Application of satellite imagery to monitoring Human Rights abuse of vulnerable communities, with minimal risk to relief staff

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Abstract. Space imagery offers remote surveillance of ethnic people groups at risk of human rights abuse. We highlight work in alleged violations in Burma and Sudan, using satellite imagery for verification with Amnesty International. We consider how imaging may effectively support small to medium-sized Non Governmental Organisations and charities, e.g. HART, working in dangerous zones on the ground. Satellite based sensing applications are now at a sufficiently mature stage for moderate Governmental funding levels to help prevent human rights abuse, rather than the greater cost of rebuilding communities and healing sectarian divisions after abuse has taken place.

1. Introduction
Climate change will increase the frequency of regional ethnic or resource driven conflict. A vital challenge for confirming Human Rights (HR) abuse allegations is quick response to reports, often without a precise location, gathered under difficult conditions. Lack of information on size of affected areas, distribution and numbers of people affected hinders effective timely response by the international community or general public. Situations are complicated by the unwillingness of governments’ to allow Non Governmental Organisations (NGO’s) and Inter Governmental Organisations (IGO’s) access to verify conditions or provide humanitarian relief on the ground as
evidenced by recent Cyclone Nargis in Burma (2008). However, prevention is better than cure. Using existing high resolution satellite imagery archives to supplement other verifiable data, e.g. eye-witness reports, helicopter and UAV flights etc., may provide a vital tool for assessing dwelling or population number changes, and detailed maps for key resource access and management: water, shelter food, etc. Space imagery may offer the role of ‘global monitor’ for at risk people groups. Ground NGO work is assisted by detailed satellite imagery and map access. Funding levels required to support ‘satellite policing’ is less than that required to support troops or humanitarian aid staff undertaking large-scale post-conflict infrastructural rebuilding projects.

2. Methodology

Photographs taken from aircraft, balloons or kites generate post-disaster images. Collection is expensive and time consuming, relying on government permission. Conflict zone flights place pilots or humanitarian staff in unnecessary danger, especially if ground forces don’t want their operations seen, potentially by a hostile global press. In some cases satellite imagery is the only recourse as NGO’s are effectively ‘barred’ from areas, even on the context of risk to their own safety. Conflicts like Darfur are high risk areas for ground personnel. In Nov. 07 13 UN and NGO vehicles were hijacked, 74 aid convoys attacked, a total of 128 vehicles hijacked in 2007. High resolution satellite imagery is suggested to monitor HR abuse. Since 2000 we have imagery of sufficient resolution to benefit aid agencies, although costlier than aerial photography.

Historically sensitive imagery was solely in the military domain and difficult to disseminate due to security classification. There is now access to US Cold War military satellite data, e.g. Corona series, as well as new commercial providers with ≥1m resolution providing ‘swords into ploughshares’ technology for various civilian applications. Quality imagery is available from 3 satellites, OrbView-3 and Ikonos operated by Geo Eye www.geeoeye.com and Quickbird (0.6m resolution) operated by Digital Globe. OrbView-3 (2003-Mar-‘07) had 1m panchromatic B&W and 5m multispectral resolution. OrbView-3 provided panchromatic image products, $10-20/km² (1m), to view houses, vehicles and generate digital maps.

Multispectral imaging can typically provide colour and near infra red data to characterise urban/rural areas, and land management change. Ikonos is a multispectral (colour) satellite with 1m panchromatic resolution (B&W), launched Sept 1999, with 4 bands (blue 0.45-0.52, green 0.52-0.6, red 0.63-0.69 & Near Infra Red (NIR) 0.76-0.90µm). Band combinations generate false colour images.1m panchromatic & 4m multispectral bands produce 1m resolution colour-merged products in terrestrial coastal multispectral imaging with channels similar to Landsat 4-5 Thematic Mapper ™ Bands 1-4. Minimum Ikonos order is 49km² 7x7km² with a minimum order at $9.8k US for new images 10x10km² costing $3500. QuickBird (0.6m resolution operated by Digital Globe) has the best resolution but a smaller archive. True colour composites are used but NIR data is available. Quickbird provides standard imagery at $18/km². The UN Operational Satellite Applications Programme UNOSAT provides satellite imagery and maps to IGOs and NGOs for early warning, crisis response, relief, sustainable recovery & vulnerability reduction. Rapid mapping in disaster management and relief, co-ordinated from Geneva operates round the clock. UNOSAT has experts or field partners to
verify products. UNOSAT maps are produced from public sources (e.g. figure 1) including imagery from high resolution sources like Ikonos, but most are not e.g. SPOT or Landsat in thematic environmental change maps. It isn’t a complete high resolution database but is a useful starting reference unosat.web.cern.ch Imagery provides GIS layers for users. Free products exist, but are limited in geographical extent.

