Monitoring 2009 Forest Disturbance Across the Conterminous United States, Based on Near-Real Time and Historical MODIS 250 Meter NDVI Products

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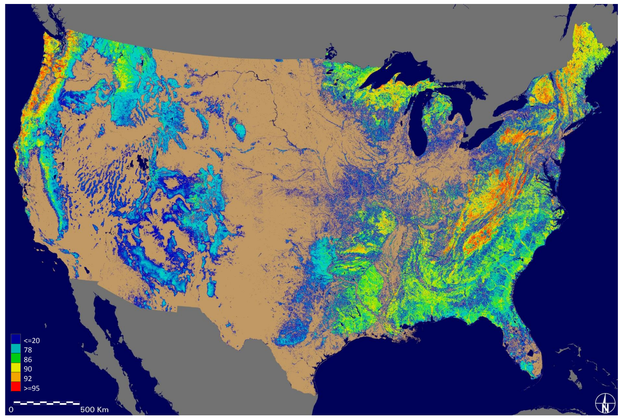

Figure 1. MODIS maximum NDVI of forests for June 10 – July 27 of 2000–2008, based on MOD13 data. Non-forested land and water areas are from a USGS 1992 NLCD product.

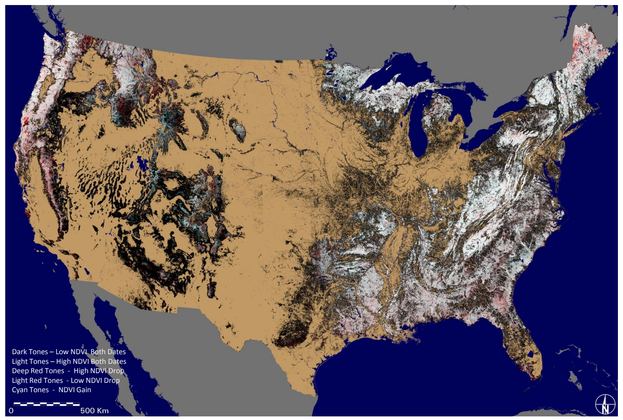

Figure 2. MODIS 2-date RGB depicting maximum NDVI of forests for June 10 – July 27 of 2000–2008 (red channel) versus 2009 maximum NDVI for same dates (blue and green channels).

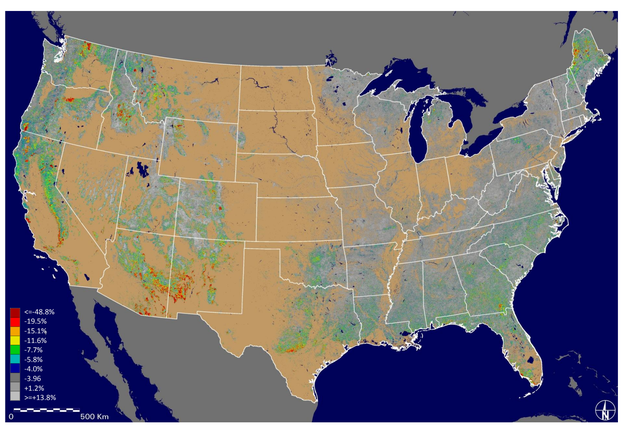

Figure 3. MODIS % change in maximum NDVI of forests for 2009 versus baseline 2000-2008 (June 10 – July 27 dates).

Introduction

- Forests occur on approximately 747 million acres of the United States, representing almost a third of the entire U.S. land base
- Such forests can be negatively impacted or threatened by disturbances from biotic and abiotic factors, some of which are associated with climate change (e.g., drought, fire, insect attacks)
- Temporally processed daily MODIS satellite data offers a potential means to monitor forest disturbances at broad regional to CONUS scales
- Current geospatial information on forest disturbances is needed as part of a national forest threat Early Warning System (EWS) being developed by the U.S. Forest Service (USFS) Threat Centers (Hargrove et al., 2009)
- In response, a study was conducted by NASA and the USFS to assess use of 250 meter MODIS NDVI products for the 2009 in-season detection of CONUS forest disturbances, based on MODIS time series data
- The case study discussed here is a subset of the Forest Threat EWS work discussed by Hargrove et al. (2009)
- This case study utilizes eMODIS expedited NDVI products for 2009 and historical MOD13 NDVI products for a comparative NDVI baseline

