Long-term Multi-sensor Record of Fire Disturbances in High Northern Latitudes

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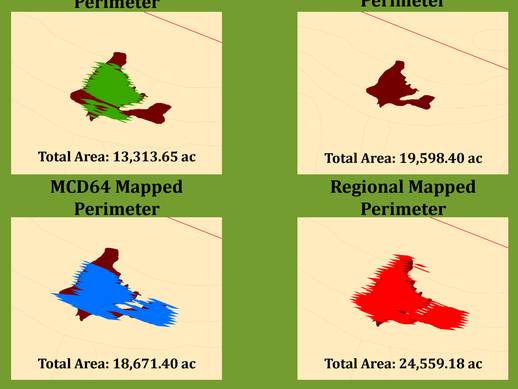
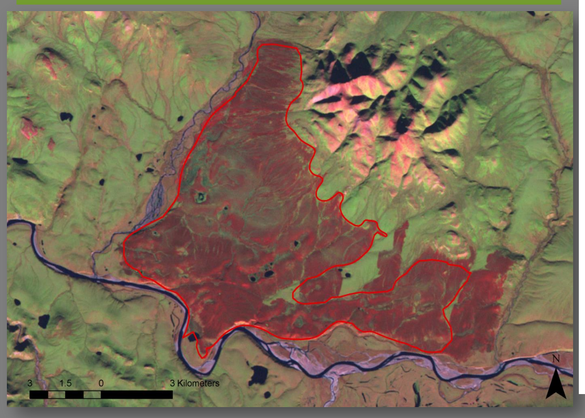
Burn Perimeter Mapping and Fire Progression

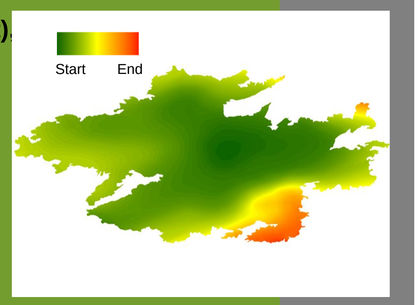
2010 Kaluktavik River Fire
Noatak National Preserve, Alaska



- MODIS and VIIRS active fire and burn area products have been used to map fire locations and timing to create fire progression maps and to demonstrate burn area record continuity with previous AVHRR products.
- A region specific approach taken by Loboda and Csiszar (2007) (bottom right of figure to left) better approximates the area and dynamics of fire progression in HNL.
- The AICC management database and standard MODIS products do not completely capture the geographic extent of all fires, as seen by the comparison of the Kaluktavik River Fire (lower left)



- The Boundary Fire (2004) progression map (right) shows the Loboda and Csiszar (2007) algorithm implemented within WFEIS.
- The dataset combines the fine-scale burn perimeter delineation of the MTBS Landsat product with the daily temporal resolution of the MODIS Active Fire product (Giglio et al. 2006).
- The fire burned from6/13/2004 (dark green) to 11/19/2004 (red).



- Giglio, L., I. Csiszar, and C. O. Justice. 2006. Global distribution and seasonality of active fires as observed with the Terra and Aqua Moderate Resolution Imaging Spectroradiometer (MODIS) sensors, J. Geophys. Res.,111.
- Loboda T.V. and I.A. Csiszar. 2007. Reconstruction of fire spread within wildland fire events in Northern Eurasia from the MODIS active fire product. Global and Planetary Change 56, 258-273.

Overview

We present outputs resulting from the first two years of a three year project to improve accounting of fire in High Northern Latitudes (HNL), defined as land north of 60° latitude. The project is to provide baseline data on fire disturbance for the upcoming Arctic Boreal Vulnerability Experiment (ABoVE). The focus is on North America but with a mind towards eventually producing circumpolar products. Results presented include preliminary products from several of these efforts that pertain to the carbon cycle. Fire products will be available to the ABoVE research community as a baseline data set.