Imagery of disaster monitoring has only produced a few papers. Of 317 International Journal of Remote Sensing papers (Jan 06-Dec 07) there were just 18 papers related to humanitarian disasters (incl. 13 on the 2004 Tsunami in a single issue), and only a few related to satellite imagery, with one covering Sudanese refugee camps using a kite system. A benefit of satellite imagery could be at the ‘whistle-blowing’ stage, before major HR crises develop, or during crises for timely IGO pressure and intervention, and after a crisis to bring perpetrators to account for verified abuse. We will discuss how satellite data aids HR monitoring and safeguards NGO relief staff.

3. Results

Satellite image analysis of Eastern Burma is available from the American Association for the Advancement of Science (AAAS) looking to corroborate reports gathered by field organisations with high resolution case studies on global trouble spots. Burmese data is found in a comprehensive report released Oct. 2007 [1] and detailed recently in other Sudanese locations [2]. Eye-witness reports are checked where possible with satellite imagery to corroborate attacks on civilians for locations with known latitude and longitude. Typical characteristic activities are noted: Village and Structure Removal, Structural burn scars, Relocated and Cleared villages, Expansion of military camps, Agricultural abandonment, and People relocated into camps over borders. Removal and abandonment reasons may not be apparent from observed structural removal, but systematic burning is compelling hostile evidence if combined with verbal ground reports to strongly indicate abuse. However, there isn’t always a ‘before’ image as high resolution imagery wasn’t available before 2000 or if imaging conditions are cloudy or dark. Key features with ‘Before and After’ imagery allows changes e.g. burnt villages to be identified. Visual comparison of new with old imagery in areas of reported abuse can be tested. Villages and structures may be removed by bulldozing or fire, and new military compounds added. Identifying motives behind building or structural clearance isn’t always clear. Land management change, e.g. agricultural or village abandonment, may be identified but reasons for abandonment mustn’t be assumed. Data from other multispectral and hyperspectral imagery sources will assist this detective process, but sadly in extreme cases we can clearly see the affects of Land Clearance in the Porta Farm Region (Zimbabwe June-July 2005) from satellite imagery provided by the GeoEye Foundation (figure 2a and figure 2b).

Figure 2a Before clearance 0.7m resolution After clearance Figure 2b ©GeoEye Foundation 2009.

One NGO, HART (Humanitarian Aid Relief Trust) www.hart-uk.org provides aid to local Burmese partners and those suffering persecution, sensitive to cultural and religious values. HART focuses on those not served by major Aid Agencies but are trapped behind closed borders. HART is committed to: assessing and providing aid, gathering first-hand evidence of oppression, and humanitarian needs. HART makes known the needs of those who are suffering to the House of Lords, US congress, and is accountable to HART’s supporters. Satellite imagery can provide accurate ground mapping ability, saving time and
potentially lives. In Burma HART supports medical or educational projects such as orphanages, clinics, schools or backpack medicine on the Thai and Indian borders working with displaced refugees from Shan, Karen, Karenni or Chin states. High resolution mapping/imagery will help HART achieve its objectives by reducing flight and ground trek times to reach critically sick patients or find out where key ground problems are. Imagery allows at risk areas to be quickly targeted with aid, rapid authentication, and for staff to evaluate their own safety. Medical support is important in such conflicts as common disease vectors arise; a recent report [3] showed malaria parasite *plasmodium falciparum*, in a large % of population in the East Burma conflict areas by comparison with a low % in neighbouring Thailand, notably amongst children. A further threat to Internally Displaced People (IDPs) is Land Mine deployment in Burma, whose military forces and opposition use mines extensively throughout this long running civil war. Satellite based sensing of Burmese minefields is a proposed future research target.

4.2 Sudan

In Central Equatoria, HART supports health clinics to improve medical facilities for vulnerable, rural people. HART is active in Uganda, Nigeria, East Timor and Armenia. Dangerous Sudan overflights require ground information, the ‘ground truthing’ talking to eye witnesses. Targeting key satellite identified areas, avoids unnecessary danger zones, and identifies areas of attack, with the same risk factors as in Burmese operations. Amnesty International AI also has satellite cameras to monitor vulnerable villages in war-torn Darfur. AI’s organisation’s monitoring is seen at the Eyes on Darfur website (www.eyesondarfur.org), representing a bold new HR approach to warn the Sudanese government that regions inside Sudan are being observed from outside.

