Development of a Drought Information Change Detection Module Using Satellite Imagery and Unity 3D

Hyeoung-Wook Choi[1*], Kyeong-Hwan Choi[2], Min-Wook Kim[3], and Yong-Cheol Seo[4]

[1]Institute of Spatial Information Technology Research, GEO C&I Co., Ltd., 435 Hwarang-ro, Dong-gu, Daegu, Republic of Korea. E-mail: hwchoi@geocni.com
[2]Institute of Spatial Information Technology Research, GEO C&I Co., Ltd., 435 Hwarang-ro, Dong-gu, Daegu, Republic of Korea. E-mail: khchoi@geocni.com
[3]Institute of Research, SELAB Co., Ltd., 435 8 Nonhyeon-ro, 150-gil, Gangnam-gu, Seoul, Republic of Korea. E-mail: minwookkim@selab.co.kr
[4]Department of Civil Engineering, Pukyoung National University, 365 Sinseon-ro, Nam-Gu, Busan, Republic of Korea. E-mail: suk@pknu.ac.kr

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ABSTRACT: In this study, a drought information change detection module that calculates the soil moisture in South Korea using MODIS images, and that provides change detection services by implementing the image calculation function, was developed. The land surface temperature (MOD11) and vegetation index products (MOD13) data of MODIS images were utilized to calculate the soil moisture index (SMI). In addition, the calculated moisture index data were converted into a base map and grid-based graphic image information capable of mash-up to implement the change detection function capable of visual services, and a change detection module based on multiple image operation was developed using the Unity 3D platform and Google Open Map. The change detection module developed in this study can monitor changes in semi-real time, and can quantitatively extract the changed information by retrieving the data of images at different times on the service interface, and manipulating the sliding tool bar. This is an advanced function that can visually display the simple change detection results of the existing image analysis software, allowing the user to intuitively monitor and analyze the status. It is expected that the use of the change detection function developed in this study will contribute to quick and scientific decision-making through the more effective monitoring of image-based climate change information.

1. INTRODUCTION

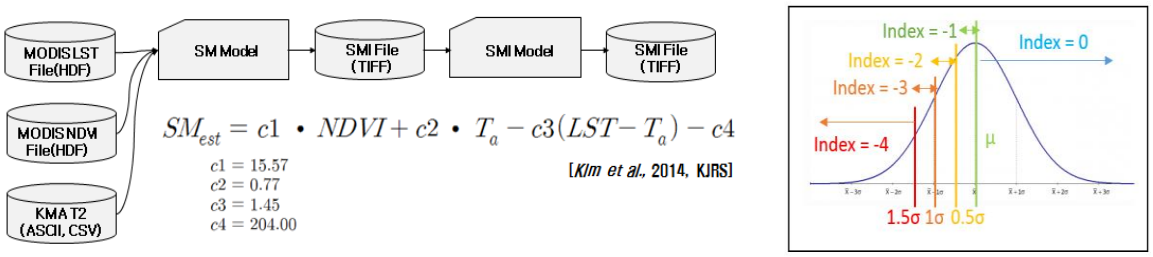
Global climate change has caused broad unexpected meteorological changes of late, such as local torrential rainfall, typhoons, and droughts. Unlike floods, droughts are characterized by slow-spreading speed and extensive occurrence, making it difficult to define the time of their occurrence and therefore to quantify the damage that they may cause. Considering these characteristics of droughts, studies were recently conducted to indirectly monitor and estimate droughts through the changes in the vegetation index and soil moisture using satellite images. In particular, drought monitoring based on the soil moisture can detect droughts in a spatiotemporal manner, and its utilization can be made more effective by using satellite images with relatively precise observation period intervals, such as MODIS. The most important purpose of analyzing the earth observation information based on satellite images is to monitor the change trend in a macroscopic manner. The existing image-based visual monitoring methods, however, have limitations in analyzing and quantitatively extracting these changes in real time. Therefore, in this study, a change detection module was developed to make up for these shortcomings and to enable the more effective use of satellite-based earth observation data. In addition, the soil moisture drought index (SMDI) based on MODIS was calculated and applied to the developed change detection module to verify its effectiveness. It is expected that the software developed in this study will be further improved through its field application, and will help enhance the utilization of satellite images in the public sector.

