Geomatics Canada
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SATELLITE OBSERVATIONS FOR DETECTION OF DUST FROM MINING ACTIVITIES IN A CARIBOU HABITAT, NORTHWEST TERRITORIES AND NUNAVUT

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1. Introduction

Diamond mining via open pit mining has been ongoing within the Wek'èezhìi region of the Northwest Territories for several decades, which includes the Bathurst Caribou Herd. This has led to the importance of developing a quantitative characterization of the Zone Of Influence (ZOI), where resource development activities may be influencing the natural behaviour of the caribou herd in the tundra environment.

As part of better defining and understanding the ZOI in this region, an initiative to evaluate the potential of detecting and mapping dust from mining activities in the surrounding environment is explored. This dust has been shown to settle upon foliage near roads, influencing the acidity levels of the surficial soil layer and impacting foliage distributions. To this end, field spectrometry was acquired at various distances from road ways. Satellite imagery from the Proba-1 CHRIS hyperspectral sensor and the multi-spectral Sentinel-2a system were also acquired of the region. This presentation will present the initial spectral analysis pursued to evaluate the potential to remotely detect waste rock dust material in the surrounding tundra vegetation.

2. Study area and field data information

The field campaigns to evaluate for dust in the environment (dust on leaves) and site target spectrometry were conducted around the Ekati Diamond Mine during the summers of 2015, 2016, and 2017 (Figure 1). The Ekati Diamond Mine is located inside the summer range of the Bathurst caribou herd, which in turn borders between NWT and Nunavut.

