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

Eric James[1], Ravan Ahmadov[1], Johana Romero-Alvarez[2,1], and Georg Grell[1]

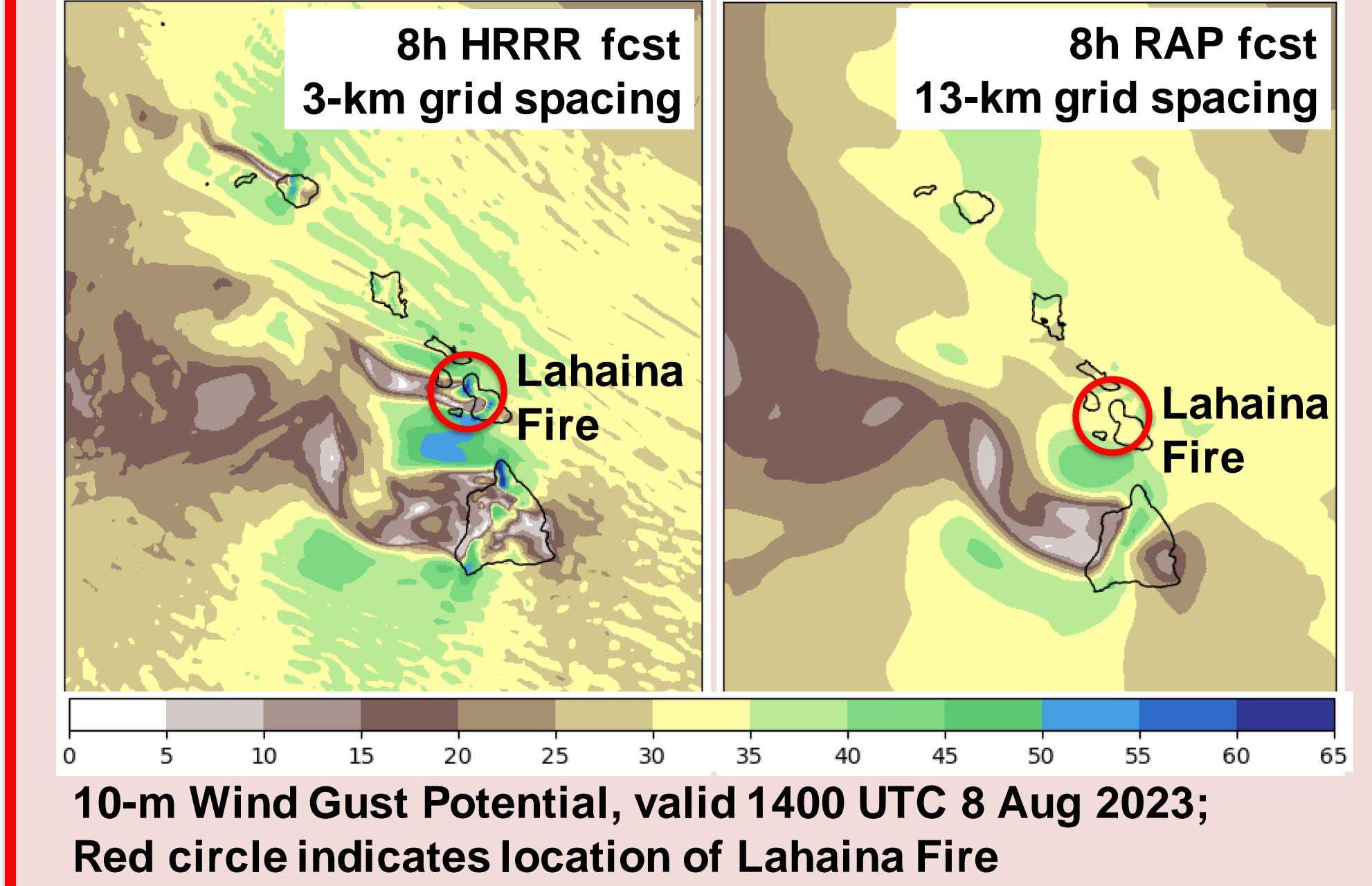[1]NOAA/OAR/GSL, Boulder, Colorado   [2]CIRES/CU, Boulder, Colorado

