Processing Sentinel data for whole of Norway with PCI GXL

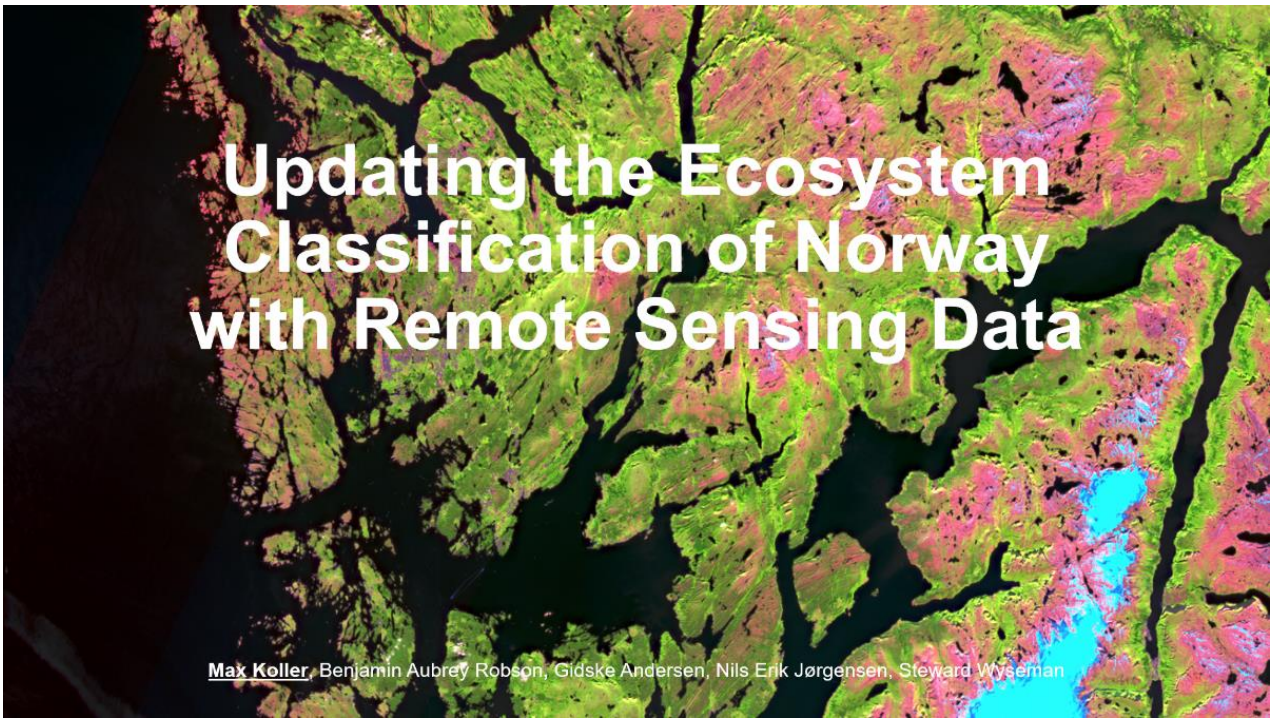


Figure 1, FALK project Hordaland

If you want to map a whole country like Norway with Sentinel data, you need a powerful system. In this document we will describe what a powerful solution like PCI GXL can do and why it is important.

In 2019 Norwegian Environmental Agency (NEA) asked a consortium of TerraNor, University in Bergen, Institute of Geography and Canadian company PCI Geomatics, to analyse Hordaland and Trøndelag counties with data from Sentinel 1, Sentinel 2, WorldView 3 and aerial images.

NEA wanted us to demonstrate a solution that could be enhanced to cover the whole of Norway and include time series images over the same area.

