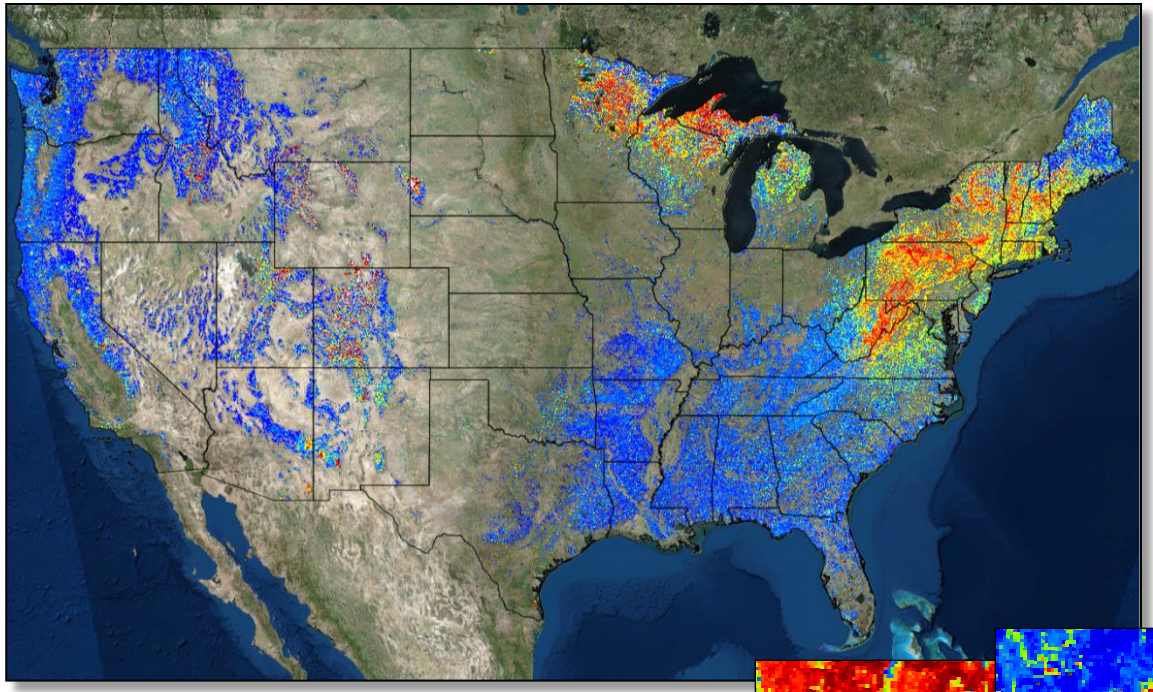
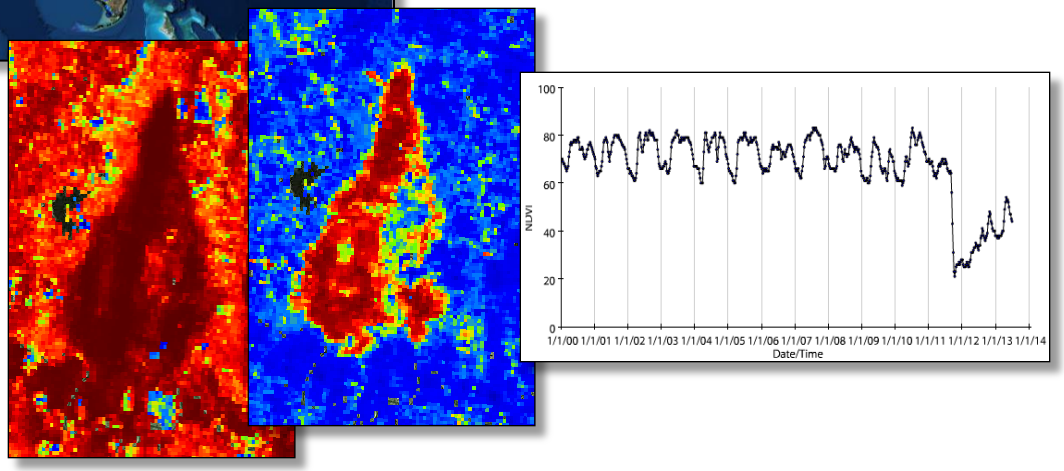
Tracking forest and landscape change from space using the *ForWarn* system



Forestry and Natural Resources Webinar

Southern Regional Extension Forestry

October 15, 2014



Steven P. Norman
William W. Hargrove
Joseph P. Spruce
William M. Christie

Outline

- Challenges of forest monitoring
- The ***ForWarn*** system
- Near-real-time change detection
- Long-term monitoring of landscapes and change
- Summary

Challenges of forest monitoring

Six herculean labors

1.) Track all forests, if not all lands, across jurisdictions.

2.) Track both disturbances and outcomes.

3.) Monitor across seasons.

4.) Have "*near-real-time*" capabilities for early intervention.

5.) Capture gradual decline, delayed disturbance impacts post-disturbance recovery and type conversions.

6.) Derive indicators that make managerial sense across regions for cross-scale needs.

Challenges of forest monitoring

A cross scale integrated strategy

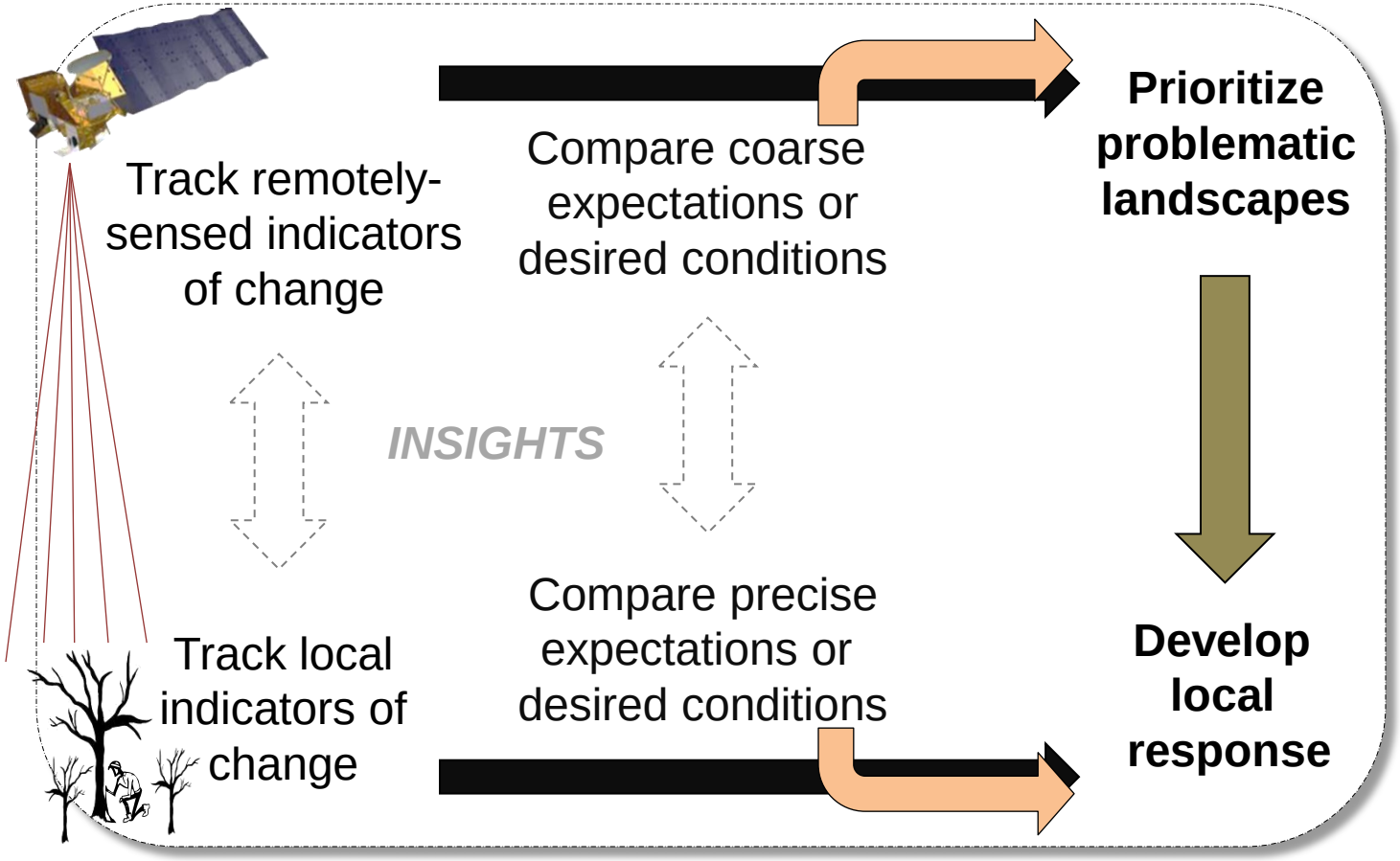
Track local indicators of change

Compare precise expectations or desired conditions

Develop local response

Challenges of forest monitoring

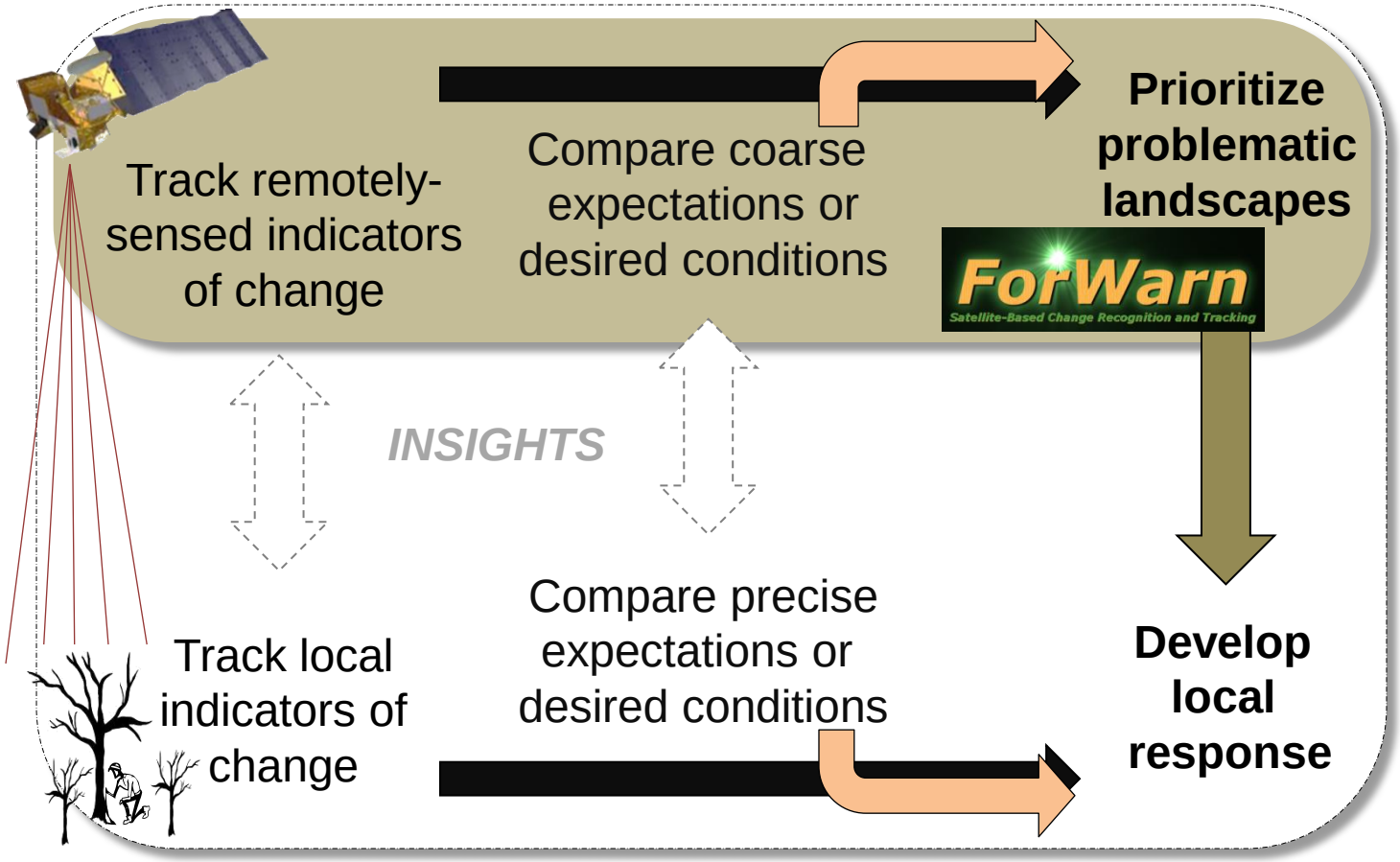
A cross scale integrated strategy



Challenges of forest monitoring

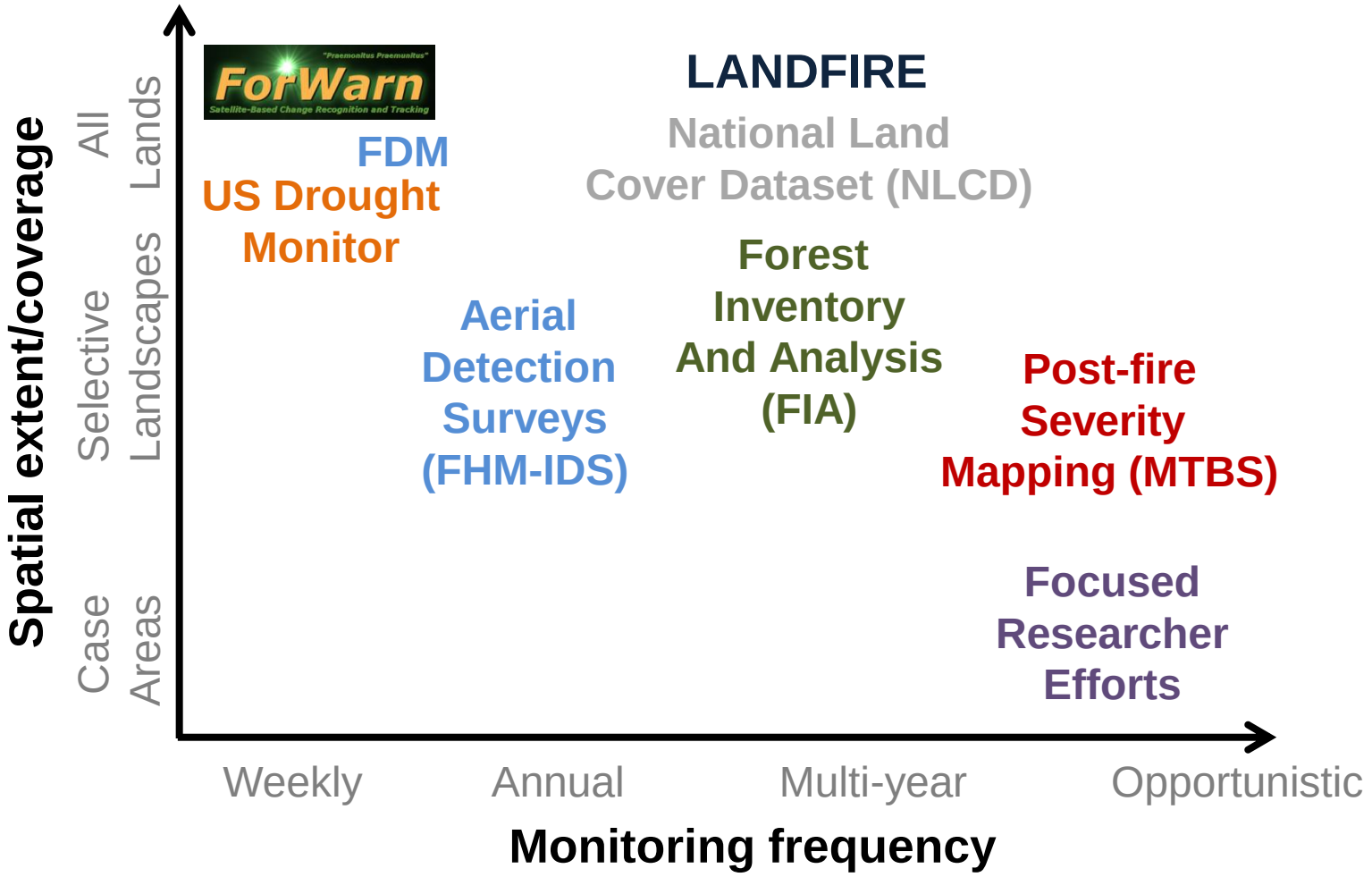
A cross scale integrated strategy

ForWarn's monitoring helps satisfy needs for higher frequency, broader coverage and greater cost efficiency, with measures that provide coarse temporal and spatial context.



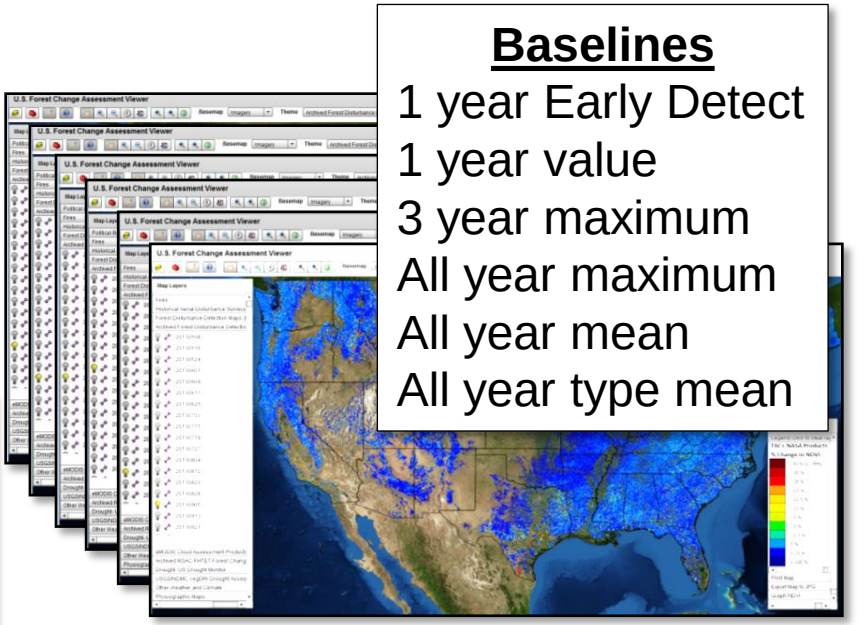
The *ForWarn* system

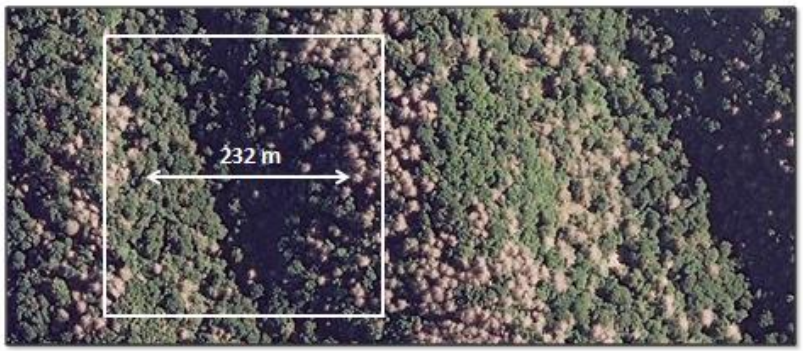
Existing programmatic approaches to US forest monitoring

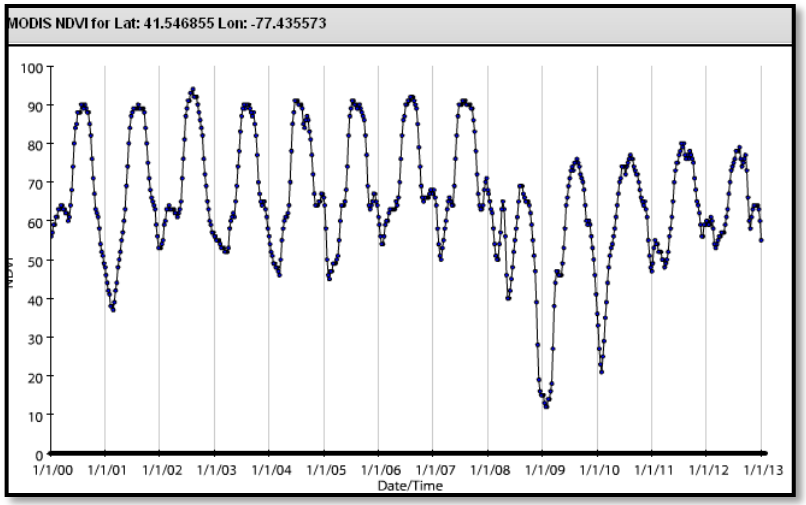


The *ForWarn* system

- Normalized Difference Vegetation Index (NDVI) from daily eMODIS and MODIS
- 232 meter resolution
- 46 periods per year (8-day intervals)
- Max value of 24-day moving window
- 2000 to present historical database
- Includes NDVI time series and change maps
- Online: http://forwarn.forestthreats.org

