



Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra

Federal Office of Topography swisstopo

wissen wohin
savoir où
sapere dove
knowing where

Updating of nationwide DTM and DSM:

Information fusion from LiDAR and
photogrammetry

swisstopo

Roberto Artuso, swisstopo



Agenda

1. swisstopo: who are we?
2. Production of swissALTI^{3D}, the current highly accurate digital terrain model of Switzerland
3. Looking forward
4. Questions?



swisstopo: who are we?

Federal Office of Topography- swisstopo

we have been founded in 1838

we employ about 360 persons

we are based in: Wabern, Dübendorf, St. Ursanne

Activities

Geodesy, photogrammetry and remote sensing, cartography, geology, Cadastral Surveying, National Geodata Infrastructure

Products

GPS Positioning Services, Maps 1:25,000-1:1Mio. (analogue und digital), Landscape Models (GIS), Height Models (DTM/DSM), Images, Orthoimages, Geodetic Software, Multimedia products, etc.

Political steering with a performance mandate und global budget

Expenditure: ca. 60 Mio. Fr.

Earning: ca. 27 Mio. Fr.



swisstopo: who are we?

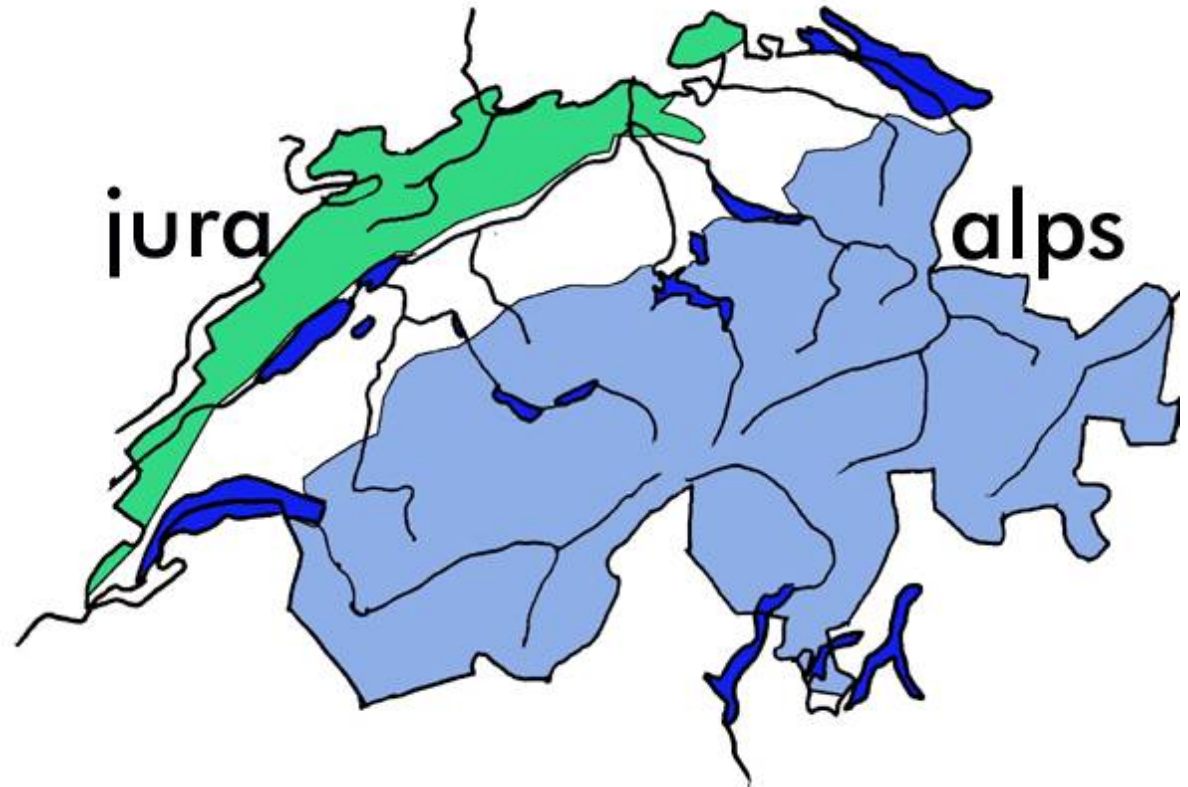


Federal Office of Topography swisstopo

EuroSDR Workshop: Nationwide generation of height data - from Airborne laser scanning and other sources
January, 12 - 13.2016



swisstopo: who are we?



- Surface of the country about 41'285 km²
- 74 mountains over 4'000 m
- Mean height of the country 1'300 m
- More than 50% of the country are situated over 1'000 m



swisstopo: who are we?

We deal with 3D and Digital Elevation Model!





swisstopo: who are we?

We deal with 3D and Digital Elevation Model!

