

Automated routines for a quality assured terrain model

Andreas Rönnberg
National mapping agency of Sweden



Topics

- Short background
- QC of laser scanning deliveries
- Ground classification
- Bridge classification
- QC of water breakline deliveries
- Updating with image data (change detection)



Background



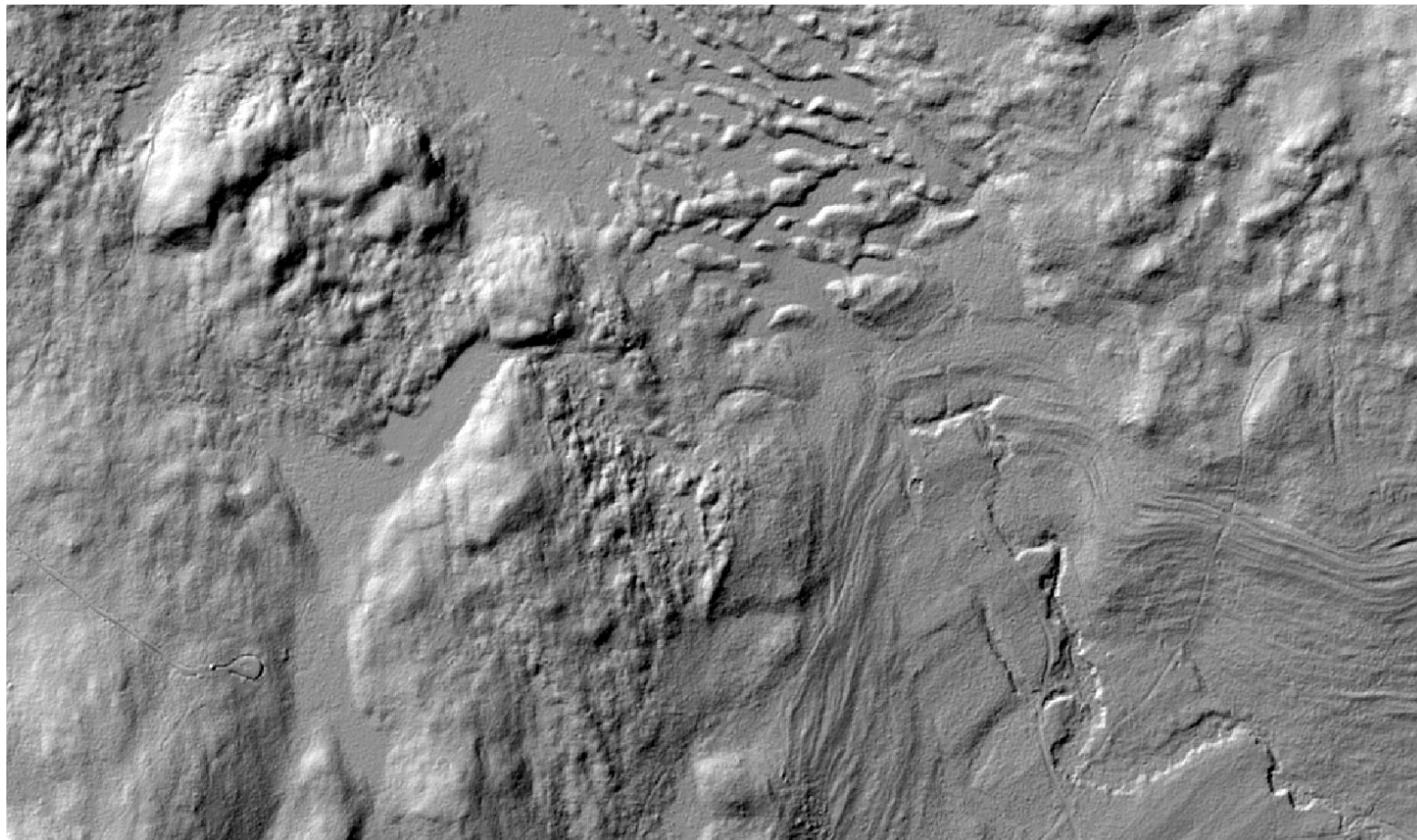
- Lantmäteriet is a government agency, responsible for national mapping and cadastral services
- Lantmäteriet started evaluation of laser scanning in 2003
- EU directive on flood risks 2007/60/EC)
- Government investigation on adaption to climate change (SOU 2007:60)
 - Lantmäteriet should get resources to create a new national elevation model with higher resolution and accuracy



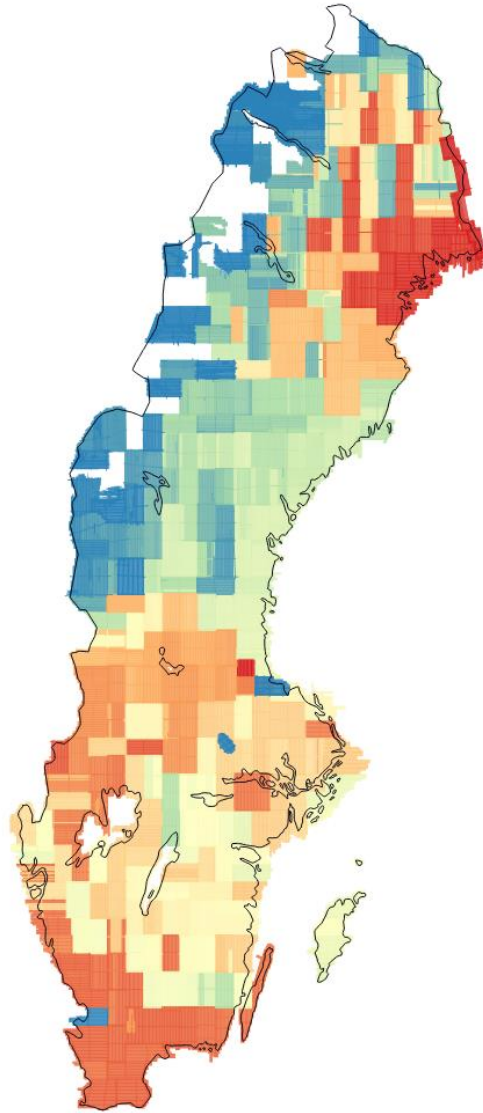
Old terrain model ...



