

## Satellite Data Captures Power Outages in Sudan's Civil War

By Mikhail Zhizhin, Kristin Ziv, Christopher Elvidge, and Morgan Bazilian

### *Background*

A horrible [full-scale civil war](#) in Sudan is creating chaos, anarchy, mass starvation, and the world's largest population of internal refugees – approximately [nine million](#).

Still, this devastation, and the complex transnational suffering in the region, are terribly underreported in the United States.

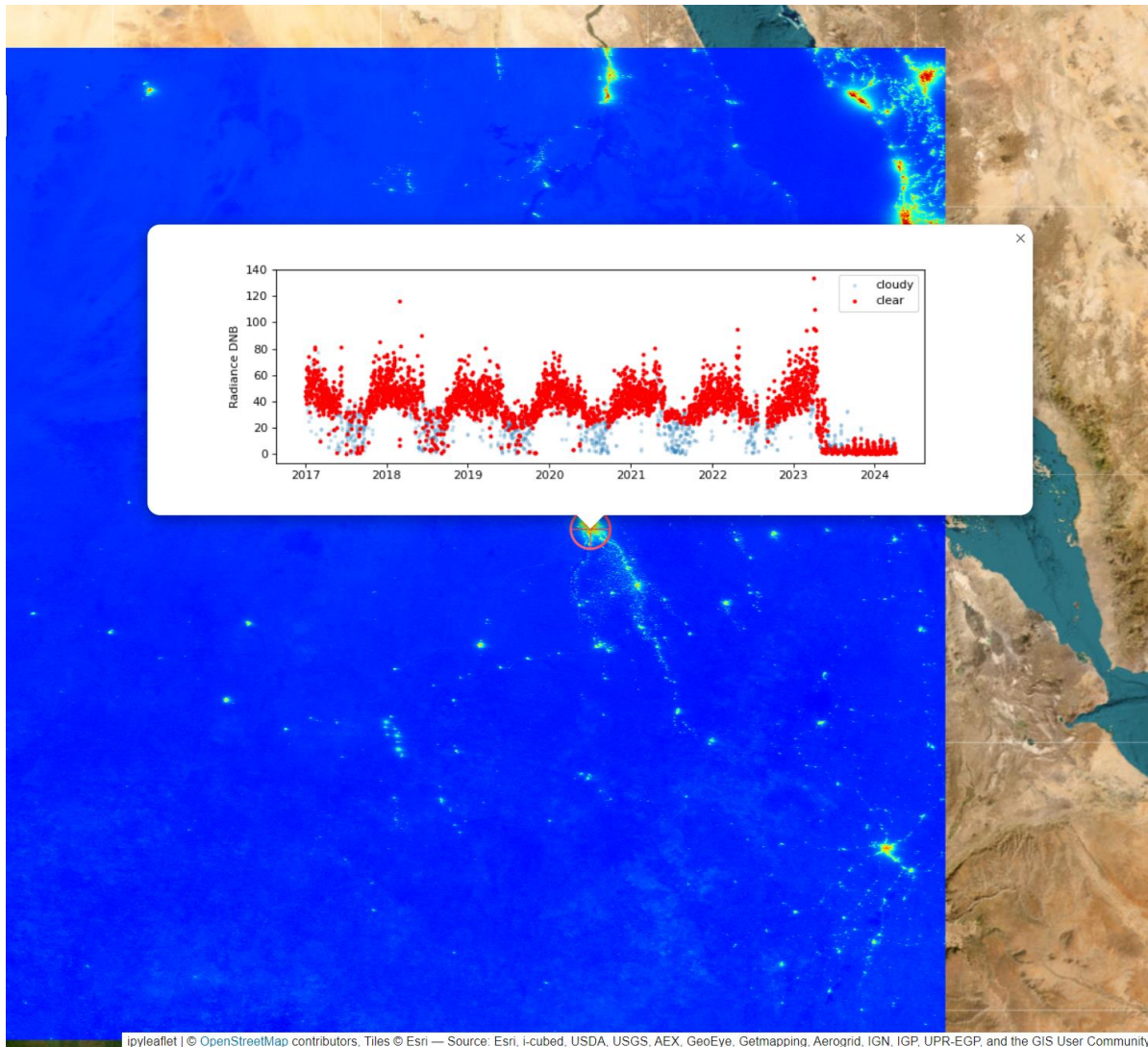
The recent fighting between the Sudanese Armed Forces and the paramilitary Rapid Support Forces, started in the capital Khartoum in April 2023 then quickly spread to the western region of Darfur. The conflict now encompasses more militias and rebels with competing agendas and threatens to [destabilize neighboring countries](#).

Reported [fatalities](#), which are likely a vast underestimate, as of last month stood at 14,790, according to the United Nations; 25 million are in dire need of humanitarian assistance.

