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Supporting Online Material for

Impact of Shifting Patterns of Pacific Ocean Warming on North Atlantic Tropical Cyclones

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Published 3 July 2009, *Science* **325**, 77 (2009)
DOI: 10.1126/science.1174062

This PDF file includes:

SOM Text
Figs. S1 to S5
Table S1
References

Supporting Online Material (SOM)

Data and model information

Figure S1 to S5

Table S1

References

Data and model information

The SST data used in this study is the Extended Reconstructed Sea Surface Temperature Version 2 (ERSSTv2) from 1950 to 2006 (14). The atmospheric circulation data is from the National Centers for Environmental Prediction/Nation Center for Atmospheric Research (NCEP/NCAR) reanalysis data from 1950 to 2006 (S1). The vertical wind shear is defined as the difference between the 200-hPa and 850-hPa zonal wind anomaly after removing any trend. All data are interpolated to a spatial resolution of 2.5° x 2.5°.

The details for ECMWF Seasonal Forecasting System used in this study are described in the web site (S2). The atmospheric component of the coupled model is the ECMWF atmospheric model integrated forecast system (IFS). The model used in this study has a nominal horizontal resolution of 1.9 x 1.9 degrees (TL95) with 40 levels in the vertical. The oceanic component is the Max Plank Institute Hamburg Ocean Primitive Equation (HOPE, S3) model which has a zonal resolution of 1.4 degrees, a meridional resolution of 0.3 degrees at the equator and 1.4 at the extratropics, and 29 vertical levels with 10 m resolution in the upper 100 m.

Figure S1-S5

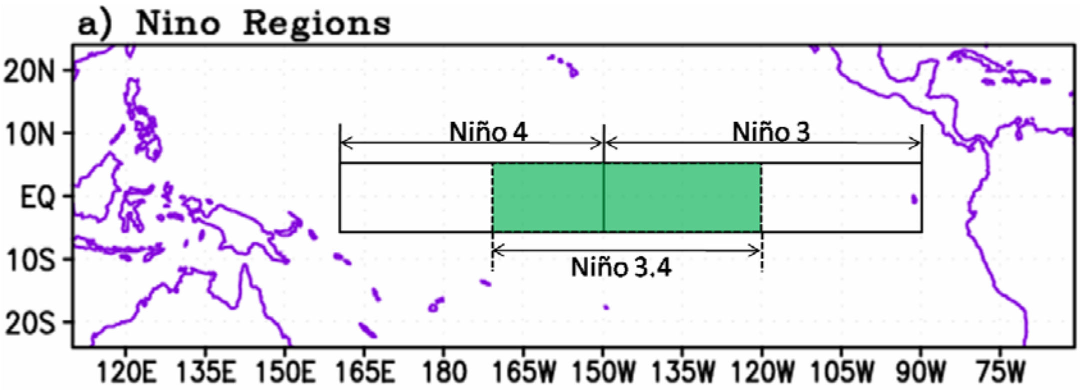

Figure S1. Location of the Niño sea surface temperature region: Niño 3.4 (5°N-5°S, 170°W-120°W), Niño 3 (5°N-5°S, 150°W-90°W), and Niño 4 (5°N-5°S, 160°E-150°W). The Niño 3.4 (S4) does not differentiate between the EPW (Niño 3) and the CPW (Niño 4).

