# Applying NDVI on Monitor the Damaged Crops Area Caused by a Hail Event—A Case Study in Assiniboia, Saskatchewan, Canada

## Introduction

The healthy vegetation reflects the near-infrared spectrum more and strongly absorbs the red range of the spectrum. According to this characteristic, an index indicating the change of vegetation was developed (Rouse et al., 1973), which is the Normalized Difference Vegetation Index (NDVI). Using the near-infrared and red range spectrums of the optical image, we can calculate the NDVI value ranging from -1.0 to 1.0.

$$\mathrm{NDVI} = \frac{NIR - R}{NIR + R} \tag{1}$$

Those areas that are covered by water, cloud or snow will result in negative values due to the higher reflection of the red-spectrum light. Soil and rocks absorb similar amount of near-infrared and red-spectrum light will result in near zero NDVI values. Higher than zero results are caused by vegetation. The NDVI value of the vegetation will range from 0 to 1, depending on the type and health conditions.

| No. | Type | Characteristic | Value |
|---|---|---|---|
| 1 | Water, cloud and snow | Near-infrared spectrum $<$ red-spectrum | $< 0$ |
| 2 | Soil, rocks | Near-infrared spectrum $\cong$ red-spectrum | $\cong 0$ |
| 3 | Vegetation | Near-infrared spectrum $>$ red-spectrum | $> 0$ |

Table1. The different types of the ground objects lead to a variety of NDVI values.

## Workflow and Data

Base on the results of our analysis, we successfully identified the impact of crop damage from the hail event on 4th of July on a large scale by applying the Sentinel-2 satellite images to the NDVI calculation. The recommended steps were implemented by following the workflow (Figure1.). The advantages of using Sentinel-2 images compared to the drone photographs are listed in Table2. Table3 indicates the date and the ID of the dataset used to present this example case.

