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SUPPLEMENTARY INFORMATION

DOI: 10.1038/NGEO1129

Winter warming inWest Antarctica caused by central tropical Pacific warming

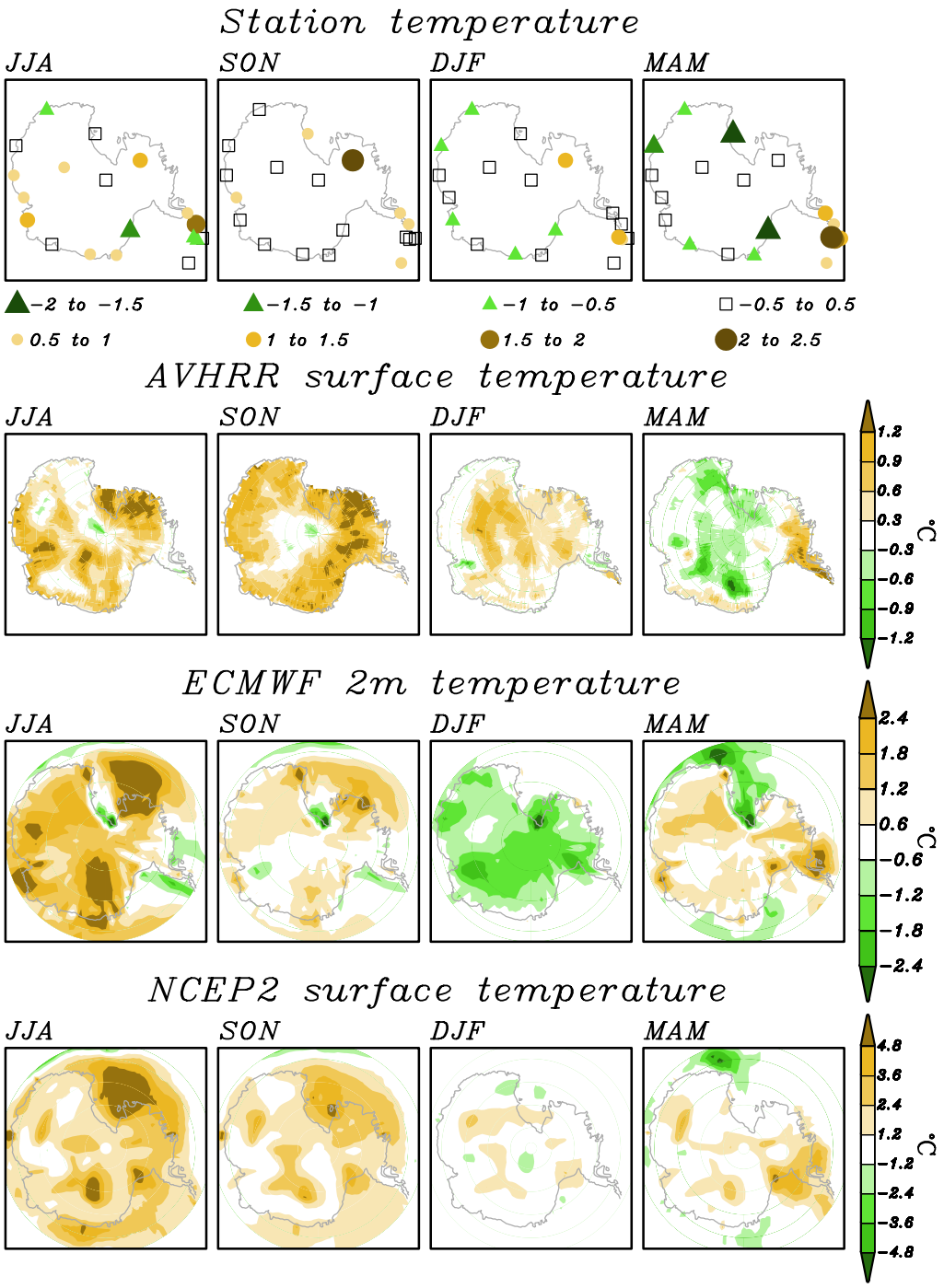

Figure S1. Seasonal Antarctic temperature change from different data sets.

