Supplemental Material

Supplement for Reconstructing an Interdecadal Pacific Oscillation index from a Pacific Basin-wide collection of ice core records

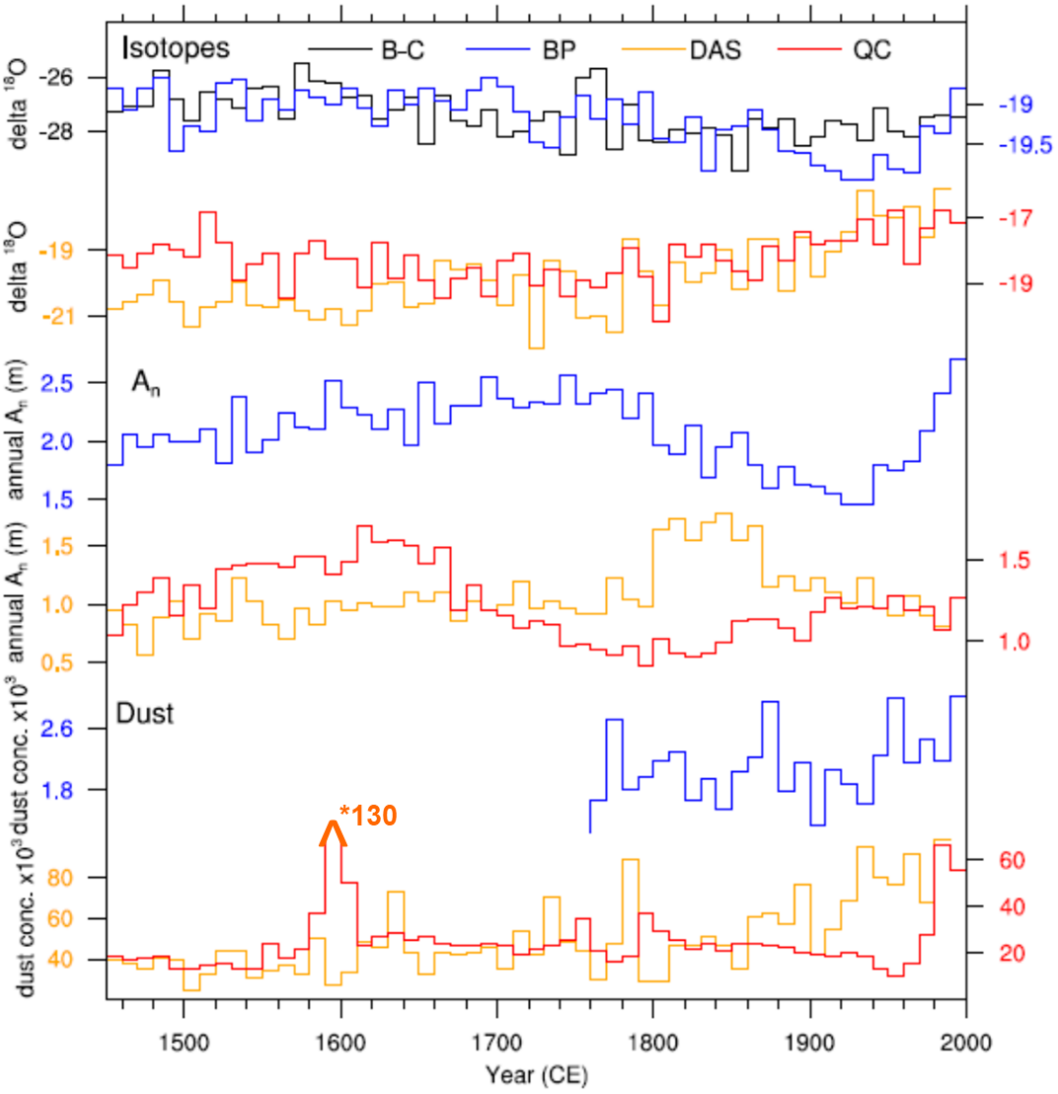

FIG. S1. Decadal averages for the ice cores employed in this study including Quelccaya (red; Thompson et al. 2013), Dasuopu (orange; Thompson et al. 2000), Bruce Plateau (blue; Goodwin 2013), and Bona-Churchill $\delta^{18}O$ (black; Porter et al. 2019). Accumulation and dust concentrations from Bona-Churchill are available upon request. The asterisk represents the high dust concentrations in the Quelccaya record due to the Huaynaputina eruption in 1600 CE.

