Improved operational approaches to high and low-intensity fire detection in Alaska using the VIIRS I-band Fire Detection Algorithm for High Latitudes (VIFDAHL)

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- Alaska Fire Science Consortium (AFSC)
- BLM/Alaska Fire Service (AICC)
- LANCE/NASA (FIRMS)
- USDA Remote Sensing Applications Center (RSAC)

Requirements are *what* users want

(Design is *how* you achieve it)

	benefits +	drawbacks -
Model1: Make use of existing **global / standard** remote sensing products (from NASA, NOAA, other agencies)	excellent validation, long time series, consistent, well-understood, quality assurance…	("one size fits all") struggle to understand and operationalize
Model2: Mobilize **local** capabilities and expertise and develop **custom** products	optimizes response to regional requirements, redundancy	ad-hoc, struggle to standardize and implement processes

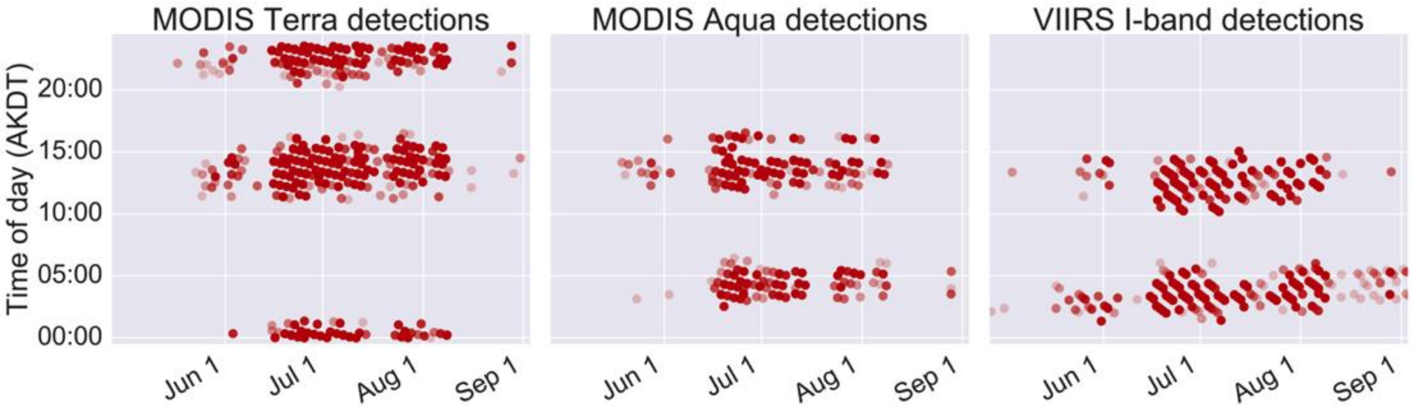
Management/user community: “We knew there was fire, but there were no MODIS detections. Why not? Can we do better with VIIRS?”

- Requirement: enhance fire management and modelling (smoke) for Alaskan fires optimizing detection for AK boreal forest fires
- Designed new VIIRS I-band algorithm based on VIIRS SDR data (downlinked locally by GINA) and compared to closely timed Landsat 8 and existing products
- For extreme 2015 fire season, we evaluated existing global MODIS (Giglio, Schroeder, Justice, 2016) and VIIRS I-band products (Schroeder et al., 2014)

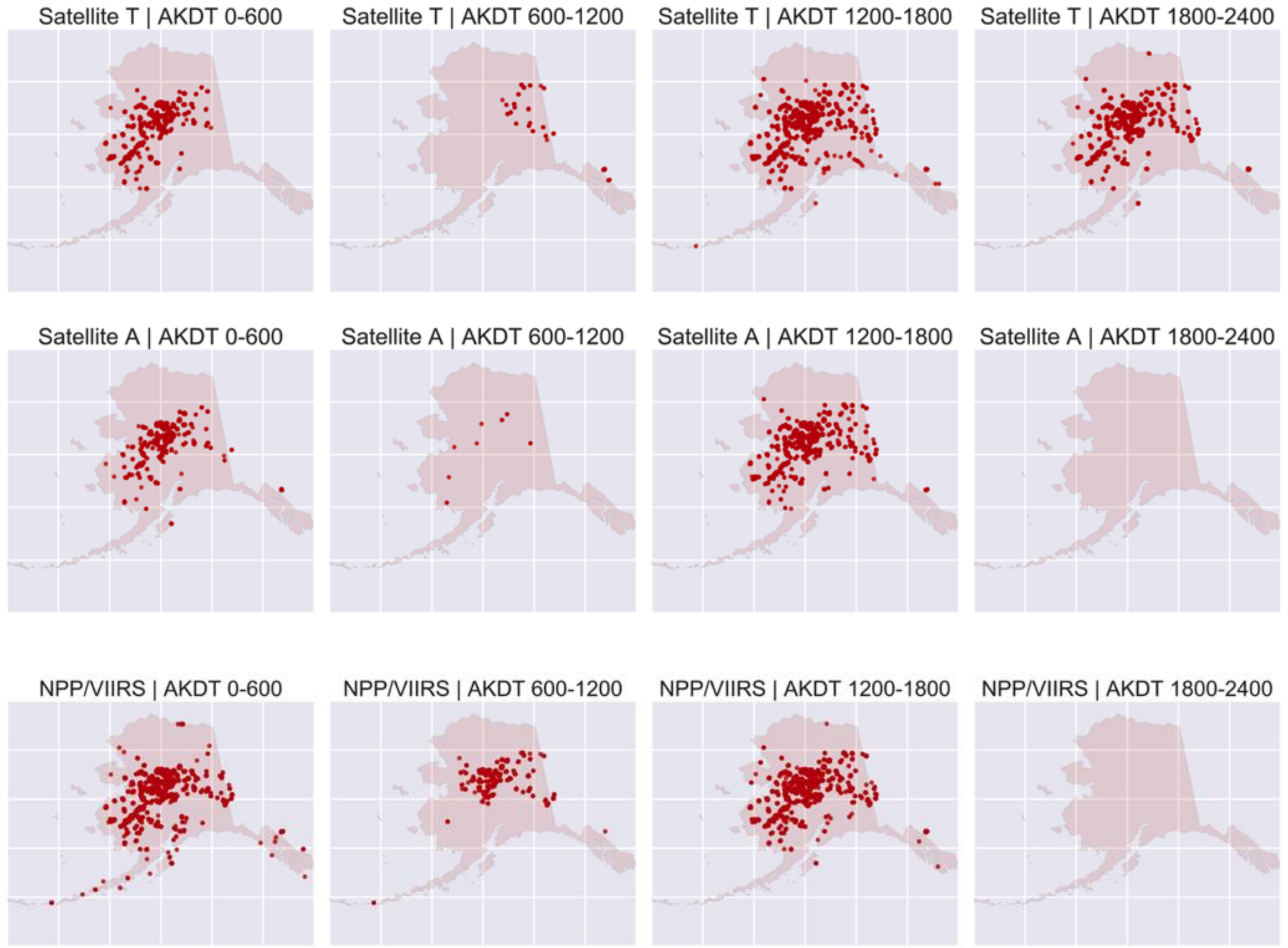
VIIRS I-band and MODIS fire detections are comparable, but consider overpass timing

