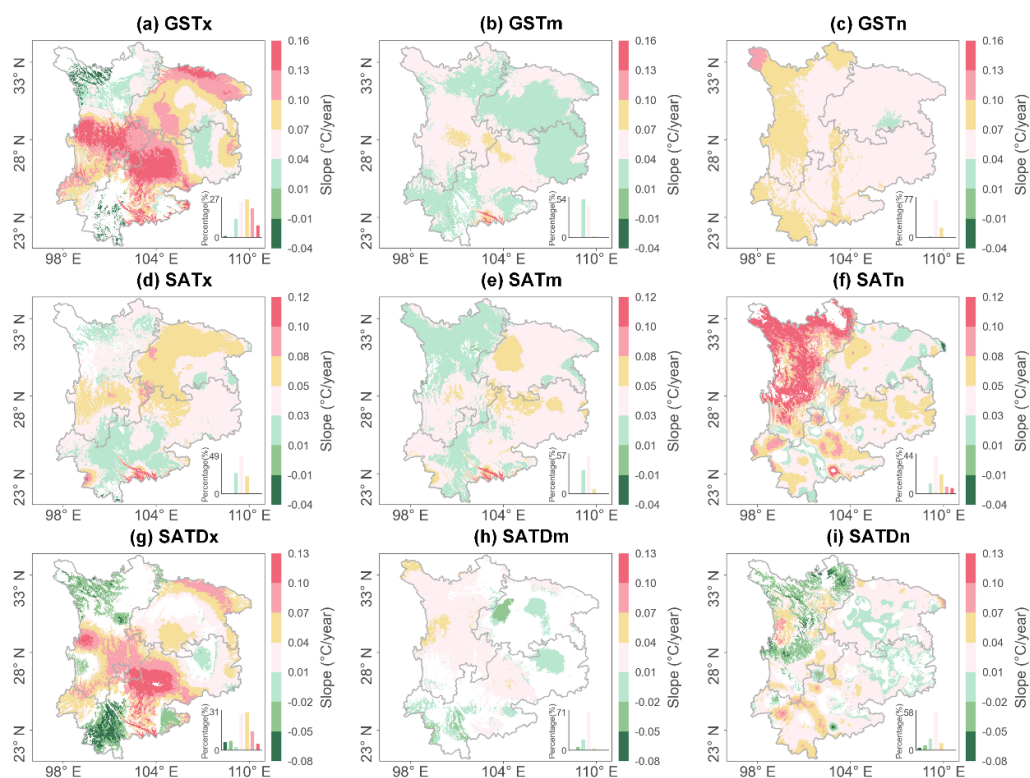


Figure S4. Significant variation rate of autumn averaged GST-, SAT-, and SATD-related indexes for each pixel during 1980 to 2019 in Southwest China.(Significance test by MMK trend mehod at the 0.05 confidence level).

