RESEARCH ARTICLE

Developing a method for understanding pasture and forage crop conditions (Comparing Satellite obtained NDVI data with UAVs obtained data)

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ABSTRACT

Scientific forage management needs accurate measurement of Normalized Difference Vegetation Index (herein after NDVI). By comparing a time series of NDVI images are valuable for forage management. The authors have developed a methodology that possibly reduces the amount of fertilizer applied thus protecting the environment. This methodology uses an unmanned aerial vehicles (herein after UAVs) and Satellites. Comparing different periods of Satellite derived NDVI, the authors propose a methodology to quickly understand forage growing conditions and leads to economical fertilizer application rates. The possibilities of combining multispectral images and Satellite images are also discussed.

Keywords: NDVI, UAVs, Satellite

Introduction

Satellite and UAVs derived NDVI data are becoming widely used in agriculture to understand growing conditions. Economical fertilizer and chemical application rates are enhanced by new technology leading to reduced production costs. Fertilizer and chemical applying UAVs such as DJI manufactured MG-1 (DJI MG-1, 2019) have become standard tools and are widely operated. One of the authors obtained a license to operate MG-1 and to confirm the benefits and research its potential possibilities. Achieving economical fertilizing requires precise surface information. The authors proposed a methodology by comparing several UAVs obtained images, the amounts of fertilizer that are needed can be optimized by analyzing the spatial grows patterns of the pasture (Matsumura and Inoue, 2018). Comparing this with different periods of Satellite derived NDVI, the authors propose a methodology to quickly understand growing conditions.

Study area and previous study

The study area is situated facing Lake Notori, in the north eastern part of Hokkaido, Japan. If the forage crop area has been used for long time, weeds prevent high productivity. To maximize productivity, practitioners rotate the area. Maize for cow was planted to replace of grassland used for author's previous study. Most recent rotation practice is a 2 to 3 years silage corn cropping followed by 6 year grass plantation. The currant study area had been used as maize field until 2018 and was planted to grassland in 2019.

Figure 1. Study area (Left) and on satellite derived NDVI (Right)

By using auto pilot software (Mission planner and Litchi, 2019) The authors directed an UAV to fly over the study area and took a series of images at 100 meters above sea level and conducted the NDVI comparisons before and after harvesting the forage crop. The experiment was conducted in 2017 (Matsumura, K., & Inoue, S., 2018). Positive NDVI value show in black and negative NDVI value show in white. In 2017, cutting was conducted between June 13th and July 14th, July 13th to August 17th. The NDVI difference subtracting June 13th from July 14th (Left in Fig2). The NDVI difference subtracting July 13th from August 17th (Middle in Fig2). Composite of left in Fig 2 and middle in Fig 2 is right in Fig2. There are some areas that show higher values. The analysis shows the highlighted areas that might be overfertilized.

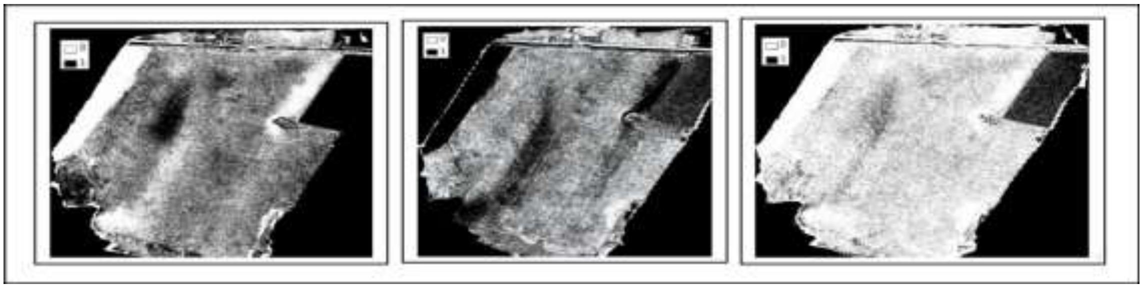


Figure 2. NDVI difference before and after cutting in 2017

Satellite obtained NDVI and a time series analysis

A methodology to quickly understand forage conditions is proposed. Space-Agri Company LTD. gets satellite image data from Planet Company LTD every day. Both NDVI and RGB images are provided. Sometimes, cloud cover prevented the authors from getting this surface information. Visible images play an important role for detecting cloud cover. The following images were obtained in 2019.

