A Real Time Fire Weather 8-14 Day Outlook Tool based on NCEP GEFS

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The Context …

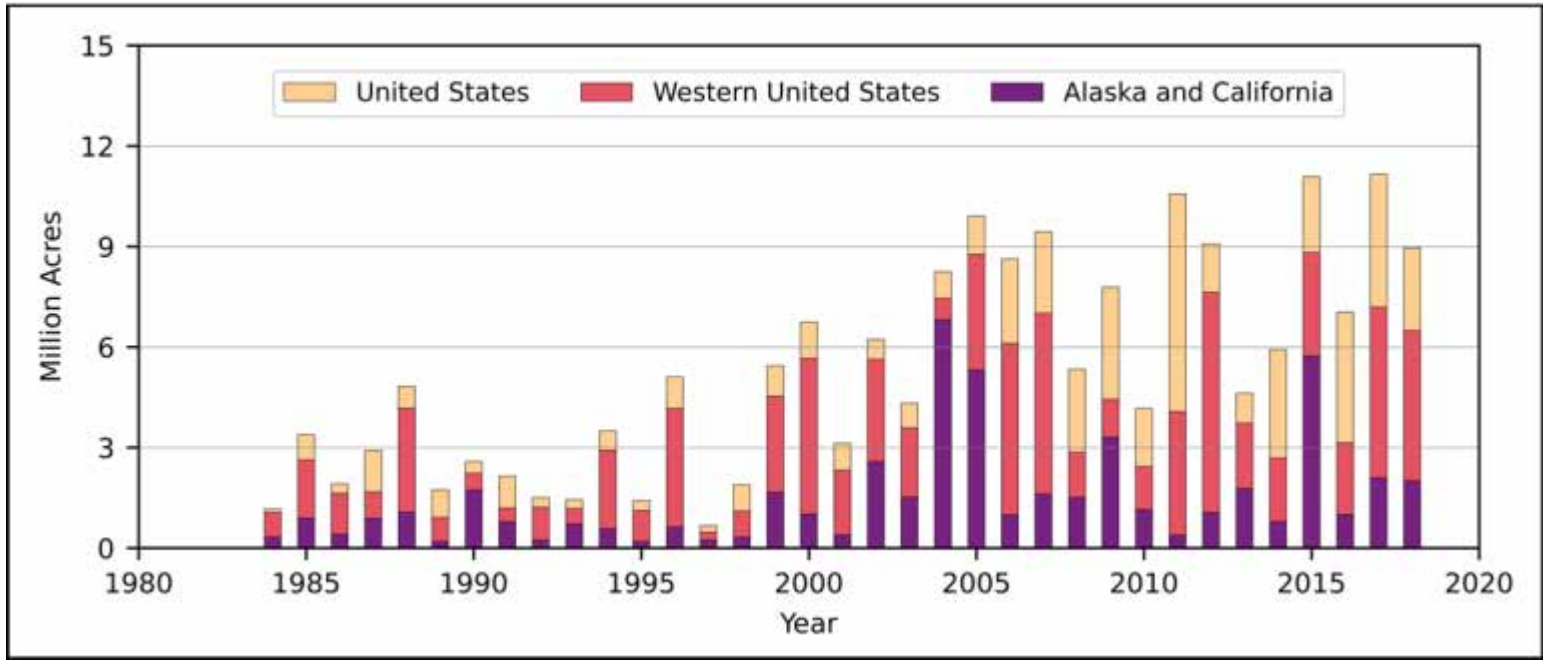


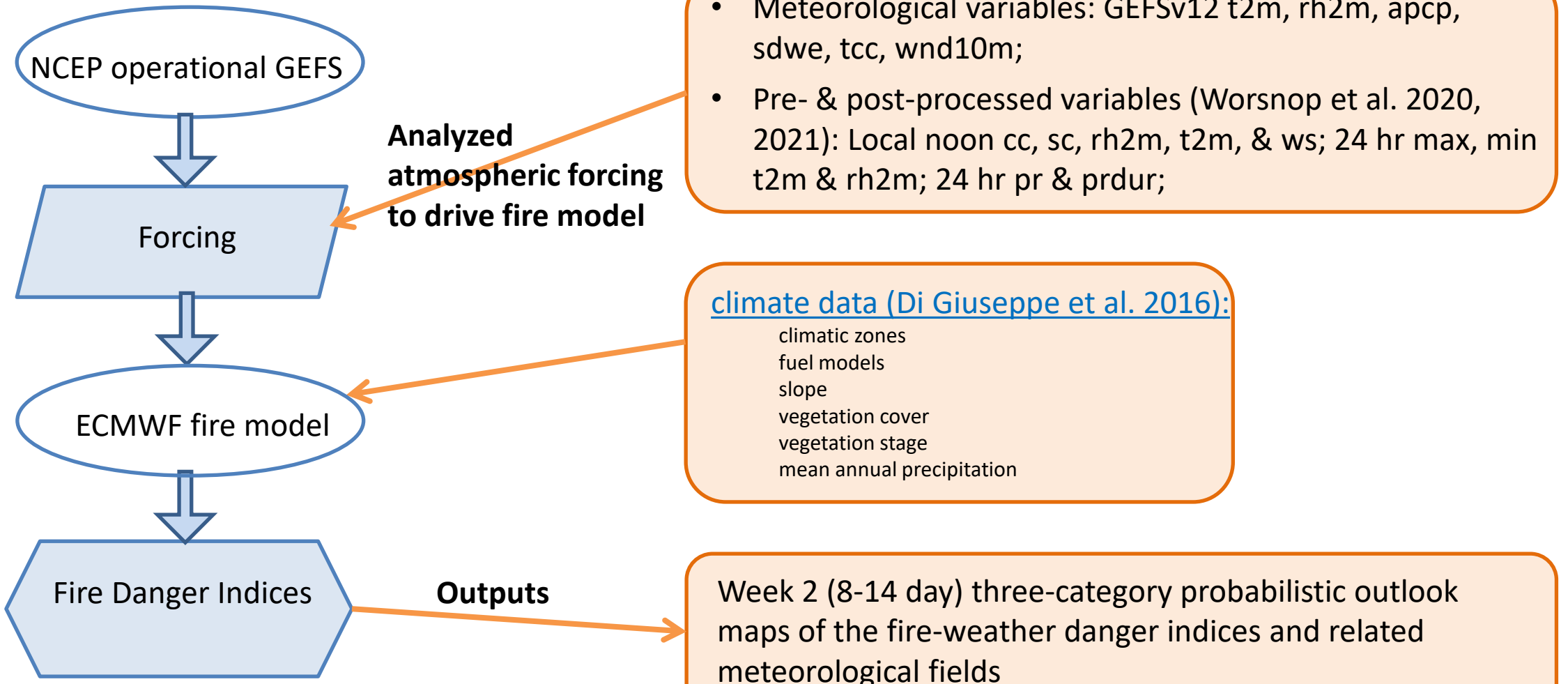
Fig. 1. Annual area burned from 1984 to 2018 in the United States in total, in the western United States, and in Alaska and California combined based on data from the federal Monitoring Trends in Burn Severity database. (Fu et al. 2021)

- Frequency and scale of wildfires have been increasing in the past decades worldwide (Jolly et al. 2015; Wang et al. 2021; Fu et al. 2021).
- Skillful forecasts of fire danger conditions can provide early warning information.
- CPC has implemented a real time fire weather week 2 outlook tool since Aug. 2021.

