CORE PROCESSING FOR ANALYSIS READY DATA OF KOMPSAT 3A IMAGE: ABSOLUTE ATMOSPHERIC CORRECTION

Kiwon Lee (1), Yongseung Kim (2), Kwangseob Kim (1), Sun-Gu Lee (2)

[1] Hansung University, 16-116 Samseongyo-ro, Seongbuk-gu, Seoul, 02876, Korea
[2] Korea Aerospace Research Institute, 169-84 Gwahak-ro, Yuseong-gu, Daejeon, 34133, Korea
Email: kilee@hansung.ac.kr; yskim@kari.re.kr; engintruder@hansung.ac.kr; leesg@kari.re.kr

KEY WORDS: Absolute Atmospheric Correction, ARD, KOMPSAT 3A, Open Data Cube

ABSTRACT: Data cube is designed as the computing platform for a multi-dimensional stack of gridded dataset analysis. Open Data Cube (ODC) is an open-source for a large volume of geo-spatial information, including optical and SAR images, and thematic raster datasets. The Group on Earth Observations (GEO) has applied it in the Global Earth Observation System of Systems (GEOSS), and the Committee on Earth Observation Satellites (CEOS) has developed and managed. GEOSS needs Analysis Ready Data (ARD) generation and building for ODC, which means the preparation of radiometric calibration and geo-rectification. ARD provides the user with immediately useful level data without users' additional correction or calibration. As for optical sensor satellite image sets in the case of Landsat series and Sentinel-2, absolute atmospheric correction to generate Top-of-Atmosphere (TOA) and Bottom-of-Atmosphere (BOA) or Top-of-Canopy (TOC) products is regarded as the first core step for ARD. For global applications of optical Korea Multipurpose satellite (KOMPSAT) images, the general processing scheme or tools absolute atmospheric correction for this sensor should be developed and released. Furthermore, this processing scheme can also be used as a solution to convert and maintain archived KOMPSAT 3/3A image data sets to a higher level for further scientific land applications. This is the main motivation of this study, towards ODC application model development of KOMPSAT. Optical calibration modules within the Orfeo Toolbox (OTB) and open source remote sensing engine, have been applied for this work. KOMPSAT 3A sensor models such as relative spectral response (RSR) specification and gain were added in the module sources and rebuilt as executable on the Ubuntu operating system (OS). A general scheme for this core processing is introduced, and some test results of generation TOA and TOC products with actual KOMPSAT 3A image sets are also presented.

1. INTRODUCTION

Since 2008, the Landsat series data have been released for anyone to use, and then the United States Geological Survey (USGS) provides approximately 5 million images for downloadable satellite data for Landsat MSS, TM, ETM+, and OLI sensors and about 4 Peta Byte (PB) of disk capacity, as of January 2015 (Wulder et al., 2016). Rather than doing a single process for a certain purpose, these data are organized into various time series; using these data, ecological changes can be quickly identified and helped in making decisions in global scale coverage. This approach requires high computing capability and performances.

Recent advances in information communication technology (ICT) have enhanced hardware and software capabilities. In particular, emerging applications such as big data, artificial intelligence, and cloud computing are leading the field of ICT, and is also affecting scientific researches. In the field of civilian satellite applications, many organizations and institutions utilize these technologies. The Group on Earth Observations (GEO), which is making efforts internationally to build the Global Earth Observation System of Systems (GOESS), supports, develops and manages technology for global observation through the Committee on Earth Observation Satellites (CEOS).

