Short-term Prediction Research and Transition (SPoRT) Center Datasets and Products for Wildland Fire Potential and Prediction

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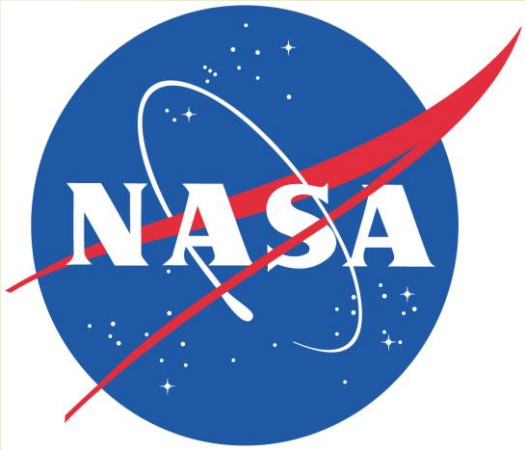


Short-term Prediction Research and Transition (SPoRT) Center

SPoRT is focused on transitioning <u>unique</u> NASA and NOAA observations and research capabilities to the operational weather community to improve short-term weather forecasts on a regional and local scale

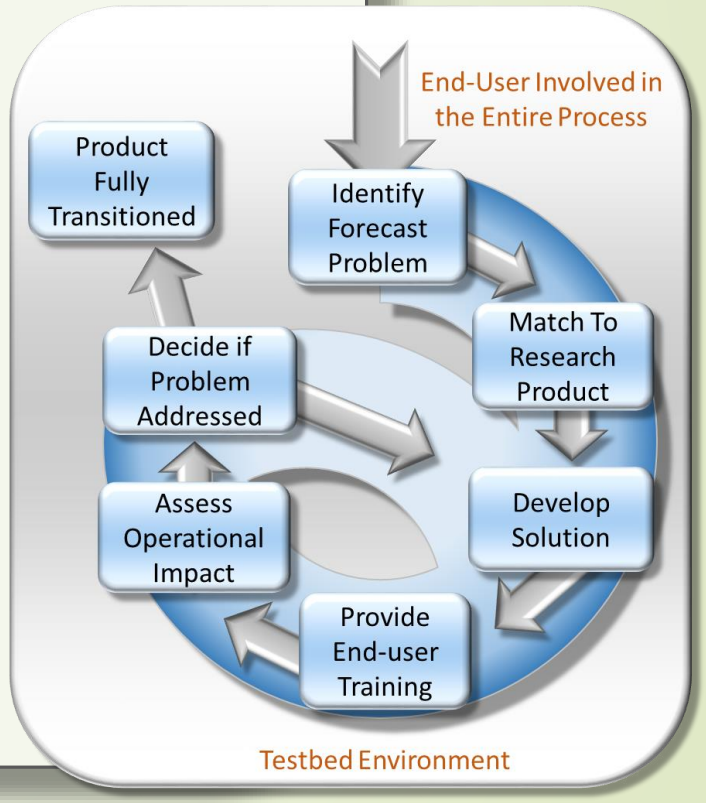
Proven paradigm for transition of research and experimental data to "operations"

<u>Benefit</u>

- demonstrate capability of NASA and NOAA experimental products to weather applications and societal benefit
- prepares forecasters for use of data from next generation of operational satellites (JPSS, GOES-16)

Operational Meteorologists and decision makers

Leveraging NASA Science Mission Directorate Earth Science Division funds to build out capabilities relevant to wildfire applications for real-time assessment of wildfire potential.



SPORT Short-term Prediction Research and Transition Center

SPoRT Areas of Expertise

- Perform targeted research activities to exploit unique capabilities of NASA satellites and technologies to solve specific weather forecasting challenges
- Support for product dissemination to AWIPS, WMS, etc.
- Apply unique R2O/O2R paradigm for transitioning data and obtaining valuable feedback from NWS forecasters

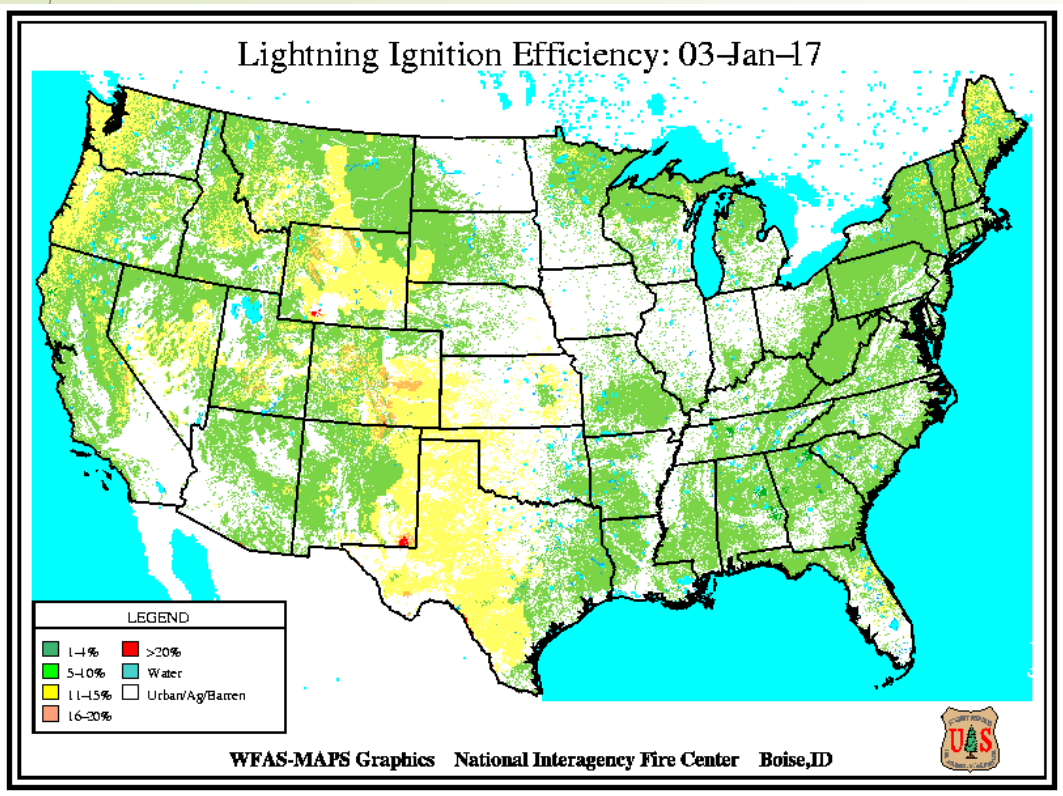
NASA SPORT
Short-term Prediction Research and Transition Center

Purpose and Goals

- Can we use modeled information of the land surface and characteristics of lightning beyond flash occurrence to increase the identification and prediction of wildfires?

- The goals of this study are to:
  - Combine observed cloud-to-ground (CG) flashes with real-time land surface model output, and
  - Compare data with areas where lightning did not start a wildfire to determine what land surface conditions and lightning characteristics were responsible for causing wildfires.