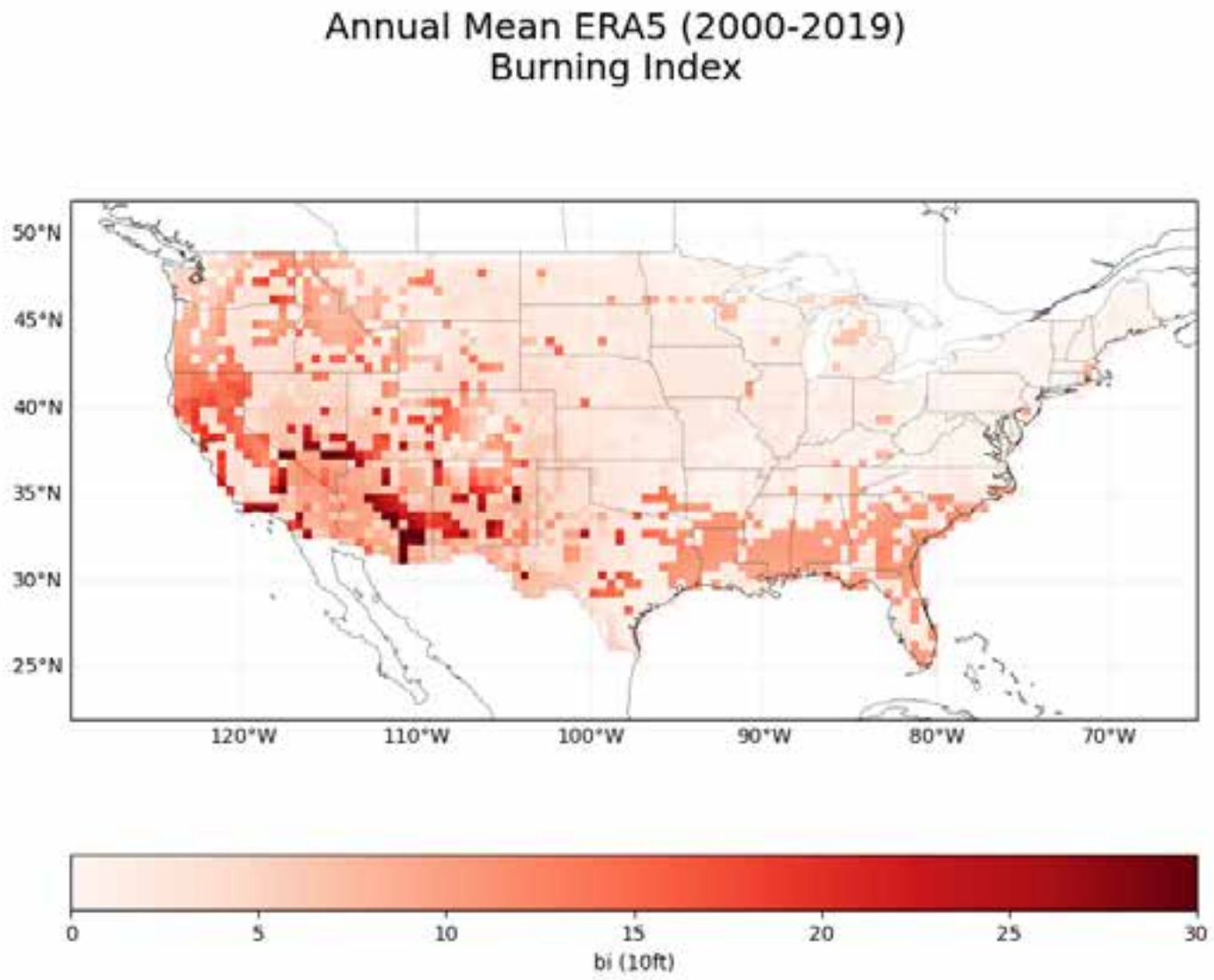
The Week 2 Fire Weather Outlook System

- The outlook system was developed by NOAA Physical Sciences Laboratory (PSL).
  - Provide state-of-the-science, reliable, skillful 8-14 day (week 2) guidance on wildfire potential hazards (Worsnop et al. 2020, 2021).
  - Use the Global ECMWF Fire Forecast (GEFF) model (Di Giuseppe et al. 2016) to simulate the fire danger indices.
- The outlook tool was implemented at CPC.
  - Run the outlook system on a real time basis.
- Potential customers:
  - NWS Fire Weather Program and Incident Meteorologists, National Interagency Fire Center and National Interagency Coordination Center, and other CPC customers.

Steps to Generate Fire Danger Indices



Wildfire Danger Indicator – Burning Index



- The fire danger indices outputted from the fire model are based on interactions among atmospheric conditions, topography, and the state of vegetation and fuels.
- Measure the potential effort to control a wildfire if one started.
- BI -- the flame length in feet at the head of the fire (x10Ft).

