Changes to Atmospheric River related Extremes over the United States West Coast under Anthropogenic Warming

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Goal: Understand Changes to Rare Extreme AR Events in Climate Warming Scenarios

- CESM2 (LENS)
- HIST (40 members) and SSP 3-7.0 (50 members)
- 8 years per ensemble member (320 years in HIST (2007-2014), 400 years in SSP 3-7.0 (2092-2099))
- December, January, and February months
- 1.25° x 0.94° horizontal grid resolution, 6-hourly temporal resolution
- HadAM4 (Weather@Home)
- HIST (1244 members), 1.5°C Increase (1338 members), and 2°C Increase (1682 members) (HAPPI framework)
- 1 year per ensemble member (1244 years in HIST (2006-2015), 1338 years in 1.5° Increase (2091-2100), and 1682 years in 2°C Increase (2091-2100)
- December, January, and February months (November discarded as spinup)
- .83° x .56° horizontal grid resolution, 6-hourly temporal resolution

Challenges of tracking ARs with traditional ARTMIP methods:

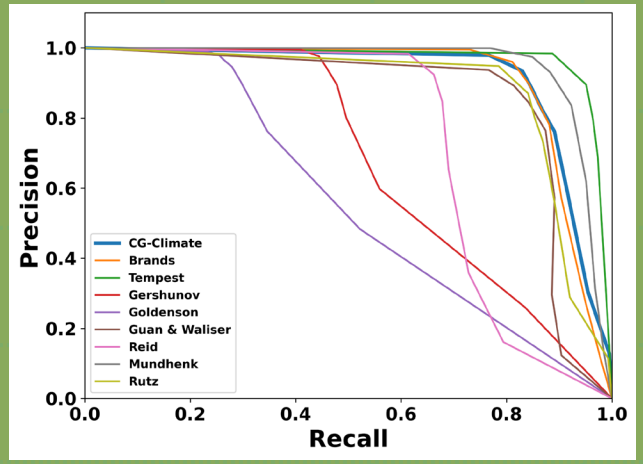
The amount of data requires an unrealistic amount of computational resources to generate AR masks

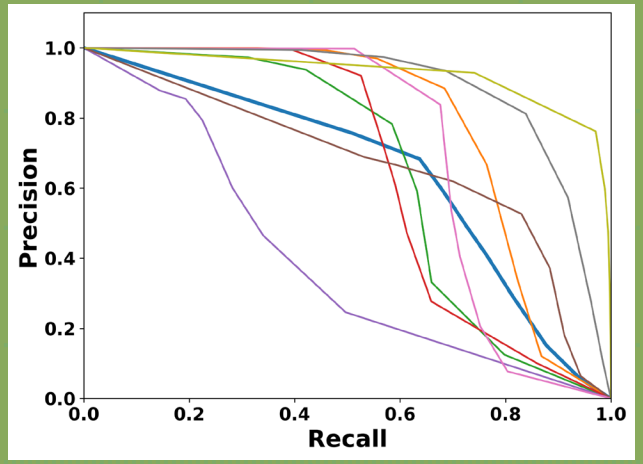
Absence of stored IVT from Weather@Home rules out most ARTMIP methods

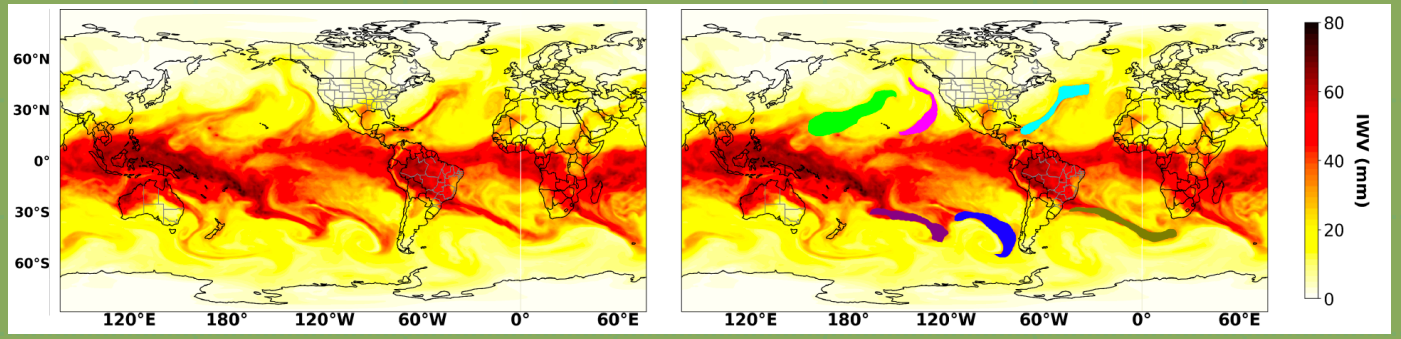
ARTMIP methods often add domain constraints (Weather@Home had a regional stored output)

