# Impact of Wildfires on Albedo in Northern Sub-Saharan Africa

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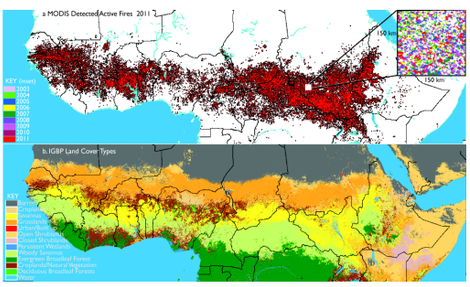
**Abstract:** Wildfires are recognized as a key physical disturbance of terrestrial ecosystems and a major source of atmospheric trace gases and aerosols, and can lead to changes in terrestrial carbon stocks and can affect the land surface energy balance through changes in albedo. Here, we estimate the darkening of surface albedo due to wildfires in different land cover ecosystems in the Northern Sub-Saharan Africa using data from the Moderate Resolution Imaging Spectroradiometer (MODIS) for the period 2003-2011. We determined a decrease in albedo after fires over most land cover types (e.g. savannas: (-4.19 ± 0.98)%), but an increase over only a few land cover types (e.g. barren or sparsely vegetated areas: (4.3±16.8)%) due to exposure of bright sandy soils. The albedo recovery progresses rapidly during the first year after fires, where savannas show one of the highest recovery (>77%) and decidous broadleaf, permanent wetlands and barren showing the least recovery (56%). The persistence of surface albedo darkening in most land cover types is limited to about six to seven years, where at least 98% of the burnt pixels recover to their pre-fire albedo.



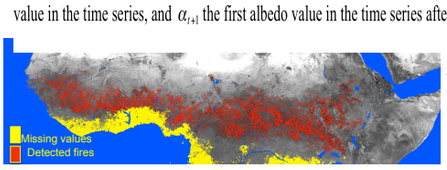

a. Spatial distribution of MODIS detected fires in 2011. A similar pattern was observed for each year between 2003-2011. The inset shows fire distribution for all the years (2003-2011) over a small area, 150 km x 150 km in Southern Sudan. Most fires occurred in the savannas and grasslands. b. Spatial distribution of the main types of land cover in the Northern Sub-saharan Africa. Barren or sparsely vegetated lands occupy the largest area (25%), followed by woody savannas and grasslands, each at 15%.

## Simple Gap Filling Method

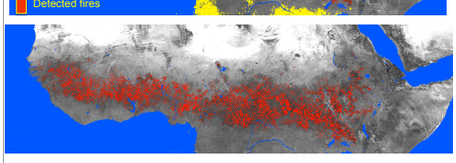
we developed a simple algorithm for producing temporally smoothed and spatially complete MODIS white-sky albedo data set. The new gap-filling algorithm first examines each pixel time-series for data gaps and then assigns it one of the five categories determined by the number of consecutive data gaps k in the time-series (k= 1, or 2, or 3, or 4, or ≥4 gaps). For classes with gaps k =1,…, 4, the missing values are determined from the following equation:

$$\alpha_t = \alpha_{t-1} + \left(\frac{\alpha_{t+1} - \alpha_{t-1}}{d_{t+1} - d_{t-1}}\right)(d_t - d_{t-1})$$

where $\alpha_t$ is the missing albedo value on a Julian day, $d_t$, $\alpha_{t-1}$ is the last existing albedo value in the time series, and $\alpha_{t+1}$ the first albedo value in the time series after the gap.

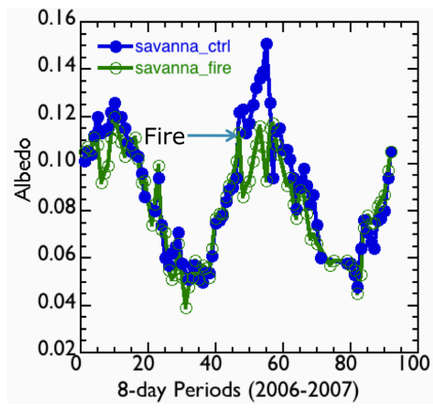



MODIS albedo with missing values in yellow (Dec 26, 2008).



Gap-Filled MODIS Albedo – Dec 26, 2008.

