Table S1 Brief introduction to the design of the experiments

Experiment	GHG forcing	AA	Model	period	Realiz-ations
Historical experiment (**His**)	CMIP5 historical forcing	CMIP5 historical forcing	HadGEM3-GC2	1960-2014	4
			GFDL-CM3	1961-2019	4
Current legislation emissions (**CLE**)	CMIP5 RCP4.5	globally as ECLIPSE high range	HadGEM3-GC2	2005-2050	4
			GFDL-CM3	2010-2050	3
Maximum technically feasible reduction (**MTFR**)	CMIP5 RCP4.5	globally as ECLIPSE low range	HadGEM3-GC2	2005-2050	4
			GFDL-CM3	2010-2050	3

Table S2 Frequency (unit: %) of different bins for each component of HWI in His, CLE and MFR

Model	Exp	deltT			U500			V850		
		≥**1**	≥**2**	≥**3**	≥**1**	≥**2**	≥**3**	≥**1**	≥**2**	≥**3**
HadGEM3-GC2	His	14.0	2.0	0.0	17.0	1.7	0.0	7.2	3.0	0.3
	CLE	29.3	5.0	0.72	26.8	4.3	0.5	16.0	2.8	0.2
	MTFR	37.2	8.8	1.2	36.3	11.5	1.7	22.7	6.5	0.5
GFDL-CM3	His	16.7	1.7	0.0	18.0	3.0	0.0	17.8	2.4	0.0
	CLE	30.2	6.0	0.0	25.1	5.1	0.0	22.2	3.2	0.6
	MTFR	35.8	6.0	0.3	32.7	5.1	1.3	23.1	4.4	0.3

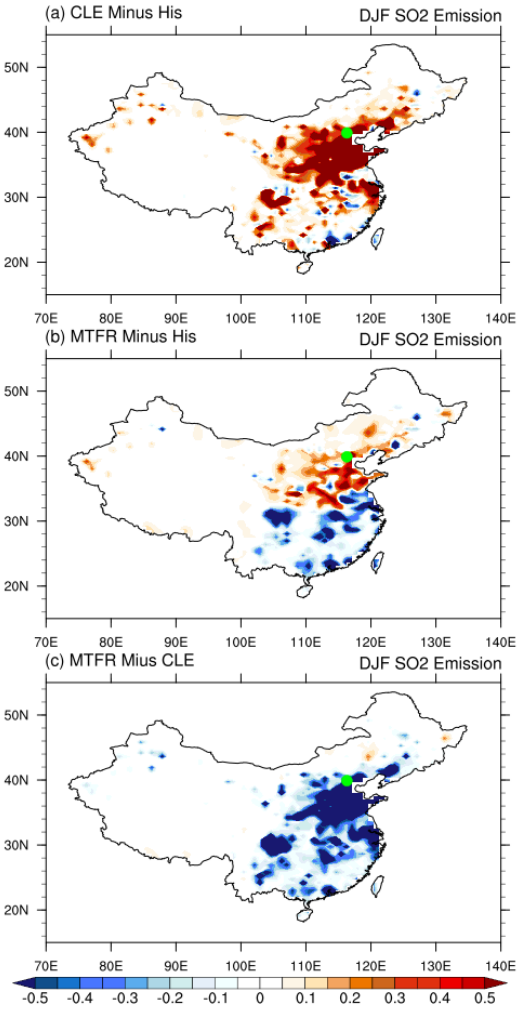

Fig. S1 Spatial distributions of the winter mean (DJF) sulfur dioxide emissions difference (kg/season) between (a) CLE (2016-2049) and His (1980-2004), (b) MTFR (2016-2049) and His (1980-2004), and (c) MTFR (2016-2049) and CLE (2016-2049). The green dot in each plot indicate the location of Beijing.

