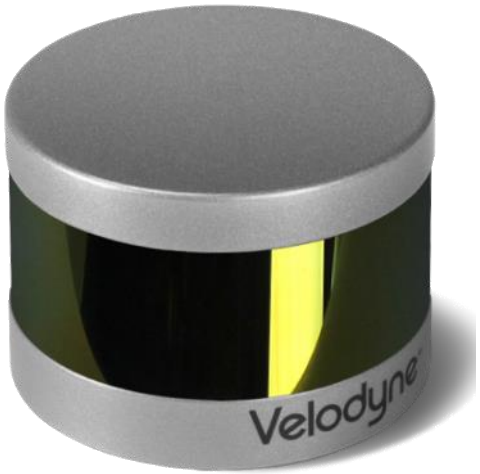
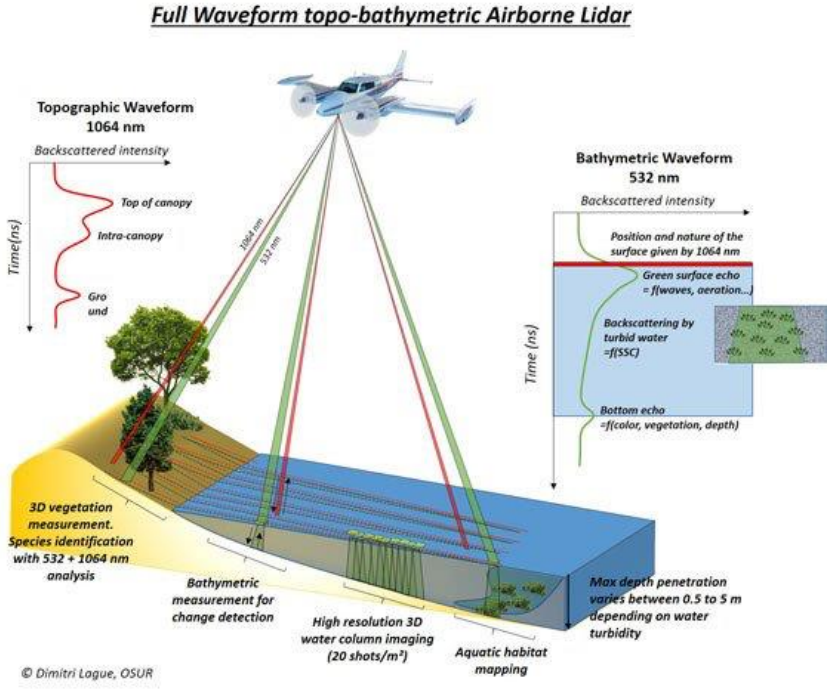
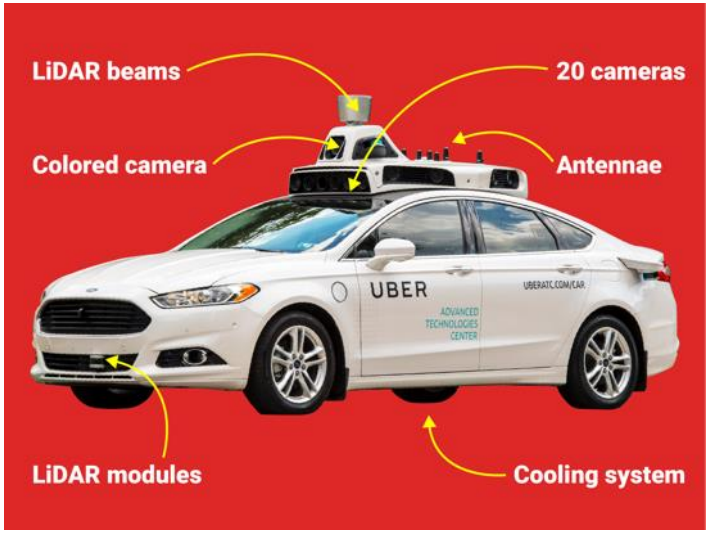
Bruk av LiDAR for modellering av geometri og hydraulikk

Knut Alfredsen
Institutt for bygg og miljøteknikk
NTNU

LiDAR


Velodyne


Full Waveform topo-bathymetric Airborne Lidar
Topographic Waveform
1064 nm
Backscattered intensity
Top of canopy
Intra-canopy
Gro
und
Time(ns)
1064 nm
532 nm
Bathymetric Waveform
532 nm
Backscattered intensity
Position and nature of the surface given by 1064 nm
Green surface echo
= f(waves, aeration...)
Backscattering by turbid water
=f(SSC)
Bottom echo
=f(color, vegetation, depth)
Time (ns)
3D vegetation measurement. Species identification with 532 + 1064 nm analysis
Bathymetric measurement for change detection
High resolution 3D water column imaging (20 shots/m²)
Aquatic habitat mapping
Max depth penetration varies between 0.5 to 5 m depending on water turbidity
© Dimitri Lague, OSUR

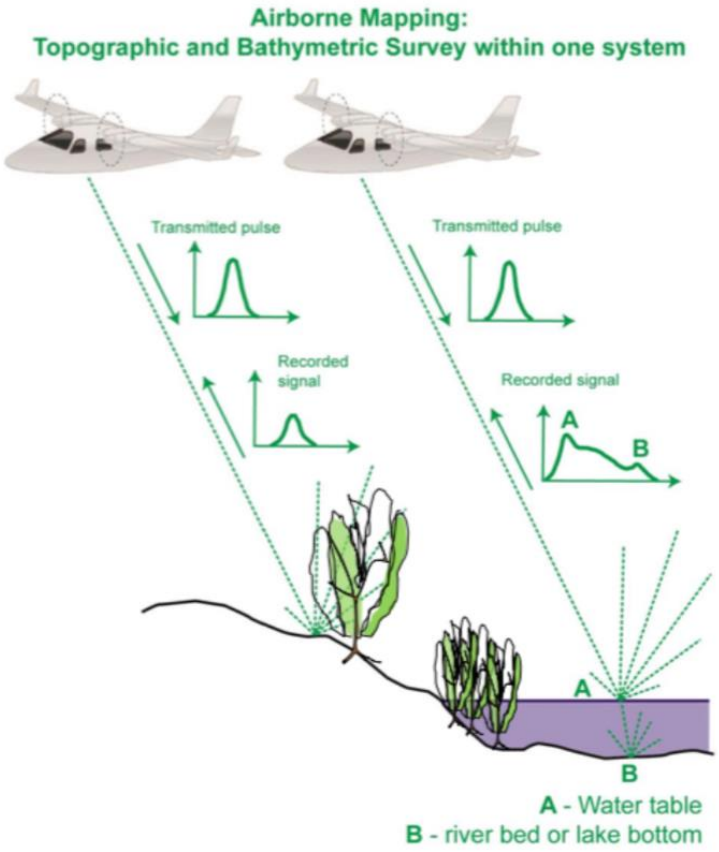

LiDAR beams
20 cameras
Colored camera
Antennae
UBER
LiDAR modules
Cooling system

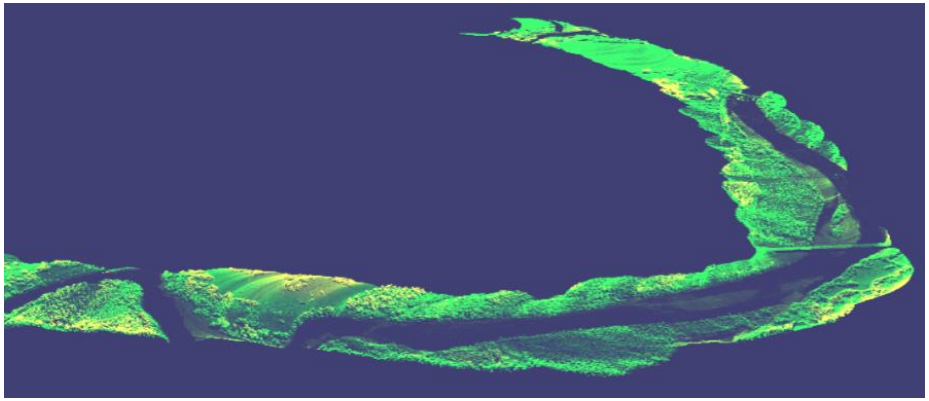
NTNU

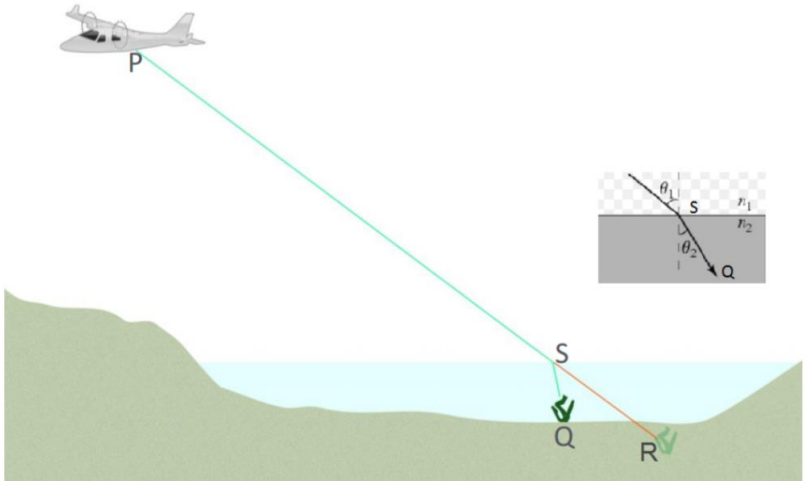
Kvifor LiDAR innan hydrologi?