Motivation

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

Calwood Fire, Colorado 14 Oct 2020

- 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


LEO FRP
Daily HDWI
Hourly HWP

Watson Creek Fire, 16-26 Aug 2019
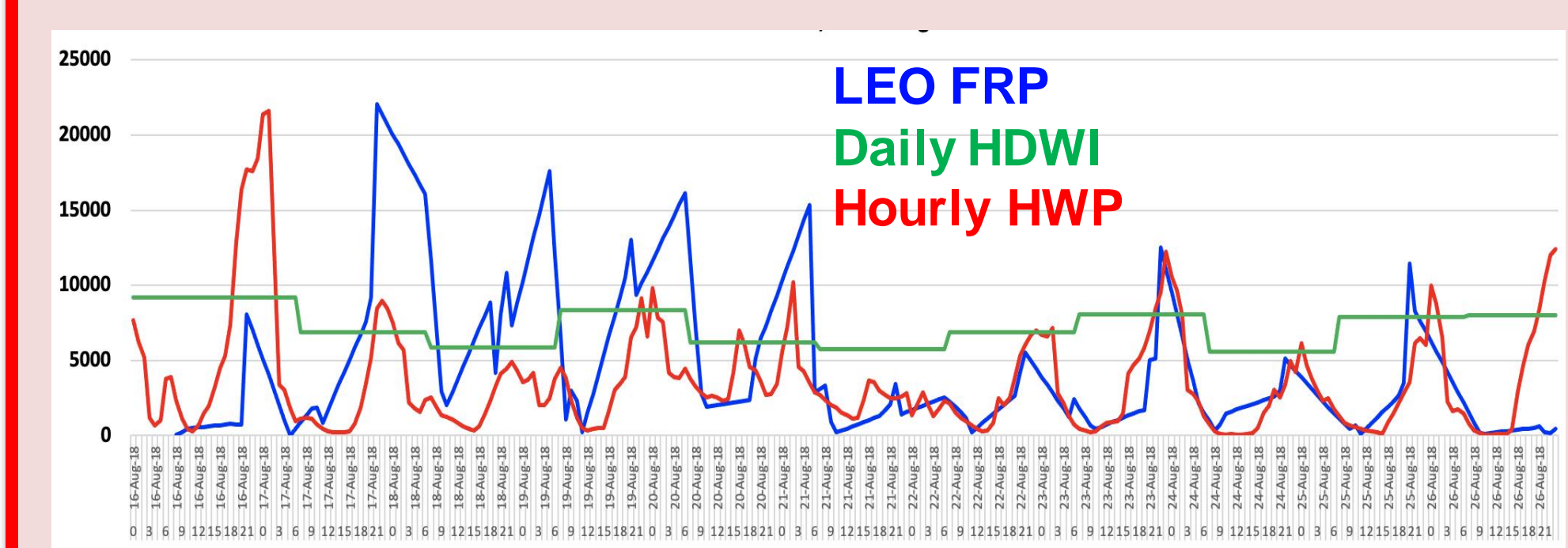
- Fire weather indices based on NWP forecasts can help anticipate sub-daily changes in fire activity; horizontal resolution is important.

8h HRRR fcst 3-km grid spacing   Lahaina Fire

8h RAP fcst 13-km grid spacing   Lahaina Fire

10-m Wind Gust Potential, valid 1400 UTC 8 Aug 2023; Red circle indicates location of Lahaina Fire

