

Climate Conditions Preceding Large Wildland Fires and their Seasonal Predictability

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Motivation

- Elevated wildland fire conditions and increasing vapor pressure deficit (VPD) in the Western US have been observed in recent years (see below)
- Increasing negative impacts on the public and environment
 - 1999–2009: Average of 1.3 structures destroyed per 4 mi² burned. 2010–2020: Average of 3.4 structures per 4 mi² ¹

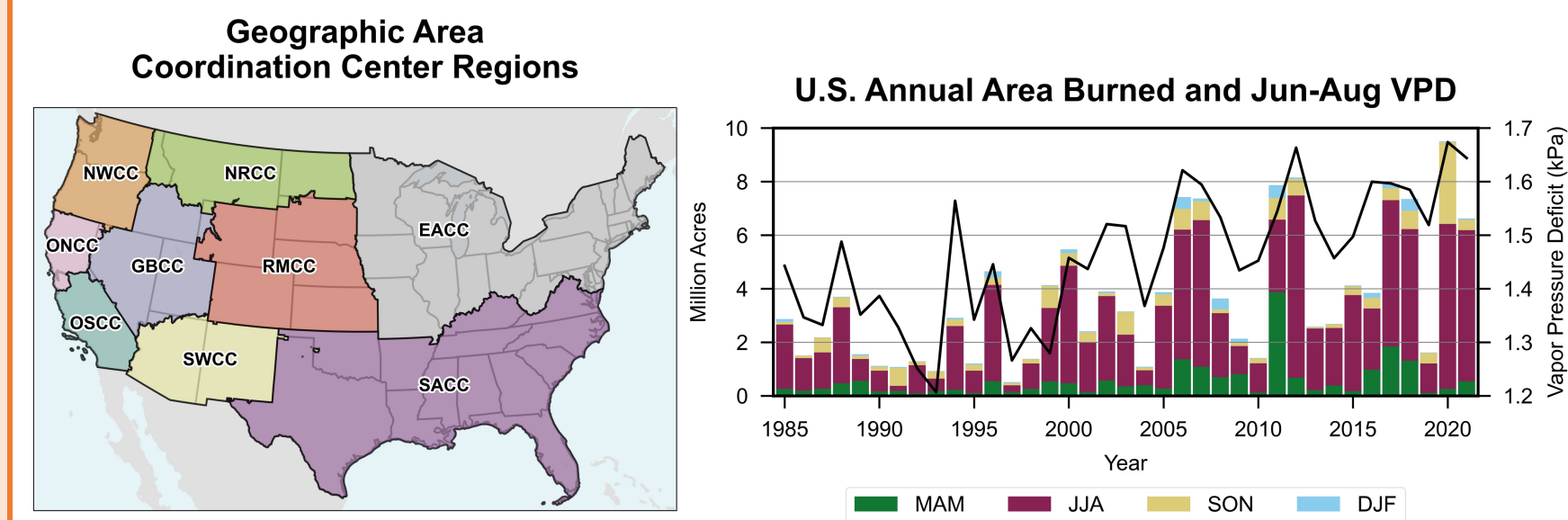


Fig 1: NIFC GACC regions (left) and time series of US annual area burned by wildfires broken down by season (bars) and mean June-August VPD (black line) from 1985-2021 (right)

Research Questions

- What climate conditions historically precede significant fire years?
- Did those climate conditions precede recent large fires in 2020, a significant fire year?
- What is the seasonal predictability of VPD in the western US?

Data

Variable(s)	Source
Burned Area Boundaries	Monitoring Trends in Burn Severity (MTBS) ²
2m Temperature/dewpoint temperature (VPD calculation)	European Centre for Medium-Range Weather Forecasts fifth generation atmospheric reanalysis (ERA5) ³
Precipitation and 2m Temperature	National Centers for Environmental Information (nClimGrid; NCEI) ⁴
Daily Optimum Interpolation Sea Surface Temperature	NCEI ⁵
Geographic Area Coordination Centers (GACCs)	National Interagency Fire Center (NIFC) ⁶

Methods

Large wildfire preconditions

- Period of focus: 1984–2021, June–August (JJA)
- Composites of top ~30% of fire years (12 yrs) averaged over 3 month seasons preceding JJA for each region
- Standardized anomalies, based on 1991–2020 averages
- VPD: actual minus saturation vapor pressure
- East Troublesome: Average conditions 3 months before fire

Seasonal VPD forecast model

- Linear inverse model (LIM)⁸ trained using monthly ERA5 SST, soil moisture, and vapor pressure deficit anomalies, 1958–2022
- Hindcasts generated using k-fold cross-validation