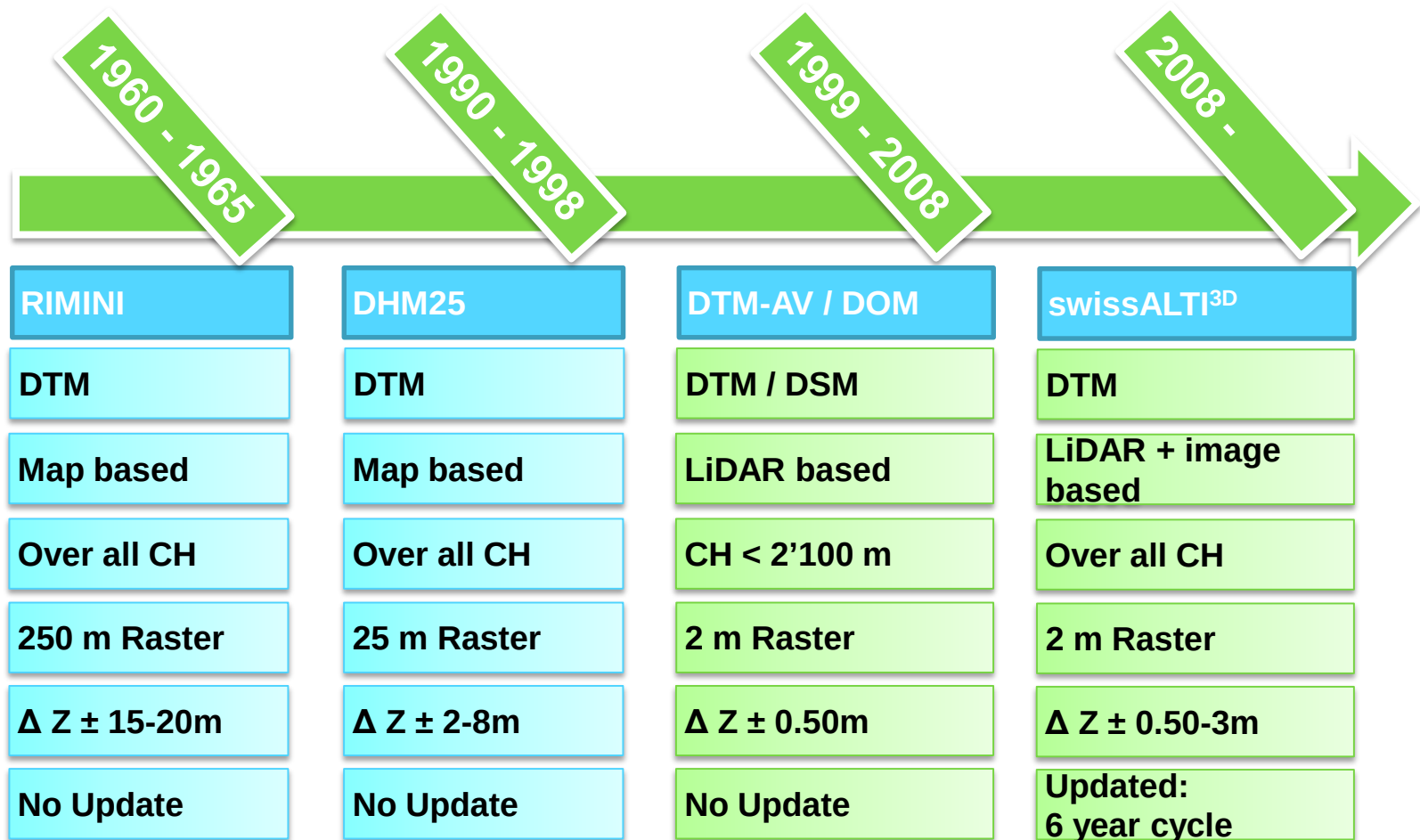




2. Production of swissALTI^{3D}, the current highly accurate digital terrain model of Switzerland

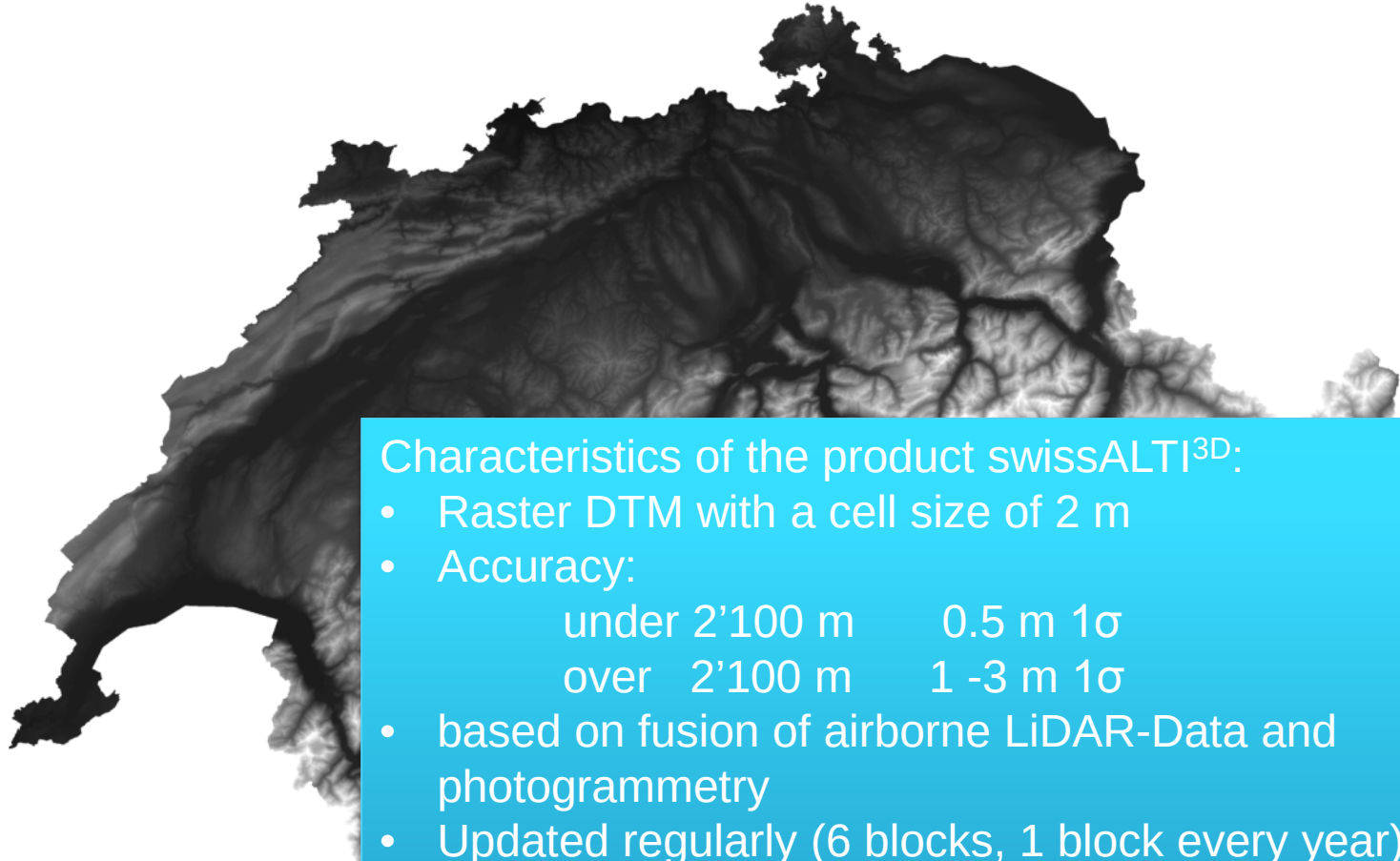


A short history of swisstopo DEM





The product swissALTI^{3D}

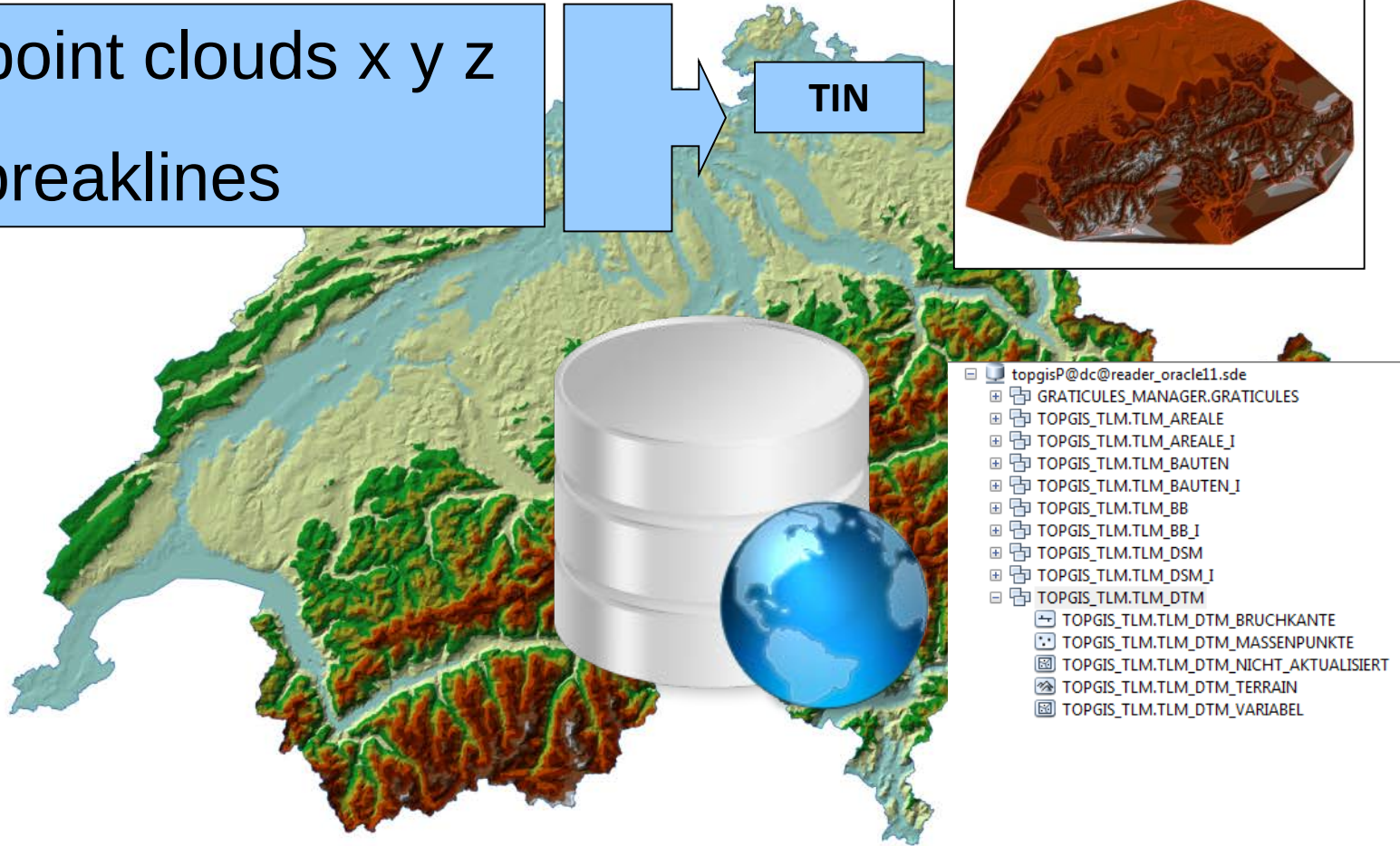
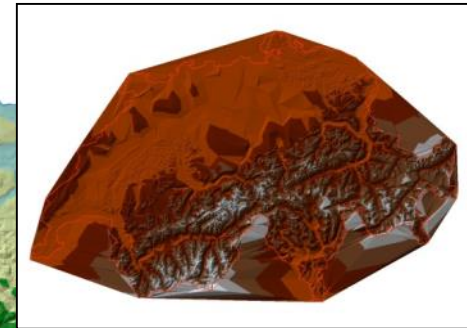




What is behind the product?

- point clouds x y z
- breaklines

TIN



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├─ TOPGIS_TLM.TLM_AREALE
├─ TOPGIS_TLM.TLM_AREALE_I
├─ TOPGIS_TLM.TLM_BAUTEN
├─ TOPGIS_TLM.TLM_BAUTEN_I
├─ TOPGIS_TLM.TLM_BB
├─ TOPGIS_TLM.TLM_BB_I
├─ TOPGIS_TLM.TLM_DSM
├─ TOPGIS_TLM.TLM_DSM_I
├─ TOPGIS_TLM.TLM_DTM
├─ TOPGIS_TLM.TLM_DTM_BRUCHKANTE
├─ TOPGIS_TLM.TLM_DTM_MASSENPUNKTE
├─ TOPGIS_TLM.TLM_DTM_NICHT_AKTUALISIERT
├─ TOPGIS_TLM.TLM_DTM_TERRAIN
└─ TOPGIS_TLM.TLM_DTM_VARIABEL
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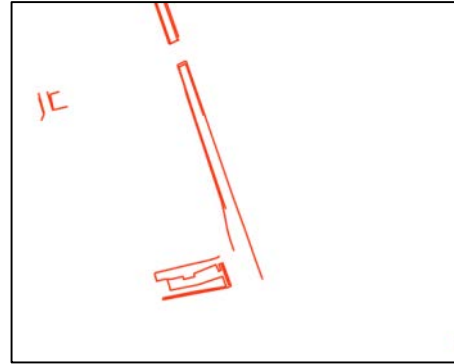


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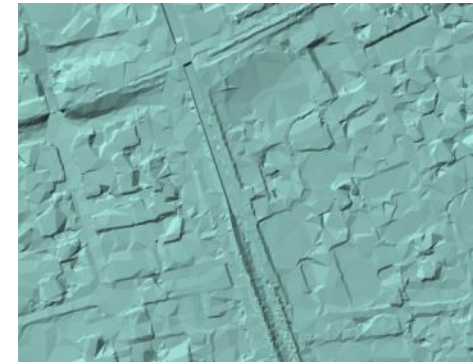
Point clouds

+



Breaklines

=



TIN

↓ Interpolation



swissALTI^{3D}

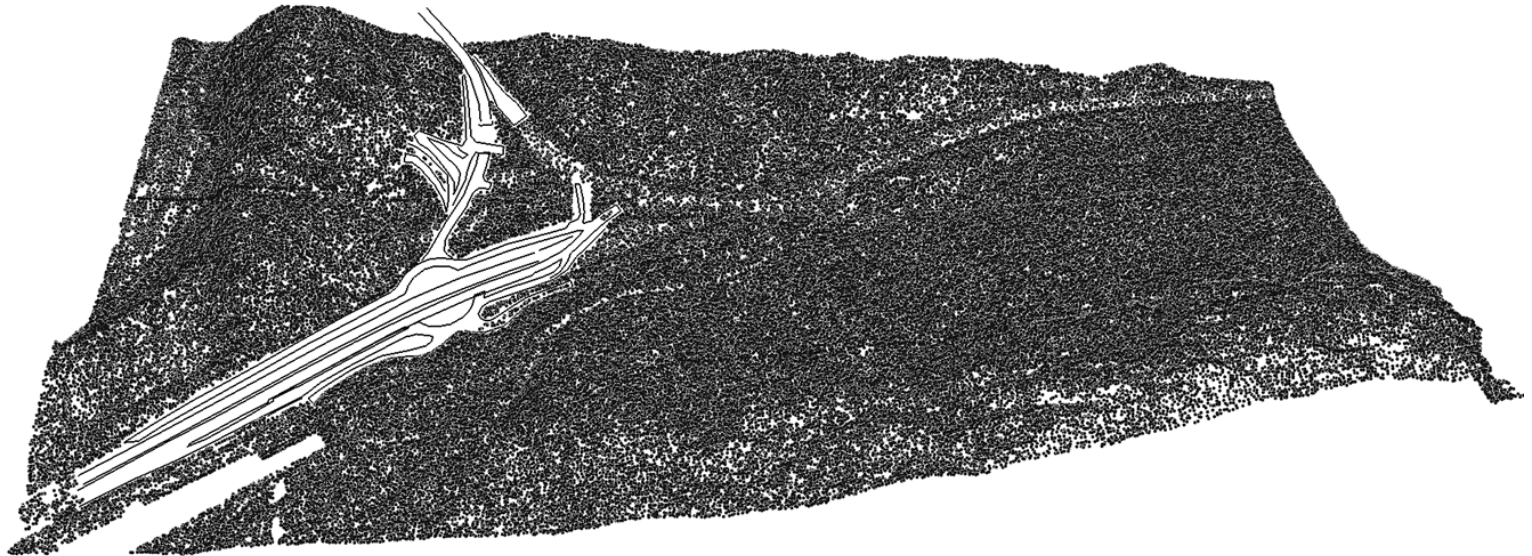


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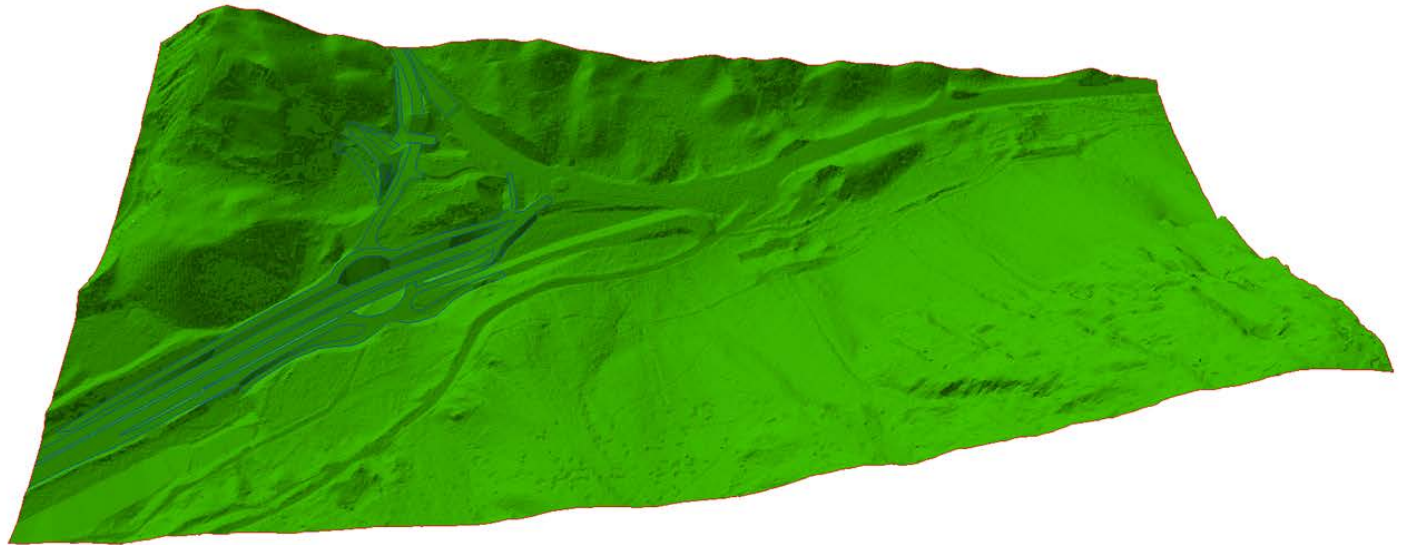


What is behind the product?



