Topofire: A system for monitoring insect and climate induced impacts on fuel moisture and fire danger in complex terrain

Project PI's:
Zack Holden (USFS Northern Region)
Erin Landguth, and Allen Warren (University of Montana)
Matt Jolly and Russ Parsons (RMRS Firelab)
John Abatzoglou (U. Idaho)

Collaborators:
Susan Frankestein (Cold regions research lab, Dept. of Defense)
Jason Forthofer (RMRS Firelab)
Anna Klene and Solomon Dobrowski (U. Montana)
Charlie Luce (RMRS Boise)

National Management Partners:
Wildland Fire Assessment System (WFAS)
USFS Research Development/Wildland Fire Decision Support (WFDSS)

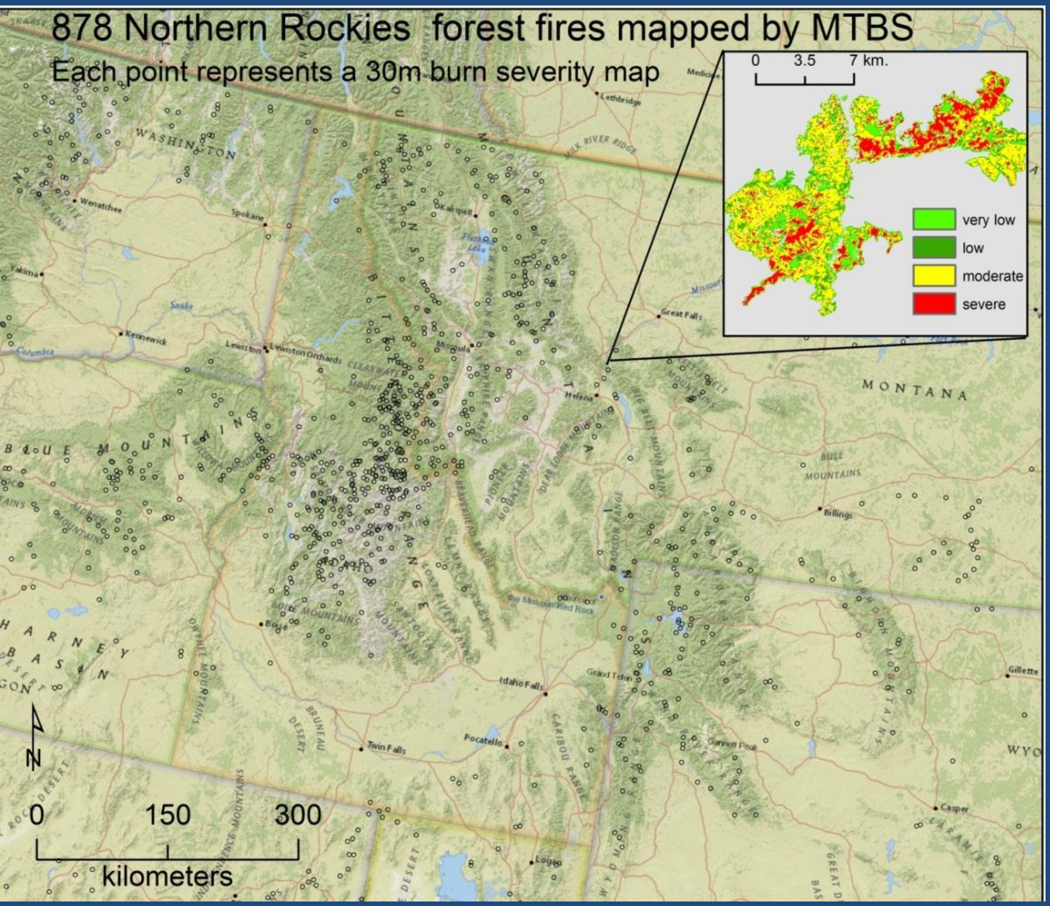
Regional Partners
USFS Region 1 Fire and Aviation
Washington Dept. Natural Resources
USFS Region 1 Forest Health and Protection
Inland Northwest Growth and Yield Technical Cooperative -

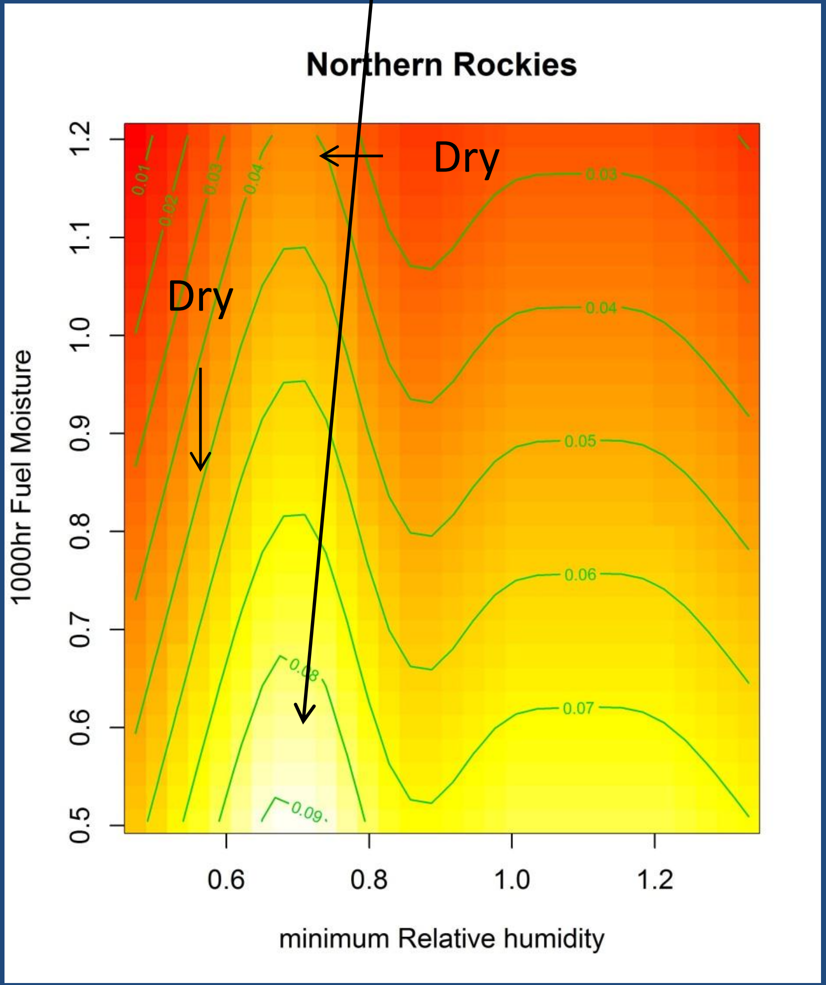
Project Motivation

- Current wildland fire decision support systems ignore fine-scale variation in fuels and weather
- Recent Mountain Pine Beetle epidemics add significant complexity to fire management
- Incorporating terrain effects on fire danger could expand windows for burning, increase understanding of fire risk and potential fire behavior
- Operational insect-induces mortality maps are essential for fire management