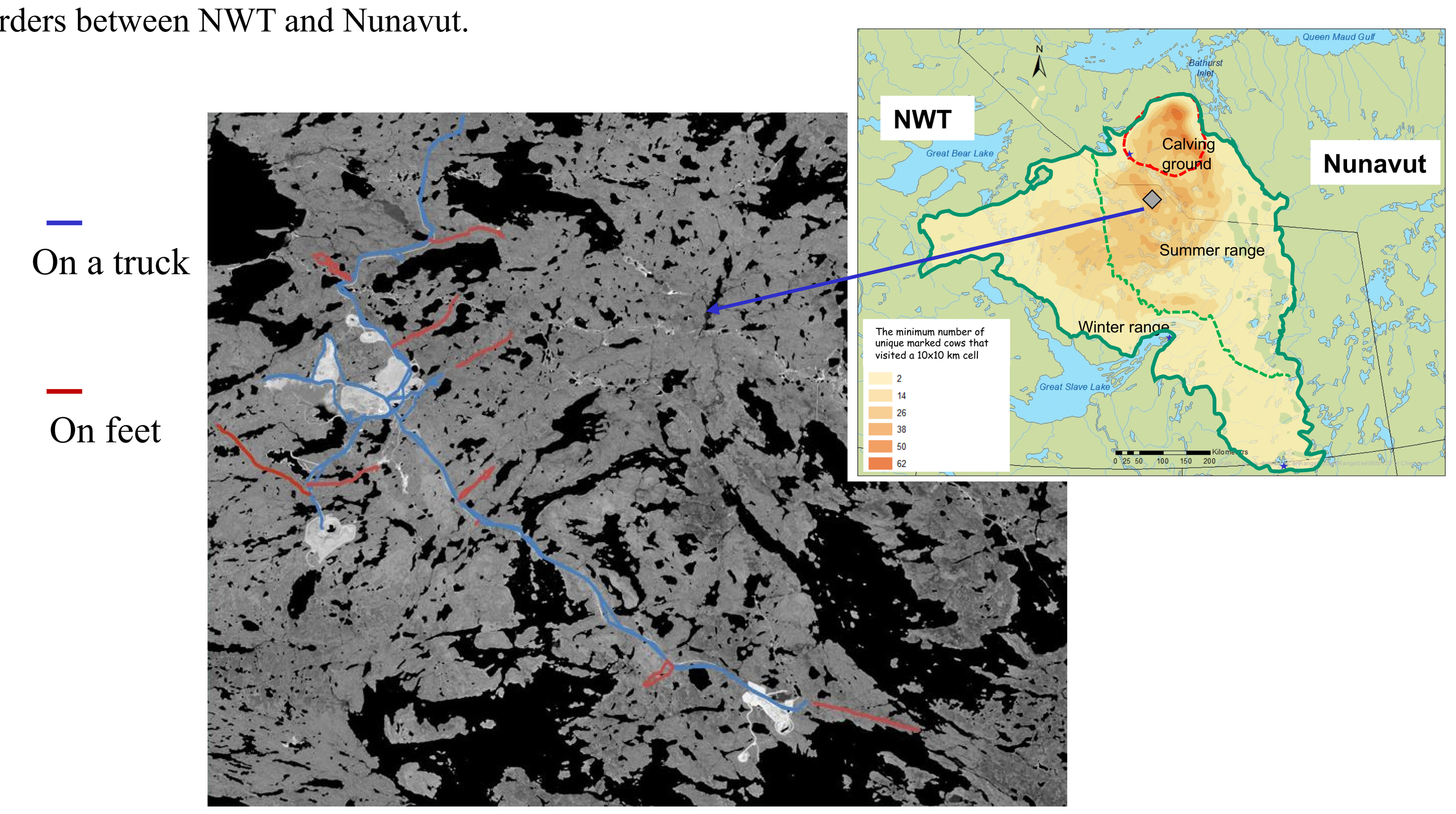

Figure 1: Sample transects around the Ekati Diamond Mine surveying for the presence of dust on vegetation and spectrometry. DEM data were also recorded along these transects.

Surface soil and birch leaves were sampled for dust along various study transects. Field spectrometry was acquired during periods of clear sky and relatively high sun elevations. The samples were used to evaluate the range of dust disposition at distance from mining activities (such as roads, waste rock piles, etc.) by determining soil pH and dust density along each transect. As a common plant species in the area, with relatively wide leaf area, dwarf birch was selected as a representative species for evaluating the dust on foliage as distributed into the environment from the mining activities. Location of each target was acquired with GNSS, processed by the NRCan Precision Point Processing service.

A study of this field data evaluating changes in soil pH and dust volume on foliage indicates that the zone of disturbed area from dust disposition ranges up to 1km from the source, dependant on the intensity of use (high traffic volume areas range further than low traffic volume areas). Beyond the 1km distance range, this study did not detect dust on foliage or soil pH beyond ambient for the region.

For more information on the results of this study, see: Chen et al. (2017), *Does Dust from Arctic Mines Affect Caribou Forage?*, **Journal of Environmental Protection, v08.**

Figure 2: (left) Dwarf birch with waste rock pile visible on horizon. NRCan photo 2022-314. (centre) Dust plume from traffic along mining road. NRCan photo 2022-315. (right) Preparing for spectrometry measurement. NRCan photo 2022-316.

3. Satellite Imagery

Satellite imagery of the Misery Road area (the ~25km stretch of road that runs NW – SE between the Misery Pit and the Main Ekati Camp) was acquired with the Compact High Resolution Imaging Spectrometer (CHRIS) sensor, part of the Proba-1 satellite mission. This sensor provides an image that covers a 14km swath with a spatial resolution of 36m. Spectrally, the sensor provides a continuous spectral bandset from 415nm (blue) through 650nm (red) to 1002nm (infrared) using 63 defined spectral bands. Once the atmospheric contributions to the observed signal has been accounted for (atmospheric correction) the shape and magnitude of the surface reflectance characterizing the surface composition can be evaluated.

4. Spectral Remote Sensing Fundamentals

With spectral remote sensing, EO imagery has several image planes (or bands) acquired simultaneously. These provide imagery with contiguous spectral detail that provides a spectral 'signature' for each pixel in the image.

