

Supporting Information

**What Caused the Recent “Warm Arctic, Cold Continents”
Trend Pattern in Winter Temperatures?**

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ERA-Interim

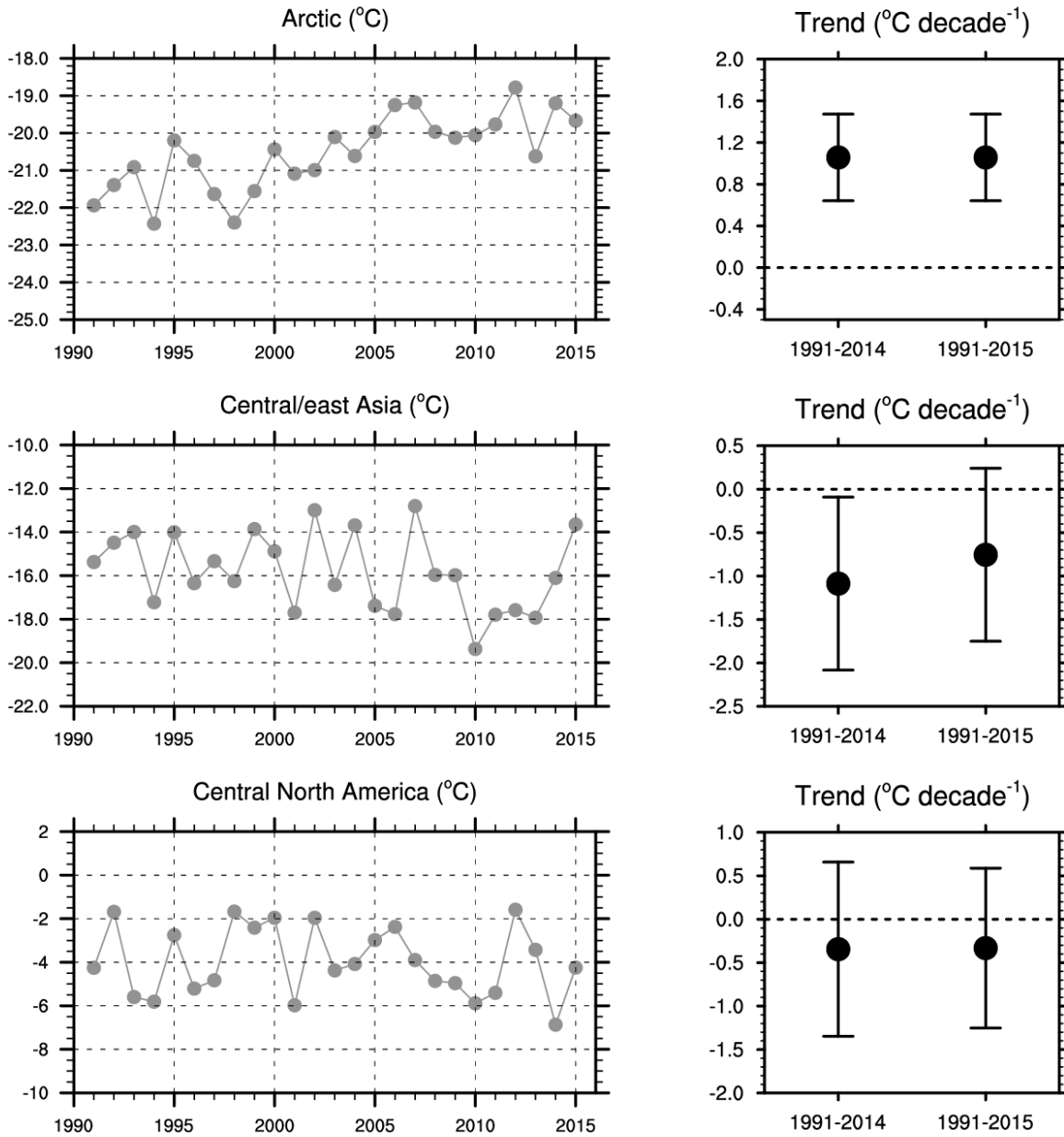


Figure S1: ERA-Interim winter temperature time series (left) and the temperature trend over the period of 1990/91-2013/14 and 1990/91-2014/15 for the Arctic region (top panel; 60-90°N polar cap average), central/east Asia (middle panel; 40-65°N, 50-130°E) and central North America (bottom panel; 35-50°N, 80W-110°W). The central/east Asia and central North America are the two continental regions showing cooling trend over 1990/91-2013/14 and they are indicated by green sectors in Figure 1, respectively. The error bar in the right panel indicates the trend and its 95% confidence interval.