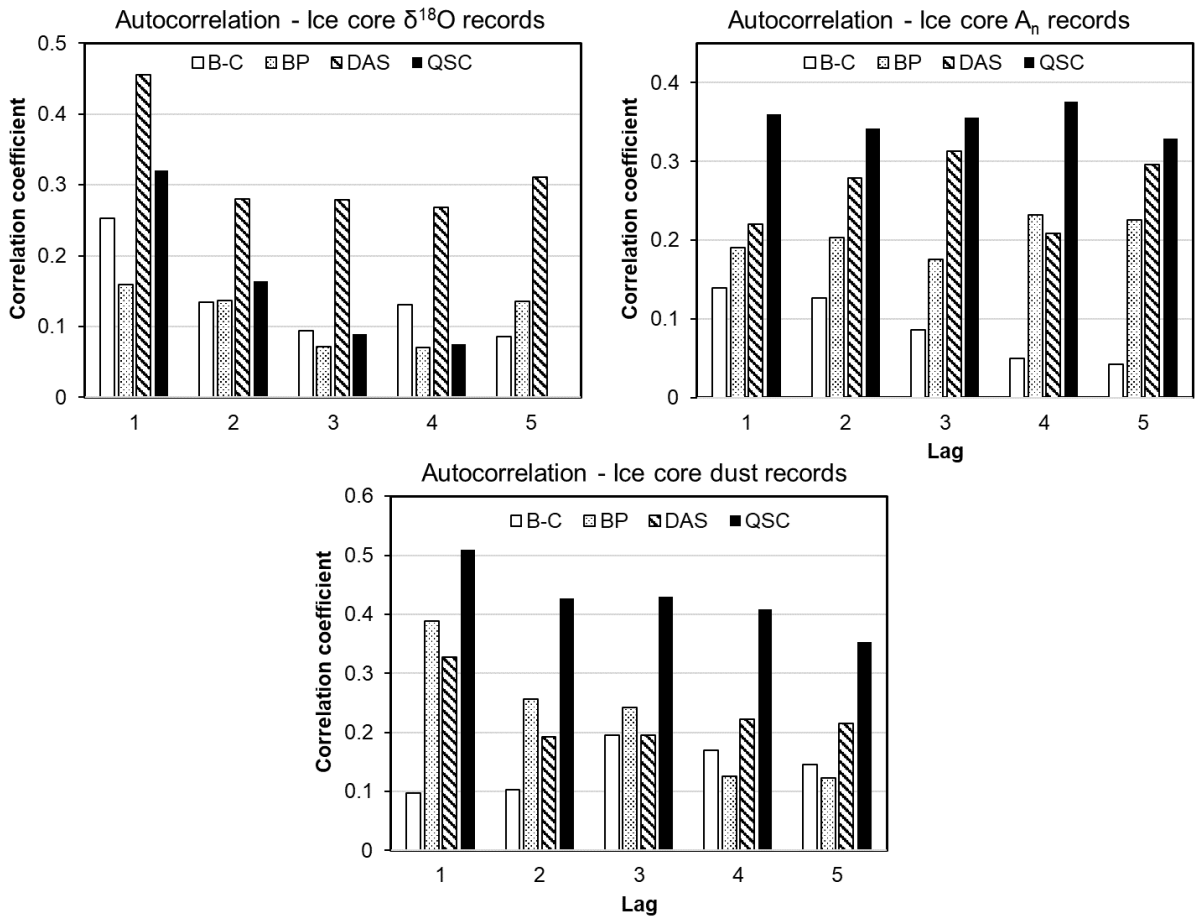

FIG. S2. Autocorrelation of the annual ice core records in this study for lags of one to five years.

