Multi-sensor Integrated Application Platform for Resource Satellite Images

Hsin-Yin Lin (1), Shu-Min Hsu (1), Yu-Heng Tai (1), Fuan Tsai (1), Li-Hsueh Chang (2)

[1] Center for Space and Remote Sensing Research, National Central University, No.300, Jhongda Rd., Jhongli City, Taoyuan, Taiwan
[2] National Space Organization, 8F, No.9, Prosperity 1st Rd., Hsinchu Science Park, Hsinchu, Taiwan
Email: singing@csrsr.ncu.edu.tw

KEY WORDS: Open Data Cube, Optical and Radar Satellite Images, Analysis Ready data (ARD), Change Detection, Multi-sensor Integrated Application Platform

ABSTRACT: The multi-temporal resource satellite images over large areas and specific regions are long-term records which can provide users spatial-temporal information for earth observations and change detections. A challenging task for users is the complicated preparation and processing of the satellite images. The multi-sensor application platform is developed to facilitate efficient analyses for various applications, which integrates frequently used optical and radar satellite images, including FORMOSAT-2/FORMOSAT-5, Landsat-7/8, Sentinal-2, Sentinal-1, TerraSAR-X, and ALOS-2. The platform can help users quickly obtain suitable multi-sensor, multi spatial-temporal data without data processing burden. This platform also supports "Open Data Cube" style analysis ready data (ARD) which is an open source project and is successfully integrated into our development of satellite image management system. The platform provides several modules, such as automatic product downloading, cataloging, preparing for ARD, archiving, querying, processing, and analyzing. With this platform, the data providers will be able to manage the significant volumes of data easily and the data users will be able to carry out different applications more efficiently.

1. INTRODUCTION

It is well known that long-term records of resource satellite images are very useful for earth observations and change detections. In typical satellite analysis process, in the beginning, the users must search and request for the data over their areas of interest over a specified time frame. However, for the traditional satellite image query platforms, to obtain an applicable satellite image, the users need to set various attribute parameters themselves to search for the suitable data which meet their application needs. This parameter-oriented platform may not be easy for a common user who has not been professionally trained to complete the process to obtain the proper satellite data, especially for multi-sensors including optical and radar satellites.

Moreover, it is difficult for user to perform complicated preparation and processing of multi-temporal satellite images. The Open Data Cube (ODC) (Lewis et al., 2017) is an open source geospatial data management and analysis software project for accessing, managing, and analyzing large quantities of satellite data which brings in ARD "Analysis Ready Data" (Killough,B., 2017). ARD comes for users to analyze without having to pre-process the imagery themselves. The main steps of the production of ARD include geometric correction, radiance correction and image quality masking. First, the satellite images should be ortho-rectified to geometric precision products. Next, the satellite data are affected by the atmosphere, so it is theoretically necessary for multi-temporal satellite images to perform radiance correction to eliminate the interference caused by changes in the atmosphere at different dates. Therefore, according to CEOS Analysis Ready Data for Land (CARD4L), for optical imagery, ARD corresponds to surface reflectance (SR) products. The final step is quality index, in which the ARD are usually masked out clouds and quality issues to reveal only useful data, so image quality mask is generated to identify scene classification such as clouds, cloud shadows, snow and water (USGS,2017).

The Open Data Cube not only provides the ARD data service, but also an open and freely

accessible exploitation tool for application, so that the user can obtain the value-added processing result directly from the Data Cube without accessing the original image data. Such application-oriented platform is much more efficient and convenient for users, while for data providers, how to manage the significant volumes of multi-satellite data is also a big issue. Therefore, this project of "Multi-sensor Integrated Application Platform" by the Center for Space and Remote Sensing Research, National Central University (CSRSR, NCU) and National Space Organization (NSPO), was initiated to develop an application-oriented image query retrieval platform which will combine self-developed image data management system with Open Data Cube framework. This multi-sensor application platform will facilitate efficient analyses for various applications, which integrates frequently used optical and radar satellite images, including FORMOSAT-2/FORMOSAT-5, Landsat-7/8, Sentinal-2, Sentinal-1, TerraSAR-X, and ALOS-2. It provides several modules, such as automatic product downloading, cataloging, preparing for ARD, archiving, querying, processing, and analyzing.