NCEP/NCAR Reanalysis

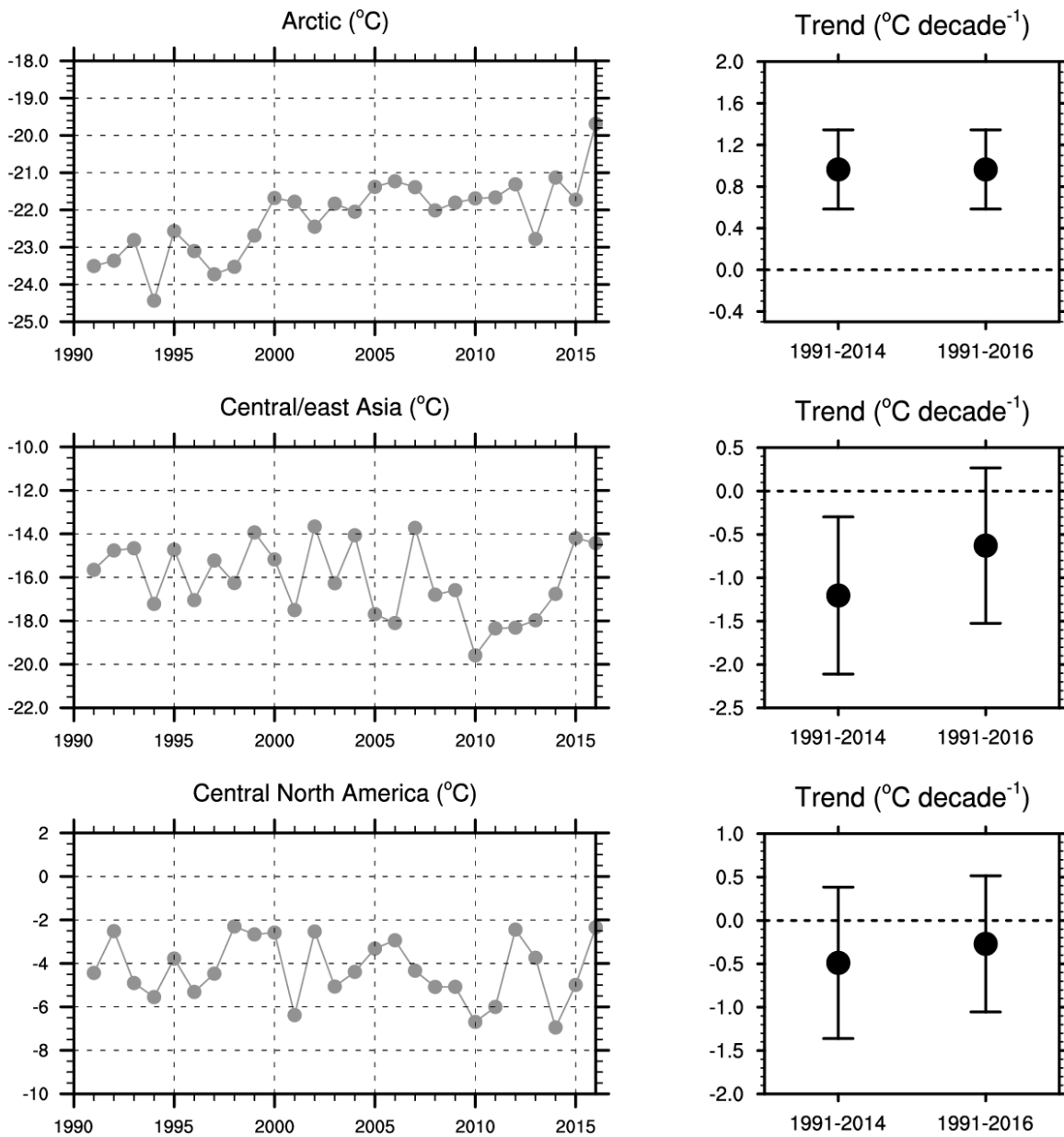


Figure S2: As in Figure S1, but for the NCEP/NCAR Reanalysis dataset. With NCEP/NCAR reanalysis dataset, the temperature series are available up to the winter of 2015/16. The right panel shows the trend and its 95% confidence interval for the period of 1990/91-2013/14 and 1990/91-2015/16.

