An hourly wildfire potential index for predicting sub-daily fire activity based on rapidly-updating convection-allowing model forecasts

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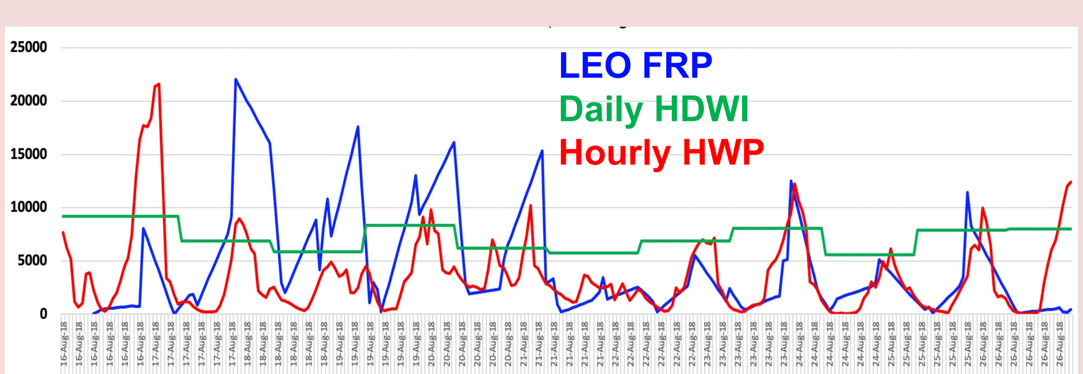
Motivation

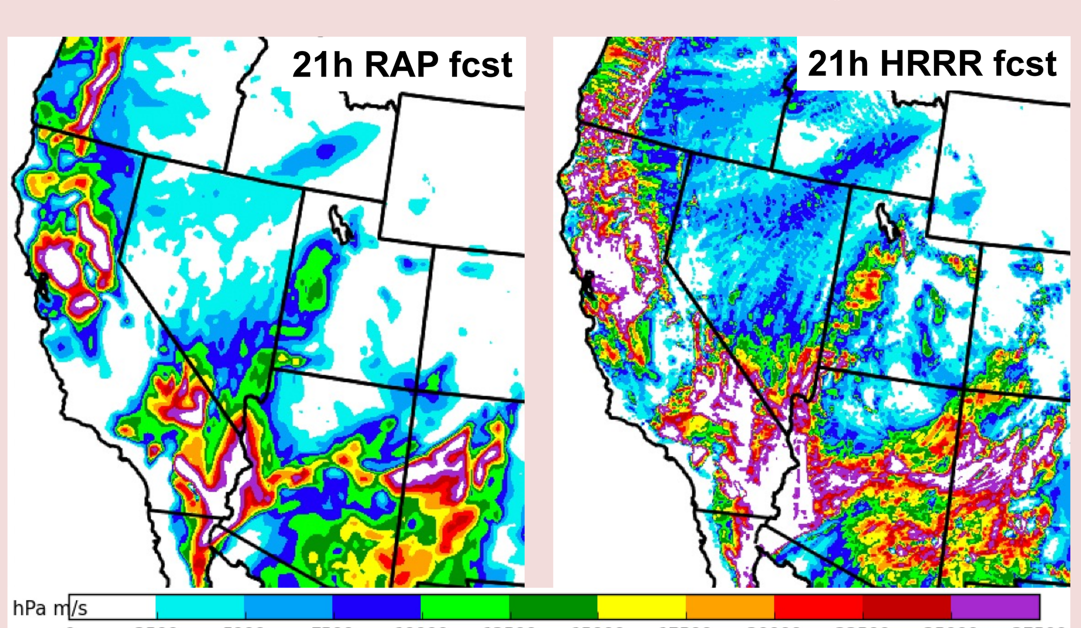
- Recent fire seasons in the western US have highlighted the need for accurate fire weather forecasts.

- Existing fire weather indices are mostly based on daily surface obs, and intended to capture fire activity of the day.
- However, fires exhibit major sub-daily variability in activity



Watson Creek Fire, 16-26 Aug 2019

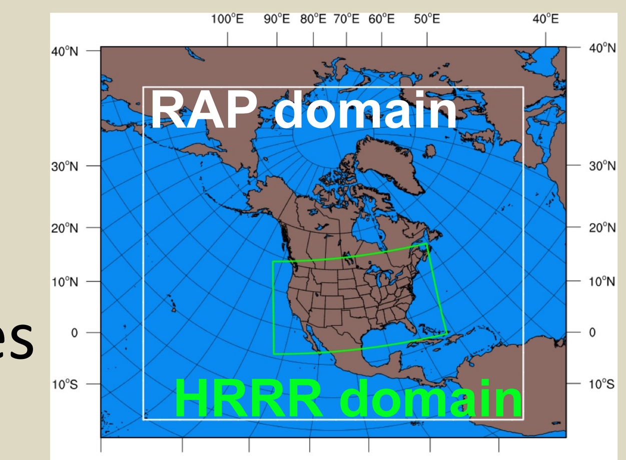
- Fire weather indices based on NWP forecasts can help anticipate sub-daily changes in fire activity; horizontal resolution is important.



