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Monitoring anthropogenic pollution in the Russian sub-Arctic with high resolution satellite imagery: An oil spill case study

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The Arctic region is a very remote and vulnerable ecosystem but also rich in natural resources, which have been exploited for many decades. These ecosystems are particularly vulnerable to any industrial accident. The Arctic has short summers, low temperatures, and limited sunlight, so it can take decades for Arctic ecosystems to recover from anthropogenic pollution. Examples of the potential hazards when exploiting natural resources in such fragile environments and the detrimental impact on the polar ecosystem and communities are all too frequent. In the case of the oil and gas industry, spills caused by the failure of old pipelines are a very regular occurrence. Given the geographical isolation of these activities, remote sensing is an obvious technology to underpin any effective monitoring solution. Increasing availability in the public domain, together with recent advances in resolution, suggest satellite imagery can play a key role in effectively monitoring oil spills and is the focus for this study.

The remote sensing of polar regions and the detection of terrestrial oil spills have both been studied previously, however, there has been little work to investigate the two in combination. The challenge is how to detect an oil spill if it is from an unknown incident or illegal activity such as discharge. Oil spill detection by applying image processing techniques to Earth Observation (EO) data has historically focused on marine pollution. Satellite-based Synthetic Aperture Radar (SAR), with its day/night and all-weather capability and wide coverage, has proven to be effective. Oil spill detection with remote sensing in terrestrial environments has received less attention due to the typically smaller regional scale of terrestrial oil spill contamination together with the overlapping spectral signatures of the impacted vegetation and soils. SAR has not proven to be very effective onshore because of the false positives and consequent ambiguities associated with interpretation, reflecting the complexity of land cover.

A number of studies have highlighted the potential of airborne hyperspectral sensors for oil spill detection either through the identification of vegetation stress or directly on bare sites, with absorption bands identified in the short-wave infrared (SWIR) range at 1730 and 2300nm. However, unlike spaceborne sensors, these devices do not provide regular coverage over broad areas. Several hyperspectral satellites have been launched to date but have technical constraints. The medium spatial resolution and long revisit times of most current hyperspectral instruments limit their use for identifying smaller incidents that often occur with high unpredictability.

No single sensor currently has all the characteristics required to detect the extent, impact and recovery from onshore oil spills. This study will look at the potential of combining medium spatial resolution imagery (Sentinel-2) for initial screening, with high spatial/temporal (WorldView-3) and high spectral (PRISMA) resolution data, both covering the key SWIR bands, for site specific analysis.