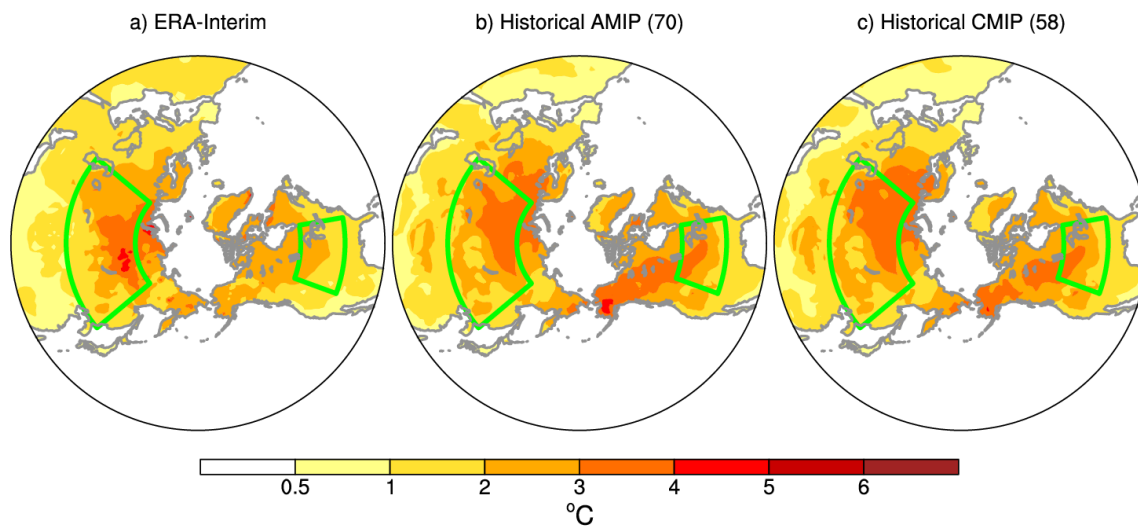


Figure S3: Winter surface air temperature standard deviation for a) ERA-Interim, b) 70-member historical *AMIP* simulation ensemble-mean and c) 58-member historical *CMIP* simulation ensemble-mean.