Epochal difference (1994-2009 minus 1979-1993) of seasonal mean surface and near-surface temperature from weather stations, AVHRR satellite data, and ECMWF and NCEP2 reanalyses. For AVHRR, the epochs are 1982-1993 and 1994-2006. Note the different color scales for each data set.

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Supplementary Figures for Ding et al., "Winter warming in West Antarctica…"

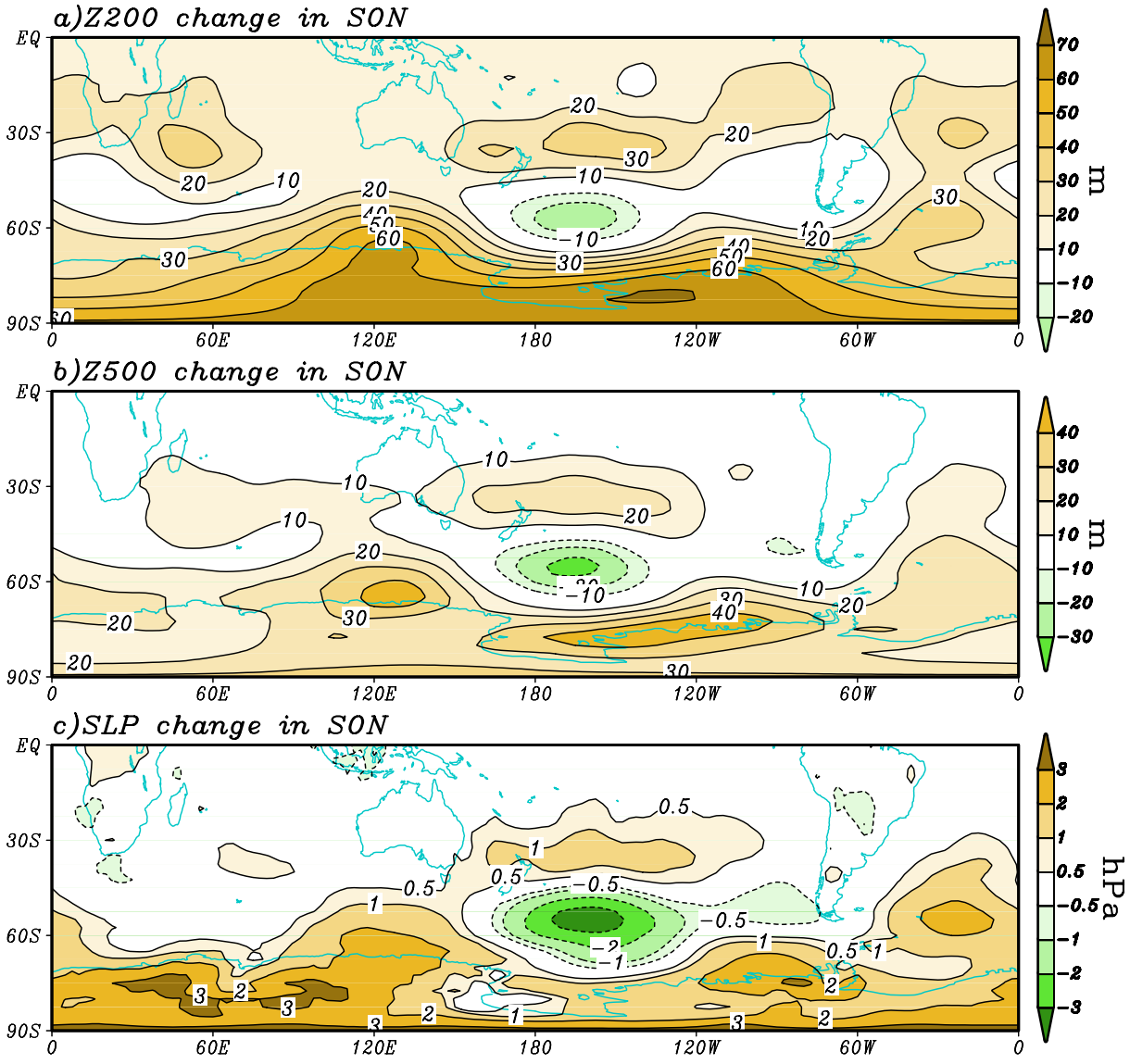

Figure S2. Geopotential height and sea level pressure change in austral spring.