2. SYSTEM DEVELOPMENT AND INTEGRATION

The Center for Space and Remote Sensing Research, National Central University (CSRSR, NCU) has been receiving satellite imagery since 1993. It has many years of experience for the management of significant volumes of multi-satellite data. Recently, CSRSR has established a multi-temporal satellite image open data service platform (Lin et al., 2015) and an automatic multi-sensor geocoded processing system (Lin et al., 2017). This project of "Multi-sensor Integrated Application Platform" will use the existing technology to expand the image data management system architecture and introduce the current trend of the ARD on the Open Data Cube system. Currently, the platform integrates optical satellite images FORMOSAT-2/FORMOSAT-5, Landsat-7/8, Sentinal-2 and radar satellite images Sentinal-1, TerraSAR-X, ALOS-2. For optical satellite images FORMOSAT-2/FORMOSAT-5 at this first stage we use the Top of Atmosphere Reflectance (TOAR) products from National Space Organization (NSPO). For Landsat-7/8, we use surface reflectance (SR) products. For Sentinal-2, we use Bottom of Atmosphere Reflectance (BOAR) products (Giuliani, G., et al.,2018). All the corresponding image quality masks of the optical satellite images are prepared readily for importing to the Open Data Cube (Jones,T., et al., 2017) . For all the radar satellite images including Sentinal-1, TerraSAR-X, ALOS-2, we use free downloadable Sentinel Application Platform (SNAP) software (http://step.esa.int/main/download/) to produce Sigma Nought images for importing to the Open Data Cube.

The system architecture is illustrated in Figure 1, which integrates self-developed image data management system (blue block) and Open Data Cube (yellow block). On the self-developed image data management system, there is a data storage for the massive multi-satellite data. We use the free Postgresql database to manage each product. Cataloging and archiving tool program of multi-sensors is well developed for extracting the useful metadata from the product and then indexed into the Postgresql database such as satellite type, satellite name, image coordinate system, view angle, product processing level, etc. then archived in the data storage. The cataloging process also recorded the link of archive, and generated the quick look image for browsing at the same time. We also try to integrate this cataloging process with Open Data Cube importing, in case this product is ARD, then it should be automatically ingested into Open Data Cube. After the cataloging process completed, the application-oriented query platform is able to dig the data storage by searching for the proper attribute of the database for the different application. Therefore, various image processing methods are introduced by the different applications, and each method has its own requirements and constrains on the satellite images. Then the search criteria is correspondingly various to the different image processing methods, and efficiently help user to achieve the suitable data which meet their application needs.