- Svært presise terrengmodellar
  - Grunnlag for å finne hydrologiske data
  - Basis for detaljerte fordelte hydrologiske modellar
- For å sjå på endring i geometri
  - erosjon/sedimentering
- Grunnlag for modellering av hydraulikk
  - Ulike problemstillingar i vassdrag
  - Detaljert geometri gir bedre modellar
  - Modellering av strømning over terreng - flom

LiDAR

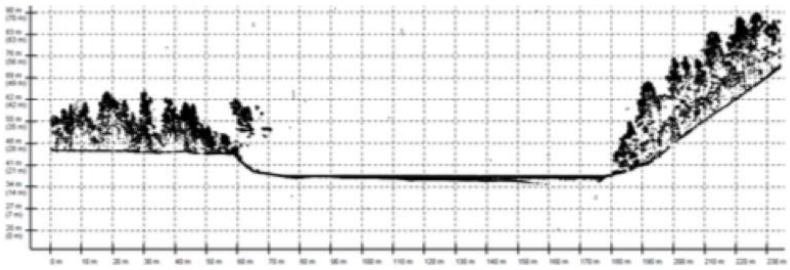




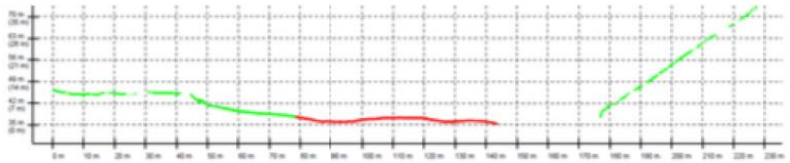


Preprocessing → Removal of Flaw Echoes → Classification → Correction of Refraction → Data Export

Dataprossesering



(a) Unclassified cross section

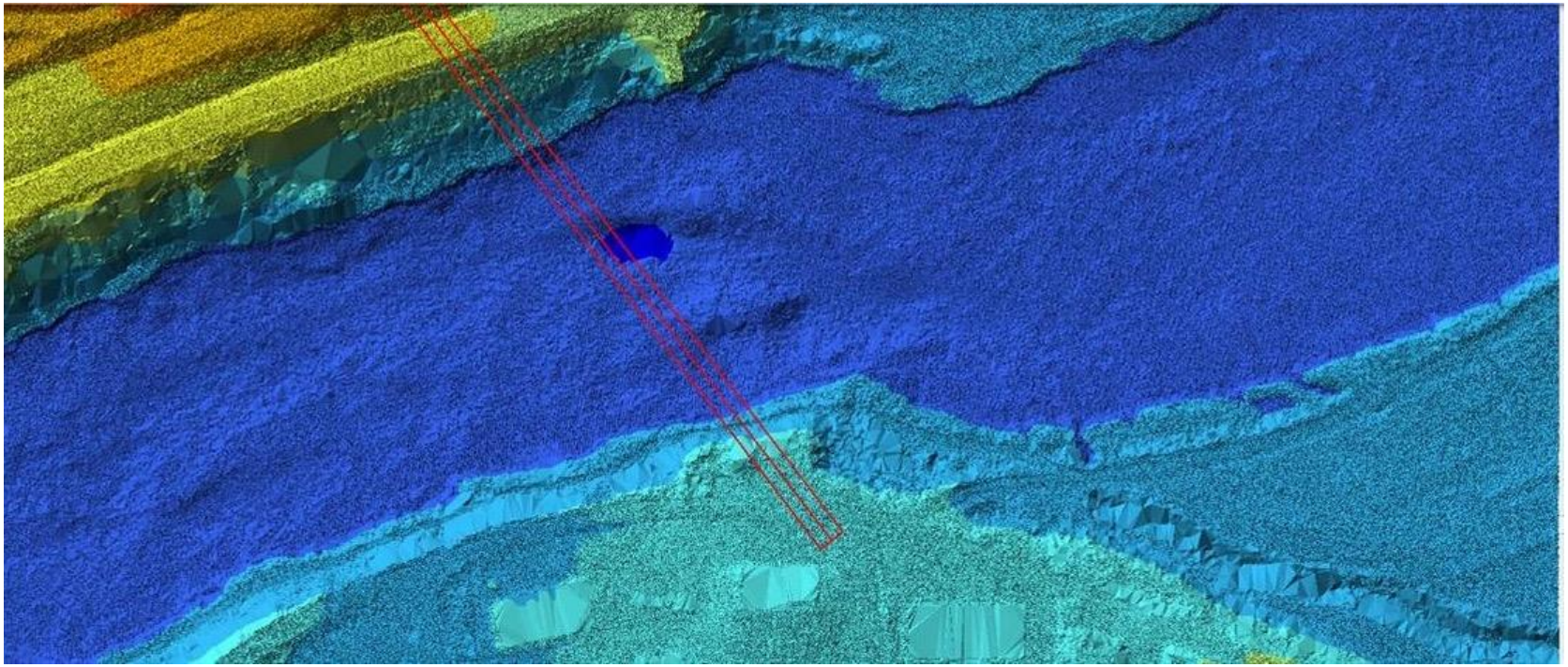


(b) Classified cross sections with river bed (red) and banks (green)

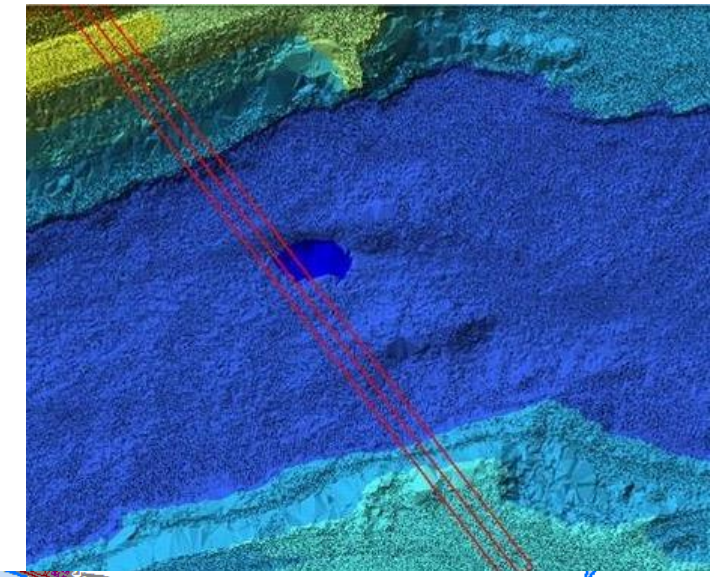
ALB Survey → GCP Measurements → Georeferencing → Post Processing → End User LiDAR Data

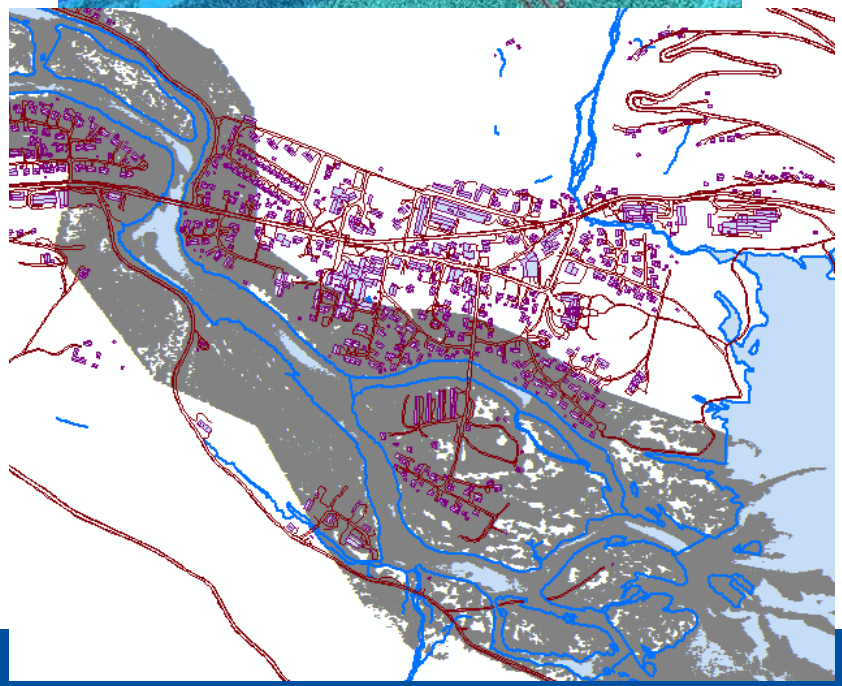
Data

- Punktdata på LAS format – klassifiserte etter type
- Ulike produkt, t.d. 1 x 1 meter terrengmodell, tverrprofil
- LAS gir størst fleksibilitet – lage eigne terrengmodellar med den oppløysinga ein vil ha.

