Recent Temperature Trends & Tracks of US West Coast Atmospheric Rivers

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International Atmospheric Rivers Conference

28 June 2018

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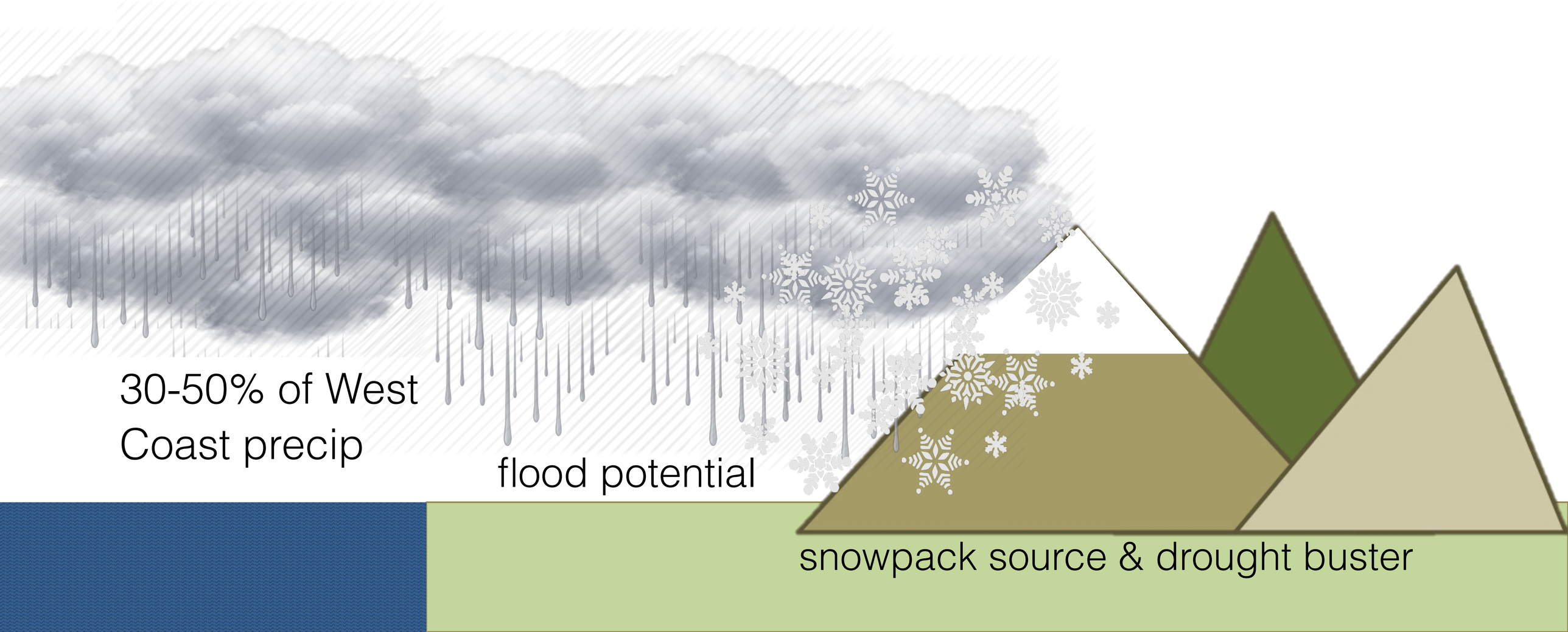
4. Woods Institute for the Environment

Atmospheric River (AR) precipitation is important to the West.

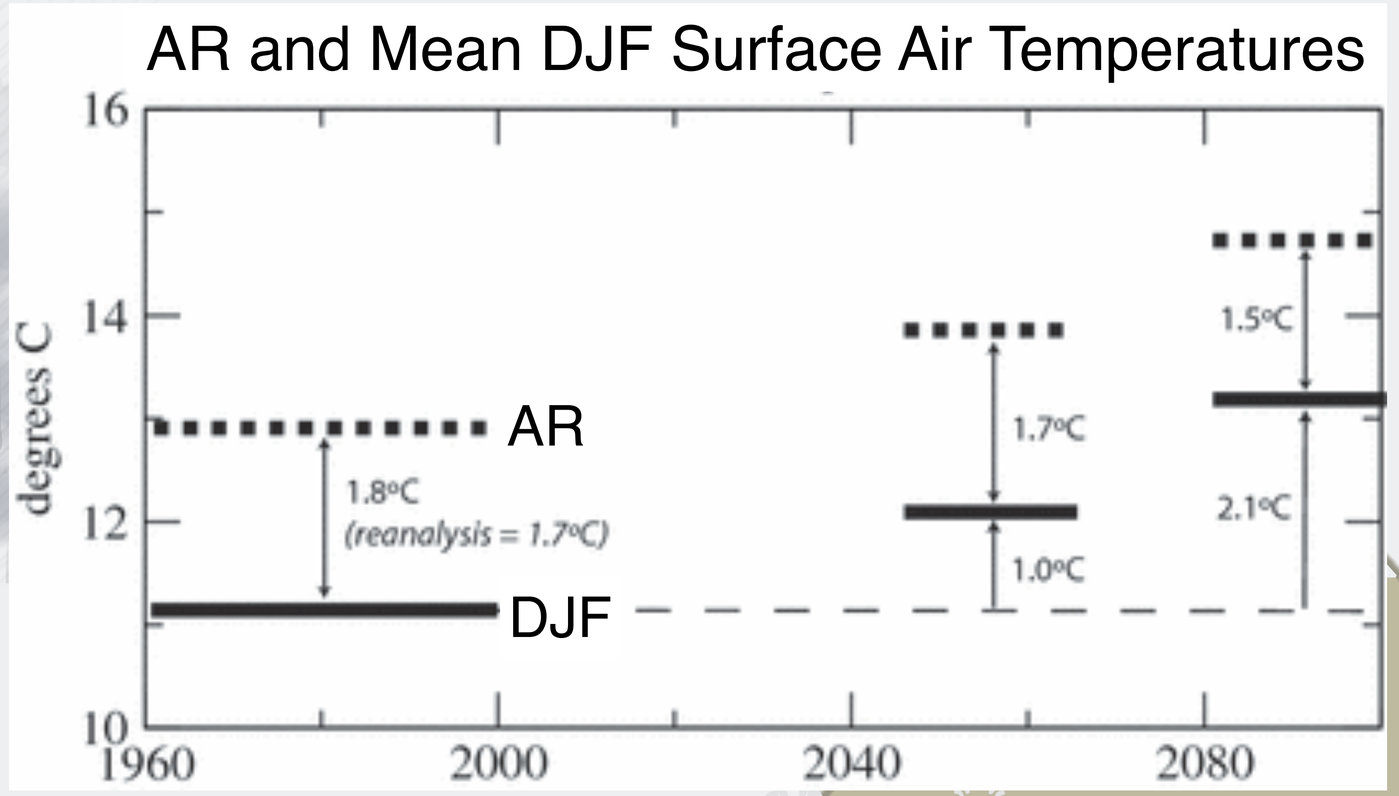


30-50% of West Coast precip

flood potential

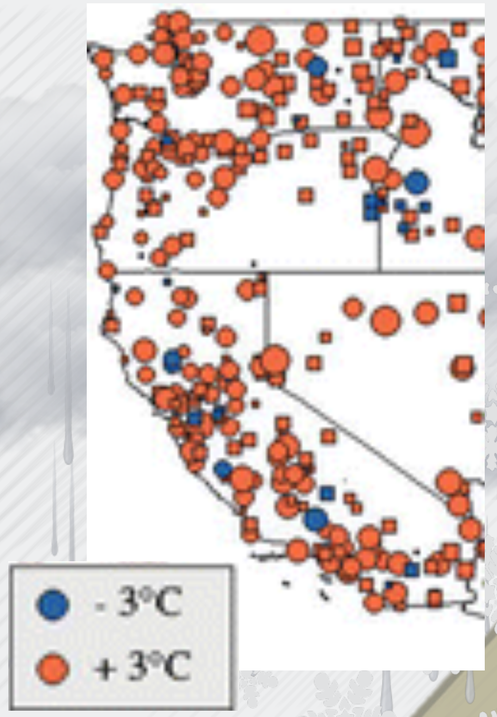
snowpack source & drought buster

ARs are projected to warm[1].



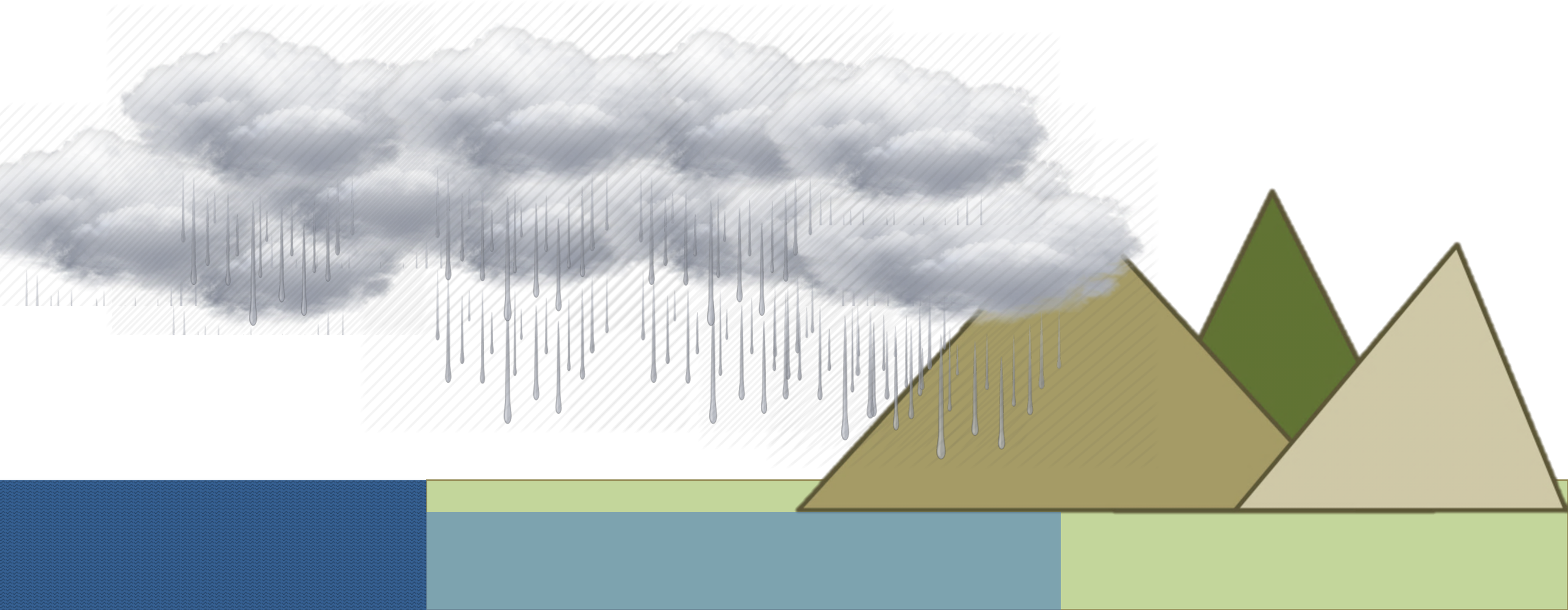
1: Dettinger 2011, JAWR

ARs are projected to warm[1].
Western precipitation is already warming[2].

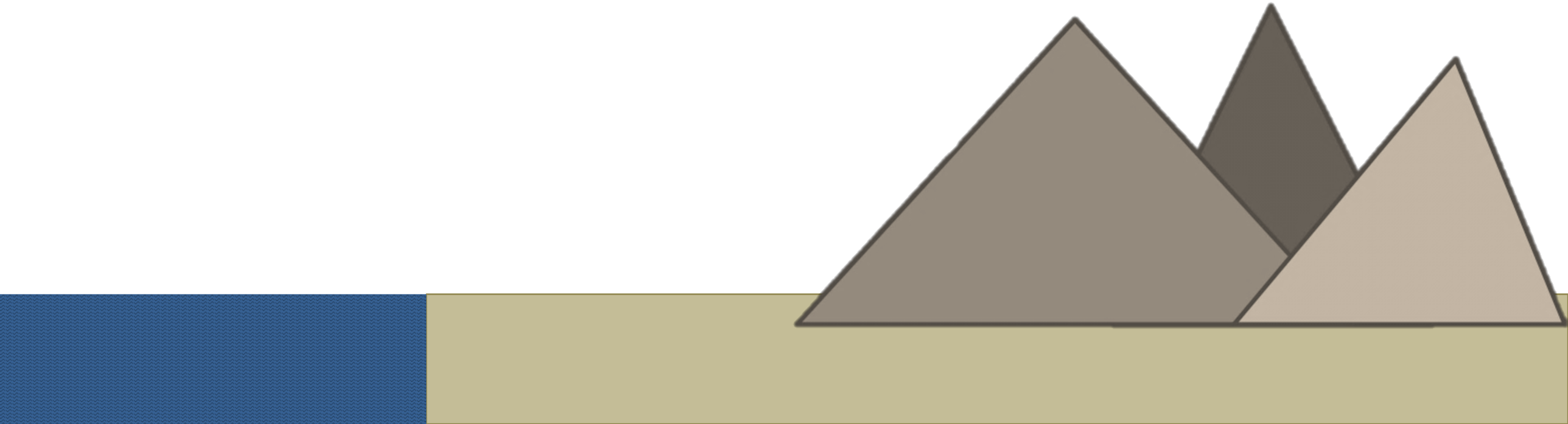


1: Dettinger 2011, JAWR
2: Knowles et al., 2006, JCLI

Warming ARs —>
Winter Floods…



…Summer Drought

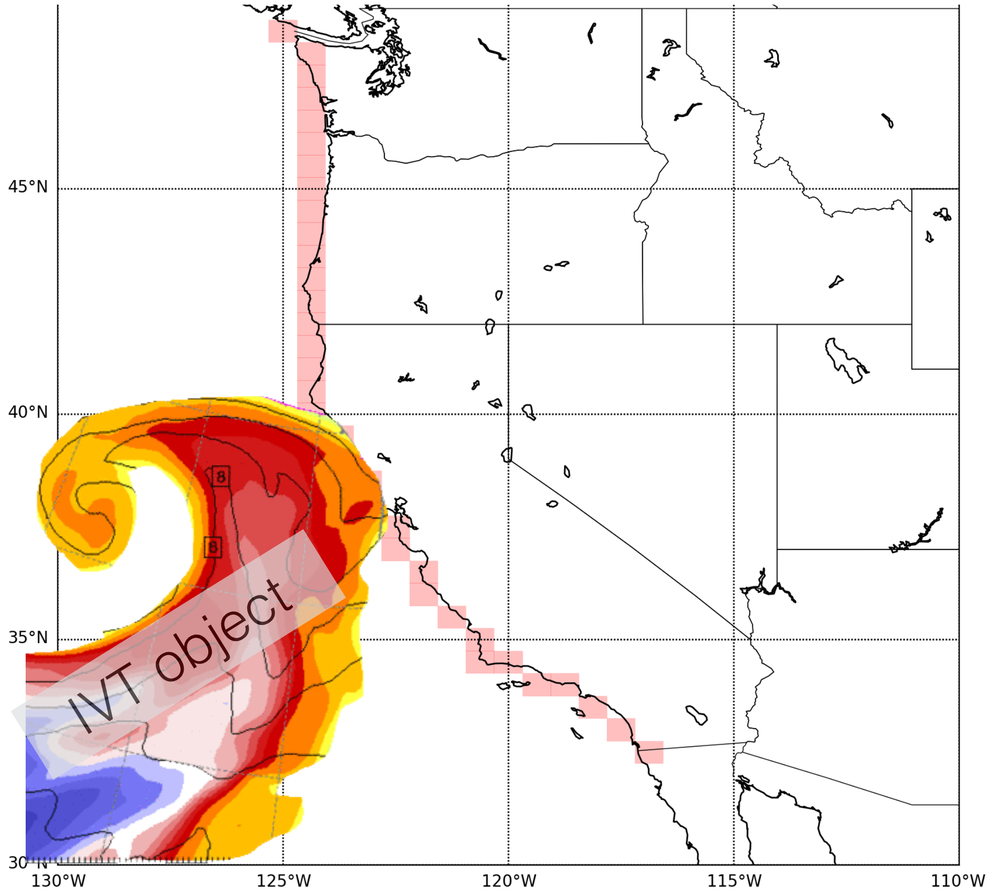


Are there observed trends in AR temperature?

