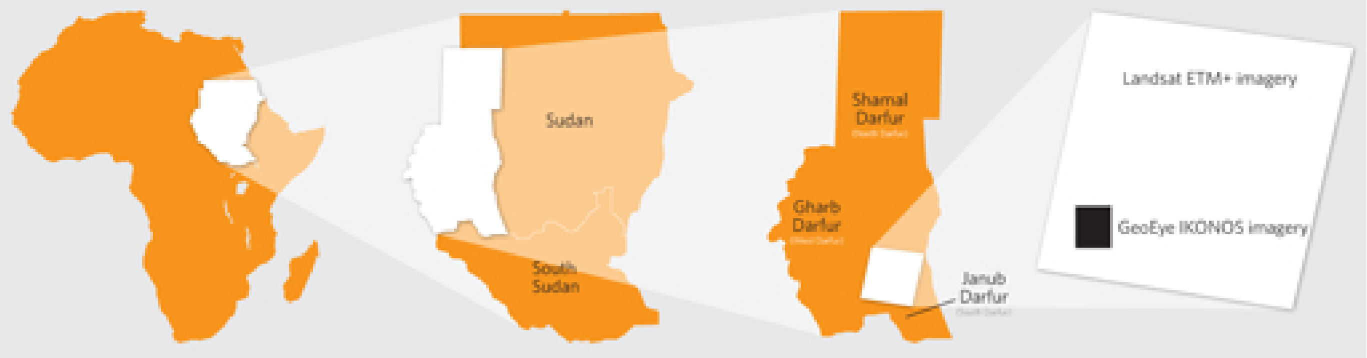
NO MORE HIDDEN SECRETS
HUMAN RIGHTS VIOLATIONS AND REMOTE SENSING

TOMMY O'CONNELL
DEPARTMENT OF GEOGRAPHY | SALEM STATE UNIVERSITY

ABSTRACT

One of the assumed problems with the failure of Western countries to respond to the genocide committed by the Nazis during World War II is that the "terrible secret" could have been prevented, or at least stopped, if there had been sufficient information. With the emergence of satellite imagery, large-scale human rights abuses are harder to keep secret. There are numerous studies on using remote sensing to study genocide and its effects, like refugee camps and burnt villages. This study tests three analytical methods on low and high resolution satellite imagery to verify reports on human rights violations in Sudan. Because huts are routinely burned down during attacks on a village, the remains of huts destroyed can be identified by comparing before and after satellite data. This process is normally a manual one, and this study examines semi-automated processes to determine if they can make this identification more efficient. Among the three methods, feature extraction appears to have some utility to hasten the manual process.



SATELLITE IMAGERY

High resolution imagery was obtained through a generous grant from the GeoEye Foundation, which provided IKONOS imagery (panchromatic and multispectral) for two days in September 2004 (before attacks) and one day in September 2006 (after attack). Pansharpened false-color infrared (NIR/R/G and NIR/R/B) imagery was created, as well as pansharpened true-color (RGB) data, with a spatial resolution of 1 meter.

Low resolution imagery was obtained through the USGS EarthExplorer, which provided Landsat ETM+ imagery for the region. The dates collected were October 17, 2000 and August 31, 2006. Pansharpened false-color infrared (Bands 4/3/2) and a pansharpened normalized burn ratio ((B4-B7)/(B4+B7)) were created, with a spatial resolution of 15 meters.

Processing was performed using ERDAS IMAGINE, Idrisi, and ArcGIS.

