Supplemental Material

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Trends and Variability in Airmass Frequencies: Indicators of a Changing Climate
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Supplementary Material For:

Trends and variability in air mass frequencies: indicators of a changing climate

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Table S1 – Spearman rank correlations between selected T&Os and each GWTC2 AM (month-by-month), 1979-2018.

RAW	HC	H	HW	C	S	W	DC	D	DW	CFP	WFP
AMO	**-0.45**	**0.71**	**0.72**	**-0.74**	**-0.32**	**0.75**	**-0.69**	**-0.69**	**0.55**	**-0.27**	**-0.49**
PDO	**-0.15**	**-0.11**	0.00	0.00	**-0.13**	-0.01	0.08	**0.09**	0.04	0.05	**0.17**
Nino3.4	**-0.27**	**0.20**	**0.23**	**-0.26**	**-0.19**	**0.25**	**-0.14**	**-0.17**	**0.23**	**-0.13**	-0.05
AO	0.07	-0.02	-0.07	0.06	0.02	-0.05	0.00	0.02	-0.01	-0.02	-0.01
AAO	**0.12**	0.04	0.00	0.04	-0.02	-0.02	-0.03	-0.09	**-0.09**	**-0.11**	**-0.22**
NAO	**0.10**	**-0.10**	**-0.15**	**0.13**	**0.11**	**-0.13**	0.07	**0.10**	-0.08	0.01	**0.10**
EA	**-0.18**	**0.26**	**0.24**	**-0.28**	**-0.14**	**0.28**	**-0.26**	**-0.28**	**0.18**	**-0.09**	**-0.12**
PNA	**-0.17**	**0.10**	**0.15**	**-0.13**	**-0.11**	**0.18**	**-0.10**	**-0.17**	**0.11**	**-0.10**	0.01
EA/WR	0.06	**-0.15**	**-0.14**	**0.15**	0.00	**-0.13**	**0.15**	**0.13**	**-0.13**	0.05	**0.16**
TNH	0.13	-0.01	-0.17	0.07	**0.22**	-0.12	-0.05	0.04	-0.10	0.15	-0.05
GISS(z)	**-0.60**	**0.73**	**0.82**	**-0.79**	**-0.47**	**0.84**	**-0.71**	**-0.75**	**0.70**	**-0.10**	**-0.30**

Table S2 – Spearman rank correlations between selected detrended T&Os and each detrended GWTC2 AM (month-by-month), 1979-2018.

Detrend	HC	H	HW	C	S	W	DC	D	DW	CFP	WFP
AMO	**-0.31**	**0.46**	**0.46**	**-0.56**	-0.08	**0.52**	**-0.50**	**-0.41**	**0.28**	**-0.28**	**-0.34**
PDO	**-0.27**	0.07	**0.29**	**-0.18**	**-0.27**	**0.24**	-0.07	**-0.09**	**0.28**	0.03	**0.10**
Nino3.4	**-0.29**	**0.26**	**0.33**	**-0.34**	**-0.22**	**0.36**	**-0.15**	**-0.23**	**0.31**	**-0.13**	-0.05
AO	**0.11**	**-0.10**	**-0.18**	**0.15**	0.07	**-0.14**	0.06	0.08	-0.04	-0.02	0.01
AAO	**0.21**	-0.08	**-0.09**	**0.19**	0.03	**-0.16**	0.07	0.02	**-0.23**	**-0.10**	**-0.18**
NAO	**0.10**	**-0.13**	**-0.20**	**0.16**	**0.14**	**-0.16**	0.07	**0.13**	-0.05	0.01	**0.10**
EA	-0.08	**0.14**	**0.14**	**-0.13**	-0.06	**0.16**	**-0.13**	**-0.15**	0.04	-0.09	-0.02
PNA	**-0.19**	**0.12**	**0.21**	**-0.17**	**-0.12**	**0.26**	**-0.13**	**-0.22**	**0.13**	**-0.10**	0.02
EA/WR	-0.01	-0.07	-0.04	0.07	-0.06	-0.04	0.08	0.04	-0.05	0.04	**0.11**
TNH	**0.18**	-0.10	**-0.25**	**0.18**	**0.25**	**-0.25**	0.03	0.15	**-0.23**	0.17	-0.01
GISS(z)	**-0.54**	**0.30**	**0.57**	**-0.54**	**-0.25**	**0.60**	**-0.40**	**-0.36**	**0.51**	-0.05	0.05

Table S3 – Spearman rank correlations between selected T&Os and alternative geographically-partitioned WCI and GEI indices, 1979-2018. LAND = land-only gridpoints used; OCEAN = ocean-only gridpoints used; TROP = only tropical latitudes (< 23.5° N/S) used; MID = only mid-latitude locations used (>23.5°, <66.5° N/S); HIGH = only high-latitude locations used (>66.5° N/S); GLOBAL = the actual indices (all gridpoints used.

