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Terrorism, geopolitics, and oil security: Using remote sensing to estimate oil production of the Islamic State

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ABSTRACT

As the world's most traded commodity, oil production is typically well monitored and analyzed. It also has established links to geopolitics, international relations, and security. Despite this attention, the illicit production, refining, and trade of oil and derivative products occur all over the world and provide significant revenues outside of the oversight and regulation of governments. A prominent manifestation of this phenomenon is how terrorist and insurgent organizations—including the Islamic State group, also known as ISIL/ISIS or Daesh—use oil as a revenue source. Understanding the spatial and temporal variation in production can help determine the scale of operations, technical capacity, and revenue streams. This information, in turn, can inform both security and reconstruction strategies. To this end, we use satellite multi-spectral imaging and ground-truth pre-war output data to effectively construct a real-time census of oil production in areas controlled by the ISIL terrorist group. More broadly, remotely measuring the activity of extractive industries in conflict-affected areas without reliable administrative data can support a broad range of public policy and decisions and military operations.

1. Introduction

While oil resources play a crucial part in conflict, geopolitics, and international affairs [1], the exploitation of oil, like other resources, often occurs where governance is unstable and transparency is absent. Illicit production, refining, and distribution of oil and products occurs even in well-established markets, such as Nigeria [2]. Like other illicit trades, the scale of production is difficult to gauge and daunting for policymakers to ignore [3]. To improve the policy response to conflict in areas with illicit oil production, we adapt earlier methods of measuring oil production from satellite data. We tailor our approach to the setting of the Islamic State group, also known as ISIL/ISIS or Daesh, in Syria and Iraq.

Measuring illicit oil production is important because natural resource extraction substantially affects conflicts. In such areas reliable external measures of forestry, mining, and oil production can enable better approaches to a broad range of challenges. In Colombia and Nigeria, for example, insurgent organizations have long controlled territory where oil is produced, and in many regions around the world public and reliable field-level production numbers are difficult to find. Estimating production remotely can enable governments and international organizations to identify illegal or untaxed production and to better understand its role in post-conflict economies as well as the impact of sanctions, trade restrictions, and other policy interventions.

Previous work on the relationship between resource exploitation and conflict underscores the relevance of this study. Even though a main concern is that resource wealth can fund armed groups either directly or via taxation, variation in the relationship occurs. For instance, Sánchez de la Sierra [4] finds that positive prices shocks to a bulky commodity leads armed groups to create a monopoly of violence to impose taxation and regulate production in Eastern Congo. Along the same lines, Maystadt et al. [5] use data on international mineral prices and historical mining concessions to show that armed groups tend to reduce violence in areas near the mines when prices go up. This

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"protection effect" is consistent with violence reducing economic profitability. Others find that fighting around diamond mines did not affect civilians in Sierra Leone, but was rather limited to violence among soldiers [6,7]. This result is echoed in Ziemke [8], who finds that violence against civilians was lower in diamond areas of Angola. Finally, Dube and Vargas [9] find that price shocks have heterogeneous effects: in labor-intensive sectors, commodity price drops result in higher incentives to join armed groups, while in the capital-intensive sector the rise in the price elicits predatory behavior from armed groups.

This study also relates to previous work on the relationship between conflict and oil extraction in particular Colgan [10] considers the impacts of conflict and the oil sector primarily as it influences domestic policy formation. Relatedly, Månsson [11] develops a framework to consider the wider issues of energy and conflict. Further work on conflict and offshore oil [12], how these issues relate to renewable energy and concepts of energy independence [13,14], and how these issues manifest in Russian and the Ukraine [15] all appear in ERSS.

This paper combines the focus on oil and conflict with the emerging literature that uses remote sensing to measure oil production. Our approach builds on previous work establishing globally how flared gas volumes from oil fields and refineries can be measured with nighttime light detecting sensors such as DMSP-OLS and SNPP-VIIIRS [16,17]. Remote sensing based estimates of gas flaring have been validated at the production site [18] and country-year levels [19] and found to be accurate and unbiased. Additional work uses satellite observations to examine the behavior in extractive industries in low-governance regions [20,21].

We make several contributions to the literature. In the remote sensing literature, we use a new method combining visible and infrared bands to detect low level production with greater sensitivity. While previous methods failed to distinguish low intensity flares from other signals of conflict in our setting, our algorithm to detect and calibrate flaring with light of the visible band when the infrared signal is below noise level is novel and effective. Further, while earlier studies have documented a robust positive correlation between radiant heat as measured from satellite and flared gas volume at the production site, we quantitatively estimate a structural relationship between oil production and radiant heat, then use the estimates to predict production in places where radiant heat can be measured but production cannot. This is, to our knowledge, the first attempt to do so. In the oil and conflict literature, we demonstrate that using remote sensing can be an appropriate method to measure socio-economic activity in environment where direct observation is either infeasible or prohibitively expensive. Variants on the approach presented here could be applied in a much broader set of geographies and circumstances.