New terrain model



Tenders



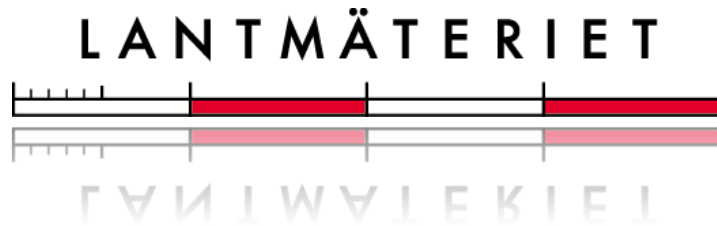
- A detailed technical specification was created 2008
- In 2009 Blom was contracted for data capture, with Cowi as subcontractor
- In 2014 Metria was contracted to capture remaining areas, with Finnmap, Fugro and Swissphoto as subcontractors
- About 93 % of Sweden was covered by 2015

The contractor's work



- Mission planning (should be approved by Lantmäteriet)
- Data capture
 - Surveying of control points and checkpoints
 - Laser scanning
- Geo-referencing
- Basic quality control (coverage and accuracy)
 - To prove that quality requirements are fulfilled

Lantmäteriet's role

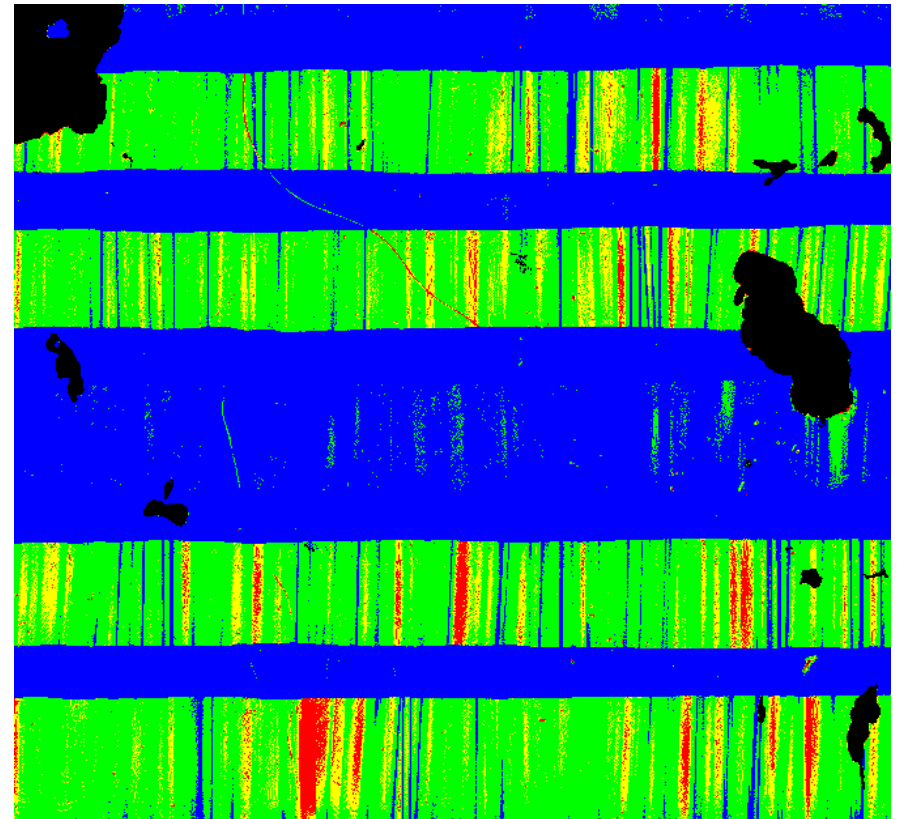


- Comprehensive project management and QA
 - Extensive QC
- Processing
 - Ground classification/filtering
 - Secrecy editing (for national security)
 - Final terrain model (with breaklines)
- Storage and delivery (including metadata)
- Updating

