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Meteorological environments associated with California wildfires and their roles in wildfire changes during 1984-2017

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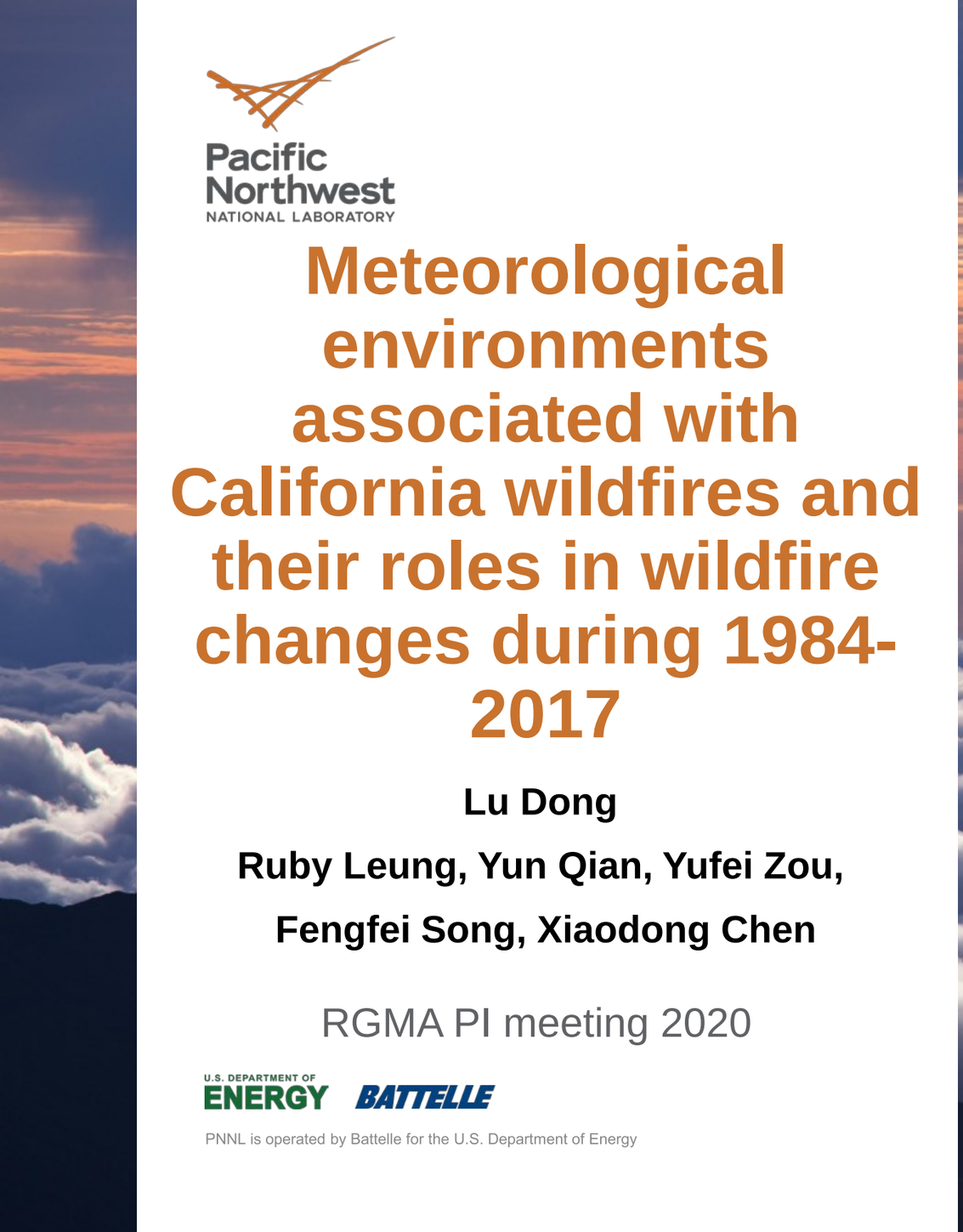
RGMA PI meeting 2020



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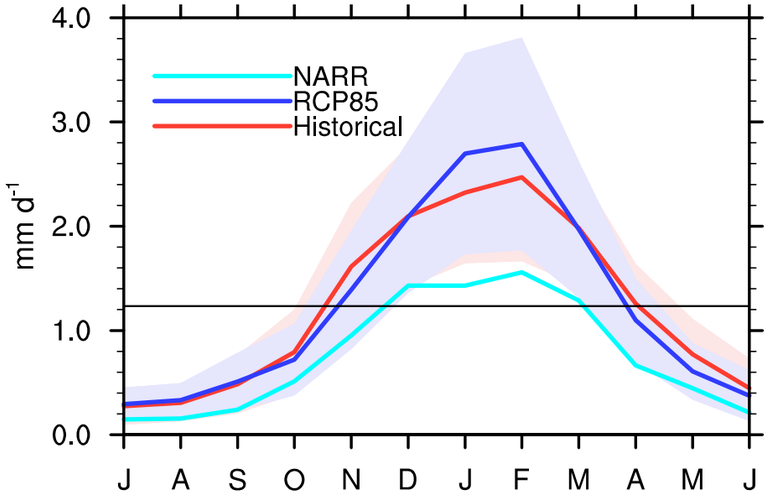
Motivation