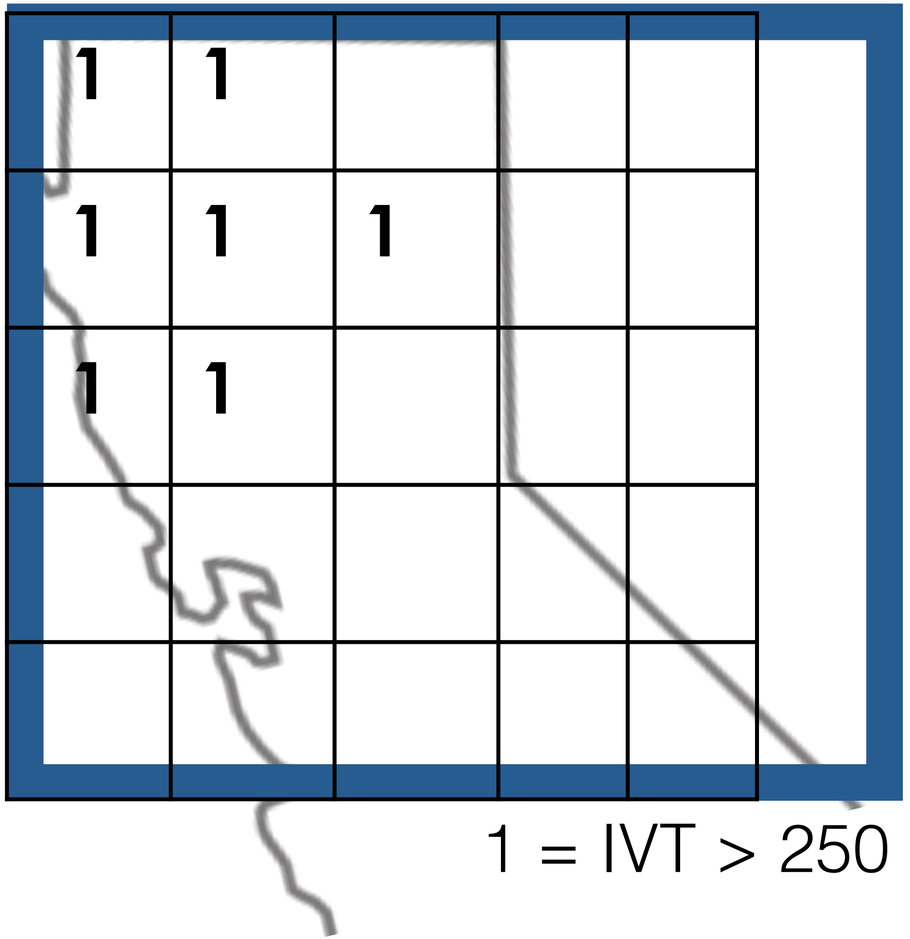
If so, do they follow the background trend?

Data & Methods

- Use external AR catalog for AR landfall timestamps
- Compiled by Kyle Nardi after Mundhenk et al., 2016 algorithm
- Detection based on vapor transport (IVT) anomalies
- AR @ landfall = crossing coastal grid box

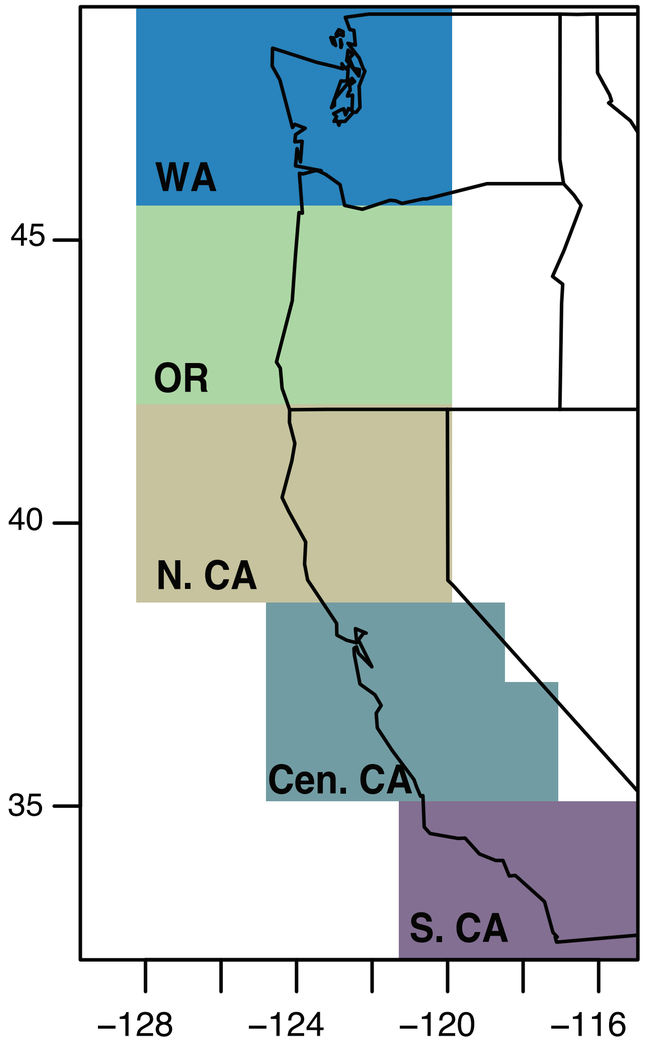


Data & Methods

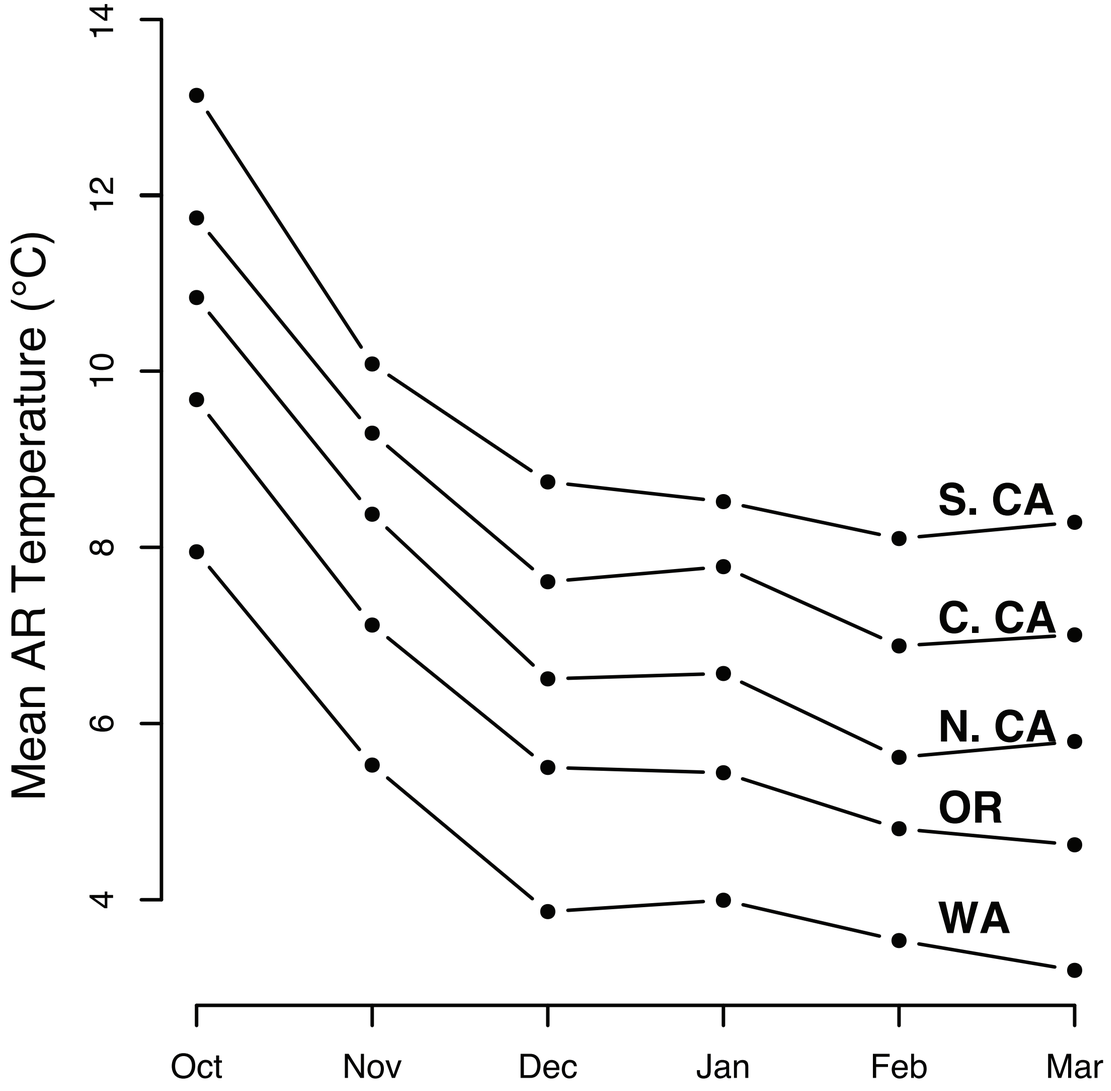


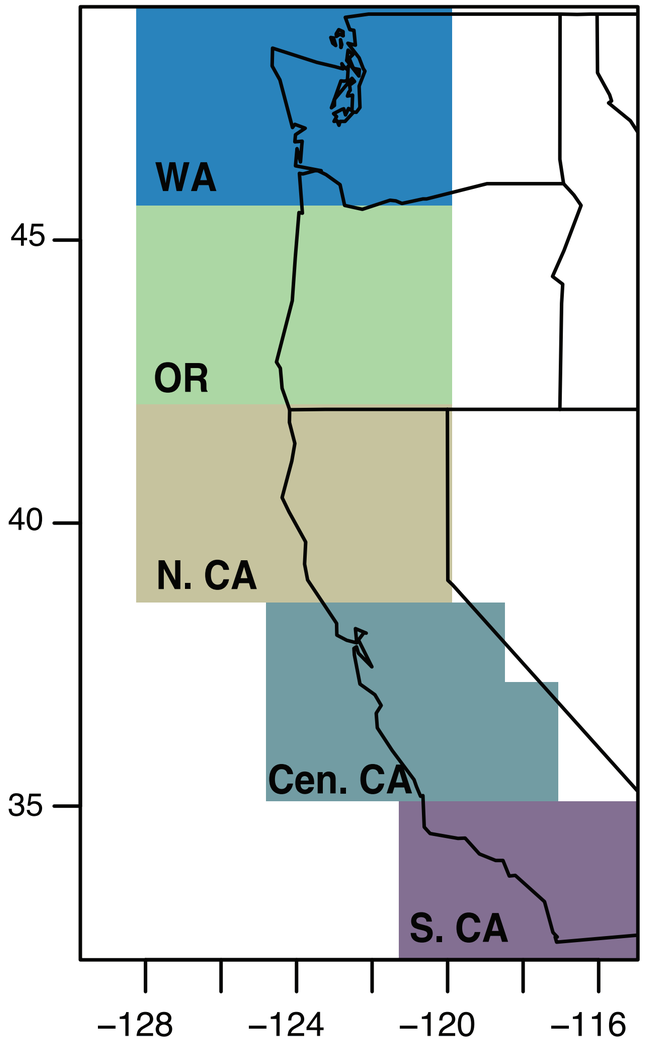
Capture AR event temperature:

- Average over lower atmosphere: 1000 – 750 hPa
- Average only over gridboxes where AR is present. AR presence threshold: 250 kg/m*s IVT, after Rutz et. al (2014)
- Representative AR time slice = time slice with peak IVT across AR event