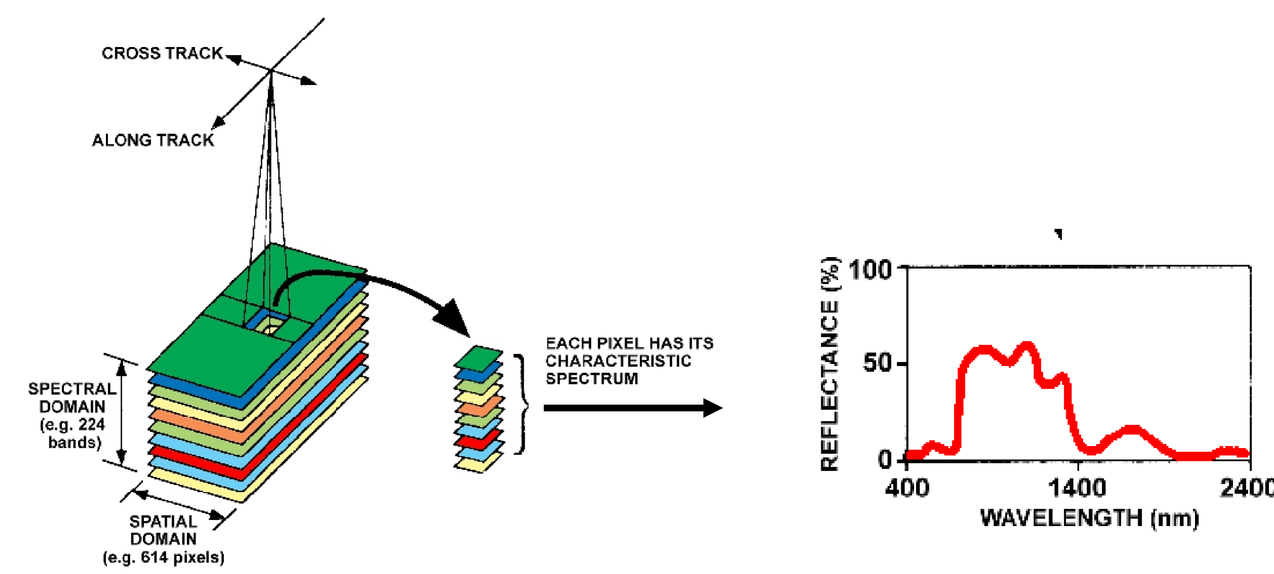

Figure 3: Spectral remote sensing fundamentals, where a spectral signature representing the combined spectral information of all constituents visible in each pixel is determined.

5. Pre-Processing

Satellite imagery (Earth Observation or EO imagery) provides snap shots of the Earth's surface at specific times when the satellite platform overpasses the area of interest. Thus an acquisition is successful when the sensor is passing over the area of interest and the cloud cover is minimal. Atmospheric constituents, such as water vapour (H_2O_v), will also impact the brightness of the imagery. This atmospheric influence can be corrected using models, resulting in an image which represents the reflectance properties of the land surface constituents alone (at-surface reflectance).