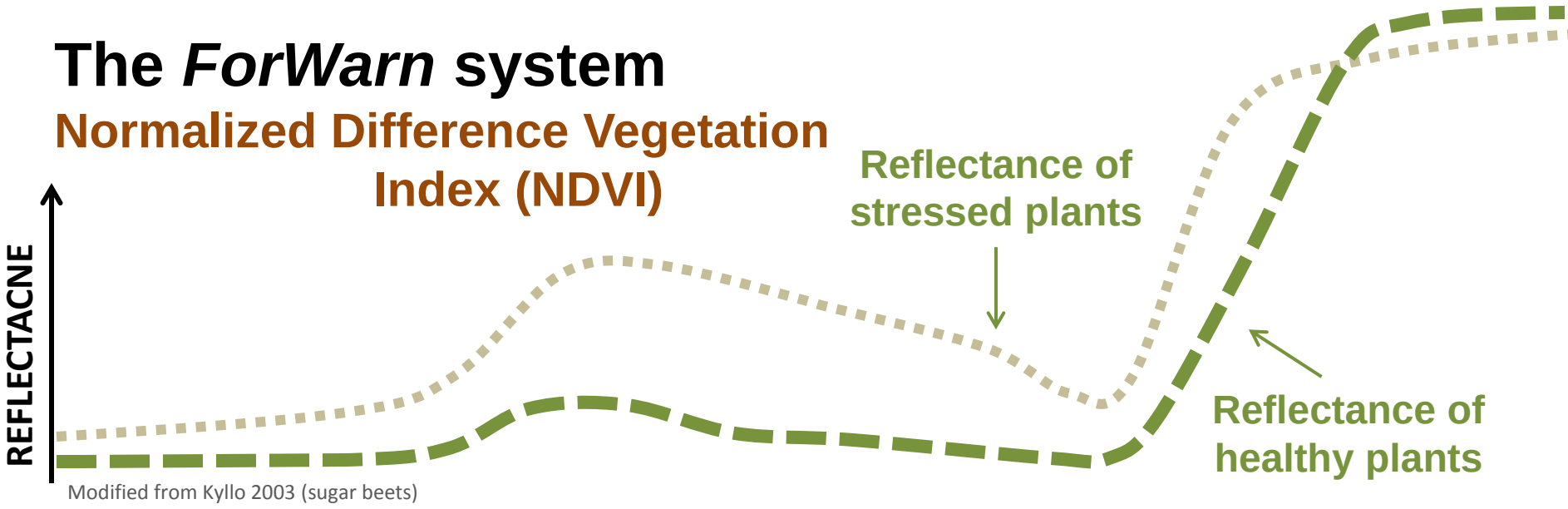


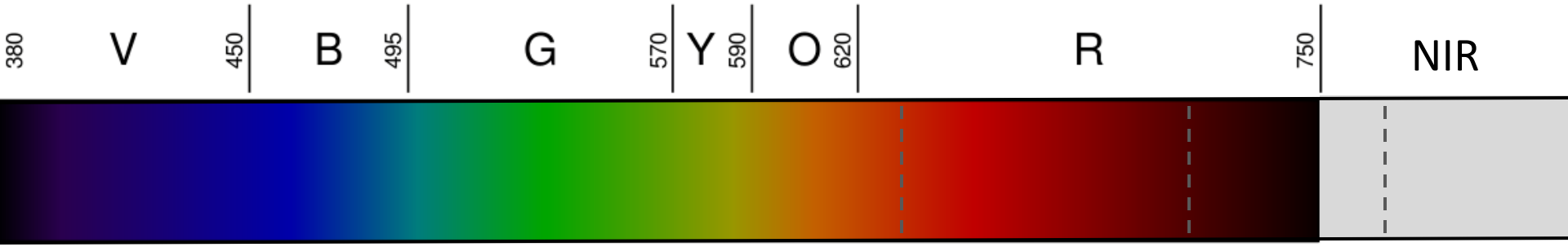




The *ForWarn* system

Normalized Difference Vegetation Index (NDVI)



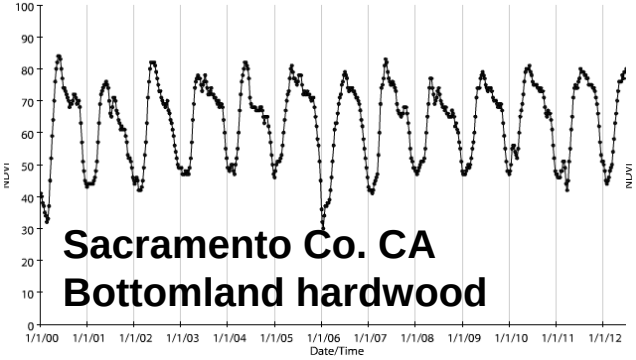


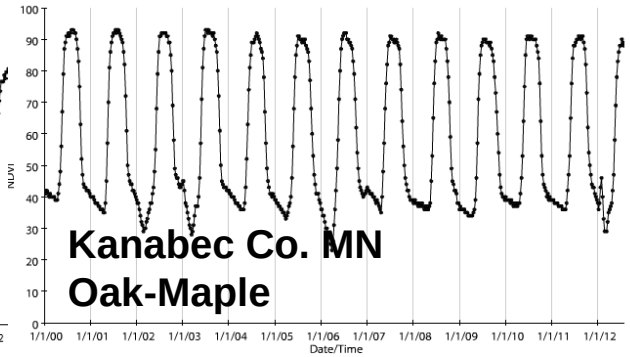
MODIS wavelengths used: 630 - 690 nm 780-900 nm

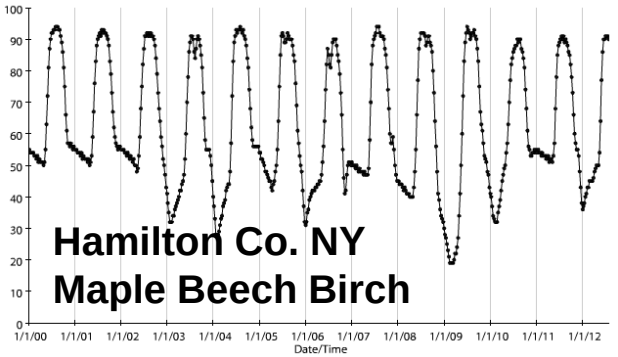
$$NDVI = \frac{(\text{Near infrared}) - (\text{Red})}{(\text{Near infrared}) + (\text{Red})}$$

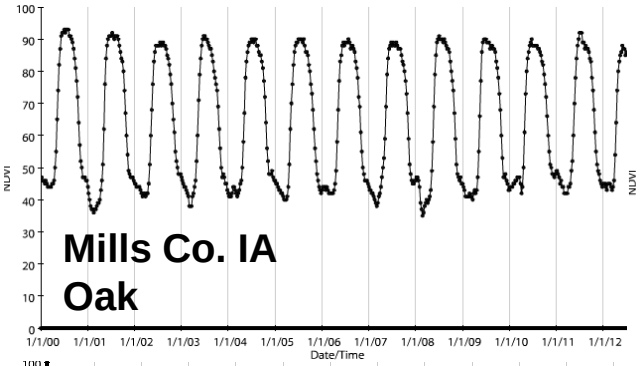
The *ForWarn* system

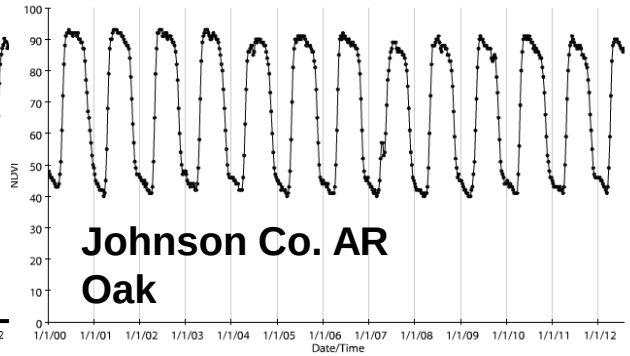
Land surface phenology of deciduous forest dominated sites

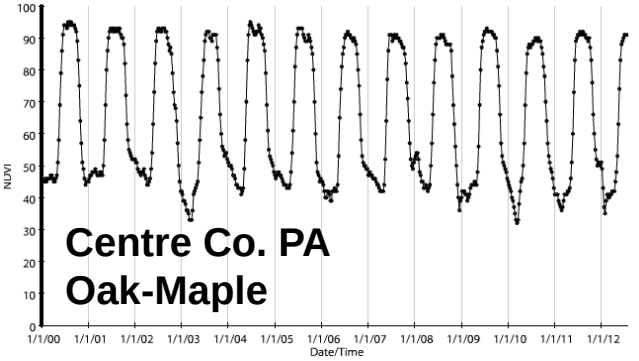


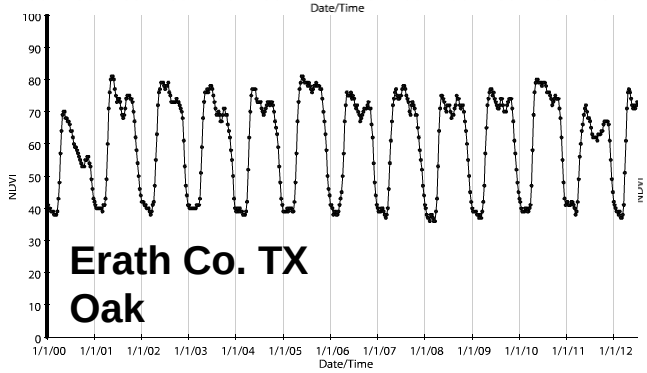


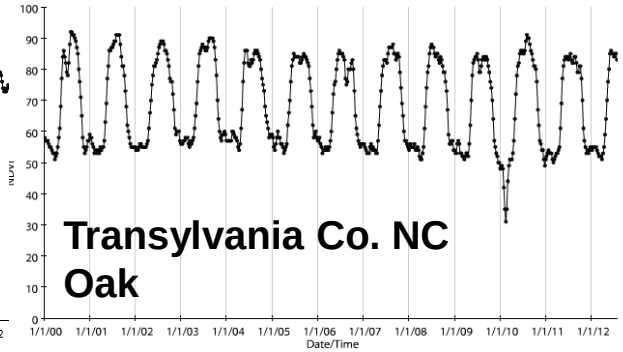


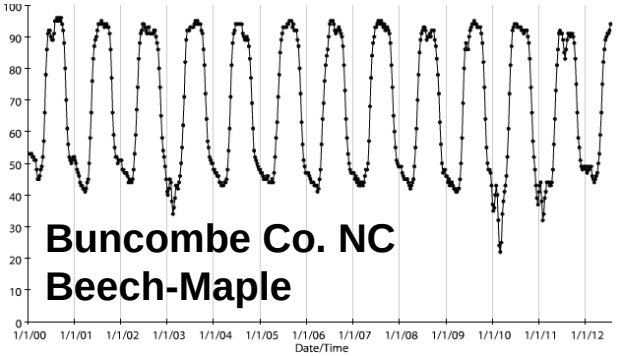






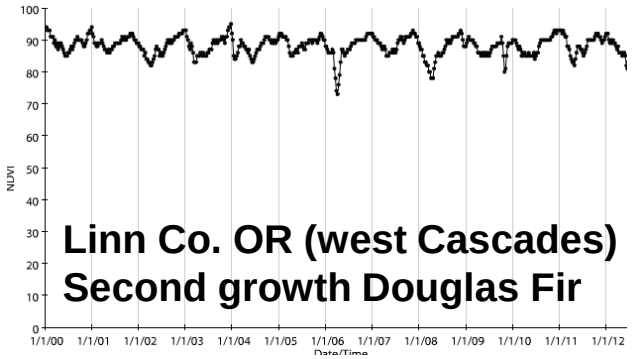


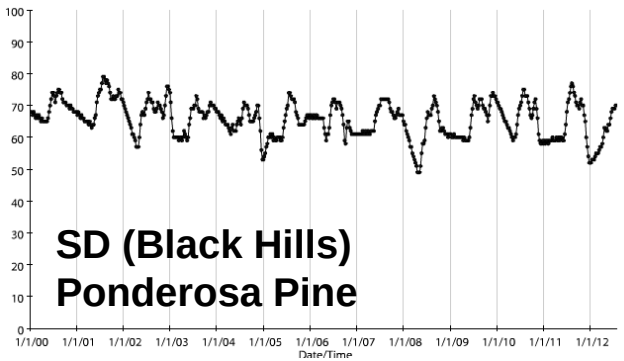


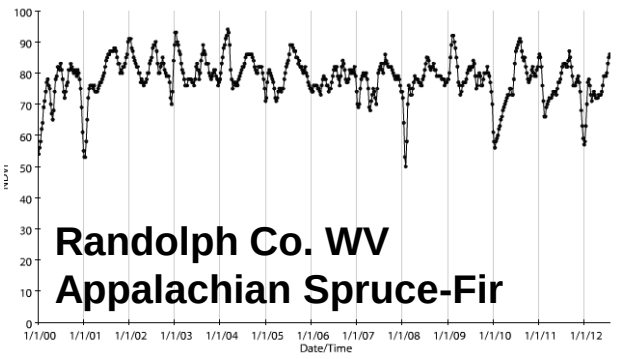


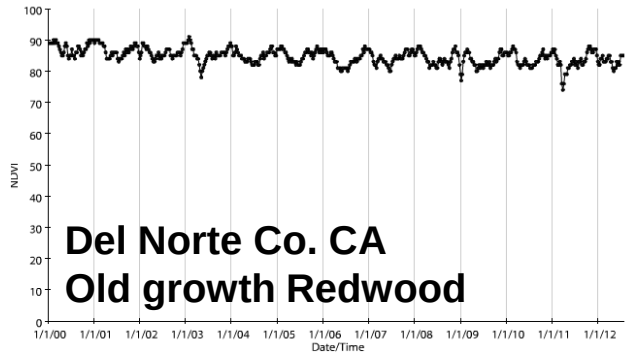
The *ForWarn* system

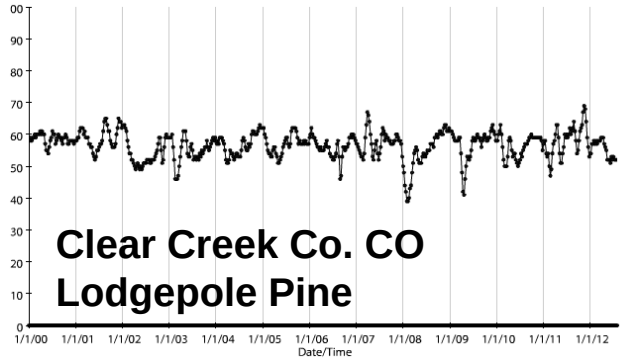
Land surface phenology of (evergreen) conifer forest