Rapidly updating convection-allowing NWP

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

RAP domain

HRRR domain

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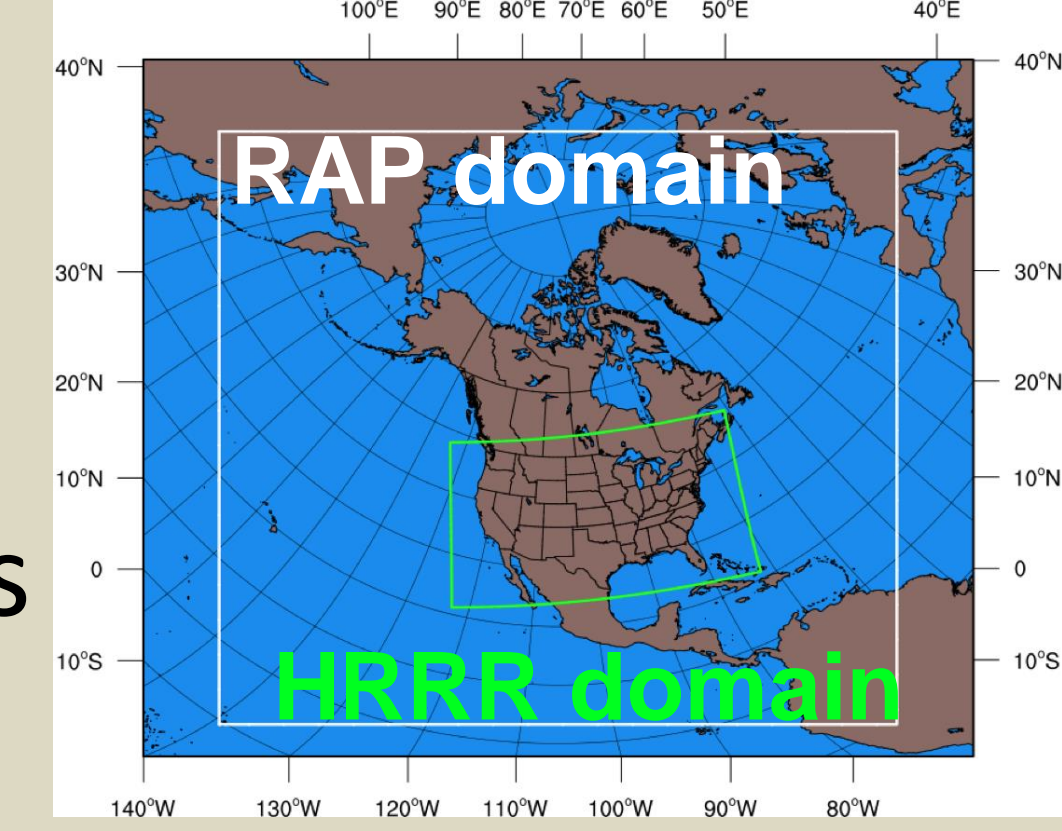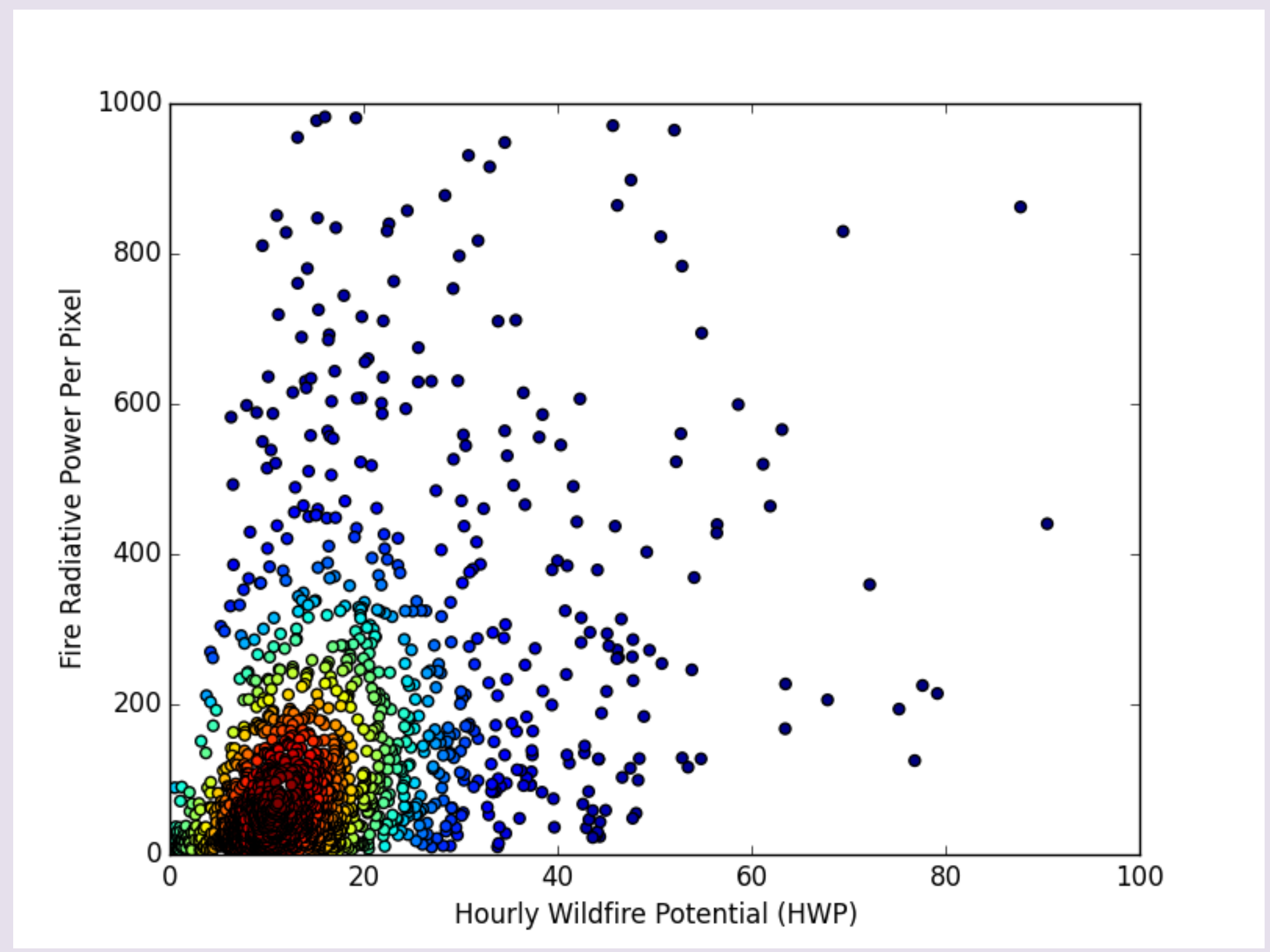
Hourly HWP Formulation