Quality control? Missing scenes?

Fire product	Number of fire detections	Number of undetected fires	Percentage undetected fires	Size largest undetected fire (acres)	Size largest undetected fire (ha)	Max. fire pixels for one fire	Percentage unassigned detections
MOD/MYD14	26,670	77/334	23.05	3,342.3	1,352.6	1,846	3.8
VIIRS I-band(*)	54,677	75/334	22.46	3,342.3	1,352.6	3,991	2.9

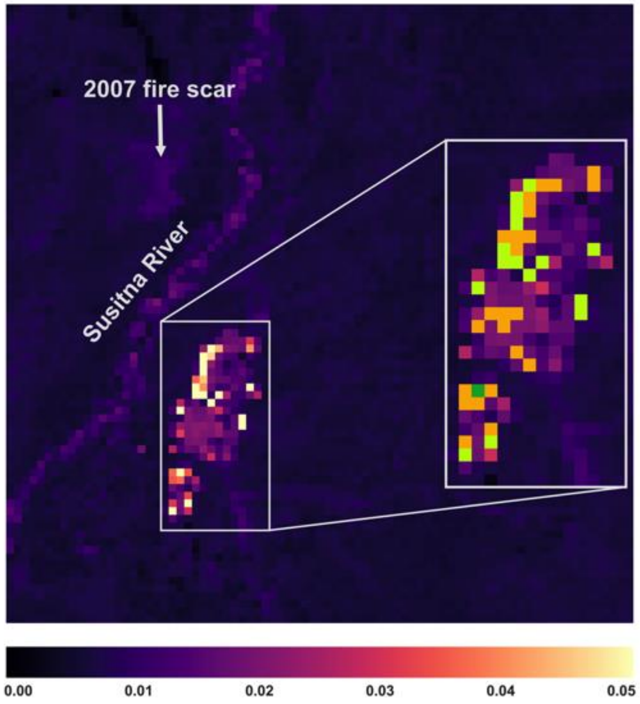


(*) RSAC – NOT official NASA distribution


Satellite T | AKDT 0-600
Satellite T | AKDT 600-1200
Satellite T | AKDT 1200-1800
Satellite T | AKDT 1800-2400
Satellite A | AKDT 0-600
Satellite A | AKDT 600-1200
Satellite A | AKDT 1200-1800
Satellite A | AKDT 1800-2400
NPP/VIIRS | AKDT 0-600
NPP/VIIRS | AKDT 600-1200
NPP/VIIRS | AKDT 1200-1800
NPP/VIIRS | AKDT 1800-2400

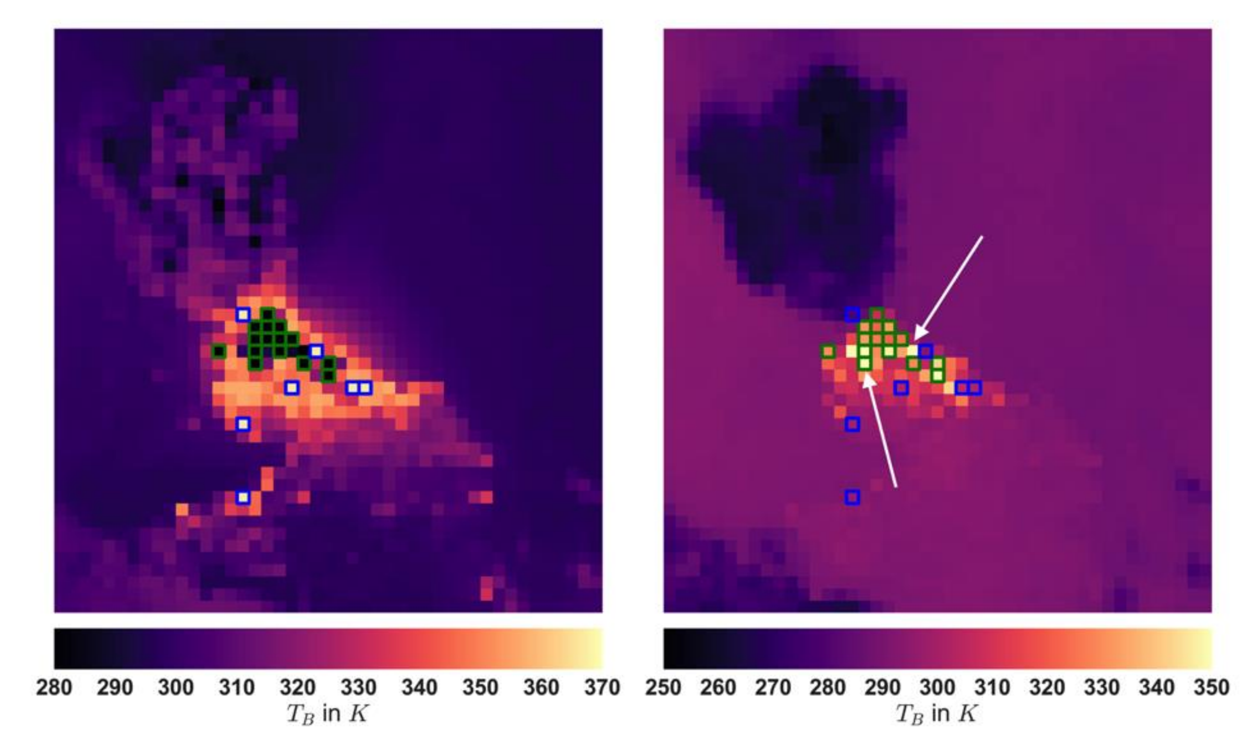
Requirements for VIIRS I-band Fire Detection Algorithm for High Latitudes:

