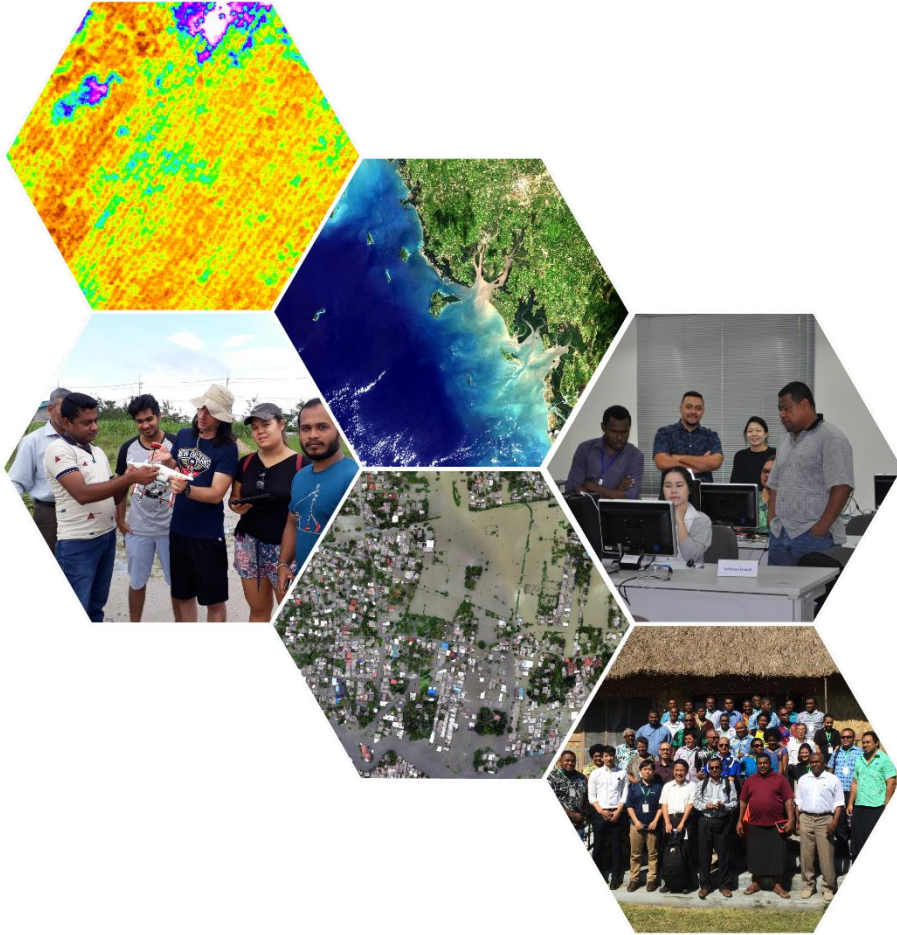


Forest Biomass Estimation

Practical Session

Chathumal Madhuranga



AIT
Asian Institute of Technology



Downloading ALOS PALSAR Data

Alaska Satellite Facility vertex

The image shows two screenshots. The left screenshot is of the Alaska Satellite Facility Vertex website. It features a header with the NASA Earthdata logo and a search bar. Below the header, there's a navigation bar with links to Vertex, Interactive Tours, Help, and ASF Home. The main content area includes a map of the world with a search area highlighted over Alaska. To the left of the map, there are search options: Geographic Region, Option 1 (Click on map and move cursor), Option 2 (Enter coordinates), and a search bar. Below the search bar, there are links to Dataset and Optional Search Criteria. The right screenshot is of the Earthdata Login page. It shows a login form with fields for Username and Password, and buttons for LOG IN and REGISTER. A message at the top says "You have been logged out of Earthdata Login".

Earthdata Login

Download Queue 1

Contact

Please use the map and/or the search parameters on the left to select your search criteria.

Earthdata Login - Google Chrome

NASA (National Aeronautics and Space Admin) | https://urs.earthdata.nasa.gov/home

EARTHDATA LOGIN

You have been logged out of Earthdata Login

Username

phathumal1436

Password

LOG IN REGISTER

I don't remember my username

I don't remember my password

Help

Why must I register?

The Earthdata Login provides a single mechanism for user registration and profile management for all EOSDIS system components (DAACs, Tools, Services). Your Earthdata login also helps the EOSDIS program better understand the usage of EOSDIS services to improve user experience through customization of tools and improvement of services. EOSDIS data are openly available to all and free of charge except where governed by international agreements.

- ALOS PALSAR data can be downloaded from this site for 2006 – 2011
- First click on the earth data login and register.
- If you have already registered, log in and look for the ALOS PALSAR data.

- Provide the relevant information to the vertex and find the ALOS PALSAR image over Nepal.

Specify the time frame

If you know the path and frame you can insert here

Specify the processing level of the images

The screenshot shows the Vertex web interface. On the left, there are search filters: 'Seasonal Search' with start and end dates (2010-08-01 to 2010-08-30), 'Path & Frame' with Path 519 and Frame 560, and 'Product Type' with 'Level 1.5 Image' selected. The main panel shows a list of datasets with 'ALOS PALSAR' checked. On the right, a map of Nepal is displayed with a search area highlighted. A legend at the bottom indicates the number of frames for different colors: 1 (purple), 2-5 (green), 6-15 (yellow), 16-20 (orange), and 21+ (red).

Specify the time frame

If you know the path and frame you can insert here

Specify the processing level of the images

Tick the dataset you need

You can select the geographical region from here

Downloading SRTM DEM

- You can use GMTSAR website for download DEM

GMTSAR

Home
Downloads
Generate DEM
SAF InSAR Time Series
Contact

Links
Get SAR data
GMT Hawaii

Generate DEM files for use with GMTSAR

Enter boundary coordinates and hit generate to run the DEM generate script. The boundary cannot span more than 4 longitude by 4 latitude degrees. Three land data bases are available:

SRTM1 - global but only extends to latitudes of +/-60 degrees, 30 m resolution
SRTM3 - global but only extends to latitudes of +/-60 degrees, 90 m resolution.
ASTER1 - global but lower quality, 30 m resolution.
(Note the SRTM data has been updated to V3 <http://www2.jpl.nasa.gov/srtm/>).

This process is slow (10 minutes) so please be patient. When it is done hit "Download" below.

"Check Status" to check the status of the query and retrieve any produced files at a later time using the ID (copy number below before moving to next page) or just wait.

Check status

e.g. 31.9
-115 -113
27.3

SRTM3

north

west east

south

Generate

© 2010 GMTSAR

Type "Gmtsar dem" in web browser and go to GMTSAR Generate DEM site.

Select the dem resolution you need(SRTM3)

Specify the latitude and longitude decimal degree coordinates of the Area of interest

Click on generate. This will take little time then you can download the DEM

Convert DEM.grd to DEM.tif

Open the downloaded dem file(dem.grd) in Arcmap

Right click on this layer and select Data >> export data.
Then convert it as a tiff file in your desired folder



Export Raster Data - dem.grd

Extent
☐ Data Frame (Current)
☒ Raster Dataset (Original)
☐ Selected Graphics (Clipping) ☐ Clip Inside

Spatial Reference
☐ Data Frame (Current)
☒ Raster Dataset (Original)

Output Raster
☐ Use Renderer ☐ Square: Cell Size (cx, cy):
☐ Force RGB Raster Size (columns, rows):
☐ Use Colormap NoData as:

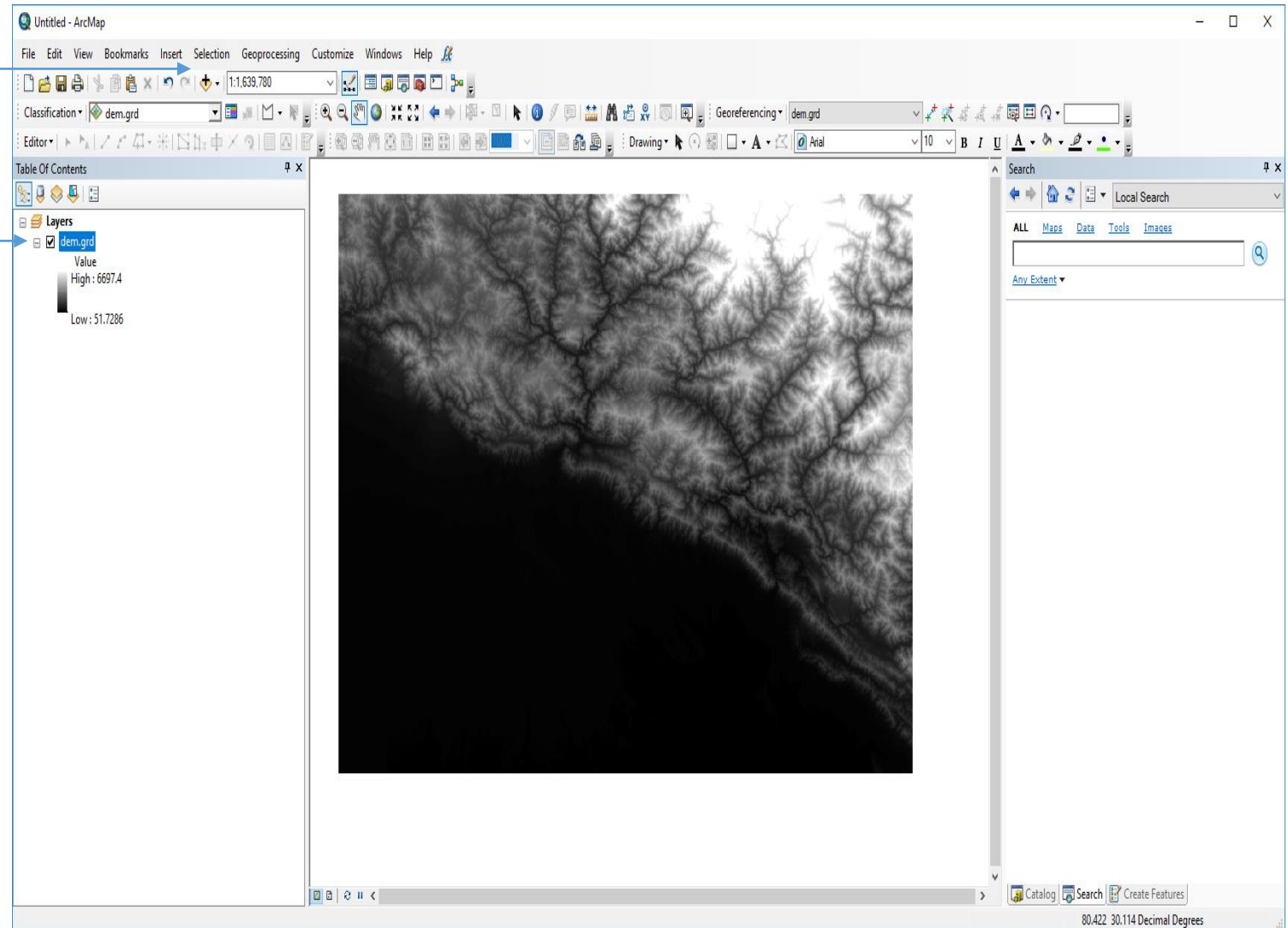
Name	Property
Uncompressed Size	32.98 MB
Extent (left, top, right, bottom)	(78.9996, 30.0004, 82.0004, 27.9996)
Spatial Reference	GCS_WGS_1984