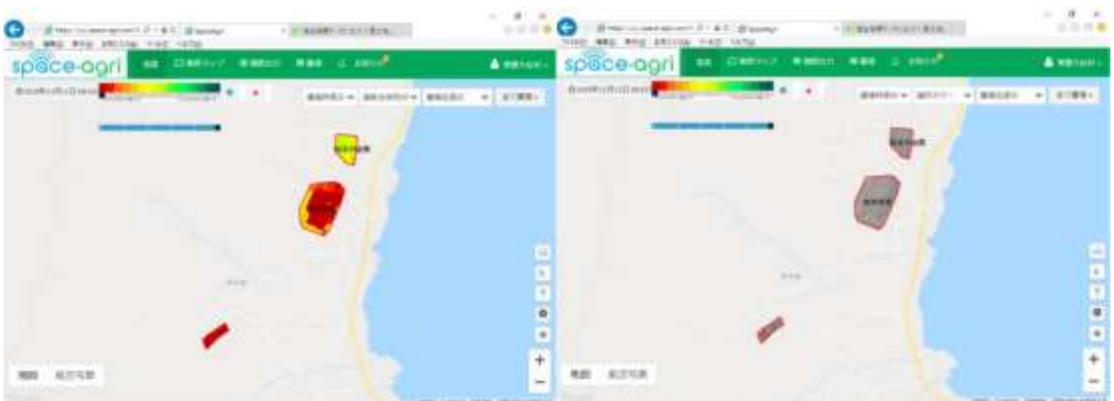


Figure 3. NDVI (Left) and Visible (Right) image

Space-Agri gets satellite images. These datasets must be transformed from a shape-format to a raster-format to conduct raster calculations.

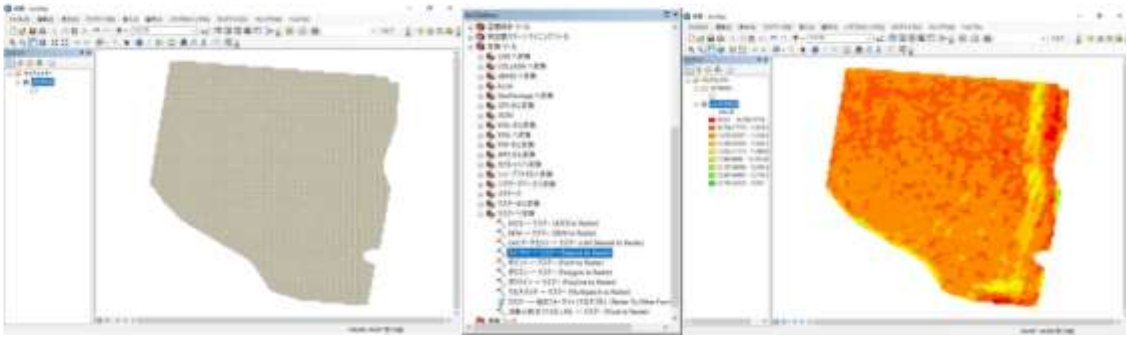


Figure 4. Transforming a shape file to a raster file in April 20th

In general, NDVI value range from -1.0 to 1.0. Space-Agri NDVI value is in an Integer format ranging from 0 to 20000. To obtain general NDVI value, the Integer value is divided by 10000 and subtracted by 1.

Figure 5. An explanation of describing how to change Integer values to NDVI values

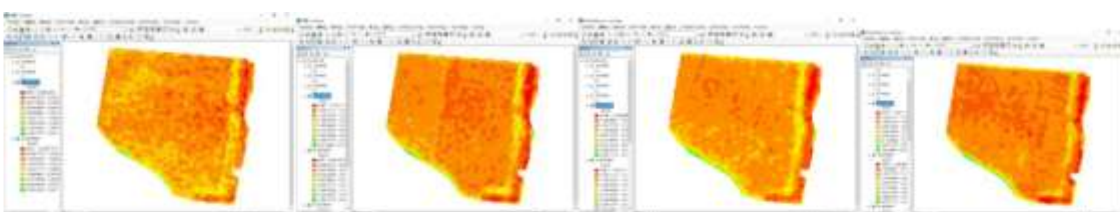


Figure 6. NDVI values, Apr 22nd, Apr 30th, May 5th and May 16th

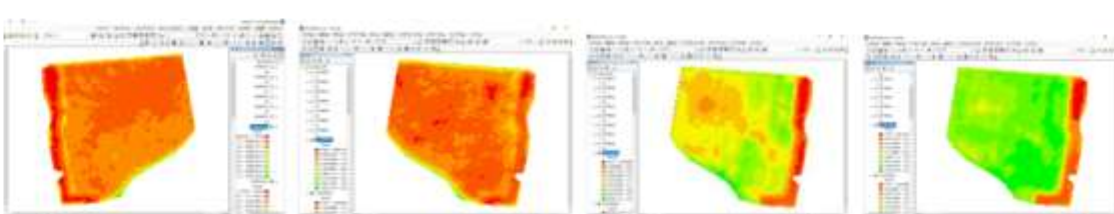


Figure 7. NDVI values, May 25th, May 30th, June 14th and June 25th

The NDVI values increases gradually due to plant growth. This increase of NDVI is higher in May to June.

