Response of North Pacific Atmospheric Rivers to Climate Change Conditions

Katerina R. Gonzales[1*], Daniel L. Swain[1], and Noah S. Diffenbaugh[1,2]

[1]Department of Earth System Science, Stanford University, Stanford, CA, [2]Woods Institute for the Environment, Stanford University, Stanford, CA

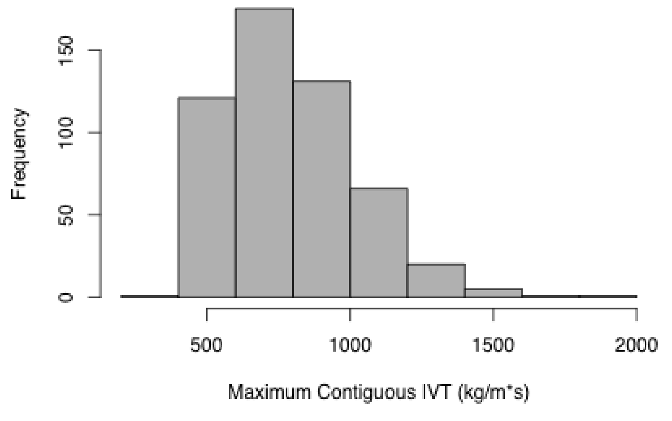
*kgonzales@stanford.edu

Motivation and Analytical Framework

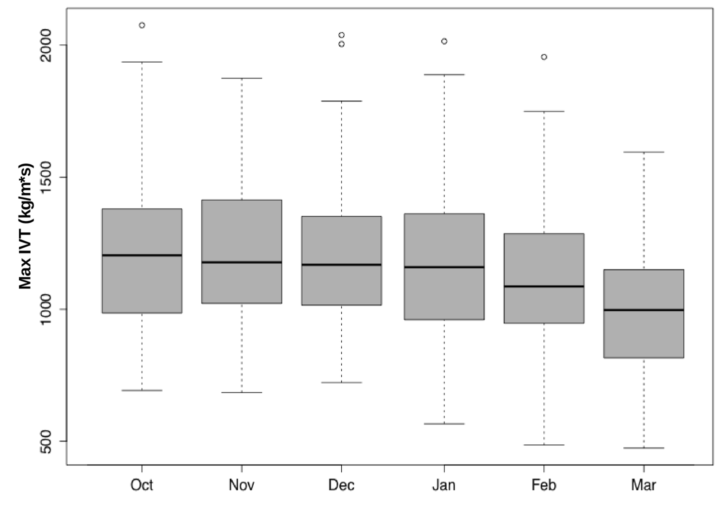
Atmospheric rivers (ARs) are known to play an important role in the global hydrologic cycle and in bringing extreme precipitation to multiple places around the globe, highlighting the necessity to understand how these features will be affected by anthropogenic warming. Numerous previous studies have used global climate models to analyze projections of AR characteristics, mostly AR frequency, but we can glean further information available on observed ARs detected in observational reanalyses to fill in this picture of expected future AR characteristics and downstream impacts in conditions expected from climate change.

A warmer earth can alter ARs by both thermodynamical and dynamical effects, including a) enabling more moisture in the air, b) changing the sea surface temperatures (SSTs) and thereby the heat transport between the ocean and atmosphere, and c) altering the atmospheric circulation patterns under which an AR occurs. Here we investigate the link between warmer SSTs and integrated water vapor transport (IVT) during landfalling North Pacific AR events.