- 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; results are shown here for 27x27 km box centered on each wildfire, and using a 4-h averaging window.
- Validation carried out against RAVE (combination of polar and geo FRP).
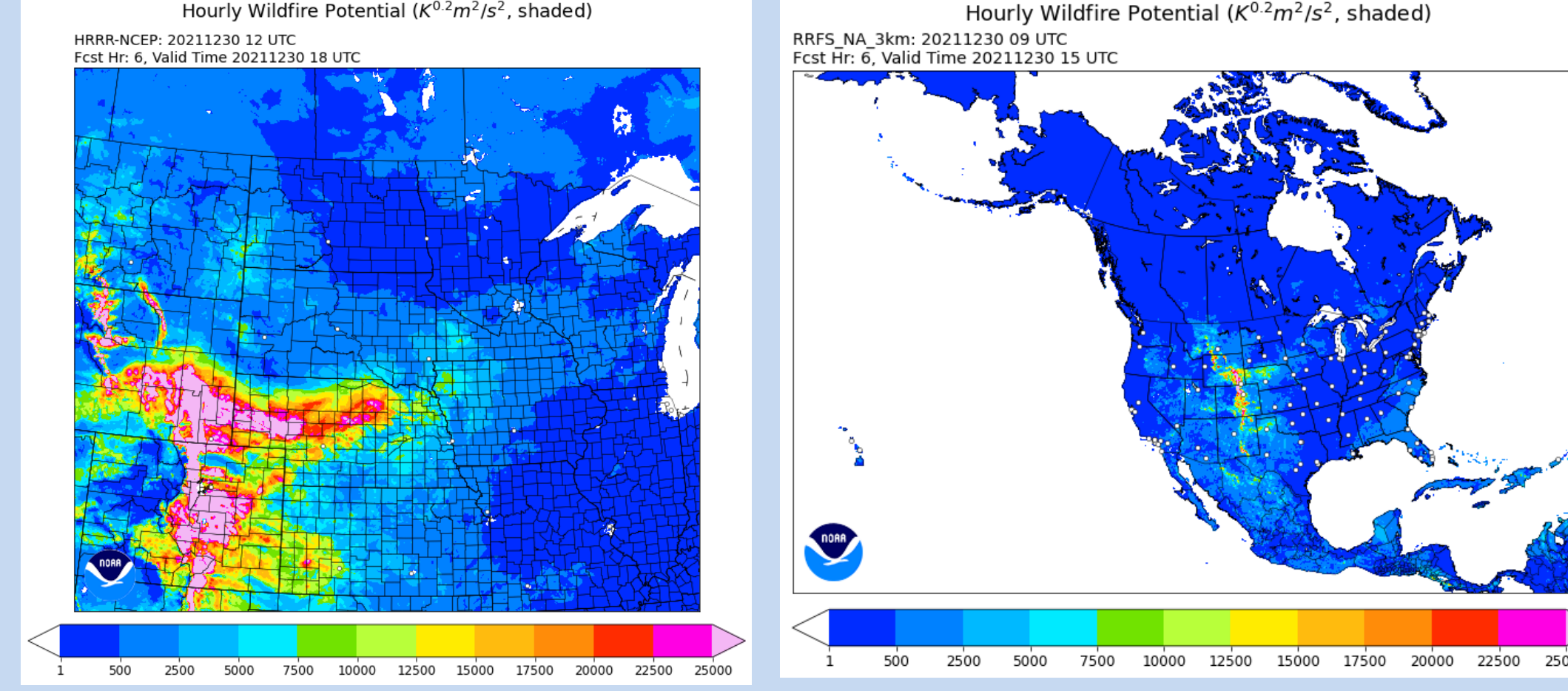
Overall HWP Performance

- HWP derived based on 9 historical CONUS wildfires from 2018 – 2020

- HWP, FRP correlation coefficient: 0.42.