Annual Cycle Daily Mean BI ERA5 (2000-2019)

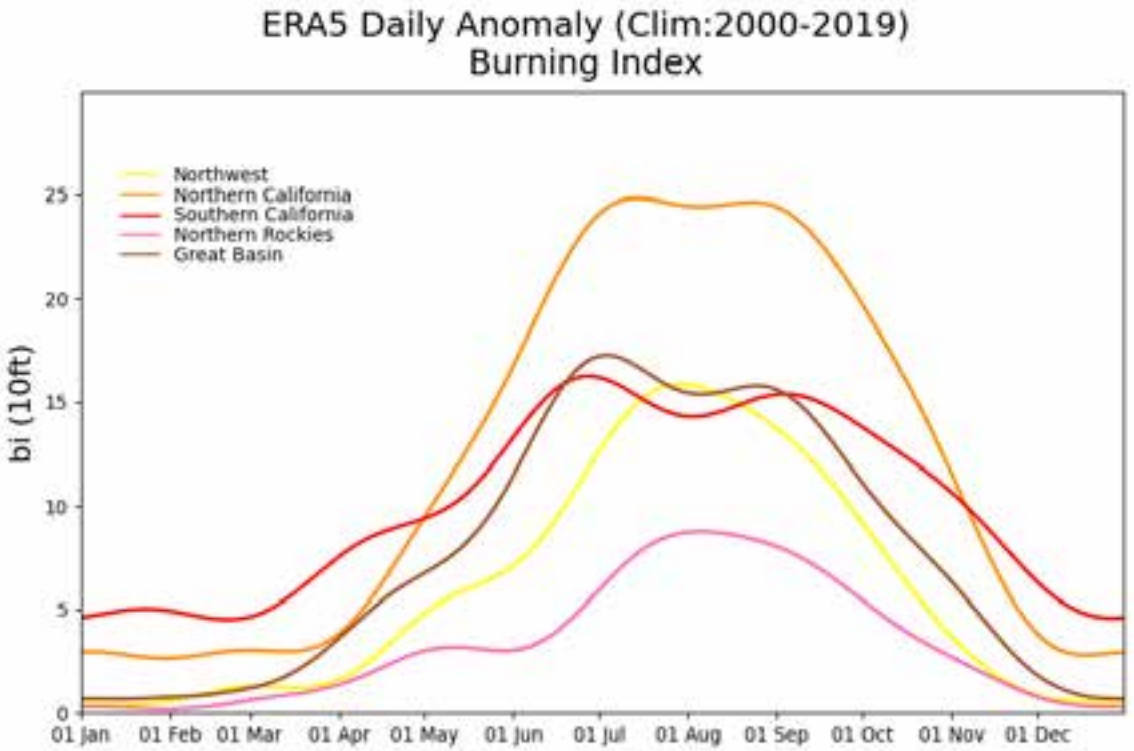
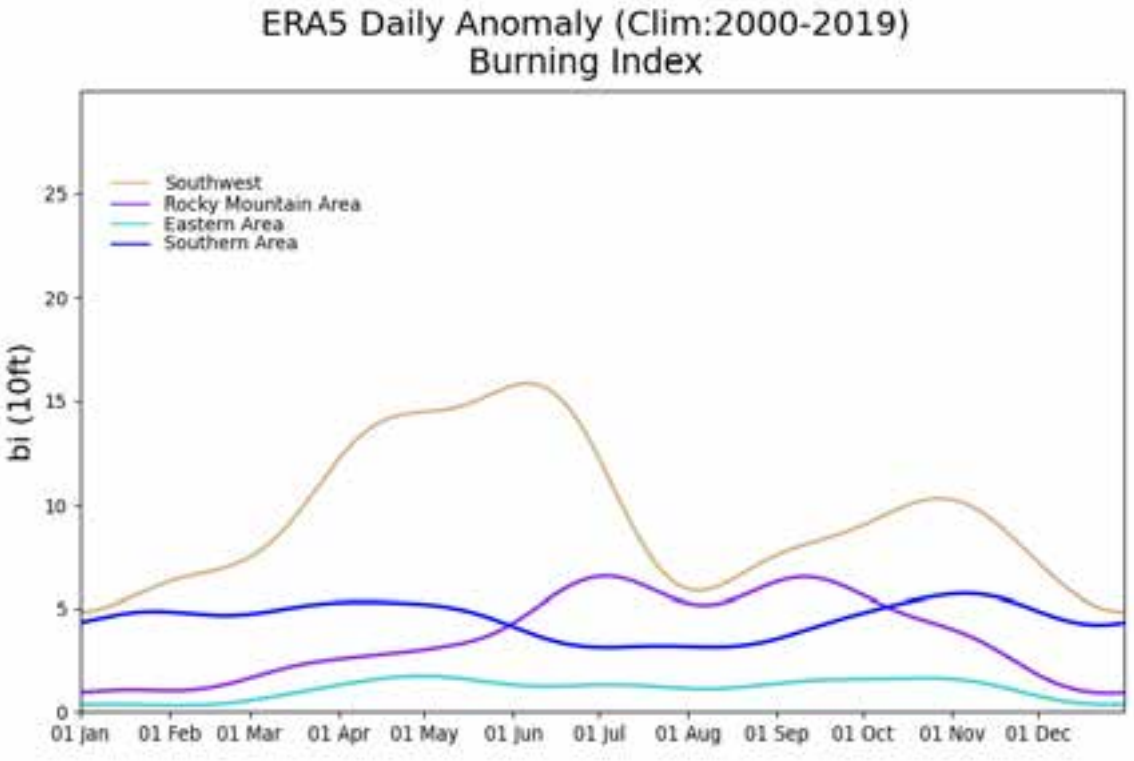


Fig. 2. The nine GACC regions within the contiguous United States (Worsnop et al. 2021)

