Use of MODIS NDVI phenology data in monitoring regional vegetation disturbances from abiotic events

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Views of Forests Damaged by 2011 Wind Storm in Minnesota and Wisconsin (Source: NOAA NWS)

Background

- Abiotic vegetation disturbances are common, variable in nature, and important to detect, monitor, and assess at multiple ecological scales
- MODIS satellite data typically is currently collected twice daily for most areas in the conterminous US
- MODIS data is being increasingly used for vegetation phenology studies, including regional vegetation health assessments

Research Objectives

- Examine use of MODIS NDVI land surface phenology data for detecting declines in vegetation greenness due to regional abiotic disturbances
- Further assess use of the on-line ForWarn vegetation change tracking system for assessing example abiotic vegetation disturbances
  - Near Real Time NDVI Change Products
  - Select Retrospective Studies

Many Types of Abiotic Vegetation Disturbances

- Abiotic disturbance factors and types:
  - Climatic (e.g., early/late spring, summer, fall, plus drought)
  - Geologic (e.g., landslides, earthquakes, volcanic events)
  - Severe Weather (e.g., flooding, wind, hail, frost, and ice)
  - Multifactorial (e.g., lightning induced fire in drought impacted landscapes)
  - Man-made (e.g., pollution or other degradation of air, water, land, and vegetation)
- Vegetation disturbance detection with MODIS 250m data can depend on damage severity and patch size

ForWarn System for Tracking Vegetation Disturbances with MODIS NDVI Phenology Data

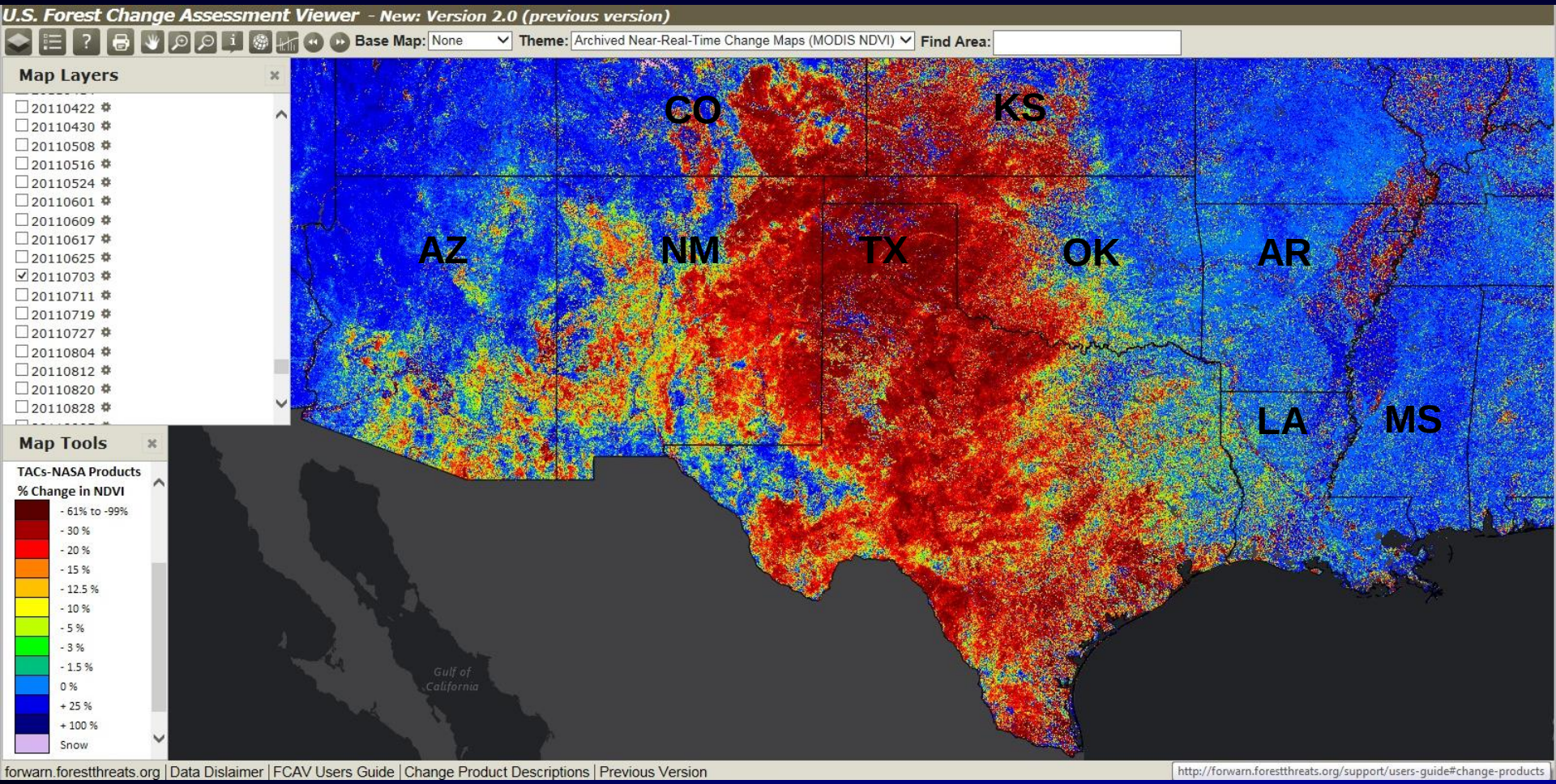
Features of the ForWarn System

- Offers suite of MODIS NDVI-based vegetation change products refreshed every 8 days
  - Historic NDVI from custom processed MOD13 data
  - Current NDVI from temporally processed eMODIS data
  - 24 day interval per date – 8 days overlap between dates
  - Each pixel is ~232m resolution (5.37 ha / cell)
- Product access with ForWarn's on-line data viewer
- Contains current and archived NDVI change products
- Also includes standard phenology products, NDVI time series profiler, and land cover masking

Series 1 – Example ForWarn NDVI change products showing climate related abiotic vegetation disturbances (e.g., 2011 Texas Drought)

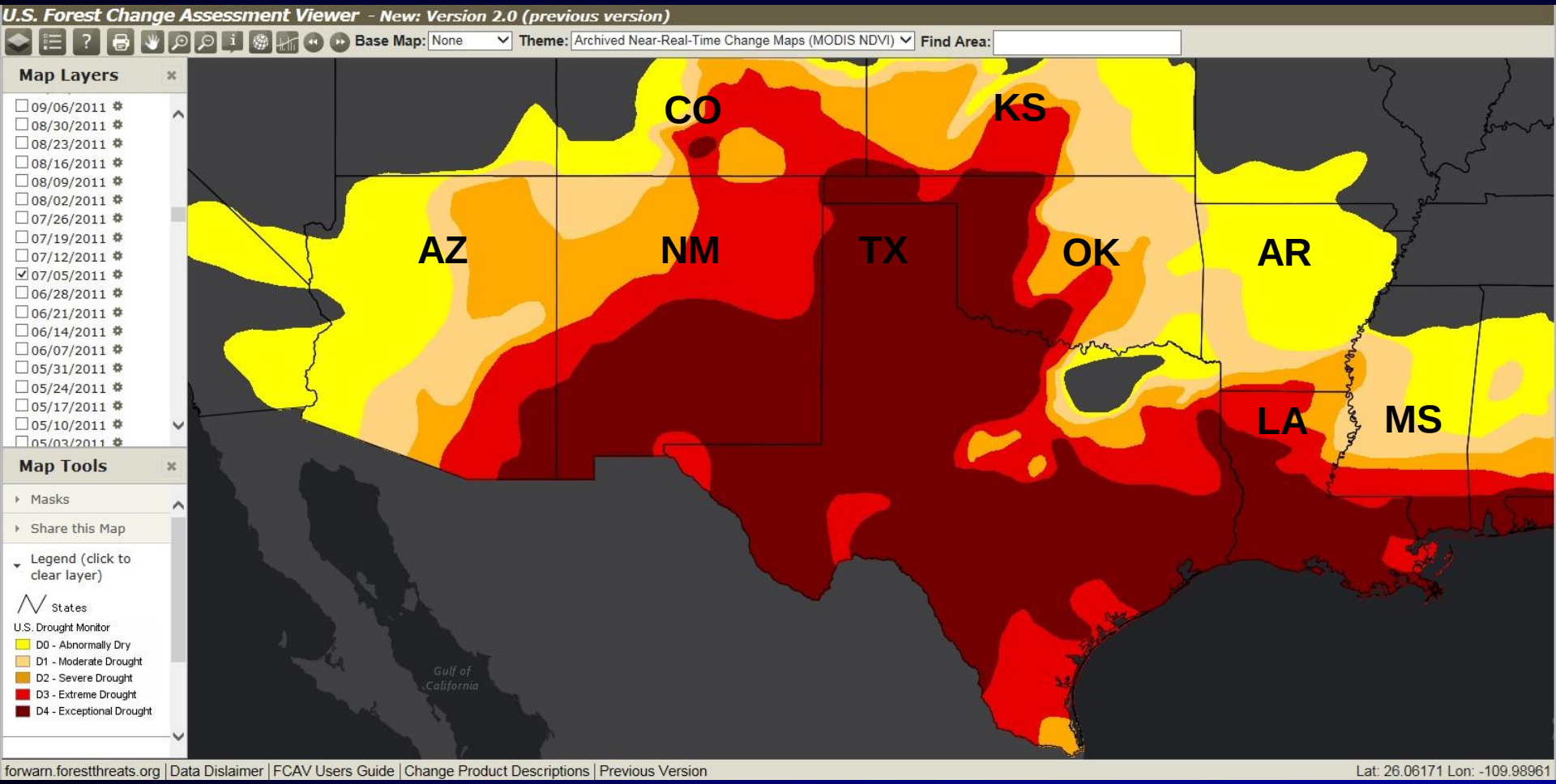
Drought killed forest in Houston, Texas (Source: Texas A&M Forest Service)