1990/91-2013/14 DJF temperature trend

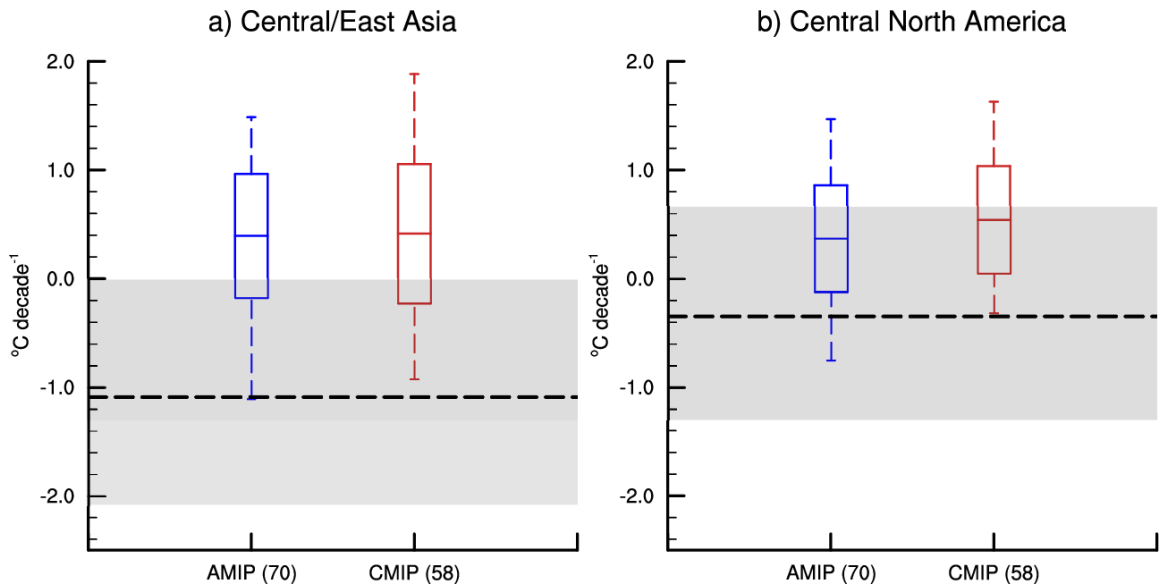


Figure S4: Box-plot of the 1990/91-2013/14 surface air temperature trend averaged over a) central/east Asia and b) central North America for historical *AMIP* (blue box) and *CMIP* (red box) simulations. The box-plots show the mean values (solid horizontal line), plus and minus one standard deviation (box outline), minimum and maximum values (whiskers) across all ensembles. The dashed line and shading area denote the ERA-Interim value ($-1.09^{\circ}\text{C decade}^{-1}$ in a) and $-0.34 \text{ K decade}^{-1}$ in b)) and its lower/upper bounds based on the 95% confidence intervals ($-2.08 \sim -0.09 \text{ K decade}^{-1}$ in a) and $-1.30 \sim 0.66 \text{ K decade}^{-1}$ in b)).

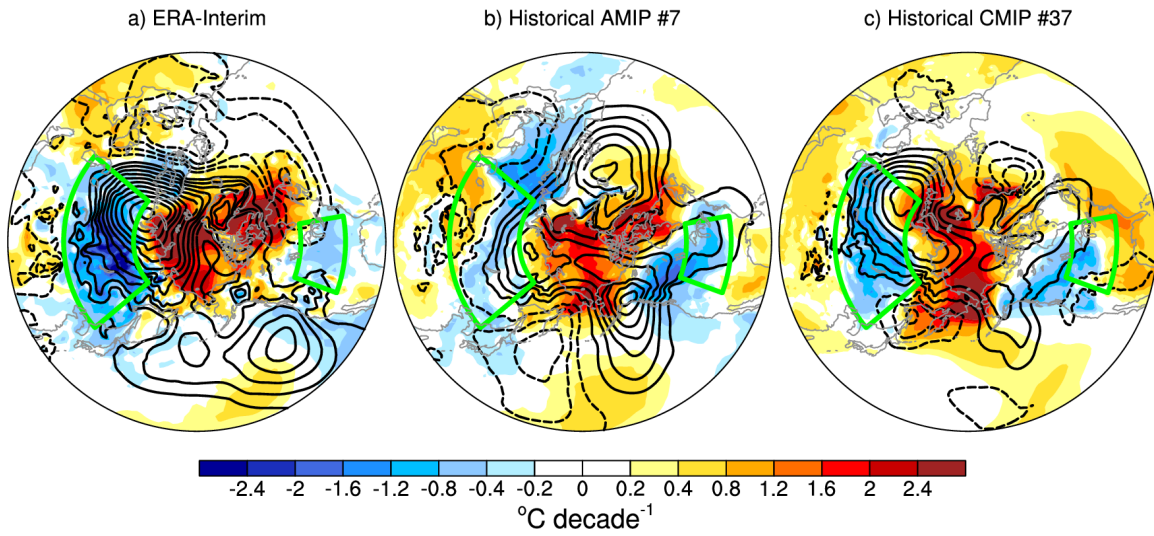


Figure S5: As in figure 1, but for the comparison between a) ERA-Interim and individual ensembles of the b) *historical AMIP* and c) *historical CMIP* simulations that show similar winter temperature trend as in observations. The contour interval for sea level pressure trend is 0.5 hPa decade $^{-1}$.