- Detect every VIIRS I-band global fire pixel (Schroeder et al., 2014)
- Improved detection of residual fires
- Saturated pixels due to fire-related radiance are detected as fire
- Classify high- and low-intensity fire
- AK-specific false detections: sand banks and old fire scars are avoided
- Bowtie duplicates are removed
- GIS-ready product (pixel polygons)



NDBTI (normalized difference mid/thermal IR), 2015-06-14

VIIRS I-band Sensor Data Record shows anomalous pixels over high-intensity fires, indicated by quality flags



Yukon-Koyukuk study site, 2015-07-06. Left: T4 (3.74 µm) and T5 (10.45 µm)

VIIRS I-band Fire Detection Algorithm for High Latitudes (VIFDAHL)

VIIRS SDS datasets (GINA):
I4 and I5- at-sensor TB and pixel quality

Retrieve georeference file

Subset data and geodata to study area/AK boreal zone

NDBTI:
(T4 – T5)/(T4+T5)

Include anomalies:
EITHER (Q4 == 9 AND Q5 == 0)
OR (Q4 == 193 AND T4 low)

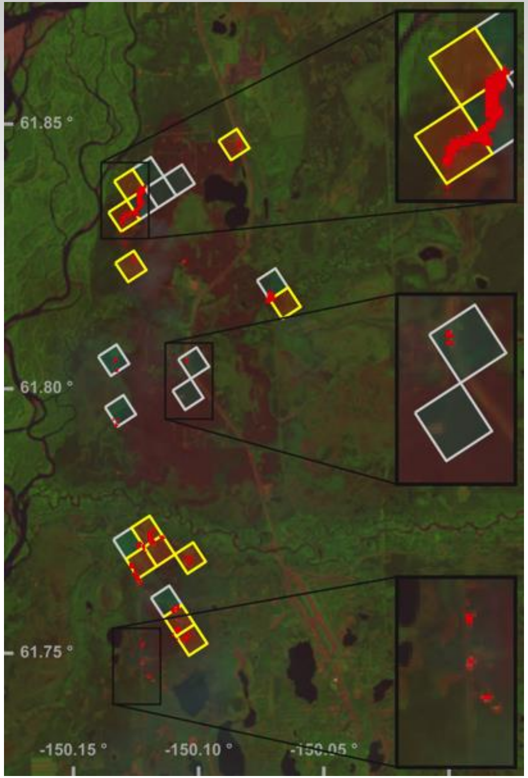
Exclude cloud, require elevated T:
T4 > 320 AND T5 > 285 (daytime) or
T5 > 265 (nighttime)

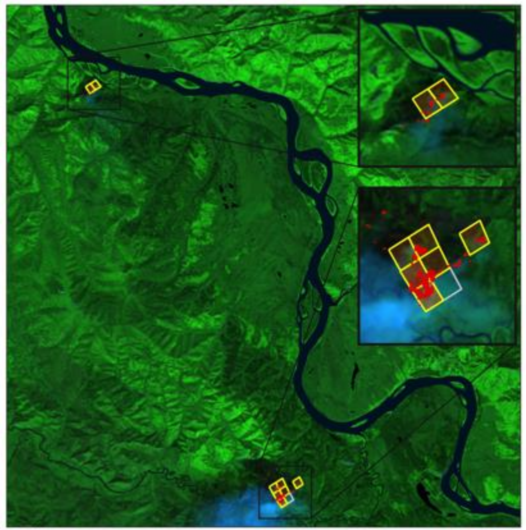
Exclude duplicate pixels (bowtie)

High-intensity :
NDBTI >= 0.05
OR anomalous values as masked above

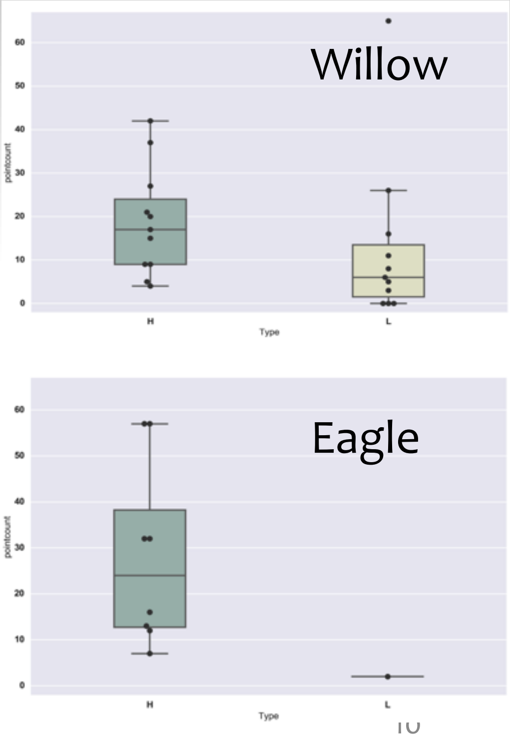
Low-intensity:
NDBTI < 0.05 AND
(NDBTI >= 0.02 OR
(NDBTI >= 0.015
NDBTI T5 > 312))

Willow and Eagle 2015 study sites: VIFDAHL compares well with near-simultaneous Landsat 8. Low- and high-intensity validated with L8 fire pixel counts

