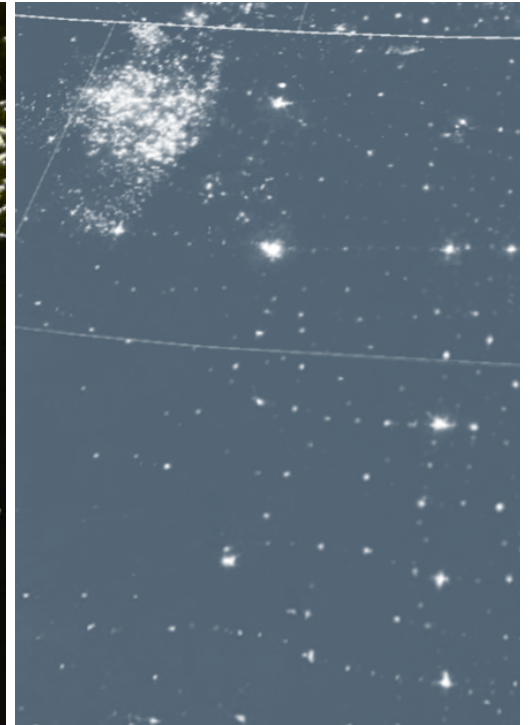
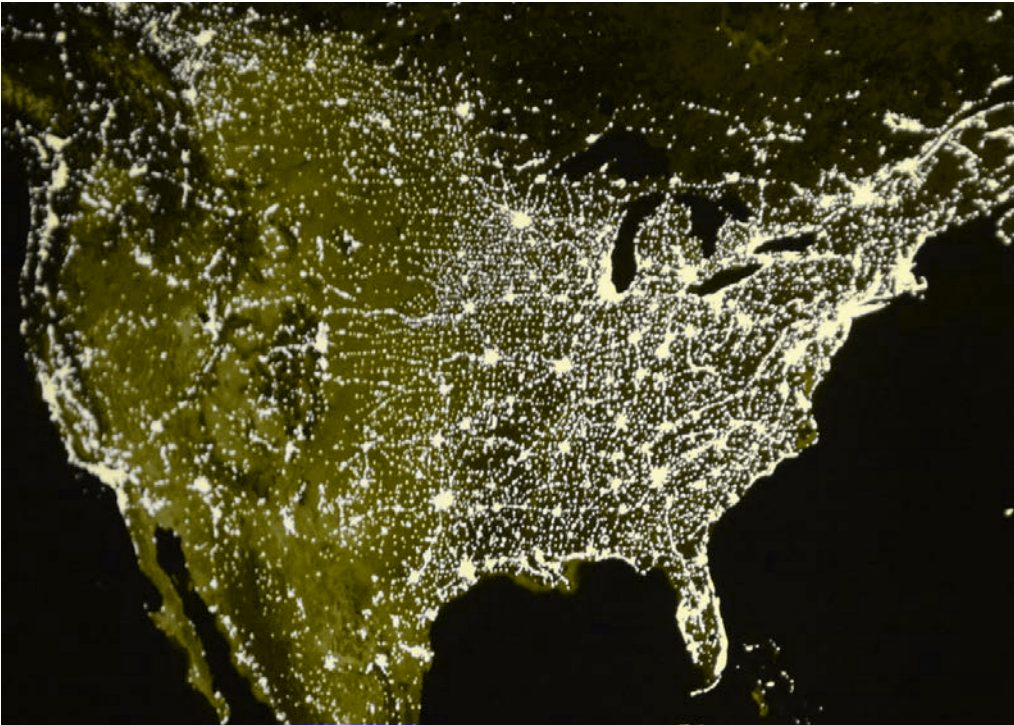


Bakken Flares and Satellite Images

THE SCIENCE AND THE FACTS



The Claim

Magazine articles published recently regarding oil production and associated gas flaring in the North Dakota Bakken oil play show satellite imagery, such as the image in Figure 1. Authors state that the night sky looks more like New York City, Boston, or Chicago than rural western North Dakota. Many presentations and publications of these images tout new types of satellite imaging that can be performed to examine gas flares but seldom explain how the images are derived.¹⁻³ These images are misleading in that they give the uninformed public the idea that flares are literally lighting up many square miles of prairie countryside, creating visible light similar to large metro areas. So does the sky in western North Dakota light up like a million-person metropolis? A casual drive on any evening through counties of the Bakken oil play shows otherwise, so how are these satellite images being formulated?