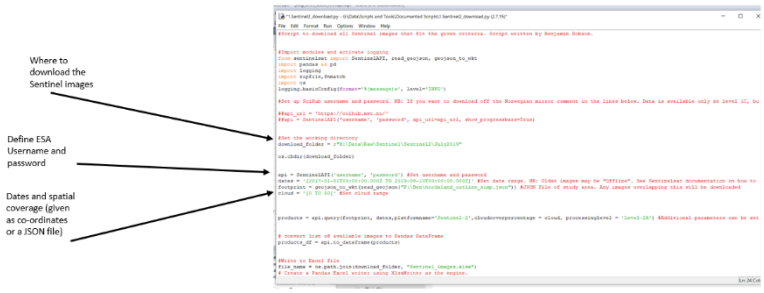
Image preparation challenges:

- Sentinel 2 over Norway, Finland and Sweden are orthorectified and atmospherically corrected by ESA using a coarse DTM. In steep terrain image pixels can be placed 50-60m off correct position according to Norwegian mapping authorities (Kartverket).
- Images in steep terrain will have different sun light that affects the values and should be corrected.
- Sentinel 2 images has 13 high quality channels in 10, 20 and 60 m resolution. We needed all in 10 m resolution to perform analysis.

We used high resolution images from Maxar and from aerial to solve special needs. We needed them to align with existing imagery we had.

The main software, **PCI GXL from PCI Geomatics,** was installed at the University in Bergen in June 2019. GXL was processing 24/7 until January 2020 without interruption and with excellent results. University in Bergen used GXL for processing images from Himalaya and Chile for their glacier projects. GXL superregistration was important for the glacier project, see below.

Download:



ESA supports use of Python to download images. We received several hundred images where we picked those without clouds.

PCI software is designed to use Python scripts. This is very efficient when you combine PCI scripts with ESA scripts. This opens the possibility to automatically download several images over the summer or years to create multitemporal analysis.

Hordaland covers 15 000 km^2 and Trøndelag 42 000 km^2. For both areas we downloaded many Sentinel 1 and 2 images. We needed cloud free data for several years. All images needed to be aligned to Kartverket Sentinel 2 mosaic for Norway.
GXL function Superregistration did this automatically for hundreds of images at the time. The accuracy between new images and Kartverkets images were extreme and at a sub pixel level.

Sentinel 2 images were downloaded as L2A. We used one L1C image to demonstrate how we could improve quality in radiometric correction. L1C format with use of local DTM is not documented and verified as a public solution. If a customer wants to purchase our solution, we can implement it.

Superregistration:

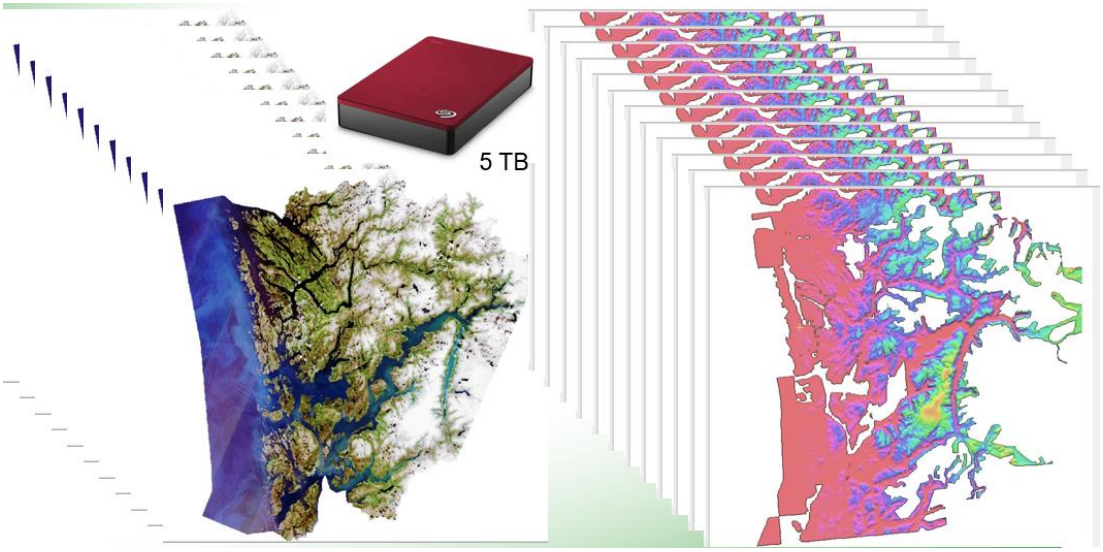


Figure 2, multitemporal to study changes over time

Change detection require many images over a time frame. Even if the images are from the same satellite, you cannot expect data from different times to be aligned. GXL Superregistration solves this problem easy. Even with several Terabytes of data, the images are automatically aligned to the base image. You just have to point to the original image and to the directory with the new images, the rest is done by GXL.