The fire map product will provide:

- A consistent account of fire in HNL regions of North America
- Methods to use new satellite resources for mapping fire for the regions

Applications:

- Improved accounting of carbon losses from fire
- Baseline data for computing fire frequency, average size, severity, and other metrics to assess fire regime

Burn Severity

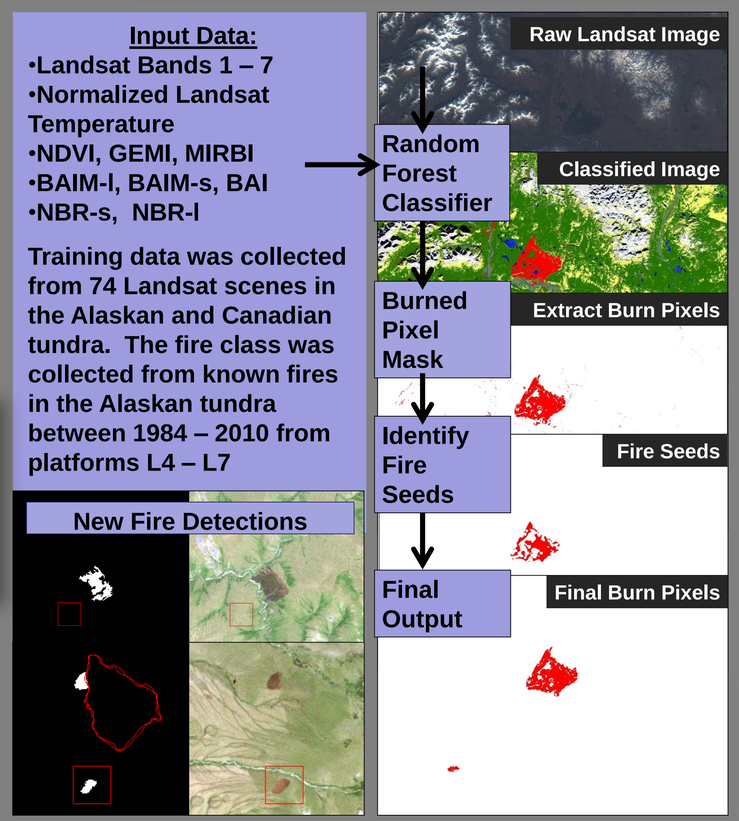
- Analysis of fires in the tundra show a large variability in the surface reflectance of burned and unburned areas across space and time.
- Spectral signatures within fires can be separated by both single and multi-date mapping approaches immediately after burning. However, the spectral signature of burned areas in tundra deteriorates rapidly and, in our study, is poorly distinguishable using electro-optical data by the end of the first post-fire season.
- Common mapping methods based on the normalized burn ratio were inferior to other spectral indices (Tasseled Cap Greenness and Brightness) and single Landsat bands (near-infrared) in separating burned and unburned areas as well as in mapping burn severity.

- Loboda, T. V., French, N. H. F., Hight-Harf, C., Jenkins, L., & Miller, M. E. (2013). Mapping fire extent and burn severity in Alaskan tussock tundra: An analysis of the spectral response of tundra vegetation to wildland fire. *Remote Sensing of Environment*, *134*, 194-209.

Input Data:

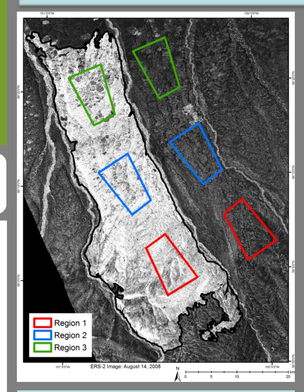
- Landsat Bands 1 – 7
- Normalized Landsat Temperature
- NDVI, GEMI, MIRBI
- BAIM-l, BAIM-s, BAI
- NBR-s, NBR-l

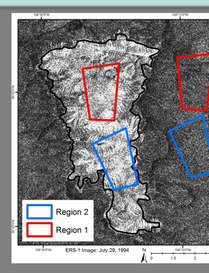
Training data was collected from 74 Landsat scenes in the Alaskan and Canadian tundra. The fire class was collected from known fires in the Alaskan tundra between 1984 – 2010 from platforms L4 – L7

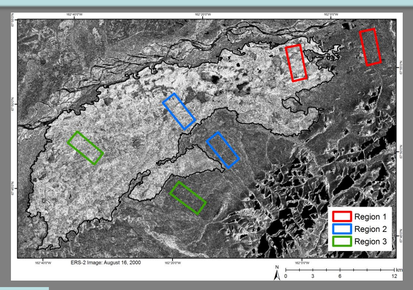


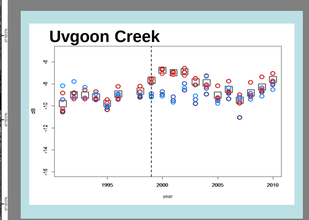
Detection and Monitoring of Fire Disturbance Using Time-series Synthetic Aperture Radar (SAR) Satellite Data