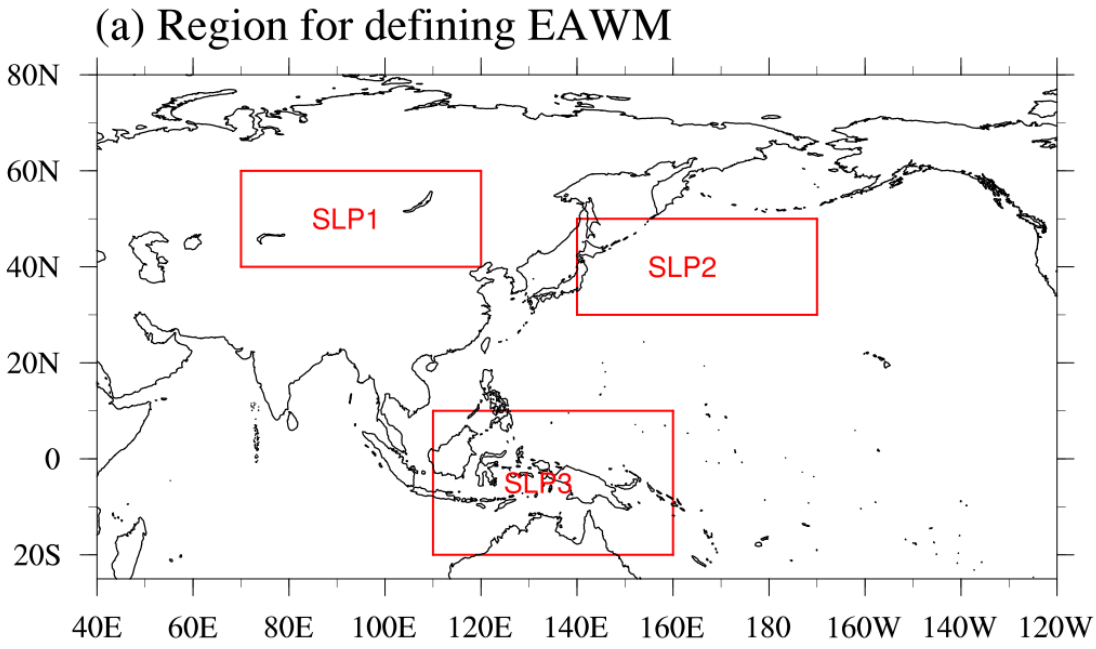

Fig. S2 Regions used to calculate the EAWM index.

