

Variability of global mean annual temperature is significantly influenced by the rhythm of ocean-atmosphere oscillations

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Supplementary Material

Table S1. Characteristics of time series of global mean temperature anomalies (land and ocean), stemming from three institutional sources. Data contain no missing values.

Data owner	Data availability	Time step	Reference period	Source	Accessed on
CRU	1850-2019	Monthly	1961-1990	https://crudata.uea.ac.uk/cru/data/temperature/	02 July 2020
NOAA	1880-2019	Annual	1901-2000	https://www.ncdc.noaa.gov/cag/global/time-series/globe/land_ocean/ytd/12/1880-2019/data.csv	02 July 2020
NASA	1880-2019	Annual	1951-1980	https://data.giss.nasa.gov/gistemp/graphs/graph_data/Global_Mean_Estimates_base_d_on_Land_and_Ocean_Data/graph.txt	02 July 2020

Table S2. Characteristics of time series of various climate variability indices.

Index	Data availability	Reference period	Source	Accessed on
SOI CRU	1866-2019	1951-1980	https://crudata.uea.ac.uk/cru/data/soi/soi.dat	02 July 2020
SOI NOAA	1951-2019	1981-2010	https://www.cpc.ncep.noaa.gov/data/indices/soi	02 July 2020
SOI AU	1876-2019	1933-1992	http://www.bom.gov.au/climate/current/soihtml.shtml	02 July 2020
Equatorial SOI	1949-2019	1981-2010	https://www.cpc.ncep.noaa.gov/data/indices/reqsoi.for	02 July 2020
Equatorial SOI Indonesia	1949-2019	1981-2010	https://www.cpc.ncep.noaa.gov/data/indices/rindo_slpa.for	02 July 2020
Equatorial SOI Eastern Pacific	1949-2019	1981-2010	https://www.cpc.ncep.noaa.gov/data/indices/repac_slpa.for	02 July 2020
Niño 1.2	1870-2019	1981-2010	https://www.esrl.noaa.gov/psd/gcos_wgsp/Time-series/Data/nino12.long.anom.data	02 July 2020
Niño 3.4	1870-2019	1981-2010	https://www.esrl.noaa.gov/psd/gcos_wgsp/Time-series/Data/nino34.long.anom.data	02 July 2020
Niño 3	1870-2019	1981-2010	https://www.esrl.noaa.gov/psd/gcos_wgsp/Time-series/Data/nino3.long.anom.data	02 July 2020
Niño 4	1870-2019	1981-2010	https://www.esrl.noaa.gov/psd/gcos_wgsp/Time-series/Data/nino4.long.anom.data	02 July 2020
EMI (El Niño Modoki)	1870-2018	1971-2000	http://www.jamstec.go.jp/frsgc/research/d1/iod/DATA/emi.monthly.txt	02 July 2020
ONI NOAA	1950-2019	A centered 30-year base period updated every 5 years.	https://origin.cpc.ncep.noaa.gov/products/analysis_monitoring/ensostuff/ONI_v5.php	02 July 2020
AMO	1856-2019	1951-1980	https://psl.noaa.gov/data/correlation/amon.us.long.data	02 July 2020
TPI IPO	1854-2019	1971-2000	https://psl.noaa.gov/data/timeseries/IPOTPI/tpi.timeseries.ersstv5.data	02 July 2020

Table S3. Values of coefficient of determination (R^2) for different selection (start month, end month) of 12-month moving average of residuals from 5-year running mean of ENSO indices and of annual temperature anomalies. The highest values are marked in bold.

