FLORENCE AFTERMATH

Can the Power Outages Be Seen from Space?

By Chris Elvidge, Kimberly Baugh, and Morgan Bazilian
September, 2018

TRACKING ENERGY DISRUPTIONS

The U.S DOE is regularly issues status reports about the impact of Hurricane Florence on the energy sector. They outline six steps for addressing power outages ranging from generating plants, to transmission, to essential services and homes. Report 11, issued on the morning of September 18th, notes: “North Carolina: 341,509 customer outages (6.9%) – Decrease of 24% since last report; South Carolina: 2,743 customer outages (<1%) – Decrease of 70% since last report; Virginia: 6,136 customer outages (<1%) – Decrease of 30% since last report.” The associated map is found in Figure 1.
The EIA (an agency of the DOE) also maintains an energy disruptions website. The impact on the load beginning on the 14th of September, across Duke Energy service areas near Wilmington, NC can be seen in Figure 2, along with the generation fleet response.
THE VIEW FROM SPACE

We consider satellite power outage detection following Hurricane Florence. One of the consequences of many natural disaster are power outages, which result in losses in electric lighting that can be detected with low light imaging data. The image here is from early in the morning of September 18, several days after landfall. The image shows clouds as blue, based on the long wave infrared radiance. City lights unaffected by the storm are a golden color. Red indicates the anticipated light was not detected and is an indication of power outage. Magenta indicates that the detection of the light is blocked by cloud.

Figures 3, 4, 5, and 6 provide an overlay of the VIIRS day / night band (DNB) and long wave infrared (LWIR) over the VIIRS reference lights from the preceding month. Clouds show up as blue, from the LWIR. Lights detected last night are yellow. Red are possible power outages.

*Charlotte, NC shows power outage on the northwest side.*
Charleston, SC shows a broken pattern of outages (red) near shore, but power is on further inland.

Power is out in Asheville, NC (red) (upper arrow)
Greenville, SC lights are on in the city center and there are outages in outlying areas.
Charlotte, NC lights are on in the city center and outages are most pronounced on the west side.

![Image of DNB and LWIR overlay](image)

By providing up-to-date spatial inventories of human activities and their consequences, remote sensing is increasingly used for public policy applications. During daytime remote sensing is ideal for the observation of the earth surface from space using solar illumination, such as the photosynthetic state of vegetation and human built infrastructure. At night, key radiant emissions resulting from human activities are best observed; this includes electric lighting observable in the visible and infrared emissions from fires, flares, and industrial sites.

It has been known for many years that power outages can be observed by satellite sensors capable of observing electric lighting at night. Elvidge et al. [1] developed the first formalized approach for the detection of power outages using before and after images to identify power outages for specific events. This method was subsequently followed by a number of investigators. In general, the technique involves the comparison of a subject image containing outages with a reference image deemed to be free of outages. Techniques based on individual images break down in cases where cloud obscuration prevents the clear observation of the lights in either the subject or reference image. We propose to build on these previous studies to develop indices of power stability that can be routinely updated worldwide.
ABOUT THE AUTHOR

Christopher D. Elvidge has 23 years of experience with satellite low light imaging data, starting in 1994. Initially this was with data collected by the U.S. Air Force Defense Meteorological Satellite Program Operational Linescan System. From 2012 forward, the effort has been with data from NOAA’s Visible Infrared Imaging Radiometer Suite. Elvidge pioneered the development of global nighttime lights and lead the production of a 21-year time series of global DMSP nighttime lights (1992-2013). His nighttime lights from DMSP and VIIRS are now a widely used satellite data product in a diverse range of fields, ranging from biology, urban sciences, economics, and astronomy. Elvidge was instrumental in establishing the DMSP digital archive at NOAA and lead the media migration needed to retain the digital records.

Starting in 2000, he led the development of near-real time data services for satellite derived low light imaging data. Initially this was the provision of nighttime DMSP suborbits to fishery agencies in Japan, Korea, and Thailand. These early near real time services evolved in the VIIRS era to SMS and email alerts for the detection of boats in Marine Protected Areas and restricted coastal waters in Indonesia and Philippines. In 2012 Elvidge conceived of and lead the development of a global multispectral nighttime fire product known as VIIRS nightfire using a combination of near-infrared, shortwave infrared and mid-wave infrared channels. VNF uses physical laws to calculate the temperature, source area, and radiant heat of combustion sources. VNF is the only global fire product reporting temperature and source area on 24-hour increments. The inclusion of SWIR bands results in an ability to construct global surveys of gas flaring sites and estimate flared gas volumes. Approximately 12,000 flaring sites are identified worldwide every year by Elvidge’s team.

In 2014, Elvidge developed methods for discriminating flaming and smoldering combustion using nighttime Landsat data. This distinction is significant for modelling smoke production. Also in 2014, Elvidge developed a nighttime boat detection product for VIIRS. These data are now used by fishery agencies Japan, Korea, Vietnam, Cambodia, Thailand, Indonesia and Philippines. Elvidge has been actively publishing papers since 1978. As of February 2018, he has more than 11,000 scholarly publication citations.

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