Dry fires burn more severely with larger patches of stand replacing fires

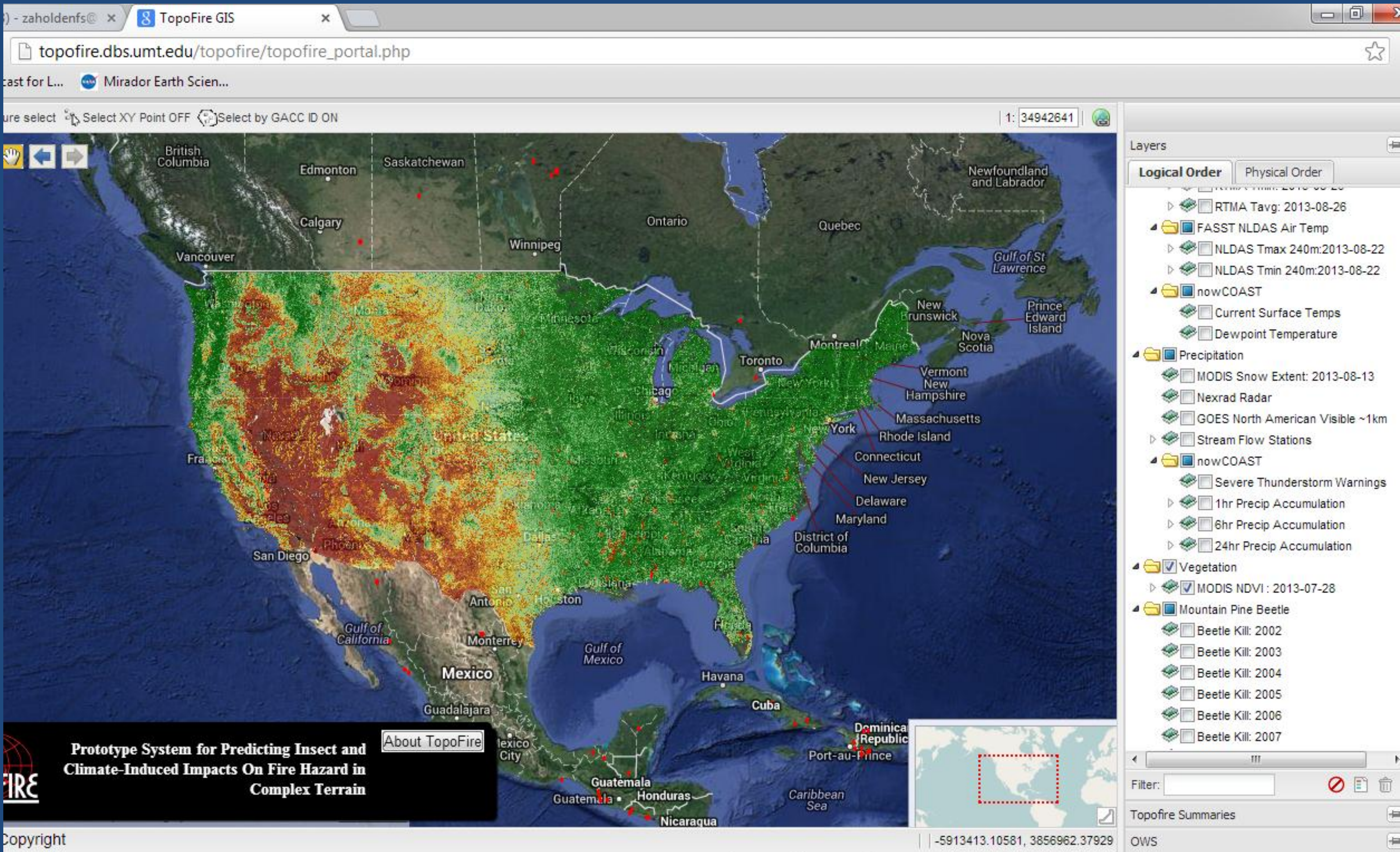
Higher percent severely burned
In fires burning at lower fuel
Moistures and lower RH



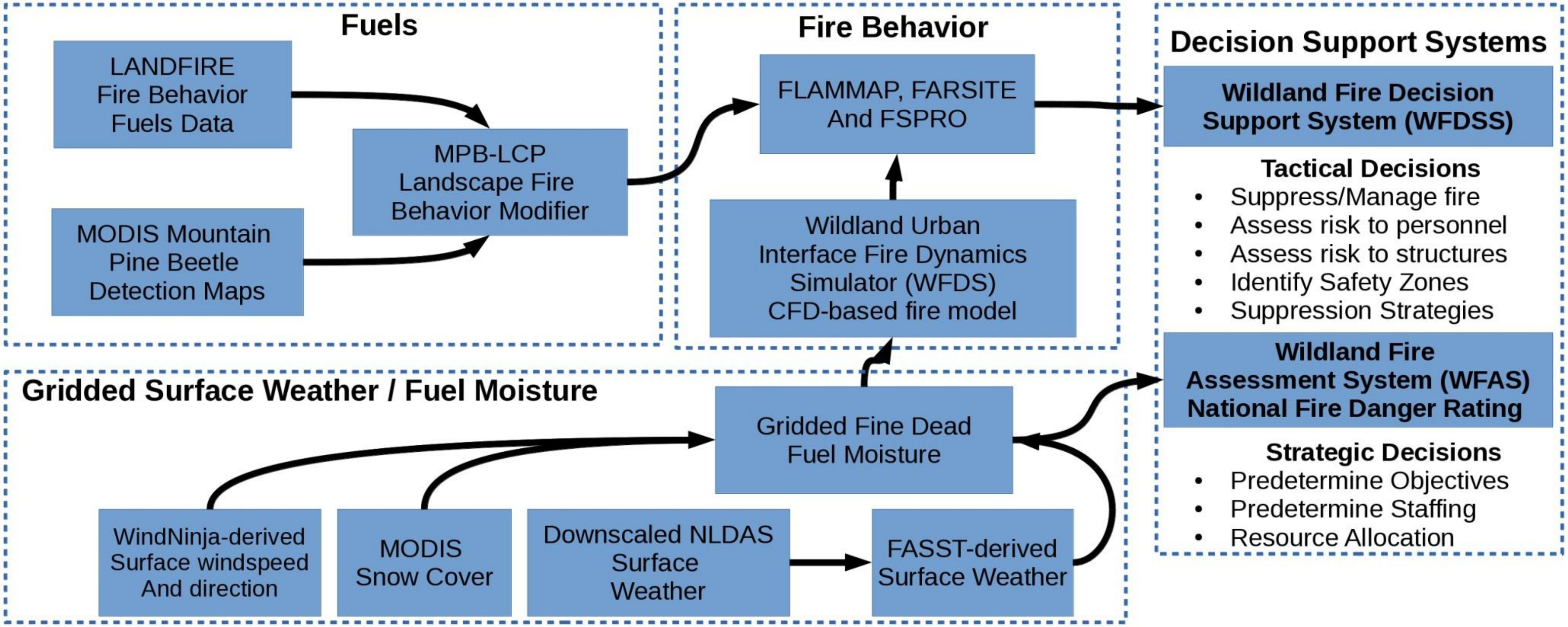


Holden et al. (in prep)

TOPOFIRE: topofire.dbs.umt.edu
Interactive web server for monitoring terrain and insect-induced effects on fire danger



TOPOFIRE overview and linkages to fire management decision making



NASA products used

- MODIS 500m snow cover
- MODIS 250m NDVI/EVI
- MODIS 500m daily/8 day reflectance data
- MODIS 24 hour active fire data
- Landsat TM5/8 imagery
- NLDAS2 gridded hourly climate data

  - temperature, humidity, pressure, wind, radiation

Objective A:
Modeling Mountain Pine Beetle Spread with Time-Space Dependent Environmental Predictions