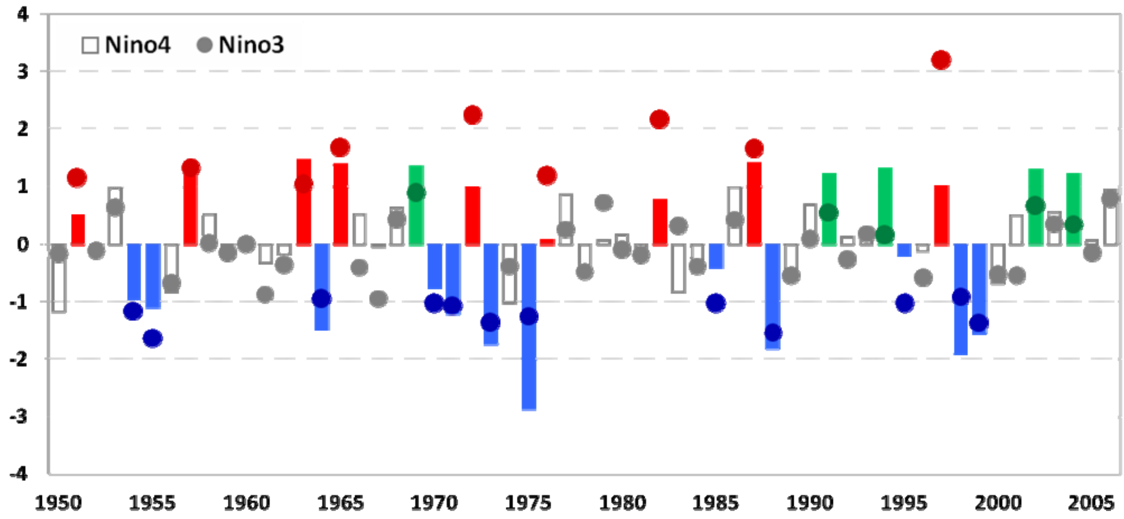

Figure S2. Time series of normalized Niño 3 (circle) and Niño 4 (bar) index based on the SST anomaly from the 1950 to 2006 average in the three-month period August-October. A total of 9 EPW years (red; 1951, 1957, 1963, 1965, 1972, 1976, 1982, 1987, and 1997), 5 CPW years (green; 1969, 1991, 1994, 2002, and 2004), and 12 EPC years (blue; 1954, 1955, 1964, 1970, 1971, 1973, 1975, 1985, 1988, 1995, 1998 and 1999) were identified. The proportion of CPW events has been increasing during recent decades.