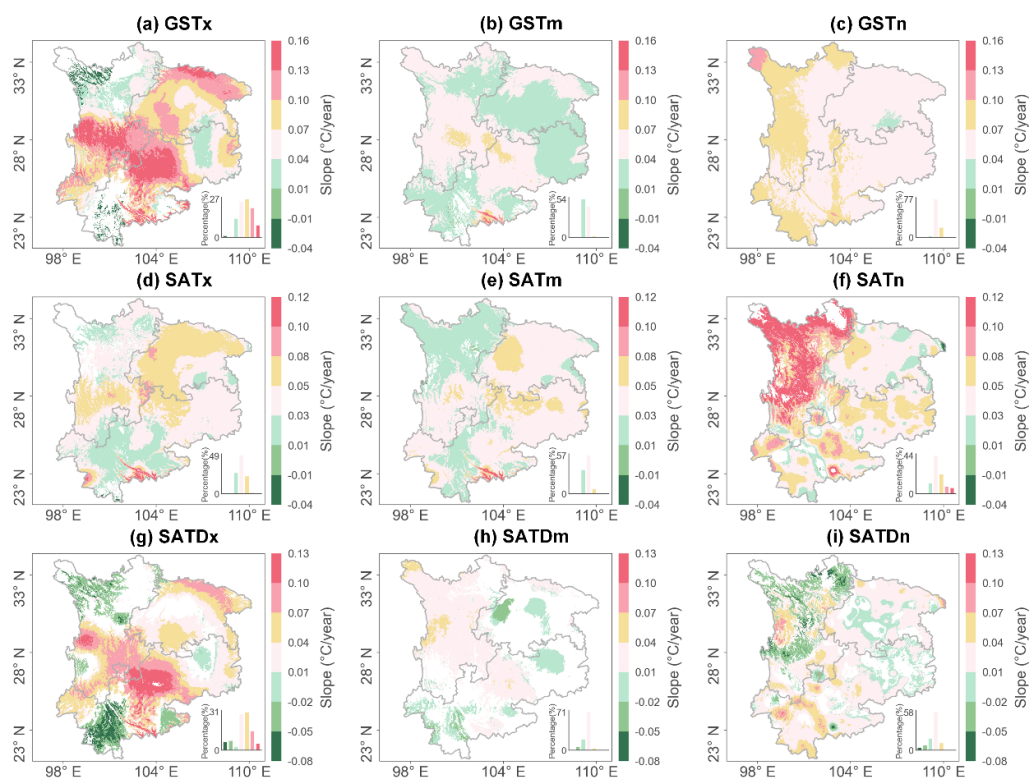


Figure S5. Significant variation rate of winter averaged GST-, SAT-, and SATD-related indexes for each pixel during 1980 to 2019 in Southwest China.(Significance test by MMK trend mehod at the 0.05 confidence level).

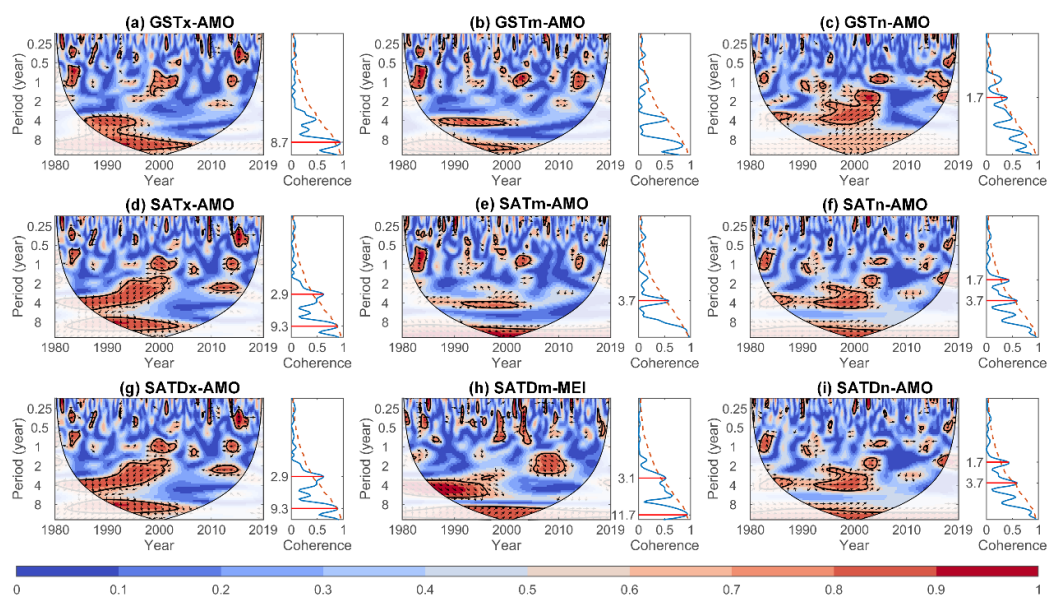


Figure S6. Wavelet and global coherence of anomaly of the monthly averaged GST-, SAT-, and SATD-related indexes with the highest PASC large-scale index from 1980 to 2019 in HDM.