Erin Landguth University of Montana

Zachary Holden USDA Forest Service, Missoula MT

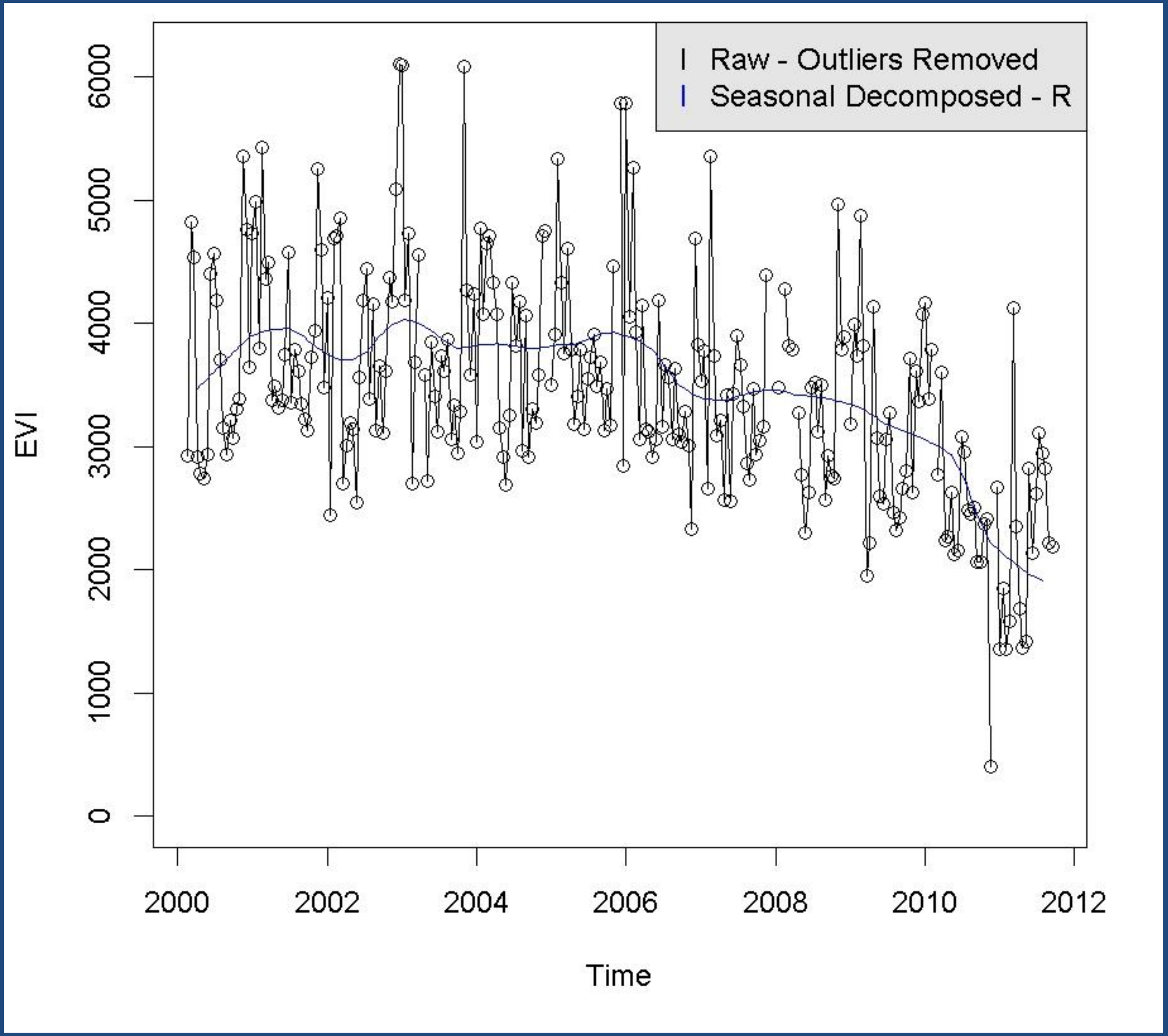
Jordan Purdy Augustus College, Rock Island, IL