Figure 3, Trøndelag is covered by several Sentinel images

As for multitemporal analysis, mosaics become much better with Superregistration. If you only need data for one year, you want the data model to fit existing maps of the area without misalignments.

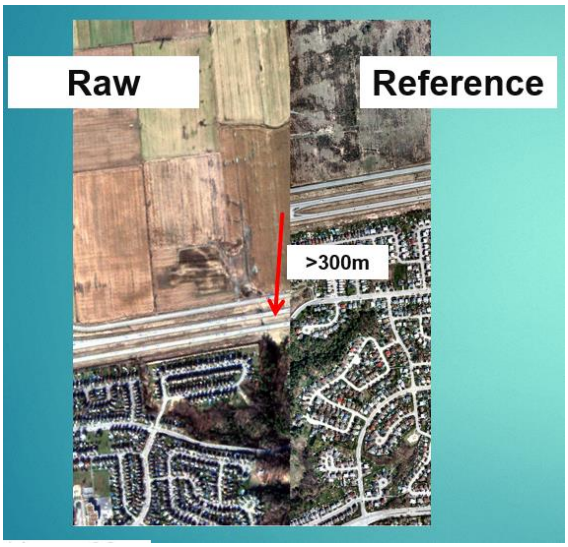


Figure 4, before superregistration

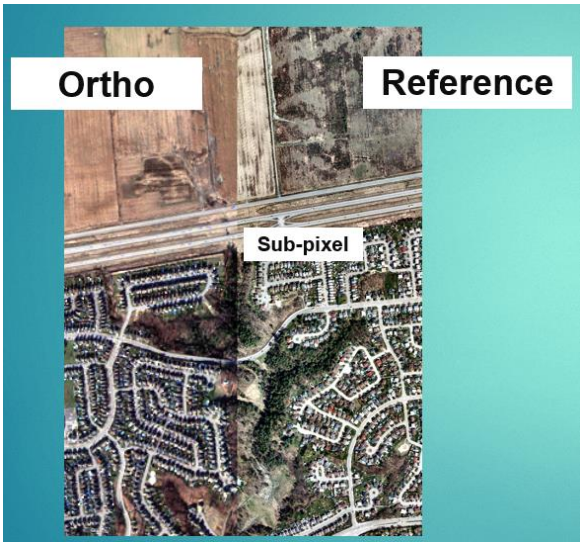


Figure 5, after superregistration

As mentioned earlier, Sentinel 2 comes orthorectified with differences up to 60m in some areas. We used Superregistration in PCI GXL to align all new images to Kartverket (Norwegian Mapping Authorities) Sentinel 2 mosaic of Norway. With this reference we know that all images we download and use, will fit together for whole of Norway.