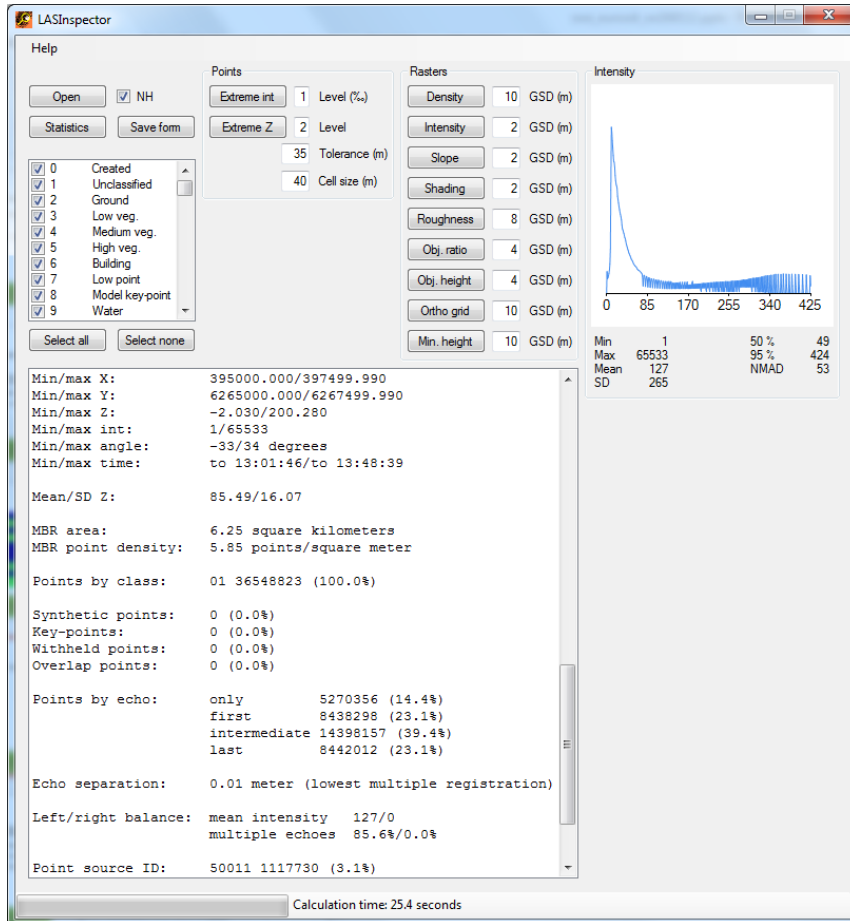


QC of laser scanning deliveries

- File level
 - Fully automated, and initiated when change in data storage
 - Control of readable files, correct point source ID, etc.
 - Drawback: Very high demands on correct data formatting!
- Coverage and density
 - Requires visual inspection
- Geometric accuracy
 - Requires visual inspection
- Intensity and echo information
 - Semiautomatic, much based on calculated statistics

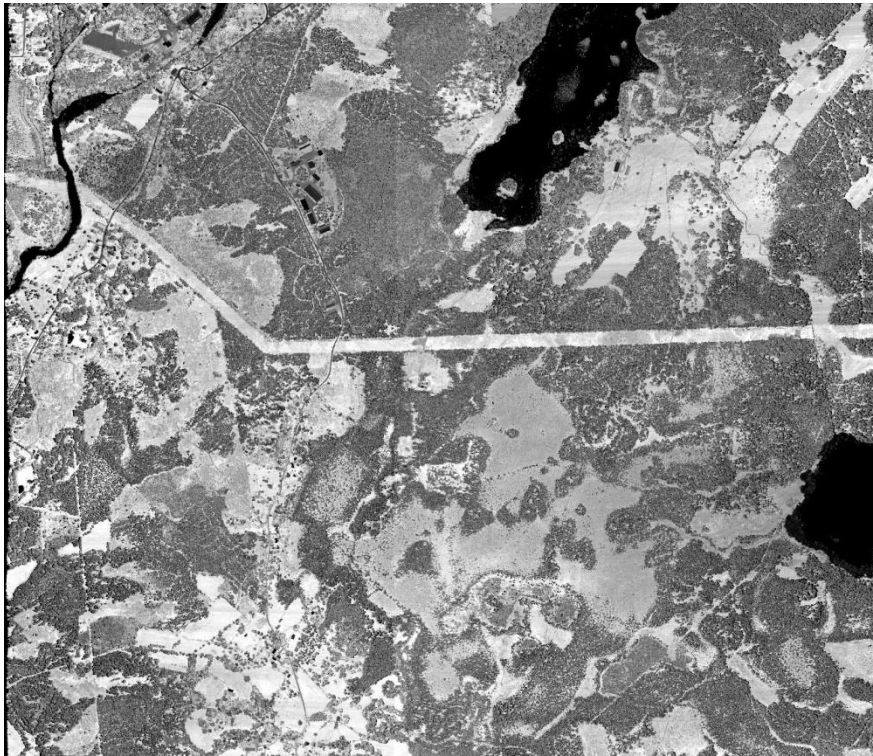


LAS statistics



- Powerful means of QC, used at different processing steps
- Reasonable/normal values for all attributes

Intensity and echo information



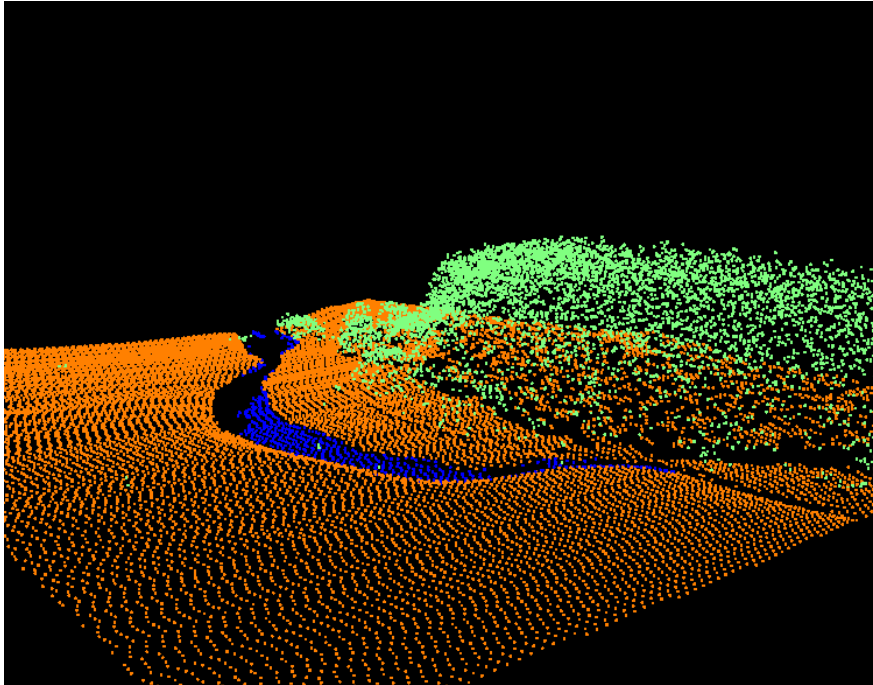
- Laser scanning is not only about geometry, but also radiometry!
- Normal values indicates good system health