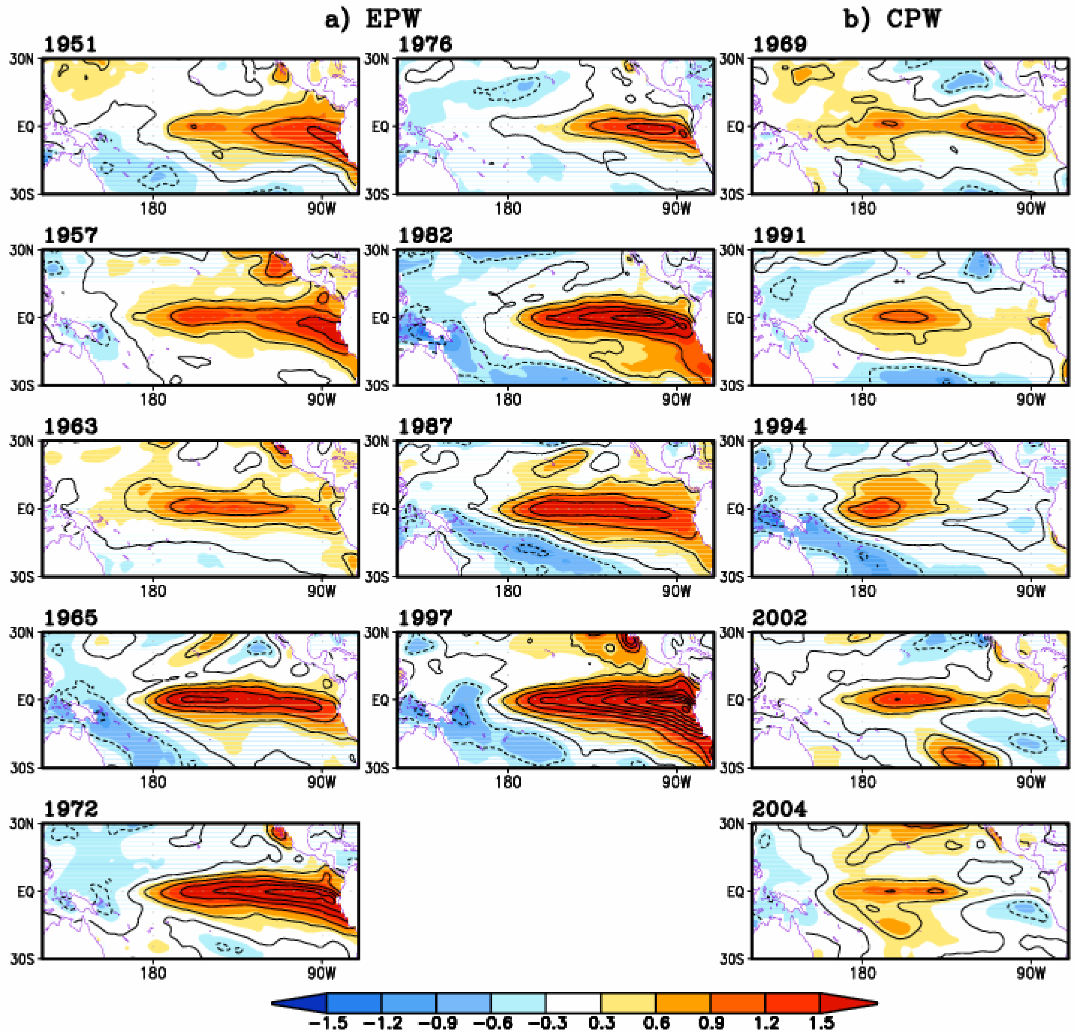

Figure S3. Sea-surface temperature anomalies (contours interval is 0.5ºC) from the long-term August-October mean fields for (a) 9 EPW years (left and middle panel) and (b) 5 CPW years (right panel).

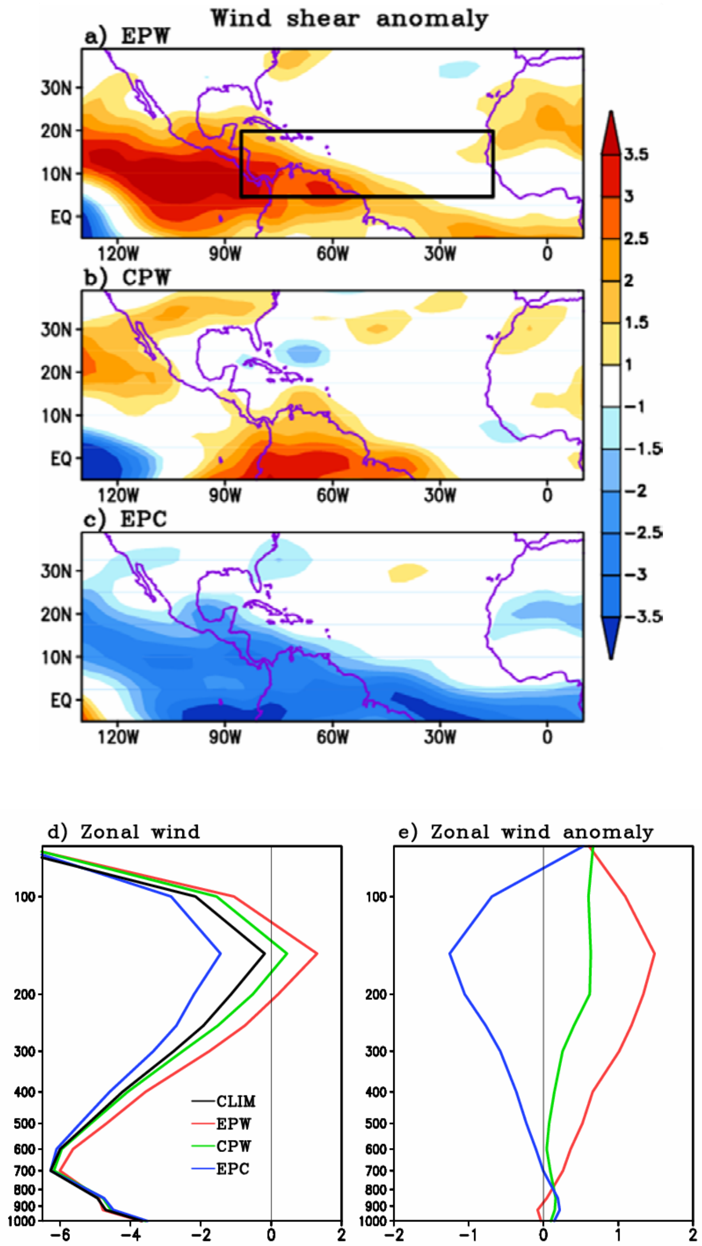

Figure S4: Composites of wind shear (difference in zonal wind speed between 200 and 850 hPa, m s^{-1}) anomalies during the August-October period for (a) EPW, (b) CPW and (c) EPC. The EPW case is similar with Bell and Chelliah (S5). The wind shear differences between the three cases are summarized in (d) and (e). Panel (d) shows the vertical profile of zonal wind structure averaged over the main development region (5°N-20°N, 85°W-15°W, box in panel a) for climatology, EPW, CPW and

EPC. Panel (e) shows anomalies in the wind profile for EPW, CPW and EPC. Strengthening or weakening the vertical wind shear through changes in the upper-level westerly flow (Fig. S5) is a major factor inhibiting or enhancing the formation and intensification of tropical cyclones *(1)*.

