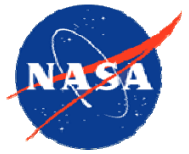
Contribution of Near Real Time MODIS-Based Forest Disturbance Detection Products to a National Forest Threat Early Warning System

Presented to the 2011 AGU Fall Meeting by:
Joseph Spruce, Computer Sciences Corporation (CSC)
William Hargrove, USDA Forest Service
Gerald Gasser, Lockheed Martin
James Smoot, CSC
Philip Kuper, CSC

Introduction

- U.S. forests occupy ~751 million acres (~1/3 of total land)
- These forests are exposed to multiple biotic and abiotic threats that collectively damage extensive acreages each year
- Hazardous forest disturbances can threaten human life and property, bio-diversity and water supplies
- Timely regional forest monitoring products are needed to aid forest management and decision making by the US Forest Service and its state and private partners
- Daily MODIS data products provide a means to monitor regional forest disturbances on a weekly basis
- In response, we began work in 2006 to develop a Near Real Time (NRT) forest monitoring capability, based on MODIS NDVI data, as part of a national forest threat early warning system (EWS)

Driver for the EWS: Healthy Forest Restoration Act of 2003



- The EWS was mandated by the Healthy Forest Restoration Act (HFRA) of 2003, Section VI
  - *"In carrying out the program, the Secretary (of Agriculture) shall develop a comprehensive early warning system for potential catastrophic environmental threats to forests"*
- Threats include those from insects, diseases, invasive species, fire, weather-related risks and other episodic events, as well as forest loss and degradation
- The HFRA discusses the EWS as part of a forest inventory and monitoring program to improve detection and response to environmental threats
- The EWS is to provide timely regional forest monitoring and threat assessment data for government and public use

Objectives for 2011 NRT MODIS Forest Disturbance Detection Products

- **Objective 1** – Contribute nationwide weekly NRT MODIS %NDVI forest disturbance detecting products to USFS EWSs
  - U.S. Forest Change Assessment Viewer (FCAV)
  - U.S. Forest Disturbance Mapper (FDM)
- **Objective 2** – Conduct in-season rapid preliminary assessments of MODIS %NDVI for detecting regional forest disturbances in NRT according to:
  - Biotic damage agents
  - Abiotic damage agents
  - Forest cover types (general and specific)
  - U.S. regions
  - Seasons within calendar year

U.S Forest Change Assessment Viewer (New Products Every 8 Days)

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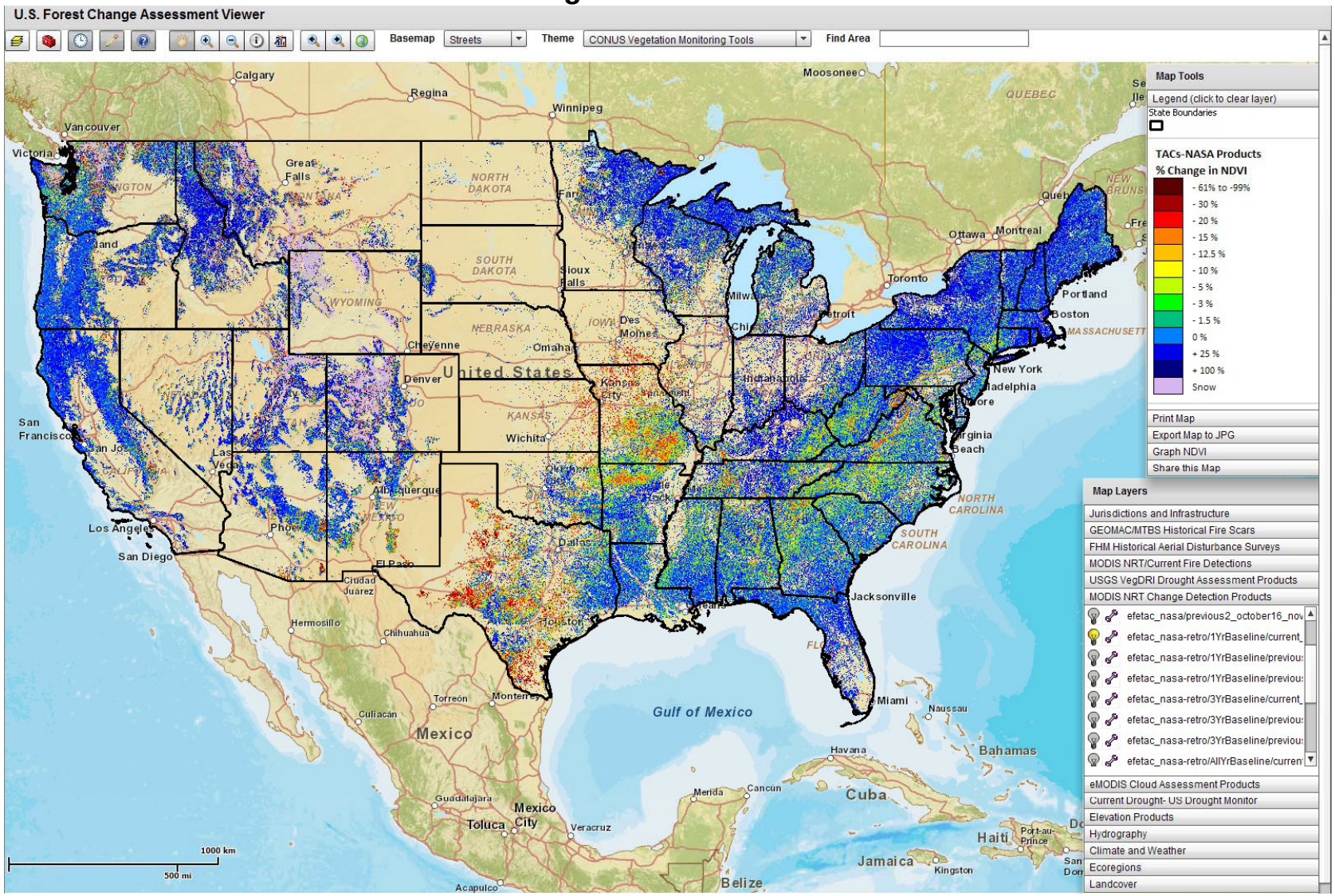
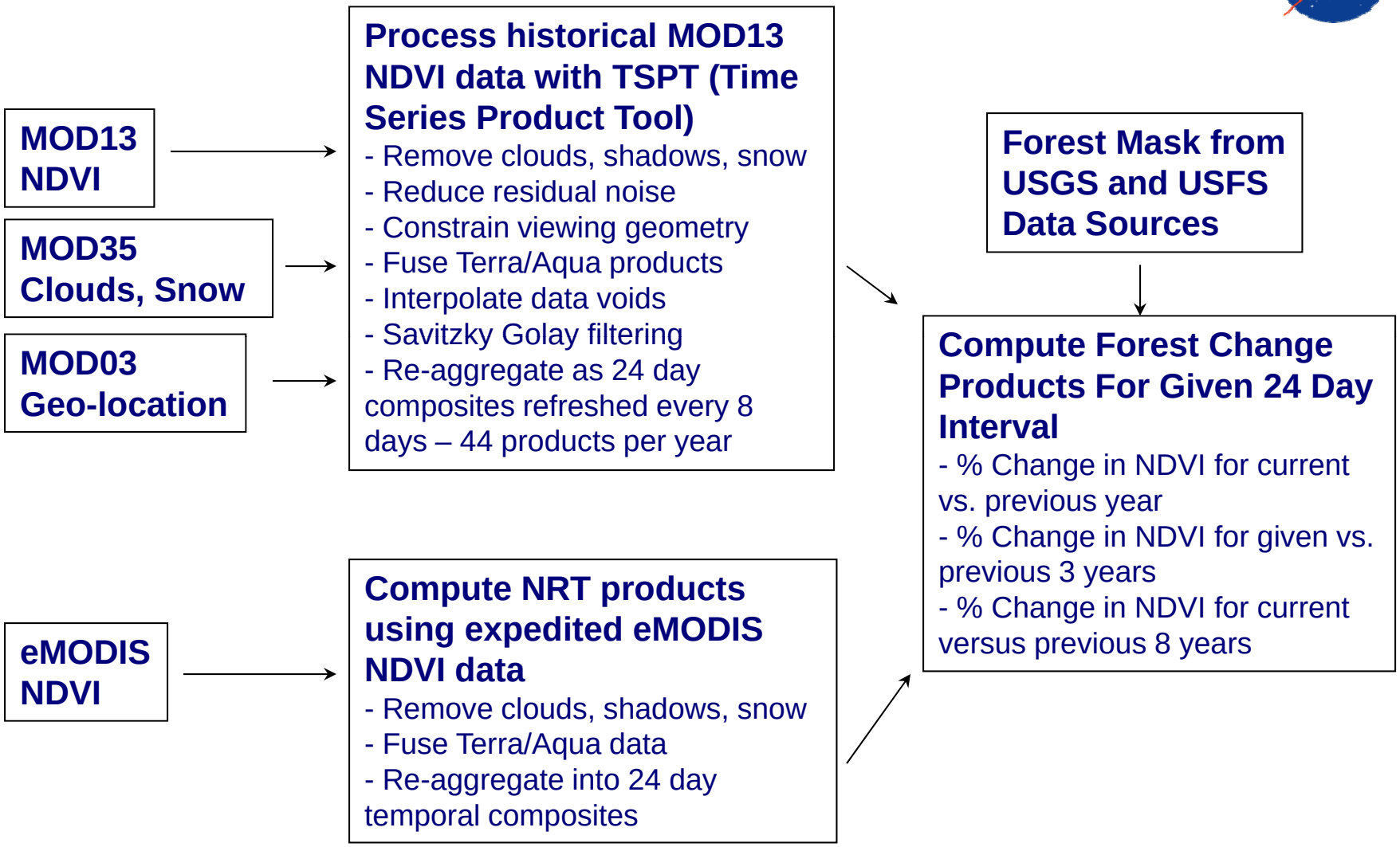
2011 Forest % NDVI Change versus Previous Year for November 1 - 24