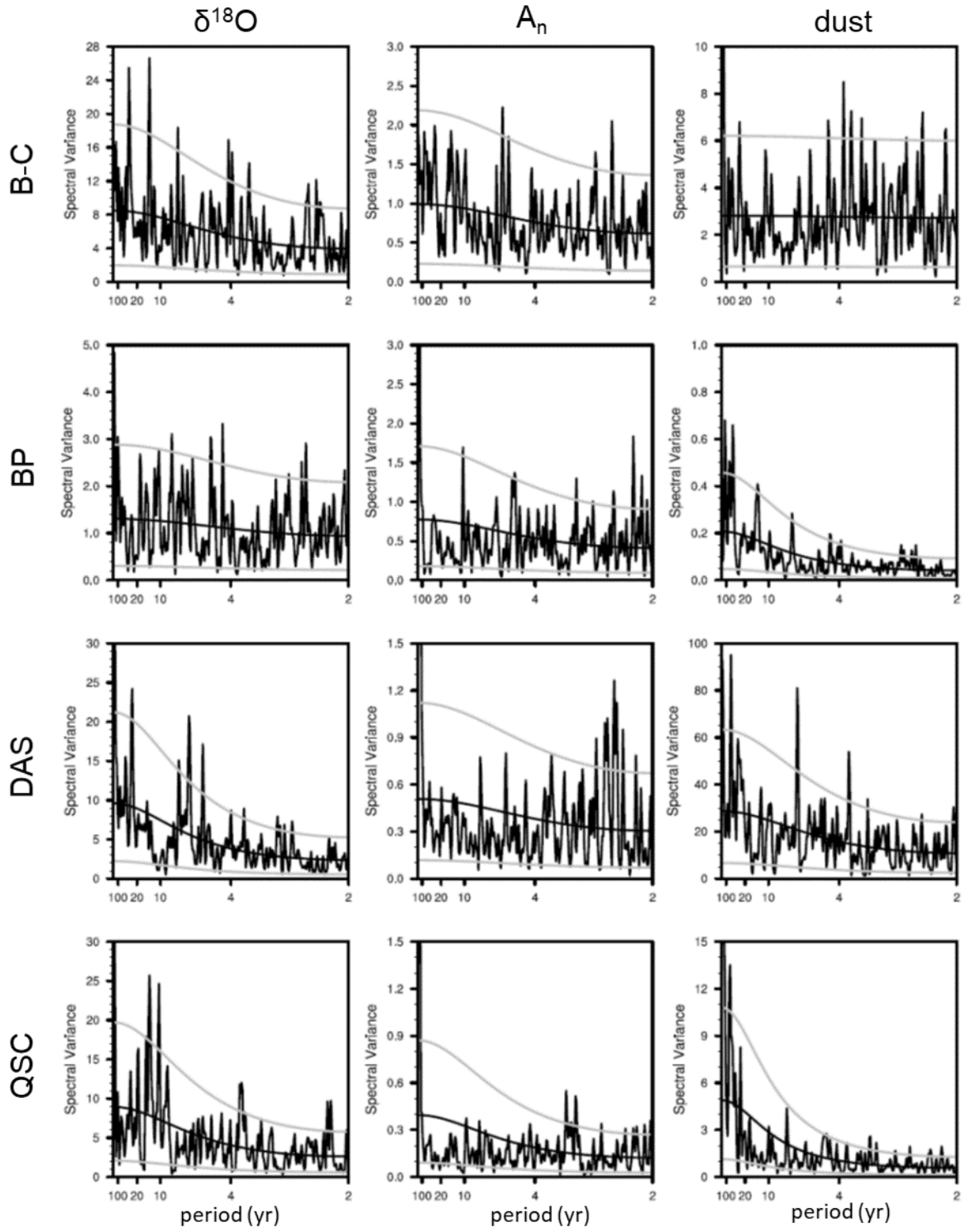

FIG. S3. The spectral variance for the ice cores used in this study. The gray lines represent the 5% and 95% confidence intervals around the Markov red noise (black line).