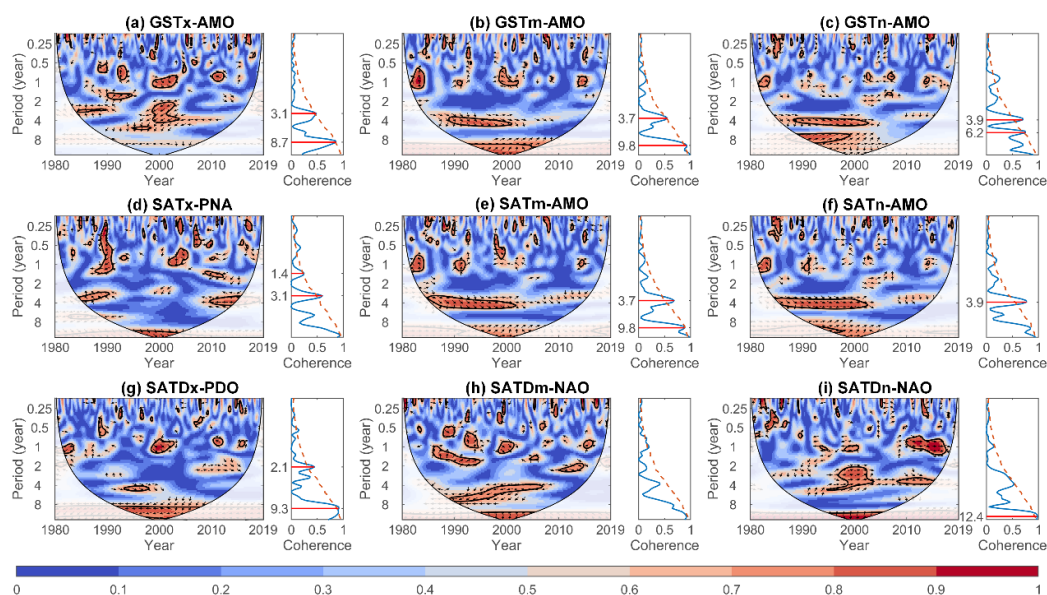


Figure S7. Wavelet and global coherence of anomaly of the monthly averaged GST-, SAT-, and SATD-related indexes with the highest PASC large-scale index from 1980 to 2019 in YGP.

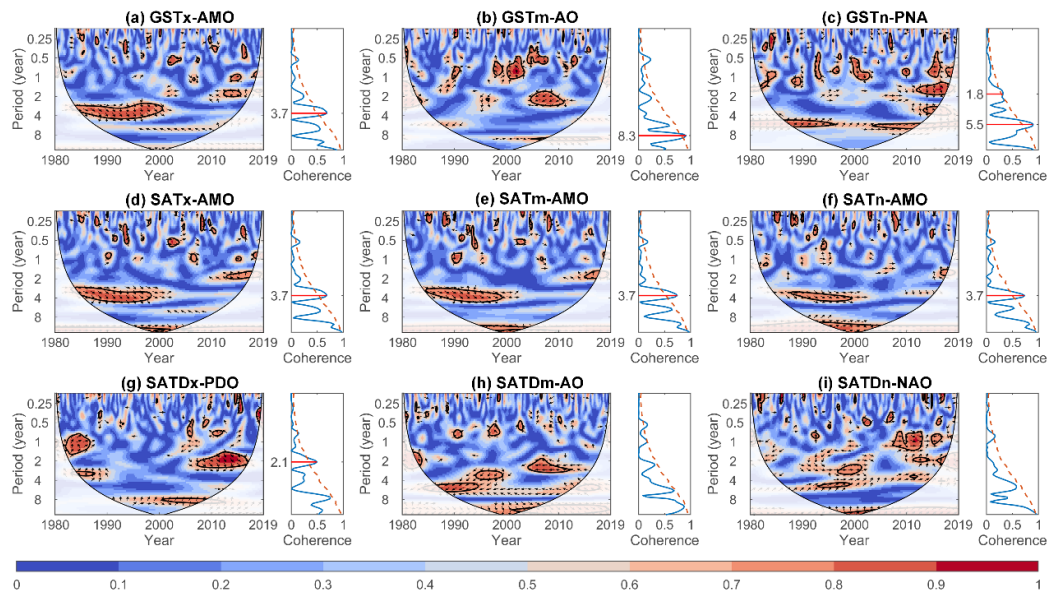


Figure S8. Wavelet and global coherence of anomaly of the monthly averaged GST-, SAT-, and SATD-related indexes with the highest PASC large-scale index from 1980 to 2019 in SCB.

Table S1. Variation rate of annual/seasonal averaged GST-, SAT-, and SATD- related indexes in three subareas (HDM/YGP/SCB, respectively).