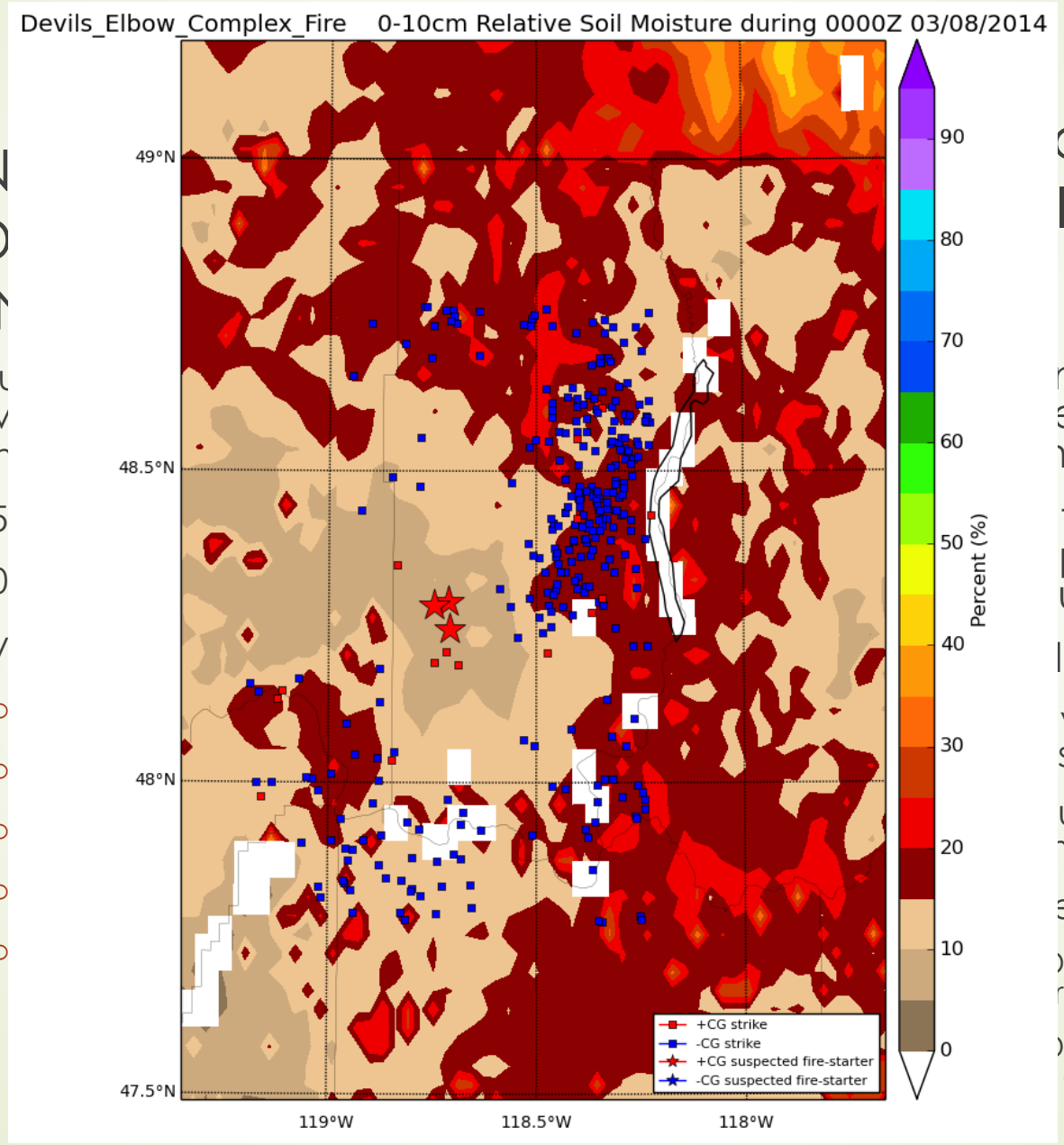
Current Methods



https://www.wfas.net/images/firedanger/ltng_pi.png

- Currently the U.S. Forest Service utilizes flash density, Normalized Difference Vegetation Index (NDVI), and fuel density/type to assess lightning ignition efficiency for the day.
- Based on this efficiency, a lightning density threshold is applied to compute the probability that a wildfire has started.
  - If the Ignition Efficiency is high (salmon color), the density required for ignition is 9 flashes km^{-2}.
  - If the Ignition Efficiency is Extreme (red), the density required for ignition is 5 flashes km^{-2}.
  - These are empirically derived metrics from Latham and Schleitter (1989).

Data Sources



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IS/VIIRS real-time daily GVF;
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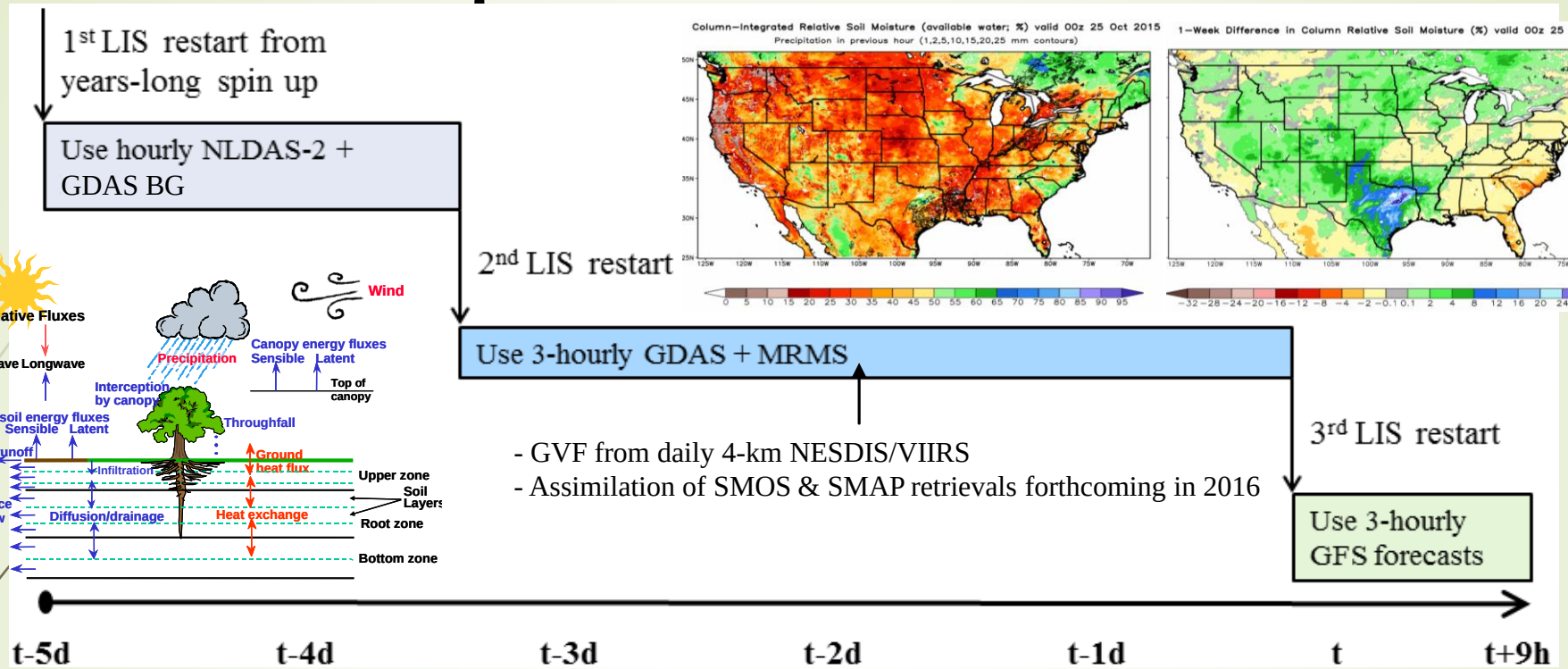
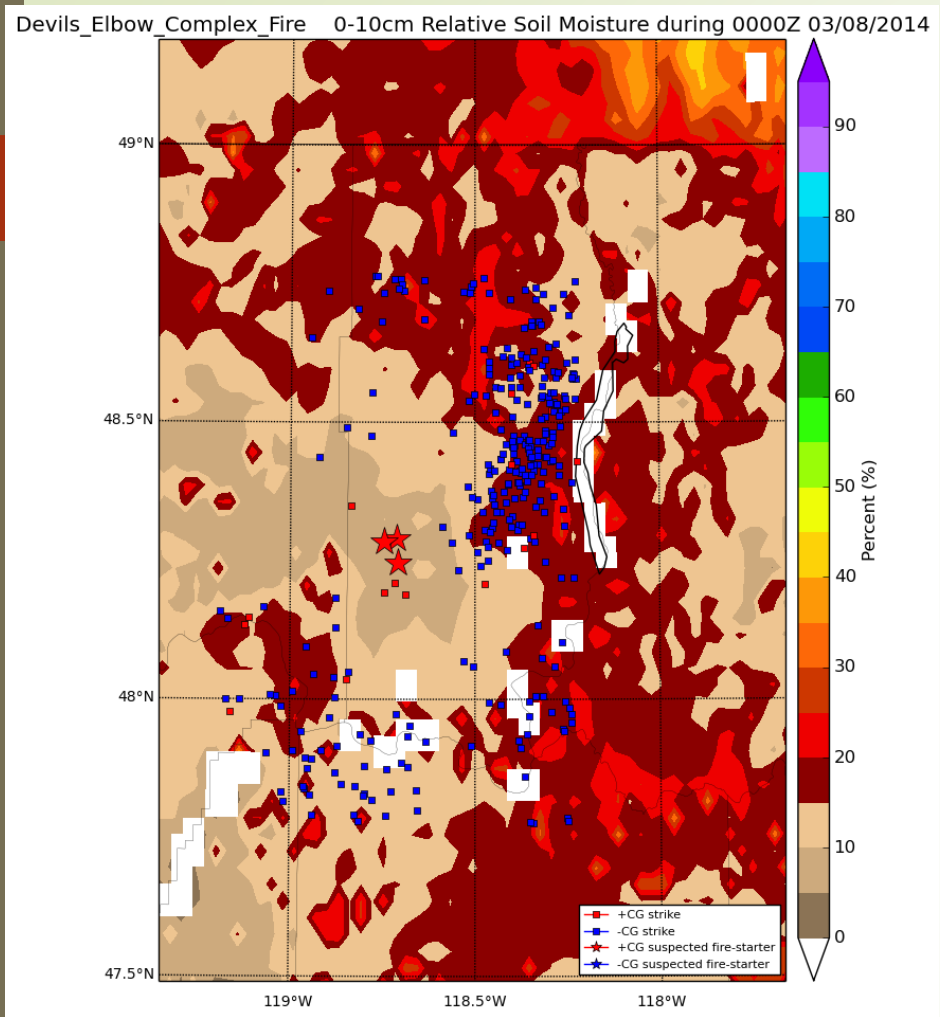
Operational SPoRT-LIS



