

Popular science summary

Mapping makeshift oil refineries in northeast Syria using satellite remote sensing¹

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Following the outbreak of the Syrian civil war in 2011 and the subsequent collapse of the national oil infrastructure, a new type of oil infrastructure emerged in northeast Syria in the form of small-scale, makeshift oil refineries. These refineries provided local access to oil products essential to sustain local livelihoods but also led to pollution of the air, soil and water. Previous reports have documented the refineries and their negative impacts, but they have been limited by labour-intensive manual labelling and infrequent data. To address this, this study develops an approach that systematically maps makeshift oil refineries using open-access satellite imagery, which is combined with household surveys to produce new estimates of the extent and impact of the refineries.

Using data from the Sentinel-2 satellite, the study examined two distinct indicators of makeshift oil refineries: contamination of the soil, and emissions of heat. Since the refineries visibly contaminate the ground, a machine learning technique was used to distinguish oil-contaminated soil from other land cover types, indicating the past or current existence of a refinery. Another indicator was the heat emitted from active refineries, which was detected through short-wave infrared satellite images. Compared with an existing data product used to detect fires, short-wave infrared imagery showed strong potential for detecting the heat emitted from active refineries. By combining these two indicators, it was possible to detect the locations of active refineries over time. In 2017, 67 locations were detected across six subdistricts, while in 2025, the 17 detected refineries were almost exclusively concentrated in two subdistricts in the northeast of the region. This decrease aligns with previous reports that refining activity became more restricted after 2017, though continued activity into 2025 was previously unreported.

However, satellites only capture a portion of these developments, and integrating household surveys in the analysis revealed new spatial patterns. While respondents in subdistricts with high concentrations of active refineries corroborated the satellite findings, households in districts with no detected refineries still reported significant exposure to oil-related air pollution and related health concerns. Such unexpected findings underscore the need for further research into the experienced impacts of refineries to fully understand the scale and nature of the conflict-driven pollution.

¹ Full original title: *“Pockmarks of conflict: Detecting makeshift oil refineries in northeast Syria using satellite remote sensing”*