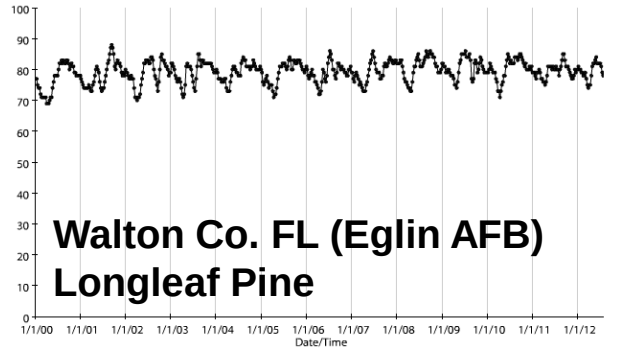


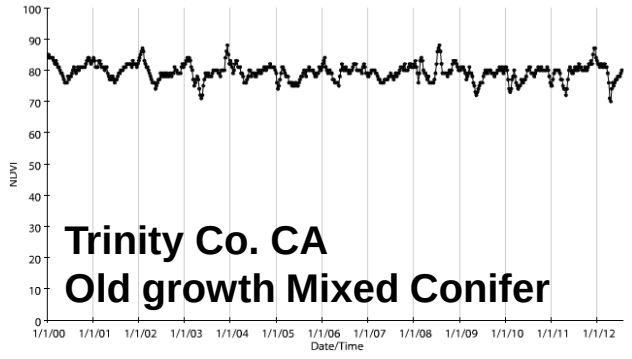


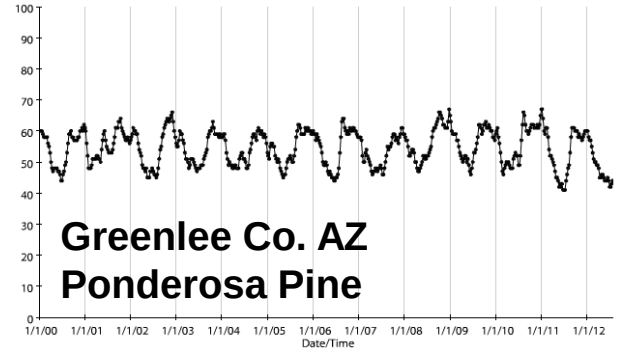


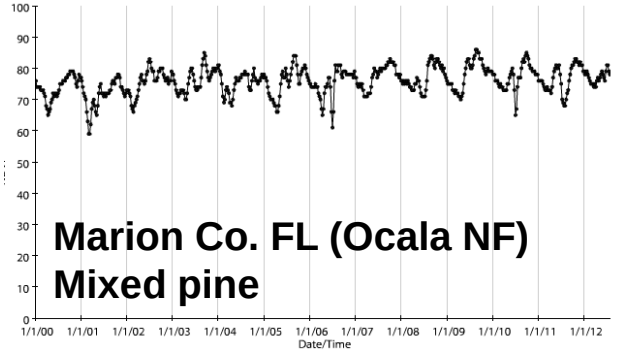






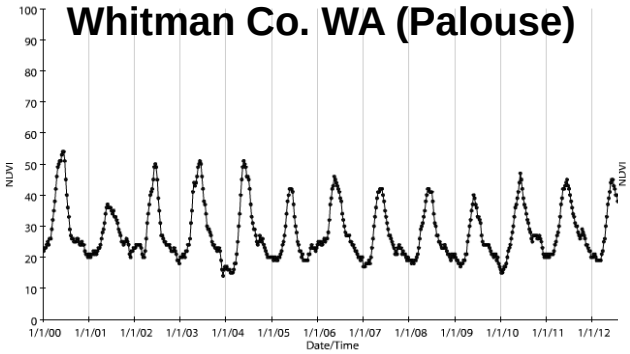


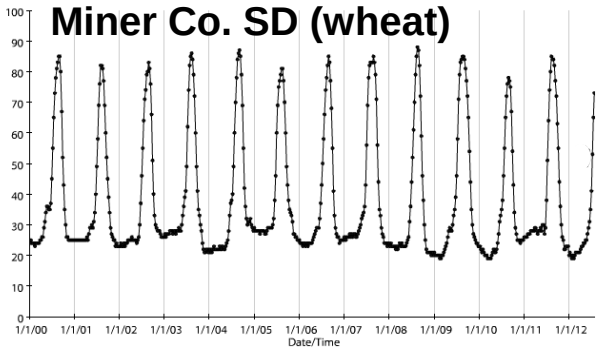


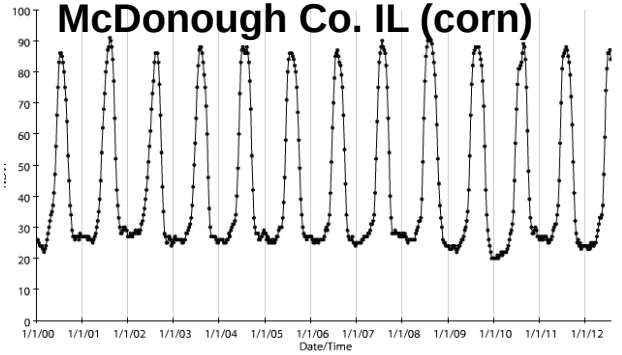


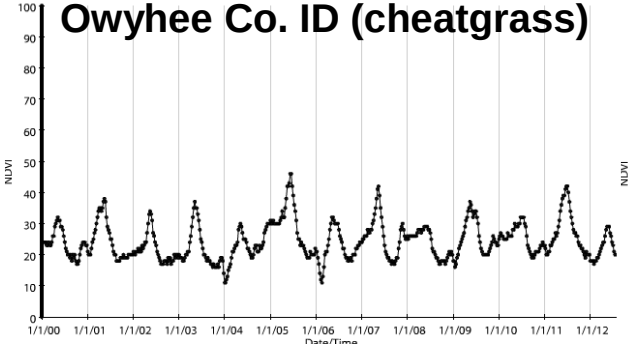
The *ForWarn* system

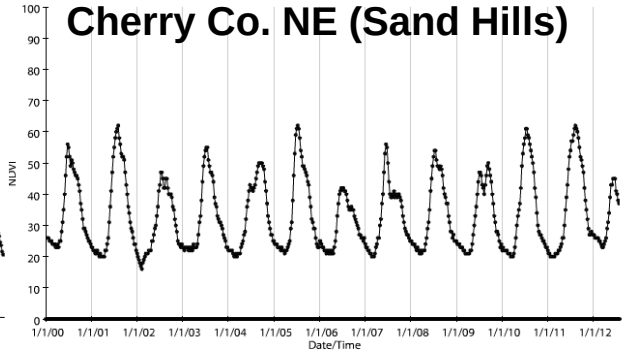
Land surface phenology of grass

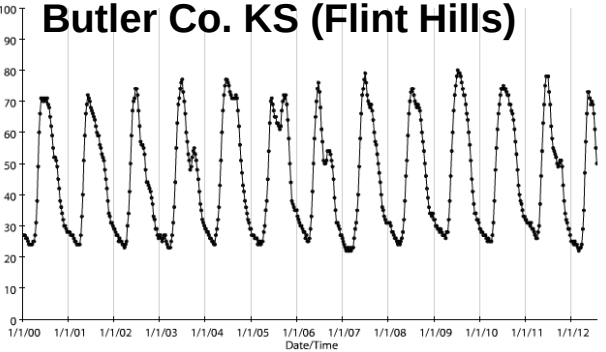


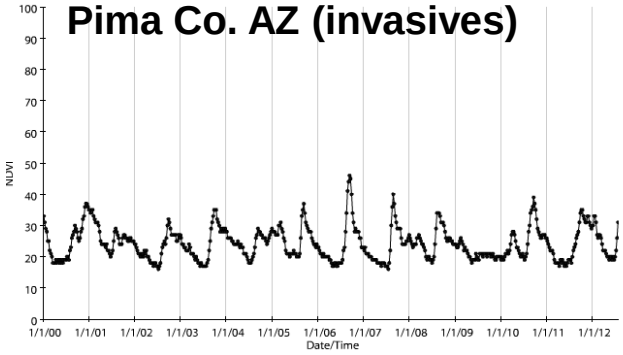


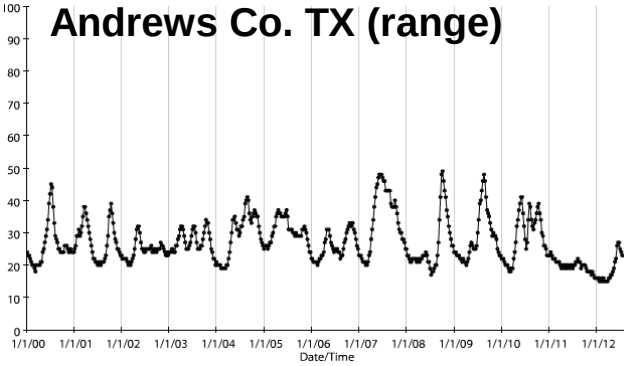


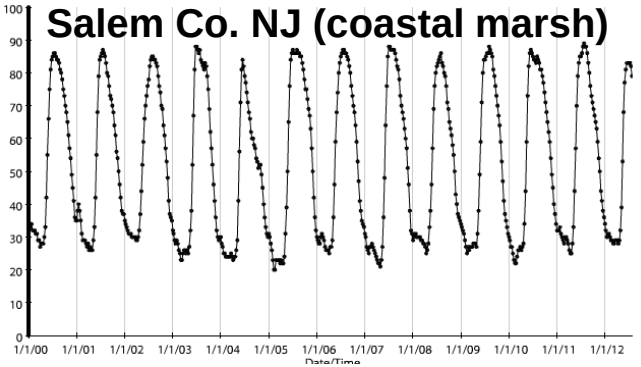






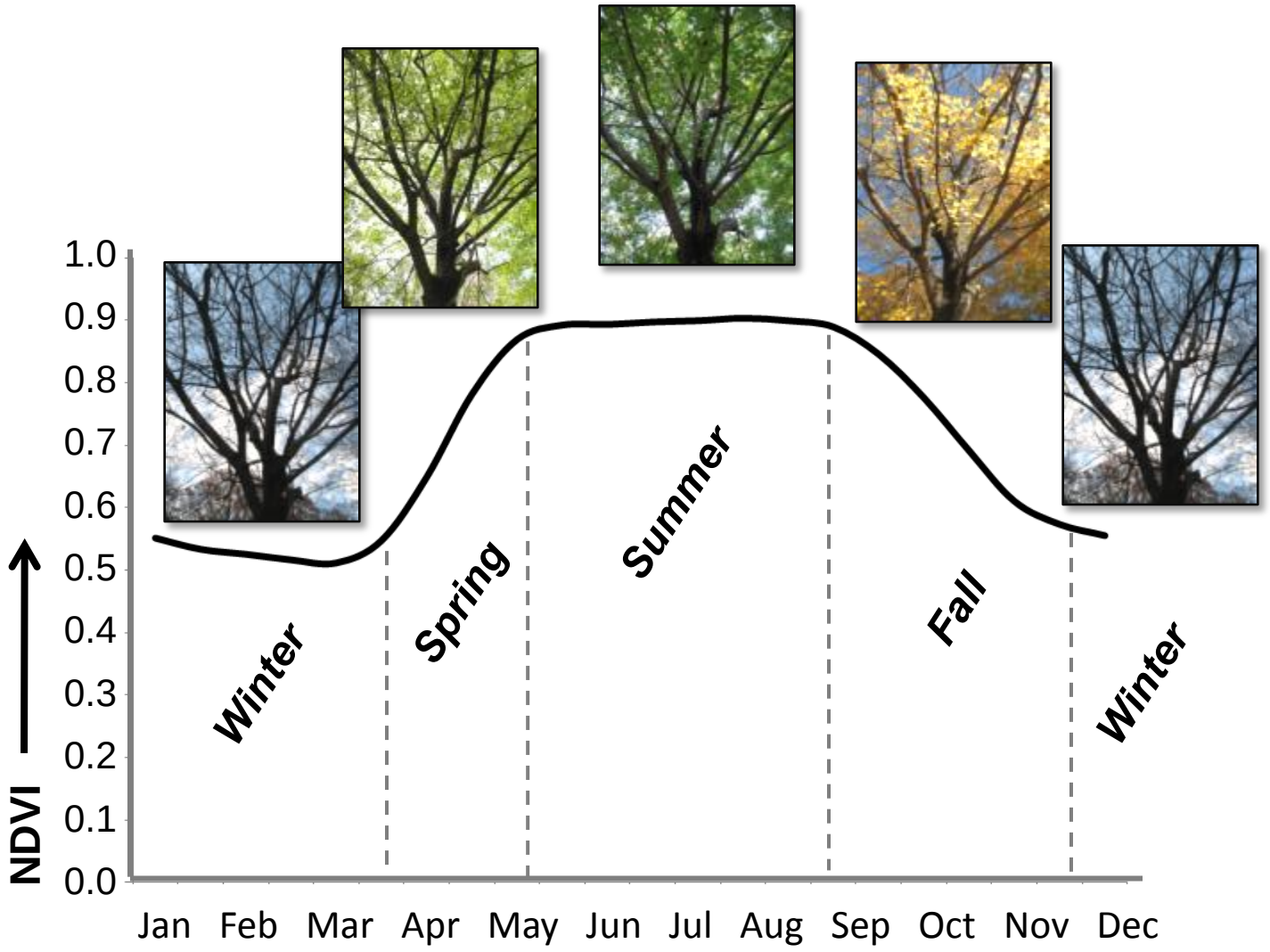






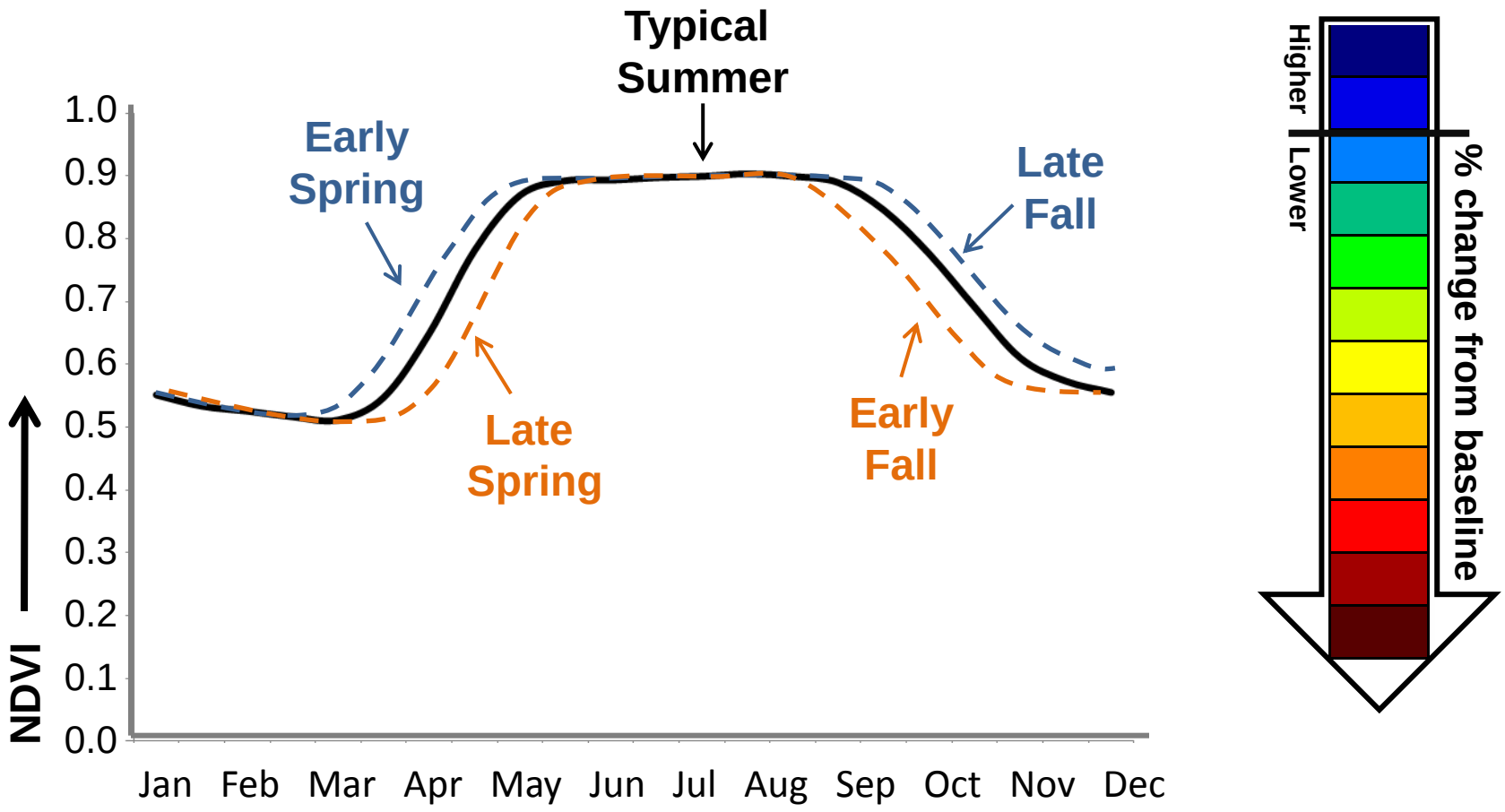
The *ForWarn* system

Seasonal change in NDVI reflects vegetational phenology



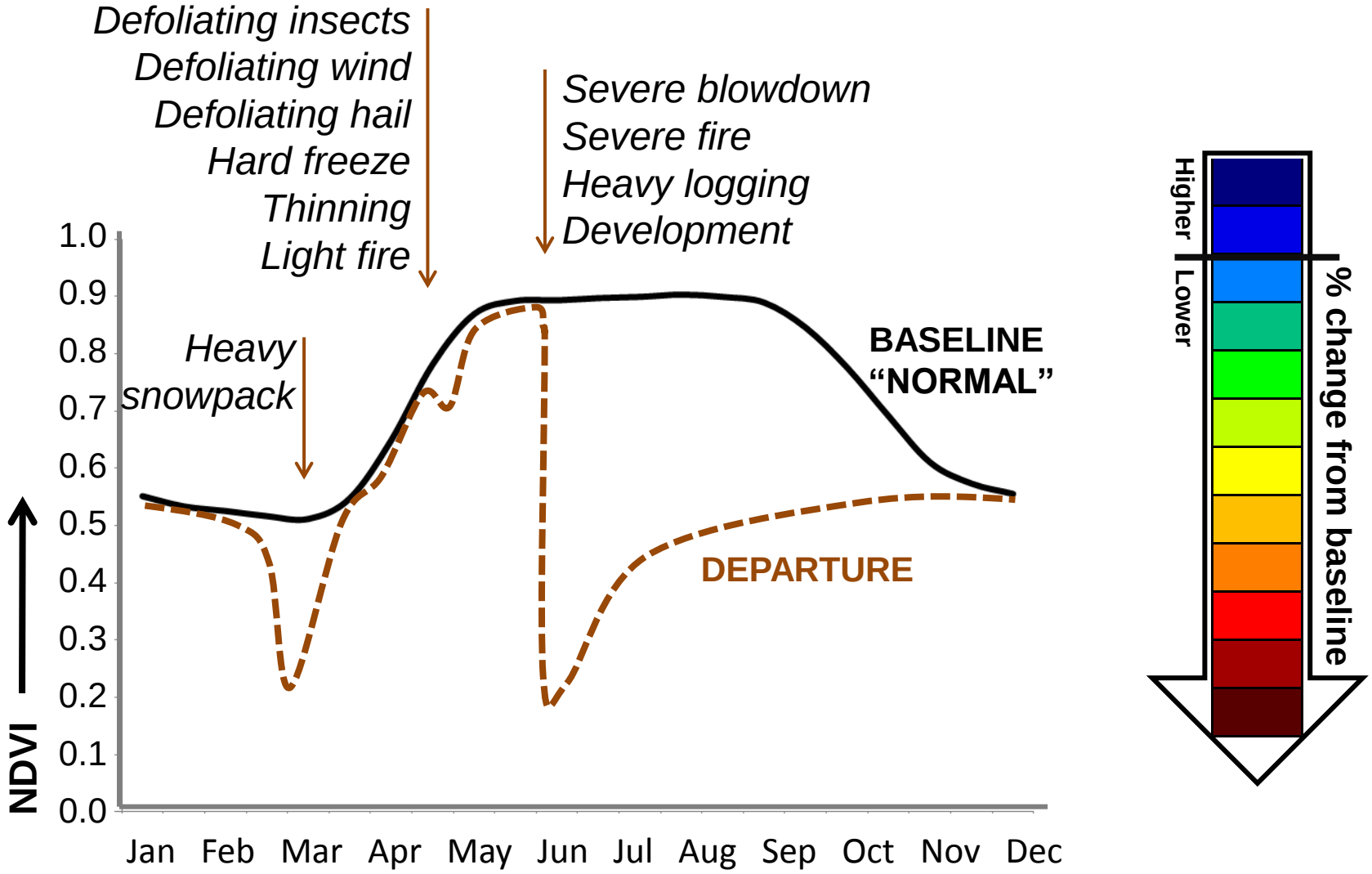
The *ForWarn* system

Baseline phenology compared to variation in Spring and Fall



The *ForWarn* system

Baseline phenology compared to disturbance effects

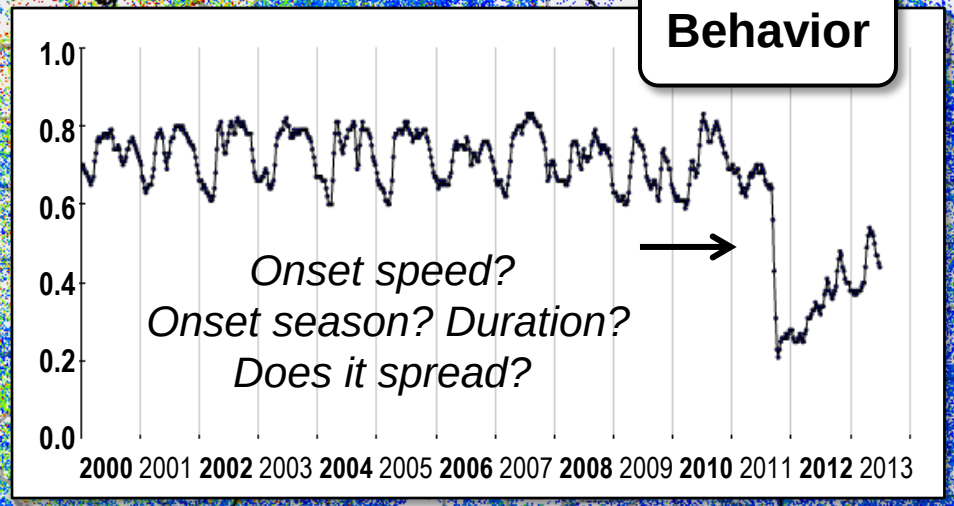


The *ForWarn* system

What caused the change?

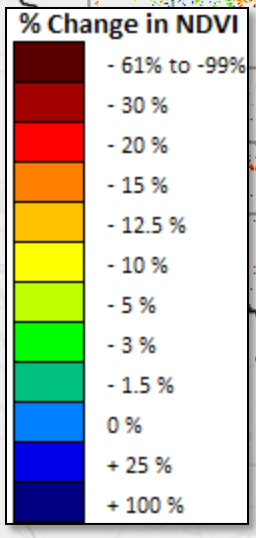
Tools of the analyst's trade

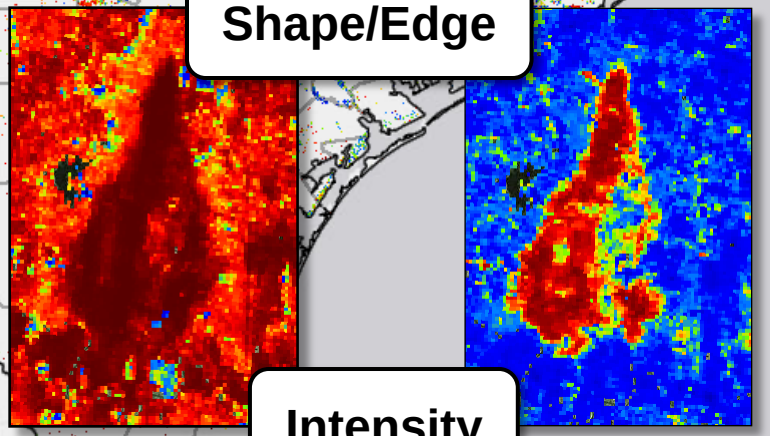
Behavior



Extent

Shape/Edge

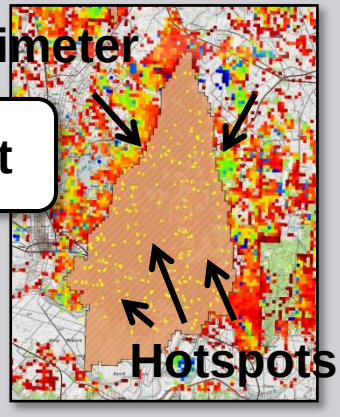




Intensity

Fire perimeter

Agreement

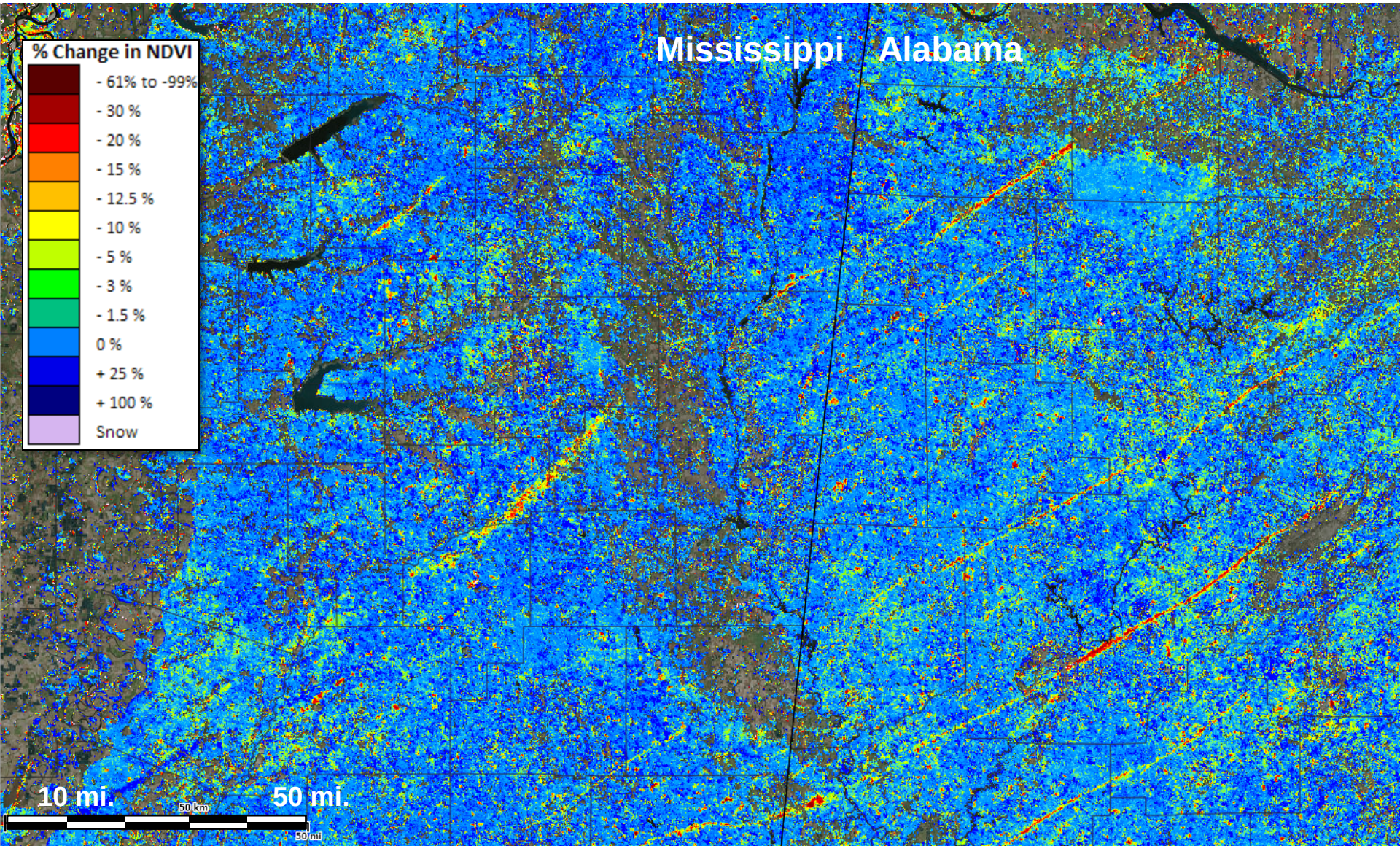


Hotspots

October 31, 2011

Near-real-time change detection

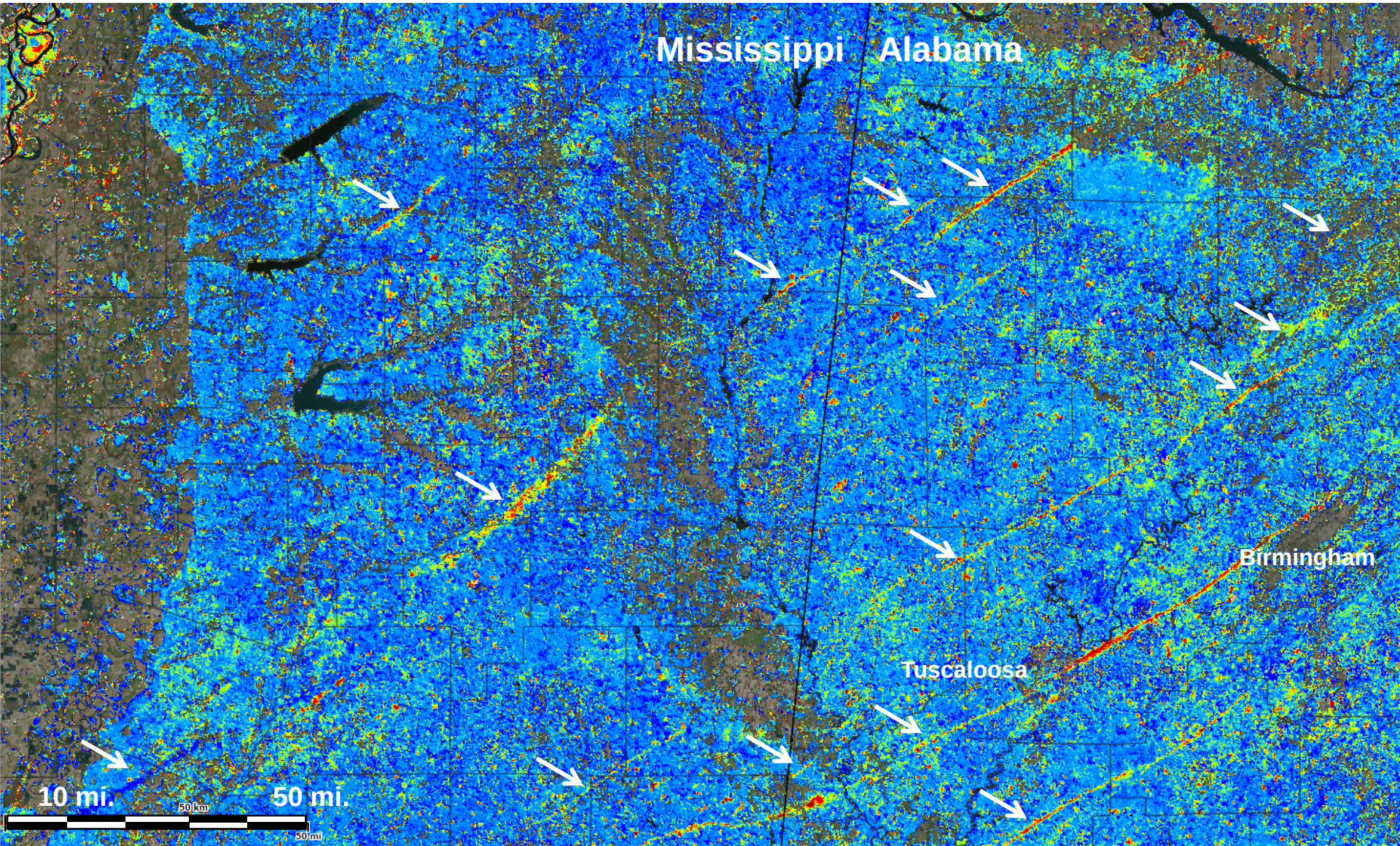
ForWarn 1 year change product ending 6/1/2011