- **NASA LIS used to perform long-term integration of Noah Land Surface Model (LSM) updated in real-time.**
- **Advantage is high-resolution (~3-km), real-time capabilities that can capture sub-county scale features that current operational soil moisture products cannot (e.g., NLDAS-2) and also includes health of green vegetation.**
- **Output used for situational awareness and local modeling by forecasters at select NWS offices and international forecasting agencies.**



Above – a combination of 0-10 cm relative soil moisture, with cloud to ground lightning overlaid on the soil information.
Boxes: flashes that did not product a fire; Stars are firestarting flashes
Polarity: blue (-) red (+)

Methods

1. 87 lightning initiated wildfires were analyzed between 2008 and 2015
   - Majority of cases from 2012-2015 time frame to take advantage of VIIRS GVF.
   - Information were obtained from InciWeb: Incident Information System Website.
   - Date/time and estimated latitude/longitude coordinates of the origin of each case were recorded.
2. Lightning data obtained from the NLDN; only CG flash designation were used.
3. Land surface data obtained from the Land Information System (SPoRT-LIS).
4. Each lightning flash within a 100-km radius of the wildfire start point was used to extract land surface model information to compare fire-starting flashes with non-fire-starting flashes.
5. Wilcoxon-Mann-Whitney Rank Sum test performed to determine degree of independence between the fire starting and non-fire starting flashes for each lightning and land surface parameter examined.
   1. A p-value of 0.05 was used for significance testing.

Results

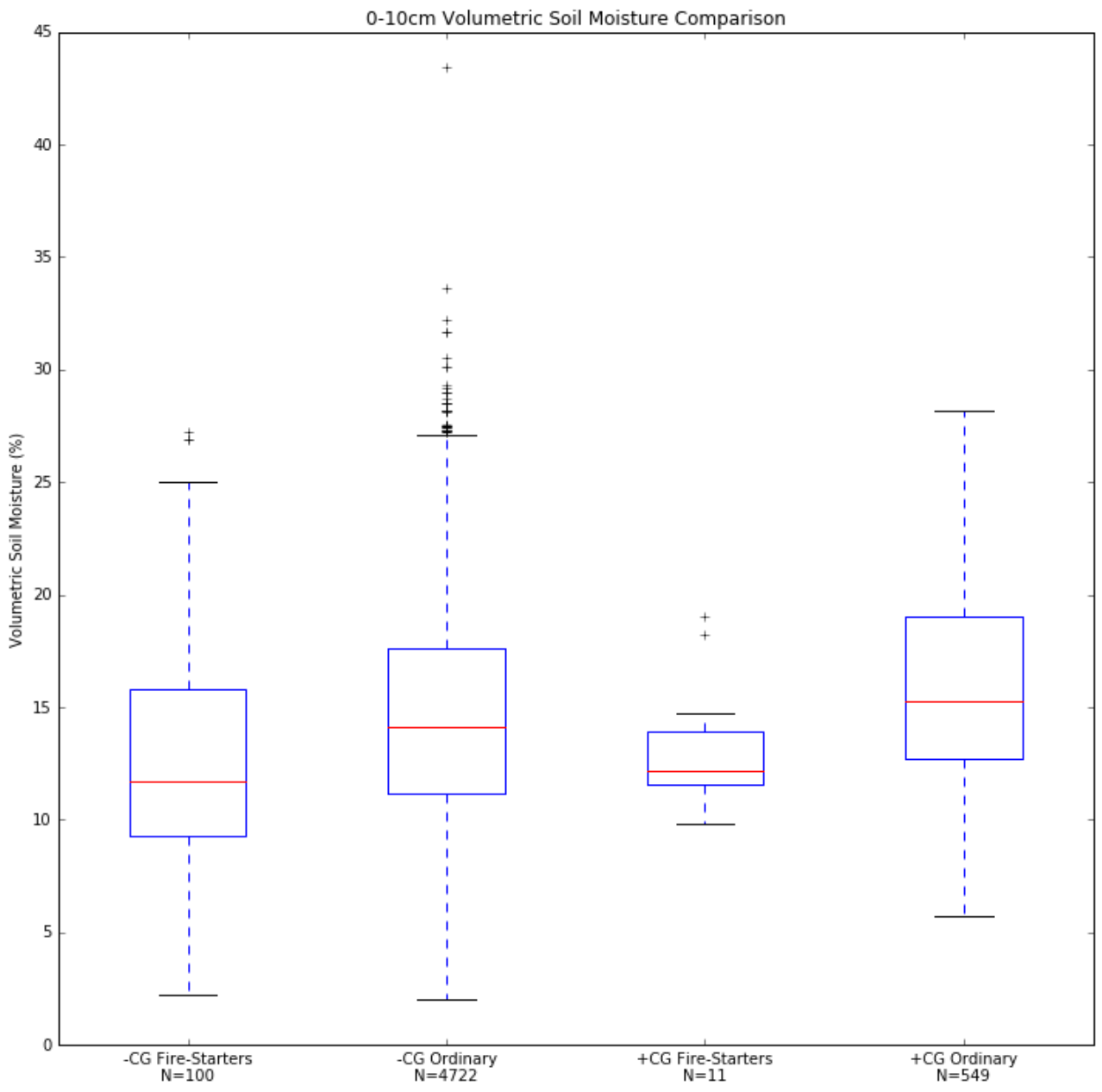
- 84 of 87 wildfires identified to be lightning initiated contained at least 1 flash at the initiation point within +/- 3 hours of the fire start time.
  - The 3 fires reported as lightning initiated may not necessarily falsely identified because smoldering can occur for days (e.g., Lang et al. 2015).
- Over 7,000 km^2 were consumed by these fires, with the largest fire analyzed burning 1,223 km^2 of land [Approximately the size of Delaware].