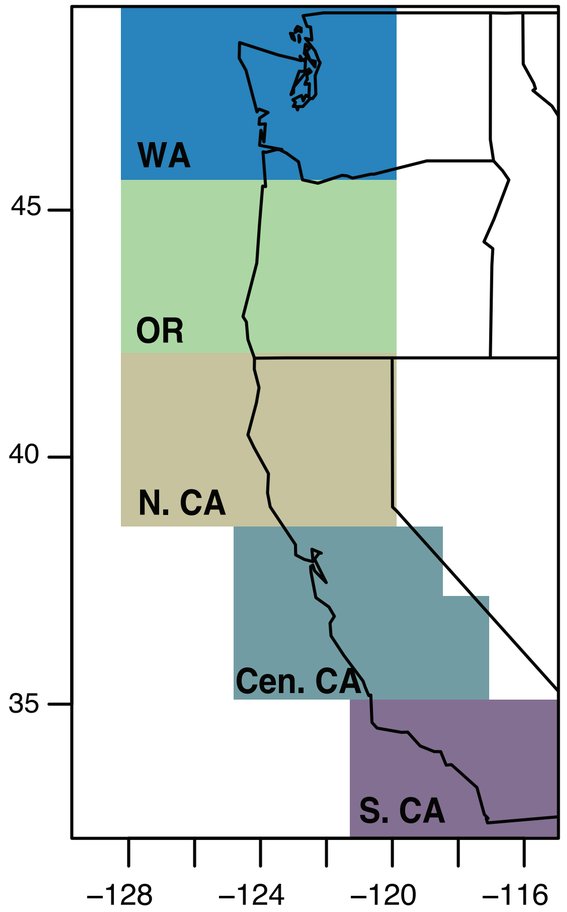

WA
OR
N. CA
Cen. CA
S. CA
45
40
35
−128
−124
−120
−116

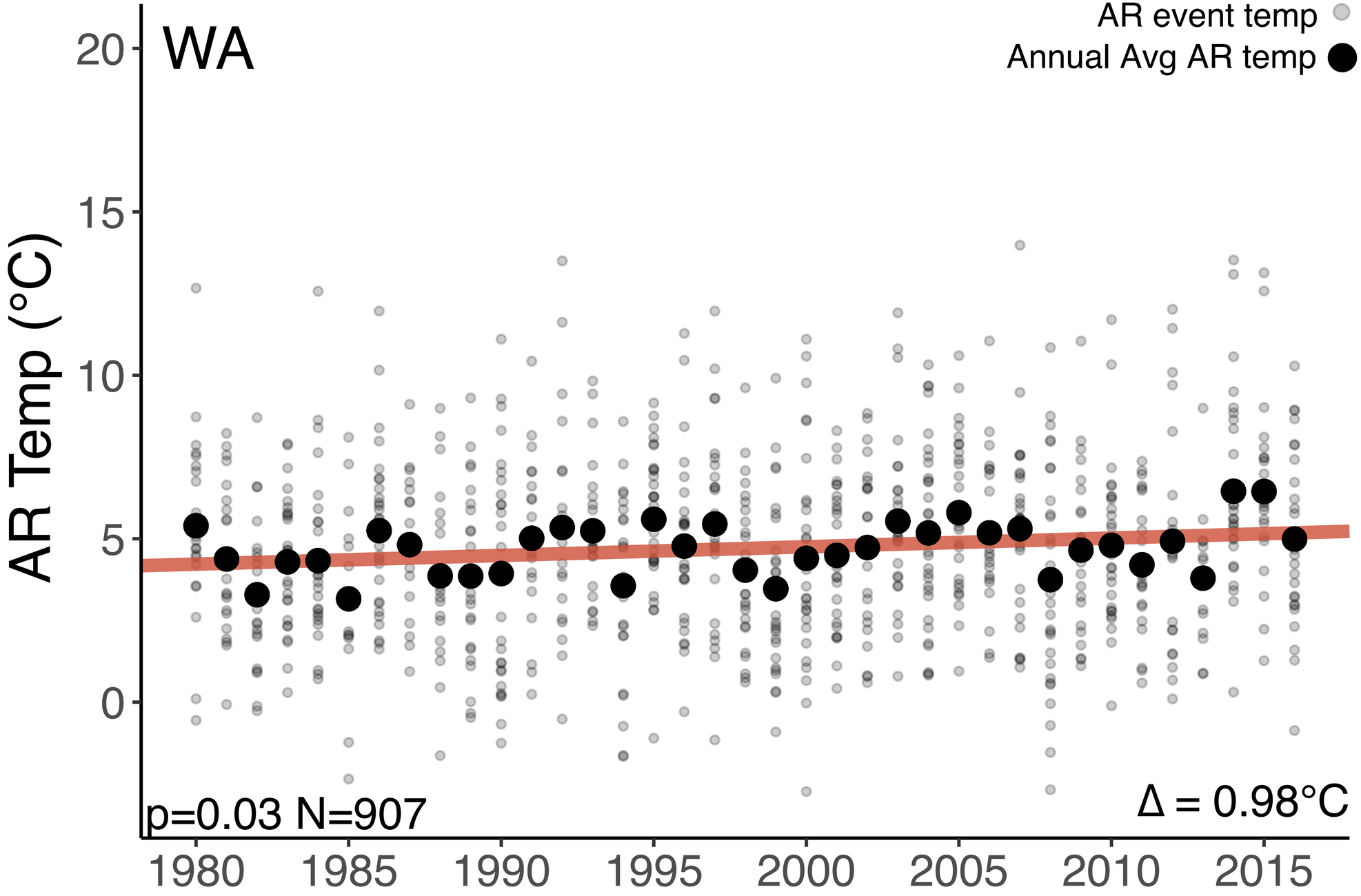
West Coast AR Temperature Climatology

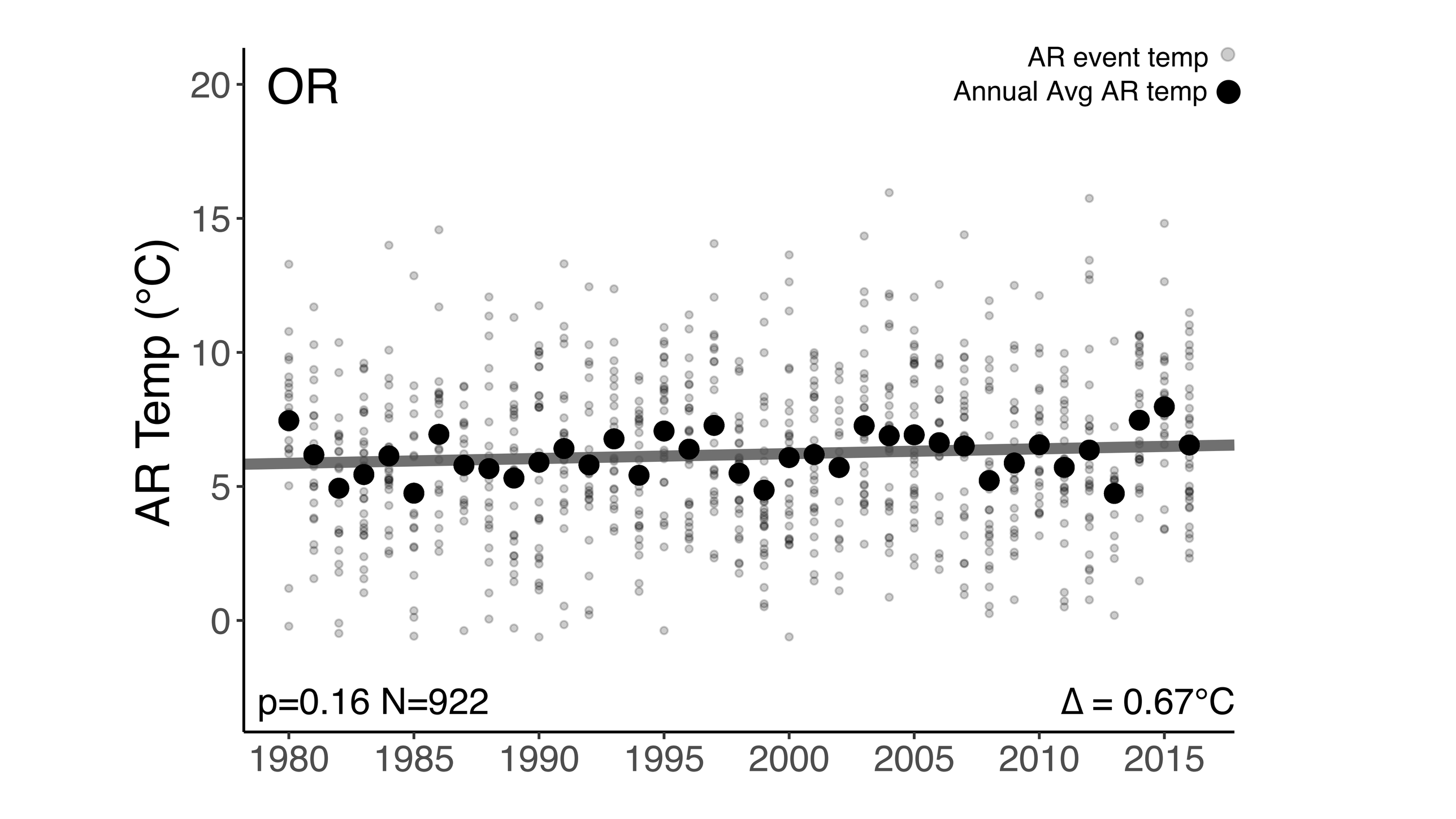


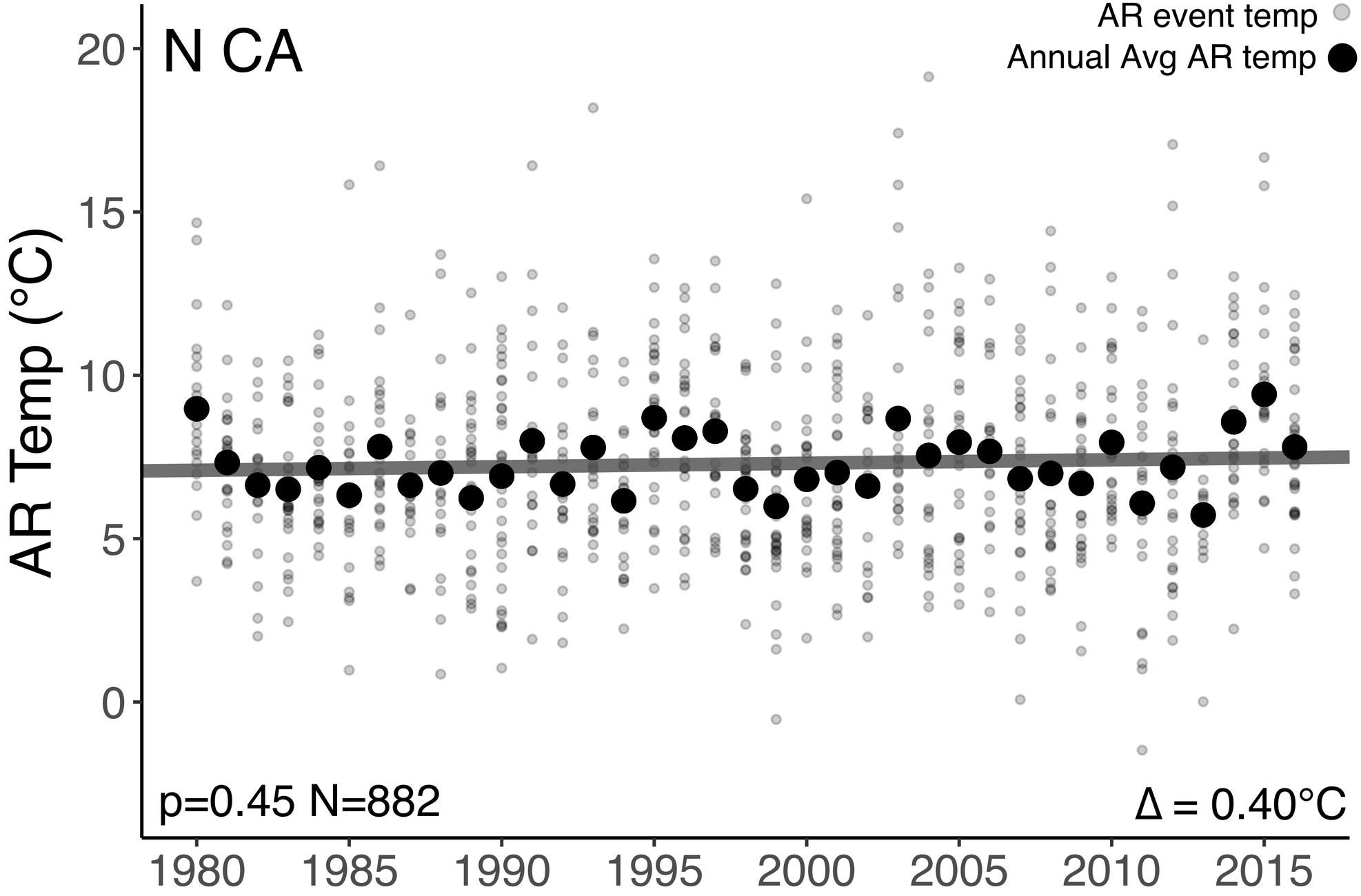


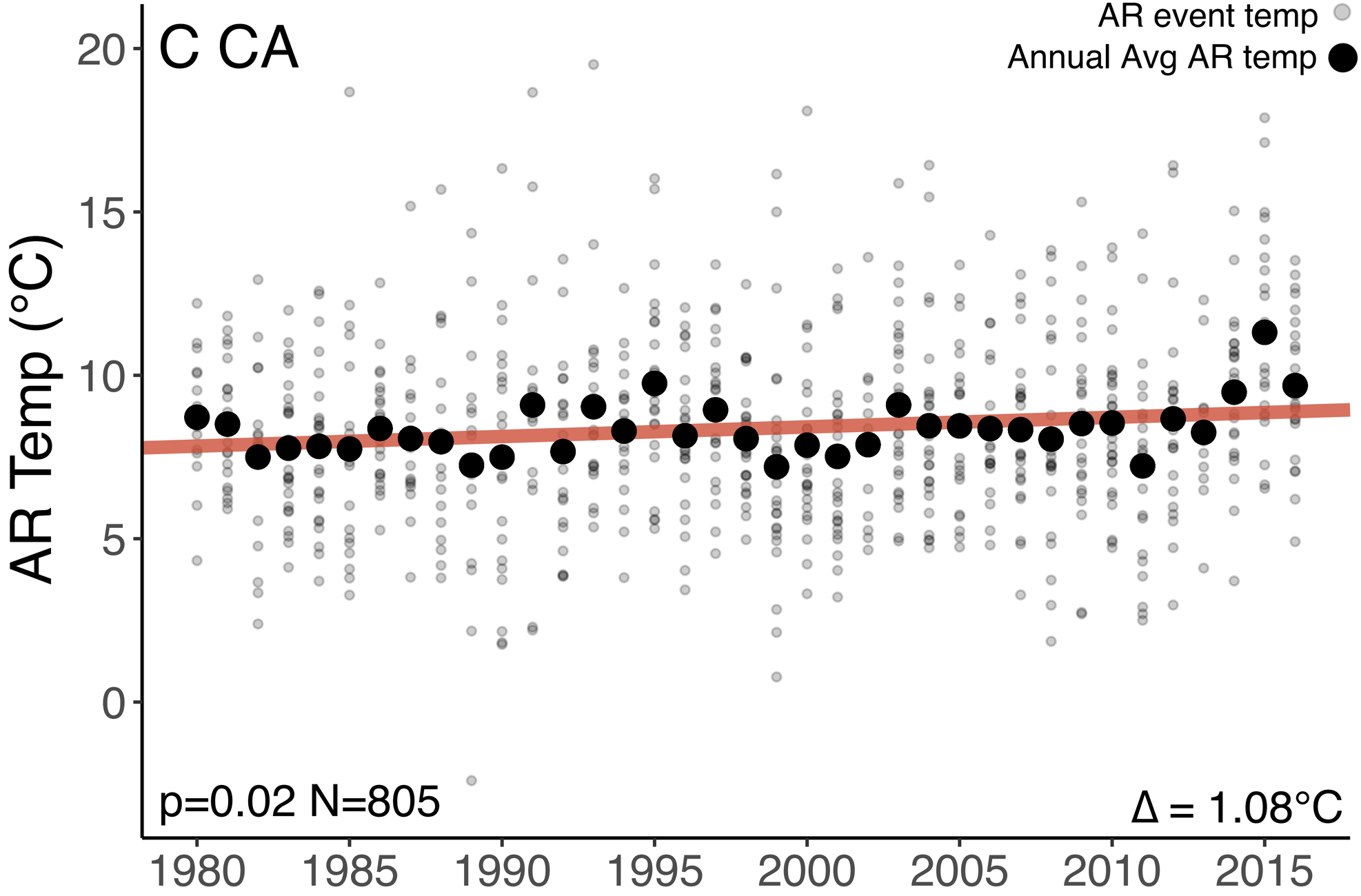
Overall Temperature Trends by Region

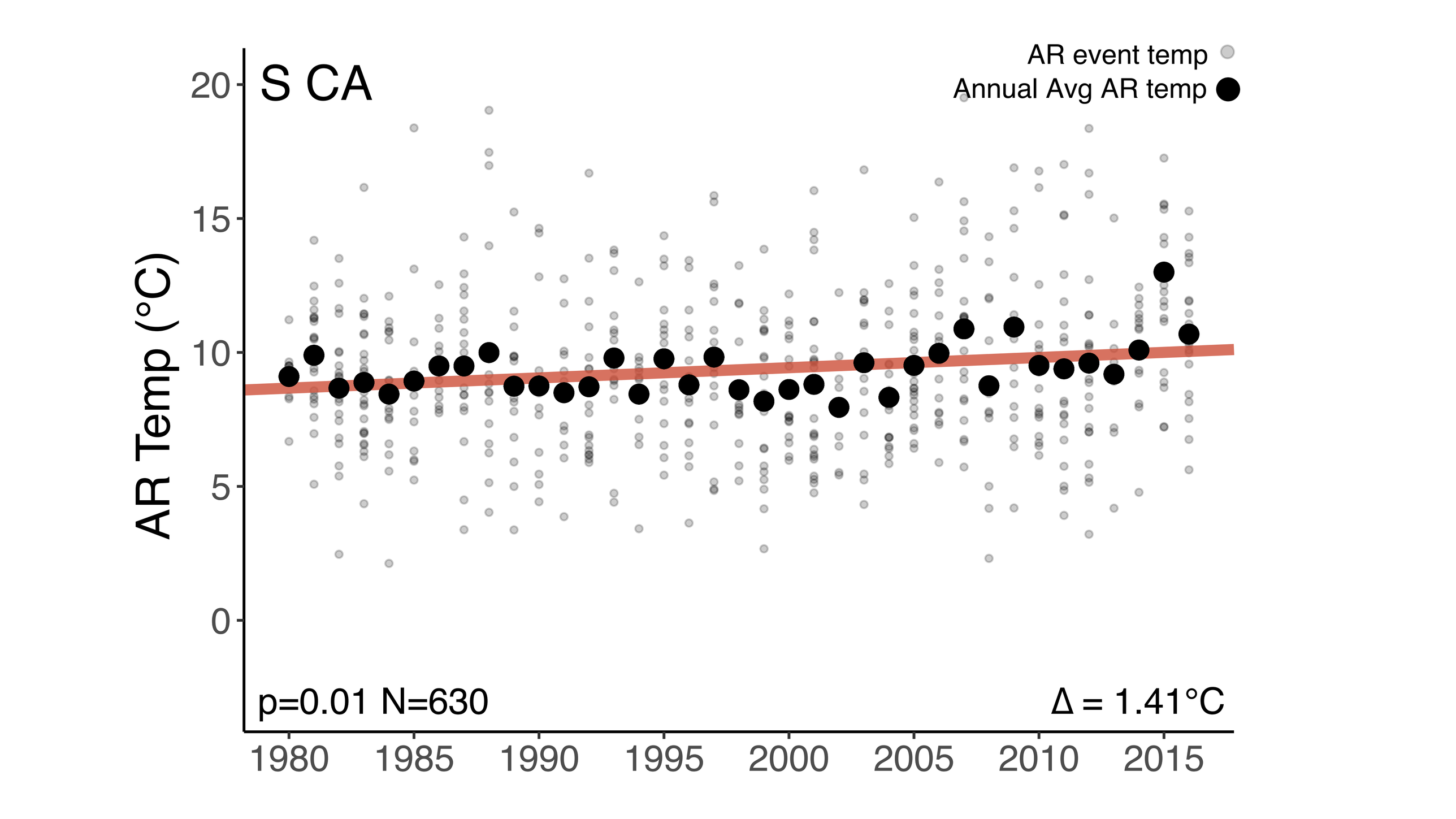



WA
AR event temp
Annual Avg AR temp
AR Temp (°C)
20
15
10
5
0
1980
1985
1990
1995
2000
2005
2010
2015
p=0.03 N=907
Δ = 0.98°C


OR
AR event temp
Annual Avg AR temp
AR Temp (°C)
20
15
10
5
0
p=0.16 N=922
Δ = 0.67°C
1980
1985
1990
1995
2000
2005
2010
2015


N CA
AR event temp
Annual Avg AR temp
AR Temp (°C)
20
15
10
5
0
1980
1985
1990
1995
2000
2005
2010
2015
p=0.45 N=882
Δ = 0.40°C