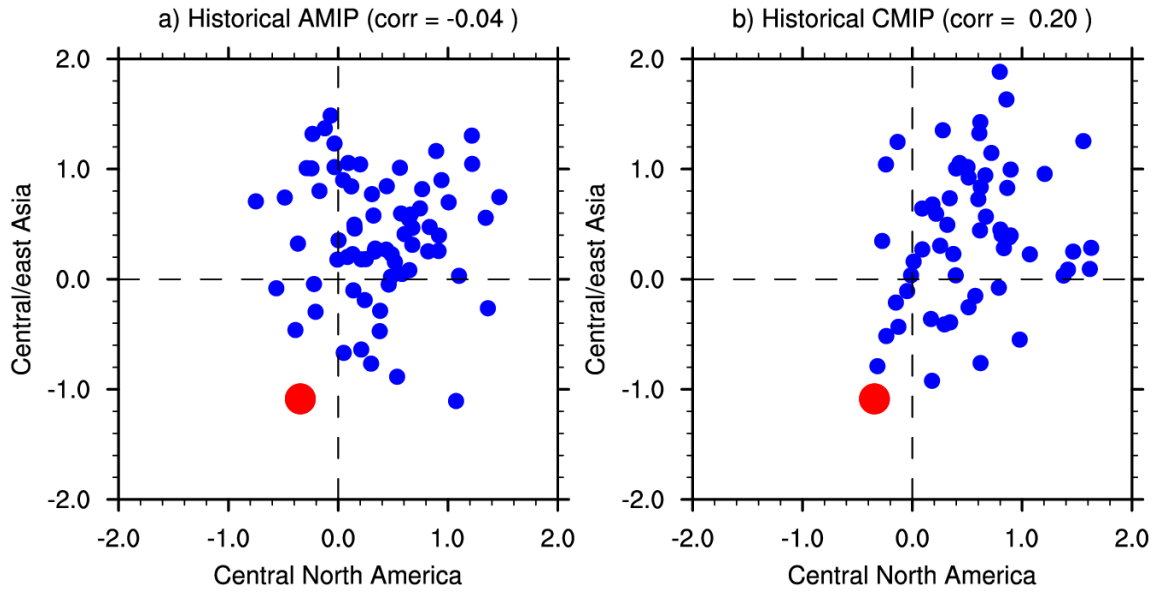


Figure S6: Scatter plot of the 1990/91-2013/14 temperature trend averaged over central North America versus the temperature trend averaged over central/east Asia for the a) *Historical AMIP* and b) *Historical CMIP* simulations. The red dot indicates the ERA-Interim result.