Large Wildfires Preceded by Regionally Varying Conditions

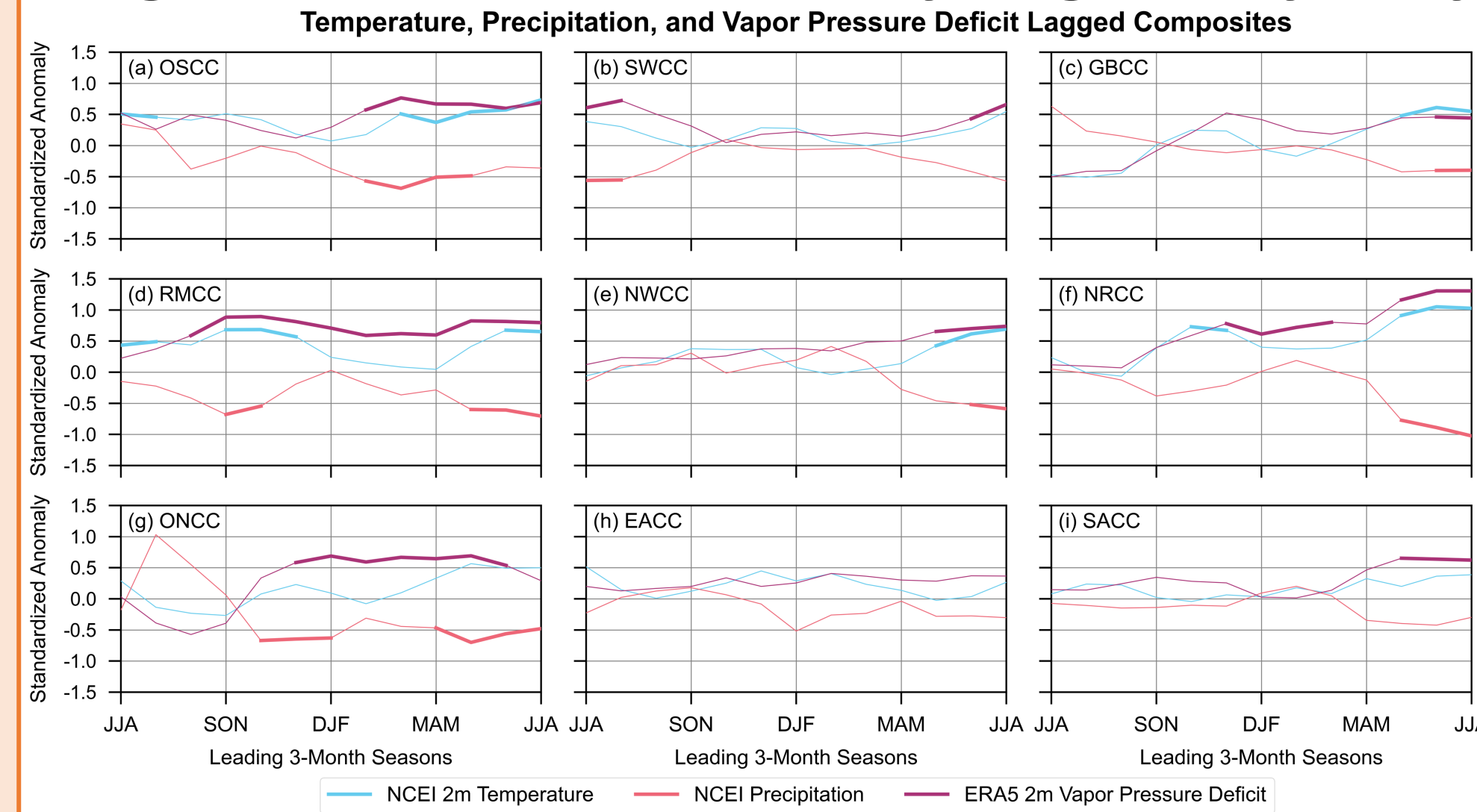


Fig 2 (left): Each panel shows 2m temperature, precipitation, and 2m VPD for each region. Thicker lines indicate statistical significance ($p < 0.05$)

- Large JJA Western US wildfires related to elevated temp/VPD and decreased precip

Fig 3 (right): Each panel shows sea surface temperature for each region. Thicker lines indicate statistical significance ($p < 0.05$)

