Influence of Long-Term Trends in Tropical Pacific SSTs on Atmospheric River Statistics in Western North America

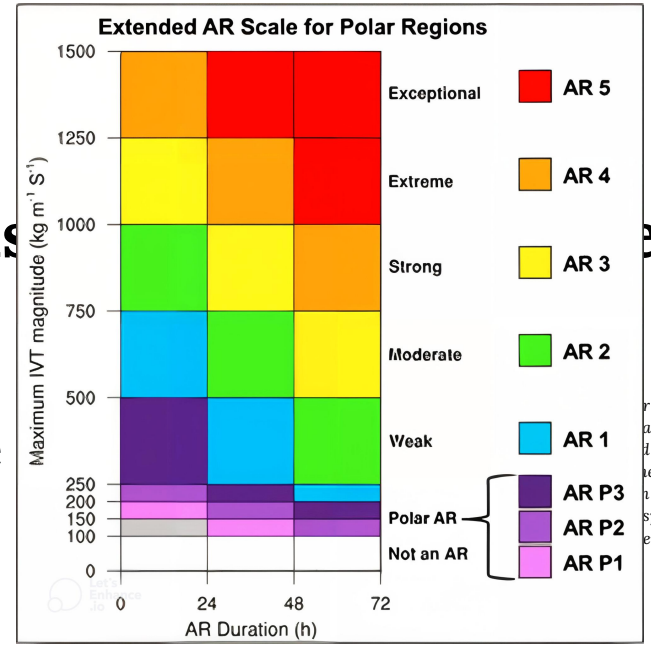
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December 6, 2024

What is ...er (AR)?

"River in the ...



...r of strong horizontal water vapor transport that is typically ...ahead of the cold front of an extratropical cyclone. The water ...d by tropical and/or extratropical moisture sources. ...eavy precipitation where they are forced upward—for example, ...n conveyor belt. Horizontal water vapor transport in the ...spheric rivers and is focused in the lower troposphere. ...ers" of fresh water on Earth, transporting on average more than

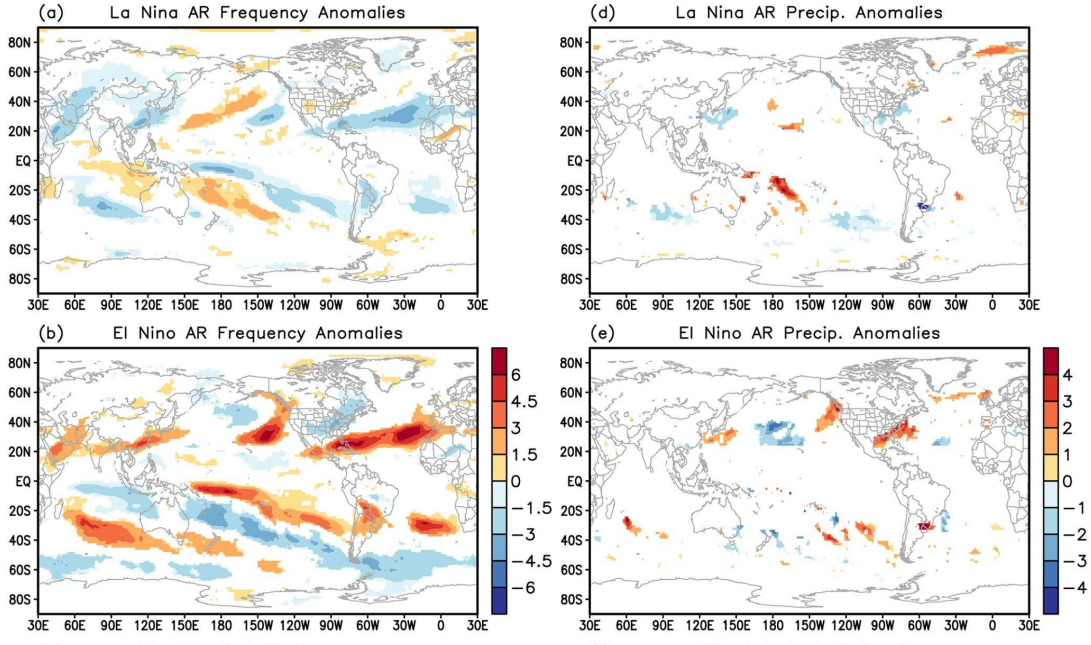
Parameter uncertainty

Algorithm uncertainty

Links of ENSO to AR Frequency and Precipitation:

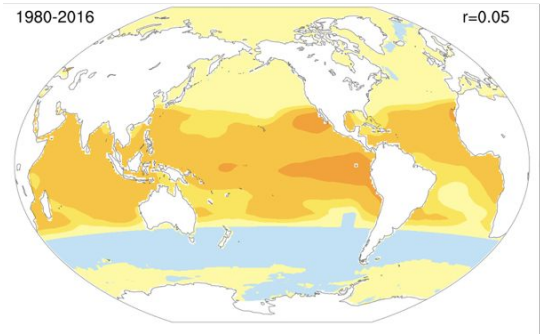
- Guan & Waliser (2015) suggest more ARs during El Niño conditions in the north Pacific.

ENSO Modulation of NDJFM AR Frequency and Precipitation

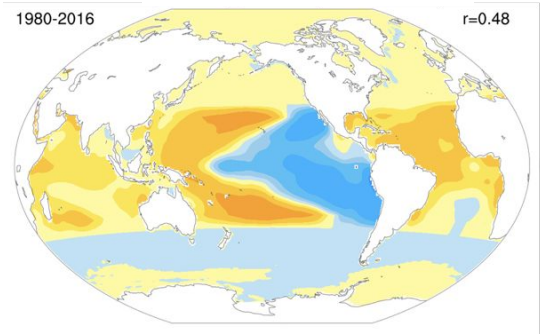


Guan & Waliser (2015)

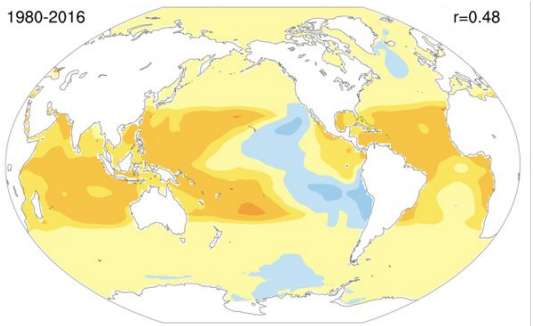
Three CAM6 Tropical Ocean Global Atmosphere (TOGA) simulations of unique long-term ENSO trends, each with 10-member ensembles.



El Niño-like Trend

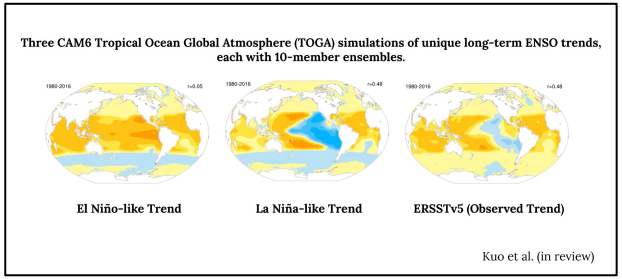


La Niña-like Trend



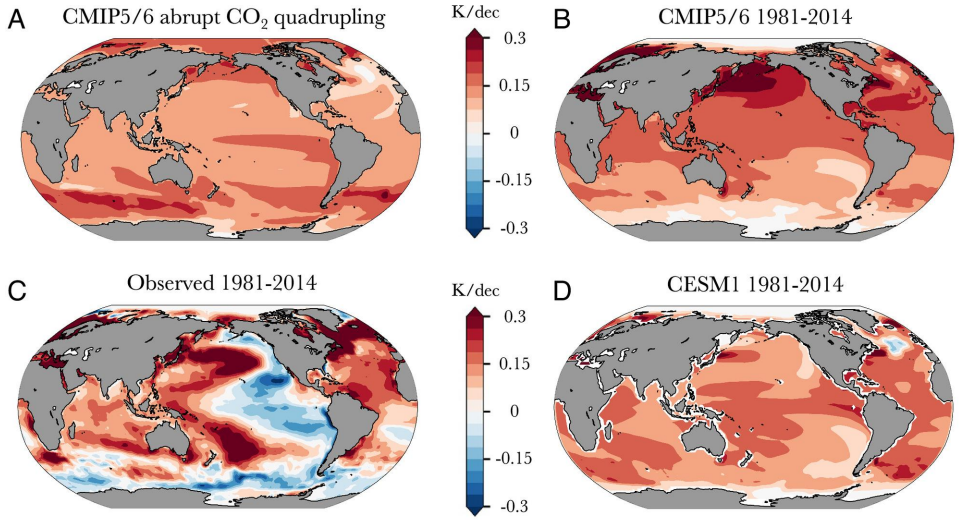
ERSSTv5 (Observed Trend)

Kuo et al. (in review)



Pattern effect

Climate models fail to reproduce observed spatial pattern of sea surface temperature (SST) changes across the Pacific Ocean, particularly since the 1970s.