Location:

Name: Format:

Compression Type: Compression Quality (1-100):

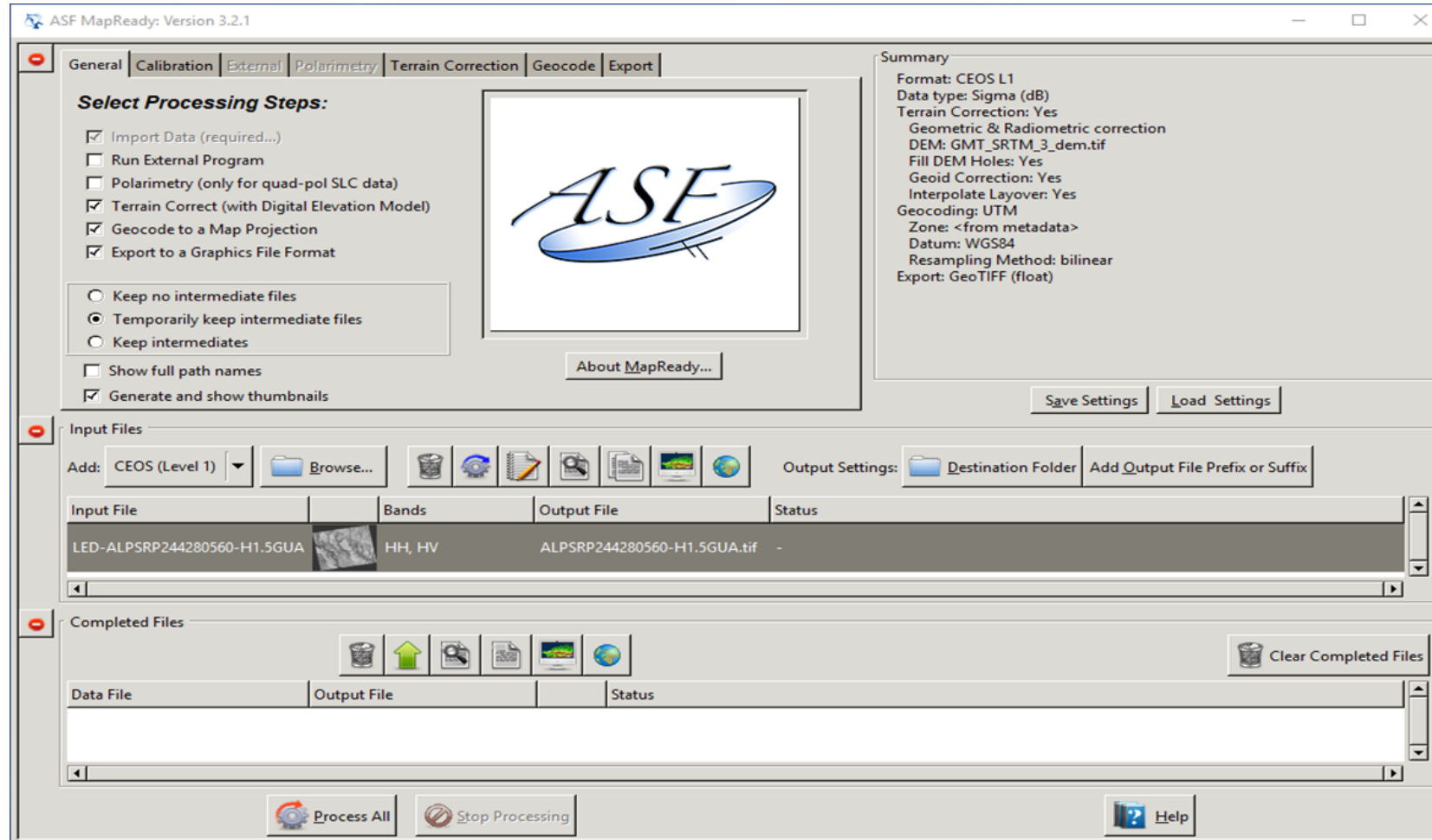
[About export raster data](#)



Pre process the ALOS PALSAR images

ASF Mapready

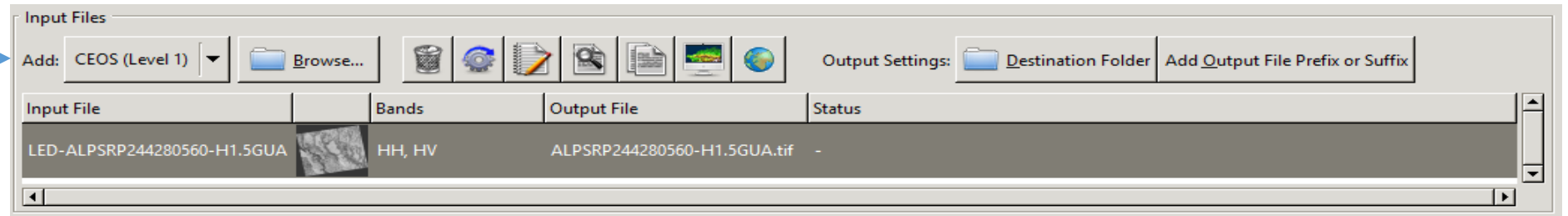
- Install the setup file for ASF Mapready software given in the software setup folder



Pre processing cont.....

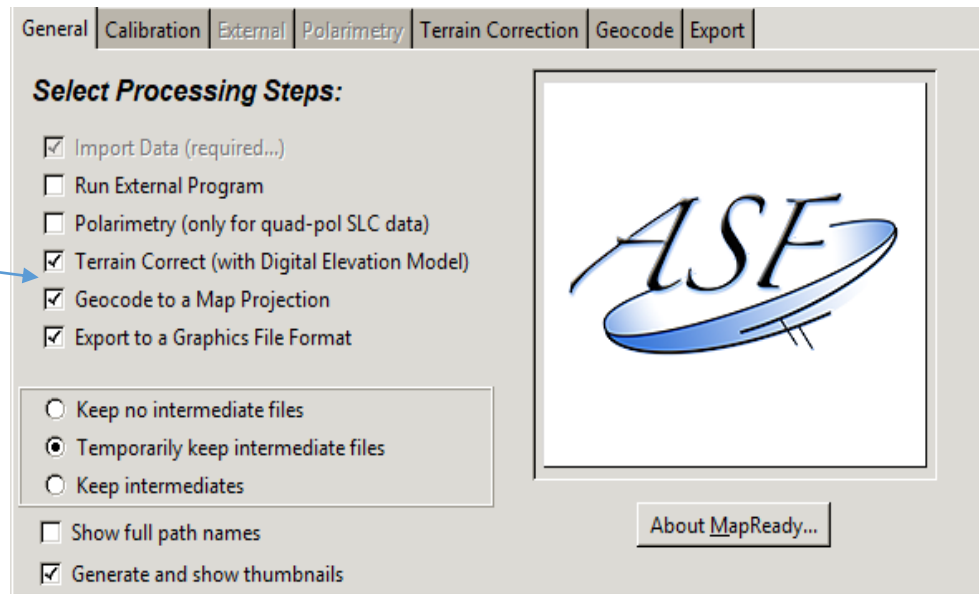
- Browse the CEOS formatted ALOS PALSAR level 1.5 Data

Select CEOS level 1
and browse the data
folder



- Tic the following options and get the final sigma naught images. (not in dB values)

Tick these options



Pre processing cont.....

General Calibration External Polarimetry **Terrain Correction** Geocode Export

Input data formats: none

Select Radiometry: Sigma

☐ Scale output to decibels (dB)

☒ Apply ERS2 Gain Correction to ERS2 data

Choose Sigma

Do not tick this. Keep it as it is.

Browse your DEM
file Here

Select the all the options
shown in this tab

General Calibration External Polarimetry **Terrain Correction** Geocode Export

DEM File: ers\Chatumal\Desktop\Biomass Analysis\DEM\GMT_SRTM_3_dem.tif Browse...

☒ Fill DEM holes with interpolated values ☒ Apply geoid correction

☐ Refine Geolocation Only

☒ Apply Terrain Correction

☐ Apply a user mask ☒ Automatically Mask ☐ Mask from File

Mask File: Browse...

☒ Perform co-registration (FFT Matching)

☒ Also apply radiometric Terrain Correction

☐ Save Incidence Angles

☒ Interpolate Layover/Shadow Regions

☐ Save Layover/Shadow Mask

☐ Save Clipped DEM

Pre processing cont.....