	Annual	Spring	Summer	Autumn	Winter
GSTx	0.039 ^b /0.036 ^b /0.058 ^b	0.062 ^b /0.062 ^b /0.074 ^b	0.031 ^b /0.015/0.076 ^b	0.038 ^b /0.048 ^b /0.031 ^b	0.041 ^b /0.03 ^b /0.058 ^b
GSTm	0.038 ^b /0.032 ^b /0.033 ^b	0.048 ^b /0.048 ^b /0.044 ^b	0.023 ^b /0.011 ^b /0.028 ^b	0.038 ^b /0.032 ^b /0.023 ^b	0.049 ^b /0.036 ^b /0.031 ^b
GSTn	0.06 ^b /0.046 ^b /0.035 ^b	0.065 ^b /0.058 ^b /0.048 ^b	0.04 ^b /0.028 ^b /0.027 ^b	0.058 ^b /0.041 ^b /0.037 ^b	0.081 ^b /0.057 ^b /0.034 ^b
SATx	0.044 ^b /0.033 ^b /0.043 ^b	0.044 ^b /0.045 ^b /0.059 ^b	0.036 ^b /0.025 ^b /0.05 ^b	0.045 ^b /0.035 ^b /0.025 ^b	0.053 ^b /0.035 ^b /0.031 ^b
SATm	0.032 ^b /0.029 ^b /0.028 ^b	0.037 ^b /0.042 ^b /0.042 ^b	0.025 ^b /0.017 ^b /0.028 ^b	0.033 ^b /0.027 ^b /0.019 ^b	0.036 ^b /0.037 ^b /0.021 ^b
SATn	0.034 ^b /0.035 ^b /0.026 ^b	0.037 ^b /0.048 ^b /0.04 ^b	0.027 ^b /0.021 ^b /0.024 ^b	0.033 ^b /0.033 ^b /0.023 ^b	0.036 ^b /0.045 ^b /0.023 ^b
SATDx	-0.006/0.001/0.02 ^b	0.015/0.021 ^a /0.021	-0.005/-0.013/0.029 ^b	-0.007/0.015 ^b /0.007 ^a	-0.009 ^a /-0.003/0.023 ^b
SATDm	0.006 ^b /0.002/0.005 ^b	0.015 ^b /0.009 ^b /0.003	0/-0.005 ^b /0.002	0.004 ^a /0.005 ^b /0.005 ^b	0.012 ^b /0.003 ^b /0.009 ^b
SATDn	0.024 ^b /0.01 ^b /0.01 ^b	0.026 ^b /0.011 ^b /0.01 ^b	0.013 ^b /0.006 ^b /0.004 ^a	0.024 ^b /0.009 ^b /0.012 ^b	0.039 ^b /0.014 ^b /0.013 ^b

Table S2. The climate jump of annual/seasonal averaged GST, SAT and SATD related indexes in three subareas (HDM/YGP/SCB, respectively).

	Annual	Spring	Summer	Autumn	Winter
GSTx	2001/-/-	-/-/-	-/-/-	-/-/-	-/-/-
GSTm	2001/2001/1996	2002/-/1996	-/-/-	1997/-/-	-/-/-
GSTn	2003/2003/2003	2003/2003/1996	2002/2004/2004	2004/-/2003	2003/-/-
SATx	2001/1997/1996	-/-/1996	2004/-/-	-/-/-	-/-/-
SATm	2002/1997/1996	-/-/1996	2004/2004/-	1997/-/-	-/-/-
SATn	2004/1997/1997	-/1997/1996	2004/2004/-	-/-/-	-/-/-
SATDx	-/-/-	-/-/-	-/-/2010	-/-/-	-/-/-
SATDm	2001/-/-	2002/-/-	-/-/-	2001/-/1997	2002/2002/2005
SATDn	2003/2003/2003	2003/2003/2004	2003/2003/2003	2003/2003/2003	2003/2003/2003

Table S3. Period, variance contribution rate of monthly averaged GST, SAT, and SATD related indexes in three subareas from 1980 to 2019.