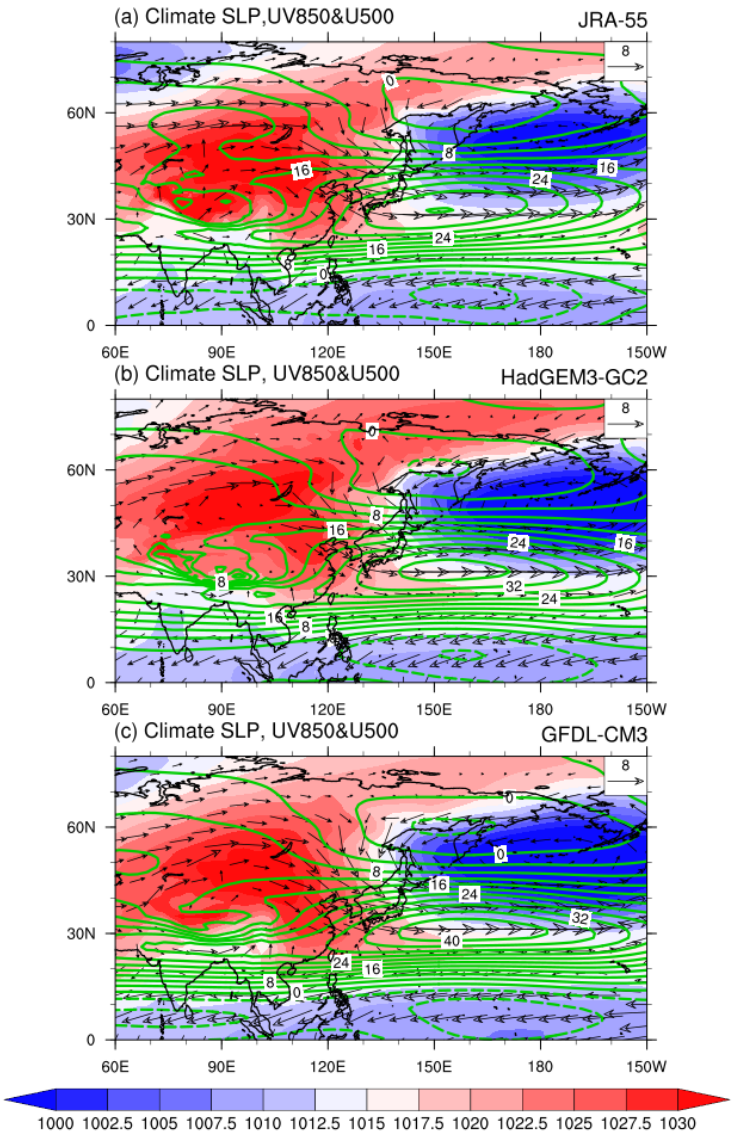

Fig.S3 DJF mean sea level pressure (shading, hPa), 850hPa winds (vector, m/s) and 500hPa zonal wind (contour, m/s) averaged over 1980-2004 in (a) JRA-55, (b) HadGEM3-GC2, and (c) GFDL-CM3.