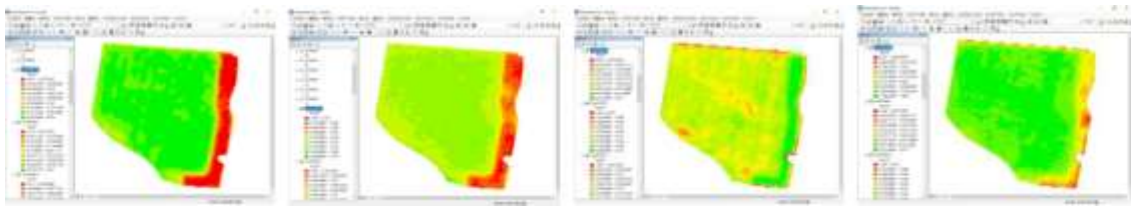


Figure 8. NDVI values, July 11th, July 22nd, August 11th and September 3rd

NDVI values on September 3rd were saturated showing the forage was ready to cut and harvesting was conducted between September 3rd to 10th. Figure 9 shows the decrease of NDVI after the harvest.

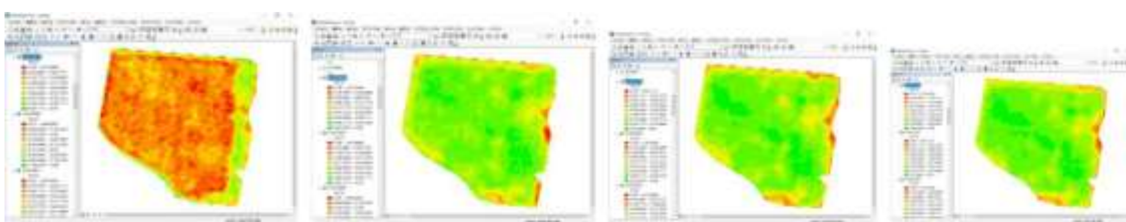


Figure 9. NDVI values, September 10th, September 30th, October 21st and November 8th

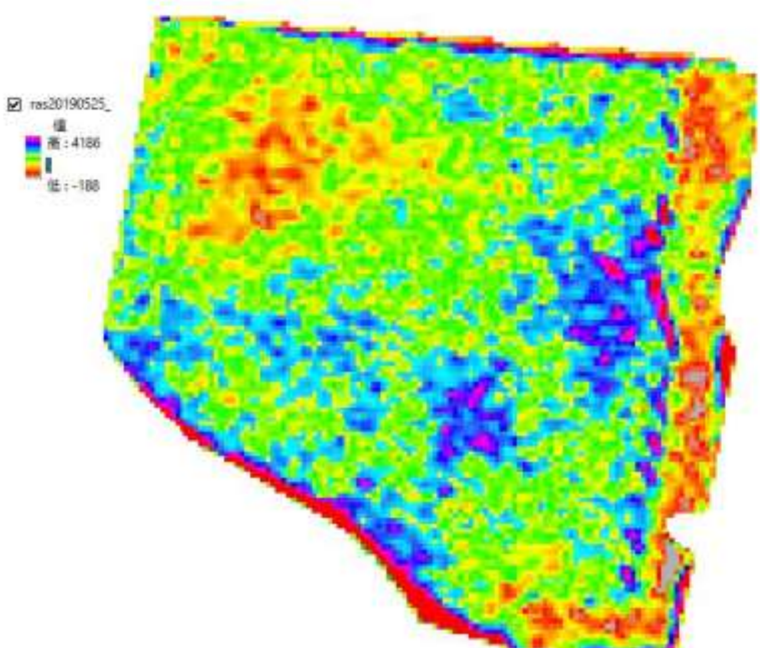


Figure 10. NDVI values (Integer format) subtracted April 22nd from May 25th

To understand the change of NDVI from April 22nd to May 25th, each NDVI value is transformed to point data.

