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Quantifying the contribution of anthropogenic influence to the East Asian winter monsoon in 1960–2012

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1. Assessment of the atmospheric circulation pattern by model in All-Hist runs

Taylor diagram (Figure S1) shows the model can well reproduce the climatology of the EAWM-related circulation features in all 15 runs, ensemble average of all runs (referred to as “ensemble_all”) and ensemble average of run1, run2, run5, run13, run14 and run15 (referred to as “ensemble_best”). The surface air temperature, Aleutian low, 500 hPa geopotential height and 300 hPa zonal wind show higher pattern correlations with observations. However, Table S1 shows the correlation between simulation and observation, and the trend coefficient, it suggests ensemble_best can better capture the variability of the EAWM indices and reliably reproduce the long-term trend (one is defined as the area-averaged surface air temperature and the other is defined as the area-averaged 500 hPa geopotential height) than others.

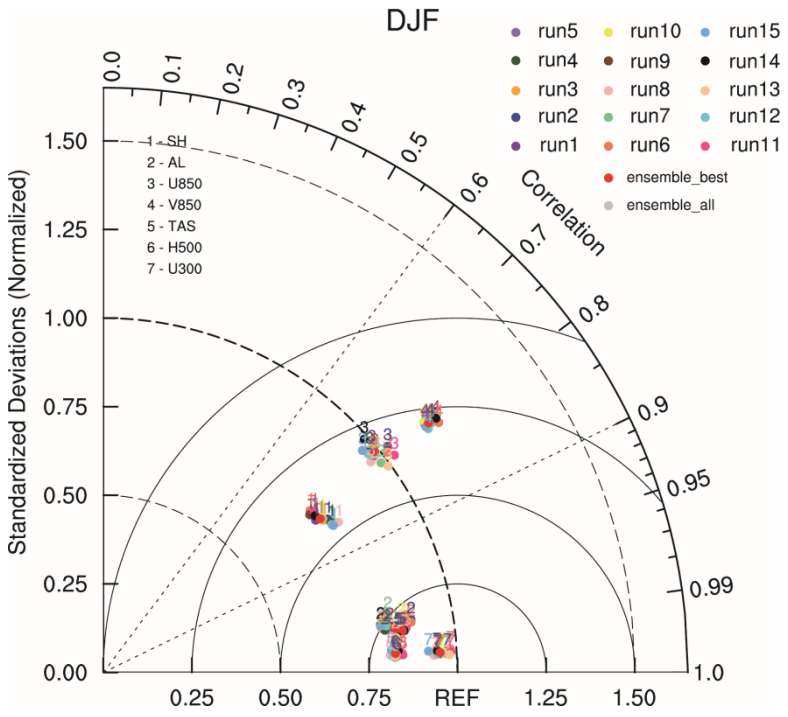

Figure S1 Taylor diagram of winter-mean climatology for Siberian high (SH; 40°–60°N, 70°–120°E), Aleutian low (AL; 40°–70°N, 110°–160°E), 850 hPa zonal wind (U850; 25°–50°N, 115°–145°E), 850 hPa meridional wind (V850; 25°–50°N, 115°–145°E), 850 hPa meridional wind (V850; 20°–40°N, 100°–140°E),

surface air temperature (TAS; 25°–45°N, 105°–145°E), 500 hPa geopotential height (H500; 25°–45°N, 105°–145°E) and 300 hPa zonal wind (U300; (27.5°–37.5°N, 110°–170°E)−(50°–60°N, 80°–140°E)). The area of meteorological variable is selected to define the EAWM index.

Table S1 “tr” is an abbreviation for “linear trend coefficient” (EAWMI_HGT/EAWMI_SAT). “cor” is an abbreviation for “correlation coefficient between simulated EAWM index under All-Hist scenario and observed EAWM index” (EAWMI_HGT/EAWMI_SAT), “cor_dec” is an abbreviation for “correlation coefficient in decadal time-scale”. As a reference, the linear trend coefficient of EAWM_HGT/EAWM_SAT is -0.02/-0.023. The red numbers are significant at the 90% confidence level.

