Catalog System for Radar Imagery

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ABSTRACT
The demand of radar imagery is increasing especially when location of object research is picked in cloudy area like Indonesia (especially in Kalimantan). Almost every day Kalimantan area covered by clouds, radar image is more needed instead of optic because optic sensor can not be used to penetrate the cloud. ALOS PALSAR (L-band) and Sentinel 1A (C-band) data are collected radar imagery also the distribution cover almost Kalimantan area. Terra SAR-X (X-band) is available for certain area according to user's demand. We can get free Sentinel radar image from Sentinel website and download its image. ALOS and Terra SAR-X data is not free and they were commercial data. Displaying availability for radar imagery with catalog system has been succesfully processed for ALOS Level 1.5 and TerraSAR-X data but for the latest radar image version like Sentinel 1A/1B data it is cannot be published untill now that is why conversion into general format file has to be done so that it can be ingested by the catalog system. Beside that ALOS data (forLevel 1.0 and 1.1) also needs to be converted manually into standard file format.

Keywords: Radar, SAR, Sentinel, ALOS, Terra SAR-X

1. INTRODUCTION

History of active microwave (RADAR) Remote sensing began when viking using crystal when they want to sail with their ship under fog condition. This first crystal technology of light then trigger to technology that lead to utilization of Radar. After that James Clerk Maxwell (1831-1879) provided the mathematical descriptions of the magnetic and electric fields which related to electromagnetic radiation (EMR). Then Heinrich R. Hertz develop some knowledge about EMR in the microwave and radio portion of the spectrum (1857-1894). Hertz brought his research to the invention of radio and radar. In 1874-1937 Guglielmo M. Marconi build an antenna that can transmitted and received radio signal. RADAR as we know it today are have being concept by A.H Taylor and L.C. Young in 1992.

1.1 Background

Radar Imagery would have need improvement for catalog system and also deep understanding for finding radar imagery, this issue still become major requirement for browsing radar catalog. Imaging mode on radar can be implemented in all radar types like SpotLight, Stripmap, ScanSAR and wide ScanSAR. Different wavelength can determine penetration through cloud, smoke, leaf and certain objects.Parameter of SAR system that should been noticed by the user are angle of incident, wavelength, polarization, spatial resolution, backscatter, and imaging cycle. The reason is because every parameter can distinguish several differentiation in SAR system, for example

like polarization can determine a certain SAR image utilization or application. Other parameter like wavelength variation can distinguish different penetration ability or operational mode which can make different types of radar image.An enhanced image processing for radar image can be categorized as an added value product like digital elevation model, interferometry, polarimetric or polarization combination and etc.Image user can search radar image based on wavelength, area of interest (coordinate), atmospheric condition, big data (swath area or size), polarization, image processing levels, etc.

LAPAN (*Lembaga Penerbangan dan Antariksa Nasional*) or National Institute Aeronautic and Space has storing radar image for a long time ago, radar data like SRTM has been use for extracted its DEM. Other radar imagery like JERS-1, ENVISAT ASAR, (European Remote Sensing) ERS-1, ERS-2 also have been recorded in CCT, DLT, DCRSy, DVD, CD, Harddrive, local server storage, negative and diapositive film. Next figure will show a radar image have been convert into negative film and rescan to digital file. Figure 1 is Bali area on July 7th 1997 where its image has copyright from ESA and produced on October 29th 1997. ERS-1 (launched 17 July 1991), ERS-2 (20 April 2005) and ENVISAT ASAR (28 february 2002) were experimental predecessors satellite before Sentinel 1 Mission. Sentinel Mission ensures continuity of C-Band SAR data to applications and builds on ESA's heritage and experience with the ERS and ENVISAT SAR instruments.

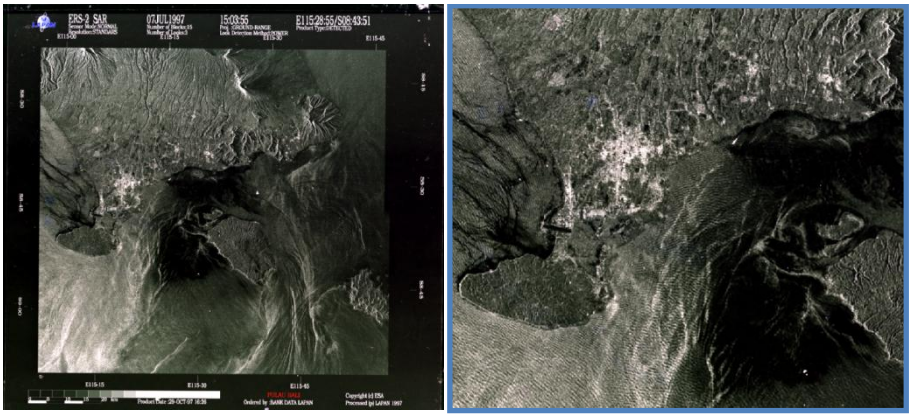

Figure 1. ERS-2 SAR 7 July 1997 Bali Island Indonesia

Another sample for radar imagery is (Japanese Earth Resource Satellite) JERS-1 for acquisition on February 8th 1997 for Nangah Sayan in West of Kalimantan Indonesia. This image has level product 2.1 and spatial resolution 12.5 meterand also ownership of the data belong to MITI or NASDA, all of metadata information being kept in image header. Projected in Universal transversal Mercator (UTM) and processed by LAPAN Pekayon on March 16th 1999 in local time 10:10:35 with scale factor compression 0.3. Japan has produces radar image like JERS-1 and ADEOS, those satellite were predecessors of ALOS PALSAR.