Open Data Cube (ODC) (https://www.opendatacube.org/) is an open-source platform in GEOSS managing by CEOS (Killough, 2018). The platform was initially built on the Australian Geoscience Data Cube (AGDC), a system that provides an efficient approach to satellite image and is utilized in Australia Geoscience Australia (GA). ODC is a set of technologies that reflect the latest trends in ICT. In particular, the data is designed to be managed and analyzed in the form of a Data Cube implemented in the cloud environment. There are a few basic needs to register, ingest or build data on the ODC. It consists of Analysis Ready Data (ARD), a processed form of data that users can analyze with minimal effort, and require an ingestion process to fit into the platform. ARD refers to data that can be used for analysis immediately because the pre-processing processes that is performed by the user are already done by the data or service provider. For Landsat, the Collection 1 processing algorithm is generating the ARD and Sentinel is also defined by the documentation for the generation of the ARD. The functionality for the ingestion process for Landsat series, Sentinel 1, 2, ALOS, and ASTER is supported by the ODC.

Korea has launched and operated the Korea Multi-Purpose Satellite (KOMPSAT) series, a high-resolution satellite, for use in various land applications. As of July 2019, KOMPSAT optical 3/3A and SAR 5 are operated, and plans to launch continuously on the relevant satellite are planned (Shin and Yang, 2018). They are not free and open data for public uses. KOMPSAT 3A has a wide area range and a resolution of 0.5~0.7 m for multi-spectral bands and 2.2~2.8 m for the panchromatic channel as the Ground Sample Distance (GSD) at nadir. Data can be retrieved by the date and time of acquisition through KSATDB (https://ksatdb.kari.re.kr) and can be ordered. If the technical platform such as ODC applied, it is expected that the ICT-based technologies will be provided to enhance its usability. The basic considerations for KOMPSAT into ODC database building were summarized (Lee et al., 2019). Because ARD is data that can be used for analysis immediately, it can be considered that the pre-processing process has been performed. ARD-related studies on Landsat have been conducted in a variety of ways, and ARD data has been released (Dwyer et al., 2018). CEOS has also established the CEOS Analysis Ready Data (CARD4L) framework for Landsat ARD (Siqueira et al., 2019). KOMPSAT images are provided in L1R or L1G, but they are not in ARD level, till now.

In this study, practical study and software implementation for ARD generation for KOMPSAT data were performed, and core processing for them is TOA and TOC generation related to the absolute atmospheric corrections. There are already several commercial and open source software for atmospheric corrections. Most software has a set of satellite types for these processes, but there is few to process atmospheric corrections for KOMPSAT images. OTB engine which supports TOA and TOC generation algorithms has no limitations on input satellite sensors for software developers. In this study, a common metadata module for KOMPSAT was inserted into the OTB internal source code and the KOMPSAT sensor model was read when performing OTB processing. Ancillary information with the processed image data set is required when performing calibration functions that obtain resultant TOA and TOC images. This process also designed and developed scripts to automatically obtain metadata for image sets and enter parameter values to minimize user input. The results of TOC processing were compared with those processed with the Dark Object Subtraction (DOS) scheme for validation the absolute atmospheric correction function.

2. ABSOLUTE ATMOSPHERIC CORRECTION FOR KOMPSAT 3/3A

Landsat ARD consists of TOA reflections, TOA brightness temperature, surface reflections (TOC reflections), surface temperature, pixel quality assignment (USGS, 2019). ARD data are generated by images of Landsat Collection 1 Level-1 images provided by USGS Earth Explorer, which can also be downloaded from Earth Explorer. As such, it is important to process ARD in a form that can be used for processing right away according to image characteristics.

Generally, TOA and TOC are necessary processing to convert original satellite images into scientific data before performing satellite image processing for eco-system application. The characteristics of the satellite sensors, the atmospheric environment for those dates and times, and other parameters are required for this process. Figure 1 is a schematic view of TOA and TOC for surface reflectance.