2011 Texas Drought – NDVI Change - All Land



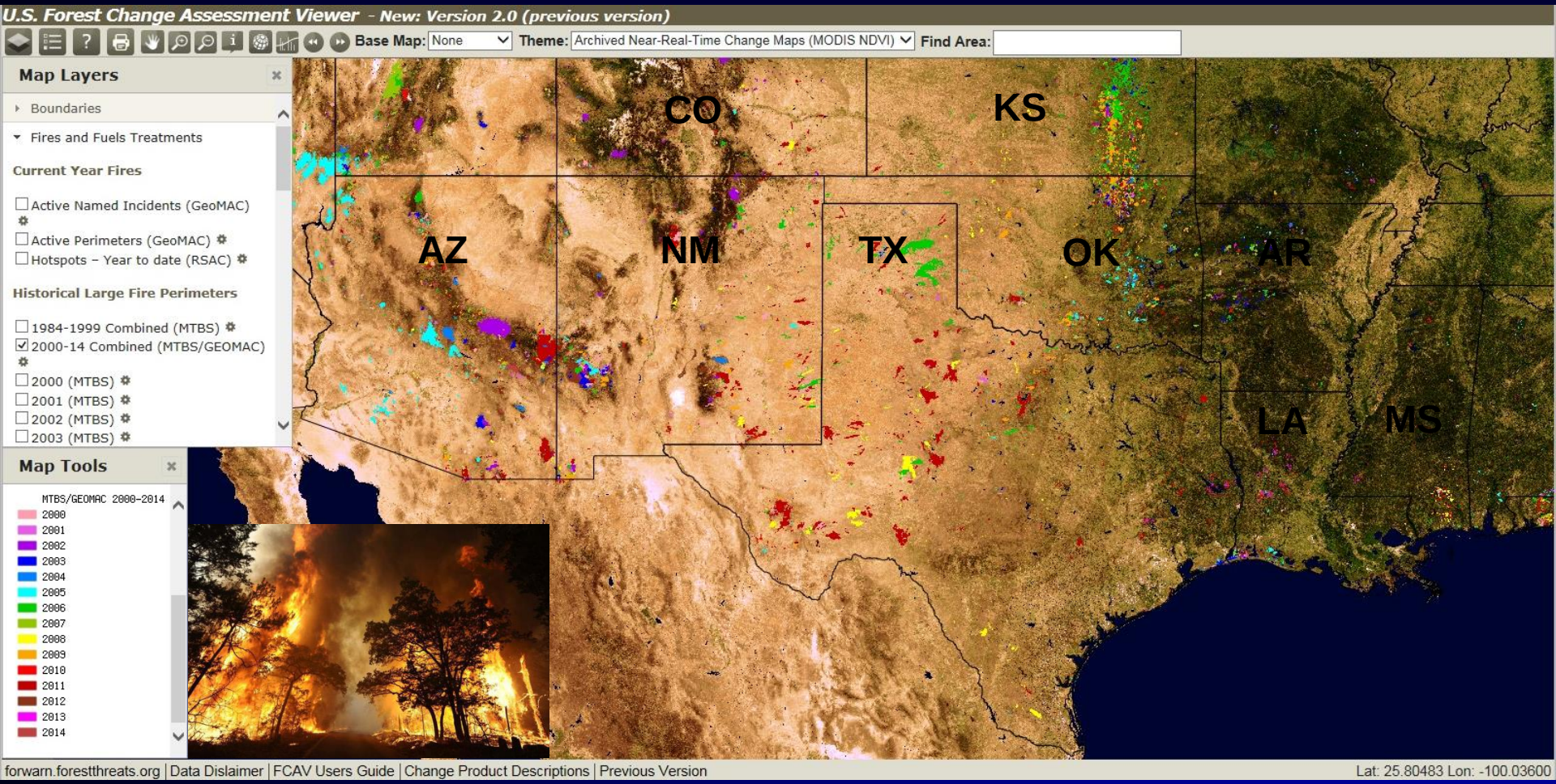
Above: NDVI Change for Current vs. Mean of Maximum NDVI for Date Ending July 3, 2011

2011 Texas Drought – US Drought Monitor



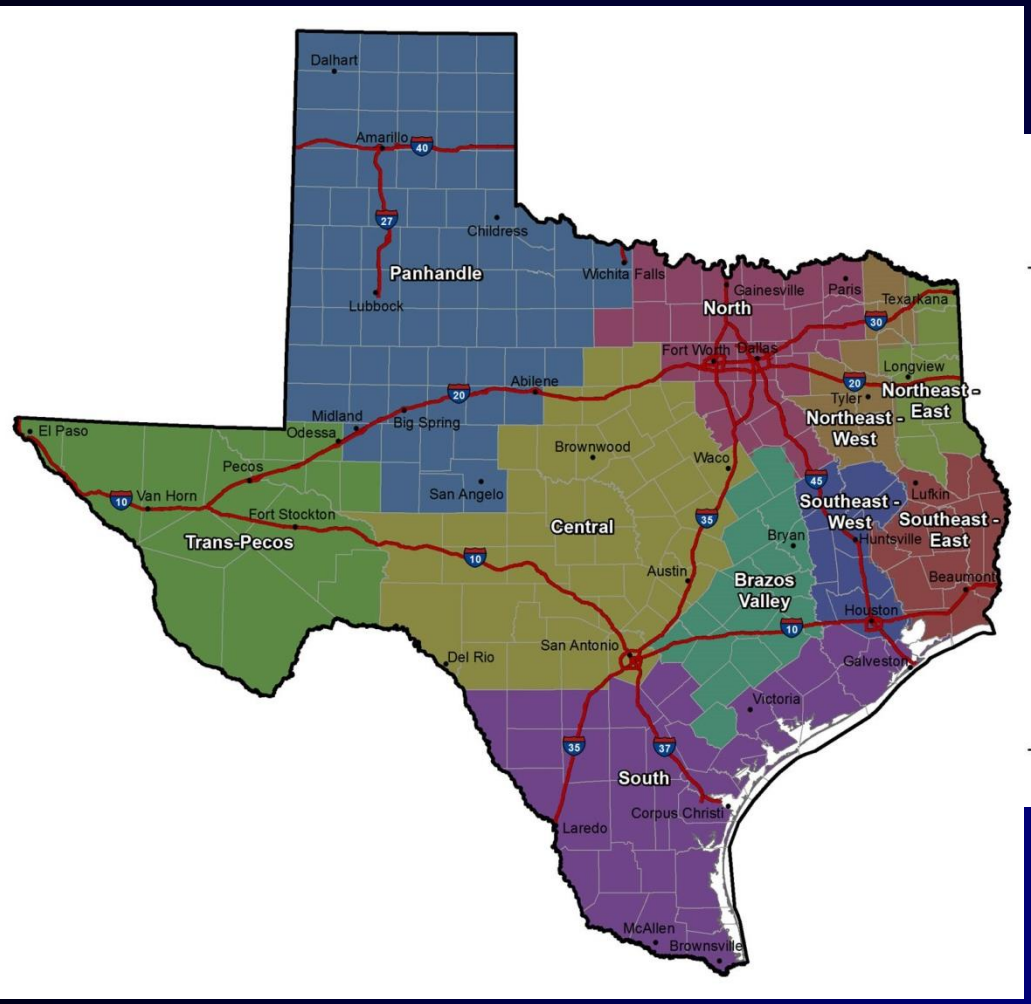
Above: US Drought Monitor Map for Date Ending July 5, 2011