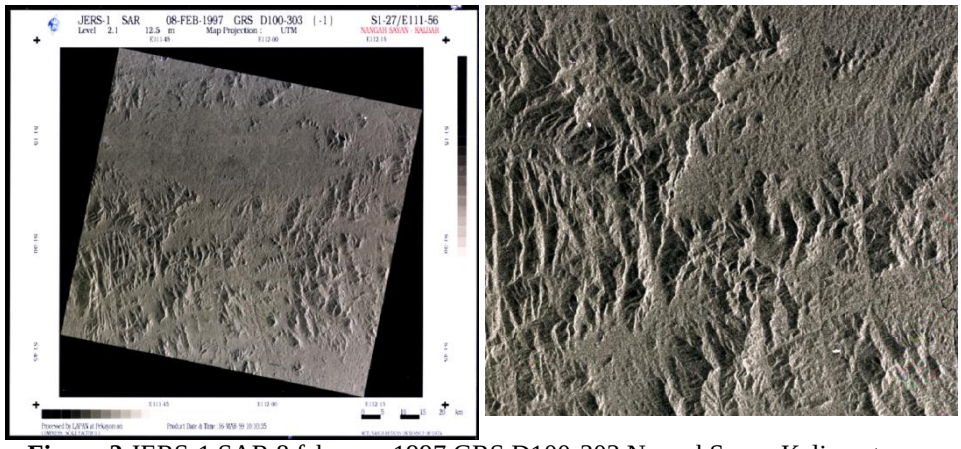

Figure 2.JERS-1 SAR 8 february 1997 GRS D100-303 NangahSayan Kalimantan Barat

The latest satellite imagery which bought by LAPAN from Airbus is an image of Terra SAR-X product with aqcuisition in 2013 to 2014 (TerraSAR-X itself launched in 2007). ALOS Data (PALSAR and PALSAR-2) were collected from colaboration between LAPAN and JAXA. Those cooperation has collected hundreds of data from year 2006 untill 2011where data availability can be found in*www.inderaja-catalog.lapan.go.id/dd3*. The new satellite radar image Sentinel 1A and 1B can be downloaded freefrom their official web address, this radar C-band has a wide swath and polization VV or VH. Information that can be retrieved from Sentinel data for Indonesia coverage is by collect a set ofKeyhole Markup Language (called KML) data then merge it all in one single image. KMLability insave multiple images in one single mosaic image is one of advantages of keyhole technology, next figure will show a set of download resultfrom Sentinel data in KML format.Figure 3 display a group of Sentinel quicklooks which consist of multi polarization combination (represented in light green and little bit orange).

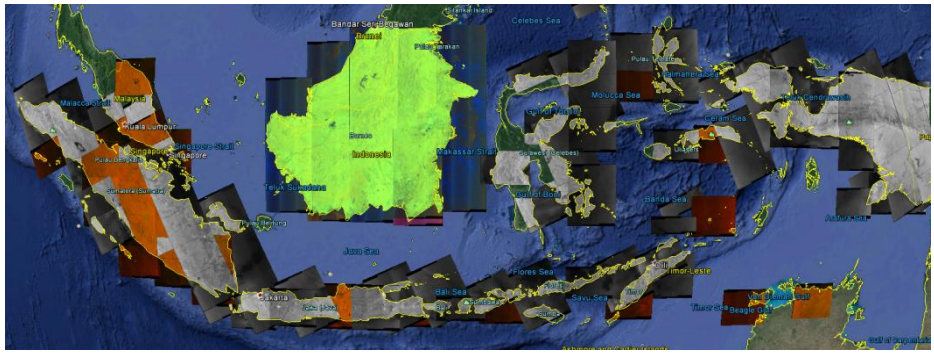

Figure 3. Availability of Sentinel 1 data with KML Quicklook

1.2 Problems

Succesful ingestion with SCIMr is ALOS PALSAR Level 1.5, LIDAR, Radarsat-2 and TerraSAR-X, while other radar imagery like Sentinal 1 A, ALOS Level 1.0, ALOS Level 1.1 and ALOS 2 still not yet ingested by SCIMr.Ingest process for Sentinel data found an empty detection due to new satellite sensor,this problem also occureto ALOS PALSAR-2 data. The big size of Sentinel file also become other problems like long process conversion, the size can reach 9 Gigabytes for one image only.Sentinel satellite give KML feature for quick look distribution for its aqcuisition, like above figure there are grey colored sentinel which means single polarization (VV or HH), second colored is brown or little bit dark orange is combination between VV and VH and the last colored sentinel is light green. The light green is consist from combination between VV and VH but have different formula for ratio from Sentinel polarization.

1.3 Theory

Radar or Radio Detection and Rangingoperate in the microwave portion of the electromagnetic spectrum beyond the visible and thermal infrared region (Henderson M Floyd, Lewis J. A., 2013). Radar is have different meaning with LIDAR and SONAR, LIDAR based on the transmission of relatively short-wavelength laser light (e.g., 1040 nm) and then recording the mount of light backscattered from the terrain. SONAR based on the transmission of sound waves through water column and then recording the amount of energy backscattered from the bottom or from objects within the water column (Jensen R. John 2007). Jensen understand radar based on the transmission of long wavelength (e.g., 3-25 cm) through the atmosphere and then recording the amount of energy backscattered from the terrain.