Index vs Temp	Feb-Jan	Mar-Feb	Apr-Mar	May-Apr	Jun-May	Jul-Jun	Aug-Jul	Sep-Aug	Oct-Sep	Nov-Oct	Dec-Nov	Jan-Dec
Equatorial SOI Indonesia vs HadCRUT	0.279	0.419	0.505	0.542	0.563	0.583	0.582	0.559	0.546	0.470	0.417	0.360
Niño 3 vs NASA	0.293	0.351	0.391	0.424	0.455	0.488	0.509	0.506	0.472	0.404	0.300	0.190

Table S4. Highest values of R^2 between time series of residuals from 5-year running mean of temperature (land and ocean), of particular ENSO indices (as indicated) and TPI IPO (as indicated). Temperature data stem from three sources: NASA; NOAA, CRU. The highest value of R^2 are marked in bold.

ENSO index residuals from 5-year running mean	Source of data for temperature anomalies					
	NASA		NOAA		CRU	
	12-month moving average	R^2	12-month moving average	R^2	12-month moving average	R^2
SOI CRU	Sep-Aug	0.458	Sep-Aug	0.500	Sep-Aug	0.476
TPI IPO	Sep-Aug		Sep-Aug		Sep-Aug	
SOI NOAA	Sep-Aug	0.485	Sep-Aug	0.571	Sep-Aug	0.595
TPI IPO	Aug-Jul		Sep-Aug		Sep-Aug	
SOI AU	Sep-Aug	0.460	Sep-Aug	0.501	Sep-Aug	0.478
TPI IPO	Sep-Aug		Sep-Aug		Sep-Aug	
Equatorial SOI	Jul-Jun	0.508	Aug-Jul	0.581	Aug-Jul	0.599
TPI IPO	Oct-Sep		Sep-Aug		Aug-Jul	
Equatorial SOI Indonesia	Jul-Jun	0.513	Jul-Jun	0.600	Jul-Jun	0.612
TPI IPO	Oct-Sep		Oct-Sep		Oct-Sep	
Equatorial SOI Eastern Pacific	Aug-Jul	0.484	Sep-Aug	0.569	Sep-Aug	0.592
TPI IPO	Aug-Jul		Sep-Aug		Sep-Aug	
Niño 1.2	Jul-Jun	0.473	Jul-Jun	0.516	Jul-Jun	0.502
TPI IPO	Oct-Sep		Oct-Sep		Oct-Sep	
Niño 3.4	Oct-Sep	0.496	Oct-Sep	0.546	Oct-Sep	0.525
TPI IPO	Nov-Oct		Oct-Sep		Oct-Sep	
Niño 3	Aug-Jul	0.506	Sep-Aug	0.553	Sep-Aug	0.542
TPI IPO	Sep-Aug		Oct-Sep		Oct-Sep	
Niño 4	Oct-Sep	0.488	Nov-Oct	0.524	Oct-Sep	0.511
TPI IPO	Sep-Aug		Aug-Jul		Sep-Aug	
EMI	Nov-Oct	0.454	Nov-Oct	0.494	Oct-Sep	0.469
TPI IPO	Sep-Aug		Sep-Aug		Sep-Aug	
ONI NOAA	AMJ	0.490	AMJ	0.572	AMJ	0.603
TPI IPO	Jul-Jun		Sep-Aug		Sep-Aug	

Table S5. Highest values of R^2 between time series of residuals from 5-year running mean of temperature (land and ocean), of particular ENSO indices (as indicated), TPI IPO (as indicated) and of AMO index (12-month average: Jan-Dec). Temperature data stem from three sources: NASA; NOAA, CRU. The highest value of R^2 are marked in bold.