- Geocode the product in the UTM projection

Select UTM →

General | Calibration | External | Polarimetry | Terrain Correction | **Geocode** | Export

Map Projection: **UTM** | User Defined

Zone: ☐ Specify Height

Avg Height: meters

☐ Specify Pixel Size

Pixel Size: meters

Datum: **WGS84**

Resample: **Bilinear**

☐ Ignore projection errors

- Export the product as a Geo-tiff product.

Select Export as
Geotiff →

General | Calibration | External | Polarimetry | Terrain Correction | Geocode | **Export**

Export Format: **GeoTIFF (.tif)**

☐ Output data in byte format (instead of floating point)

Sample mapping method: **Statistical 2 Sigma**

☒ Export All Bands as Separate Images

☐ Export RGB Image according to Polarimetric selection

☐ Export Multiple Bands in a Single RGB Image

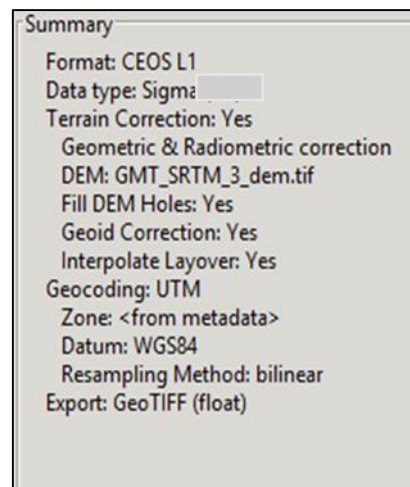
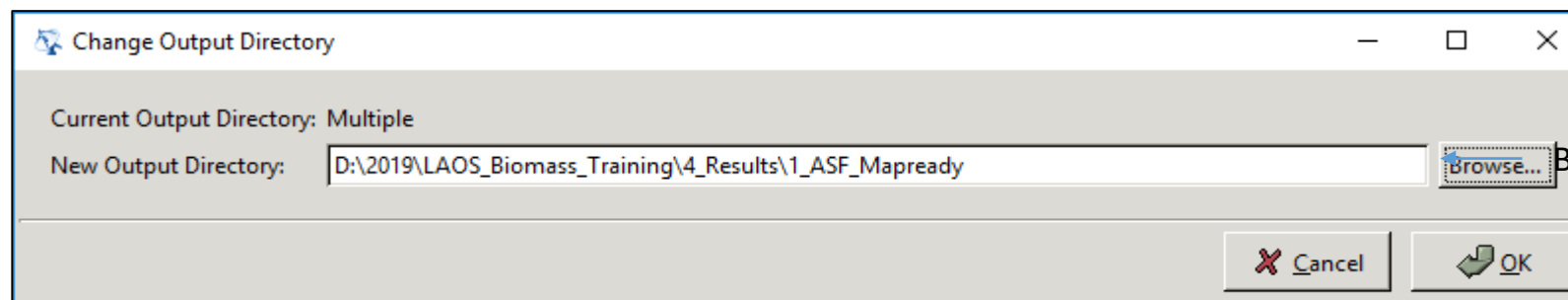
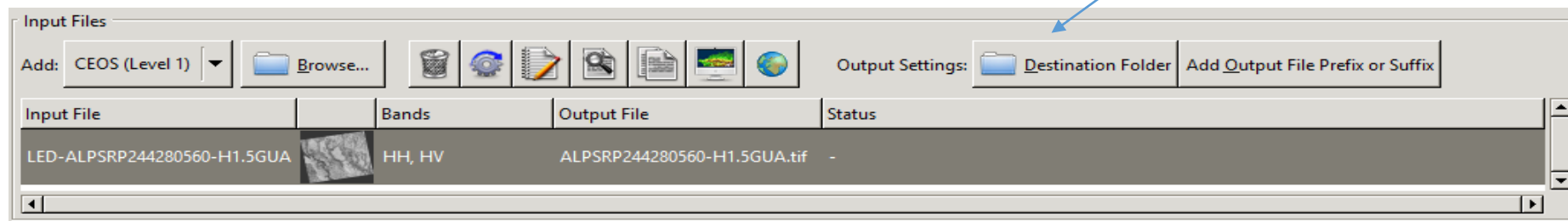
☒ User Defined ☐ True Color ☐ False Color

Red Band:

Green Band:

Blue Band:

Pre processing cont.....