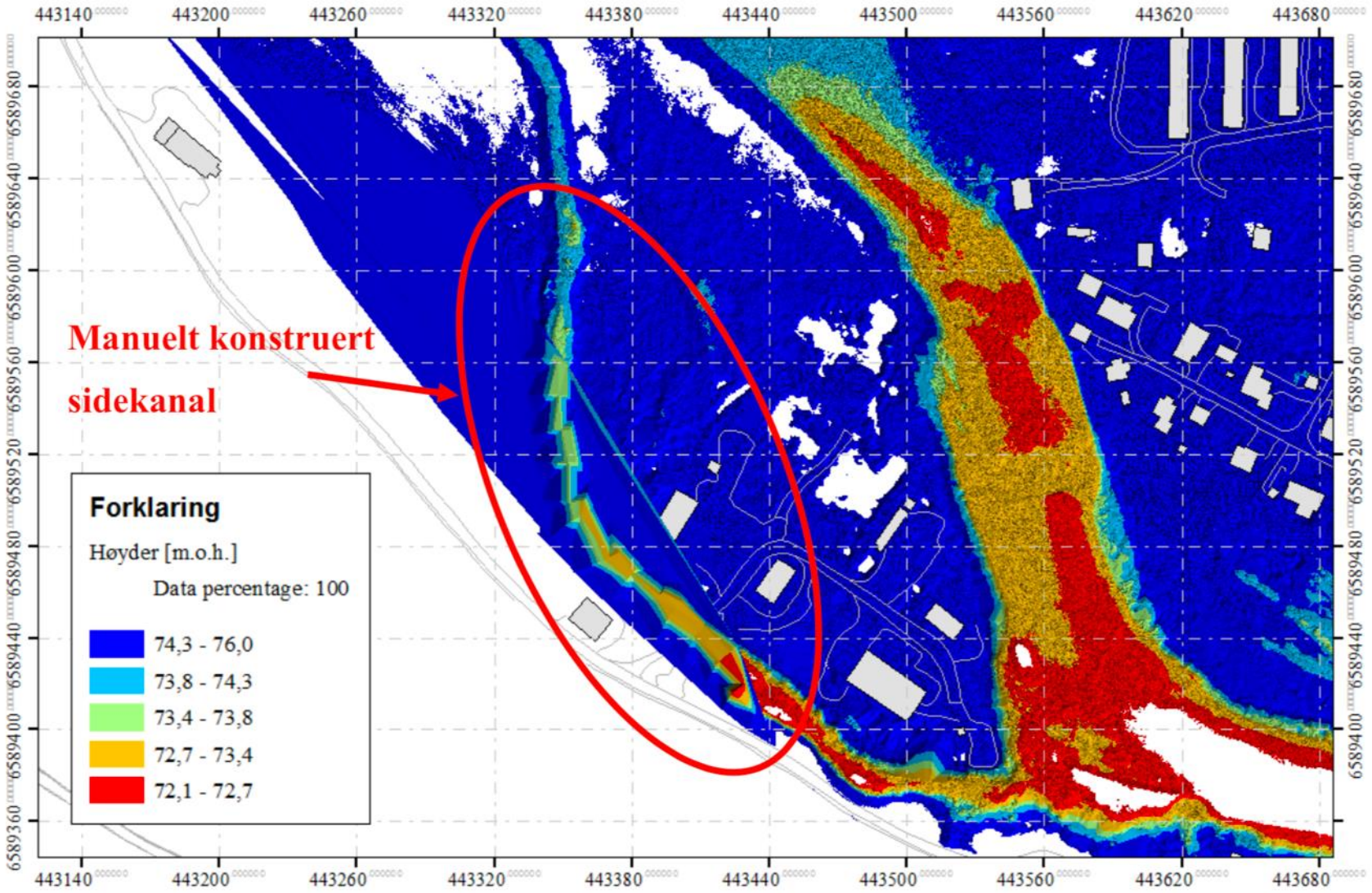


Manglande data ved bruk av grøn laser



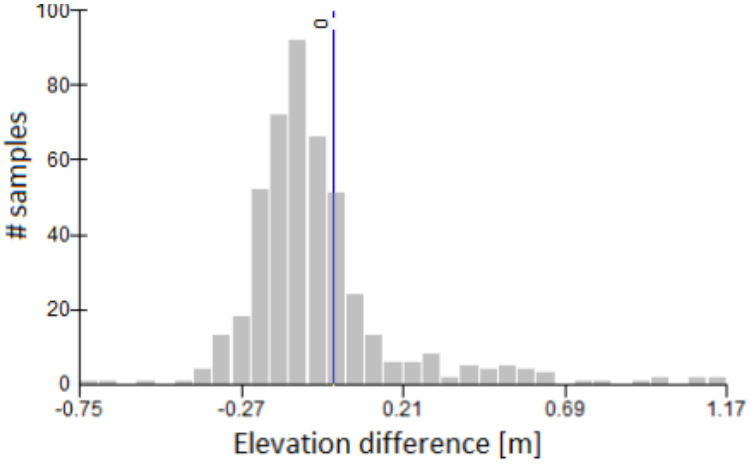


Manglande data

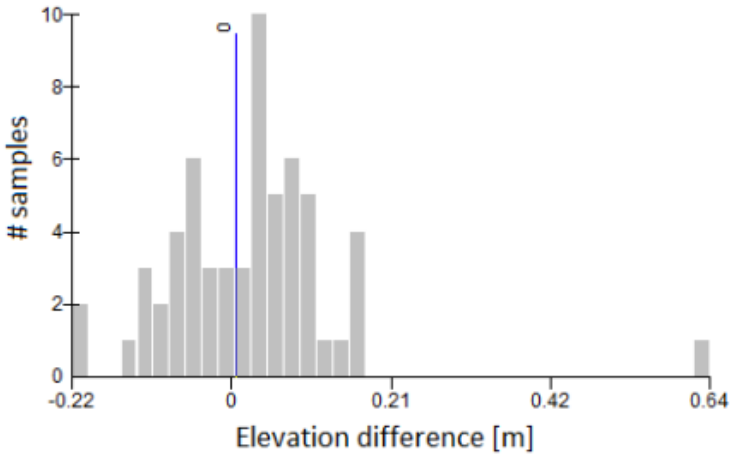


L. Skeie (2016) "Hydraulisk modellering av kraftverksdrift i Tokkeåi " MSc. NTNU

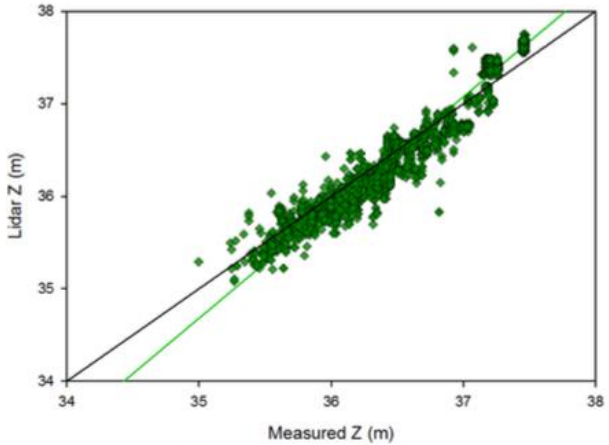
Vurdering av data - Ljungan



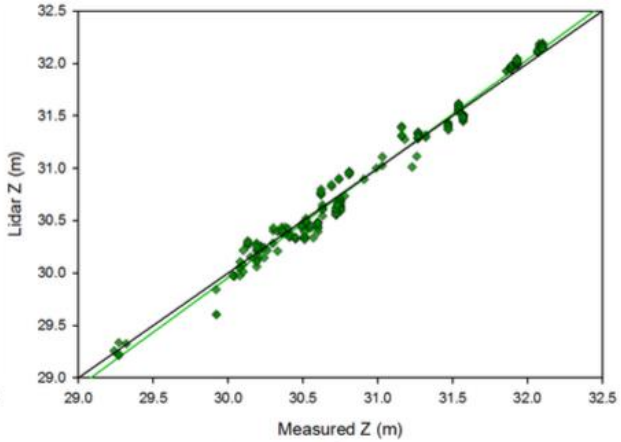
(a) Deep glide



(b) Pool



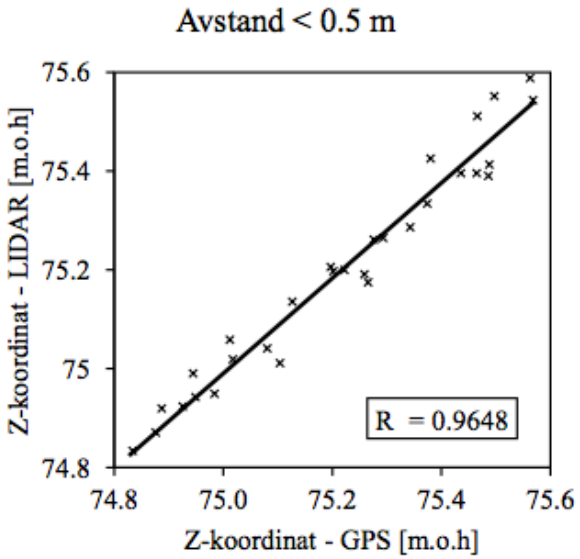
(a) Deep glide R^2=0.97

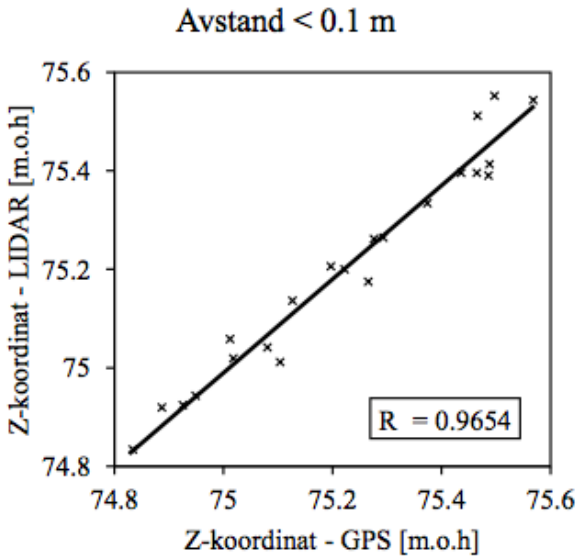


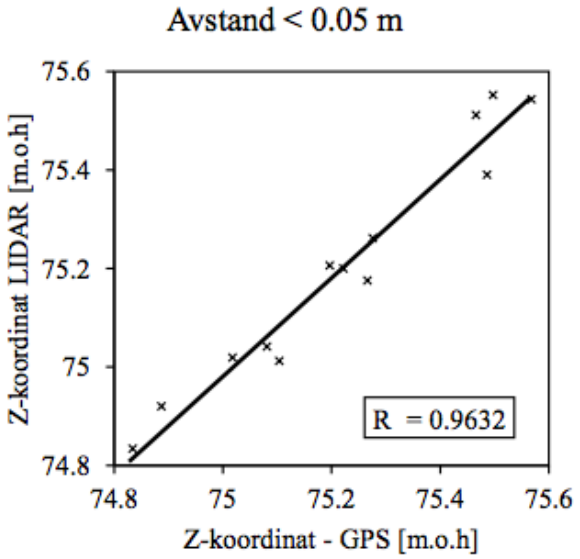
(b) Pool R^2=0.98

Målt på djupt vatn med DPGS og sonar. Basert på næraste punkt.
Omrekna til ortometrisk med gjennomsnitsverdi