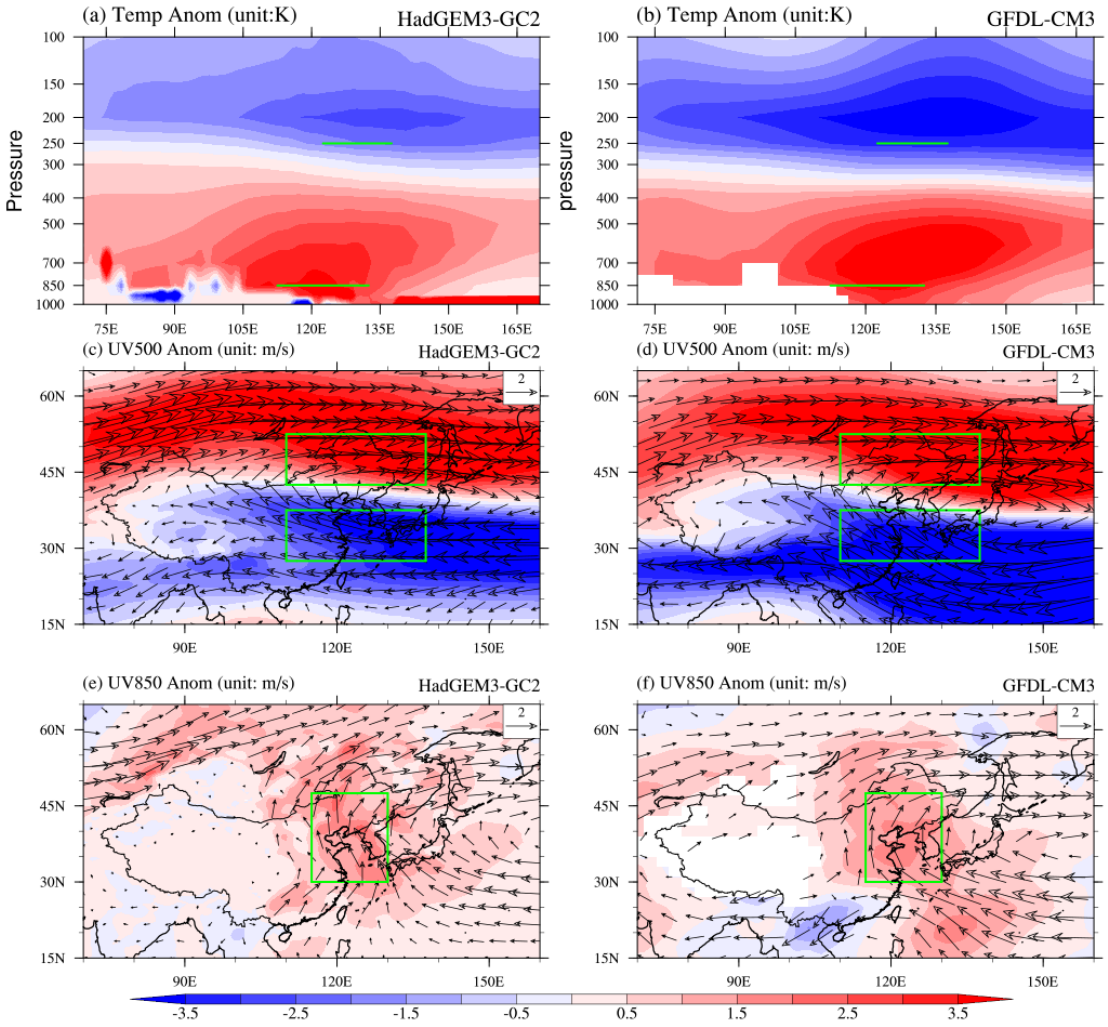

Fig.S4 Composite circulation anomalies with monthly HWI≥1.0 during 1980-2004 in HadGEM3-GC2 (left) and GFDL-CM3 (right). (a)-(b) temperature anomalies (K) along 40N, (c)-(d) 500hPa winds anomalies (vector, m/s) and 500hPa zonal winds anomalies (shading, m s^{-1}), (e)-(f) 850hPa winds anomalies (vector, m s^{-1}) and 850 hPa meridional winds anomalies (shading, m s^{-1}).