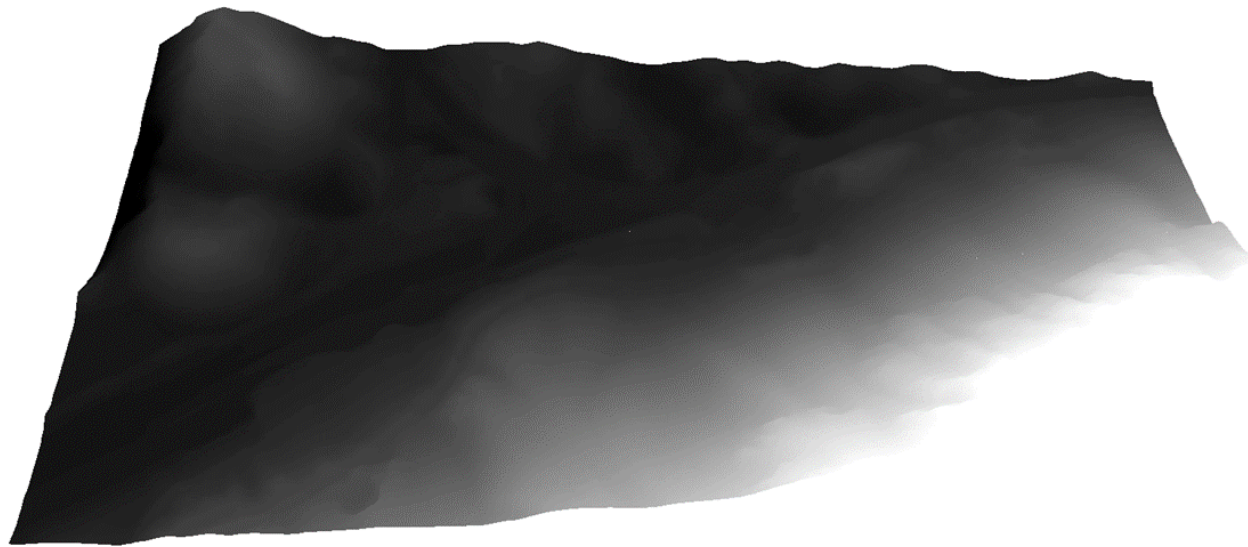


What is behind the product?





What is behind the product?



What is behind the product?

Source of the basis data:

x y z point clouds: aerial images (stereo measurements / image matching)
or Airborne LiDAR

Breaklines: aerial images (stereo measurements)

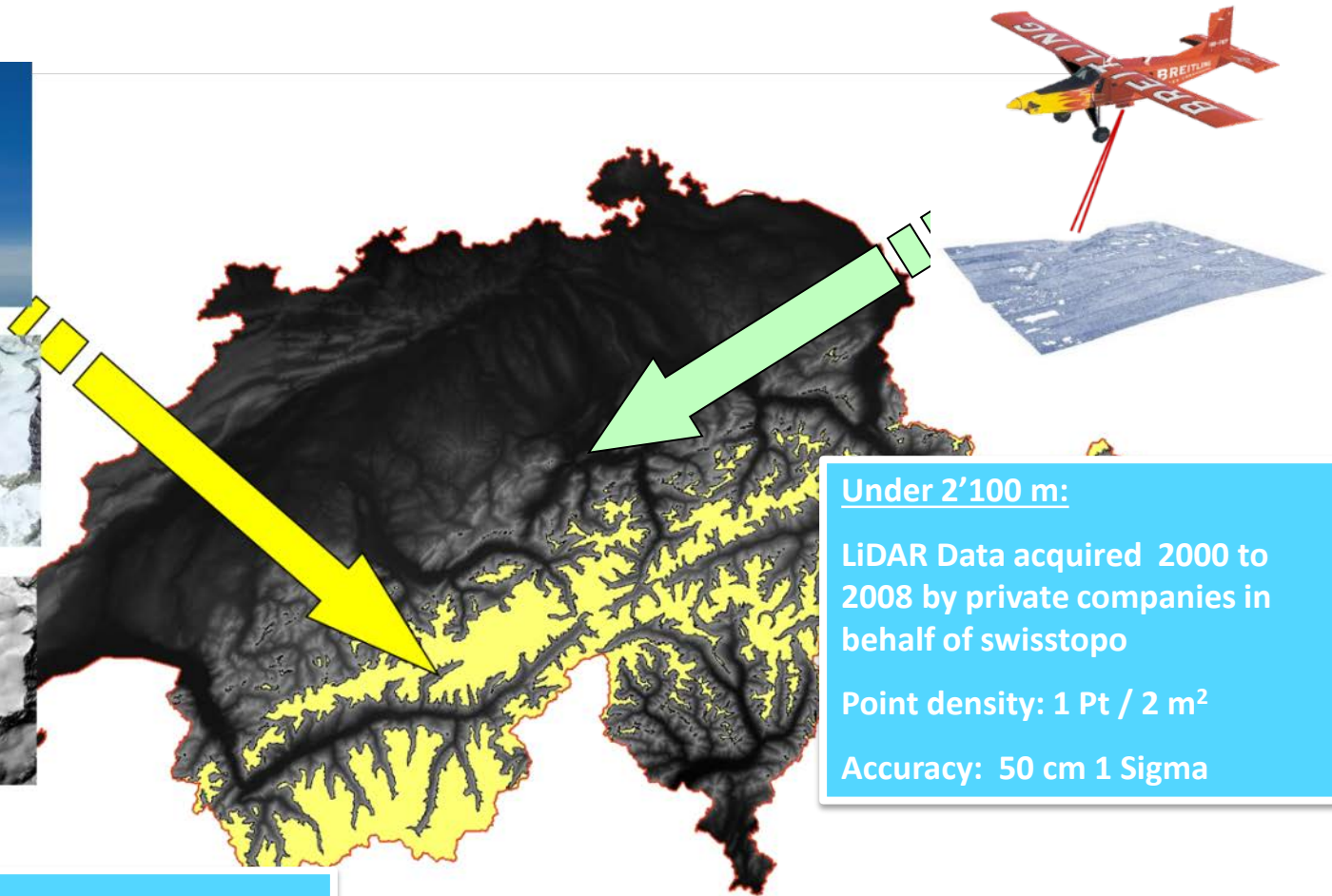
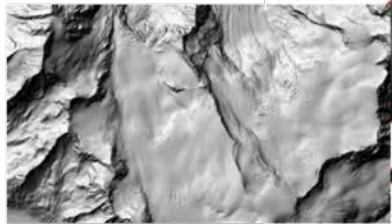


+





Production of swissALTI^{3D} / build-up



Under 2'100 m:

LiDAR Data acquired 2000 to 2008 by private companies in behalf of swisstopo

Point density: 1 Pt / 2 m²

Accuracy: 50 cm 1 Sigma

Over 2'100 m:

Data based on swisstopo aerial imagery (GSD 50 cm)

Image matching and photogrammetry



Production of swissALTI^{3D} / Update



Digital Photogrammetry

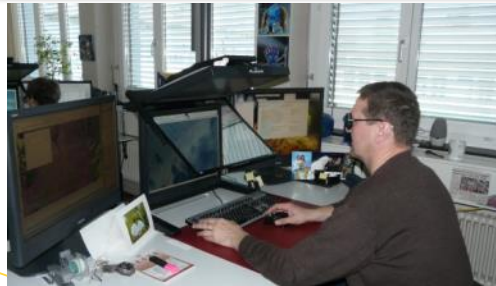
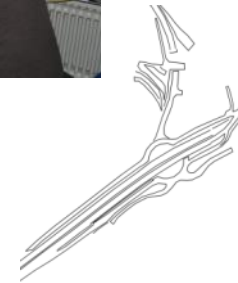
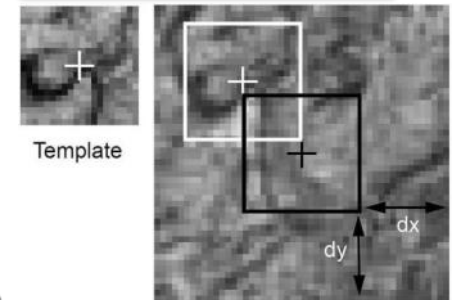


Image Matching





Production of swissALTI^{3D} / Update





Production of swissALTI^{3D} / Update

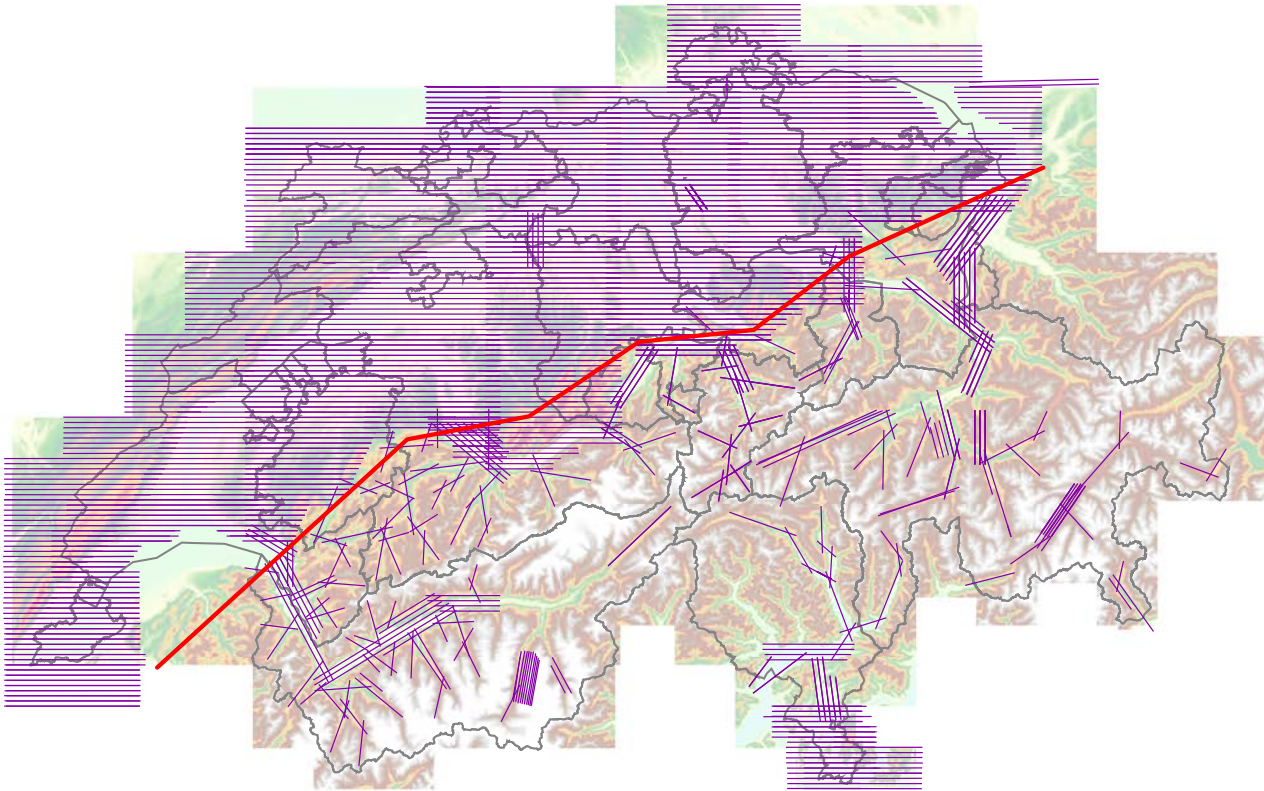
- 2 x ADS Leica Digital Pushbroom Cameras
Model ADS80, Sensor Head SH82
- 2 x PAV 100 stabilization Platforms