Polarization is how to resolve electromagnetic radiation (also called EMR) into its horisontal and vertical component. Jensen R. John, (2007) define polarization as a pulse of EMR sent out by antenna may be vertically or horisontally polarized. Various types of backscattered polarized energy may recorded by radar, for example is possible to

- Send vertically and receive vertically polarized energy (VV)
- Send horisontally and receive horisontally polarized energy (HH)
- Send horisontally and receive vertically polarized energy (HV)
- Send vertically and receive horisontally polarized energy (VH)

Application that might be suitable for different combination of single or multi-polarization from Synthetic Aperture Radar (SAR) data. For example like Forestry (Biomass estimation and species determination use multipolarization HV+VV+HH, other example for clear cut mapping using single polarization HV. Figure 4 below will show thata lot of applications that can be implemented for these preferable C-band polarization.

Polarimetric SAR ～Preferable polarization (C-band)～

Application	Preferred Single Polarization	Preferred Multi-Polarization
Agriculture		
Crop Type		
・Grains (vertical)	VV or HV	HV + VV + HH
・Canola/Peas (horizontal)	HH	HV + VV + HH
Crop Monitoring	HV or VV	HV + VV + HH
Land Use Mapping	HV	HV + VV + HH
Defense		
Maritime Surveillance	HH	HV + HH
・Ship (shallow incidence)	HV	HV + HH
・Ship (steep incidence)	HH	HV + HH
・Wakes	HV or HH	HV + HH
Land Surveillance Mapping	HV	HV + HH
Forestry		
Clear-cut Mapping	HV	HV + HH
Biomass Estimation	HV	HV + VV + HH
Species Determination	HH	HV + VV + HH
Geology		
Structural Mapping	HV	HV + HH
Lithologic Mapping	HH or VV	HV + VV + HH
Hydrology		
Flood Mapping	HH	HV + HH
Soil Moisture Estimation	HV	HV + VV + HH
Snow Wetness Estimation	HH or VV	HV + VV + HH
Oceans		
Wave Spectra	HH or VV	HH + VV
Mesoscale Features	HH or VV	HH + VV
Bathymetric Mapping	VV	HH + VV
Oil Slick Detection	VV	HH + VV
Sea Ice		
Ice Classification	HV	HV + VV + HH
Ice Edge Mapping	HV	HV + VV + HH
Ice Topography	HV	HV + HH

(C)CSA 1996

Figure 4. Polarization and its application

Operational Mode is the single receive antenna mode from which of the following imaging mode can be retrieved. Sentinel has only four operational modes that designed like strip map, Interferometric Wide Swath, Extra Wide Swath and Wave Mode. Other Satellite like Terra SAR-X has seven mode which are Staring SpotLight (ST), High Resolution Spot Light 300 Mhz (HS300), High Resolution Spot Light (HS), SpotLight (SL), StripMap (SM), ScanSAR (SC) and WideScanSAR (WS). ALOS PALSAR imaging modes are Fine Beam Single (FBS), Fine Beam Dual (FBD), WB1, WB2, DSN and PLR then for PALSAR 2 three modes which are Spot light, Strip Map and ScanSAR.

Level product processing this means every level that own by radar image have different level name and image processing. For example like ALOS PALSAR (Level 1.0, 1.1 and 1.5), PALSAR-2 (Level 1.1, 1.5, 2.1, 3.1). TerraSAR X has different level types, its level are Level 1B products, Single Look Slant Range Complex (SSC), Multi Ground Range Detected (MGD), Geocoded Ellipsoid Corrected (GEC), and Enhanced Ellipsoid Corrected (EEC).Level product for Sentinel 1 is Level 0 RAW product, Level 1 Single Look Complex (SLC), Ground Range Detected and Level 2 product.

Band Microwave: The name of band is come from second world war and it is code names (Ka, K, Ku, X, C, S, L, P) then IEEE use the name to representate the radar image for its band. The microwave band is ranging from 1 untill 100 GHz, this band range has subdivided in a number of subbands. Figure 5 show about detail information about frequency, wavelength and band.

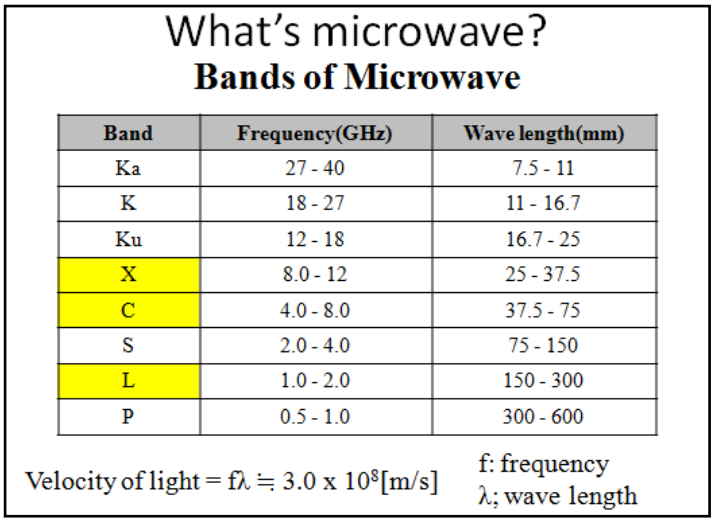

Figure 5 Band of Microwave

Spatial SAR resolution is describe the ability of the radar imaging to separate two closely spaced scatterers, to achieve high resolution in range then very short pulse durations are necessary.