2011 TX Drought – Fires on MODIS RGB



Above: Historic Fire Perimeters for 2000-2014 from MTBS/GEOMAC – Overlain onto MODIS RGB from 7/3/2011
Most Observed Fire Scars in TX from 2000-2014 Are From 2011 (dark red tones)
Inset Image of Bastrop, TX Fire Occurring During 2011 Drought (Source: TX A&M Forest Service)

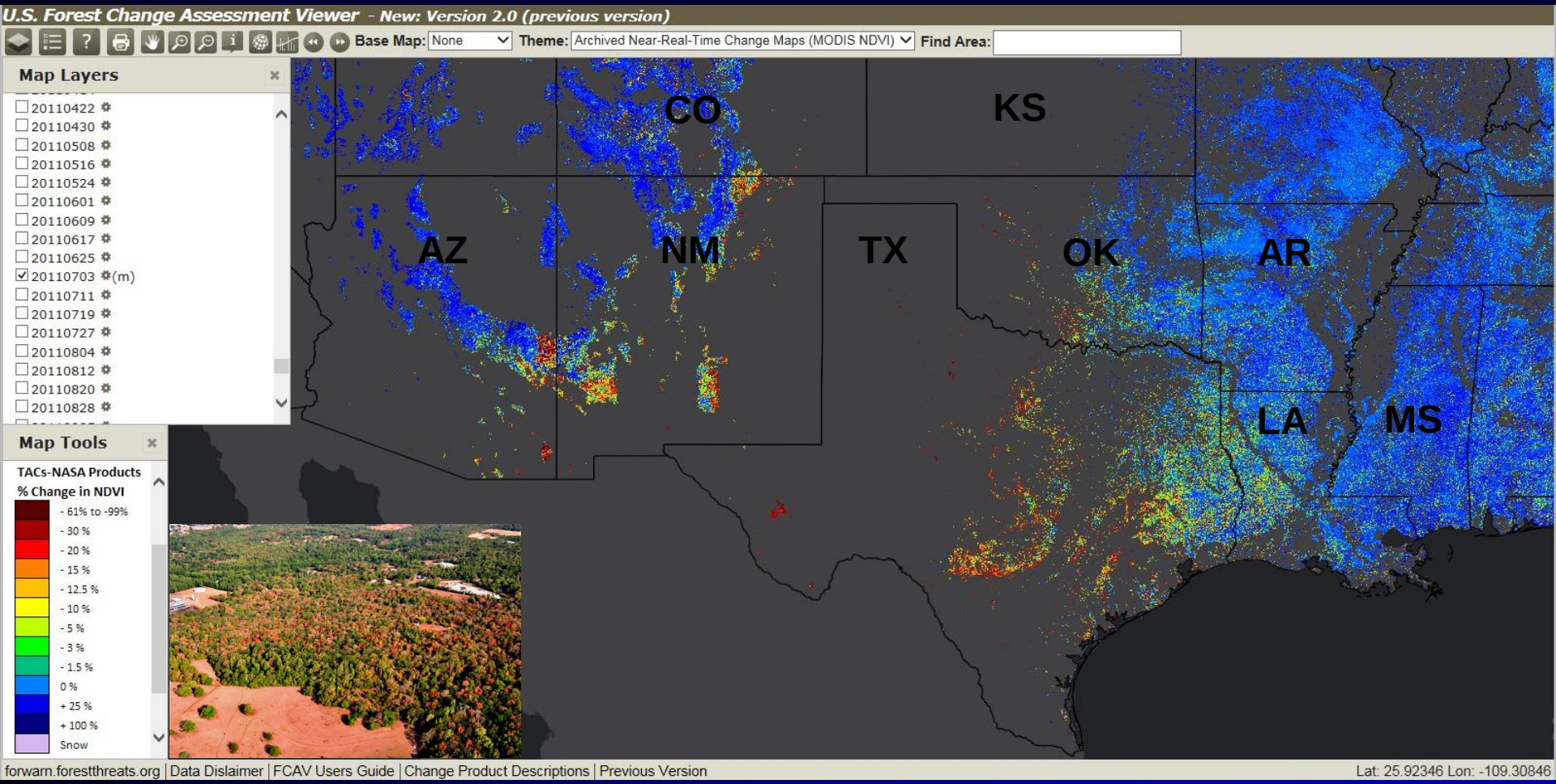
2011 Texas Drought Killed Lots of Trees



Region	Drought-related mortality (million trees)	Drought-related mortality (percentage)
Southeast - East	7.5	1.3
Southeast - West	18.8	6.5
Northeast - East	13.9	3.9
Northeast - West	25.3	8.2
North	30.9	8.3
Brazos Valley	24.9	9.7
South	31.7	7.4
Central	102.3	6.6
Panhandle	33.1	6.0
Trans-Pecos	12.2	7.5
Total	**300.6**	**6.2**

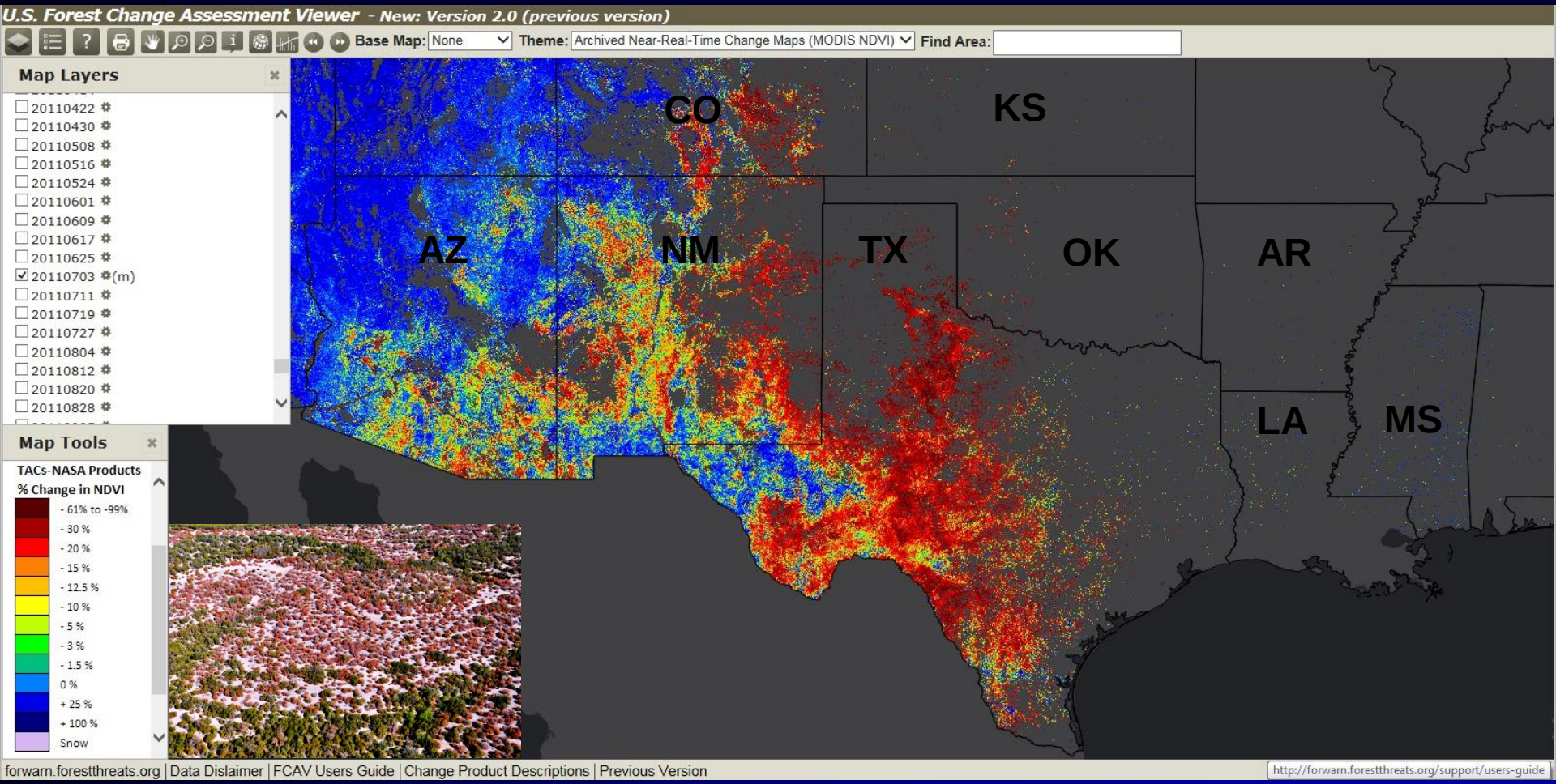
Source of Above Map and Summary Area Table: Texas A&M Forest Service)