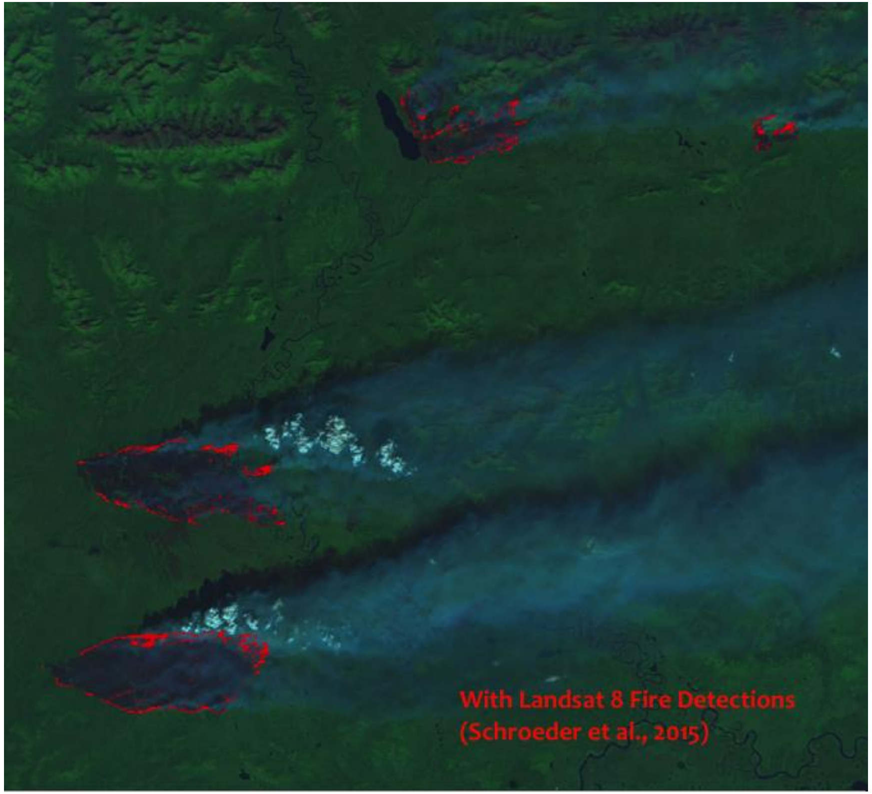


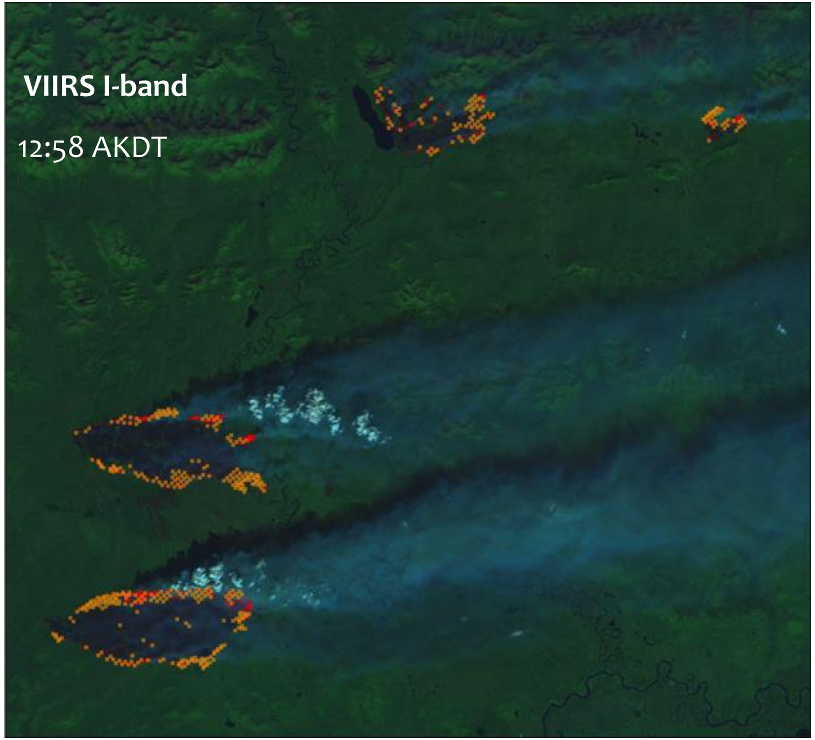


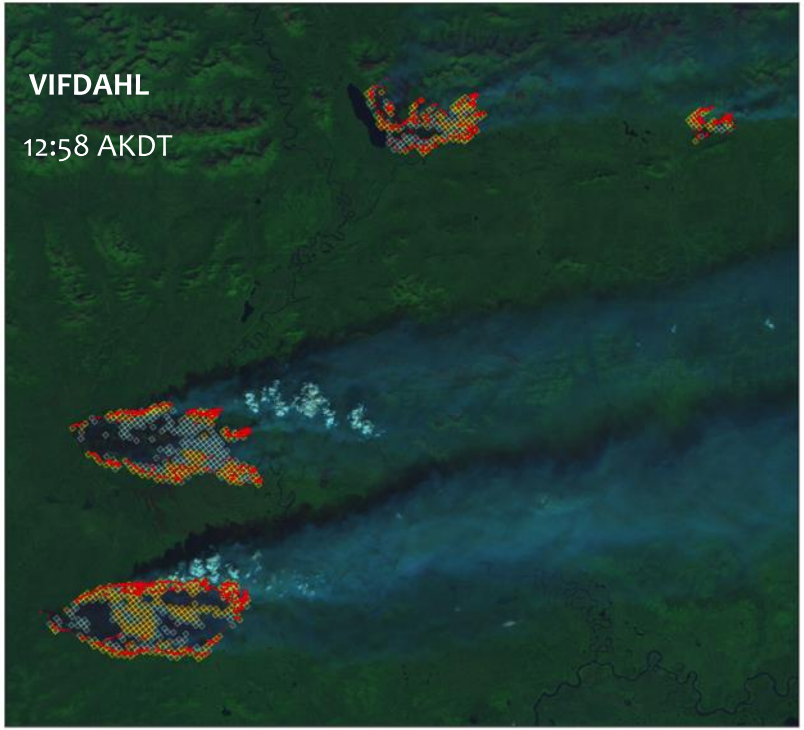
VIFDAHL vs. L8 fires
(Schroeder et al. 2015)