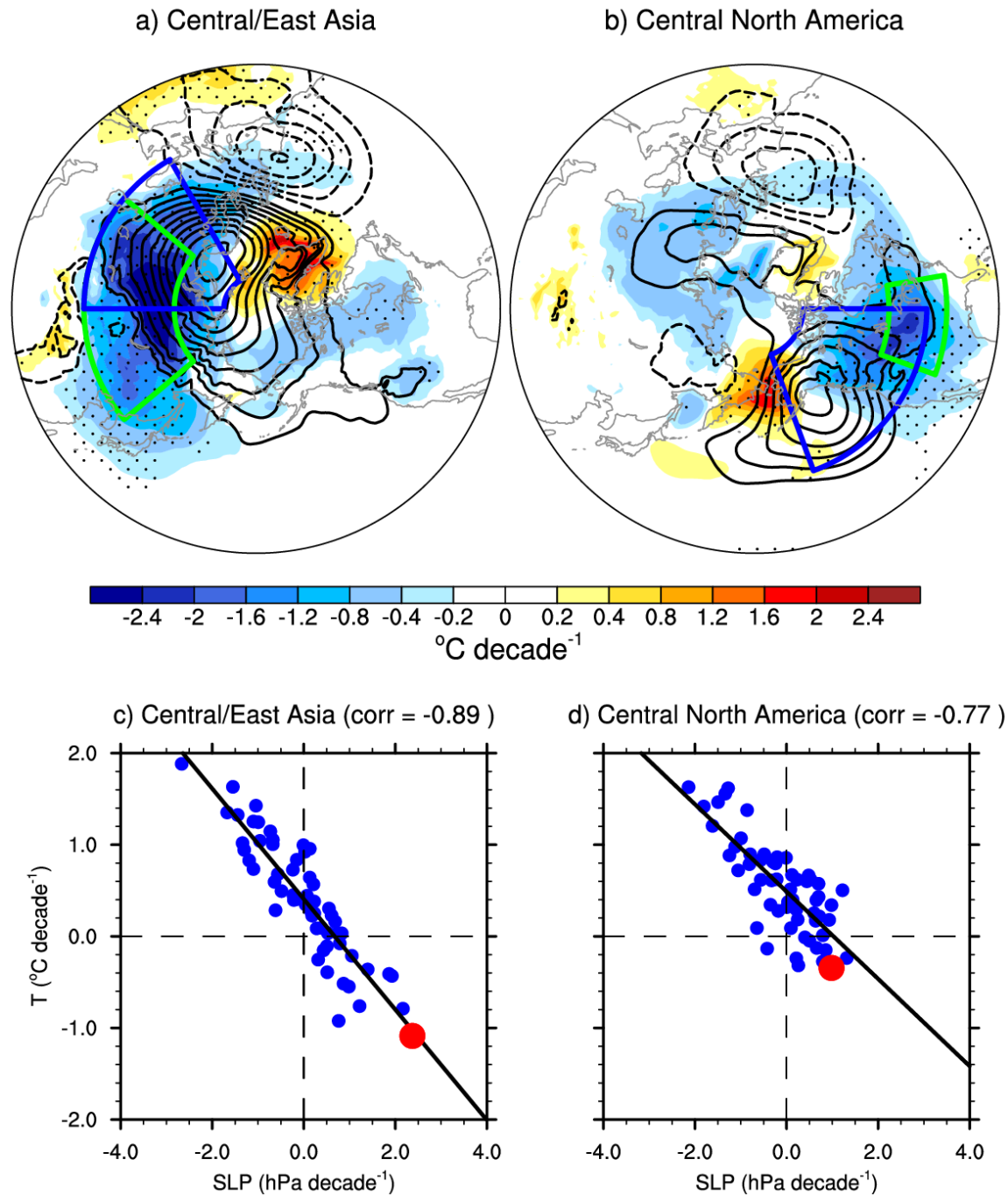


Figure S7: As in Fig. 2, but for the *Historical CMIP* experiments. The composite is constructed based on the difference between 12-sample lowest quintile and 12-sample highest quintile surface air temperature trend over a) central/east Asia and b) central North America. The stippling in a) and b) denotes the 95% statistical significance based on two-sided student's t-test.

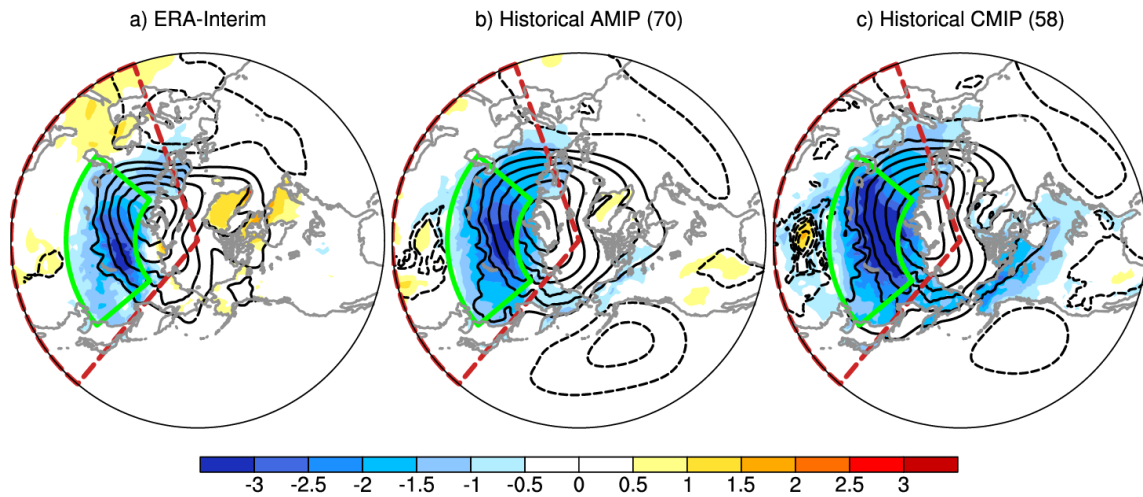


Figure S8: Leading empirical orthogonal function (EOF) pattern of the sea level pressure in the region of 20-140°E; 23-90°N (contours; interval of 1 hPa) as indicated by the dashed red sector, and the corresponding surface air temperature anomaly (shading, units of °C) for a) ERA-Interim, b) *historical AMIP* and c) *historical CMIP* simulations. The same 1990/91-2013/14 period is used to conduct the EOF analysis for both ERA-Interim and model data.