	run 1	run 2	run 3	run 4	run 5	run 6	run 7	run 8
Cor	0.23/0.21	0.21/0.09	-0.19/-0.17	0/0.16	0.24/0.14	0.17/0.05	0.08/0.22	0.02/0.21
Cor_dec	0.64/0.44	0.63/0.81	-0.16/0.04	0.64/0.52	0.6/0.53	0.25/0.4	0.3/0.78	-0.31/0.37
tr	-0.032/-0.016	-0.018/-0.023	-0.003/-0.011	-0.016/-0.012	-0.016/-0.018	-0.016/-0.014	0/-0.017	0/-0.013
	run 9	run 10	run 11	run 12	run 13	run 14	run 15	ensemble_all
Cor	0.1/0.05	0.24/0.02	0.18/0.13	0.027/-0.055	0.23/0.3	0.11/0.18	0.07/-0.06	0.26/0.23
Cor_dec	0.27/0.6	0.57/0.38	0.54/0.14	0.12/0.42	0.67/0.63	0.76/0.64	0.67/0.49	0.67/0.57
tr	0/-0.014	-0.011/-0.015	-0.019/-0.017	-0.006/-0.023	-0.02/-0.018	-0.016/-0.013	-0.02/-0.023	-0.03/-0.04
	ensemble_best							
Cor	0.31/0.3							
Cor_dec	0.76/0.7							
tr	-0.038/-0.044							

2. Possible reasons for the increase trend in EAWMI in Nat-Hist runs

Previous studies indicated that the Atlantic multidecadal oscillation (AMO) and Pacific decadal oscillation (PDO) favor a low-frequency variability of the EAWM, and that is the EAWM is weakened (enhanced) during the warm (cold) phase of the AMO/PDO (e.g., Li and Bates 2007; Ding et al., 2014; Hao and He, 2017). As shown in Fig. 2, an obviously increasing in EAWMI during 1960-1980 in Nat-Hist runs. During 1960-1980, both the PDO (downloaded from http://research.jisao.washington.edu/pdo/PDO.latest.txt) and AMO (Trenberth and Shea, 2006) were in a cold phase (Fig. S2), leading an enhanced EAWM. However, the PDO and AMO were out-of-phase after 1980s, causing a combined effect on the EAWM. Thus, we consider that the AMO and PDO may be responsible for the increase trend of EAWMI in Nat-Hist runs.

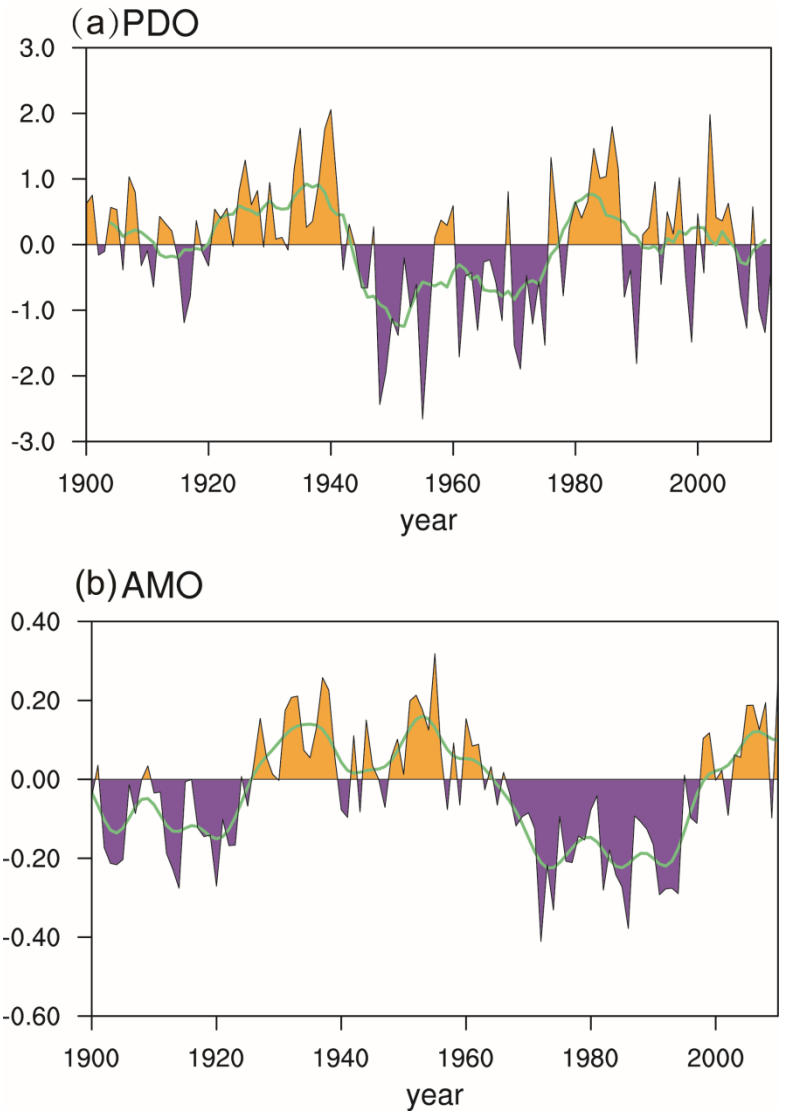

Fig. S2 Time series of the Pacific decadal oscillation (PDO; a) and Atlantic multidecadal oscillation (AMO; b) during 1960-2012.