LETTER

Reply to Abatzoglou et al.: Atmospheric controls on northwest United States air temperatures, 1948–2012

We recently documented a strong relationship between northeast Pacific sea-level pressure (SLP) and coastal North American sea surface temperature (SSTs) and surface air temperatures (SATs), concluding that atmospheric circulation changes produced nearly all observed coastal warming from 1900 to 2012 (1). In our report, we present a simple, successfully cross-validated time-series model that reproduces interannual, decadal, and century-long variations in the SST record from current and prior SLP anomalies. Our primary SLP data, from the National Centers for Atmospheric Research (NCAR), depict a century-long SLP decline in the northeastern Pacific, as previously shown for the central North Pacific and supported by independent precipitation records (2).

Abatzoglou et al. (3) speculate that SLP indices from HadSLP2 and 20th Century Reanalysis (20CR) datasets may be more reliable than NCAR, particularly before 1921. Early HadSLP2 and 20CR SLP data rely heavily on monthly ship-based estimates that are less than 20% complete in the North Pacific from 1900 to 1915. In contrast, NCAR SLP is constructed from daily Northern Hemisphere weather map analyses with nearly complete spatial and temporal coverage in the North Pacific back to 1899 (www.lib.noaa.gov/collections/imgdocmaps/synoptic_weather_maps_northern_hemisphere.html). These maps include information on winds and fronts as well as SLP, and are likely to provide a more physically realistic picture of SLP fields and gradients than time averages of sparse point measurements (4).

In our report (1) we show that HadSLP2 and 20CR SLP fail basic quality checks from 1900 to 1920, leading us to conclude that these early data are unreliable. Therefore, 1900–2012 trends, such as those presented by Abatzoglou et al. (3), are likely to be erroneous. Based on statistical tests in our report (1), unchallenged by Abatzoglou et al. (3), we remain confident in the superiority of NCAR SLP in the northeastern Pacific before 1921.

A second issue raised by Abatzoglou et al. (3) is the applicability of our findings to 1948–2012 surface warming in the northwestern United States from 49° to 42°N and 125° to 110°W, a region that extends considerably further inland than any we considered. Here we first show that, within this region, coastal SATs west of 120°W (annual July–June means, 1948–2012) correlate with 20CR SLP similarly to our long-term SLP1 index (Fig. 1 *A* and *B*), with warmth promoted by cyclonic wind anomalies, low SLP, and a weak ocean–land SLP gradient in the NE Pacific region. Contrary to claims by Abatzoglou et al. (3), recent SLP changes support our original findings during a period when NCAR, HadSLP2, and 20CR SLP are in generally good agreement.

Regional interior SATs east of 120°W are also significantly, but modestly, correlated with SLP1 and the midtropospheric (500 hPa level) Pacific North American (PNA) pattern emphasized by Abatzoglou et al. (3). This preselected PNA index has no significant 1948–2012 trend, but a slightly modified 500 hPa circulation index, more relevant to interior NW SAT, has changed significantly in a manner that accounts for nearly all 1948–2012 warming (Fig. 1 *C* and *D*). This result highlights the necessity of appropriately-defined circulation indices for attribution of regional temperature variations and changes, a key point in our original study.

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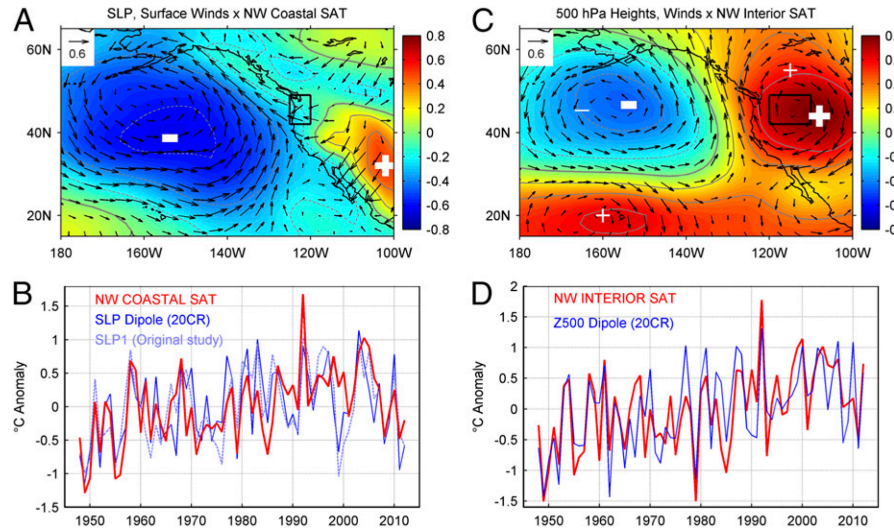

Fig. 1. Correlations of gridded 20CR circulation variables with annual (July–June) surface air temperature (SAT) anomalies in the northwest US, 1948–2012. (*A*) SLP (shading) and surface wind (vector) correlations with coastal SAT (49°N–42°N, 125°W–120°W). (*B*) Time series comparison of coastal SAT (red), normalized SLP dipole index (dark blue), and the original SLP1 index from NCAR SLP in ref. 1 (dashed, light blue). (*C*) Midtropospheric (500 hPa) geopotential height (Z500, shading) and wind (vector) correlations with interior SAT (49°N–42°N, 120°W–110°W). (*D*) Time series comparison of interior SAT anomalies (red) and normalized Z500 dipole index (blue). Large "+" and "−" markers identify locations and signs of local series used in dipole indices. Small markers identify local Z500 series contributing to the PNA index. Northwestern United States boxes mark areas of SAT averaging; circulation time series are scaled to have identical means and standard deviations as SAT indices.