WFIWC conference, CDA Idaho, 2013; Powerpoint available on eBooks

Remote imagery / time series data

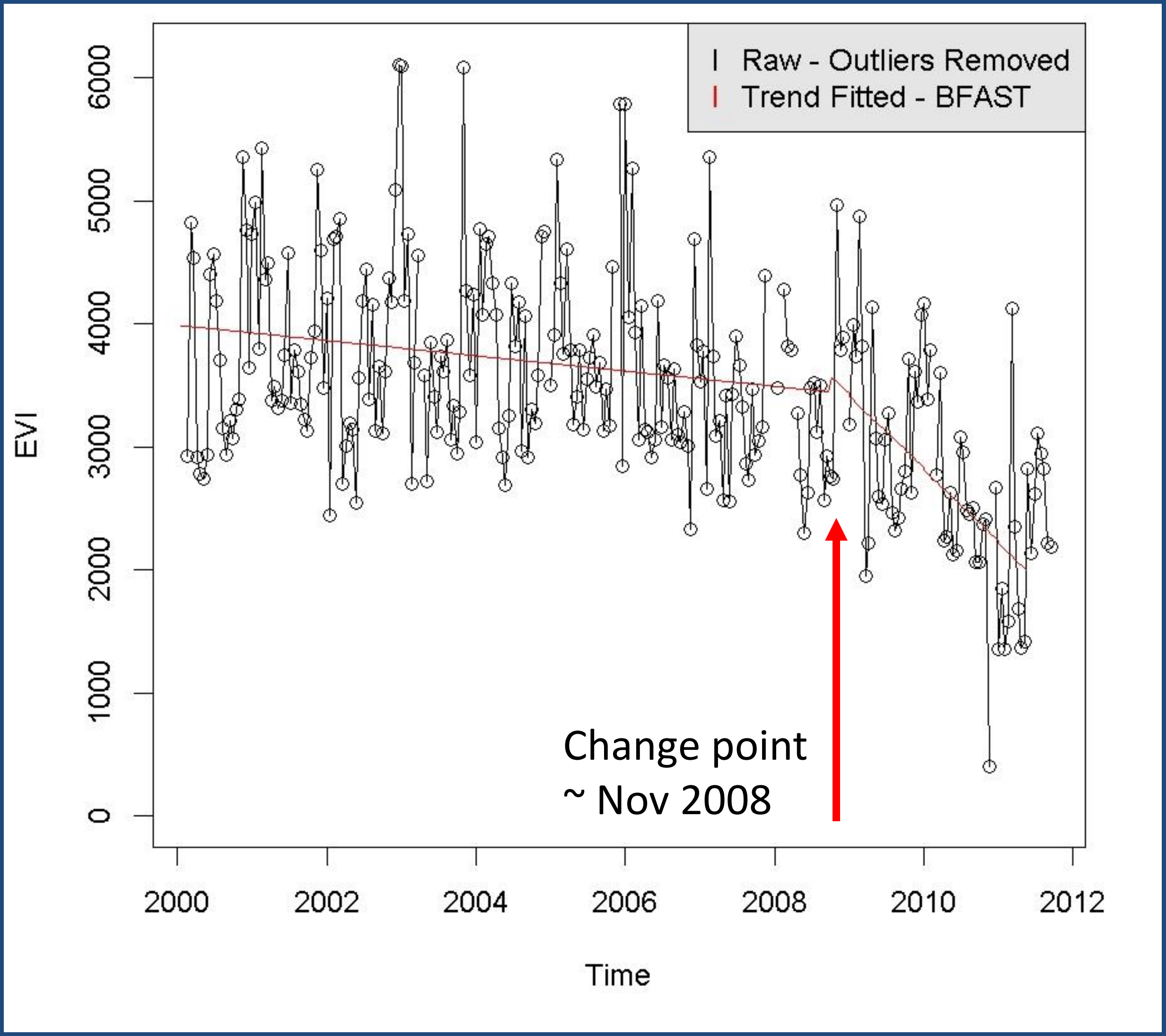
MODIS 250 m^2 EVI 2000 – 2011

- Outliers removed, convolved, seasonal decomposed…



Change point detection algorithm

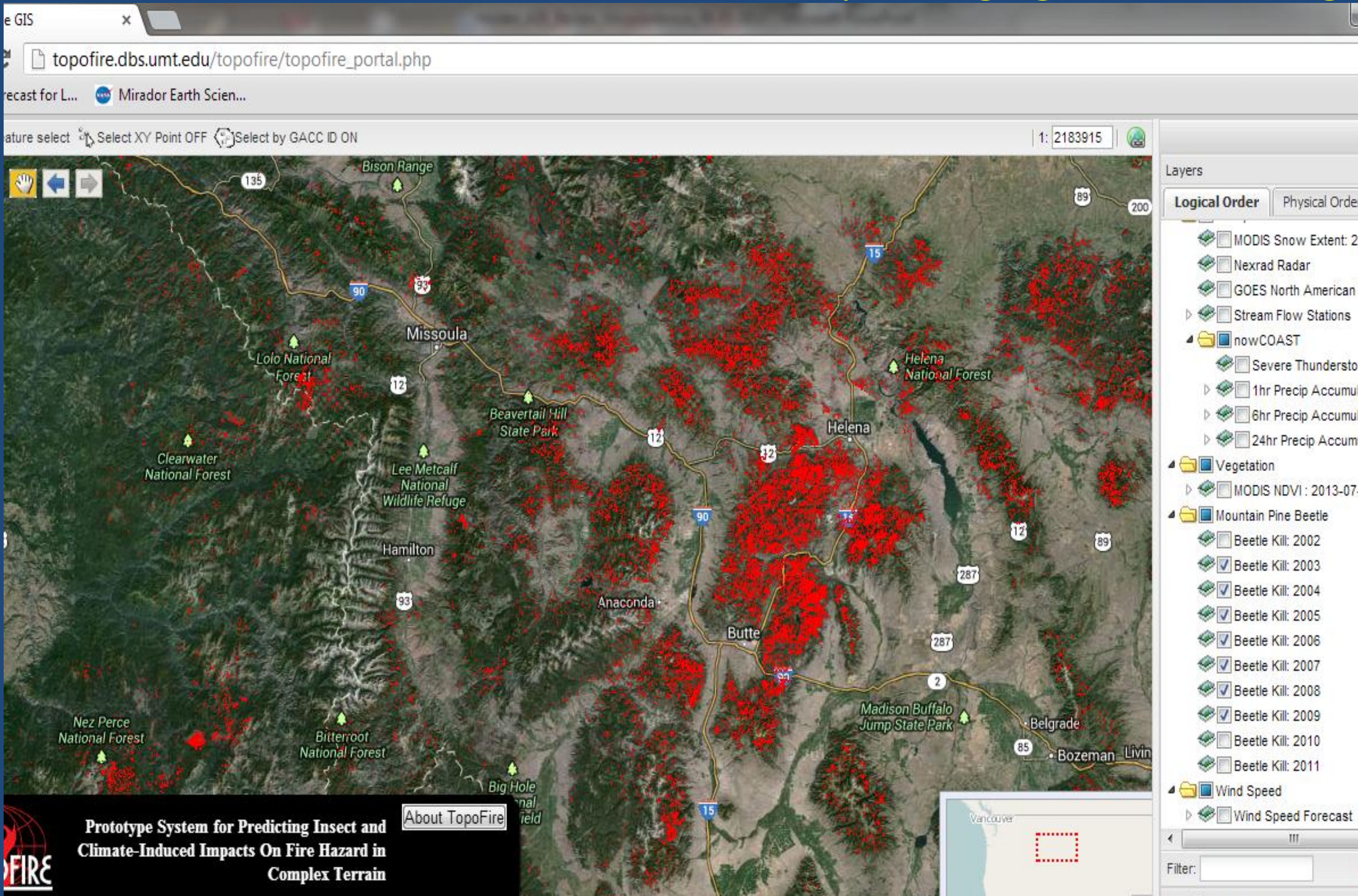
Breaks for Additive Seasonal Trend (BFAST; VerBesselt et al. 2010)



Algorithm tested at 274 Remeasured FIA plots

Year of attack predicted with 78% overall accuracy

Year of attack maps available on TOPOFIRE (2002-2011)
Process will be automated in Phase 2 to map emerging red attack stage



Objective B:
Fire modeling in TOPOFIRE: extending understanding across spatial scales in support of fire management

-Operational fire models (FARSITE, FLAMMAP) do not account for changes in Fuels/structure associated with MPB attack

-Fluid dynamics models CAN, but aren't suited for operational use

-Need to extend knowledge from CFD models to Landscape scales

Fire modeling Team:
Russ Parsons, Matt Jolly, Greg Cohn
USFS Fire Sciences Lab, Missoula MT

The MPB-LCP modifier tool:

Many WFDS fluid dynamics simulations run across levels of mortality, wind speed and canopy cover

Develop empirical coefficients from CFD models based on magnitude of MPB-induced mortality

Results used to parameterize a fire behavior/spread multiplier for FARSITE

FARSITE results with MPB-LCP adjustment

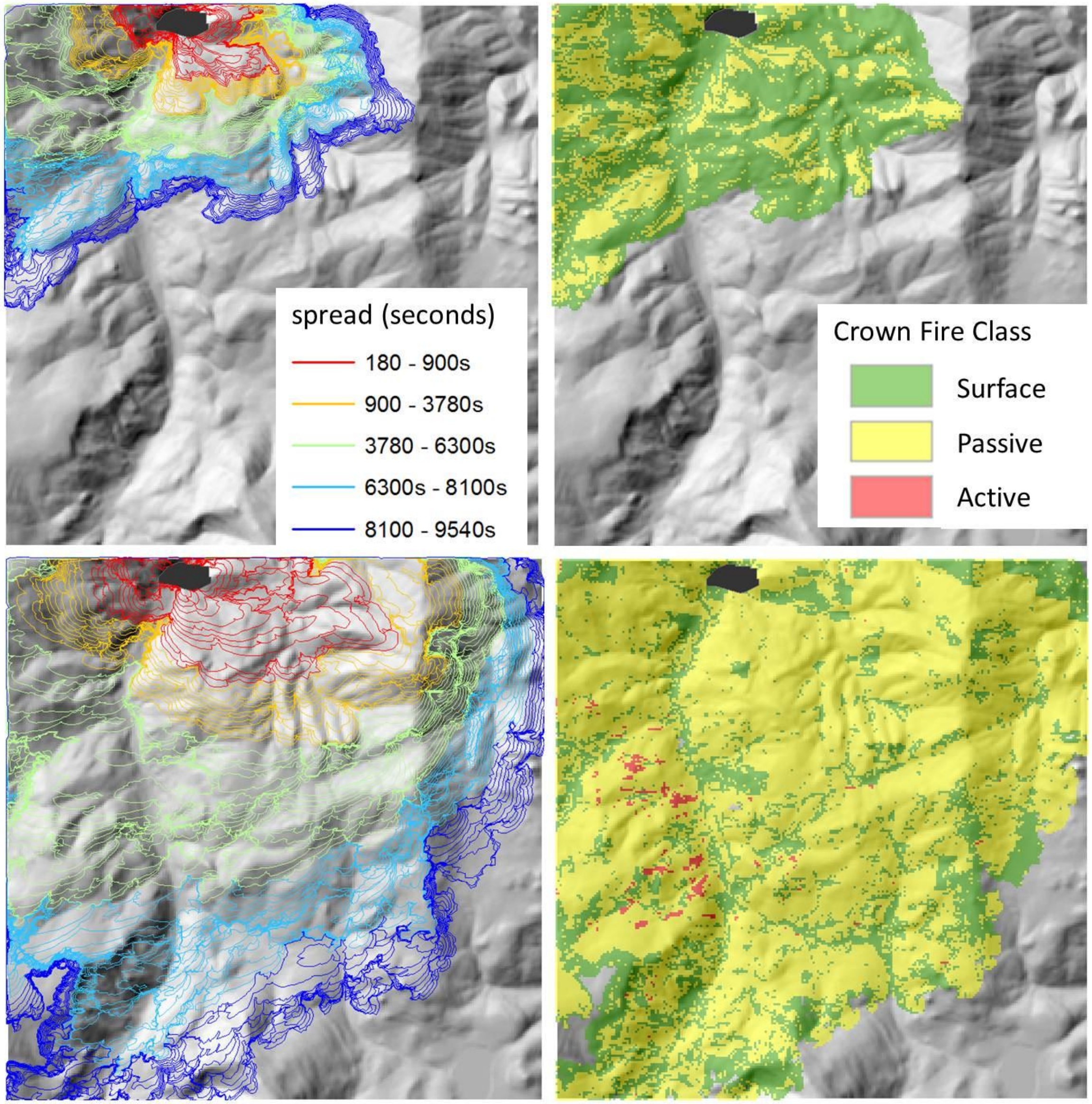
Rate of spread strongly dependent on magnitude mortality