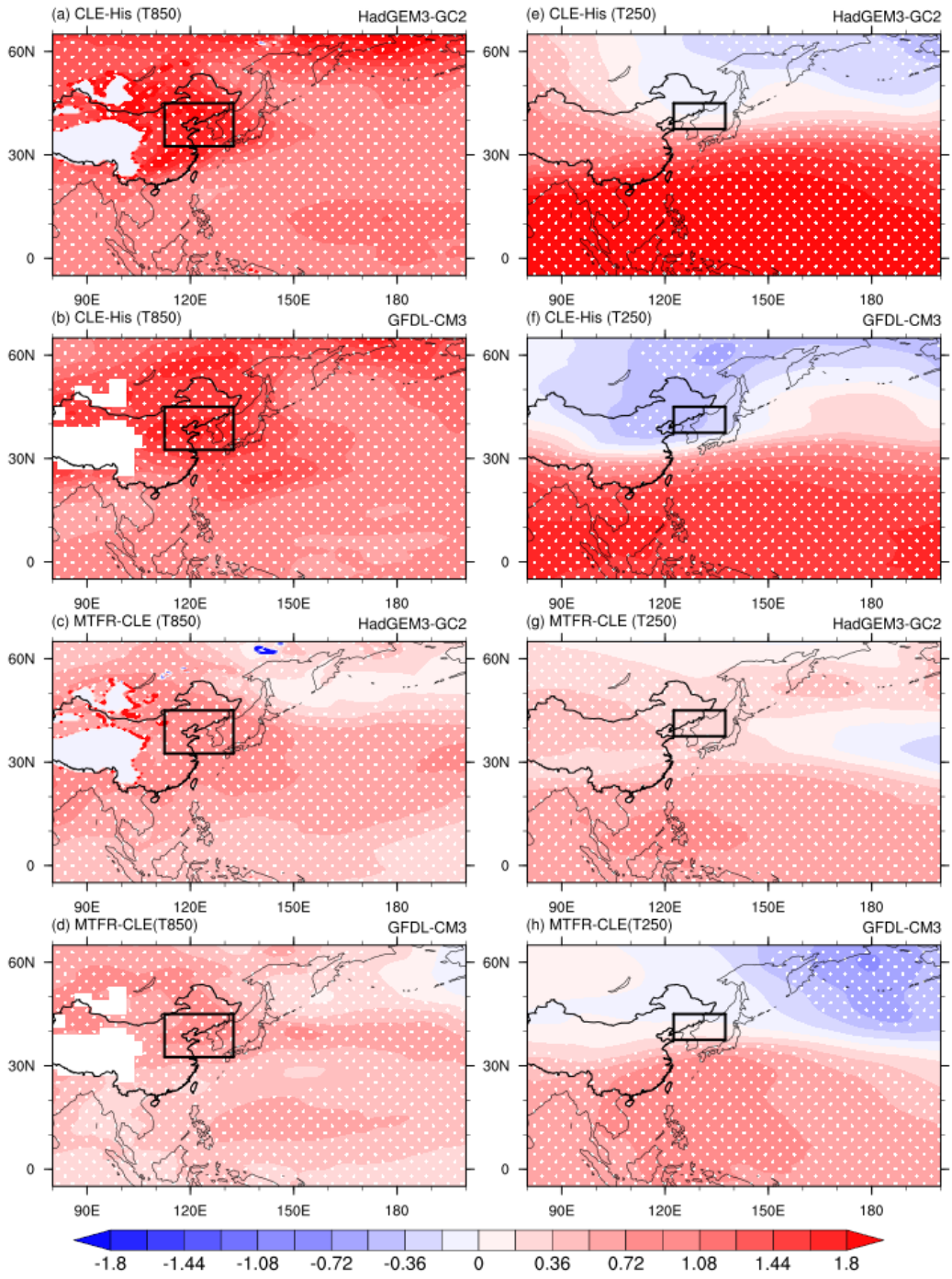

Fig.S5 Difference in DJF 850hPa temperature (left) and DJF 250hPa temperature (right) between (a)-(d) CLE and His, and between (e)-(h) MTFR and CLE for HadGEM3-GC2 and GFDL-CM3.

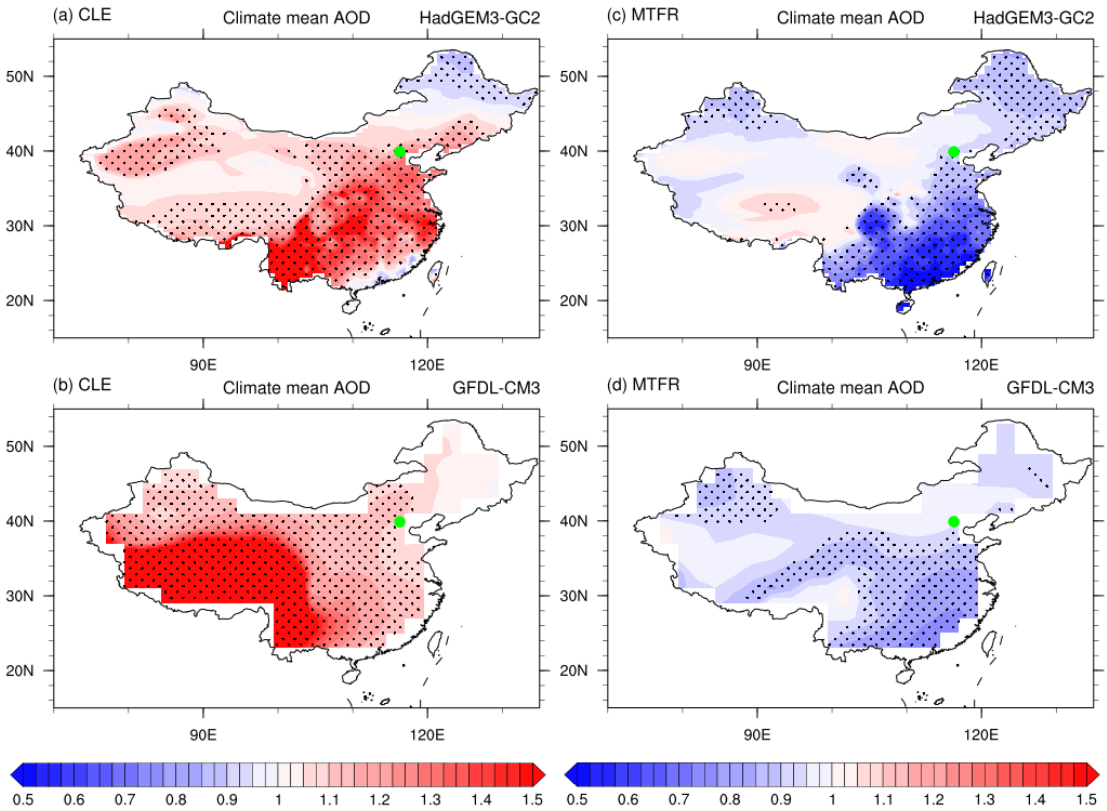

Fig. S6 Ratio of DJF mean AOD in CLE (left) and MTFR (right) relative to the present climate winter mean in (a)-(b) HadGEM3-GC2 and (c)-(d) GFDL-CM3. Dotted area denotes the difference from present climate mean is statistically significant at the 10% level. Blue and red shadings are lower and higher than present climate mean, respectively.