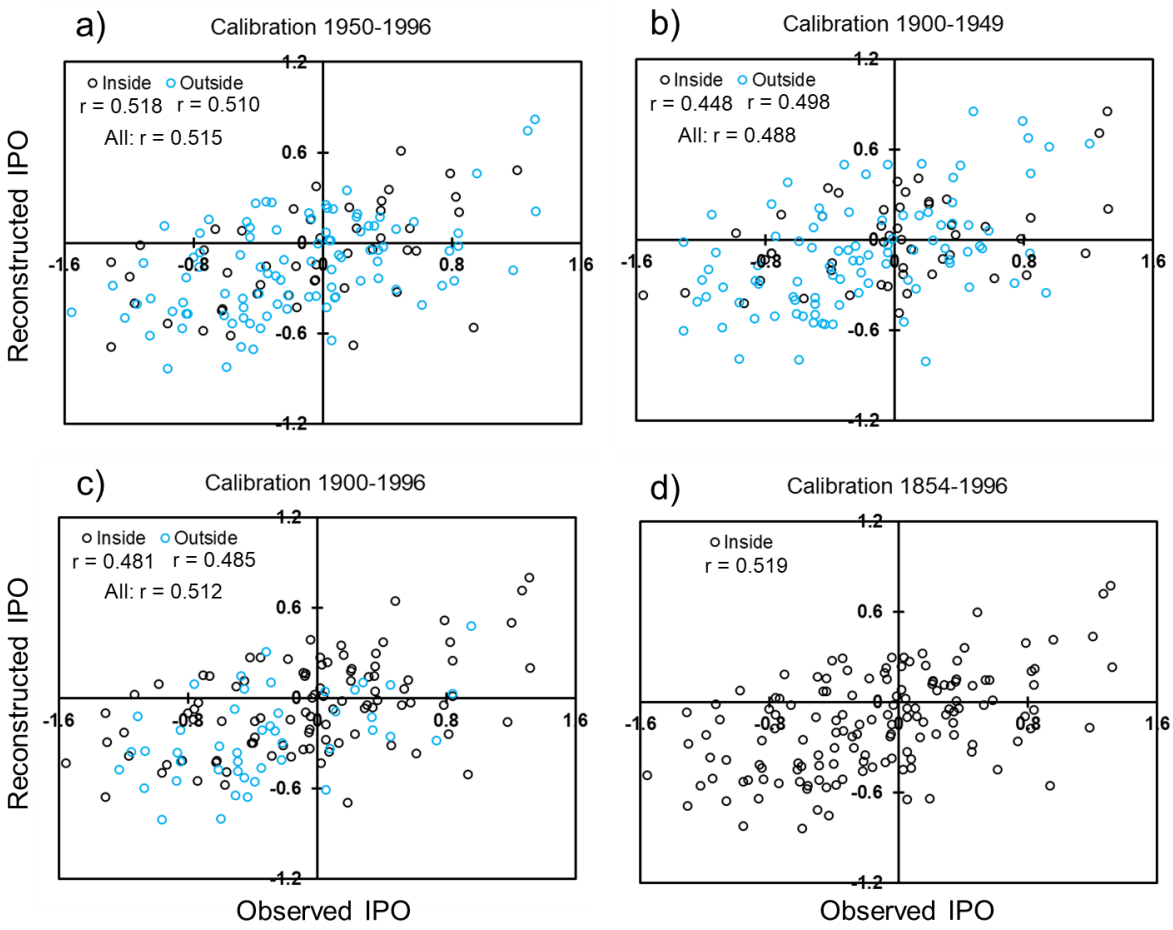

FIG. S4. Scatterplot of the observed versus reconstructed IPO for various calibration periods. Relationships are shown between the observed and reconstructed IPO indices for the period 1854-1996 for years within the calibration period (black) and outside of the calibration period (blue). All correlation coefficients are significant at the 99% level ($p < 0.01$). The 1900-1996 calibration period (c) is used for this study.