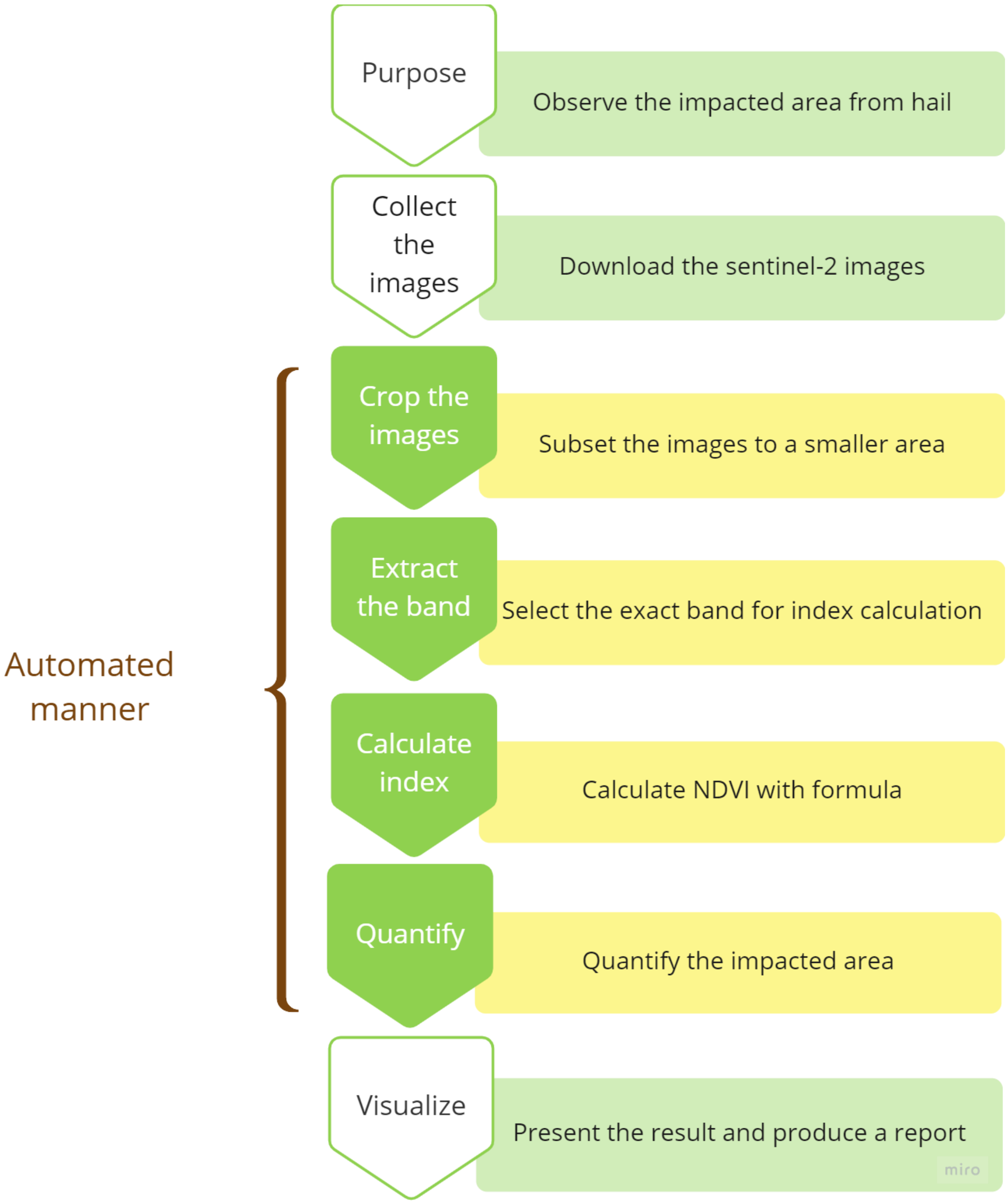


Figure 1. The recommended workflow conducting in the analysis

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| | Drone photographs | Sentinel-2 |
|---|---|---|
| coverage area | Limited coverage | Wide coverage |
| price | costly | Open data |
| Period | Can't get the images in time for an emergency, it takes time to conduct a flying plan. | Revisit every 10 days for each satellite, 5 days revisit period combine other constellation. |

Table2. The comparison between drone photographs and Sentinel-2 images.

| Date | Resolution | Dataset ID |
|---|---|---|
| 3 July 2020 | 10m | S2B_MSIL2A_20200703T175919_N0214_R041_T13UDR_20200703T204345 |
| 6 July 2020 | | S2B_MSIL2A_20200706T180919_N0214_R084_T13UDR_20200706T222223 |

Table3. The data set of Sentinel-2 images.

## Result

The NDVI results before and after the hail event are demonstrated in Figure 2. and Figure 3., these two images were taken on the 3rd and 6th of July 2020. Using NDVI higher values correspond to higher vegetation density and better vegetation health. Figure 2. shows the distribution of the vegetation before the hail. The changes caused in the ground objects by the hail are clearly visible between the two images. We get more occurrences of NDVI values that are between 0.2 to 0.4 after the hail, so we can infer that the natural disaster certainly damaged the crops.

The NDVI values decrease from healthy crops to damaged crops, hence, we take the difference of the two results to get the change during the time interval. It can be inferred that the difference values will be positive in the damaged area. Comparing this result with the satellite image, we set the threshold for NDVI difference values to filter the ground objects not related to the hail event, for example: lakes, the channel for irrigation (Figure 4.), and get the optimized threshold at 0.2.

In addition, we applied the erosion and dilation algorithms during the image processing to filter the ground objects that couldn't be removed completely in the previous step. After the erosion step, the size of the targets will decrease which reaches the goal of eliminating the ground objects, meanwhile, this process also removes part of the real damaged area. Therefore, we used dilation to widen the objects in the next step.