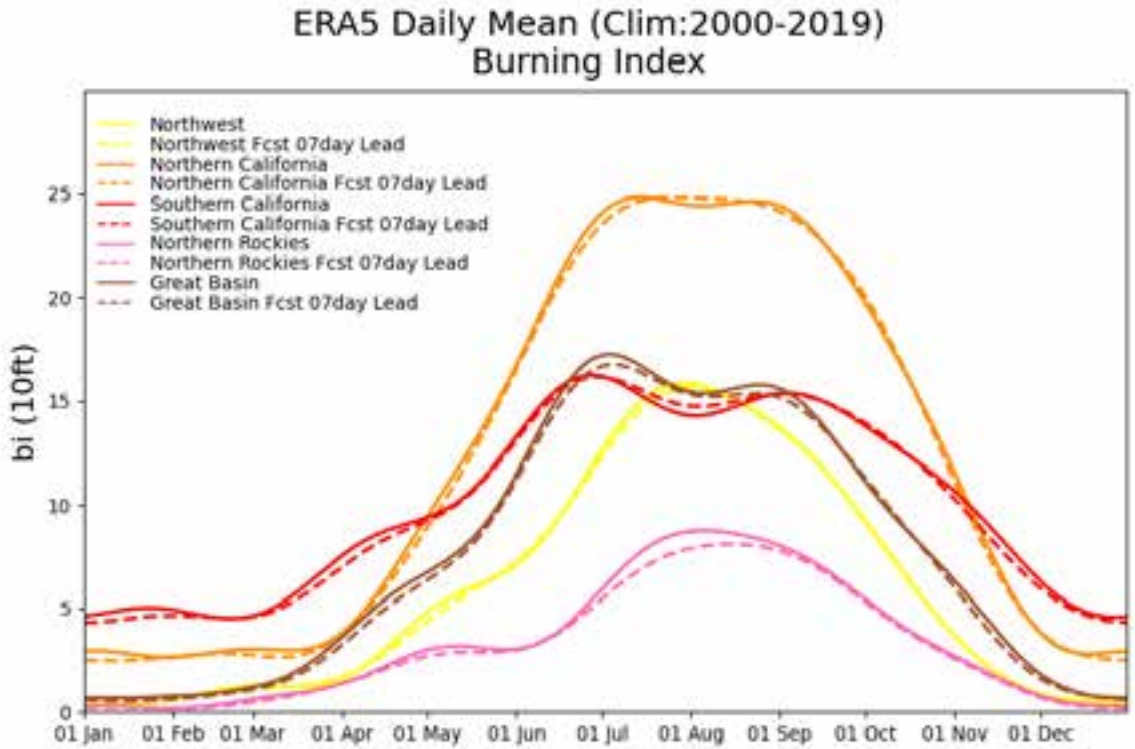


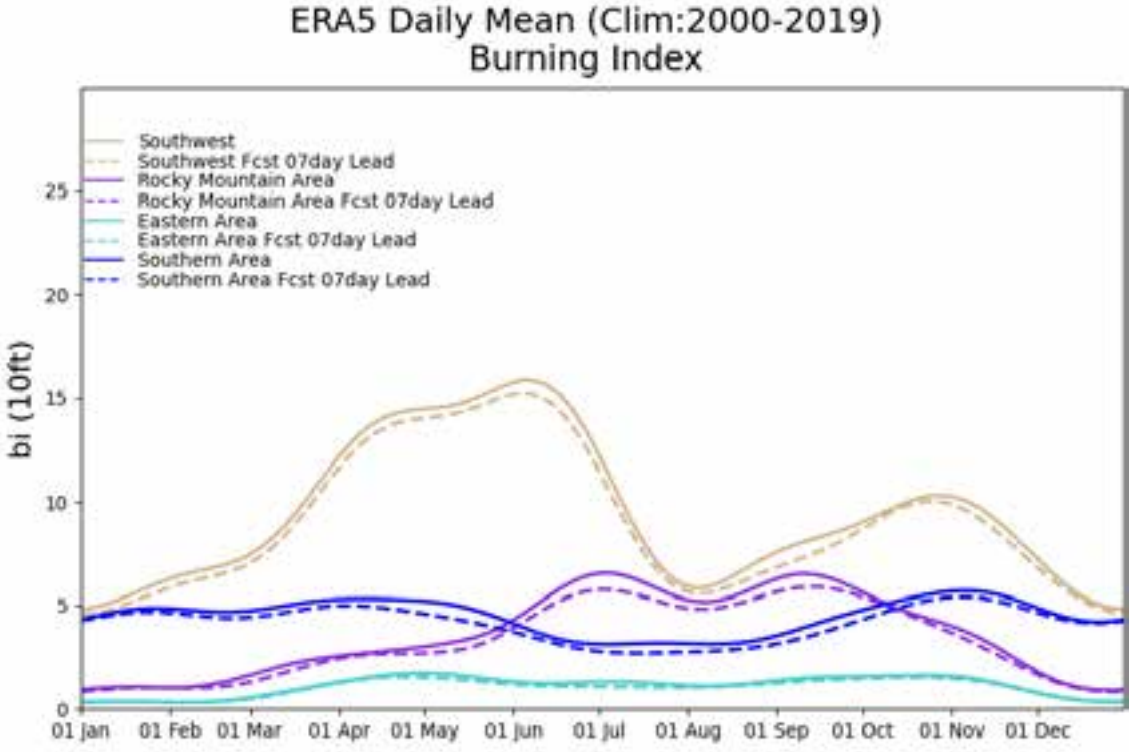
Fire Weather Week 2 Forecast Skill Assessment

- Skill in reproducing the fire danger index value:
  - Comparing the fire danger index week2 forecast with that from ERA5 analysis

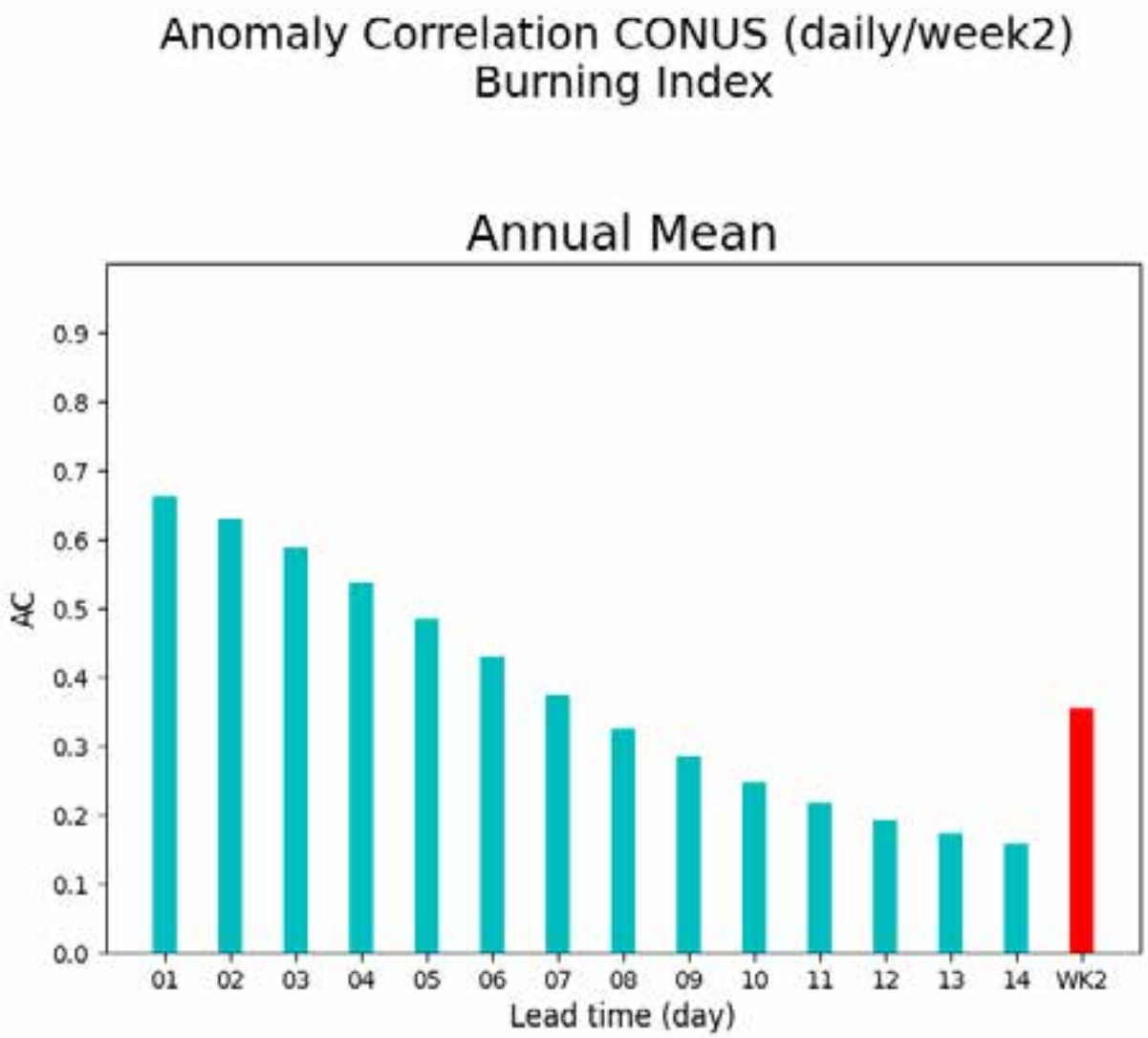
- Skill in detecting fire events:
  - How well does the fire danger index forecast match the occurrence of actual fires?

