# Evaluating Fire Weather Indices to Support Fire Management Decisions in Alaska

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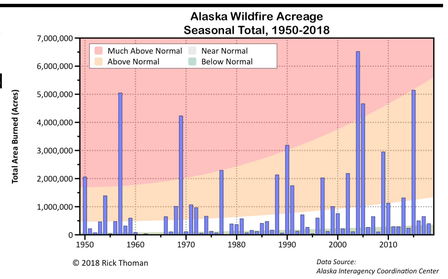
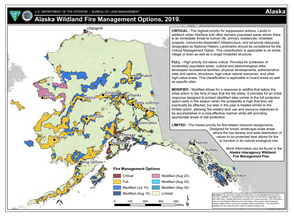
**Main Results**

- Daily variability of fire weather parameters compare favorability station vs downscaled reanalysis
- EDDI and SPEI show some promise for identifying MODIS fire detection days
- Fire weather conditions may generally worsen in Jun-Jul by the 2040s according to two model projections

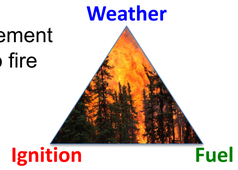
## Motivation

- Summer wildfires can burn large areas and most of Alaska area burned is due to lightning-ignited fires
- Few seasons have large area burned (>1 million acres)
- Large season have occurred more often in recent decades



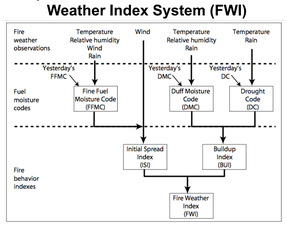

- Wildfires are managed in Alaska
- Operational management decisions are tied to fire weather conditions




## Data and Methods

- Alaska fire managers base operational decisions on the Canadian Forest Fire Weather Index System (CFFWIS)
- Calibrated for the boreal forests
- Other fire weather indices are available: do they work in Alaska?

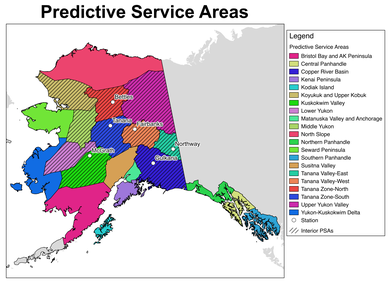
**Components of the Canadian Forest Fire Weather Index System (FWI)**




- The fire weather indexes evaluated in this study all derived from a combination of daily temperatures, humidity, winds and precipitation

| Fire Weather Index | Temperature | Humidity | Wind Speed | Precipitation |
|---|---|---|---|---|
| Canadian Fire Weather Index (FWI) | X | X | X | X |
| Evaporative Demand Drought Index (EDDI) | X | X | X | |
| Standardized Precipitation Evapotranspiration Index (SPEI) | X | X | X | X |
| Vapor Pressure Deficit (VPD) | X | X | | |
| Growing Season Index (GSI) | X | X | | |

**Predictive Service Areas**




- Analysis conducted over the Predictive Service Areas (PSAs) used by fire managers
- Five approaches are compared with active fire data:
  - FWI (Van Wagner 1987)
  - EDDI (Hobbins et al. 2016)
  - SPEI (Vicente-Serrano et al. 2010)
  - VPD (Seager et al. 2015)
  - GSI (Jolly et al. 2005)

**Data:**

- Dynamically downscaled 20km ERA-Interim reanalysis (Bieniek et al. 2016), GFDL-CM3 and NCAR-CCSM4 RCP 8.5 for 1979-2100
- Global Summary of the Day (GSOD) daily station data
- Alaska Fire and Fuels CFFWIS index/codes (based on stations)
- MODIS daily hotspots 2003-2017

## Downscaling captures variability of key observed variables

- The downscaled ERA-Interim contains a wet bias in summer (Bieniek et al. 2016) that lowers the magnitudes of some indices (especially FWI/BUI)
- Downscaled ERA-Interim PSA vs. GSOD stations correlations of daily GSI, VPD, reference evapotranspiration (ET0; input for EDDI) and precipitation minus ET0 (input for SPEI) show good agreement within corresponding PSA (seasonal cycle removed).