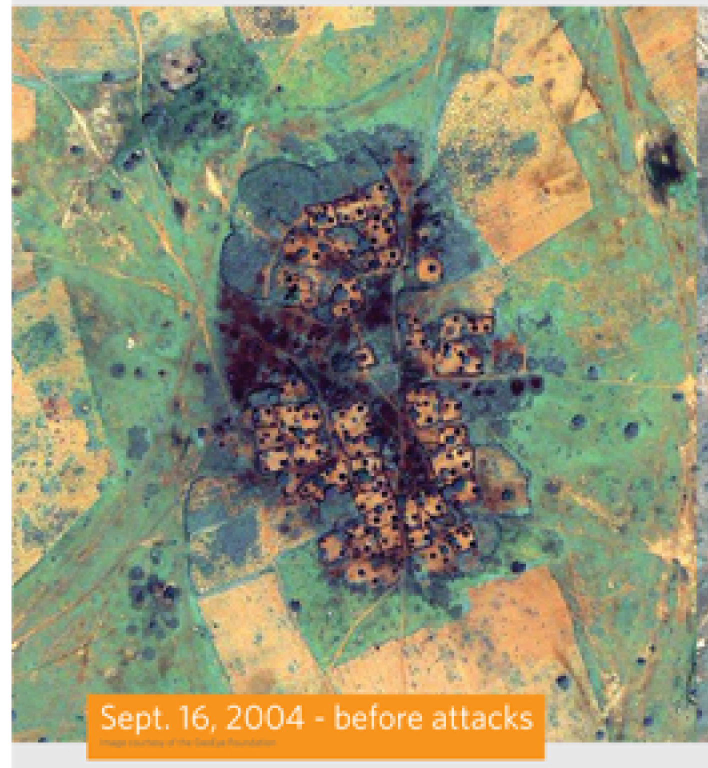
BACKGROUND

In the early 1990s, three tribes from the western regions of Sudan (the Masalit, Fur, and Zaghawa tribes) formed the Sudan Liberation Army, a rebel group that accused the Arab Sudanese government in Khartoum of oppressing non-Arab tribes and of neglecting the Darfur regions in the west. Protests occurred in early 2003, and the Sudanese government retaliated with aerial bombings of rebel strongholds and by using the Janjaweed, an Arab militia, to attack the tribes on the ground (BBC 2010).

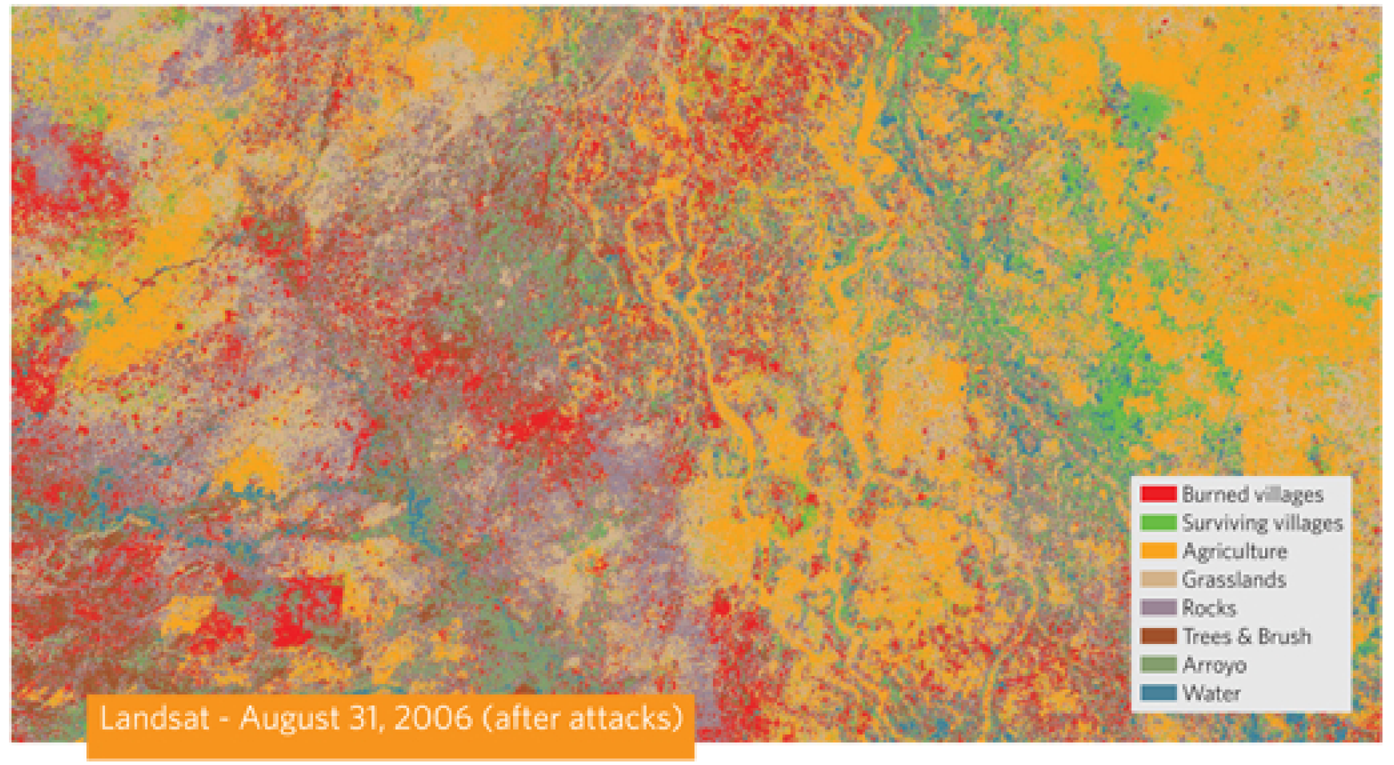
The Gereida area of Janub Darfur, south of the capital Nyala (pop. approx. 500,000), is home to the Masalit tribe. The Masalit live in a primarily agricultural society, growing peanuts, sorghum, millet, and other grains as both cash crops and subsistence (Joshua Project 2011). On February 16, 2006, 2,000 Janjaweed riders attacked and burned villages in the Gereida area. Thirty-three people were reported killed, and the rest fled as their huts were looted and then burned to the ground (Amnesty International 2007).