Methods



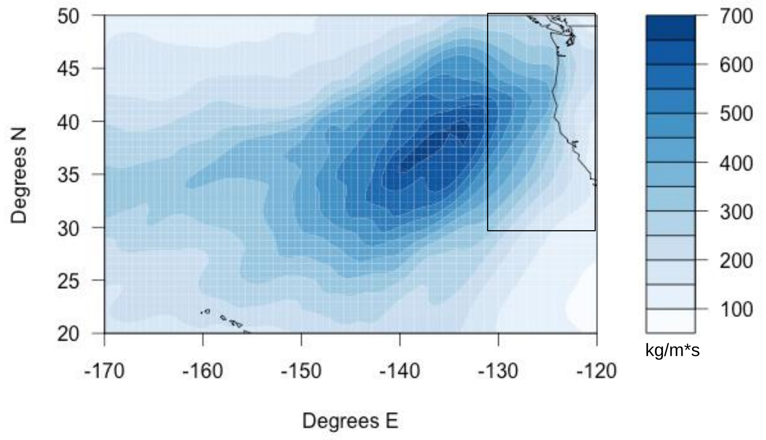
Above: Distribution of maximum IVT during AR events from which percentiles of events are calculated.



Above: Maximum IVT values for AR events by month.

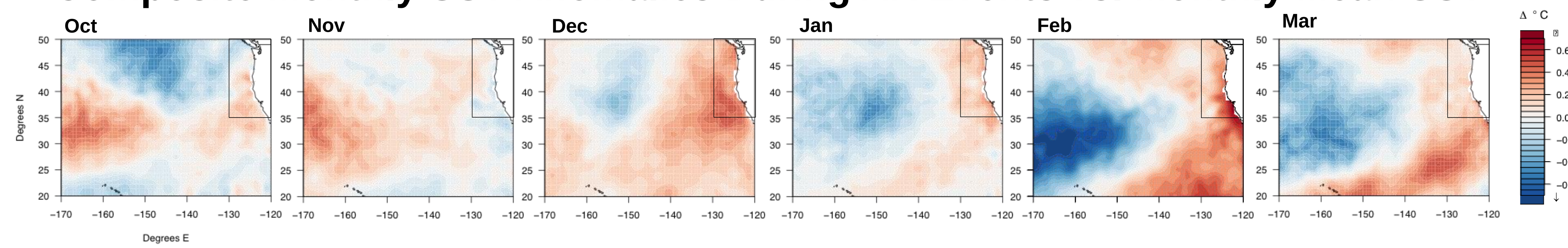
We use model output from ERA-Interim with a six-hourly time resolution. We use the global archive of detected ARs compiled by Brands et. al (2016). We limit our analysis to ARs that make landfall on the northwest coast of North America (35 to 50 degrees N). From the time stamps provided by the AR archive, we calculate IVT for these events by integrating moisture transport up to 300 hPa. AR plumes are isolated by masking out IVT values that fall below the 85th percentile of IVT for all AR events. From these contiguous plumes of IVT, we calculate the maximum IVT value over a box domain for the entire AR event by considering adjacent AR days.

Upon calculating the maximum contiguous IVT value for each AR event, we use the distribution of these values for our percentiles of "high IVT".

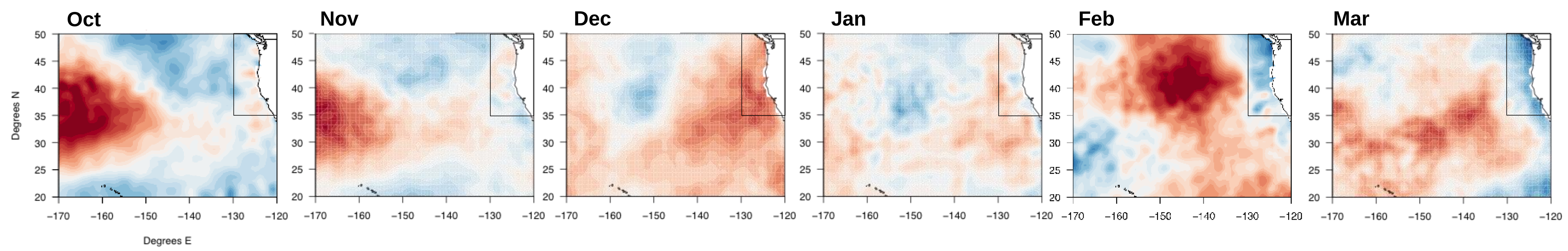


Left: Composite mean IVT during p75 max IVT AR events over the box domain.