MODIS NDVI Processing Method



Series 1 – Examples of MODIS Change Products Detecting Regionally Evident Abiotic Forest Disturbances

- April 27, 2011 tornadoes in Mississippi and Alabama
- 2011 Los Conchas fire of New Mexico
- 2011 Mississippi River flooding impacts on wetland forests of Louisiana and Mississippi
- 2011 drought in Texas and adjacent states
- All shown products were posted in NRT on the FCAV during 2011

MODIS View of April 27, 2011 Tornadoes in Mississippi and Alabama

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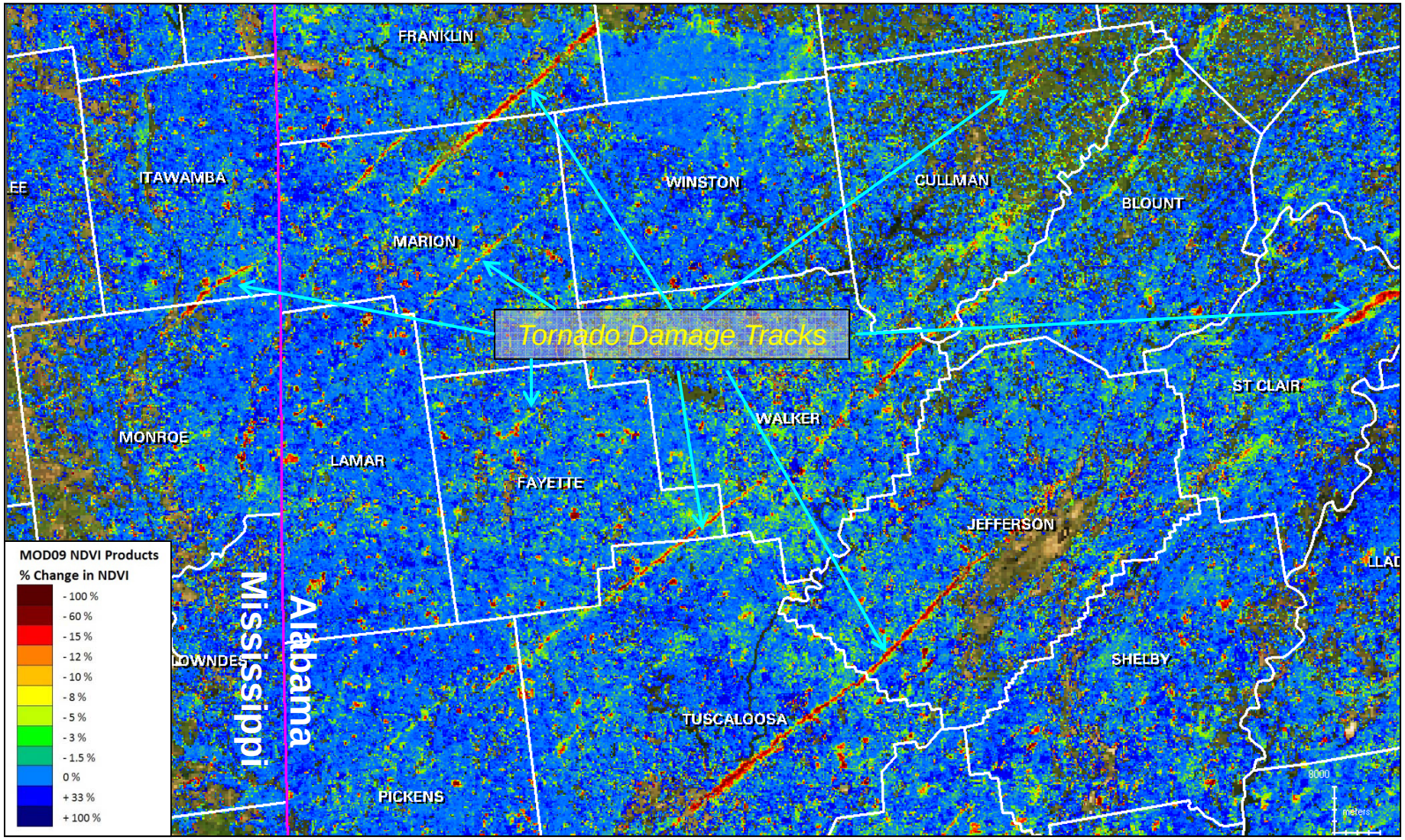
Forest %NDVI Change for May 1-24, 2011 versus 2010 – Counties in White