Epochal difference (1994-2009 minus 1979-1993) of spring (SON) seasonal mean a) 200 hPa geopotential height, b) 500 hPa geopotential height and c) sea level pressure from ECMWF.

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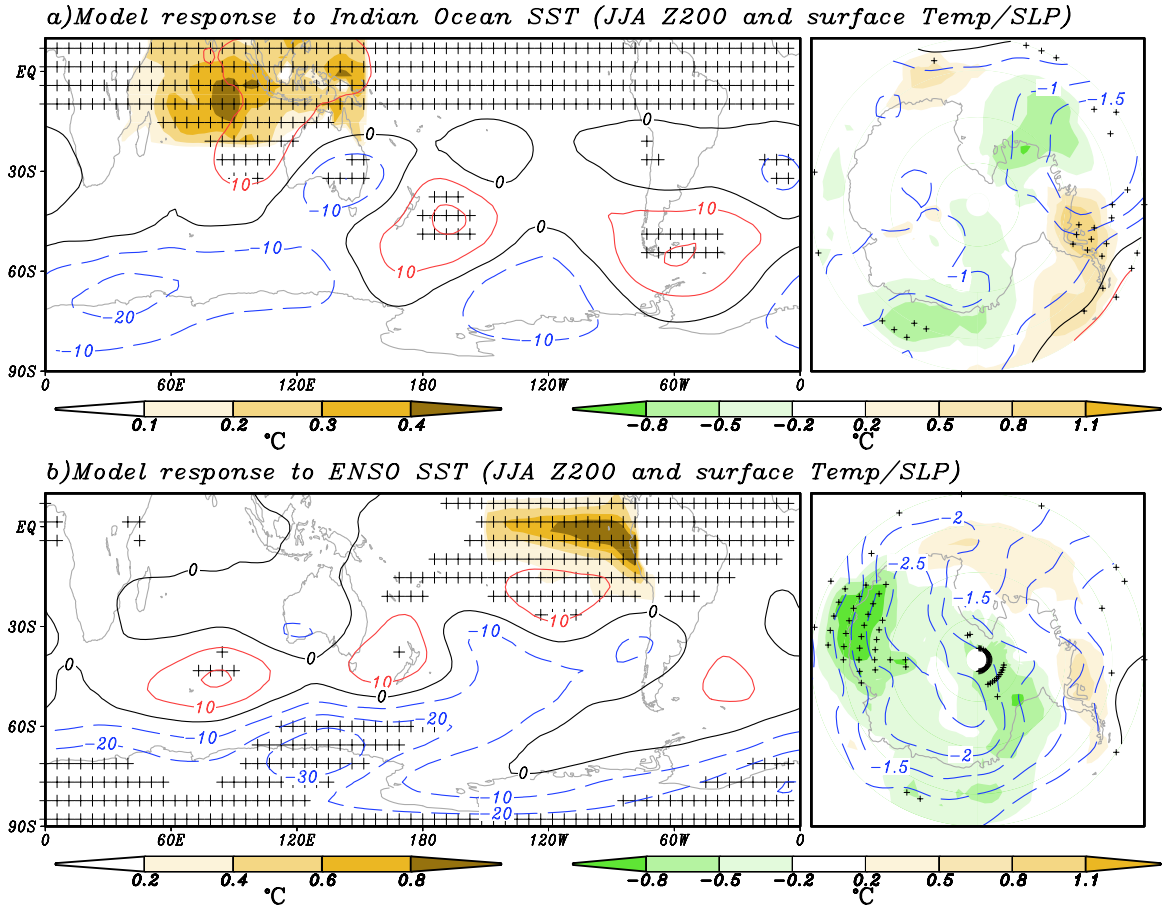

Figure S3. Response of ECHAM4.6 atmospheric model to anomalous warm sea surface temperature in the Indian Ocean and eastern tropical Pacific Ocean.