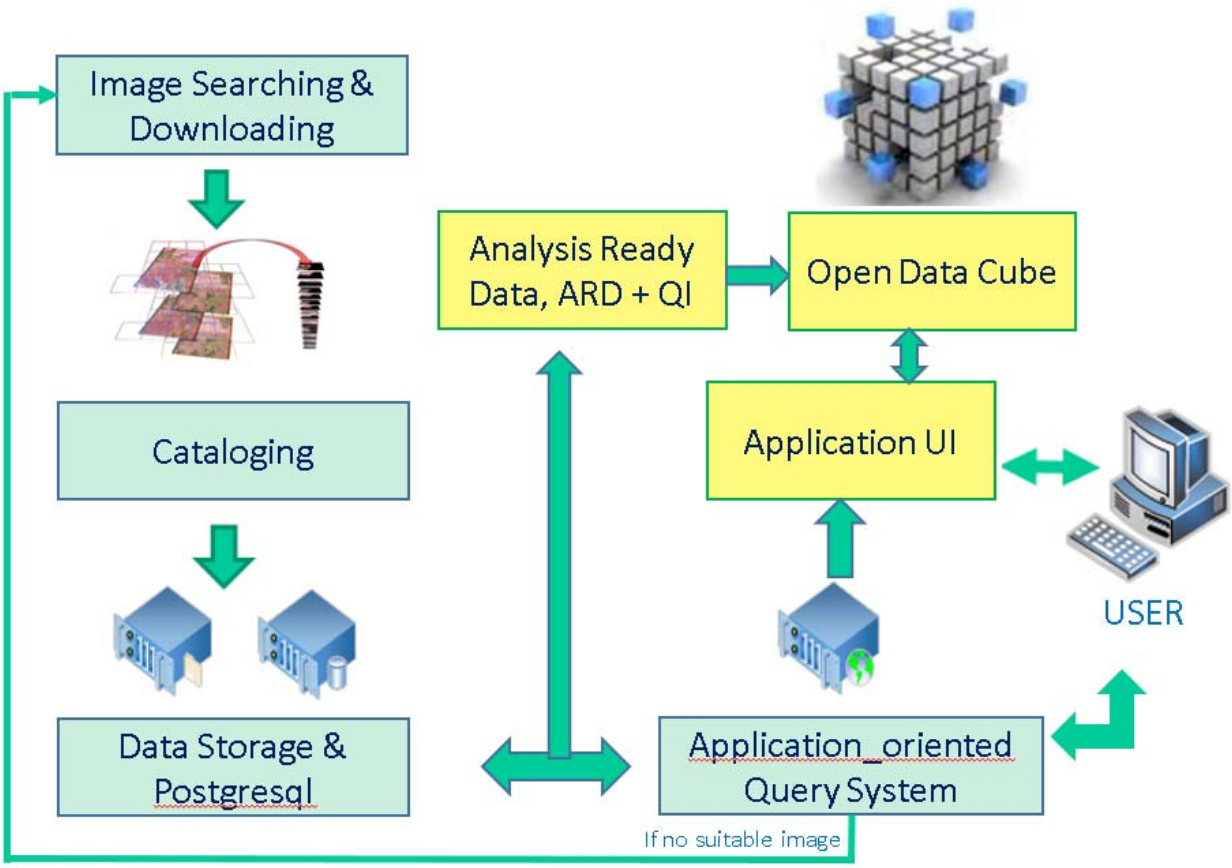

Figure 1 - System Architecture

This project also provides automatic product downloading. For Sentinal-1 and Sentinal-2, the Copernicus Open Access Hub website is open to the public for downloading. Based on the dedicated APIs provided by the Copernicus website, the automatic downloading program is also well developed for retrieving the eligible satellite image data which meets the criteria such as AOI, satellite type, product processing mode or level, acquisition time, etc. The query result is then imported into wget utility to download the data in batch mode. After downloading, the cataloging process will be performed then insert the data into the data storage and in the Open Data Cube warehouse.

The current Open Data Cube system provides basic image processing modules, Urbanization, Spectral Indices, Slip, NDVI Anomaly, Fractional Cover, Water Detection, Water Quality DSM, Coastal Change, Custom Mosaic and Cloud Coverage (Rizvi, S., et al.2018;ARDC 2018). In this project we will try to expand the image processing modules for change detection of optical satellite image and backscattering analysis of radar satellite.

Finally, the expected Multi-sensor Integrated Application Platform for Resource Satellite Images will provide functions of automatic product downloading, cataloging, ARD preparation, archiving, querying, and also processing and analyzing.

3. RESULTS

The current results of the developed Multi-sensor Integrated Application Platform consist of four parts, including data storage management, application-oriented image query system, Open Data Cube and automatic downloading module.

3.1 Data Storage Management

There are several types of products archived in the data storage, and several types of ARD

imported into Open Data Cube, as shown in Figure 2, including optical and radar satellites, original and ARD products. According to the different format of each product, we developed multi-sensors cataloging tool program for indexing into the Postgresql database and archiving in the data storage, for users to query and access the data easily.