Vurdering av data - Tokke

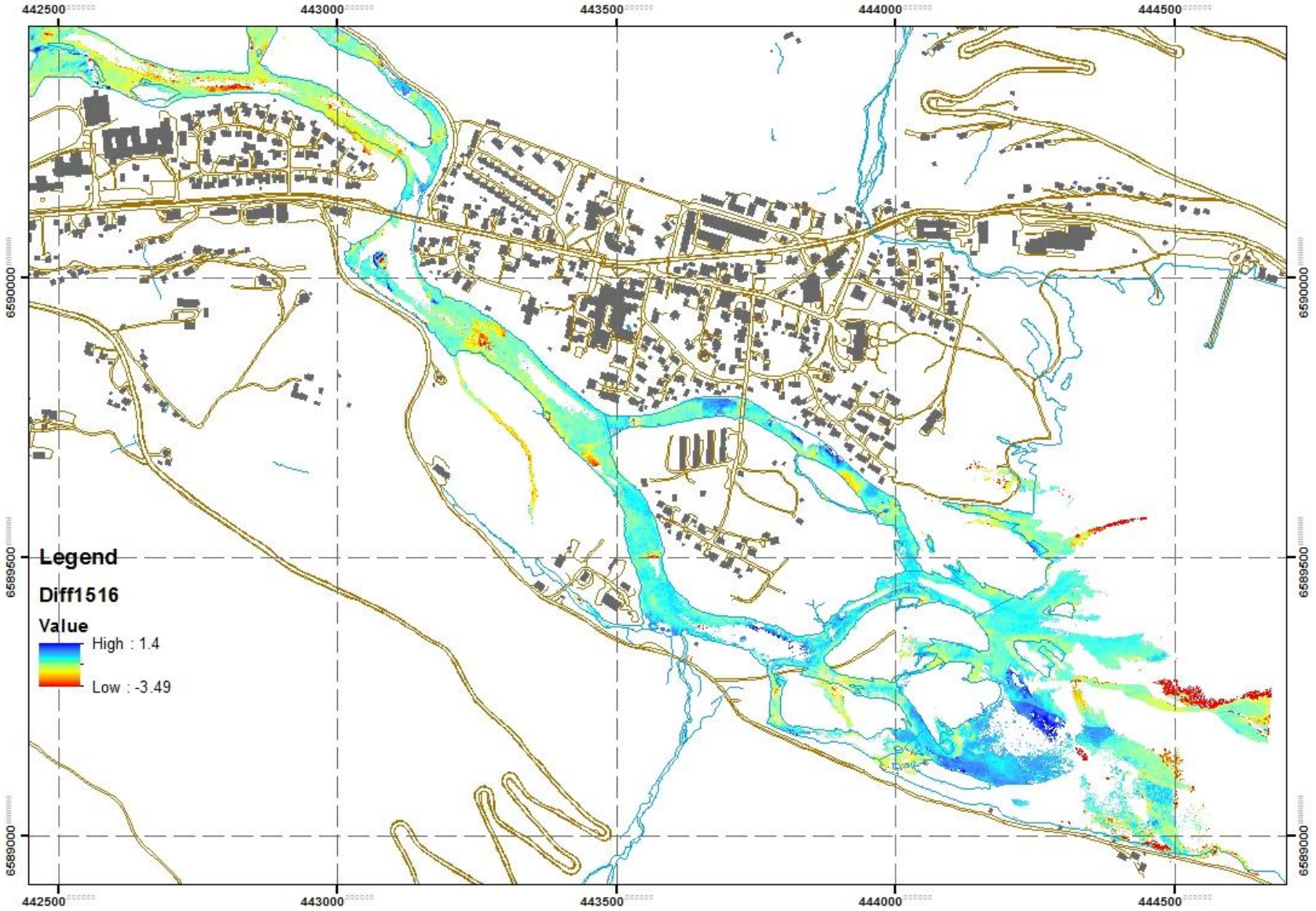




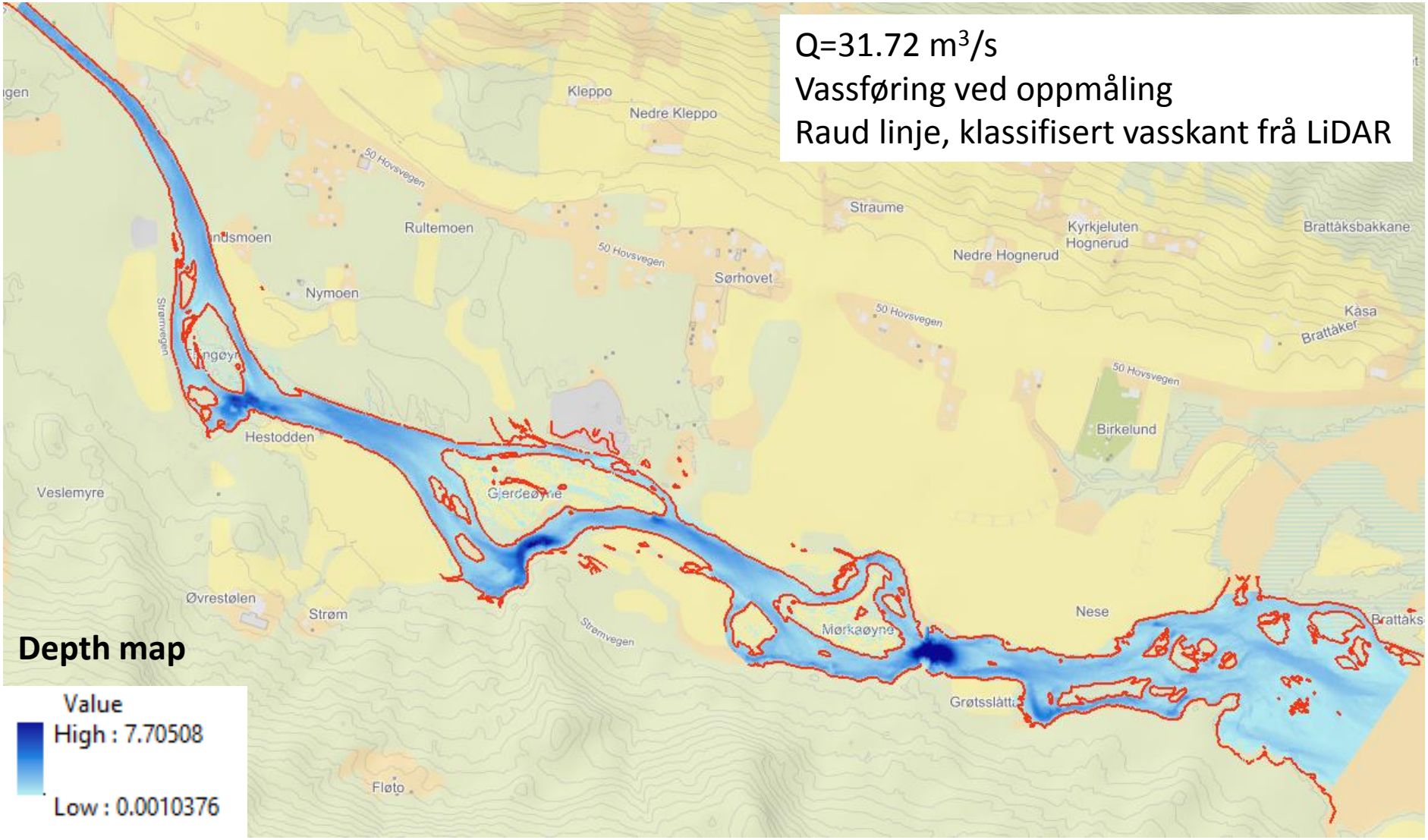


Sted	Avstand [m]	Antall data [-]	Middelfeil [m]	Standardavvik [m]	R^2 [-]
Fotballbane ved skolen (GPS)	0.5	29	0.16	0.035	0.85
	0.1	20	0.15	0.035	0.86
	0.05	13	0.14	0.031	0.84
Buøy camping (GPS)	0.5	31	0.017	0.044	0.96
	0.1	23	0.021	0.044	0.97
	0.05	14	0.019	0.049	0.96
Nedstrøms bru (ADCP)	1	1788	-0.021	0.29	0.72
	0.5	1647	-0.0087	0.27	0.75
	0.1	598	0.049	0.23	0.71
	0.05	185	0.054	0.23	0.68
Oppstrøms Buøy (ADCP)	1	221	-0.070	0.16	0.88
	0.5	149	-0.079	0.17	0.80
	0.1	42	-0.028	0.14	0.85
	0.05	11	-0.0071	0.13	0.87