Lightning

Red: Fire-starter	Green: Non-fire starter	
	Peak Amplitude (kA)	
-CG 25th Percentile	-13.475	-7.0
-CG Median	-22.25	-12.9
-CG 75th Percentile	-39.5	-23.1
+CG 25th Percentile	+25.25	+19.7
+CG Median	+36.0	+27.2
+CG 75th Percentile	+51.15	+41.5
-CG Mean	-30.9	-18.92
+CG Mean	+47.19	+35.09
-CG Rank-sum p-value	2.48×10^{-11}	
+CG Rank-sum p-value	0.139	

- A total of 5,382 locations where a cloud-to-ground flash occurred were analyzed
  - 4,822 negative CG
  - 560 positive CG flashes
- 110 flashes could be associated with a wildfire initiation point
  - 100 of these were negative CG; 10 were positive CG
  - 26 ignition locations had multiple flashes
- 61 of 100 negative fire-starting flashes were single-stroke negative flashes.
- All 10 fire-starting positives were single-stroke flashes.
- The null hypothesis was rejected for magnitude of –CG flashes between FS and NFS (meaning the populations are statistically different); it was supported for +CG flashes (meaning no statistical difference between FS and NFS)

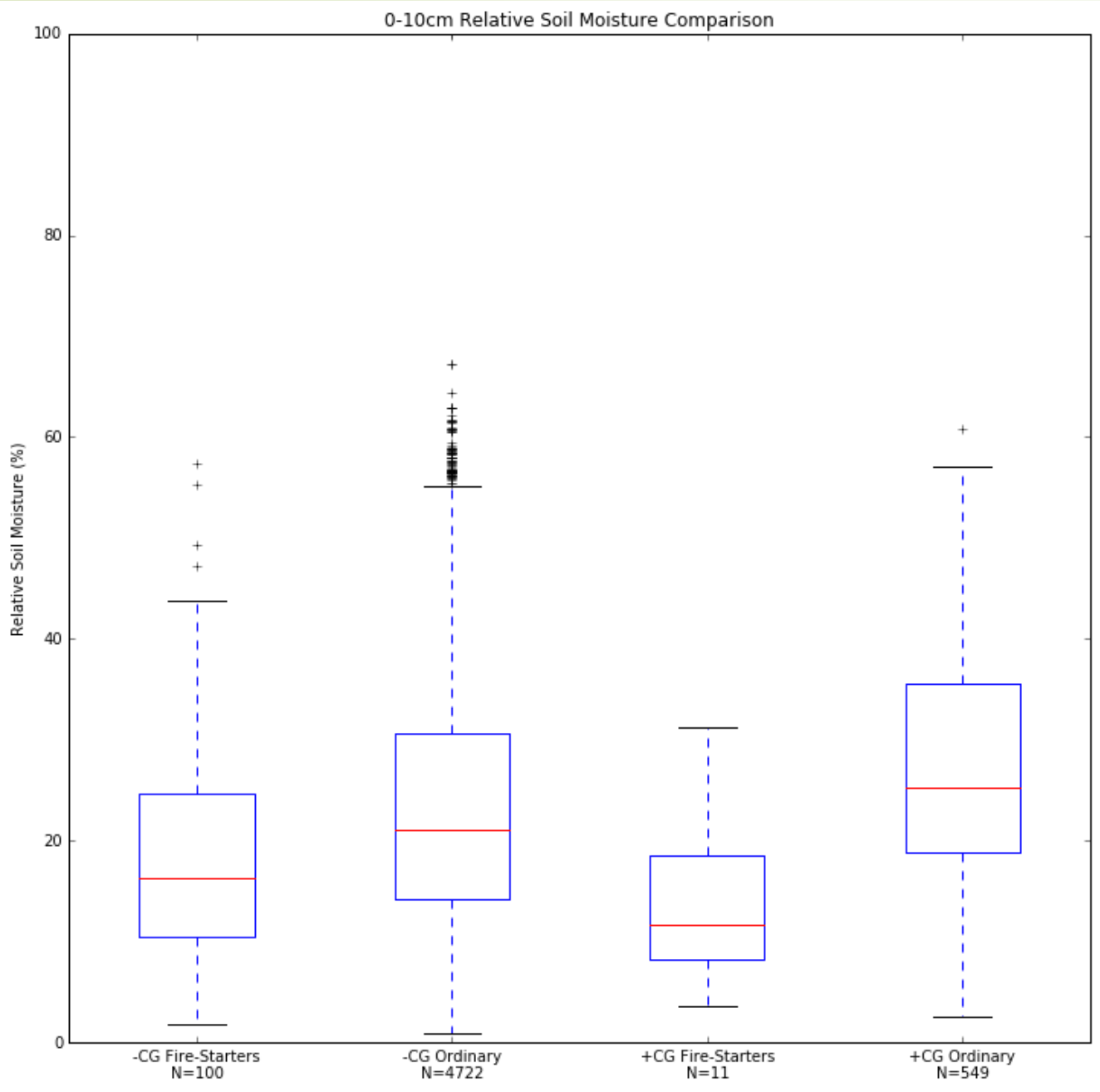
0-10 cm Volumetric Soil Moisture



Red: Fire-starter	Green: Non-fire starter	
	0-10 cm Volumetric Soil Moisture (%)	
-CG 25th Percentile	9.3%	11.2%
-CG Median	11.7%	14.1%
-CG 75th Percentile	15.8%	17.6%
+CG 25th Percentile	11.55%	12.7%
+CG Median	12.2%	15.3%
+CG 75th Percentile	13.9%	19.0%
-CG Mean	13.07%	14.88%
+CG Mean	13.21%	15.89%
-CG Rank-sum p-value	2.53×10^{-4}	
+CG Rank-sum p-value	2.61×10^{-2}	

- Suspected fire-starters occurred over areas of lower volumetric soil moisture on average.
- P-values for both polarities less than 0.05 indicating that the medians and distributions are shifted toward slightly drier values.