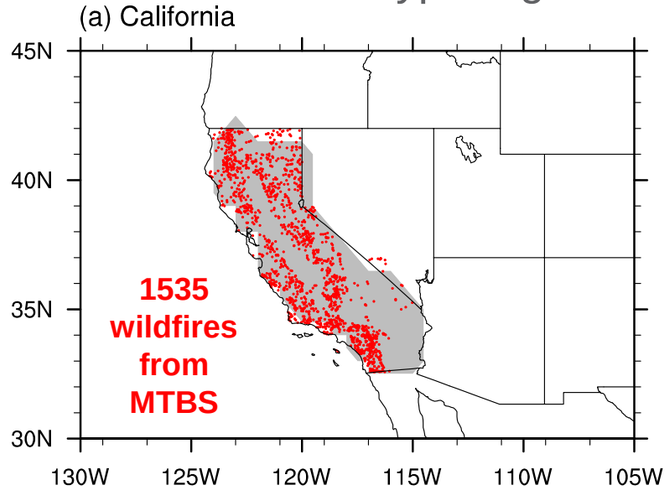
Frequent wildfires in California occur during summer and fall.

Seasonal cycle of California precipitation



Wet winter and dry summer

Mediterranean-type region

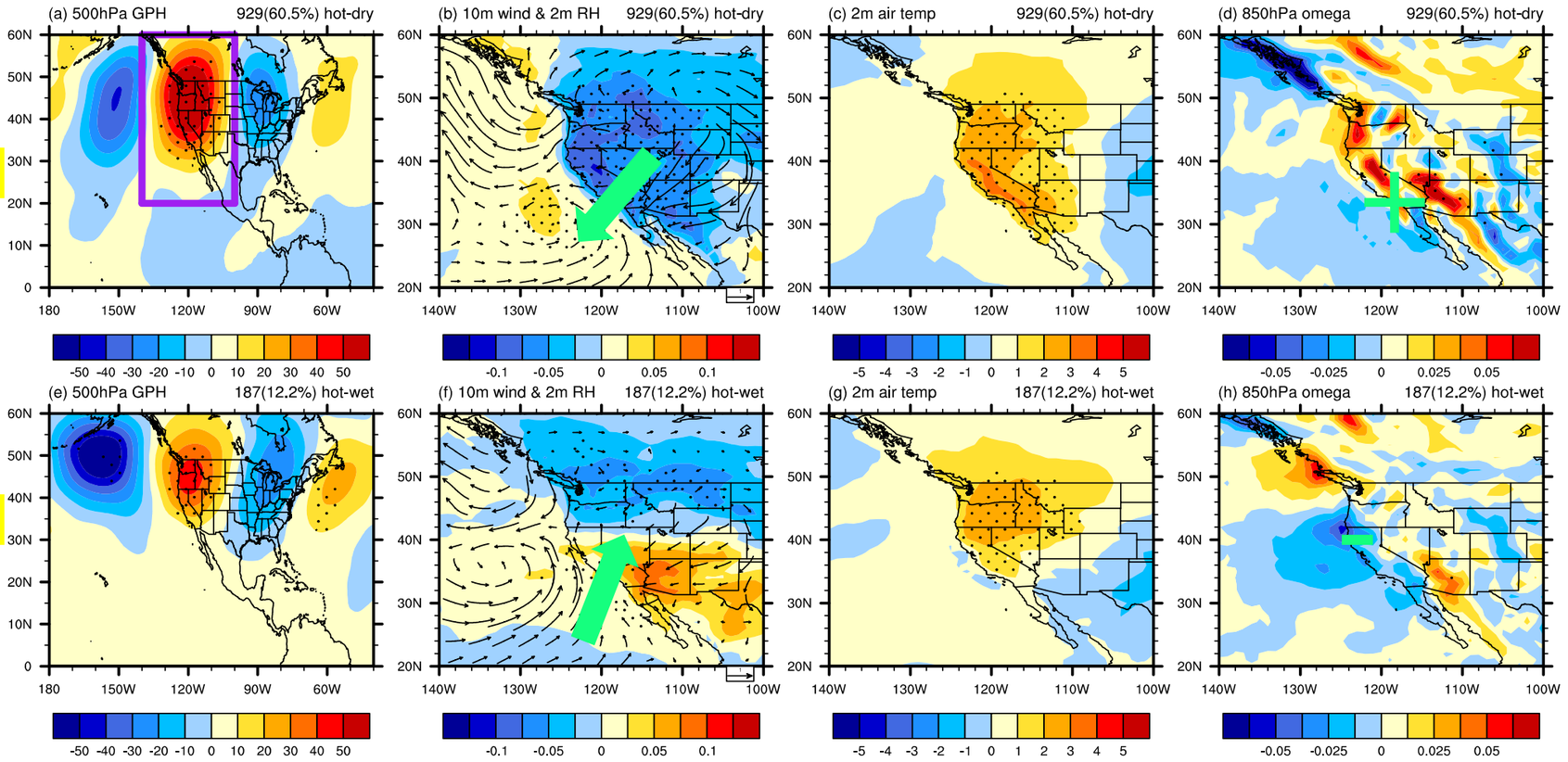


- **California has experienced more wildfires in recent years, resulting in huge economic losses and threatening human health.**
- **Meteorology** (weather/climate) is the most important natural factor influencing the ignition, growth, and death of wildfires (Flannigan et al. 2000; Hely et al. 2001; Sedano and Randerson 2014; Coffield et al. 2019).
- **Clarifying the meteorological environments of wildfires is foundational to improving the understanding and prediction of wildfires and their impacts.**

Large-scale and regional environments associated with California wildfire occurrences

Hot-dry: 60.5%

Hot-wet: 12.2%



Dotted areas indicate that at least 70% of the wildfires agree on the sign of anomalies.