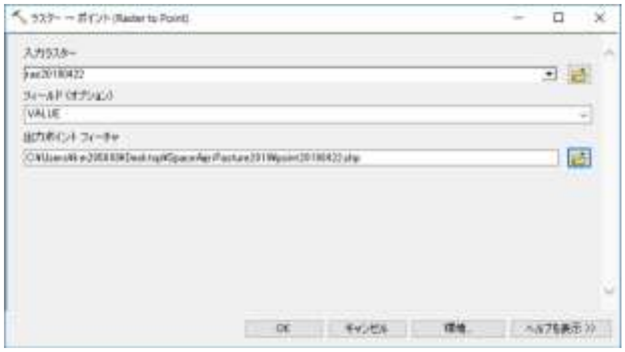
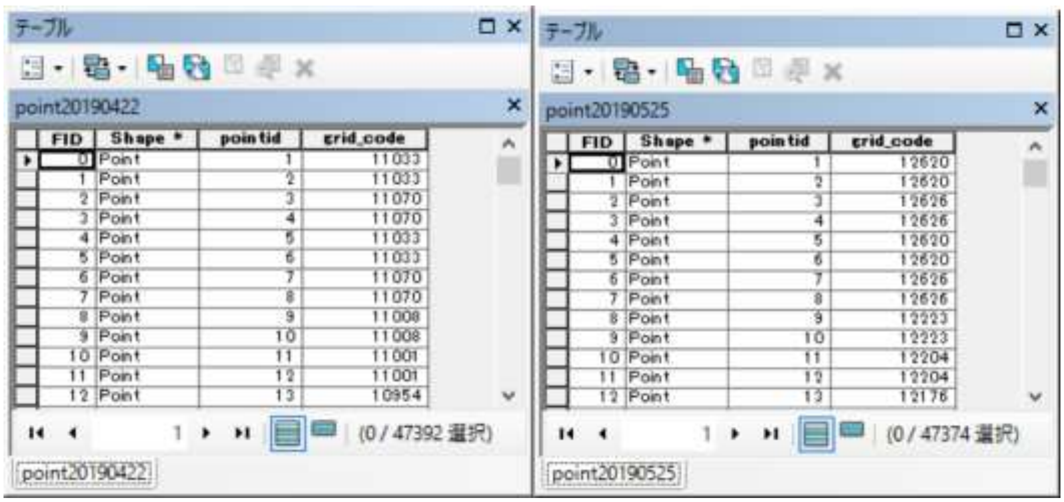


Figure 11. Raster to point function

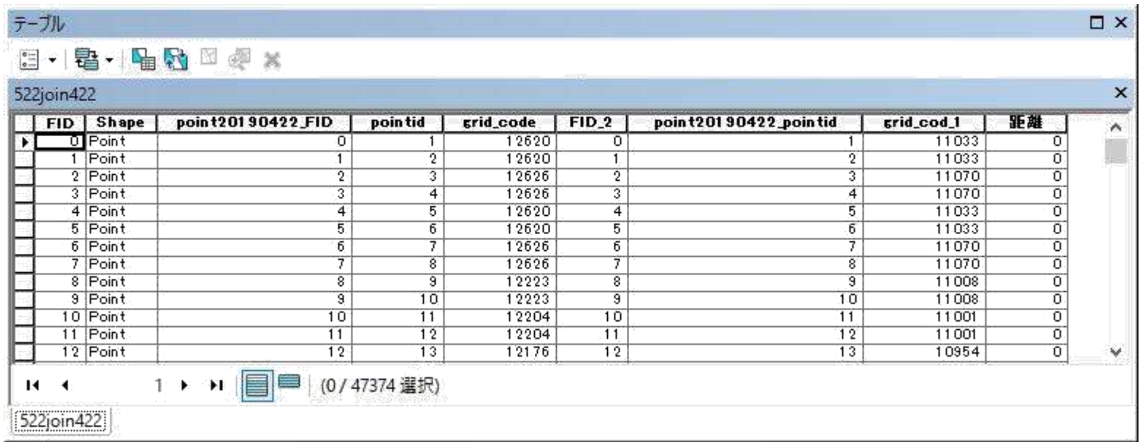


FID	Shape *	pointid	grid_code
0	Point	1	11033
1	Point	2	11033
2	Point	3	11070
3	Point	4	11070
4	Point	5	11033
5	Point	6	11033
6	Point	7	11070
7	Point	8	11070
8	Point	9	11008
9	Point	10	11008
10	Point	11	11001
11	Point	12	11001
12	Point	13	10954