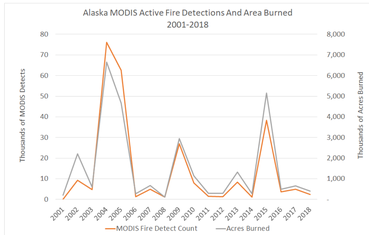
**May-Aug correlation of daily fire weather index/parameter at stations vs. PSAs 1979-2017**

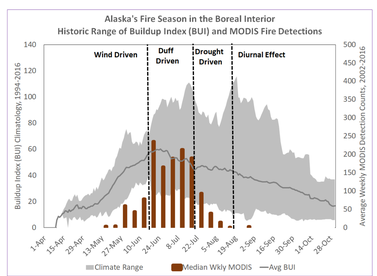
| | | Northern Panhandle | Central Panhandle | Southern Panhandle | Matanuska Valley and Anchorage | Kenai Peninsula | Tanana Valley-West | Susitna Valley | Tanana Zone-South | Koyukuk and Upper Kobuk | Lower Yukon | Middle Yukon | Upper Yukon Valley | Copper River Basin | Kodiak Island | North Slope | Tanana Zone-North | Seward Peninsula | Bristol Bay and AK Peninsula | Yukon-Kuskokwim Delta | Tanana Valley-East | Kuskokwim Valley |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| GSI | Fairbanks | 0.39 | 0.43 | 0.39 | 0.50 | 0.51 | 0.70 | 0.60 | 0.68 | 0.48 | 0.59 | 0.64 | 0.57 | 0.44 | 0.44 | 0.25 | 0.64 | 0.46 | 0.51 | 0.47 | 0.72 | 0.61 |
| | McGrath | 0.50 | 0.45 | 0.44 | 0.61 | 0.55 | 0.64 | 0.61 | 0.72 | 0.66 | 0.72 | 0.76 | 0.61 | 0.54 | 0.51 | 0.39 | 0.75 | 0.68 | 0.61 | 0.65 | 0.66 | 0.71 |
| | Tanana | 0.28 | 0.30 | 0.31 | 0.34 | 0.26 | 0.50 | 0.34 | 0.56 | 0.55 | 0.53 | 0.64 | 0.53 | 0.27 | 0.21 | 0.32 | 0.67 | 0.53 | 0.28 | 0.43 | 0.47 | 0.43 |
| | Bettles | 0.34 | 0.33 | 0.33 | 0.39 | 0.27 | 0.50 | 0.30 | 0.57 | 0.60 | 0.54 | 0.67 | 0.62 | 0.32 | 0.24 | 0.37 | 0.74 | 0.58 | 0.30 | 0.46 | 0.47 | 0.43 |
| | Gulkana | 0.43 | 0.39 | 0.37 | 0.46 | 0.39 | 0.30 | 0.34 | 0.29 | 0.27 | 0.35 | 0.36 | 0.26 | 0.47 | 0.33 | 0.13 | 0.30 | 0.36 | 0.34 | 0.36 | 0.38 | 0.34 |
| | Northway | 0.40 | 0.41 | 0.39 | 0.45 | 0.38 | 0.46 | 0.41 | 0.47 | 0.42 | 0.50 | 0.52 | 0.40 | 0.42 | 0.33 | 0.21 | 0.50 | 0.47 | 0.38 | 0.44 | 0.55 | 0.46 |
| VPD | Fairbanks | 0.24 | 0.26 | 0.19 | 0.00 | 0.15 | 0.51 | 0.33 | 0.74 | 0.40 | 0.37 | 0.53 | 0.66 | 0.30 | -0.11 | 0.36 | 0.60 | 0.38 | 0.07 | 0.26 | 0.57 | 0.39 |
| | McGrath | 0.17 | 0.19 | 0.11 | 0.08 | 0.38 | 0.56 | 0.53 | 0.75 | 0.42 | 0.74 | 0.71 | 0.43 | 0.34 | 0.17 | 0.28 | 0.58 | 0.50 | 0.47 | 0.57 | 0.31 | 0.77 |
| | Tanana | 0.17 | 0.19 | 0.12 | 0.02 | 0.21 | 0.61 | 0.37 | 0.75 | 0.52 | 0.53 | 0.71 | 0.54 | 0.28 | -0.02 | 0.37 | 0.72 | 0.53 | 0.21 | 0.41 | 0.34 | 0.48 |
| | Bettles | 0.12 | 0.14 | 0.06 | -0.02 | 0.14 | 0.54 | 0.29 | 0.64 | 0.66 | 0.47 | 0.70 | 0.64 | 0.22 | -0.06 | 0.48 | 0.82 | 0.58 | 0.15 | 0.39 | 0.32 | 0.40 |