Some encountered problems

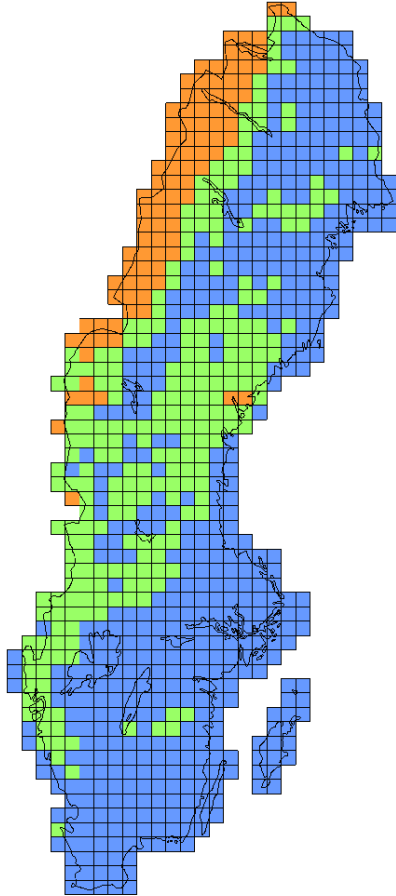
- Bad data formatting from contractor
- Wrong PSID, which in our data model links each laser point to metadata about the scanning mission
- Low percentage multiple echoes in forested areas
- Bad Left/right intensity balance (Optech ALTM Gemini)

Ground classification



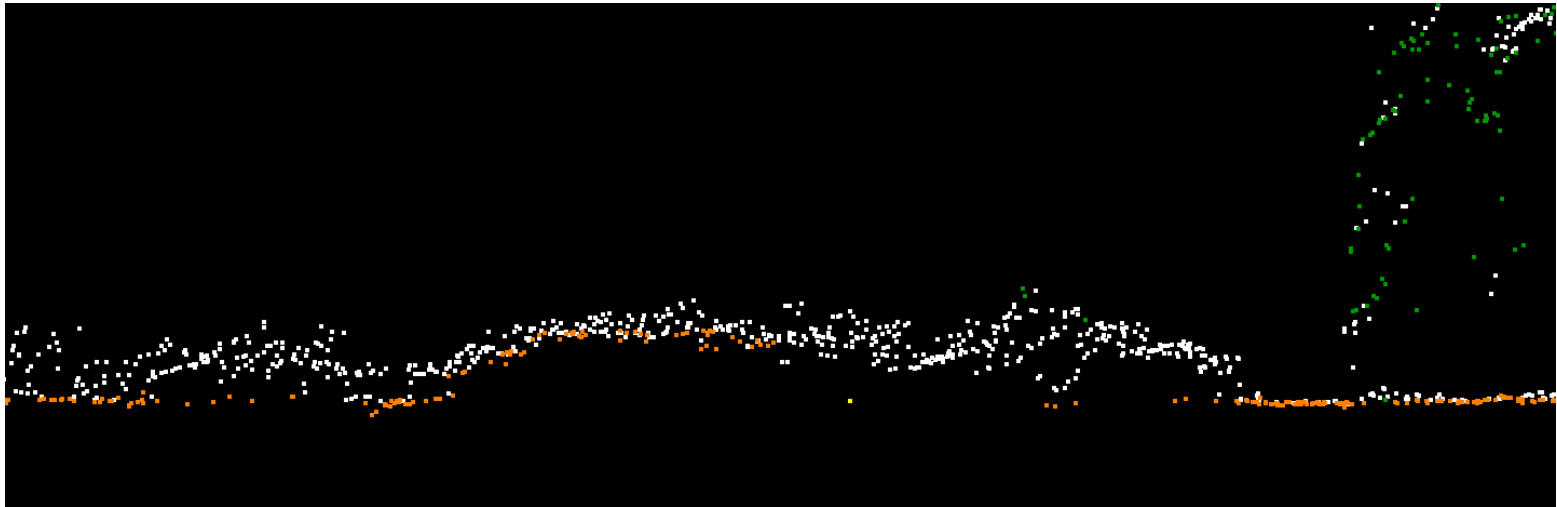
- Important and difficult step in the creation of a terrain model
- Automatic classification with TerraScan from TerraSolid
 - A few parameters (limits) controls the result
 - Some help from other geodata (buildings and water areas)
- Other applications have been tested, but without relevant improvement