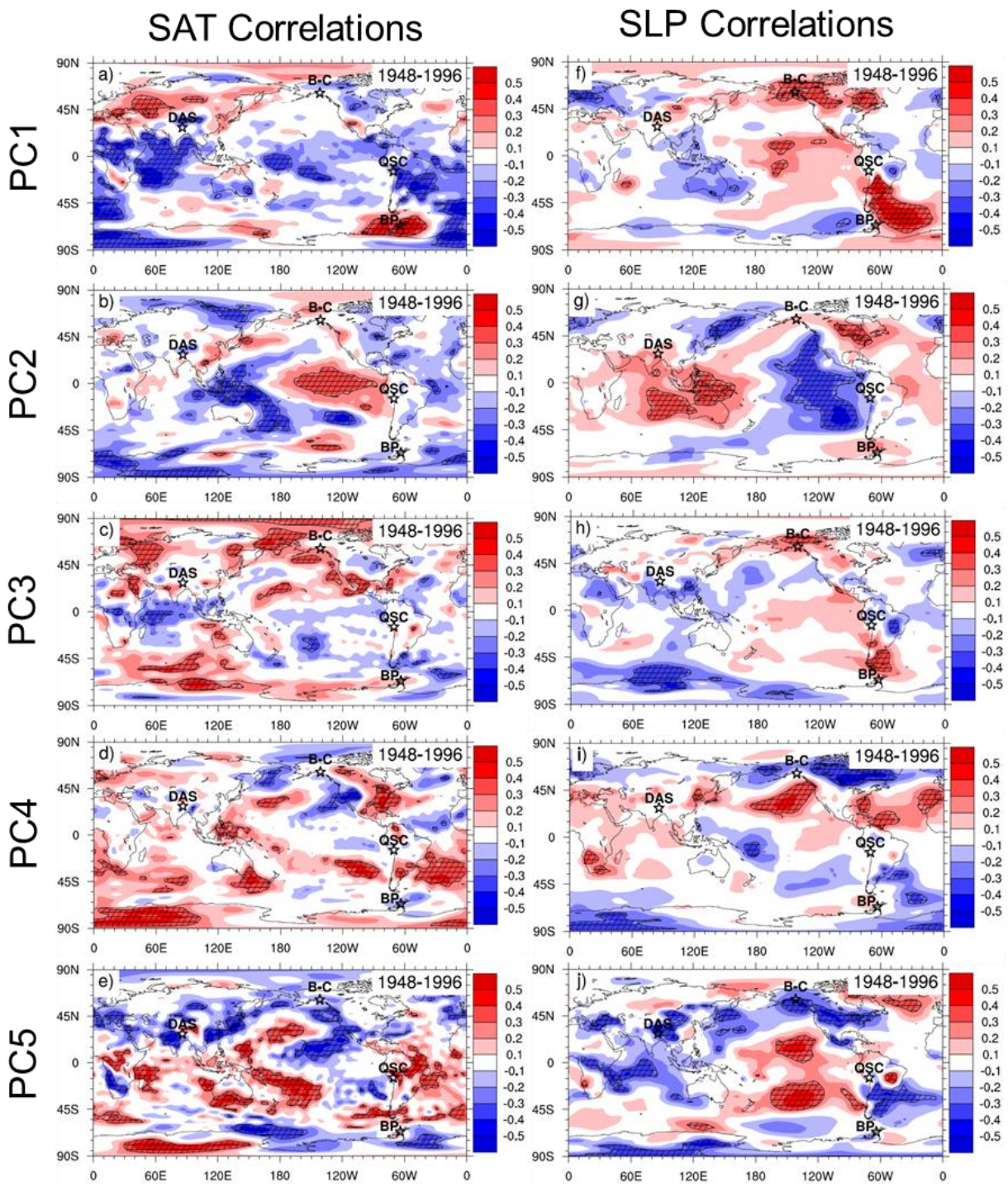

FIG. S5. Spatial correlation fields between the five principal components and surface air temperature (SAT; a-e) and sea level pressure (SLP; f-j) from NCEP/NCAR reanalysis for the 1948-1996 period. Data are detrended and hatching indicates 95% significance.

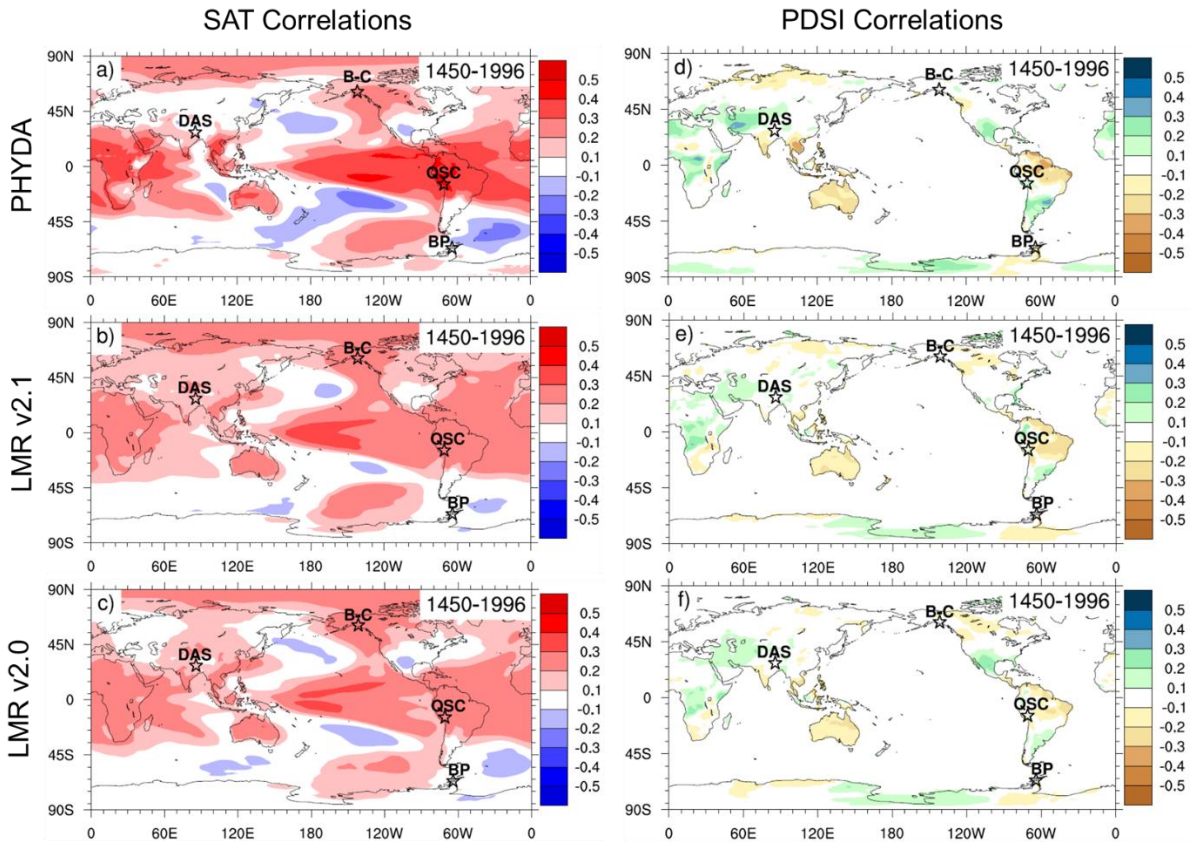

FIG. S6. Spatial correlation fields between the reconstructed IPO and (a-c) surface air temperature and (d-f) PDSI from (a, d) PHYDA, (b, e) LMR v2.1, and (c, f) LMRv2.0 for the 1450-1996 CE period. Shading indicates 95% significance.