- **About 60% of wildfires in 1984-2017 occur under hot-dry conditions with high pressure, strong northeasterly wind from inland and downdraft.**
- **Hot-wet conditions account for 12% of wildfires with southerly onshore flow, anomalous convection, precipitation, and lightning flashes.**

Wildfire changes during 1984-2017

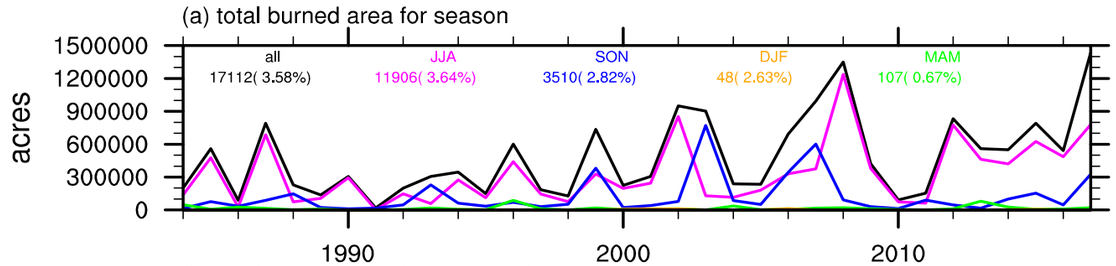
- **Annual burned area by wildfires have significantly increased by ~3.6% per year, indicating a doubling of burned area in 2017 relative to 1984, dominated by hot-dry wildfires in summer.**

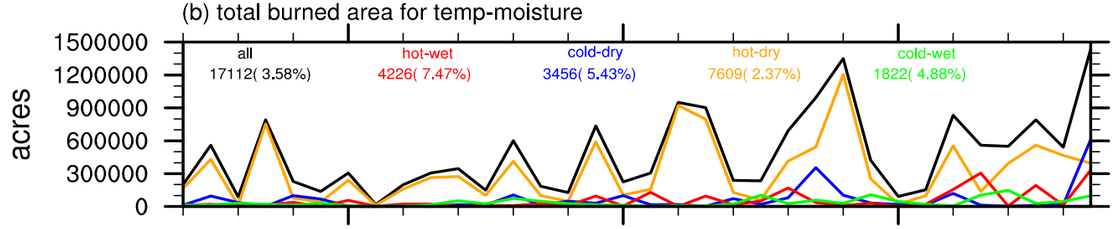
- **Summer (JJA): warming and drying + high pressure strengthening →**

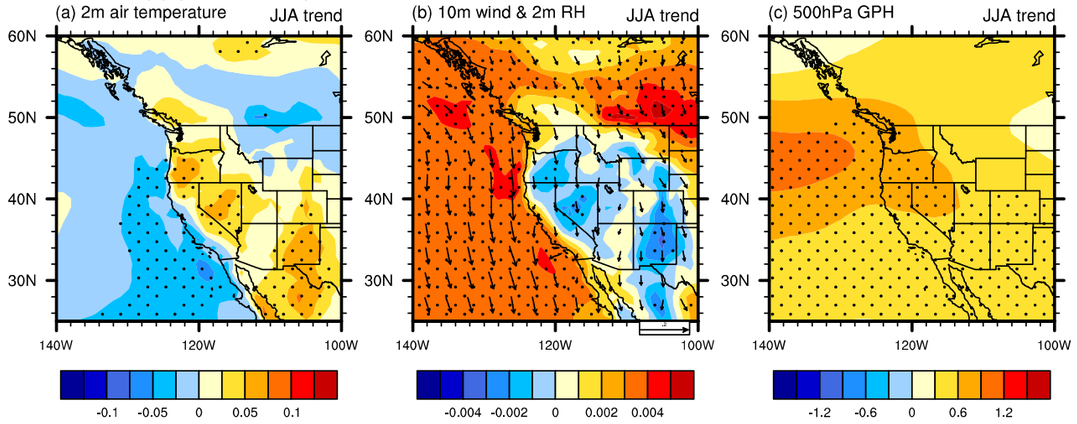
  more and larger hot-dry wildfires in summer

- **Increasing lightning →**

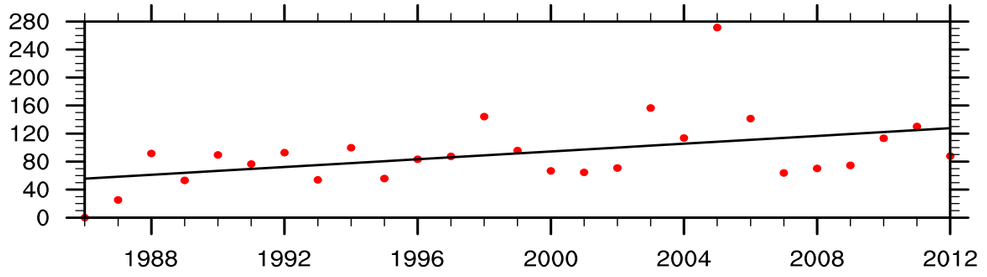
  more hot-wet wildfires







Lightning count over CA



Research and opportunities in the future

- **3-5 years:** (1) Adopt and improve a storyline approach to study the role of climate change in the increased wildfires in recent years over California and constrain future projections of wildfire changes. (2) Use machine learning and numerical models to understand and quantify the sources of predictability for wildfires.