Terrain adaption



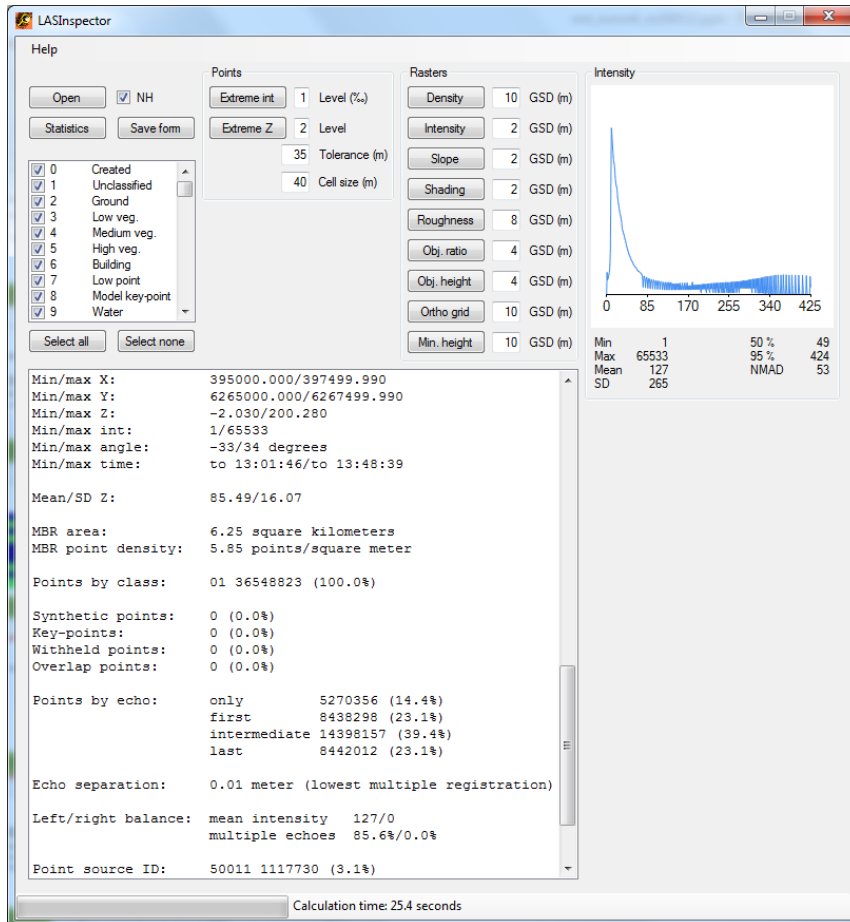
- Ground classification parameters adjusted for terrain roughness
- Further adaption to local topography would improve results
 - Difficult for a large project

Classification problems



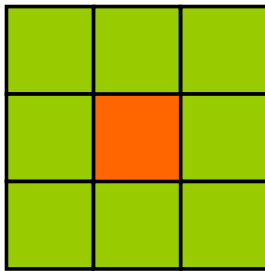
- Low points (noise, especially with Riegl scanner)
- Dense, low vegetation (bushes)
- Steep terrain, with abrupt changes
- Buildings (large, unusual forms), bridges, dams ...
- Water

QC of ground classification



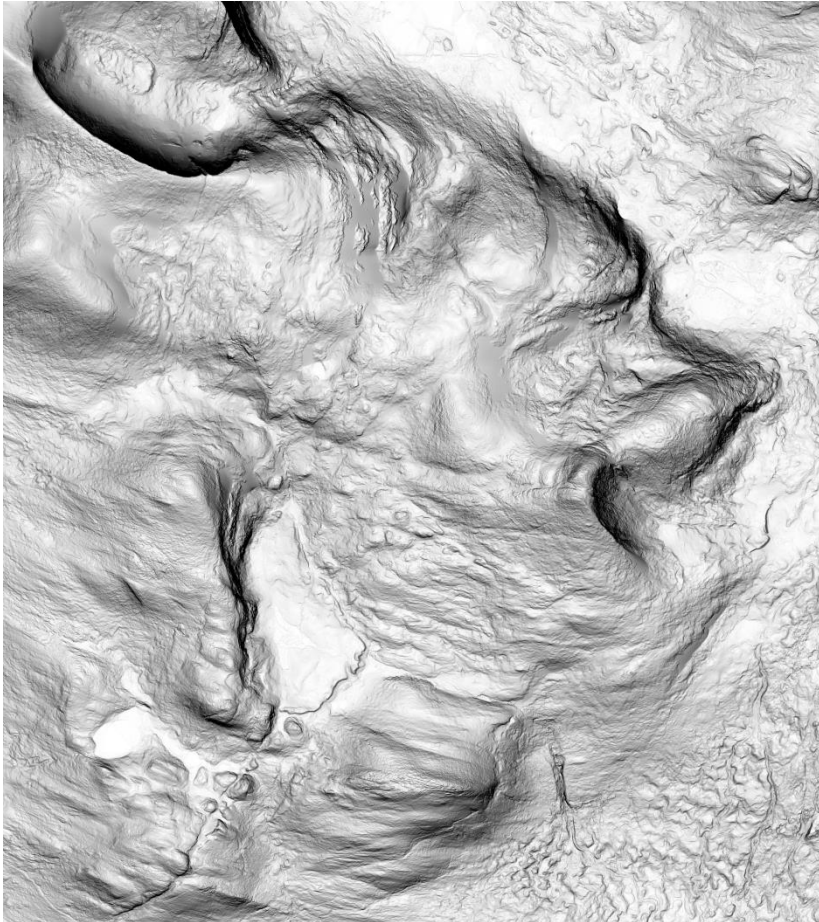
- Too large areas to rely solely on manual inspection
- Automatic routine identifies ground or water points with a high probability of being misclassified
- Visual check to decide if points should be reclassified
- Most applications does not require further editing

Simple but efficient algorithm



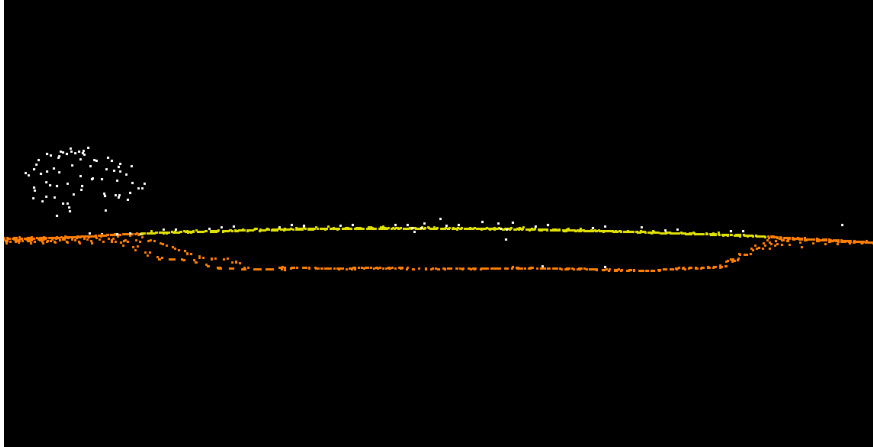
- Points within center cell compared to mean elevation and mean SD for all nine cells
- Repeated a few times, with different settings
- Run separately for ground and water points