Period (year)										Contribution (%)								
Subar	GST	GST	GST	SAT	SAT	SAT	SATD	SATD	SATD	GST	GST	GST	SAT	SAT	SAT	SATD	SATD	SATD
ea	x	m	n	x	m	n	x	m	n	x	m	n	x	m	n	x	m	n
HDM	0.31	0.24	0.25	0.37	0.48	0.25	0.48	0.27	0.25	7.01	43.38	13.92	10.48	16.21	4.63	14.77	6.28	24.57
	0.98	0.46	0.85	0.98	0.98	0.98	0.98	0.98	0.66	92.52	20.13	77.66	89.1	83.49	93.72	84.96	90.52	55.19
	1.54	0.87	1.18	1.82	1.67	1.54	1.9	1.67	1.05	0.22	8.59	6.26	0.2	0.12	0.9	0.16	0.82	16.36
	3.98	2.13	3.03	3.93	3.93	3.67	4.08	4.33	2.74	0.12	5.88	1.04	0.14	0.05	0.46	0.06	0.45	1.27
	9.4	5.38	5.18	7.77	8.35	7.27	7.41	8.49	5.24	0.05	5.72	0.48	0.04	0.04	0.16	0.03	0.33	0.99
	19.78	17.45	10.72	20.88	20.53	21.16	18.58	24.33	11.8	0.07	13.64	0.32	0.02	0.08	0.07	0.02	1.48	0.53
YGP	0.29	0.24	0.26	0.29	0.41	0.28	0.36	0.24	0.25	5.76	54.28	11.1	8.03	13.33	5.32	12.39	14.39	35.63
	0.98	0.45	0.83	0.98	0.98	0.98	0.98	0.91	0.63	93.58	17.77	81.2	91.43	86.34	93.49	87.2	76.34	46.53
	1.6	0.89	1.14	1.74	1.9	1.54	1.82	1.14	1.03	0.4	13.03	6.36	0.29	0.19	0.74	0.23	5.24	13.56
	4.04	2.02	3.02	4.02	4.01	4.01	3.97	3.03	2.42	0.19	7.11	0.72	0.19	0.08	0.35	0.13	0.73	1.9
	8.58	4.01	4.72	7.78	8.42	7.52	6.86	6.51	5.05	0.02	3.36	0.37	0.04	0.04	0.06	0.03	1.25	1.01
	19.56	23.57	11.91	14.47	17.54	10.53	15.74	11.62	9.23	0.05	2.78	0.2	0.02	0.01	0.03	0.02	0.91	0.6
SCB	0.31	0.24	0.25	0.34	0.48	0.27	0.4	0.24	0.25	10.4	55.05	6.28	12.66	20.51	7.24	17.5	15.74	18.06
	0.98	0.48	0.98	0.98	0.98	0.98	0.98	0.83	0.78	89.01	20.83	92.12	86.82	79.12	92.07	82.09	72.32	70.25
	1.82	0.87	1.54	1.82	2	1.82	1.9	1.18	1.11	0.32	8.71	1.01	0.25	0.16	0.35	0.21	6.78	9.08
	4.05	1.85	4.28	4.07	4.07	4.06	4.08	2.7	2.82	0.2	5.65	0.43	0.2	0.1	0.24	0.13	0.89	1.53
	7.52	4.69	7.06	7.41	9.79	7.92	9.6	6.86	5.51	0.06	3.35	0.08	0.06	0.06	0.09	0.05	1.45	0.87
	14.34	8.87	14.11	13.78	21.02	13.42	17.95	19.86	10.45	0.01	3.05	0.06	0.01	0.03	0.01	0.01	1.75	0.1

Table S4. Percentage of significant ($p \leq 0.05$) increasing/decreasing stations of GST-, SAT-, and SATD-related indexes in three subareas during 1980 to 2019.

	HDM					YGP					SCB				
	Annual	Spring	Summer	Autumn	Winter	Annual	Spring	Summer	Autumn	Winter	Annual	Spring	Summer	Autumn	Winter
GSTx	61.19/1 6.42	58.21/1 3.43	46.27/2 8.36	49.25/1 3.43	64.18/8 .96	63.19/1 0.44	63.19/1 0.99	34.07/2 0.88	60.44/9 .34	58.24/9 89	83.19/0 .84	84.03/2 .52	73.95/4 .2	63.87/5 .04	91.6/0. 84
GSTm	91.04/0 .0	88.06/4 .48	70.15/7 .46	91.04/0 .0	95.52/1 .49	89.56/2 .2	89.56/3 .3	46.15/1 3.74	86.26/2 .2	90.66/0 55	92.44/1 .68	94.12/1 .68	84.03/3 .36	86.55/0 .84	90.76/ 0.84
GSTn	94.03/0 .0	94.03/0 .0	95.52/0 .0	95.52/0 .0	91.04/1 .49	98.35/0 .0	98.35/0 .0	90.66/1 .1	91.21/1 .1	98.35/0 0	97.48/0 .84	97.48/0 .84	91.6/1 68	94.96/1 .68	97.48/ 0.84
SATx	98.51/0 .0	95.52/0 .0	98.51/0 .0	98.51/0 .0	97.01/0 .0	97.8/1 65	91.21/0 .0	89.56/1 .65	94.51/1 .65	190.66/1 1	94.12/0 .0	96.64/0 .0	94.96/0 .84	81.51/0 .0	92.44/ 1.68
SATm	98.51/0 .0	95.52/0 .0	91.04/0 .0	95.52/0 .0	95.52/0 .0	96.15/1 .65	95.05/0 .0	83.52/1 .65	95.6/1 65	93.41/1 1	93.28/0 .0	94.12/0 .0	92.44/1 .68	84.03/0 .0	87.39/ 1.68
SATn	95.52/1 .49	95.52/1 .49	94.03/0 .0	95.52/1 .49	94.03/1 .49	96.15/1 .1	95.6/0 55	90.11/1 .65	93.96/1 .65	196.15/0 55	92.44/1 .68	94.96/0 .0	88.24/3 .36	90.76/1 .68	83.19/ 1.68
SATD	28.36/2 x	37.31/2 9.85	25.37/3 0.9	29.85/3 8.81	34.33/2 1.34	38.46/2 3.63	40.11/2 4.18	18.68/3 4.62	41.76/1 8.68	35.71/2 9.12	48.74/1 0.92	38.66/1 2.61	50.42/1 9.33	41.18/1 8.49	57.98/ 6.72
SATD	49.25/1 m	52.24/1 3.43	23.88/3 1.94	38.81/1 4.93	65.67/1 0.45	40.11/2 9.12	43.41/1 8.68	20.88/4 4.51	42.86/2 0.88	47.25/2 3.08	45.38/2 1.01	38.66/2 2.69	36.97/2 9.41	50.42/1 8.49	63.87/ 8.4