MODIS View of 20111 Los Chonchas Fire in New Mexico

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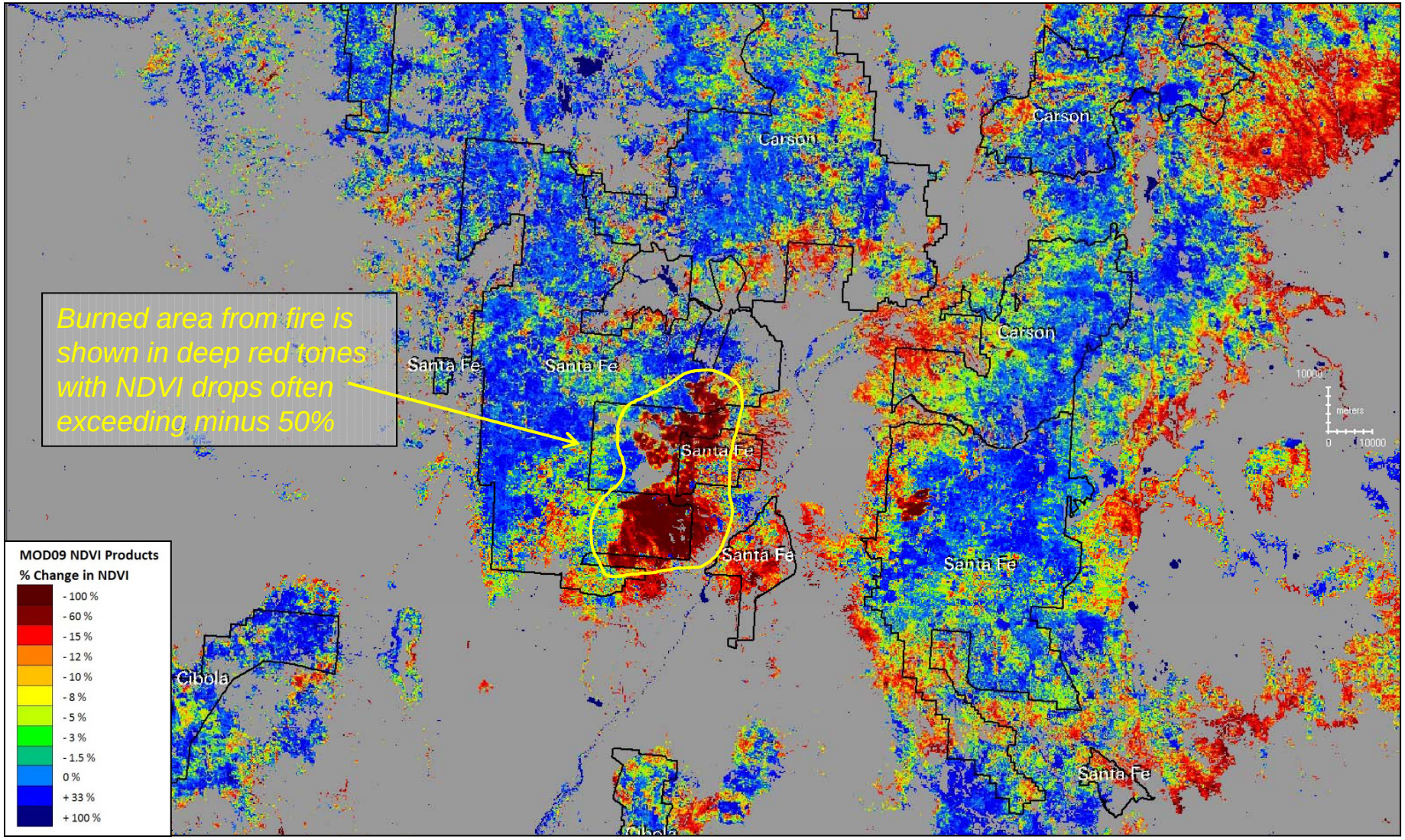
Forest %NDVI Change for August 5 – 28, 2011 versus 2010 – National Forests in Black