Incidence angle is the angle between the radar pulse of energy and a line perpendicular to the Earth Surfaces where it makes contact.

Look direction or Range is the direction of the radar illumination that is at right angles to the direction the aircraft or spacecraft is travelling.

Imaging radar interferometry is the process whereby radar images of the same location on the ground are recorded by antennas at different location and times.

Some Definitions is Datadoors (Gumelar O., et al (2015)

SCIMror The Supplemental Content Ingestion Manager (SCIMr) is a tools that provided by icubed and Airbus which can manage and publish image satellite from certain directory in a server or network computer.

Ingest is mean identification proccess to an image satellite with extraxcted raster image and metadata information so that it can be built some catalog information and spatial database.

Vaultis a set of file or data in some network in this case is in LAPAN network. These files can be found in various location through network under certain circumstance like file format, spatial resolution and also these files locked and untouchable to the user.

Productis derivation form the vault which consist of collection of instructions, these instructions can be implemented based on user request.

Archiveis a collection from several products, these collections is being served through web client and mapped in single organization.

2. DATA AND METHOD

2.1 Data

ALOS PALSAR and ALOS 2 (L-band), TerraSAR-X Level 1 B (X-band) and Sentinel 1 A (C-band). For ALOS PALSAR the data is from year range 2006 untill 2011 and Level 1.0, 1.1 and 1.5 with every polarization. TerraSAR-X data range is from year 2009 untill 2014 with Level 1B and EEC or SSC product. Sentinel 1A data range from 2014 untill 2016 with SLC and GRD products.

2.2 Methods

Procedure of image satellite ingestion

Next figure will explain how radar image can be published in catalog Datadoors system. Figure6 explain that for the first stage begin with accessing the SCIMr account, it has to be filled by the registered username. Second stage select types of radar that will be ingested then type the directory address on the system, SCIMr will inform that data were detected or not. For example ALOS fine beam single with 16 bit unsigned, HH polarizationand spatial resolution 6.25 meter for FBS ALOS data but SCIMr rounded the number into 6.3 meter. After data selection has been made then click next button to the tab vault, this was the fourth stage in ingestion proccess. Defining name of the vault and give detail about radar information will available in Description box. Resampling method available for options like nearest neighbour, bilinear and Cubic Convolution. Fifth step fill the form in the Product or Archive tab which define name and detail of product. Sixth step select the proccess that can be added to image proccessing like copy source data, deliver source data, color balancing, mosaic and other POPS Common processes. Seventh step the SCIMr will display sort of the list images that has been input into the system. Last step is testing datadoors catalog processby verify the catalogue process, is the radar image have been cataloged or not. Figure 6 visualize all steps and procedure how radar image being ingested and published.

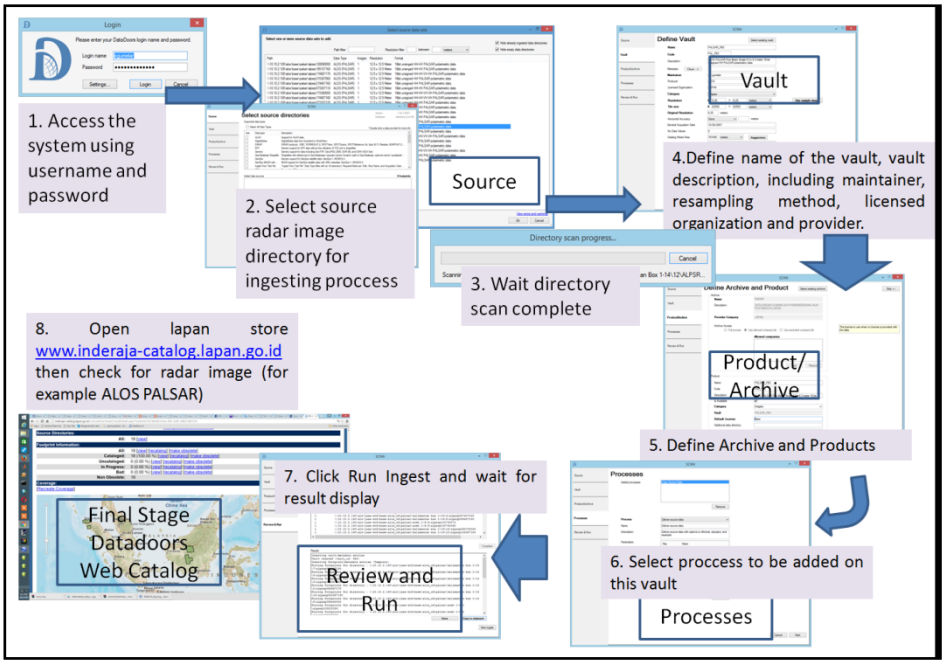

Figure 6. Ingesting procedure

3. RESULTS AND DISCUSSION

Study of several radar catalog system has been done by register the account for every web Catalog , like ALOS PALSAR, Sentinel and TerraSAR-X. Other method is analyzing website features in select and filter radar imagery in their web catalog. Literature has been collected and learned for understanding each of radar image and sensor characteristic. Catalog for radar imagery has been checked for the latest version and update of the websiteon July 2016. Single band polarization is frequently used for display availability of the radar imagery, most of website seldom use an enhanced processing radar image like polarization combination or interferometry because it can give confusing information about colour radar even though radar imagery has properties for its greyscale image or single band image not true color like optics.

