Developing an hourly fire weather index for use with convection-allowing model (CAM) forecasts

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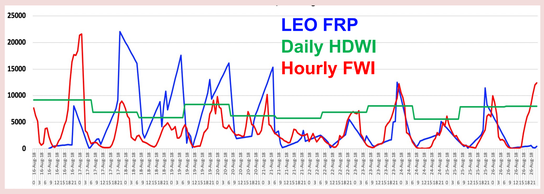
Motivation

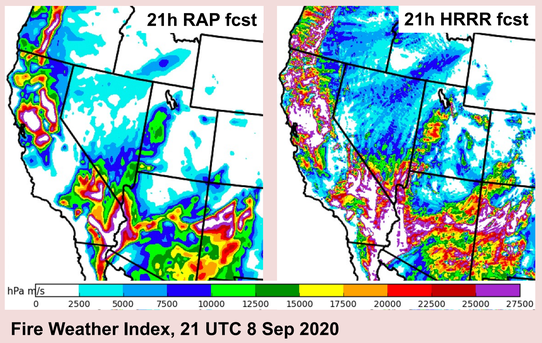
- Recent fire seasons in the western US have highlighted the need for accurate fire weather forecasts.

- 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

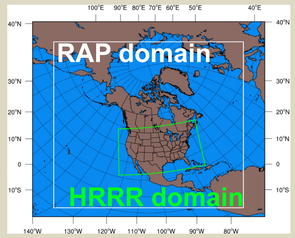
- Fire weather indices based on NWP forecasts can help anticipate sub-daily changes in fire activity; horizontal resolution is important.



Fire Weather Index, 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).



- CAM Development within NOAA is now transitioning to the FV3-based Rapid Refresh Forecast System (RRFS), slated for implementation in 2023-24.

Hourly FWI Formulation

$$FWI = G^2 \times VPD \times (1-SM1) \times (1-SF)$$

- G = wind gust diagnostic (m s^{-1})
- VPD = water vapor pres. deficit (Pa)
- SM1 = top level soil moisture (frac.)
- SF = snow factor (see below)

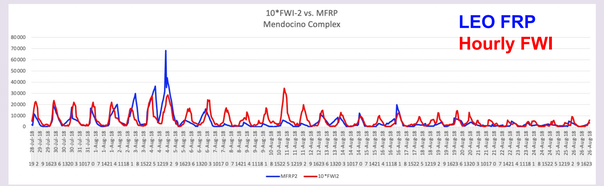
- SF is based on snow water equivalent (SWE) on the ground. The factor varies from 1 with no snow cover, to 0 with >50mm (>2 in) of SWE. Note this is liquid equivalent, not snow depth.

- More information on the wind gust diagnostic (based on modeled boundary layer height) available here: (https://rapidrefresh.noaa.gov/Diag-vars-NOAA-TechMemo.pdf)

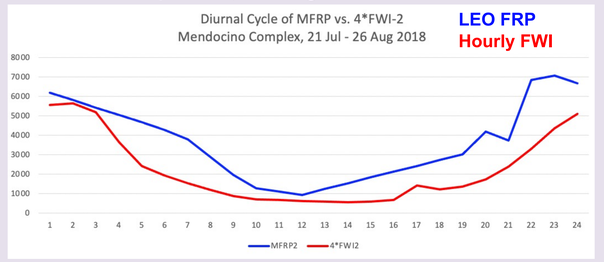
- Hourly FWI correlations with FRP are highest with some spatial averaging, and when FRP lags FWI by ~1h.

Diurnal Cycle of FWI

- Here we look at the Mendocino Complex Fire (CA, 2018), which had a consistent diurnal cycle of activity.



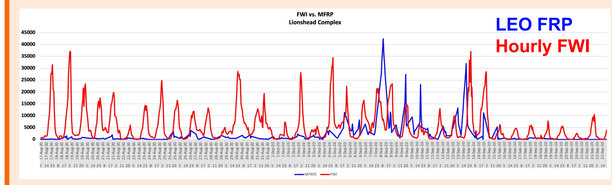
Mendocino Complex Fire, 1-26 Aug 2018



- FWI using NWP forecasts captures well the diurnal cycle of fire activity.

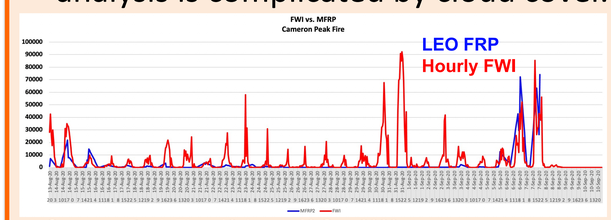
Ongoing work on impacts of synoptic-mesoscale weather events

- The Lionshead Complex (OR, 2020) was subject to strong offshore winds.



Lionshead Complex Fire, 17 Aug – 22 Sep 2020

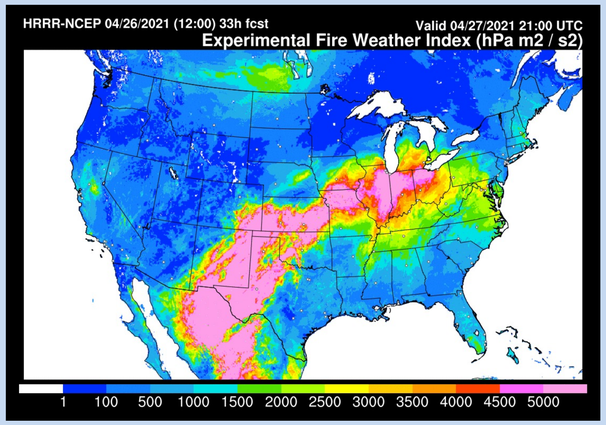
- The Cameron Peak Fire (CO, 2020) had significant snowfall on the fire, but the analysis is complicated by cloud cover.



Cameron Peak Fire, 13 Aug – 10 Sep 2020

Realtime FWI forecasts

- Realtime hourly fire weather index (FWI) forecast graphics are plotted from the operational HRRR.



33h Forecast Fire Weather Index, valid 21 UTC 27 Apr 2021

- Realtime graphics will be produced from the prototype Experimental RRFS system soon.

Future Work

- There are many uncertainties in this analysis, including fuel variability, limited satellite sampling in cloudy regions, and fire suppression efforts.
- We hope to use FWI 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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