Production of swissALTI^{3D} / Update

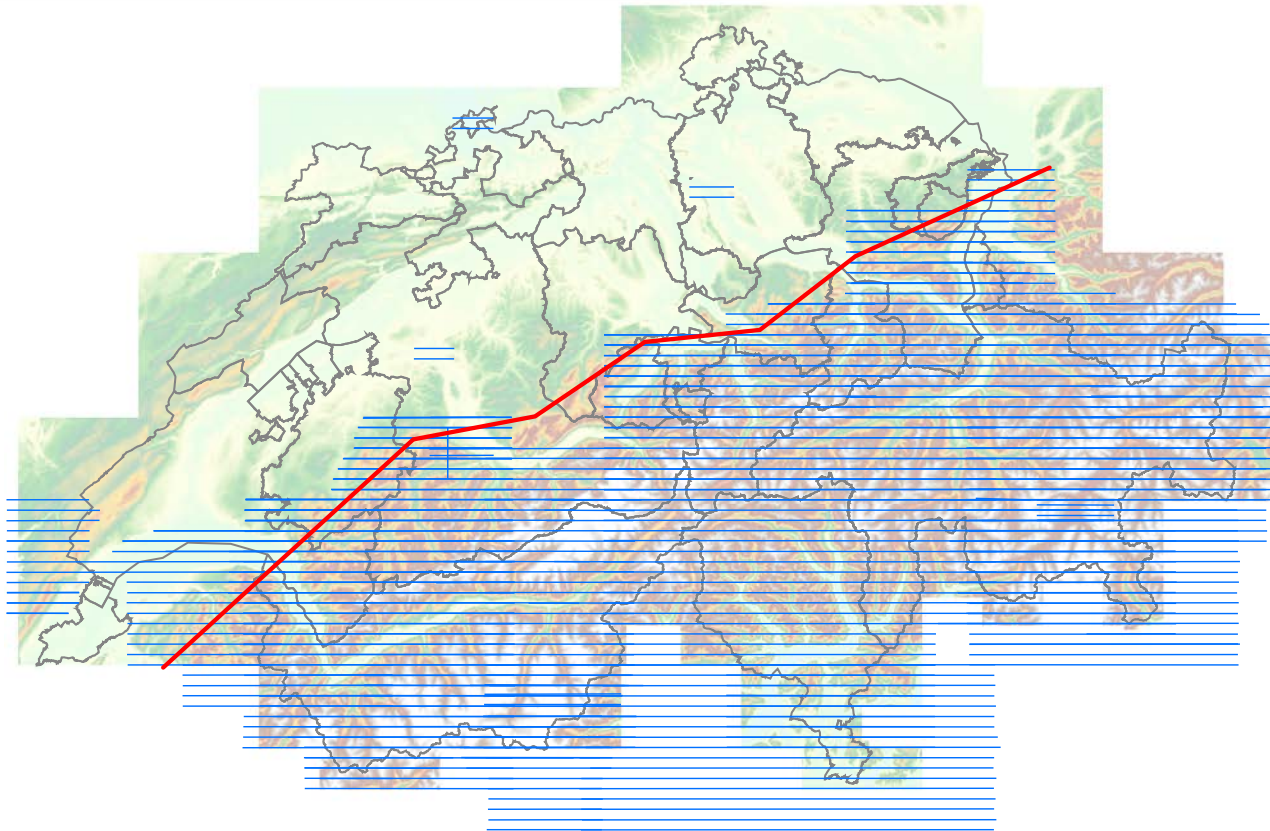
swisstopo imagery GSD 25cm





Production of swissALTI^{3D} / Update

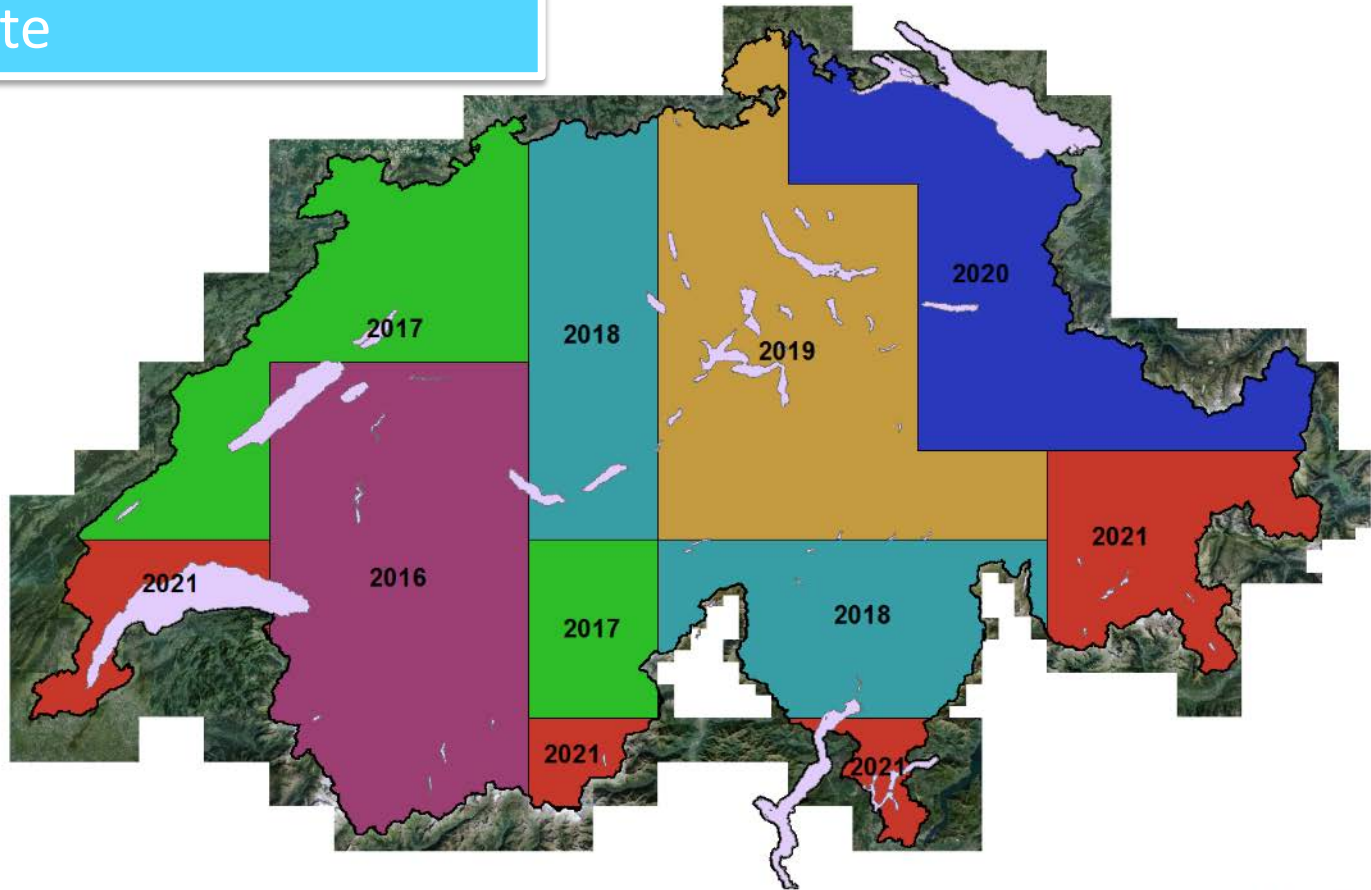
swisstopo imagery GSD 50 cm





Production of swissALTI^{3D} / Update

swisstopo flight blocks for
DTM update



Bundesamt für Landestopografie GeoData



Production of swissALTI^{3D} / Update



Philosophy

- Integration of effective changes
- **> 50 cm** (new road, new houses, new constructions, glaciers, natural hazards...)
- Improvement of the **homogeneity** (Bridges, Lakes...)
- Where possible and needed: improvement of the original LiDAR Data



Production of swissALTI^{3D} / Update

What is typically updated in the DTM

- Construction (roads, houses, bridges, railways,...)
- Accumulation, gravel-pit, banking, earth-wall...
- Revitalisations
- Glacier, landslide, rockslide, deformation due to natural hazards
- ...



Production of swissALTI^{3D} / Update

To find the **changes** in topography and the regions where we have to update the DTM we:

- use a **Change Detection** based on the difference between the old DTM and an image-matched DSM, based on the newest swisstopo aerial images. The main goal of this **Change Detection** is to identify the regions where the DTM hasn't changed!
- We check the **DTM points and breaklines** with the newest stereo images in the region for potential changes and update the DTM, adding new points or breaklines where necessary.