2011 Texas Drought – NDVI Change - Forest



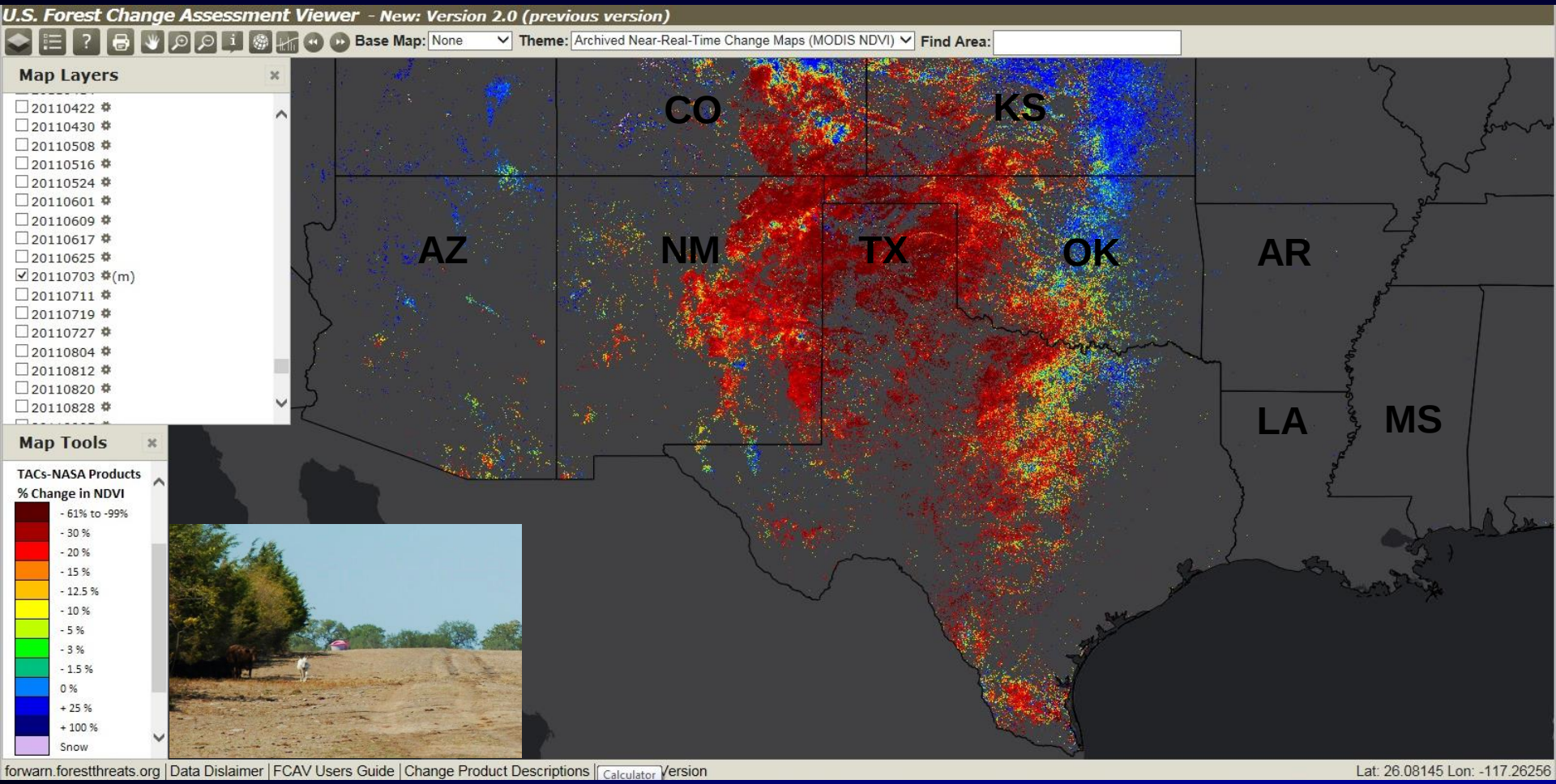
Above: NDVI Change for Current vs. Mean of Maximum NDVI for Date Ending July 3, 2011
Source of Forest Mask: NLCD Data
Inset Image of 2011 Forest Drought Damage in Palestine, TX (Source: TX A&M Forest Service)

2011 TX Drought – NDVI Change - Shrub/Scrub



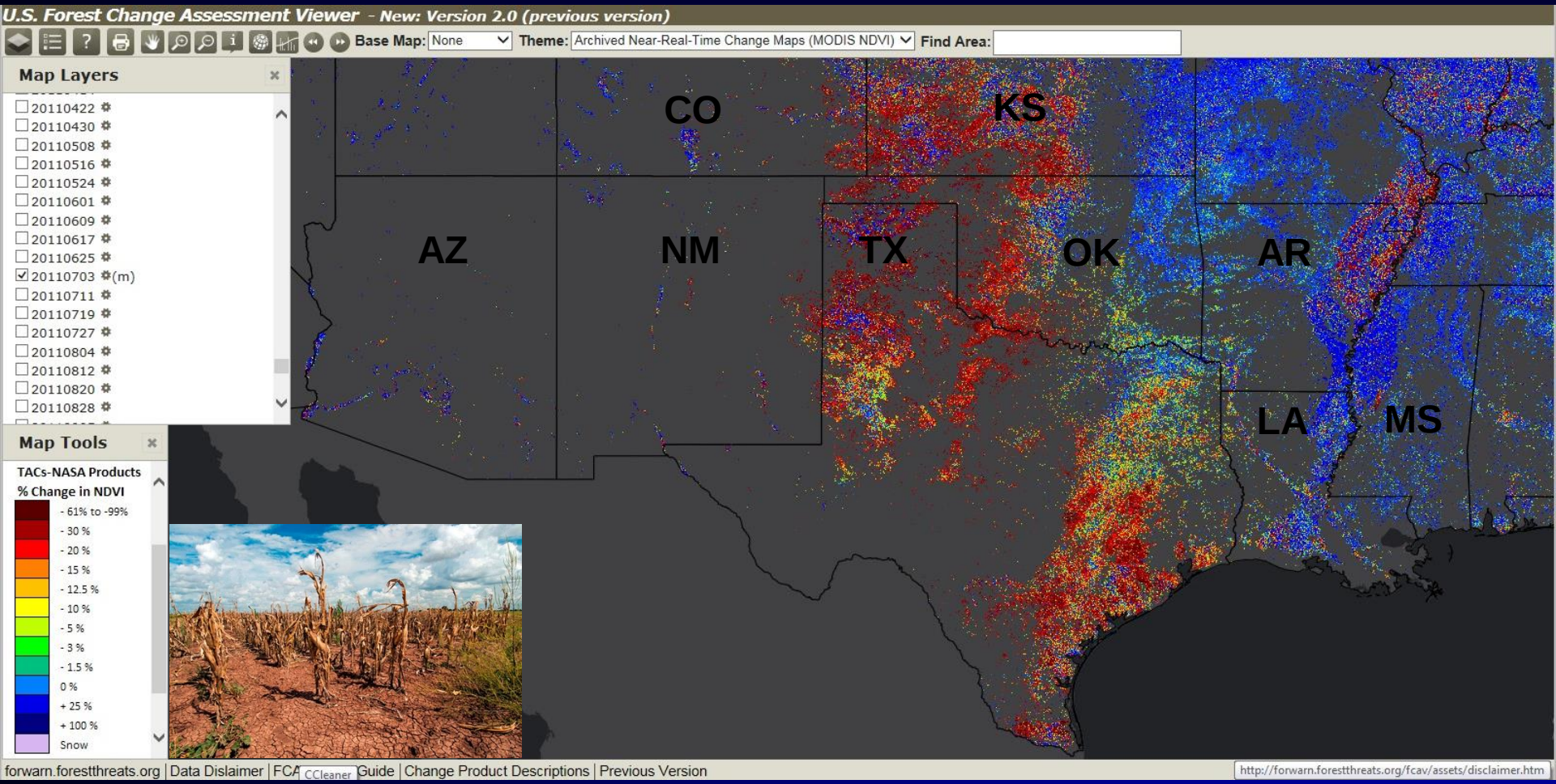
Above: NDVI Change for Current vs. Mean of Maximum NDVI for Date Ending July 3, 2011
Source of Shrub/Scrub Mask: NLCD Data
Inset Image of Juniper Woodland Mortality in Junction, TX (Source: TX A&M Forest Service)