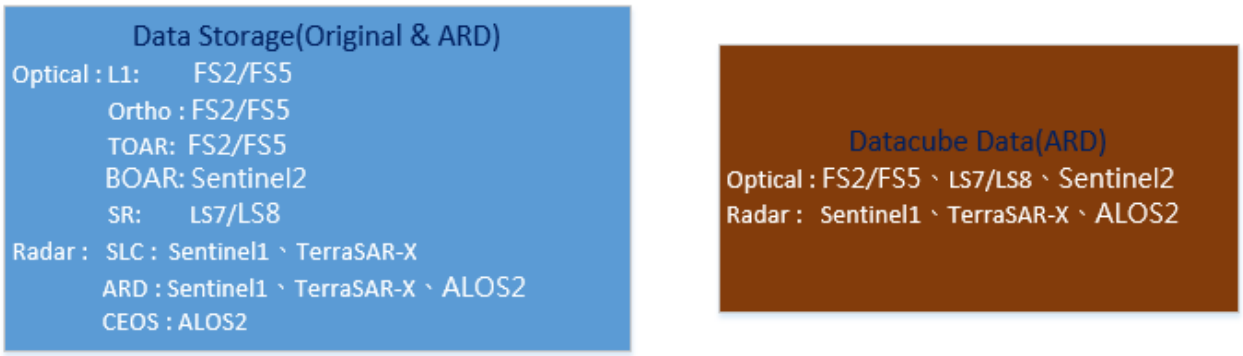

Figure 2 - Data Types of Storage

3.2 Application-Oriented Image Query System

The interface of the application-oriented image query system is developed as Figure. 3. There are three major application groups: disaster monitoring, earth observation and change detection. Currently, in this project we only plan to implement change detection of optical satellite image and flooding detection by backscattering analysis of radar satellite as examples. This query system is able to select the suitable data by searching the attributes from the database for different applications.