Production of swissALTI^{3D} / Update

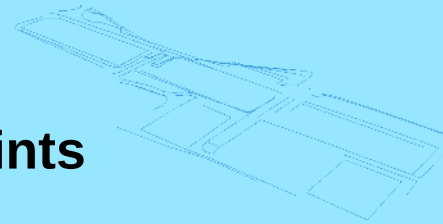


TOPGIS:
ArcGIS +
Stereo Analyst



Manual stereo measurements

- delete points
- measure new points
- measure and integrate breaklines



Local image matching

- Process new elevation points

Import of external

- LiDAR Data
- Image matching Data



Production of swissALTI^{3D} / Update

Example 1: Update with breaklines and local image matching

Situation 2008





Production of swissALTI^{3D} / Update

Example 1: Update with breaklines and local image matching

Situation 2014





Production of swissALTI^{3D} / Update

Example 1: Update with breaklines and local image matching

Situation 2008, Hillshade swissALTI^{3D}





Production of swissALTI^{3D} / Update

Example 1: Update with breaklines and local image matching

Situation 2008, TIN swissALTI^{3D}





Production of swissALTI^{3D} / Update

Example 1: Update with breaklines and local image matching

Situation 2008, point cloud swissALTI^{3D}





Production of swissALTI^{3D} / Update

Example 1: Update with breaklines and local image matching

Situation 2014





Production of swissALTI^{3D} / Update

Example 1: Update with breaklines and local image matching

Image matched DSM with aerial images 2014





Production of swissALTI^{3D} / Update

Example 1: Update with breaklines and local image matching

Change Detection Diff: DSM 2014 / swissALTI^{3D} 2008

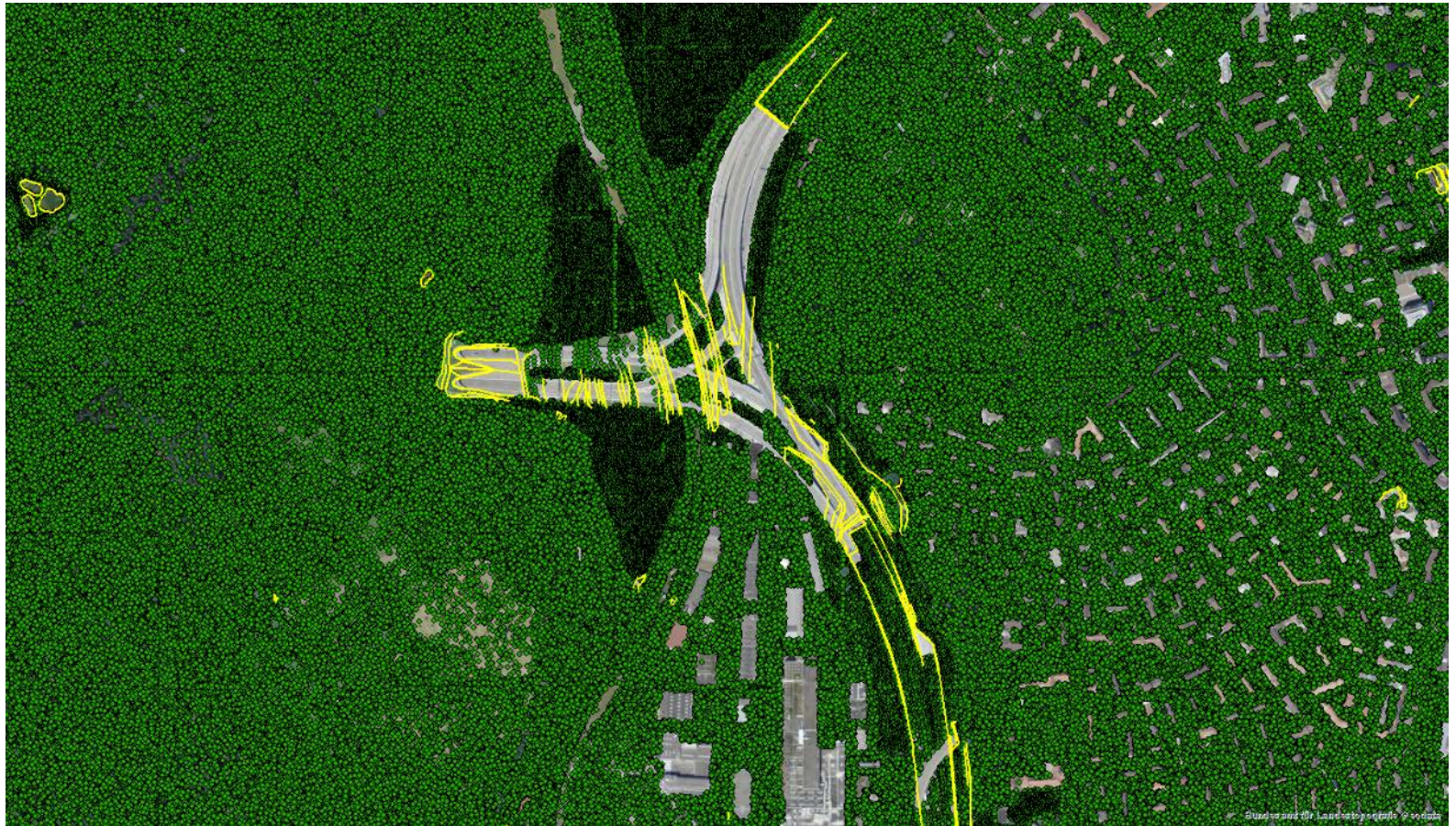




Production of swissALTI^{3D} / Update

Example 1: Update with breaklines and local image matching

Updated in TIN swissALTI^{3D}