	WCI						GEI					
	GLOBAL	**LAND**	**OCEAN**	**TROP**	**MID**	**HIGH**	**GLOBAL**	**LAND**	**OCEAN**	**TROP**	**MID**	**HIGH**
AMO	0.76	0.70	0.74	0.71	0.70	0.37	0.27	0.20	0.28	0.17	0.33	-0.03
PDO	0.01	-0.13	0.05	0.10	-0.17	-0.09	0.10	0.07	0.10	0.18	-0.05	0.03
Nino3.4	0.26	0.18	0.27	0.38	0.00	-0.06	0.16	0.11	0.16	0.22	-0.01	-0.07
AO	-0.07	-0.01	-0.08	-0.10	0.04	-0.03	-0.04	-0.08	-0.02	0.00	-0.06	-0.04
AAO	-0.02	-0.10	0.00	-0.01	0.04	-0.33	0.02	-0.02	0.03	0.05	-0.03	-0.06
NAO	-0.14	-0.17	-0.12	-0.15	-0.07	-0.06	-0.11	-0.13	-0.09	-0.08	-0.12	-0.07
EA	0.28	0.20	0.29	0.26	0.28	0.05	0.09	0.09	0.09	0.10	0.06	-0.01
PNA	0.16	0.13	0.17	0.19	0.08	0.05	0.09	-0.01	0.11	0.13	0.01	-0.01
EA/WR	-0.15	-0.13	-0.15	-0.11	-0.17	-0.19	-0.04	-0.08	-0.02	0.06	-0.14	-0.03
TNH	-0.11	-0.10	-0.12	-0.14	-0.03	0.14	-0.23	-0.09	-0.24	-0.22	-0.05	-0.17
GISS(z)	0.85	0.70	0.83	0.76	0.77	0.56	0.41	0.19	0.45	0.31	0.42	-0.03

Table S4 – The names, abbreviations and sources for all teleconnection and oscillation data and surface temperature datasets used in this research. Notes describing special considerations

Full Name	Abb.	Source of Data	Notes
Atlantic Multidecadal Oscillation	AMO	https://www.esrl.noaa.gov/psd/data/correlation/amon.us.long.data	data are detrended every time it is updated, meaning the data will be slightly different now than when they were when downloaded for this research (in January 2019)
Pacific Decadal Oscillation	PDO	http://jisao.washington.edu/pdo/PDO.latest	
El Nino Southern Oscillation Index Nino 3.4	Nino 3.4	https://www.esrl.noaa.gov/psd/data/correlation/nina34.data	standardized for all analyses
Arctic Oscillation	AO	ftp://ftp.cpc.ncep.noaa.gov/cwlinks/norm.daily.ao.index.b500101.current.ascii	averaged daily values into monthly values for analysis
Antarctic Oscillation	AAO	ftp://ftp.cpc.ncep.noaa.gov/cwlinks/norm.daily.aao.index.b790101.current.ascii	averaged daily values into monthly values for analysis
Madden Julian Oscillation	MJO	https://www.esrl.noaa.gov/psd/mjo/mjoindex/omi.1x.txt	averaged daily OMI values into monthly values for analysis. Time series end on 28 August 2018
North Atlantic Oscillation	NAO	ftp://ftp.cpc.ncep.noaa.gov/wd52dg/data/indices/tele_index.nh	
East Atlantic	EA		
West Pacific	WP		
East-Pacific-North Pacific	EP/NP		
Pacific/North American	PNA		
East Atlantic / Western Russia	EA/WR		

Scandinavia Pattern	SCA		
Tropical Northern Hemisphere	TNH		
Polar/Eurasia	POL		
Pacific Transition	PT		
Quasi-Biennial Oscillation	QBO	https://www.cpc.ncep.noaa.gov/data/indices/qbo.u30.index	standardized 30 mb zonal wind index - CDAS.
Global Temperatures	GISS(z)	https://data.giss.nasa.gov/gistemp/	Standardized (z) for global mean time-series. Non-standardized for gridded spatial analyses
Sea Ice Data	Sea Ice	https://www.ncdc.noaa.gov/snow-and-ice/extent/sea-ice/N/9.csv	September Northern Hemisphere Sea Ice Extent (1979-2019) Units: million square km 1981-2010 Mean: 6.41, retrieved on 19 December 2019.

