Satellite-Based Detection and Monitoring of Fire and Fire Effects in the North American Tundra

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Observed warming in the high northern latitudes has implications related to increased fire in both boreal forest systems and tundra. Warming and modifications to climate patterns has led to an increase in fire occurrence in the tundra, a biome not known for broad-scale fire. The overarching question we are addressing is:

If fire increases in landscapes where fire is neither currently nor historically of great importance, what impacts will this have on ecosystems and ecosystem services?

Current accounting of historical fire for the circumpolar arctic is not complete, partly due to lack of developed algorithms for tundra fire detection. Current satellite-based methods for mapping fire at northern latitudes are focused on algorithms tuned to forested landscapes rather than treeless tundra types, and characteristics of fire effects in tundra are not well understood for development of such algorithms. Fire regime, including the occurrence and severity of fire, is most likely changing, and will be changing quickly since fire is strongly driven by climate. This has important implications regarding carbon cycling and impacts on ecosystems and ecosystem services.

Field Assessment

- **Field Sites**
  - 2012 Kucher Creek Fire, North Slope, AK, early spring, light severity fire
  - 2010 Kalaktivik River Fire, Noatak National Preserve, AK
  - Other field data: five 2010 burn sites in the Noatak, data collected by NPS (Jennifer Barnes, et al.)
- **Data Parameters Collected:**
  - Latitude/longitude, date, time
  - GPS-tagged photographs in 4 cardinal directions (N, E, S, W) and nadir
  - Site description
  - Burn severity assessment
  - Soil organic material profile
  - Kucher Creek, burn versus unburn, significant parameters: active layer, soil moisture 6 cm, and soil temperature
- **Generalized linear models to predict to parameters as a function of burn severity, significant parameters**
  - Active layer ***
  - Soil moisture 6 cm ***
  - Soil moisture 12 cm **
  - Depth to mineral soil *
- **Fully-polarimetric Radarsat-2 synthetic aperture radar (SAR) data collection coincident with Kucher Creek field campaign**
- **Soil moisture: best correlation between VV and soil moisture at 12 cm (R2=0.87), good correlations were also found between HH and soil moisture at 6 cm (R2=0.80)**
- **SAR data will be used to look at burn severity in our field sites**
- **Plans for 2013 summer field work in the Noatak National Preserve**

Additional Research Team Members: Michael Flannigan, Carolyn Harf, Randy Jandt, Evan Kane, Eric Kasischke, Charles Racine, David Riano

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**Landsat-Based Fire Detection**

- **Set of 500 classification trees (a forest)**
- **Thresholds for classification based on randomly selected variables**
- **Final pixel class decided by majority vote**
- **Training data from 23 Landsat scenes, hand delineated by land cover class using fire records from the Alaskan Tundra between 1984 – 2010 for platforms L4 – L7.**
- **Validation data set currently consists of 14 Landsat scenes.**
- **Initial post clumping fire commission and omission error < 10%.

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**Fire Occurrence Modeling (FOM)**

- Based on MODIS observations of active fires (MCD14ML) clustered in space-time to identify the proxy for the point of ignition (Loboda and Csiszar, 2007)
- Ignition-driven spatial clustering to define contiguous landscape sections with similar ignition patterns
- Assign ignition loading per unit area

**Risk of Ignition Module**

- Vegetative cover (%), average height, and distribution
- Tussock characteristics
- Shrubs
- Soil moisture, soil temperature
- Active layer depth (Kucher Creek only)
- Latitudes/longitude, date, time
- GPS-tagged photographs in 4 cardinal directions (N, E, S, W) and nadir
- Site description
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**Spatial clusters of similar landscape conditions for ignition patterns**

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**Historical Fire Database**

- **Tundra fire records**
- **Training Path/Row**
- **Validation Path/Row**
- **Tundra**

An important component of our work is gathering historical fire locations. The data set is dynamic, and the assembled data will serve as validation and training data for further research activities. Parameters and points are obtained and derived from numerous sources and methods:

- Canadian Large Fire Database (publically available)
- AIC (Alaska Interagency Coordination Center)
- MTBS (Monitoring Trends in Burn Severity)
- Yukon fire service
- Northwest Territories fire service
- NASA FLAFlight website for GOES and MODIS hotspots

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**Historical Fire Database**

- **Soil moisture 12 cm**
- **Vegetative cover (%, average height, and distribution)**
- **Soil moisture 12 cm**
- **Depth to mineral soil**
- **Active layer depth (Kucher Creek only)**
- **Latitudes/longitude, date, time**
- **GPS-tagged photographs in 4 cardinal directions (N, E, S, W) and nadir**
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