Select the output folder

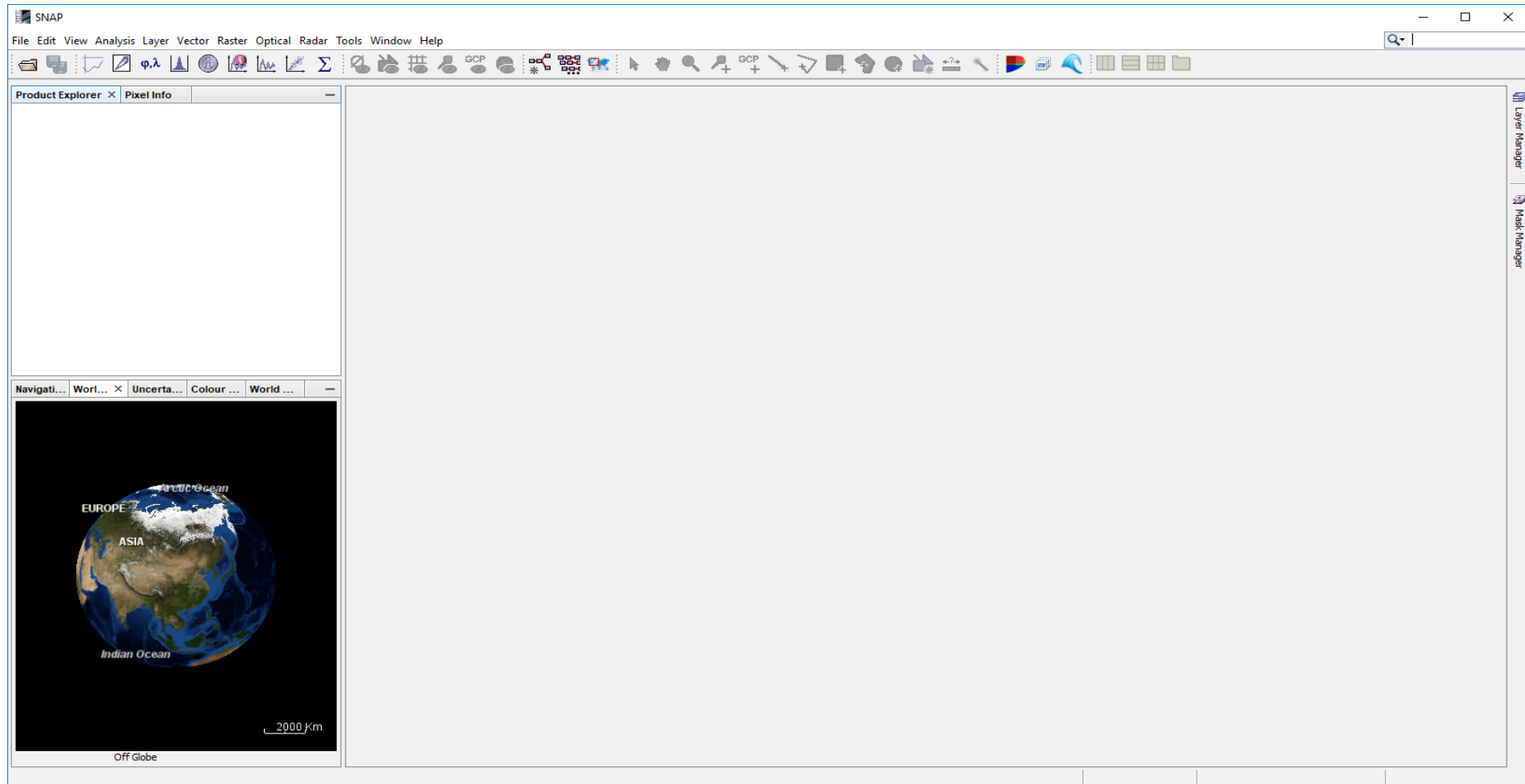
Browse and press OK

This will be the summary of your product

Speckle filtering

SNAP

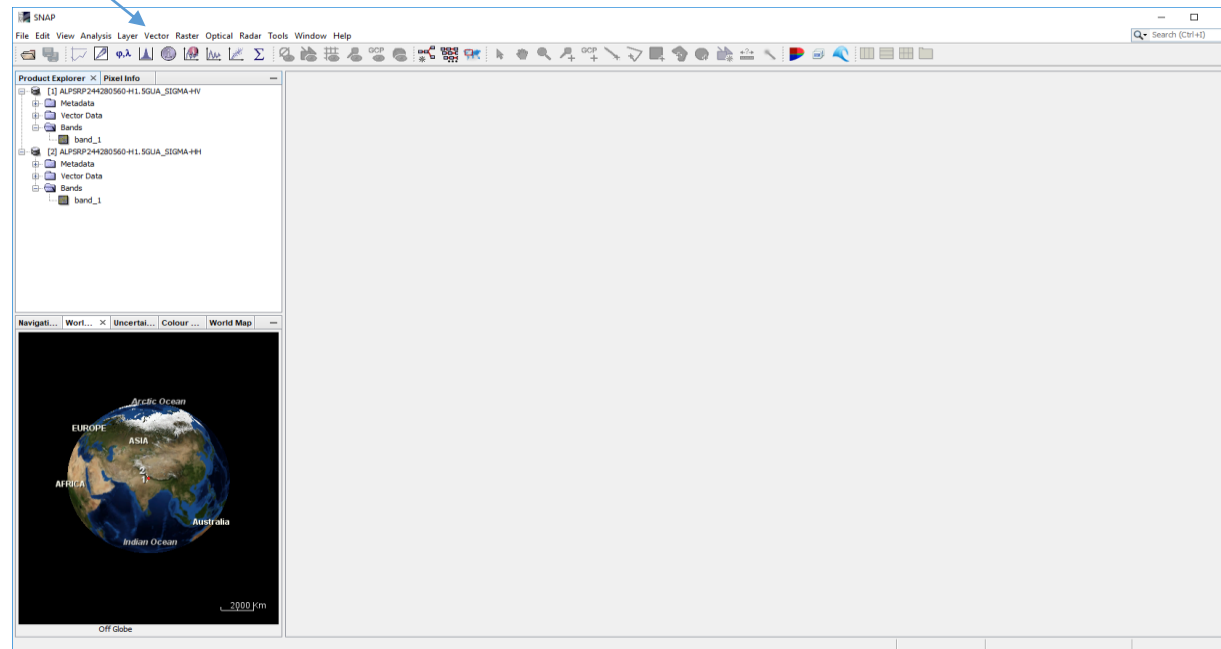
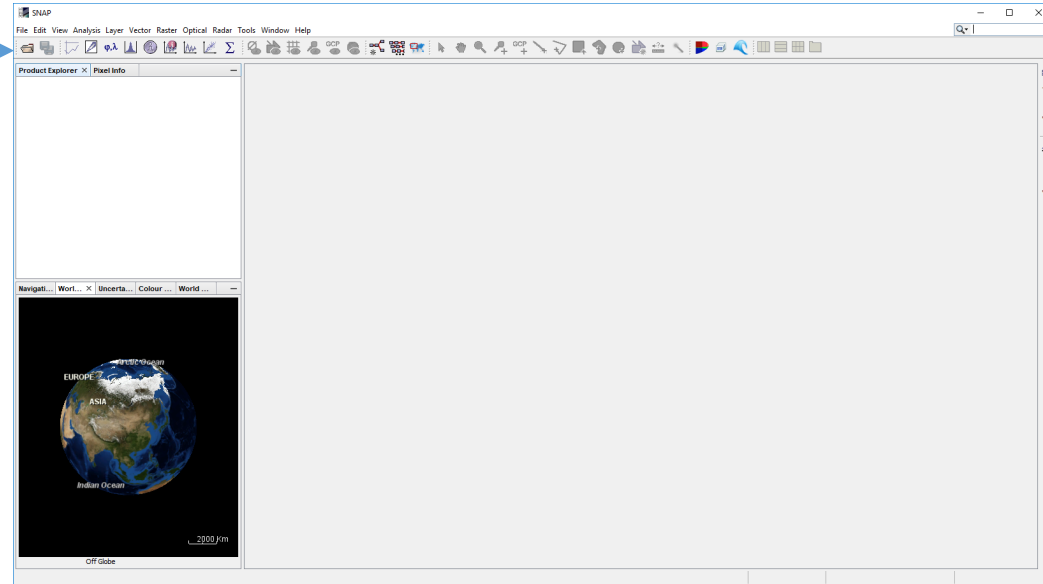
- First install the SNAP software using the setup file in the software setup folder.



SNAP speckle filtering cont.....

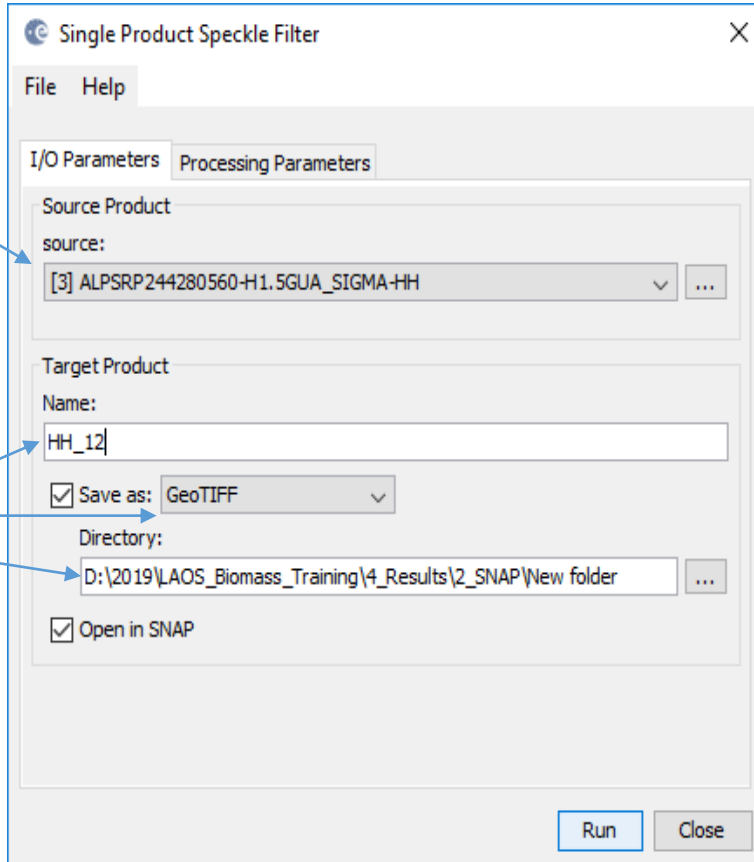
Open the product you got from the ASF Mapready.
(ALPSRP244280560-H1.5GUA_SIGMA-HH.tif,
ALPSRP244280560-H1.5GUA_SIGMA-HV.tif)

- 1) Click on radar tab.
- 2) Select single product speckle filtering



SNAP speckle filtering cont.....

1). Select the product you want to filter

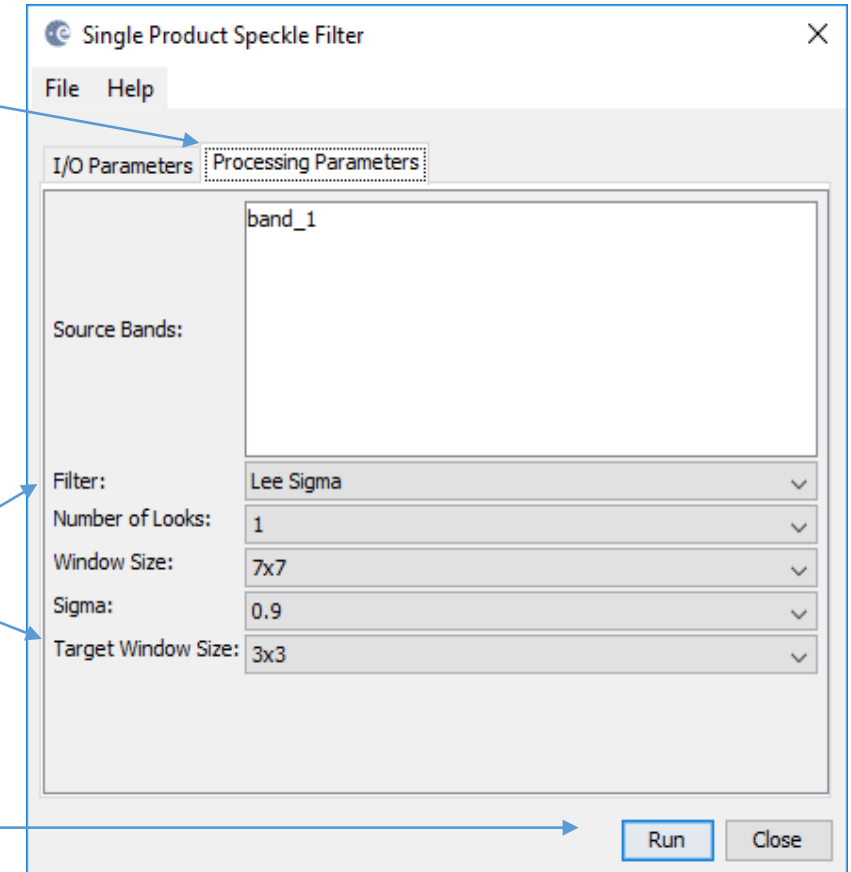


2). Give the output name, format and location

3). Select processing parameters

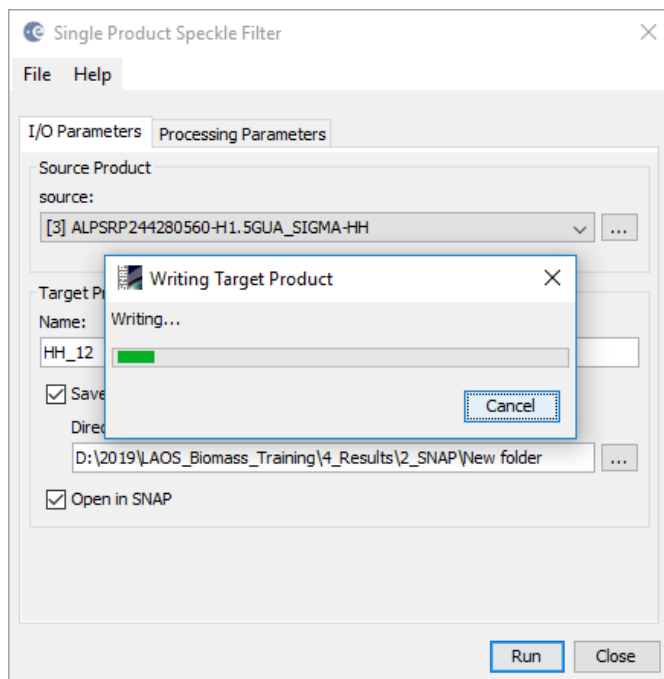
4). Select filter type and the target window size

5). Click Run



SNAP speckle filtering cont.....