Solution:

CG-Climate (Higgins et al. 2023, *JAMES*)





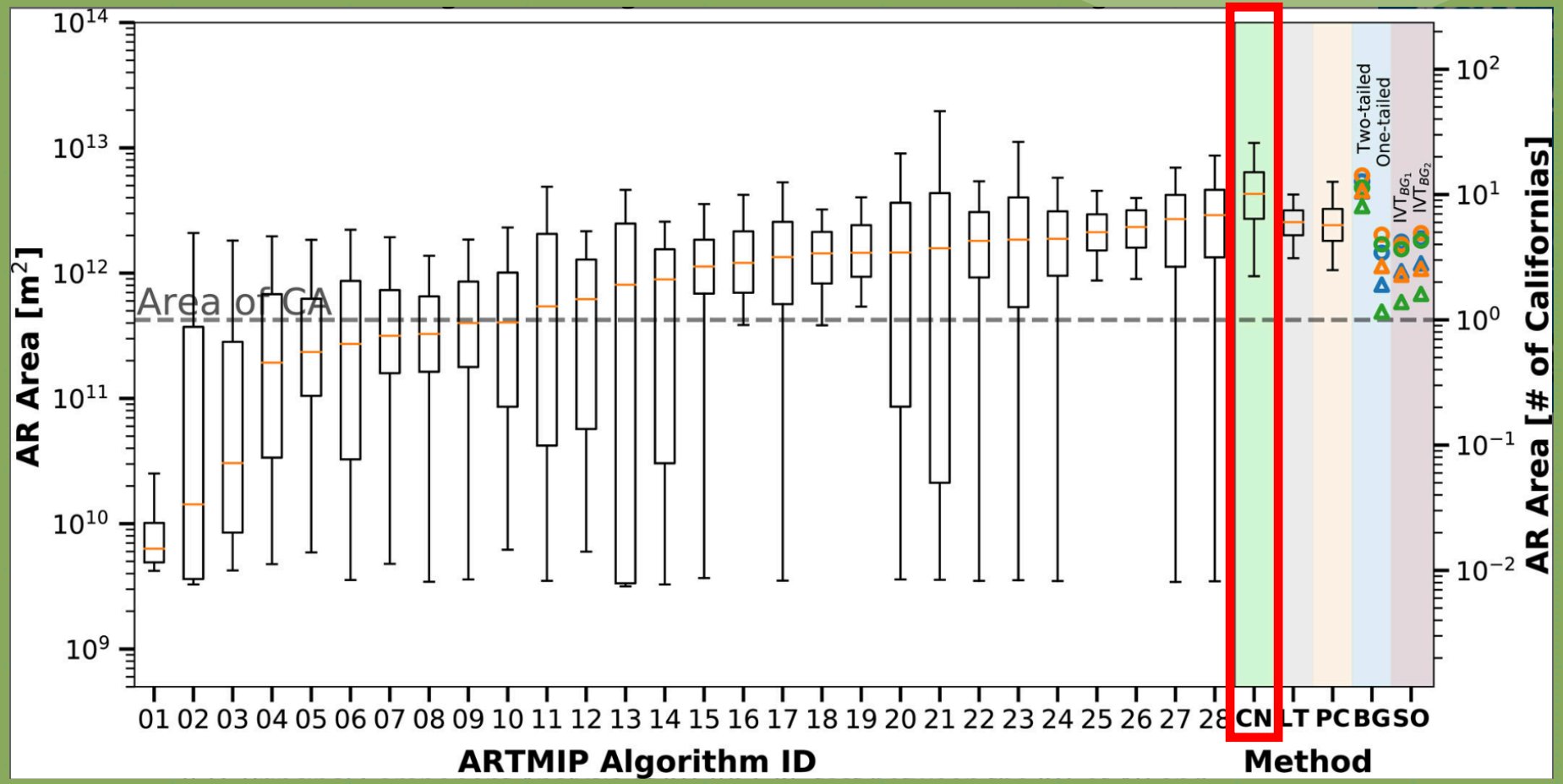


> Reasonably consistent with ARTMIP, computationally efficient, and highly flexible with data