FID	Shape *	pointid	grid_code
0	Point	1	12620
1	Point	2	12620
2	Point	3	12626
3	Point	4	12626
4	Point	5	12620
5	Point	6	12620
6	Point	7	12626
7	Point	8	12626
8	Point	9	12223
9	Point	10	12223
10	Point	11	12204
11	Point	12	12204
12	Point	13	12176

Figure 11. Raster to point data on April 22nd (Left) and May 25th (Right)

Figure 12. Connecting April 22nd with May 25th using spatial information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	FID	Shape	point20190422_FID	pointid	grid_code	FID_2	point20190422_pointid	grid_cod_1	距離
▸	0	Point	0	1	12620	0	1	11033	0
	1	Point	1	2	12620	1	2	11033	0
	2	Point	2	3	12626	2	3	11070	0
	3	Point	3	4	12626	3	4	11070	0
	4	Point	4	5	12620	4	5	11033	0
	5	Point	5	6	12620	5	6	11033	0
	6	Point	6	7	12626	6	7	11070	0
	7	Point	7	8	12626	7	8	11070	0
	8	Point	8	9	12223	8	9	11008	0
	9	Point	9	10	12223	9	10	11008	0
	10	Point	10	11	12204	10	11	11001	0
	11	Point	11	12	12204	11	12	11001	0
	12	Point	12	13	12176	12	13	10954	0

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Figure 13. Spatially connected point data from April 22nd and May 25th

In Figure 13, "Gridcode1" expresses the data on May 25th and "Gridcode_1" expresses the data on April 22nd. A combined graph is finally obtained.

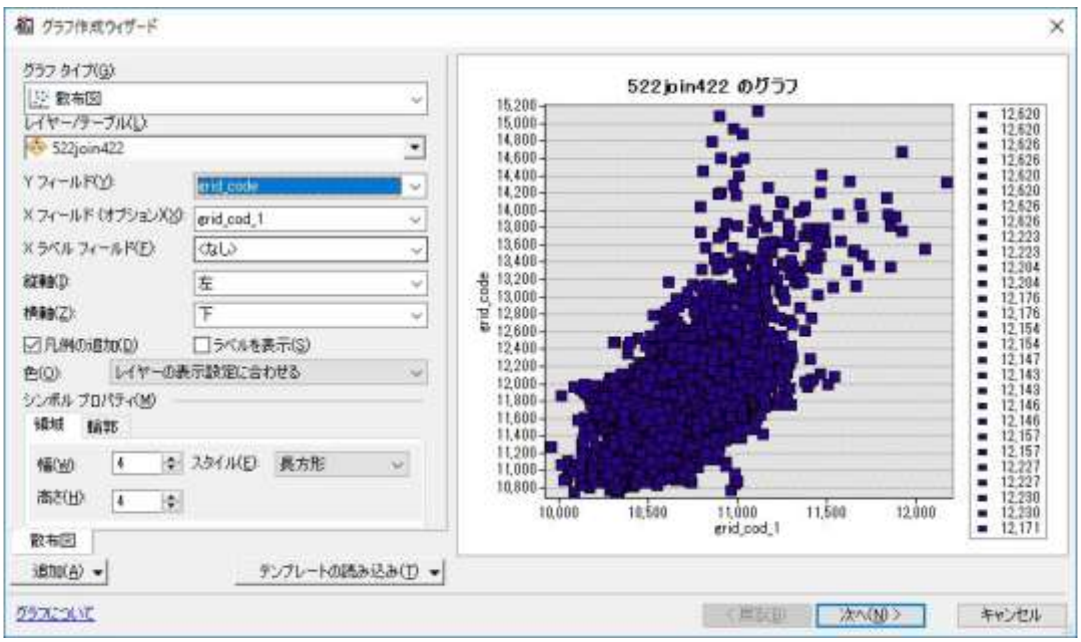

Figure 14. NDVI changes from April 22nd to May 25th

X-axis shows April 22nd and Y-axis shows May 25th. Figure 14 quickly shows the increase of NDVI. Each point has latitude and longitude co-ordinates, so that the information can be used for precision fertilizing. There are points NDVI integer increase from 11,000 to 15,200. That means NDVI value increases from 0.11 to 0.53, a dramatic change. Thus, the analysis shown in figure 14 provides useful information

Multispectral Images obtained from UAVs

The authors started to use Parrot Sequoia+ with a sunshine sensor from late summer 2019. Thanks to the Pix4D software, the Parrot Sequoia+ becomes the first commercial multispectral camera to provide absolute reflectance measurements without the need for reflectance targets (Pix4d and Sequoia, 2019). This camera captures, Green, Red, Red edge and NIR. The reflectance and wavelength (Cybernetech, Sequoia camera, 2019) are shown in Figure 15.