ECHAM4.6 model response to JJA SST forcing mimicking (a) the SST pattern of JJA mode 2 over the Indian ocean and (b) the ENSO forcing of JJA mode 1 over the equatorial Eastern Pacific. Colors show the tropical SST temperature forcing (left panels) and Antarctic region surface temperature response (right panels). Contours show Z200 height anomalies over the entire Southern Hemisphere (left panels), and SLP anomalies over the Antarctic region (right panels). '+' signs indicate where the Z200 (left) and surface temperature responses (right) are significant at greater than 99% confidence, based on a two-tailed Student's *t*-test. For the Indian Ocean, a +2 standard deviation forcing is used, because the response is quite weak. For the eastern Pacific, a +1 standard deviation forcing is used, as for the central Pacific forcing in Figure 4 (main text).

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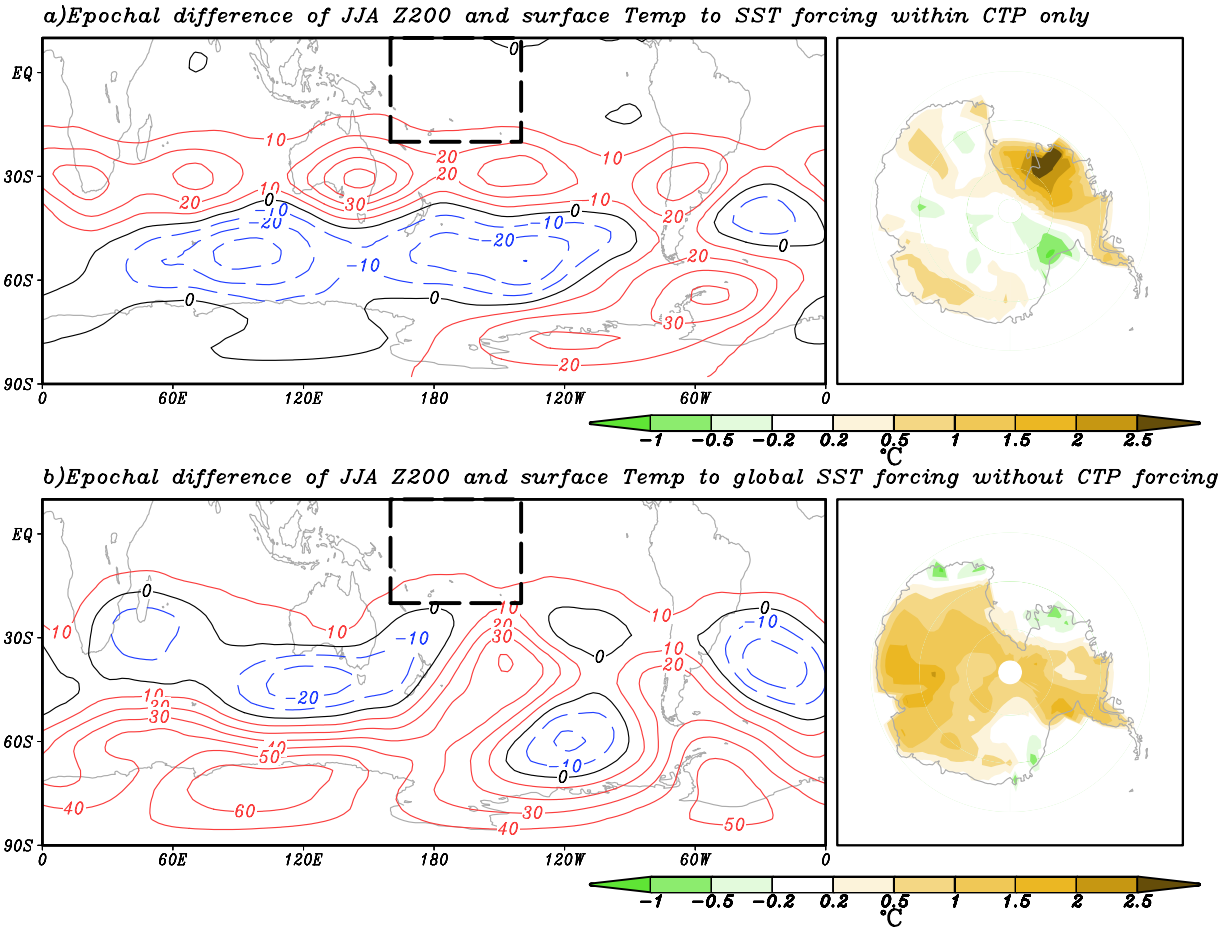

