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LETTER

Questionable evidence of natural warming of the northwestern United States

Johnstone and Mantua (1) claim that changes in atmospheric circulation were the primary cause of the observed warming of sea surface temperature around the northeastern Pacific margins and surface air temperature (SAT) in Northern California, Oregon, and Washington from 1901 to 2012. The results of Johnstone and Mantua's report contradict our previous finding (2) that anthropogenic forcing was the leading contributor to century-scale warming in the northwestern United States. Johnstone and Mantua's results (1) are potentially important; however, we suspect that their results depend on the choice of sea-level pressure (SLP) data, as their conclusions are predicated on a long-term decrease in SLP over the northeastern Pacific.

Although Johnstone and Mantua (1) examined correlations between sea surface temperature and SLP from different data sources in justifying their use of National Center for Atmospheric Research (NCAR) SLP data, large structural uncertainty in SLP trends is seen across different datasets. NCAR data contain a long-term decrease in SLP over the Pacific basin and surrounding land masses, including the region highlighted by Johnstone and Mantua (1), whereas the other datasets fail to show such features (Fig. 1 *A* and *D–F*). Resultant changes in near-surface circulation, given trends in NCAR SLP, would differ from those assumed from SLP1 by Johnstone and Mantua (1), as changes in SLP gradients—not SLP itself—are the first-order drivers of surface winds. Moreover, Johnstone and Mantua (1) assume a strengthening of southerly winds that contradicts studies that have found an intensification of the northerly upwelling-inducing winds in summer (3).

Repeating the analysis of Johnstone and Mantua (1) with other SLP datasets indicates negligible change in northwestern United States SAT from 1901 to 2012 from SLP1 using non-NCAR datasets (Fig. 1 *B* and *C*). Furthermore, SLP1 trends are small and not comparable to observed SAT trends from 1948 to 2012, when most of the anthropogenic forcing occurred. Observed northwestern United States warming from 1901 to 2012 has tracked strongly with global mean SAT (2), including most of the warming since 1970, whereas the mechanism described in Johnstone and Mantua's report (1) would produce most of the warming before 1940.

Finally, we used multiple linear regression following our previous findings (2) to better understand the role of SLP1 on seasonal northwestern United States SAT trends. In addition to anthropogenic, solar, and volcanic forcing, we considered low-frequency internal variability arising from the Multivariate El Niño Southern Oscillation Index (MEI), the Pacific North American (PNA) pattern, and SLP1 (defined as the average SLP1 of the three datasets). The PNA was calculated using the modified-point PNA index following ref. 4 and nondetrended 500-hPa height fields from Compo et al. (5). We avoided collinearity by removing the SLP1 signal linearly congruent from the MEI and PNA. Including SLP1 did not modify our original findings that anthropogenic forcing is the leading driver of long-term changes in seasonal temperature (Fig. 2). Furthermore, we find no statistical evidence linking SLP1 with northwestern United States temperature variability in summer or fall.

Although the conclusions of Johnstone and Mantua (1) may be more robust for sea surface temperature around the northeastern Pacific margins, we fail to find support that such changes explain the observed northwestern United States warming, as their results are not substantiated over the more applicable and robust 1948–2012 period.

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1 Johnstone JA, Mantua NJ (2014) Atmospheric controls on northeast Pacific temperature variability and change, 1900–2012. *Proc Natl Acad Sci USA* 111(40):14360–14365.

2 Abatzoglou JT, Rupp DE, Mote PW (2014) Seasonal climate variability and change in the Pacific Northwest of the United States. *J Clim* 27(5):2125–2142.

3 Sydeman WJ, et al. (2014) Climate change and wind intensification in coastal upwelling ecosystems. *Science* 345(6192):77–80.

4 Wallace JM, Gutzler DS (1981) Teleconnections in the geopotential height field during the Northern Hemisphere winter. *Mon Weather Rev* 109(4):784–812.