2011 Texas Drought – NDVI Change - Grass



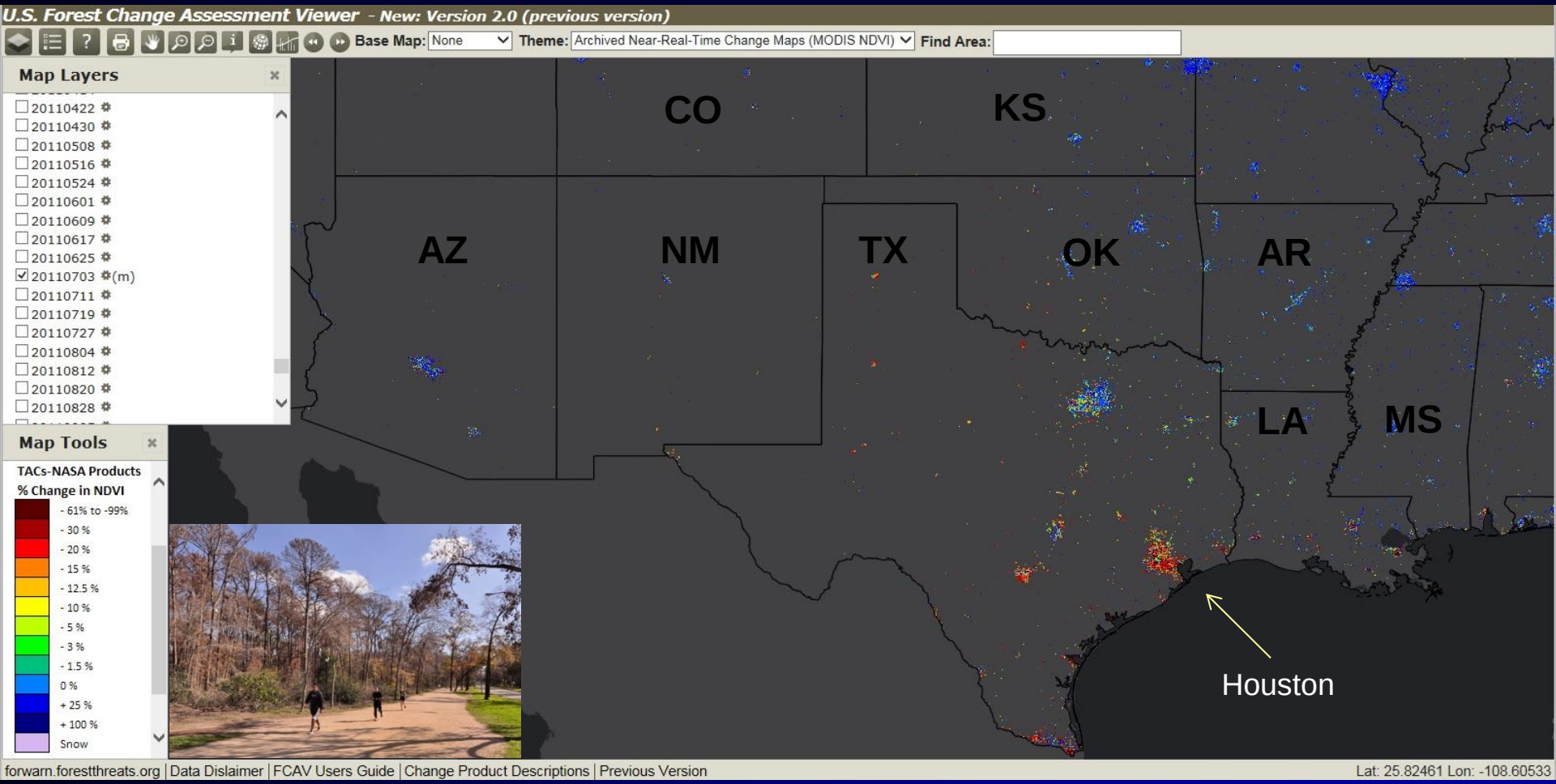
Above: NDVI Change for Current vs. Mean of Maximum NDVI for Date Ending July 3, 2011
Source of Grass Mask: NLCD Data
Inset Image of 2011 Drought Impacted TX Pasture (Source: TX A&M AgriLife Extension)

2011 TX Drought – NDVI Change - Agriculture



Above: NDVI Change for Current vs. Mean of Maximum NDVI for Date Ending July 3, 2011
Source of Agriculture Mask: NLCD Data
Inset Image of Drought Damaged Corn Field in Texas (Source: USDA)

2011 Texas Drought – NDVI Change - Urban

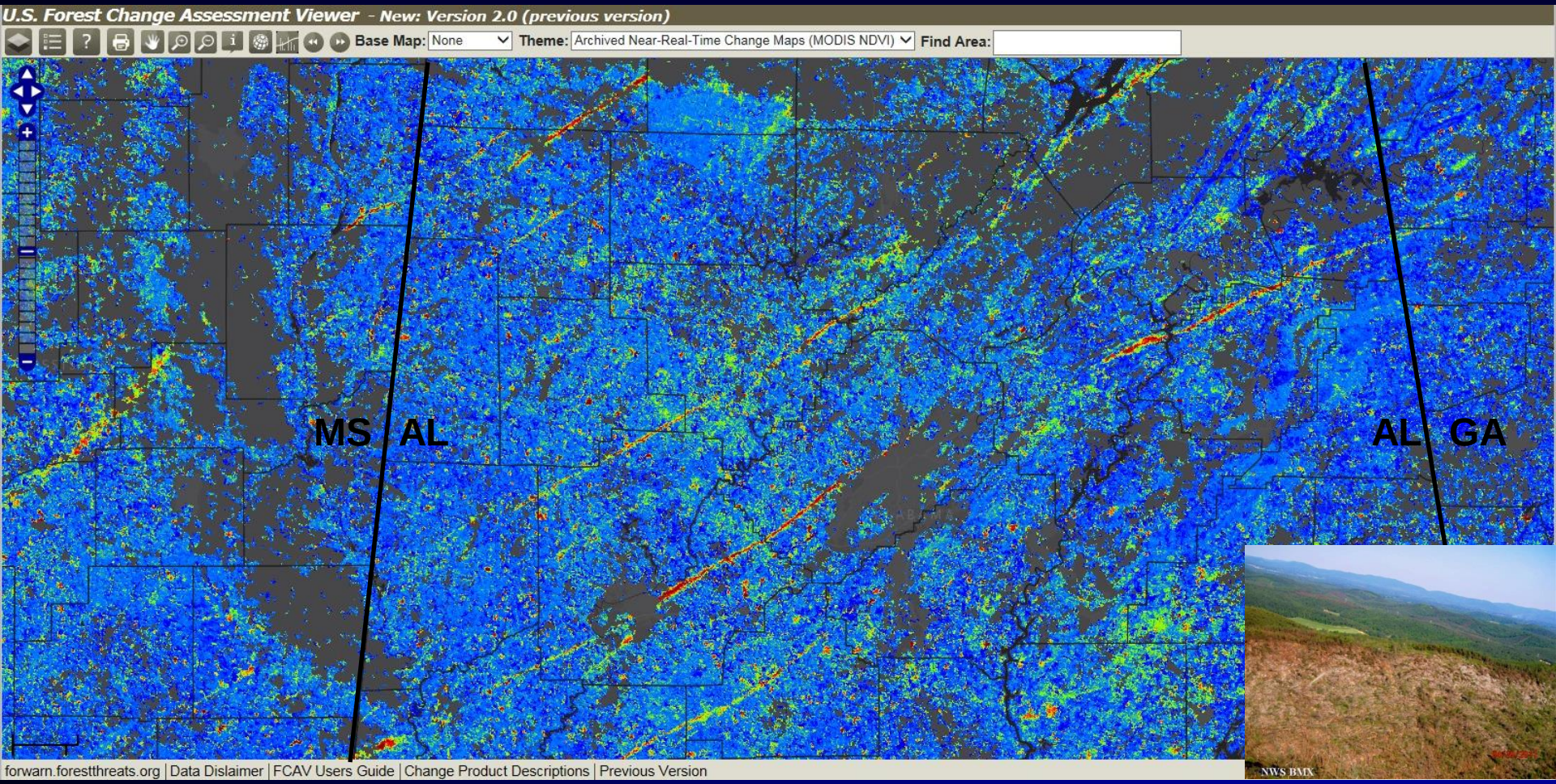


Above Map: NDVI Change for Current vs. Mean of Maximum NDVI for Date Ending July 3, 2011
Source of Urban Mask: NLCD Data
Inset Image of Forest Mortality in Houston, Texas Park (Source: Texas A&M Forest Service)

Series 2 – Example ForWarn NDVI change products for detecting severe weather related disturbances (e.g., 2011 Tornado Outbreak in Southeast US)