Running the speckle filtering



Speckle Filtered Image Result

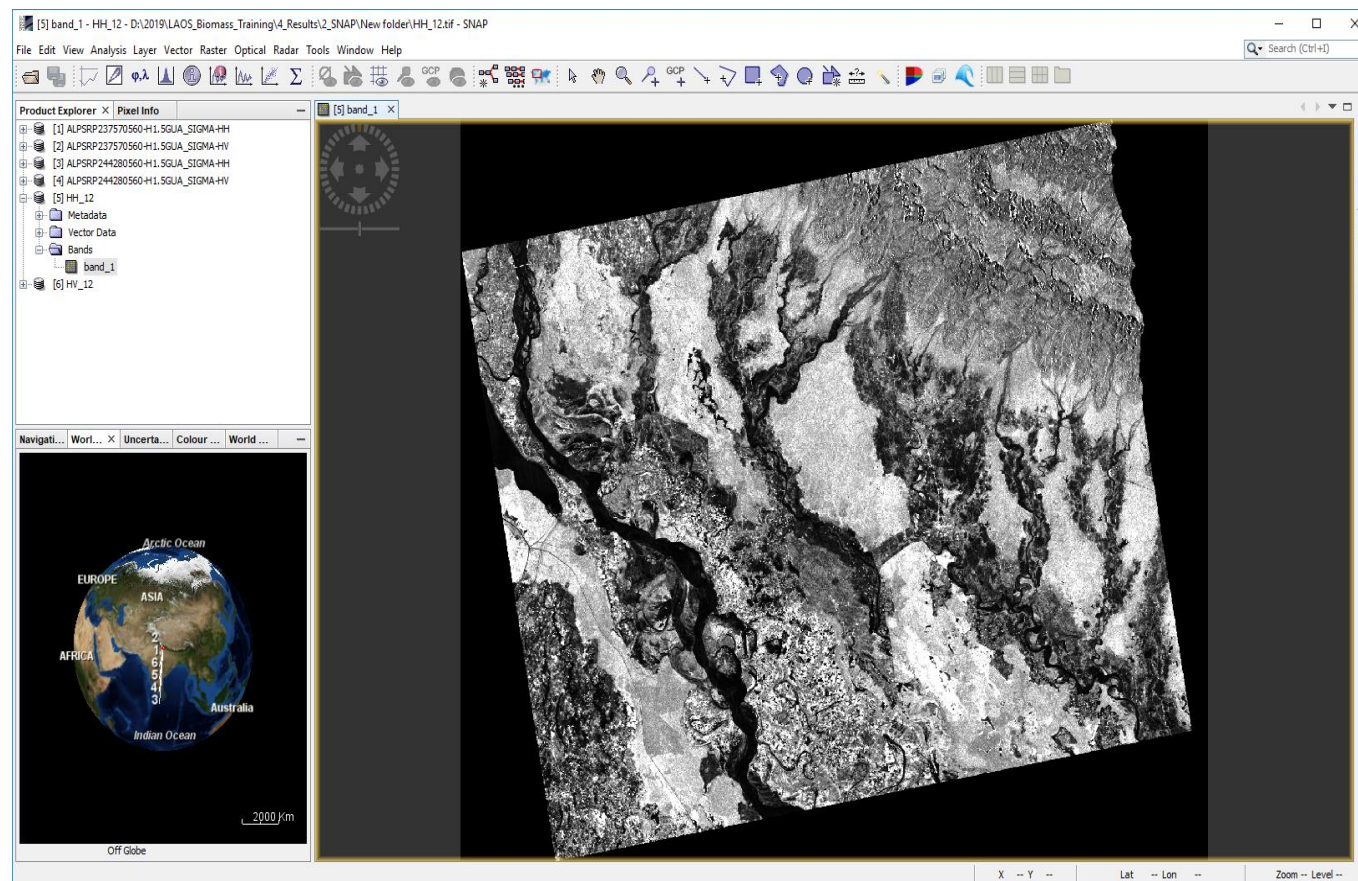


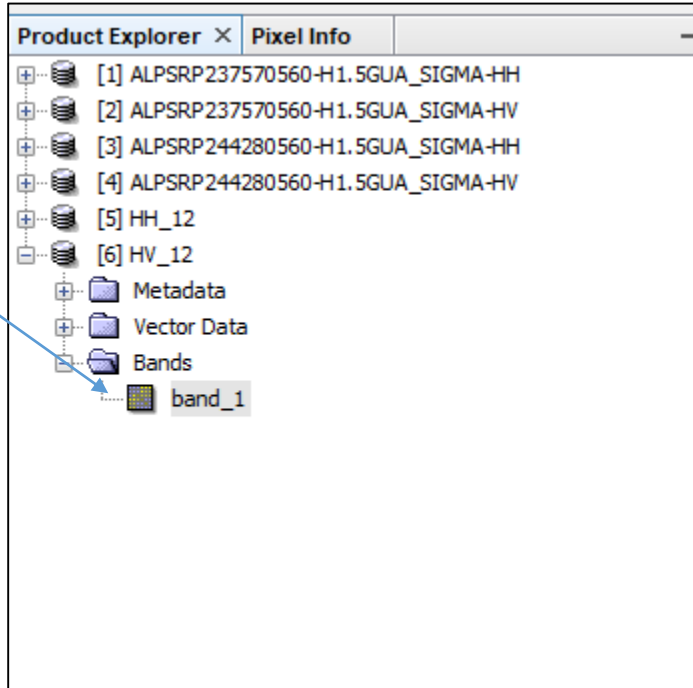
Image conversion to dB and band extraction

dB conversion

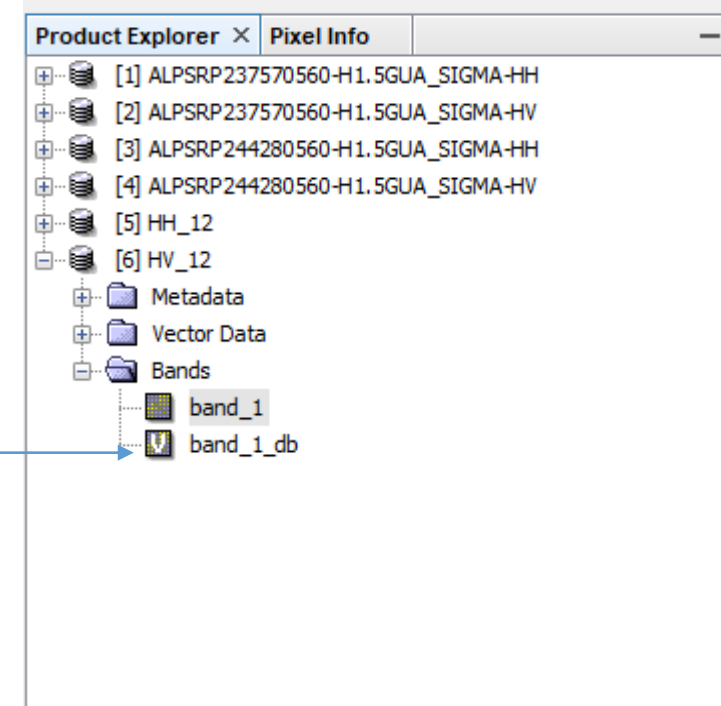
Now you can convert the speckle filtered image DN values to the **Sigma Naught dB** values.

1). Select the resulted band.

2). Right click on the band and click on **linear to/from dB**



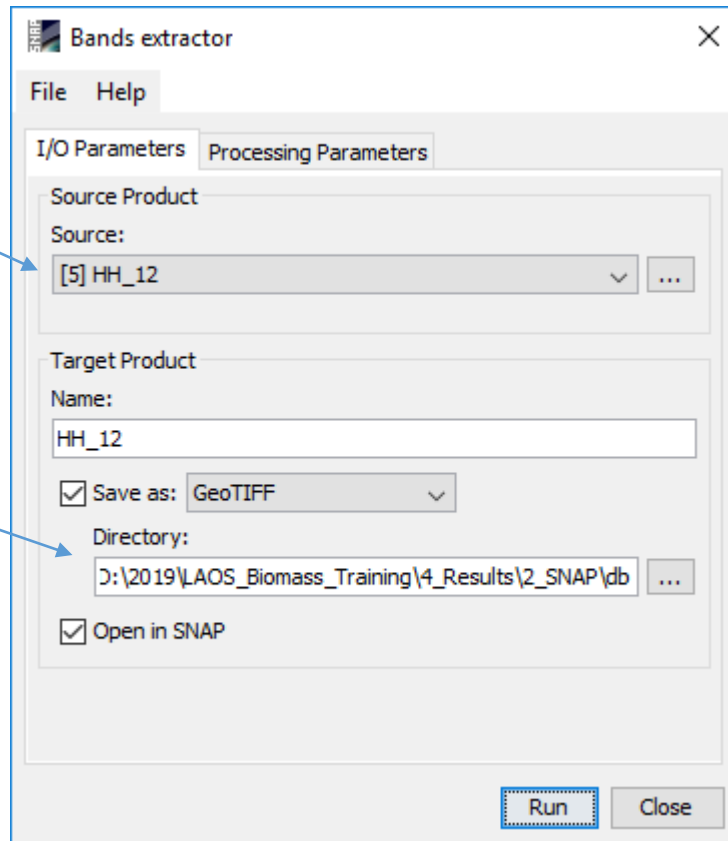
Band in dB



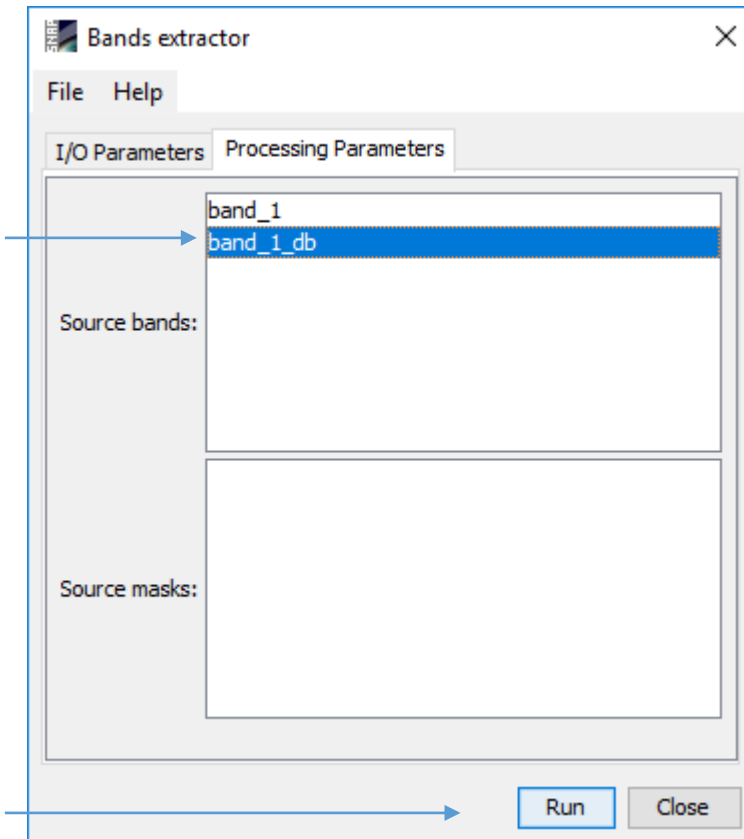
Band extraction

Now you can extract the speckle filtered dB band and export it into a geotiff file.