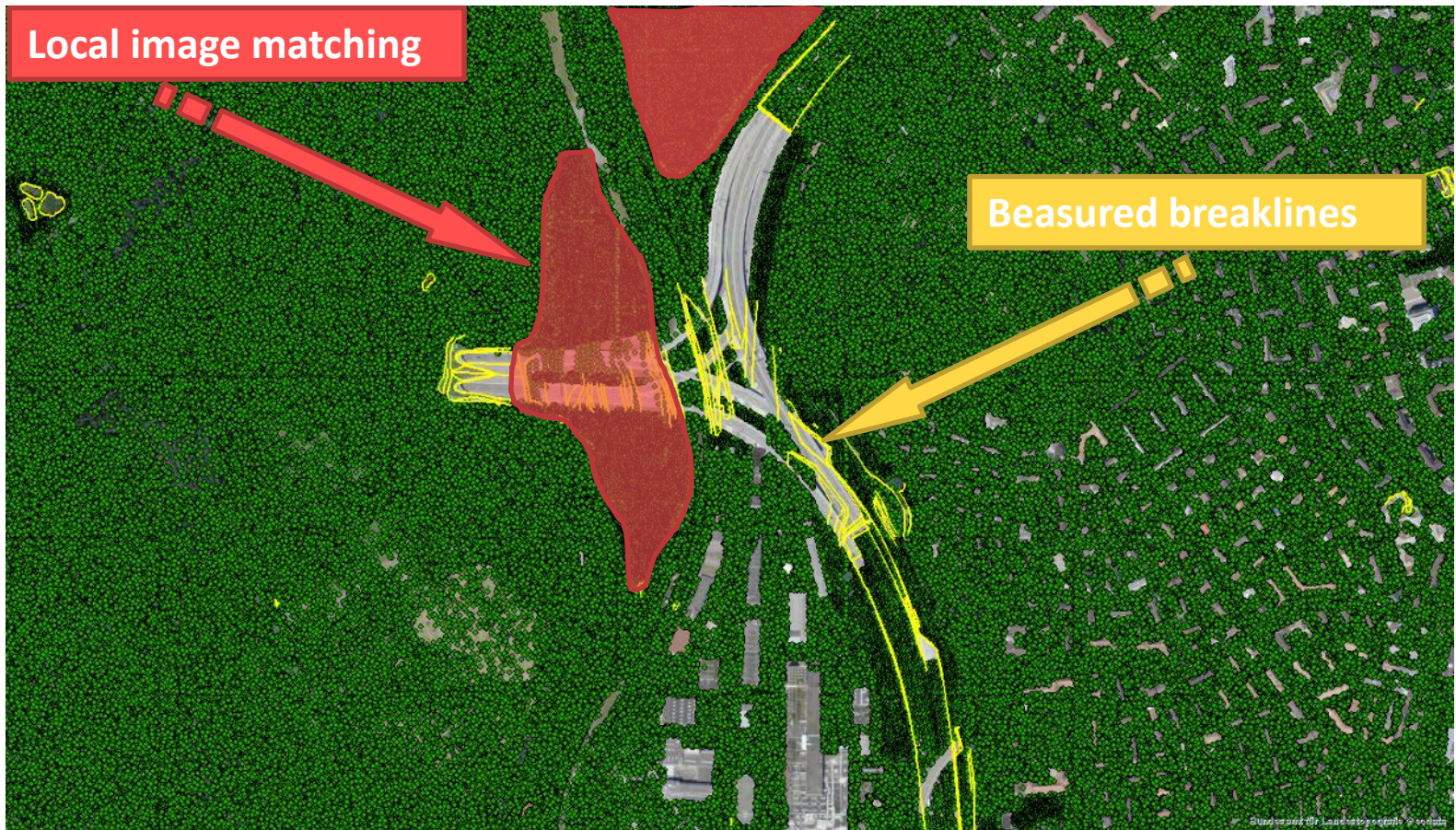




Production of swissALTI^{3D} / Update

Example 1: Update with breaklines and local image matching

Update in TIN swissALTI^{3D}





Production of swissALTI^{3D} / Update

Example 1: Update with breaklines and local image matching

New TIN swissALTI^{3D} 2014





Production of swissALTI^{3D} / Update

Example 1: Update with breaklines and local image matching

Hillshade Updated swissALTI^{3D} 2014

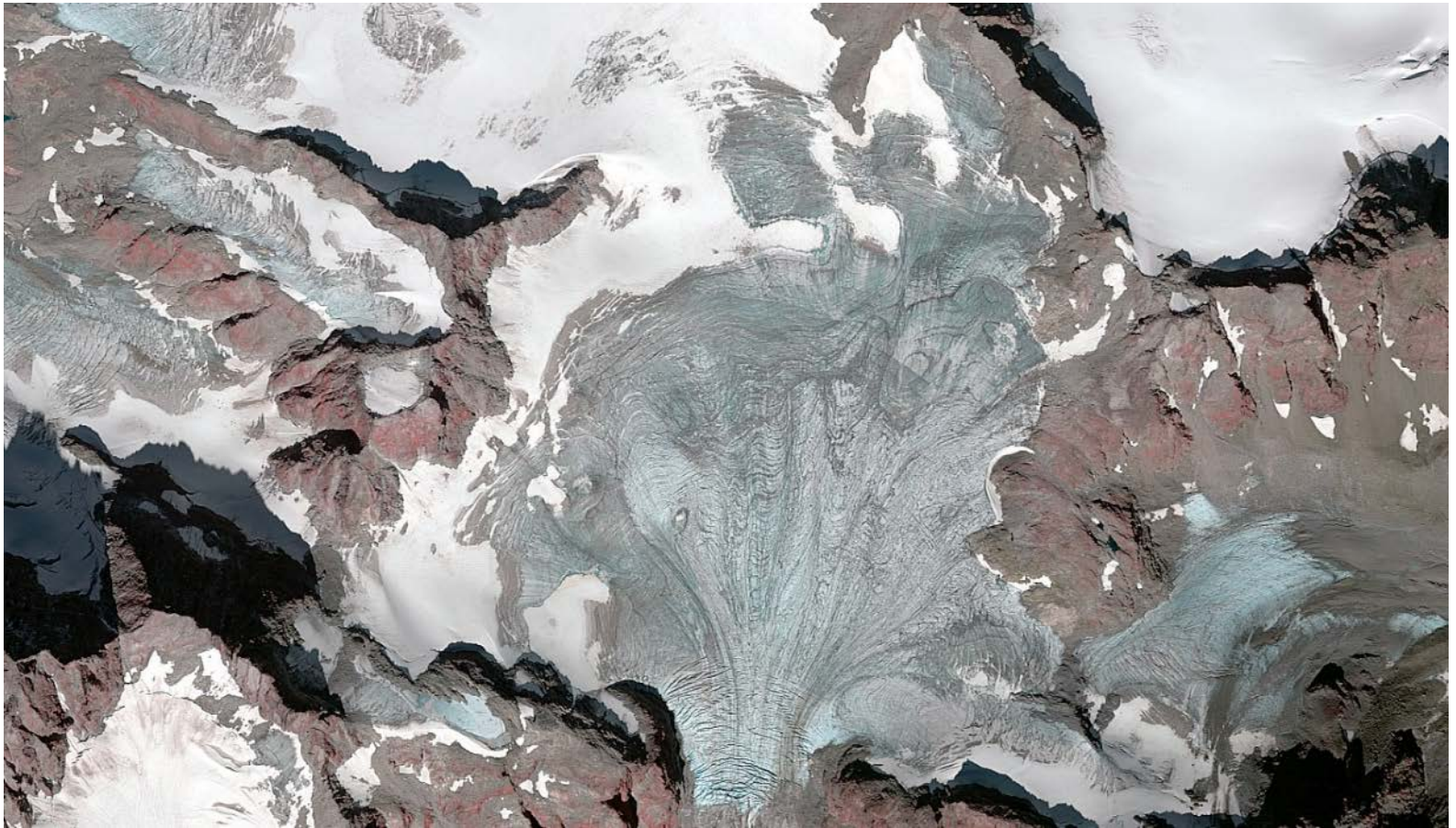




Production of swissALTI^{3D} / Update

Example 2: Update with external image matching

Glacier Situation 2008





Production of swissALTI^{3D} / Update

Example 2: Update with external image matching

Glacier Situation 2008

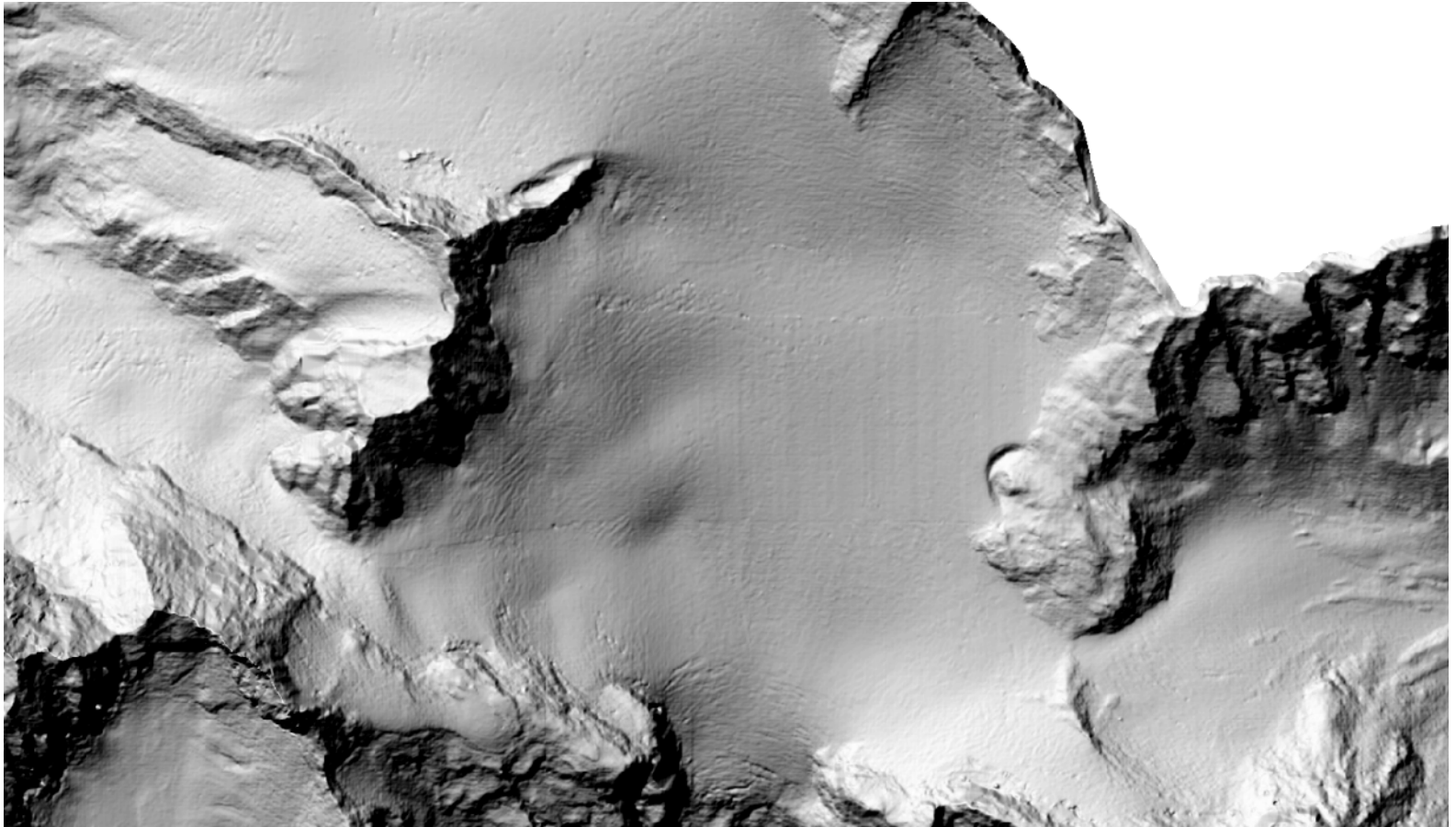




Production of swissALTI^{3D} / Update

Example 2: Update with external image matching

Hillshade swissALTI^{3D} 2008





Production of swissALTI^{3D} / Update

Example 2: Update with external image matching

Glacier Situation 2008

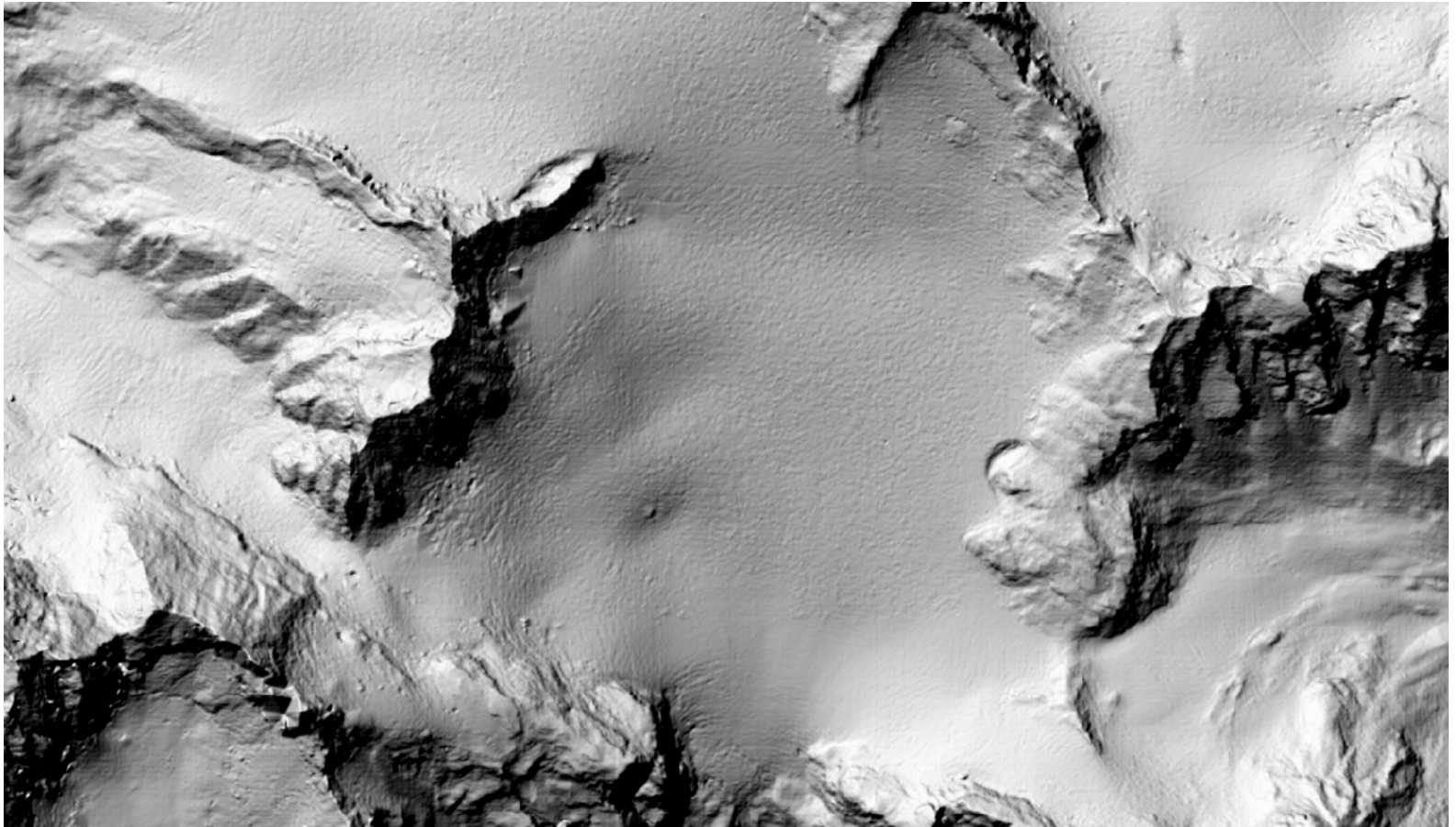




Production of swissALTI^{3D} / Update

Example 2: Update with external image matching

Image matched DSM with aerial images 2014





Production of swissALTI^{3D} / Update

Example 2: Update with external image matching

Extraction Zone for updating swissALTI^{3D}

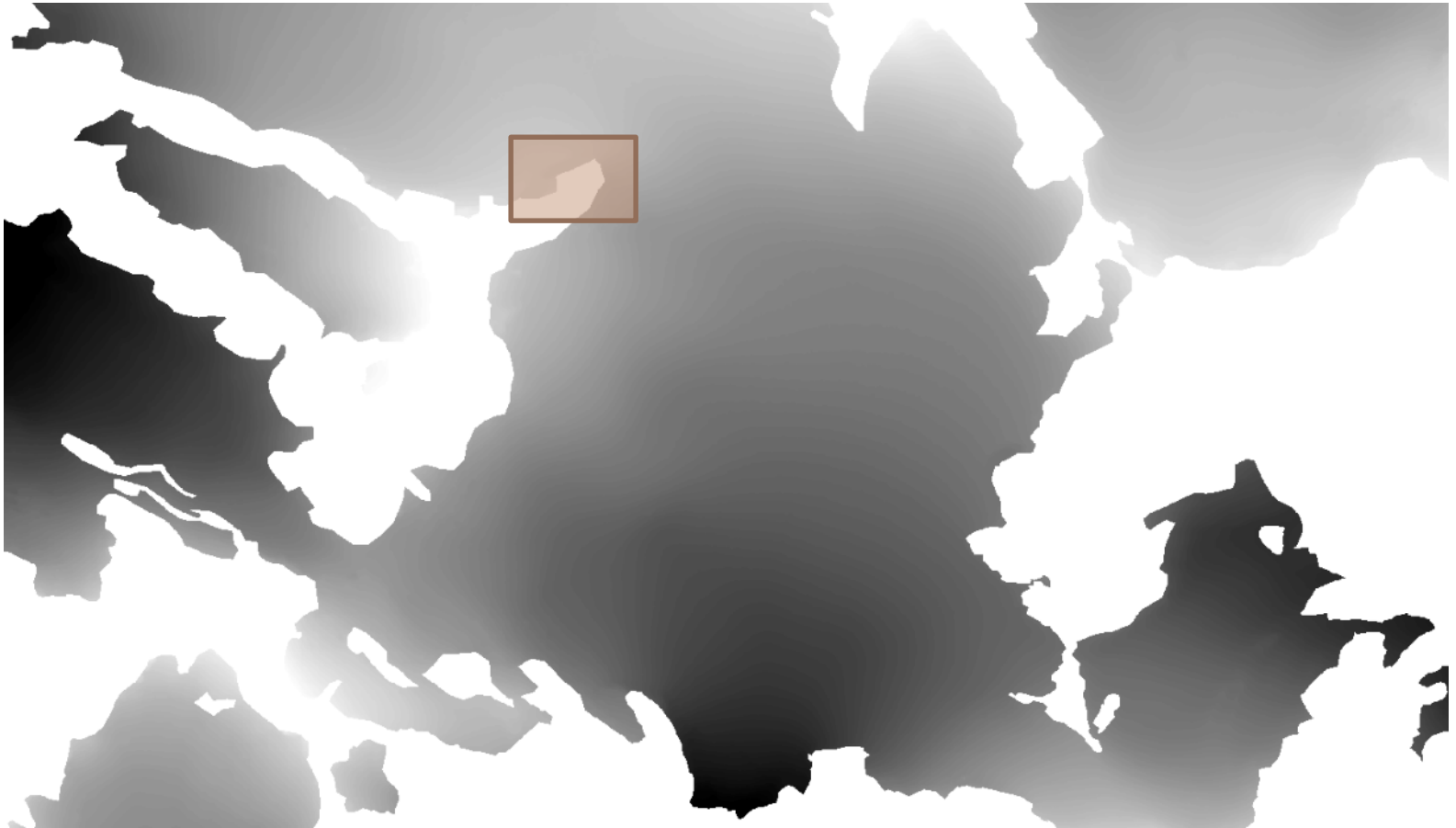




Production of swissALTI^{3D} / Update

Example 2: Update with external image matching

Extracted Image matched DSM with aerial images 2014

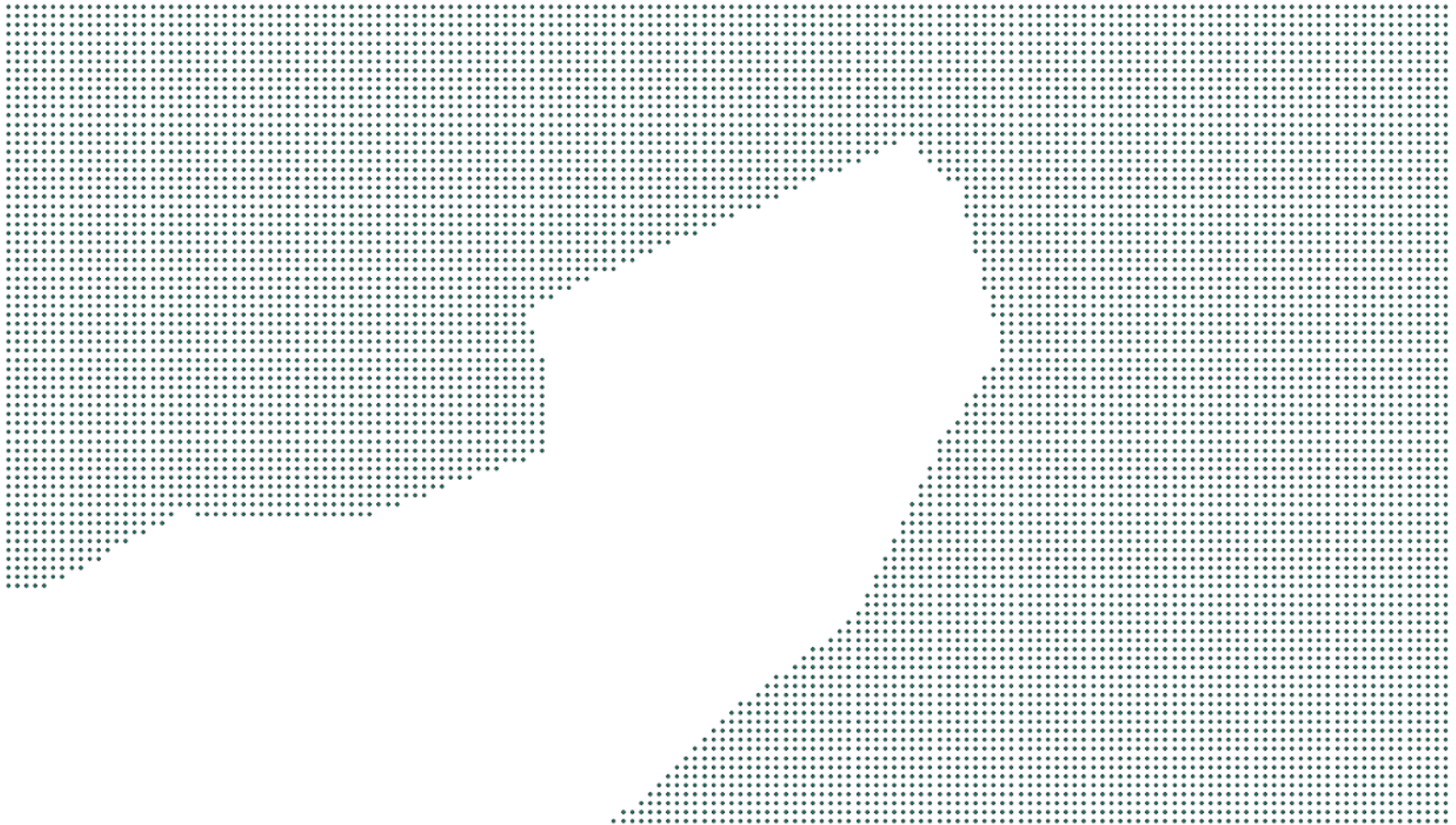




Production of swissALTI^{3D} / Update

Example 2: Update with external image matching