MODIS View of Mississippi River Flooding of Wetland Forests

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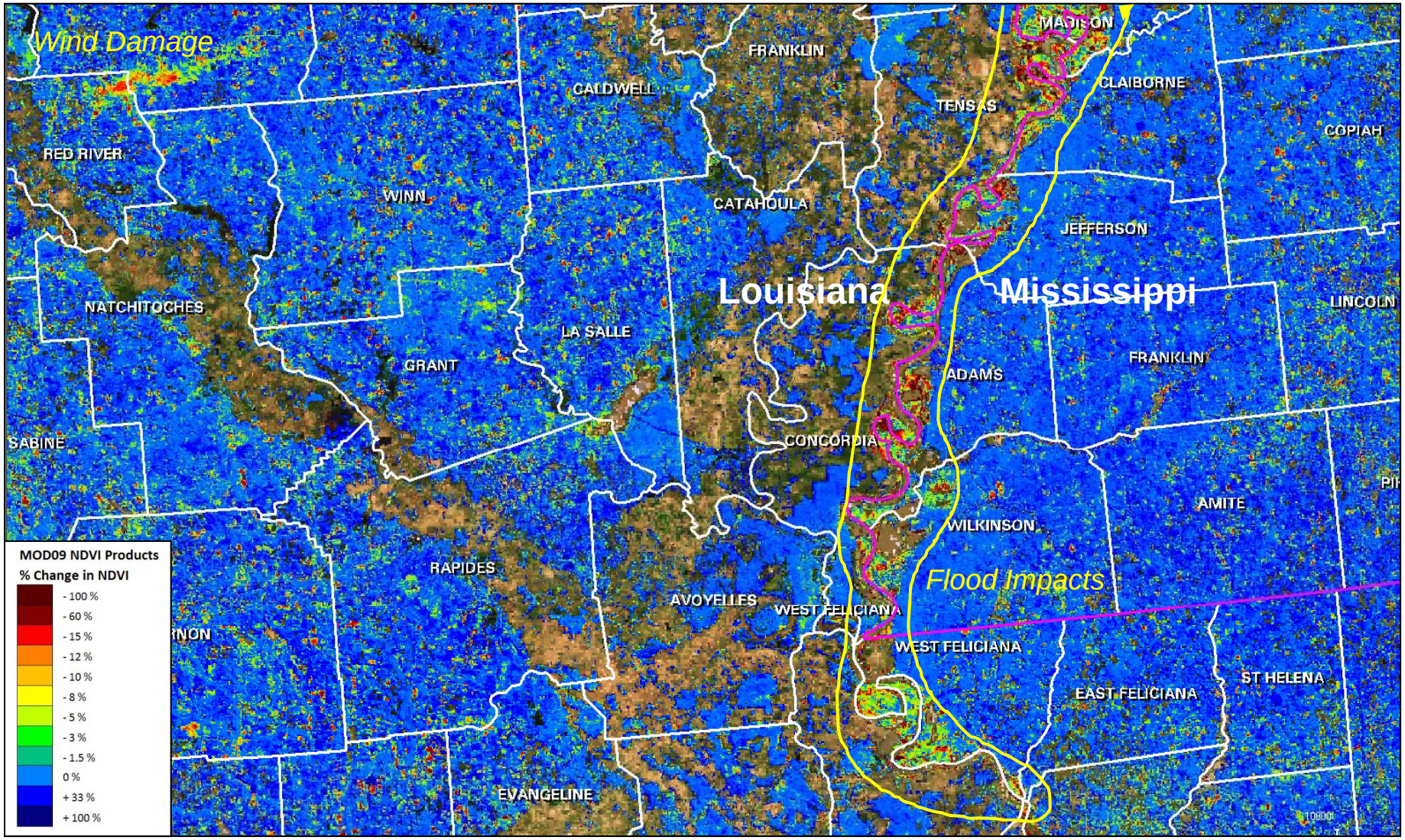
Forest %NDVI Change for May 9 through June 1 of 2011 versus 2010 – Counties in White



MODIS View of 2011 Drought in Texas and Adjacent States

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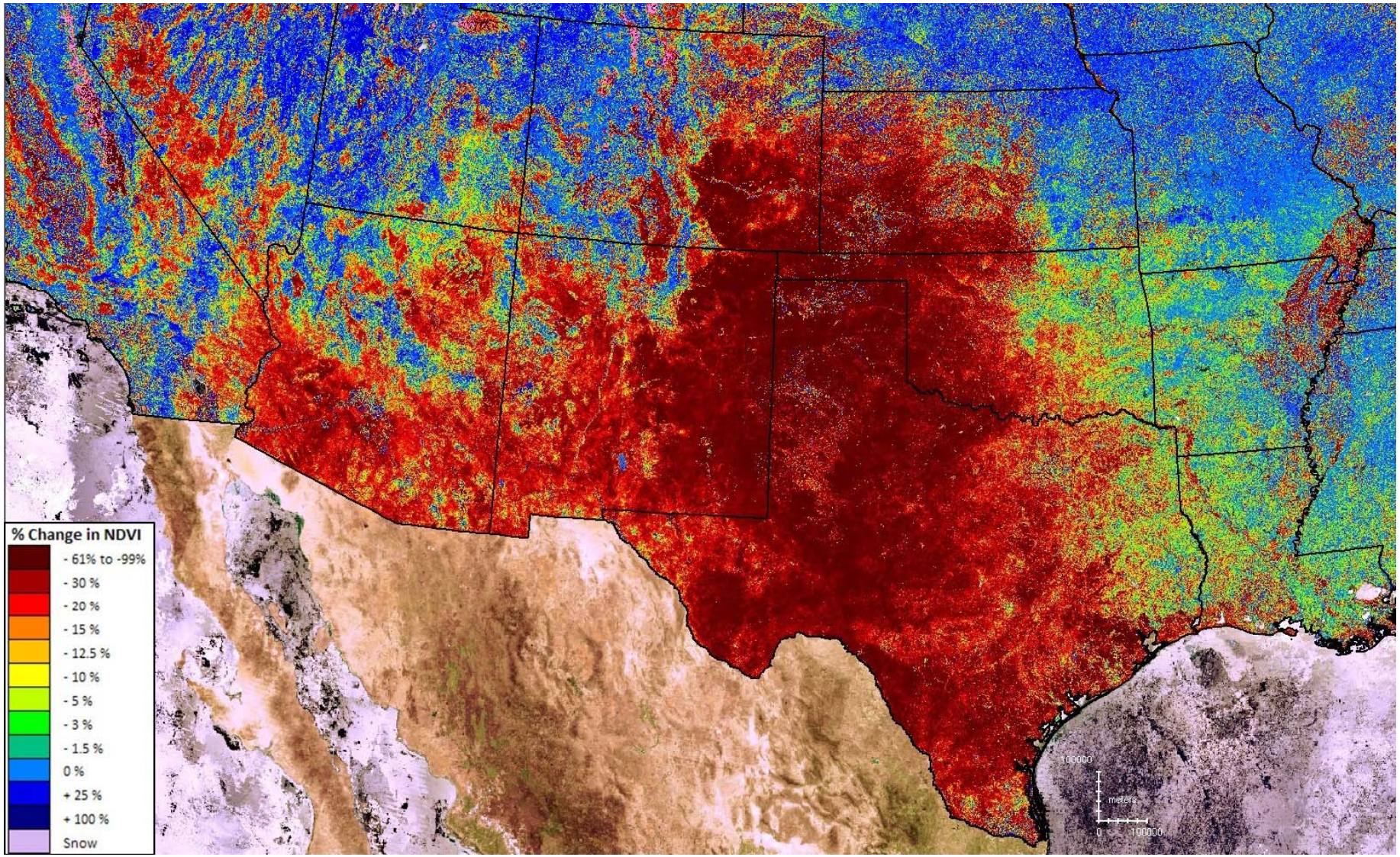
Land %NDVI Change for June 18 through July 11 of 2011 versus 2003-2010