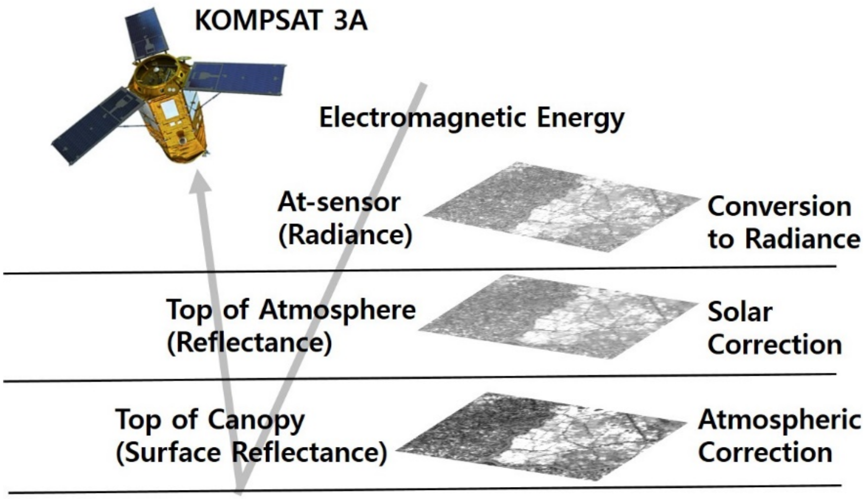

Figure 1. Concept of TOA and TOC by the absolute atmospheric correction.

Because the characteristics of the satellites currently in operation are mostly different, both the data registering method and the operation method are different. This requires process methods for each sensor and provides the TOA and TOC processing interfaces in commercial and open source libraries and software for the satellites that are in use.

However, it only supports some of the satellites that have been released, and the processing process for the TOC is more complex than the TOA processing, so there are not many libraries and software to support. There are currently no tools to support radiometric calibration processing for KOMPSAT optical images, but OTB is available as a library to enable it. OTB is a project initiated by France's National Centre for Space Studies (CNES) since 2006 and provides a dual interface of a software engine for developers and a tool for general users. Under Apache licenses, source code recompiling is possible. Developed on a C++ basis, it supports a broad range of Windows, Linux (Ubuntu), and Mac OS operating systems. The OTB is equipped with the many interrelated modules to handle optical image atmospheric correction and officially reports that it supports QuickBird, IKONOS, WorldView 2, Formosat, Pleiades and SPOT satellites (Orfeo Toolbox, 2019), but unlike other software, the interface is not limited to the sensor, which can be further processed by adding sensor metadata to the OTB. Figure 2 represents relation and workflow among ARD, OTB, and ODC in OpenStack (https://www.openstack.org/) as Open cloud, as main themes or concepts dealing within this study.

This study modified and recompiled existing OTB source codes as shown in Figure 3 to further develop and build sensor metadata for KOMPSAT so that it can read KOMPSAT model parameters when processing OTB functions. Additional scripts to automate input parameters for atmospheric correction was developed.

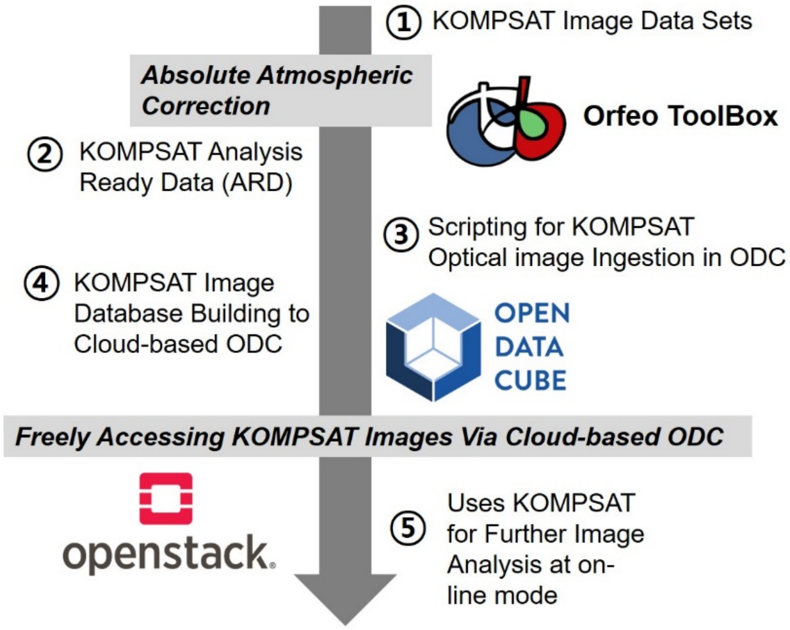

Figure 2. ARD, OTB, and ODC in Open cloud: relation and workflow.