- **5-10 years:** A prediction system needs to be established for California wildfires based on the preceding atmospheric and oceanic conditions.

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Questions?

Thank you

Data

Fire data:

1535 California wildfires from satellite remote sensing provided by the Monitoring Trends in Burn Severity Project (MTBS) during 1984-2017 are systematically investigated.

Lightning data:

Lightning flash count per day is obtained from National Lightning Detection Network (NLDN) over 1986-2012.

Meteorological anomalies:

Daily meteorological data is from ERA-Interim at a resolution of 1° × 1°.

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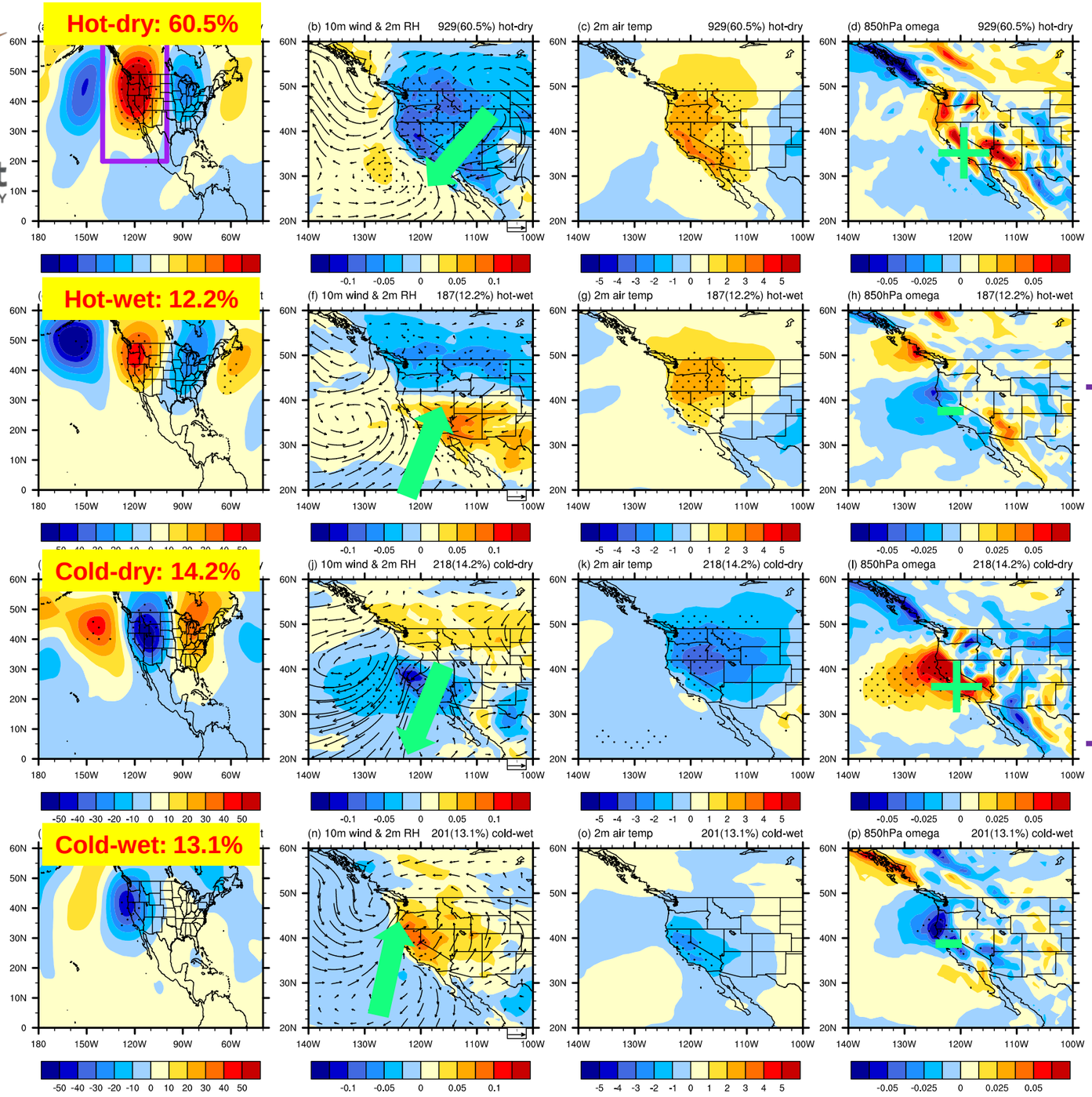