3.1. Sample catalog for Terra SAR-X (x-band)

Terra SAR-X products were well detected by the system and the image has been published through inderaja-catalog.lapan.go.id. Acquistion of TerraSAR X image is in 2009to 2014, their availability can be seen in Search results box dialog. Spatial resolution from 1 meter, 1.3 meter and 8.3 meter like in figure below, these means that there were several high resolustion radar images from Terra SAR X.

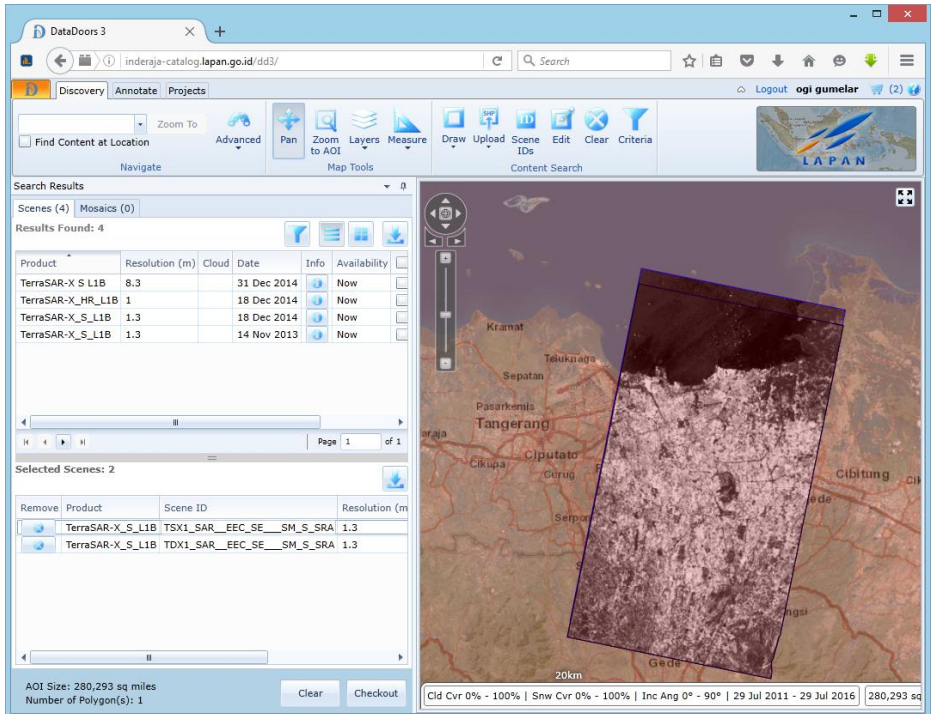

Figure 7. Web display of inderaja-catalog.lapan.go.id

Terra SAR X image with level 1B processing and EEC product which mean multi-look detected, projected and resampled products to the WGS 84 reference ellipsoid. Availibility for Terra SAR X in around Jakarta area give result four scene filtered by drawing area of interest with box filter. Cloud fields were empty because there are no information of the clouds even though X-band cannot penetrate certain clouds.

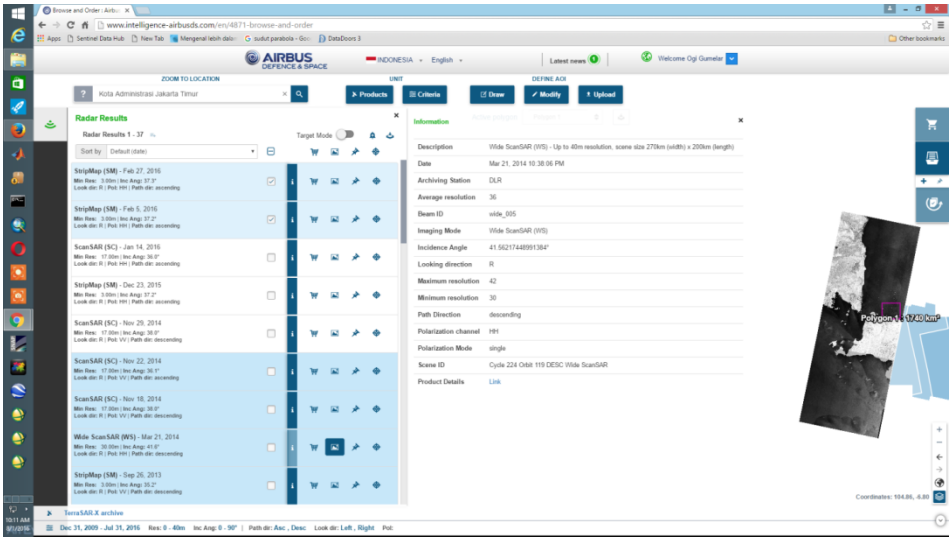

Figure 8. Official web Terra SAR X in GeoStore

Geostore catalog airbus in*http://www.intelligence-airbusds.com/en/4871-browse-and-order*explain that there were several of imaging modes for TerraSAR-X like High Resolution Spotlight (HS), Spotlight (SL), StripMap (SM), ScanSAR (SC) and Wide ScanSAR (WS). Spatial Resolution is depend on this imaging mode for example Spotlight has spatial resolution for about 1 until 3 meter.