Skill in Reproducing Burning Index (BI) -- Biases



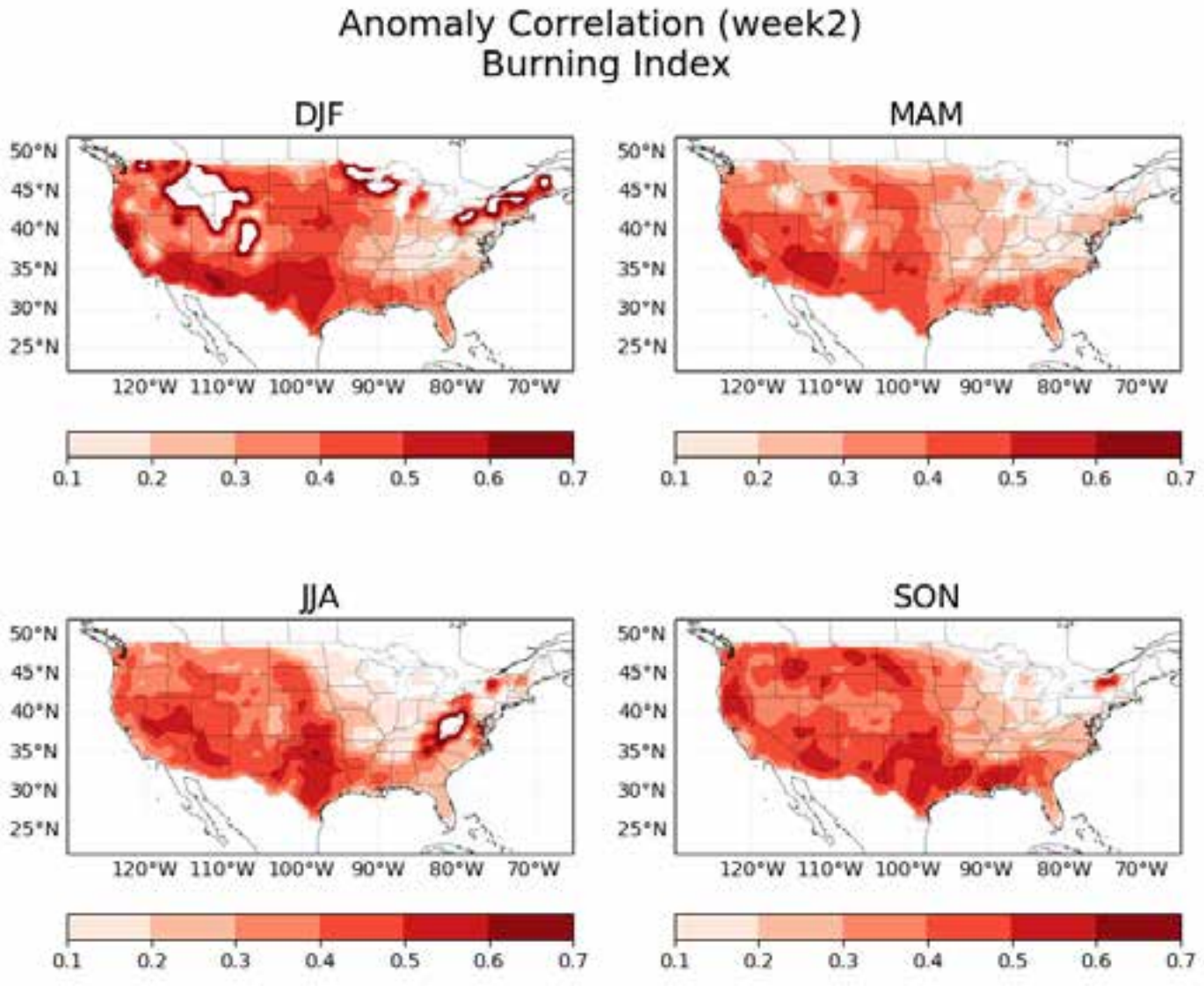


Skill in Reproducing Burning Index (BI) -- Correlation



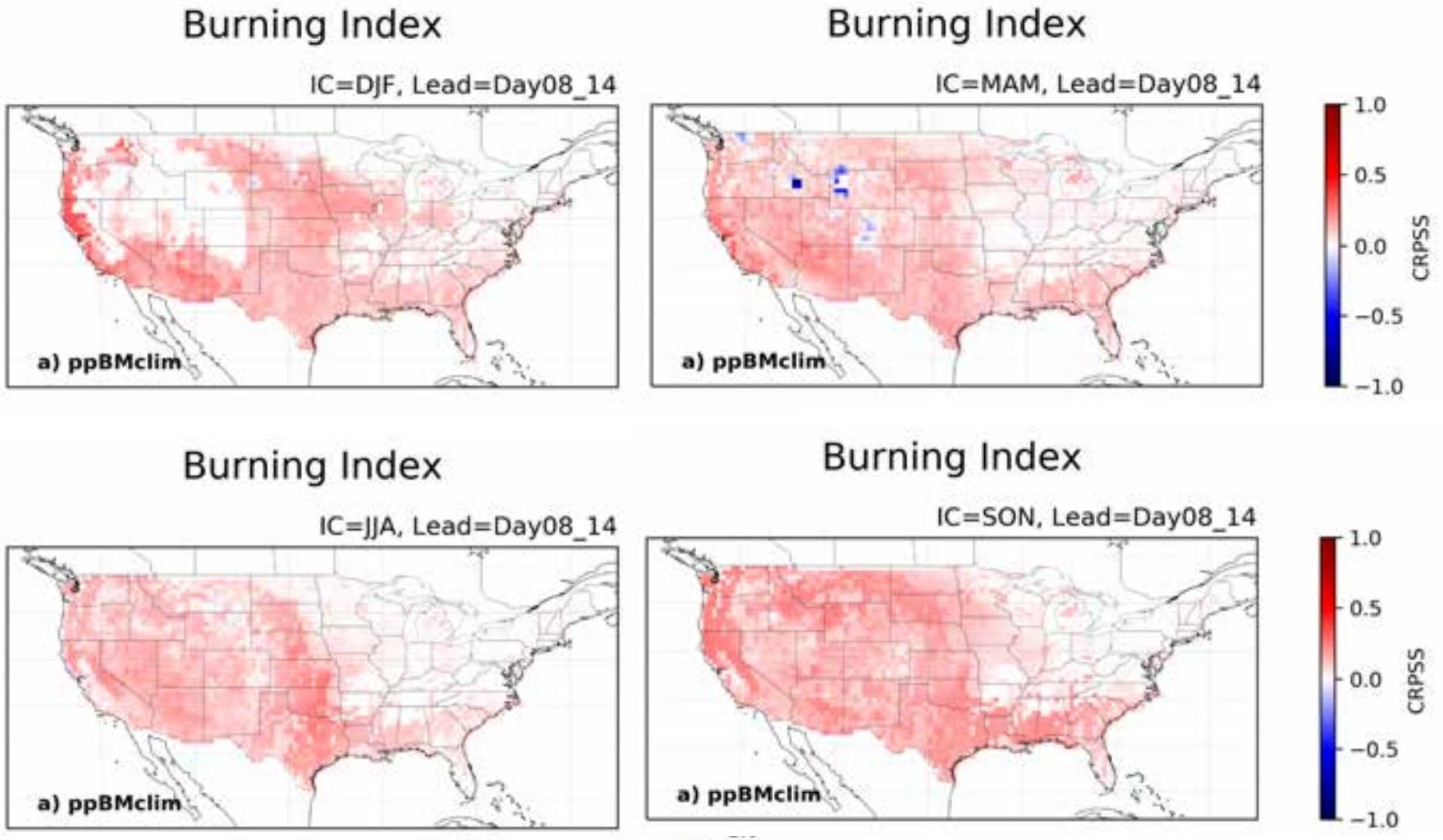
- GEFSv12 vs ERA5, 2000-2019;
- Daily forecast as lead time;
- Week2 forecast (8-14 days);
- Averaged over the CONUS;

Skill in Reproducing Burning Index (BI) -- Correlation



- GEFSv12 vs ERA5, 2000-2019;