Methods

- Computed CONUS historical baseline from fused MODIS Aqua and Terra MOD13 maximum value NDVI for the June 10 – July 27 period of 2000–2008 (Figure 1)
- Composited CONUS 2009 maximum value NDVI for June 10 – July 27, using eMODIS atmospherically corrected products from USGS EDC – generated and revised during growing season as new products came available
- Stacked 2009 and baseline NDVI products, developing 2-date RGB for forest disturbance visualization (Figure 2)
- Shared initial products with prospective end-users during growing season of 2009
- Later calculated % change in NDVI product, comparing 2009 eMODIS NDVI to baseline NDVI (Figure 3)
- Also applied 2-date stack to compute preliminary CONUS forest disturbance classification product (Figure 4)
- Performed additional qualitative assessment of these products via comparisons with available reference data (USFS, Landsat, aerial, and other geospatial data) (Figures 5, 8, and 9)

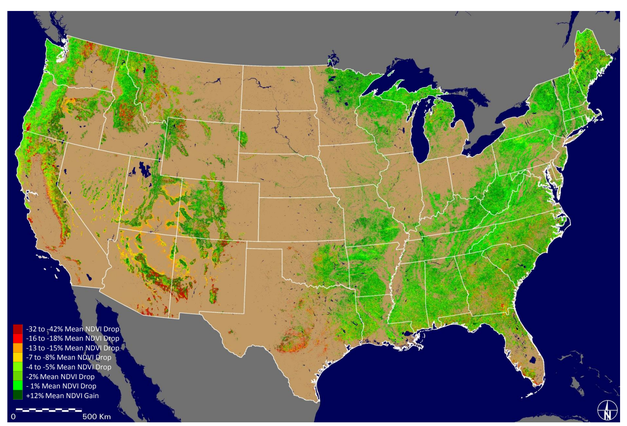

Figure 4. Preliminary CONUS forest disturbance classification for 2009, based on 2 channel MODIS maximum NDVI data stack shown in Figure 2.

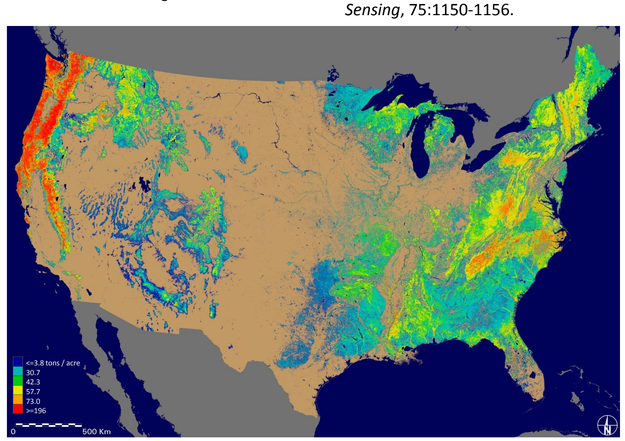

Figure 5. CONUS forest biomass based on 250 meter USFS Forest Inventory and Assessment product that integrates field surveys, 2003 MODIS, and other geospatial data.

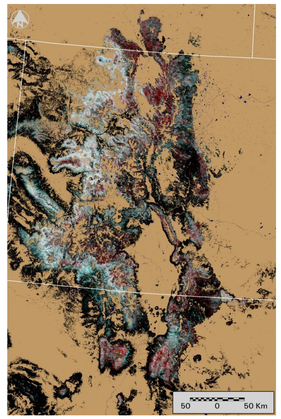

Figure 6. Enlarged subset of Figure 2 for Colorado Front Range.

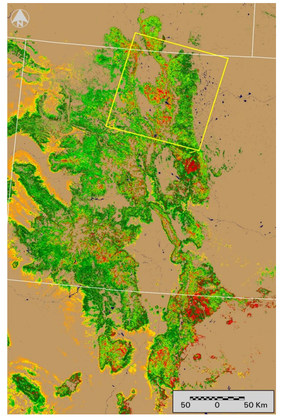

Figure 7. Enlarged subset of Figure 4 for Colorado Front Range.