Table S5 – The descriptions of the 26 ETCCDI indices used in the research. Green shaded rows are precipitation-based indices. All others are temperature-based. Additional information can be found at: https://www.climdex.org/learn/indices/.

Abbreviation	Description	Notes
CDD	Maximum length of dry spell: maximum number of consecutive days with RR < 1mm	RR ≥ 1.0mm
CSDI	Cold spell duration index: annual count of days with at least 6 consecutive days when TN < 10th percentile	TN = daily minimum
CWD	Maximum length of wet spell: maximum number of consecutive days with RR ≥ 1mm	RR ≥ 1.0mm
DTR	Daily temperature range	
FD	Number of frost days	
GSL	Growing Season Length	
ID	Number of Icing days	
PRCPTOT	Annual total precipitation on wet days	
R10mm	Annual count of days when PRCP ≥ 10mm	
R20mm	Annual count of days when PRCP ≥ 20mm	
R95p	Annual total PRCP when RR > 95th percentile	RR ≥ 1.0mm
R99p	Annual total PRCP when RR > 99th percentile	RR ≥ 1.0mm
Rx1day	Monthly maximum 1-day precipitation	
Rx5day	Monthly maximum consecutive 5-day precipitation	
SDII	Simple precipitation intensity index	
SU	Number of Summer Days	
TN10p	Percentage of days when TN < 10th percentile	TN = daily minimum
TN90p	Percentage of days when TN > 90th percentile	TN = daily minimum
TNn	Monthly minimum value of daily minimum temperature	
TNx	Monthly maximum value of daily minimum temperature	
TR	Number of Tropical Nights	
TX10p	Percentage of days when TX < 10th percentile	TX is daily maximum
TX90p	Percentage of days when TX > 90th percentile	TX is daily maximum
TXn	Monthly minimum value of daily maximum temperature	
TXx	Monthly maximum value of daily maximum Temperature	
WSDI	Warm spell duration index: annual count of days with at least 6 consecutive days when TX > 90th percentile	TX is daily maximum

Supplementary Figures:

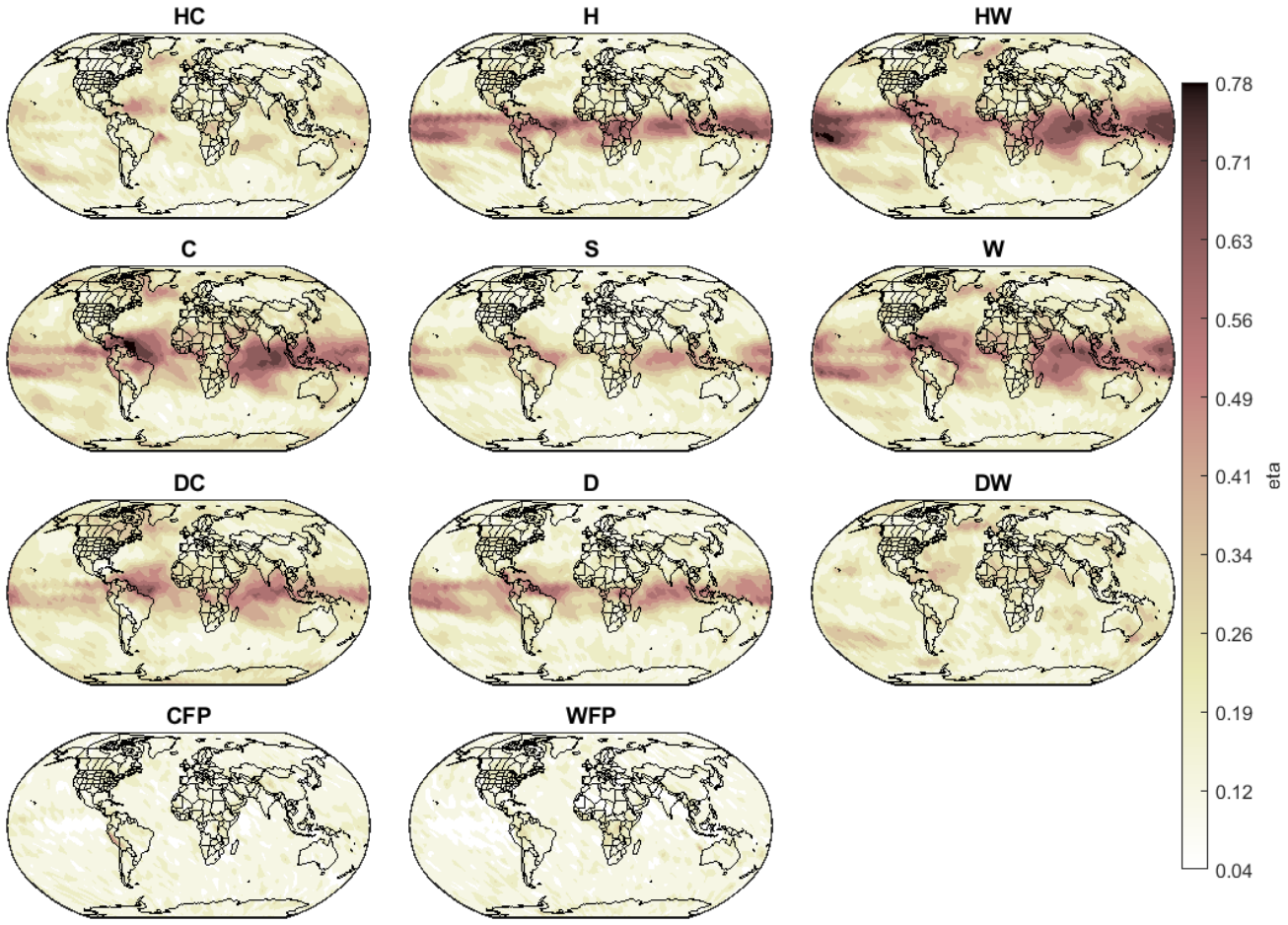

Figure S1 – Spatial nonlinear eta correlations between monthly frequencies of each GWTC2 AM and the WCI.