Donkey Dereis in Southern Darfur, 2004 had hundreds of huts, but in 2006 images shows 1000+ homes gone and a landscape overrun with vegetation figure 3. Political conditions in the Southern Sudan are once again of concern, in spite of a comprehensive peace settlement, with the recent ICC action to indite President Bashar of Sudan for failing to prevent militia attacks, and acute low rainfall in late 2008 (lower than the norm for the time of year). There is little rain annually in the spring (Jan-April) throughout Sudan. In spite of the apparent green hue observed in Nile regions such as Malakal viewed in moderate resolution (2.4m) with imagery provided by DMC International Imaging via the TopSAT consortium figure 4, with unfortunate consequences for relocated Internally Displaced People in this region. Current work is comparing 2.4m data with IKONOS 0.7m resolution data.
5. Analysis

The ‘Eyes on Darfur’ web project may maximise public awareness or gain financial support, but requires funding ‘at risk’ imagery updates- costly for organisations without the financial resources of the UN. A solution is to provide accessible shared archives of free/low cost imagery for HR monitoring, ‘baseline’ imagery which NGOs use strategically and safely to authenticate abuse or provide aid effectively. Free imagery for relief is available via the Geo Foundation, for some qualifying humanitarian organisations, but there is the danger that the timeline from image request to acquisition makes most relief information perishable. GeoEye’s satellite imagery archive of over 278M km² of map-accurate imagery will be a vital data source. Archive imagery requests are reviewed by a Foundation Advisory Committee. Imagery is given to support target research or environmental projects over specific areas. Most awards are a few 100km² on a case-by-case basis. Darfur’s relief operation costs in 2008 are estimated at $825M US, in a conflict with 200,000+ dead and 2.5M IDP’s driven from their homes since 2003. Compared with abuse costs in conflicts or reconstruction, satellite data is valued for HR activities. We are also in the process of comparing the imagery of Malakal taken with both lower resolution TopSat satellite and also with the higher resolution GeoEye Foundation data.

Imagery must convince. Is there an abuse report at a specific latitude/longitude? Are there other likely reasons for observed people movement, e.g. soil degradation, leading to abandonment? Are we comparing like for like? Visible images compared with another NIR may not be appropriate e.g. Red/NIR views show similar yet dissimilar detail [4]. Direct imagery comparison between satellites even in the same band is often simplistic. Previous work fused terrestrial acquired visible: NIR: and thermal data scaled to give the same pixel number (spatially co-registering image points of different resolutions to create the same pixel number in a region) [4]. Heat imagery is lower resolution compared with visible or NIR images. Similar fusion of Ikonos imagery was tested with airborne Lidar data re-sampled to the same ground interval as Ikonos images [5]. In both cases registration of 2+ channels must occur before classification, as mis-registration affects classification. Fused NIR channel imagery with visible data evaluated observer perception [4]. Heat imagery validates dwelling occupancy by noting radiated heat, which although of poor resolution provides ‘hot spots’ for correlation with visible/NIR imagery. Fused thermal imagery ‘filters’ occupancy represented in colour composites. Regarding different times of acquired views, is lighting similar or is there disproportionate shadow? We may see building outlines on an early image, which is not apparent in later imagery, leading to the misconception that buildings are gone, confusing ground damage earthquake assessment, so line/edge features and improving contrast will form a critical part of signal processing. Environmental considerations include: cloud cover, night and revisit delays to time sensitive monitoring. Microwave and to a lesser extent thermal systems are cloud penetrating or night capable. Active microwave resolution is better than passive systems and a rapid military declassified data stream would be valued. At BRNC we are looking at small changes between images for increased sensitivity and are using multispectral astronomy imaging processes on each pixel to improve resolution. Mine-field detection is proposed as a future target research area, via ISIS and IDL astronomy processing techniques as is comparison of 2.4m imagery with 0.6m resolution imagery of the Malakal site.

6. Conclusions

High resolution commercial satellite images reveals evidence of violations if combined with eye-witness accounts of abuse in inaccessible regions. Imagery in the Court of International Law may help prosecute fundamental human rights abuse. Space imagery provides practical benefits to HR ground staff, e.g. our research partner HART, and other NGO organisations such as Release International, allowing imagery to be co-ordinated with staff needing current data in changing hostile conditions to be established. The Eyes on Darfur site is a practical way to present high risk problems to a global audience, maintaining pressure to preserve life. The method is applicable to many ethnic crises, but website development for every humanitarian crisis is beyond the scope of one group. Activity coordination, with the UN taking the lead, may achieve economies of scale. Imagery costs, for Governmental users although high, is low compared with the cost of redevelopment after ethnic clashes or the spread of regional instabilities, either politically or economically.
7. Acknowledgements

The authors would like to thank the TopSat Consortium and DMC II for supplying imagery and advice freely, and an imagery award from the GeoEye Foundation, which has very rarely been made outside of the United States of America and Eli Doerr with her help in preparation of the GeoEye award applications. The authors would also like to thank Ms Suzanne Trimel of the US Amnesty International Office for permission to use the Darfur image of Donkey Dereis.

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