2x spread rates in areas
With significant MPB mortality

Simple method for generating LCP files for FARSITE adjusting
For canopy condition

Phase 2: Make operational on Topofire

On demand simulations using MODIS mortality maps



Objective C:
Modeling topoclimatic influences on fuel moisture and fire danger in complex terrain

Fire danger and hydrologic models ignore effects of terrain

Terrain induced variation in fuel and soil moistures are an important but poorly understood aspect of fire behavior and spread

Contents lists available at SciVerse ScienceDirect
Forest Ecology and Management
journal homepage: www.elsevier.com/locate/foreco

Modeling topographic influences on fuel moisture and fire danger in complex terrain to improve wildland fire management decision support

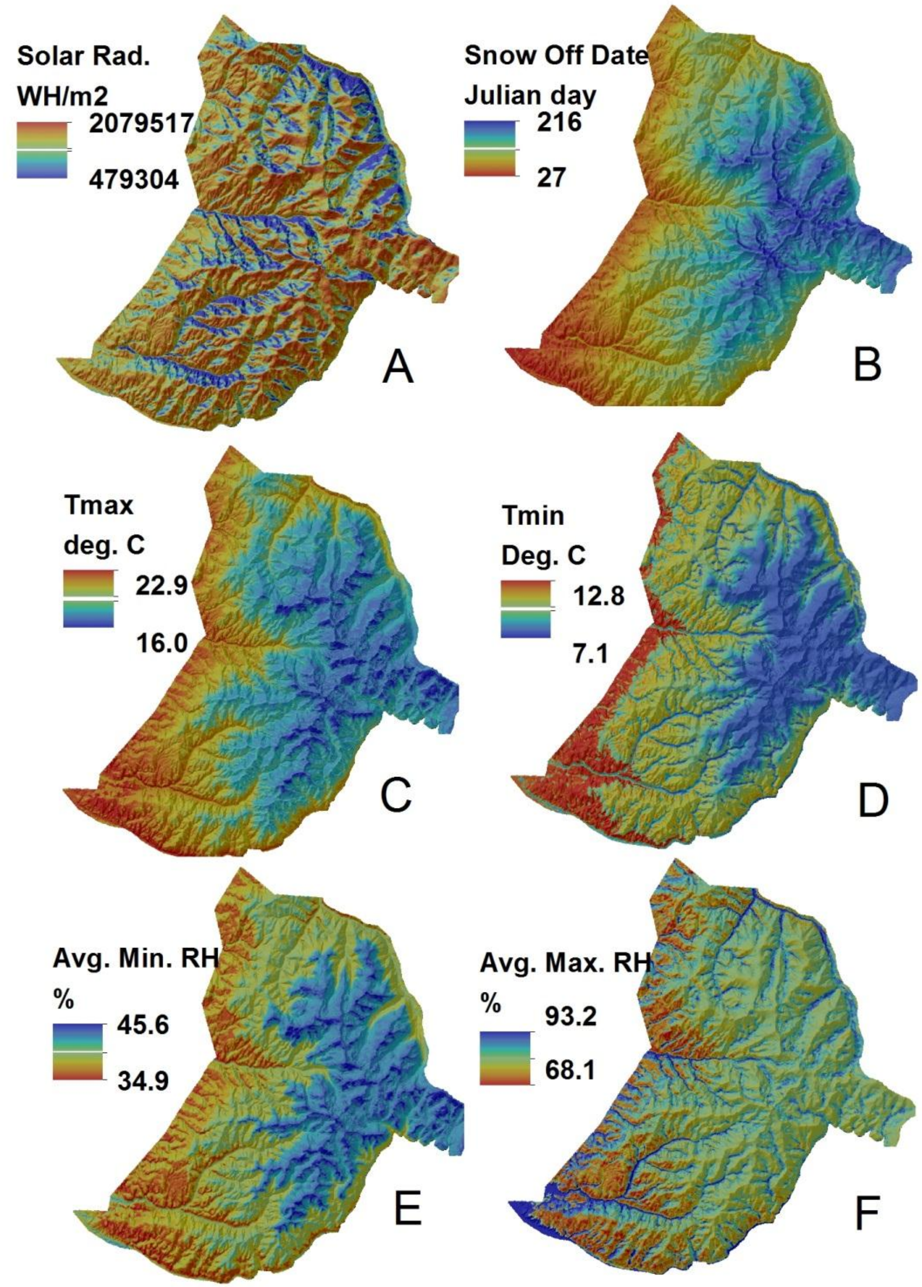
Zachary A. Holden[a,*], W. Matt Jolly[b]
[a] US Forest Service, 200 East Broadway, Missoula, MT 59807, USA
[b] US Forest Service Rocky Mountain Research Station, Fire Sciences Laboratory, Missoula, MT 59808, USA

Tmin, Tmax, Rhmin, Rhmax modeled using PCA and networks of ibuttons

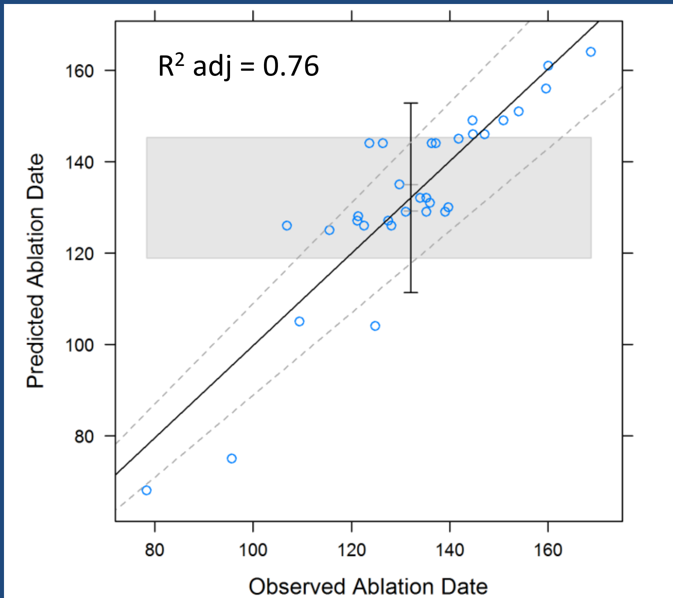
Lower maximum temperatures and Higher RH on north slopes

Delayed snowmelt timing on high Elevation north slopes

Lower minimum temperatures and higher RH in valley bottoms



Holden and Jolly (2011)