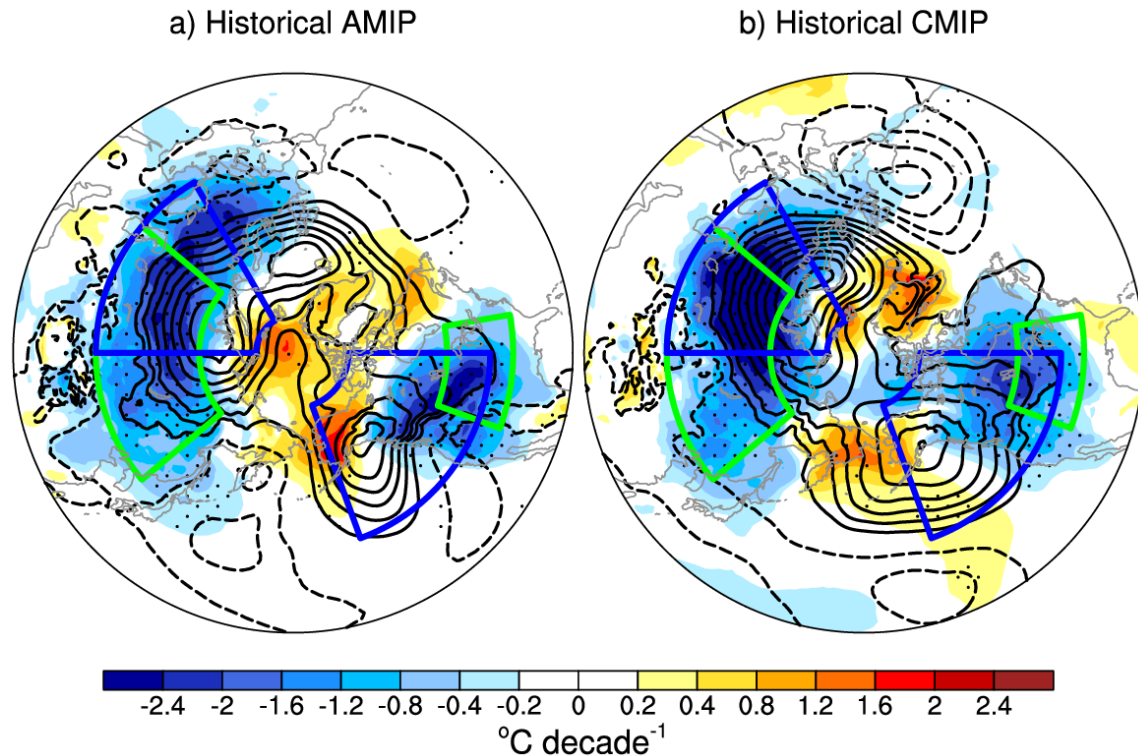


Figure S9: As in Figure 2 a b, but for the composite of the difference between lowest and highest quintile surface air temperature trend over both central/east Asia and central North America. The contour interval of the sea level pressure trend is $0.5 \text{ hPa decade}^{-1}$. The composite for the *historical AMIP* simulations in a) is constructed based on the difference between 3 samples for the lowest quintile and 3 samples for the highest quintile. The composite for the *historical CMIP* simulations in b) is constructed based on the difference between 7 samples for the lowest quintile and 4 samples for the highest quintile. The stippling denotes the 95% statistical significance based on the two-sided student's t-test.

Table S1: Overview of model experiments.

Experiments	SST	SIC	Radiative forcing	Models (number of ensembles)
<i>Historical AMIP</i>	1990-2014	1990-2014	1990-2014 ¹	CAM4 (20); ECHAM5 (30); CAM5 (50)
<i>Historical CMIP</i>	-----	-----	1990-2014 ²	CCSM4 (20); CESM1 (38)
<i>CLIM_POLAR AMIP</i>	1990-2014	1979-1989 climatology	1990-2014 ¹	CAM4 (20); ECHAM5 (30)

¹For both *Historical AMIP* and *CLIM_POLAR AMIP* experiments, the observed radiative forcing is used for the period of 1990-2005 and RCP4.5 radiative forcing is used afterwards.

²From 1990-2005, the observed radiative forcing is used for both CCSM4 and CESM1. From 2006-2014 the RCP4.5 radiative forcing is used for CCSM4 but RCP8.5 radiative forcing is used for CESM1. This, however, does not seem to affect our results given the similar trend in temperature and sea level pressure across the period of 1990/91-2013/14.