HWP Performance for Individual Wildfires

Dolan Fire (CA), 1-15 Sep 2020
Strong offshore winds
RAVE FRP
HWP
HDWI
Fosberg

Cameron Peak Fire (CO), 1-15 Sep 2020
Strong winds followed by snowfall
RAVE FRP
HWP
HDWI
Fosberg

East Troublesome Fire (CO), 15-25 Oct 2020
Period of hot, dry, windy conditions
RAVE FRP
HWP
HDWI
Fosberg

Mean RMSE   Mean Bias
HWP
HDWI
Fosberg
Climo

Average diurnal cycle (UTC) for 6 eval fires (56 days)
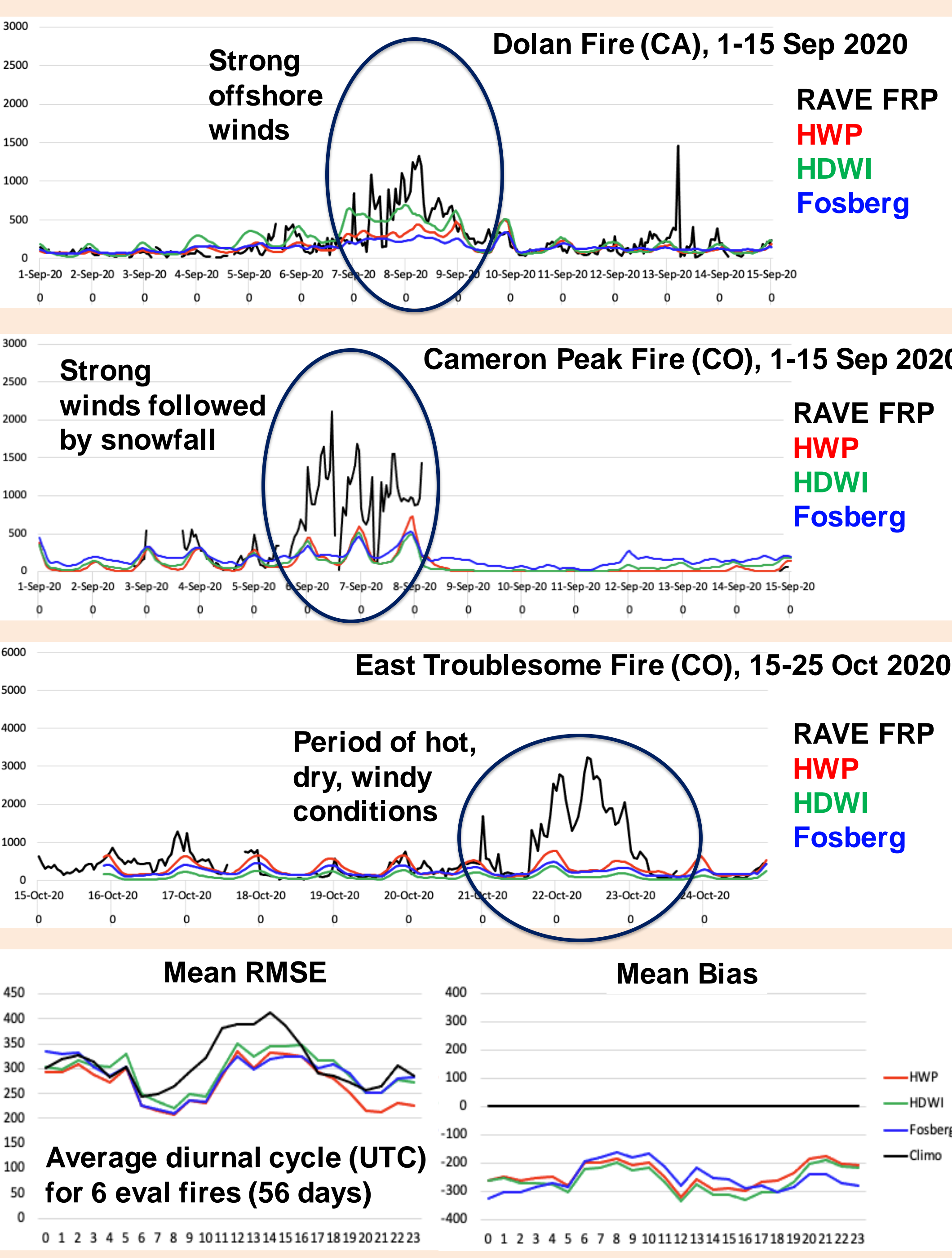
Realtime HWP forecasts

- 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.
- We hope to use HWP to predict emissions for smoke forecasting (for example in HRRR).
- HWP can also be used to inform the modeling of chemical emissions
- 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.

eric.james@noaa.gov