

Recent amplification of the North American winter temperature dipole

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Contents of this file

Figures S1 to S5 and Table S1.

Introduction

This file contains five supplementary figures and one table.

Figure S1 is a comparison of the frequency and intensity of the North American Winter Dipole events from 3 different datasets.

Figure S2 shows the composite 500mb geopotential height anomalies and 2-m temperature anomalies for each of the 20 clusters of daily wintertime mid-tropospheric circulations over North America.

Figure S3 shows the time series of persistence of the six “leading” SOM patterns.

Figure S4 compares the composite spatial patterns of temperature dipole events from observations and the historical LENS simulations for increasing fractions of grid cells experiencing warm/cold extremes in the western/eastern domains.

Figure S5 examines the influence of different levels of radiative forcing on trends in the characteristics of dipole events with increasing fractions of grid cells experiencing warm/cold extremes in the western/eastern domains.

Table S1 summarizes the fraction of total positive or negative trends in PIcontrol and Historical climates that are also significant.

Supplementary Figure/Table Captions

Figure S1. Dataset Intercomparison: Figure S1. Dataset Intercomparison: Linear trends in winter (DJF) season (a-c) frequency of NAWTD event occurrences and (d-f) average intensity of NAWTD events from three additional datasets – PRISM, METDATA, and North American Regional Reanalysis (NARR). Magnitude of linear trends and their p-values (in parentheses) are indicated on the panels and summarized in Table 1. Trends in dipole frequency from PRISM closely match the NCEP/NCAR R1 trends.

Figure S2. Atmospheric Circulation Characteristics: (a) Self-Organizing Maps (SOMs) of mid-tropospheric (500mb) daily winter (DJF) geopotential height anomalies topologically ordered into 20 clusters. Each map is a composite of the 500mb circulation anomalies on all days within a cluster. Correlation (C) between the cluster circulation composite with the NAWTD event composite (Fig. 1b) is indicated in the bottom left. Linear trend magnitudes in the seasonal frequency of occurrence of each cluster circulation pattern are shown in the bottom right. (b) Composites of 2m temperature anomalies on all days associated with each cluster. The overall fraction of cluster pattern occurrences associated with NAWTD events (F) is indicated in the bottom left. Linear trend magnitudes in the fraction of pattern occurrences producing NAWTD events are shown in the bottom right. Bold indicates significance of trends at the 10% level.

Figure S3. Persistence of circulation patterns: Time-series of the seasonal mean (blue) and maximum duration (red) of each of the 6 leading SOM patterns that have the highest correlations with the NAWTD circulation composite (Fig. 1b). Linear trend magnitudes of mean and maximum duration of each SOM occurrence and their p-values (in parentheses) are indicated on the panels. There are no significant changes in the either the average or maximum persistence of these six patterns over the 36 year period.

Figure S4. Model Validation: Composites of daily average 2m temperature anomalies for NAWTD events from (a) NCEP-NCAR R1 and (b) LENS historical simulations. NAWTD events are defined based on different minimum fractions (5%-30%) of the

western and eastern domains exceeding their corresponding warm ($>86^{\text{th}}$ percentile of daily maximum temperatures) and cool ($<14^{\text{th}}$ percentile of daily minimum temperature) grid-cell thresholds. The magnitude and location of the largest temperature anomalies for the dipole events are comparable between the LENS ensemble average and NCEP R1 in the western domain. However, the magnitude of the temperature anomalies are larger in LENS relative to the NCEP R1 composites in the eastern domain and the location of the largest anomalies are concentrated in relatively northern regions.

Figure S5. Dipole Characteristics in the control, historical and future (RCP 8.5) climates: (a,c) Distribution of 36-year trends in NAWTD occurrence and intensity from the pre-industrial (PIControl) and historical (HIST) LENS simulations. Box-whisker plots present the standard distribution percentiles (5th, 25th, 50th, 75th, and 95th), while open circles depict outlier trends. Percentages of positive trends are indicated above/below box-whisker plots (see Table S1 for the fraction of these trends that are significant at the 5% level in the PIControl and HIST climates). (c,d) Time series of NAWTD occurrence and intensity from the 35 realizations of historical and RCP8.5 future climate for different fractional area thresholds used to define dipole events. Dashed lines in (a,c) indicate the magnitude of the NCEP/NCAR R1 trends. NCEP/NCAR R1 time series are the solid black lines in panels (b,d). Solid colored lines are the 5-year moving averages of the LENS ensemble mean.