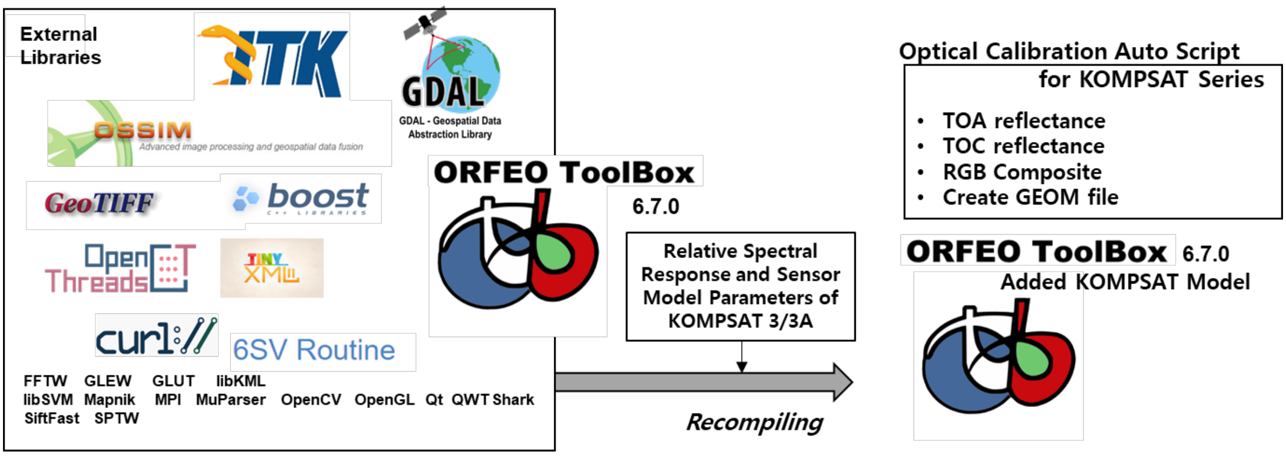

Figure 3. New implementation of TOA and TOC generation program for KOMPSAT 3/3A.

In OTB, the Second Simulation of the Satellite Signal in the Solar Spectrum (6S) model is adopted and used as input values for altitude, atmospheric pressure, temperature, water density, ozone density, moisture content, and ozone. By default, these parameters already set in OTB and can be entered if the user has measured data or field data. Besides, spectral aerosol optical depth (AOD) files received from the Aerosol Robotic NETwork (AERONET)(https://aeronet.gsfc.nasa.gov/) established by NASA and PHOTONS (PHOtométrie pour le Traitement Opérationnel de Normalisation Satellitaire) can be processed. The study processed with KOMPSAT 3A and AERRONET data in Canberra, Australia. Figure 4 is the result of TOA and TOC by newly implemented KOPMSAT 3A modules within OTB. Figure 4 (a), (b) and (c) show RGB composite using original bands, TOA bands, and TOC bands, respectively.