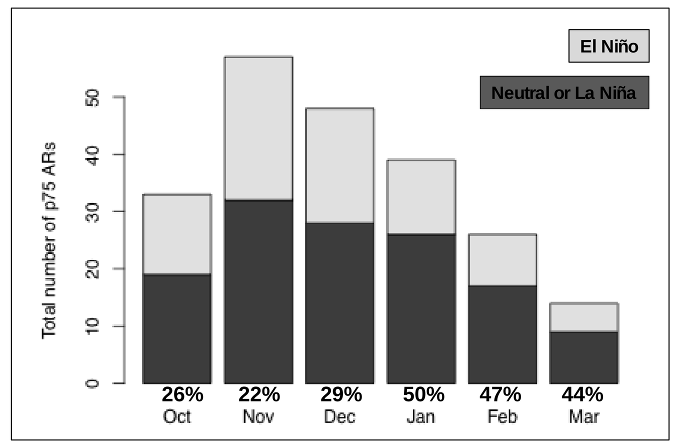
Composite Monthly SST Anomalies During AR Events vs. Monthly Mean SST



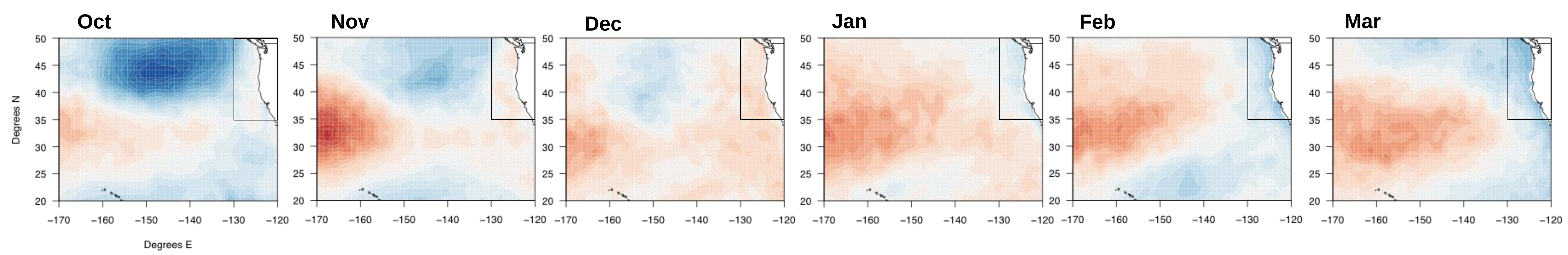
Above: Composite anomaly for SSTs during p75 AR events over the box domain. Anomaly baselined in each ***month's*** mean SST 1979 to 2014.

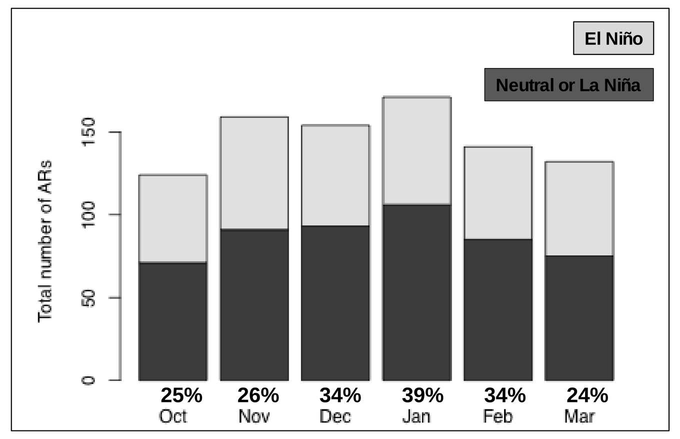


Above: Composite anomaly for SSTs during p75 AR events over the box domain (same as Row 1), but with events during El Niño excluded. Anomaly baselined in each ***month's*** mean SST 1979 to 2014.