***Results:*** A majority of the missing values were determined from the above equation, but the method does not work well when there are more than four consecutive missing values in a time series. In this case, an attempt was made to use neighboring pixels to estimate the missing albedo value within a given window size (starting with the smallest (11 x 11) to the highest (121 x 121) window-size. If the algorithm finds no pixels within the maximum search distance (121 × 121 MODIS 500-m pixels), the missing value was replaced by a long-term average albedo derived from the 2003-2011 MODIS albedo of each land-cover type in the entire study region. To verify the efficacy of the new gap filling algorithm, we masked a part of the 'good' data, and found smallest errors for 1 gap (<1%) and largest errors for 4 gaps (<25%), which also depended on land cover type.

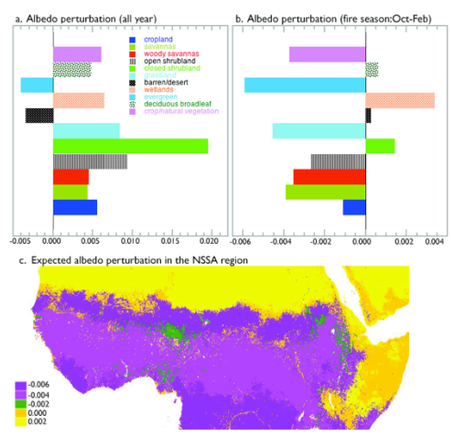



## Determination of albedo perturbation by wildfires

The albedo change caused by biomass burning was determined at the pixel level for each land cover type using the 2003-2011 MODIS albedo data record in the entire NSSA region on a monthly basis. A pixel was considered burned when an active fire was reported in the MODIS Level-3, 8-day daily active fire product (MOD14A2) at the 1 km grid cell and at all the fire detection confidence (low-confidence fire, nominal-confidence fire, or high-confidence fire). The decision to consider fires in all confidence classes was meant to boost the number of burnt pixels for some land cover types (e.g permanent wetlands and closed shrublands), especially during the non-fire season months. The albedo perturbation was defined by the difference between post-fire and pre-fire albedo of a given pixel.

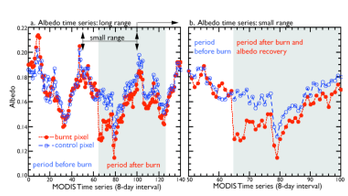
## Results of albedo Perturbation

The albedo perturbation averaged over nine years (2003-2011) varies by ecosystem type as depicted in (a). The relatively few fires during the northern hemisphere summer months cause an increase in albedo that is sufficiently large to dominate the annual average of the albedo perturbation for all fire events. However, since most fires occur between October and February in the NSSA region, (b), shows the albedo perturbation during the biomass burning season, where most land cover types now show a decrease in albedo after fires. c. shows spatial distribution of albedo perturbation if fires would burn everywhere in the NSSA region.

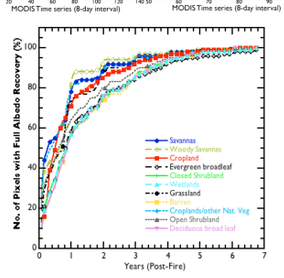



## Post-fire albedo recovery

This is deduced from the time it takes albedo to return to its pre-fire value. Our approach involves tracking albedo at the pixel level comparing both burned and unburned (control) cases for the same ecosystem. The unburned case was carefully selected from neighbouring pixels and same land cover type that show similar albedo characteristics over an extended period of time (at least two years), under similar conditions.




a. An example of albedo time series of a burned pixel (red line) and its corresponding control pixel (blue line) beginning 10 Feb 2005 to 2 Feb 2008. The gray-shaded area represents mostly the post-fire period. b. Same as a., but zooming into the post-fire period. The control pixel mim-ics how the burned pixel would have behaved without fire. Fire was de-tected on 26 June 2006 and its effect on albedo lasted for about 288 days.




Percentage of pixels burned in 2003 that has recovered by each subsequent year tracked over a period of seven years for different land cover types in northern sub-Saharan Africa. Points are plotted every 30 days.

*For more info: http://car.gsfc.nasa.gov/publications/ : Gatebe et al. 2012 - submitted to remote sensing of the environment*