Results and Discussion

- Produced multiple MODIS-based visualization products that depicted regionally evident forest disturbance patches associated with caterpillars, bark beetles, ice storms, wind storms, and wildfire
- These products show forest disturbance but not the date in which the disturbance first occurred – this could be addressed with additional work
- The % change in NDVI and the classification products clearly improved the visualization of change in low NDVI forests, compared to the 2-date NDVI RGB
- The classification product contains disturbance cluster classes that pertains to NDVI level and % change in NDVI. Severe disturbance (e.g., mortality) usually shows higher NDVI drops than ephemeral disturbance (e.g., caterpillar defoliation).
- The product may show false indications of NDVI drops when frequent bad weather occurs during the observed time frame. A potential example is for Maine, where it was unusually cloudy during the early summer of 2009.

Conclusions and Future Work

- This case study shows the promise of computing current season forest disturbance detection products at regional to CONUS scales. Use of the eMODIS expedited product enabled a NRT CONUS forest disturbance detection product, a requirement for an eventual, operational forest threat EWS.
- The 2009 classification product from this study can be used to quantify the areal extent of forest disturbance across CONUS, although a quantitative accuracy assessment still needs to be completed. However, the results would not include disturbances that occurred after July 27, such as the Station Fire.
- While not shown here, the project also produced maximum NDVI products for the June 10 – July 27 period of each year of the 2000–2009 time frame. These products could be applied to compute forest change products on an annual basis. GIS could then be used to assess disturbance persistence. Such follow-on work could lead to attribution of year in which a disturbance occurred.
- These products (e.g., Figures 6 and 7) may also be useful for assessing forest change associated with climate change , such as carbon losses from bark beetle-induced forest mortality in the Western United States.
- Other MODIS phenological products are being assessed for aiding forest monitoring needs of the EWS, including cumulative NDVI products (Figure 10).

References

- Hargrove, William W., Joseph P. Spruce, Gerald E. Gasser, and Forrest M. Hoffman (2009). Toward a national early warning system for forest disturbances using remotely sensed canopy phenology. *Photogrammetric Engineering & Remote Sensing*, 75:1150-1156.

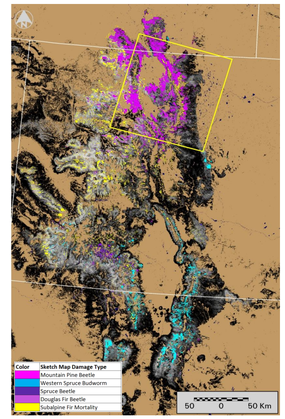

Figure 8. USFS sketch map of 2008 forest disturbances draped on Figure 6.

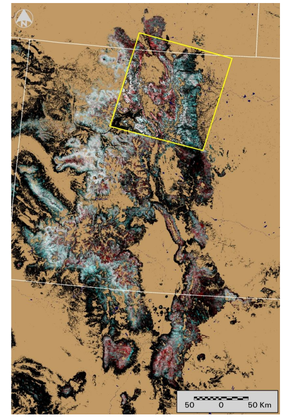

Figure 9. Landsat 2-date NDVI RGB - 8/1995 (red) versus 8/2009 (blue, green) – Landsat RGB overlain onto Figure 6.

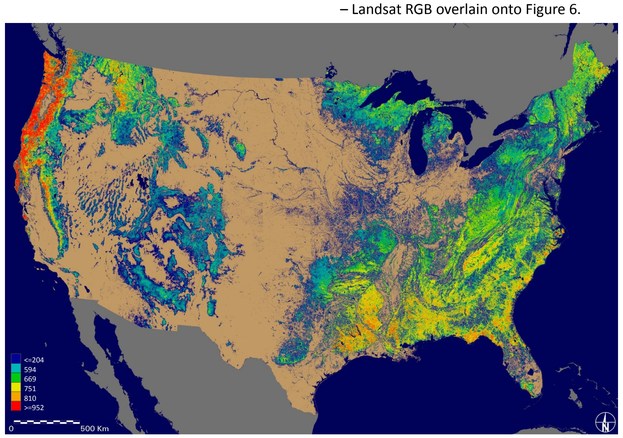

Figure 10. Example MODIS 250 meter phenological parameter product with potential for monitoring forest disturbance (e.g., 2007 cumulative NDVI for Julian days 1–192).