1). Goto the optical tab in SNAP and select Band Extractor



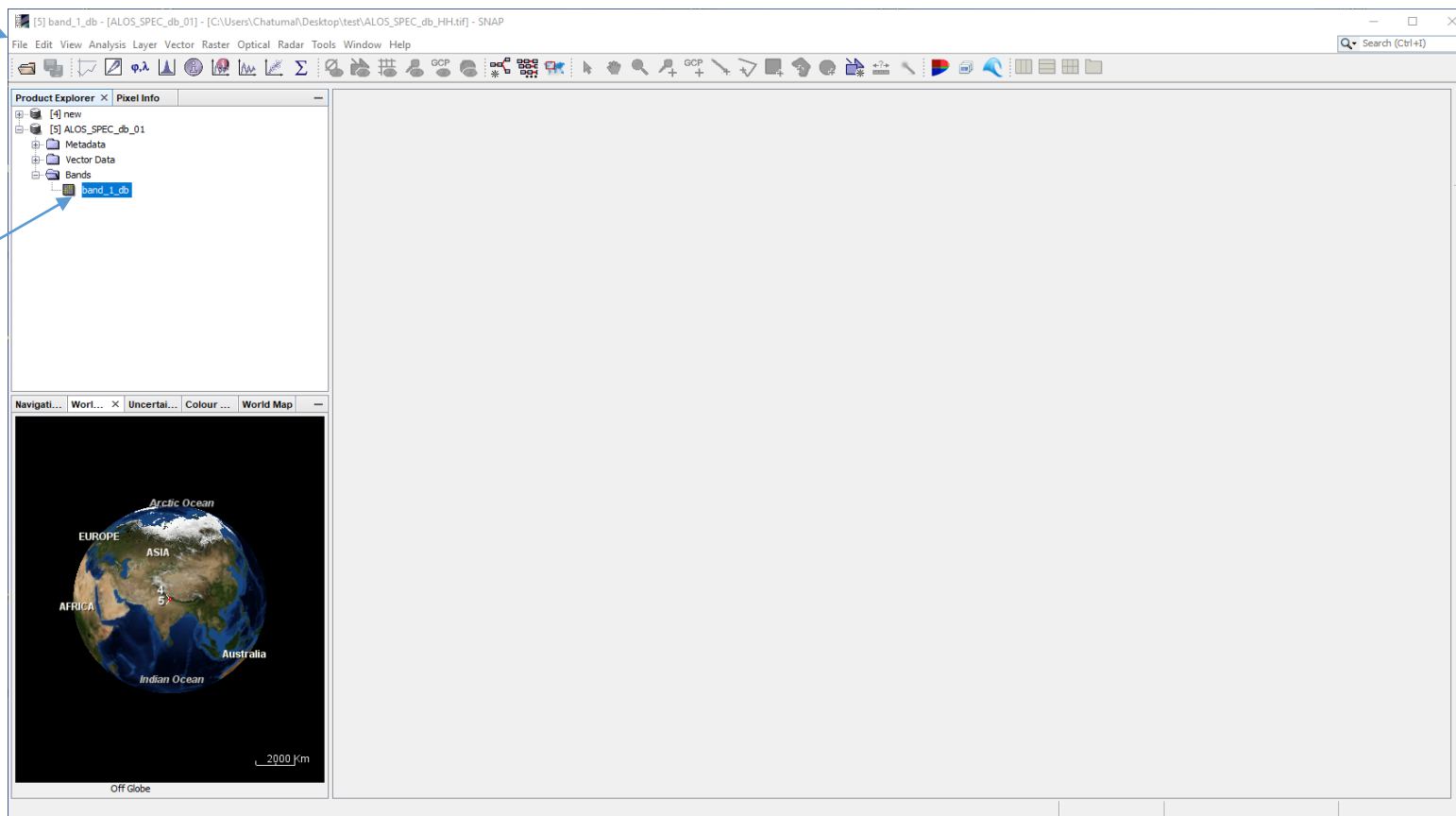
4). Select the band you want extract. (dB)



Export the final preprocessed image as a geotiff from SNAP

2).Click on the file tab.
File>> Export>>Geotiff

1). Select the extracted band
from the product explorer tab



Biomass Estimation Analysis

1).Analysis of Lidar data using R

```
#install.packages("raster")  
#install.packages("rgdal")  
#install.packages("sp")  
#install.packages("ggplot2")  
#install.packages("mosaic")  
#install.packages("mapview")
```

```
#setwd()
```

```
library(raster)  
library(rgdal)  
library(ggplot2)  
library(mosaic)  
library(mapview)
```

#importing rasters

```
dsm<- raster("D:\\2019\\LAOS_Biomass_Training\\2_Training_Data\\Lidar\\dsm_5m.tif")  
dtm<- raster("D:\\2019\\LAOS_Biomass_Training\\2_Training_Data\\Lidar\\dtm_5m.tif")  
NAvalue(dsm)=0  
NAvalue(dtm)=0
```


Analysis of Lidar data using R cont....

#Generation of canopy height raster

```
canopy_H = dsm - dtm
```

```
canopy_H[canopy_H < 0 ] <- 0
```

```
writeRaster(canopy_H,"D:\\2019\\LAOS_Biomass_Training\\4_Results\\3_R_Lidar\\canopy_H.tif",  
            format="GTiff",datatype='FLT4S', overwrite=TRUE)
```

```
plot(canopy_H)
```

```
#canopy_H
```

#CHM resample it to different resolutions (10m)

```
canopy_H10 = projectRaster(canopy_H,res=10,crs = crs(canopy_H), method='ngb')
```

```
writeRaster(canopy_H10,"D:\\2019\\LAOS_Biomass_Training\\4_Results\\3_R_Lidar\\canopy_H10.tif",  
            format="GTiff", datatype='FLT4S',overwrite=TRUE)
```

#Importing the plot shape file

```
plots=readOGR("D:\\2019\\LAOS_Biomass_Training\\2_Training_Data\\Ground_Plots\\Plot.shp",stringsA  
sFactors = FALSE)
```

Analysis of Lidar data using R cont....

#Plotting the shape file

```
plot_map <- ggplot() + geom_polygon(data = plots, aes(x =  
long, y = lat, group = group), colour = "black")  
plot_map
```

#View it on a base map

```
mapviewOptions(basemaps = c("Esri.WorldImagery"))  
mapview(plots, color = "red")
```

#Extract Mean Canopy Height values from the canopy height layer

```
MCH = extract(canopy_H10, plots, fun = mean, na.rm = TRUE)  
MCH=data.frame(MCH)
```

##Finding the linear correlation between MCH and AGB

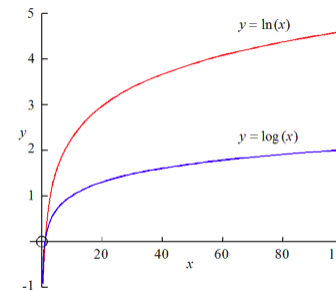
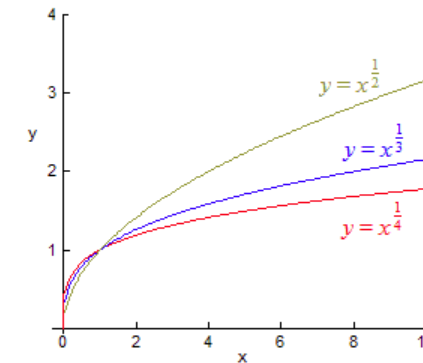
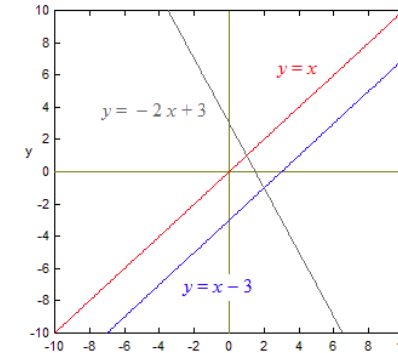
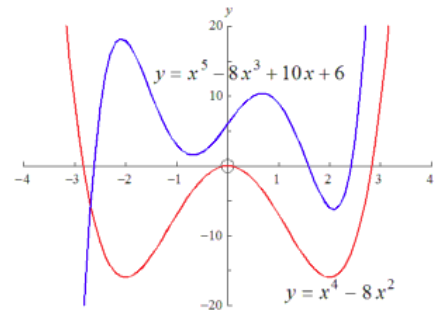
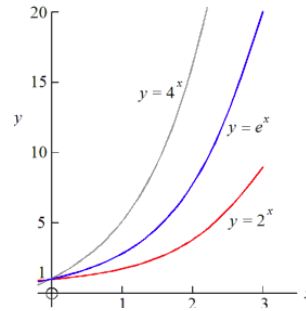
#Combining the shape file data and the extracted data

```
write.table(plots@data,"D:\\2019\\LAOS_Biomass_Training\\4_Results\\3_R_Lidar\\Data_shp.csv",quote=F,row.names=F,sep=",")  
data_shp=read.csv("D:\\2019\\LAOS_Biomass_Training\\4_Results\\3_R_Lidar\\Data_shp.csv")  
Final_Data=cbind(data_shp,MCH)
```