- Large JJA Western US wildfires generally related to La Niña conditions

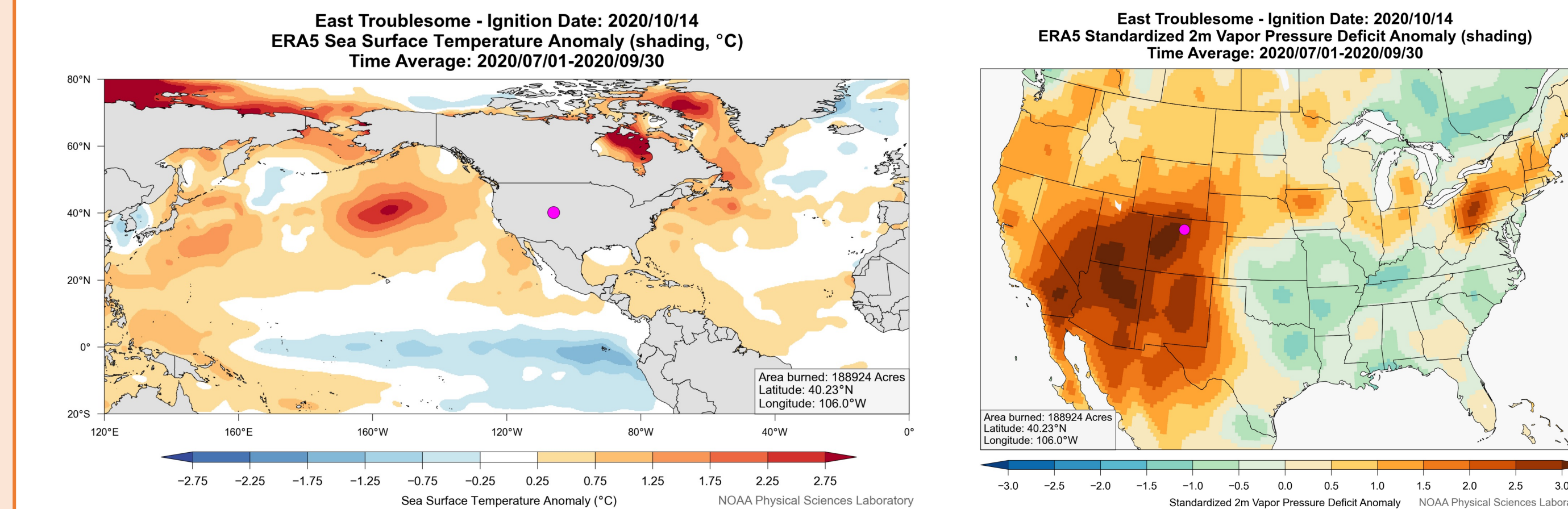