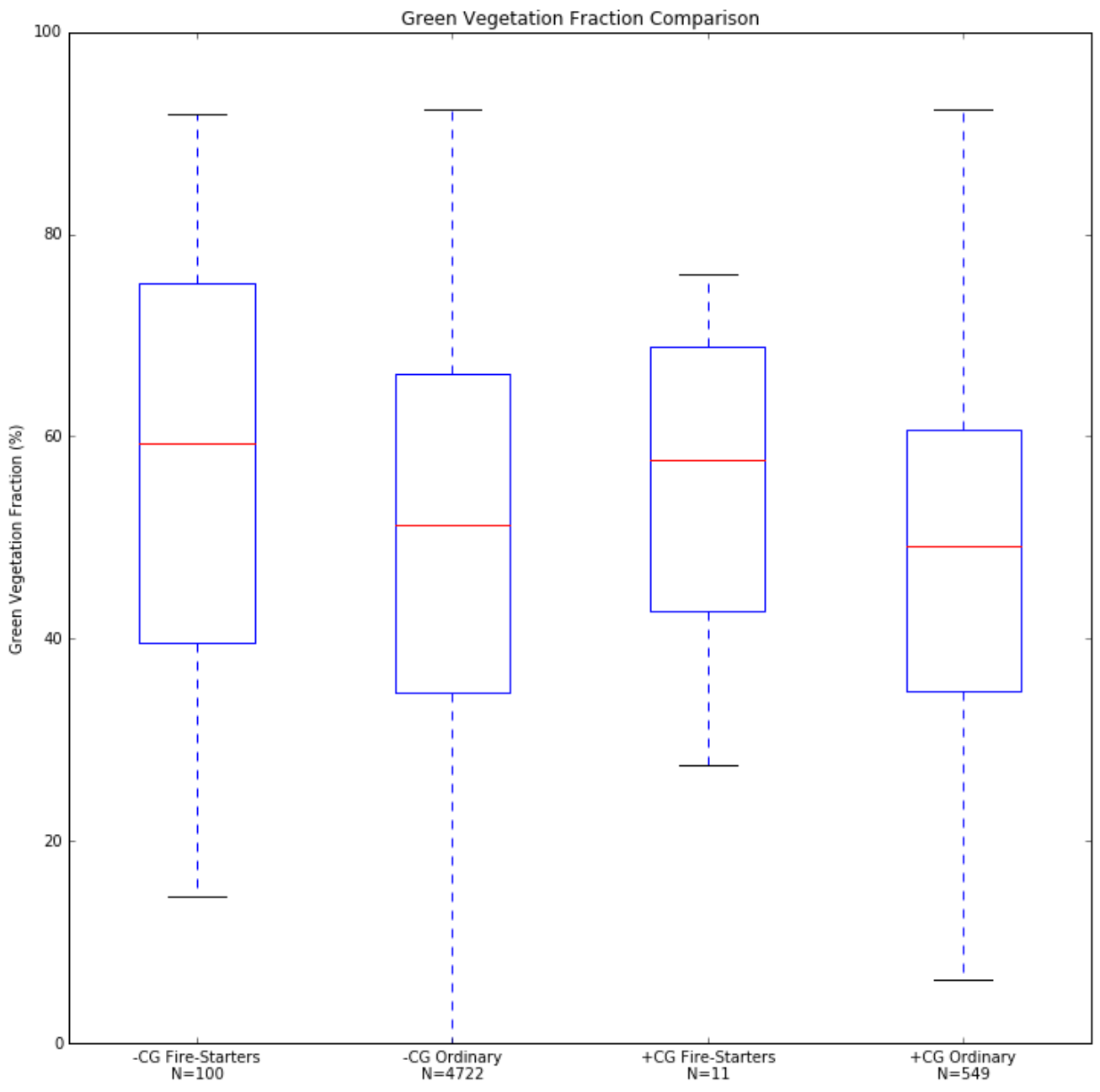
0-10 cm Relative Soil Moisture



Red: Fire-starter	Green: Non-fire starter	
	0-10 cm Relative Soil Moisture (%)	
-CG 25th Percentile	10.52%	14.18%
-CG Median	16.27%	21.13%
-CG 75th Percentile	24.65%	17.6%
+CG 25th Percentile	8.21%	18.83%
+CG Median	11.61%	25.32%
+CG 75th Percentile	18.52%	35.54%
-CG Mean	18.89%	23.82%
+CG Mean	14.24%	26.93%
-CG Rank-sum p-value	2.57×10^{-5}	
+CG Rank-sum p-value	4.78×10^{-4}	

- Boxplot shows significant difference between distributions of suspected fire-starters and ordinary strikes of both polarities.
  - P-values less than 0.05 indicating separation of distributions are most prevalent with the +CG flashes
  - Suspected fire-starters were primarily in areas of lower relative soil moisture.

Green Vegetation Fraction



Red: Fire-starter	Green: Non-fire starter	
	Green Vegetation Fraction (%)	
-CG 25th Percentile	39.67%	34.69%
-CG Median	59.29%	51.2%
-CG 75th Percentile	75.08%	66.24%
+CG 25th Percentile	42.81%	34.76%
+CG Median	57.63%	49.11%
+CG 75th Percentile	68.95%	60.63%
-CG Mean	56.49%	50.97%
+CG Mean	55.63%	49.24%
-CG Rank-sum p-value	9.15×10^{-3}	
+CG Rank-sum p-value	0.179	

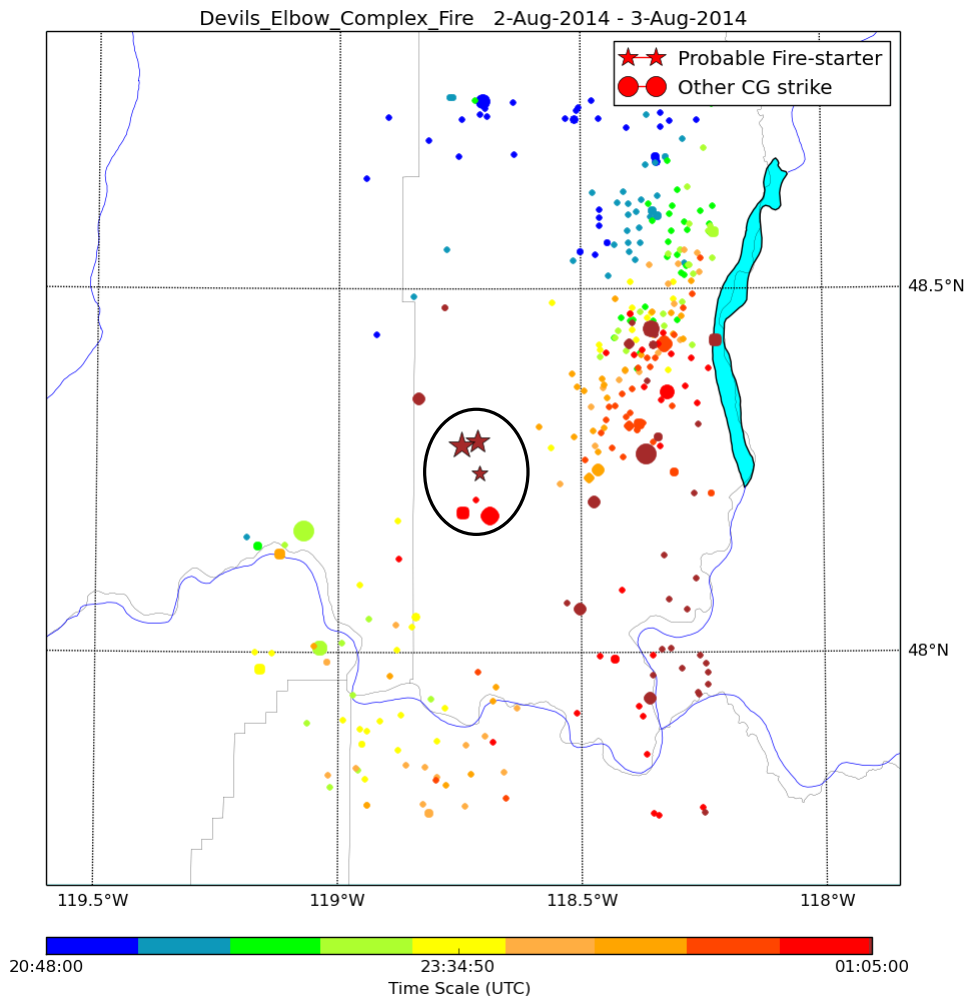
- Boxplot shows suspected fire-starters typically occurred over relatively well-vegetated areas.
  - True for –CG strikes due to low p-value.
  - Not necessarily true for +CG strikes due to p-value > 0.05.
    - Affected by low sample size compared to –CGs recorded.