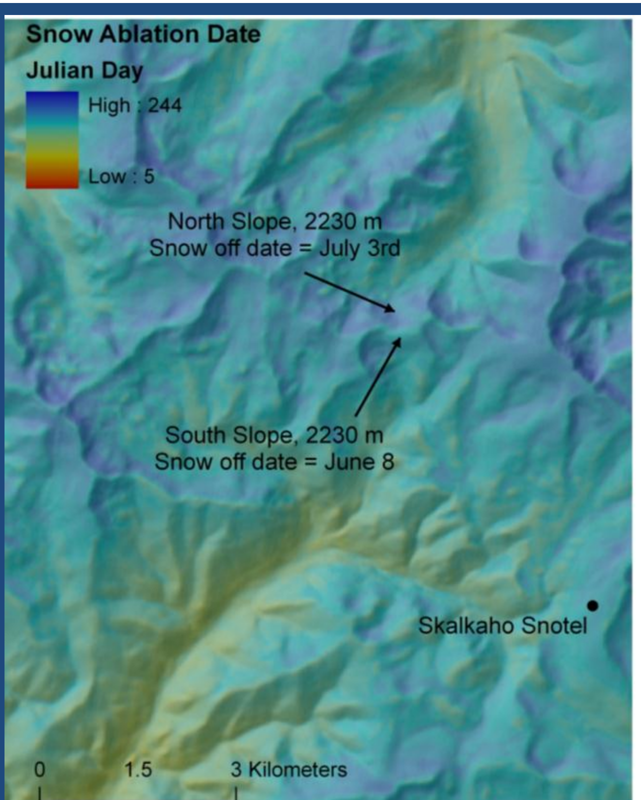


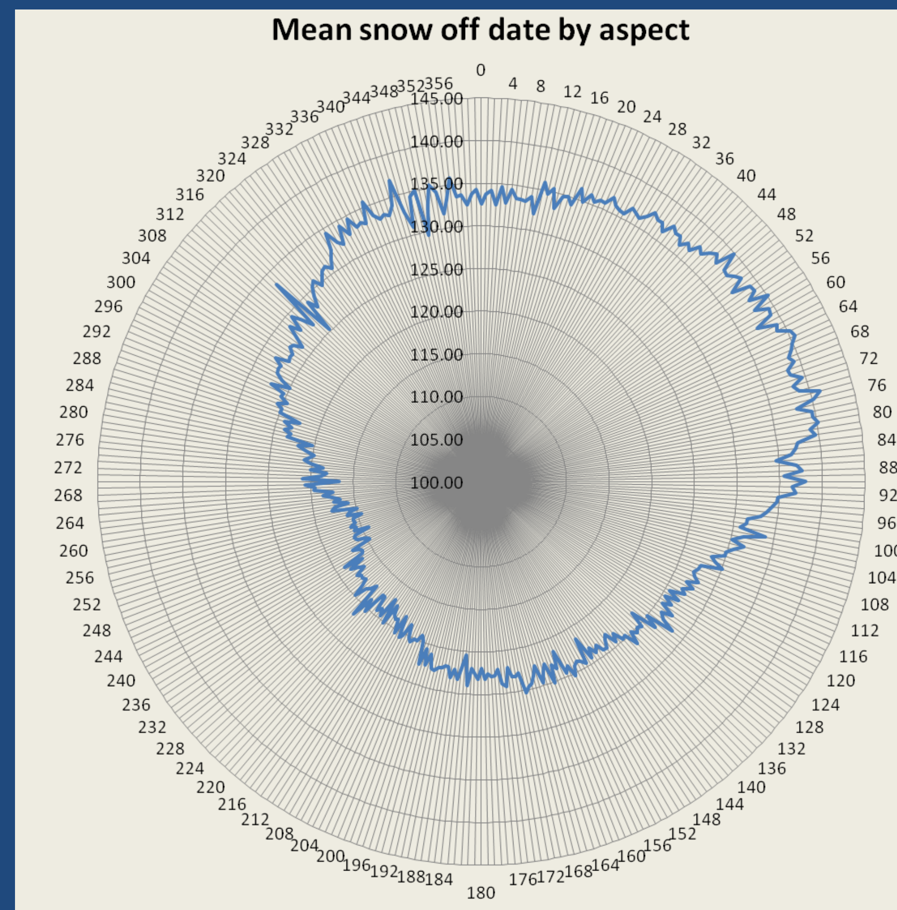
A simple empirical model of snow ablation date Using distributed temperature sensors

Captures physics of snow accumulation and melt

Earliest melt on Southwest-facing slopes (interaction betweeen radiation and temperature)

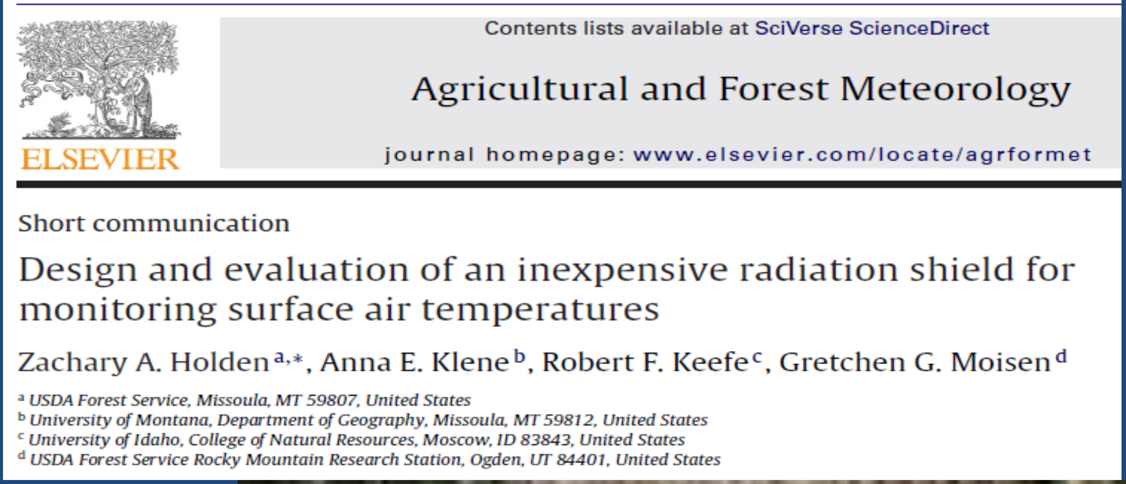
4 week delay on high elevation North slopes





Massive microclimate sampling
With low-cost sensor networks

2000 sensors distributed across
PNW and Canada (2009-2012)


Contents lists available at SciVerse ScienceDirect

Agricultural and Forest Meteorology

journal homepage: www.elsevier.com/locate/agrformet

Short communication

Design and evaluation of an inexpensive radiation shield for monitoring surface air temperatures