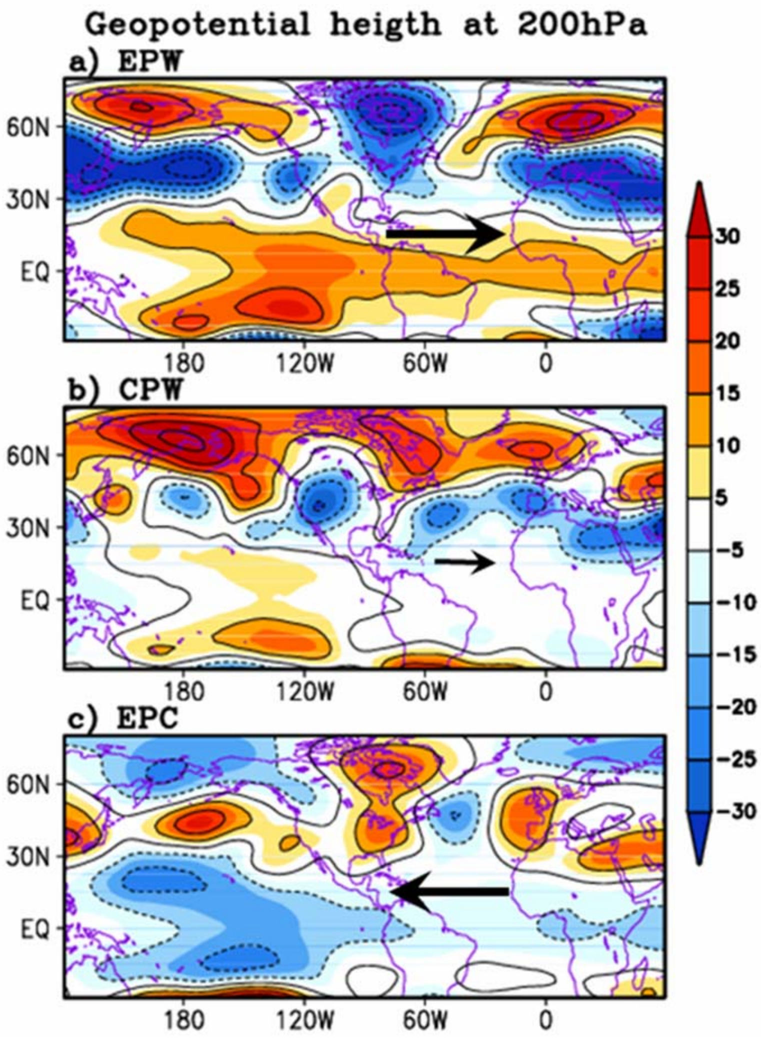

Figure S5. Composite of geopotential height (meter) anomaly at 200 hPa for (a) EPW, (b) CPW, and (c) EPC averaged from August to October. The schematics of arrows indicate the direction and relative magnitude for zonal wind anomaly at 200 hPa. Different warming pattern in the Pacific Ocean changes the atmospheric circulation.

Table S1

Table S1. Average of Accumulated Cyclone Energy (ACE) value for climatology, EPW, CPW, and EPC events. ACE is an index that combines the numbers of systems, how long they existed and how intense they became. It is calculated by squaring the maximum sustained surface wind in the system every six hours and summing over the cyclone season (S6).

Events	CLIM	EPW	CPW	EPC
ACE (10^4 kt^2)	**101.85**	**70.55**	**102.80**	**125.58**

References

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S2. http://www.ecmwf.int/products/forecasts/seasonal/documentation/system3

S3. J. E. Wolff, E. Maier-Reimer, S. Legutke, *Technical Report* **13**, German Climate Computer Center (DKRZ) (1997).

S4. A. G. Barnston, M. Chelliah, S.B. Goldenberg, *Research Note: Atmosphere-Ocean* **35**, 367 (1997).

S5. G. D. Bell, M. Chelliah, *J. Climate* **19**, 590 (2006).

S6. http://www.aoml.noaa.gov/hrd/tcfaq/E11.html