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Article

Combining UAV and satellite image for monitoring drifting ice

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Abstract
Satellite and UAV images are widely used for ecological field analysis and interpretation. Drifting ice and Seagrass habitat are discussed. Collaborating with our Indian satellite data acquisition company, the system can acquire Normalized vegetation index (NDVI) and Normalized Moisture index (NDMI) for the targeted area. The author compared satellite obtained NDMI and UAV data, against NDVI data over grassland. The possibilities of using NDMI as a forecaster for NDVI is proposed. The possibilities applying this system for drifting ice is also proposed.

Key words: drifting ice, NDMI, NDVI, UAVs

1. Introduction

Conventional aerial imagery from UAV is increasingly used in the acquisition of high spatial resolution imagery (Pajares, 2015). The open source software (Mission Planner, 2019) makes it possible to conduct and manipulation flight waypoint. On the Mission Planner, and area is chosen and flagged. Flags are associated with coordinates and altitude above ground (not sea level) and then a flight plan is obtained. A flight plan on Mission Hub is transformed to auto pilot software (Litchi) on iOS tablet. Litchi lets the UAV fly over the pre-programmed course. Lake Notori district was study area. The Authors set a flight plan over the study area. Moba seagrass habitat is thought to be a carbon dioxide sink, and plays an important role in the carbon cycle (Nihon Keizai Newspaper, 2019).The Authors directed an UAV to fly over the study area and shot a series of pictures 100 meters above sea level. Satellite image is obtained from Sentinel-2 (Restec, 2020).

2. Drifting ice and its impacts on Seagrass

Lake Notori is situated in the eastern part of Hokkaido, Japan. The authors have been conducting surveys in this district. Identifying the distribution of seagrass patches is important to understand Hokkai shrimp habitat. Hokkai shrimp contributes fisherman. Seagrass patches are influenced by drifting ice. Small (young) individuals strongly depend on seagrass during both night and day. Large (i.e. old) individuals go out from a seagrass patch at night and return to the patch in the daytime. During winter season 2018-2019, the extremely low temperature made drifting ice thick and dense. Upon melting during warm periods, the angular blocks of crumbling ice would shred the seagrass beds are torn into smaller parches, the large juvenile-shrimp habitats would be compromised and reduced spatially. This would result in diminished Hokkai shrimp hatching populations. The authors conducted an observation at same place in 2018 and 2019 by using UAVs. A Series of pictures are transformed to three dimensional pictures by using Structure from Motion (SfM) (Inoue et al., 2014). Orthorectifying Aerial Photograph is invaluable as it offers detailed sub-meter accuracy information. Each orthorectifying aerial photograph is transformed to Google Earth KML format and compared to check the difference.

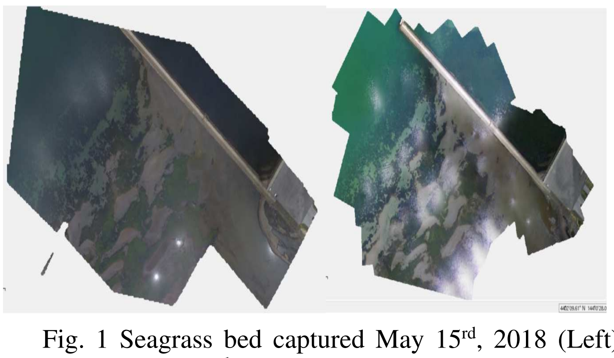

Fig. 1 Seagrass bed captured May 15rd, 2018 (Left) and May 22nd, 2019 (Right)

Circled area in Fig 2 highlights the damaged and shredded by thickened drifting ice during 2018-2019 winter season.