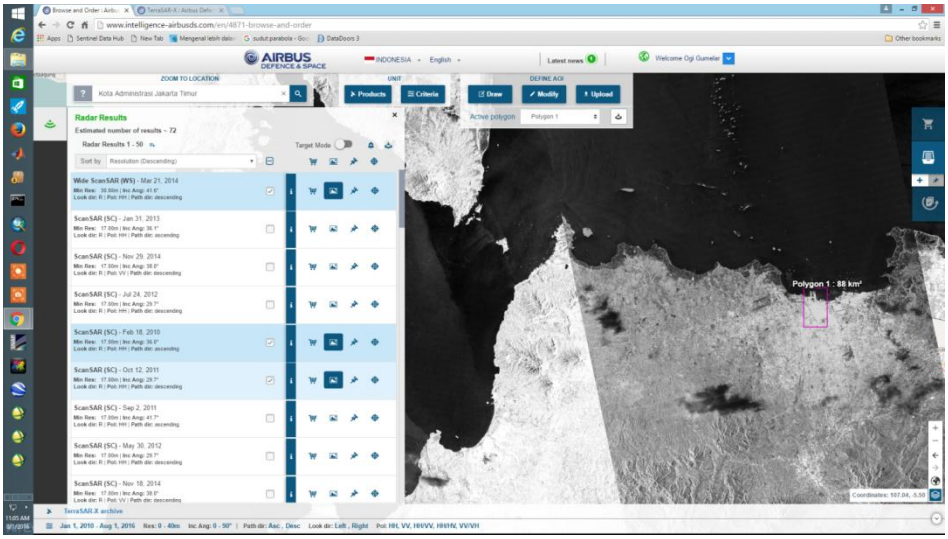

Figure 9. Sample data order of TerraSAR-X

Filtering option from Sentinel web catalog offering user for selecting date acquisition range, spatial resolution, incidence angle, path direction (ascending or

descending), look direction and polarization. As you can see polarization Single HH, single VV, Dual HH/VV, Dual HH/HV, Dual VV/VH are available options for TerraSAR-X.

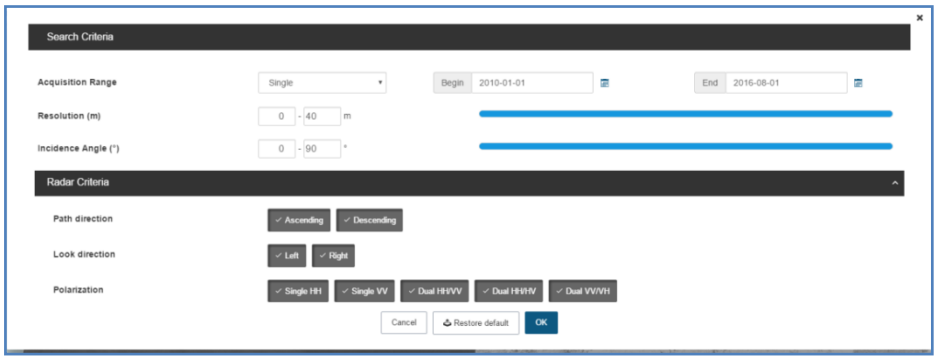

Figure 10. Filtering options

3.2 Sentinel 1A and 1B

Sentinel radar C-band data can be found in *https://scihub.copernicus.eu/dhus/#/home* and download it free, and register an account and email in this web address. Filter for the image is available for Sentinel 1, 2 and 3 but we can configure it manually for Sentinel 1A or 1 B availabiltyor by determine their years and area. Configuration of the filter change over time and the major change happen in graphical display. SCIMr Datadoors cannot ingested this Sentinel format file unless we can convert it first to GeoTIFF file from zip folder then ingestion can be started and select the generic TIFF file. Conversion untill now using SNAP software and need more time of process depend on Sentinel size of image.

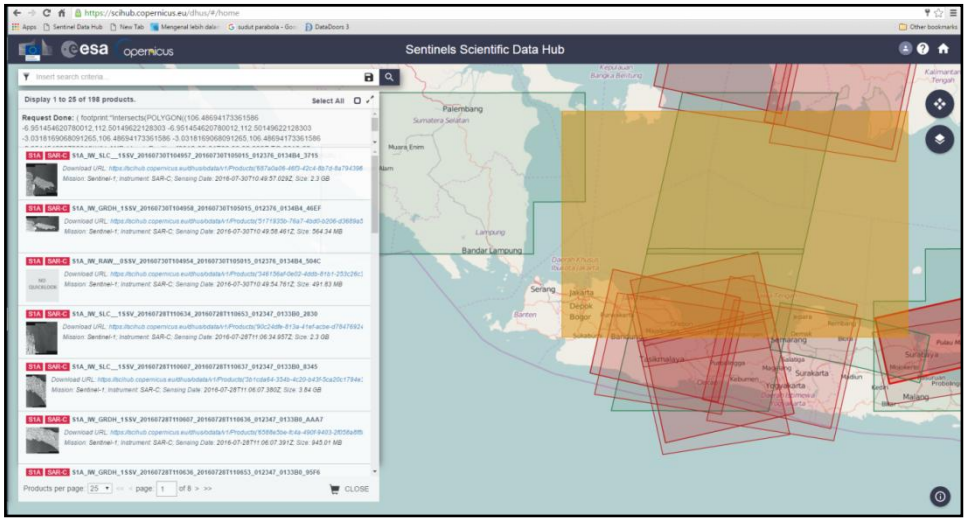

Figure 11. Sentinel official web catalog scihub

Search criteria shown in the left Figure 11 is displaying list results of Sentinel 1A SAR-C band, Level Sentinel has various types like RAW, SLC and GRDH.