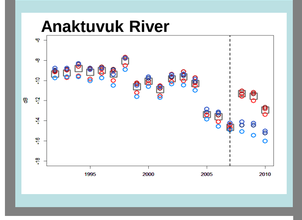
- Using historical ERS-1 and -2 SAR images, this analysis demonstrates that fire disturbance can be effectively detected and monitored in high northern latitudes using radar technology. A total of 392 SAR images from May to August spanning 1992-2010 were analyzed from three study fires in the Alaskan tundra. The investigated fires included the 2007 Anaktuvuk River Fire, the 1993 DCKN178 Fire, and the 1999 Uvgoon Creek Fire.

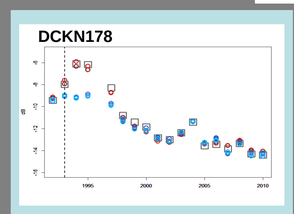












Fire	Year of Burn	Fire Duration	Fire Size	Area Burned (km^2)	Location	Years of ERS SAR Data Available
Anaktuvuk River	2007	July 16 - October 9	Large	1,039	North Slope Foothills	15 pre-burn/ 3 post-burn
Uvgoon Creek	1999	June 26 - August 3	Medium	359	Noatak National Preserve	7 pre-burn/ 11 post-burn
DCKN178	1993	July 9 - August 17	Small	68	North Slope Foothills	1 pre-burn/ 16 post-burn

- Plots of the radiometric response over the entire ERS data record (above) clearly show the fire event (dashed line) and the lasting impact on the record. Fire scars are brightest one year post fire with the brightness gradually decreasing each subsequent year post fire.
- The fires evaluated are approximately 3.0 to 3.3 dB brighter than adjacent unburned areas during the end of the growing season one year post fire.
- Landscape recovery as detected by the SAR were on the order of four to five years instead of one observed with electro-optical sensors.
- The best time for burned area detection is as late in the growing season as possible before frozen ground conditions develop. This corresponds to mid August for the study fires.

- Jenkins, Liza K.; Bourgeau-Chavez, Laura L.; French, Nancy H.F.; Loboda, Tatiana V.; Thelen, Brian J. 2014. "Development of Methods for Detection and Monitoring of Fire Disturbance in the Alaskan Tundra Using a Two-Decade Long Record of Synthetic Aperture Radar Satellite Images." Remote Sens. 6, no. 7: 6347-6364.

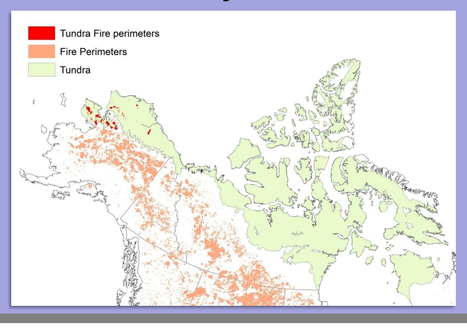
Tundra Fire Detection Algorithm: Landsat Based Decision Trees

- Random Forest is a machine learning algorithm that takes advantage of an ensemble of decision tree (700) classifiers built using training data.
- Classified Images contain up to 34 land cover classes, fire pixels are extracted and then clumping and sieving is used to identify and map fires.
- Computational processing and storage needs are extensive: MTRI has 11,000+ arctic tundra scenes in house requiring 8 terabytes of space to store and process.
- Further processing is being conducted on the ABoVE cloud at NASA

Preliminary Results

Classified	Ground Truth Values: Burned	Not Burned	Sum	Commission error	User Acc.
Burned	16248	27	16275	0.17%	100%
Not Burned	2789	74604	77393	3.60%	96%
Sum	19037	74631	93668		
Omission error	14.65%	0.0%			
Prod. Acc.	85%	100%			
Overall accuracy		97.0%		$\hat{k}$	90.2%

Study Area



Fire has relevance for Carbon and other biogeochemical cycling, so understanding prevalence and patterns of fire is key for studies at local to global scales.