Limitations of training on ClimateNet

AR area is larger than ARTMIP methods

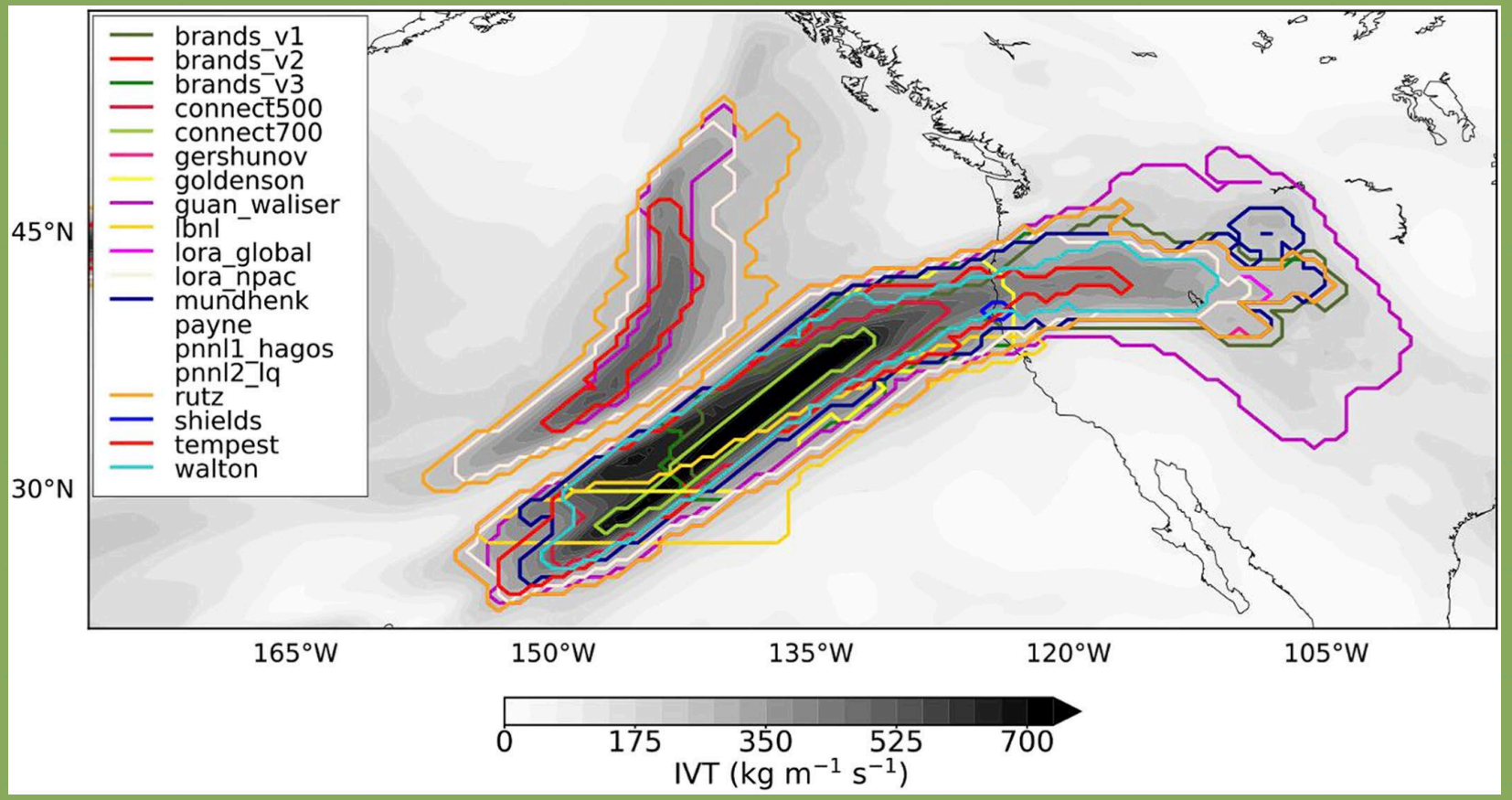
Uncertainty across AR detection methods exceeds climate model uncertainty (Shields et al. 2023)