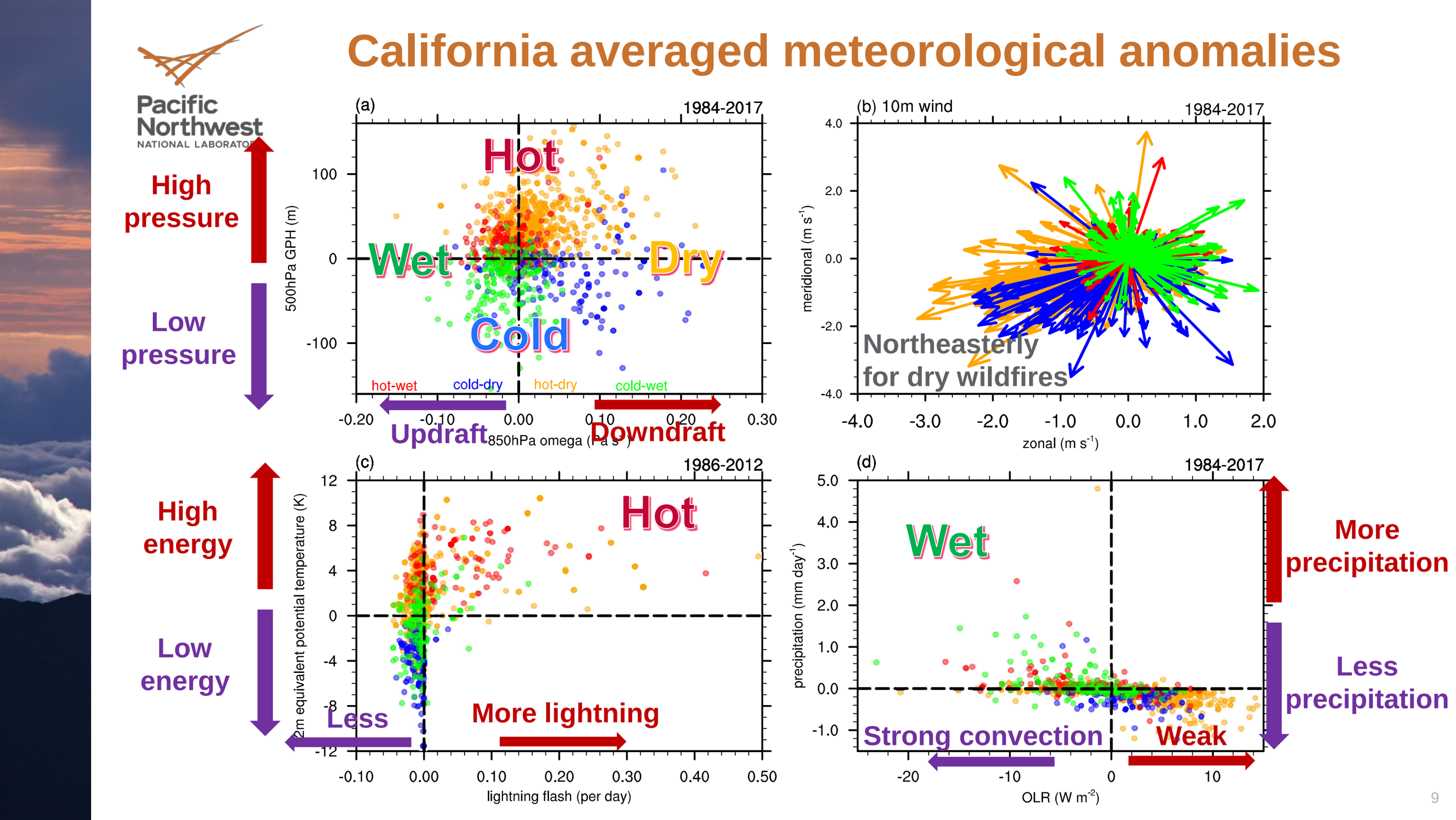
Dotted areas indicate that at least 70% of the wildfires agree on the sign of anomalies.

Large-scale and regional environments associated with California wildfire occurrences