U.S. Drought Monitor View of 2011
Drought in Texas and Adjacent States

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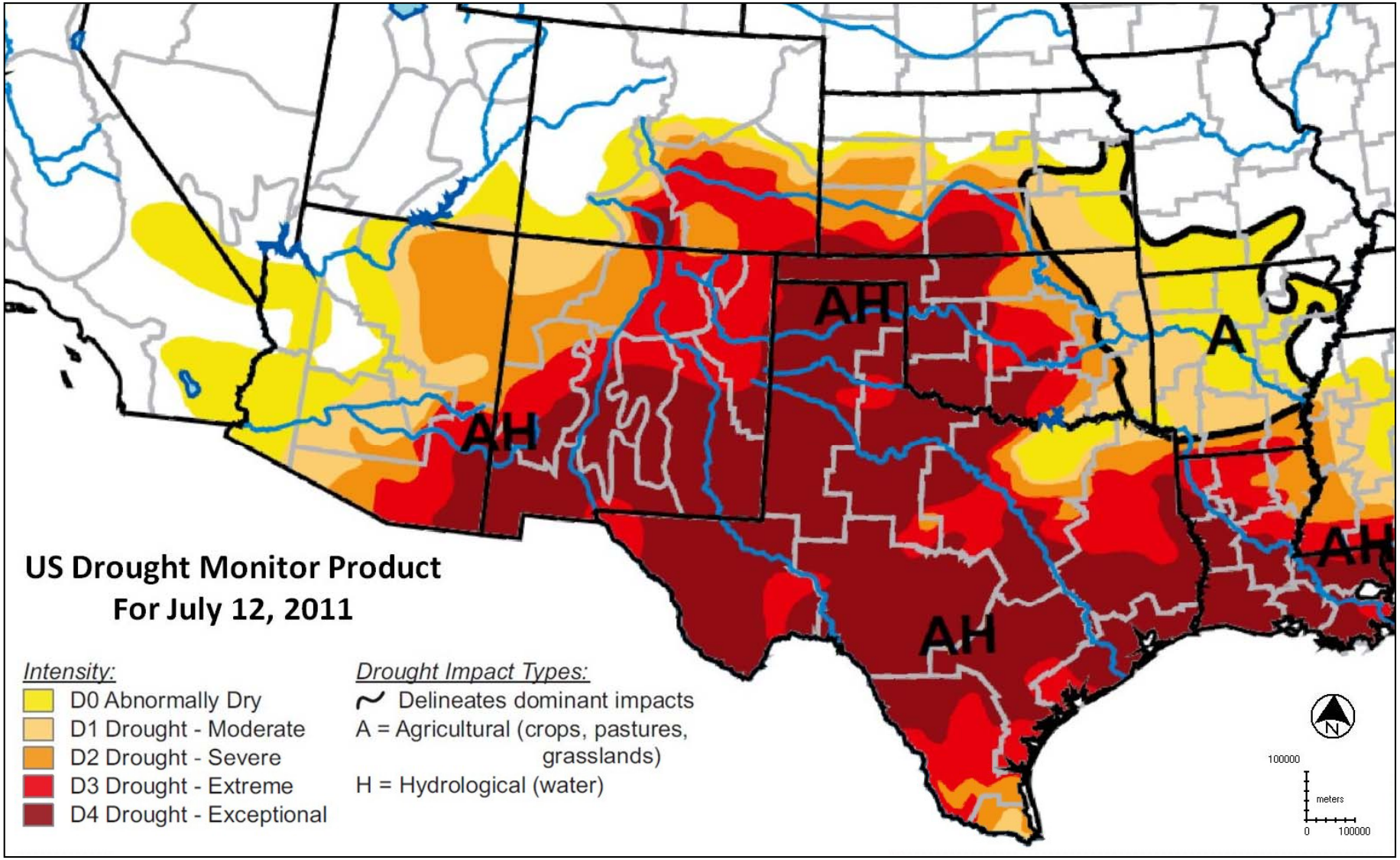
U.S. Drought Monitor Product for July 12, 2011



Series 2 – Examples of MODIS Change Products Showing Regionally Evident Biotic Forest Disturbances

- Spring 2011 - wetland forest defoliation in Louisiana
- Summer 2011 – potential bark beetle induced forest mortality in Utah
- Summer 2011 - spruce budworm forest defoliation in Washington
- Fall 2011 - fall webworm defoliation in Pennsylvania
- All shown products were posted in NRT on the FCAV during 2011

View of Wetland Forest Defoliation in Coastal Louisiana

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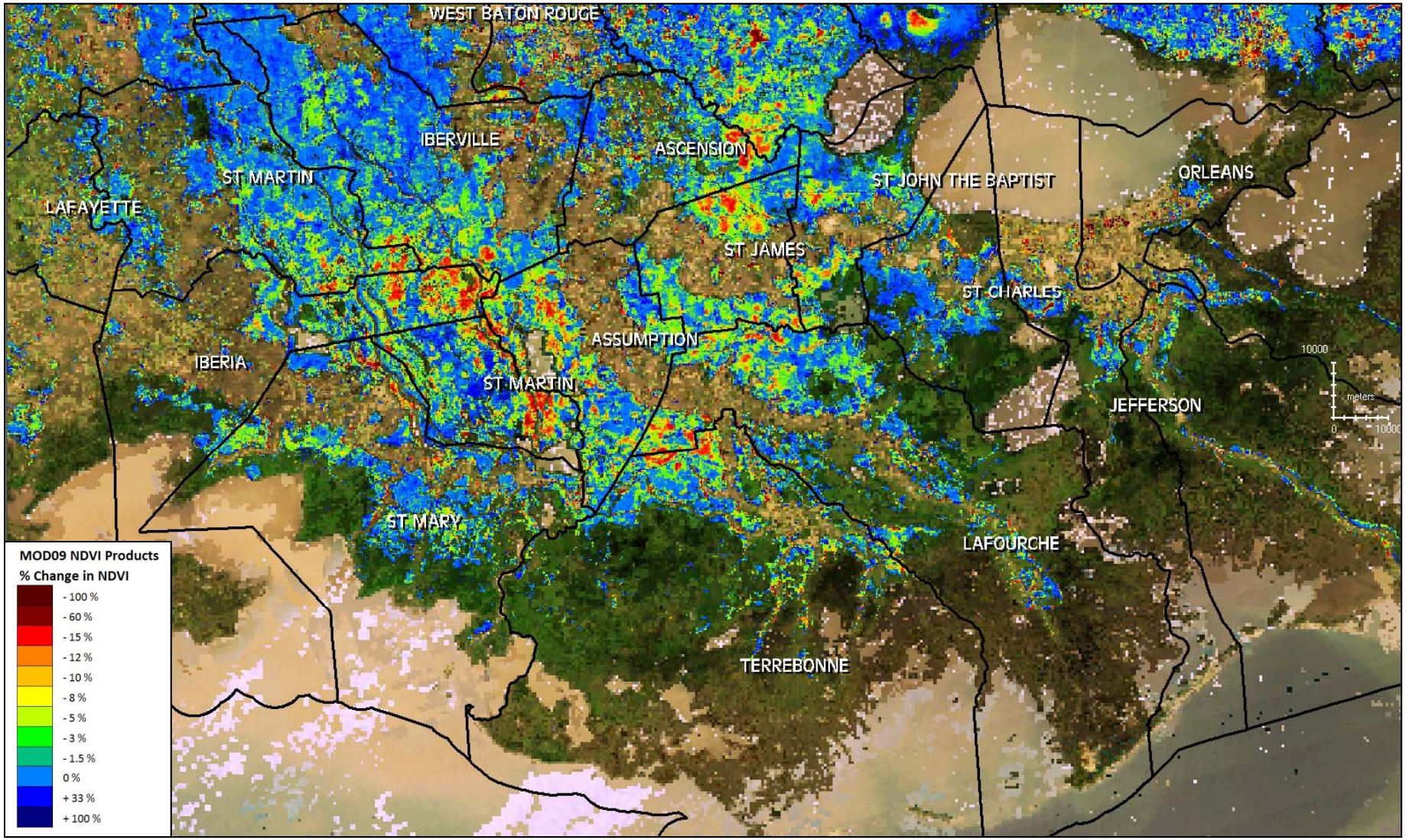
Forest %NDVI Change for April 15 through May 8 of 2011 versus 2003-2010 – Counties in Black