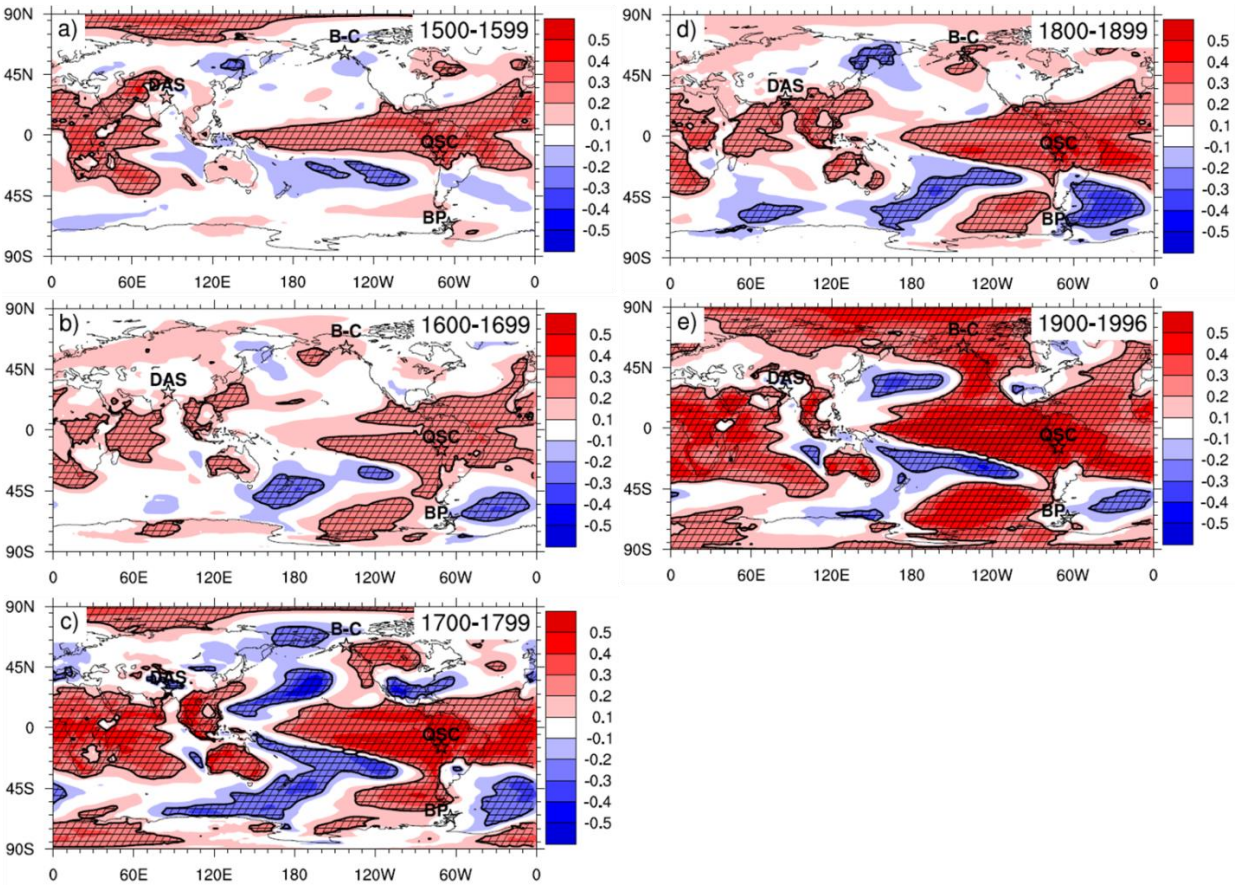

FIG. S7. Spatial correlation fields between the reconstructed IPO index and surface air temperature from PHYDA for each century. Hatching indicates 95% significance.