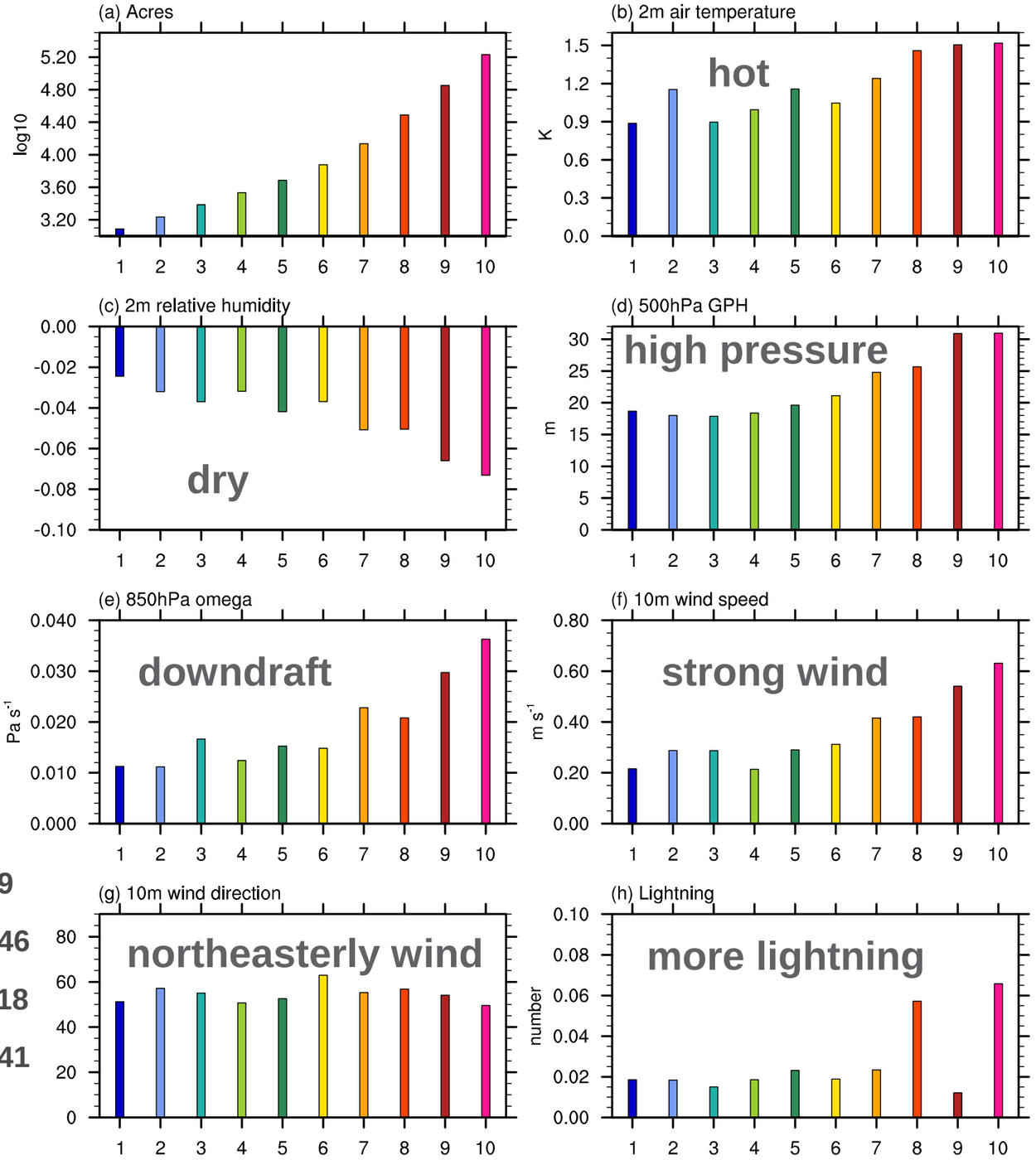
opposite

What kind of meteorological environments contributes to wildfires?

California averaged meteorological anomalies



Relationship between meteorological anomalies and wildfire sizes



- 1-10 bins classified by acres:

1000~1500: 320

1500~2000: 210

2000~3000: 230

3000~4000: 137

4000~6000: 164

6000~10000: 149

10000~20000: 146

20000~50000: 118

50000~100000: 41

>100000: 20

Ridge regression

	ta	qa	Wind speed	Wind direction	lightning
size	0.66	**-13.6**	1.36	0.002	4.63

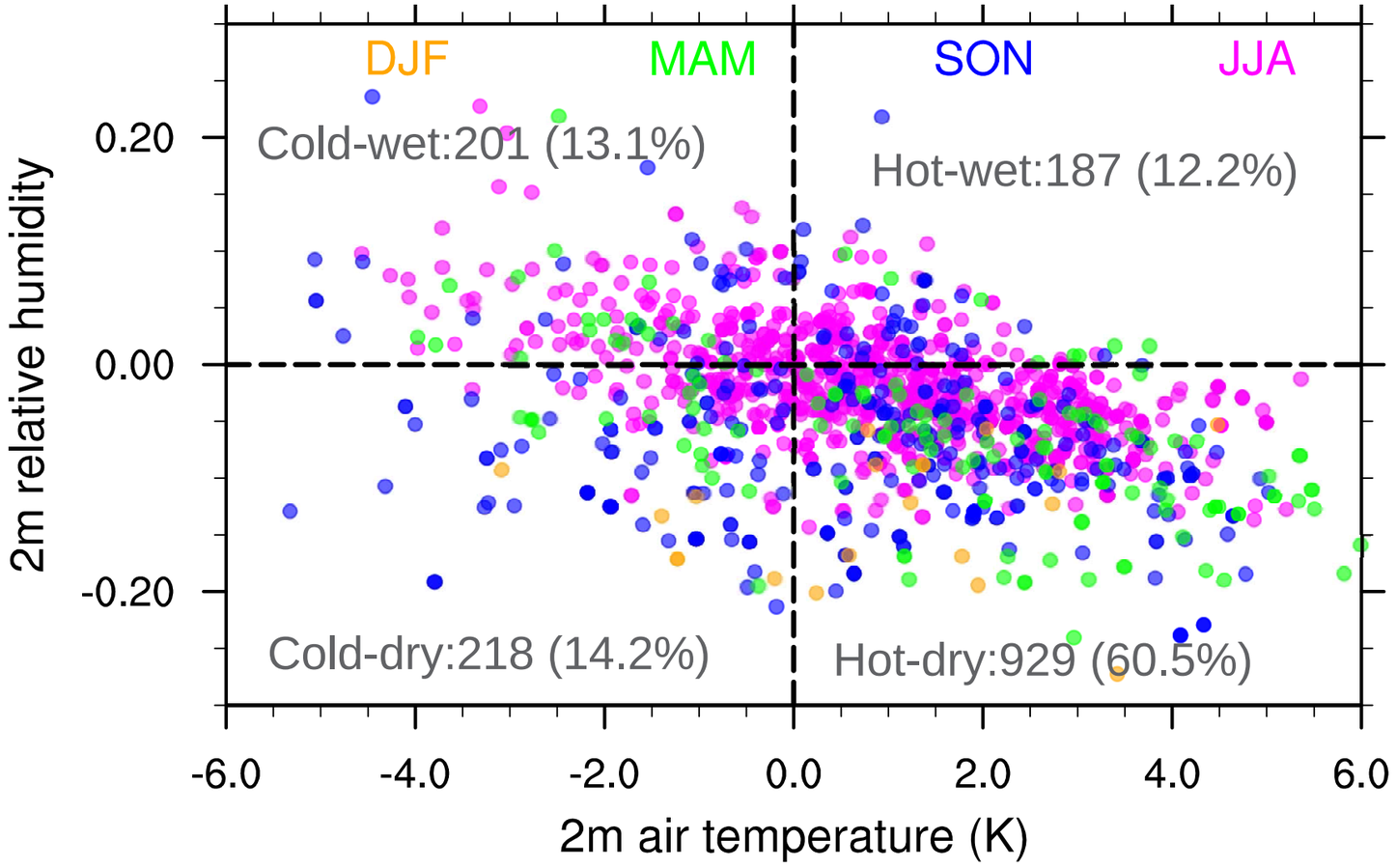
- The regression coefficients are for the normalized variables.