MODIS View of Potential Expansion of Bark Beetle Mortality in Utah

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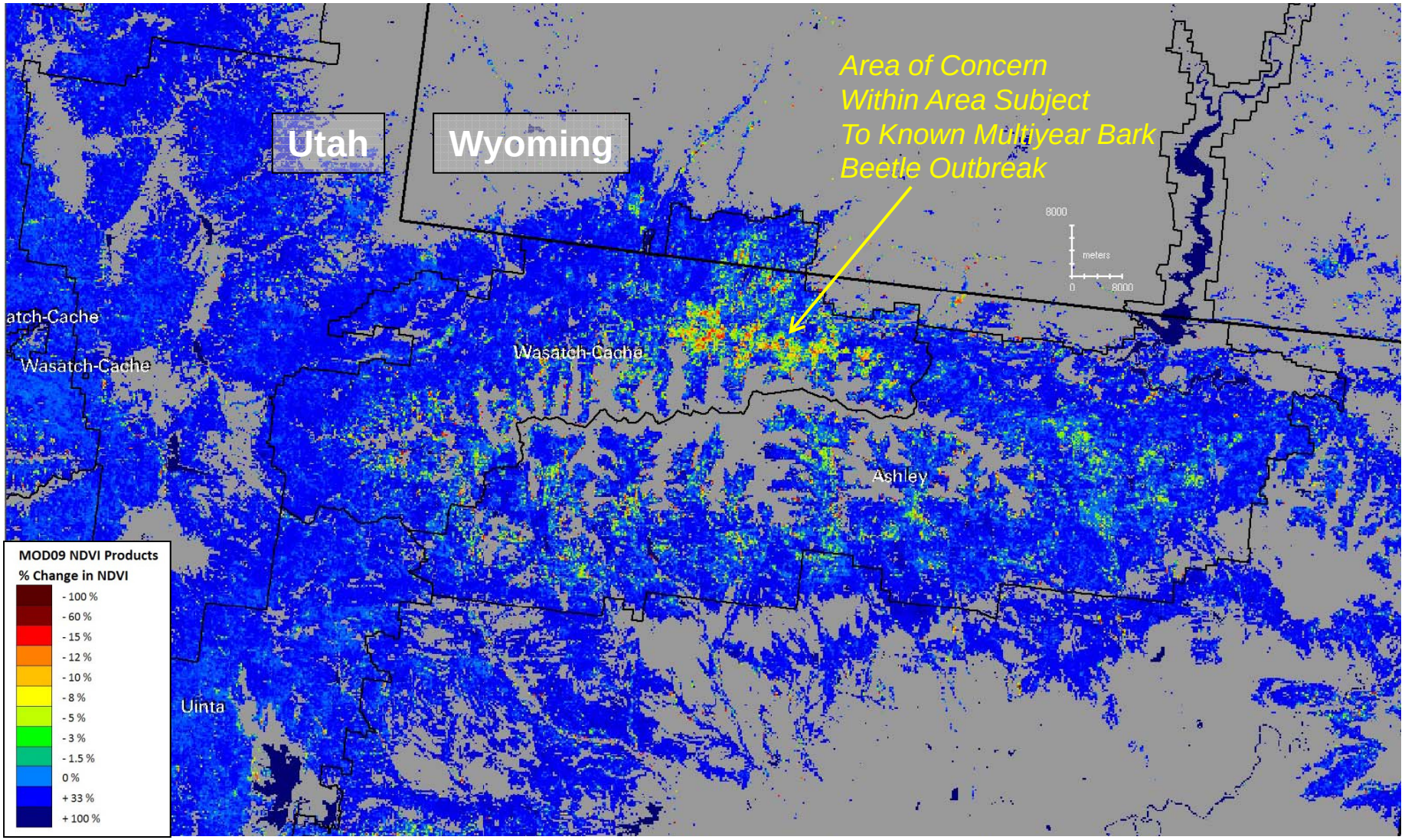
Forest %NDVI Change for 8/21 through 9/13 of 2011 versus 2010 – National Forests in Black