C CA
AR event temp
Annual Avg AR temp
AR Temp (°C)
20
15
10
5
0
1980
1985
1990
1995
2000
2005
2010
2015
p=0.02 N=805
Δ = 1.08°C

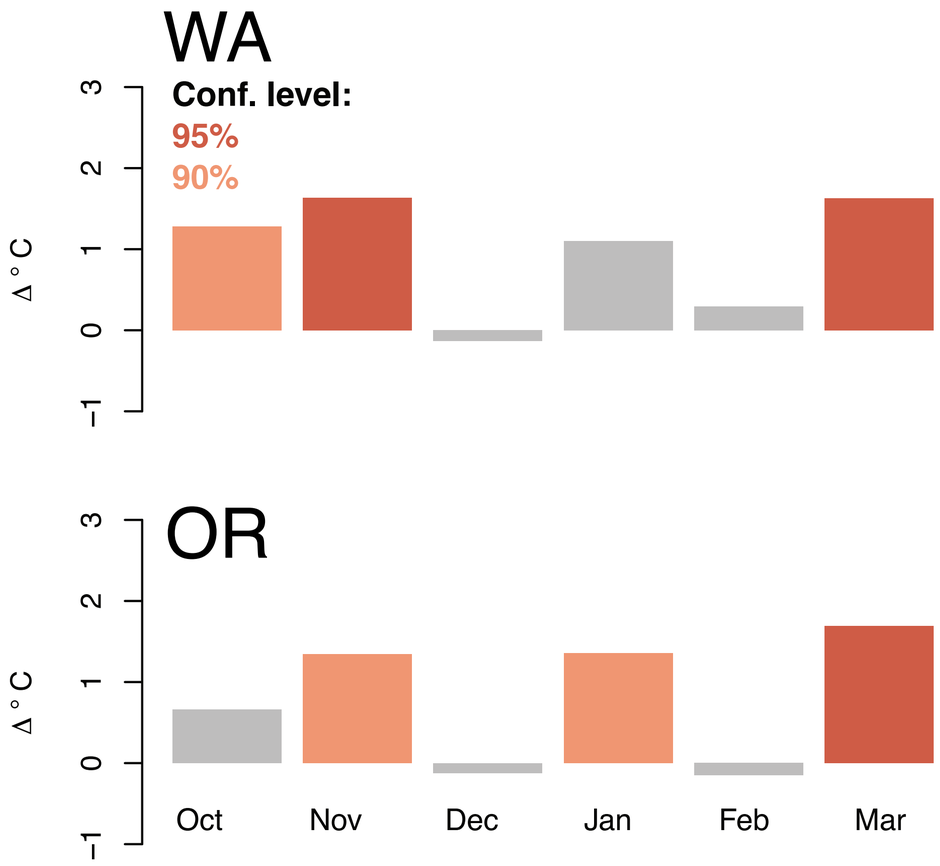

S CA
AR event temp
Annual Avg AR temp
AR Temp (°C)
20
15
10
5
0
1980
1985
1990
1995
2000
2005
2010
2015
p=0.01 N=630
Δ = 1.41°C

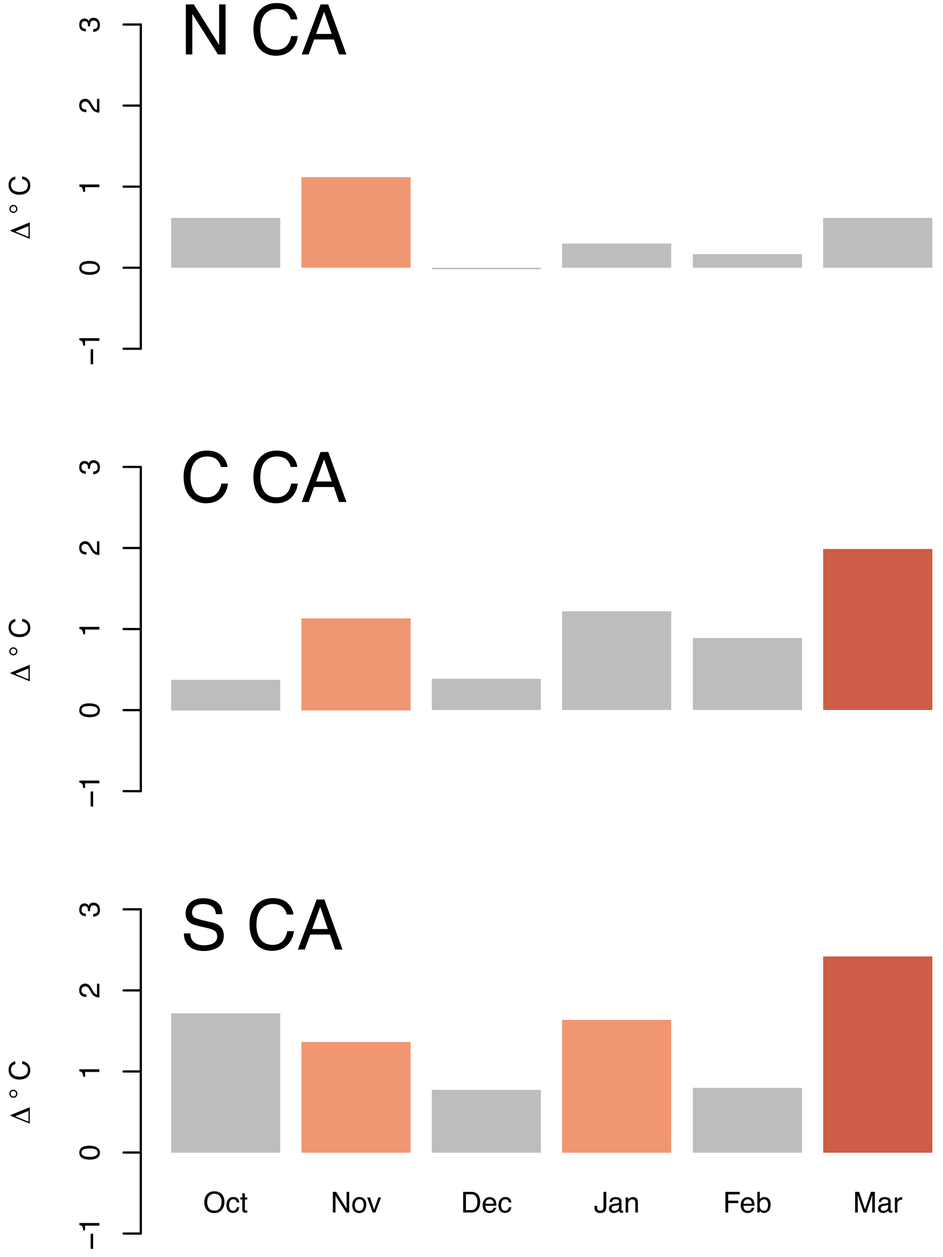
Monthly Temperature Trends by Region

Δ°C = change over 37 years

Monthly Temperature Trends by Region

Δ°C = change over 37 years

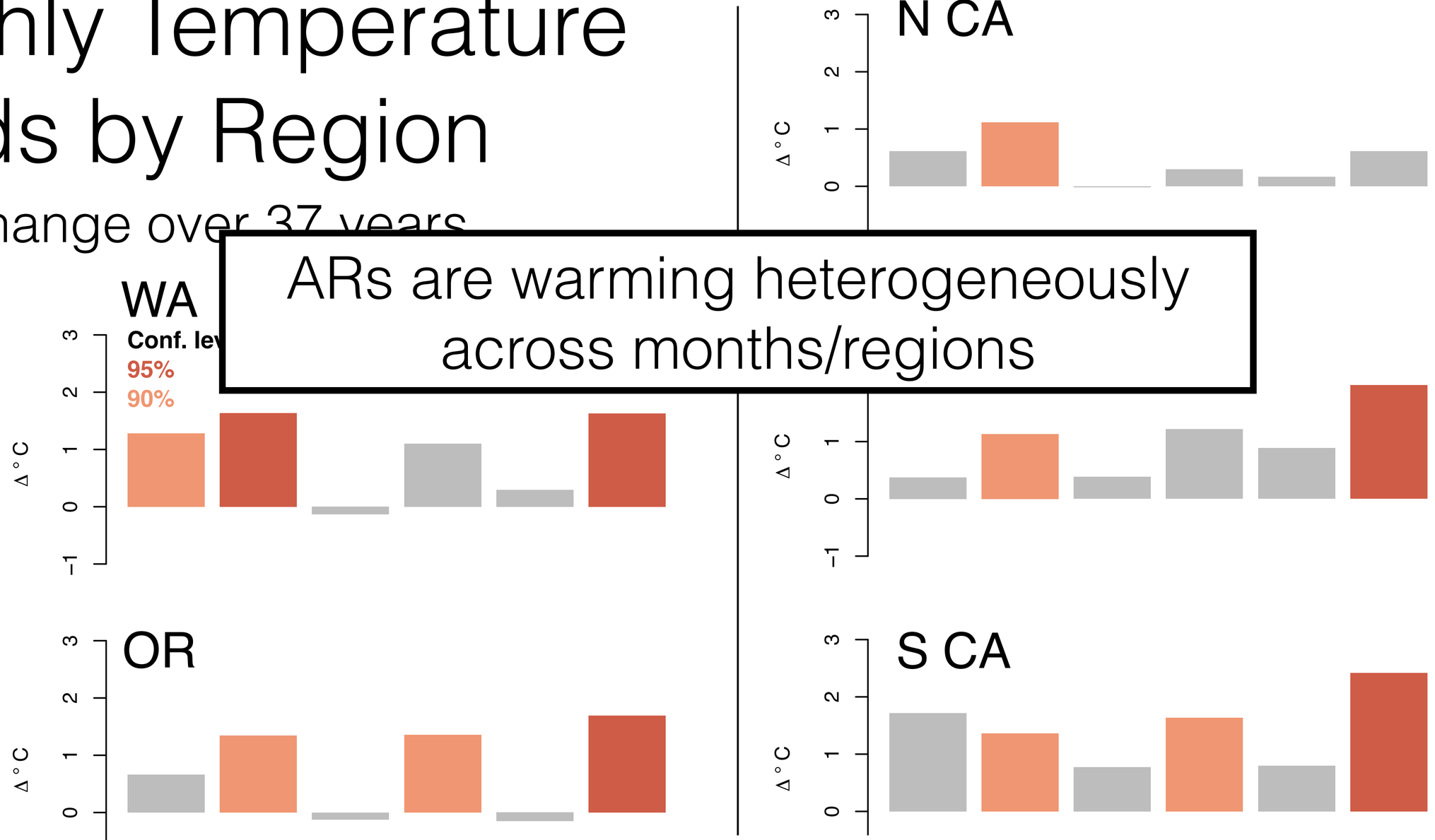




Monthly Temperature Trends by Region

Δ°C = change over 37 years

ARs are warming heterogeneously across months/regions



Note: no significant trends in freq by month

Are Background Destination or Along-Track trends similar to AR Destination trends?