partial correlation coefficient

	ta	qa
size	0.37 (14%)	**-0.83 (69%)**

Wildfire size mainly depends on moisture (relative humidity).

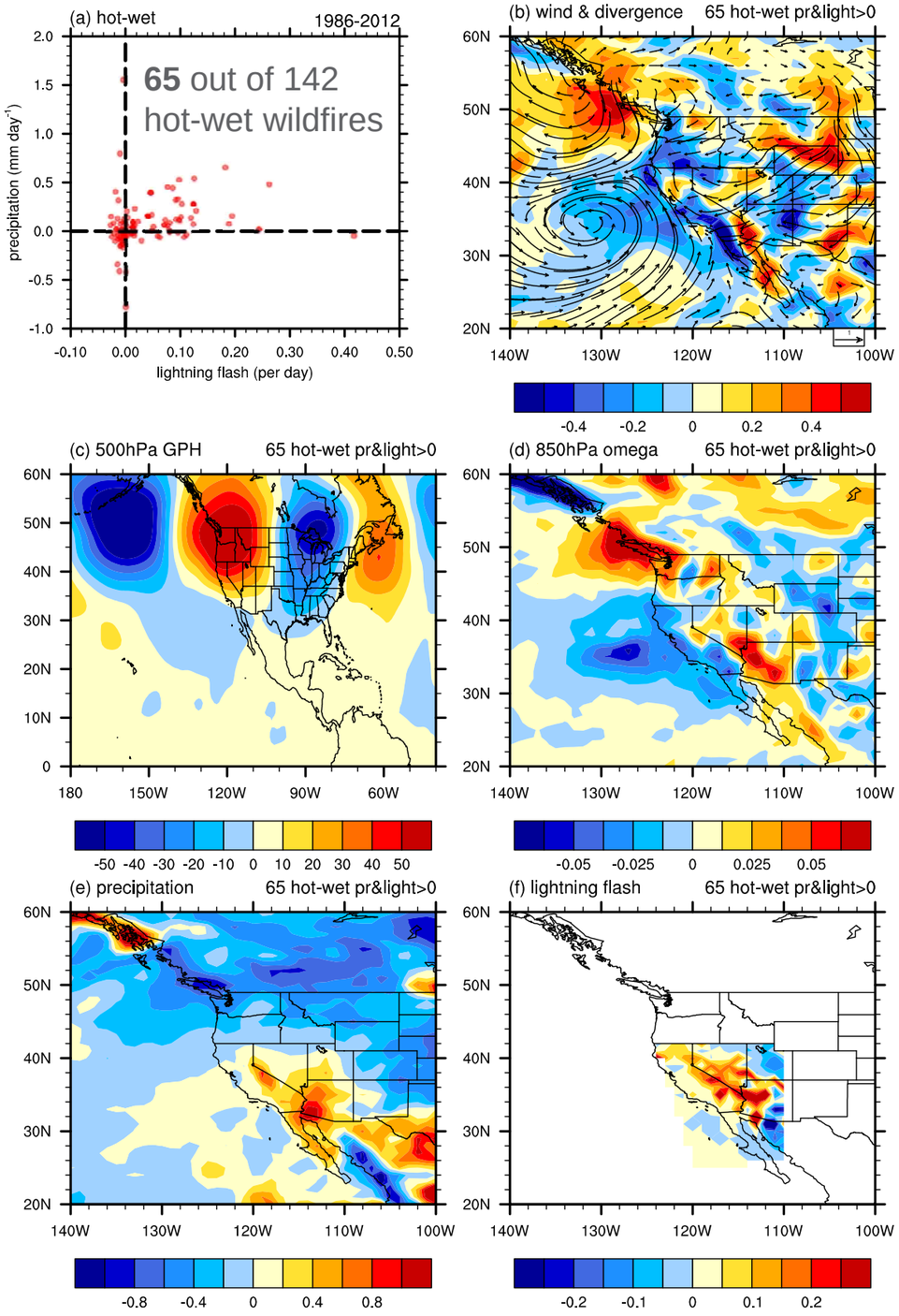
Temperature anomalies vs. moisture anomalies for wildfire days



- **Most wildfires in California happen in summer and fall.**
- **Wildfires can occur on both warm and cold days, as well as wet and dry days.**
- **Most (60.5%) wildfires occur on hot-dry days.**
- **Except for the dominance of hot-dry days, the likelihood of wildfires occurring on cold-dry, cold-wet, and hot-wet days is similar.**

Anomalies are created by subtracting the climatological mean for each day over 1984-2017 at each grid.