Visual control still important



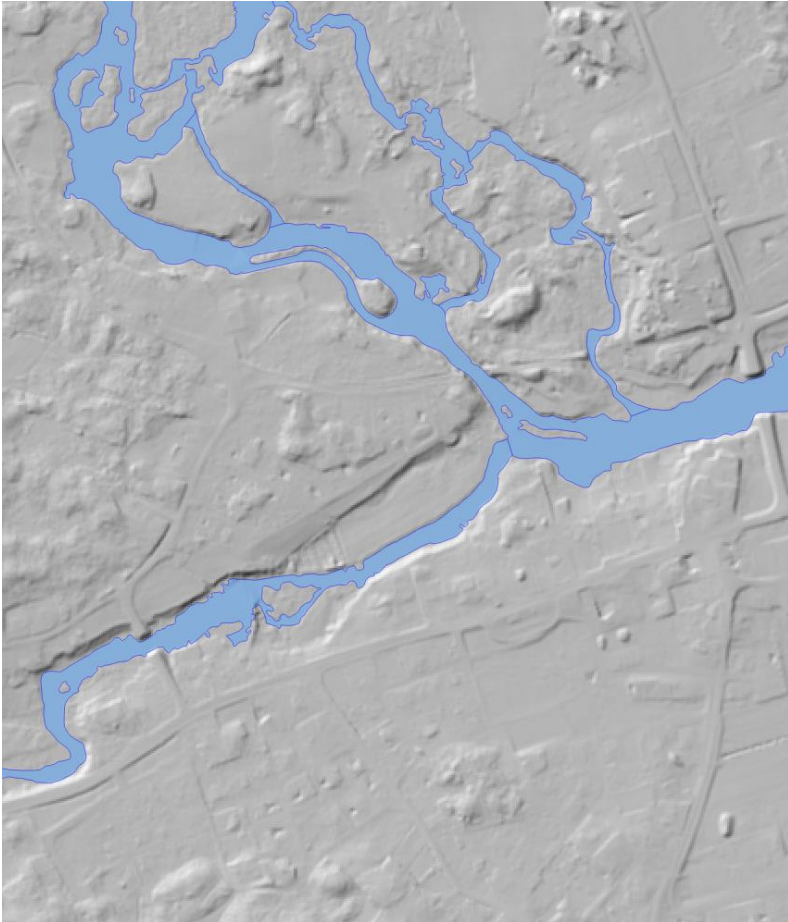
- Visual control of high contrast slope model will guide the operator
 - Many typical errors will be clearly seen, e.g. single low points

Bridge classification



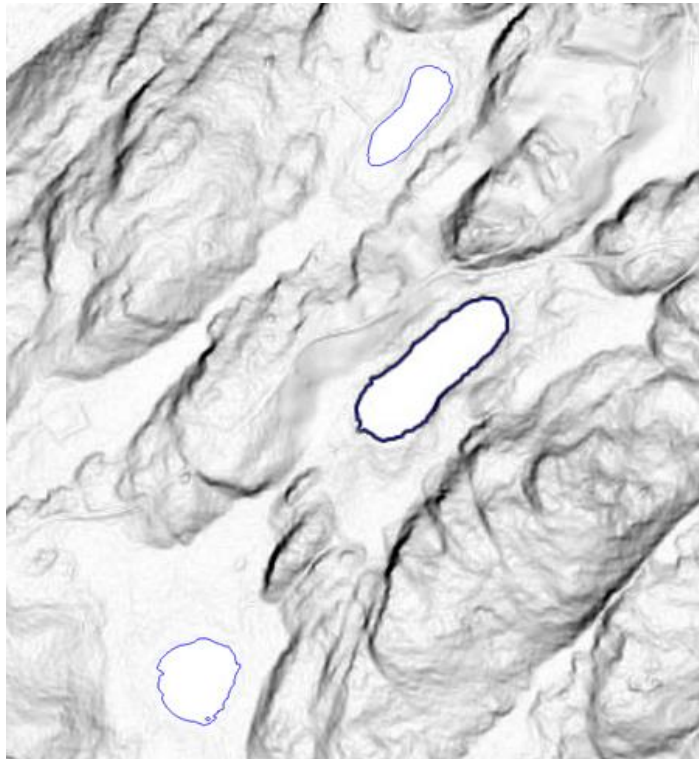
- Bridge classification needed for
 - Obstruction free terrain model
 - Ortho rectification model
- Bridges are automatically classified with custom built application from Foran RS
 - Only minor manual adjustment is needed
- Special gridding routine creates a smooth rectification model used within Lantmäteriet