2016 Upper Koyukuk (2016-07-15): Landsat 8 true color (visible bands 4-3-2) vs. false natural color (VNIR bands 7-5-3)

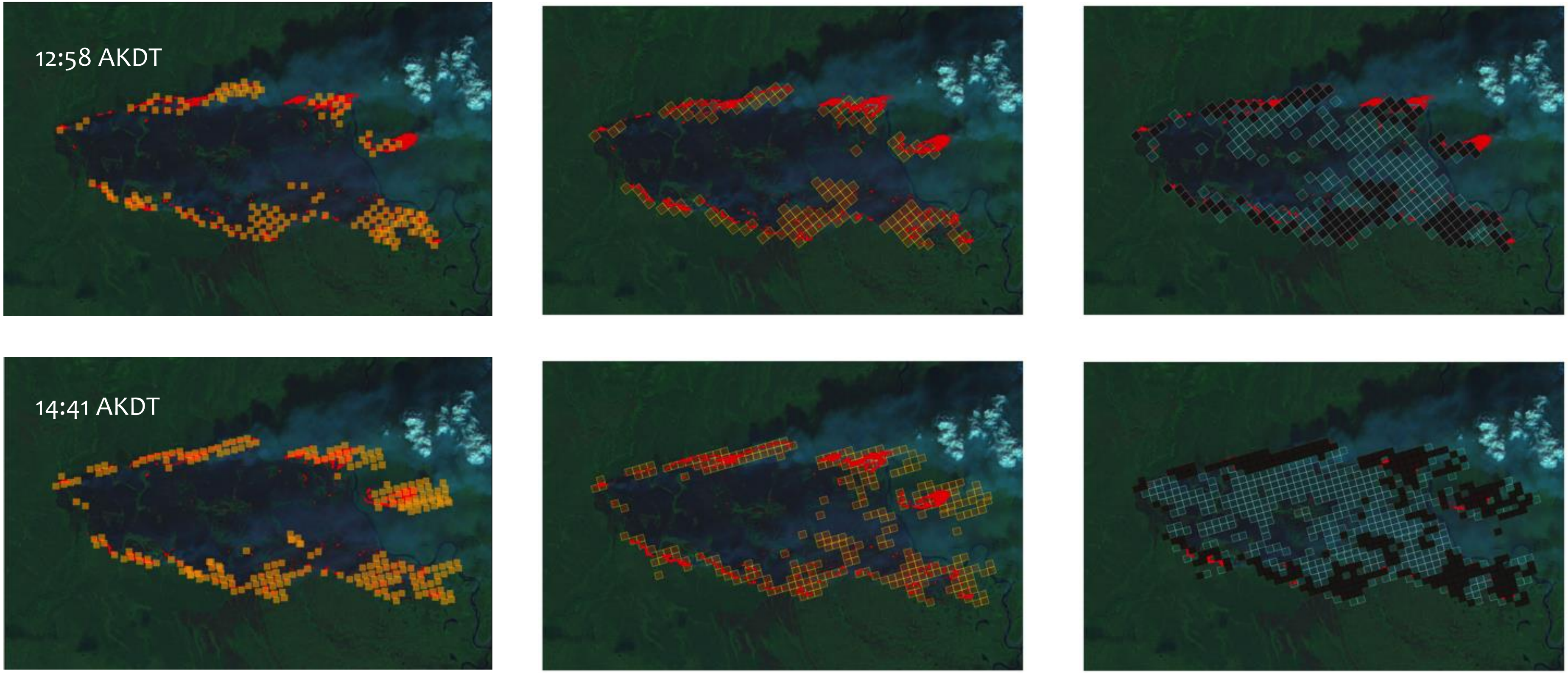






Timestamp	VIFDAHL high	VIFDAHL low	VIFDAHL total	VIIRS I-band
2015-07-15 12:58 AKDT	458	438	896	440
2015-07-15 14:41 AKDT	1143	913	2056	1006

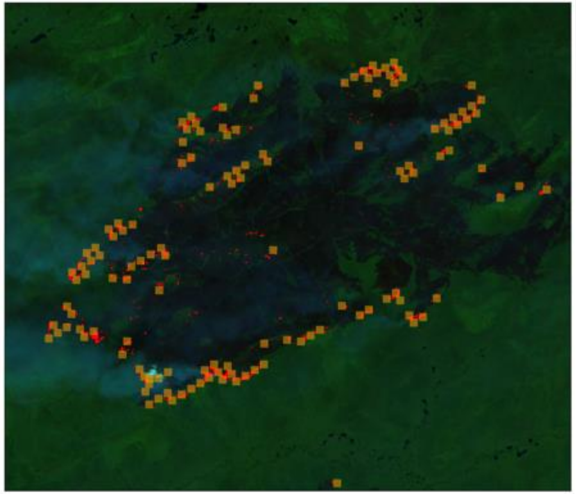
VIIRS global I-band | VIFDAHL high intensity | VIFDAHL low intensity

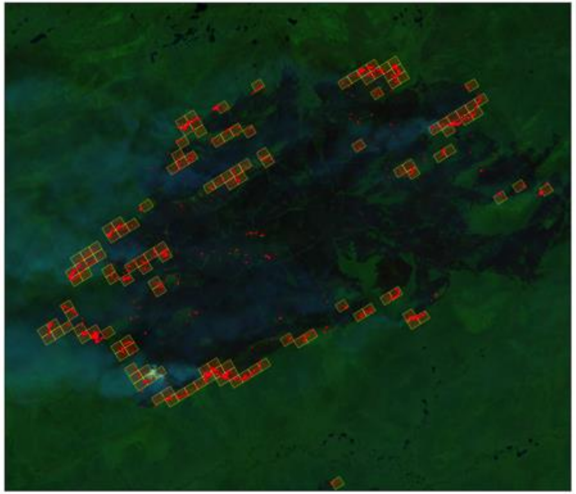


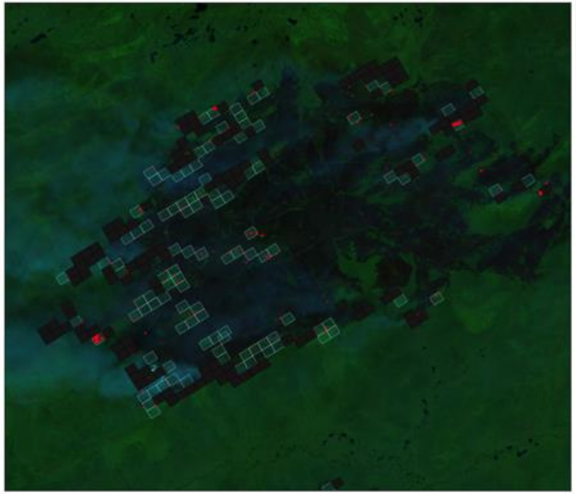
Underlying Landsat 8 scene is at 13:48 AKDT

