CIWRO/SPC Activities in Fire Weather Research

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Support SPC forecasters in their operational duties for the generation of fire weather outlooks.

SPC Mesoscale Assistant/
Fire Weather Forecasters:

- Evan Bentley
- Andrew Lyons
- Andrew Moore
- Brian Squitieri
- Emily Thornton
- Harry Weinman
- Nathan Wendt

New Fire Weather SOO!  Nick Nauslar
SPC Fire Weather Outlooks are intended to delineate areas of the contiguous U.S. where pre-existing fuel conditions, combined with forecast weather conditions during the next 8 days, will result in a significant threat for the ignition and/or spread of wildfires. This product is intended for use by WFOs, as well as other federal, state, and local government agencies.

**Fuels**
1. Assess Fuel Status
   - Energy Release Component (ERC)
   - Burning Index (BI)
   - Fuel Moisture
2. Look for Potential Changes
   - Recent Precip
   - Forecast Precip
3. Are there Fuels Present to Burn?
   - Wildfire Hazard Potential

**Weather**
1. Wind/Relative Humidity
   - Criteria
     - SPC Risk Category
     - Sustained Wind Threshold (mph)
     - RH Threshold
   - Elevated: 15-20 (or 20+ < 3 hrs)
   - Critical: 20-30 (or 30+ < 3 hrs)
   - Extremely Critical: 30+
   - 5% More Than Regional Threshold
   - See Regional Thresholds Map

2. Forecast

3. Dry Thunderstorms
   - Minimum criteria to consider for Critical risk from Dry Thunderstorms:
     1. ≥ 40% coverage of cloud-to-ground lightning strikes with rainfall accumulation ≤ 0.10".
     2. RH AOB regional thresholds; refer to regional low RH criteria graphic.
     3. Temperatures ≥ 60°F (50°F) in the warm (cool) season.
     4. GACC fuel dryness levels of dry, very dry, or high risk. In the absence of GACC outlooks, NFDRS Fire Danger Class of 3, 4, 5 and 100/1000-hr fuels ≤ 10% in the West or 10-hr fuels ≤ 10% in the East, and/or severe to exceptional long-term drought.

**Other Factors**
1. WFO Hazard Products
2. GACC Forecasts
3. IMET
4. Ongoing Fires
5. Drought Monitor
Outline of Research Topics

Lightning density prediction: Predicting Probabilistic Lightning Flash Density from the HREF Calibrated Thunder Guidance, *David Harrison (CIWRO/SPC)*

Fire occurrence prediction: Exploring the Role of Weather Forecasts in Predicting Wildfire Occurrence for CONUS Using the Unet3+ Deep Learning Model, *Bethany Earnest (CIWRO/SPC)*

Resource planning: SPC fire weather outlooks and associated observed fire behavior and deployed mitigation resources, *David Jahn (CIWRO/SPC)*
Predicting Probabilistic Lightning Flash Density from the HREF Calibrated Thunder Guidance

David Harrison\textsuperscript{1,2}, Patrick Marsh\textsuperscript{2}, Israel L. Jirak\textsuperscript{2}

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The HREF Calibrated Thunder guidance (HREFCT) was made operational within NWS in May 2021

- Uses prognostic HREF storm-scale attributes and environmental parameters to predict the probability of ≥ 1 CG flash
- \( Z_{-10C} \), Accumulated Precipitation, MU LI
- Proven to be skillful and reliable at 1-, 4-, and 24-hour intervals
- Widely used within SPC to help produce Thunderstorm Outlooks


https://www.spc.noaa.gov/exper/href/?model=href&product=guidance_thunder_hrefct_004h
Labels: CG lightning flashes provided by Vaisala’s NLDN

Input variables:
- HREF calibrated guidance 4-hour forecasts
  - operational system that predicts probability of lightning occurrence, but not density
  - Based on HREF storm and env. attributes, observed radar reflectivity and env. stability
- Neighborhood Maximum Updraft Vertical Velocity
- Ensemble Mean/Max Fractional Coverage $Z_{-10C} \geq 40 \text{ dBZ}$