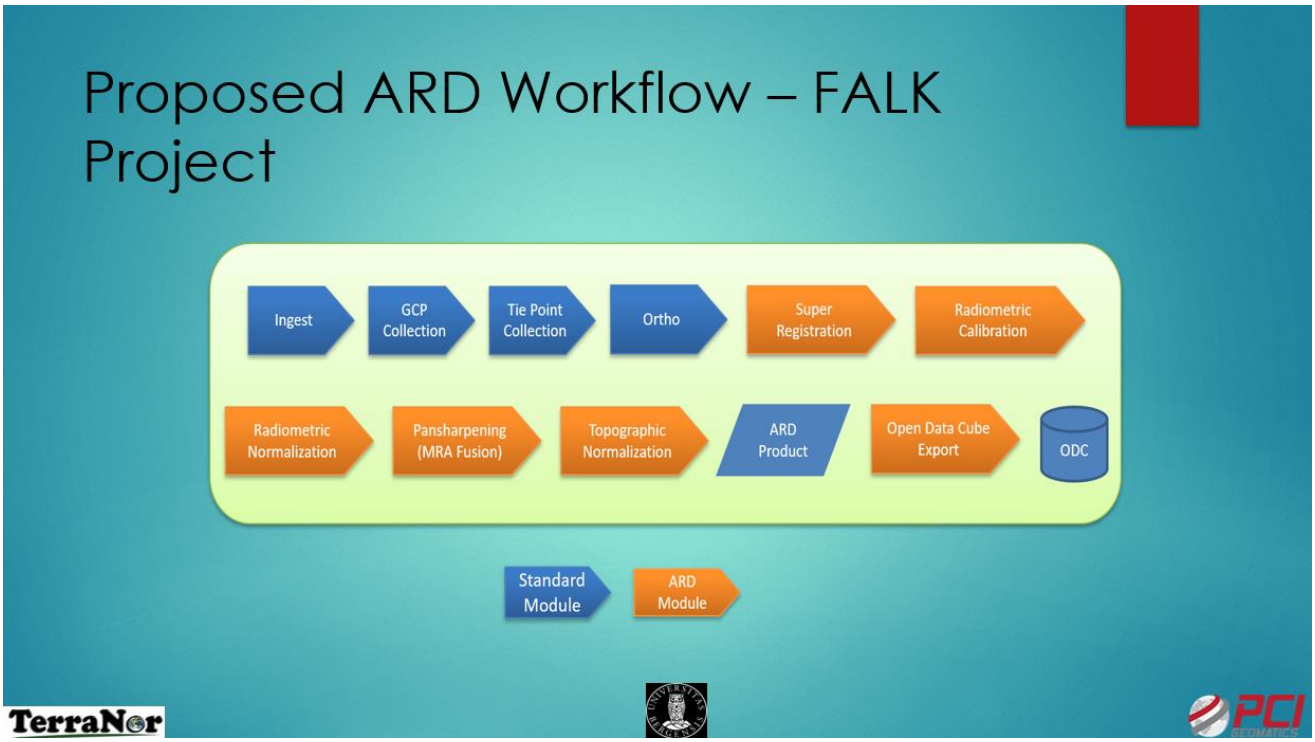
World View 2:

We used GXL for preparation and alignment of World View 2 images from Maxar:

Figure 6, superregistration of World View 2

The result had extremely high accuracy. To the left is the aerial ortho of Bergen and to the right WV 2 image.
The whole process is automatic. You need to specify catalogue with images and reference image. GXL will do all the work and save the result where you want it.

Workflow:



World View 2 images came Ortho ready and needed to be orthorectified. The steps:

- GCP collection from existing aerial orthophoto
- Tie Point collection – not used, only one image
- Ortho processing with use of dtm from lidar data (hoydedata.no)

were completely automatic. We entered the name of the image to process and the reference image. GXL fixed the rest for us.

With Sentinel 2 images we went straight for Superregistration.

At this point several hundred Sentinel 2 images and one WV2 image were aligned.
We could continue with radiometric correction.

Topographic Normalisation:

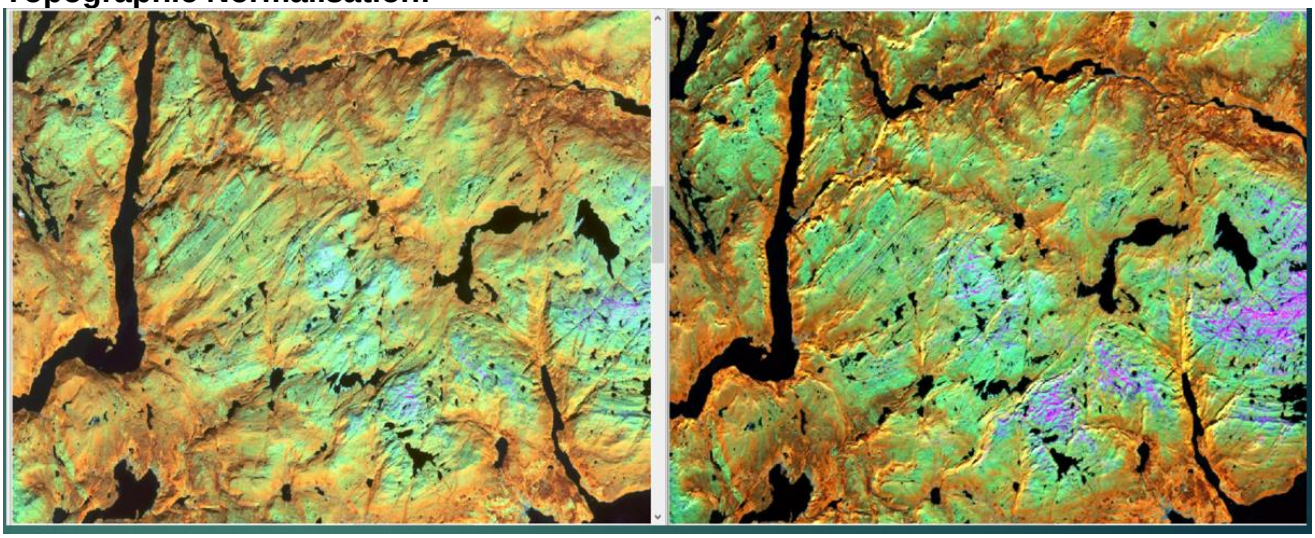


Figure 7, topographic normalisation

To the right we have the original L2A image from ESA. To the left is the image corrected for terrain by GXL. This was a new function we tested out for this project.
If you look closely, the original image has more variation due to terrain.

Pan sharpening, MRA fusion:

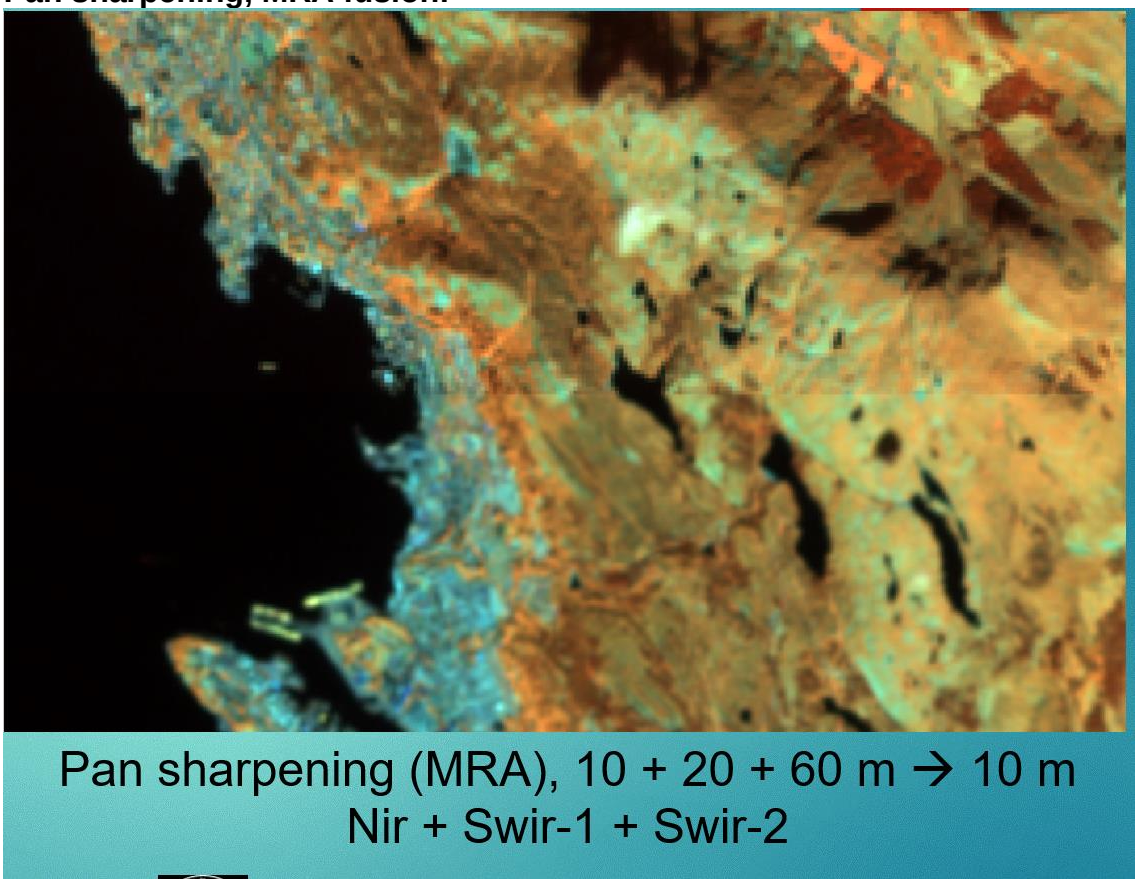


Figure 8, MRA fusion, top: 60m res, bottom: 10m res

An important function is MRA fusion that lets you convert all Sentinel 2 channels into 10 m resolution. Top is 60 m resolution; bottom is 10 m resolution. It is easy to see that colour values are maintained during the process. This is Pan sharpening scientifically correct!

DTM challenges:

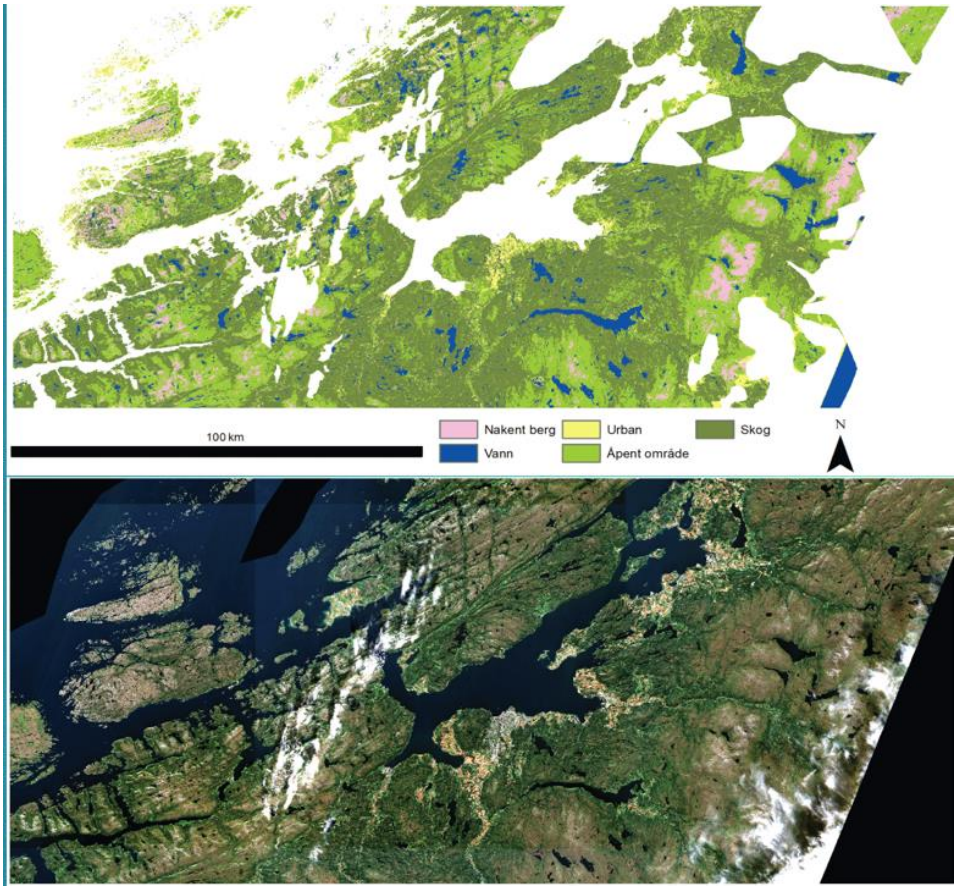


Figure 9, DTM analysis

DTM and DSM data were downloaded from hoydedata.no and mosaicked in GXL. Norway has a lot of different DTM datasets based on lidar data with different point density and old digitised maps. Some places we found that the DSM (surface) was below DTM (terrain). Other places DTM data were totally missing. The white areas in the classified image above, is due to missing or wrong DTM data.
Some of the missing data were due to clouds. It was not possible to find cloud free areas we could fill in for the same time period. In our nature analysis we needed the data to be from the same month.