| | Gulkana | 0.47 | 0.46 | 0.33 | 0.15 | 0.42 | 0.60 | 0.51 | 0.49 | 0.14 | 0.25 | 0.28 | 0.43 | 0.61 | 0.09 | 0.20 | 0.31 | 0.16 | 0.17 | 0.13 | 0.89 | 0.37 |
| | Northway | 0.40 | 0.42 | 0.38 | -0.01 | 0.08 | 0.59 | 0.20 | 0.39 | 0.06 | 0.09 | 0.16 | 0.44 | 0.37 | -0.17 | 0.17 | 0.23 | 0.07 | -0.09 | 0.01 | 0.77 | 0.16 |
| ET0 | Fairbanks | 0.16 | 0.26 | 0.20 | -0.08 | 0.10 | 0.76 | 0.28 | 0.73 | 0.42 | 0.41 | 0.55 | 0.62 | 0.19 | -0.12 | 0.34 | 0.59 | 0.42 | 0.07 | 0.30 | 0.50 | 0.40 |
| | McGrath | 0.09 | 0.20 | 0.11 | 0.03 | 0.33 | 0.54 | 0.50 | 0.76 | 0.50 | 0.78 | 0.74 | 0.46 | 0.26 | 0.11 | 0.29 | 0.62 | 0.55 | 0.45 | 0.63 | 0.30 | 0.80 |
| | Tanana | 0.09 | 0.18 | 0.11 | -0.03 | 0.17 | 0.63 | 0.35 | 0.79 | 0.60 | 0.60 | 0.75 | 0.58 | 0.20 | -0.05 | 0.37 | 0.76 | 0.60 | 0.22 | 0.47 | 0.32 | 0.53 |
| | Bettles | 0.05 | 0.12 | 0.07 | -0.09 | 0.06 | 0.52 | 0.23 | 0.65 | 0.67 | 0.51 | 0.71 | 0.64 | 0.12 | -0.11 | 0.46 | 0.81 | 0.62 | 0.13 | 0.43 | 0.29 | 0.41 |
| | Gulkana | 0.36 | 0.42 | 0.33 | -0.04 | 0.26 | 0.56 | 0.39 | 0.45 | 0.18 | 0.22 | 0.26 | 0.41 | 0.40 | 0.00 | 0.21 | 0.30 | 0.17 | 0.08 | 0.12 | 0.65 | 0.32 |
| | Northway | 0.36 | 0.45 | 0.42 | -0.12 | 0.09 | 0.56 | 0.18 | 0.39 | 0.12 | 0.12 | 0.19 | 0.43 | 0.28 | -0.14 | 0.18 | 0.25 | 0.11 | -0.06 | 0.04 | 0.76 | 0.20 |
| P-ET0 | Fairbanks | 0.02 | 0.03 | 0.02 | 0.05 | -0.05 | 0.50 | 0.08 | 0.35 | 0.04 | 0.05 | 0.13 | 0.37 | 0.03 | -0.10 | 0.09 | 0.19 | 0.03 | -0.08 | -0.01 | 0.15 | 0.09 |
| | McGrath | 0.01 | -0.01 | -0.03 | 0.22 | 0.17 | 0.23 | 0.35 | 0.44 | 0.19 | 0.44 | 0.39 | 0.25 | 0.16 | 0.06 | 0.15 | 0.33 | 0.19 | 0.18 | 0.25 | 0.09 | 0.52 |
| | Tanana | -0.01 | -0.03 | -0.04 | 0.09 | 0.04 | 0.33 | 0.17 | 0.48 | 0.21 | 0.21 | 0.36 | 0.37 | 0.08 | -0.03 | 0.21 | 0.45 | 0.18 | 0.02 | 0.12 | 0.06 | 0.18 |
| | Bettles | 0.02 | -0.01 | -0.04 | 0.06 | 0.03 | 0.17 | 0.12 | 0.27 | 0.30 | 0.19 | 0.37 | 0.37 | 0.08 | 0.00 | 0.32 | 0.51 | 0.26 | 0.03 | 0.12 | 0.04 | 0.13 |
| | Gulkana | 0.20 | 0.20 | 0.15 | 0.10 | 0.00 | 0.23 | 0.04 | 0.07 | -0.06 | -0.06 | -0.04 | 0.15 | 0.18 | -0.09 | 0.01 | 0.00 | -0.09 | -0.08 | -0.08 | 0.31 | 0.01 |
| | Northway | 0.09 | 0.16 | 0.13 | -0.01 | -0.06 | 0.22 | -0.04 | 0.04 | -0.10 | -0.08 | -0.07 | 0.10 | 0.03 | -0.09 | -0.08 | -0.05 | -0.10 | -0.09 | -0.09 | 0.35 | -0.03 |