We calculated the affected area before and after applying the morphological algorithms. The pixel size of Sentinel-2 image is 10m x 10m. We can obtain the estimated size of the area by calculating the number of pixels which values are above 0.2. The estimation of the damaged area is from 104.732 $km^2$ to 120.367 $km^2$.

$$\text{Original:} \quad 120{,}367 \times 10m^2 = 1{,}203{,}670\ m^2 = 120.367\ km^2 \tag{2}$$

$$\text{Eroded and Dilated:} \quad 104{,}732 \times 10m^2 = 1{,}047{,}320\ m^2 = 104.732\ km^2 \tag{3}$$

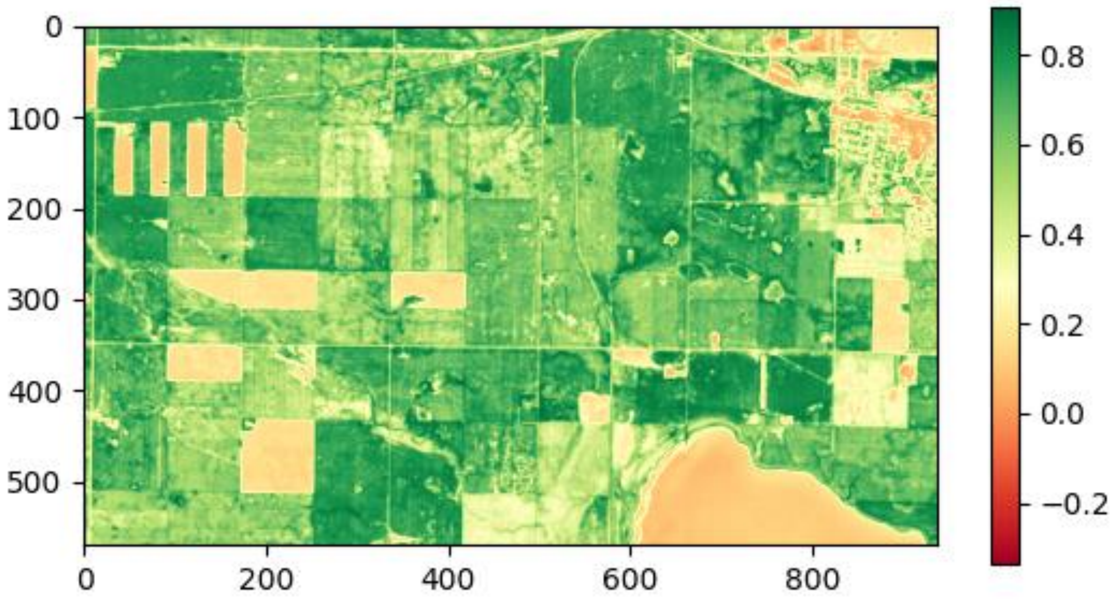


Figure 2. The NDVI values on 3rd of July.