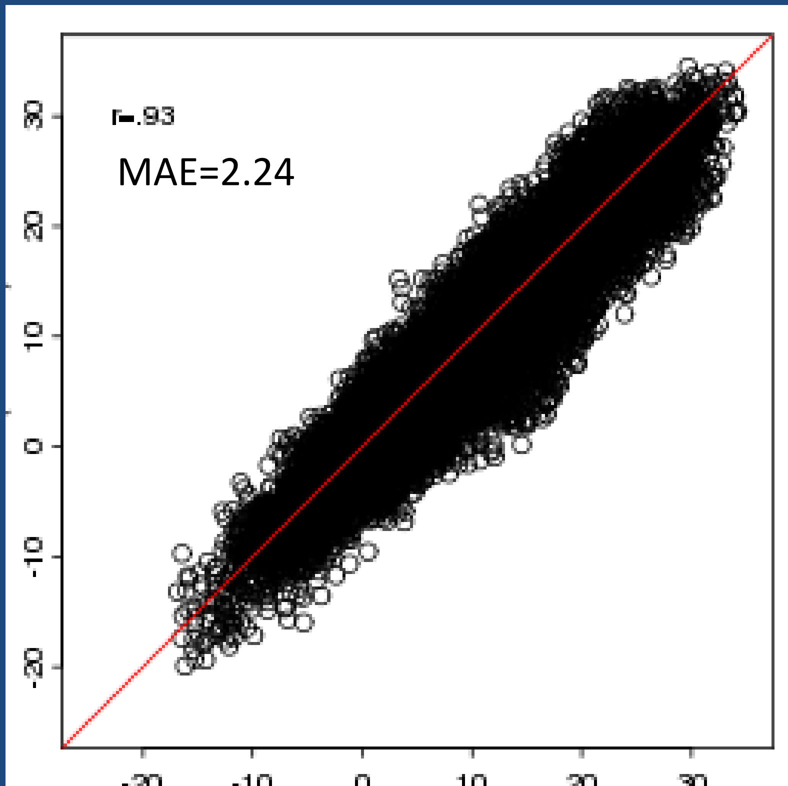
Zachary A. Holden[a,*], Anna E. Klene[b], Robert F. Keefe[c], Gretchen G. Moisen[d]

[a] USDA Forest Service, Missoula, MT 59807, United States
[b] University of Montana, Department of Geography, Missoula, MT 59812, United States
[c] University of Idaho, College of Natural Resources, Moscow, ID 83843, United States
[d] USDA Forest Service Rocky Mountain Research Station, Ogden, UT 84401, United States

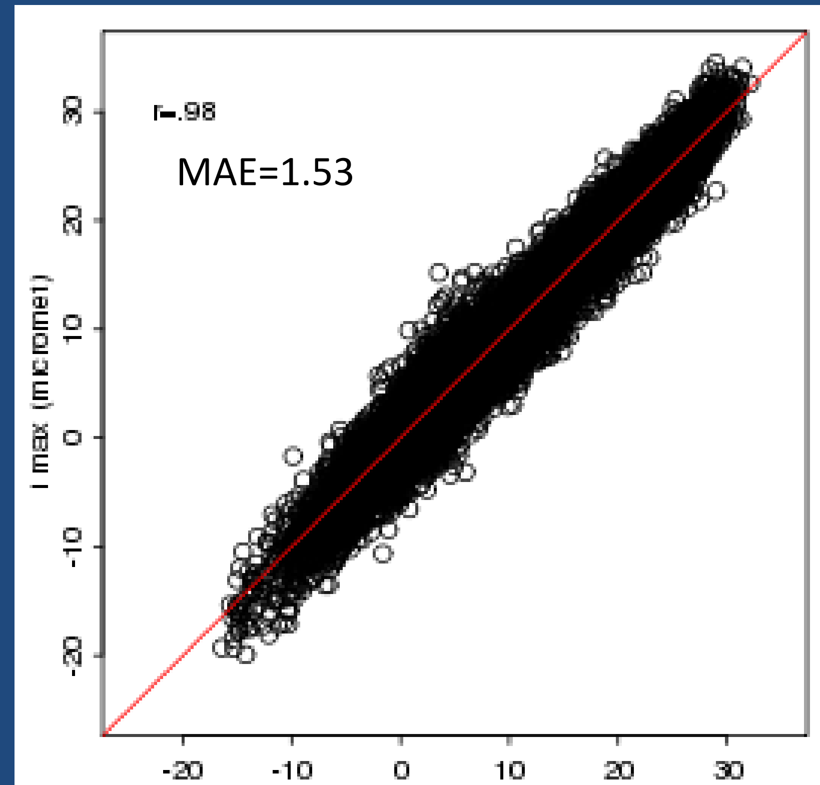
$2.00 material costs

12-15 minute construction time

NLDAS (4km Bias Corrected)

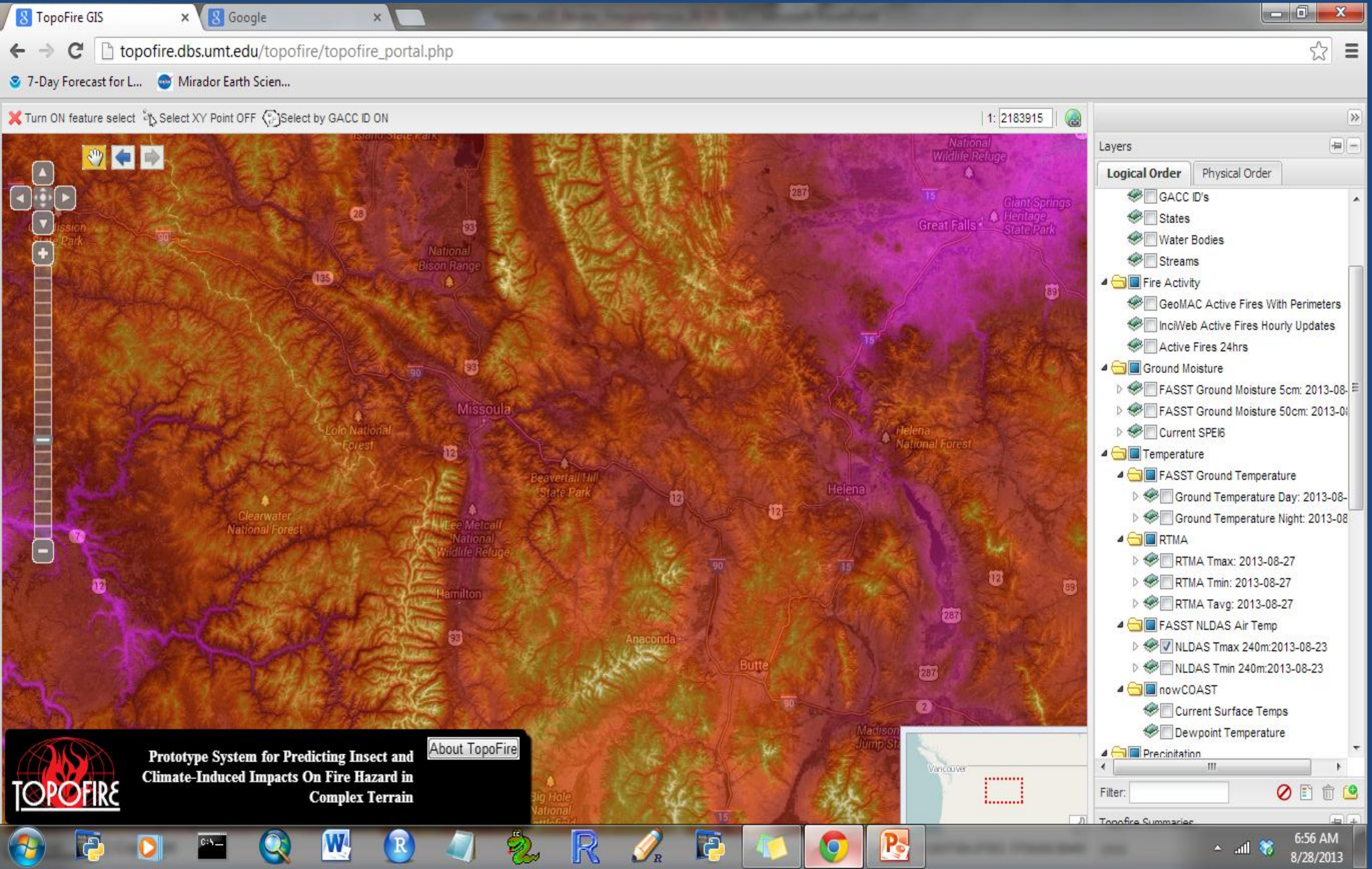


Downscaled (Mixed Effects Regression)