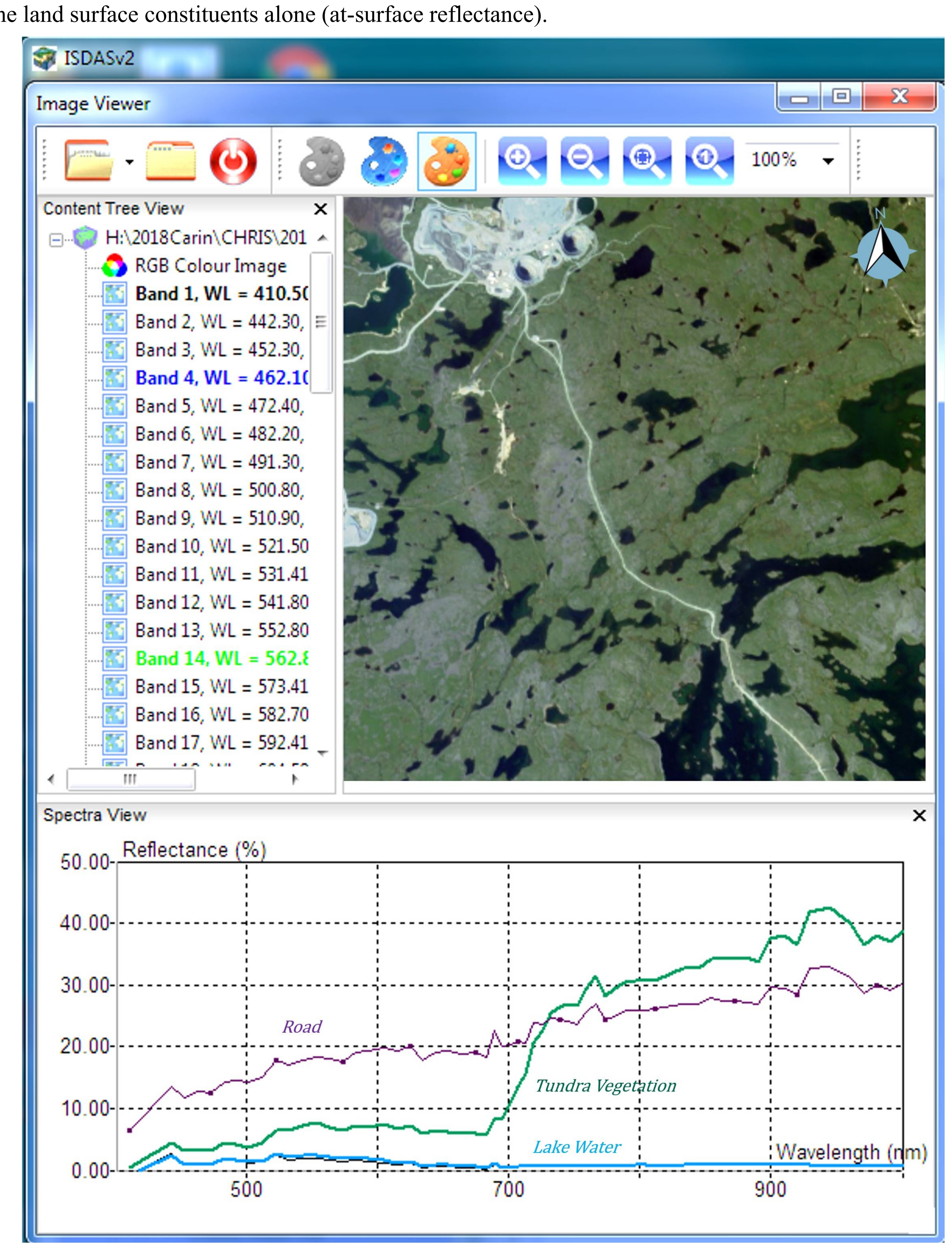

Figure 4: CHRIS Imagery of the Ekati Mine – Misery Road (RGB Display) acquired 12 August 2017. Imagery has 62 contiguous spectral bands, ranging from 410 nm (blue) to 1002 nm (near infrared). The main mine campus, including the Koala and Panda Pits are located near the top left of the image. Other features visible in this image includes an esker (upper right, brownish feature), Misery Road (running from bottom right to upper left), a boulder fields (gray-green areas such as seen centre image, just west of Misery Road) and several lakes. Three sample spectral profiles are provided showing Tundra Vegetation (green), Water (blue) and Road (brown).

4. Spectral Unmixing Fundamentals

Spectral mixing within a pixel is the result of the light reflected from a target on the ground being observed as an integrated signal by the sensor. Thus all surface constituents contribute to the observed reflected signal. By identifying "pure" spectral signatures of these surface constituents (endmember spectra), either by identifying in the imagery or by acquiring field spectral reflectance, the proportion of each constituent endmember can be derived. This process is referred to as unmixing. The more spectral distinct an endmember is, the easier it is to distinguish using this process.