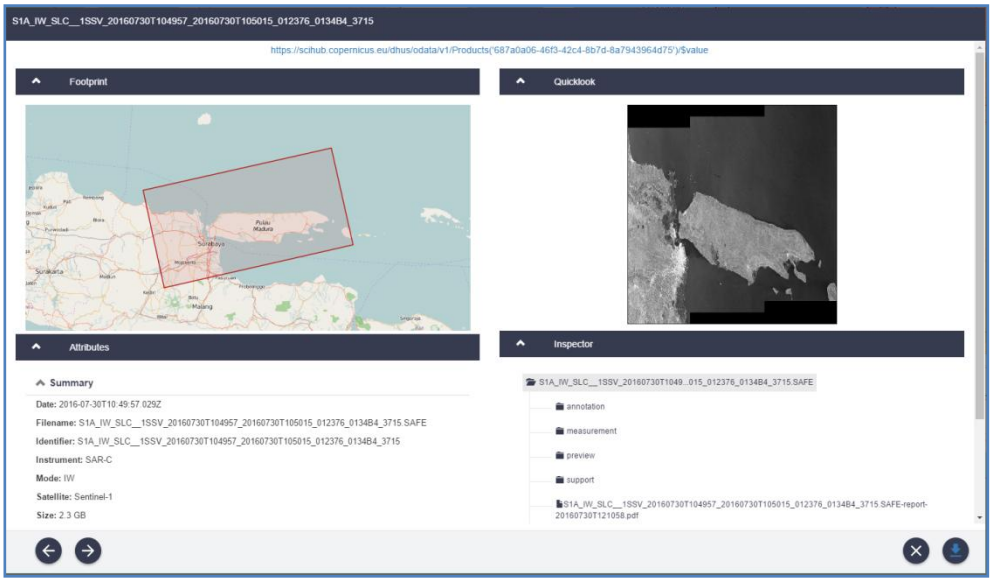

Figure 12. Filtering options Sentinel

3.3. ALOS PALSAR

Radar user can browse and order ALOS PALSAR and PALSAR-2 in several web address, for example like *https://satpf.jp/spf/?sb=search&sensor=ALOS-2_PALSAR-2&item=sb1_sar_palser2*. Website make user to install Microsoft Silverlight for running the radar web catalog.

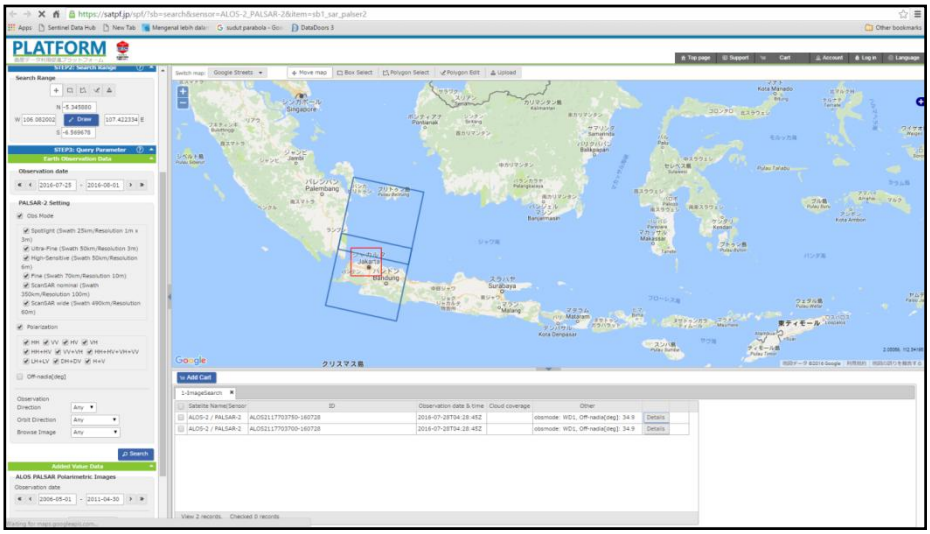

Figure 13.ALOS Web Catalog

Second web adress for ALOS data catalogue is recommended to be opened with mozilla firefox browser and it will need instalation of Microsoft Silverlight, its official ALOS web adress can be found in*https://auig2.jaxa.jp/ips/home*. User can find image detail in other popups which generated by web application in other page. Options is not limited only for PALSAR but for AVNIR And PRISM sensor which brought by ALOS Satellite. List of the result can be exported to CSV, SHP or even KML format which is standar for web catalog based on GIS.