Analysis Ready Data:

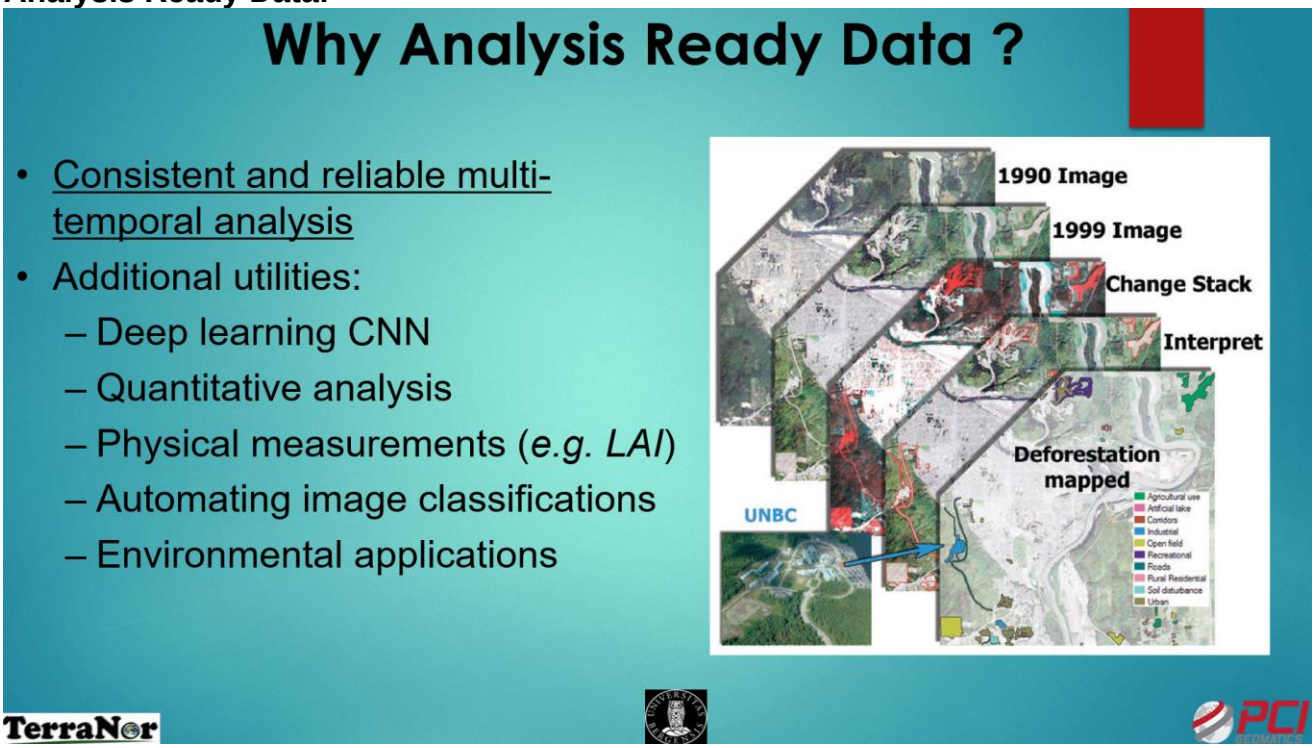


Figure 10, Analysis ready data

The final result of GXL pre-processing is Analysis ready data:

- Orthorectified
- All images aligned at sub pixel level
- Radiometrically correct
- Correct resolution for analysis
- Mosaicked

You can now analyse images of large areas and over several years and know that classification will be correct.

At University in Bergen, Institute for Geography you can learn how to do all these processes with use of PCI Geomatics software. There are many more universities in Scandinavia and rest of the world who offer the same type of training with PCI Geomatica.
Geomatica is GXL little sister/brother and can do most of the same stuff, but not with high speed and automatic.

Contact TerraNor and we can show you how to do the same and try it out for free.

Vestland

We want to thank our colleagues for brilliant cooperation and excellent work in the project:

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