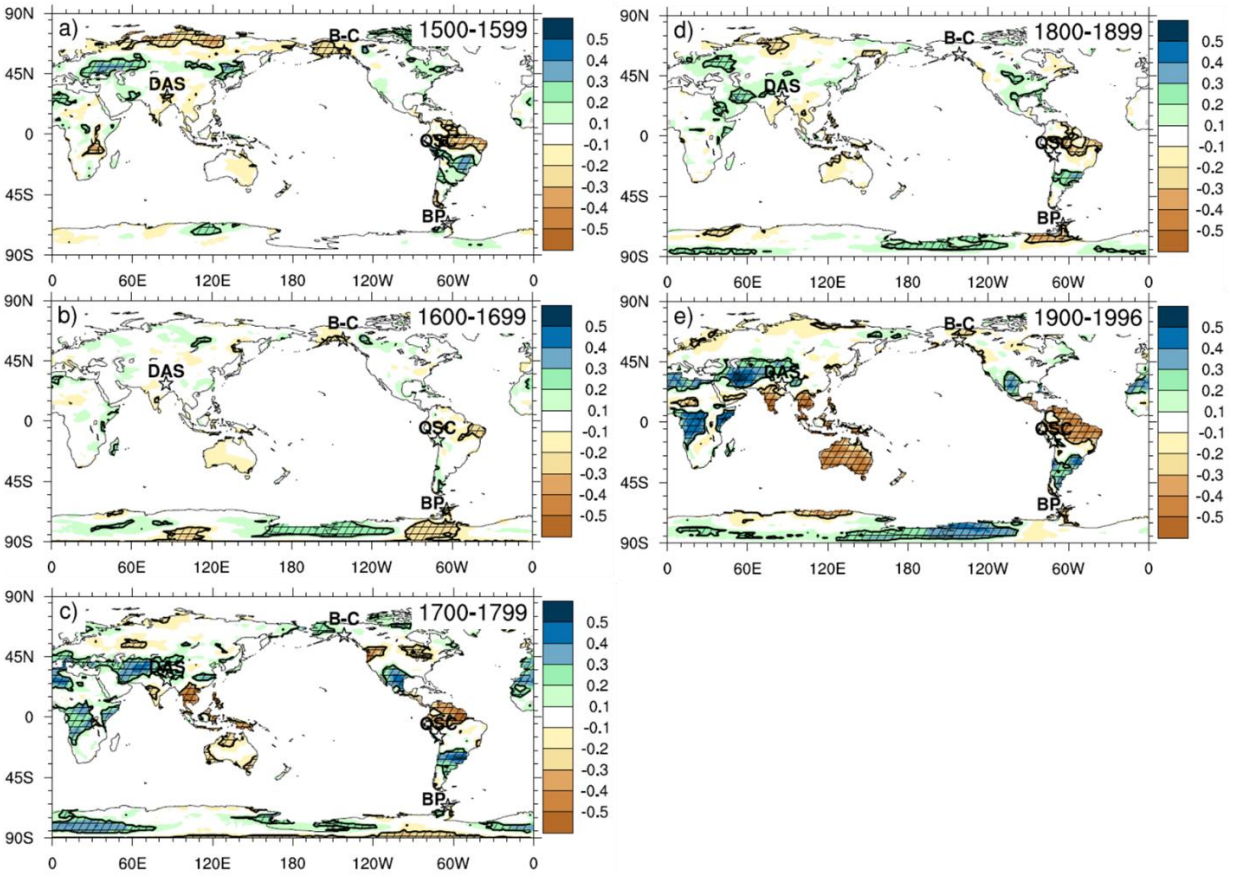

FIG. S8. Spatial correlation fields between the reconstructed IPO index and PDSI from PHYDA for each century. Hatching indicates 95% significance.

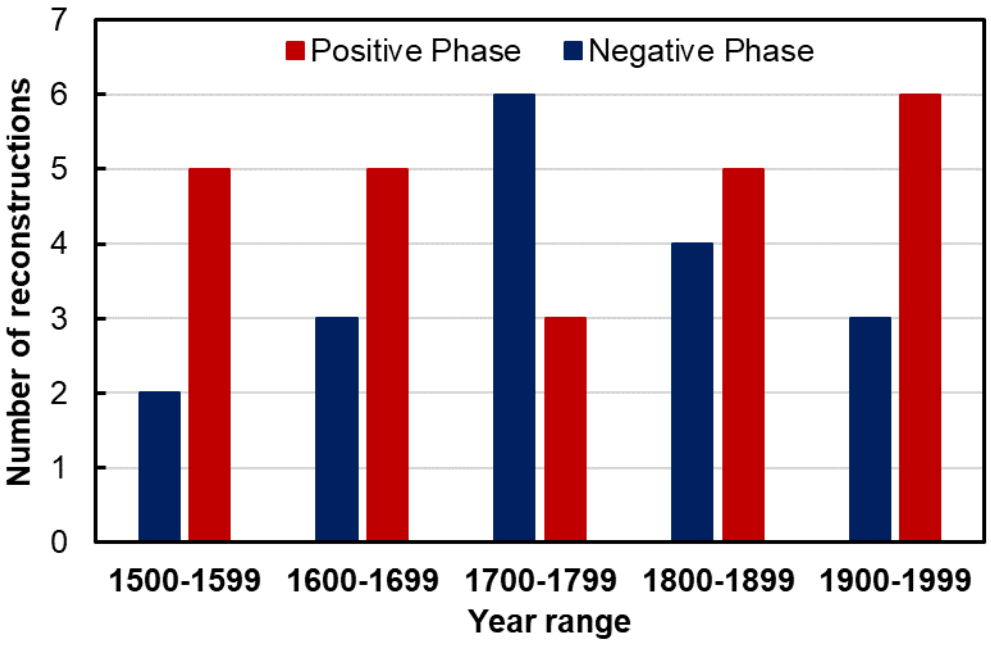

FIG. S9. Frequency plot of the predominance of positive (red) and negative (blue) IPO/PDO phases for each century determined from this study and previous reconstructions shown in Fig. 6 of the main text.

Table S1. Correlation coefficients for annual ice core data (1450 – 1996 CE). Bold indicates 99% significance.