Figure S4. Epochal differences (1994-2009 minus 1979-1993) of response of ECHAM4.6 atmospheric model to observed SST winter forcing in a) the central tropical Pacific (CTP) and b) excluding the central tropical Pacific

Panel a) shows the 200 hPa response (left) and the temperature response (right) in ECHAM4.6 to 31-year forcing of observed SST in JJA (ERSST3) in the central tropical Pacific region (outlined by box), with climatological SSTs used everywhere else. Panel b) shows the same but for climatological SSTs in the central tropical Pacific, and observed SSTs everywhere else. Contours are in meters.

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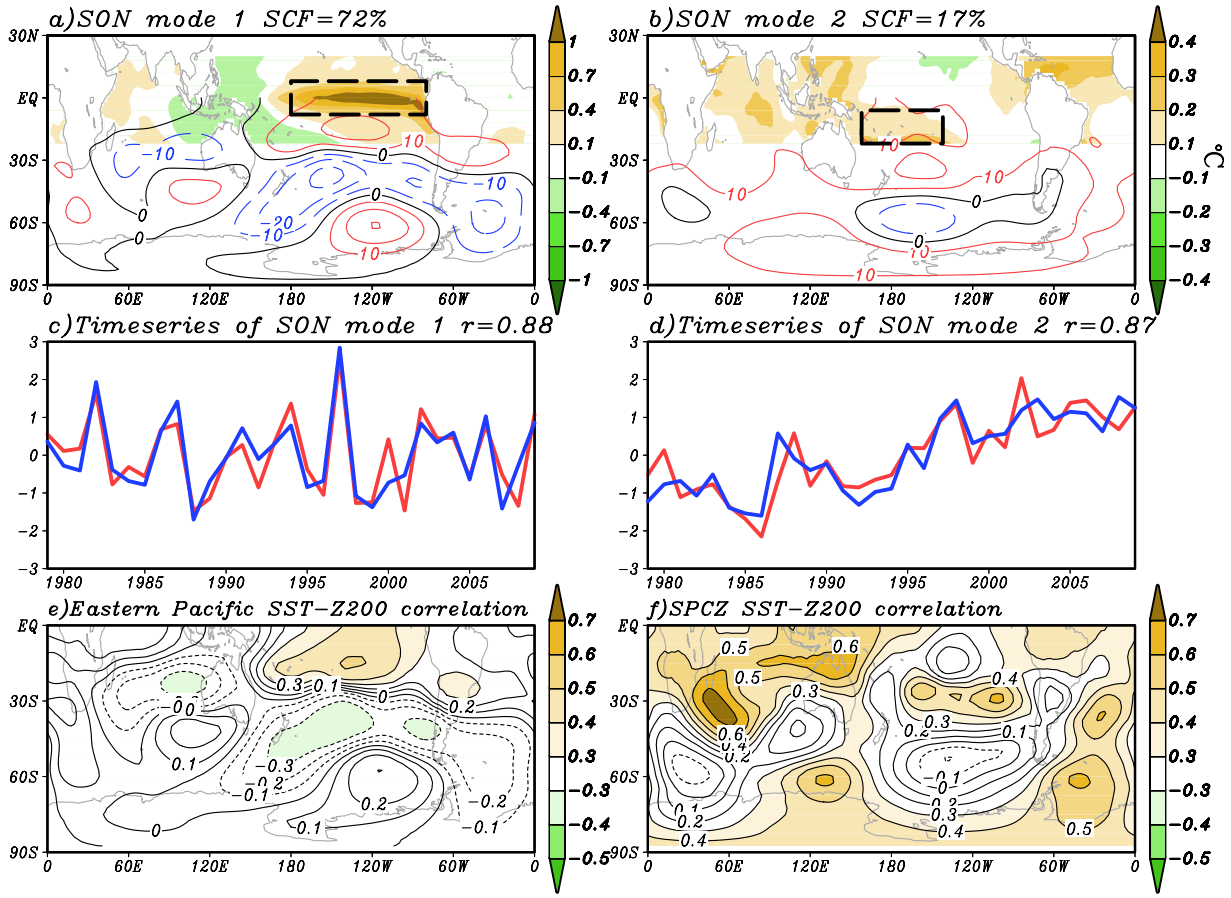