Table S1. Significance of trends in forced and unforced climates: The percent of total 36-year trends in the preindustrial control (PIControl) climate and the percent of 35 historical ensemble members that show positive, significantly positive, negative and significantly negative trends. Significance level for both positive and negative trends is 5%.

NAWTD EVENT OCCURRENCE

NAWTD EVENT INTENSITY

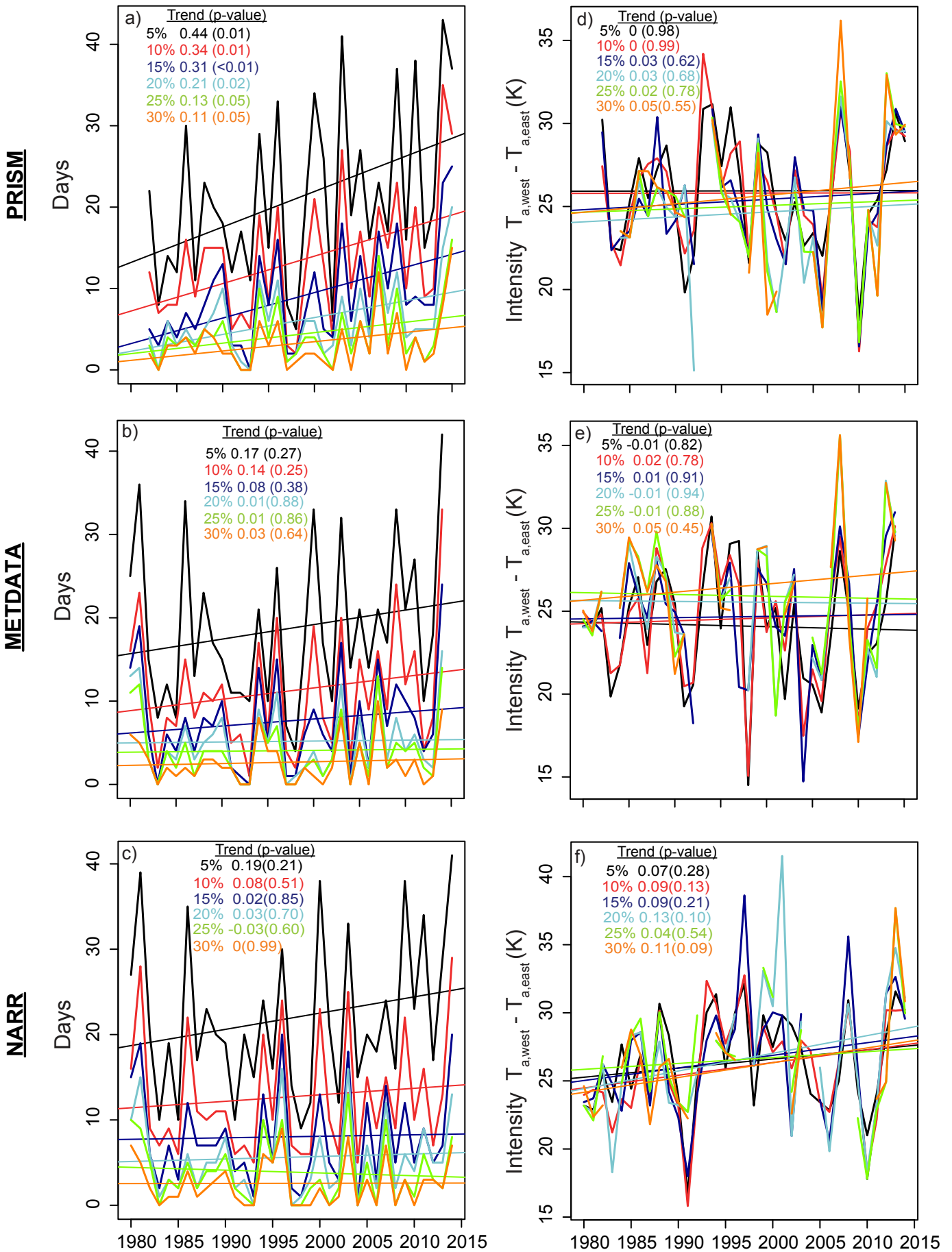
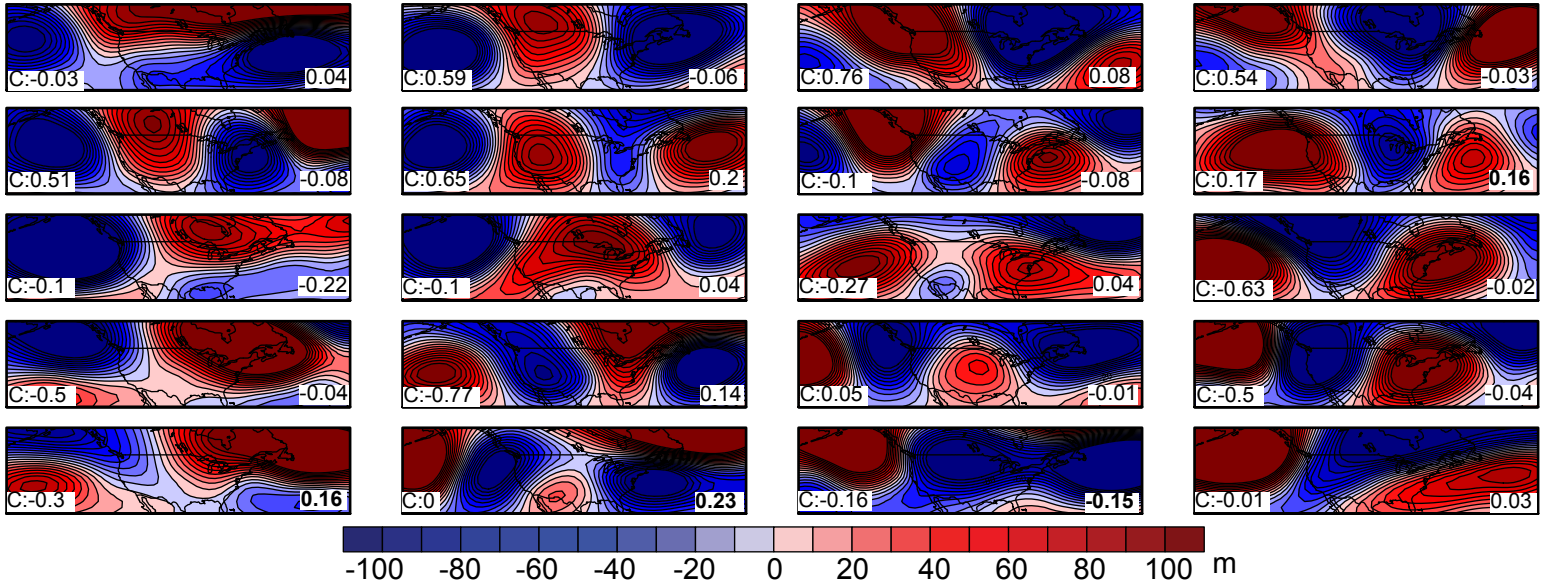


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(a) 500 mb geopotential height anomaly composites of each SOM cluster