- Seasonal variations of week2 forecast anomaly correlation skill;
- Skills are generally higher over regions of large BI;

Skill in reproducing Burning Index (BI) -- CRPSS

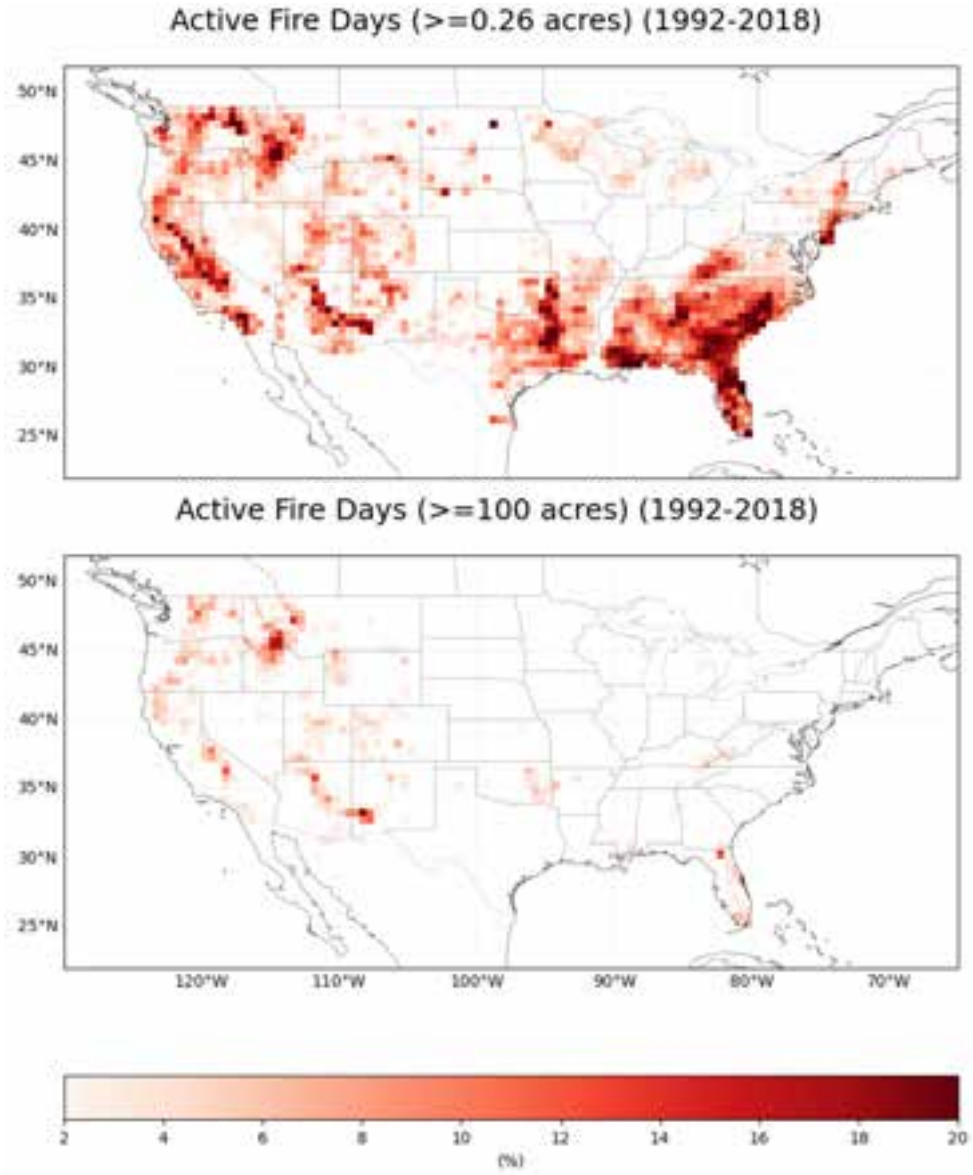


- GEFSv12 vs ERA5, 2000-2019;
- Week2 forecast CRPSS in each four seasons;
- Benchmark forecast of climatology;
- Skills are generally higher over regions of large BI