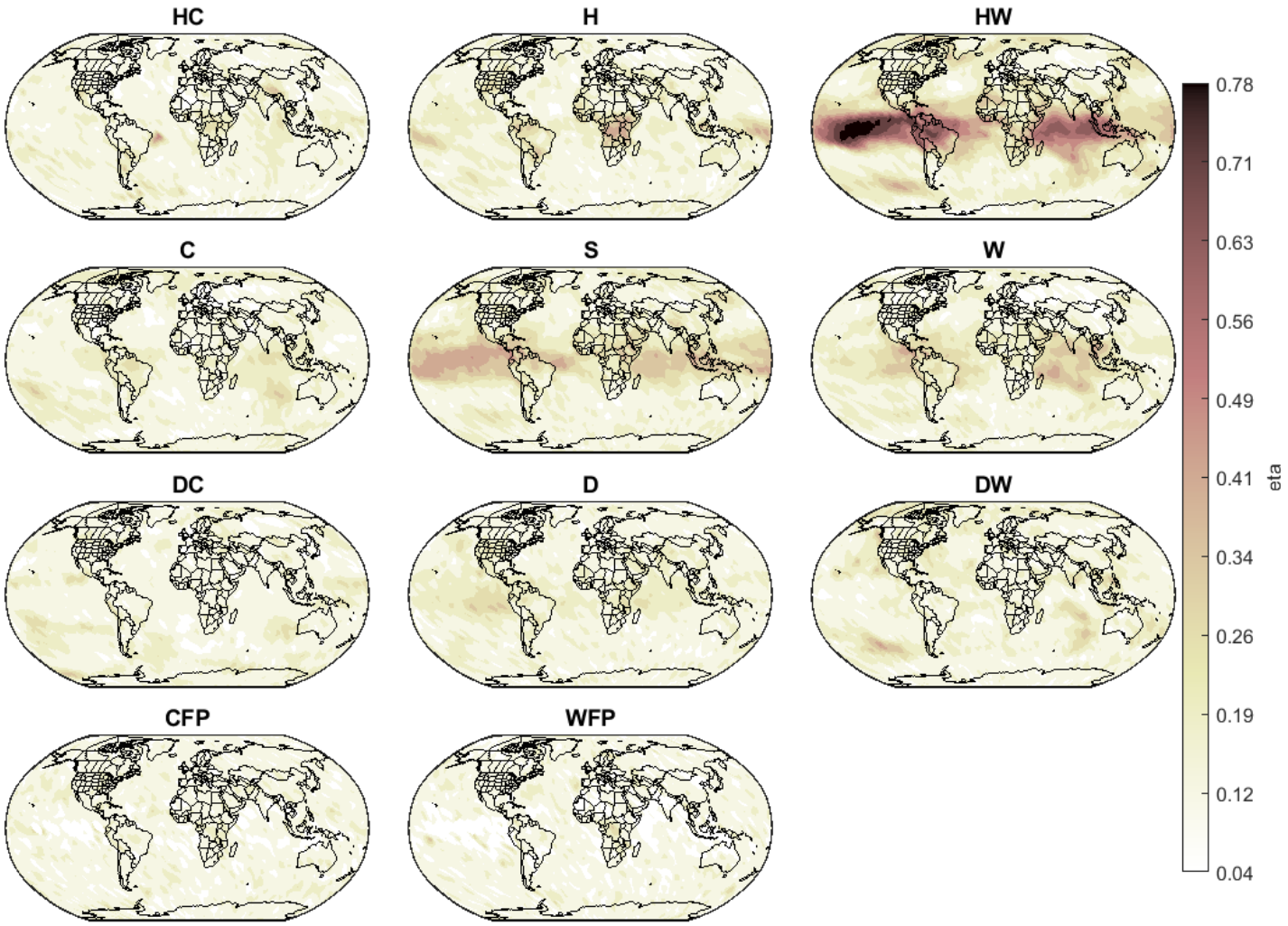

Figure S2 – Spatial nonlinear eta correlations between monthly frequencies of each GWTC2 AM and the GEI.