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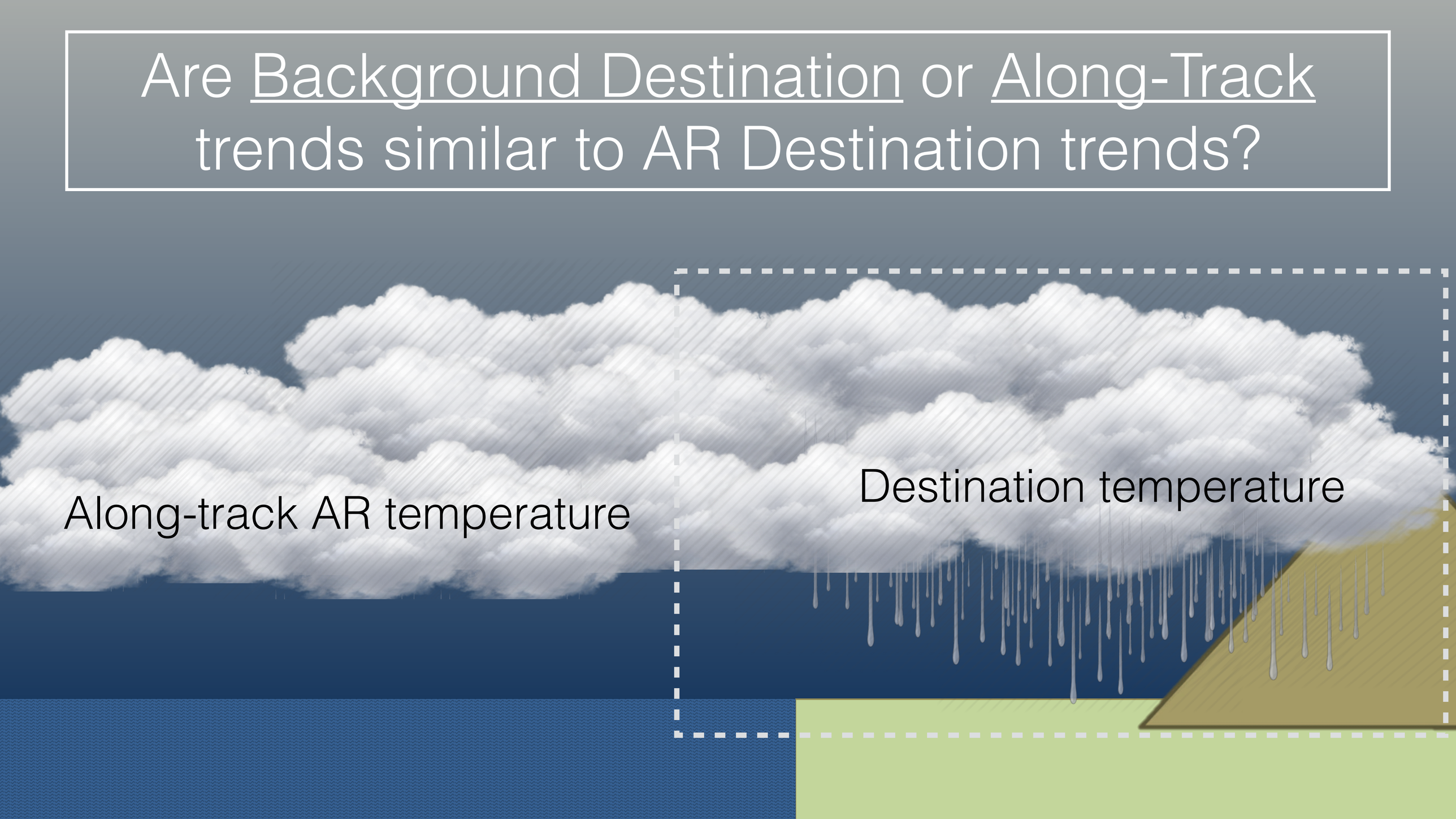
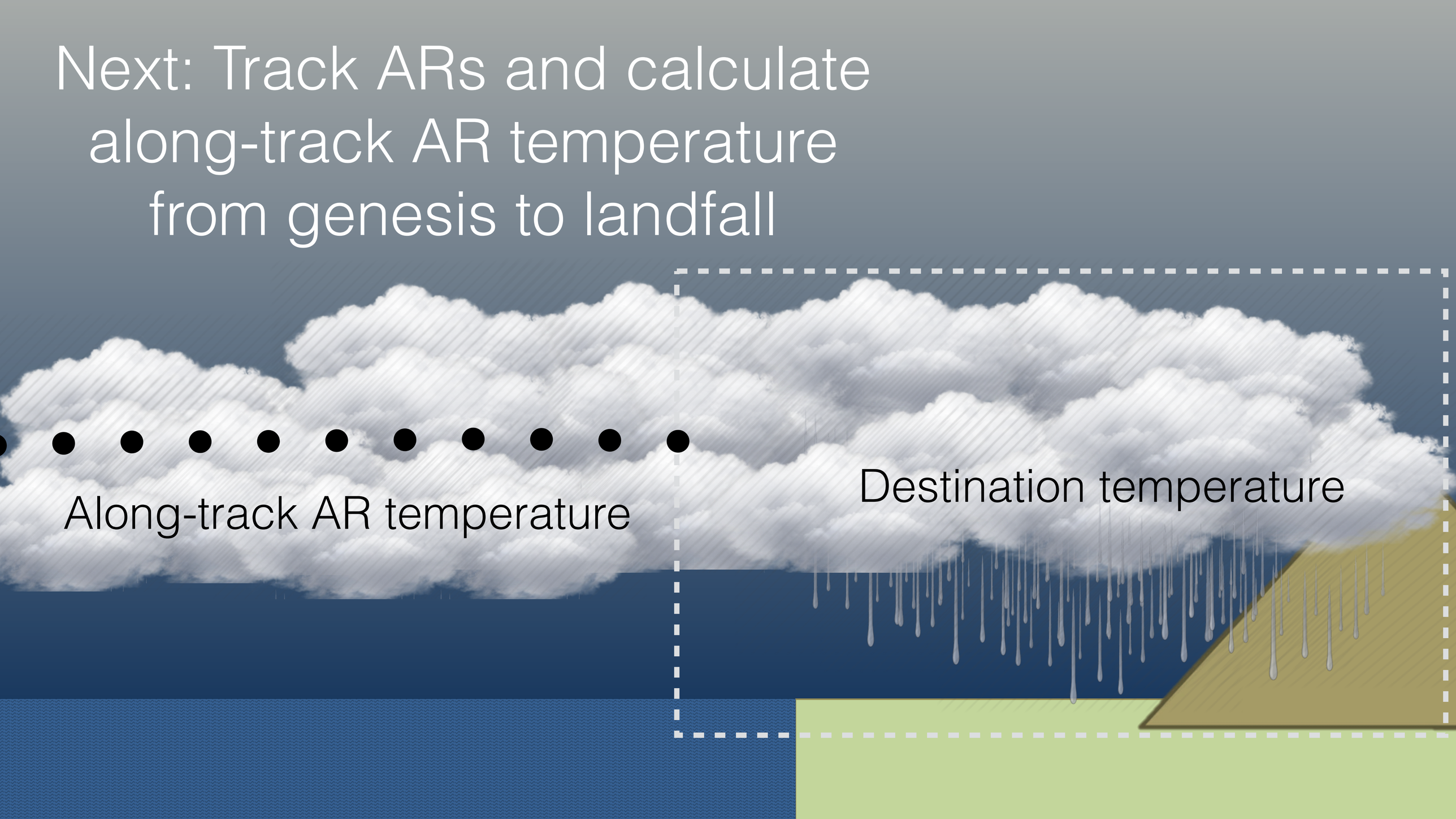
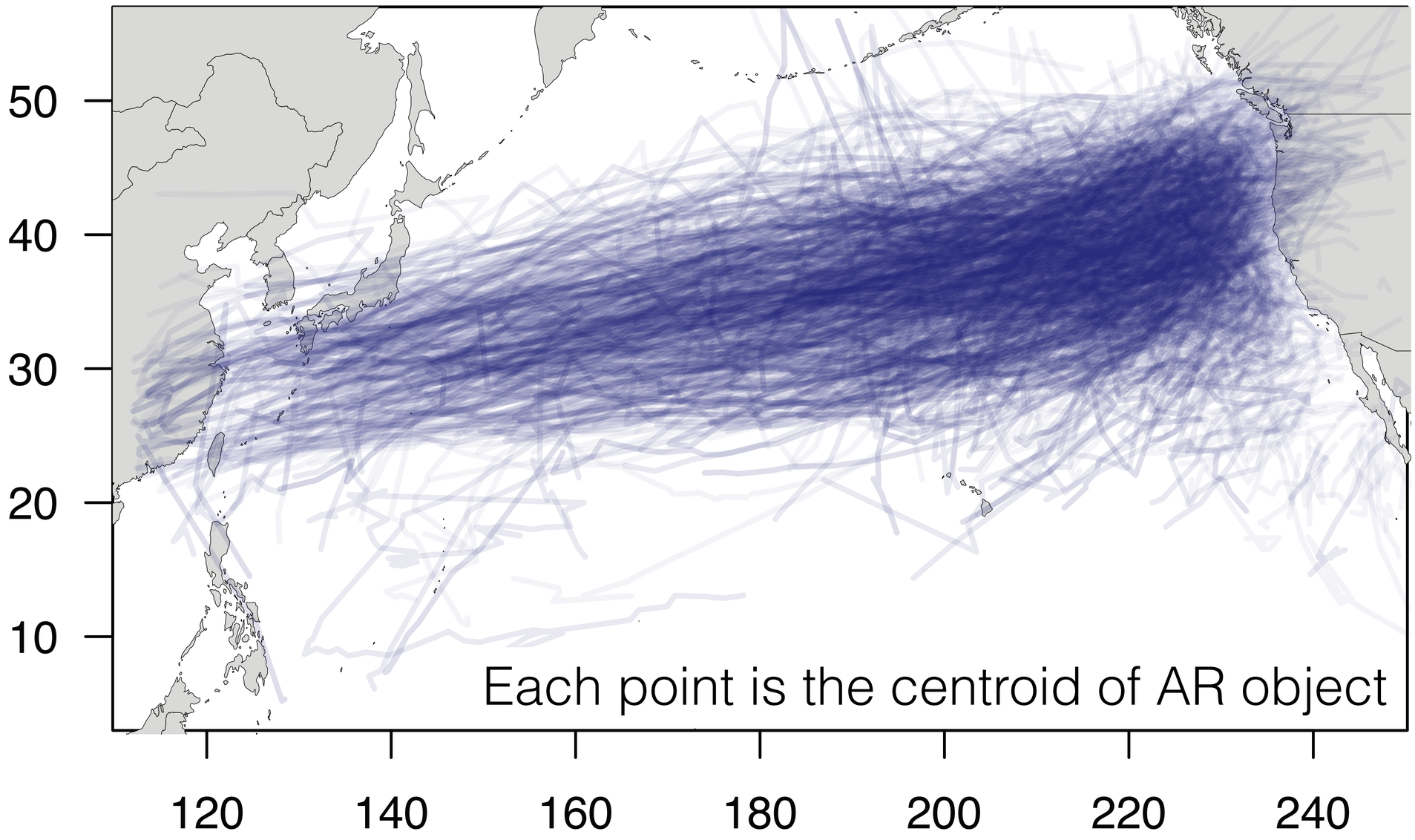
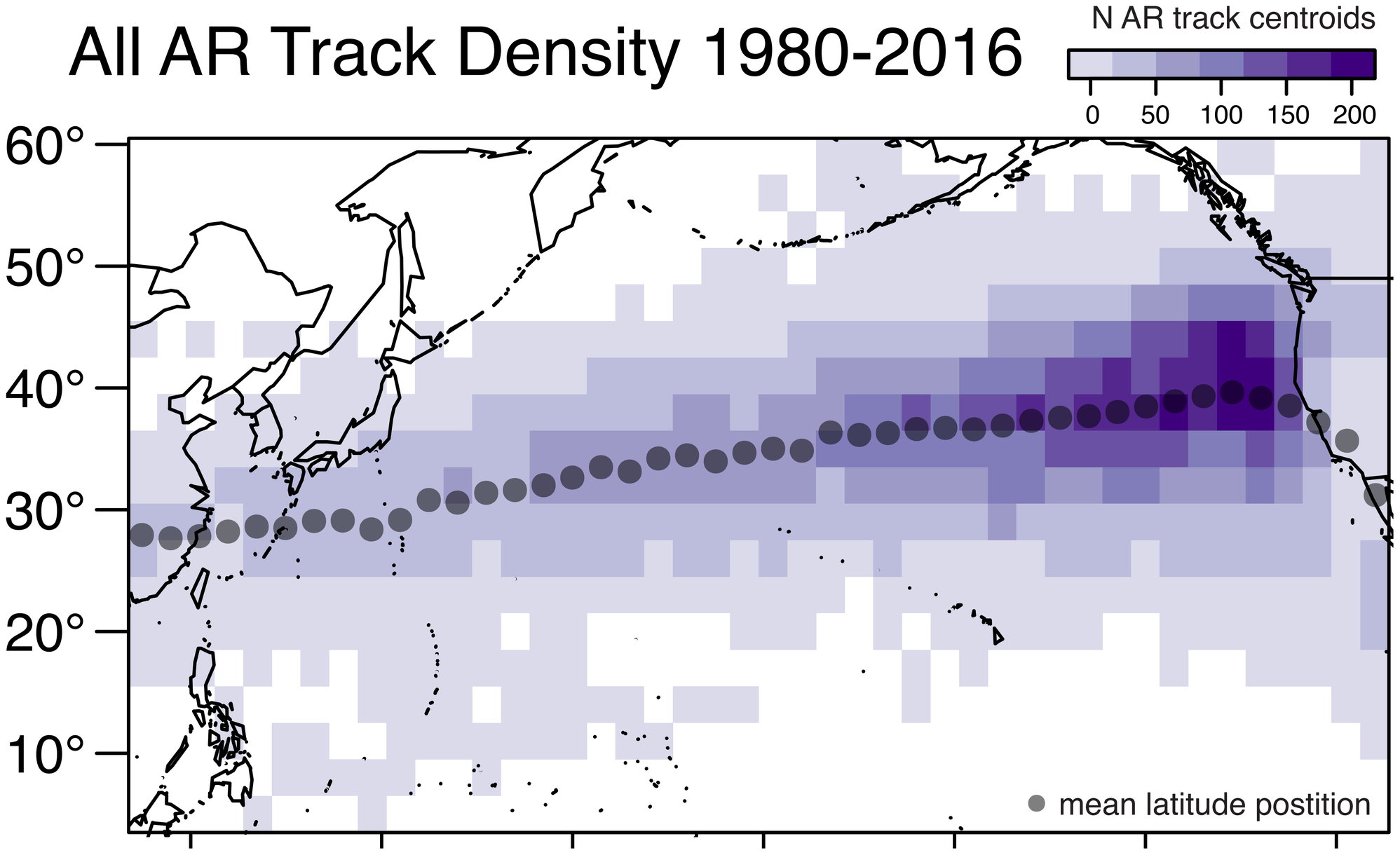


Next: Track ARs and calculate along-track AR temperature from genesis to landfall

