Re-evaluating the Haines Index: A Case Study of Major Wildfires

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1. Introduction

Wildfires pose a serious risk to life, property, and the environment.

Variables influencing wildfire growth (i.e. stability, humidity, wind speed, fuel moisture, etc.) change rapidly, making fire weather forecasting difficult.

Haines Index (HI):
- Most commonly used fire weather index in the U.S.
- Considers atmospheric stability and relative humidity
- Fails to account for wind speed and fuel moisture
- Elevation Dependent

Science Questions:
- To what extent does the inclusion of wind speed and fuel moisture influence the HI's ability to identify the potential for rapid wildfire growth?
- What impact would the inclusion of wind and fuel moisture have on the geographic application of the HI?

2. Methods

Meteorological Assimilation Data Ingest System (MADIS):
- Compiles data recorded at METARs, Mesonets, etc.
- Data analyzed:
  - Temperature (T), Dew Point Temperature (Td), Wind Gusts (FFGUST), and 24-hour precipitation

Sounding Data (via University Wyoming Sounding Archive):
- Lower atmospheric stability determined using T_{p1} and T_{p2}

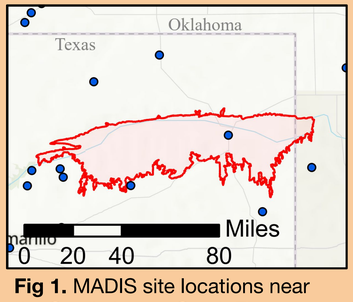


Fig 1. MADIS site locations near the Smokehouse Creek Fire

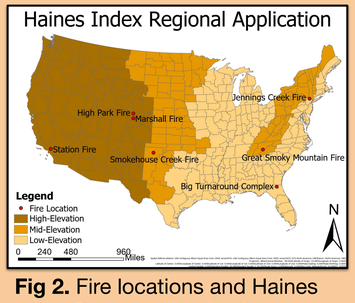


Fig 2. Fire locations and Haines Index Regional Application

Equation (Assigned Index Values in Table 1):
- HI = Stability_Index + Humidity_Index

Table 1. HI Index Classification Chart

Elevation	p1 (hPa)	p2 (hPa)	Tp1 -Tp2 (°C)			T-Td (°C)		
			1	2	3	1	2	3
High (>3000ft)	700	500	<18	18-21	>21	<15	15-20	>20
Mid (1000-3000ft)	850	700	<6	6-10	>10	<6	6-12	>12
Low (<1000ft)	950	850	<4	4-7	>7	<6	6-9	>9

3. Results

New_HI = HI + Wind_Index + Precip_Index

Table 2. New Index Classification Chart (wind is analyzed every 2 hours, dryness is based on precipitation from the month before the fire)

FFGUST (m/s)			Dryness (Monthly Precip/Climate Avg)		
1	2	3	1	2	3
< 4.5	4.5 - 11	> 11	>= 0.3	0.1 - 0.3	<= 0.1

Example: Comparison of the New and Old HI

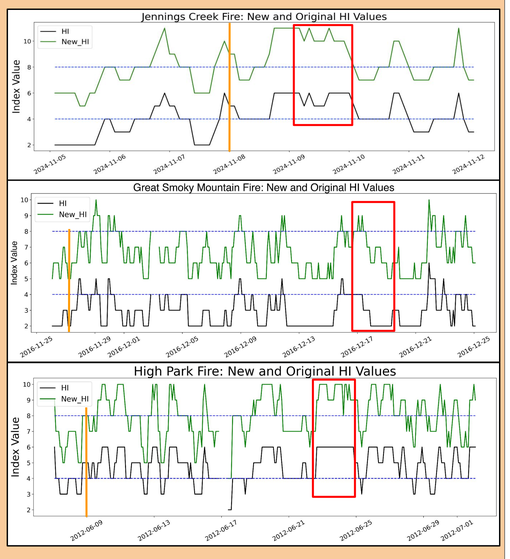
Fig 3. Original and New HI Values for Jennings Creek - JC (above), Great Smoky Mountain - GSM (middle), and High Park - HP (below) fires

Fire start date (orange)

Original HI (black) ranges from 2 to 6

New_HI (green) ranges from 4 to 12

Original and New HI generally follow the same trend, with some deviations (red)



Example: Comparison of Term-Averaged New and Old HI

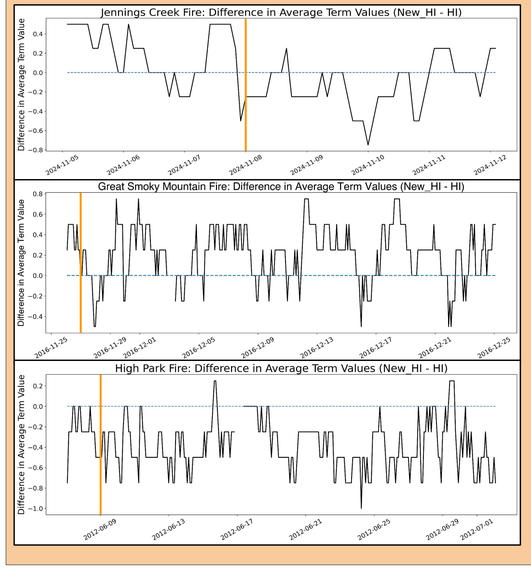


Fig 4. Difference in Average Term Value for JC (above), GSM (middle), and HP (below) fires

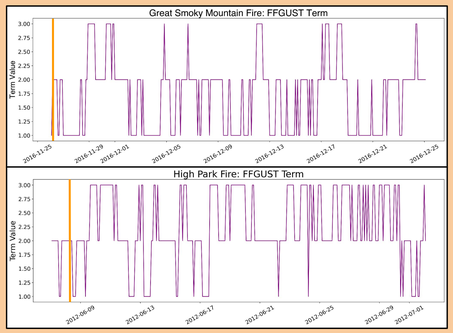
If above 0-line (blue), the new variables resulted in higher term values on average.

Original HI larger for HP Fire

New_HI larger for GSM Fire

3. Results Cont.

Fig 5. Wind term for GSM (above) and HP fires (below)



Wind speeds are greater on average for the HP fire
- **HOWEVER:** New_HI is smaller
- **WHY?**
  - Dryness may play a role
  - Dryness = 2 (GSM) vs. Dryness = 1 (HP)

4. Discussion

Drought and Wind:
- New_HI values maximized when Wind_Index and Precip_Index terms agree
- Both terms need to be adequately severe for New_HI to reflect their inclusion
  - Original terms dominate otherwise

Elevation
- Elevation differences can influence how fire behavior evolves

Limitations:
- Time scale of terms
- Observation locations from MADIS dataset
- Sounding Data Location/Availability

5. Conclusions

The New_HI:
- Depends on both wind and moisture variables
- Varies with elevation

New_HI responds well when both variables are high, but is inconsistent otherwise.

Inconsistencies may be attributed to the discussed limitations.

When wind and drought conditions are known, use of the New_HI may be beneficial for fire response and mitigation activities.