Box = PSA where station is located

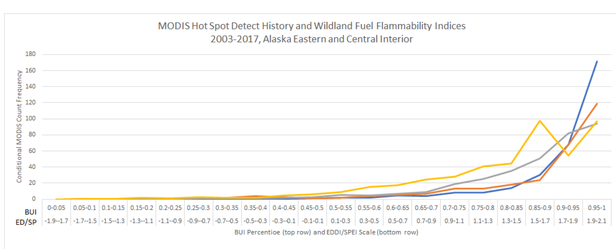
## High EDDI and SPEI values capture fire detections

- More than 250K MODIS fire detections across Alaska in 2003-2017
- MODIS hotspot detections are a good proxy of area burned and therefore a good tool for evaluating fire indices
- Good relationship with fire detections already established for FWI/BUI



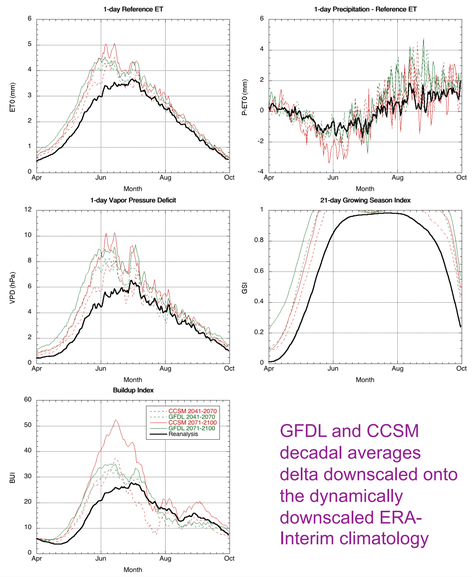

- Conditional frequency analysis based on the level of each index and occurrence/non-occurrence of hotspots in a PSA
- Timescale (daily, weekly, etc.) is an important factor when comparing indices
- 15-day EDDI and SPEI both show higher frequency of high values during MODIS fire detect days along with the baseline BUI
- Challenges when incorporating precipitation in SPEI




## Jun-Jul fire weather conditions projected to generally worsen

- Alaska is at the forefront of climate change due to Arctic Amplification and understanding if the future will see more flammable conditions is important for long-term planning
- Analysis across the Interior PSAs indicate that ET0, VPD and BUI all show projected increases in magnitude in Jun-Jul by the 2040s.
- GSI is projected to increase at the beginning and ends of the season indicative of a lengthened growing season
- However, fire seasons are often driven by more short term conditions so these results do not necessarily indicate that more extreme fire seasons are projected

**Projected changes in Alaska fire indices**




GFDL and CCSM decadal averages delta downscaled onto the dynamically downscaled ERA-Interim climatology

## Summary

- Downscaled ERA-Interim reanalysis matches the variability of station derived GSI, VPD and input parameters for EDDI and SPEI. The exact magnitudes may be impacted by a wet bias in summer precipitation
- EDDI and SPEI show favorable agreement with BUI and MODIS fire detection days at the PSA level
- Future projections indicate that fire weather conditions in Jun-Jul will likely worsen by the 2040s according to the EDDI, VPD and BUI in Interior Alaska. More uncertainty in SPEI.

**Next Steps:**

- Evaluate GSI and VPD against MODIS detections and FWI/FFMC
- Consider extremes in the evaluation of future projections

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