Enhanced detection of residual burning behind the fire front (example: YK 2015 -subset)

Global VIIRS I-band	VIFDAHL – high	VIFDAHL –low
633 detections in scene	796 detections in scene	739 detections in scene

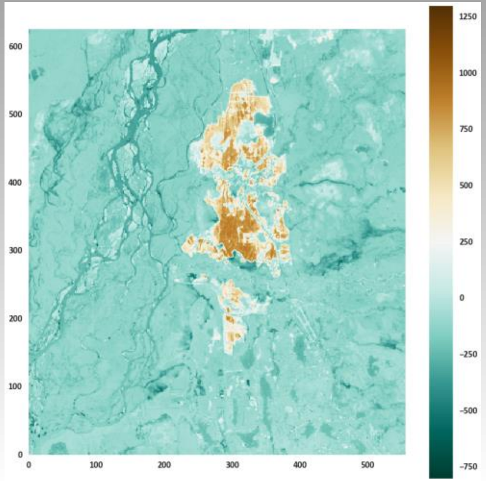


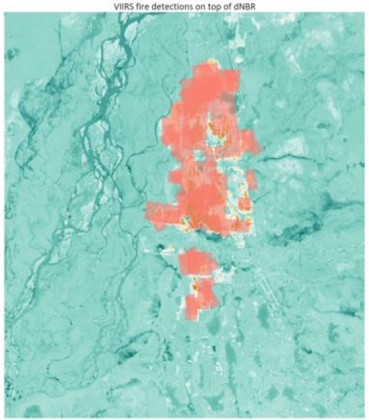




Ongoing work to operationalize and extend VIFDAHL

- VIFDAHL to run on GINA infrastructure during 2017 fire season, with GIS feed of detections sent to management agencies
- Use as input to WRF-Chem smoke forecast
- Combine I-band (detection) and M-band data for temperature retrieval for fire characterization
- Link fire severity to number of recurring detections (right: dNBR map vs. all VIFDAHL detections, Willow) – airborne HySpex opportunities



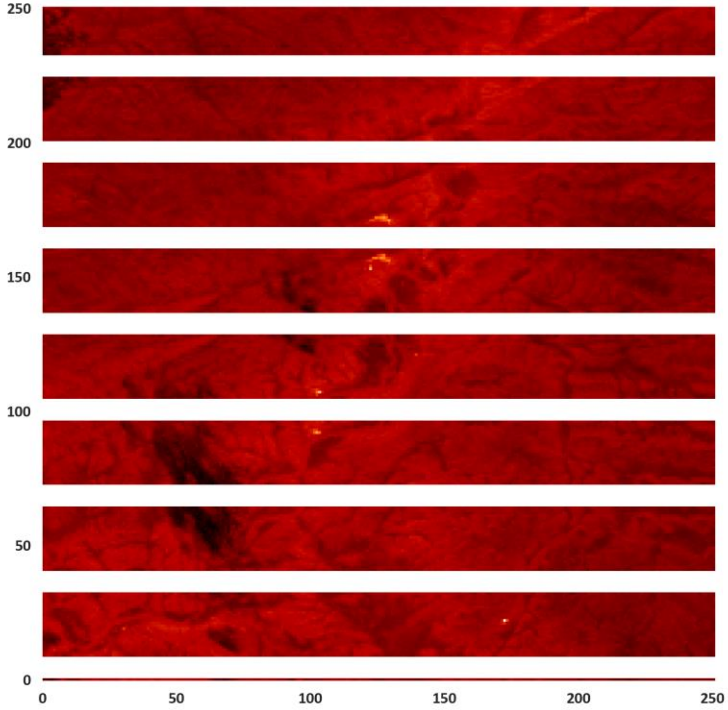


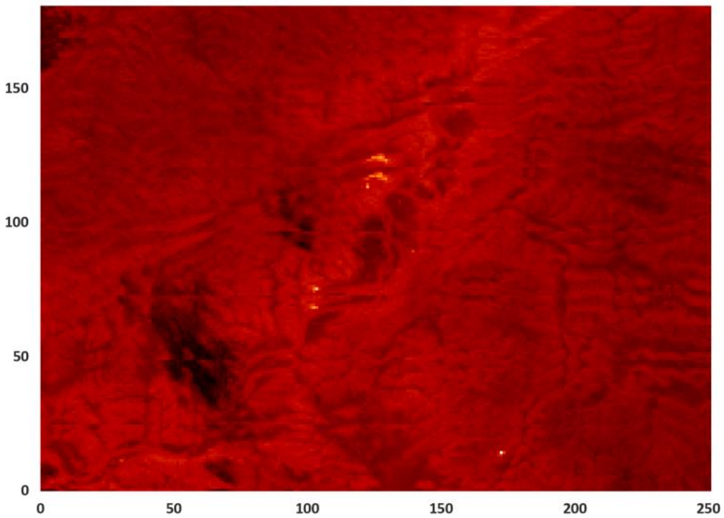
Conclusions

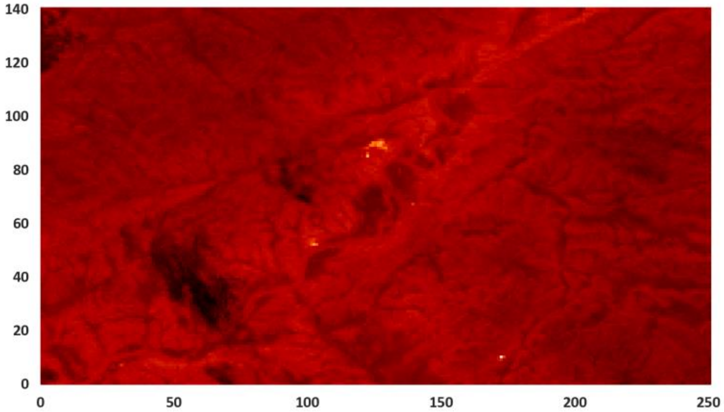
- Global fire products for Alaska boreal forest fires: VIIRS I-band product provides higher number of detections than MODIS, but no greatly enhanced coverage of fire
- New VIFDAHL approach improves low-intensity fire pixel detection and mapping