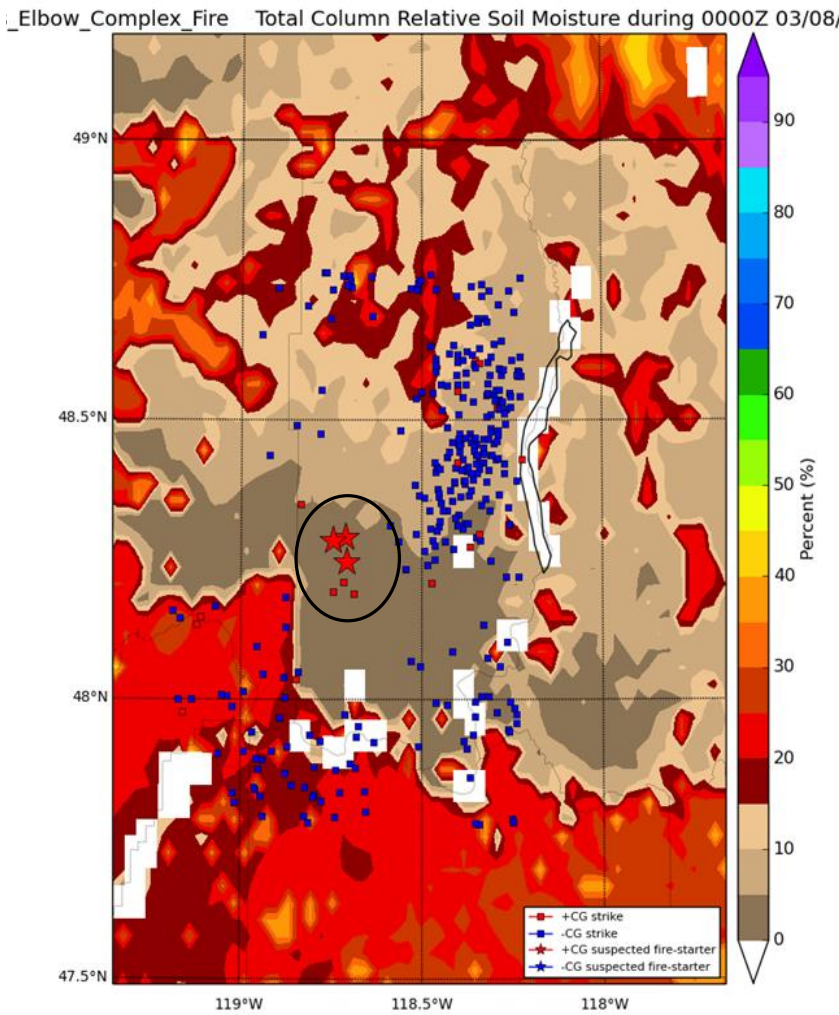
Random Sampling to test hypotheses

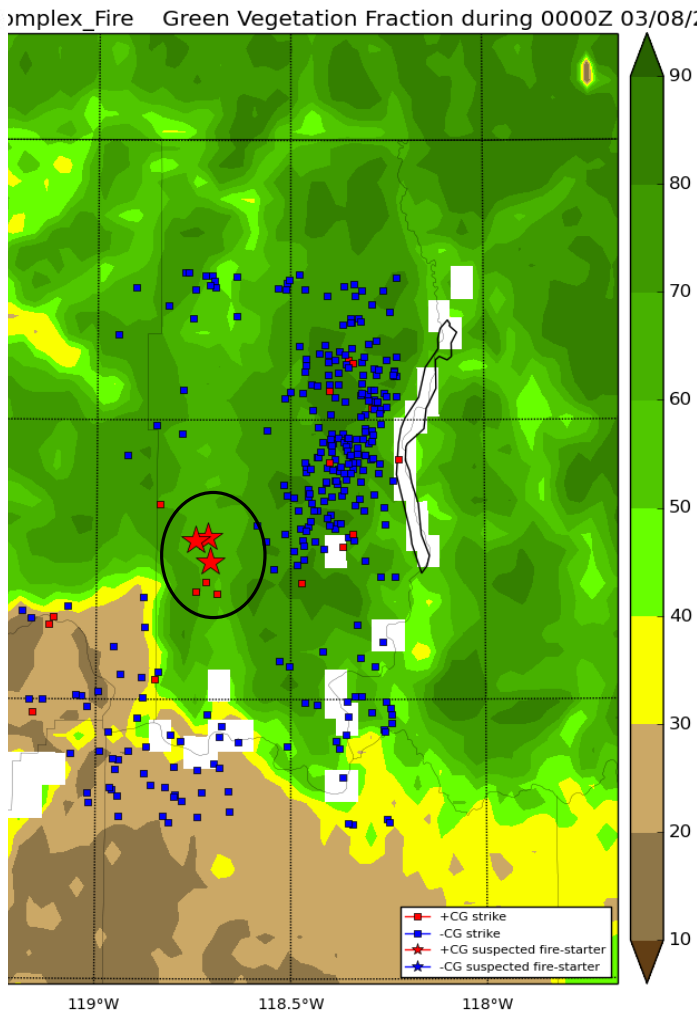
Parameter	Overall	Random sample
Flash Magnitude	**-CG: reject** **+CG: accept**	**-CG: reject (30/30)** **+CG: accept (26/30)**
Multiplicity	**-CG: accept** **+CG: accept**	**-CG: accept (28/30)** **+CG: accept (30/30)**
0-10 cm soil moisture content	**-CG: reject** **+CG: reject**	**-CG: reject (30/30)** **+CG: reject (30/30)**
0-10 cm relative soil moisture	**-CG: reject** **+CG: reject**	**-CG: reject (30/30)** **+CG: reject (30/30)**
GVF	**-CG: reject** **+CG: accept**	**-CG: accept (18/30)** **+CG: accept (26/30)**
0-200 cm relative soil moisture	**-CG: accept** **+CG: reject**	**-CG: accept (30/30)** **+CG: accept (21/30)**

- 10 different random samples were computed for the positive and negative polarity non-fire-starting populations for each parameter and then compared to the fire- starting population.

- GVF for –CGs and 0-200 cm relative soil moisture for +CG occurrence from rejecting the null hypothesis of different distributions to accepting that the distributions were the same the majority of the random samples.