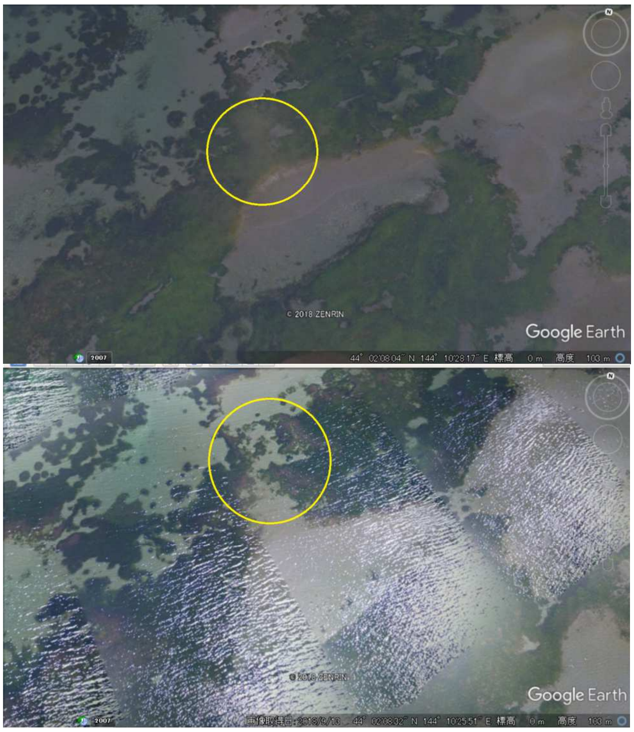

Fig 2. Highlight the place scratched by drifting ice. The image in 2018 (Above) and 2019 (Bottom).

3. Satellite and UAV Images

One of the authors used to work for the University of Tokyo. His classes were attended by numerous foreign students. The author gave support to a proposal to create an English editing business based in India. The growth of this company has created more than 0.41 million customers (https://www.editage.com/). The CEO of Editage introduced an enterprising company and created a busines called "Agriforetell" in India (https://agriforetell.com/). These two companies joined forces. By using Copernicus: Sentinel-2-The Optical Imaging Mission for Land Services, "Agriforetell" can provide satellite images such as Normalized Vegetation Index (NDVI), Normalized Moisture Index (NDMI), and visible image values to worldwide locations. 10meter resolution is available bi-weekly. The author has been working on providing printed images derived from Agriforetell satellite analysis to farmers. Great effort is made to collect farmer feedback. The cost is an issue with many farmers; however, those concerns are allayed upon analyzing the usefulness of the data. The formula for NDMI is calculated (NIR-SWIR)/(NIR+SWIR). NIR is Near infrared and wavelength is 835.1nm (S2A) and 833nm (S2B). SWIR is short wave infrared and wavelength is 1613.7nm (S2A) / 1610.4nm (S2B). Agriforetell satellite analysis provides information by weekly. NDMI on July 27th 2020 and NDVI on September 9th obtained over the rice field in Asahikawa are shown in Fig 4. According to the owner of this rice field, NDMI image expresses NDVI one month earlier. Low moisture zone result in higher NDVI zone one month later.

Fig 4. NDMI(Left) and NDVI(Right)

The advantage of using UAVs is that data can be obtained at the time required by farmers. Sentinel satellite images restricted to the satellite flyover periods. The grassland in the eastern part of Hokkaido, NDMI on August 27th, 2020 and NDVI on October 8th (UAV obtained) are shown in Fig 5. One month later, lower NDMI zone results in higher NDVI zone.

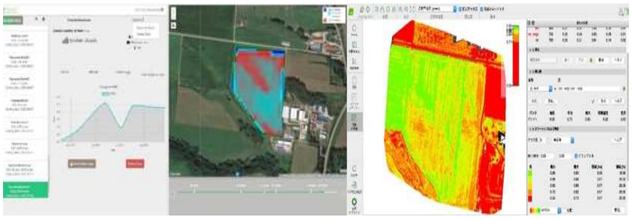

Fig 5. NDMI (Satellite) and NDVI(UAV)

Lake Notori is also famous for scallop aquaculture. At the entrance of lake, there is a chain wire preventing ice from drifting into the lake. NDMI and NDVI images on February 29th, 2020 over the entrance are shown in Fig 6. RGB shows the existence of drifting ice, however NDMI using short wave infrared detects the presence of drifting ice at the lake entrance.