Village in South Sudan


Burned village in South Sudan


Sept. 16, 2004 - before attacks

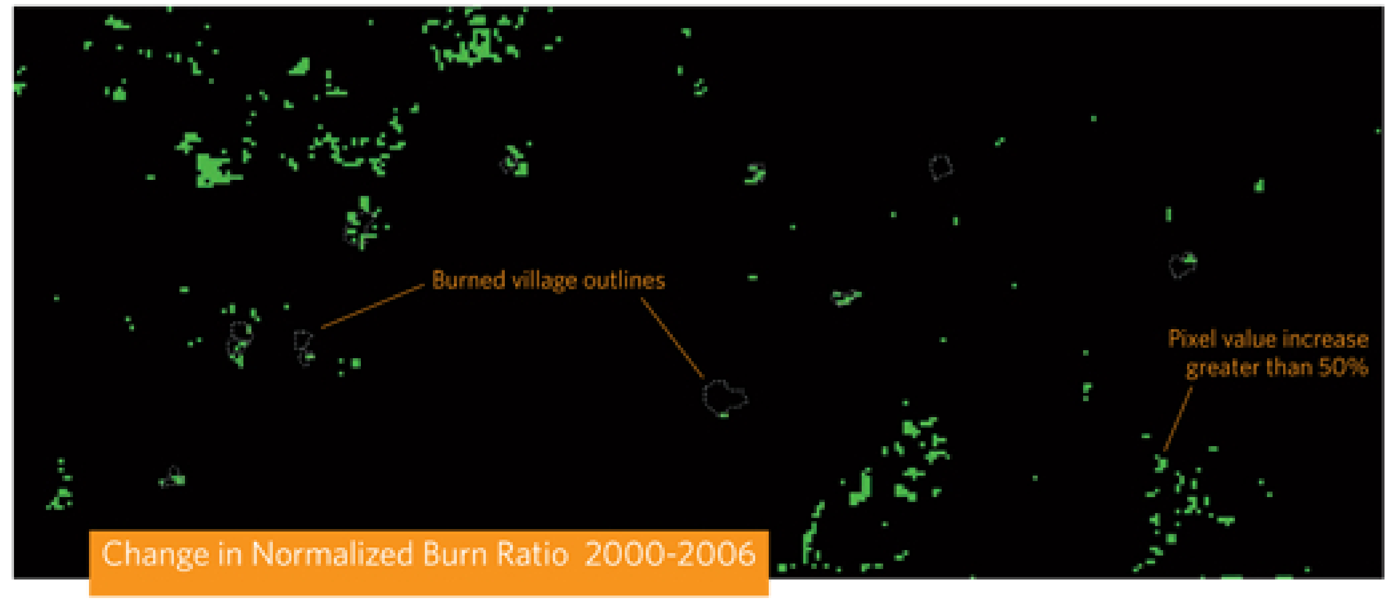

Sept. 8, 2006 - after attacks



Landsat - August 31, 2006 (after attacks)