(b) 2-m temperature anomaly composites associated with SOM cluster

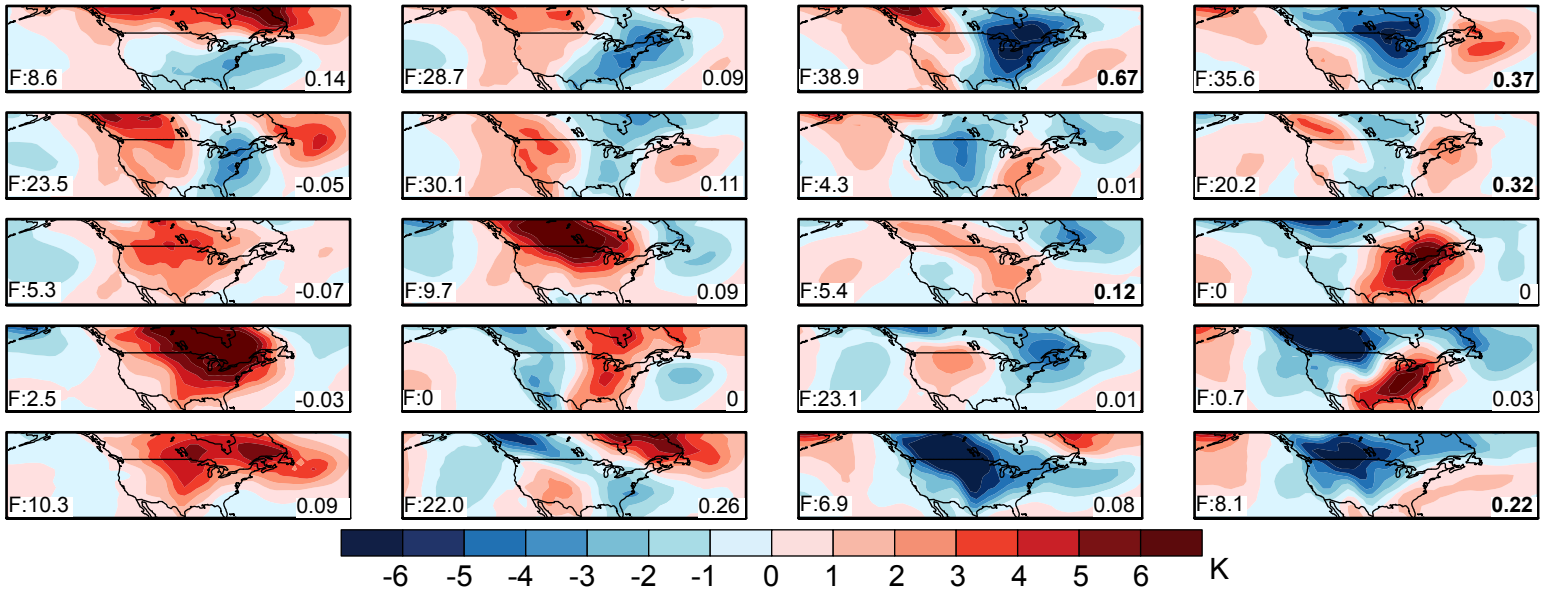