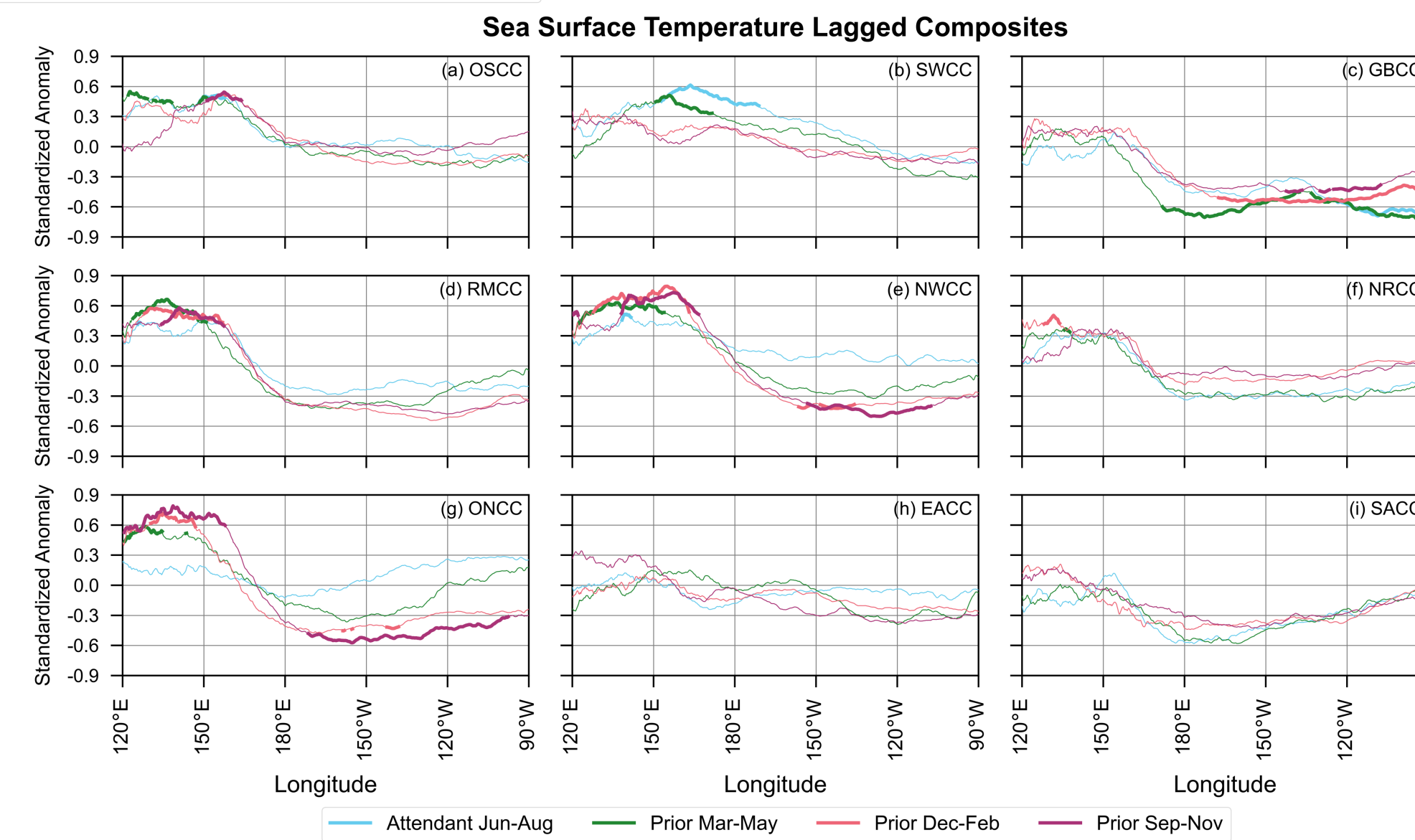
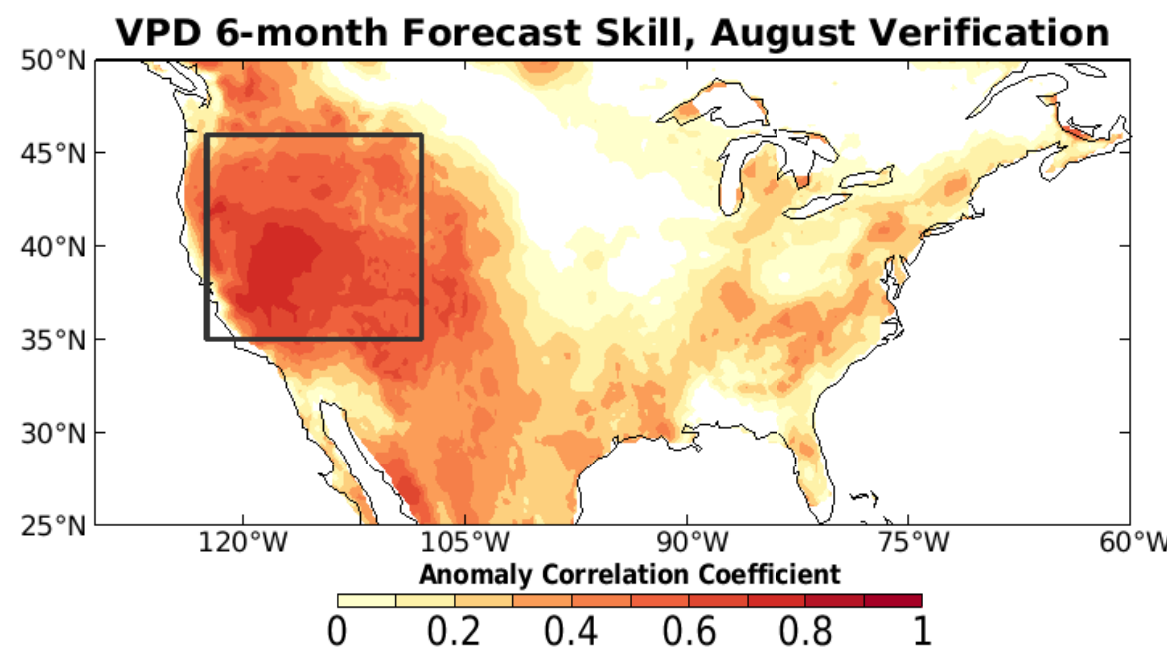