SATD	67.16/7	70.15/8	68.66/8	65.67/7	62.69/8	52.75/1	54.4/14	52.75/1	51.65/1	57.14/1	52.94/1	57.14/1	42.02/3	61.34/5	63.87/
n	.46	.96	.96	.46	.96	4.29	.29	7.03	8.13	0.44	3.45	4.29	0.25	.88	9.24

Table S5. Percentage of significant ($p \leq 0.05$) increasing/decreasing pixels of GST-, SAT-, and SATD-related indexes in three subareas during 1980 to 2019.

	HDM					YGP					SCB				
	Annual	Spring	Summer	Autumn	Winter	Annual	Spring	Summer	Autumn	Winter	Annual	Spring	Summer	Autumn	Winter
GSTx	74.18/4.67	09/4.63	88/56	56/2.40	93/1.77	92/5.73	74/6.46	22.39/66	67/0.46	15/1.97	47/97	46/0.89	89/0.51	17/0.85	01/2.0
GSTm	99.99/0.98	81/0.69	0/0.79	1/0.07	1.51/0.97	65/0.88	34/0.46	17/100	0/0.98	91/0.100	0/100	0/99.3	0/90.22	0/99.9	0/98.96
GSTn	100.0/0.100	0/0.100	0/0.100	0/0.100	0/0.99	99/0.100	0/0.100	0/0.100	0/0.100	0/0.100	0/0.100	0/0.100	0/0.100	0/0.100	0/0.100
SATx	100.0/0.72	92/0.97	4/0.55	45/6.100	0/0.100	0/0.95	17/0.98	5/0.99	54/0.95	95/0.100	0/99.5	0/99.97	0/89.51	0/93.01	0/0.0
SATm	100.0/0.92	71/0.87	08/27	48/136	68/0.99	79/0.98	34/0.86	39/99	26/0.96	92/0.99	8/0.99	82/0.98	71/0.92	83/1.83	71/0.0
SATn	97.34/0.92	74/0.99	99/85	06/0.79	89/0.94	94/0.93	41/0.99	92/98	01/0.95	11/0.94	1/0.96	86/0.99	68/0.97	62/0.87	78/1.0
SATDx	29.43/3.82	36.0/12.76	18.02/6.01	34.16/1.018	10.63/0.39	30.42/3.34	57.26/1.676	5.71/2.059	24.41/1.433	14.27/5.671	60.17/6.71	65.33/67	0/61.53	10.24/5.51	22.99/4.34
SATDm	51.71/3.37	59.19/0.38	3.83/3.95	49/0.72	39/0.43	83/2.18	08/1.33	5/76	54/1.51	19/9.61	3/8.10	02/1.33	67/2.80	48/0.80	69/1.0
SATDn	87.4/0.7	33.23/2.97	71/89	05/0.80	74/0.71	78/1.65	86/3.72	75/69	75/0.68	19/2.78	76/71	91/3.54	11/4.89	35/0.88	51/0.0

Table S6. The slope of variation rate of annual and seasonal averaged GST-, SAT-, and SATD-related indexes from 1980 to 2019 with elevation in three subareas.