2. SMDI CALUCATION AND CHANGE DETECTION MODULE DEVELOPMENT USING MODIS IMAGE

2.1 Drought index calculation using MODIS soil moisture data

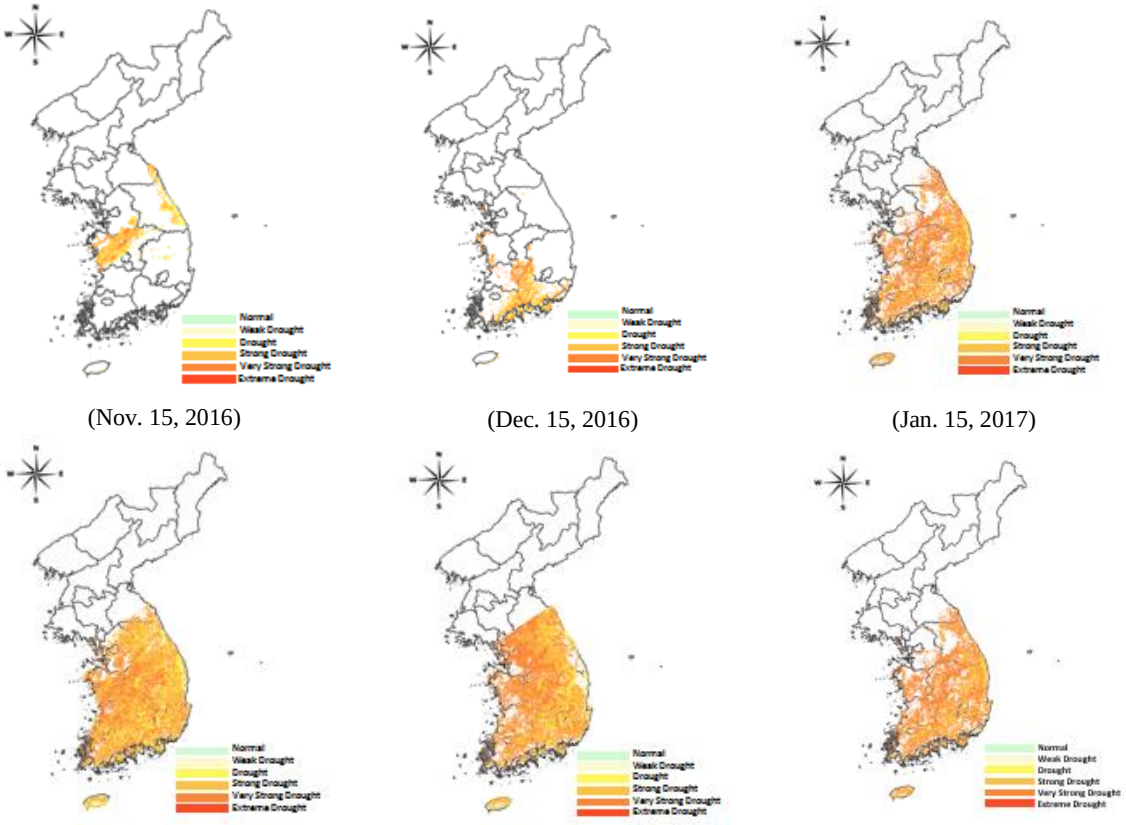
To calculate the soil moisture index (SMI) based on MODIS images, the MODIS land surface temperature

(MOD11) and vegetation index products (MOD13) were used. In addition, the automatic weather station (AWS) data provided by Korea Meteorological Administration (KMA) were used for the calibration and verification of the ground temperature data. The soil moisture was calculated for the entire analysis area according to the MODIS satellite image grid, using Krging interpolation and the soil moisture calculation equation. Based on this, the SMDI in the ASCII format was calculated through statistical analysis (Figure 1(a)). In addition, the average and standard deviation of the soil moisture were calculated based on the SMDI and SMI calculation results. An index capable of GIS mapping was determined by dividing the standard deviation interval by 0.5 steps (Figure 1(b)).



(a) SMI calculation algorithm (b) Definition of SMDI

Figure 1. MODIS-based SMI calculation algorithm and definition of SMDI



(Nov. 15, 2016) (Dec. 15, 2016) (Jan. 15, 2017)

(Feb. 15, 2017) (May 15, 2017) (May 10, 2017)

Figure 2. Results of the MODIS-based SMDI calculation

2.2 Change detection module development using the Unity 3D platform

The Unity 3D platform was used to develop the proposed change detection module. Unity is a general-purpose three-dimensional (3D) graphics platform that does not require a separate license for system development, and that has

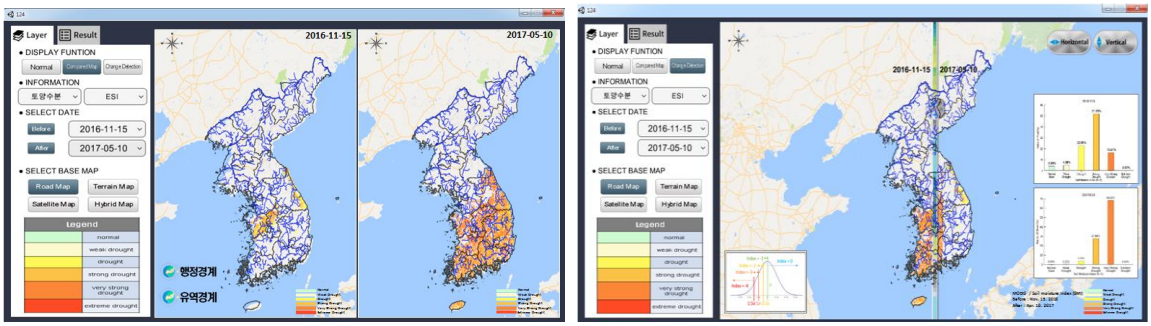
many advantages in terms of scalability. Table 1 shows the details of the development environment. For the GIS mapping of the SMI data, the data were displayed using Google Open API Map.

