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# Observing power blackouts from space - A disaster related study

C. Aubrecht (1), C.D. Elvidge (2), D. Ziskin (2), K.E. Baugh (2), B. Tuttle (2), E. Erwin (2), and N. Kerle (3)

(1) Austrian Research Centers - GmbH, systems research, Vienna, Austria (christoph.aubrecht@arcs.ac.at, +43 50550 4599), (2) National Oceanic & Atmospheric Administration (NOAA), National Geophysical Data Center (NGDC), Boulder, CO, USA, (3) International Institute for Geo-Information Science and Earth Observation (ITC), Department of Earth Systems Analysis, Enschede, The Netherlands

ABSTRACT

In case of emergency disaster managers worldwide require immediate information on affected areas and estimations of the number of affected people. Natural disasters such as earthquakes, hurricanes, tornados, wind and ice storms often involve failures in the electrical power generation system and grid. Near real time identification of power blackouts gives a first impression of the area affected by the event (Elvidge et al. 2007), which can subsequently be linked to population estimations. Power blackouts disrupt societal activities and compound the difficulties associated with search and rescue, clean up, and the provision of food and other supplies following a disastrous event. Locations and spatial extents of power blackouts are key considerations in planning and execution of the primary disaster missions of emergency management organizations.

To date only one satellite data source has been used successfully for the detection of power blackouts. Operated by NOAA's National Geophysical Data Center (NGDC) the U.S. Air Force Defense Meteorological Satellite Program (DMSP) Operational Linescan System (OLS) offers a unique capability to observe lights present at the Earth's surface at night. Including a pair of visible and thermal spectral bands and originally designed to detect moonlit clouds, this sensor enables mapping of lights from cities and towns, gas flares and offshore platforms, fires, and heavily lit fishing boats. The low light imaging of the OLS is accomplished using a photomultiplier tube (PMT) which intensifies the visible band signal at night. With 14 orbits collected per day and a 3.000 km swath width, each OLS is capable of collecting a complete set of images of the Earth every 24 hours. NGDC runs the long-term archive for OLS data with the digital version extending back to 1992. OLS data is received by NGDC in near real time (1-2 hours from acquisition) and subscription based services for the near real time data are provided for users all over the world.

Elvidge et al. (1998) first demonstrated that under certain conditions a detection of power outages is possible using OLS data. A standard procedure for visual detection of power outages has been developed. The procedure is based on identifying locations where consistently observed lighting is missing or reduced following a disaster event. Visible and thermal spectral bands of the event-related OLS data are compared to a recent cloud-free composite of nighttime lights by producing a color (RGB) composite image. For the cloud-free nighttime lights composite serving as reference information both monthly and annual composites can be used, depending on the respective availability and suitability of OLS data. The RGB color composite uses the reference lights as red (R), the current visible band as green (G) and the current thermal band as blue (B). The thermal band is typically inverted to make clouds appear bright. As clouds are typically colder than the surface of the Earth, in the thermal band higher values are observed on cloud-free areas, which thus appear brighter in standard visualization modes.

The resulting color composite is visually interpreted to identify power outages, which show up as red lights on a dark (cloud-free) background. Red color stands for high values in the reference data (red band of the RGB composite) compared to low values in the event data (green and blue bands of the RGB composite), thus showing the disaster-related absence or reduction of lighting. Heavy cloud cover also obscures lights, resulting in red lights on a blue background. Yellow color in the RGB composite indicates areas where the lights are on, i.e. both red and green band (reference composite and visible band of the event image) feature high values with no cloud cover present (low values in the blue band). Under ideal conditions the presented procedure detects individual cities and towns where power has been lost or has been reduced. Conditions reducing or eliminating the capability of detecting power blackouts in OLS data have been identified (e.g. sunlight, heavy cloud cover and bright

moonlight). Furthermore, the change detection procedure only works when power blackouts happen or still persist at night at the time of an OLS overpass.

In some cases (e.g. Hurricane Katrina) it has been possible to track the gradual recovery of power by repeating the procedure on nights following a disaster event. In this paper several examples of successful power blackout detection following natural disasters including hurricanes (e.g. Isabel 2003 and Wilma 2005 in the USA) and earthquakes (e.g. Gujarat Earthquake 2001 in India) will be presented, whereas overlaid hurricane paths and earthquake epicenters serve as landmarks and indicate locations around the potential highest impact.

Disaster impact assessment and post-disaster research is strongly related to impacts on population, related infrastructure and activities (Kerle et al. 2005, Zhang and Kerle 2008). In particular in the case of emergency management and response humans are the main actors and first-pass assessment of affected population and locations of affected areas are essential. Space-based power blackout detection, as described above, has the potential to delineate the spatial extent of the disaster impact. Overlaying the respective OLS data with regional population data such as LandScan (Dobson et al. 2000) or Gridded Population of the World (CIESIN and CIAT 2005) allows estimating a potential number of affected people. Without a doubt such estimates comprise a considerable number of uncertainties. However, the capability of providing the information in near-real time as offered by using DMSP-OLS makes the presented approach very valuable for emergency and disaster managers worldwide.

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