Armour et al. (2024)

What are the implications of these trends on atmospheric rivers (ARs)?

Objective:

Identify responses to atmospheric river statistics (frequency and intensity) to different SST trend patterns.

What will atmospheric river patterns look like under future climates?

Parameters for AR detection

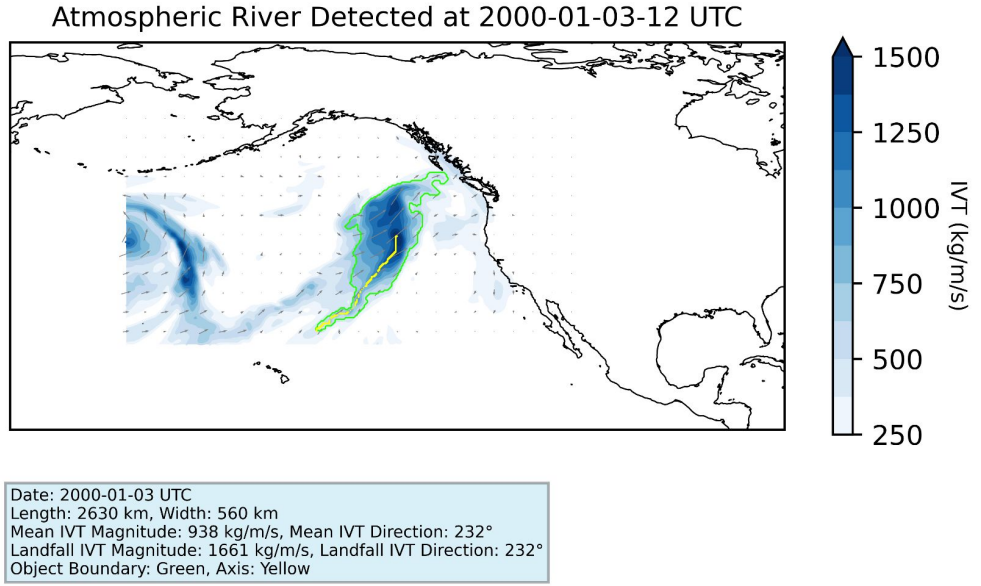
Geometric Criteria

1. **Length check**: Object exceeds 1000 km
2. **Narrowness check**: Object is not wider than it is long
3. **Mean meridional IVT check**: Mean IVT transport is poleward

Integrated Vapor Transport (IVT) Criteria:

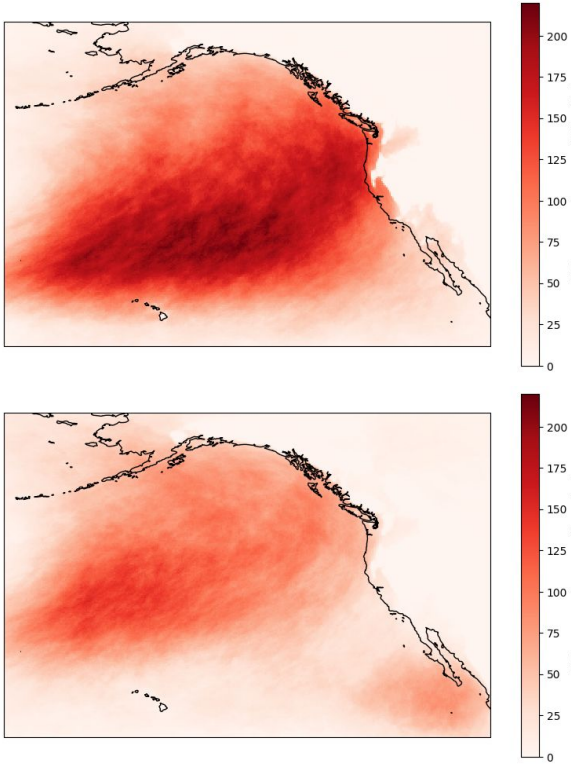
- **Relative threshold**: 85th percentile specific to each season and grid cell
- **Absolute threshold**: IVT ≥ 100 kg m^{-1} s^{-1}