### *Mapping the devastation through light*

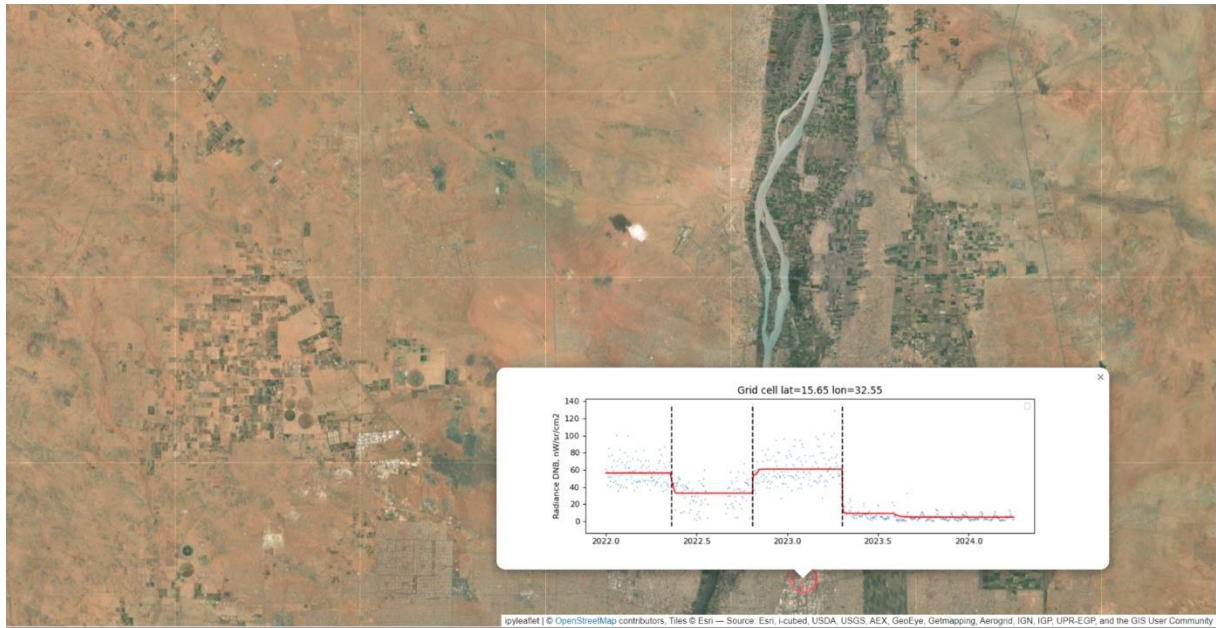
A common weapon of war is attacking electricity and other energy systems. Sudan is no exception. Civilians in power outage zones are more at risk of rape, pillaging, and murder by invading forces. More than [1,000 rapes](#) have occurred in Khartoum state alone, according to doctors and lawyers.

The Earth Observation Group at the Payne Institute for Public Policy, Colorado School of Mines, has created a temporal profile of nighttime lights for Khartoum, as shown in Figure 1 below. With data collected by NOAA's Visible Infrared Imaging Spectrometer Suite (VIIRS), seasonal variations in lights within a year can be seen, but the interannual radiance was stable until the conflict started in April 2023.



**Figure 1: Satellite imagery from Payne Institute for Public Policy, May 15, 2024**

Trend analysis for 2022-2024 (Figure 2 below) confirms that in May 2023 the lights in the capital were dimmed to the noise level. EOG scientists can't say definitively that there are no lights at all, but their brightness is below moonlit-clouds level.



**Figure 2: Satellite imagery from Payne Institute for Public Policy, May 15, 2024**

The Earth Observation Group has also created a video (Figure 3 below) showing country-wide power outages from January 2023 until March 2024. Dimming, indicating outages, happens gradually with a two- to three-week delay after the beginning of the civil war in April 2023. Scientists created the video by downloading nightly global VIIRS day/night band (DNB) low-light imaging data, detecting lights at the earth's surface.



Sudan\_movie\_bounds\_colorbar.mp4

**Figure 3: Satellite imagery from Payne Institute for Public Policy, May 15, 2024**

\* Notes: VIIRS is the Visible Infrared Imaging Radiometer Suite which is flown jointly by NASA and NOAA. The VIIRS design was set by meteorologists, but other valuable products are also produced from VIIRS data. The Earth Observation Group developed the Nightfire algorithms in 2012 for quantifying natural gas flaring and biomass burning. It is the only global fire detection product that calculates fire temperatures, source sizes and heat output using physical laws.

## **ABOUT THE AUTHORS**

### **Mikhail Zhizhin**

#### **Research Associate, Earth Observation Group**

Mikhail Zhizhin, M.Science in mathematics from the Moscow State University in 1984, Ph.D. in computational seismology and pattern recognition from the Russian Acad. Sci. in 1992. Research positions from 1987 to 2012 in geophysics, space research and nuclear physics at Russian Acad. Sci., later at NOAA and CU Boulder. Currently he is a researcher at the Earth Observation Group at Colorado School of Mines. His applied research fields evolved from high performance computing in seismology, geodynamics, terrestrial and space weather to deep learning in remote sensing. He is developing new machine learning algorithms to better understand the Nature with Big Data.

### **Kristin Ziv**

#### **Payne Institute Communications Associate**

After receiving a master's degree in journalism from Northwestern University's Medill School, Kristin worked as a public relations professional in Chicago. She has both agency and non-profit experience. After raising a family, she campaigned for and was elected to public office, serving a term as a Village Trustee in Winnetka, IL, before moving to Colorado in 2019.

### **Christopher Elvidge**

#### **Senior Research Associate, Director of Earth Observation Group**

Christopher D. Elvidge has decades of experience with satellite low light imaging data, starting in 1994. He pioneered nighttime satellite observation on visible lights, heat sources including gas flares and wildfires, as well as bright lit fishing vessels. He led the development of these nighttime remote sensed products with images from DMSP, JPSS, and Landsat satellites. These data are very popular and used globally in both public and private sectors. As of February 2018, he has more than 11,000 scholarly publication citations.

### **Morgan Bazilian**

#### **Director, Payne Institute and Professor of Public Policy**

Morgan Bazilian is the Director of the Payne Institute and a Professor of public policy at the Colorado School of Mines. Previously, he was lead energy specialist at the World Bank. He has over two decades of experience in the energy sector and is regarded as a leading expert in international affairs, policy and investment. He is a Member of the Council on Foreign Relations.



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