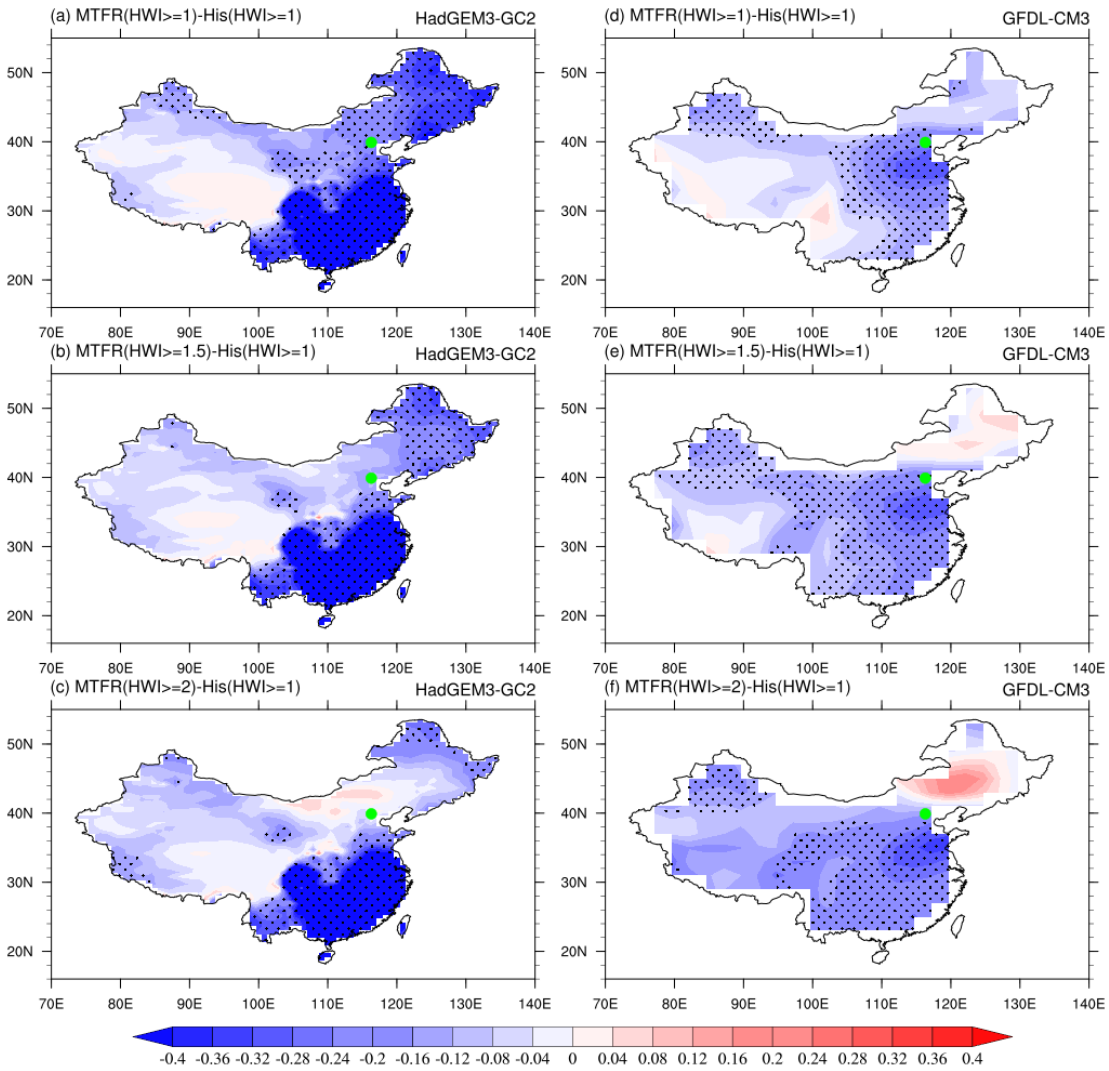

Fig. S7 Same as Fig.11, but for the difference between AOD when (a) HWI≥1, (b) HWI≥1.5 and (c) HWI≥2 in MTFR relative to AOD when HWI≥1 in His simulated by HadGEM3-GC2. (d)-(f) are same as (a)-(c), but simulated by GFDL-CM3.