		BP	DAS	QC	B-C	BP	DAS	QC	B-C	BP	DAS	QC
		$\delta^{18}O$			A_n				Dust			
$\delta^{18}O$	B-C	0.09	-0.09	0.00	**0.18**	**0.12**	**-0.13**	0.09	**-0.21**	-0.03	-0.06	0.11
	BP		**-0.19**	**-0.12**	-0.01	**0.51**	-0.09	**0.14**	-0.05	0.05	**-0.21**	0.04
	DAS			0.11	**0.18**	**-0.20**	0.05	-0.10	**0.14**	-0.06	**0.50**	-0.05
	QC				0.07	**-0.14**	-0.03	-0.07	0.07	0.01	**0.17**	-0.04
A_n	B-C					-0.04	0.03	-0.10	0.04	-0.09	0.09	0.02
	BP						-0.09	0.06	-0.04	0.02	**-0.14**	**0.13**
	DAS							**-0.15**	**0.19**	-0.04	0.04	-0.05
	QC								**-0.20**	**0.12**	-0.06	0.04
Dust	B-C									-0.05	0.05	-0.05
	BP										-0.04	-0.03
	DAS											-0.03

Table S2. Loading factors for the first five principal components determined by rotated varimax principal component analysis of four ice core records from 1900 to 1996 CE.

Ice core site	Variable	Principal Component				
		1 (13.4%)	2 (12.7%)	3 (11.7%)	4 (9.8%)	5 (9.5%)
Dasuopu, Tibet	$\delta^{18}O$	-0.05	0.76	-0.02	-0.03	0.10
	A_n	-0.11	-0.32	-0.26	-0.19	0.18
	Dust	-0.07	0.80	-0.04	0.07	0.07
Quelccaya, Peru	$\delta^{18}O$	-0.29	0.35	0.02	-0.24	-0.52
	A_n	0.12	0.10	0.52	-0.16	0.50
	Dust	0.30	-0.15	0.04	-0.16	-0.60
Bona-Churchill, Alaska	$\delta^{18}O$	0.05	-0.01	0.65	0.44	0.04
	A_n	-0.06	0.09	-0.06	0.84	0.01
	Dust	0.04	0.07	-0.80	0.18	0.05
Bruce Plateau, Antarctica	$\delta^{18}O$	0.83	-0.02	0.06	0.01	-0.02
	A_n	0.84	-0.06	-0.00	-0.05	-0.02
	Dust	0.02	0.09	0.01	-0.31	0.46

Table S3. Skill statistics for the four different calibration periods

	Skill statistics over the 1854-1996 period			
Calibration Period	1950-1996	1900-1949	1900-1996	1854-1996
Bias	0.002	0.071	0.021	-0.0005
Mean Average Error	0.416	0.427	0.417	0.416
Root Mean Square Error	0.527	0.542	0.528	0.525
	Skill statistics outside of the calibration period			
Calibration Period	1950-1996	1900-1949	1900-1996	1854-1996
Bias	0.004	0.109	0.067	n/a
Mean Average Error	0.417	0.409	0.381	n/a
Root Mean Square Error	0.523	0.528	0.470	n/a

Table S4. Years included in the reconstructed and observed IPO composites in Fig. 5

Reconstructed 1450-1996	**Years Included**
+IPO (+1.5σ) 35 years total	1451, 1460, 1489, 1504, 1524, 1527, 1530, 1565, 1633, 1634, 1655, 1660, 1722, 1723, 1740, 1763, 1770, 1792, 1794, 1795, 1804, 1825, 1833, 1846, 1880, 1888, 1906, 1940, 1941, 1987, 1990, 1991, 1992, 1993, 1994
-IPO (-1.5σ) 28 years total	1544, 1547, 1552, 1557, 1587, 1600, 1637, 1662, 1674, 1677, 1691, 1700, 1715, 1717, 1724, 1731, 1778, 1779, 1785, 1786, 1797, 1816, 1819, 1848, 1860, 1874, 1953, 1955
Observed 1948-2018	**Years Included**
+IPO (10 highest)	1958, 1965, 1969, 1982, 1983, 1987, 1992, 1993, 1997, 2015
-IPO (10 lowest)	1950, 1955, 1956, 1971, 1974, 1975, 1999, 2000, 2008, 2011

Table S5. Correlation coefficients between the ice core-derived IPO index from this study and previous reconstructions of Pacific climate variability shown in Fig. 6 of the main text. Bold indicates 99% significance.

Reconstruction	1750 - present	1450 - 1749	1450 - present
Biondi et al. 2001	**0.115**		
D'Arrigo et al. 2001	**0.658**		
D'Arrigo and Wilson 2006	-0.107		
Shen et al. 2006	**0.237**	**0.263**	**0.235**
MacDonald and Case 2005	**0.161**	**0.274**	**0.225**
Vance et al. 2015	**0.394**	-0.041	**0.161**
LMR v2.0	**0.461**	-0.110	**0.144**
Composite	**0.399**	0.046	**0.187**

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