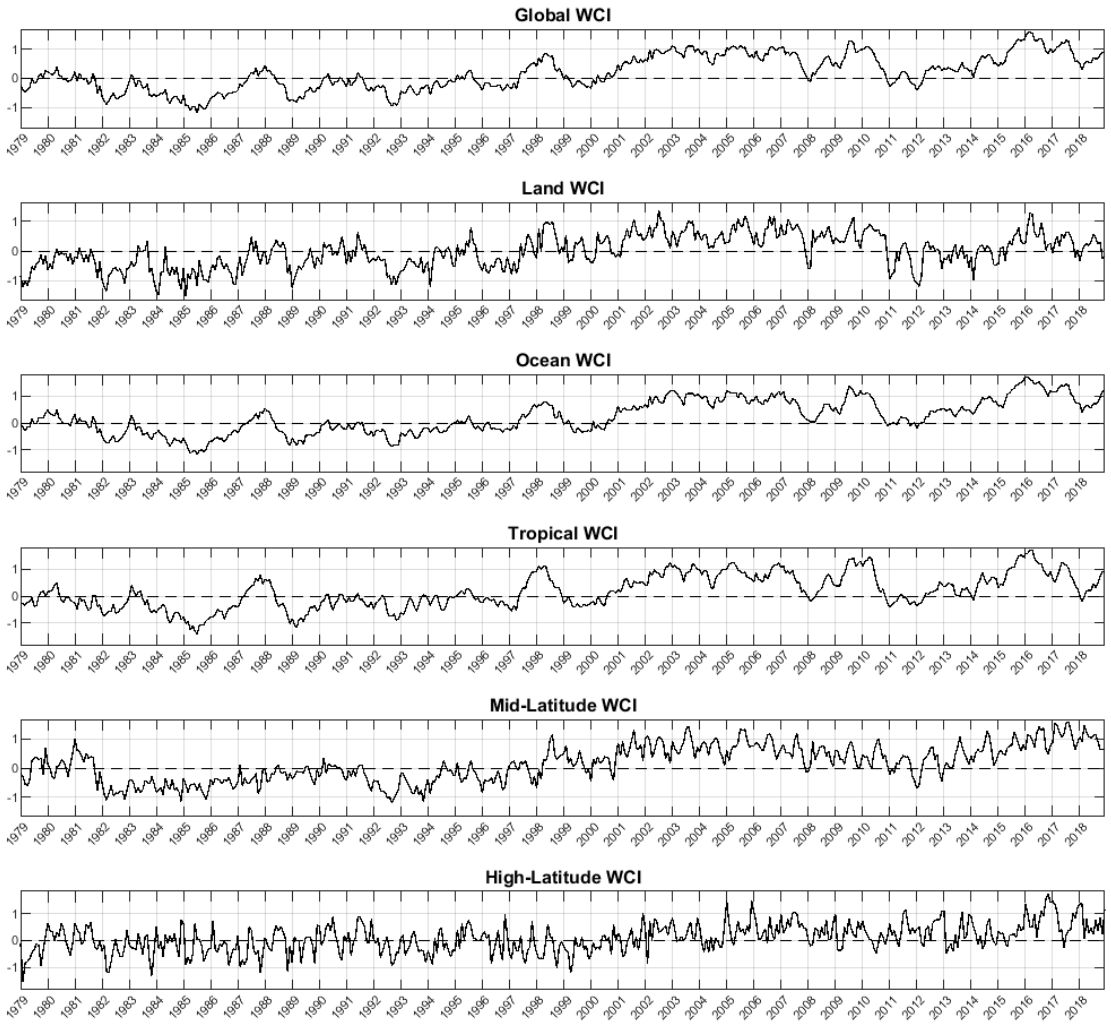

Figure S3 – Time series of alternative geographically-partitioned WCI, 1979-2018. Land = land-only gridpoints used; Ocean = ocean-only gridpoints used; Tropical = only tropical latitudes (< 23.5° N/S) used; Mid-Latitude = only mid-latitude locations used (>23.5°, <66.5° N/S); High-Latitude = only high-latitude locations used (>66.5° N/S); Global = the actual indices (all gridpoints used).