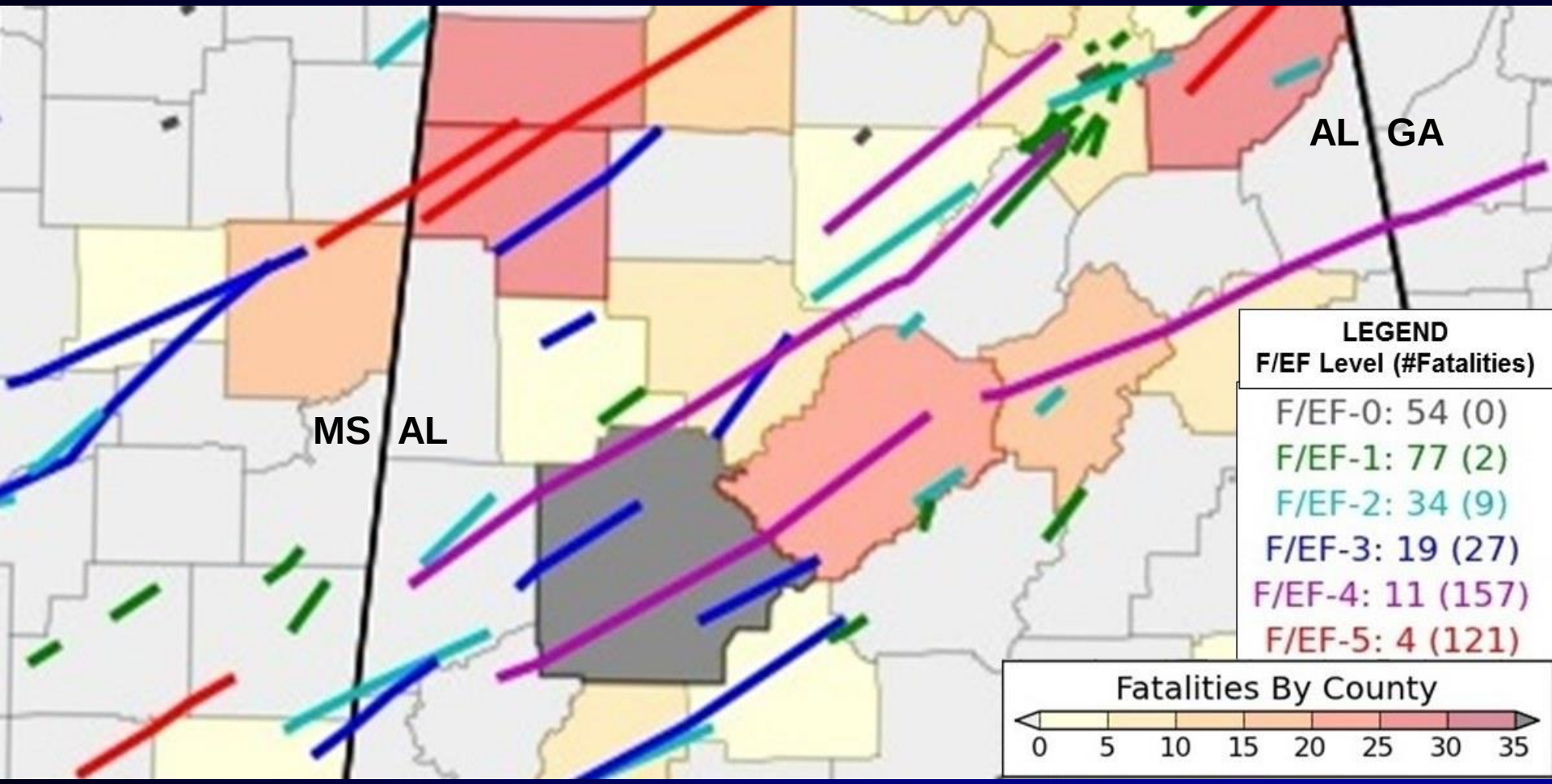
2011 Tornado Induced Forest Damage - Chattahoochee National Forest, Georgia
Source: US Forest Service

2011 Tornados– NDVI Change – Forests



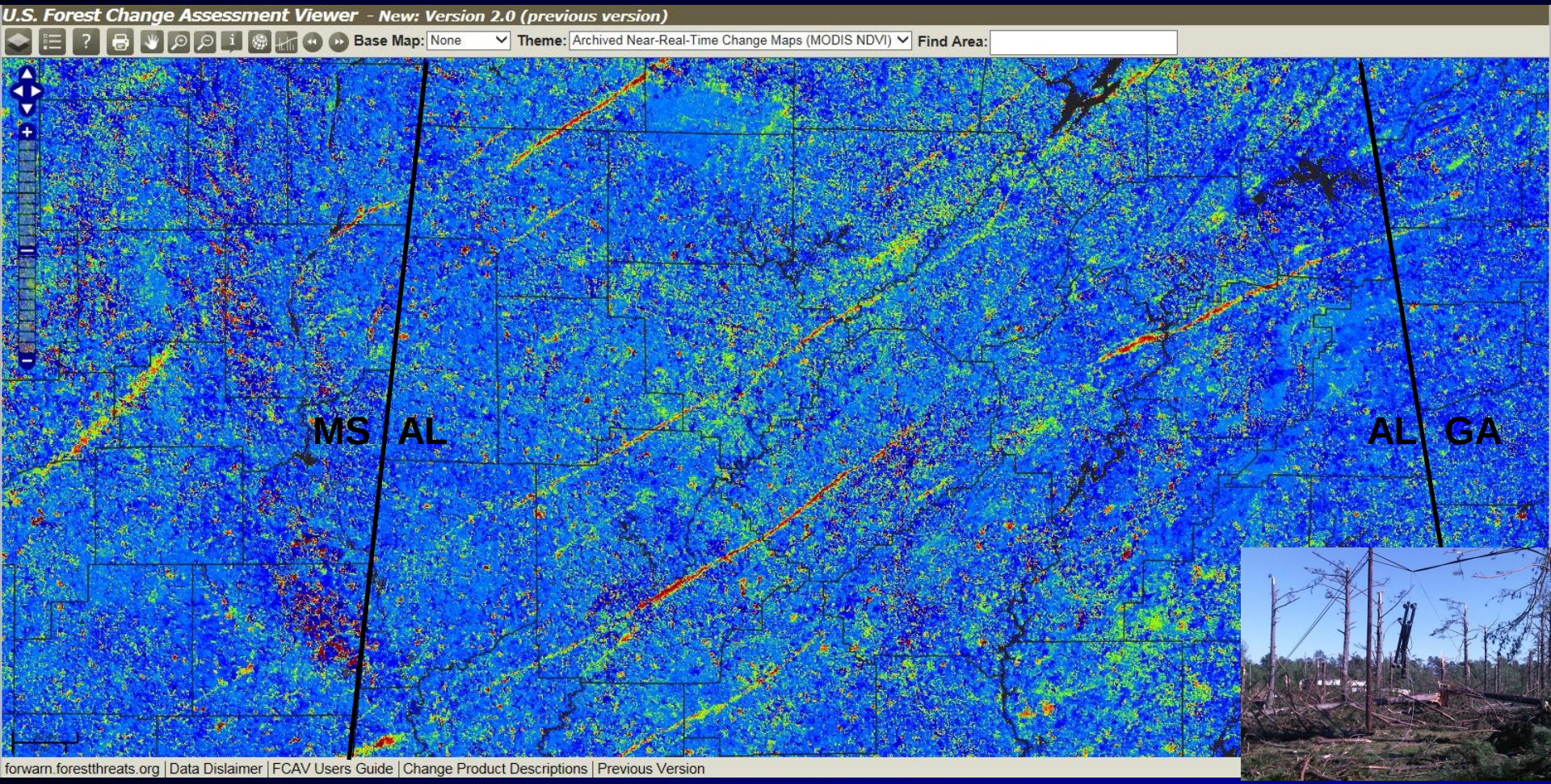
Above Map: NDVI Change for Current vs. Previous Year Maximum NDVI for Date Ending May 24, 2011
Source of Forest Mask: NLCD Data
Inset Image of 2011 Tornado Induced Forest Damage (Source: NOAA NWS)

2011 Tornados – NOAA NWS Map



Above: Preliminary Map of April 27, 2011 Tornado Tracks
From December 2011 NOAA NWS Report
This Preliminary Map is General and Also Has Some Errors Noted by NOAA