ENSO index residuals from 5-year running mean	Source of data for temperature anomalies					
	NASA		NOAA		CRU	
	12-month moving average	R^2	12-month moving average	R^2	12-month moving average	R^2
SOI CRU	Nov-Oct	0.576	Nov-Oct	0.646	Oct-Sep	0.599
TPI IPO	Nov-Oct		Nov-Oct		Nov-Oct	
SOI NOAA	Dec-Nov	0.614	Dec-Nov	0.701	Dec-Nov	0.704
TPI IPO	Apr-Mar		Apr-Mar		Apr-Mar	
SOI AU	Nov-Oct	0.575	Nov-Oct	0.645	Nov-Oct	0.598
TPI IPO	Nov-Oct		Nov-Oct		Nov-Oct	
Equatorial SOI	Dec-Nov	0.584	Dec-Nov	0.680	Oct-Sep	0.675
TPI IPO	Oct-Sep		Oct-Sep		Nov-Oct	
Equatorial SOI Indonesia	Jan-Dec	0.604	Jan-Dec	0.707	Jan-Dec	0.706
TPI IPO	May-Apr		May-Apr		May-Apr	
Equatorial SOI Eastern Pacific	Sep-Aug	0.580	Nov-Oct	0.679	Nov-Oct	0.676
TPI IPO	Nov-Oct		Nov-Oct		Nov-Oct	
Niño 1.2	Aug-Jul	0.577	Aug-Jul	0.648	Aug-Jul	0.603
TPI IPO	Nov-Oct		Dec-Nov		Dec-Nov	
Niño 3.4	Oct-Sep	0.591	Nov-Oct	0.659	Nov-Oct	0.613
TPI IPO	Dec-Nov		Dec-Nov		Sep-Aug	
Niño 3	Sep-Aug	0.592	Oct-Sep	0.656	Sep-Aug	0.622
TPI IPO	Jan-Dec		Jan-Dec		Jan-Dec	
Niño 4	Nov-Oct	0.592	Nov-Oct	0.661	Nov-Oct	0.619
TPI IPO	Dec-Nov		Dec-Nov		Dec-Nov	
EMI	Jan-Dec	0.579	Jan-Dec	0.649	Jan-Dec	0.600
TPI IPO	Nov-Oct		Dec-Nov		Nov-Oct	
ONI NOAA	AMJ	0.602	AMJ	0.693	AMJ	0.690
TPI IPO	Sep-Aug		Nov-Oct		Nov-Oct	

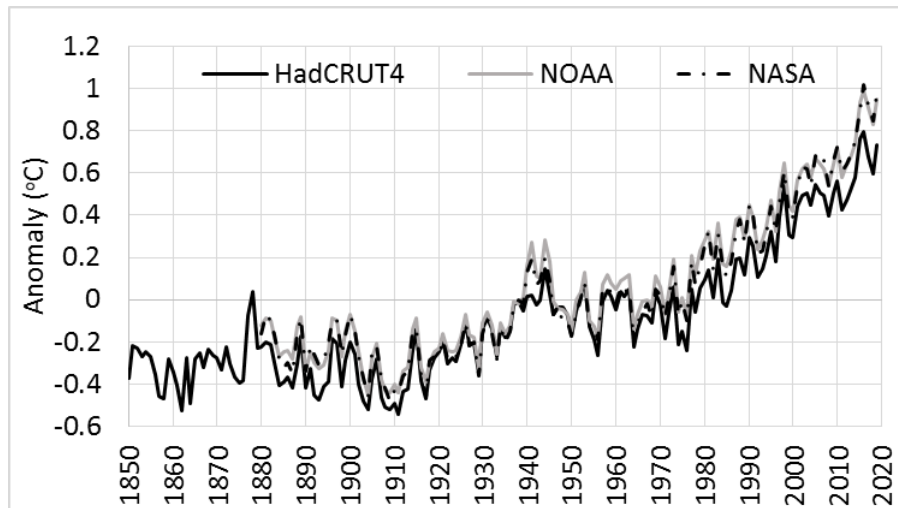


Figure S1. Global mean temperature anomalies (land and ocean) for three series: HadCRUT4 of CRU (1961-1990); NOAA (1901-2000) and NASA (1951-1980).
 CRU – Climatic Research Unit (University of East Anglia, Norwich, UK)
 NOAA – National Oceanic and Atmospheric Administration (USA)
 NASA – National Aeronautic and Space Administration (USA)