Based on Guan & Waliser (2015)



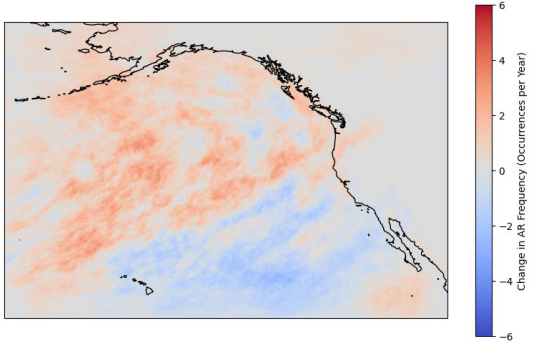
Kennett (2021) algorithm outputs: AR snapshot (above), AR masks, spreadsheet data, etc.

1978-2014

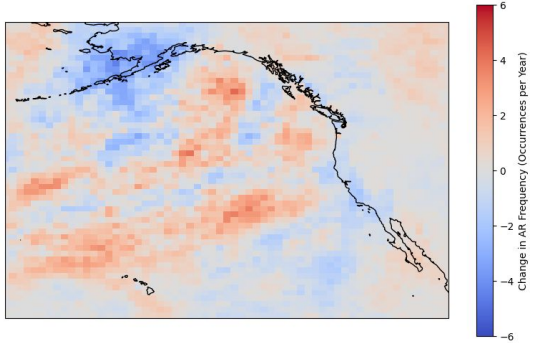


AR Seasonal Occurrence Pattern

Winter months (Top);
Summer months (Bottom)



ERA5

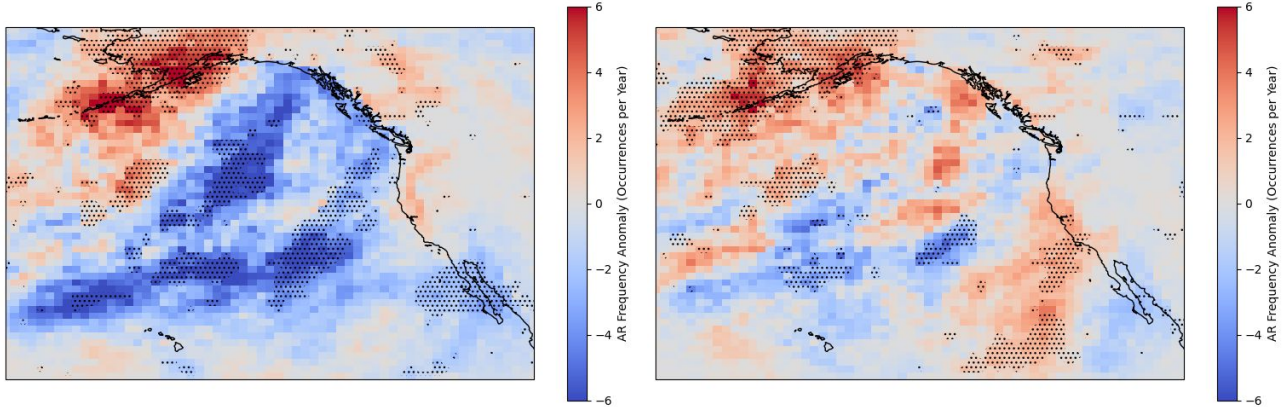


ERSSTv5 Historical Trend

AR Frequency Trend Pattern

Difference in AR frequency: 1981-1996 vs. 1999-2014

AR Frequency Trend Anomaly Pattern



La Niña and Historical SST Trend Difference

El Niño and Historical SST Trend Difference

α=0.10

Significant modulations in both a La Niña-like trend and El Niño-like trend.

Conclusion and Future Steps

1. We find a decrease in AR frequency over the central Pacific in a La Niña-like trend and an increase in AR frequency off the California coast in an El Niño-like trend.
2. We also find an increase in AR frequency over time in both a La Niña-like and El Niño-like trend near Alaska, which warrants further research.

Different AR Detection Algorithm(s):

- Toolkit for Extreme Climate Analysis Bayesian AR Detector (TECA-BARD) for model validation to evaluate algorithm and parameter uncertainties.

Attribution at Regional Scales:

- Determine precipitation trends from AR events for CAM6 simulations at regional scales.

Questions