Section 2 considers the context of Islamic State oil production. Section 3 presents our methodology, Section 4 provides results, and Section 5 concludes.

2. Background on Islamic State oil production

The non-state insurgent organization known as the Islamic State group (also called the Islamic State [IS], the Islamic State of Iraq and the Levant [ISIL], the Islamic State of Iraq and al-Sham [ISIS], or Daesh, its Arabic acronym) took control of large swathes of territory in Syria and Iraq beginning in mid-2013 (Fig. 1).[1] Its rapid territorial expansion began when fighters from the Islamic State of Iraq (ISI) started operating in Syria in April 2013 and accelerated from early 2014 onwards when the group moved aggressively back into Iraq [22]. For a time, the group was considered the richest jihadist group in the world and was thought to raise money from a variety of sources [23]. In 2014 and 2015 revenue from oil production in areas the group controlled was often cited as its largest potential source of revenue flow, with estimates of weekly oil revenue ranging from "several million" to US$28 million [24,25]. Any reasonable assessment of the organization's long-run survival prospects had to account for these revenues and identify how sustainable they were [26]. Yet no reliable sources existed at the time. Beginning in late of 2015, ISIL steadily lost territory in both Iraq and Syria, but still maintained substantial territory in both countries as of early 2017.

Much was written in the media about the ISIL oil revenue stream, including its severe decline due to Coalition operations [27–49].[2] Warrick [50] shows how satellite images can identify ISIL micro-refining (or "teapot") capability, asserting that "[t] he proliferation of micro-refineries is the latest sign of strain in the group's self-declared caliphate, which has lost half its territorial holdings in Iraq since late 2014." Robinson et al. [51] offer a wider look at how remote sensing techniques can be employed to understand the ISIL economy. Several news reports, show the more recent strategy by the Trump Administration against ISIL oil [52]. Metrics of the effort include the amount of oil trucks across the supply chain from distribution to production and refining destroyed by Coalition forces. The numbers show a massive uptick in targets just in the first half of 2017, part of the roughly two-year old Operation Tidal Wave II. Significant detail on the ways the failing ISIL is finding revenue are detailed in a recent article in the Financial Times, which includes starting their own currency [53].

Early accounts of the group's oil production and the revenues generated indicated that oil was a significant source of financing for the organization. The 2014 Oil Market Report of the International Energy Agency estimates an output of 70,000 barrels per day (bpd) [54]. Other news outlets give numbers around 50–60,000 bpd yielding an income of US$2.5m per day [55] to more than US$3m per day [56]. Early estimates by the US Departments of State and Treasury put the organization's oil revenues at around US$1m per day [57]. These estimates were then revised down to "a couple million dollars a week" after the U.S. started air-strikes against the organization's assets [58]. Views as to whether ISIL was financing itself through oil, external support, extortion, or taxes then evolved, with higher emphasis put on taxes and extortion as primary sources of revenues over time. Die Zeit for instance reported December 2014 oil revenues to be a mere US$370,000 per day or even lower at US$260,000 [59]. An October 2015 article however gives an estimated output of 34–40,000 bpd, earning the organization an average of US$1.5m per day [60]. In sum, there was no consensus on the production numbers or revenue they created.

3. Methodology

3.1. Data

We use data from the Visible Infrared Imaging Radiometer Suite (VIIRS) sensors deployed on the NOAA/NASA Suomi NPP satellite [17,61,62] to detect location of all oil flares over Syria and Iraq from March 2012 to November 2016. VIIRS data have moderate spatial resolution (~1 sq km) and cover the globe every 24 h. We used a combination of manual infrastructure checks and algorithms to ensure all flaring sites were associated with oil production [63]. For each oil production site in the region we use news outlets' reports, agencies' press releases and Institute for the Study of War (ISW) maps allow us to assign individual oil wells to the Islamic State group's control at the daily level. During our period of study, 42 production sites in both Syria and Iraq (34 in Syria and 8 in Iraq; see map on Fig. 1) had been or are under ISIL control, out of a total of 75 identified oil sites in Syria and 114 in Iraq. Finally, we combine the satellite data with data on oil

[1] We henceforth use ISIL, Daesh, and Islamic State interchangeably.

[2] For more recent coverage see, e.g., https://www.brookings.edu/on-the-record/how-isis-uses-oil-to-fund-terror/ or https://www.newyorker.com/news/news-desk/the-isis-oil-trade-from-the-ground-up.