2014 NEWS Science Team Meeting

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Observations show the tropical belt has widened since ~1979.

\[
NH: 0.35^\circ \pm 0.09^\circ \text{ decade}^{-1}
\]

\[
SH: 0.17^\circ \pm 0.10^\circ \text{ decade}^{-1}
\]

CMIP5 coupled simulations significantly underestimate tropical expansion.

Prescribed SST simulations (AMIP) come closest.

Real-world evolution of SSTs important!
NH Tropical Expansion and PDO

- NH Jet latitude variations from prescribed SST runs resemble observed -PDO.
- Jet latitude trends are correlated with PDO trends in 20th century coupled and preindustrial control simulations.
Removal of PDO variability negates NH tropical expansion.

PDO is related to recent NH tropical expansion.
Prior to the recent tropical widening, the tropical belt contracted from 1950-1979.

Continued relationship between JET latitude and PDO.

PDO is also related to NH tropical contraction.
Observed PDO trend has opposite sign from 1950-1979 versus 1979-2009. 20th century coupled simulations reproduce this reversal. Trend reversal also occurs in anthropogenic aerosol only simulations. Why? Is this related to the transition from solar “dimming” to “brightening”? Is it related to increased east Asian absorbing aerosol?

PDO is partially externally forced, primarily by aerosols. Indirectly implies aerosol forcing of tropical contraction/expansion.
Regional Implications: Southwest United States

PDO-Precipitation Correlation

+ (-) PDO is associated with more (less) SW US precipitation
Regression of 300 hPa Zonal Winds (Jet) onto PDO

The Pacific jet stream controls the trajectory of mid-latitude cyclones, a dominant source of SW US precipitation.

+ (-) PDO associated with equatorward (poleward) displacement of Pacific jet stream.

The PDO modulates SW US precip by shifting storms north/south
Aerosol Influence on SW US Precipitation

→ SW US precipitation trend reversal consistent with PDO reversal.
→ Anthropogenic aerosols are partially responsible for PDO trend reversal.

Aerosols account for ~1/3 of recent SW US precipitation trends!
Future Aerosol Trends

All RCPs project significant reductions in aerosol emissions, reaching preindustrial values by 2100.

How does this impact the PDO, atmospheric circulation, and the edge of the tropics?

Can we predict the PDO?
CAM5 21\textsuperscript{st} Century PDO Trends

\[ m = -0.126 \text{ [std dev/dec]} \text{ 99\%} \]

\[ m = -0.109 \text{ [std dev/dec]} \text{ 99\%} \]

\rightarrow CAM5 RCP4.5 simulations yield negative 21\textsuperscript{st} century PDO trends.

\rightarrow Anthropogenic aerosols are responsible for the bulk of the trend.

Future decreases in anthropogenic aerosols may force a – PDO!
Anthropogenic aerosols drive 21\textsuperscript{st} century poleward displacement of NH tropical edge and subtropical dry zone
CAM5 AA 21st Century Trends

850-300 hPa Zonal Wind

SW US Precipitation

→ AA yields a northward shift in tropospheric jet, especially in the Pacific sector.
→ Corresponding precipitation shift & decreased SW US precipitation.

Consistent with the –PDO trend, AA yield a poleward jet shift and SW US drying trends.
The Role of Mid-latitude Warming Amplification

Climate forcing agents that preferentially warm the NH mid-latitudes—like anthropogenic aerosols—yield tropical widening
Summary

• Subtropical dry zone expanded during 1979-2009.
• Greatly underestimated by coupled model ensemble mean.
• Strong association between expansion (contraction) and − (+) PDO.
• Could have substantial natural variability component.
• Substantial contribution from aerosol radiative forcing.
• Aerosols have likely contributed to recent SW US precipitation trends.
• Future reductions in aerosol emissions may force –PDO, NH tropical widening and continued SW US drying.

Implications for NEWS

• Does regional aerosol radiative forcing drive circulation and precipitation patterns on decadal time scales?
• Can we project aerosol radiative forcing changes in coming decades and the likely PDO, atmospheric circulation and precipitation response?
Conference Presentations

- Invited Talk: “Heterogeneous Warming Agents and Widening of the Tropical Belt”, AGU Meeting of the Americas, Cancun, Mexico, May 2013.
- Talk: “Widening of the Tropical Belt and the PDO”, Davos Atmosphere and Cryosphere Assembly, Davos, Switzerland, July 2013.

Symposium Organization


Papers

- “The importance of anthropogenic aerosols to recent precipitation trends in the Southwest United States”, in prep.
- “Anthropogenic aerosol widening of the Northern Hemisphere tropical belt through the 21st Century”, in prep.