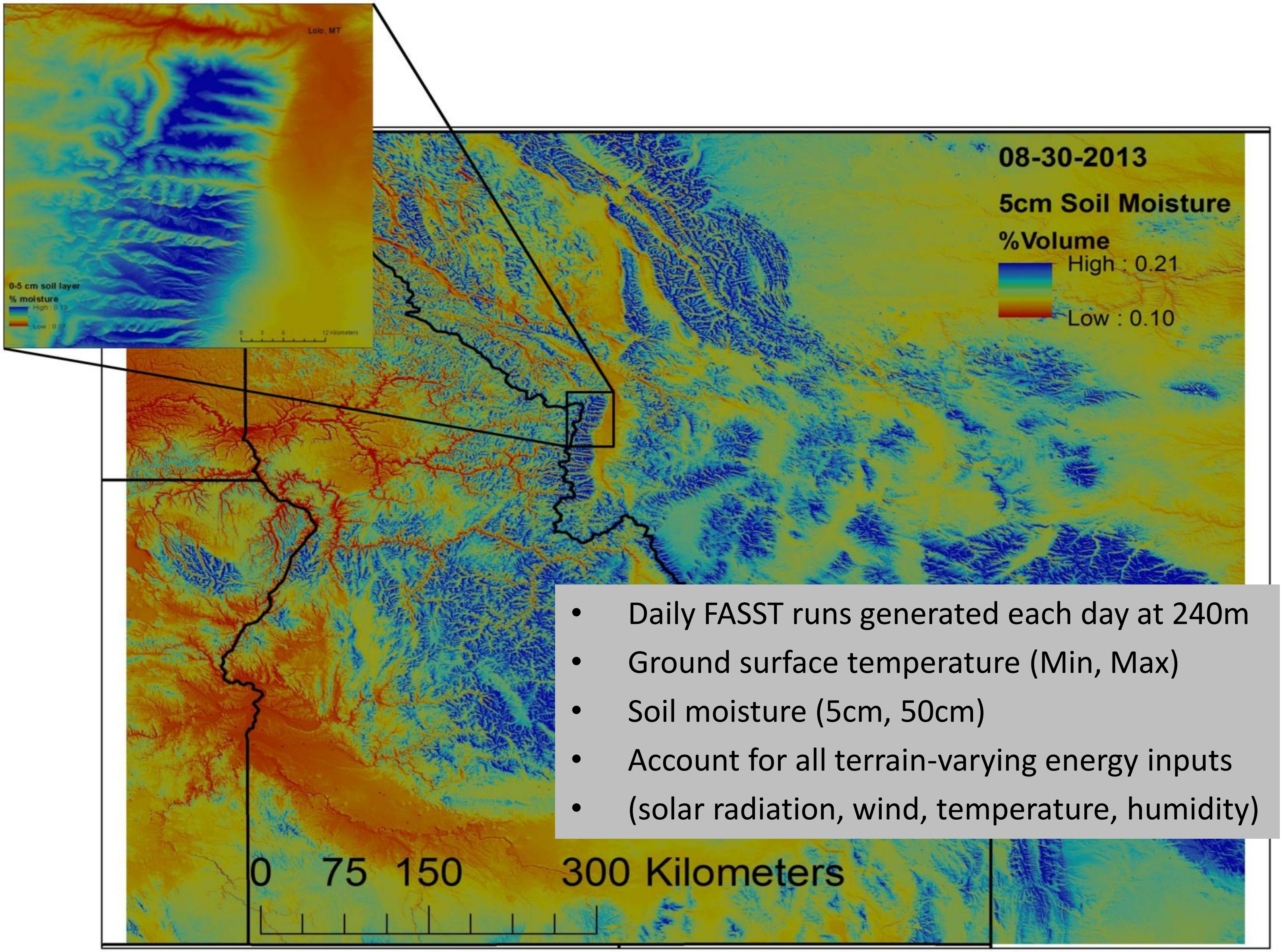


More accurate air temperature model using coefficents derived from microclimate sensors
Capture important terrain effects on temperature (radiation, cold air drainage)

Daily Tmin/Tmax at 240m resolution
Generated each day as NLDAS becomes available



Example FASST hydrologic model output



- Daily FASST runs generated each day at 240m
- Ground surface temperature (Min, Max)
- Soil moisture (5cm, 50cm)
- Account for all terrain-varying energy inputs
- (solar radiation, wind, temperature, humidity)

Summarizing complex information for fire management decision support

TOPOFIRE

Prototype System for Predicting Insect and Climate-Induced Impacts On Fire Hazard In Complex Terrain

National Code:NR03
PSA Name:North Central Idaho / Southwest Montana
GACC:Northern Rockies

Snow Extent for:2013-08-21
Snow Extent Avg for:2012-08-20

```
MODIS Snow Extent:
------------------
GACC ID:137
Current Snow Extent:0.00
12 Year Mean:0.00
Average is zero.
Percent of Normal:0.00
```

NDVI for:2013-07-28
NDVI Avg for:2012-07-27

```
Relative Greenness:
------------------
GACC ID:137
Current Greenness Avg:5793.97
Historical Greenness Average:6104.29
Relative Greenness:0.95
```

Area Beetle Kill:2013-07-28

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Beetle Kill:
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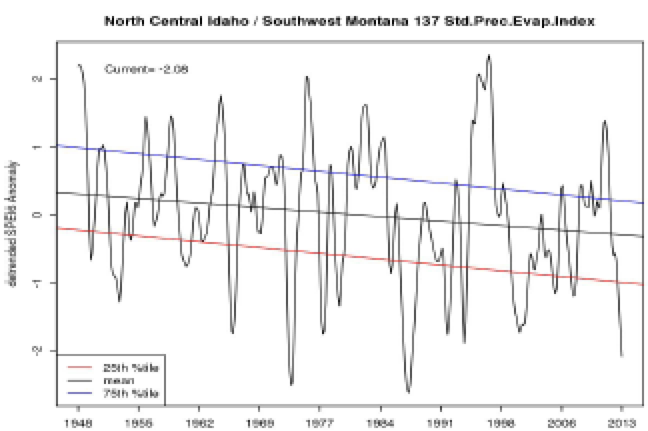
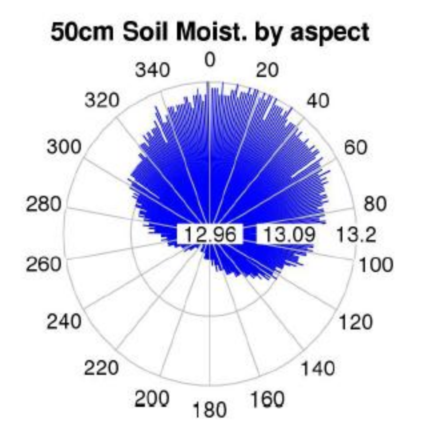
GACC ID:137

Area Beetle Kill Hectares:1393.92
Area Beetle Kill Acres:3444.38
```





Topofire summary report (downloadable PDF)

Quickly synthesize information for incident support

Key fire mgmt decisions made in 1st 24 hours after

Fire detection

Hydrologic condition, MPB distribution, timing of snow

Melt etc.

All imagery/spatial data can be downloaded by user-defined region and date

Phase 2:

- Extend all products to CONUS
- Develop modified FARSITE to ingest fine-scale fuel moisture/fire danger data
- On demand fire behavior simulations that account for fuels/MPB and topoclimate
- Interface with smart phones for real-time weather assimilation/distribution to firefighters in the field