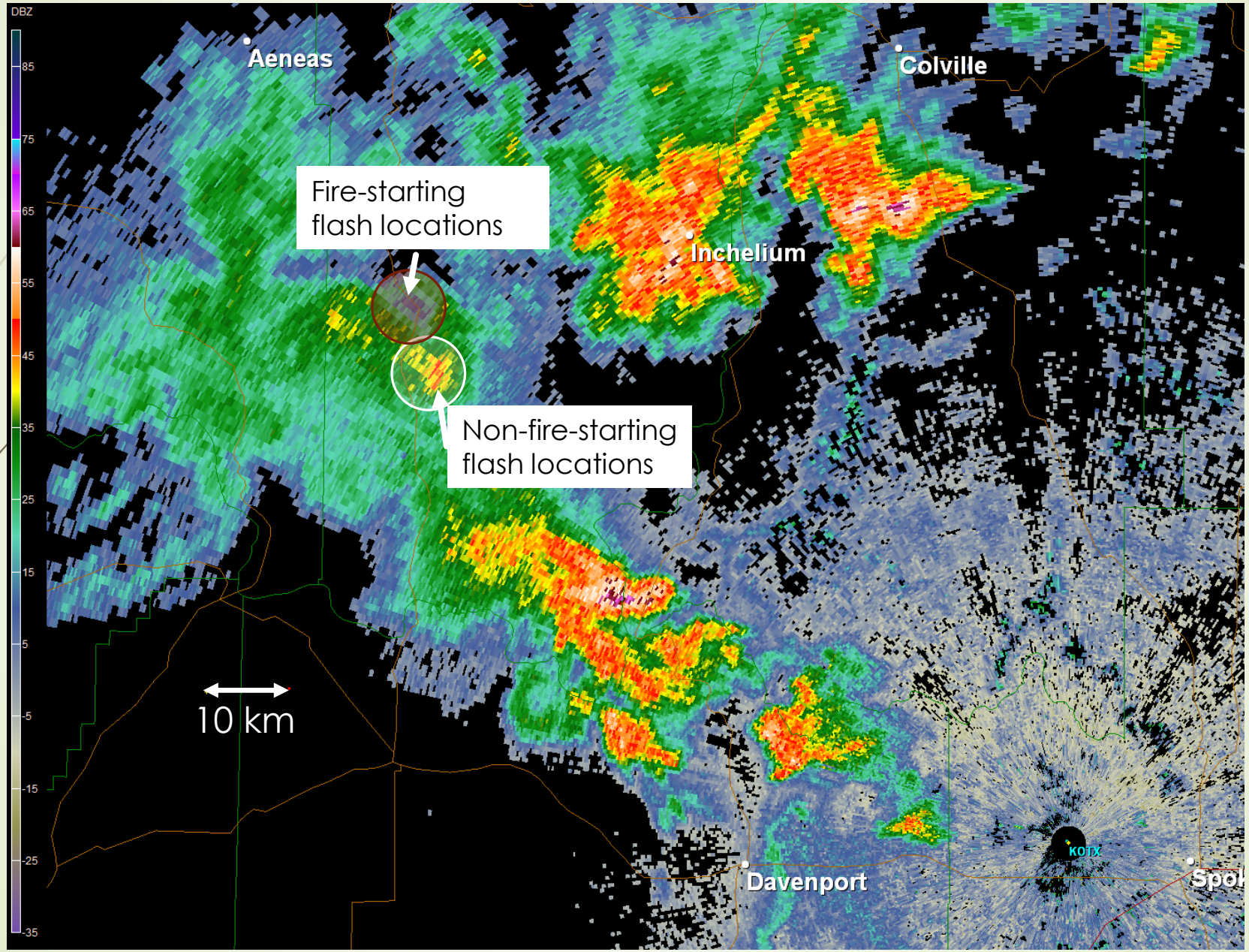




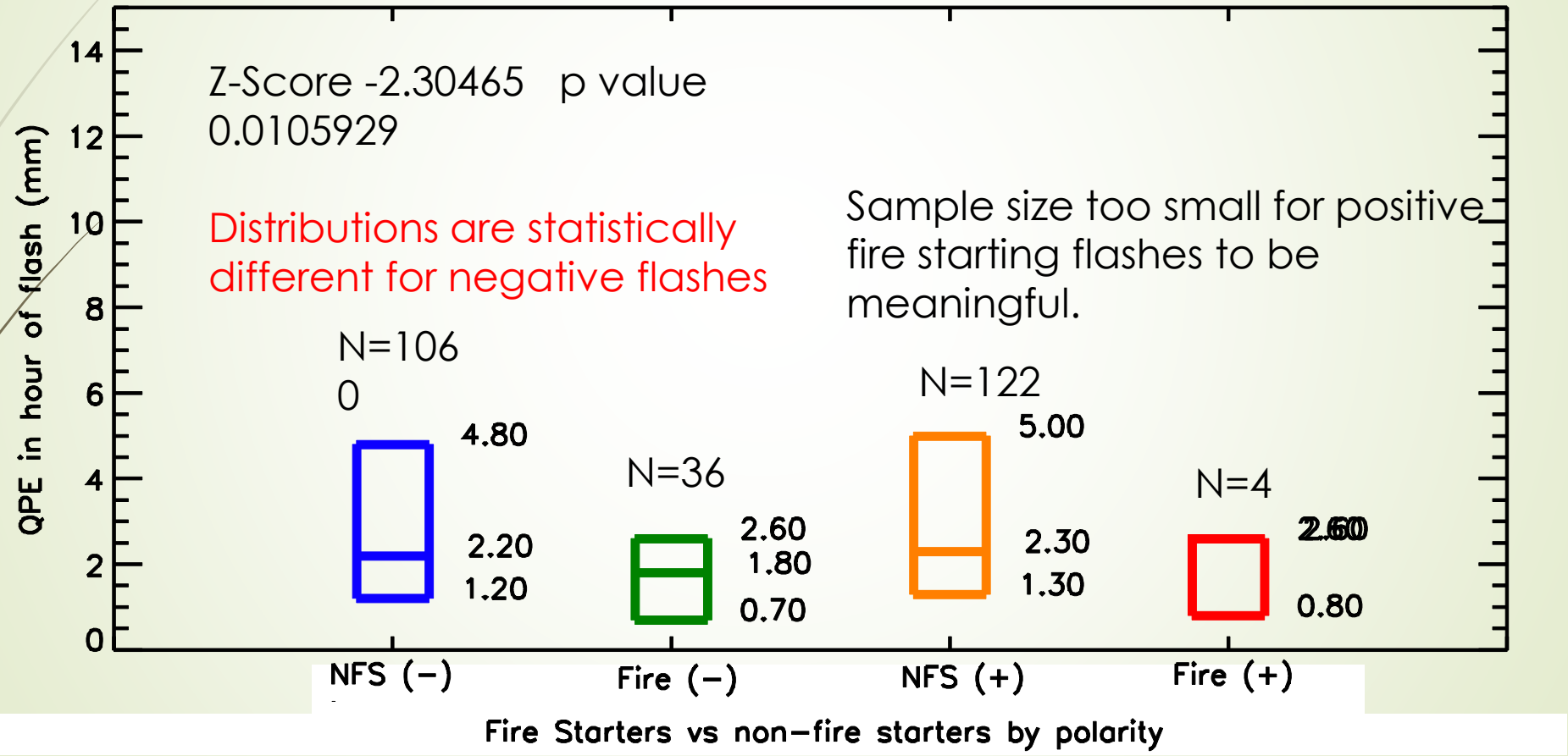
Very similar characteristics of 3 fire-starting and 3 non-fire starting positive flashes

What was different?

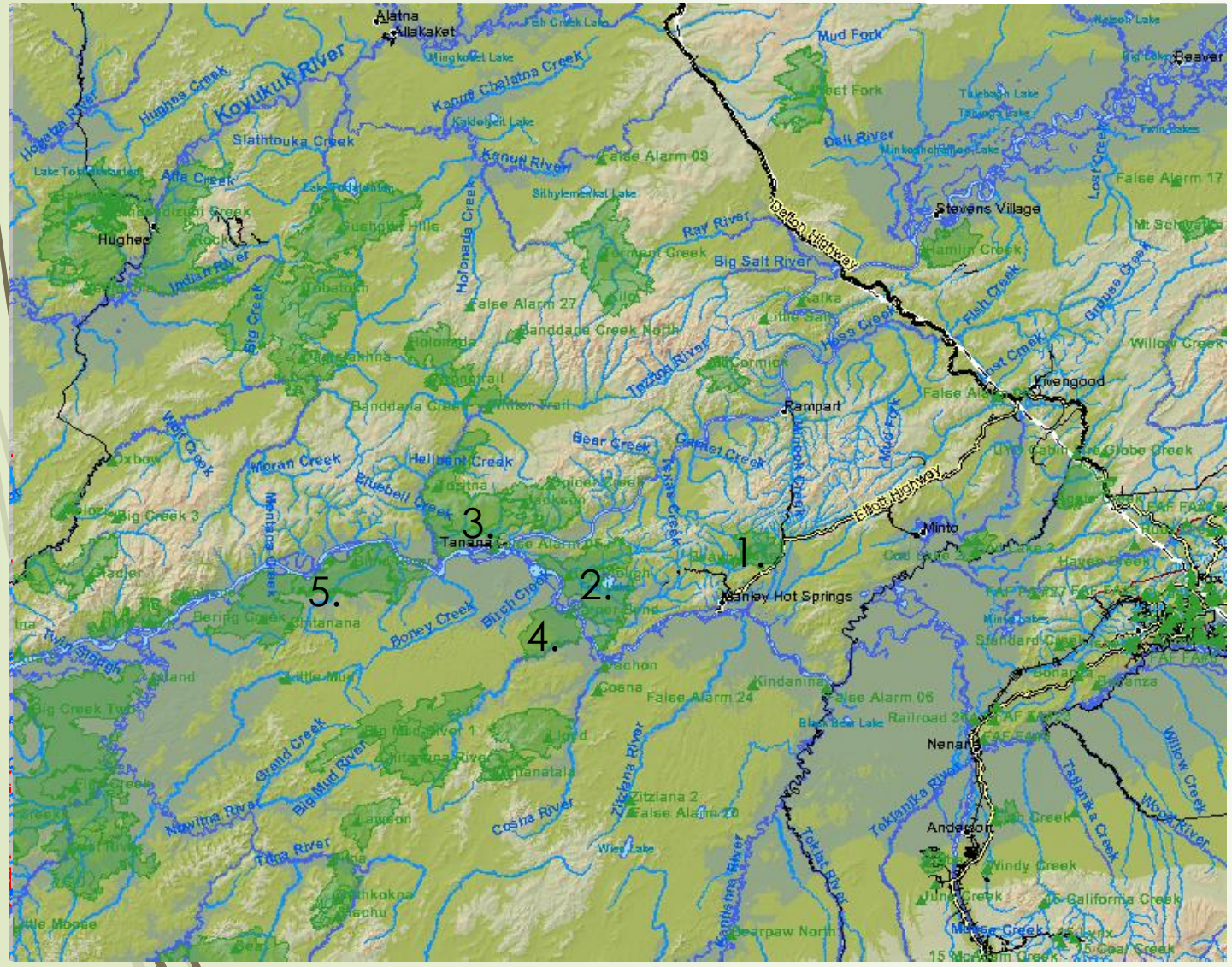
The flash location relative to precipitation cores…



Incorporating Rainfall Information



Expanding Lightning Work from CONUS to Alaska: Step 1: Characterizing Lightning and Fire Datasets



The lightning detection network in Alaska is different than the CONUS datasets we've used:

1) has different spatial accuracy than the CONUS network (< 25 km accuracy vs < 250 m accuracy in CONUS).

Working to understand the datasets and how they integrate with the fire databases.