References

Waigl C., Stuefer M., Prakash A., Ichoku C. (2016). Detecting high and low-intensity fires in Alaska using VIIRS I-band data: an improved operational approach for high latitudes (submitted for publication)

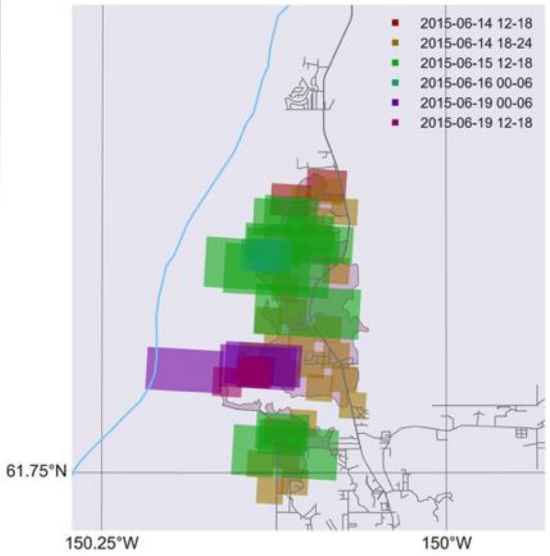

250
200
150
100
50
0
0
50
100
150
200
250


150
100
50
0
0
50
100
150
200
250

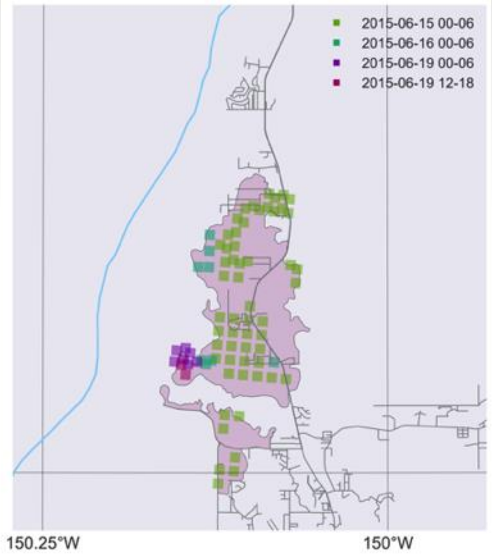

140
120
100
80
60
40
20
0
0
50
100
150
200
250

VIFDAHL improves fire spread mapping (example: Willow)