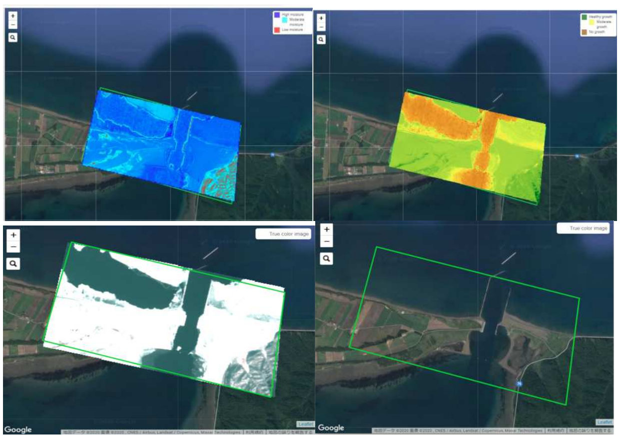

Fig 6. NDMI (Top Left), NDVI (Top Right) RGB (Bottom Left), Base Map (Bottom Right)

Agriforetell satellite system increased the frequency of procuring data at the beginning of year 2021. Improved system is 50 times faster than the previous system and obtaining 3 to 5 images per month. During the drifting ice season, we set an observation point at Kitahama. The authors developed a drone movie here (Overtone 2015). By using Agriforetell system, NDMI and RGB images in February and March 2020 are shown below.

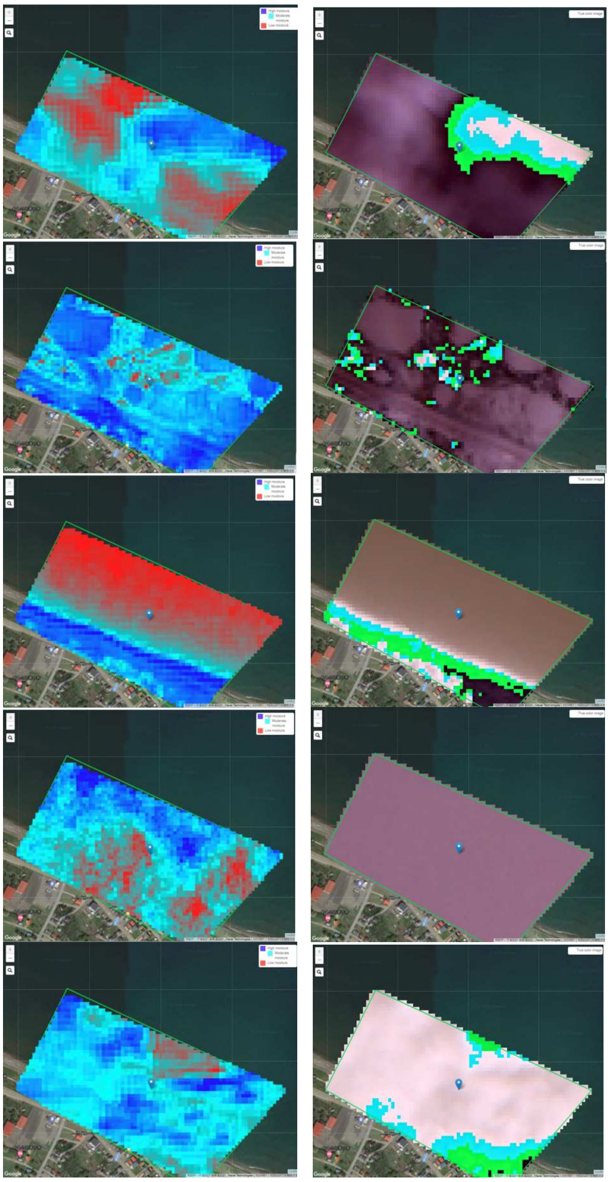

Fig 7. NDMI (left) and RGB (right) Feb 9th, Feb 14th, Feb 24th, Feb 29th and Mar 10th in 2020

Fig 8. Enlarged NDMI (left) and RGB (right) Feb 24th

NDMI shows moisture index and corresponds to open sea or thin ice. The satellite sensor is optical and is sometimes limited by cloud cover. In Figure 8, ice covered area shows lower moisture value (light blues).