Inda-Diaz et al. 2021, *JGR Atmospheres*

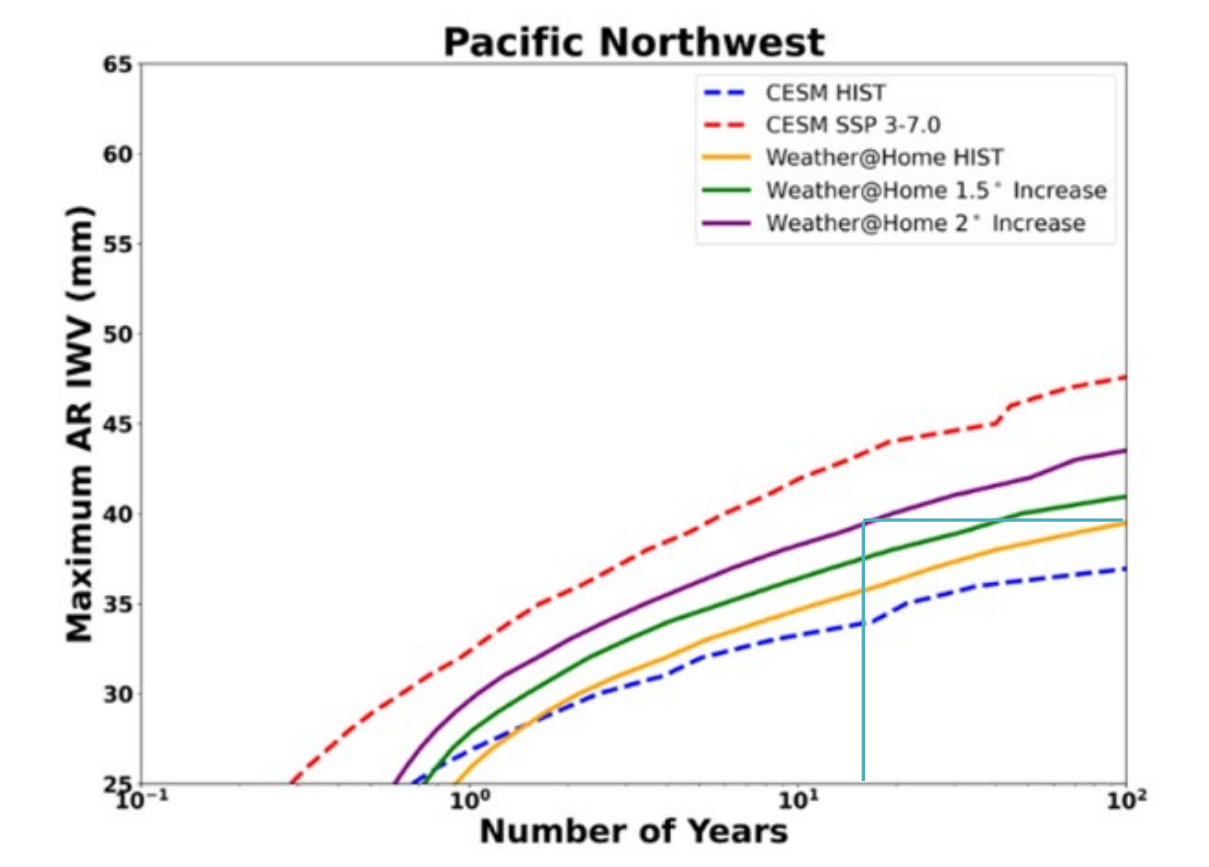
AR Extremes

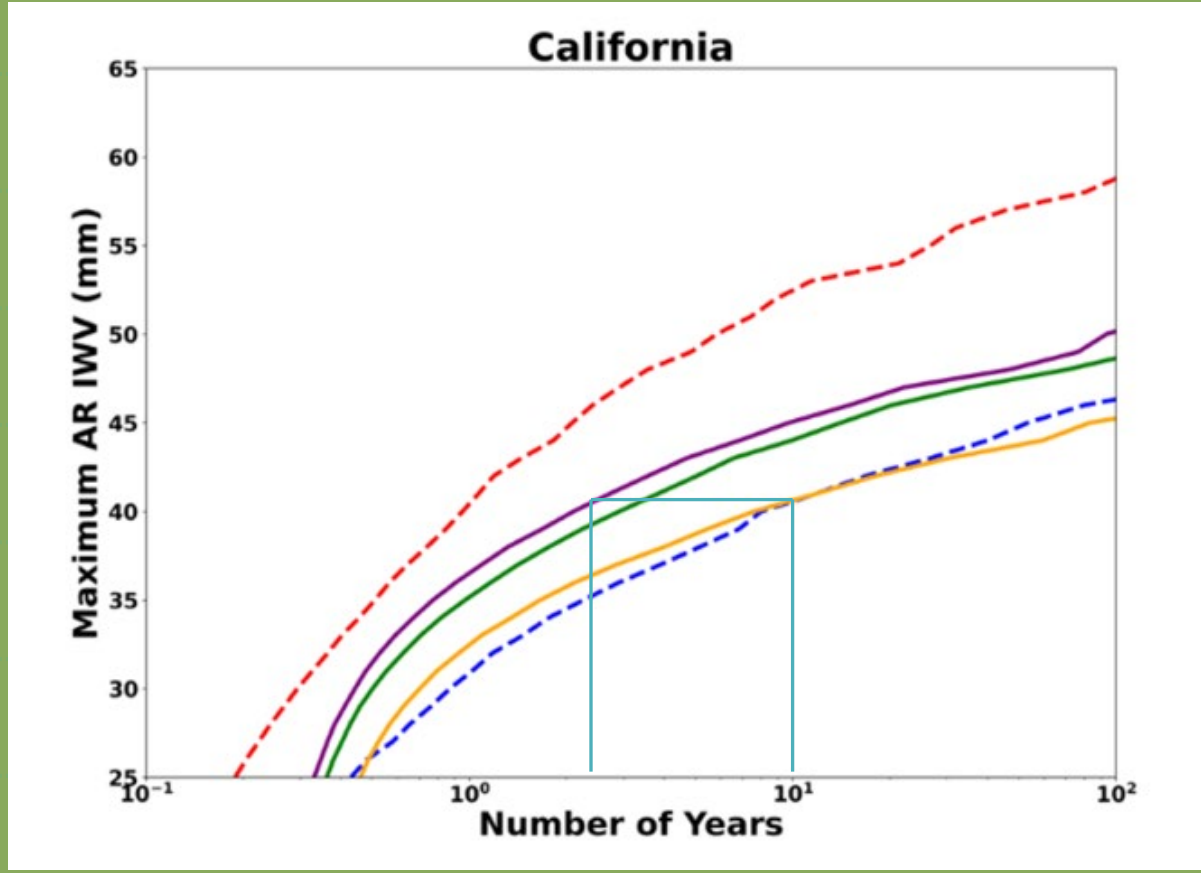
- Weaker ARs can often have greater detection uncertainty than stronger ARs
- Events that have maximum landfalling IWV value that occurs <once per year on average in historical simulations (32.98 mm in Weather@Home, 32.34 mm in CESM2) are analyzed