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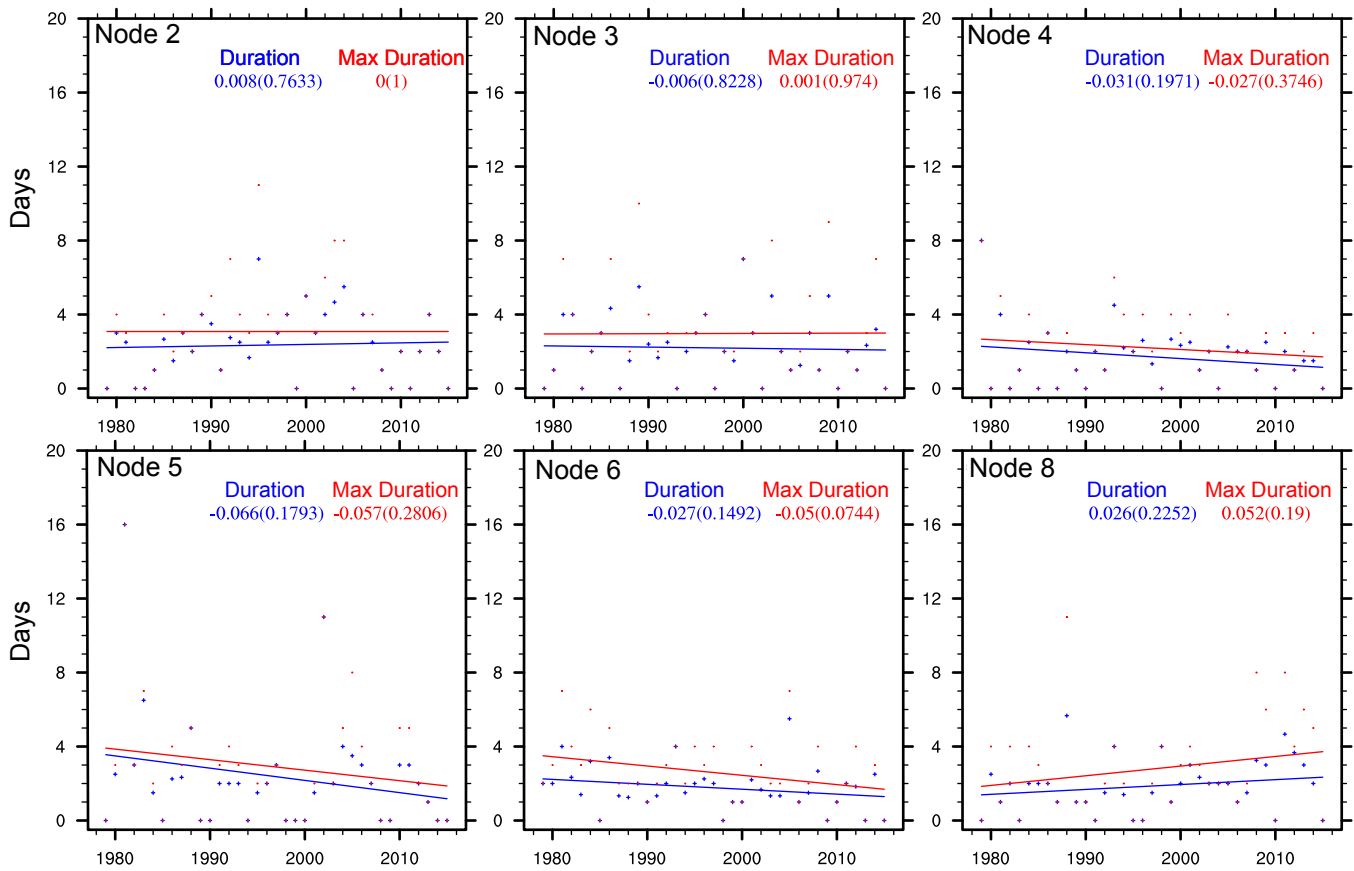