Sub-region	Timescale	GSTx	GSTm	GSTn	SATx	SATm	SATn	SATDx	SATDm	SATDn
HDM	Annual	-0.002	0.017 ^b	0.022 ^b	-0.001	0.011 ^b	0.012 ^b	-0.006	0.006 ^b	0.01 ^b
	Spring	-0.009 ^b	0.002 ^b	0.002 ^a	-0.006 ^b	-0.005 ^b	0.007	-0.001	0.012 ^b	0.002
	Summer	-0.001	0.006 ^b	0.008 ^b	0.001	0.006 ^b	0.006 ^b	0.014 ^a	-0.003	0.003 ^b
	Autumn	-0.001	-0.002	0.024 ^b	-0.003	-0.025 ^b	-0.002	0.01 ^b	0.019 ^b	0.027 ^b
	Winter	-0.005 ^a	0.003 ^a	0.029 ^b	0.005 ^b	-0.004 ^a	0.004 ^b	-0.011 ^b	0.005 ^b	0.03 ^b
YGP	Annual	0.007	0.008 ^a	0.016 ^b	-0.003 ^a	0.004 ^b	0.003 ^b	0.011 ^a	0.0	0.013 ^b
	Spring	0.008	0.0	0.004 ^b	-0.004	-0.01 ^b	0.002	0.015	0.005	0.01 ^b
	Summer	-0.008	-0.004	0.005 ^b	0.0	-0.0	0.0	0.007	0.004	0.007 ^b
	Autumn	-0.013 ^a	0.003 ^b	0.012 ^b	-0.0	-0.003	-0.005 ^b	0.011	0.017 ^b	0.017 ^b
	Winter	0.011	0.009 ^b	0.014 ^b	0.003 ^a	-0.005 ^a	-0.004	-0.001	0.013 ^b	0.019 ^b
SCB	Annual	-0.005 ^a	0.012 ^b	0.019 ^b	-0.002 ^a	0.012 ^b	0.01 ^b	-0.016 ^b	0.002	0.008 ^b
	Spring	-0.012 ^b	0.002	0.003 ^b	-0.007 ^b	-0.006 ^b	0.008 ^a	-0.012 ^a	0.01 ^b	0.004
	Summer	-0.011 ^b	0.0	0.005 ^b	-0.002	0.002	0.004 ^b	-0.008	-0.005	0.003 ^b
	Autumn	0.001	-0.002 ^a	0.019 ^b	-0.003 ^a	-0.02 ^b	-0.002 ^b	0.009 ^a	0.017 ^b	0.022 ^b

Winter -0.007 0.003^a 0.022^b 0.009^b -0.006 0.0 -0.017^b 0.005^b 0.026^b

Table S7. Percentage area of significant ($p \leq 0.05$) coherence in bi-wavelet coherence between anomaly of the monthly averaged GST-, SAT-, and SATD-related indexes and large-scale indexes in from 1980 to 2019 in three subareas.

		GSTm	GSTx	GSTn	SATm	SATx	SATn	SATDx	SATDn	SATDm
HDM	AMO	9.09	13.92	9.18	13.69	12.39	14.78	15.42	11.13	9.38
	AO	4.88	5.98	2.48	3.38	3.52	3.97	8.99	5.47	9.7
	MEI	5.87	6.54	8.22	8.07	5.41	13.91	10.54	3.03	18.39
	NAO	4.75	4.33	6.93	5.19	3.97	6.52	5.14	4.51	11.32
	PDO	2.95	4.56	4.89	3.25	2.74	4.06	5.64	4.21	9.68
	PNA	2.23	7.25	3.7	2.74	2.46	4.76	10.09	3.99	5.6
SCB	AMO	15.02	4.07	6.44	10.09	8.15	9.73	4.01	8.34	5.18
	AO	4.48	4.92	3.11	3.8	3.14	3.65	4.06	10.85	6.06
	MEI	4.03	5.43	2.41	3.96	5.2	3.48	3.23	12.97	5.31
	NAO	4.13	6.44	2.44	4.03	4.88	2.1	7.18	13.34	13.87
	PDO	3.48	3.87	3.23	3.5	4.13	3.27	12.36	11.17	6.7
	PNA	5.05	6.27	2.86	9.13	11.33	3.78	9.97	7.17	3.23
YGP	AMO	4.67	5.94	2.99	9.15	9.03	8.65	6.5	4.1	4.92
	AO	7.08	5.74	6.09	6.19	5.87	5.79	3.79	8.11	8.33
	MEI	3.24	4.06	4.57	3.18	3.63	3.4	4.48	6.45	6.21
	NAO	4.53	4.46	2.97	4.35	5.01	3.41	4.13	9.06	7.42
	PDO	5.55	5.31	4.52	4.96	5.74	3.39	6.62	6.96	7.88
	PNA	6.15	4.41	9.15	7.47	5.62	7.24	3.05	5.71	0.74

Entries in bold indicate the factor with the highest PASC.