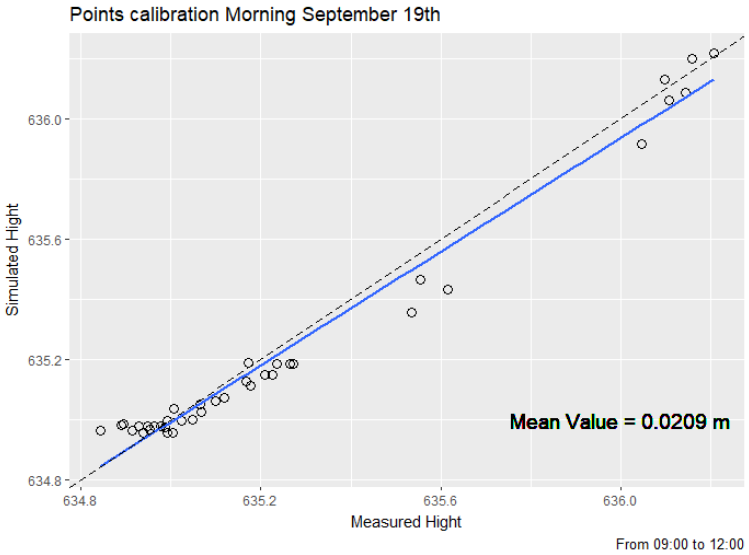
Endring i geometri

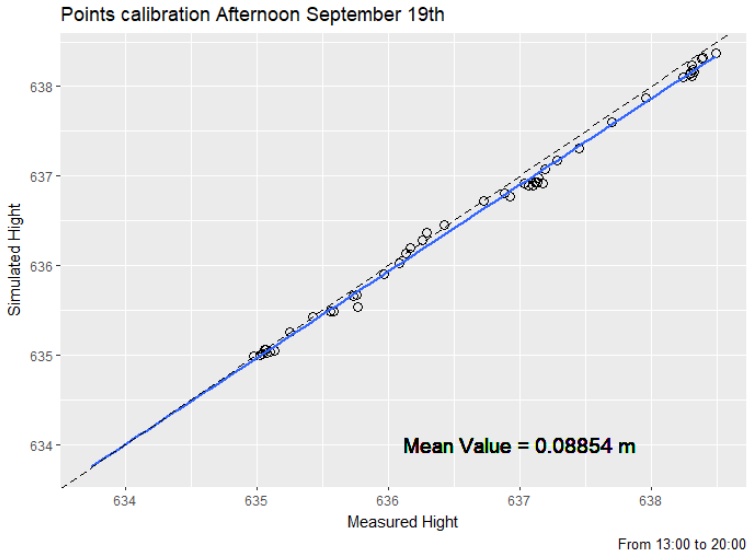


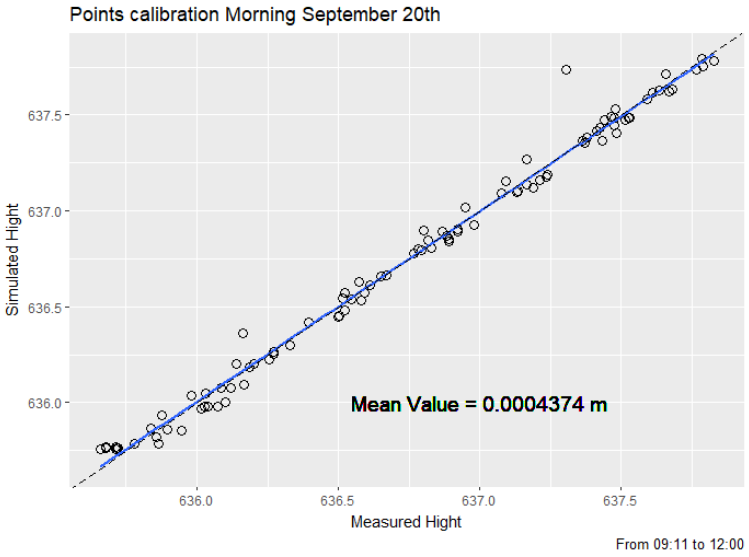
Modellering av tørrlegging

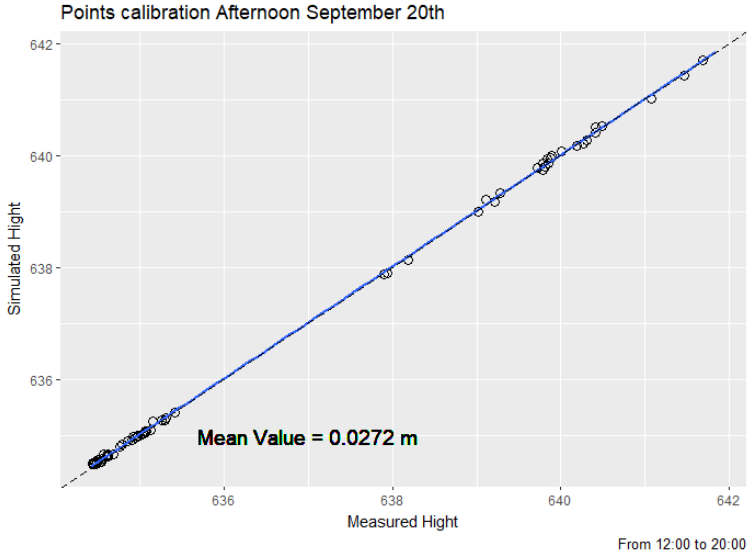


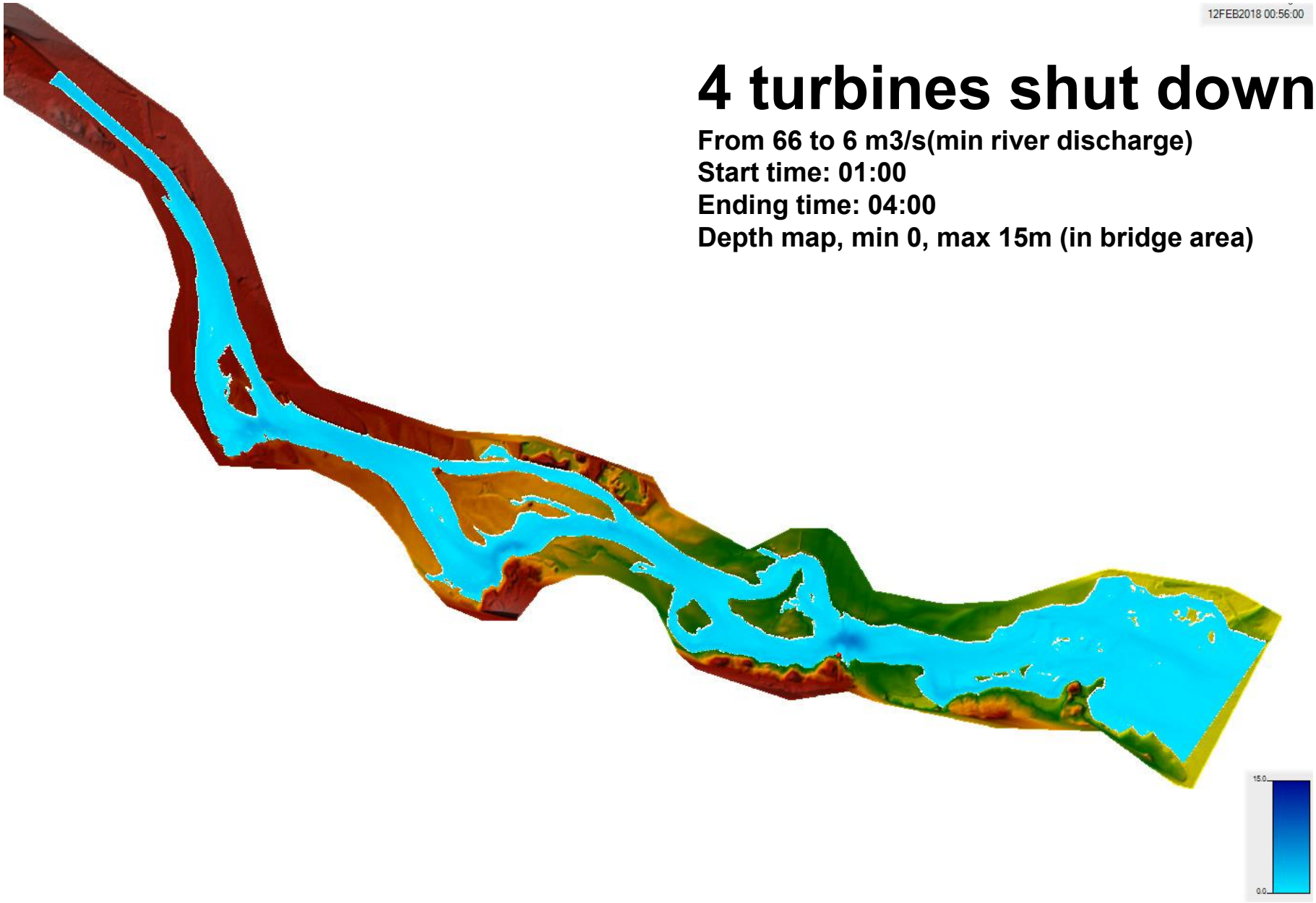
Kontroll målt vannlinje