Extracted Image matched DSM with aerial images 2014, point conversion

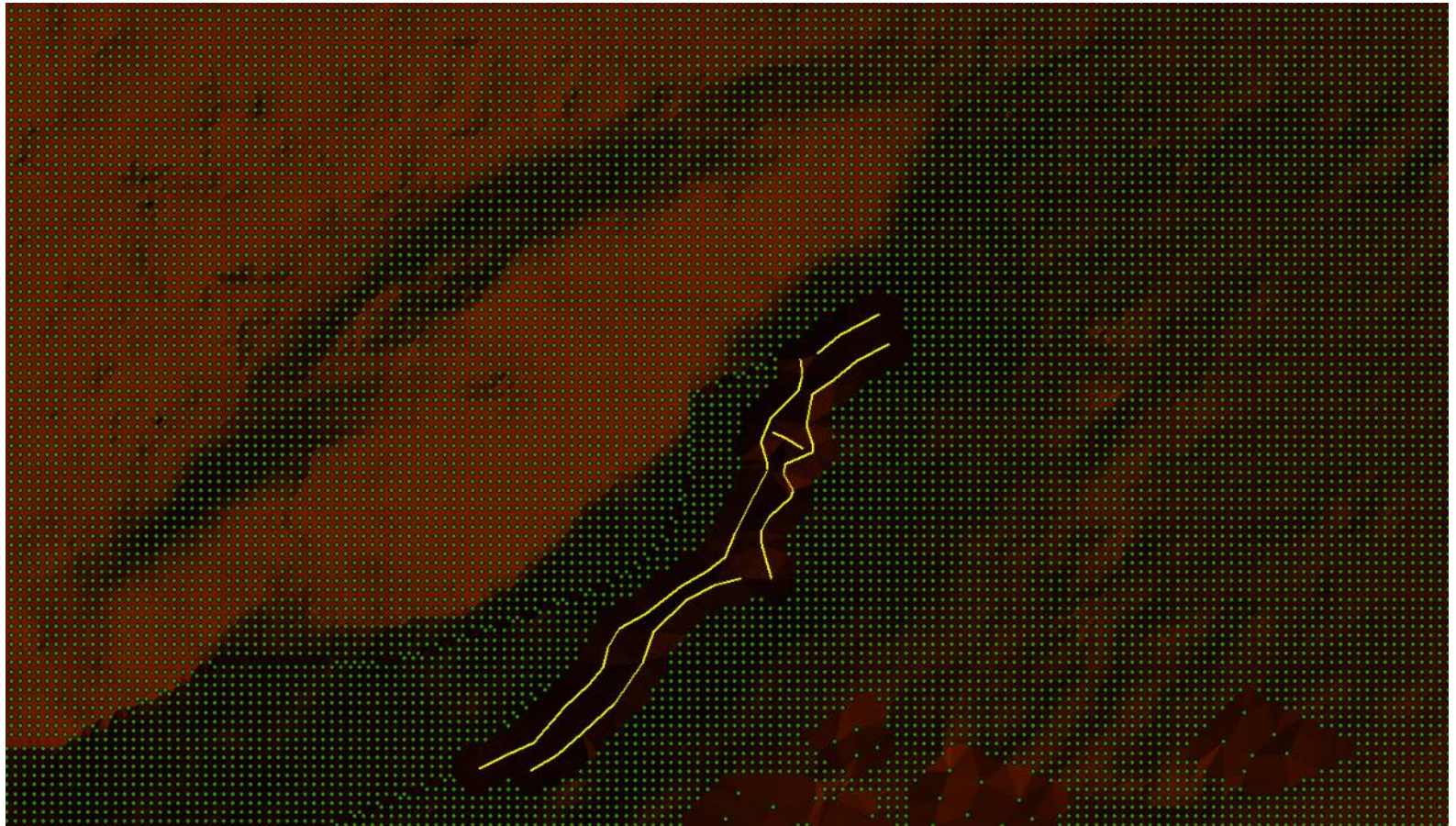




Production of swissALTI^{3D} / Update

Example 2: Update with external image matching

Updated TIN swissALTI^{3D} 2014

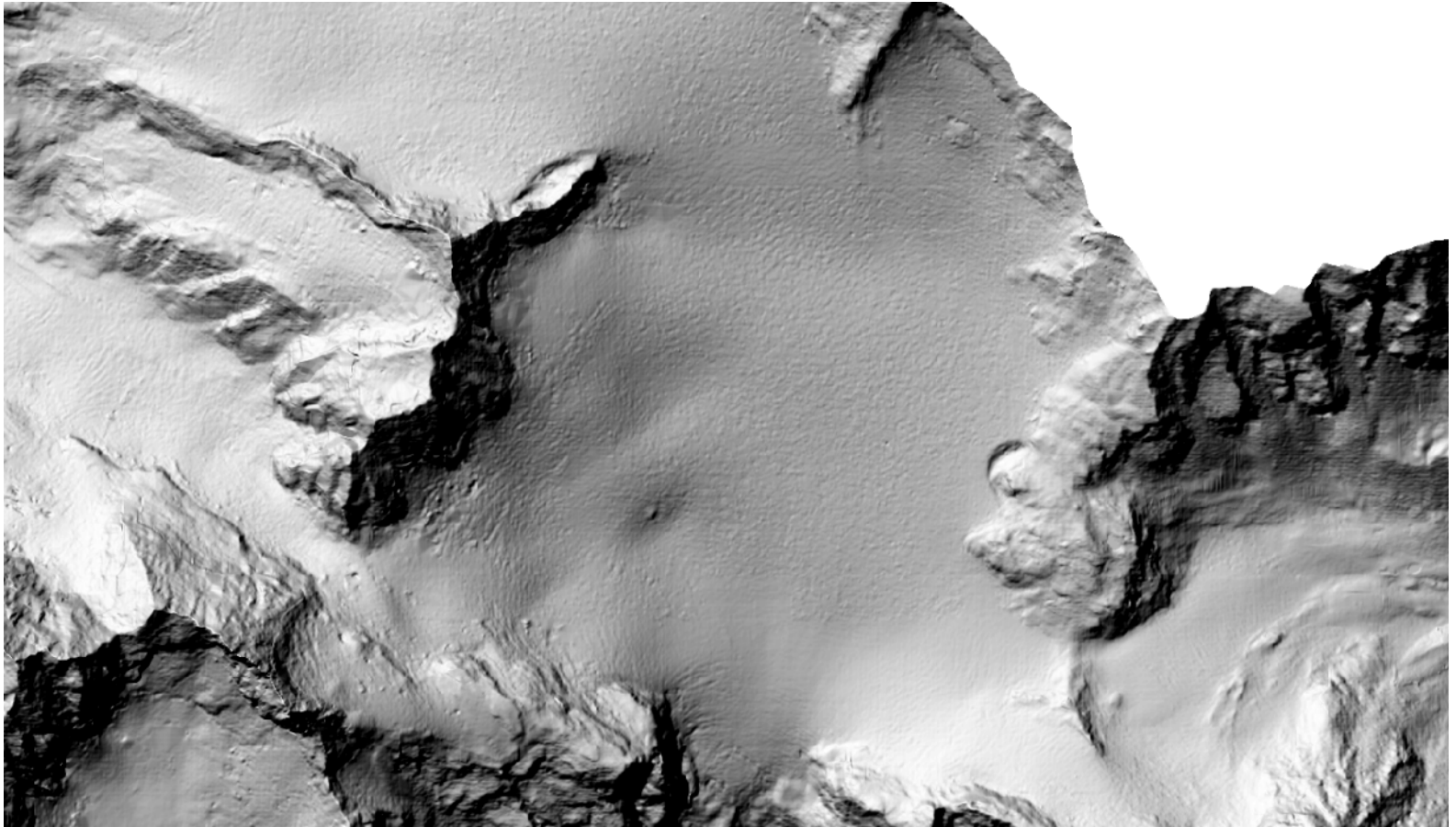




Production of swissALTI^{3D} / Update

Example 2: Update with external image matching

HillshaUpdated swissALTI^{3D} 2014





Production of swissALTI^{3D} / Update

- ☺ Fusion of LiDAR and photogrammetry works well
- ☺ We are able to update our DTM regularly
- ☺ All the production can be done from swisstopo
- ☺ One imagery for all our products
- ☺ Synchronized production DTM / 3D vectors/ Orthophotos
- ☺ The dataset is seamless and managed in one geodatabase
- ☺ We are very flexible

- ☹ Patchwork of different elevation data sets
- ☹ We depend a lot on the quality of the original LiDAR Data
- ☹ Height accuracy and point density can not be improved
- ☹ No possibility to update the DTM in forested area
- ☹ 6 years to update the data can be too long!
- ☹ No possibility to have a new DSM
- ☹ New LiDAR Technology available. Better DTM are wanted!



Looking forward





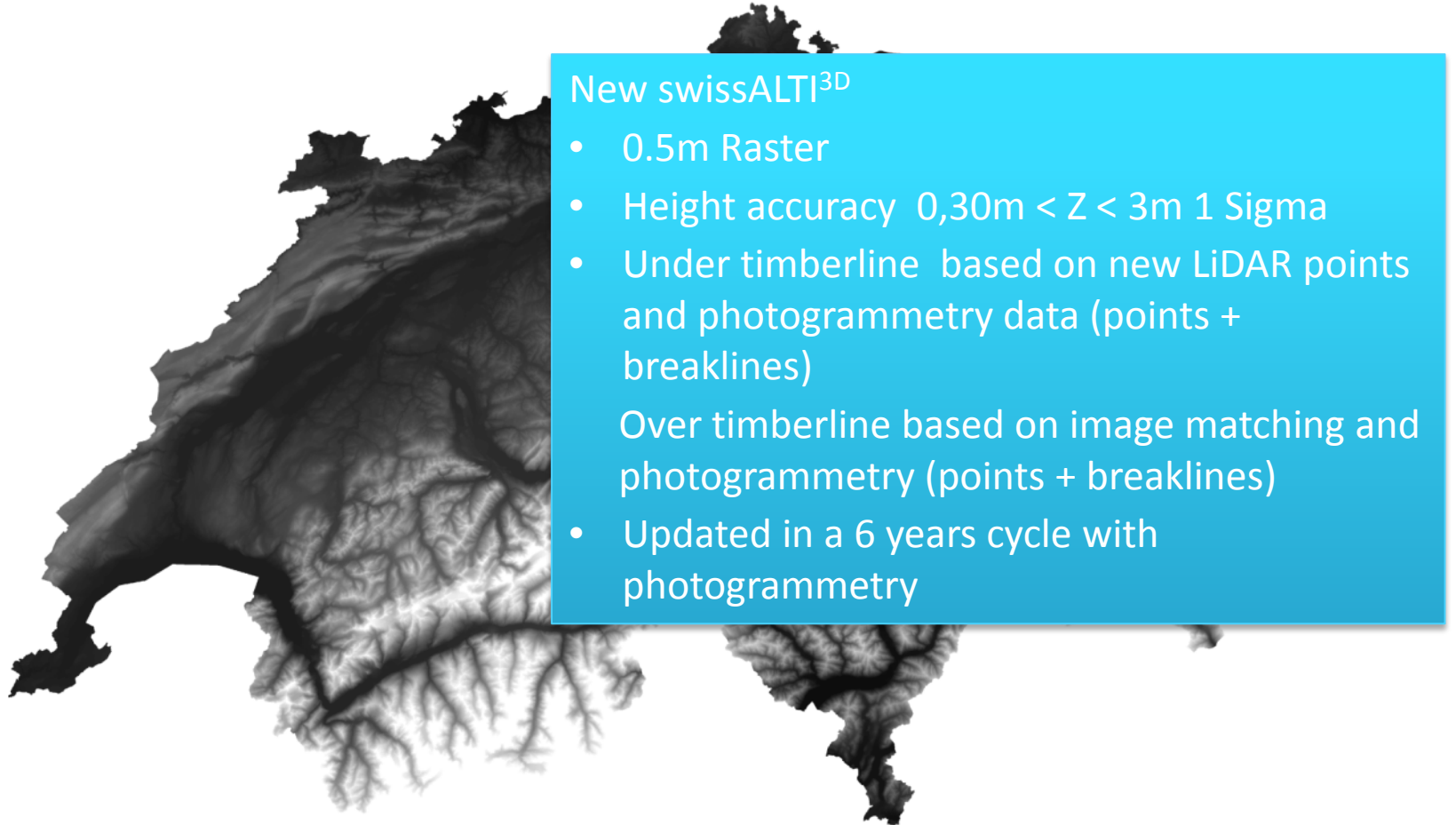
Looking forward « Goals of the project »

1. Acquisition of new LiDAR data over all Switzerland to produce a DSM and DTM for the needs of swisstopo and the Cantons
2. Integration of the new LiDAR data in the height models production of swisstopo
 - Improvement of resolution and height accuracy of the product swissALTI^{3D} (swisstopo actual DTM)
 - Deliver a new DSM product (swissSURFACE^{3D})