**20221104 4-hour Lightning Density Forecasts**
12z HREF/HREFCT; F04 – F39

Probability of > 25 CG flashes within 12 miles

$Z_{-10C} \geq 40 \text{ dBZ}$
20221104 4-hour Lightning Density Forecasts
12z HREF/HREFCT; F04 – F39

≥ 25 Flashes

≥ 50 Flashes

≥ 100 Flashes

Probability of ≥ 25 CG flashes

Probability of ≥ 50 CG flashes

Probability of ≥ 100 CG flashes
Exploring the Role of Weather Forecasts in Predicting Wildfire Occurrence Using the Unet3+ Deep Learning Model

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$^2$OU School of Computer Science
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Example daily guidance product showing the probability of fire occurrence (generated separately for days 1-10)
Predictors:
- GEFS reforecast fields
- temperature, winds, moisture
- 2000-2019


Fire occurrence guidance (days 0-10)
(11 models trained: one for each forecast day)
Daily 40-km gridded GEFS reforecast fields (2000-2019)
24-hr. max/min/mean. field, normalized (0-1)

Wildfire data:
- FAP-FOD database (USDA Forest Service)
- All fires included (all sizes, all causes)
- Each point: at least one fire within 40 km grid cell within 24hr period

Input Variables:
- 2 Wind
- 2 Moisture
- 1 Temp

Data Sources
Model trained separately for days 0-10, and separately using as inputs observations (day 0) OR GEFS forecast (of respective model forecast day, 0-10)

U-Net 3+ Model: Neural network w/ encoder-decoder architecture and full-scale skip connections
South Sugarloaf
Largest Lightning Fire of 2018
Observed Fire Behavior and Deployed Mitigation Resources Related to Risk Categories of SPC Fire Weather Outlooks

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For an example case (2018-08-11), SPC Fire weather outlook critical level (yellow contour: ‘elevated’, red contour: ‘critical’); dashed circles show wildfires with FSR [acres/day]
Goal: Identify a statistical relationship among risk categories of SPC fire weather outlooks and fire behavior as well as required suppression resources.
Relate SPC outlook risk category data and wildfire data

ICS-209 Plus Data

- Data for each wildfire: projected cost, fire spread rate, deployed personnel, ... *(much more!)*

- 2% of all wildfires during 1999-2020 that represents 80% of suppression costs.

- [https://doi.org/10.6084/m9.figshare.19858927.v3](https://doi.org/10.6084/m9.figshare.19858927.v3)


For an example case (2018-08-11), SPC Fire weather outlook critical level (yellow contour: ‘elevated’, red contour: ‘critical’); dashed circles show wildfires with FSR [acres/day]
Probability of fire spread rate (FSR) related to fire risk category

Violin plots (Based on 15 years of data)

Probability density (Weibull fit)

Cumulative distribution function
Probability of fire spread rate (FSR) related to fire risk category

<table>
<thead>
<tr>
<th>Max. FSR [acres/day]</th>
<th>Elevated</th>
<th>Critical</th>
<th>Extreme</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prob. &gt; 2000 [acres/day]</td>
<td>0%</td>
<td>1.9%</td>
<td>13.0%</td>
</tr>
<tr>
<td>Prob. &gt; 1000 [acres/day]</td>
<td>0.1%</td>
<td>17.1%</td>
<td>38.6%</td>
</tr>
<tr>
<td>Prob. &gt; 500 [acres/day]</td>
<td>12.9%</td>
<td>43.3%</td>
<td>68.1%</td>
</tr>
</tbody>
</table>
Posters

Fire Management and Risk Perception Through an Organizational Lens, Evan Bentley, SPC

Exploring the Role of Weather Forecasts in Predicting Wildfire Occurrence for CONUS Using the Unet3+ Deep Learning Model, Bethany Earnest, CIWRO/SPC

Predicting Probabilistic Lightning Flash Density from the HREF Calibrated Thunder Guidance, David Harrison, CIWRO/SPC

SPC fire weather outlooks and associated observed fire behavior and deployed mitigation resources, David Jahn, CIWRO/SPC