QC of water breakline deliveries



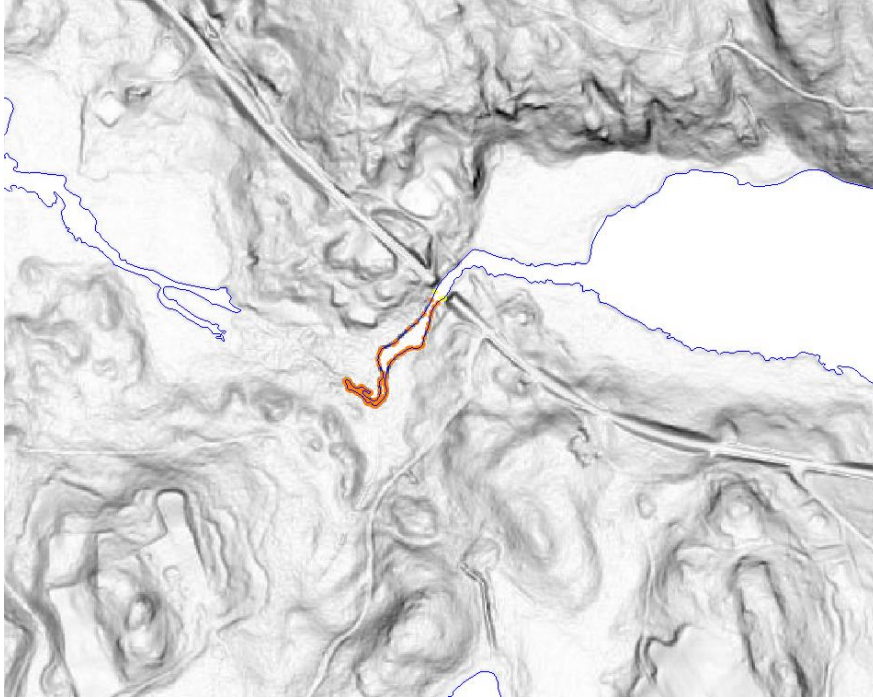
- Demand for smooth water surfaces in terrain model
- 200 000 km shoreline is being mapped as 2.5D polygons by an Indian company
- QC is highly automated
 - Fully automatic validation of geometry and attributes
 - Visual control guided by slope model and vertex deviation map

Guidance by slope model



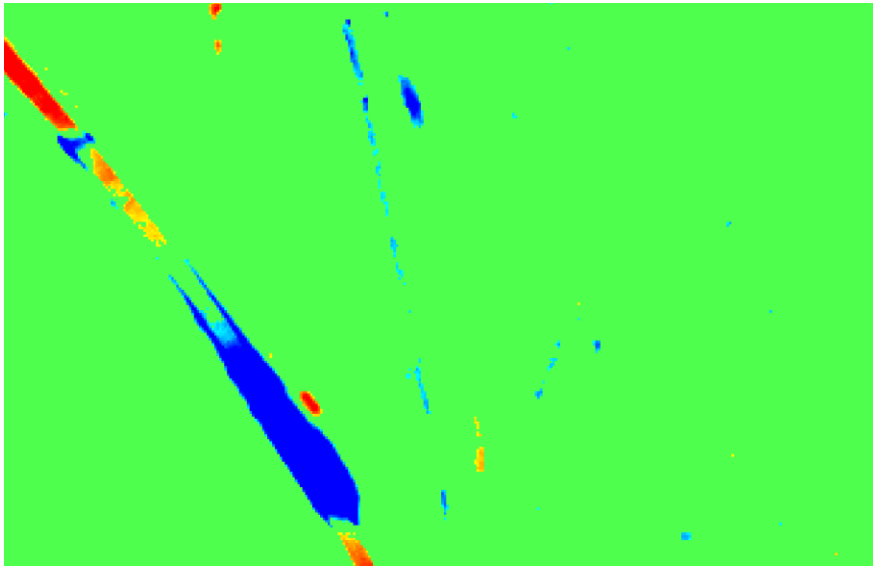
- Big deviations are clearly visible
 - In this case a lake is mapped at wrong height

Guidance by vertex deviation map



- Locally, water is usually the lowest terrain surface
- Elevation model from lowest ground or water points is created, and further minimum filtered
- Shoreline vertices with high deviation from this elevation model is highlighted and visually checked
 - In this case, a small part of a lake is mapped at wrong height

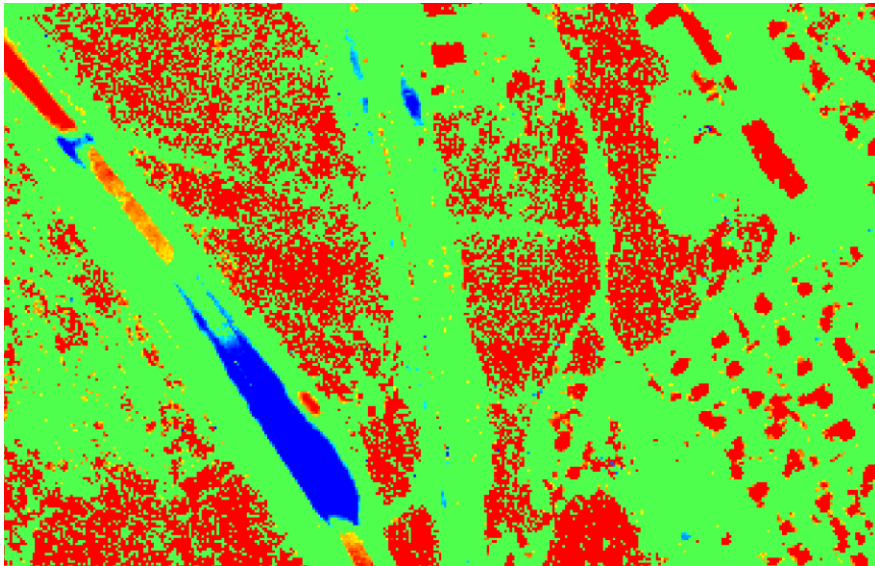
Updating with image data



True ground change

- Laser scanning started in 2009
 - Many areas already out of date
- No funding for new nation wide campaign
- The plan is to update mainly with image data
 - Captured every second year for most areas
 - Point cloud from image matching is the base for change detection