Near-real-time change detection

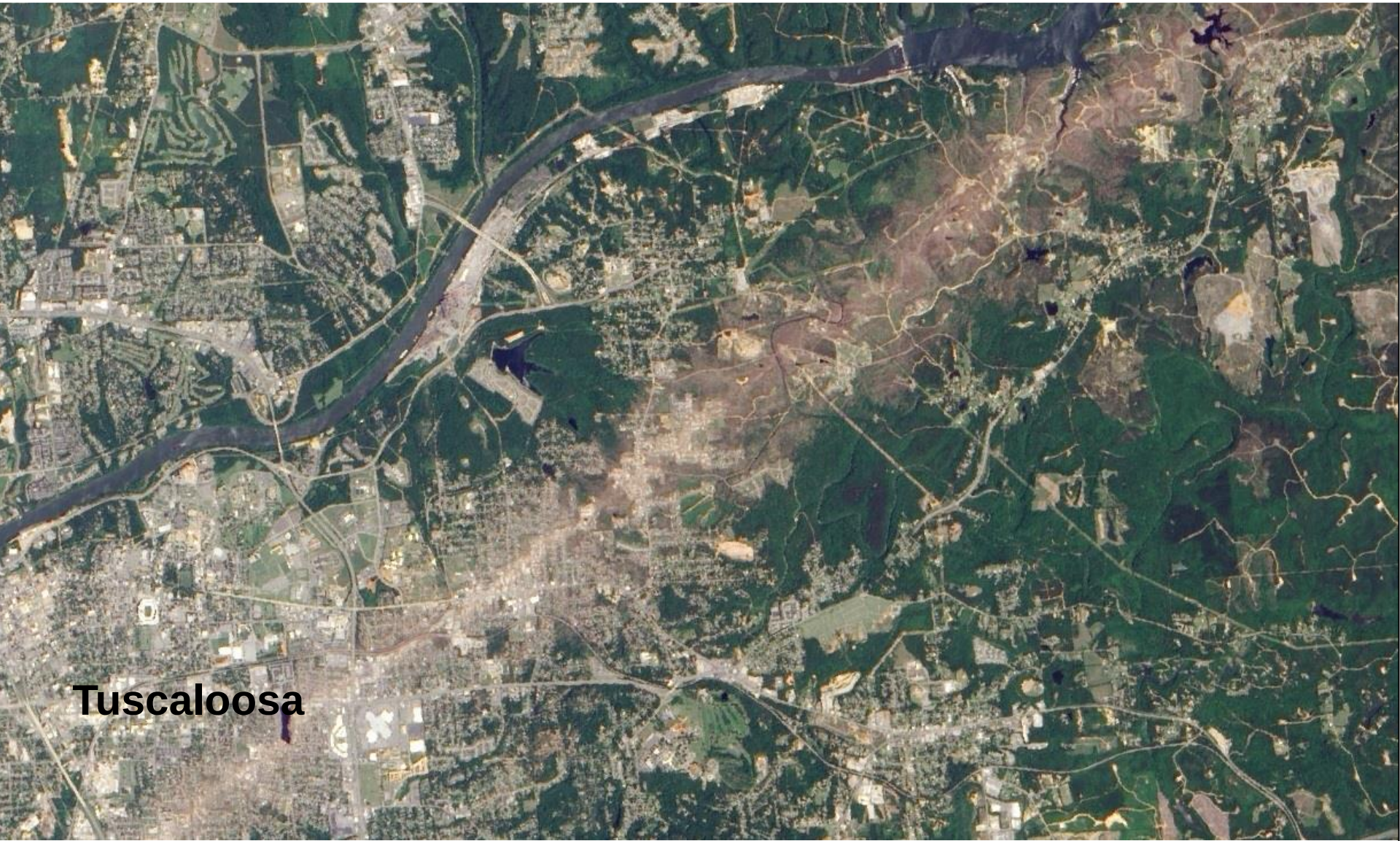
Southeast tornado outbreak, April 27, 2011

Jun 1, 2011; 1 year baseline



Near-real-time change detection

Southeast tornado outbreak, April 27, 2011



Near-real-time change detection

Southeast tornado outbreak, April 27, 2011

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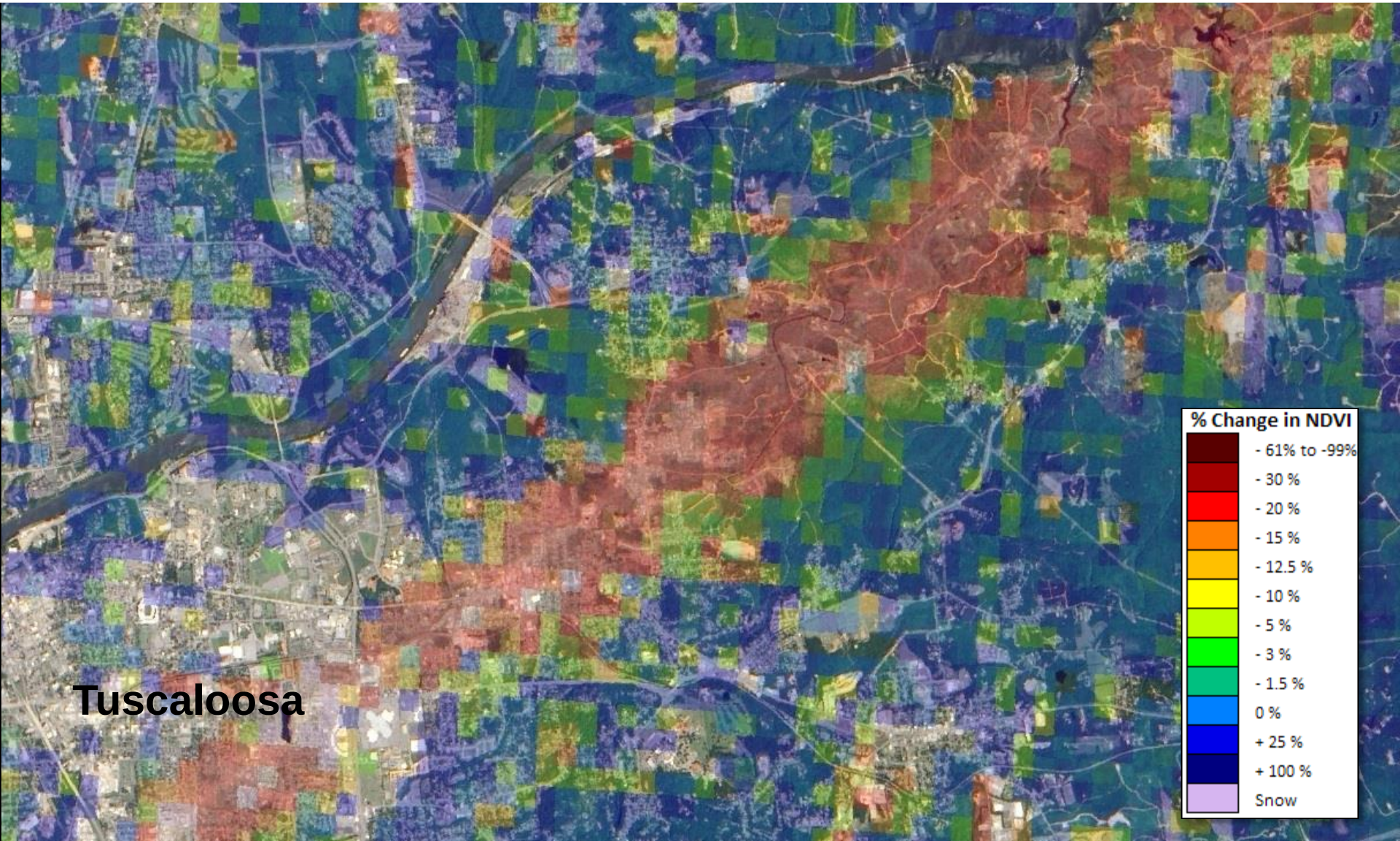
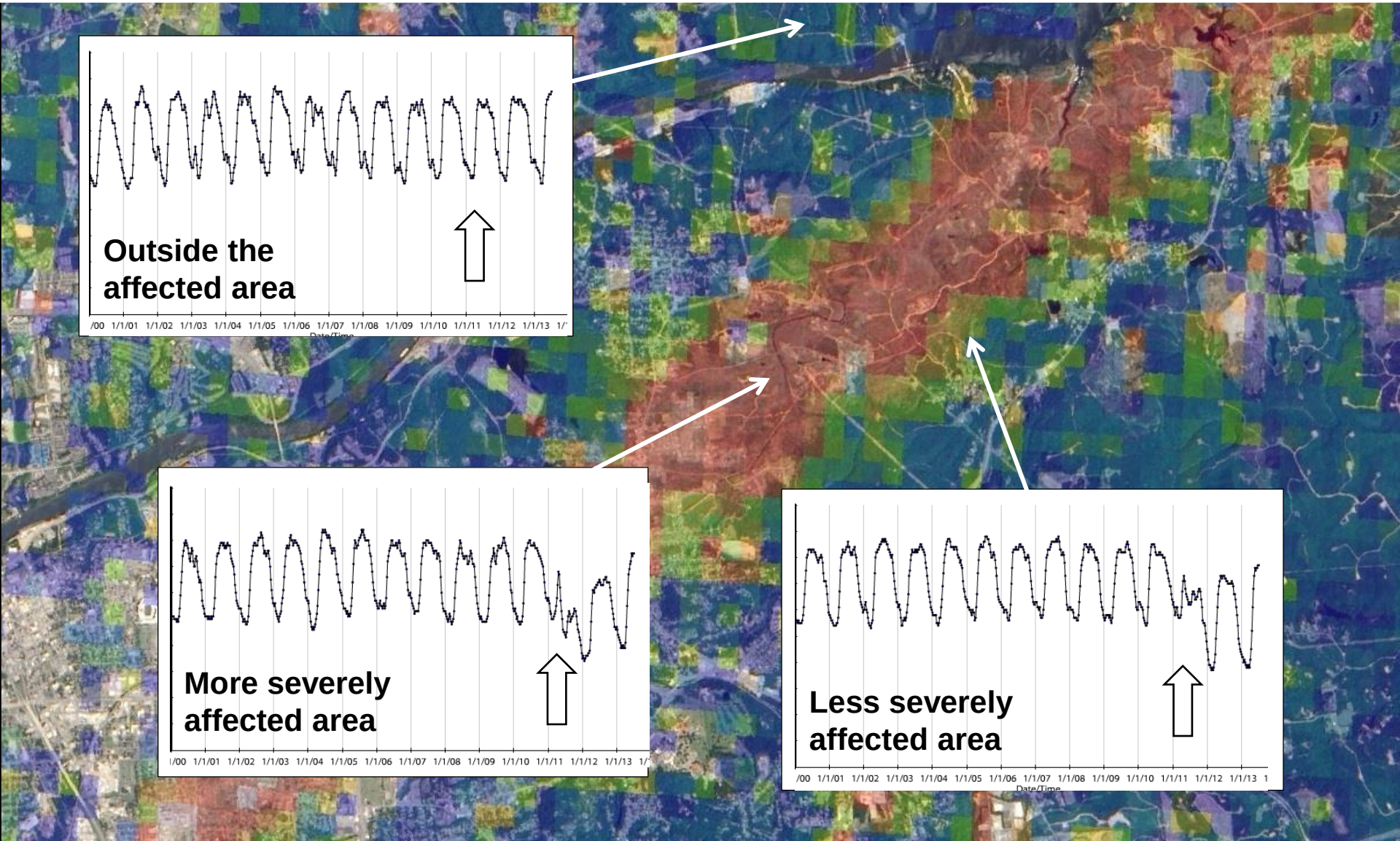


Near-real-time change detection

Southeast tornado outbreak, April 27, 2011

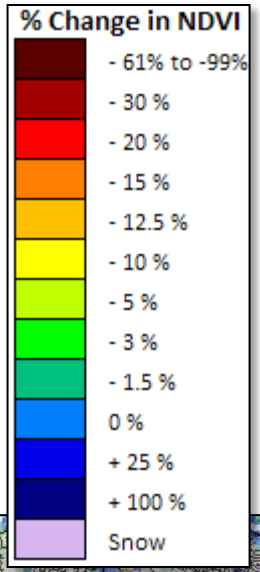
Jun 1, 2011; 1 year baseline



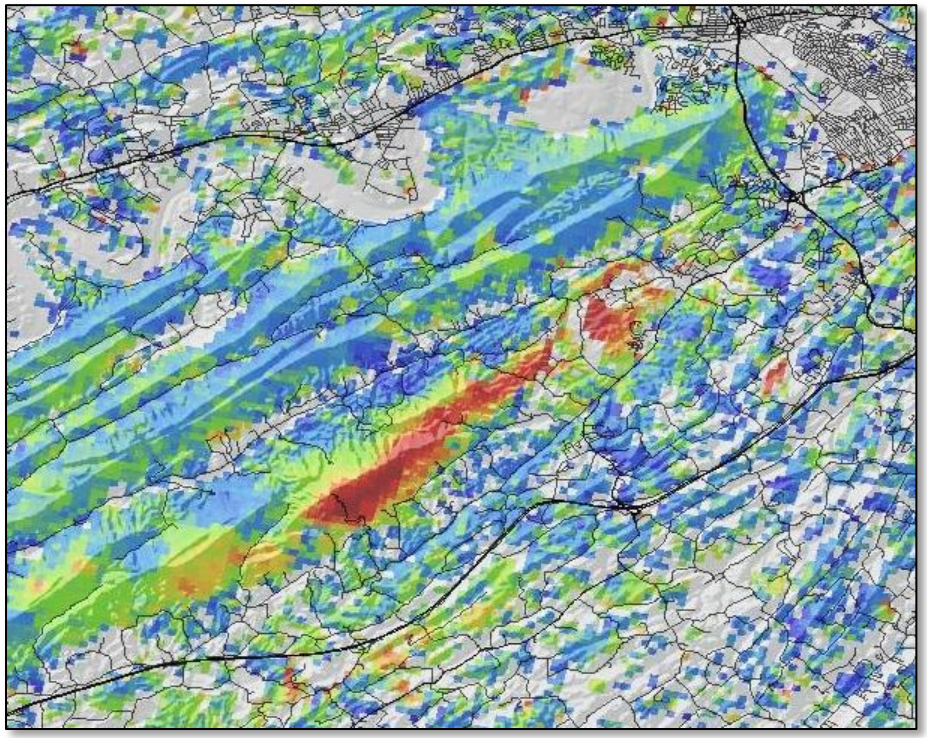
Near-real-time change detection

ForWarn 1 year change product ending 6/1, 7/3/2011

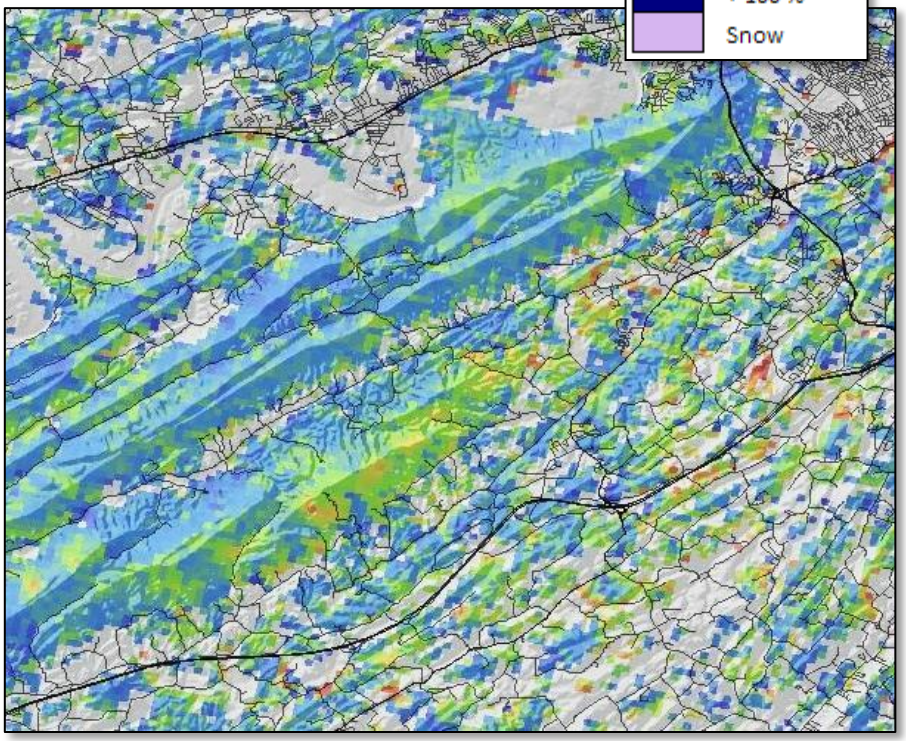
?



June 1, 2011

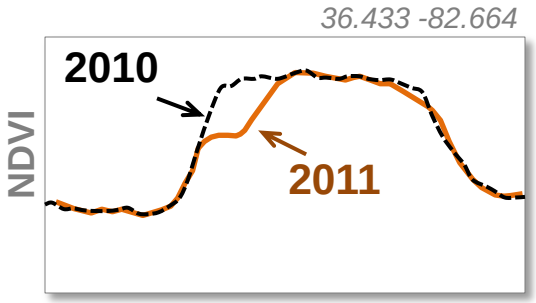


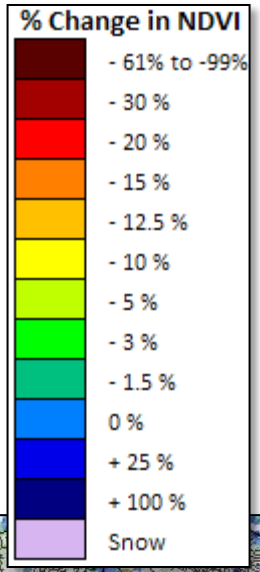
July 3, 2011



Near-real-time change detection

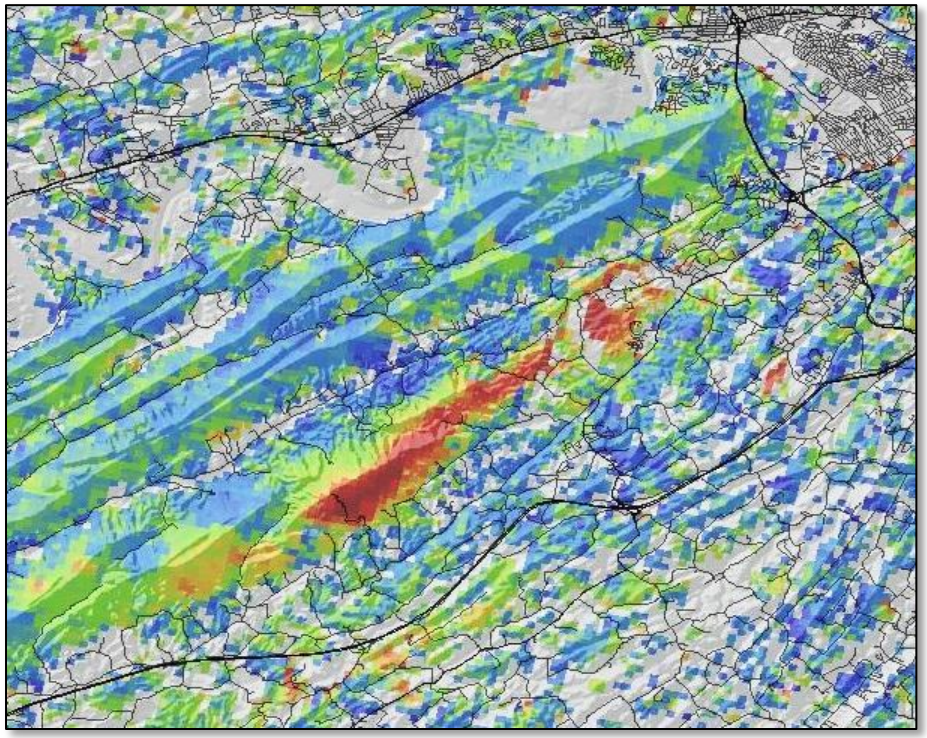
Wind-hail defoliation and refoliation in northeast TN