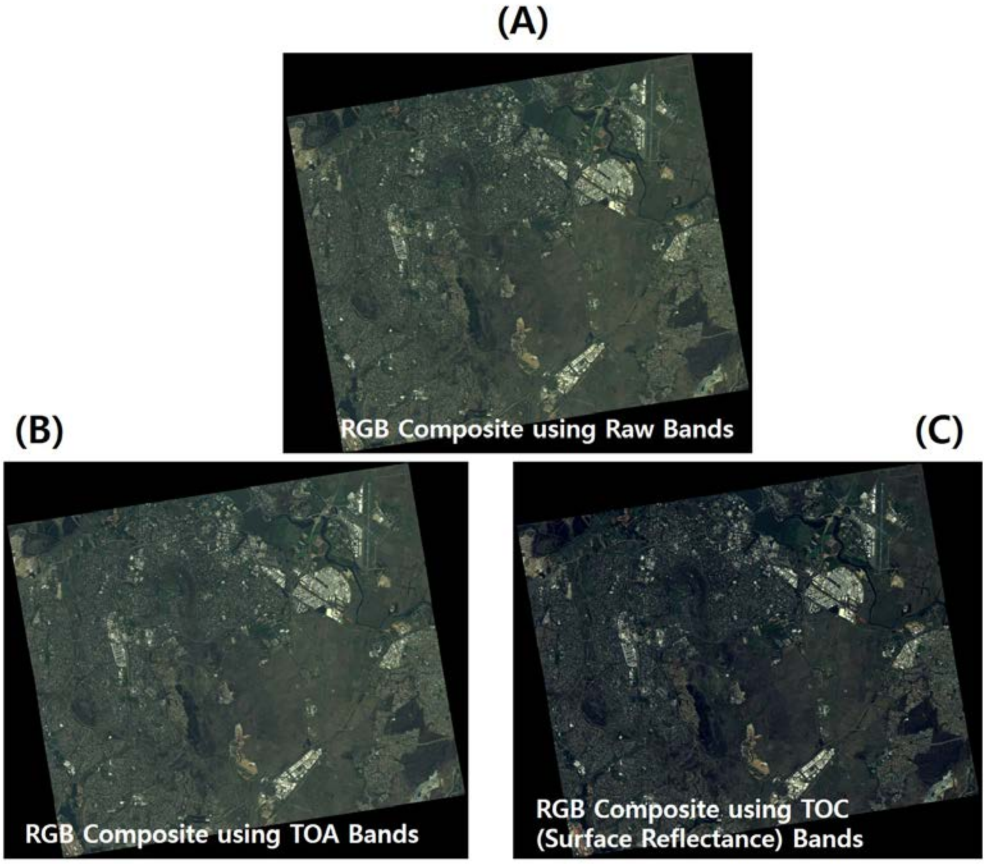

Figure 4. The processing results of RGB composite: (A) Original bands, (B) TOA bands, (C) TOC bands.

3. COMPARISON OF RESULTS OF TOC AND DOS

This is the first case that the TOC processing of KOMPSAT data is performed, so the verification process for the resultant image is essential. The TOC result is the process of calculating the surface reflection and removing the actual atmospheric effects to make it scientific data, absolute surface reflection. This is an essential process for improving accuracy in the processing satellite image, such as time series analysis or change detection, but it is not easy to handle for all satellites, so it is often replaced by a relative method for DOS. The DOS method is an algorithm that assumes that the darkest areas have the least atmospheric effects and extracts the differential computational results based on them (Zhang et al. 2010).

Of course, this process does not explicitly eliminate atmospheric values. However, if TOC processing is not provided, it is one of the most commonly used methods. However, each scene requires a zone setting and the values vary depending on the user selection processing. To verify the TOC results accurately, the researcher measured and compared the atmospheric reflectivity values for target features on the ground at the same date and time, and compared them to the TOC results computed, but compared to investigate if they were related to the DOS scheme that was used a lot before then.

Figure 5 (a), (b), (c) and (d) show the processed data value in the form of a histogram and scatter plot of DOS and TOC results for R band, G band, B band, and NIR band, respectively. The histogram shows that the DOS results are slightly lower and the form is similarly drawn.

Most of the scatterplot is drawn linearly, with R band, G band, and N band, showing a correlation of 99% and B band of 88% the lowest. However, since DOS is the result of relative processing for image scenes and TOC is the value calculated from the actual atmospheric value, there are many limitations to comparing the two. This result is not a generalized one because it is the result of one case. It is necessary to produce results through various experiments in the future.