2011 Tornados– NDVI Change – All Lands

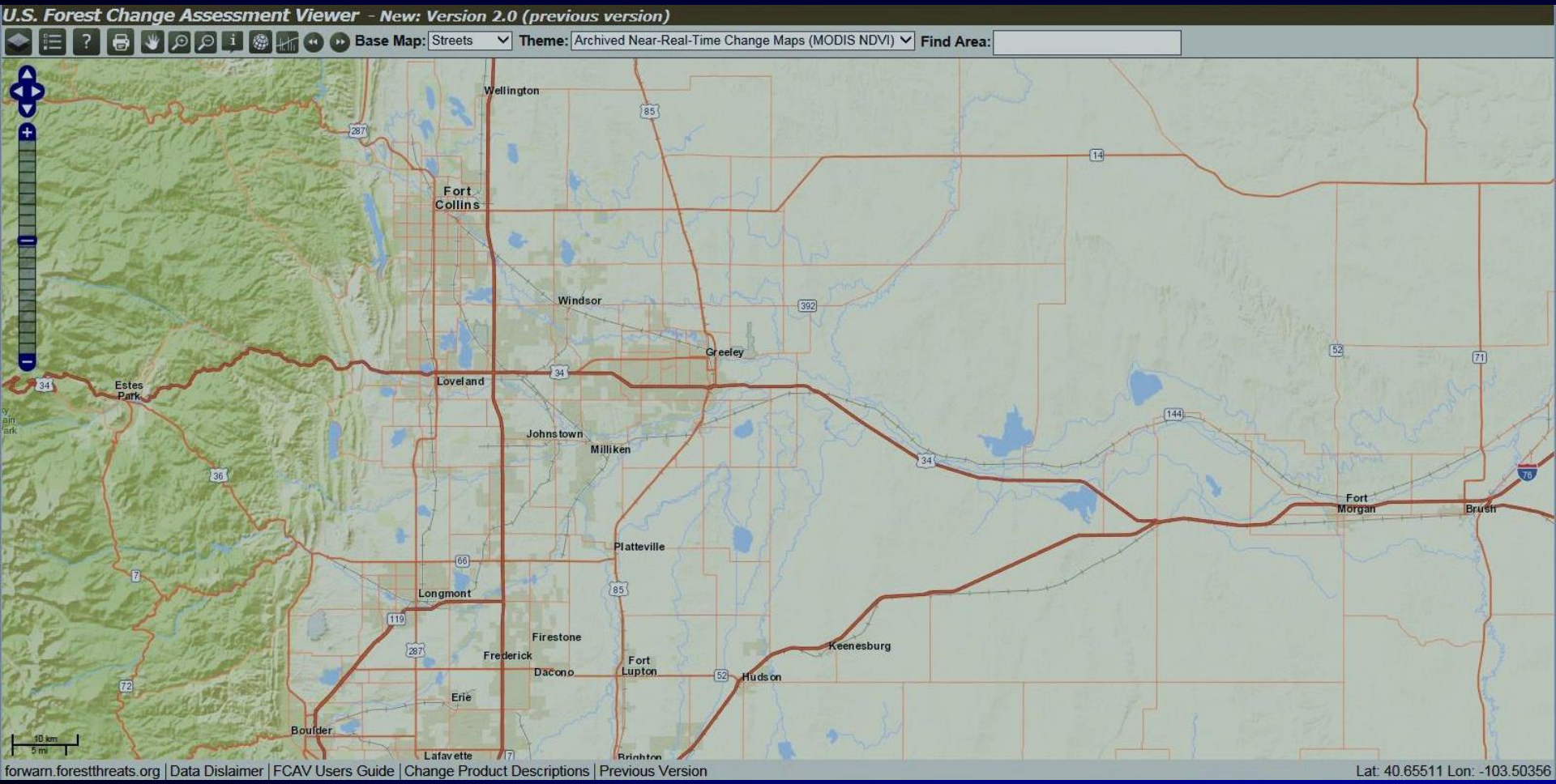


Above Map: NDVI Change for Current vs. Previous Year Maximum NDVI for Date Ending May 24, 2011
Inset Image of 2011 Tornado Induced Forest Damage (Source: US CDC)

Series 3 – Example ForWarn NDVI change products for detecting severe weather related disturbances (e.g., 2013 Colorado Flood)