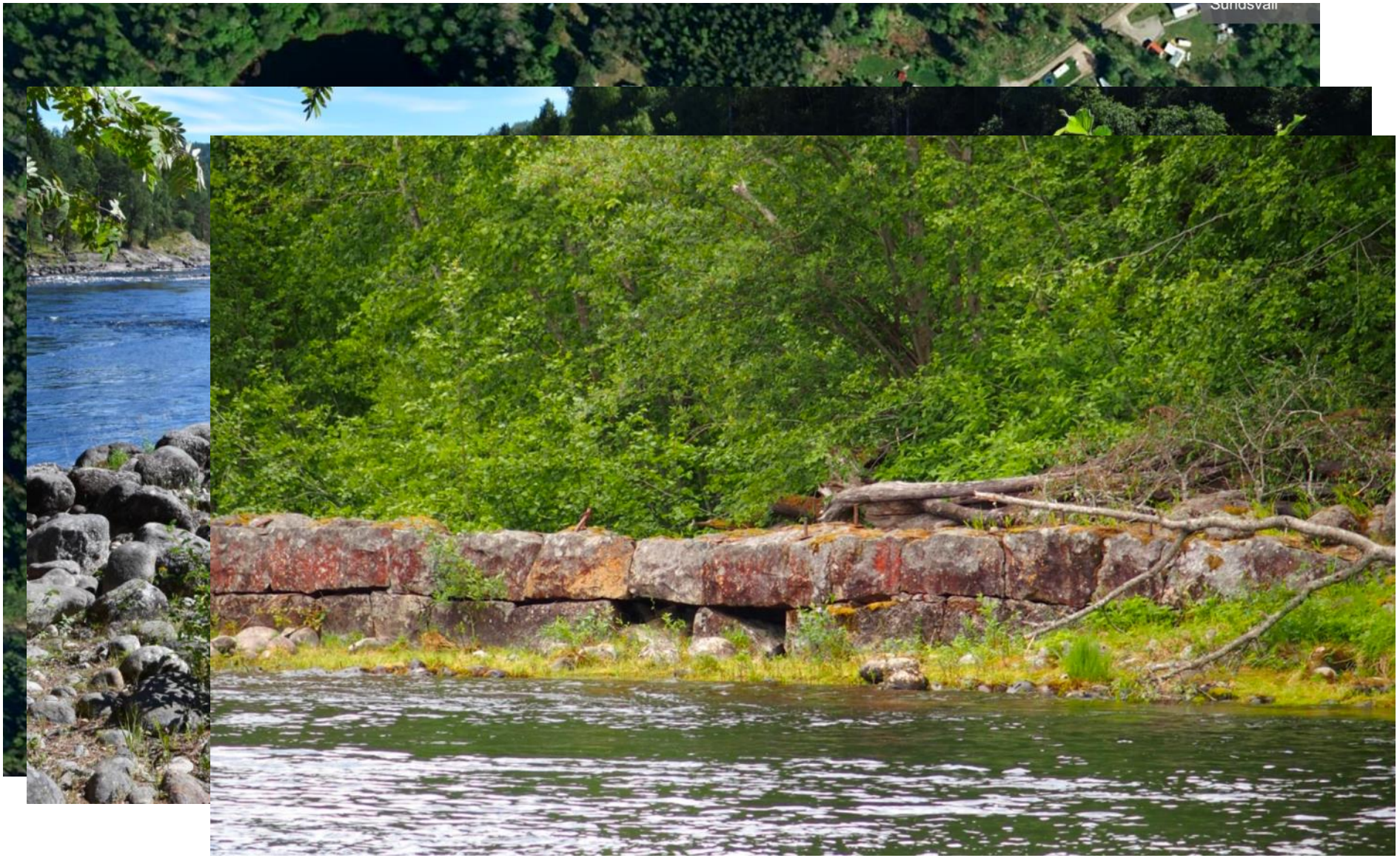


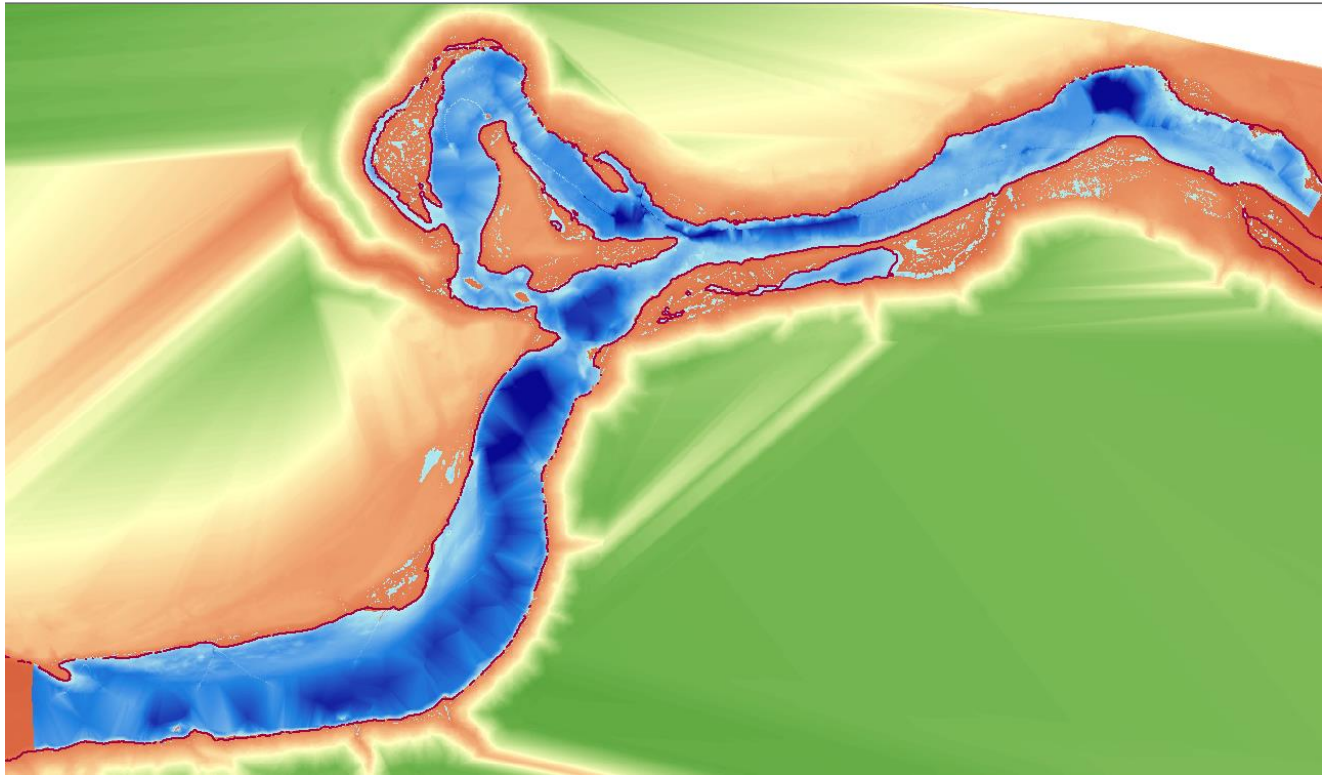


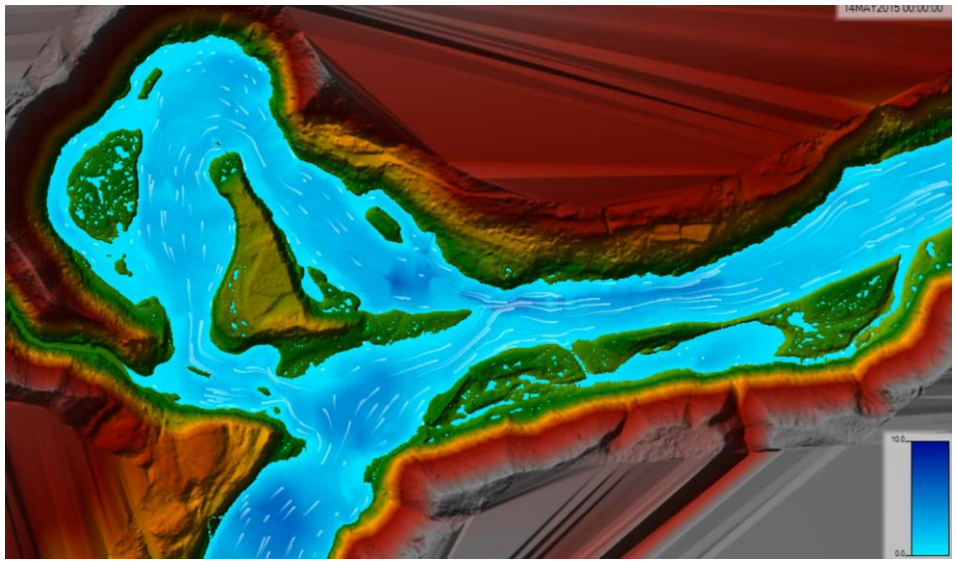
4 turbines shut down

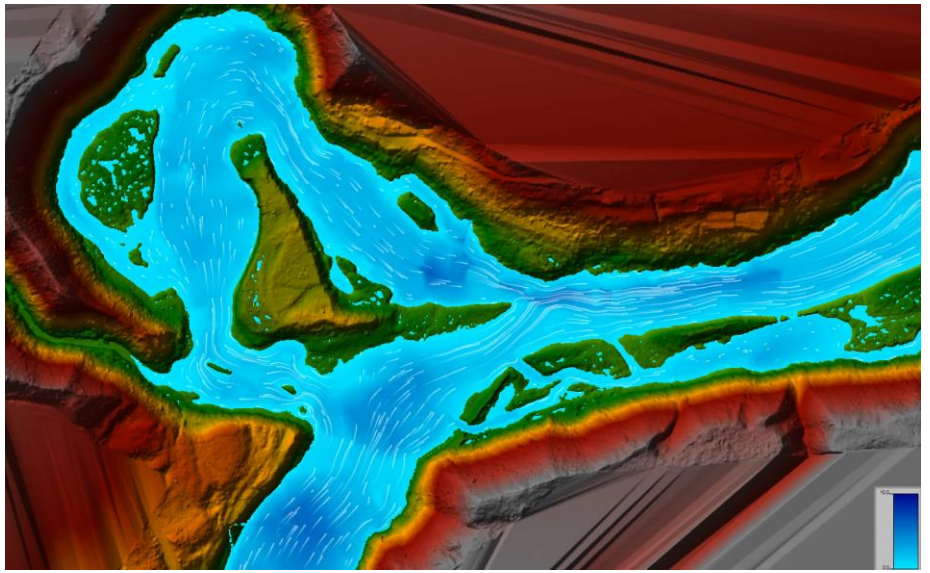
From 66 to 6 m3/s(min river discharge)
Start time: 01:00
Ending time: 04:00
Depth map, min 0, max 15m (in bridge area)