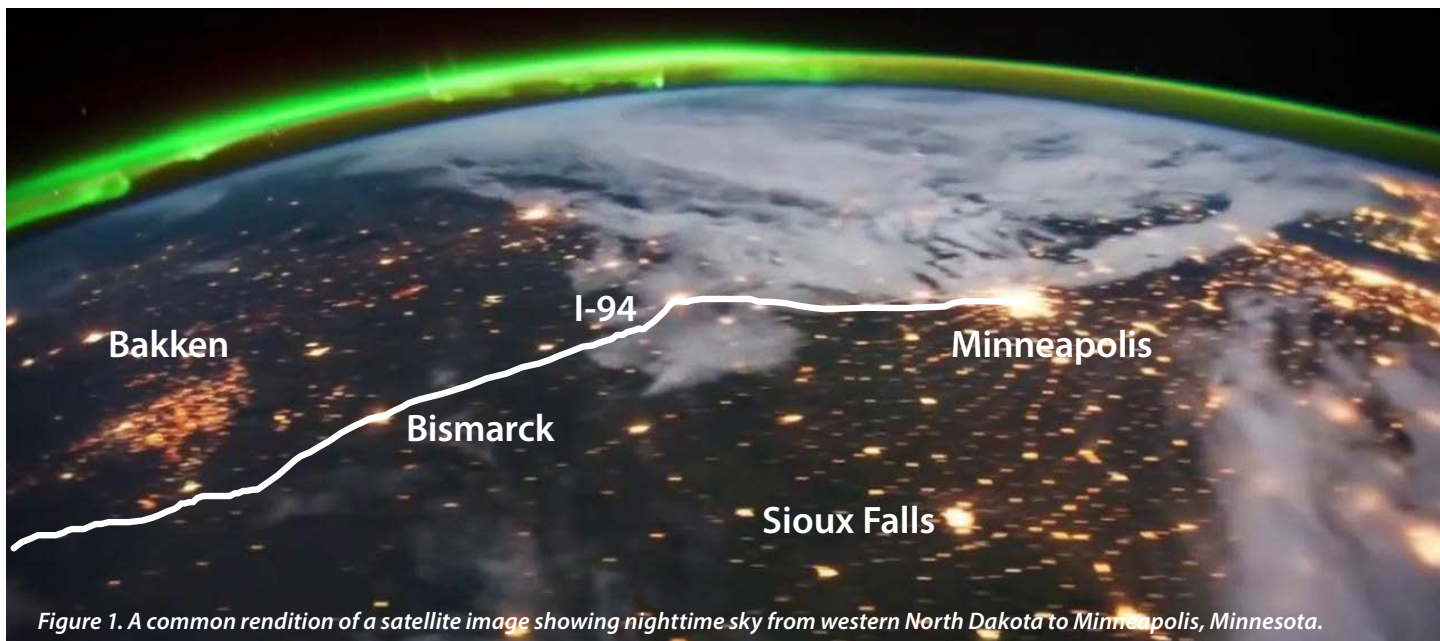


Figure 1. A common rendition of a satellite image showing nighttime sky from western North Dakota to Minneapolis, Minnesota.

source: <http://midwesternenergynews.com/2011/11/14/the-bakken-north-dakota-oil-field-from-space/>

Background

Researchers from the University of North Dakota (UND) Energy & Environmental Research Center and the John D. Odegard School of Aerospace Science's Department of Earth System Science and Policy joined forces to get a better understanding of these bright satellite images. With images available through the National Oceanic and Atmospheric Administration (NOAA), improved methodologies were developed for identifying, characterizing, and processing flare images for several locations in western North Dakota.

The Bakken shale or Bakken Formation ranks as one of the largest oil developments in the United States in the past 40 years. Even though oil was discovered in the Bakken in the 1950s, production had not been consistent until early this century when horizontal drilling techniques coupled with high-pressure hydraulic fracturing were introduced. In late 2014, the Bakken and Three Forks Formations were producing more than 10% of all U.S. oil production, giving North Dakota the distinction as the second-largest oil-producing state in the United States. Bakken oil is considered a sweet crude with

abundant associated natural gas and natural gas liquids that are coproduced with the crude oil to the surface. Flaring has been a routine temporary practice in the petroleum industry for over a century, burning off associated gas until gathering infrastructure is installed. Flaring in the Bakken and other North Dakota oil formations constituted about 300 million cubic feet a day of gas in 2014, and although a large number, it accounts for less than 5% of North Dakota's total oil and gas production on an energy-content basis.

When this study began in late 2013, the North Dakota Industrial Commission (NDIC) Department of Mineral Resources listed the state's flaring at about 29% of all coproduced gas, down from about 36% 2 years prior. By October 2014, flaring had declined to 22%, and the current goal is to reduce flaring to less than 10% by 2020 while continuing to increase oil production in the state (Figure 2). New regulations, improved coordination between industry stakeholders, and ongoing investment in gas-gathering and processing infrastructure are having a significant and positive impact on gas utilization in North Dakota.