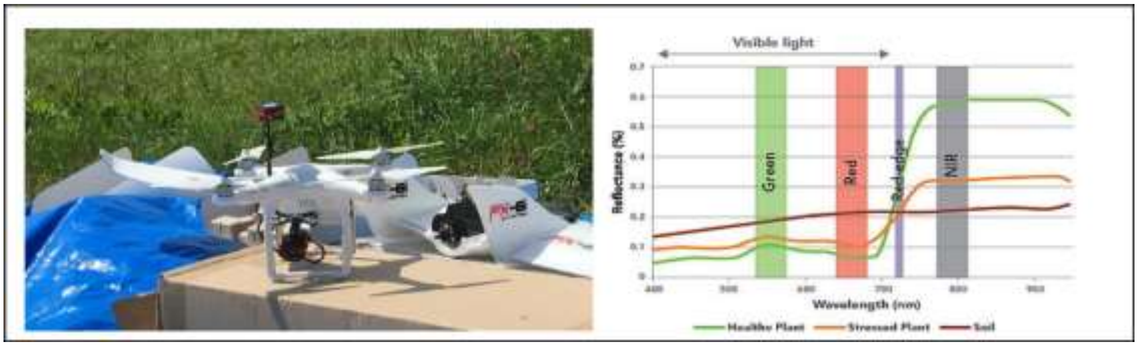

Figure 15. UAVs with multispectral camera (Left) and wavelength and Reflectance (Right) (Cybernetech, Sequoia camera, 2019)

By using multispectral reflectance ratio, following indexes such as (NIR-Red) / (NIR+Red), (NIR-Green)/(NIR+Green), (NIR-RedEdge) / (NIR+RedEdge) can be calculated. The index "(NIR-Red) / (NIR+Red)" defined as NDVI is used for comparison. Planet Company LTD provides 3meter resolution satellite image data anywhere on the earth, every day (Planet, 2019). Space-Agri Company LTD gets the data from Planet Company and divide and deliver satellite obtained data to individual farmers. The authors purchased data and got the NDVI data for the study area. From late summer 2019, the authors flew a sequoia equipped UAV over the study area collected a series of multispectral images. Table 1. shows data collections from both of the multispectral camera and satellite image. Clouds sometimes prevents a satellite from getting NDVI information. The authors conducted a comparison between UAV and Satellite obtained images. The same days both UAV and Satellite images were obtained without clouds were on September 2nd, 10th ,19th, October the 21st and November 8th.

Table 1. Data collection calendar, both UAV (Multispectral) and Satellite (Planet) images

	August	September			October			November
Multispectral Camera	27	2	10	19	25 21415	21	29	8
Planet image (NDVI)	31	2	10	19	much cloud	21		8