Fig 9. Planet Images over Lake Notori 2016 Jan Feb Mar and those of 2017

One of the authors has used PlanetScope images covering the study area and downloaded from the https://www.planet.com/. PlanetScope image is multispectral data comprising of 4-bands in the visible-Infrared electromagnetic spectrum. The advantage of Planet constellation satellite over other imageries is that they can capture the same location daily with 3-meter pixel size and 16-bit radiometric resolution (Marta 2018). The movement of drift ice and snow cover over Notoro lake can be clearly seen during different seasons using Planet images. The movement of drift ice can be monitored by looking into the change in position of the iceberg in the area.

Again, the advantage of using UAVs is that imagery can be obtained when necessary. Satellite image availability can be complimented by UAV fly overs as required. A balanced use of these two monitoring styles is very useful for completing analysis and interpretation. Satellite images are influenced by the cloud cover, so that combination of satellite and UAV is also useful. However, operation of UAVs is costly. Agriforetell system is expected to get not only images but also shape file format. Shape file format can be transformed to numerical values. The resolution of this satellite system is 10 meters and that of UAVs is 0.1 meter. The relationship between Satellite and UAV obtained values makes it possible to create higher resolution data by using only satellite image data (Matsumura and Ram, 2020).

The authors are using fixed wing UAVs to cover the larger area and for dealing with extreme weather conditions. A special material "Jellafin" makes it possible to develop a waterproof instrument and applying this material for fixed wing UAVs is in progress. Under the very cold conditions, batteries can not last long, reducing the power duration. This sometimes results in serious damage to the UAVs. The authors are also trying to adapt the wired system shown in Fig 8. Consulting with Helvetia Inc., the possibilities of using powered wire connected UAVs are proposed. To reduce the wire weight, a 400-volt transmitter is applied.

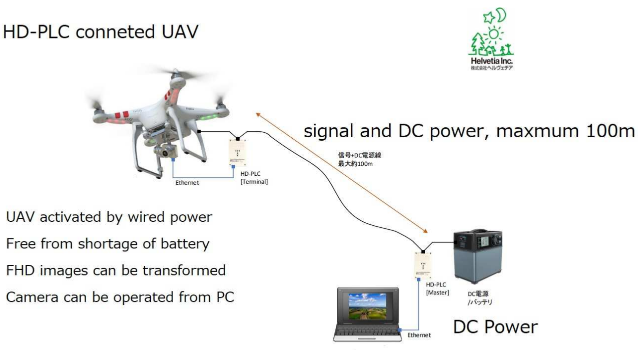

Fig 10. Wired connected UAVs

4. Conclusion and Future Prospects

Satellite and UAV obtained images are examined over seagrass patches, rice field, and drifting ice. To see the distribution of seagrass patches, the authors conducted surveys by using UAVs to understand the modification of patch morphology caused by driving ice. Orthorectifying aerial photographs in 2018 and 2019 highlights the damaged and shredded seagrass beds by thickened drifting ice in 2018-2019 winter. The Indian company is developing a system that can get NDVI, NDMI and RGB images over the targeted area in a simple way. Time series analysis of NDVI and NDMI reveal that NDMI can be used for forecasting NDVI in advance (one month earlier) for a rice field. Agriforetell system can observe drifting ice conditions by using NDMI. The possibilities of combining Satellite and UAV images are proposed.

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Summary in Japanese
和文要約

UAVと人工衛星を組み合わせた流氷観測の可能性

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北海道の能取湖における北海エビの住処である藻場が流氷の影響による変化をUAVにより捉えることができた。インド企業が開発したAgriforetellのシステムは、任意の選択地域を対象としてSentinel衛星によるNDMI, NDVI,RGBを体感的に取得できる。稲作と牧草地においてNDMIが事前にNDVIの状況を把握できる可能性を指摘し、NDMIを用いた流氷観測の可能性、さらにUAVとの組み合わせによるデータ精度向上の可能性を言及した。

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