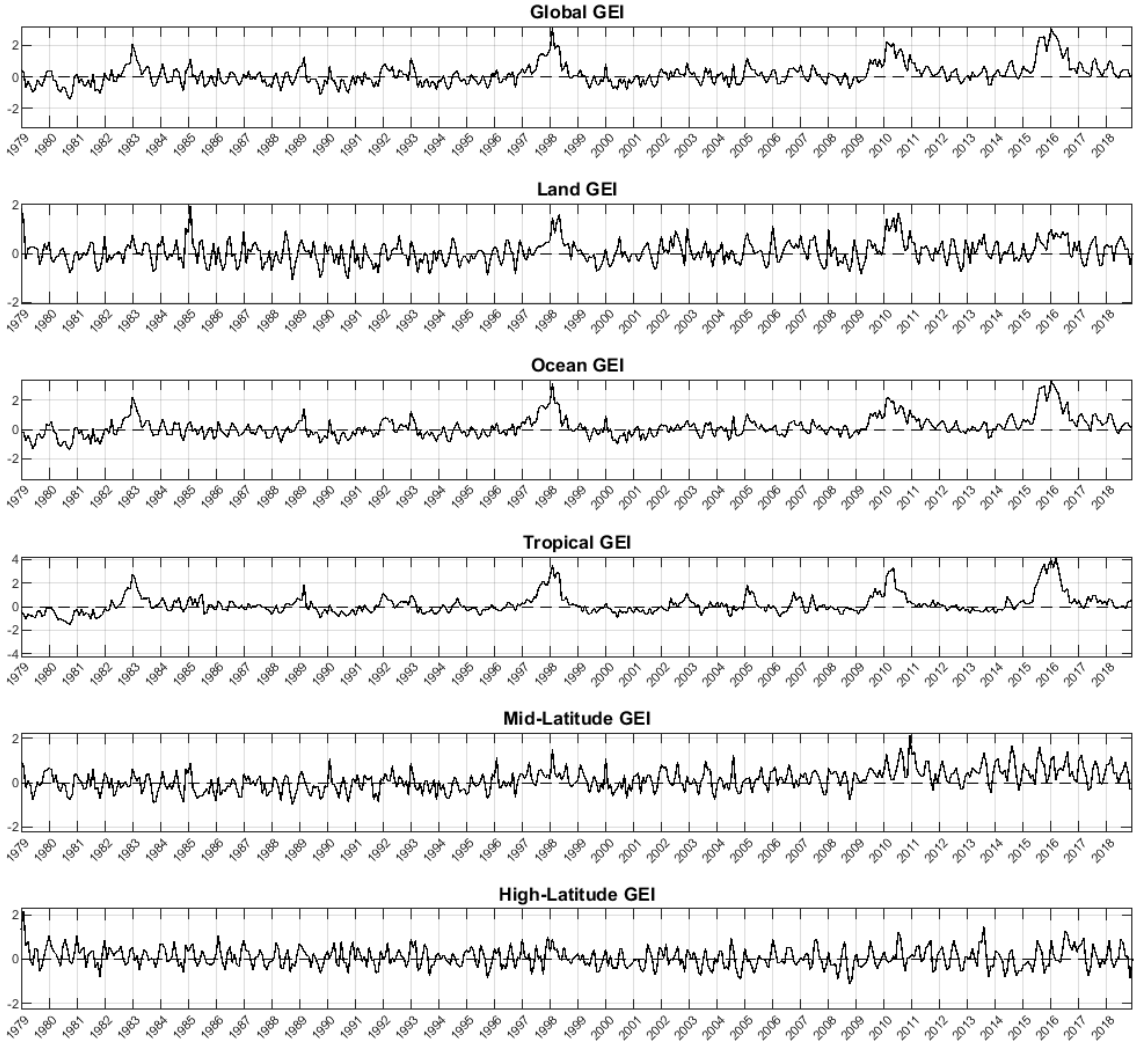

Figure S4 – Time series of alternative geographically-partitioned GEI, 1979-2018. Land = land-only gridpoints used; Ocean = ocean-only gridpoints used; Tropical = only tropical latitudes (< 23.5° N/S) used; Mid-Latitude = only mid-latitude locations used (>23.5°, <66.5° N/S); High-Latitude = only high-latitude locations used (>66.5° N/S); Global = the actual indices (all gridpoints used).

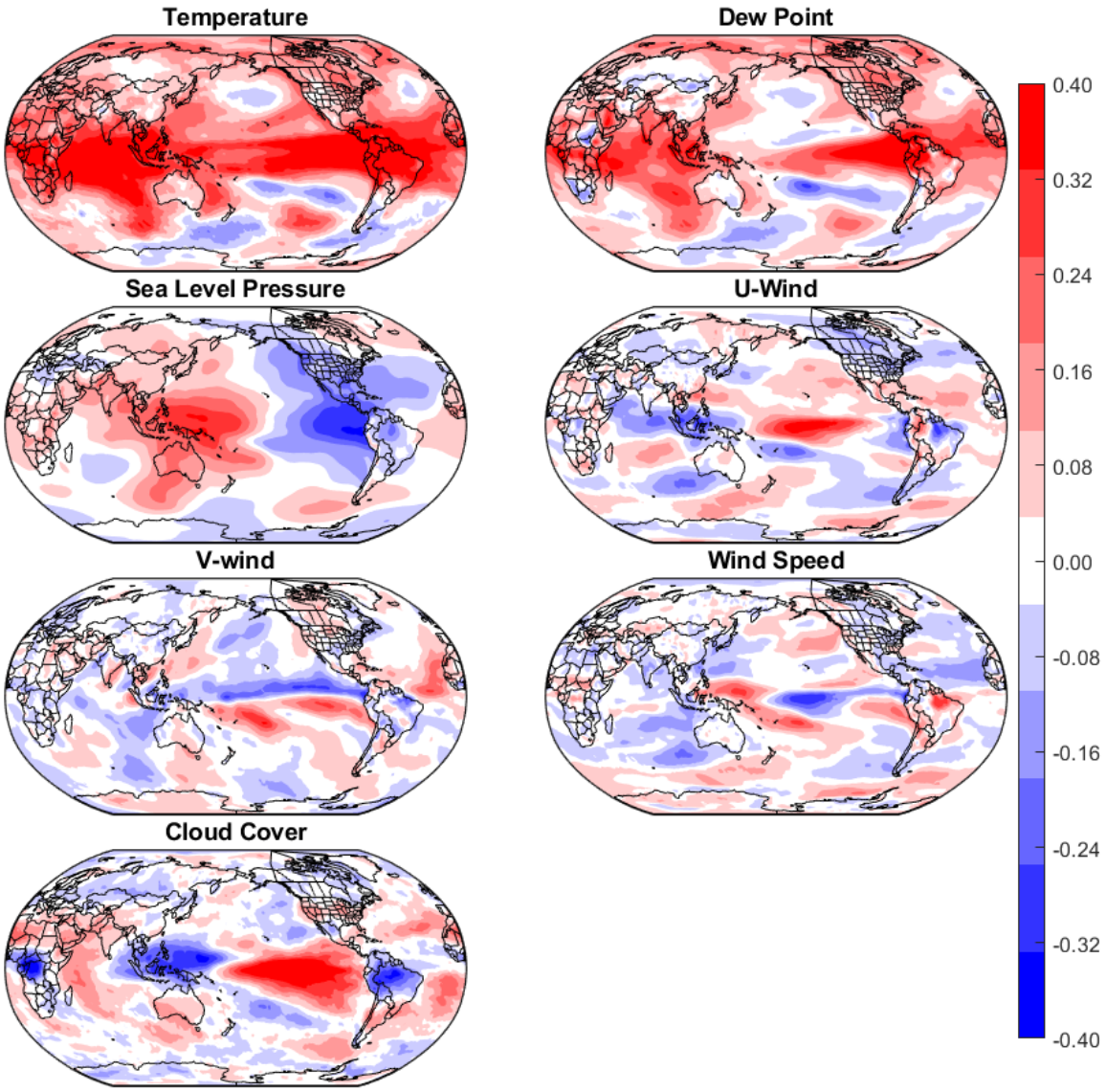

Figure S5 – Spatial Pearson correlation coefficients between the GEI and each the of seasonally and geographically standardized ERA-5 variables