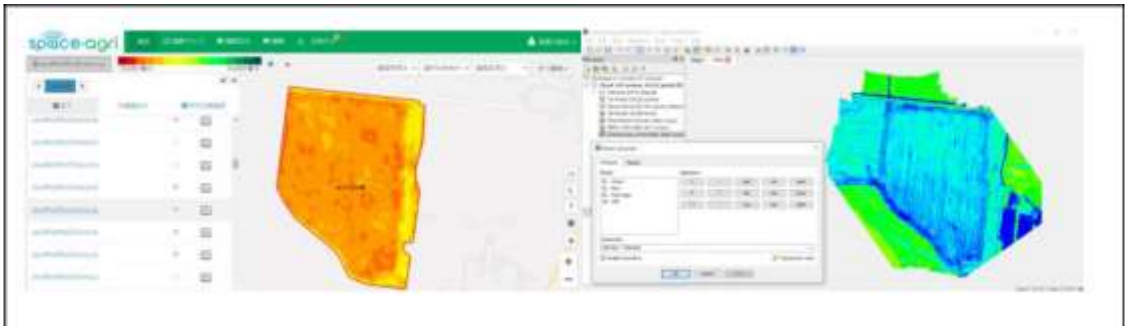

Figure 16. Satellite (Left) and Multispectral (Right) derived NDVI image

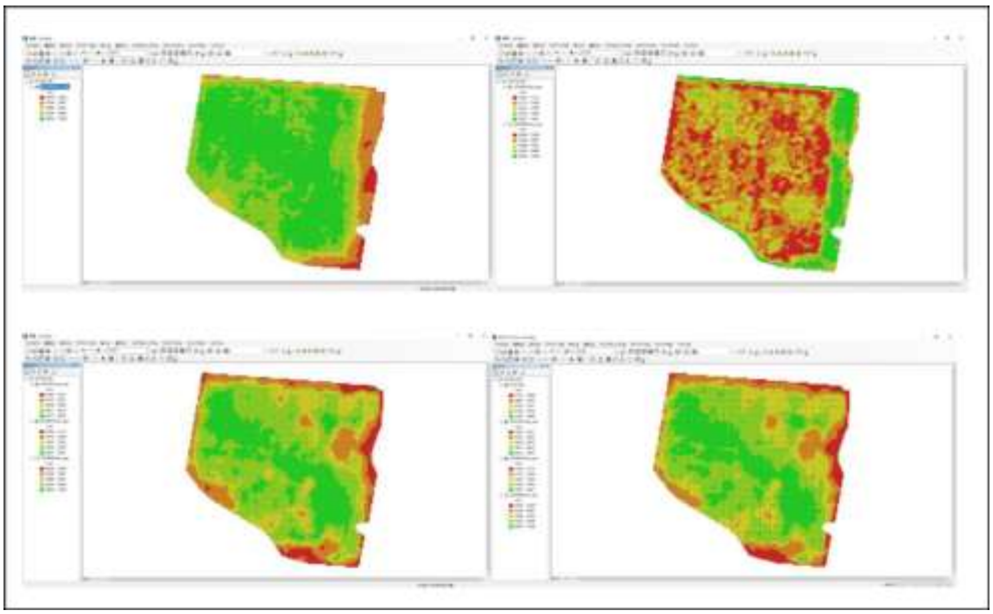

Figure 17. Satellite derived NDVI image on September 2nd (Upper Left), 10th(Upper Right), October 21st(Lower Left), and November 8th(Lower Right).
All images above have clear sky, without clouds.

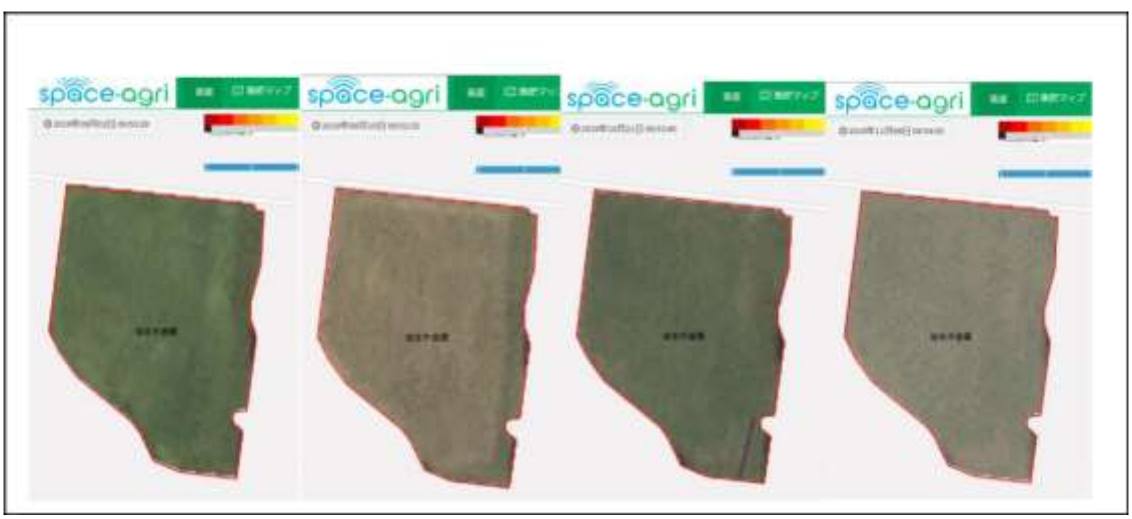

Figure 18. Visible images from September 2nd , 10th , October 21st, and November 8th

Datasets obtained from Space-Agri company are shape file format and should be transformed to raster format. By using the raster calculator equipped on ArcGIS software, Feature to raster function is conducted. As explained above, its value is integer format ranging from 1 to 20000. To obtain NDVI value, the formula: NDVI=Integer/10000-1 is applied.