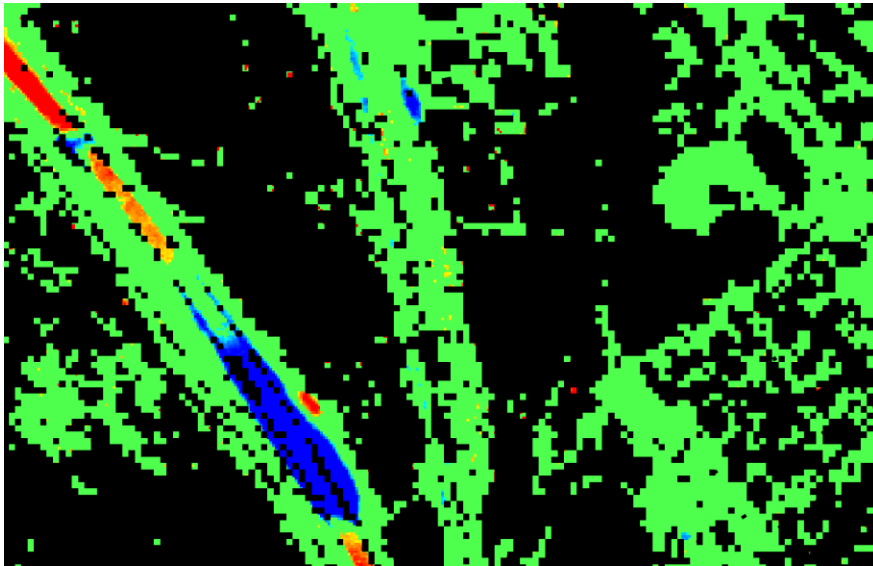
Change detection concept



Surface change

- A simple subtraction of old terrain model from new surface model will show the changes
- Main problem is to avoid influence of vegetation
 - Vegetation mask created from filtered surface roughness model
 - Ancillary water and building polygons from map database
 - Small changes ignored

Vegetation masked out



Vegetation mask

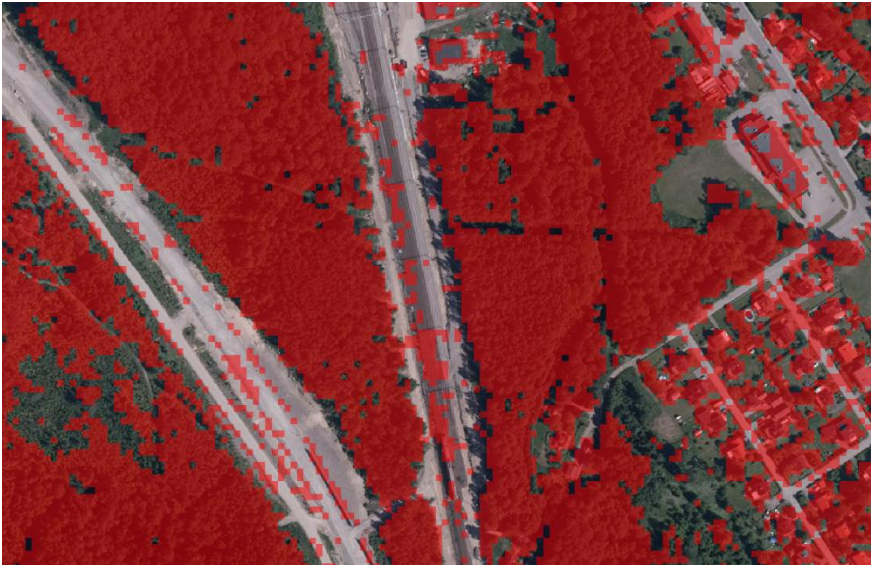


Remaining surface change vectorized

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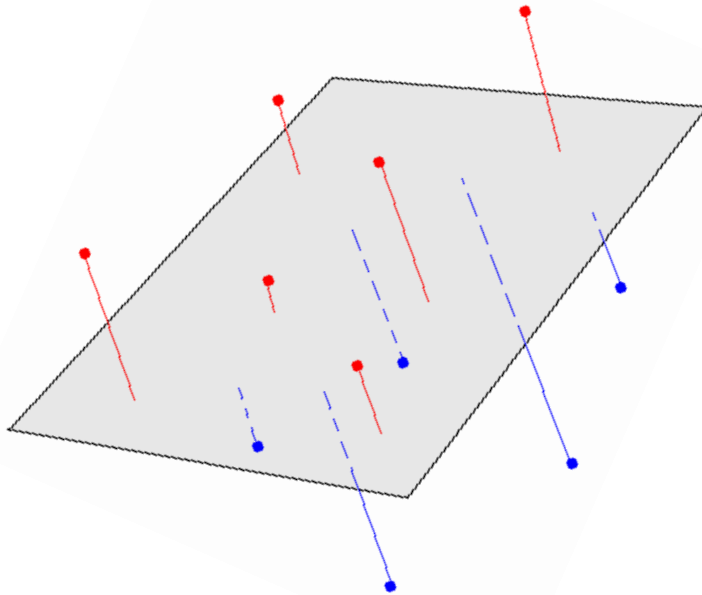


Change detection results



- Vegetation mask from surface roughness is very efficient
 - Based on geometry only
 - Not sensitive for sensor and time of year color variations
 - Smart filtering routine required (mean filter with 3D constraints)
- Preliminary detection rate is 80% with only 40% false hits

Calculation of vegetation mask



- Within each raster cell, fit a plane to points with least squares adjustment
- Surface roughness = SD of residuals
- Roughness raster is mean filtered with 3D constraint (similar to region growing)
 - To cover low SD areas in smooth vegetation