MODIS View of Apparent Spruce Budworm Defoliation in Washington

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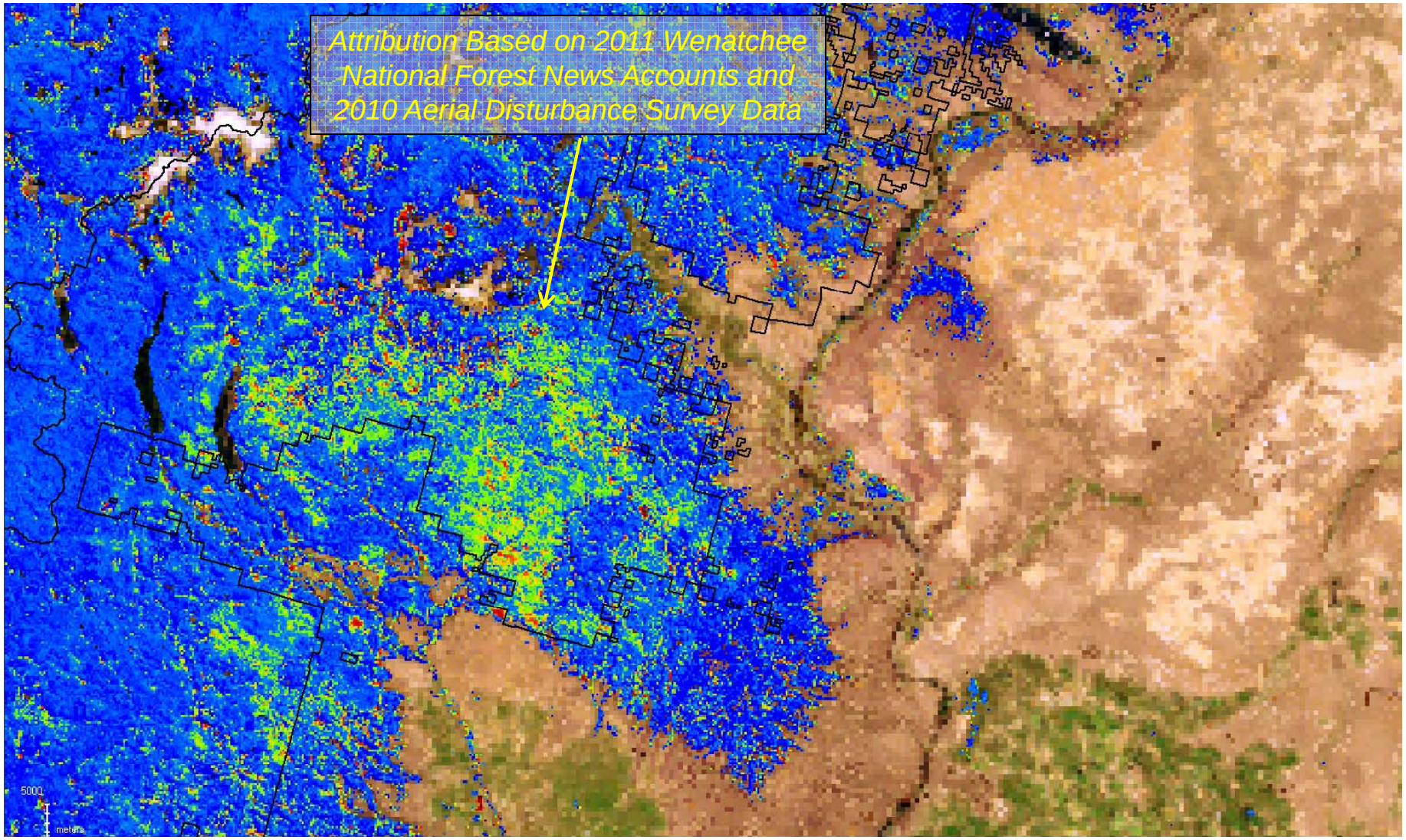
Forest %NDVI Change for 8/21 through 9/13 of 2011 versus 2008-2010 – National Forests in Black



MODIS View of Fall Webworm Defoliation in Pennsylvania

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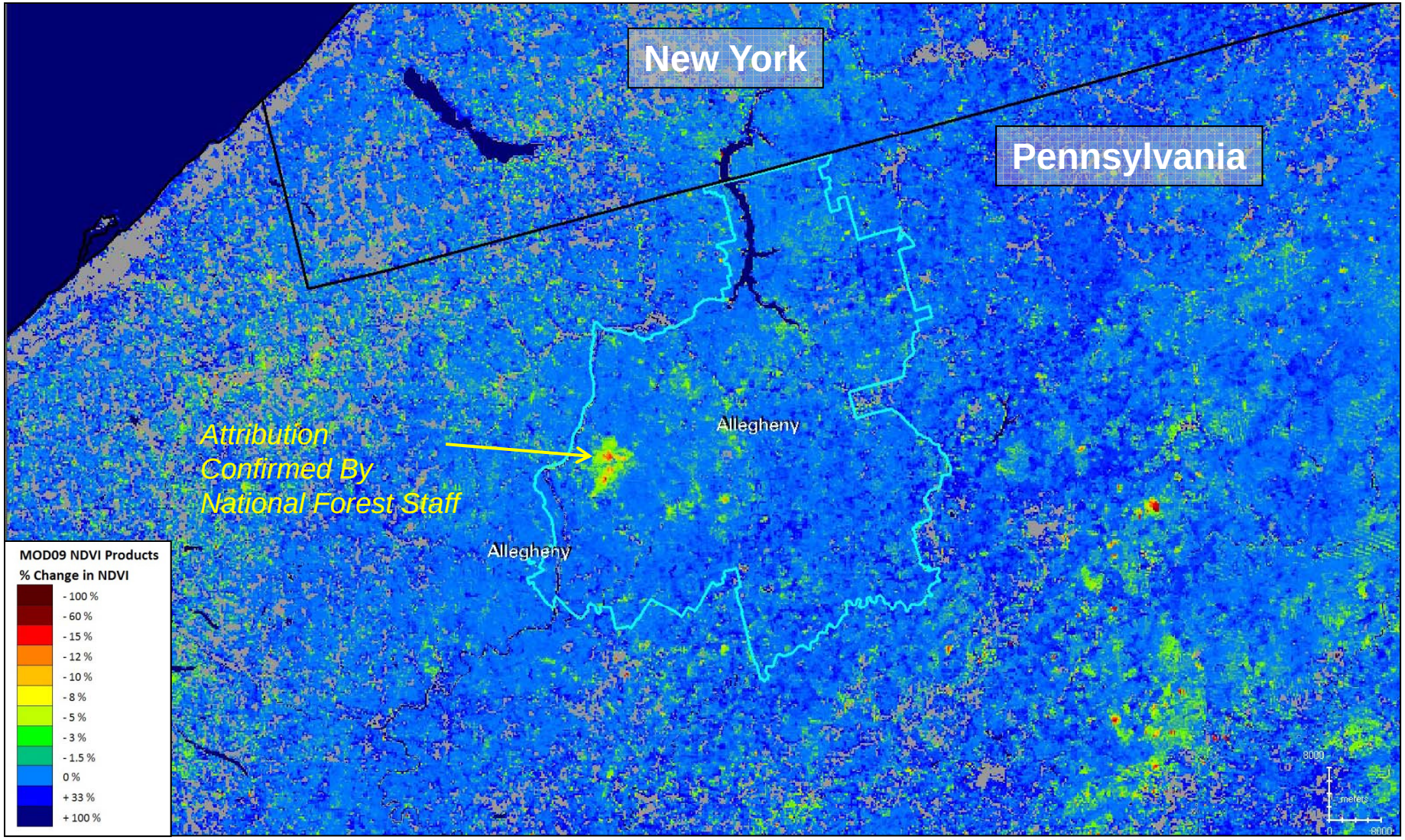

