Improving Post-Hurricane Katrina Forest Management with MODIS Time Series Products

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ABSTRACT
Hurricane damage to forests can be severe, causing millions of dollars of timber damage and loss. To help mitigate these costs, state agencies require information on the extent, intensity, and timing of forest damage. NASA's MODIS Normalized Difference Vegetation Index (NDVI) time series data products offer a potential resource for state agencies to evaluate hurricane-induced forest damage and recovery across a forest region. In response, a project was conducted to produce and assess 250 meter forest disturbance and recovery maps for southeast Mississippi impacted by Hurricane Katrina. The products and capabilities developed were compiled and used to aid Mississippi Inventory and Forest Inventories (MIFI) timber inventory planning and to prepare for damage assessments due to future hurricane events.

BACKGROUND
• Hurricane Katrina was one of the most powerful and devastating storms ever to make landfall in the United States.
• It was also the costliest in U.S. history, causing estimated damages in excess of $180 billion.23
• The damage caused by Hurricane Katrina extended well beyond the Mississippi Gulf Coast region. Coastal Mississippi, especially in the Southeast Mississippi Inventory District (S-MID), was impacted by the hurricane.
• The products and data that were developed for this project are an example of how MODIS data can be used to aid forest resource planning and management.
• The products developed included 250 meter forest disturbance and recovery maps for areas in southern Mississippi impacted by Hurricane Katrina.
• These products were generated by comparing MODIS 'pre Katrina' data to post Katrina data, each time comparing the same annual Window.
• The pre Katrina MODIS was defined as the minimum NDVI of the years 2003 and 2004, normalized percentage change was calculated thus:
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  \text{Normalized Percent Change} = \left( \frac{\text{NDVI}_{03-04} - \text{NDVI}_{2005}}{\text{NDVI}_{03-04}} \right) \times 100
  \]

RESULTS
• The immediate poststorm change product shows evident regional impacts to forests (Figure 3) with the greatest negative NDVI changes in coastal and barrier island forest areas. Seventy-two NDVIs were noted in storm surge exposed forests. As expected, the areas closest to the coast tended to show more severe NDVI drops than others further from the shoreline. NDVI drops occurred in island forests where sustained winds were responsible for structural damage to the trees as well as blow down and gale damage; these effects are noticeable across the entire Mississippi southeast inventory district.
• Among the poststorm change products it was evident that the effects of Hurricane Katrina were far more severe than those associated with Hurricane Ivan 2004. The region affected by Ivan was smaller and the effects of Ivan were limited to the immediate coastal region.
• The most significant economic impact of the hurricane was the harvesting of damaged wood. The devastation caused by Katrina made much of the forested land in the southeastern United States unsalvageable. As a result, the United States Forest Service initiated the national emergency forest management program.

CONCLUSIONS
• Validation efforts support the technique of using MODIS-based NDVI percent change products to quantify the extent of Hurricane Katrina coastal forests. Furthermore, this technique can be extended to evaluations of other natural events to forestlands such as disease, insect and fire. While the spatial resolution of MODIS may be too coarse for some applications, the approach can be used to extract more spatially directed timber inventories with ground sampling. Since ground sampling timber inventory activities can be costly, this MODIS-based approach can significantly reduce costs by reducing time and labor.

REFERENCES

METHODOLOGY
• MODIS MOD13 Normalized Difference Vegetation Index (NDVI) 16-day temporal composite data were used to generate forest disturbance products.
• NDVI mean composite providing the benefits of eliminating cloud cover found in daily images as well as mitigating temporal noise.
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Figure 1: Study Area: The 15 Mississippi counties of MIFI Southeast Inventory District. The blue line is hurricane Katrina’s track on August 29, 2005.

Figure 2: Window 15 2005 disturbance map of the MODIS Southeast Inventory District for the years 2005 and 2006.

Figure 3: Composition of MIFI's Southeast Inventory District by age and forest type. These products were originally compiled from LIDAR data.

Figure 4: Comparison of the MODIS-based NDVI change classes for hurricane Katrina over the years 2003-2005. Refer to Figure 3 for damage class legend.

Figure 5: Composition of MIFI’s Southeast Inventory District by age and forest type. These products were originally compiled from LIDAR data.

Figure 6: Classification of the MODIS-based NDVI change classes for hurricane Katrina over the years 2003-2005. Refer to Figure 3 for damage class legend.

Figure 7: Composition of MIFI’s Southeast Inventory District by age and forest type. These products were originally compiled from LIDAR data.

Figure 8: Classification of the MODIS-based NDVI change classes for hurricane Katrina over the years 2003-2005. Refer to Figure 3 for damage class legend.

Figure 9: Measured MOIs 15 disturbed areas by damage class for Hancock County from 2005-2009, refer to Figure 3 for damage class legend.

Figure 10: Classification of the MODIS-based NDVI change classes for hurricane Katrina over the years 2003-2005. Refer to Figure 3 for damage class legend.

Figure 11: Classification of the MODIS-based NDVI change classes for hurricane Katrina over the years 2003-2005. Refer to Figure 3 for damage class legend.