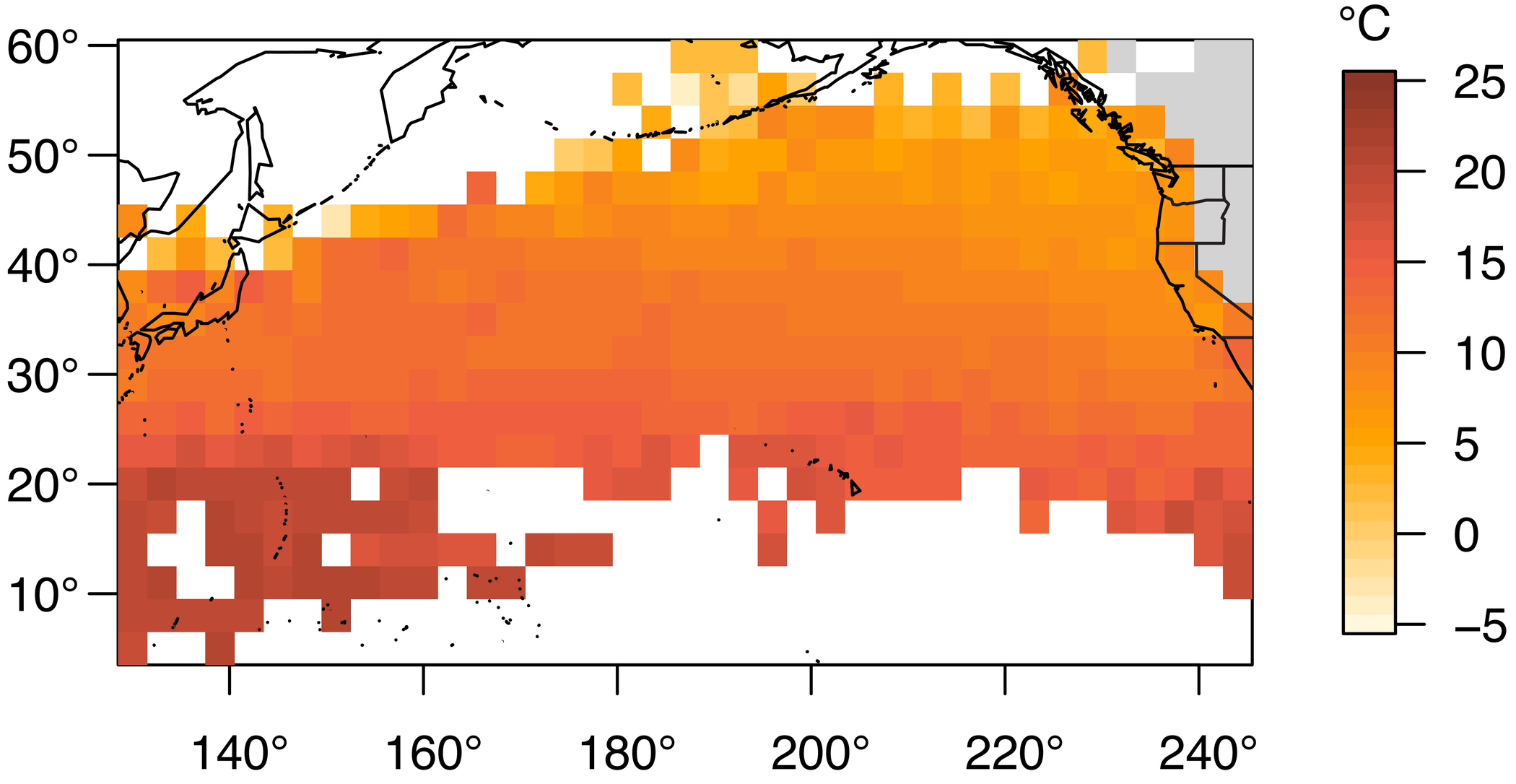


All AR Tracks 1980-2016




All AR Track Density 1980-2016
N AR track centroids
0
50
100
150
200
60°
50°
40°
30°
20°
10°
mean latitude postition

Average AR Track Temperature 1000-750hPa



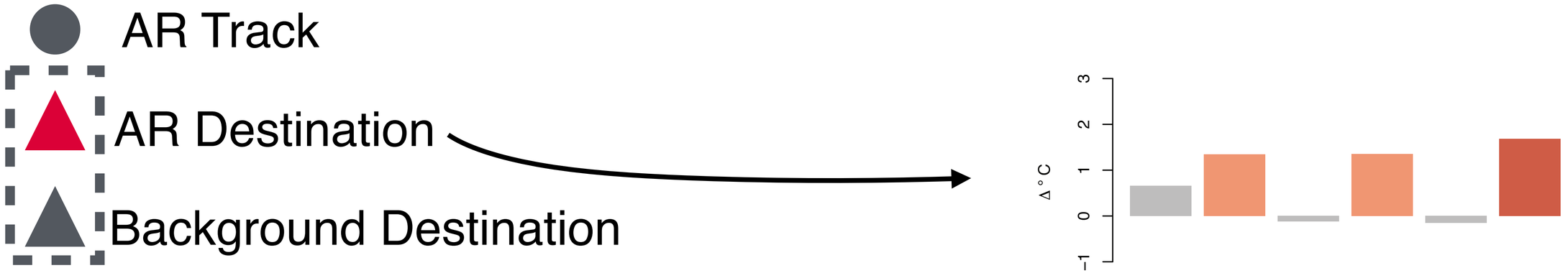
How do AR landfall temperature trends compare with Background and Track Temperature trends?

AR Track

AR Destination

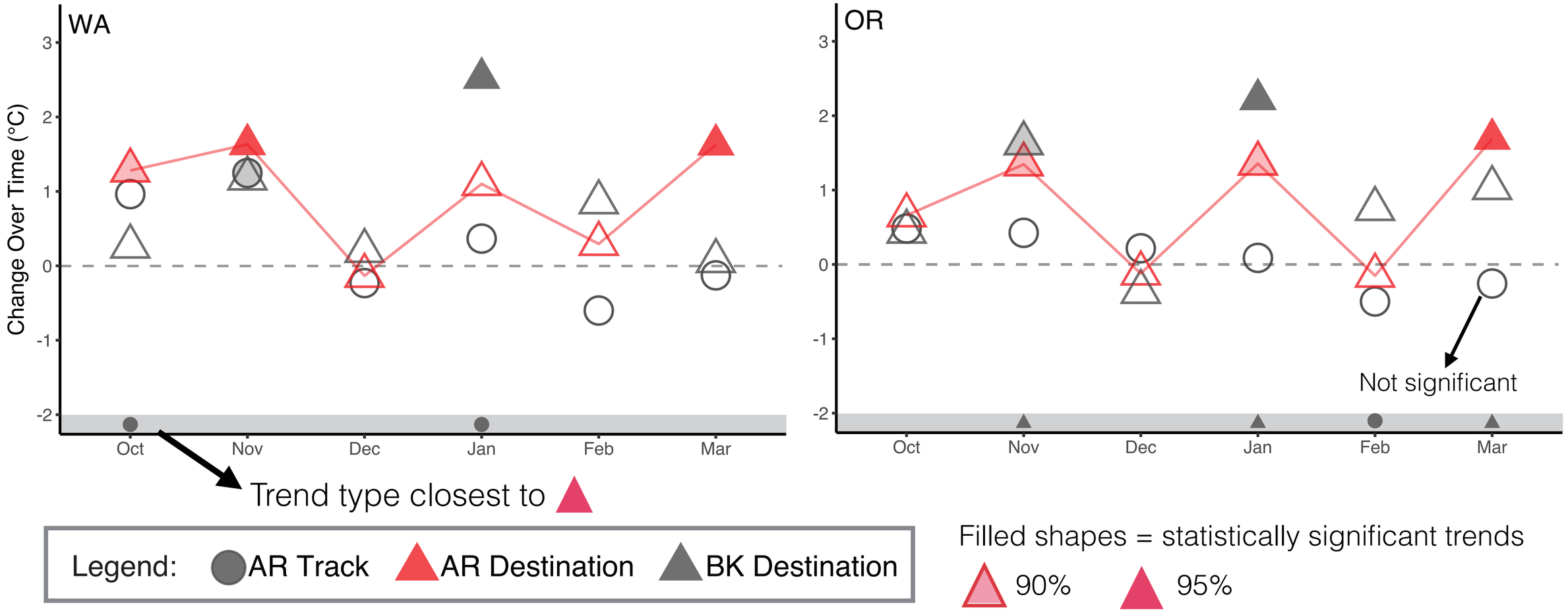
Background Destination

How do AR landfall temperature trends compare with Background and Track Temperature trends?



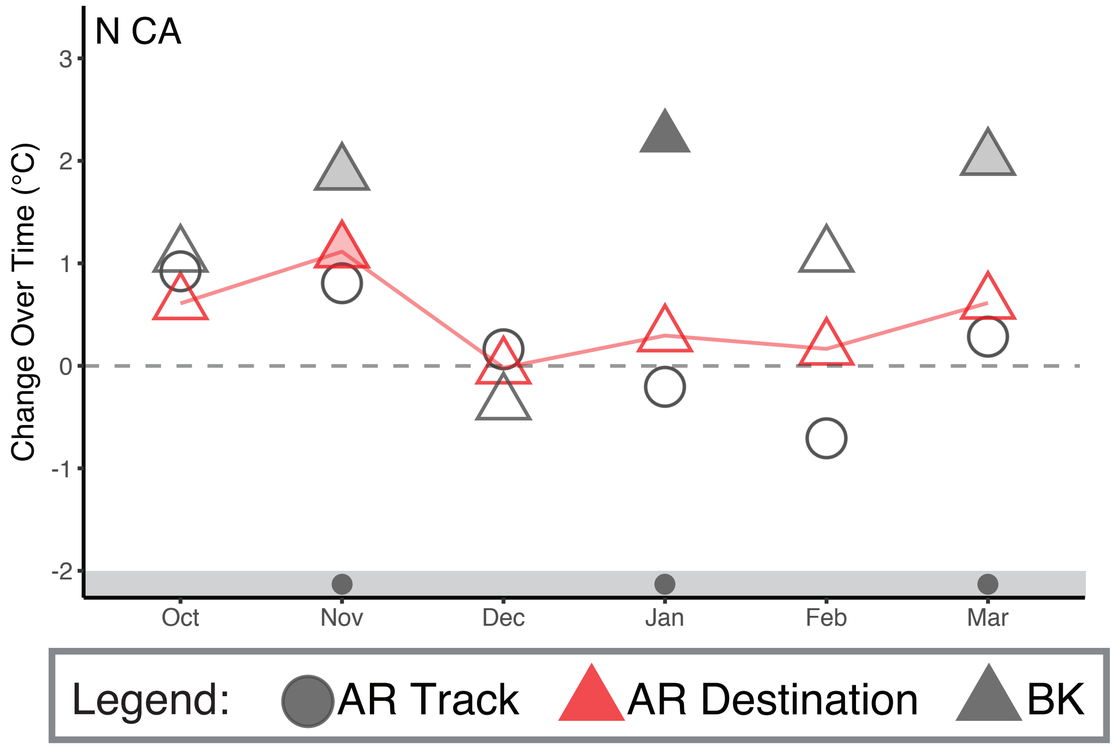
PNW Trend Comparison

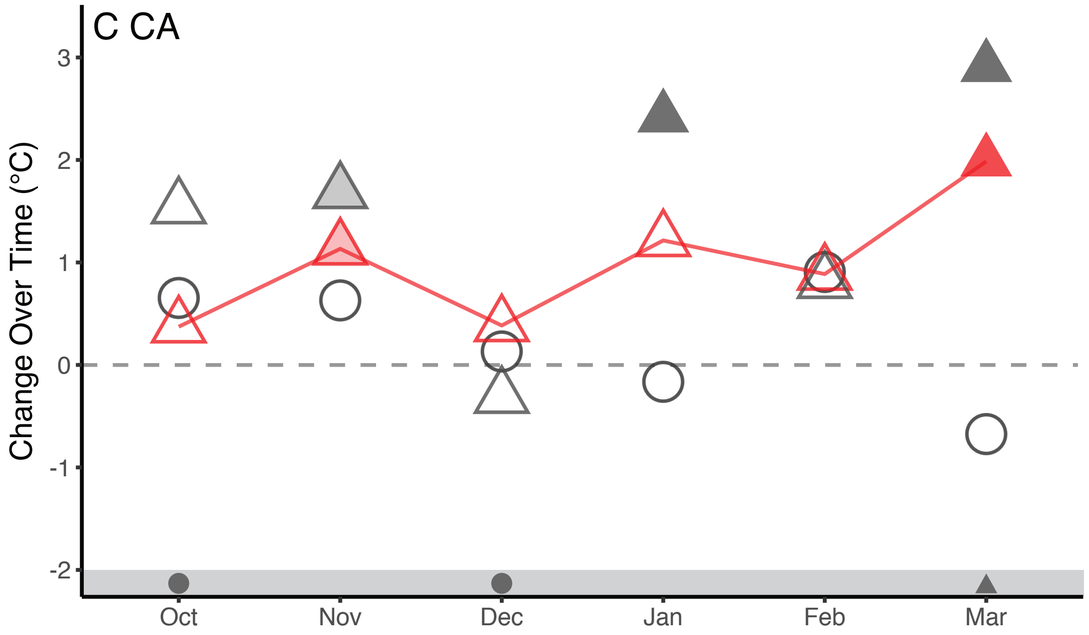
- AR track trends close to 0
- AR Dest trends between Track and BK
- AR warming higher than BK and Track in March

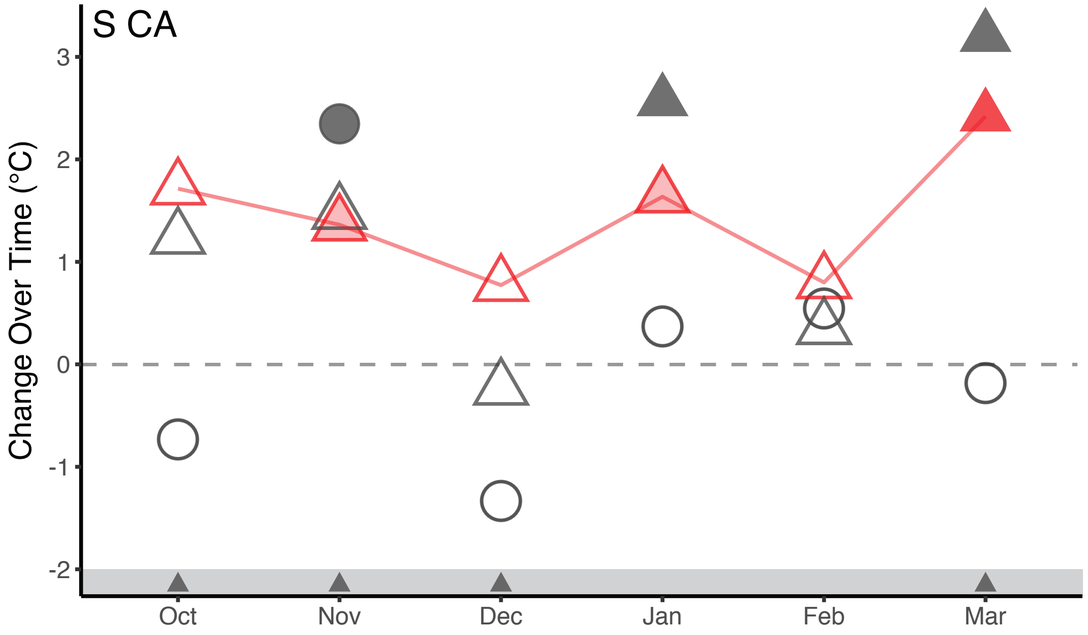


CA Trend Comparison

- Robust March AR Dest warming:
  - least robust in NCA
  - coincident with strong BK warming
- BK is closer to AR Dest in SCA