Skill in detecting fire events:

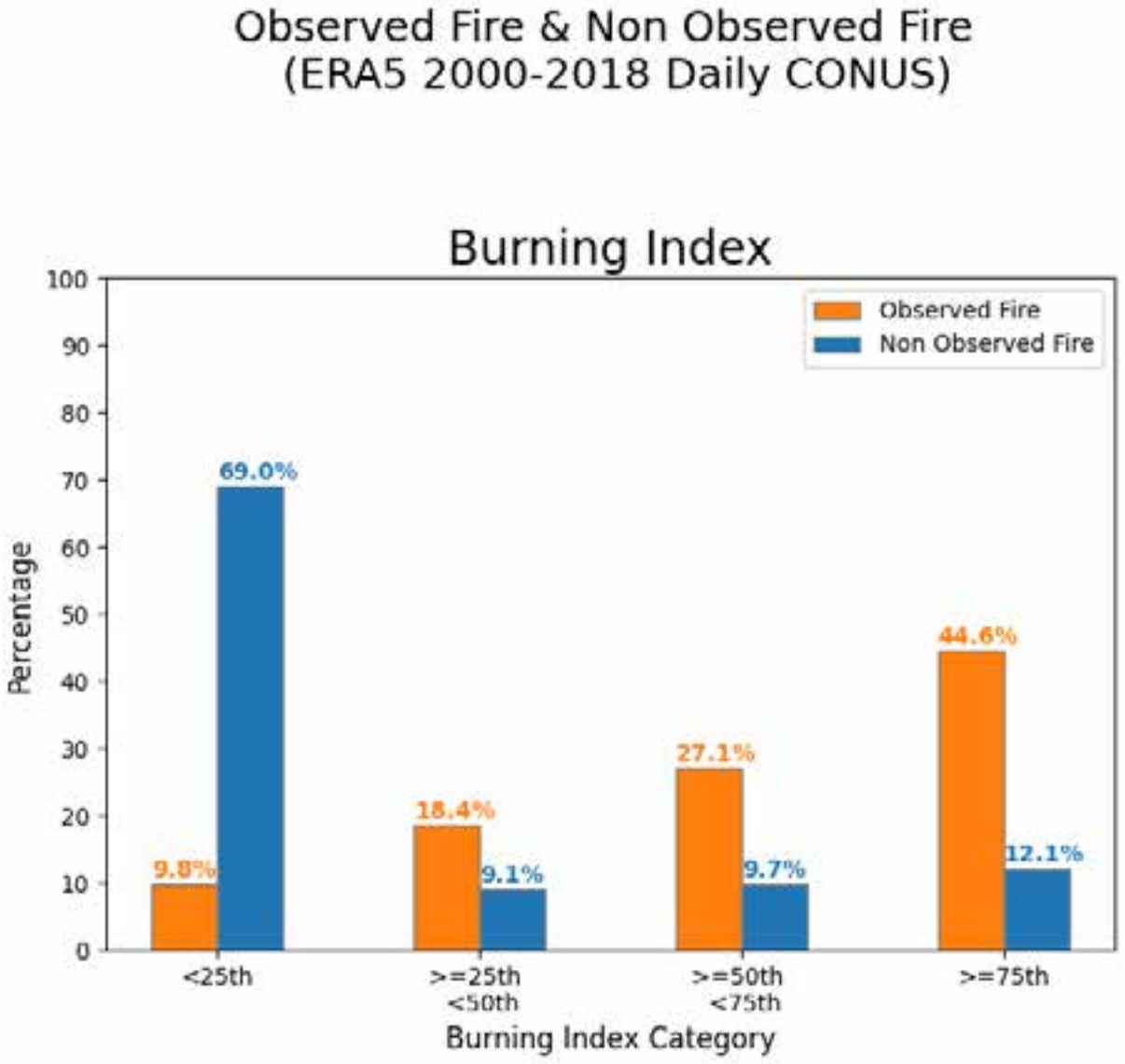
- How well does the fire danger index forecast match the occurrence of actual fires?

Observed Active Fire Days in a Year



- Percentage of observed fire days in a year;
- Averaged in 1992-2018;
- Allocated into 0.5deg grid box, ~50kmx50km ~12,500 acres;
- 2% ~7days every year average;
- Data source: the USDA Fire Program Analysis fire-occurrence database (FPA_FOD) 5th Edition

Potential Predictability of Fire Danger



- BI being in any of four quartile intervals when a fire occurred (orange bars) and when it did not (blue bars).
- Daily BI from ERA5 2000-2018, aggregated over CONUS;
- A fire >10 acres is defined as an active fire, aggregated to 0.5deg grid box;
- >70% of fire events developed (not developed) in above normal (below normal) values of BI;
- A fire developed ~45% of time in the BI upper percentile;