Hourly Wildfire Potential, 21 UTC 8 Sep 2020

Rapidly updating convection-allowing NWP

- The HRRR system has been operational since 2014, and includes smoke prediction in HRRRv4 (since Dec 2020).



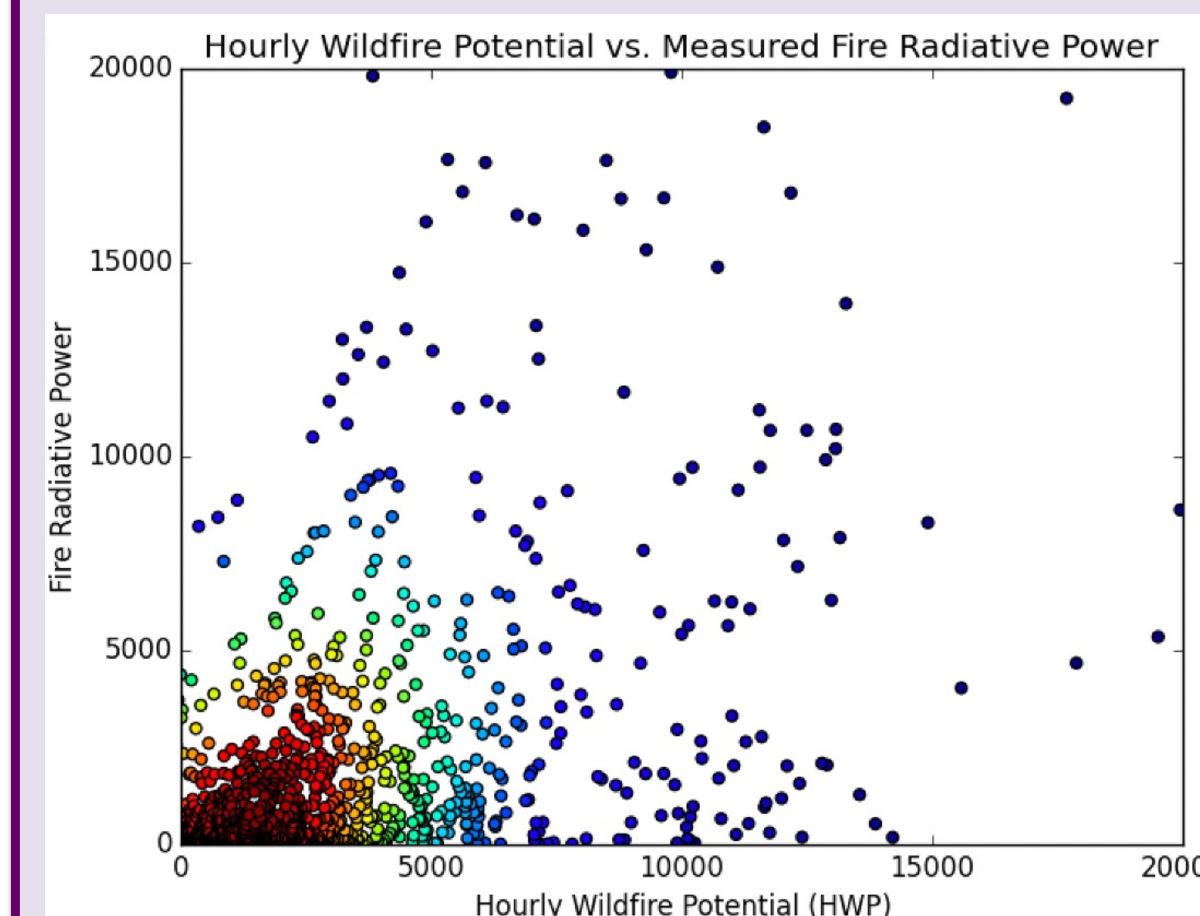
- CAM Development within NOAA is now transitioning to the FV3-based Rapid Refresh Forecast System (RRFS), slated for implementation in ~2024.

Hourly HWP Formulation

- We derived the formulation based on sub-daily fire radiative power (FRP) from polar-orbiting satellites (thanks to **NOAA/NESDIS**) , and 0-24h forecasts from HRRR.
- **HWP = A M^a G^b D^c S V + C**
- **M:** Soil moisture availability term (100 – MSTAV in %)
- **G:** 10-m wind gust potential (m/s)
- **D:** 2-m dewpoint depression (K)
- **S:** snow water equivalent factor (linear from 0 when SWE > 50 mm)
- **V:** vegetation cover factor (0-1)
- **A, C, a, b, c:** determined objectively using scipy.
- We examined sensitivity to degree of spatial and temporal smoothing.
- Optimal performance occurs using a 4h averaging window for the HWP
- For the relationships shown here, we used a 9x9 gridpoint box (27x27 km) to calculate mean, max, and min HWP.