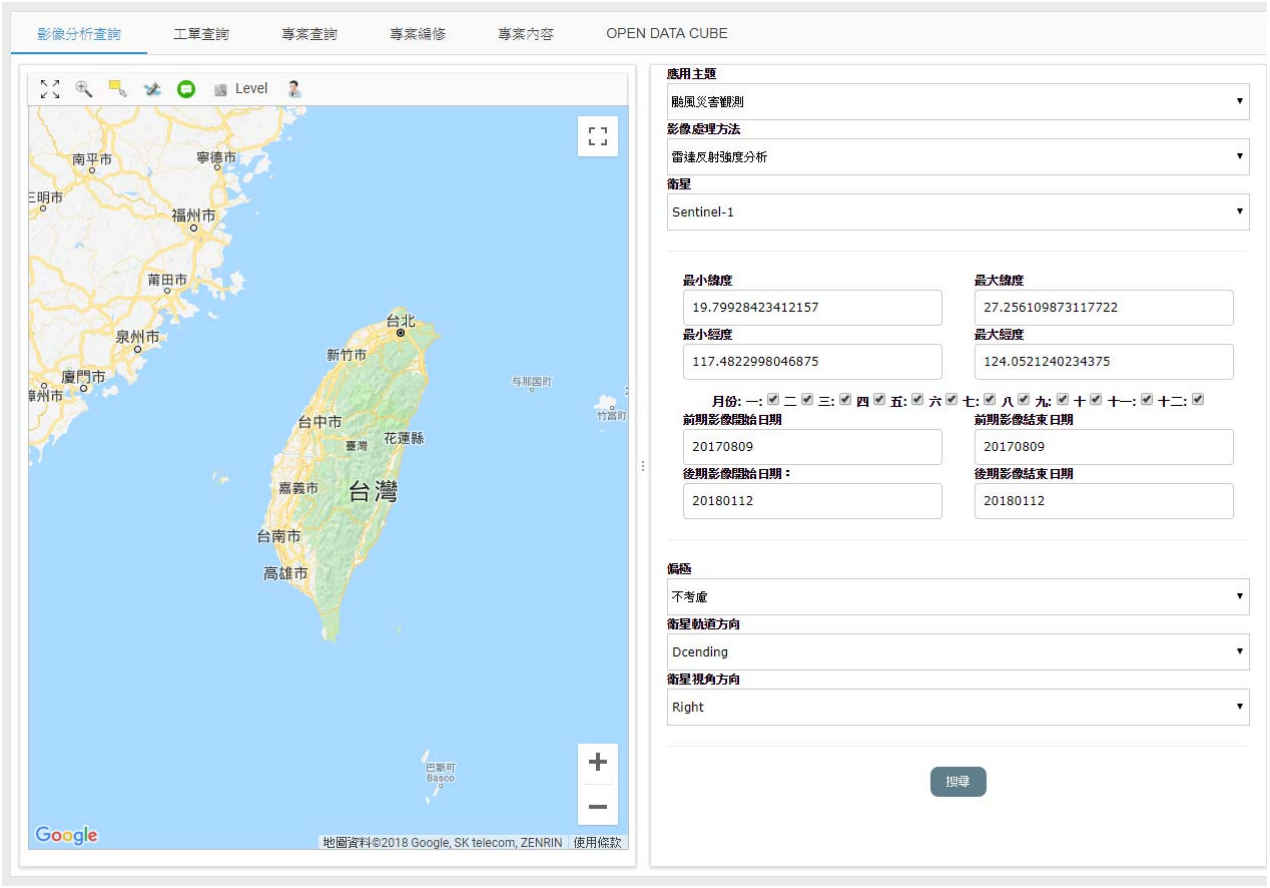

Figure 3 - Application-Oriented Image Query System

3.3 Open Data Cube

Following the installation steps of Open Data Cube (https://www.opendatacube.org/), the Cube in the developed platform was established. Multiple data, such as Landsat-7/8, FORMOSAT-2/FORMOSAT-5, Sentinal-2 and Sentinal-1, TerraSAR-X, ALOS-2, can then be ingested into the Cube system successfully as shown in Figure 4. For most of the data importing, at first, we need to define the configuration files of product input/output type, and generate the corresponding metadata yaml file for each image, then use the Open Data Cube utility command to index and produce the output NetCDF tiles. After data importing completed, we can use the application of Open Data Cube UI to access the imported data correctly as demonstrated in Figure 5. In this project, we plan to add our algorithm of change detection of optical satellite image and flooding detection by backscattering analysis of radar satellite image on Open Data Cube UI.