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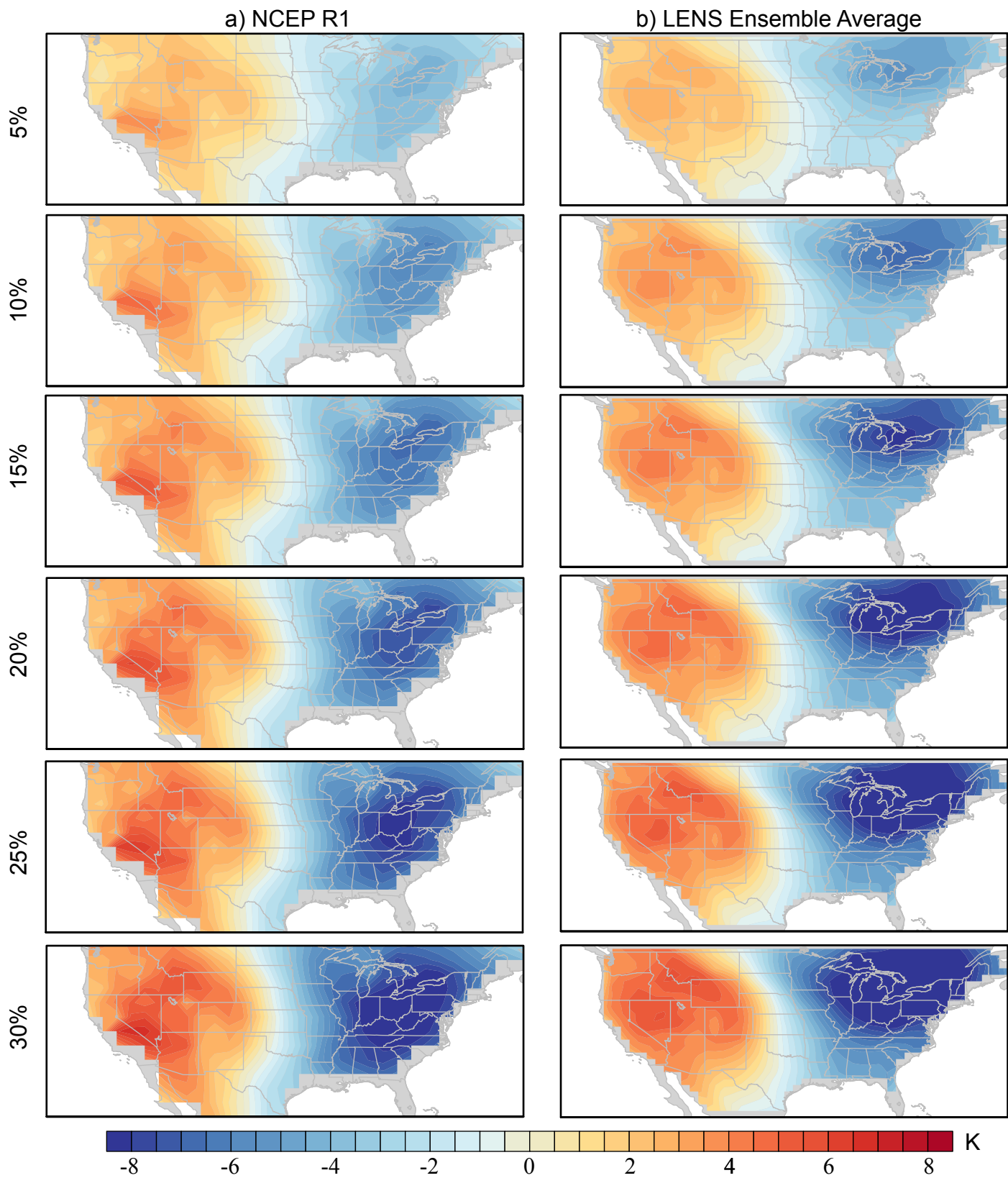


