The role of the atmosphere in northeast Pacific warming: Century-long trends and recent anomalies

Jim Johnstone Seattle, WA jajstone@gmail.com

Nate Mantua NOAA/NMFS Southwest Fisheries Science Center City, Santa Cruz, CA nate.mantua@noaa.gov

Abstract:

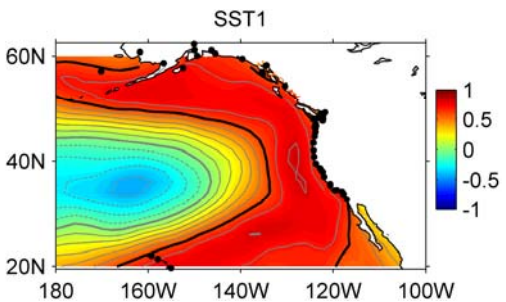
Sea surface temperatures (SSTs) in the northeast Pacific (NEP) vary in coherent fashion, largely in response to regional wind forcing of surface turbulent heat fluxes. Century-long records of regional sea-level pressure (SLP) suggest that weakening winds and net increases in turbulent fluxes can account for the entirety of NEP surface warming from 1900 to 2012. Here we focus on the historically warm period from 2013 to 2015, placing recent atmosphere-ocean anomalies in the context of longer trends.

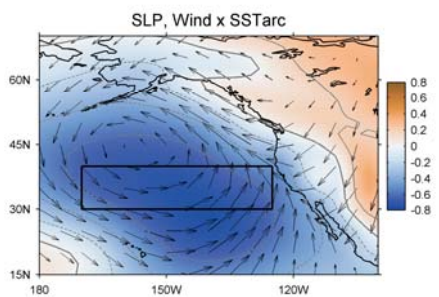
We also show that recent warm conditions in the Gulf of Alaska (GoA, i.e. 'the blob') reflect forcing by atmospheric patterns that operate on two different spatial scales. At the basin scale, GoA warming occurs in conjunction with the broader NEP 'Arc' region that extends from the coastline to ~1000 km offshore. Arc SST changes are sensitive to strength of the mean anticyclonic winds, centered around the subtropical high northeast of Hawaii. Warming ensues when *negative* SLP anomalies in this area lead to large-scale reductions in wind speeds and lower evaporative cooling rates over much of the Arc.

At the smaller regional scale of the GoA, however, SST increases with locally *positive* SLP anomalies, which generate local wind speed reductions and net positive turbulent fluxes. We show that atmospheric forcing of GoA SSTs includes two opposite scale-dependent responses to SLP, and that understanding of recent and long-term changes can be improved by separately accounting for basin-scale and regional forcing patterns.

1) SSTs in the Northeast Pacific 'Arc'

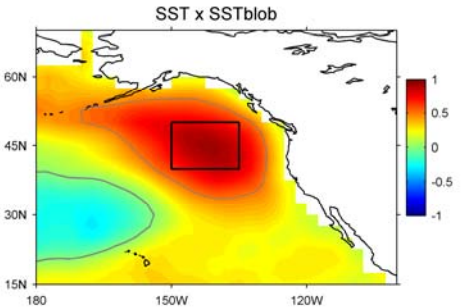
SST variability of the Northeast Pacific region is dominated by coherent variability within a basin-scale 'Arc' pattern that stretches around the North American coastline to ~1000km offshore, including coastal areas of Alaska, the western United States, and Hawaii. The Arc pattern resembles the eastern pole of the Pacific Decadal Oscillation (PDO). Unlike the PDO, the Arc SST index is defined by an EOF pattern includes the century-long warming trend. Coherent warming of the Arc is favored by *negative* SLP and *cyclonic* wind anomalies centered over the subtropical NE Pacific (35N-30N).

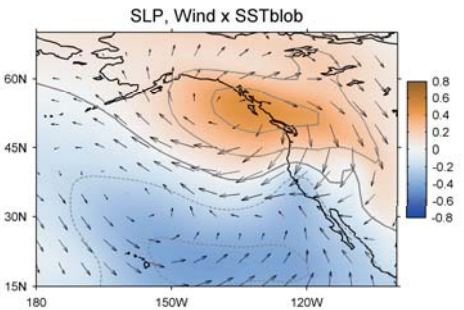


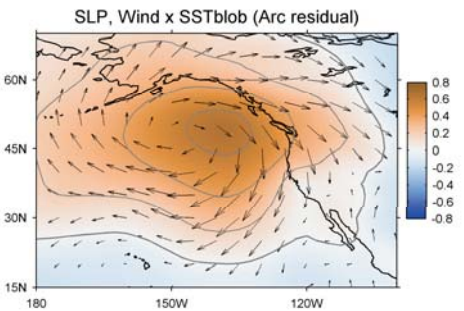


2) SSTs in the Gulf of Alaska 'Blob' region:

SSTs in the Gulf of Alaska (GoA, 50N-40N, 150W-135W) are moderately correlated with those throughout the Arc, but generally exhibit smaller-scale regional coherence. GoA, i.e. 'Blob' SST anomalies warm with *positive* local SLP anomalies and anticyclonic wind around 50N-45N, but *negative* subtropical SLP anomalies. However, when the larger-scale Arc SST signal is removed from the GoA SST time series, stronger *positive* SLP relationships are observed at the regional scale.

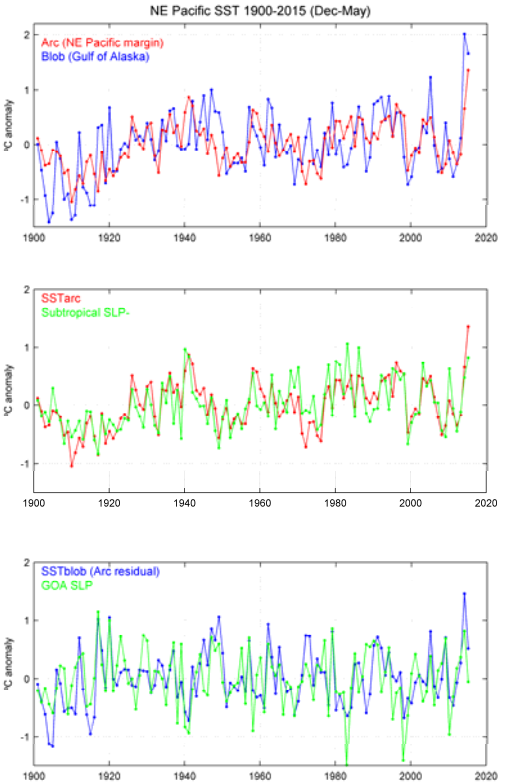






3) SLP and SST evolution 1901-2015

Over the past century, SSTs in the Arc and GoA have evolved similarly, with rapid warming before 1940, relatively stable conditions through the early 2000s, and abrupt warm anomalies in recent years of 2013-14 and 2014-15. The warming of the Arc is well-explained by declining subtropical SLP. When the Arc signal is removed from GoA SST, no significant linear warming is evident. Consistent with this result, GoA SLP has changed little over the past century.



4) Recent SLP and SST anomalies

In 2013-14 the warm 'Blob' was favored by high GoA SLP and low subtropical SLP that contributed to broader warming of the Arc. In 2014-15, warming was dominated by the Arc pattern and negative SLP anomalies at subtropical latitudes.