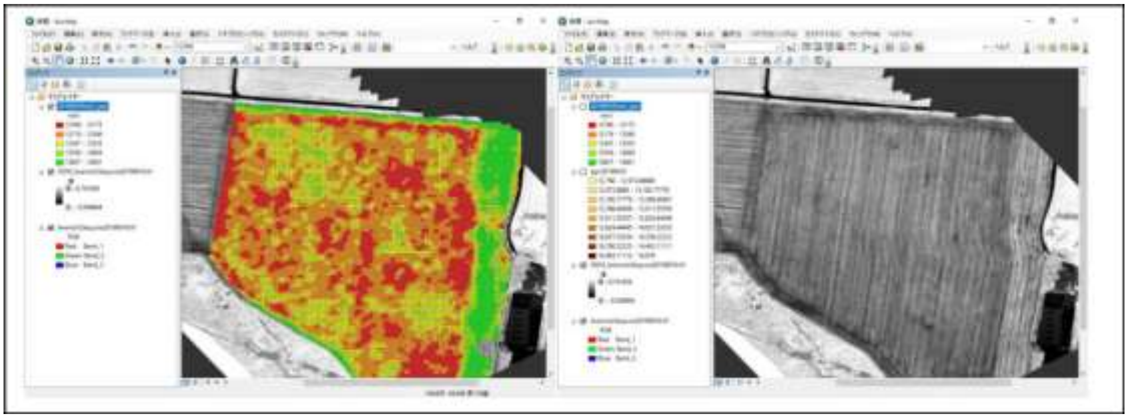

Figure 19. Satellite (Left) and Multispectral (Right) NDVI image on September 10th, 2019

To compare Satellite and Multispectral image, NDVI value on multispectral camera is transformed to integer format using following formula: Integer value =(NDVI+1)∗10000. The resolution of Satellite image is 3 meters and that of UAVs is less than 0.1 meter. Satellite image and UAVs image show same NDVI values. Calculating the relationships among Satellite and UAVs derived data, there seems to be a possibility to obtain precise data where UAVs are not operated by using a digital elevation model and deep learning methodology. However, the authors have tried to find out the relationships among satellite and UAVs, the lack of computer ability prevented the authors from calculating the following formula.

(Precise NDVI)= f(Satellite derived NDVI, topography information)

Conclusions and future prospect

A methodology to quickly asses forage growth conditions was proposed above and the comparison between UAV and Satellite derived data are conducted. The authors contribute to precision forage management such as automatically taking data described above and immediately applied to fertilizer delivering UAVs, or land-based applicators. Researches for soil conditions and other growth valuables are required.

Acknowledgement

Owing to great support from The Iwamoto Farm in the eastern part of Hokkaido, Japan, this research is working in progress. This work is supported by matching fund between National Agriculture and Food Research Organization (NARO) and Tokyo University of Agriculture 2019.

References

1. AGRAS MG-1S, https://www.dji.com/mg-1s. Accessed November 17, 2019

2. Hilker, T., M.A. Wulder and N.C. Coops., Update of forest inventory data with LiDAR and high spatial resolution satellite imagery. Can. J. Remote Sens. 2008; 34(1): 5–12. doi.org/10.5589/ m08-004

3. Lu, S., Inoue, S., Shibaike, H., Kawashima, S., Yonemura, S., & Du, M. Detection potential of maize pollen release stage by using vegetation indices and red edge obtained from canopy reflectance in visible and NIR region. Journal of Agricultural Meteorology. 2015; 71(2), 153-160.

4. Matsumura, K., & Inoue, S., Unmanned Aerial Vehicle for fertilizer management and human health. Medical Research Archives. 2018; 6(3).

5. Mission planner, http://ardupilot.org/planner/. Accessed November 17, 2019.

6. Litchi, https://flylitchi.com/. Accessed November 17th, 2019.

7. Pajares, G., Overview and current status of remote sensing applications based on Unmanned Aerial Vehicles (UAVs). Photogramm. Eng. Rem. S. 2015; 81(4): 281–329. doi.org/10.14358/ PERS.81.4.281

8. Pix4d and Sequoia, https://www.pix4d.com/product/sequoia. 2019; Accessed November 17, 2019.

9. Cybernetecch, Sequoia camera. http://www.cybernetech.co.jp/product/flycyber_sequoia.html. Accessed November 9, 2019.

10. Daily Satellite Imagery and Insights | Planet. https://www.planet.com/. Accessed November 9, 2019.

11. Space-Agri. https://www.space-agri.com/. Accessed November 9, 2019.

12. Matsumura, K., Unmanned Aerial Vehicle for fertilizer management on grassland, Hokkaido Japan. In: Ram Avtar, Teiji Watanabe ed. Unmanned Aerial Vehicle: Applications in Agriculture and Environment, , Springer, Inc; 2019: 39-50

13. Normalized Vegetation Index, Kokudo Chirin. https://www.gsi.go.jp/kankyochiri/ndvi.html. Accessed November 9, 2019.