Composite for hot-wet wildfires with more precipitation and lightning flashes



➢**Meteorological anomalies of the 65 wildfires are in general consistent with, but stronger than, those of all hot-wet wildfires.**

Southerly onshore flow and wind convergence

↓

Anomalous updraft

↓

Hot-Wet condition ← **High pressure**

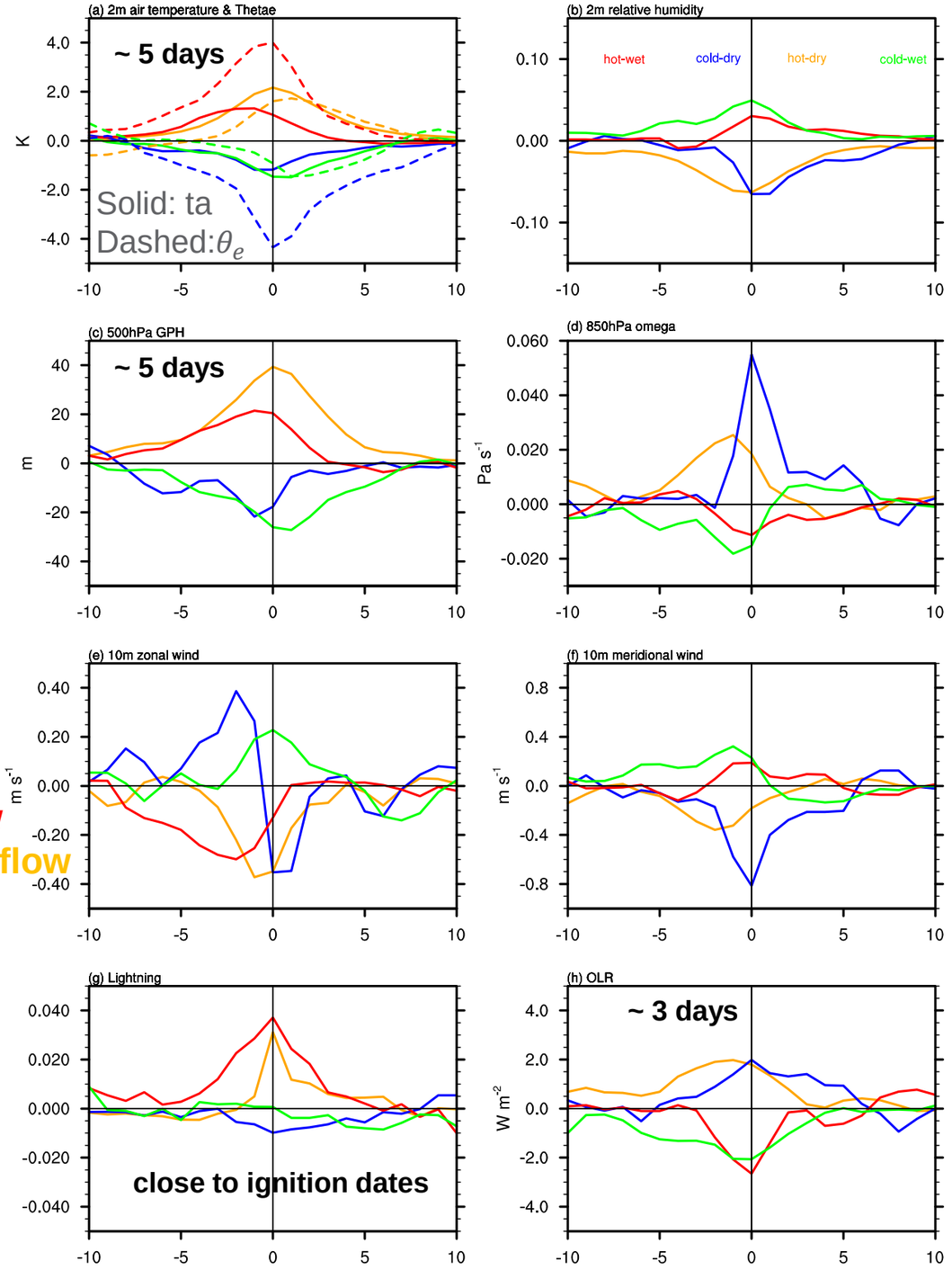
↓

more precipitation and lightning

↓

wildfire occurrence

Meteorological signals as precursors for wildfires



southerly onshore flow

northeasterly offshore flow

- **Persistent positive GPH anomalies, anomalous onshore (offshore) flow and enhanced (suppressed) convection over California are possible precursors for hot-wet (hot-dry) wildfire occurrence.**