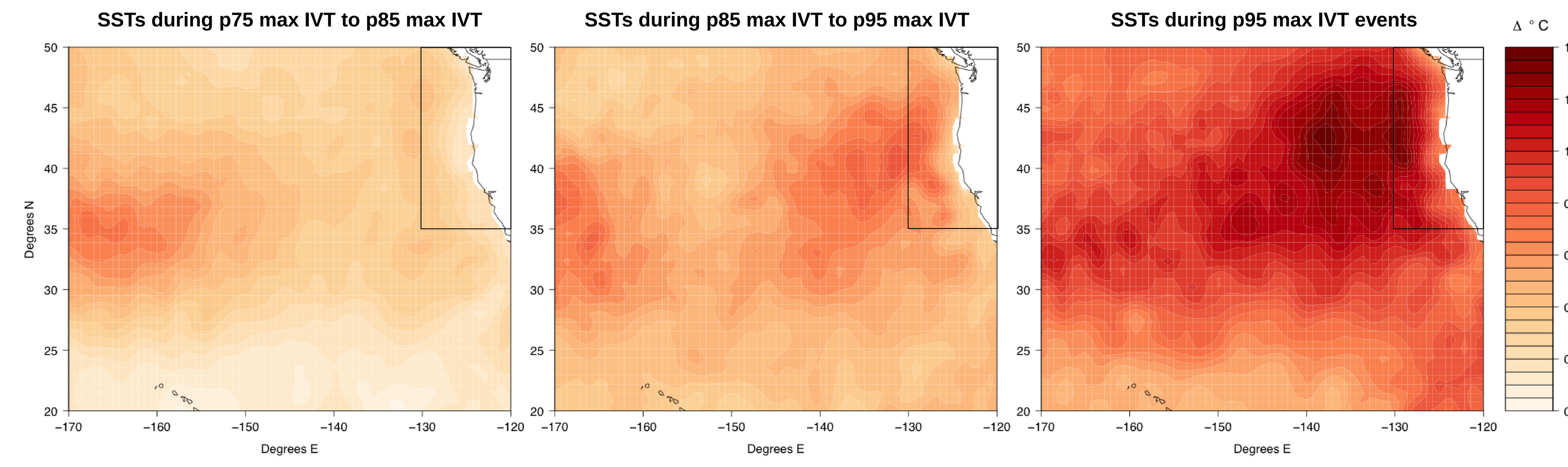
Above and Below: Total number of AR events per month, events during El Niño months in light gray.





Above: Composite anomaly for SSTs during all contiguous AR events over the box domain, events during El Niño excluded. Anomaly baselined in each ***month's*** mean SST 1979 to 2014.

SST During High Max IVT ARs vs. Other ARs



Above: Composite anomaly for SSTs during bracketed high IVT AR events over the box domain. Anomalies are baselined in SSTs during AR events that are below p75.

Summary

- **Patterns of warmer SSTs emerge during AR events with high maximum water vapor transport**
- **Seasonality emerges: remote warm SST patterns for early in cool season, local warm patterns for late in cool season**
- **Patterns of remote SST warming in early in the cool season are coherent even when including El Niño; patterns of warm SSTs in late cool season are distinct from El Niño SSTs**
- **AR SST warm anomalies have corresponding sensitivity to higher percentiles of high IVT ARs**

Future Work

- **Analyze links between North Pacific air temperature and IVT**
- **Evaluate influences of SSTs and air temperatures during varying positions and strengths of the storm track**
- **Include precipitation data in analysis of AR characteristics**
- **Use WRF to capture vertical fine-scale features**

References: Brands, S., Gutiérrez, J.M. & San-Martín, D. Clim Dyn (2016)

Acknowledgements: Funding for this research was provided by the National Science Foundation Graduate Research Fellowship under Grant No. DGE-114747 and the Stanford VPGE EDGE Fellowship. We would like to thank Stanford University and the Stanford Research Computing Center for providing computational resources and support that have contributed to these research.