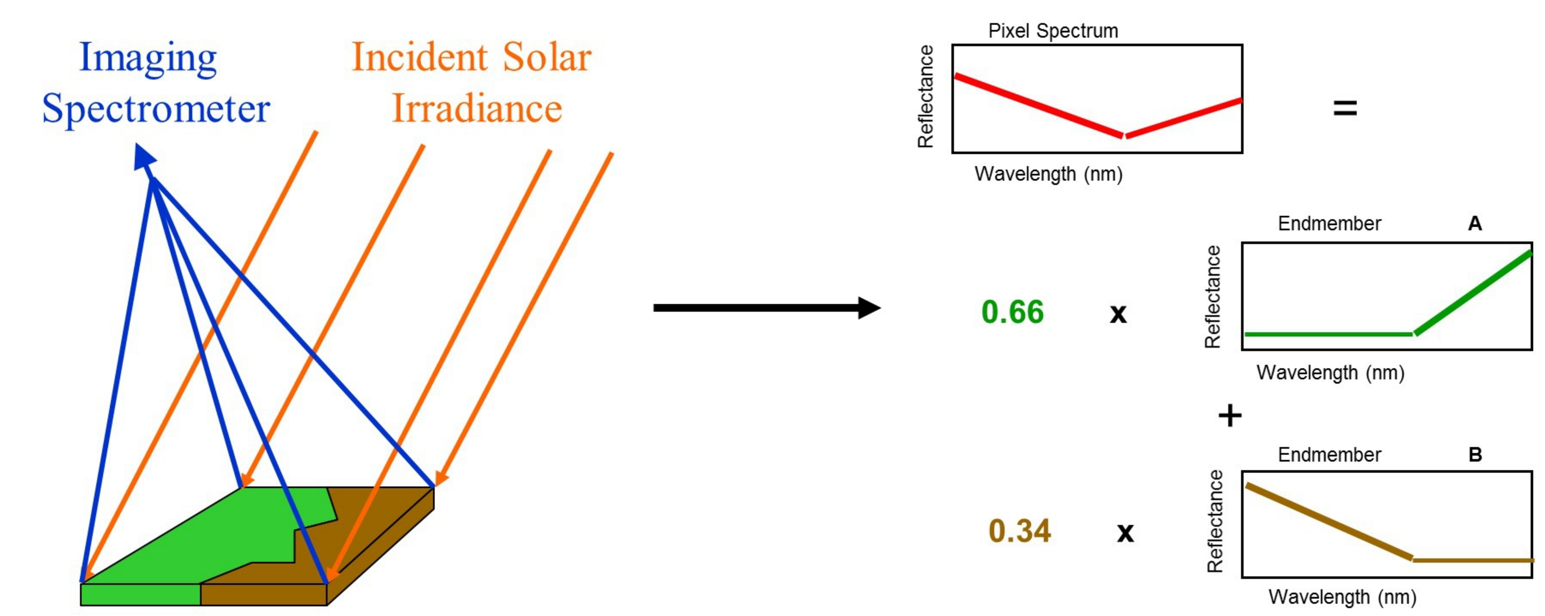

Figure 5: The process of spectral unmixing a pixel to distinguish various constituents contributing the observed spectral reflectance.

4. Results

Spectral unmixing analysis of the CHRIS imagery provides a distribution map of the Road spectral endmember extracted from the imagery. The reflectance spectra of this endmember well corresponds to the spectral reflectance acquired with the hand-held spectrometer during field campaigns in the area.

Note the Misery Road in the unmixed endmember map (Figure 6), shown as a high fraction (red). Other high concentrations of this end member is seen in the waste rock pile area just north of the Panda and Koala pits. Due to spectral reflectance similarities of the Road endmember to the naturally distributed boulders and rocks in the area, this analysis also detects areas of relatively large boulder concentration (yellow/green) and lower boulder concentration (blue).

This analysis suggests a consistent fall-off of this endmember concentration from the road centre into the tundra areas. While there are no specific spectral features differentiating the road endmember from the naturally distributed boulders and rocks, it is distinguishable from vegetated areas due to its relatively brighter visible and less-bright infrared reflectance magnitude. In this analysis, a zone of dust concentration above ambient appears to be detected up to 500m from the road. The decrease in this endmember concentration from the road centreline and into the surrounding tundra supports field analysis of dust density decreasing to ambient values within the 1 km distance range.