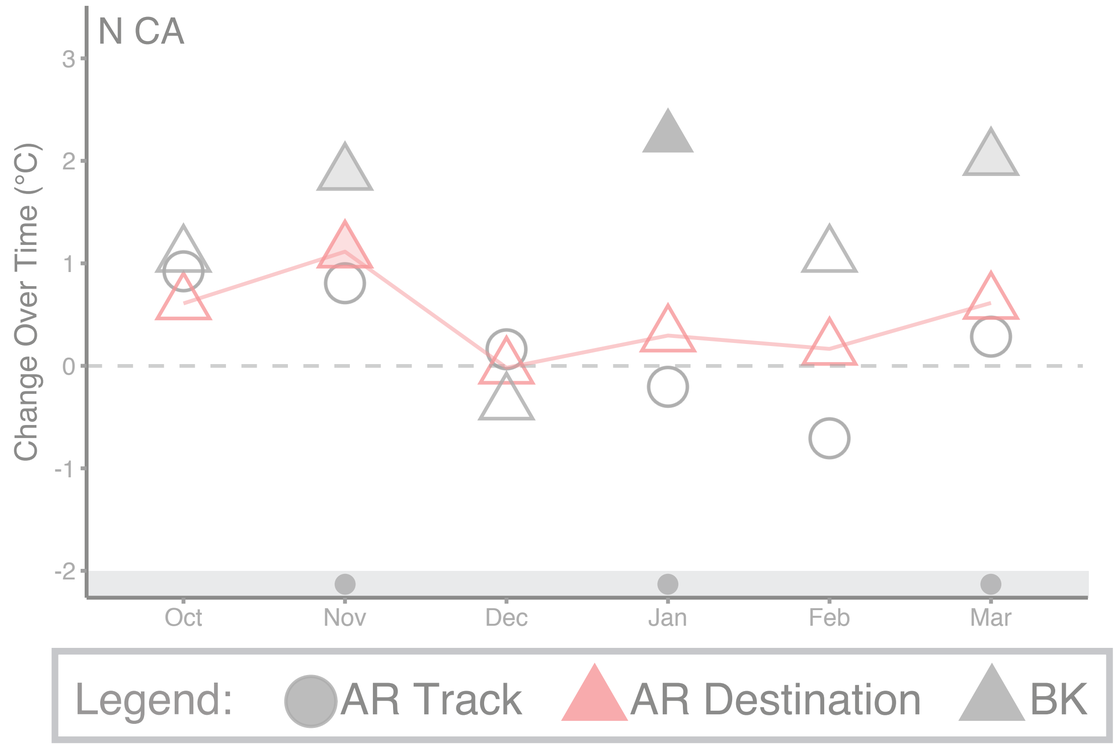


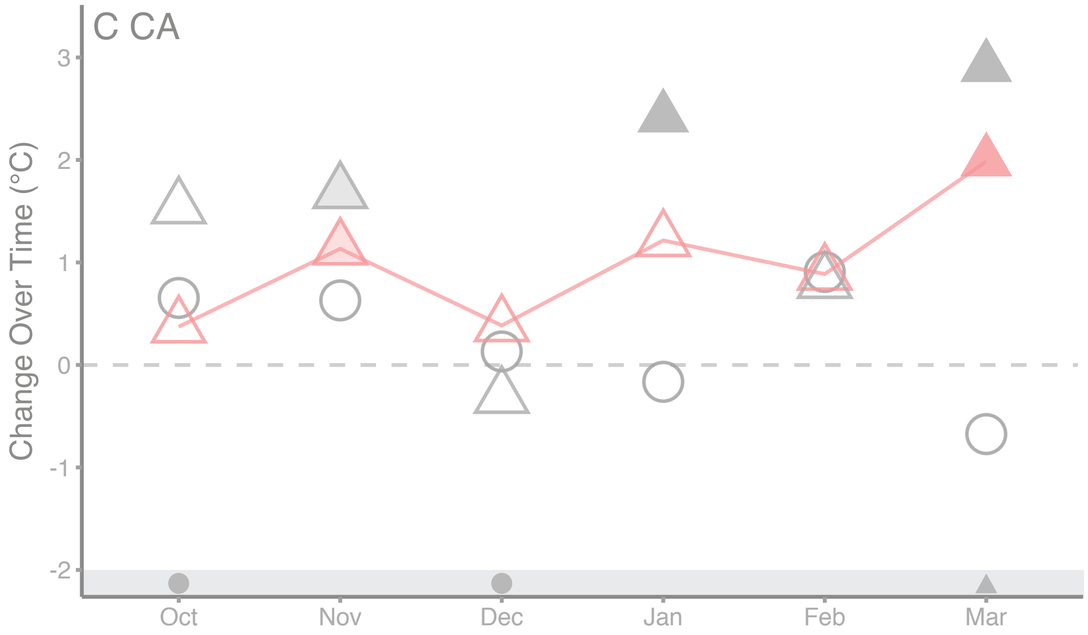


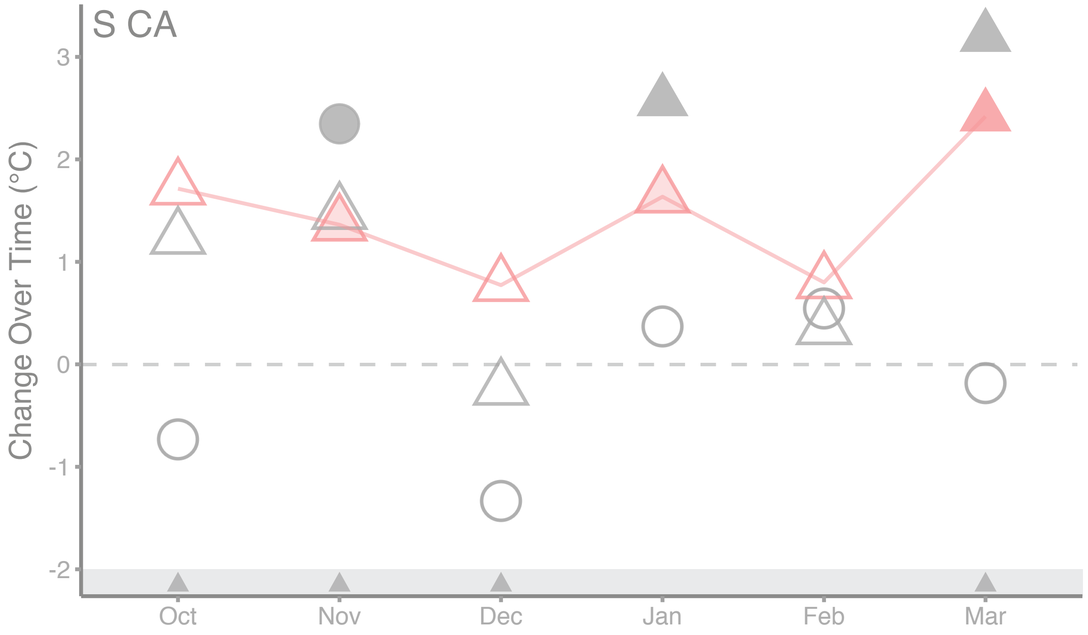


Overall

AR destination trends do not appear to be systematically following track or background trends







Conclusions

1. Overall AR temperature is increasing significantly in most regions
   - Significant in WA, C CA, S CA
   - 0.5 to 1.4°C of change over time
2. Warming is heterogenous across months: Robust Nov and Mar warming
3. Sources of warming: Background or AR Track?
   - Investigated both; results vary by month/region
   - Suggests that understanding both important for determining temp @ landfall

Thank you

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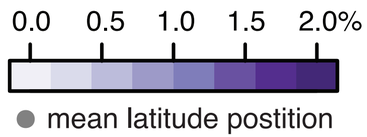
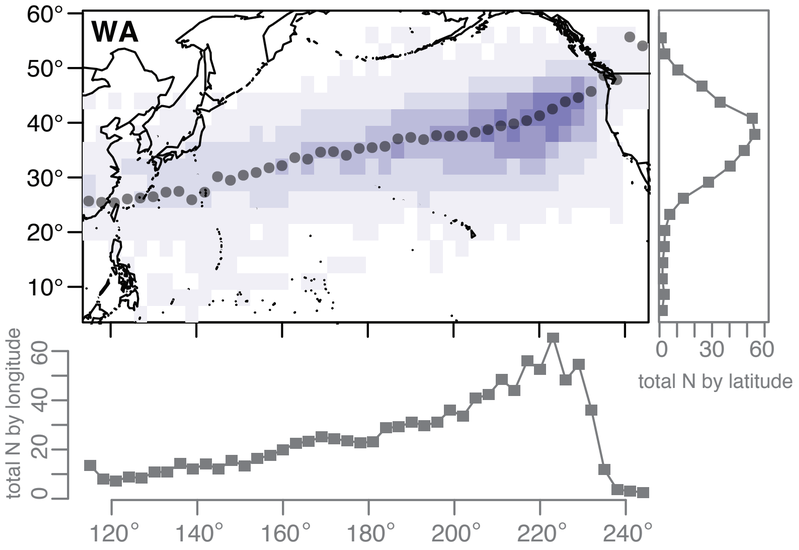
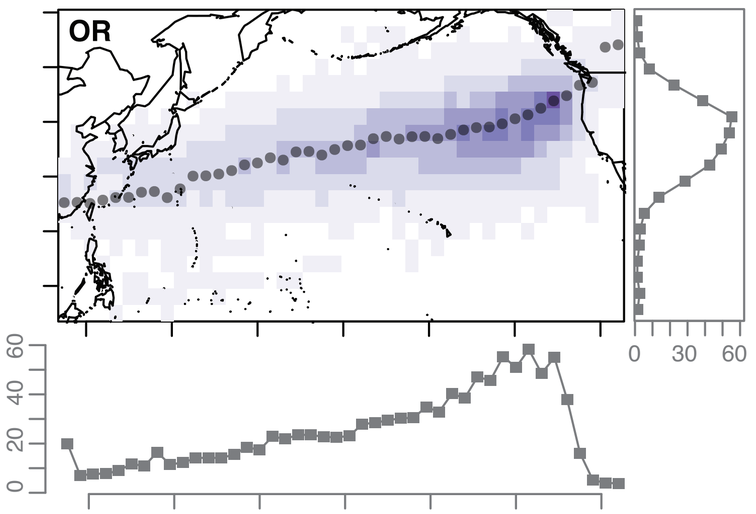
NSF Grant No. DGE-114747
Stanford VPGE EDGE Fellowship
Stanford Research Computing Center

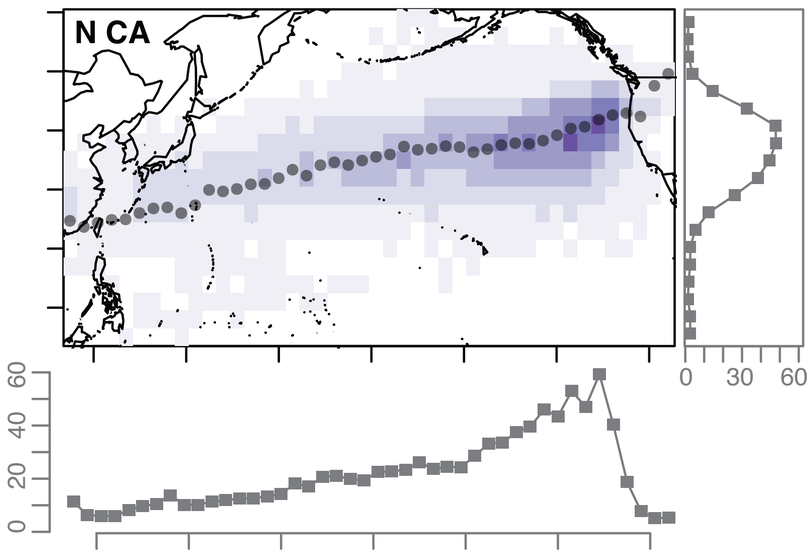
KMN and EAB were funded in part by a sub-grant from CW3E of Scripps Institution of Oceanography under the FIRO project.