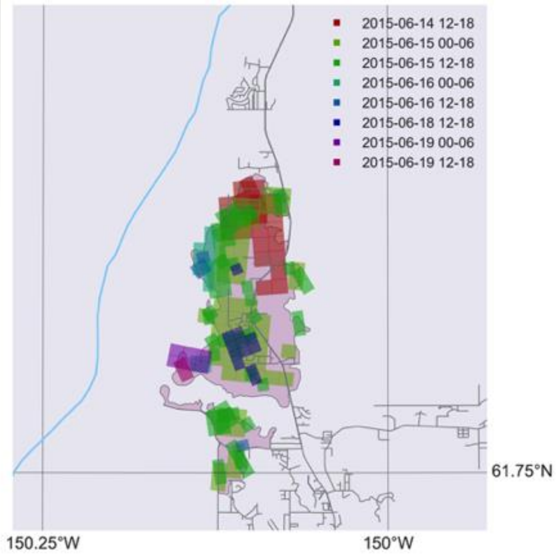
MOD/MYD14



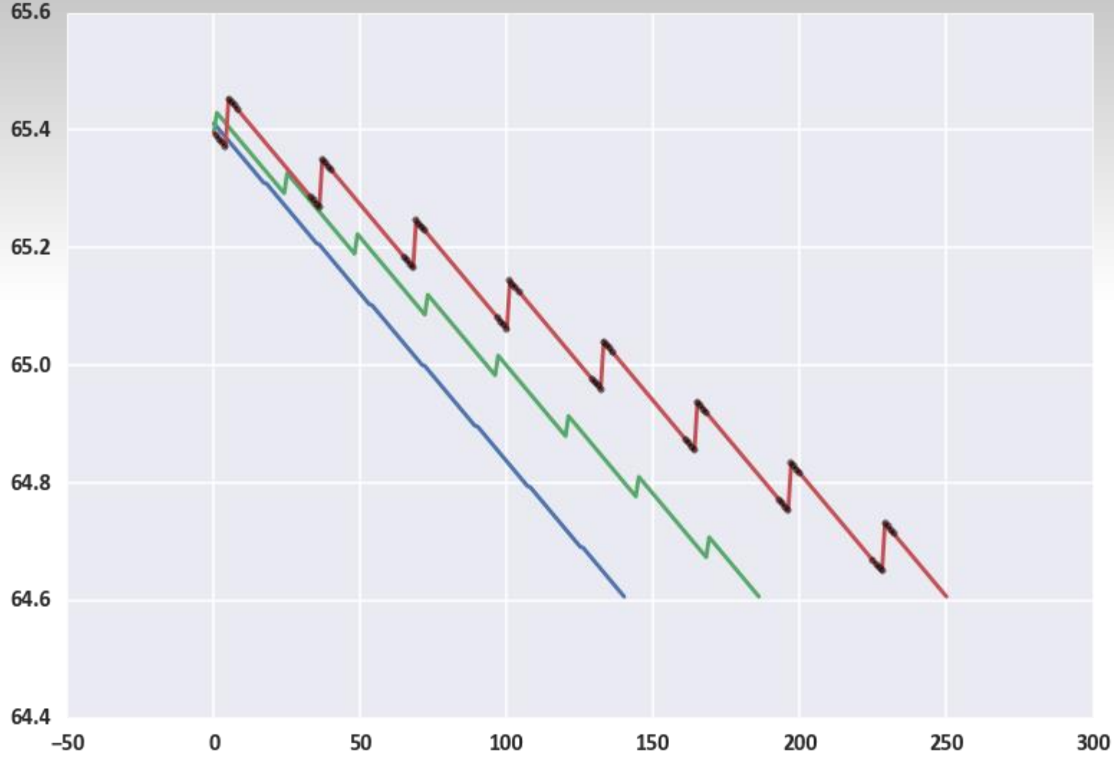
Global VIIRS I-band



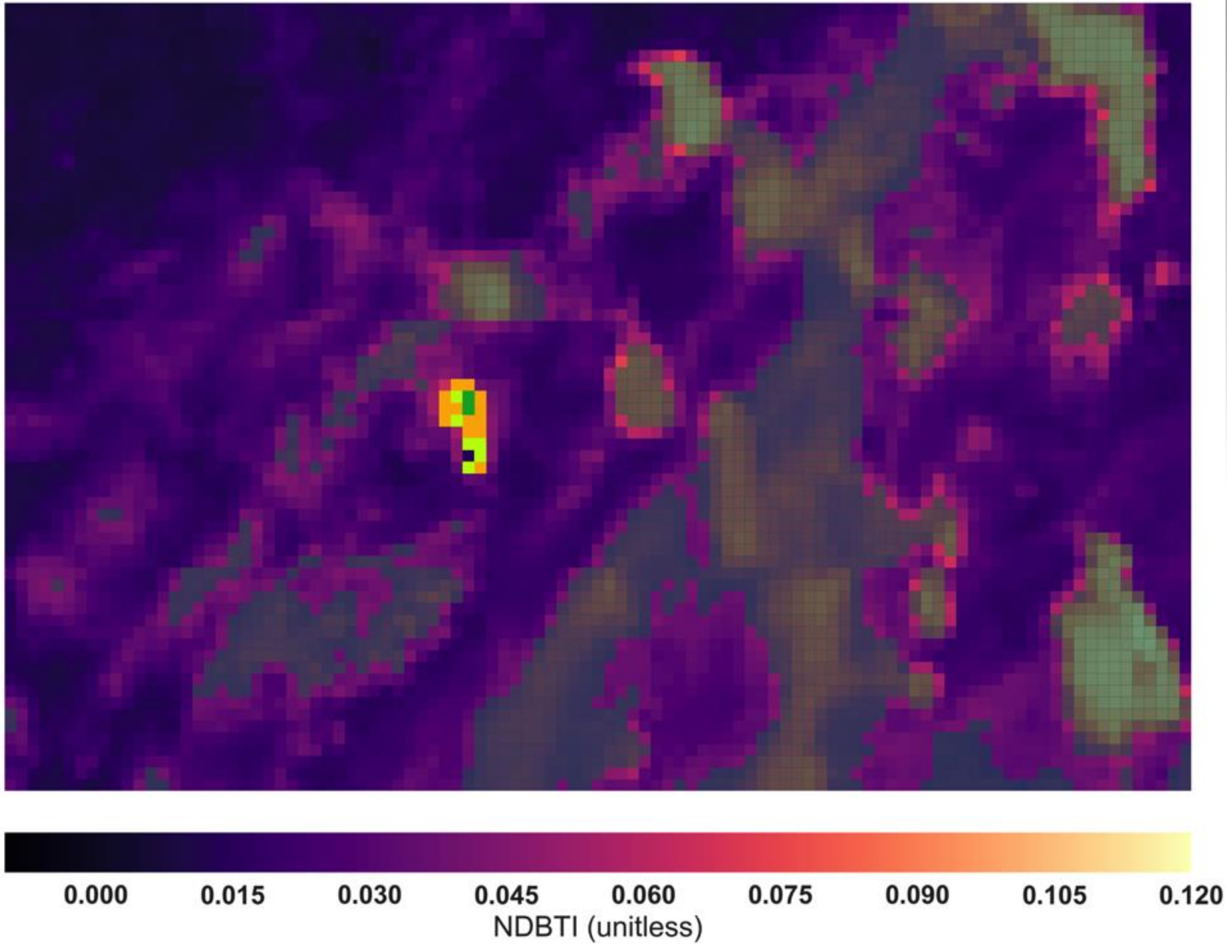
VIFDAHL



Extra slide: bowtie effect elimination by skipping pixels containing duplicate data



Red: all rows
Green: bowtie flagged rows removed
Blue: VIFDAHL bowtie removal

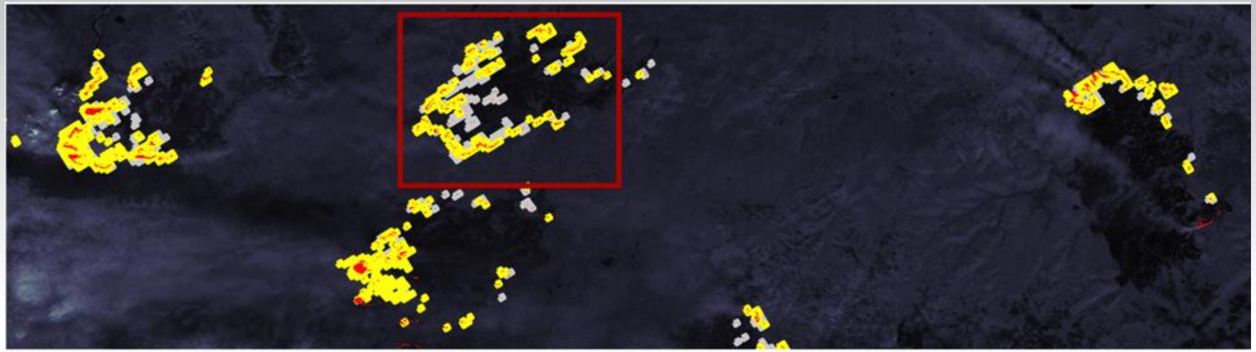

0.000
0.015
0.030
0.045
0.060
0.075
0.090
0.105
0.120
NDBTI (unitless)

Whole scene detections:

Timestamp	VIFDAHL high	VIFDAHL low	VIFDAHL total	VIIRS I-band
2015-07-15 12:58 AKDT	458	438	896	440
2015-07-15 14:41 AKDT	1143	913	2056	106

Yukon-Koyukuk study site: comparison VIFDAHL and global VIIRS I-band product

VIFDAHL



Global VIIRS I-band

Multiple fire events. Image width approx. 150 km.