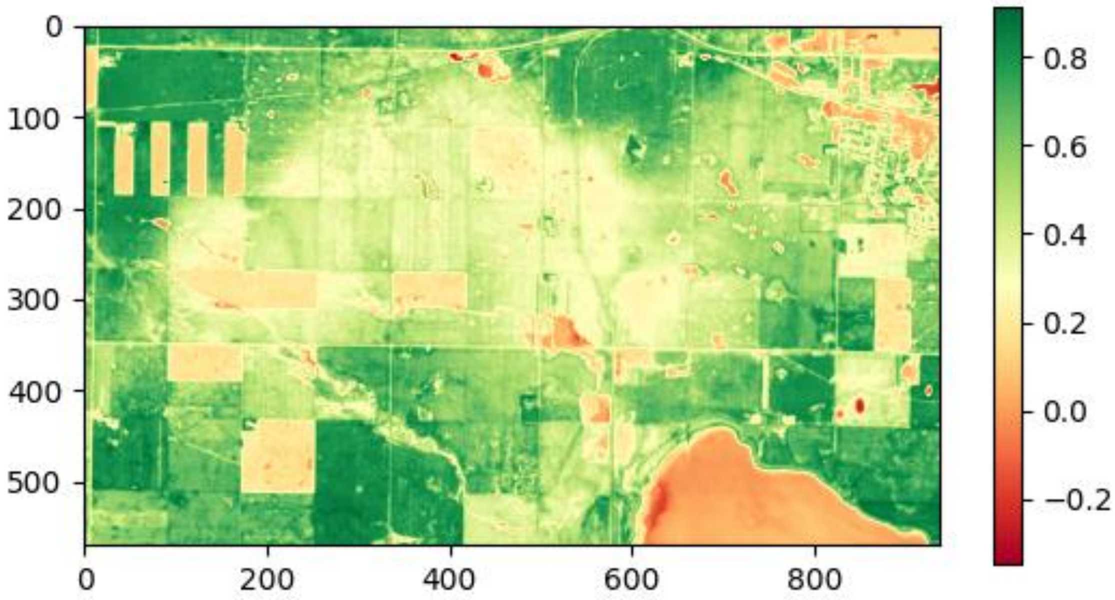


Figure 3. The NDVI values on 6th of July.

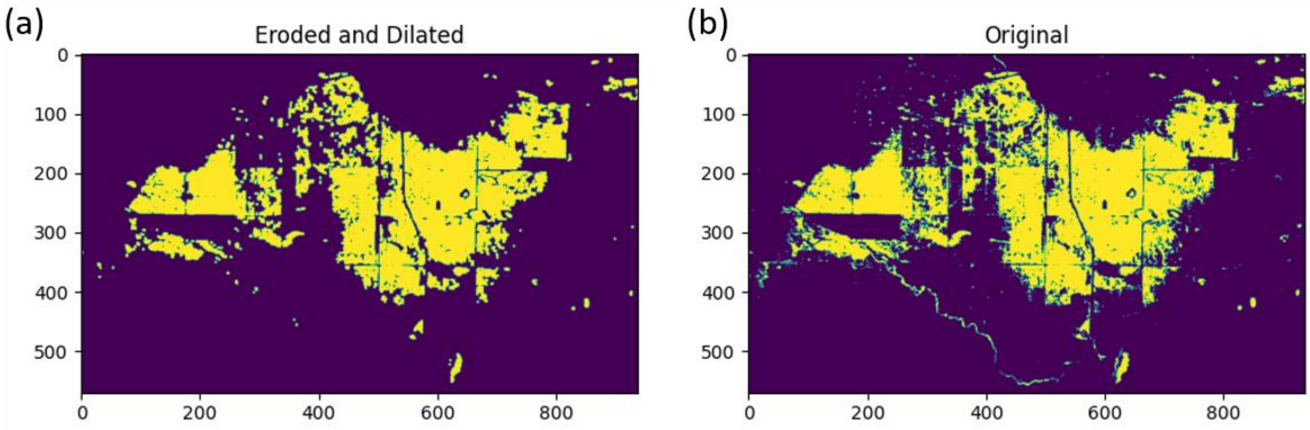


Figure 4. The difference between the NDVI results on the 3rd of July and the 6th of July. (a) applied morphological algorithm to filter the ground objects that are not related to the crops area with threshold 0.2, (b) only applied the threshold 0.2.

## Conclusion

1. According to our analysis, it is feasible using optical satellite images to observe the crop damage from hail applying NDVI.
2. The estimation size of damaged area is from 104.732 $km^2$ to 120.367 $km^2$.
3. The current workflow couldn't remove the ground objects that are not related to the crop damage completely. Better solution might be setting a threshold to the NDVI results first and then taking their difference.

## Reference

Rouse Jr, J. W., Haas, R. H., Schell, J. A., & Deering, D. W. (1973). *Monitoring the vernal advancement and retrogradation (green wave effect) of natural vegetation* (No. NASA-CR-132982).