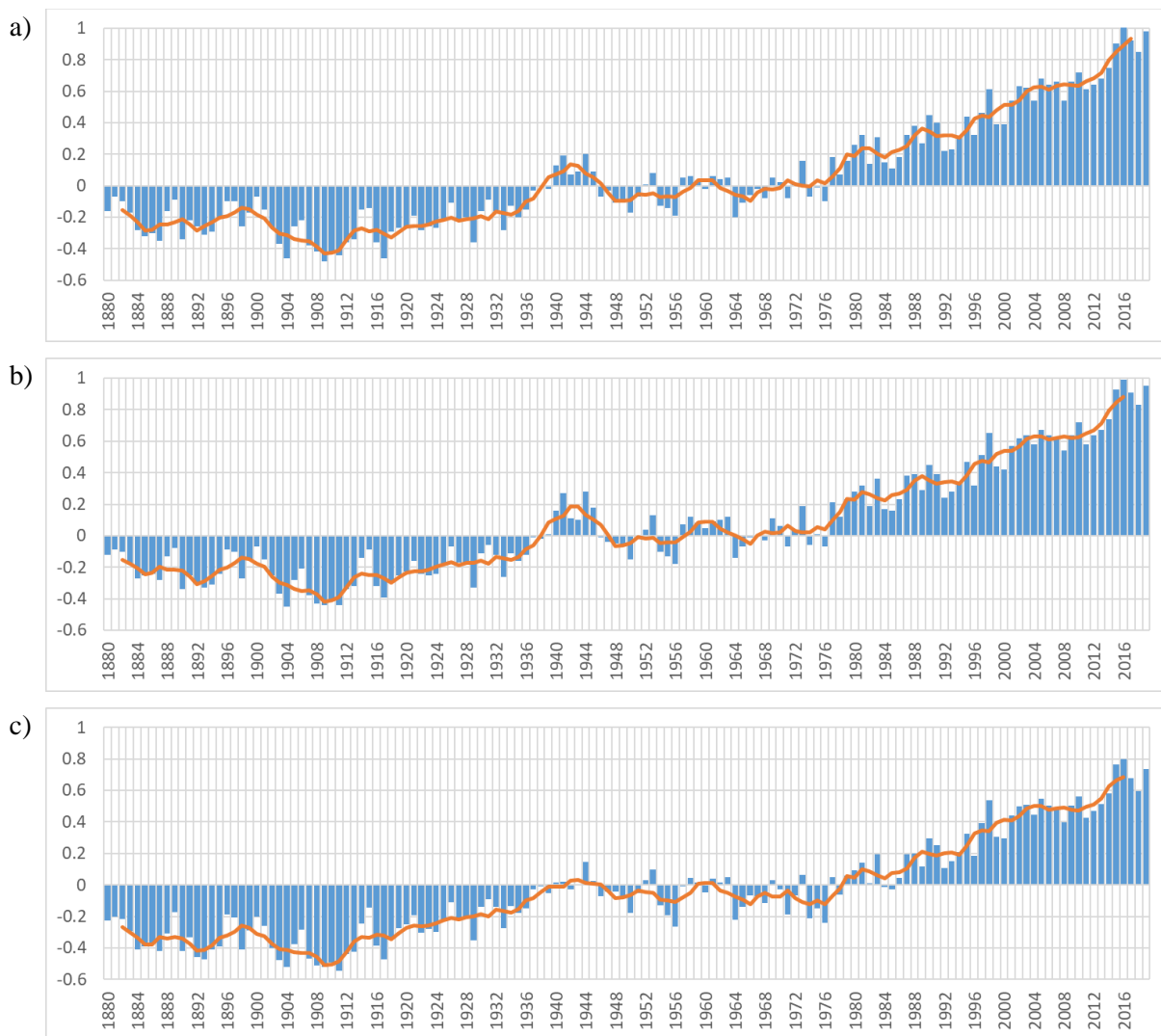


Figure S2. Global mean temperature anomalies (land and ocean) and 5-year running mean, after NASA (a), NOAA (b), and CRU (c).