Figure S5. Principal modes of covarying tropical sea surface temperature and Southern Hemisphere circulation in austral spring.

Maximum covariance analysis (MCA) results for spring (SON) 1979-2009 Southern Hemisphere 200 hPa geopotential heights (Z200) and tropical (20°S to 20°N) sea surface temperature (SST). a) mode 1 and b) mode 2 Z200 (contour interval 10m) and tropical SST (shading). c) mode 1 and d) mode 2 expansion coefficient of the Z200 (red) and SST mode (blue). e) correlation between Z200 and SST averaged over the eastern tropical Pacific (180-280°E, 8°S-8°N, outlined in black in panel a). f) correlation between Z200 and SST averaged over the SPCZ region (158-218°E, 22-6°S, outlined in black in panel b). Amplitudes in (a) and (b) are scaled by one standard deviation of the corresponding time series in (c) and (d). Squared covariance fraction (SCF) and temporal correlation coefficient (*r*) between the two expansion coefficient time series are indicated above each panel.

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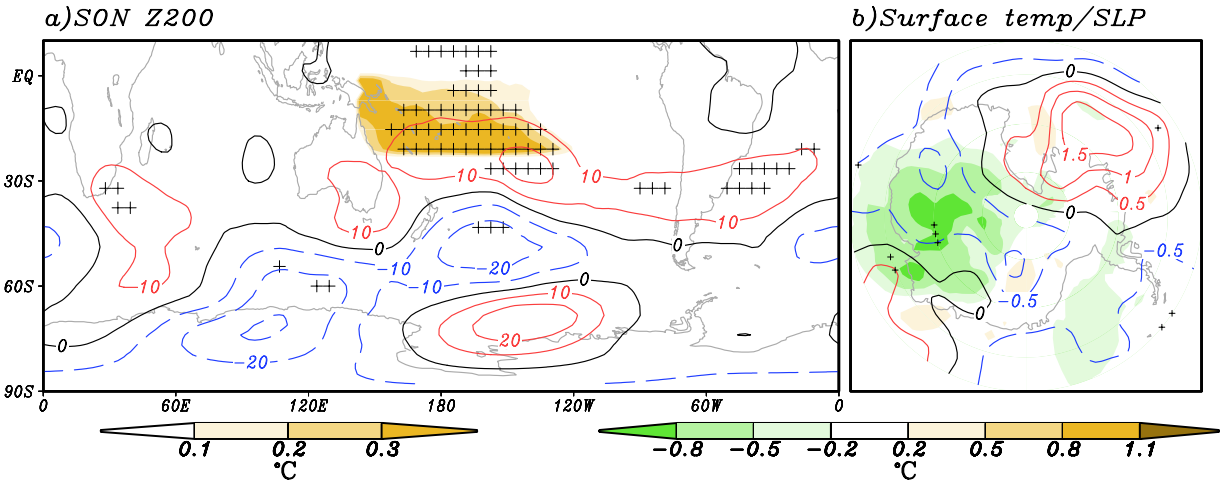