Comments on 2011 Results

- NRT MODIS CONUS forest change products were used to detect multiple regional biotic and abiotic forest disturbances
- Recent disturbances were most readily identified on change products using the previous year NDVI as a baseline
- Longer multiyear NDVI baselines were useful for assessing insect defoliation, as well as chronology, persistence, and duration of multiyear disturbance events
- News accounts, aerial disturbance surveys, fire maps, and Landsat data were used to evaluate apparent forest disturbances
- Forest disturbance detection can depend on the damage agent, season, and location
- Improved snow masks aided change product interpretability

Final Remarks

- The 2011 NRT MODIS % NDVI change products in the FCAV enabled regional forest monitoring across the U.S.
- Regional disturbance events observed on these products tended to show visual agreement with reference data
- Weekly change products were contributed to the FCAV and FDM with typical latencies of 1-2 days after the last collection date
- Future work will include additional product automation, validation, testing alternative historical baseline methods, and improving MODIS true color composite products
- The FCAV can be viewed on-line at ews.forestthreats.org/gis/ews_gis.htm
- For additional information, email joseph.p.spruce@nasa.gov

Project Publications

W.W. Hargrove, J.P. Spruce, G.E. Gasser, and F.M. Hoffman, 2009, Toward a national early warning system for forest disturbances using remotely sensed canopy phenology. Photogrammetric Engineering & Remote Sensing 75:1150-1156.

McKellip, R., D. Prados, R. Ryan, K. Ross, J. Spruce, G. Gasser, and R. Greer, 2008: Remote-sensing time series analysis, a vegetation monitoring tool, NASA Tech Briefs 32(4):63-64.

Ramsey E., J. Spruce, A. Rangoonwala, Y. Suzuoki, J. Smoot, and J. Gasser, and T. Bannister, 2011: Daily MODIS data trends of hurricane-induced forest impact and early recovery, Photogrammetric Engineering and Remote Sensing, 77 (11):133-143.

Spruce, J.P., S. Sader, R. E. Ryan, J. Smoot, P. Kuper, K. Ross, D. Prados, J. Russell, G. Gasser, R. McKellip, and W. Hargrove, 2011, Assessment of MODIS NDVI time series data products for detecting forest defoliation from gypsy moth outbreaks, Remote Sensing of Environment, 115:427–437.

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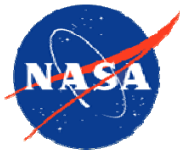
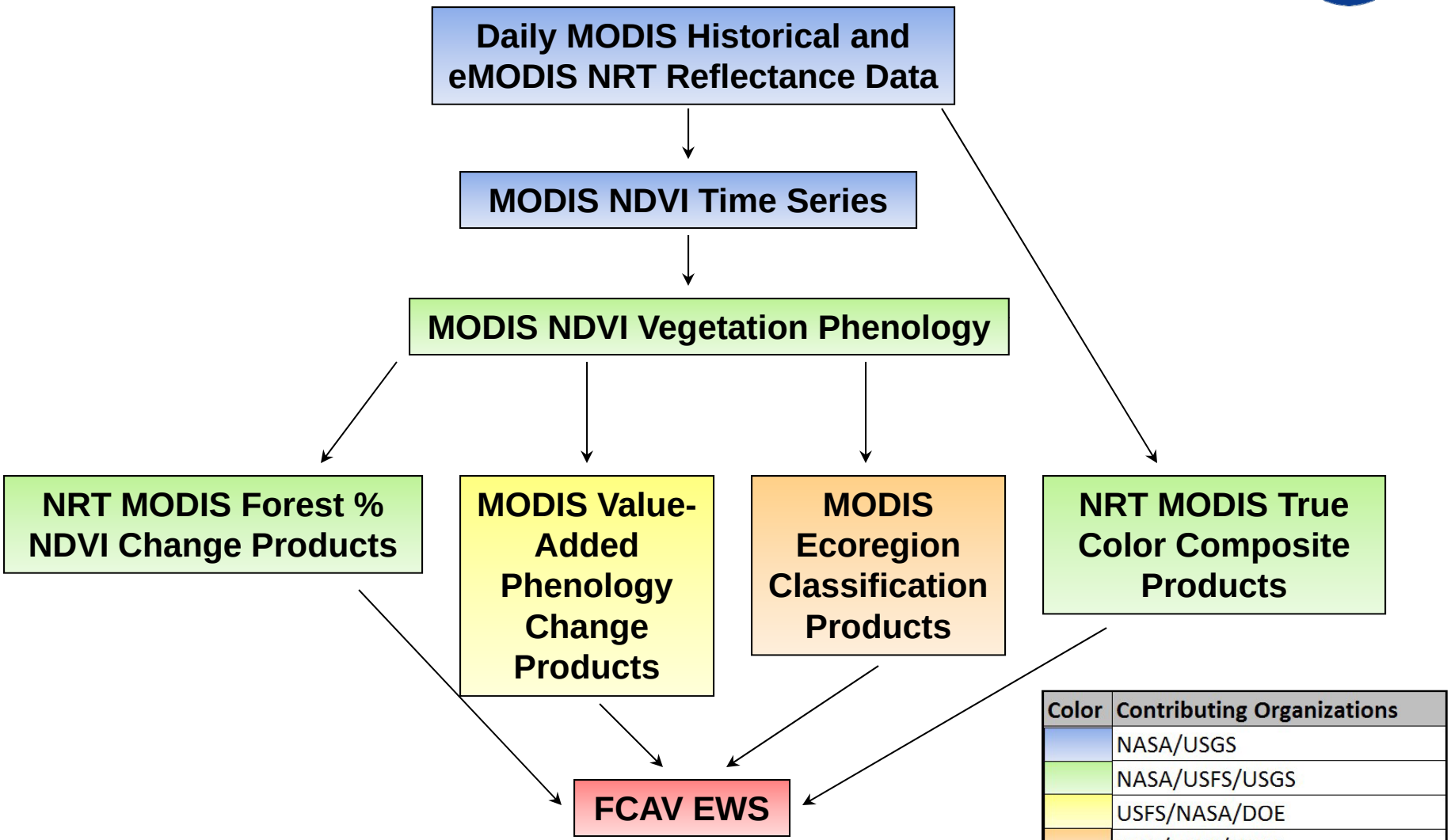


Extra Slides

MODIS Products for FCAV EWS Use



Product Development History

- 2006-2008
  - Conducted R&D to compute regional forest monitoring products
  - Began computing CONUS MODIS vegetation phenology products
  - Performed retrospective regional forest disturbance detection studies, based on MODIS NDVI phenology products
- 2009
  - Began NRT regional forest disturbance detection studies
  - Published PE&RS highlight article on initial NRT results
- 2010-2011
  - Weekly NRT CONUS forest disturbance detection products posted on multiple USFS prototypical EWS web mapping services, including the U.S. Forest Change Assessment Viewer (FCAV)
  - RSE publication - initial retrospective case study on use of MODIS NDVI for detecting regional forest defoliation from gypsy moths