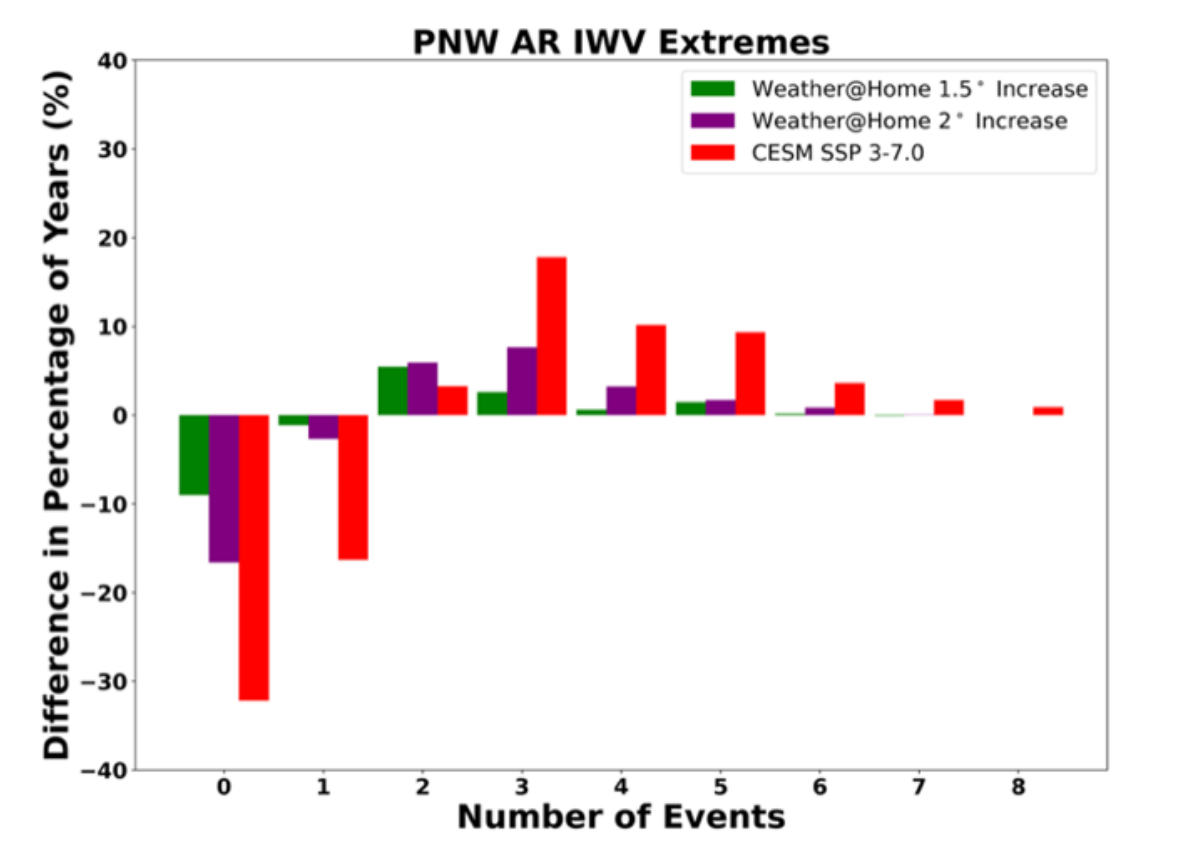
Rutz et al. 2019, *JGR Atmospheres*

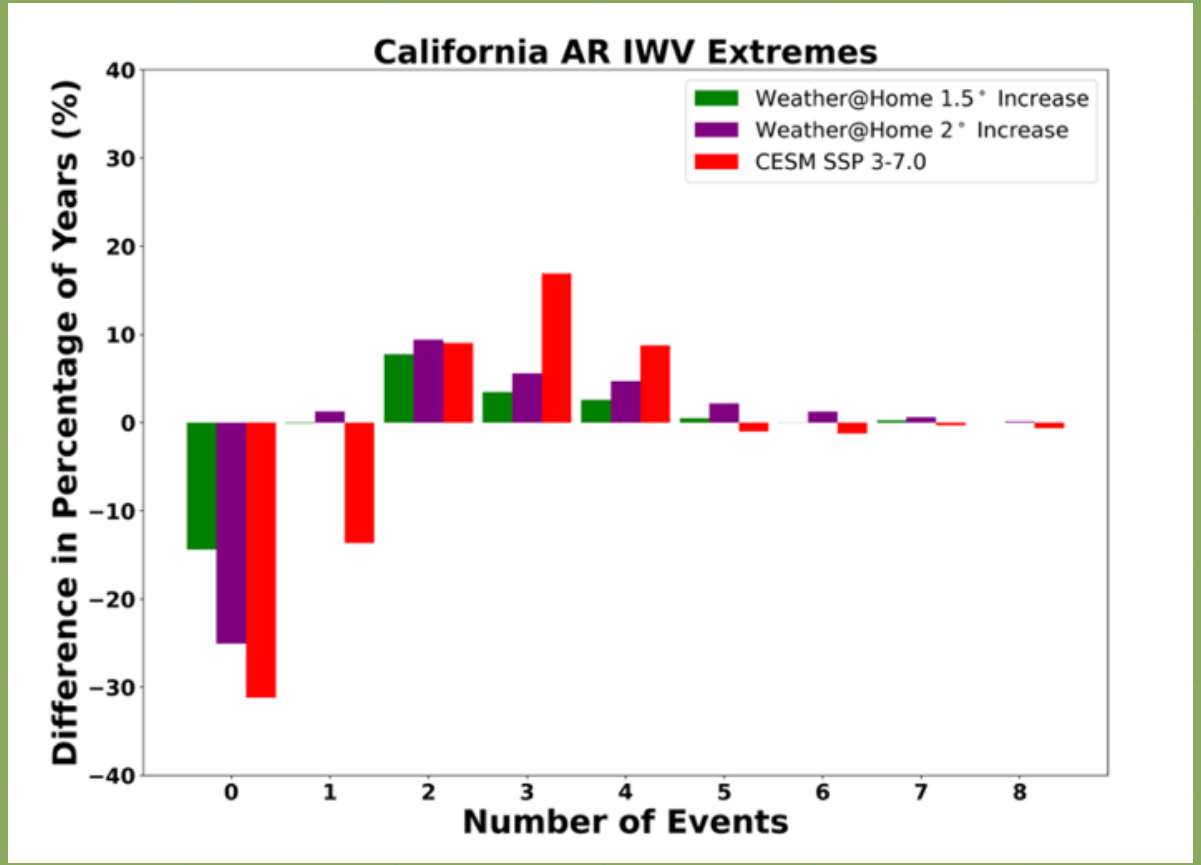
Changes to Rare Extreme Events



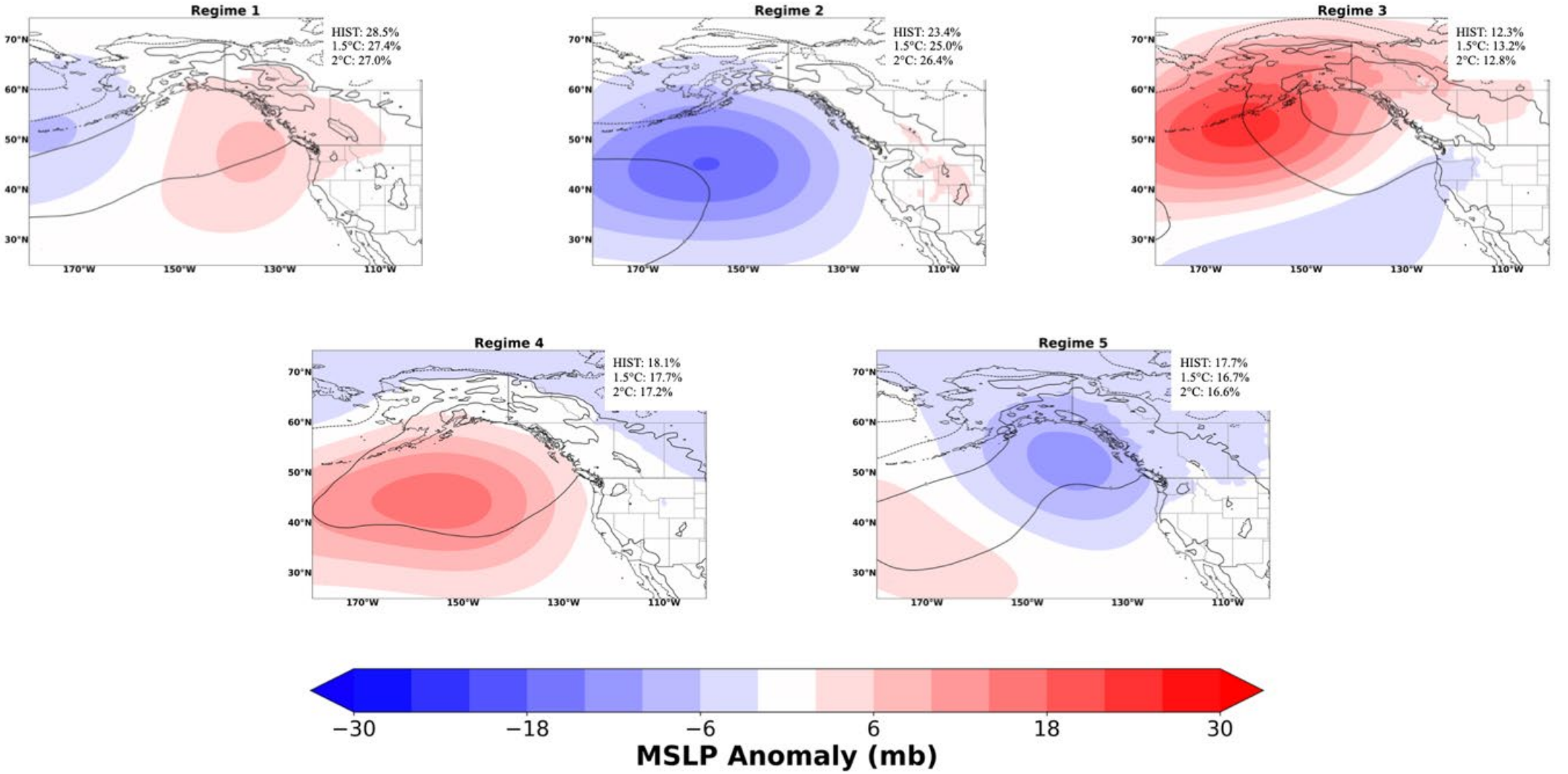


Changes to Seasonal Distributions

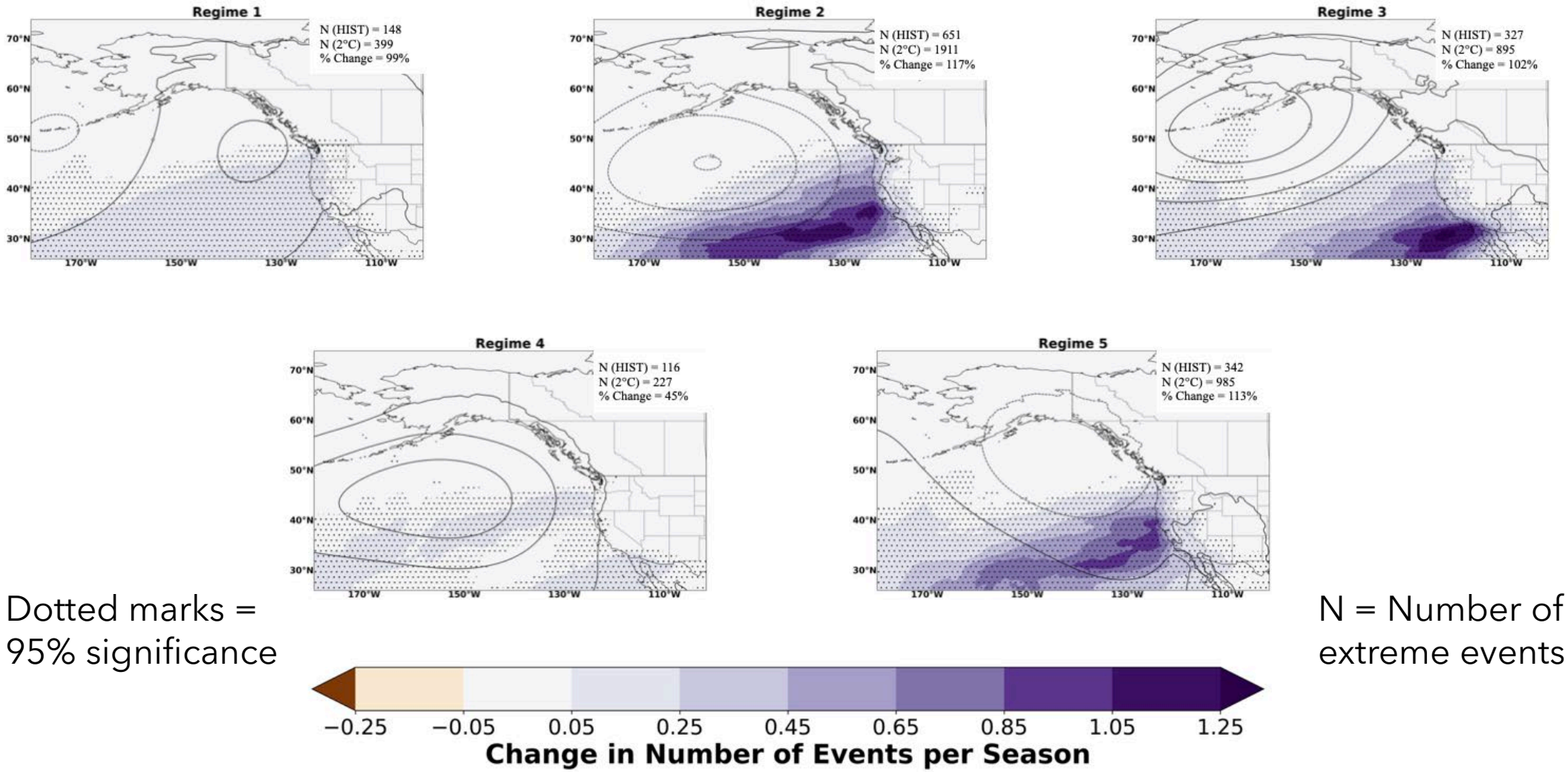




Weather Regimes - MiniSOM



Extremes during Regimes



Dotted marks = 95% significance

N = Number of extreme events

Key Takeaways

- In just a 2°C temperature increase scenario, extreme ARs at various severities increase in frequency almost one order of magnitude compared to early 21st century forcing
- In all warming scenarios, the percentage of seasons with 0 extreme events decreases while the percentage of seasons with 2+ extreme ARs increases
- Extreme AR frequencies increase disproportionately during regimes with low pressure anomalies near the coast