The Research

Researchers collected remote sensing data over western North Dakota with NOAA's Suomi National Polar Partnership (NPP) Visible Infrared Imaging Radiometer Suite (VIIRS) and Nightfire Project.⁴ NOAA's Nightfire project had recently developed a new data-processing system to automatically find and collect data on heat sources around the world—flares included. UND researchers were able to utilize these satellite images and validate them with “ground” data collected from active gas flares consisting of monthly average gas consumed via flaring for 2013 and the first 6 months of 2014.

To better characterize the Bakken oil play associated gas flares, UND researchers developed improved processing methods and a subpixel technique on data collected in nine spectral bands: one day–night band (DNB) and eight infrared bands of the NOAA VIIRS sensor. Because a typical flare only occupies a 1/6000 fraction of a satellite pixel (800 m × 800 m), any contamination can easily skew the estimate of flares. To avoid possible contaminations, only VIIRS nighttime images that were cloud-free and only the middle portion of an image not affected by Earth curvature and geometric effects were used. The daily VIIRS data collected were aggregated into monthly estimates and validated with ten specific active flares.

Figure 3 compares images from the western North Dakota Bakken region processed in this study. This highly sensitive DNB is a broad band sensor measuring emission sources, including visible light and heat sources. This wide range of

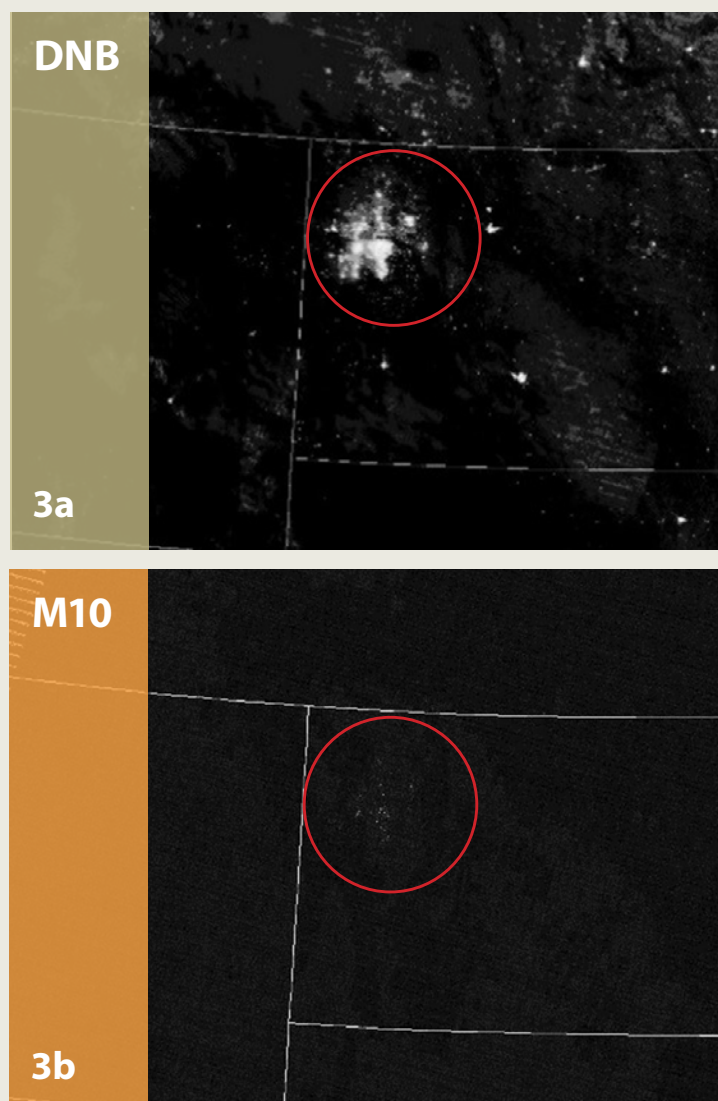


Figure 3. Satellite images of Bakken flares derived from VIIRS satellite spectral bands DNB (top) and M10 (bottom).