Fire 1 – Report time June 21
- lightning time June 21

Fire 2 – Report time June 21
- lightning time June 20 or 21

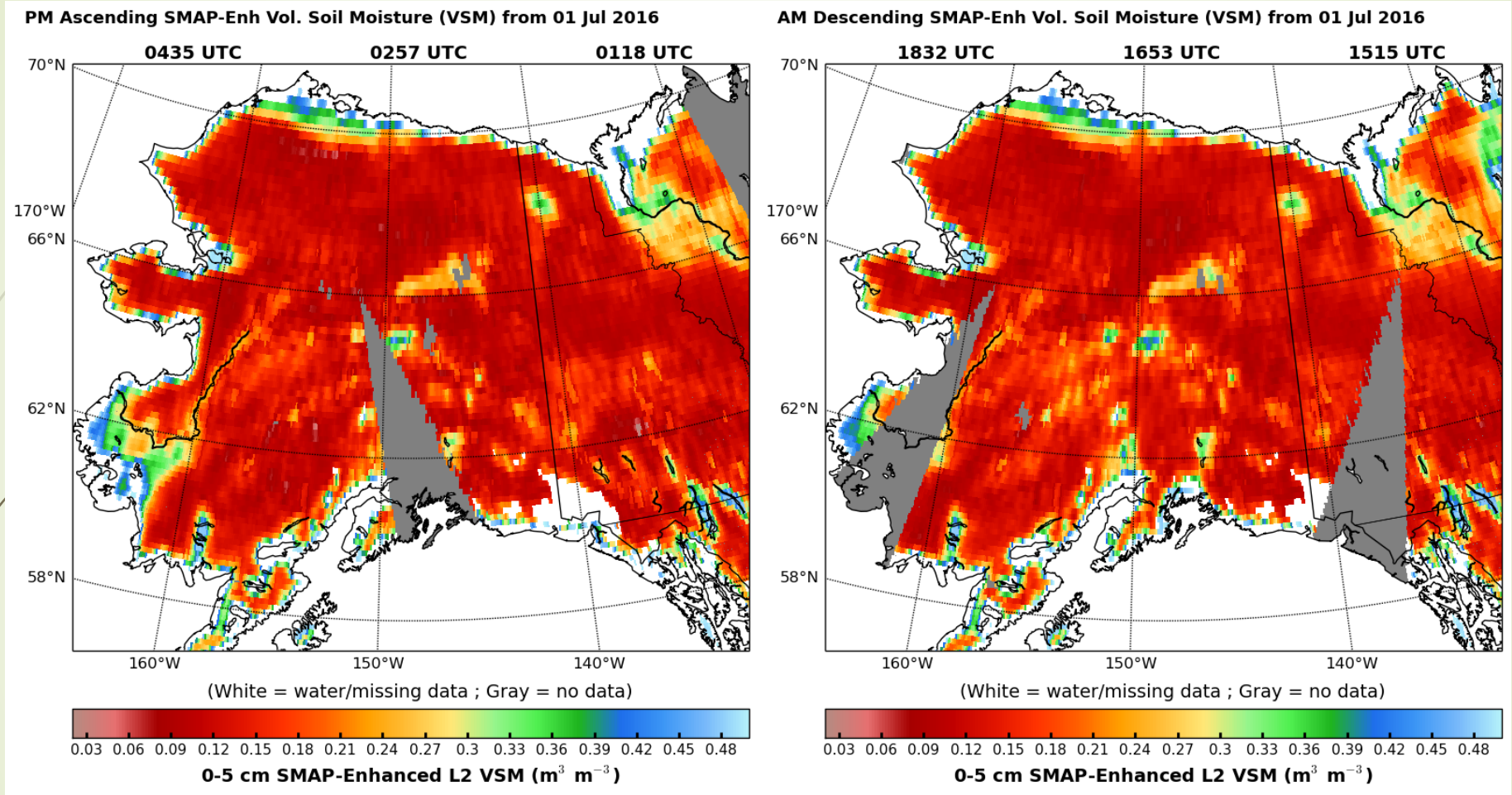
Fire 3 – report time June 21
- lightning time June 20 or 22 (after report time)

Fire 4 – report time June 21
- lightning time June 21

Fire 5 – Report time June 22
- lightning time June 21

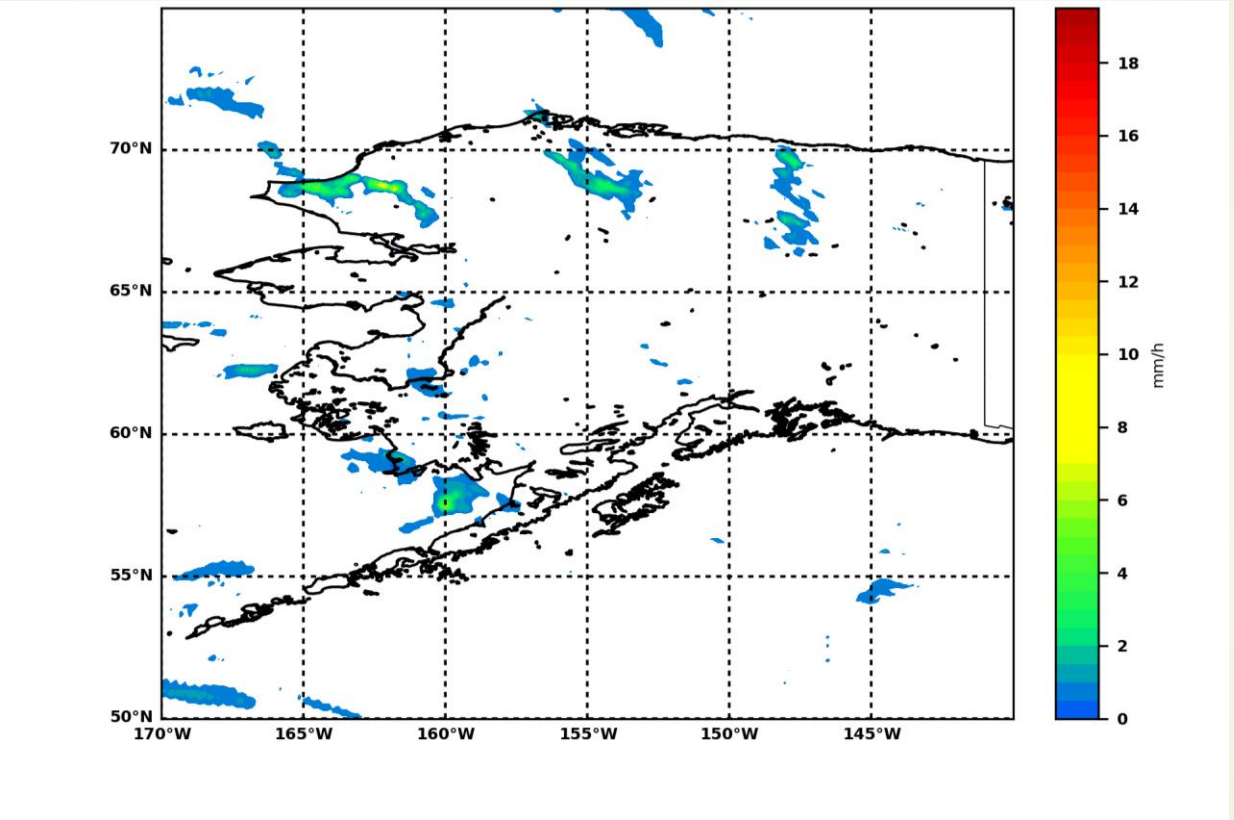
Dark green areas – footprints of fires

Expanding the Operational LIS to Alaska



Because soil moisture sensors are far between, we are utilizing the Soil Moisture Active Passive (SMAP) satellite to assimilate soil moisture content in the near surface in Alaska.

GPM



Because of radar limitations we can utilize GPM constellation overpasses to represent precipitation in radar void regions. .

Conclusions

- Statistical differences between suspected fire-starters and non-fire-starters were peak-current dependent.
  - More intense strikes typically were suspected fire-starters.
  - Majority of flashes (71 of 110) were single-stroke flashes.
  - -CG p-value = 2.48×10^{-11} (distributions were significantly different).
  - +CG p-value = 0.14 (distributions were similar).
- 0-10 cm Volumetric and Relative Soil Moisture comparisons were statistically dependent to at least the p = 0.05 independence level for both polarity flash types.
  - Suspected fire-starters typically occurred in areas of lower soil moisture than non-fire-starters.
- GVF value comparisons were only found to be statistically dependent for -CG flashes.
  - However, random sampling of the –CG non-fire starter dataset revealed that this relationship may not always hold.
- We are adapting our methodology to incorporate additional satellite datasets to expand the analysis to Alaska.