Figure S6. Response of ECHAM4.6 atmospheric model to anomalous warm central Pacific and SPCZ sea surface temperature in austral spring.

a) 200hPa geopotential height anomalies (contour interval 10m) over the Southern Hemisphere arising from +1 standard deviation anomalous SST forcing (shading); b) sea level pressure anomalies (contour interval 0.5 hPa) and surface temperature anomalies (shading) in the Antarctic region. Crosses denote regions of Z200 anomalies in panel (a) and surface temperature anomalies in panel (b), where the model response is above the 99% confidence level as assessed by a two-tailed Student's *t*-test.

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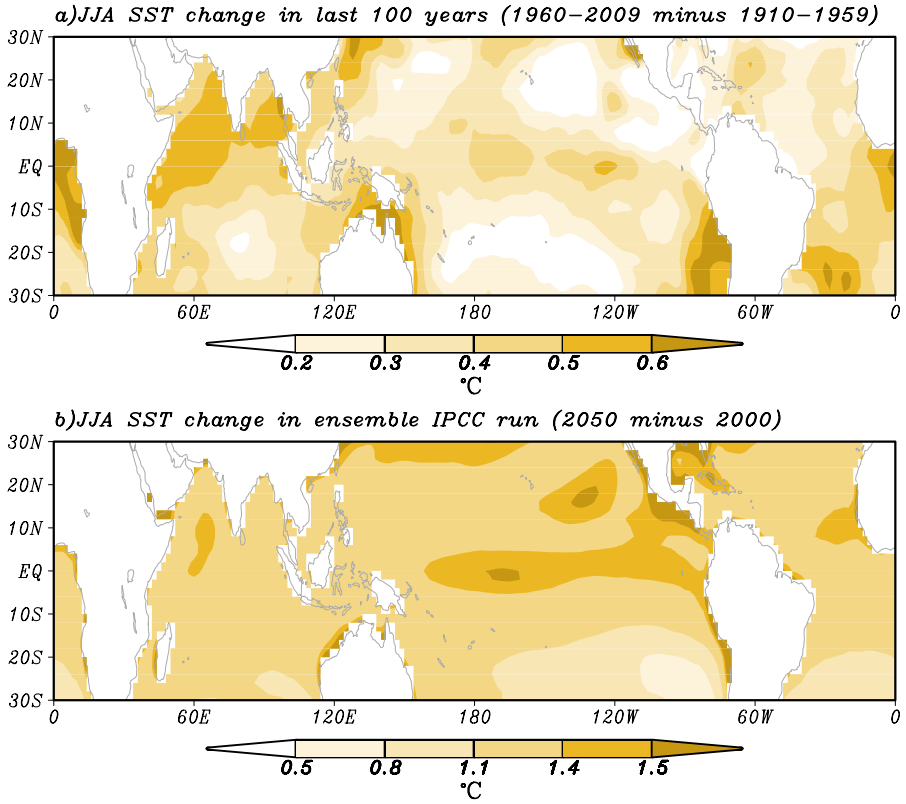

Figure S7. Tropical Pacific sea surface temperature anomalies in austral winter over the last century and in the future.

a) Epochal difference (1960-2009 - 1910-1959) of JJA tropical SST (30°S-30°N) from ERSSTv3 data. A similar pattern of central tropical Pacific warning is seen for the most recent 60 years, and in HADSST2 data for the same time periods.

b) JJA SST change (2050 minus 2000) in an ensemble of coupled model runs under the IPCC A1B scenario. The model output in panel (b) is the ensemble mean from the 23 climate models used in the Intergovernmental Panel on Climate Change (IPCC) Fourth Assessment Report (AR4) and archived in the CMIP3 Multi-Model Dataset Archive at the Program for Climate Model Diagnosis and Intercomparison (PCMDI): www-pcmdi.llnl.gov/ipcc/about_ipcc.php. The projection from this model ensemble suggests that the central tropical Pacific will be the region with the most significant warming in JJA.