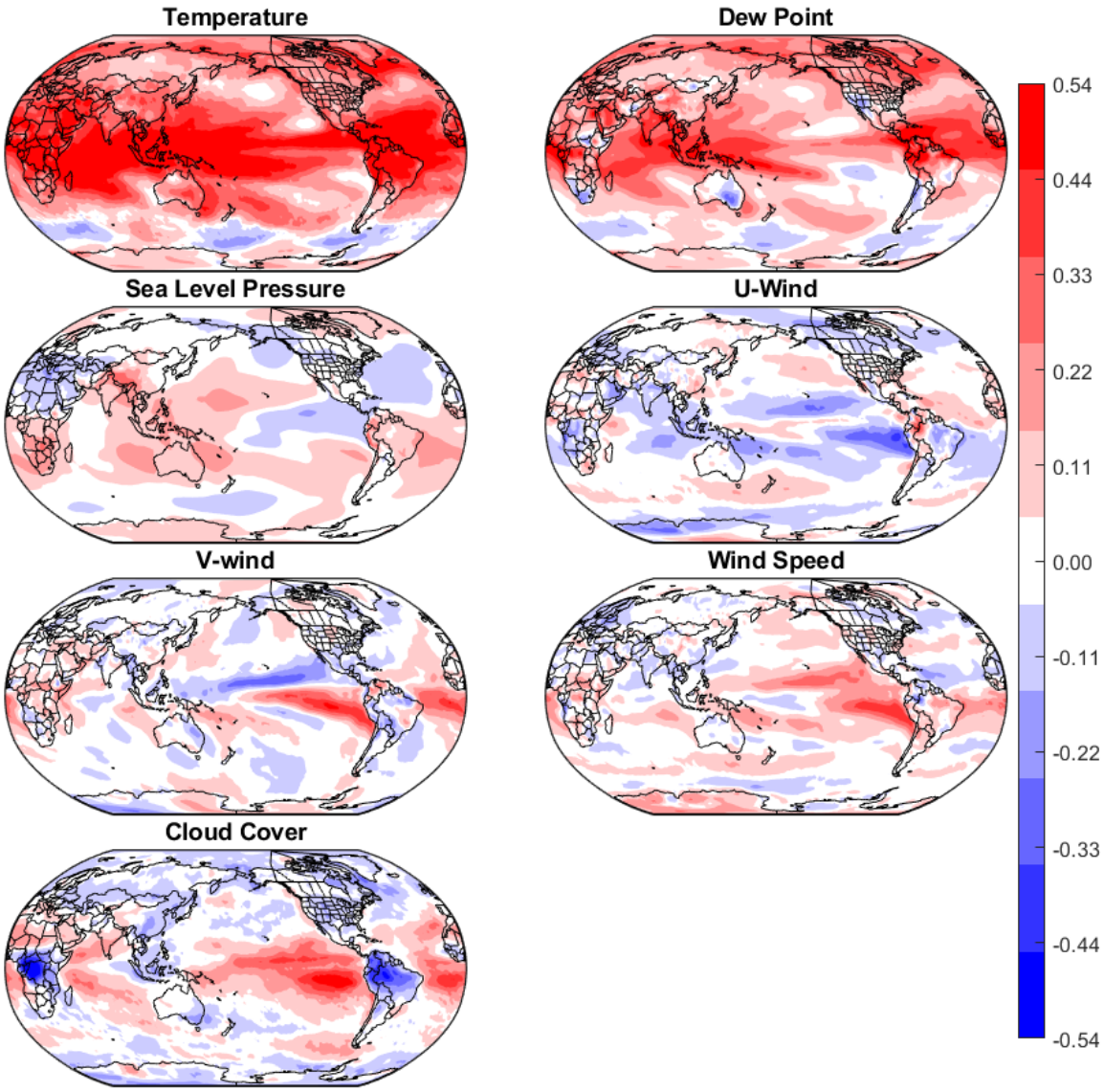

Figure S6 – Spatial Pearson correlation coefficients between the WCI and each the of seasonally and geographically standardized ERA-5 variables