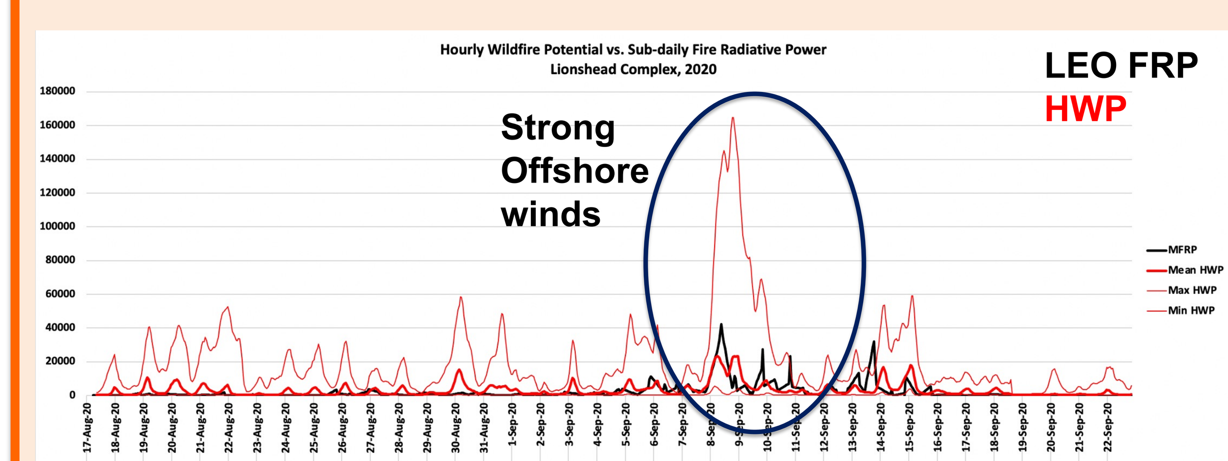
Overall HWP Performance

- HWP derived based on 10 historical fires from 2018 – 2020, CONUS + AK

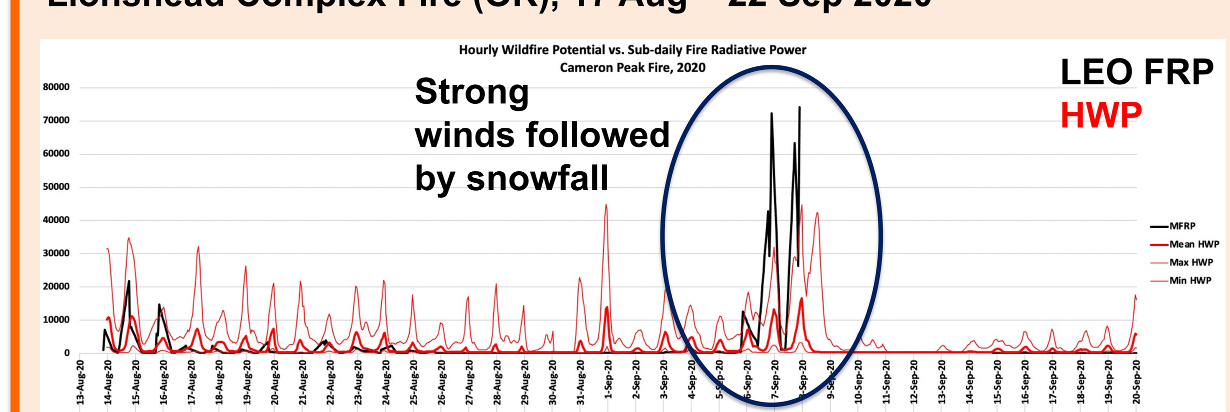


- HWP, FRP correlation coefficient: 0.46.