Example of 2013 Flooding in Colorado
Source: US Army Corps of Engineers

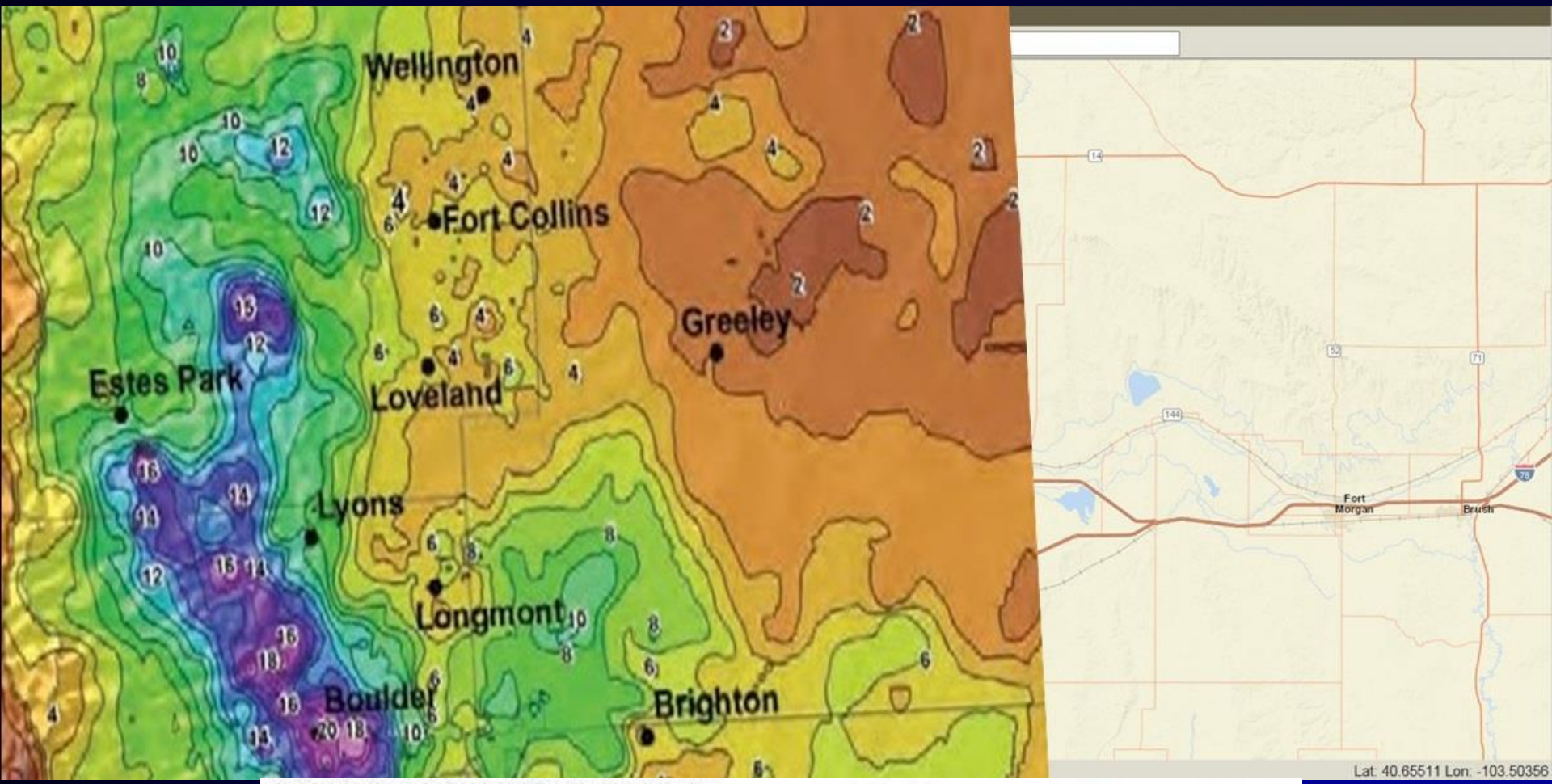
2013 CO Flood – Study Area



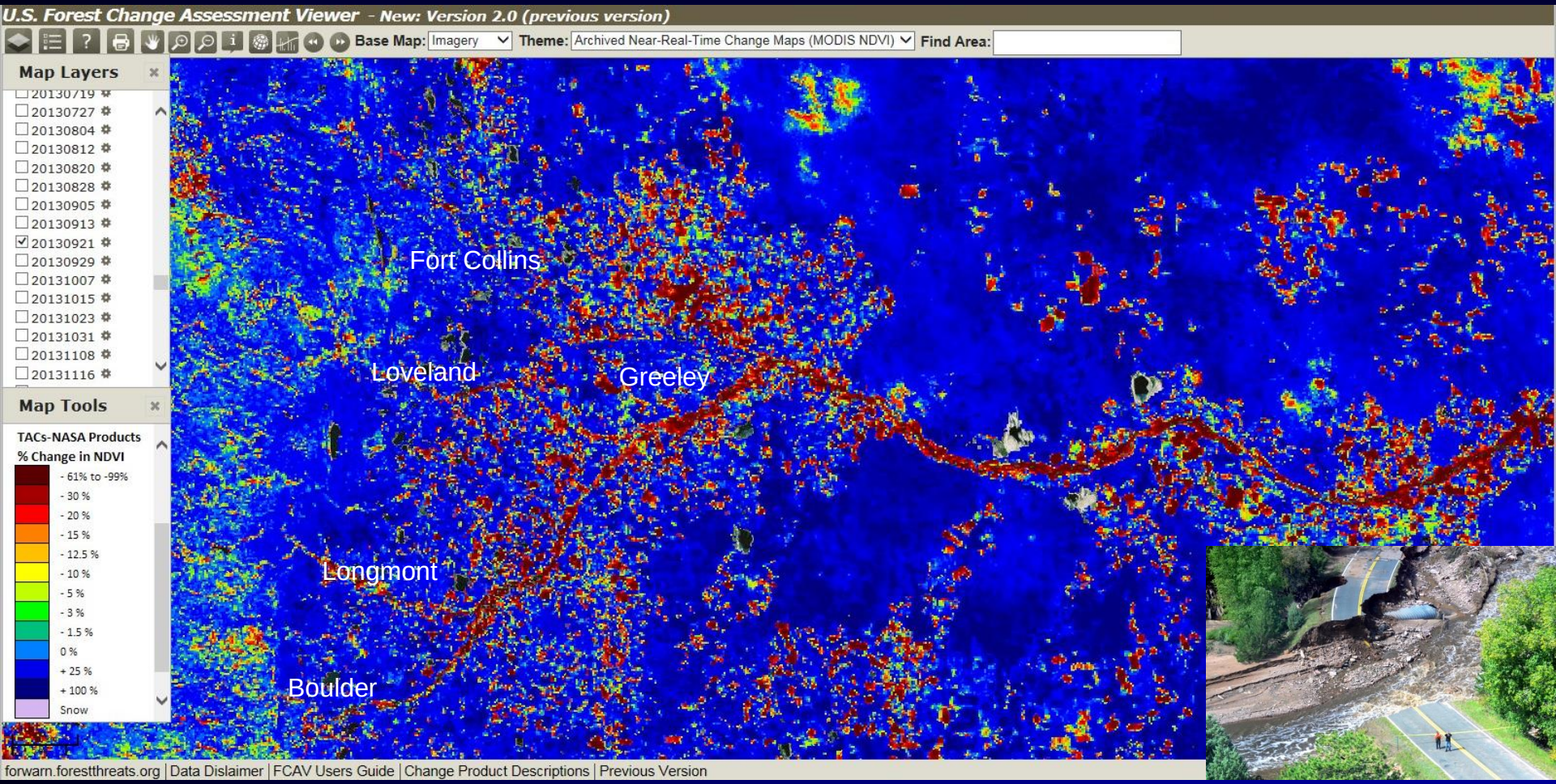
Above: Street Map Option with ForWarn's Data Viewer

2013 CO Flood – Total Precipitation for Event

Total from September 9-15, 2013 (Source: NOAA NWS)

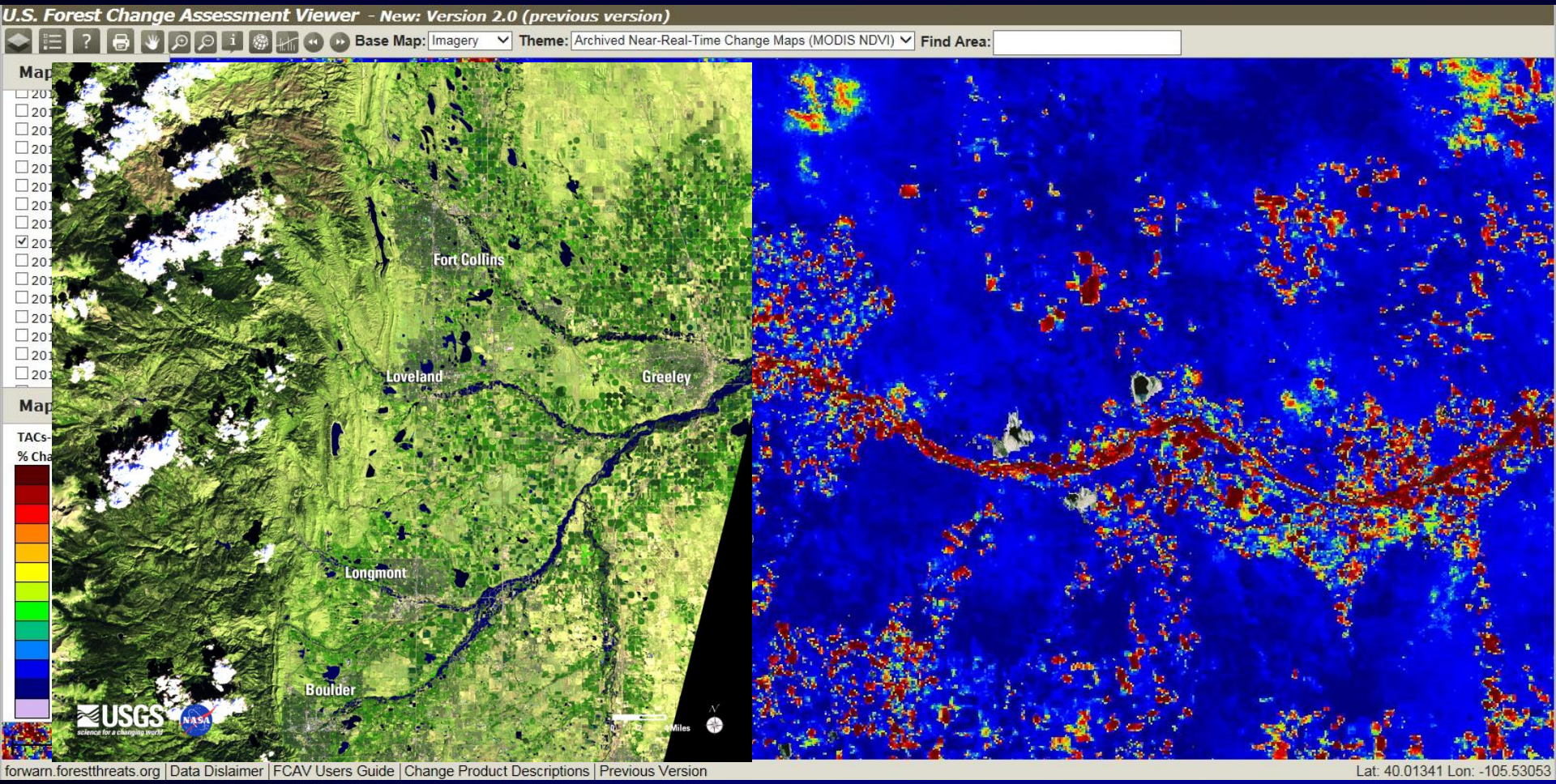


2013 CO Flood – NDVI Change – All Lands



Above: "Rapid Detect" NDVI Change for Current vs. Previous Year Maximum NDVI as of 9/21/2013
Inset: Aerial View of 2013 Colorado Flood Damage (Source: US Army)

2013 CO Flood – Landsat False Color RGB



Foreground Left: Landsat OLI False Color RGB from September 17, 2015 (Source: USGS/NASA)
Above Right: “Rapid Detect” NDVI Change for Current vs. Previous Year Maximum NDVI as of 9/21/2013

2013 CO Flood – NDVI Change – Grass

Above: "Rapid Detect" NDVI Change for Current vs. Previous Year Maximum NDVI as of 9/21/ 2013
NDVI Change is Masked to Show Only Grass (Mask Source: NLCD)
Inset: Aerial View of 2013 Colorado Flood Damage (Source: US Air National Guard)

2013 CO Flood – MODIS False Color RGB

Above : Daily MODIS Aqua False Color RGB from September 17, 2015
(Source: USFS Remote Sensing Applications Center)

Main Findings

- In this study, MODIS 24 Day NDVI change products were used to assess regional vegetation disturbances due to drought, tornadoes, and flooding
- ForWarn's NDVI change products compared well to other geospatial data on these events
- The ForWarn system includes archived NDVI change products available for retrospective studies of vegetation disturbance from abiotic events
- ForWarn's masking functions improved the ability to assess regional abiotic vegetation disturbances

Suggested Future Work

- ForWarn's masking functions could be improved by adding masks for woody wetlands, non-woody wetlands, and water
- Use of the ForWarn's NLCD-based masks could be improved if the NLCD product used in the masks is the same vintage as one in the ForWarn data viewer
- ForWarn's NDVI profiler could be upgraded if the mean NDVI response could also be displayed and if each profile's data could be exported as an ascii file
- This study's results are promising but more work is needed to assess NDVI phenology data for aiding studies of other types of abiotic disturbances
- More work is needed to automate attribution of vegetation disturbances according to abiotic/biotic causal agents