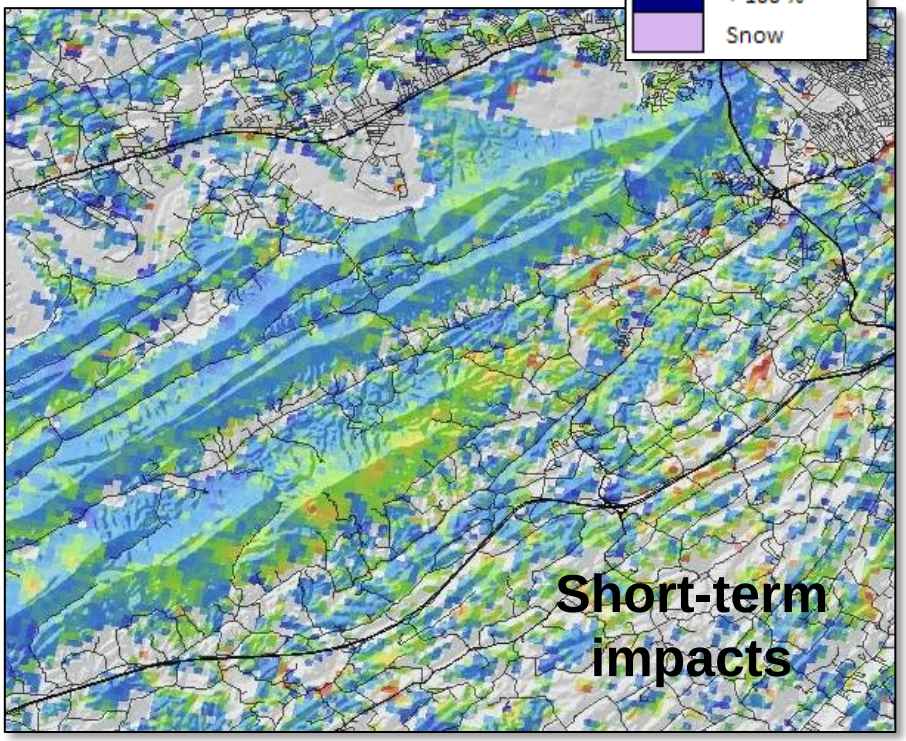




June 1, 2011

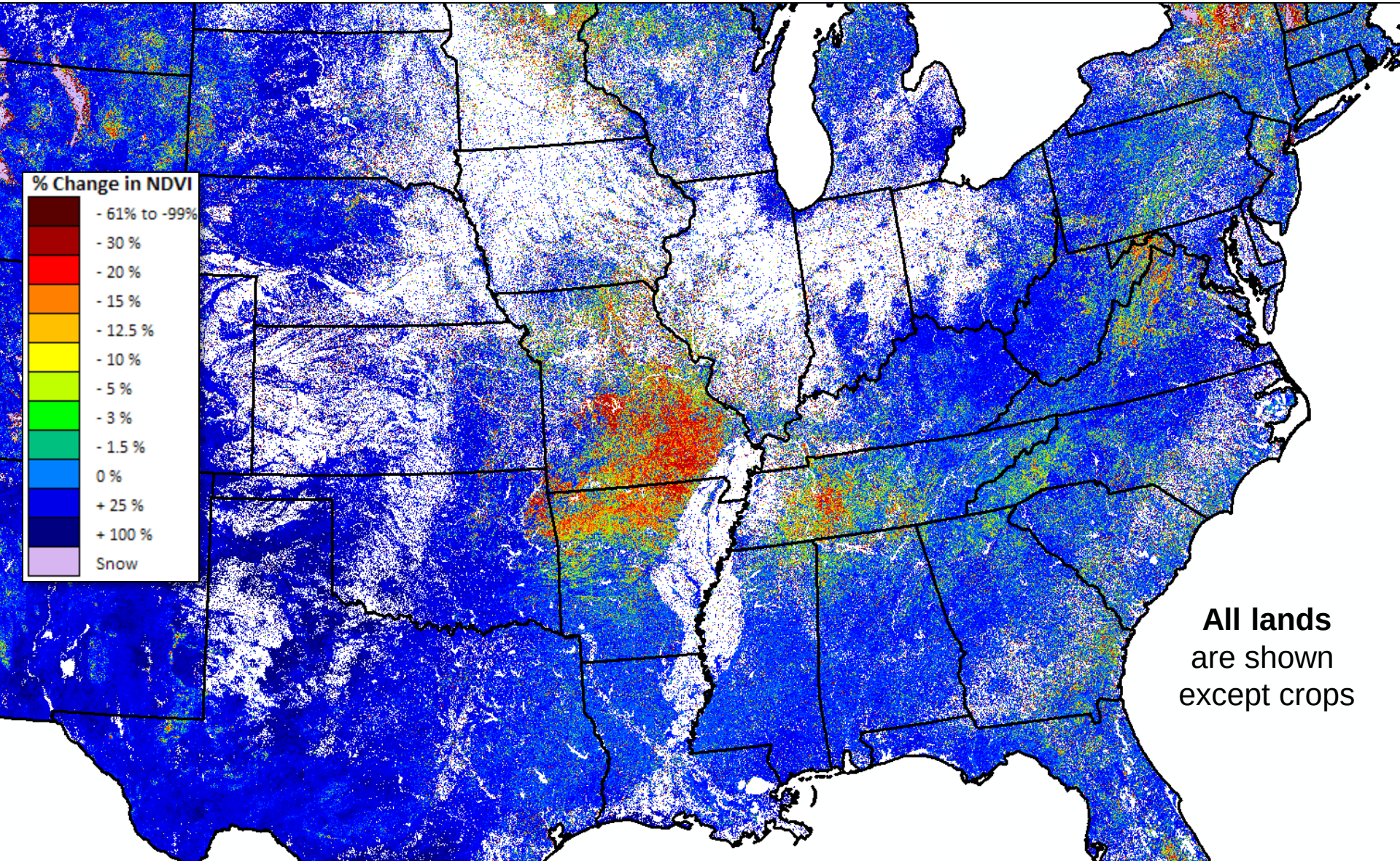
July 3, 2011





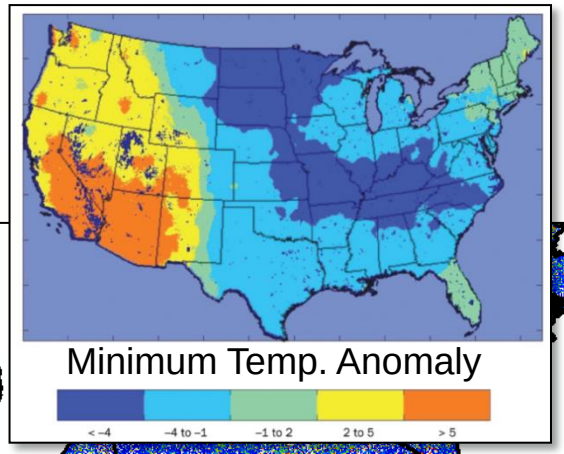
Near-real-time change detection

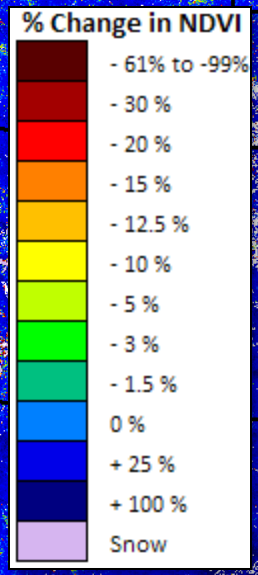
ForWarn 1 year change product ending 4/30/2007



Near-real-time change detection

The Big Freeze of April 5-9, 2007



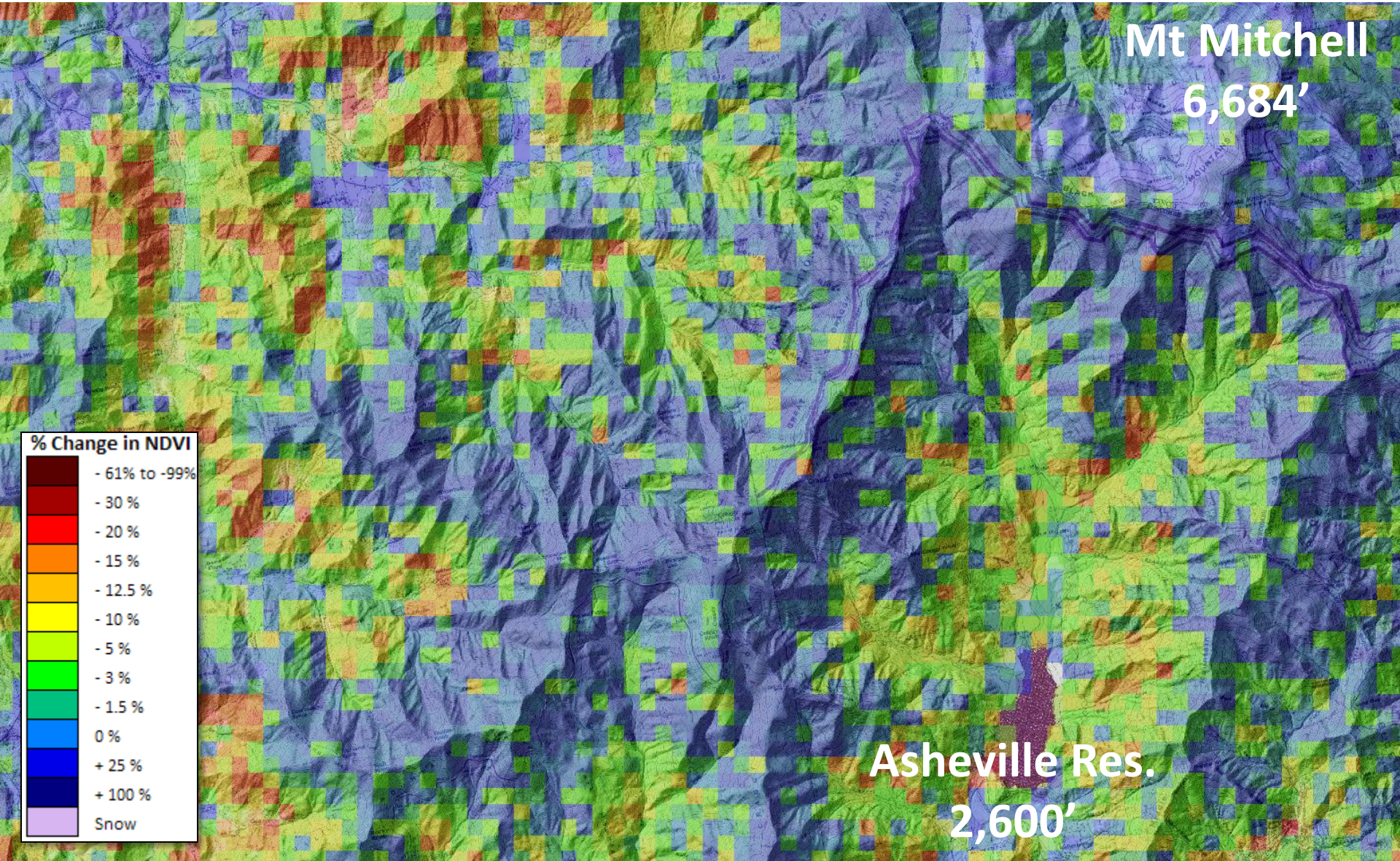


Near-real-time change detection

The Big Freeze of April 5-9, 2007

Near-real-time change detection

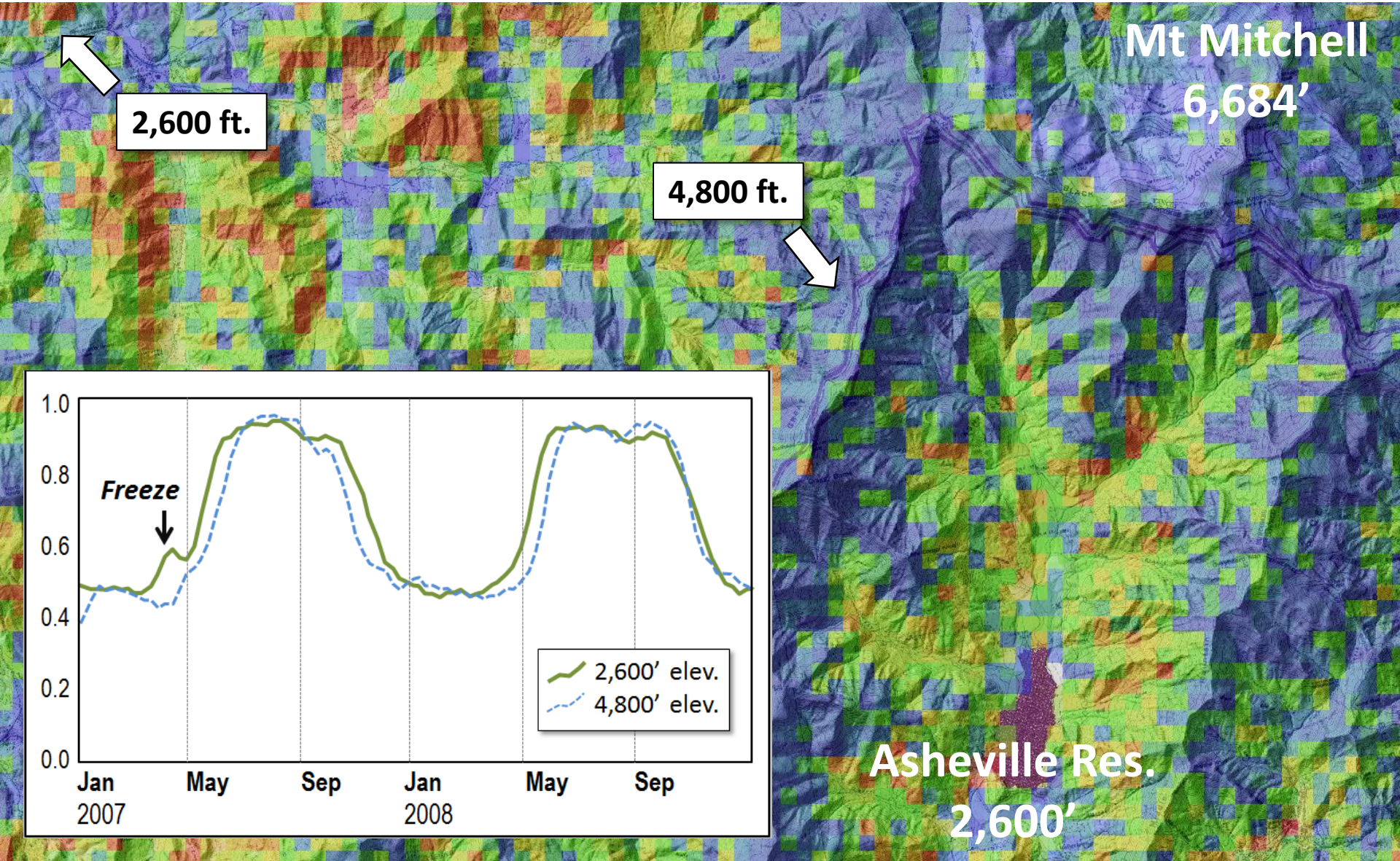
The Big Freeze of April 5-9, 2007



Near-real-time change detection

The Big Freeze of April 5-9, 2007

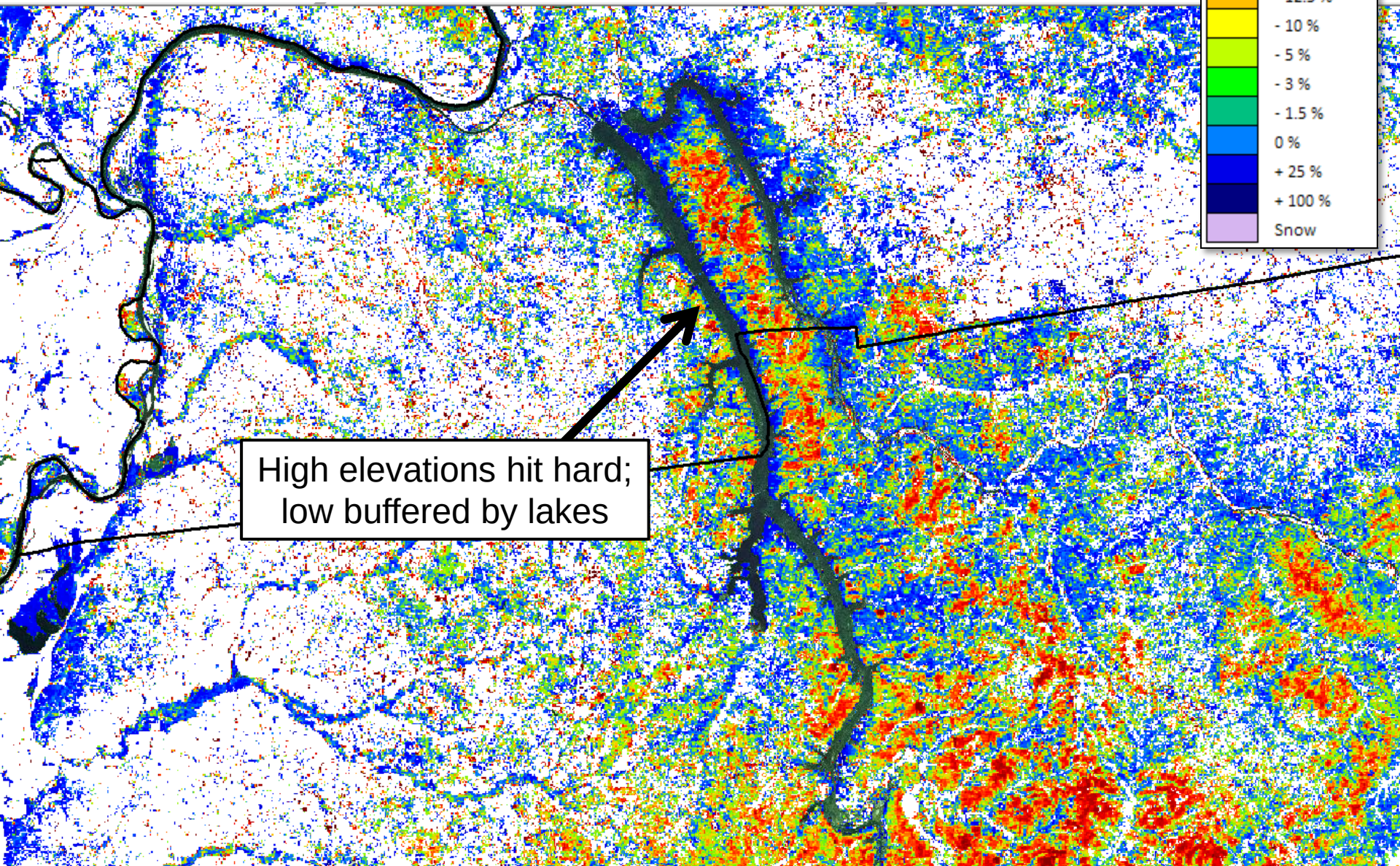
2,600’ site: N of Barnardsville: 35.79107 -82.45575
4,800’ site: W of Parkway, Locust Ridge: 35.73165 -82.35573



Near-real-time change detection

The Big Freeze of April 5-9, 2007

ForWarn: 1 year ending 4/30/07



Near-real-time change detection

ForWarn 1 year change product ending 9/29/2011

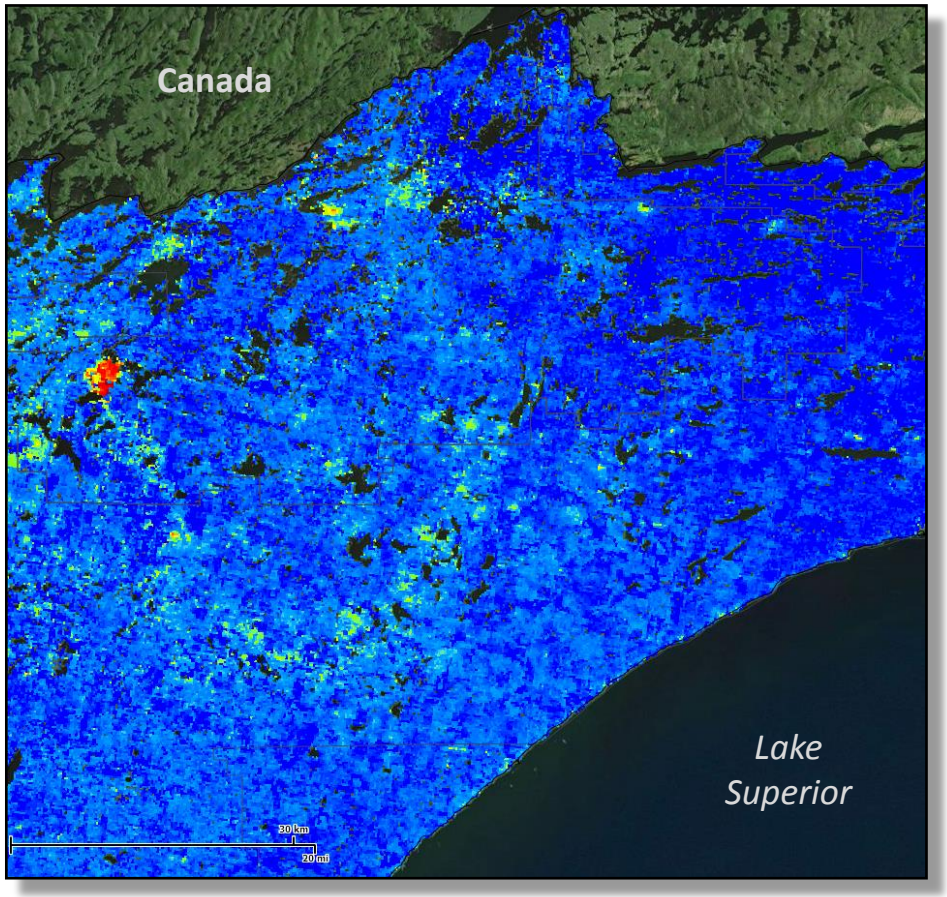
Aug. 04 Aug. 12 Aug. 20 Aug. 28 Sep. 05 Sep. 13 Sep. 21 **Sep. 29**

24 day window

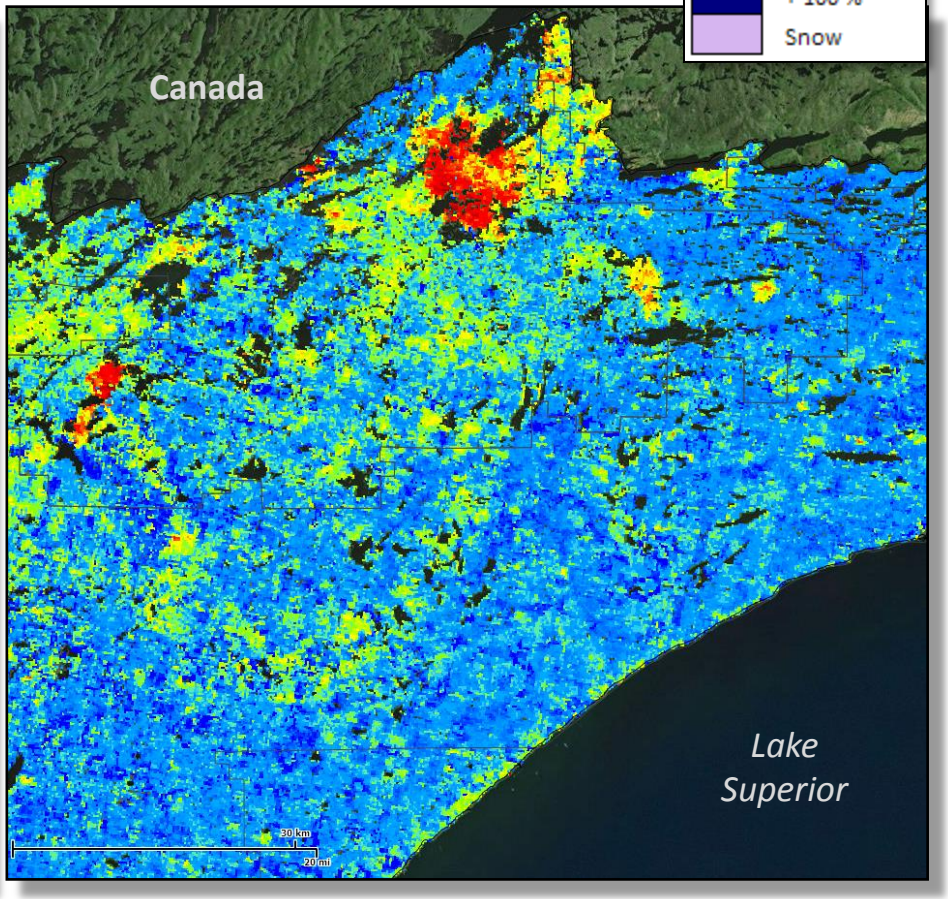
?