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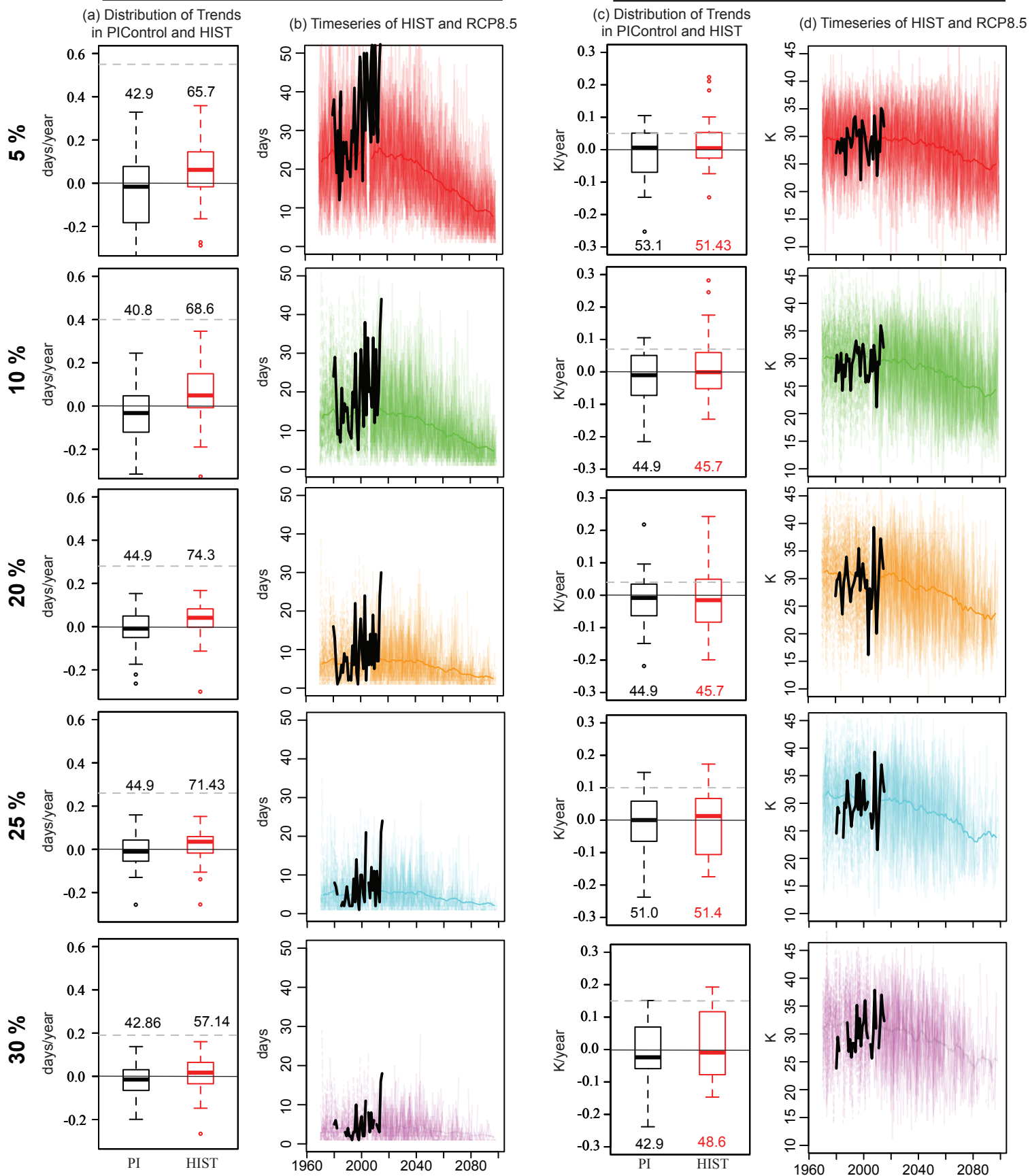


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	PICONTROL				HISTORICAL			
	percent +ve	percent -ve	percent +ve sig	percent -ve sig	percent+ve	percent -ve	percent +ve sig	percent -ve sig
Western U.S. Temperature	44.9	55.1	4.45	3.63	77.14	22.86	14.82	0.00
Eastern U.S. Temperature	48.98	51.02	4.08	0.00	65.71	34.29	21.75	8.34
Extreme Area Fraction West	46.94	53.06	4.26	7.73	77.14	22.86	22.22	0.00
Extreme Area Fraction East	46.94	53.06	0.00	7.73	28.57	71.43	10.01	24.00
Event Severity								
5% Events	53.06	46.94	0.00	4.35	51.43	48.57	11.10	0.00
10% Events	44.9	55.1	0.00	11.11	45.71	54.29	12.49	0.00
15% Events	38.78	61.22	0.00	3.33	42.86	57.14	6.67	0.00
20% Events	44.9	55.1	4.54	0.00	45.71	54.29	6.26	0.00
25% Events	51.02	48.98	0.00	4.16	51.43	48.57	5.56	0.00
30% Events	42.86	57.14	0.00	7.18	48.57	51.43	0.00	0.00
Event Frequency								
5% Events	42.86	57.14	0.00	0.00	65.71	34.29	8.69	0.00
10% Events	40.82	59.18	0.00	6.93	68.57	31.43	8.33	0.00
15% Events	48.98	51.02	4.16	12.0	74.29	25.71	3.85	10.01
20% Events	44.9	55.1	0.00	0.00	74.29	25.71	0.00	11.12
25% Events	44.9	55.1	0.00	3.70	71.43	28.57	4.17	0.00
30% Events	42.86	57.14	0.00	7.14	57.14	42.86	5.01	0.00

percent +ve/-ve:	percent of total ensemble members that have a positive (+ve) or negative (-ve) trend
percent +ve/-ve sig	percent of positive or negative trends that are also significant

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