CLASSIFICATION

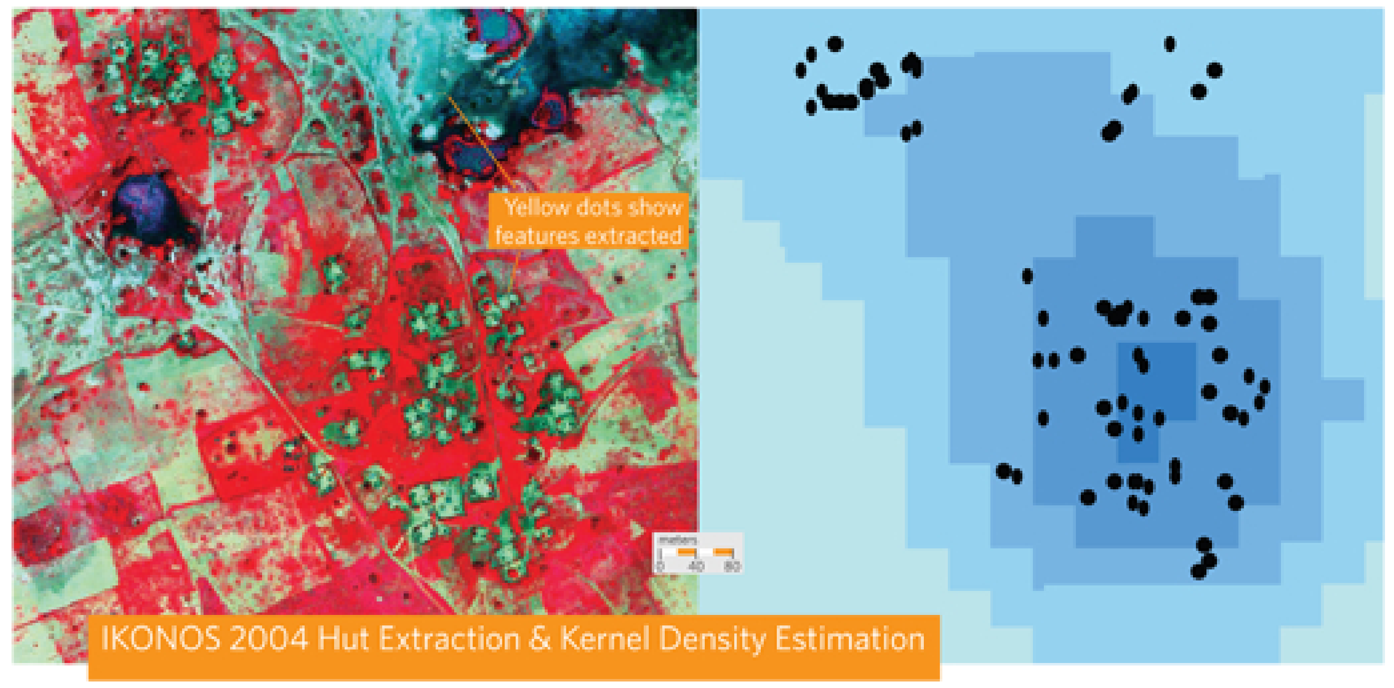
Data IKONOS (NIR/R/G and NIR/R/B) & Landsat ETM+ (4/3/2)
Methodology Performed three classification methods on imagery before and after the attacks – Maximum Likelihood, Minimum Distance, and Mahalanobis Distance. Training sites were created for villages, grassland, water, arroyo, trees, and rocky outcrops.
Results In general, village classification accuracy ranged from 45-78% using the Mahalanobis distance classifier, which resulted in the highest accuracy rates of the three classifiers. However, a large amount of false positives occurred, as 12%-36% of total pixels were classified as villages.



Change in Normalized Burn Ratio 2000-2006

CHANGE DETECTION

Data: IKONOS (NIR/R/G and NIR/R/B) & Landsat ETM+ (4/3/2 and normalized burn ratio)
Methodology Change detection was performed using ERDAS IMAGINE. Multiple percentage thresholds were applied (10%, 20%, 25%, and 35%) to test if any useful data resulted.
Results The IKONOS data had pixels change in different rates between the NRG and NRB data, however when polygon outlines of the villages that existed were layered over the results, no clear pattern emerged during the visual analysis. Landsat data had a high percentage of pixels change at all of the thresholds for the normalized burn ratio data, while the NRG data had very few pixels that changed. Visual analysis with village outlines proved inconclusive, as some villages clearly had changes and others had no change in pixel values.



IKONOS 2004 Hut Extraction & Kernel Density Estimation

FEATURE EXTRACTION

Data IKONOS (NIR/R/G and NIR/R/B)
Methodology Using the Feature Analyst module for ERDAS IMAGINE, huts were outlined with polygons as training sites, and the extraction process was run with two rounds of clutter removal and remove clutter by shape function. Resulting shapefiles were converted to points, and brought into ArcMap for analysis. A hand count of 3,190 individual huts and 78 villages was performed to create a baseline for accuracy calculations.
Results NRG had 83.89% of huts correctly identified, while having 34.09% false-positive identifications outside of villages. NRB had 47.43% of huts correctly identified, with 17.73% false-positive identifications. When the kernel density module was conducted, villages can be visually identified by the clustering of identified huts. As no villages survived in the imagery from 2006, feature extraction could not be performed on that data.

CONCLUSION

When using satellite imagery to confirm human rights violations, feature extraction appears to be a useful tool in narrowing down areas where villages may exist. While change detection proved inconclusive, data may have been inadequate due to the fluctuation between rainy and dry seasons. In 2000 the Darfur region experienced a drought (which was confirmed using TRMM data analysis) and between 2000 and 2007 rainfall remained at relatively low levels, and the rainy season shortened by two months from May-September to July-August (Yale University Genocide Studies Program 2009). This decrease can skew the data, and any analysis may be inconclusive. Supervised classification of the huts had poor results, and part of this may be due to the fact that hut roofs are constructed with grass and branches, which would have similar spectral signatures as the area surrounding the village (Sulik and Edwards 2010).

Contact Information t_oconnell2@salemstate.edu tboconnell@gmail.com

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All High Resolution Imagery provided by GeoEye Foundation