Looking forward

Characteristics of the new swissALTI^{3D}



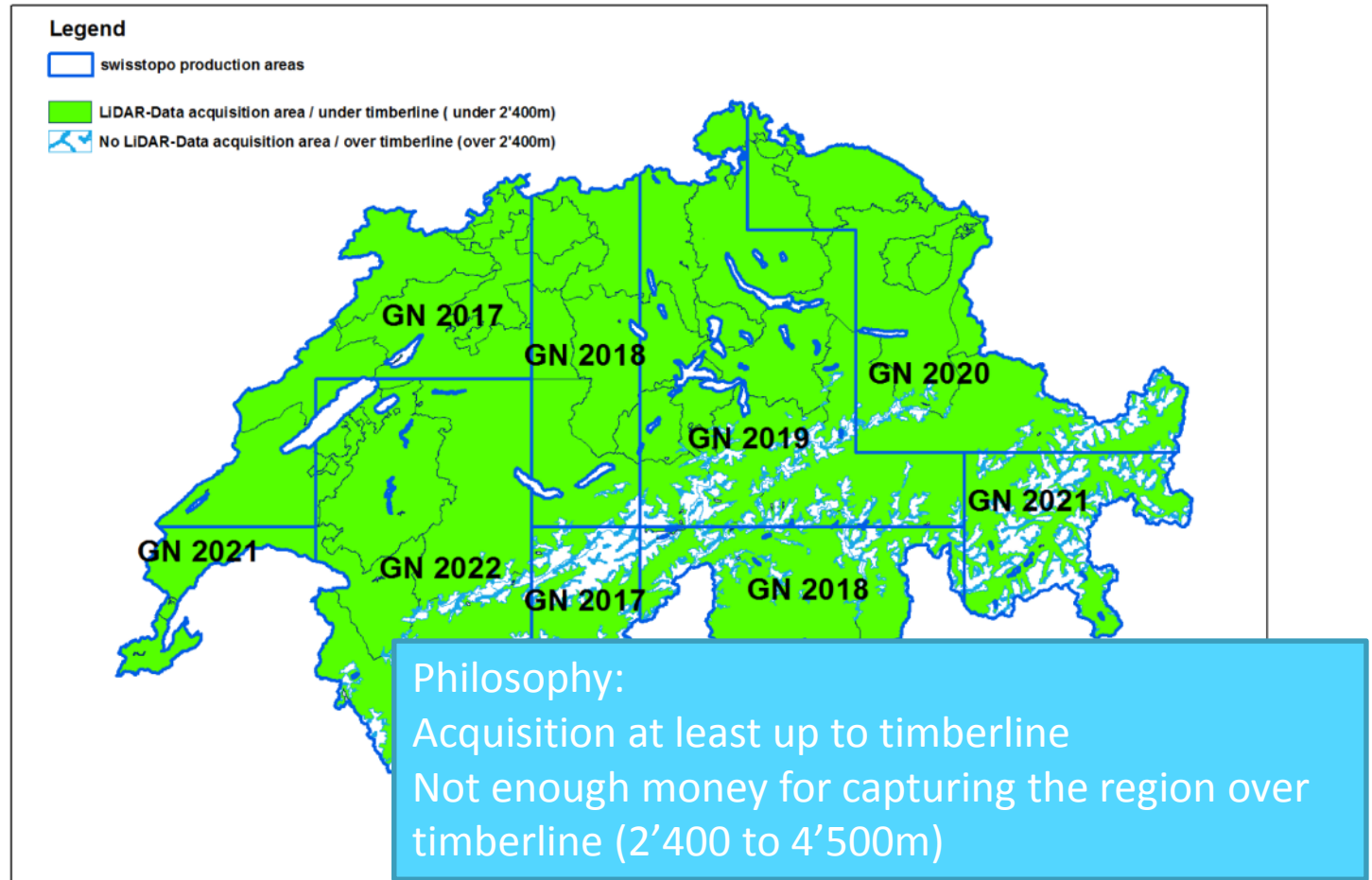
New swissALTI^{3D}

- 0.5m Raster
- Height accuracy $0,30\text{m} < Z < 3\text{m}$ 1 Sigma
- Under timberline based on new LiDAR points and photogrammetry data (points + breaklines)
- Over timberline based on image matching and photogrammetry (points + breaklines)
- Updated in a 6 years cycle with photogrammetry



Looking forward

Characteristics of the new LiDAR-Data





Looking forward

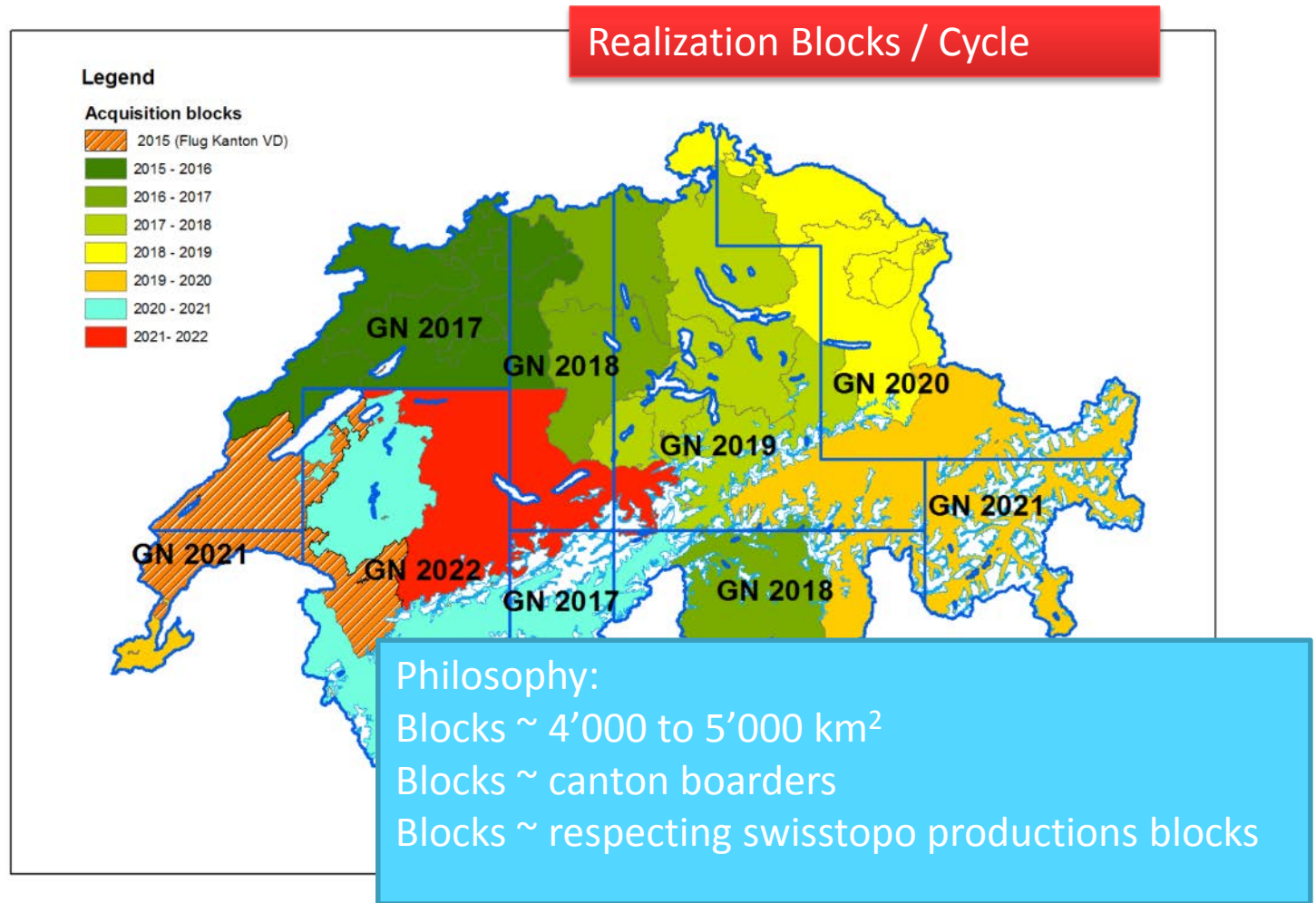
Characteristics of the LiDAR-Data

- The focus is on the production of a DTM. Flights are mainly done in periods with little foliage on the trees!
- Point density: Min 5 Pts./m², Max 8 Pts./m²
No fullwave
- Accuracy Z: 10 cm / X, Y: 20 cm
- Classification: bare earth, vegetation, buildings, bridges, water, rest
- Format: LAS 1.2 / 1 x 1 km²
- Coordinates: LV95/LHN95 / LV95/LN02



Looking forward

Characteristics of the LiDAR-Data





Looking forward

Products

DSM = swissSURFACE^{3D}

- Classified LiDAR-Point Cloud
- LAS 1.2 / 1 x 1km²
- LV95/ LHN95 / LV95/LN02 / CH03/LN02

DTM = swissALTI^{3D}

- Raster DTM 0.50 cm
- Tif, ASCII, File Geodatabase,...
- LV95/LN02 / CH03/LN02

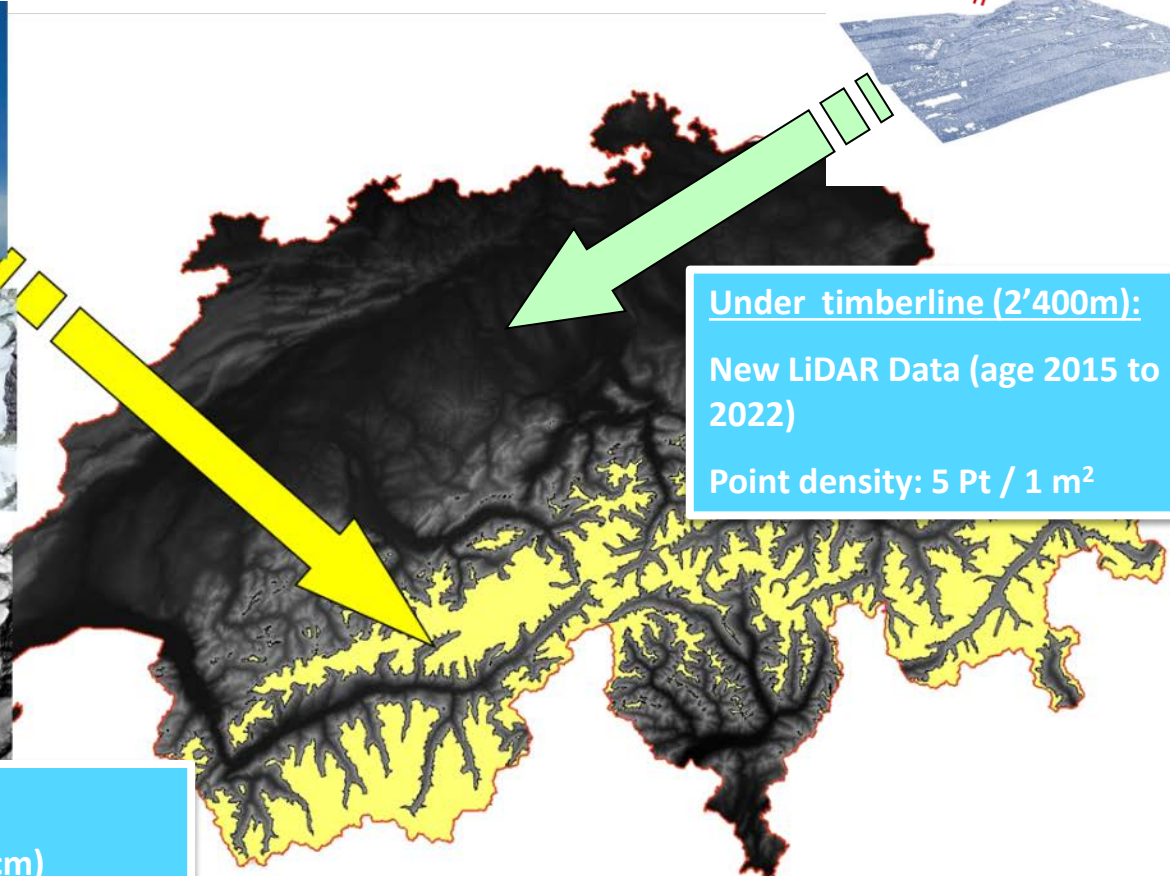
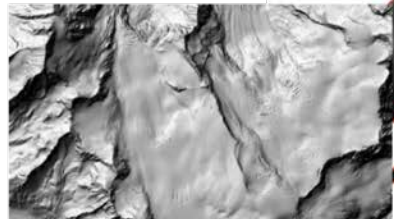
Cost for the data:

Cantons: (cadastral administration):	free
Other:	not defined yet



Looking forward

New swissALTI^{3D} / Buildup



Under timberline (2'400m):
New LiDAR Data (age 2015 to 2022)
Point density: 5 Pt / 1 m²

Over timberline (2'400 m):
Data based on imagery (GSD 25 cm)
(Image matching and photogrammetry)



4. Questions?