Restaurering av vassdrag

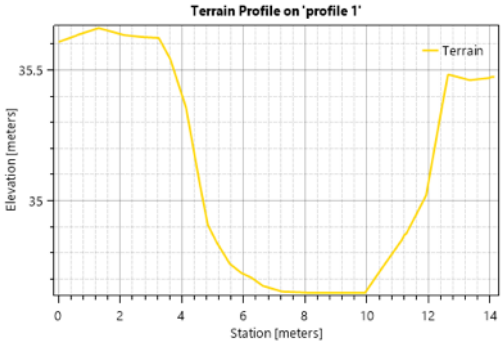


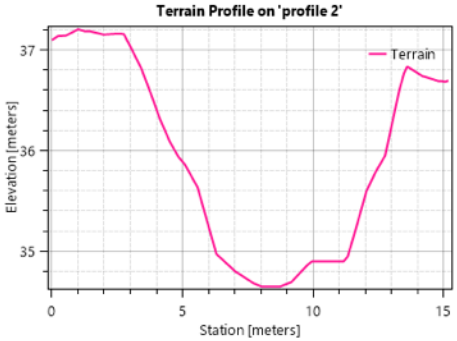


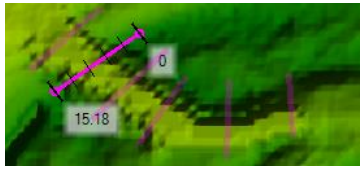


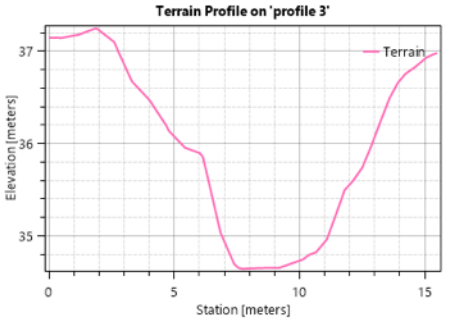


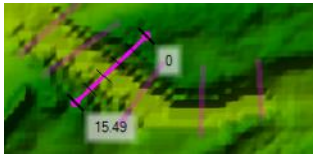
Utforming av ny kanal

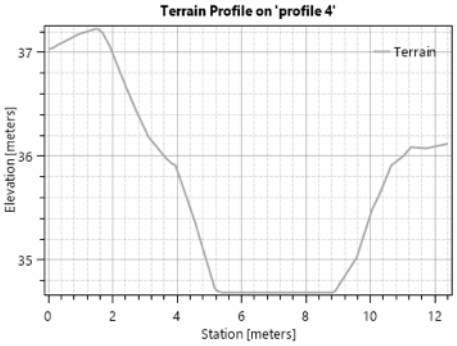


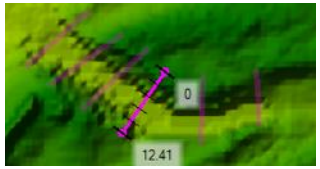


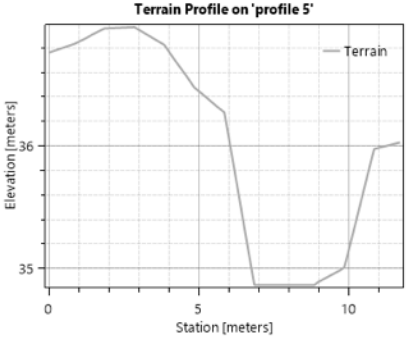


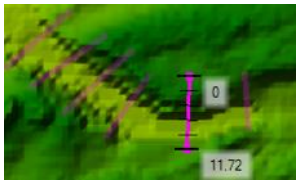


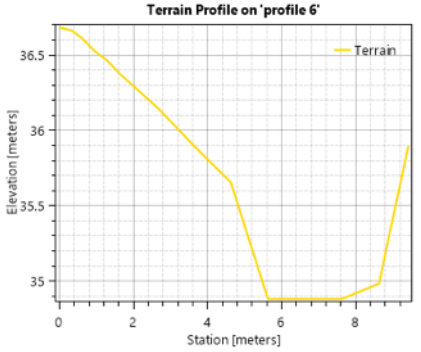






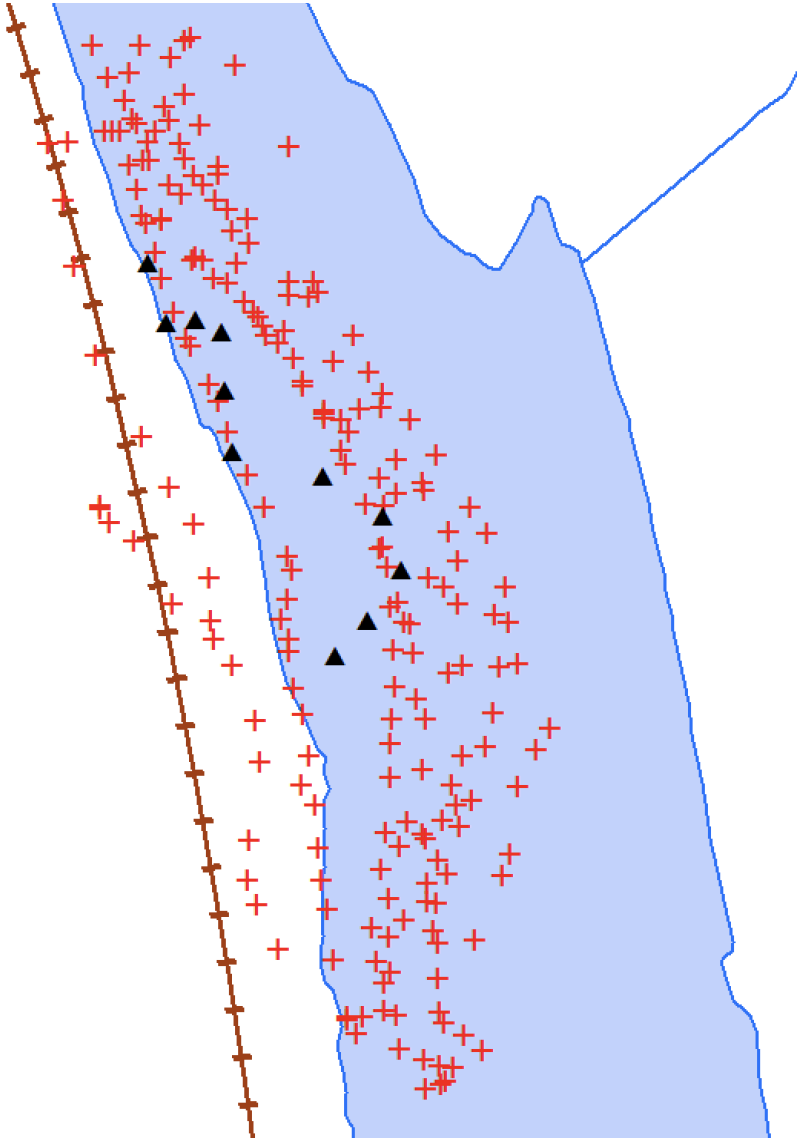






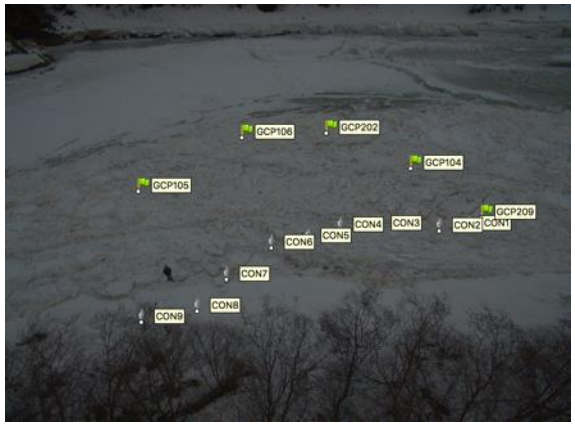
Grenforsen – etter endringar

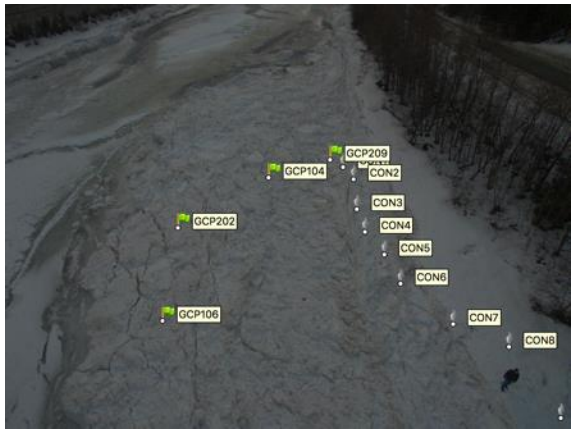
Kopling LiDAR andre geometridata



Structure from motion

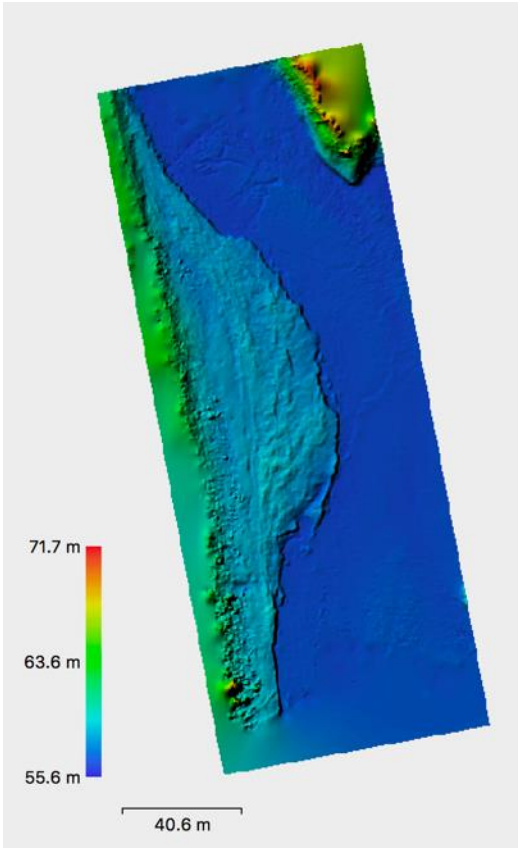
Bilete med kontrollpunkt