% Change in NDVI
- 61% to -99%
- 30 %
- 20 %
- 15 %
- 12.5 %
- 10 %
- 5 %
- 3 %
- 1.5 %
0 %
+ 25 %
+ 100 %
Snow

1 Year Baseline

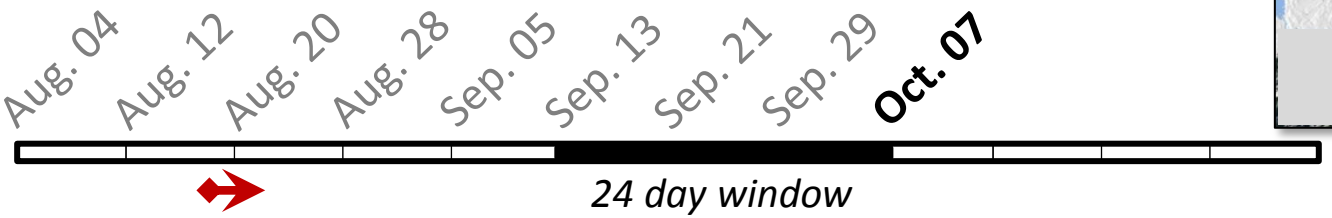


All Year Maximum Baseline

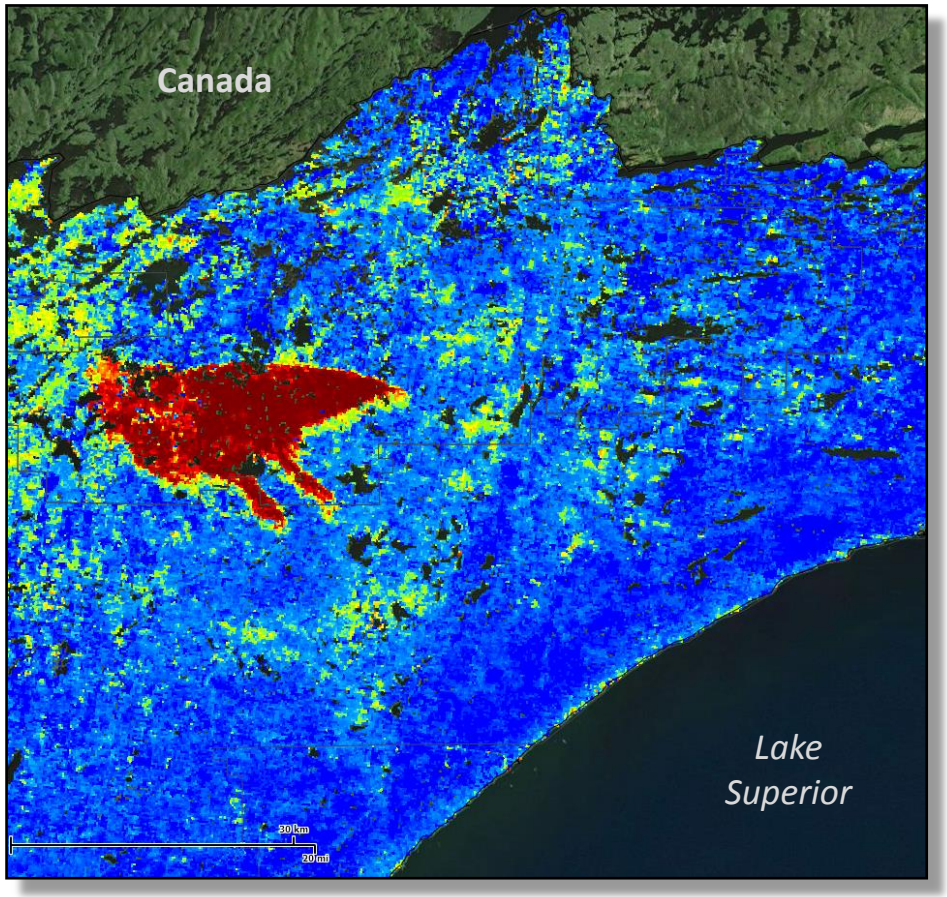


Near-real-time change detection

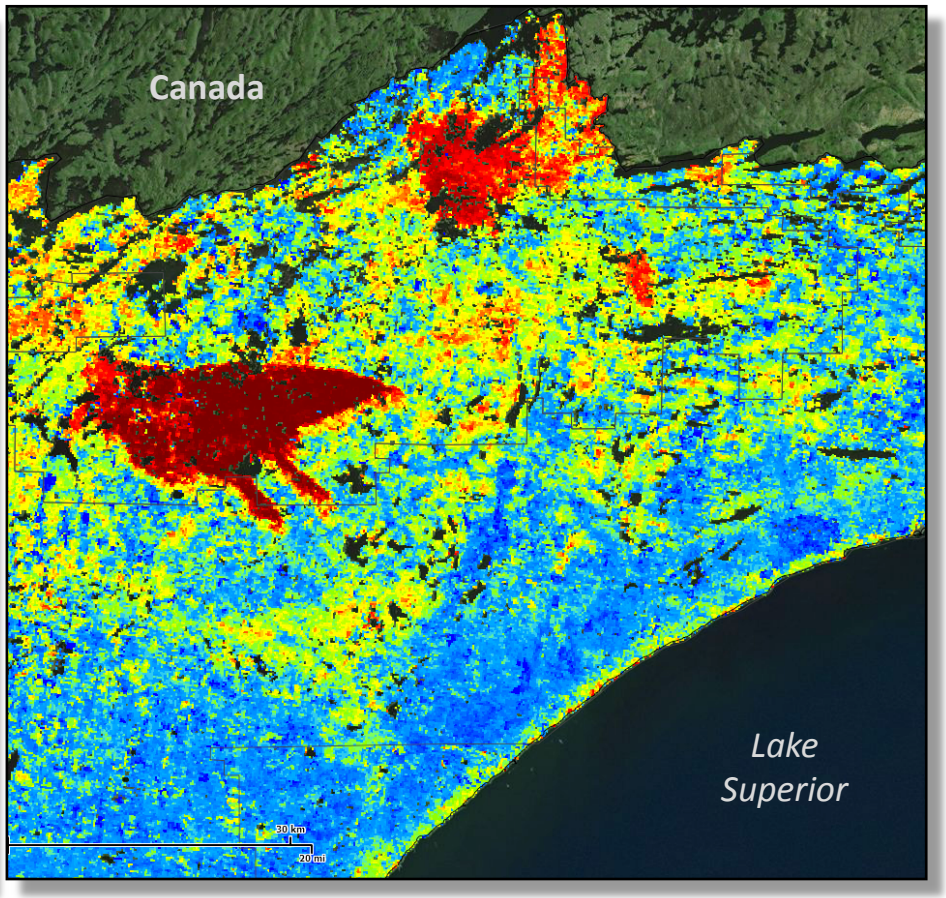
Pagami Creek Fire and early fall, MN



1 Year Baseline



All Year Maximum Baseline

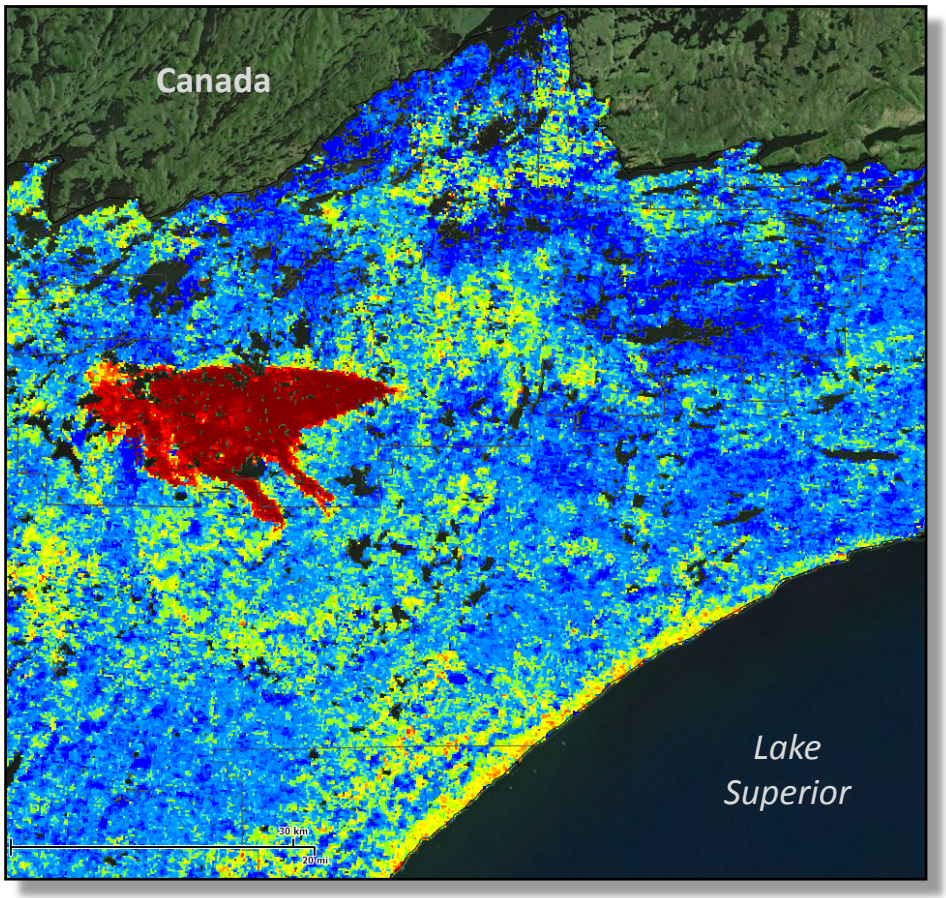


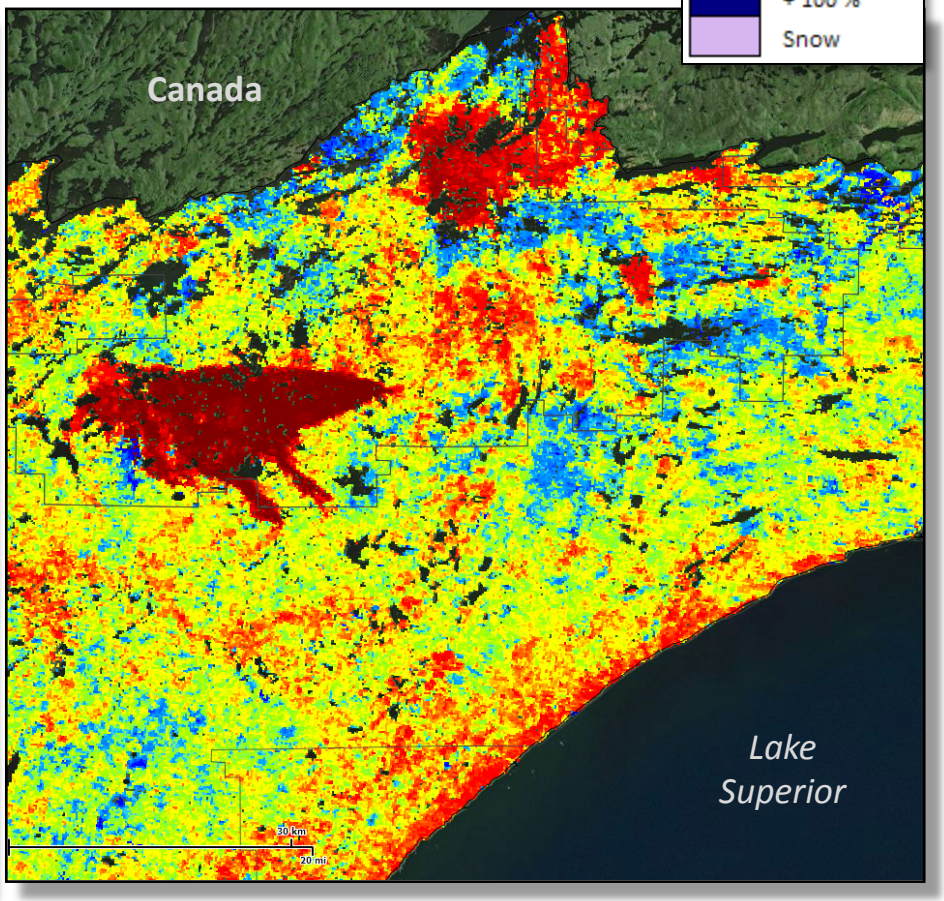
Near-real-time change detection

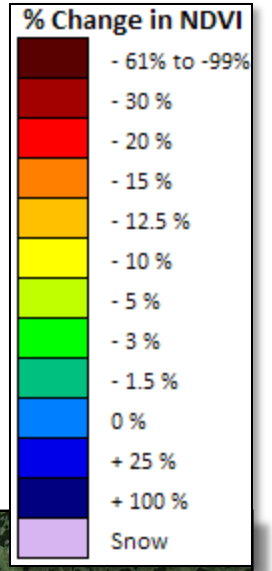
Pagami Creek Fire and early fall, MN

Aug. 04 | Aug. 12 | Aug. 20 | Aug. 28 | Sep. 05 | Sep. 13 | Sep. 21 | Sep. 29 | Oct. 07 | **Oct. 15**

24 day window

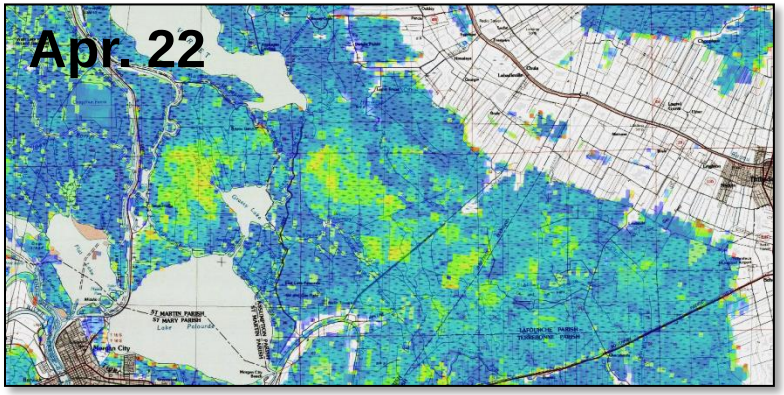


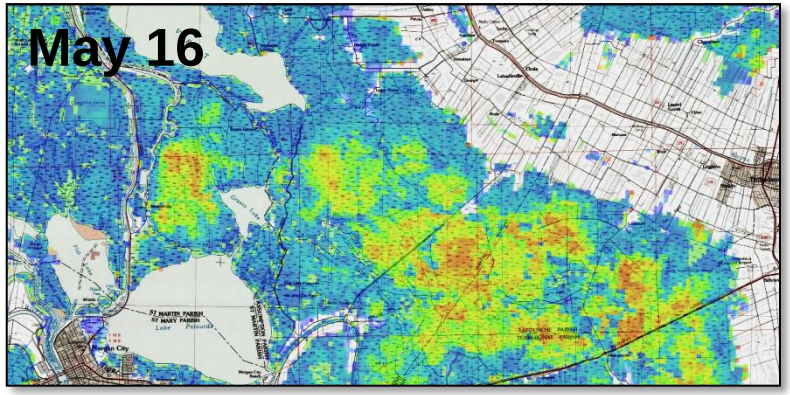




Near-real time to long-term monitoring

ForWarn 1 year change during 2010: Atchafalaya Basin, LA





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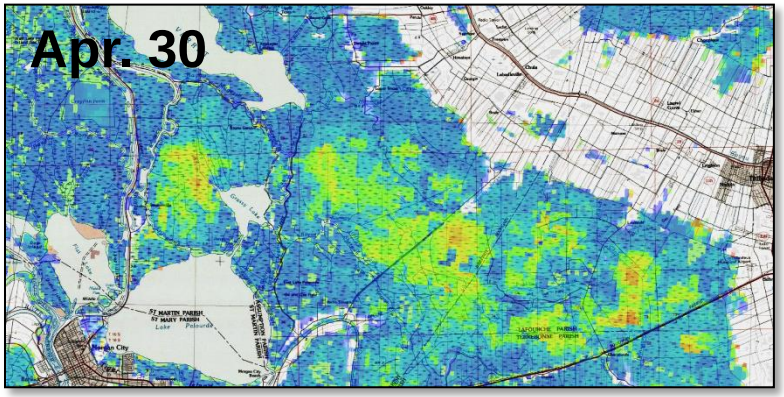
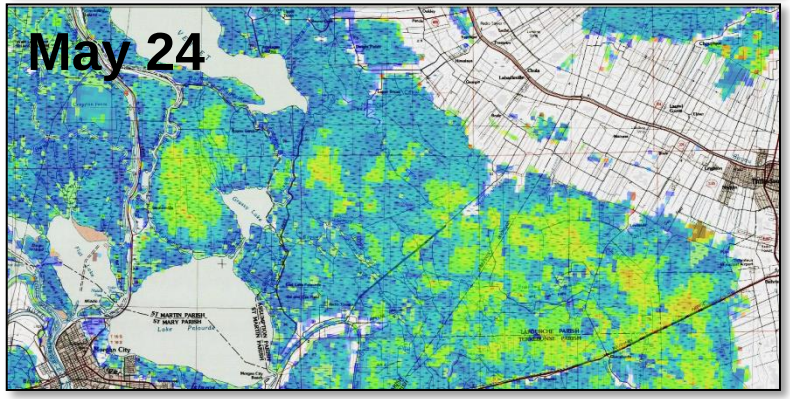
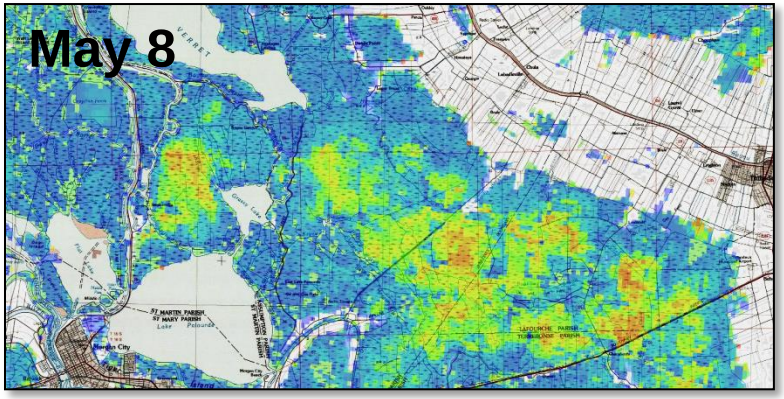
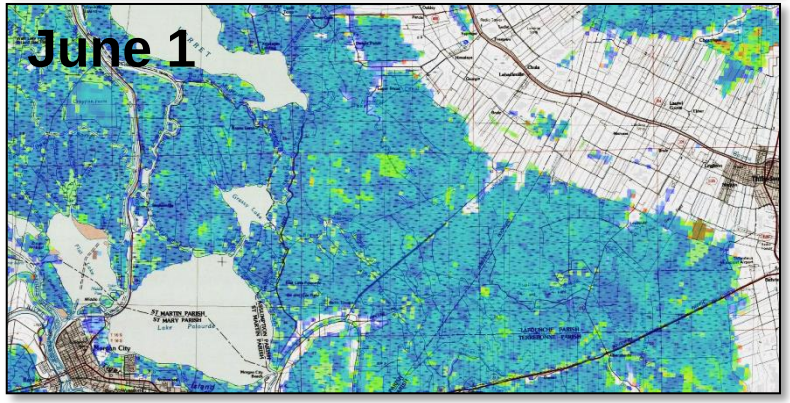
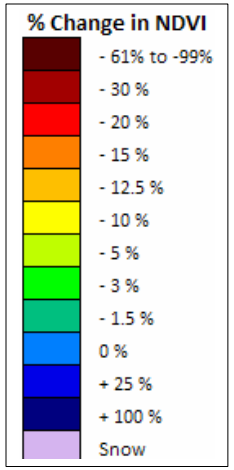