Methodology to Assess Skill in Detecting Fires for Week 2 Forecasts

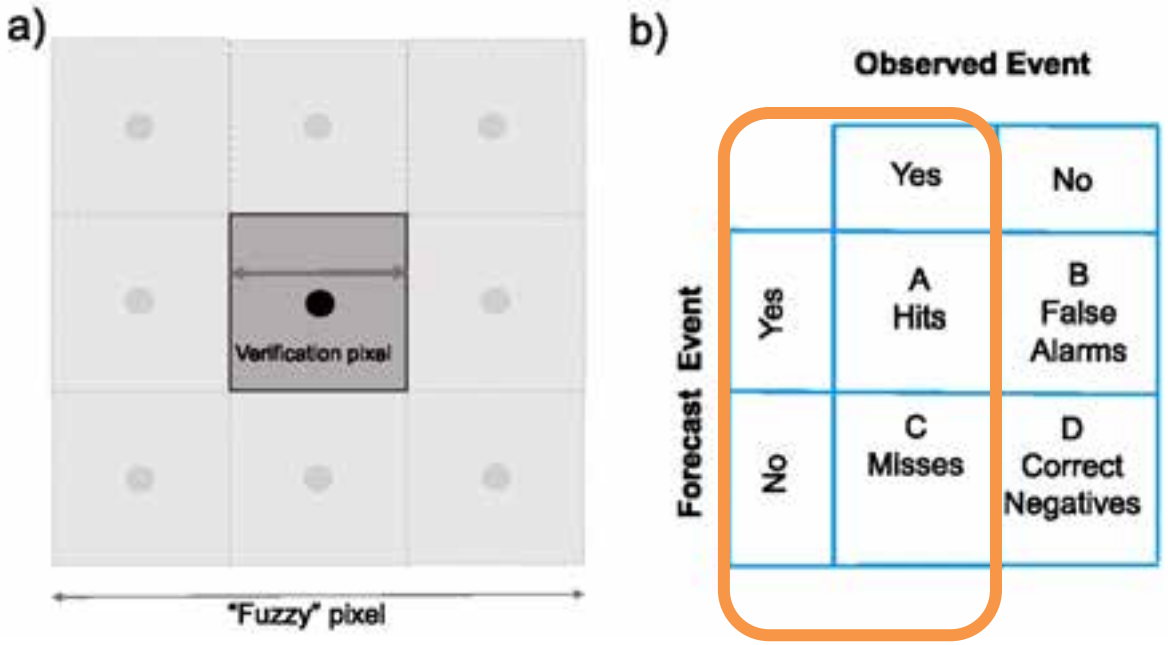


Fig. 5 Di Giuseppe et al. 2016

- Fires are rare events:

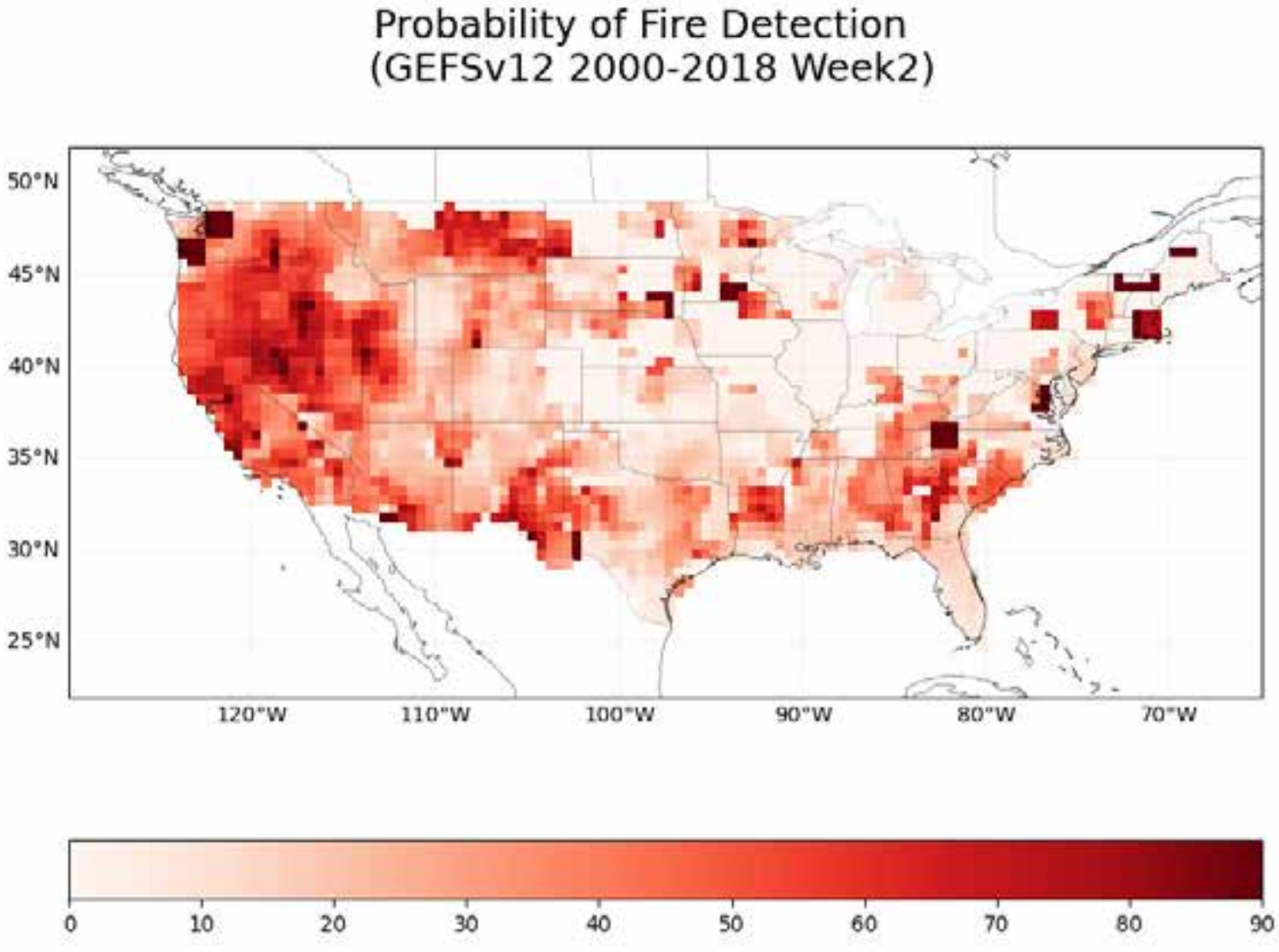
  POD = A/(A+C)

- The neighborhood high fire danger forecast adds useful information for emergency planning:

  A fuzzy approach (3x3 pixels around the verification point)

- BI>=75th percentile defined as forecast fire;
- Observation fire >10 acres defined as observed fire;

Probability of Fire Detection for Week 2 BI



Summary

- The week 2 fire-weather forecast system forced with the calibrated GEFSv12 meteorological variables show improved skill of the fire-indicator forecasts relative to the climatological forecasts.
- The system shows potential capability to flag out most of fire events (>70%) in the above normal conditions of simulated fire danger index.
- Week 2 forecasts are able to detect ~50% fire events over the relative fire active regions.
- The week 2 outlook tool can add potential useful early warning information for fire control strategic planning.

Future Work:

Explore possible reasons for those missed fire events in the forecasts;

Analyze selected major fire events;

Enhance the real time outlook monitoring system:

https://www.cpc.ncep.noaa.gov/products/people/mchen/fireWeather/cpc_wk2fw_index.html

Acknowledgments:

Thanks Dr. Rochelle Worsnop from PSL for her assistance in the transition of the fire weather week 2 outlook tool to CPC.