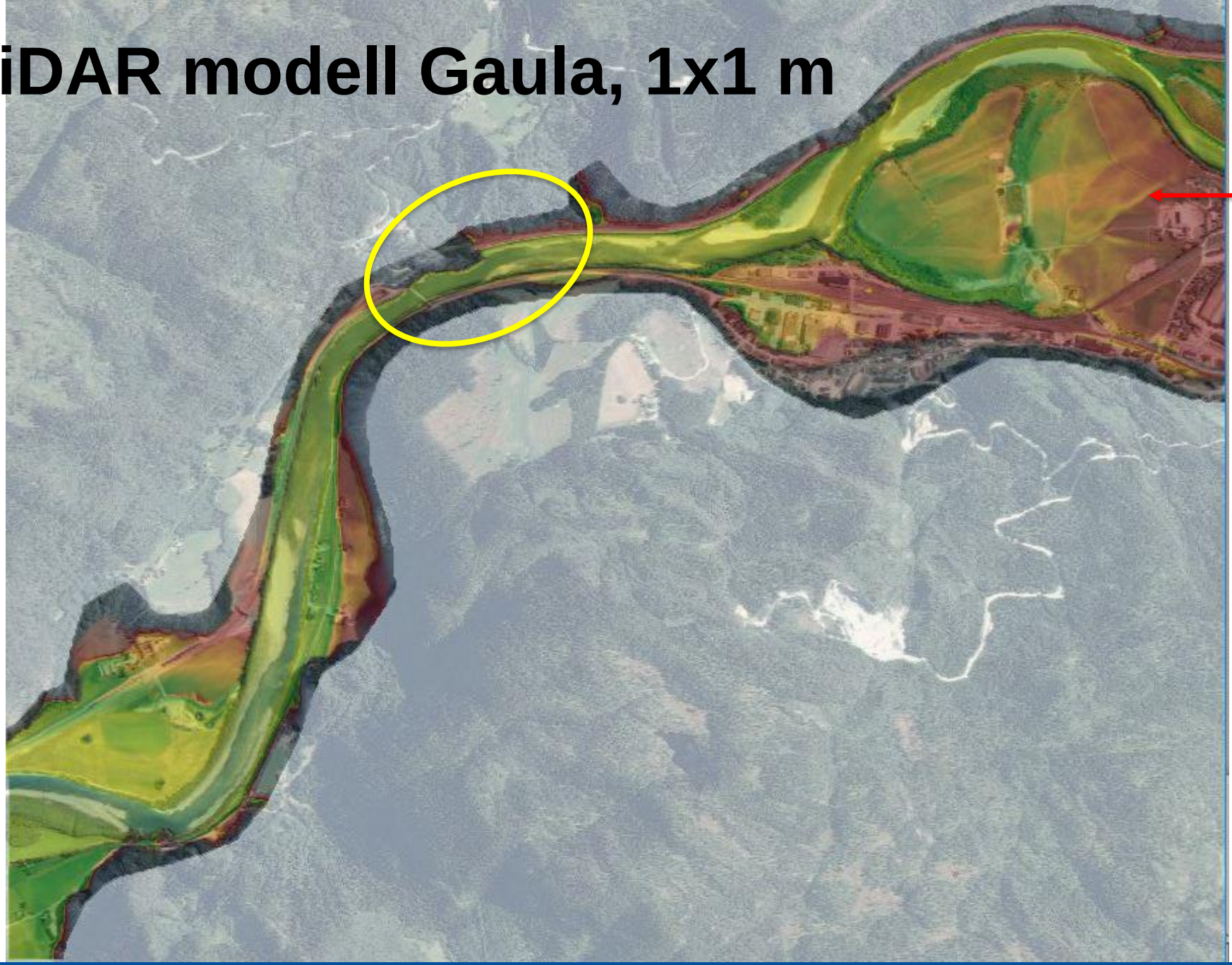


Punktsky

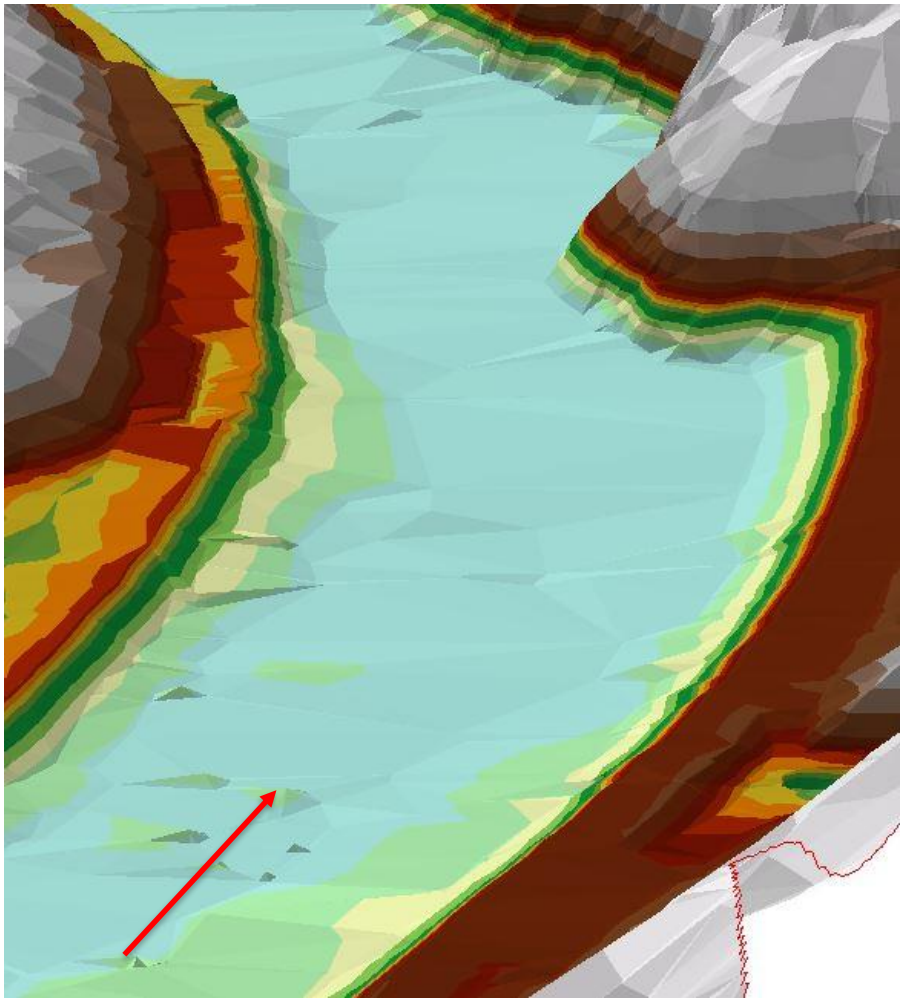
Digital Terreng Modell

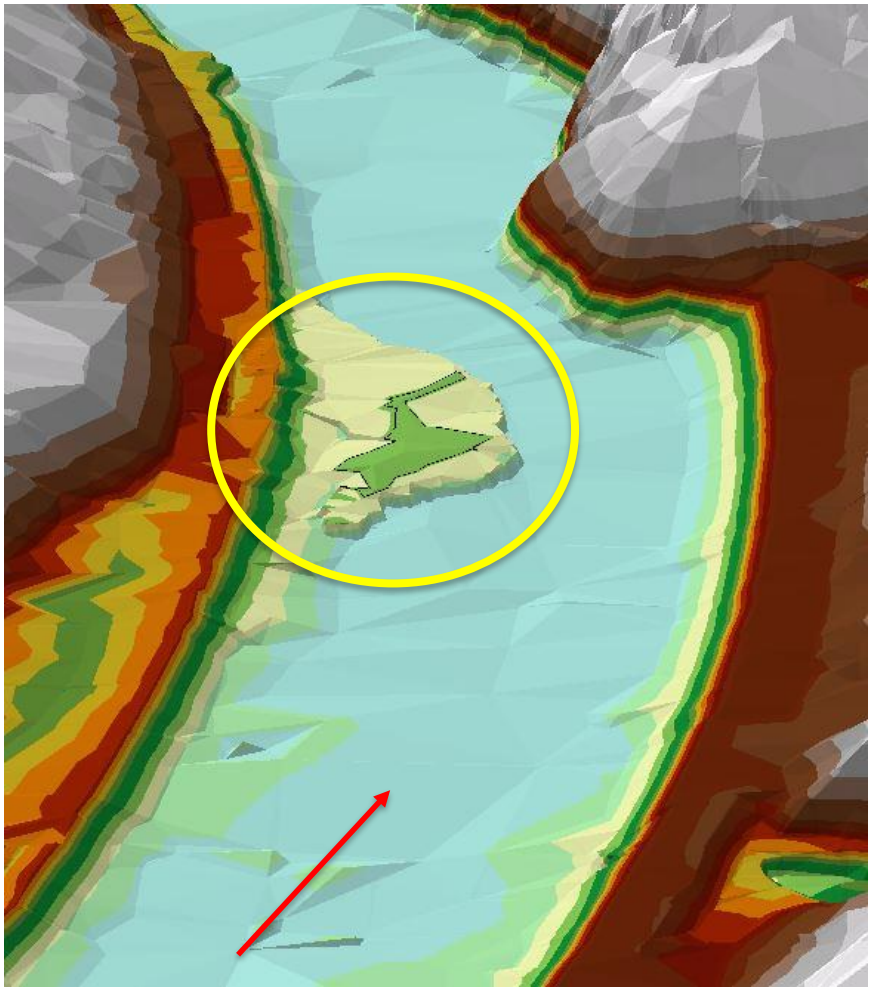


LiDAR modell Gaula, 1x1 m

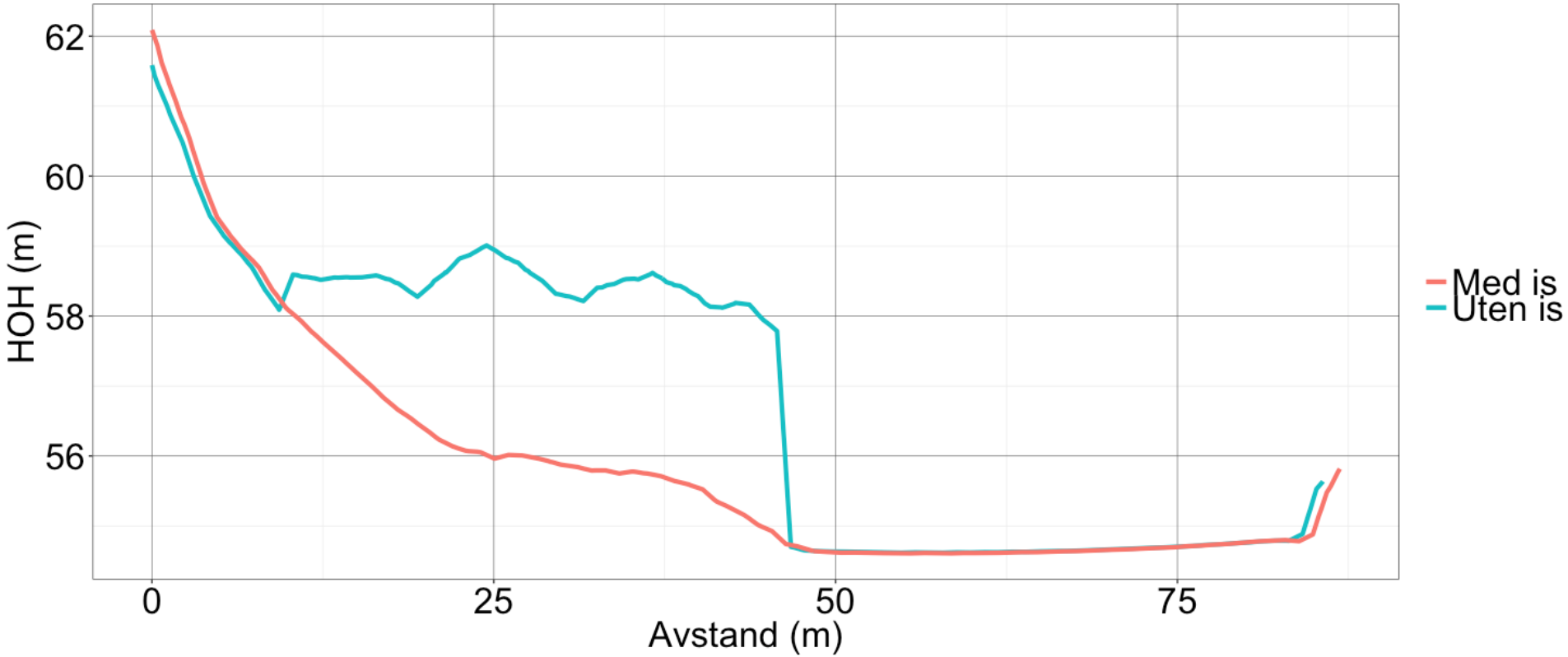


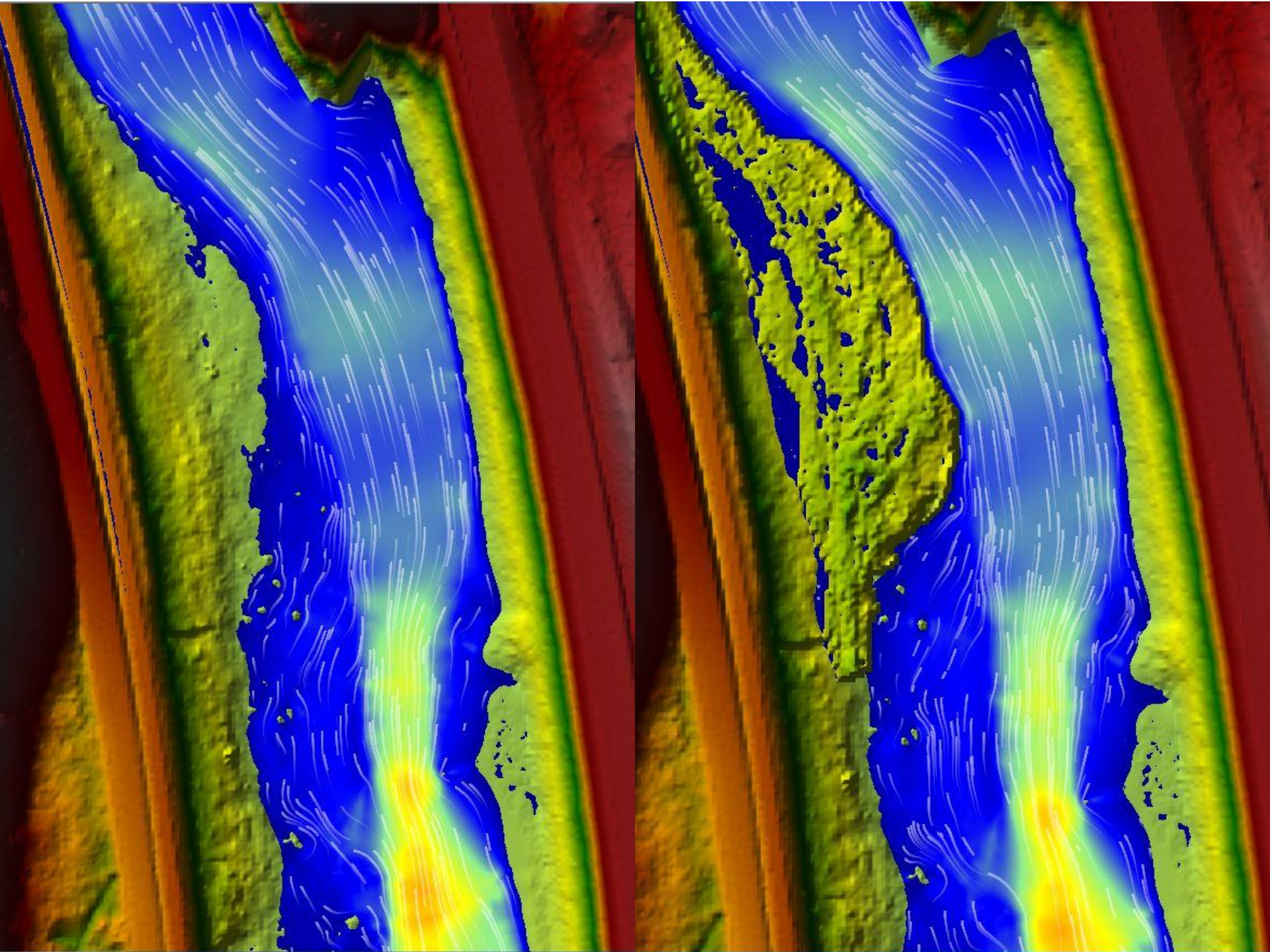
Batymetri med og utan is





Tverrprofil





Oppsummering

- Effektiv måte å skaffe svært detaljerte datasett
- Presisjonen verkar å vere god.
- Grunnlag for analyse av terreng - t.d. erosjon
- Svært godt grunnlag for modellering innan hydrologi og hydraulikk

Takk til: Ingrid Alne, Ragnhild Hammeren, Ana Adeva Bustos, Carole Rozier, Aurelie Gosset, Iacopo Muscara,Lars Skeie, Konstantina Papanikolaeu og Ana Juarez.

Morten Stickler, Bjørn Otto Dønnum og NVE for data.