Fig 4 (above): Average SST anomalies (left) and average standardized 2m VPD anomaly (right) 3 months prior to the East Troublesome fire

- La Niña signal and elevated VPD preceded the East Troublesome fire
- Not shown: Elevated temperatures and lower precipitation; See https://psl.noaa.gov/fire_weather/historical/ for more conditions related to large US fires!

Seasonal VPD Prediction

Fig 5: Anomaly correlation coefficient (ACC) for LIM-based VPD hindcasts, August initializations 1958–2022.



LIM VPD forecasts have peak skill in Jul-Aug-Sep and display skill higher than persistence for most lead times.

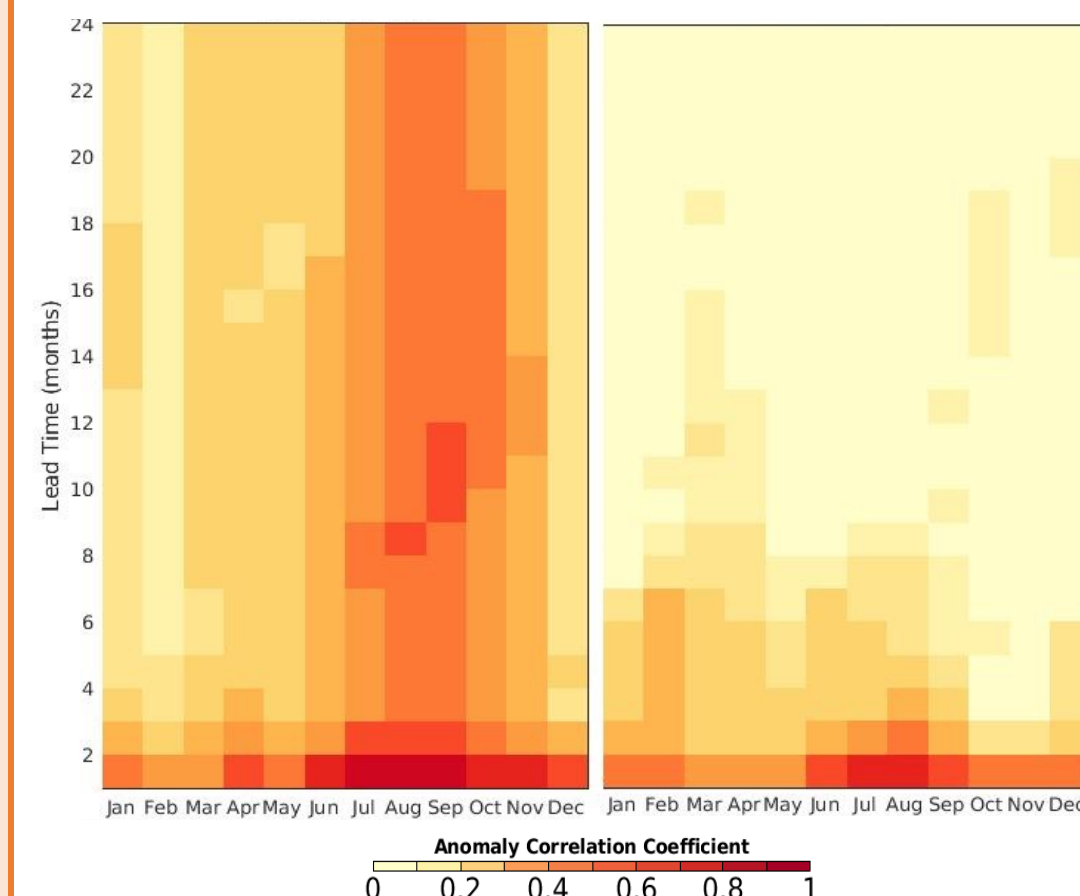


Fig 6: Area-averaged ACC from LIM (blue) and persistence (orange) hindcasts.

A detrended LIM has reduced skill at long lead times, but skill remains up to six months for verification months Jan – Sep.

Fig 7: Area-averaged ACC from LIM as a function of lead time and verification month, for a LIM including the trend (left) and detrending prior to LIM training (right).

Conclusions

- La Niña precedes large Western US wildfires by at least six months in some regions, enhancing the effects of low precipitation, elevated VPD and higher temperatures.
- New website displays antecedent climate conditions for the largest fires in each GACC region.
- A linear inverse model produces seasonal VPD skill greater than a persistence forecast at > three month lead times.
- VPD skill is dominated by a long-term warming trend, though skill remains up to six months after trend removal.

References

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