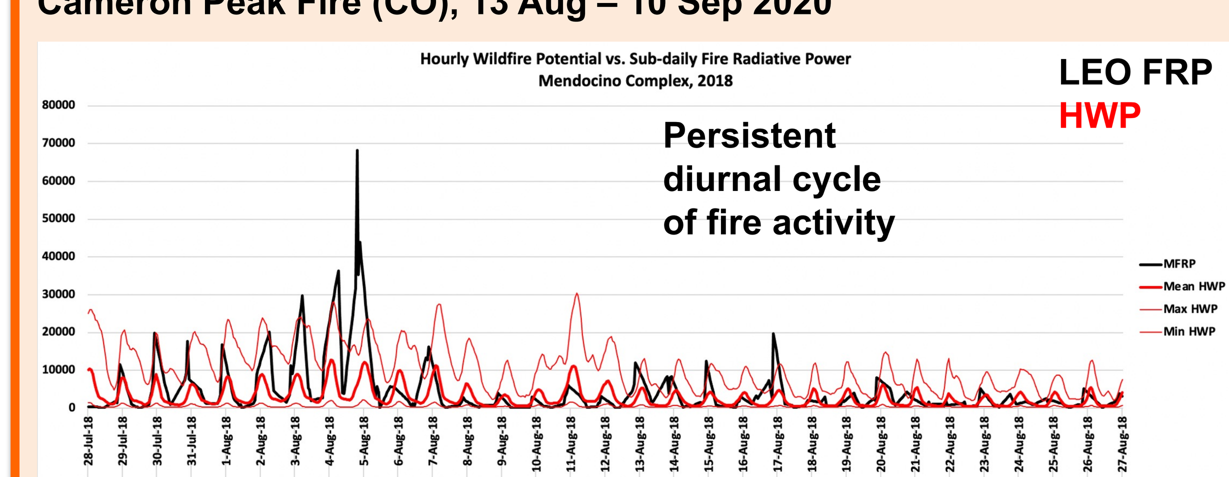
HWP Performance for Individual Wildfires



Lionshead Complex Fire (OR), 17 Aug – 22 Sep 2020



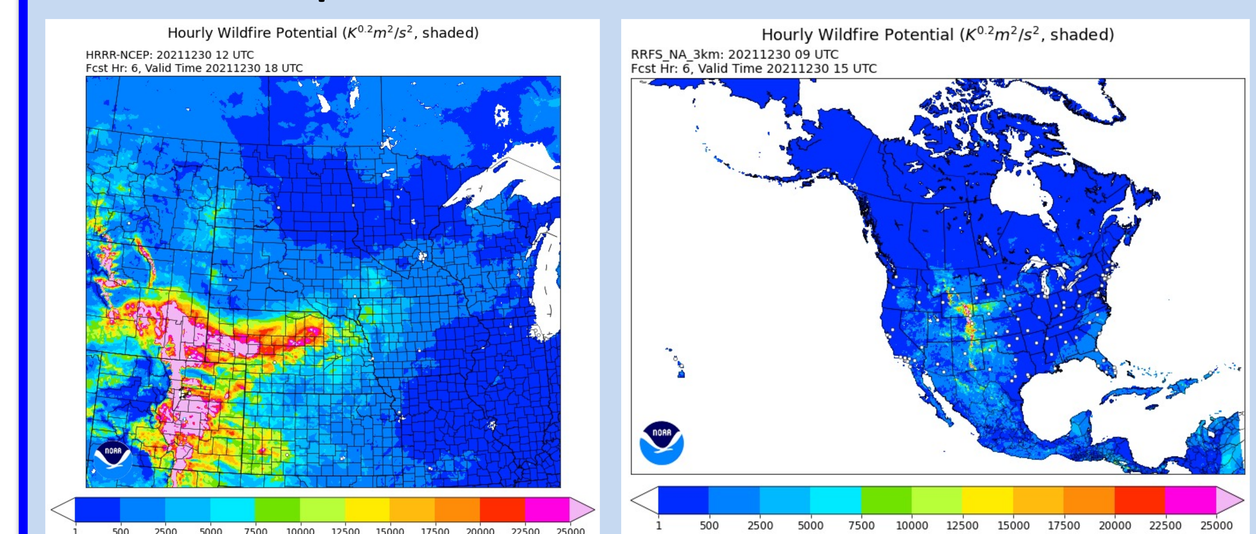
Cameron Peak Fire (CO), 13 Aug – 10 Sep 2020



Mendocino Complex Fire (CA), 28 Jul – 27 Aug 2018

Realtime HWP forecasts

- Realtime HWP forecast graphics are plotted from the operational HRRR and experimental RRFS.



- HWP forecasts for 30 Dec 2021 highlighted extreme fire danger in the lee of the Front Range due to ongoing drought and severe downslope winds, which led to the Marshall Fire, most destructive fire in CO history.

Future Work

- There are many uncertainties in this analysis, including fuel density, terrain, fire suppression, and limited satellite sampling in cloudy regions.
- In the short term, we plan to account for fire size (number of pixels w/ FRP).
- We hope to use HWP to predict emissions for smoke forecasting (for example in HRRR).
- The fire response to precipitation should be closely linked with the land surface model, and may vary by vegetation type. For example, grassland fire danger may be more closely tied to near-surface soil moisture, while forest fire danger may be more closely tied to soil moisture in a deeper root zone.

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