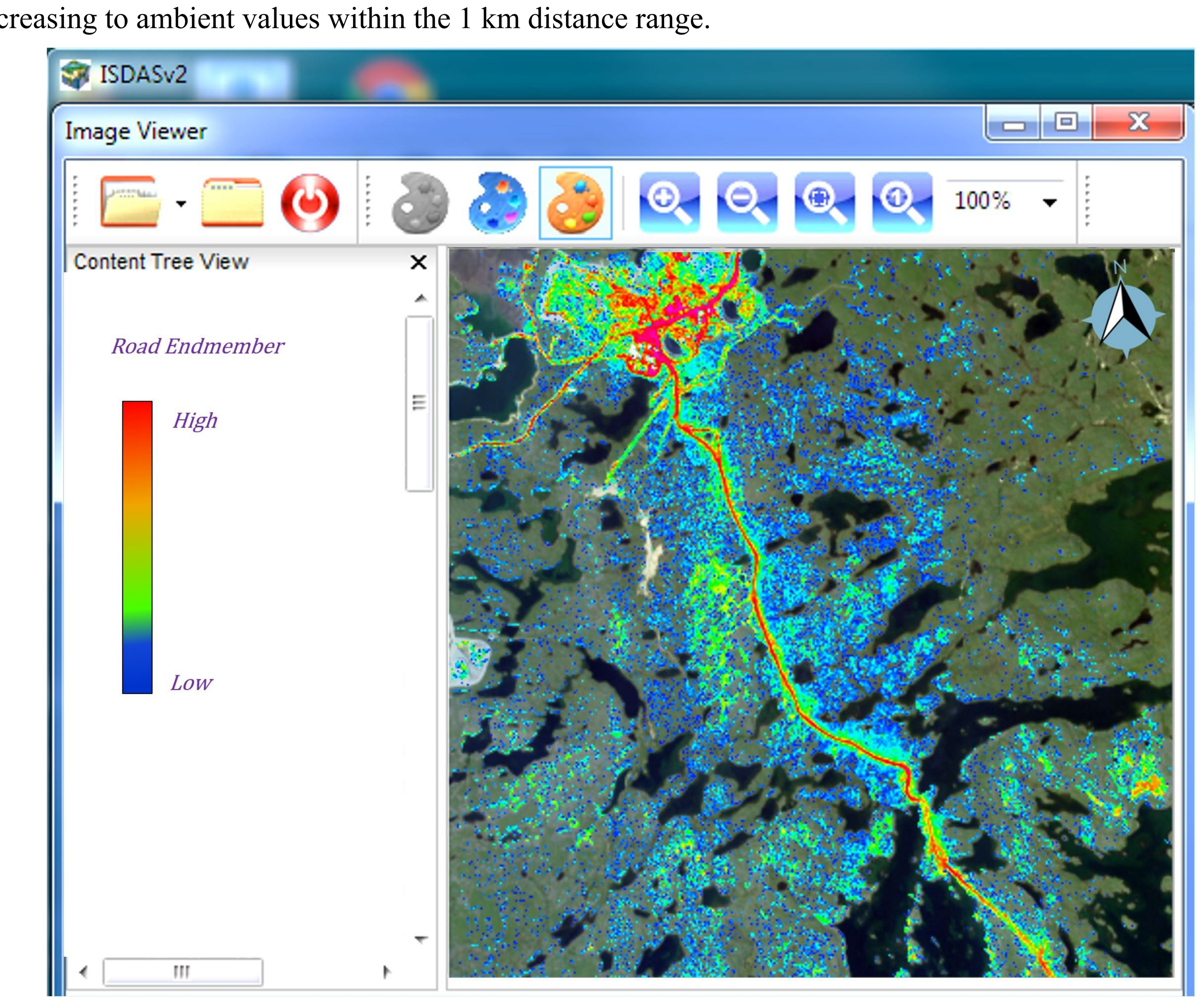

Figure 6: An endmember analysis of detecting the spectral profile of road dust along Misery Road. Note how the concentrations of dust appear to decrease with distance from the road. Areas of waste rock and natural boulder fields are also detected.

This poster was originally presented at the 17th North American Caribou Workshop (2018) (See page 160 of the abstract booklet - (https://www.cclmportal.ca/resource/conference-program-17th-north-american-caribou-workshop-2018).

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Permanent link: https://doi.org/10.4095/330548

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Recommended citation
White, H.P., Chen, W., and Leblanc, S.G., 2022. Satellite observations for detection of dust from mining activities in a caribou habitat, Northwest Territories and Nunavut; Geomatics Canada, Open File 71, 1 poster. https://doi.org/10.4095/330548