Table S8. Percentage area of significant coherence (PASC) in multi-wavelet coherence between anomaly of the monthly averaged GST-, SAT-, and SATD-related indexes and large-scale indexes from 1980 to 2019 in three subareas.

		Maximum temperature		Mean temperature		Minimum temperature	
		Combination	PASC (%)	Combination	PASC (%)	Combination	PASC (%)
GST		AMO	13.92	AMO	9.09	AMO	9.18
		AMO+NAO	17.56	AMO+MEI	16.20	AMO+PDO	25.09
		AMO+NAO+PNA	16.94	AMO+MEI+NAO	15.88	AMO+PDO+NAO	21.66
		AMO+NAO+PNA+MEI	16.44	AMO+MEI+NAO+PDO	14.20	AMO+PDO+NAO+PNA	16.64
		AMO	12.39	AMO	13.69	AMO	14.78
HD	SAT	AMO+MEI	12.89	AMO+AO	16.20	AMO+PDO	18.89
		AMO+MEI+AO	13.45	AMO+AO+MEI	14.53	AMO+PDO+MEI	15.86
		AMO+MEI+AO+NAO	10.62	AMO+AO+MEI+NAO	13.24	AMO+PDO+MEI+NAO	14.05
		AMO	15.42	MEI	18.39	AMO	11.13
		AMO+NAO	18.00	MEI+AO	17.82	AMO+NAO	20.08
D		AMO+NAO+MEI	16.81	MEI+AO+PDO	15.32	AMO+NAO+PDO	17.29
		AMO+NAO+MEI+PDO	15.18	MEI+AO+PDO+NAO	15.00	AMO+NAO+PDO+PNA	15.97
		NAO	6.44	AMO	15.02	AMO	6.44
	YGP GST	NAO+AO	8.72	AMO+NAO	12.14	AMO+PDO	20.21
		NAO+AO+PNA	8.27	AMO+NAO+PNA	10.80	AMO+PDO+NAO	16.17

	NAO+AO+PNA+PDO	8.19	AMO+NAO+PNA+AO	10.94	AMO+PDO+NAO+PNA	13.65
	PNA	11.33	AMO	10.09	AMO	9.73
SAT	PNA+AMO	9.32	AMO+NAO	12.74	AMO+NAO	11.55
	PNA+AMO+MEI	6.78	AMO+NAO+MEI	10.80	AMO+NAO+PDO	10.85
	PNA+AMO+MEI+NAO	6.87	AMO+NAO+MEI+PNA	10.71	AMO+NAO+PDO+MEI	9.35
	PDO	12.36	NAO	13.87	NAO	13.34
SAT	PDO+PNA	14.02	NAO+MEI	13.36	NAO+PDO	19.39
D	PDO+PNA+AO	9.01	NAO+MEI+AO	12.33	NAO+PDO+AMO	17.39
	PDO+PNA+AO+NAO	7.56	NAO+MEI+AO+PNA	10.34	NAO+PDO+AMO+AO	15.44
	AMO	5.94	AO	7.08	PNA	9.15
GST	AMO+PDO	10.70	AO+PNA	11.97	PNA+AMO	13.67
	AMO+PDO+MEI	6.54	AO+PNA+AMO	9.69	PNA+AMO+AO	12.50
	AMO+PDO+MEI+AO	6.08	AO+PNA+AMO+MEI	7.85	PNA+AMO+AO+MEI	11.54
	AMO	9.03	AMO	9.15	AMO	8.65
SCB SAT	AMO+PDO	11.34	AMO+PNA	11.43	AMO+AO	12.68
	AMO+PDO+NAO	11.16	AMO+PNA+AO	10.77	AMO+AO+PNA	11.53
	AMO+PDO+NAO+PNA	10.05	AMO+PNA+AO+PDO	10.88	AMO+AO+PNA+NAO	10.00
	PDO	6.62	AO	8.33	NAO	9.06
SAT	PDO+AMO	9.25	AO+NAO	10.49	NAO+AMO	16.59
D	PDO+AMO+MEI	7.73	AO+NAO+PDO	9.08	NAO+AMO+MEI	14.55
	PDO+AMO+MEI+PNA	7.02	AO+NAO+PDO+PNA	7.43	NAO+AMO+MEI+PNA	13.60