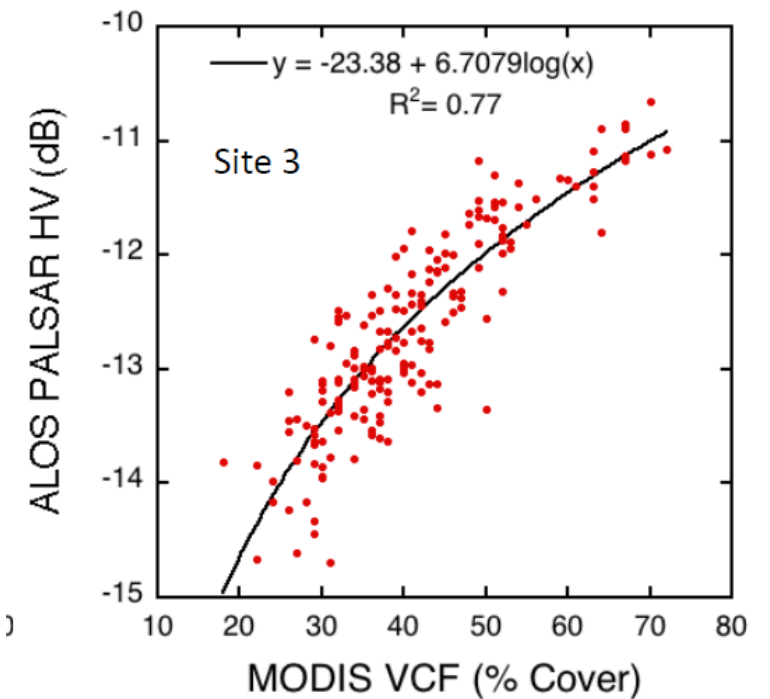
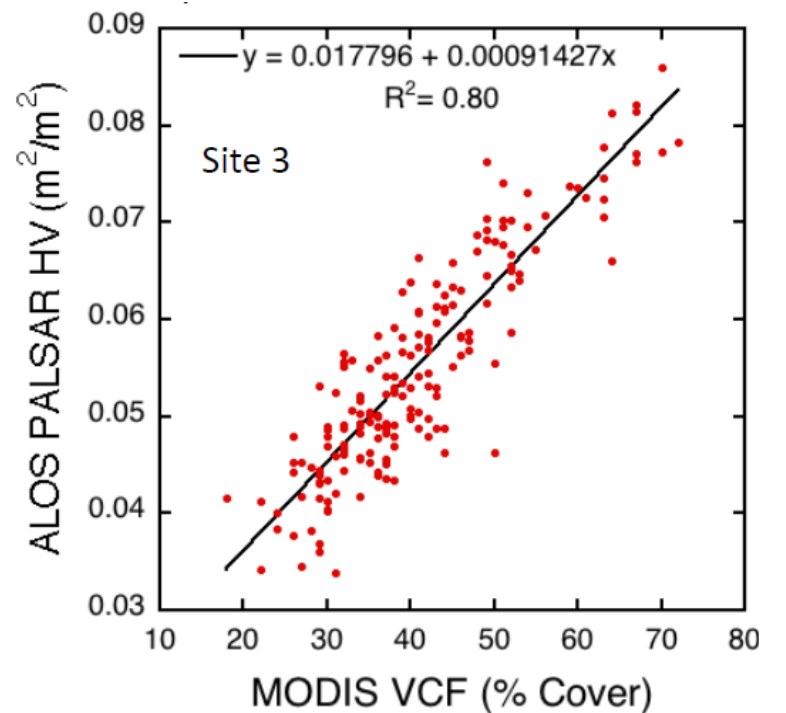
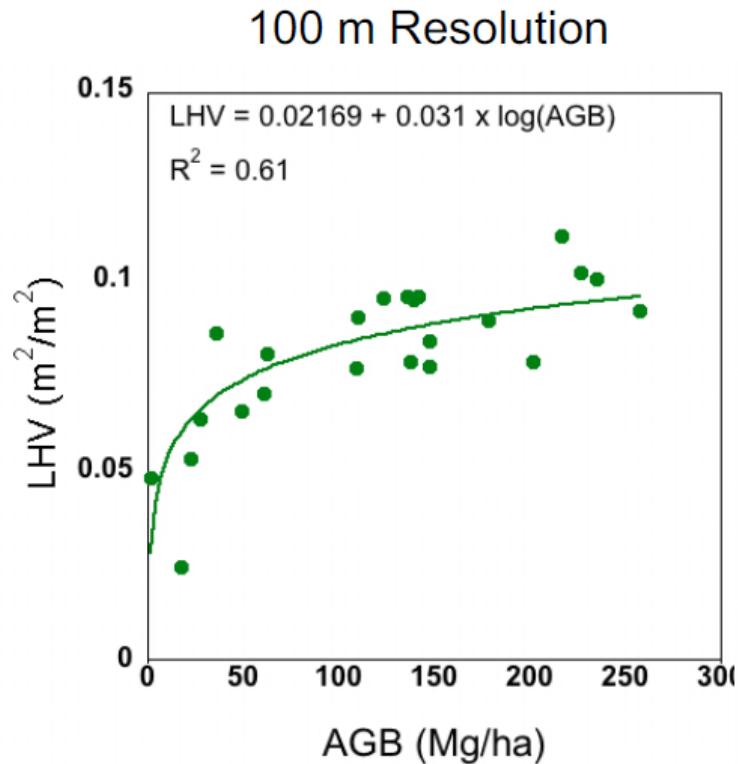
```
cor.test(Final_Data$AGB,Final_Data$MCH)  
plot(Final_Data$MCH,Final_Data$AGB)
```

Curve types need for the analysis

- Linear functions
- Exponential functions
- Logarithmic functions
- Polynomial functions
- Power functions



Curve fitting to the data set



Analysis of Lidar data using R cont....

#Estimation of goodness of fit

##Linear fitting

```
f1=fitModel(MCH~C+M*(AGB),data = Final_Data)
plotPoints(MCH~AGB,data = Final_Data)
plotFun(f1(AGB)~ AGB,add = TRUE, col = 'red')
y1=f1(Final_Data$AGB)
cor.test(y1~Final_Data$MCH)
```

##Curve fitting

```
f2=fitModel(MCH~A+B*log(AGB),data = Final_Data)
plotPoints(AGB~MCH,data = Final_Data)
plotFun(f2(AGB)~ AGB,add = TRUE, col='blue')
coef(f2)
y2=f2(Final_Data$AGB)
cor.test(y2~Final_Data$MCH)
```

#same fitting with "nls" command

```
#f22=nls(MCH~A+B*log(AGB),data = Final_Data)
#x<- predict(f22, newdata=Final_Data$AGB)
#cor.test(x~Final_Data$MCH)
```


Analysis of Lidar data using R cont....

```
#A=-22.188819  
#B= 7.151892  
#MCH~A+B*log(AGB)  
#AGB~exp((MCH-A)/B)
```

```
#Biomass map creation from the fitted model  
bio=exp((canopy_H10+22.188819)/7.151892)  
NAvalue(bio)=0  
bio[bio>1000] <- 1000
```

```
writeRaster(bio,"D:\\2019\\LAOS_Biomass_Training\\4_Results\\3_R_Lidar\\LidarBiomass.tif" ,  
            format="GTiff",datatype='FLT4S', overwrite=TRUE)
```