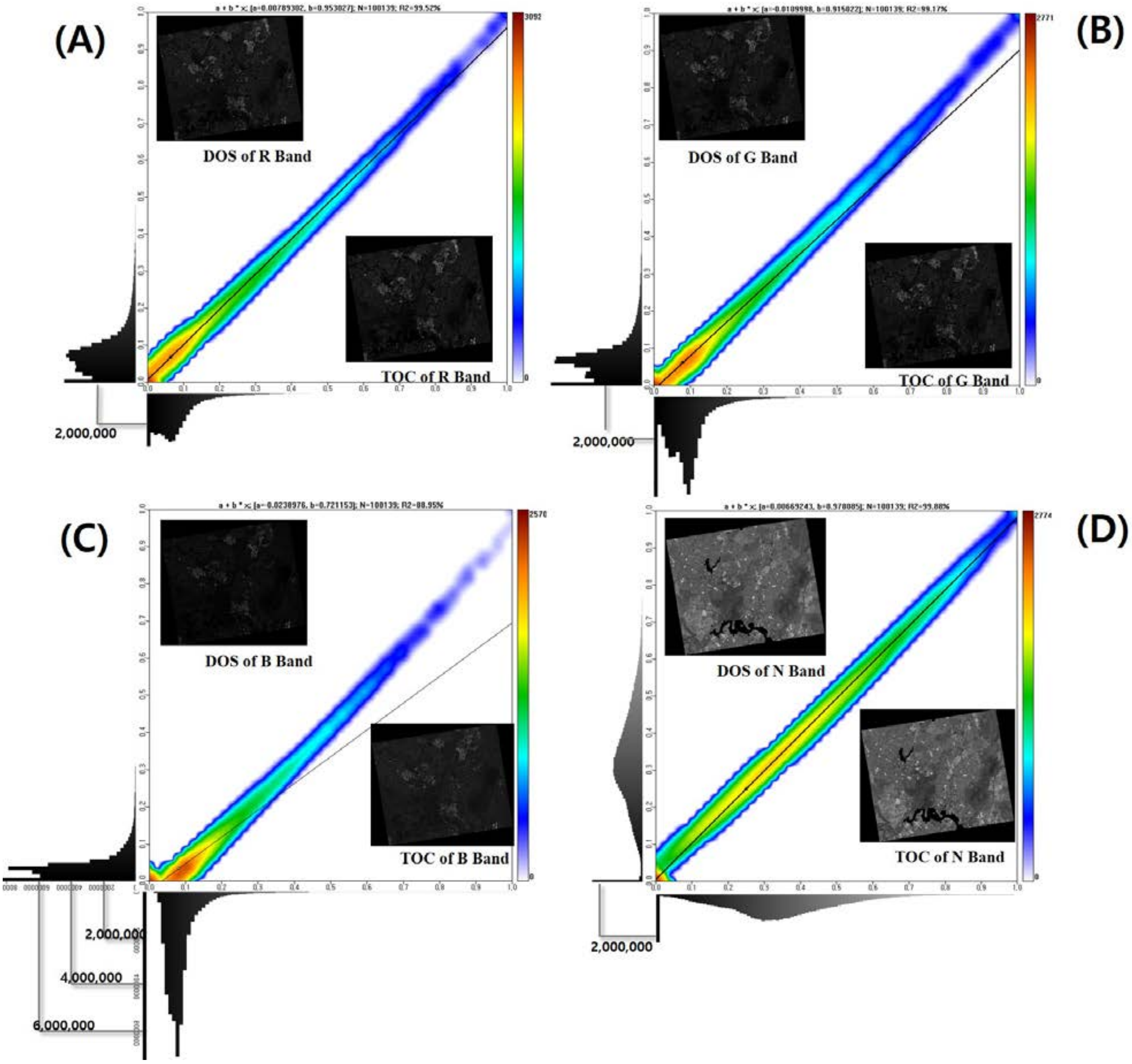

Figure 5. Scatterplots of DOS and TOC results: (A) R band, (B) G band, (C) B band, (D) NIR band.