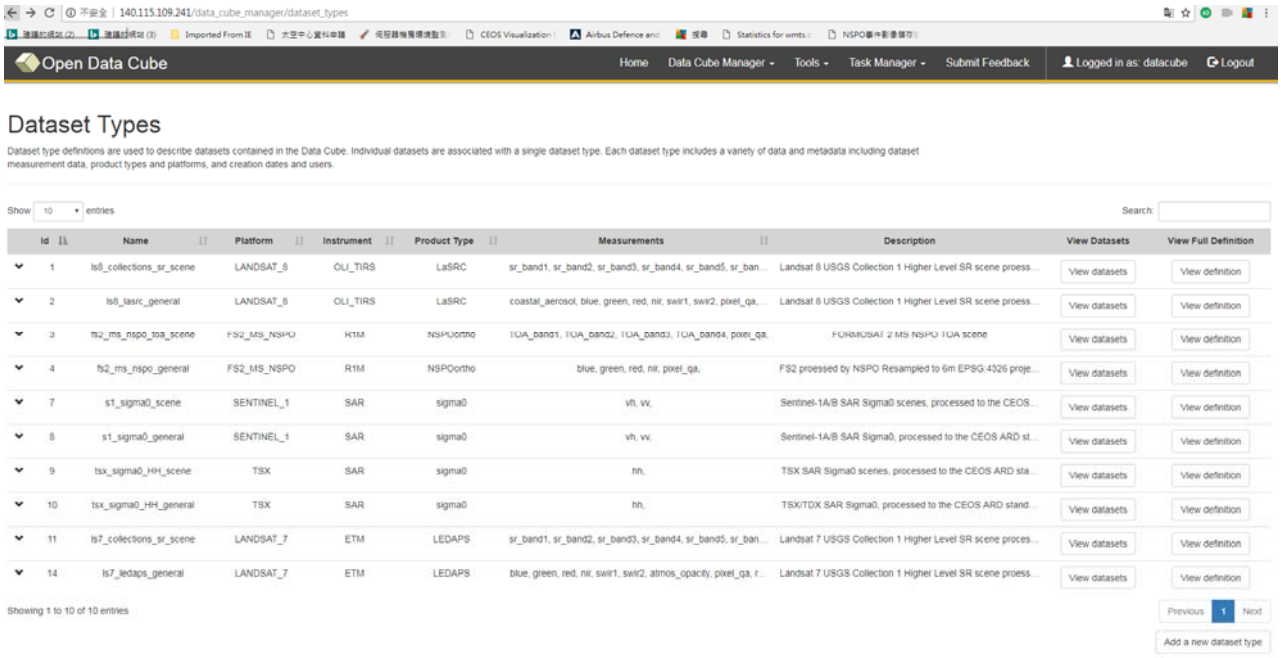

Figure 4 – Open Data Cube LS7/8, FS2/5, Sentinel2, Sentinel1, TerraSAR, ALOS2 imported