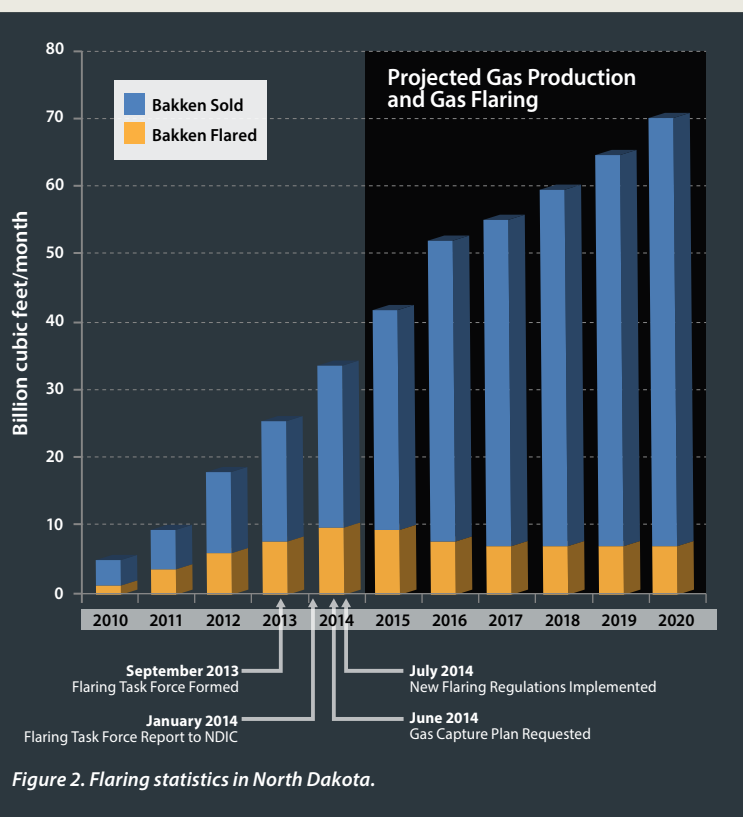


Figure 2. Flaring statistics in North Dakota.

wavelengths from visible to near-infrared results in a much brighter representation of “light” from the Bakken region than the more selective M10 band which shows only the wavelength associated with combustion sources such as flares. The picture in Figure 3a is a typical, highly sensitive DNB image showing accumulative light saturation. Figure 3b, in contrast, is the same area with a near-infrared spectral image showing faint, yet discernible, infrared heat signatures, more characteristic of what flares look like from space in the Bakken oil play region of western North Dakota. For example, a highly sensitive camera taking separate pictures of a 75-watt incandescent bulb and a candle will show an incandescent bulb image that is saturated by light (all white), but the candle image will also show an “all white” saturation. Even though the two pictures may look the same, as illustrated in Figure 4, the incandescent bulb emits nearly 1000 times more light than the candle.

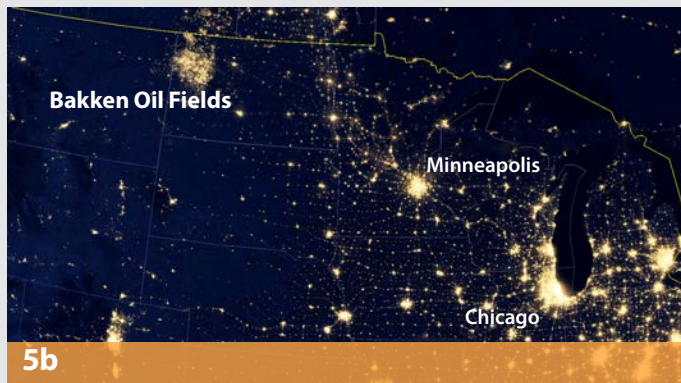
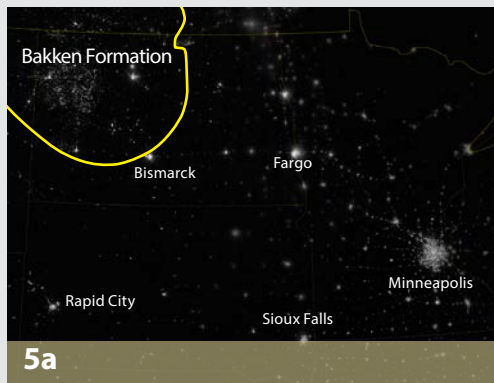


Figure 4. Photographs of an incandescent bulb (1000 lumens) and a candle (1 lumen), illustrating the similar light saturation captured in some satellite images.

In summary, this study produced images which, when including only light attributable to combustion sources (flared associated gas), would look more like the image in Figure 5a. This image shows faint, yet discernible, patches of light on a nighttime map

of North Dakota, distinctly different from the various night sky images in newspaper and trade magazines that compare the Bakken region to New York City, Boston, and Chicago (Figure 5b).

Figure 5a. Realistic satellite images of associated natural gas flaring in the Bakken oil play region of western North Dakota. Figure 5b. Inaccurately derived flare images that are usually highly processed, manipulated, and often amplified 100x.



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