Table 1. Development environment of the developed change detection module

Category	Tool
3D Program	Unity 3D
Language	C#
Editor	MS Visual Study, Mono Develop
3D Modeling	3DS MAX

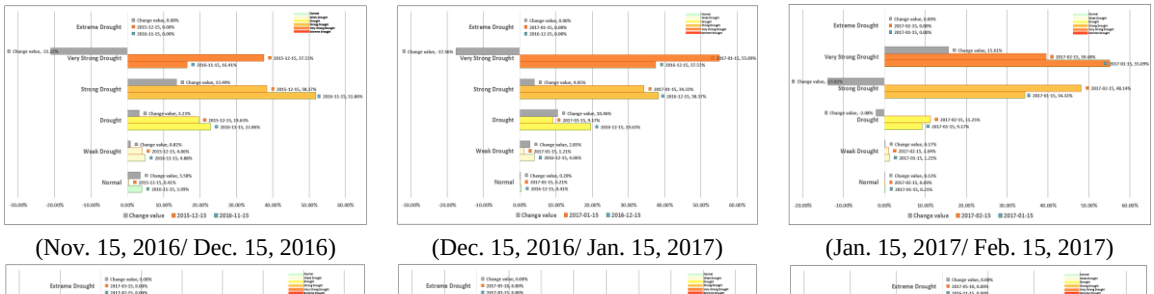
3. APPLICATION OF THE DEVELOPED CHANGE DETECTION MODULE AND RESULTS ANALYSIS

To examine the utilization and usefulness of the change detection module developed in this study, its functions were verified using the SMDI calculation results. The developed change detection module has two functions: that of visually detecting the distributional characteristics by mapping the SMI data from different time periods onto different viewer windows (Figure 3(a)), and that of detecting the changes in the selected region and calculating the quantitative changes by mapping the image data from different time periods onto a single viewer and using the sliding control bar (SCB) (Figure 3(b)).



(a) Compared map (b) Change detection map

Figure 3. Application and function implementation of the developed change detection module



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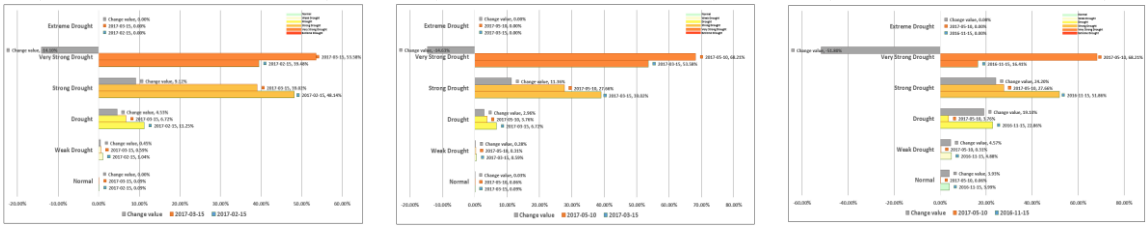

(Feb. 15, 2017/ Mar. 15, 2017) (Mar. 15, 2017/ May 10, 2017) (Nov. 15, 2016/ May 10, 2017)

Figure 4. Results of the SMDI change detection analysis using the developed change detection module

In addition, the satellite analysis information mapped by the installed GIS function can be extracted based on the grid, its stepwise distribution can be quantitatively calculated, and its changes can be quantitatively analyzed (Figure 4).

4. CONCLUSION

In this paper, the development and application of a change detection module based on Unity and Google Open Map for the effective utilization of satellite-image-based observation information are discussed. The results were verified by applying the developed module to MODIS-based soil moisture drought index (SMDI) analysis information (Figure 3). The developed change detection module has the function of comparing the satellite image data obtained at regular intervals or conducting an overlapping data analysis and quantitatively analyzing the difference. As this function can be used to effectively monitor macroscopically changing information about the earth, it can be used as a monitoring tool for effective decision-making on climate-change-related matters. Furthermore, the software was developed based on a general-purpose three-dimensional (3D) graphics platform that does not require a separate license and that has an advantage in terms of scalability. If various satellite-based observation factors, including SMDI, are monitored using the developed change detection module, and if the use of the satellite observation information is expanded through quantitative change trend analysis, the utilization of such information in the public sector will be increased.

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REFERENCES

Hyunji Kim, Jae-Hyun Ryu, Min Ji Seo, Chang Suk Lee and Kyung-Soo Han, 2014. Approximate estimation of soil moisture from NDVI and Land Surface Temperature over Andong region, Korea. Korean Journal of Remote Sensing, 30(3): 375-381.

Hyeoungwook Cjoi, Soomyung Kang, Kyyungjun Kim, Dongyoung Kim and Yunjae Choung, 2015. Development of the Visualization Prototype of Radar Rainfall Data Using the Unity 3D Engine. Jurnnal of Korea Association of Geographic Information Studies, 18(4): 131-144