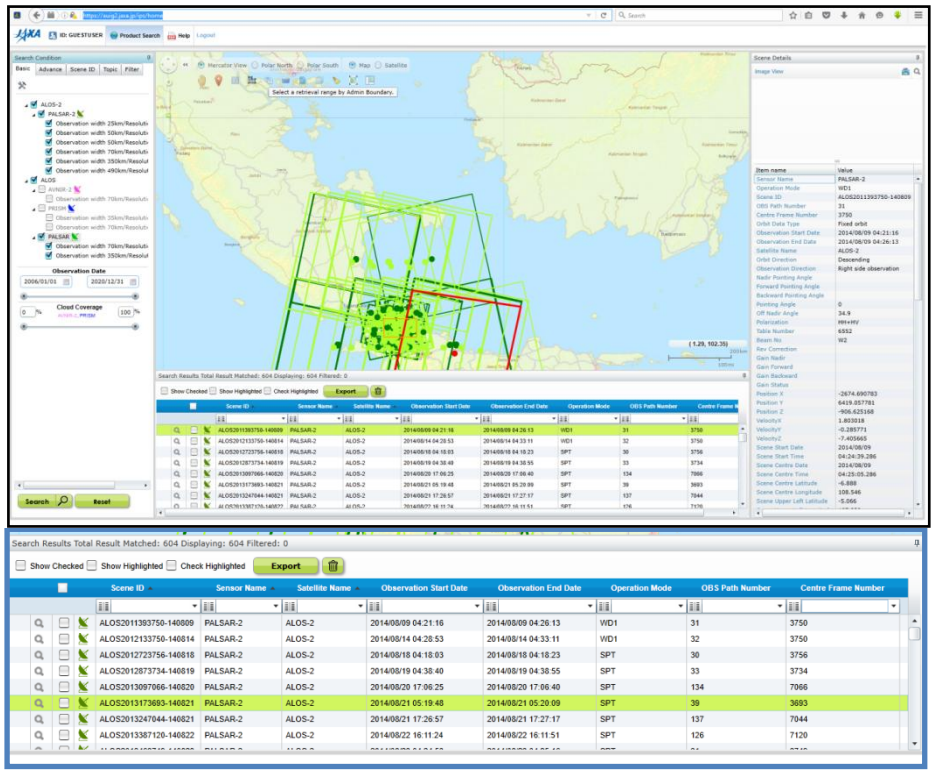

Figure 14. Official web catalog for ALOS PALSAR and PALSAR-2

List results show filenaming of ALOS file, with sensor name, satellite, observation start date and end date, operation mode, OBS Path number and Centre Frame Number. Figure 15 below is comparation between PALSAR and PALSAR-2, user can analyze this matter based on metadata information in this web catalog feature. Polarization both image was same which are dual polrization HH+HV, but have different operation mode FBD and WD1. Descending path direction in PALSAR-2 make the quicklook image rotate to the right (based on north up map) and for ascending path direction rotate to left picture.

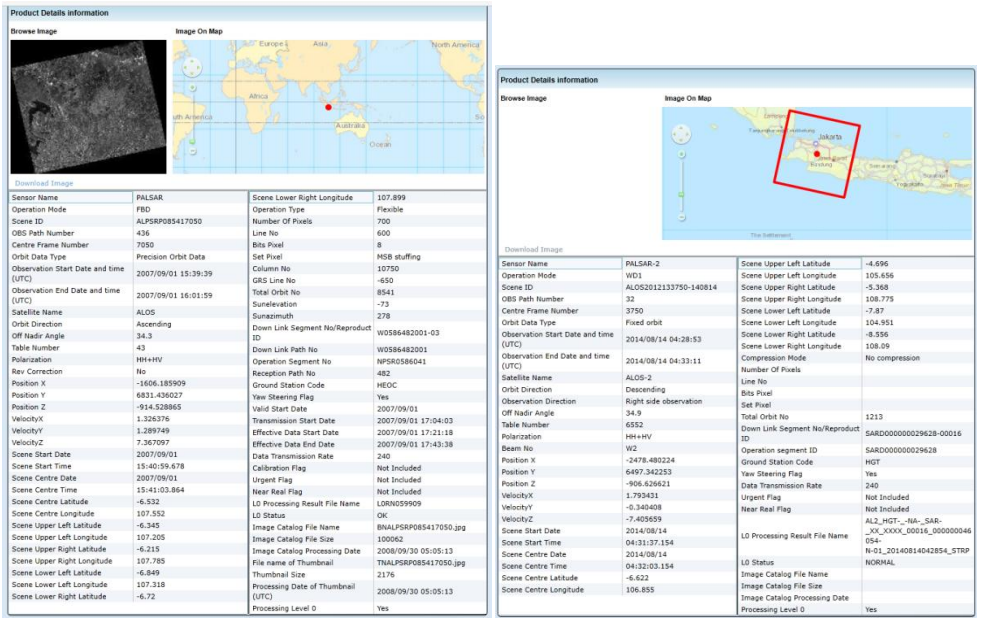

Figure 15. Detailed ALOS PALSAR product in ALOS web

Product detail information seem extracted from ALOS PALSAR metadata, because if we open with SNAP or other radar software processing then we can extract information like above figure. Solution for failed ingestion is by convert the radar data with Pixel Factory and GDAL, if the size were huge then there will be some tiling procces to simplify the automation ingestion proccess.

4. CONCLUSIONS

Radar image catalog has difficult requirement because it would need a lot of parameter filtering for displaying the image for example like swath width, imaging mode, wavelength, backscatter properties, dielectric constant and other. Sample catalog for radar like Terra SAR-X (in Geostore Airbus), Sentinel (in Scihub) and ALOS data (in restec JAXA) will be studied in a higher level. Next upgrading for Datadoors catalog hopefully will have a better display and improvement feature

especially for displaying the availability of Radar Imagery. There are others Radar SAR sensor that not been expose in this research like SEASAT, SIR-A, SIR-B, SIR-C, ALMAZ-1, Radarsat 2, SRTM, IFSAR, LIDAR, SONAR and so on. The writer hope that research for Radar Remote Sensing will continue to deeper knowledge.

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