5 Compo GP, et al. (2011) The twentieth century reanalysis project. *Q J R Meteorol Soc* 654(137):1–28.

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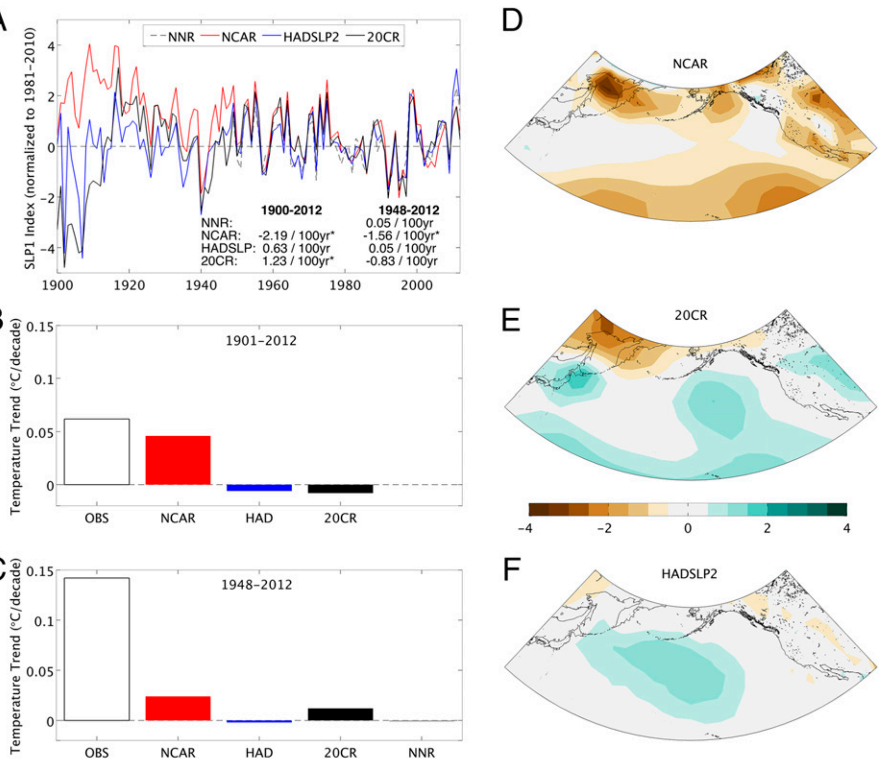

Fig. 1. (*A*) Standardized annual SLP1 from four SLP datasets normalized to a common 1981–2010 time period. Estimated linear least-squares trends in annual SLP1 from 1900 to 2012 and 1948–2012 are reported in units of SD per century; an asterisk denotes statistical significance at $P < 0.05$. (*B* and *C*) Linear temperature trends for annual SAT for the northwestern United States (Oregon, Washington, Idaho, and western Montana) for (*B*) both 1901–2012 and (*C*) 1948–2012 from observations (using an average of three temperature datasets from ref. 2) and trends estimated through simple linear regression between annual SLP1 and annual temperature using NCAR, 20th Century Reanalysis (20CR), HadSLP2, and National Centers for Environmental Prediction-NCAR Reanalysis 1 (NNR). Trends from NNR were only calculated from 1948 to 2012. (*D*–*F*) Linear trends in SLP from 1900 to 2012 in units of millibars per century for (*D*) NCAR, (*E*) 20CR, and (*F*) HadSLP2 datasets.

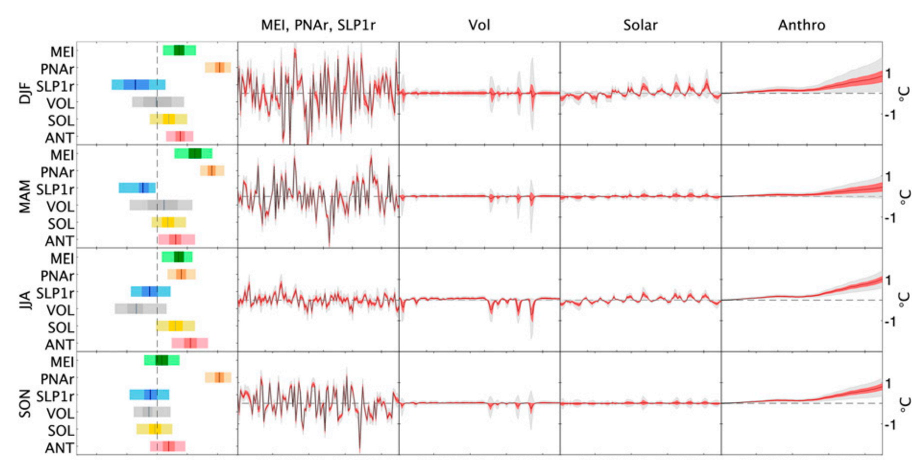

Fig. 2. (*Left* column) Pearson's correlation coefficient between seasonal SAT for the northwestern United States (Oregon, Washington, Idaho, and western Montana) and (*i*) MEI, (*ii*) PNA index after removing the linear contribution from MEI, (*iii*) SLP1 after removing the linear contributions from MEI and PNA, (*iv*) volcanic aerosols, (*v*) solar variability, and (*vi*) anthropogenic factors (see ref. 2 for full details). The boxplots show the 95% confidence interval, interquartile range, and median of bootstrapped correlations by the light shading, dark shading, and solid line, respectively. (*Right* four columns) Reconstructed contribution to seasonal temperature from the multiple linear regressions for individual factors. The 95% confidence interval, interquartile range, and median of bootstrapped multiple linear regression contributions are denoted by the light gray shading, red shading, and black line, respectively. The combined influence of MEI, PNA, and SLP1 is shown in the second column.