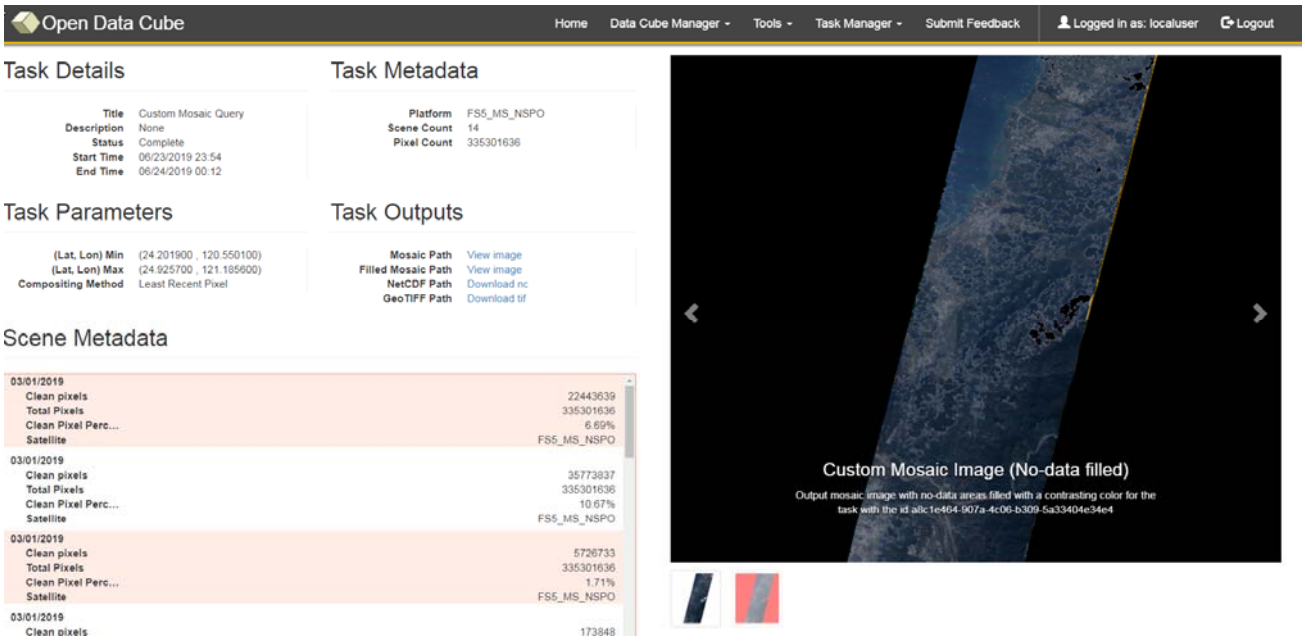

Figure 5 – FORMOSAT-5 Open Data Cube Custom Mosaic

3.4 Automatic Downloading Module

The automatic downloading program is well developed for retrieving Sentinel-1/Sentinel-2 data. Before downloading, a search setting configuration file should be done, to fill in the download path, username/password of Copernicus Open Access Hub website, and the parameters such as AOI, satellite type, product processing mode or level, acquisition time, cloud cover percentage, etc. Then the downloading program will send query to the website and feedback the result downloading in batch automatically.

4. CONCLUSION

This project of “Multi-sensor Integrated Application Platform for Resource Satellite Images” by CSRSR, NCU and NSPO successfully developed an application-oriented image query retrieval platform which combines self-developed image data management system with Open Data Cube. It will facilitate efficient analyses for various applications of resource satellite images, including optical and radar satellites such as FORMOSAT-2/FORMOSAT-5, Landsat-7/8, Sentinal-2, Sentinal-1, TerraSAR-X, and ALOS-2. The platform will help promote efficient use of multi-source satellite data, for data providers will be able to manage the significant volumes of data easily, and for data users will be able to support the applications of earth observations efficiently. Currently, the platform is still in a very early stage, or like a proto-type. In the future, more applications may be provided to promote the usage of different resource satellite data for different users in assorted fields.

References:

ARDC, Africa Regional Data Cube (ARDC) Open Data Cube (ODC) Training Workshop May 9th – 11th,2018, Nairobi, Kenya.

Giuliani, G., Chatenoux,B., Honeck E., Richard, J., Towards Sentinel-2 Analysis Ready Data: a Swiss Data Cube Perspective. In: IGARSS 2018 - 2018 IEEE International Geoscience and Remote Sensing Symposium. 2018. pp. 8668-8671.

Jones,T., Wicks,D., Agass S., Bunting P., Developing standards and automated production for Sentinel-2 Analysis Ready Data, Satellite Applications Catapult, 2017.

Killough,B., Status of the Open Data Cube, CEOS Systems Engineering Office, WGISS-44 Meeting September 27, 2017.

Killough,B., Open Data Cube Example Applications July 2017.

Lewis, A., Oliver, S., Lymburner, L., Evans, B., Wyborn, L., Mueller N., Raevksi, G., Hooke, J., Woodcock, R., Sixsmith, J., Wu, W., Tan, P., Li F., Killough, B., Minchin, S., Roberts, D., Ayers, D., Bala, B., Dwyer, J., Dekker, A., Dhu, T., Hicks ,A., Ip, A., Purss,M., Richards, C., Sagar, S., Trenham, C., Wang, P., Wang, L.W., 2017. The Australian Geoscience Data Cube — Foundations and lessons learned, Remote Sensing of Environment, vol.202, pp276-292.

Rizvi. S, Killough,B., Cherry A., Wagner O., Williams E., Gowda S., Open Data Cube (ODC) Training Workshop Open Data Cube Tutorial at IGARSS, July 22, 2018 Valencia, Spain.

USGS, Department of the Interior U.S. Geological Survey, PRODUCT GUIDE LANDSAT 8 SURFACE REFLECTANCE CODE (LASRC) PRODUCT,Version 4.2 December 2017, Table 7-2 Landsat 8 Pixel Quality Attributes (pixel_qa) Bit Index, p. 21.

Lin H.Y., Chang L.Y., Chang C.P., Tsai F., 2015. Open Data Service for Multi-temporal SPOT Images, Remote Sensing Satellite Technology Workshop 2015, National Nano Device Laboratories, Nov. 20, 2015.

Lin H.Y., Hsu S.M., Tsai F., 2017. Integrated Automatic Multi Sensor Geocoded Processing System, Remote Sensing Satellite Technology Workshop 2017, National Nano Device Laboratories, Hsinchu, Dec. 5, 2017