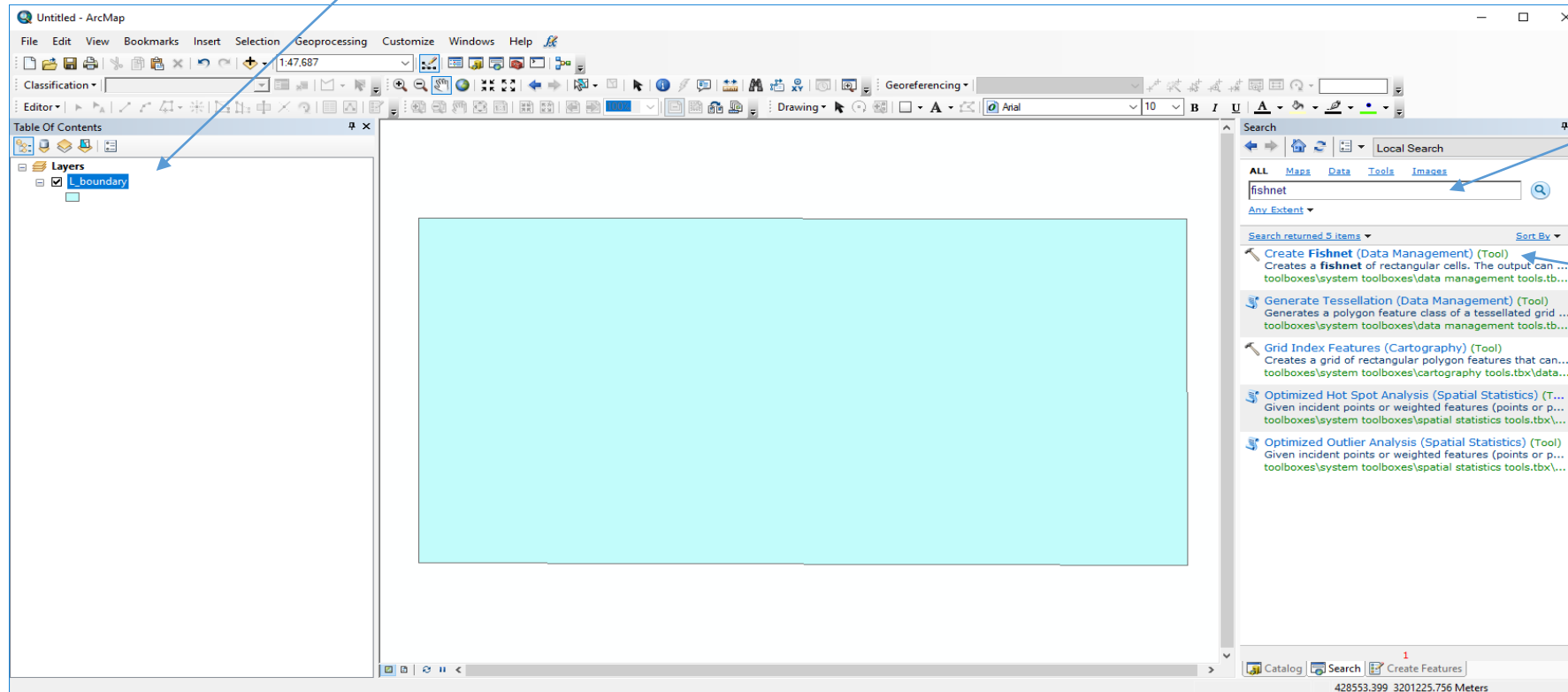
```
plot(bio)
```

Creating a grid network to densify Plots

Using fishnet tool in Arcmap

We can create a grid network as plots and extract the biomass values into these grid points.

1).Open Arcmap and insert the “L_boundary” shape file from the Training data



2).Search for "fishnet"
in the search bar

3).Click on **Create Fishnet
(data management) tool**

Fishnet tool cont.....

1).Give the output location

2).Select the L_boundary layer

3).Give the cell size
As 700*700 and
click OK

Create Fishnet

Output Feature Class
C:\Users\Chatumal\Desktop\test\grid.shp

Template Extent (optional)
Same as layer L_boundary

Left: 417883.868695, Top: 3199926.589777, Right: 428321.702071, Bottom: 3194727.516879

Fishnet Origin Coordinate
X Coordinate: 417883.8686949804, Y Coordinate: 3194727.516878724

Y-Axis Coordinate
X Coordinate: 417883.8686949804, Y Coordinate: 3194737.516878724

Cell Size Width: 700
Cell Size Height: 700

Number of Rows:
Number of Columns:
Opposite corner of Fishnet (optional)
X Coordinate: 428321.7020708516, Y Coordinate: 3199926.589776974

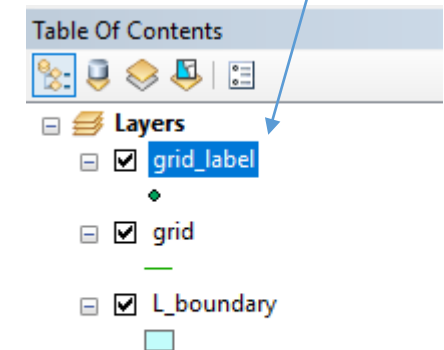
☒ Create Label Points (optional)

Geometry Type (optional)
POLYLINE

Cell Size Height
Determines the height of each cell. If you want the height to be automatically calculated using the value in the Number of Columns parameter, leave this parameter empty or set the value to zero—the height will be calculated when the tool is run.

OK Cancel Environments... << Hide Help Tool Help

This is the created grid point shape file. You can write click and export it to a new one if you need.



Biomass Estimation Analysis

2).Analysis of ALOS PALSAR data using R

```
#install.packages("raster")  
#install.packages("rgdal")  
#install.packages("sp")  
#install.packages("ggplot2")  
#install.packages("mosaic")  
#install.packages("mapview")
```

```
#setwd()
```

```
library(raster)  
library(rgdal)  
library(ggplot2)  
library(mosaic)  
library(mapview)
```

```
#Importing the speckle filtered ALOS PALSAR HH, HV data
```

```
HH_12=raster("D:\\2019\\LAOS_Biomass_Training\\4_Results\\2_SNAP\\dB_images\\HH_12.tif")
```

```
HV_12=raster("D:\\2019\\LAOS_Biomass_Training\\4_Results\\2_SNAP\\dB_images\\HV_12.tif")
```

#Resampling HH_12 and HV_12 into different resolution (40m)

```
HV_40 =projectRaster(HV_12,res=40,crs = crs(HV_12), method='ngb')
writeRaster(HV_40, filename="D:\\2019\\LAOS_Biomass_Training\\4_Results\\4_R_ALOS\\HV_40.tif",
            format="GTiff", overwrite=TRUE)
names(HV_40)<-"HV_40"
```

```
HH_40 =projectRaster(HH_12,res=40,crs = crs(HH_12), method='ngb')
writeRaster(HH_40, filename="D:\\2019\\LAOS_Biomass_Training\\4_Results\\4_R_ALOS\\HH_40.tif",
            format="GTiff", overwrite=TRUE)
names(HH_40)<-"HH_40"
```

#Creating a list of rasters

```
raster_list= list(HH_12,HV_12,HH_40,HV_40)
```

#Importing the densified plot shapefile

```
dense_plots=readOGR("D:\\2019\\LAOS_Biomass_Training\\2_Training_Data\\Ground_Plots\\
dense_plot_700.shp",stringsAsFactors = FALSE)
```


##importing the lidar derived biomass raster

```
L_bio=raster("D:\\2019\\LAOS_Biomass_Training\\4_Results\\3_R_Lidar\\LidarBiomass.tif")
```

```
L_bio_40 =projectRaster(L_bio,res=40,crs = crs(L_bio), method='ngb')
```

##extracting AGB values for Denseplots from biomass map createed from Lidar

#Extract Mean Canopy Heght values from the canopy height layer

```
AGB = extract(L_bio_40, dense_plots,fun = mean, na.rm = TRUE)
```

```
AGB=data.frame(AGB)
```

#Combining the shape file data and the extracted data

```
write.table(dense_plots@data,"D:\\2019\\LAOS_Biomass_Training\\4_Results\\4_R_ALOS\\Data_shp.csv",  
quote=F,row.names=F,sep=",")
```

```
data_shp=read.csv("D:\\2019\\LAOS_Biomass_Training\\4_Results\\4_R_ALOS\\Data_shp.csv")
```

```
Final_Data_ALOS=cbind(data_shp,AGB)
```

##Cropping the rasters to the extent of Lidar_boundary

```
for (x in raster_list){  
  crop <- crop(x, L_bio_40)  
  writeRaster(crop, file.path("D:\\2019\\LAOS_Biomass_Training\\4_Results\\4_R_ALOS\\crop_rasters" ,  
names(x)), bylayer=TRUE,  
            format="GTiff", overwrite=TRUE)  
}
```

#creating a cropped raster list

```
current.list <- list.files(path="D:\\2019\\LAOS_Biomass_Training\\4_Results\\4_R_ALOS\\crop_rasters",  
                          pattern=".tif$", full.names=TRUE)
```

```
raster_list <- c()  
for (x in current.list){  
  y=raster(x)  
  raster_list <- append(raster_list, y)  
}
```

Analysis of ALOS PALSAR data using R cont....

#extraction of backscatter values

#Extracting the backscatter values for AGB plots

```
BS_values =list()
for (raster in raster_list){
  backscatter <- extract(raster,dense_plots,na.rm=TRUE)
  #Append value to the list
  BS<- as.data.frame(backscatter)
  BS_values<-append(BS_values,BS)
}
```

```
BS_values =data.frame(BS_values)
```

#Getting the name of Rasters

```
raster_names = list()
for (ras in raster_list){
  x=names(ras)
  raster_names=append(raster_names,x)
}
colnames(BS_values)= raster_names
```

#Combining the plot AGB values and the Raster backsactter values to a Dataframe.

```
AGB_final=cbind(AGB,BS_values)
View(AGB_final)
AGB_final=na.omit(AGB_final)
write.csv(AGB_final,"D:\\2019\\LAOS_Biomass_Training\\4_Results\\4_R_ALOS\\AGB_final.csv")
```

#Pearson correlation for identify the basic relationships of the AGB values and the Data.

```
cor.test(AGB_final$AGB,AGB_final$HV_40, method = "pearson")
cor.test(AGB_final$AGB,AGB_final$HV_12, method = "pearson")

plot(AGB_final$AGB,AGB_final$HV_40,xlim=c(20,25))
```

Analysis of ALOS PALSAR data using R cont....

##Curve fitting

```
f2=fitModel(HV_40~A+B*log(AGB),data = AGB_final)
plotPoints(HV_40~AGB,data = AGB_final)
plotFun(f2(AGB)~ AGB,add = TRUE, col='blue')
coef(f2)
y2=f2(AGB_final$AGB)
cor.test(y2~AGB_final$HV_40)
```

#same fitting with "nls" command

```
#f22=nls(MCH~A+B*log(AGB),data = Final_Data)
#x<- predict(f22, newdata=Final_Data$AGB)
#cor.test(x~Final_Data$MCH)
```

```
#A=-21.052473
```

```
#B=1.746382
```

```
#BS~A+B*log(AGB)
```

```
#AGB~exp((BS-A)/B)
```

```
crop_HV40=raster("D:\\2019\\LAOS_Biomass_Training\\4_Results\\4_R_ALOS\\crop_rasters\\HV_40.tif")
```

```
#Biomass map creation from the fitted model
```

```
bio=exp((crop_HV40 +21.052473)/1.746382)
```

```
NAvalue(bio)=0
```

```
bio[bio>1000] <- 1000
```

```
writeRaster(bio,"D:\\2019\\LAOS_Biomass_Training\\4_Results\\4_R_ALOS\\ALOSBiomass.tif" ,  
            format="GTiff",datatype='FLT4S', overwrite=TRUE)
```

```
plot(bio)
```



Thank you!!!!