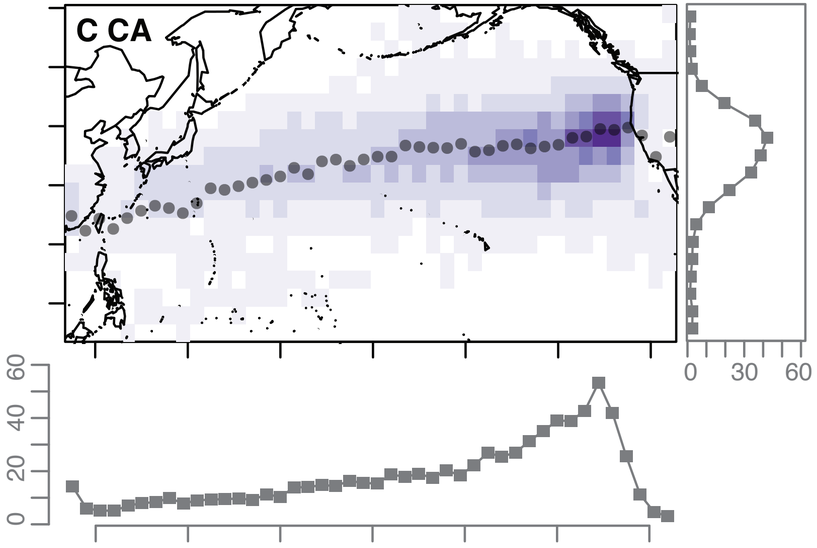
AR Track Density by Region

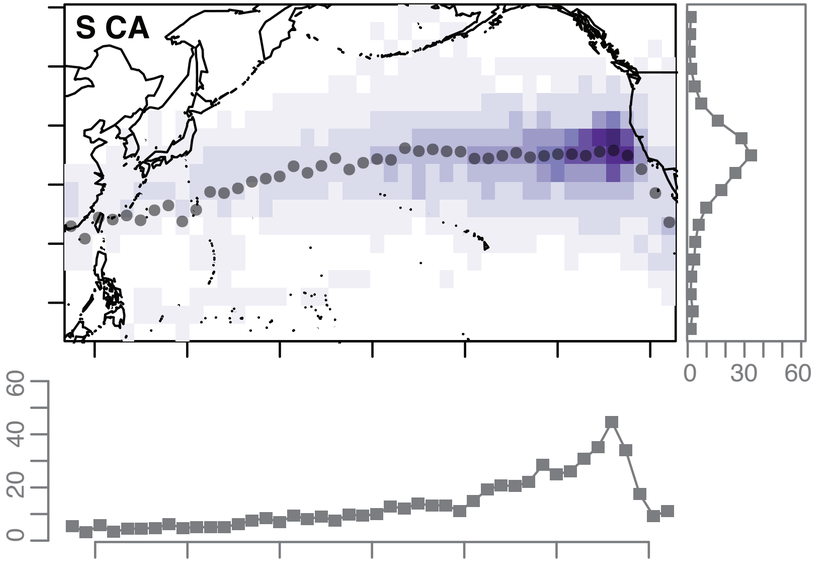




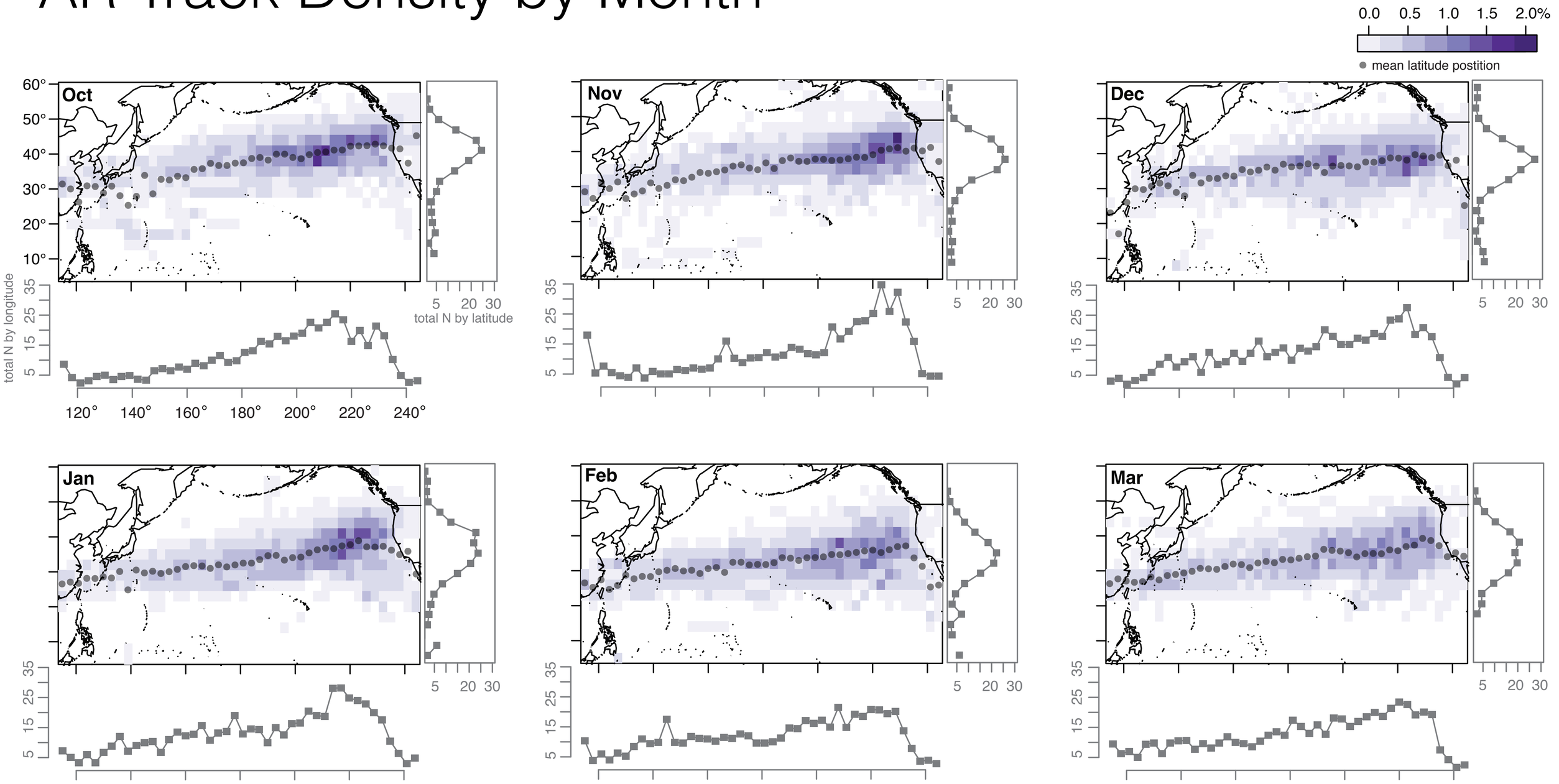


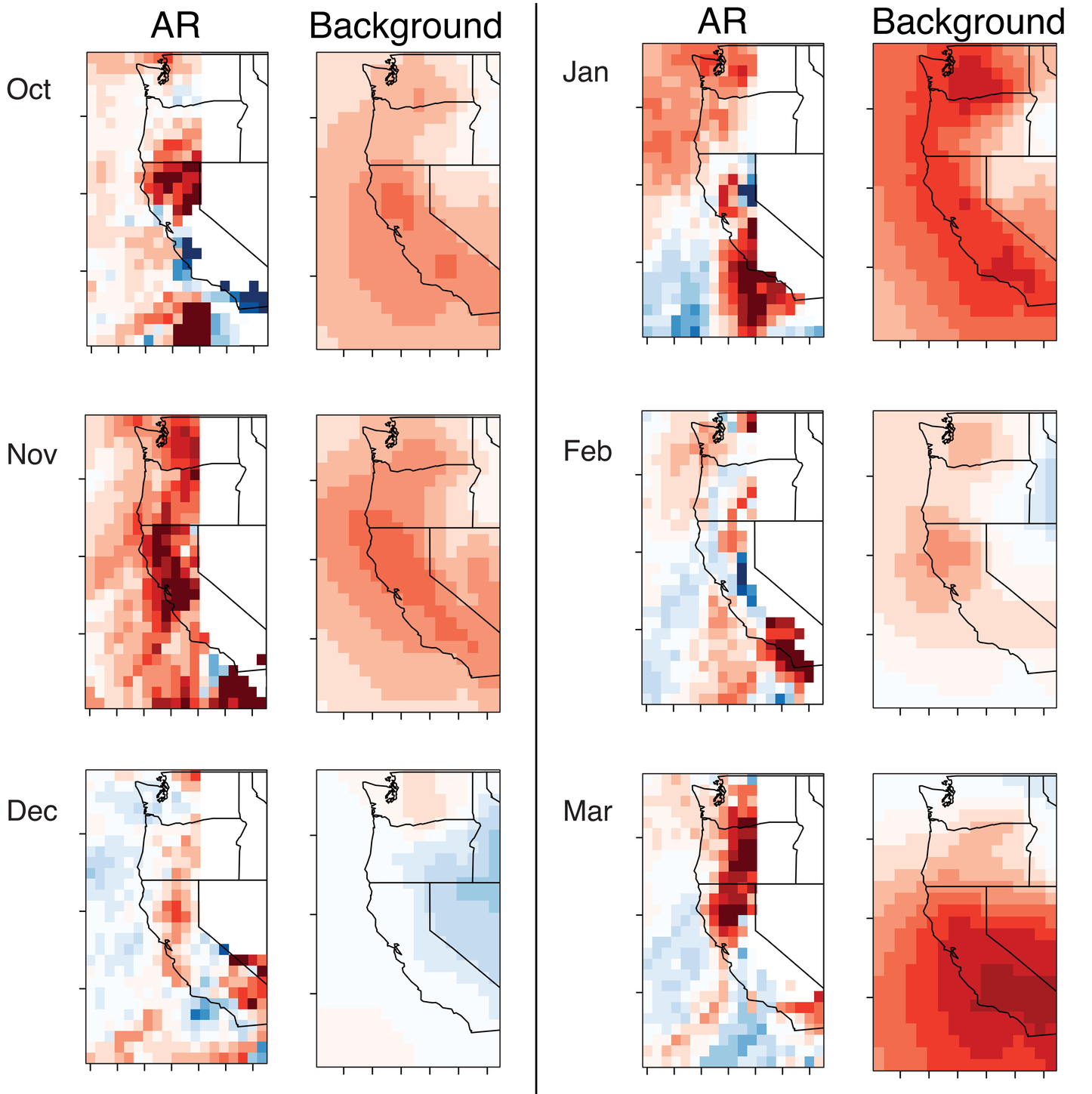






AR Track Density by Month



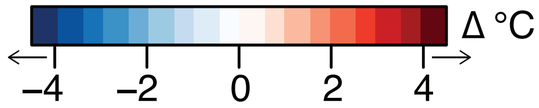


AR & Background trends at Destination

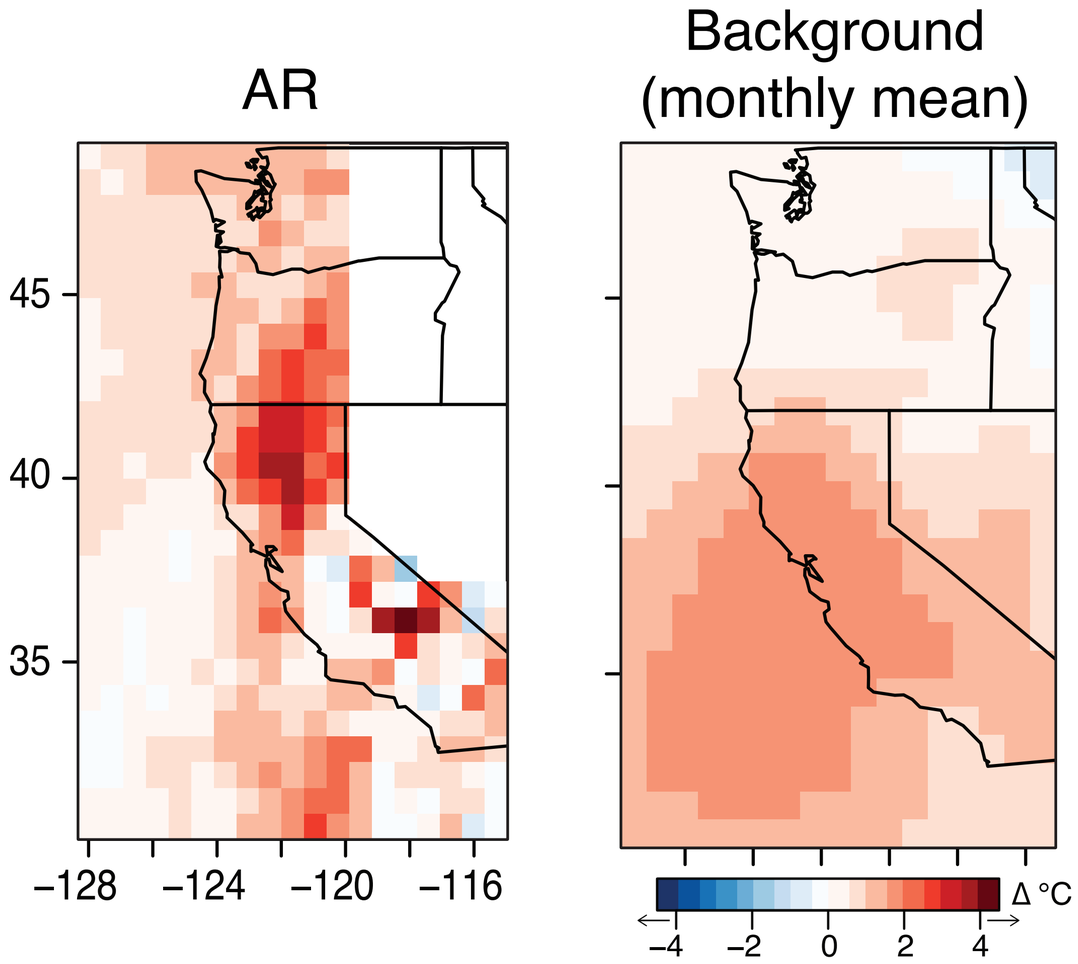
- Background = monthly mean
- Trend @ each grid point

<u>Results:</u>

- Magnitude and spatial pattern of trends differ
- Nov is warming in both
- March pattern is opposite

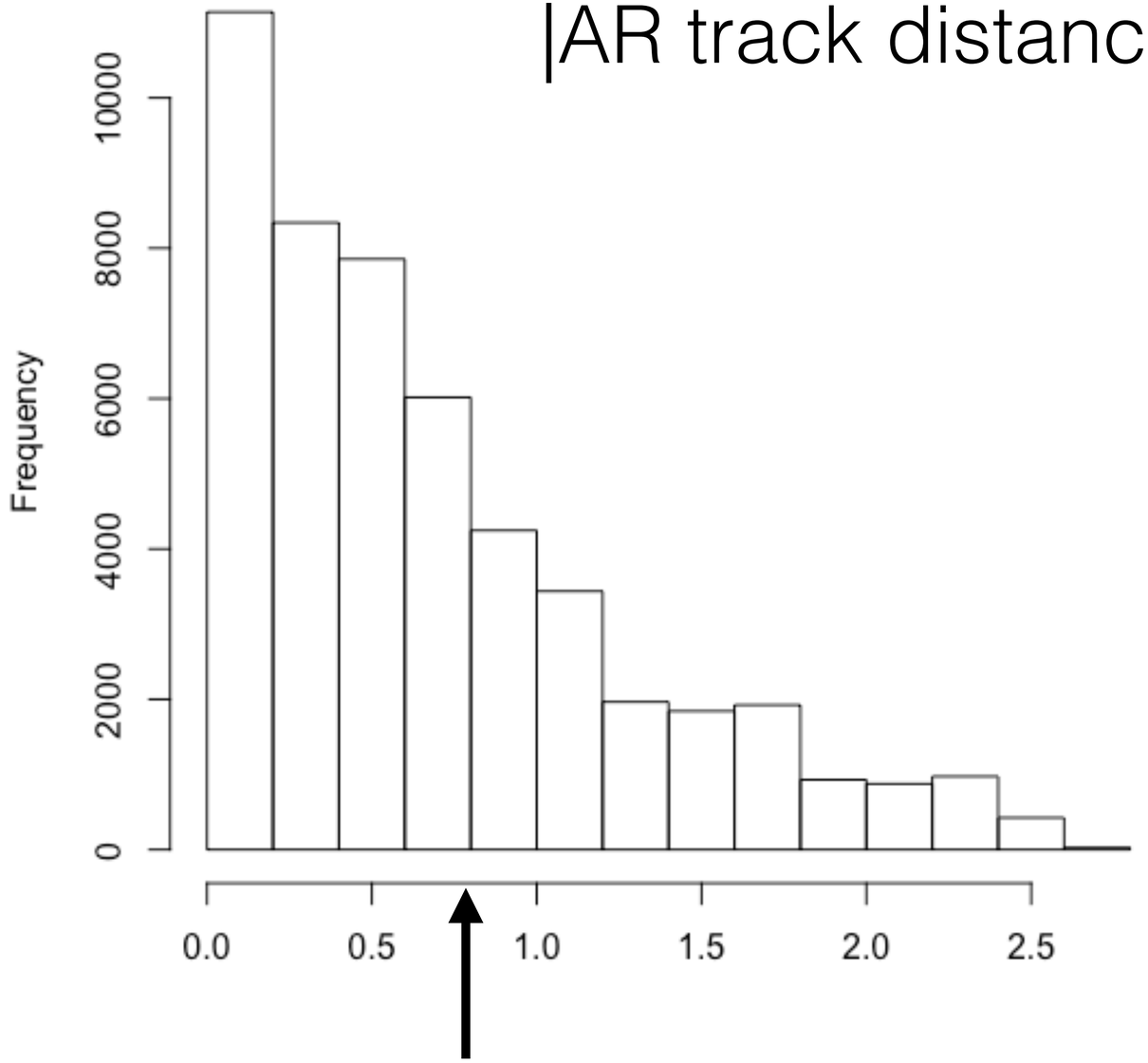


Trend comparison: AR at destination vs Background at destination



Bootstrapped distribution of

|AR track distance - BK distance|



- Sample from the 30 instances (6 mo*5 regions)
- s = 0.58
- Choose 1σ above 0 as the threshold
- Absolute values of differences above 0.58° get visualized