4. CONCLUDING REMARKS

For satellite data to be utilized much, comfort and optimized access to them must be considered. Accessibility is to disclose like data but to establish the application environment for other uses. Examples of Landsat and Sentinel are that research has been conducted for a long time to provide users with different forms of ARD rather than simple data releases. At the same time, it can be applied to ODC platforms, which can increase utilization possibility and accessibility. The most important product developed in this study is the first open source software to automatically extract surface reflectance as ARD from KOMPSAT 3/3A image.

As long as ARD typed scientific data from sub-meter high-resolution satellite were extracted, it is expected that access to utilization will definitely increase if it is provided in ARD formats, such as Landsat and Sentinel, although KOMPSAT data is not provided free of charge, Therefore, research for processing with KOMPSAT ARD should be carried out continuously. In this study, as absolute atmospheric corrected KOMPSAT data, resultant images of TOA and TOC bands were compared with those of the existing popular DOS scheme. Since this is the result of TOA and TOC calculations with AERONET data through OTB, there are still many works to be carried out for KOMPSAT ARD, including actual ground measurement, as well as algorithm verification methods.

ACKNOWLEDGMENTS

This research was supported by the National Land Space Information Research Program from the Ministry of Land, Infrastructure and Transport, Korea (No. 14NSIP-B080144-01). And this research was supported by the Korea Aerospace Research Institute for International Cooperation Promotion Study for K-GEO Role Enhancement (2019).

REFERENCES

Dwyer, J. L., P. R. David, S. Brian, B. J. Calli, K. Z. Hankui and L. Leo, 2018. Analysis Ready Data: Enabling Analysis of the Landsat Archive. Remote Sensing, 10(9), 1363.

Killough, B., 2018. Overview of the Open Data Cube Initiative, in Proc. of the IGARSS 2018 in Valencia, Spain, 27 July.

Kim, K and K. Lee, 2019. Ingestion process of KOMPSAT data in open data cube on open source cloud computing environment, in Proc. of the IGRASS 2019, in Yokohama, Japan, July, 2019.

Lee, K.., K. Kim, S. G. Lee, and Y. S. Kim, 2019. Consideration Points for Application of KOMPSAT Data to Open Data Cube. Journal of the Korean Association of Geographic Information Studies, 22(1), pp.62-77.

OTB, 2018. OTB CookBook Documentation Release 6.6.1. https://www.orfeo-toolbox.org/CookBook/ (Accessed August 2019).

Shin, K. W. and J. M. Yang, 2018. Introduction to the Enforcement Situation of the CAS500 Series Development. 2018 SASE Spring Conference, April, 2018.

Siqueira, A., A. Lewis, M. Thankappan, Z. Szantoi, P. Goryl, S. Labahn, J. Ross, S. Hosford, S. Mecklenburg, T. Tadono, A. Rosenqvist and J. Lacey, 2019. CEOS Analysis Ready Data for Land – an Overview on the Current and Future work, in Proc. of the IGRASS 2019, in Yokohama, Japan, July, 2019.

USGS, 2019. https://www.usgs.gov/land-resources/nli/landsat/us-landsat-analysis-ready-data?qt-science_support_page_related_con=0#qt-science_support_page_related_con (Accessed August 2019).

Wulder, M. A, J. C. White, T. R. Loveland, C. E.Woodcock, A. S. Belward, W. B. Cohen, E. A. Fosnight, J. Shawf, J. G. Masek, D. P. Roy, 2016. The global Landsat archive: Status, consolidation, and direction, Remote Sensing of Environment, 185, pp. 271–283.

Zhang, Z, G. He and X. Wang, 2010. A practical DOS model-based atmospheric correction algorithm, International Journal of Remote Sensing, 31(11), pp.2837-2852.