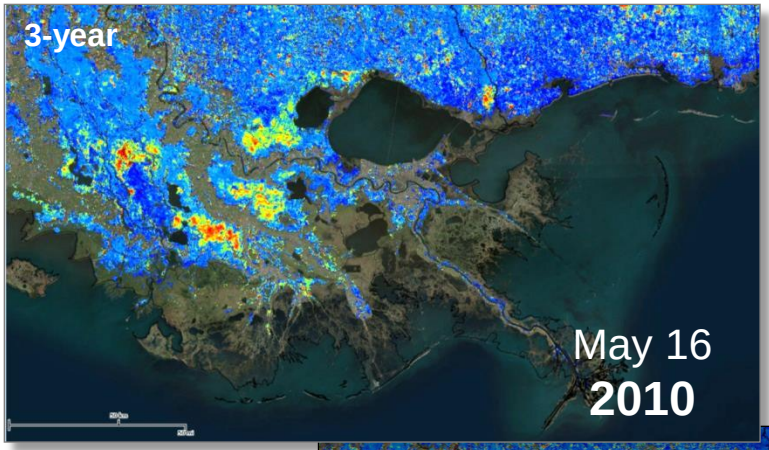


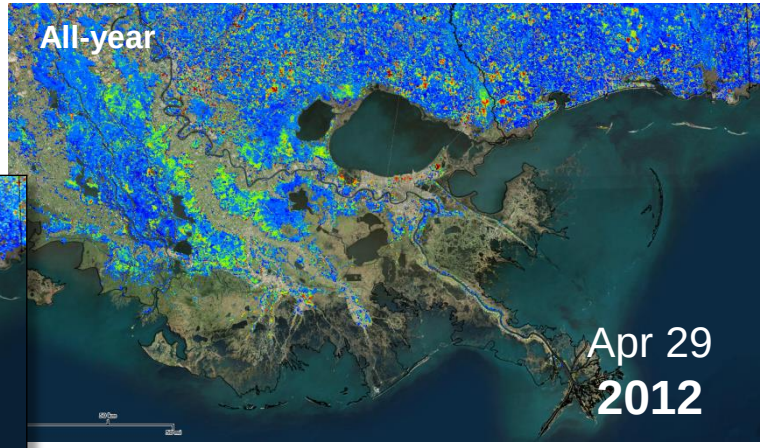


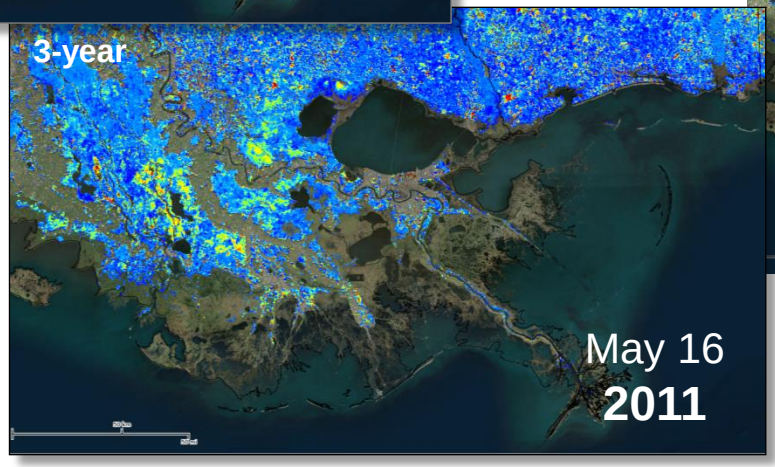


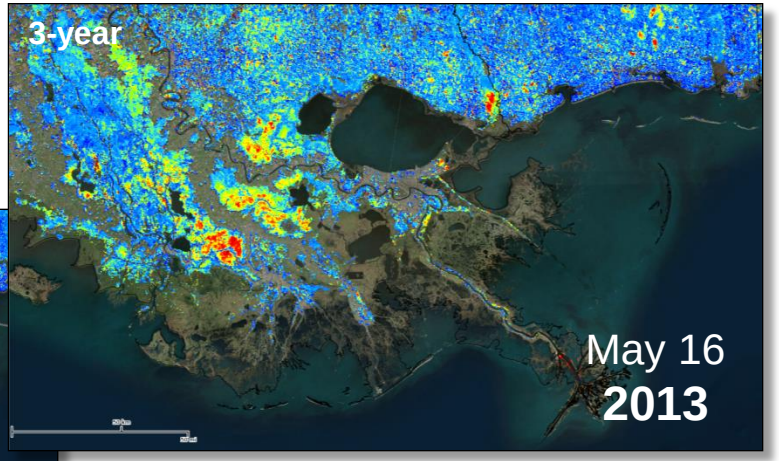
Long-term (regime) monitoring

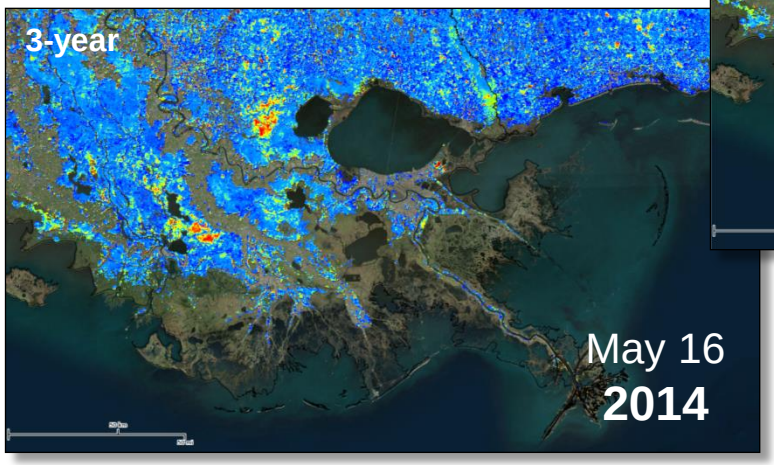
Defoliation of forested wetlands by the Forest Tent Caterpillar and Bald Cypress Leafroller











% Change in NDVI

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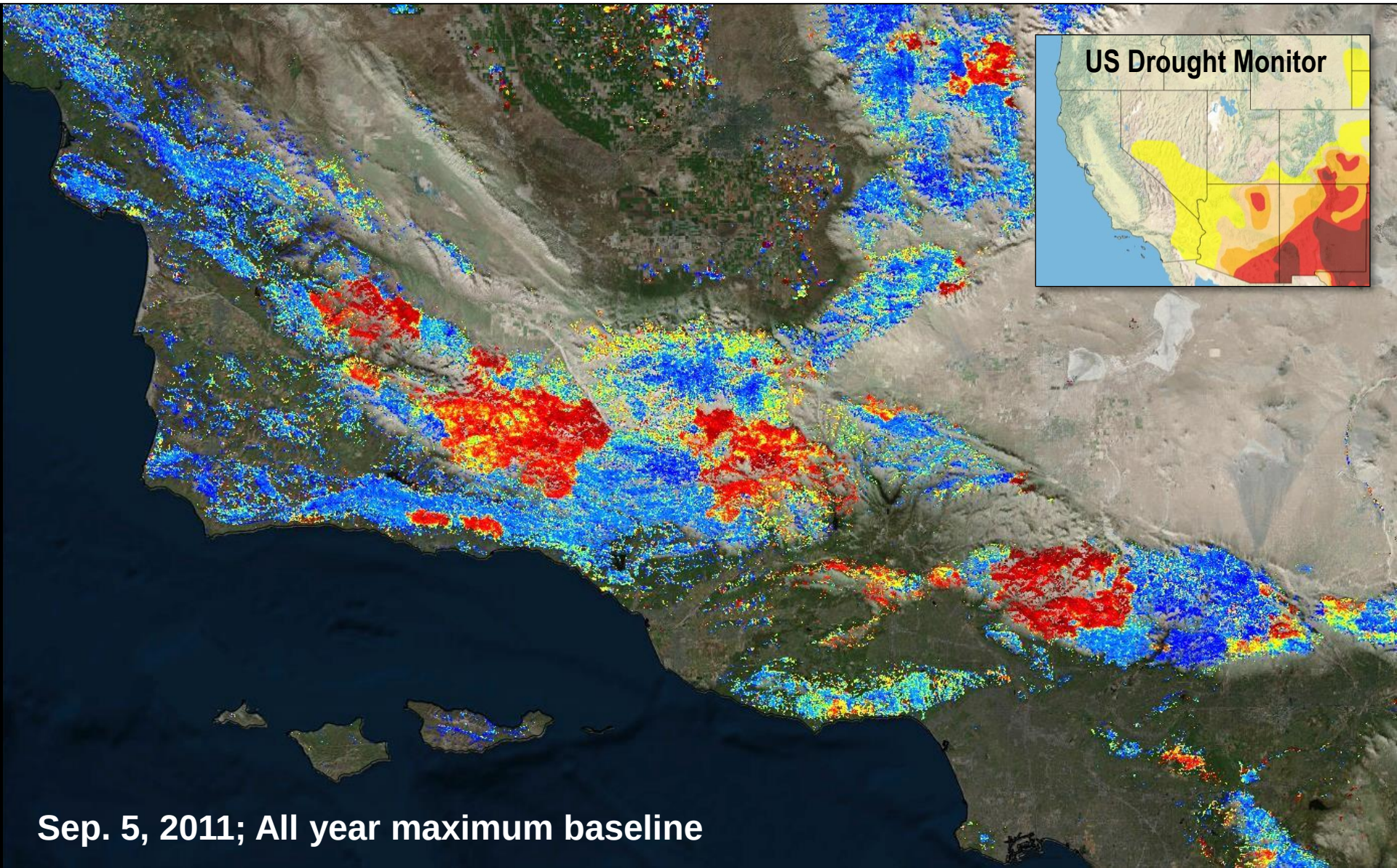
- 30 %
- 20 %
- 15 %
- 12.5 %
- 10 %
- 5 %
- 3 %
- 1.5 %
- 0 %
- + 25 %
- + 100 %

How frequent does native insect defoliation recur?

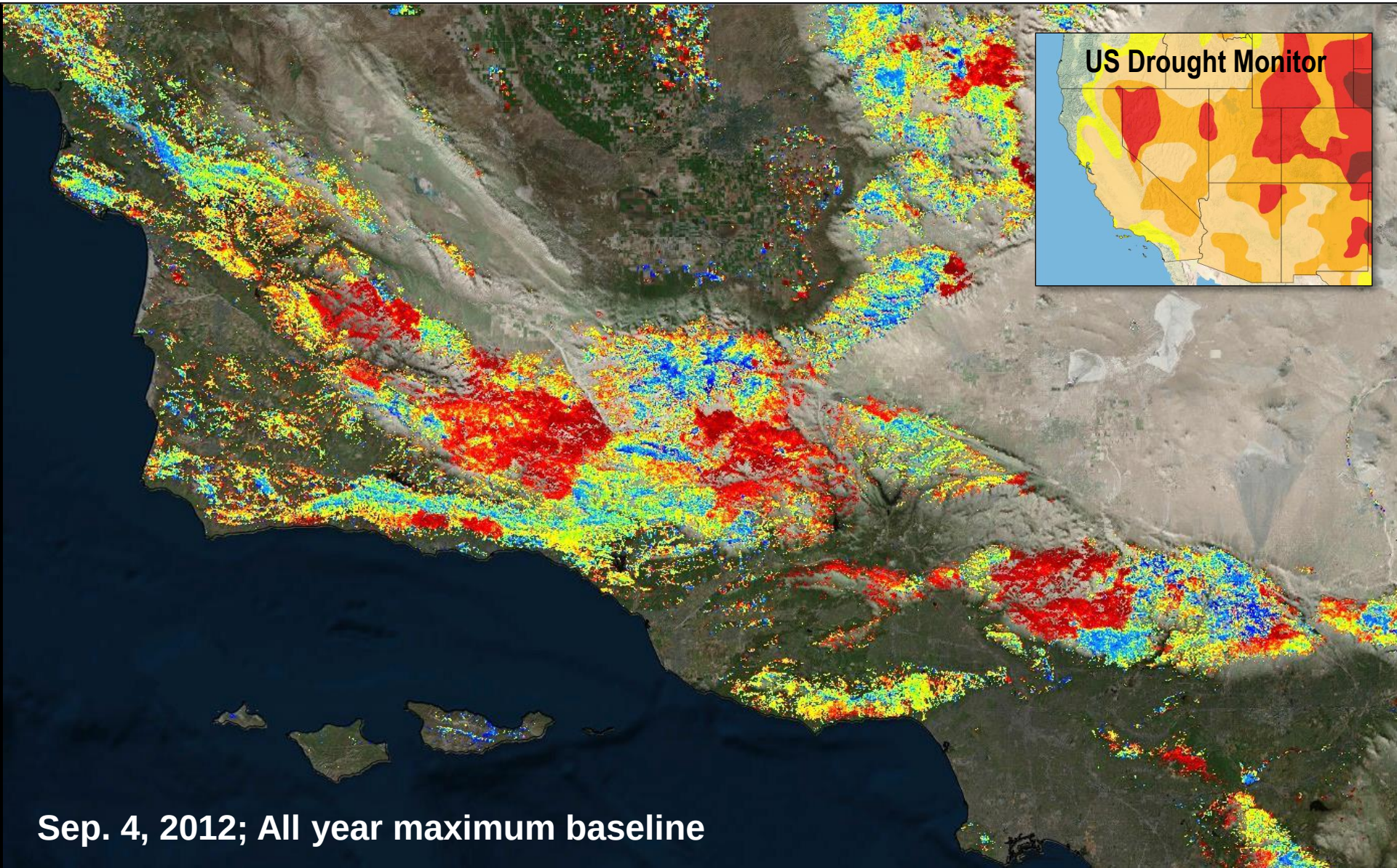
Long-term monitoring

Using the All-Year Maximum baseline



Long-term monitoring

Drought stress and erosion of forest cover from wildfires in CA



Long-term monitoring

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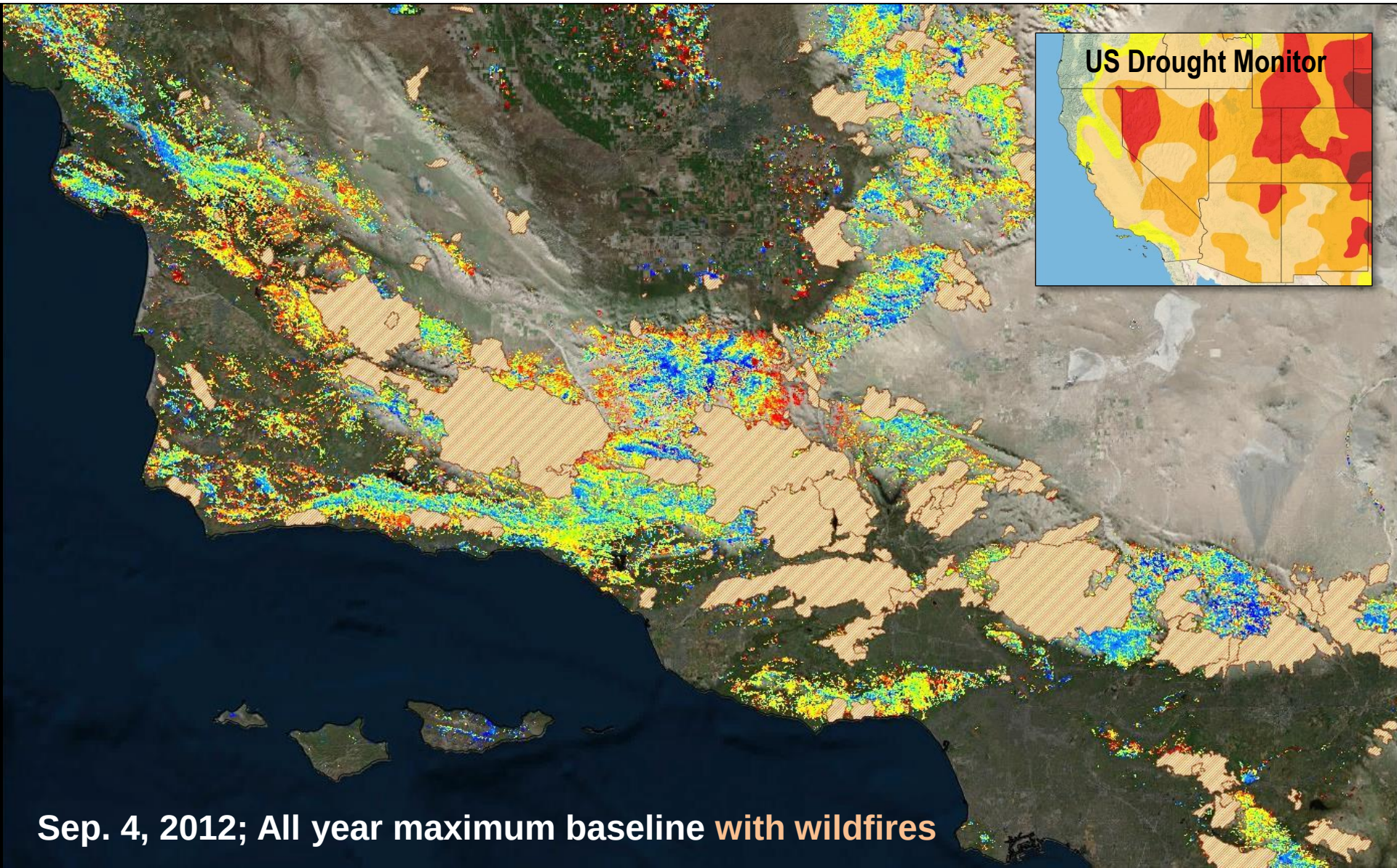
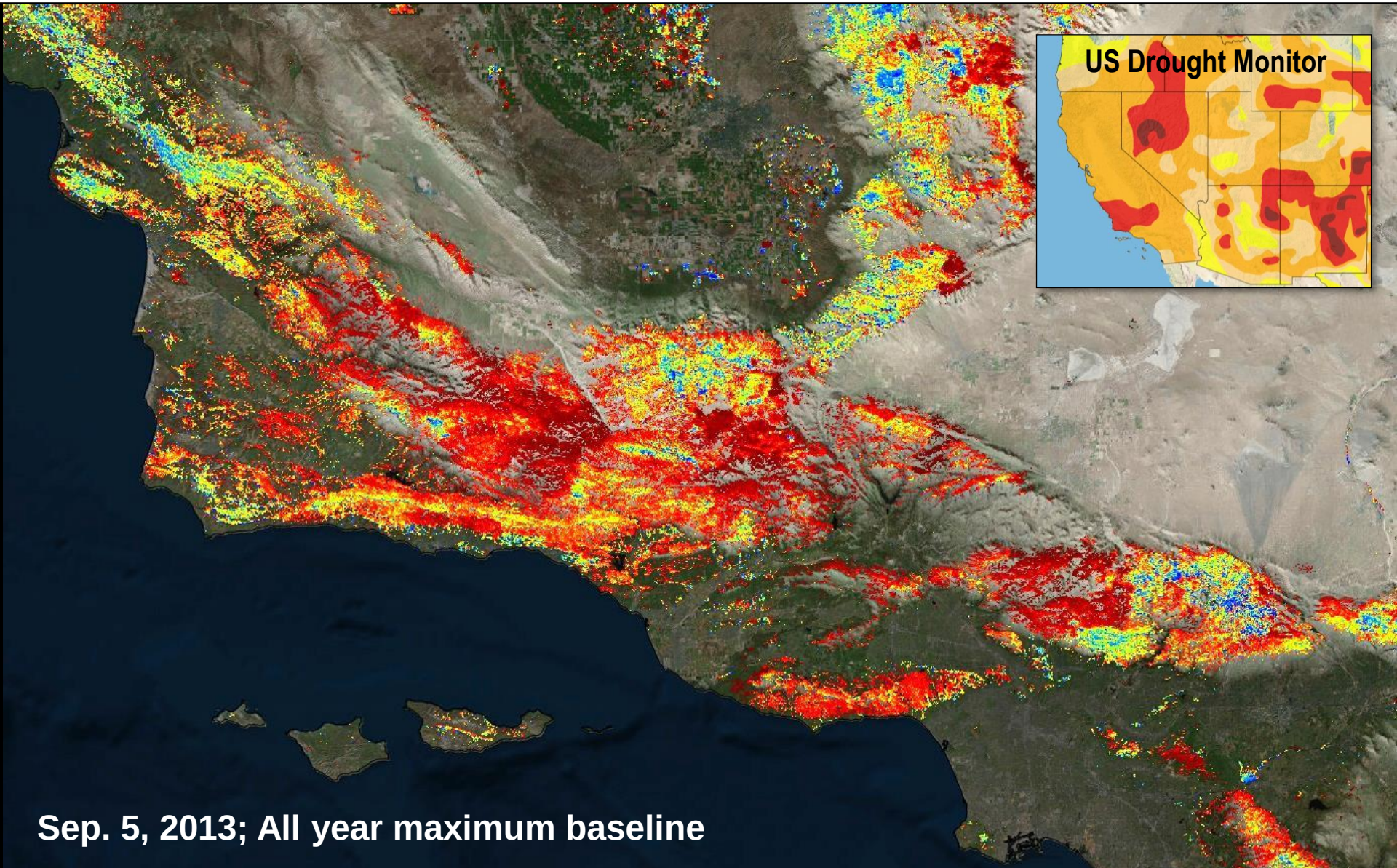


Long-term monitoring

Drought stress and erosion of forest cover from wildfires in CA



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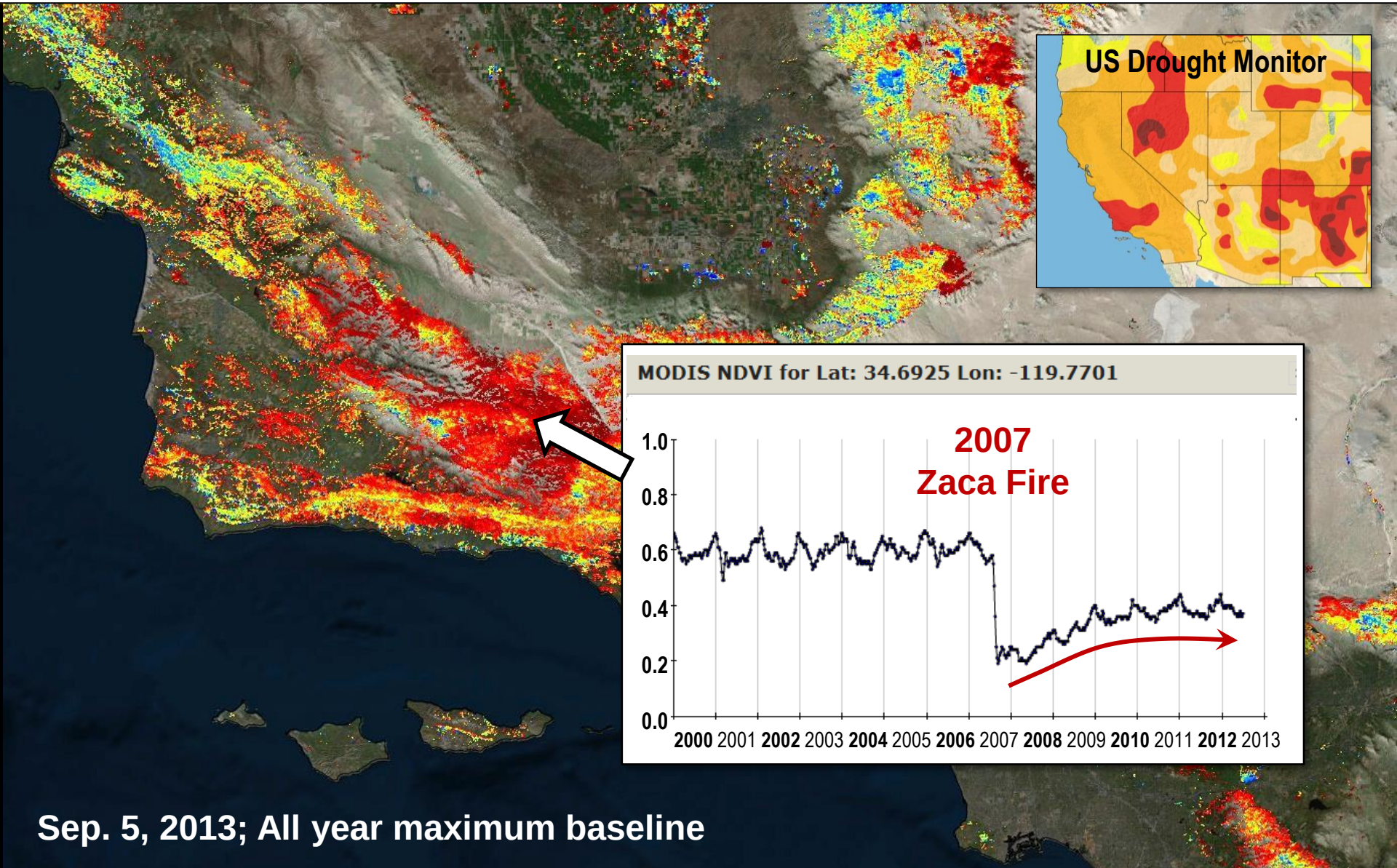
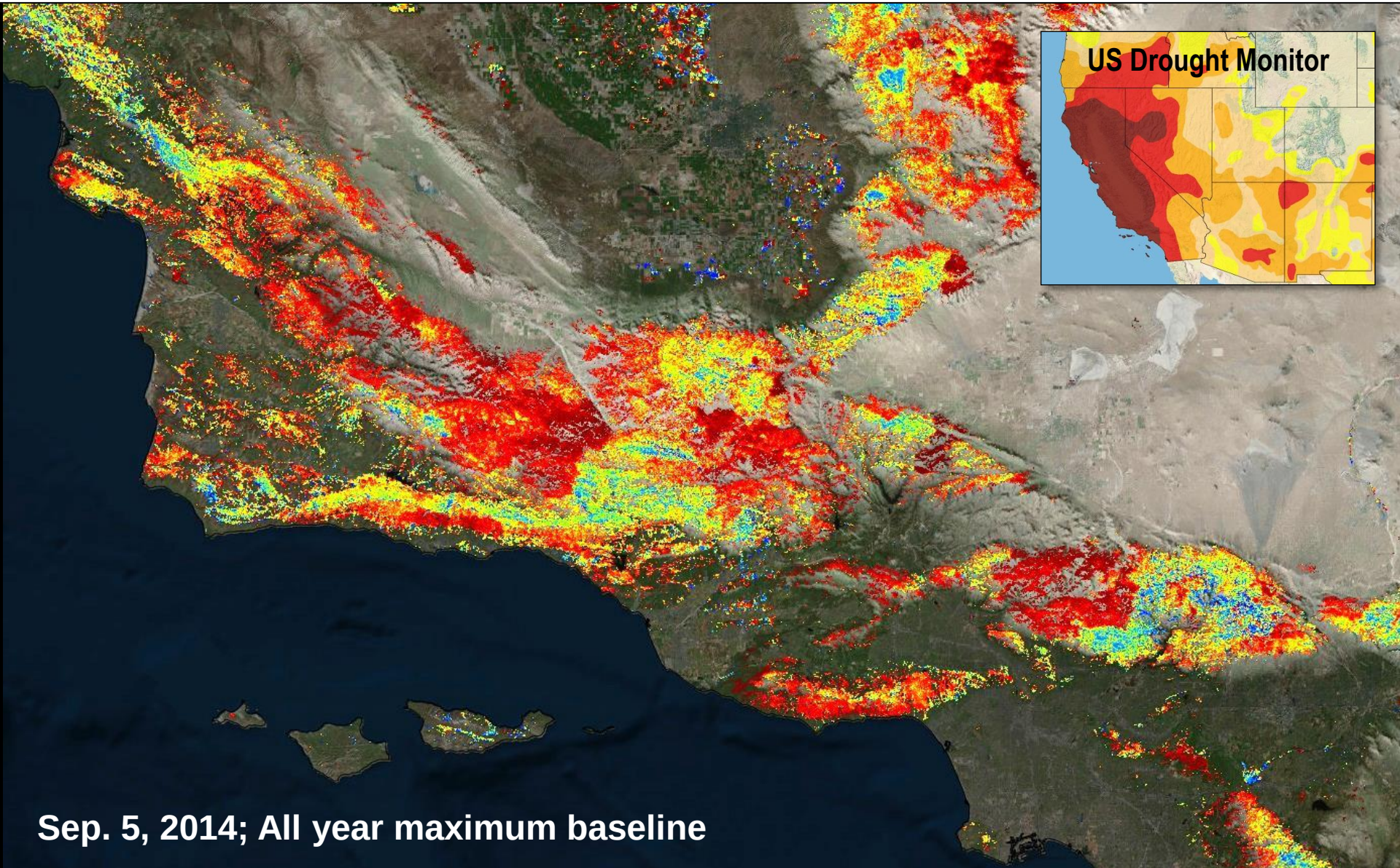
Drought stress and erosion of forest cover from wildfires in CA



Sep. 5, 2013; All year maximum baseline

Long-term monitoring

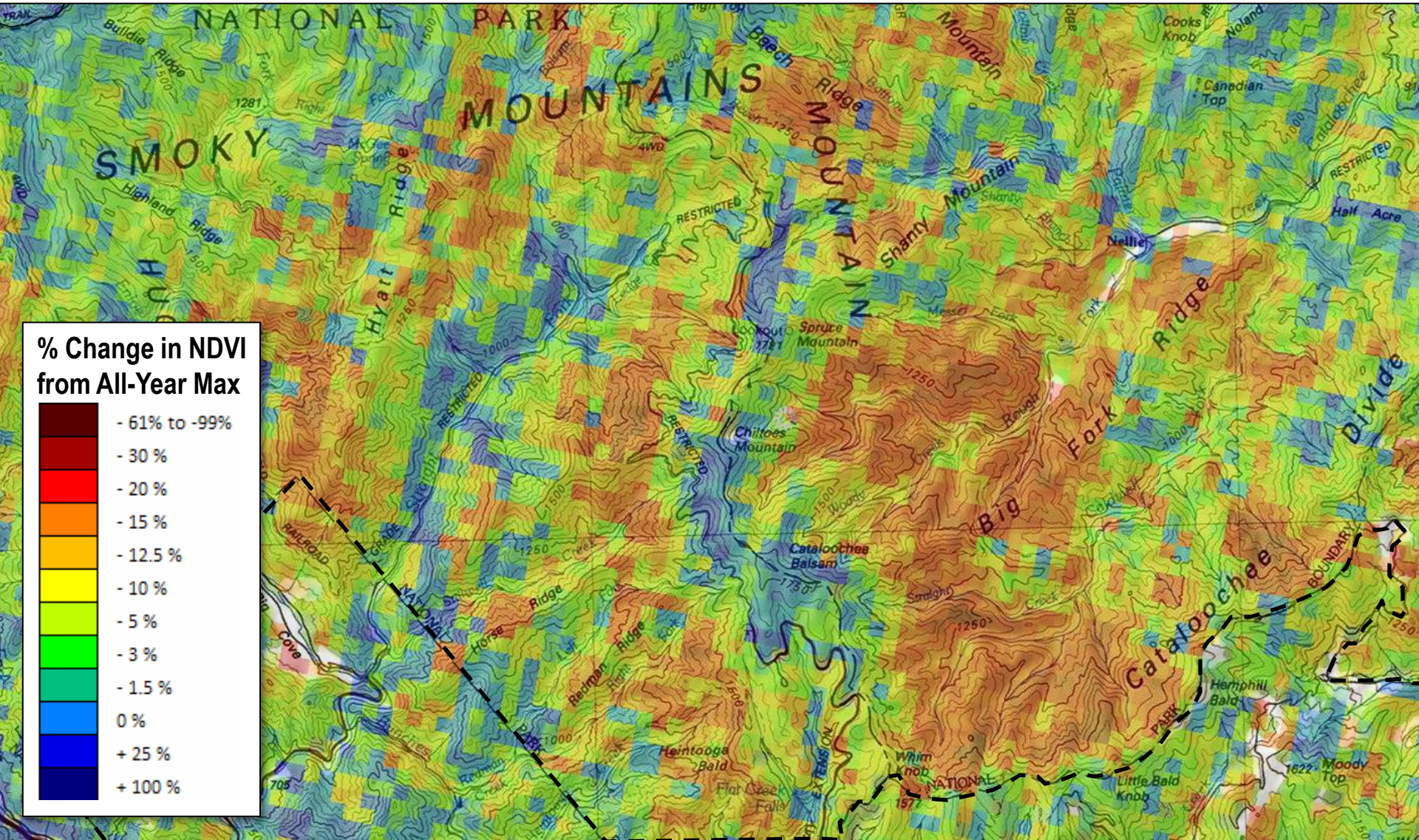
Drought stress and erosion of forest cover from wildfires in CA



Long-term monitoring

Change from All-Year-Max NDVI for 12/18/2011

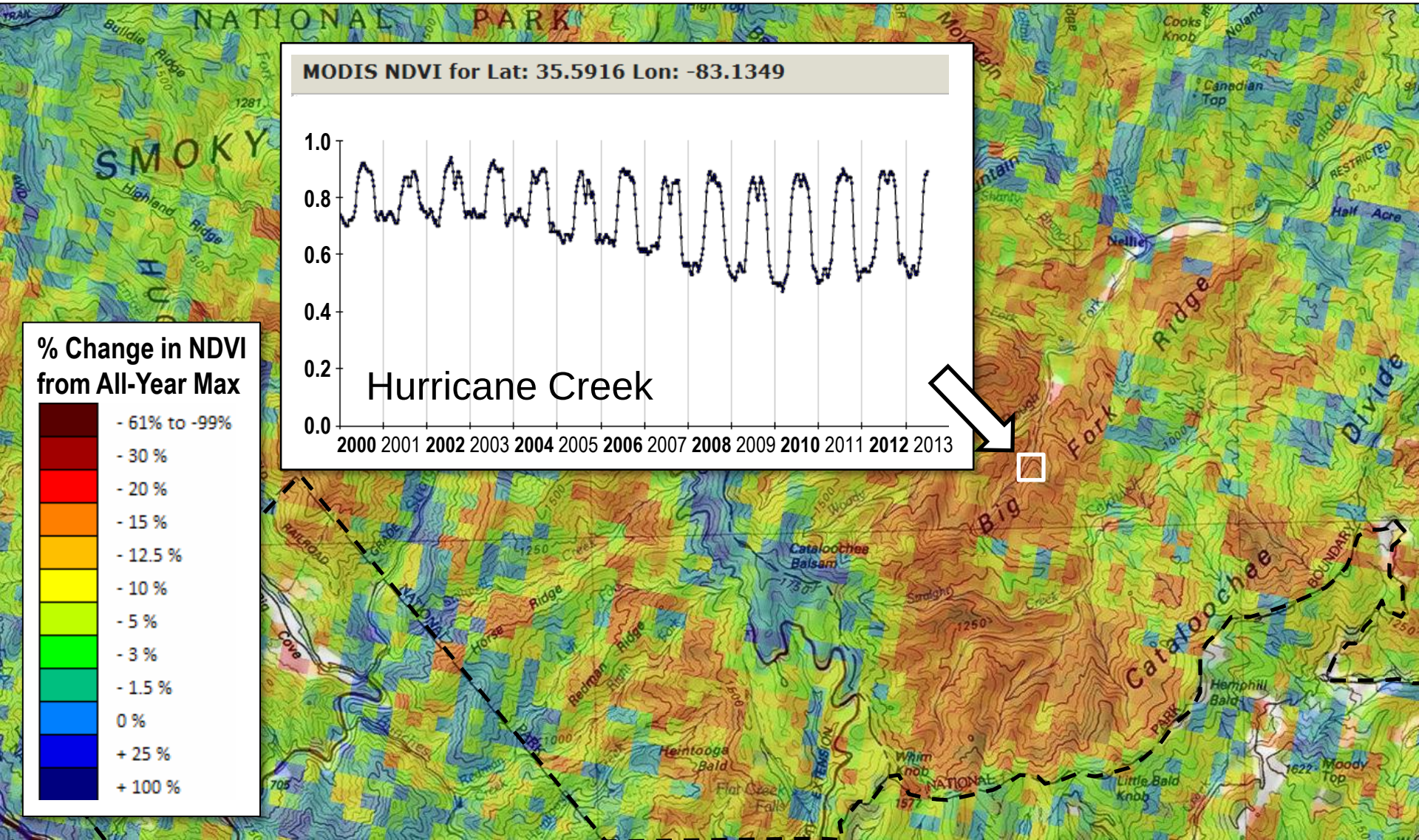
?



Long-term monitoring

Change from All-Year-Max NDVI for 12/18/2011

?



Long-term monitoring

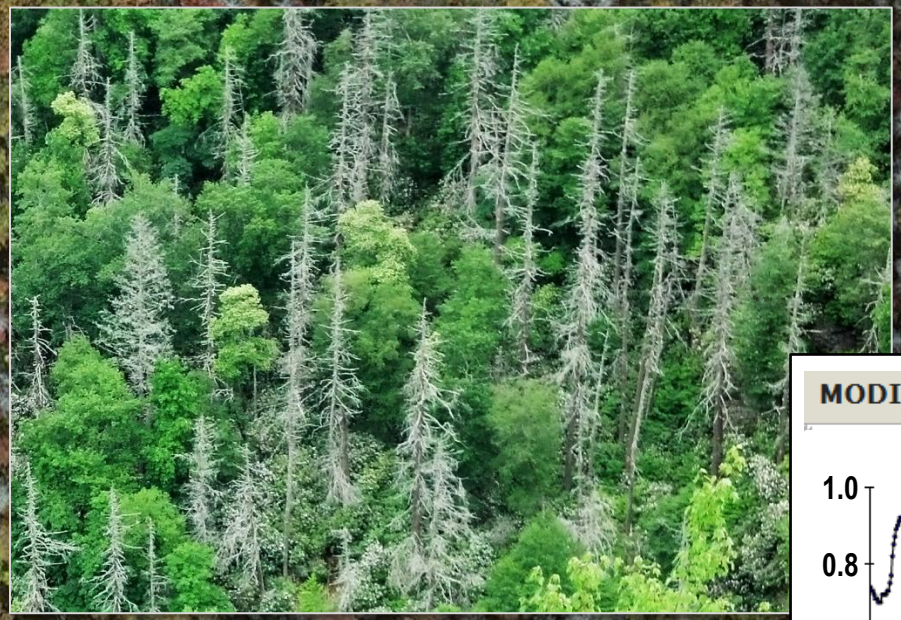
The view over Hurricane Creek, Great Smoky Mountains National Park

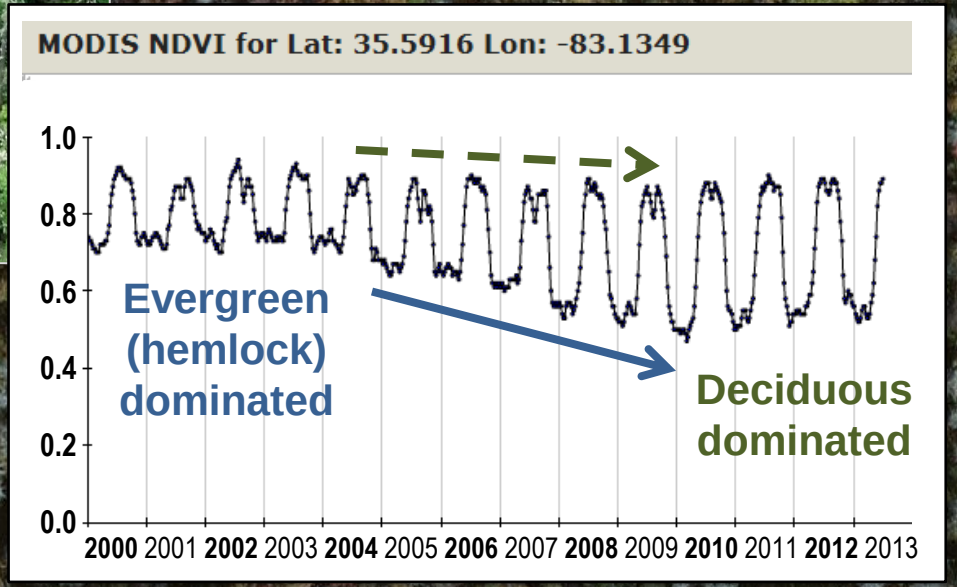
?

Long-term monitoring

Gradual mortality from the non-native Hemlock Woolly Adelgid

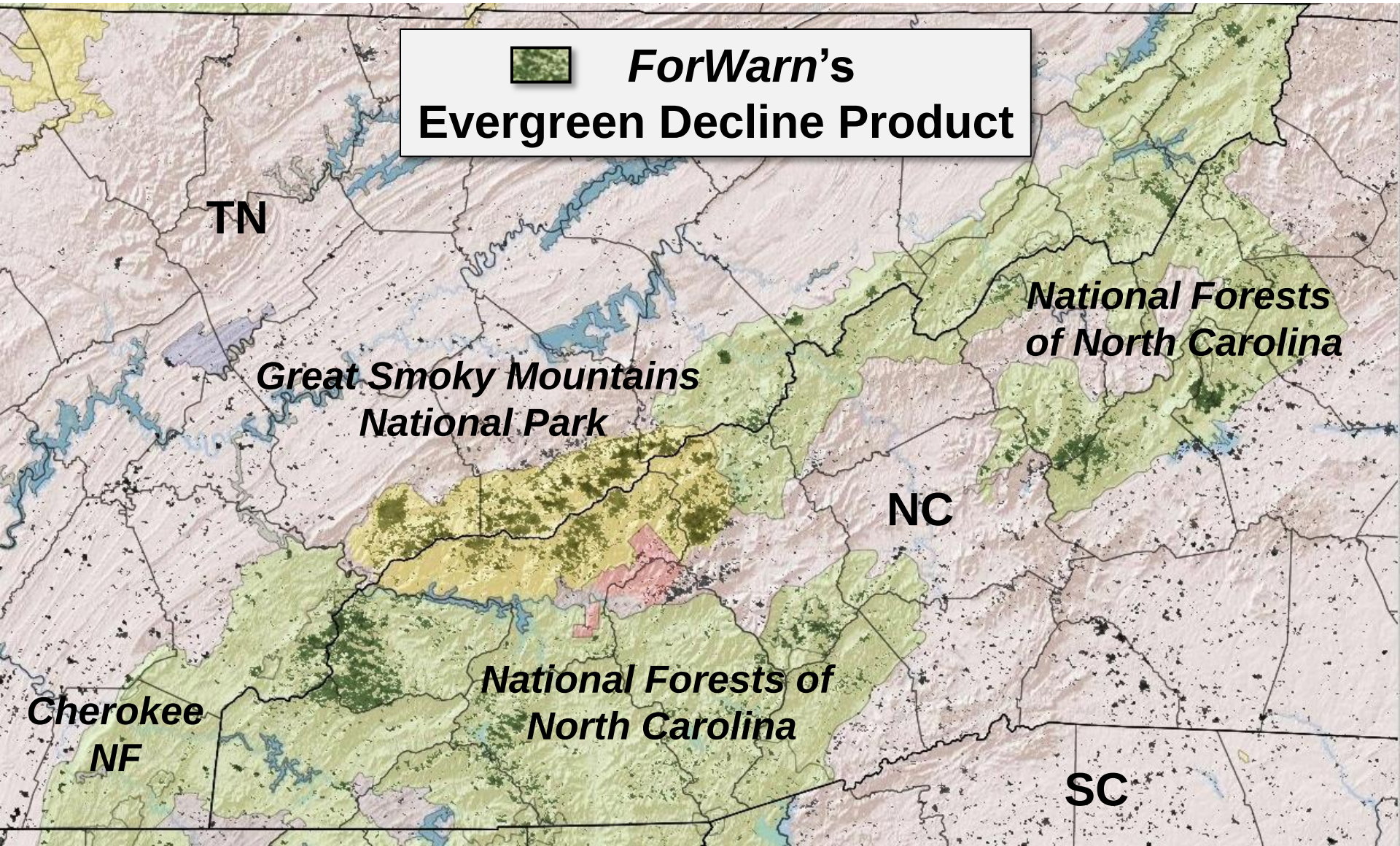
Evergreen forests have a high winter NDVI and low inter-seasonal amplitude.





Long-term monitoring

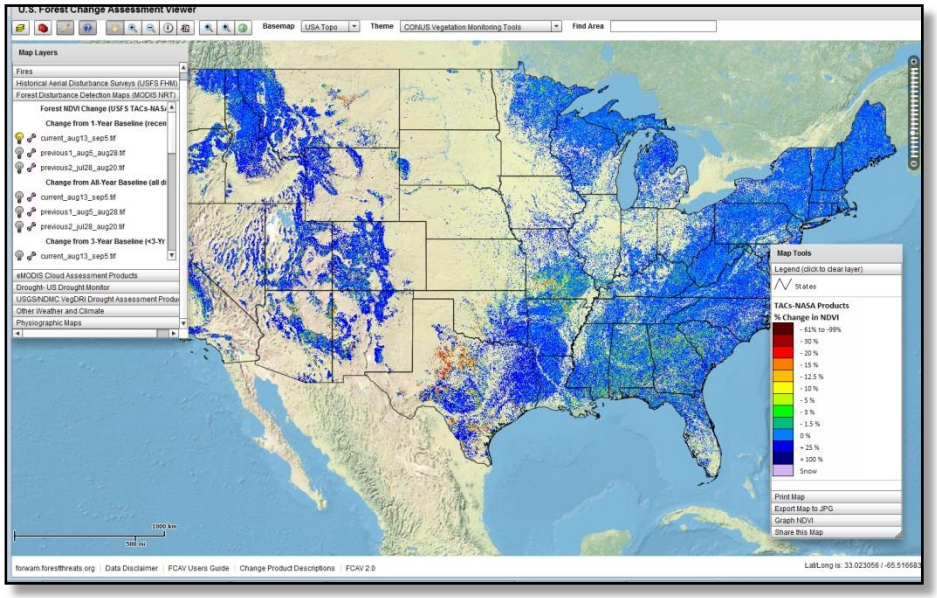
Gradual mortality from the invasive Hemlock Woolly Adelgid and rapid evergreen loss from fire and logging



Summary

- Satellite-based monitoring can play an important role in forest management by documenting disturbances and contextualizing change.
- ***ForWarn*** demonstrates how satellite technology can be used for near real time disturbance tracking.
- Often neglected, efficient long-term landscape monitoring of gradual disturbances and recovery is also important and possible with this technology.

For more information, see the ***ForWarn*** Website and Viewer:



http://forwarn.forestthreats.org

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Eastern Threat Assessment Center