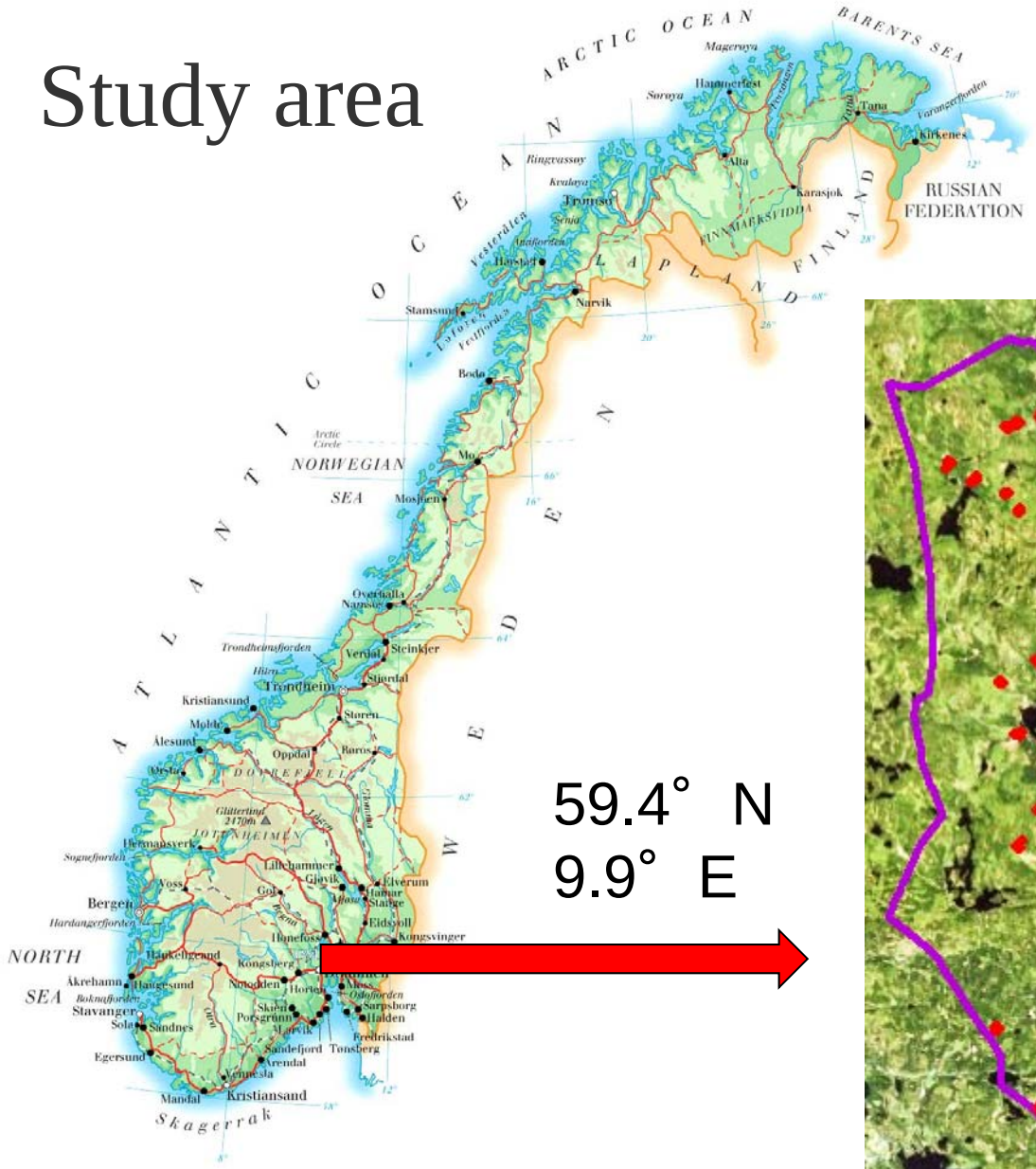
Monitoring forest biomass with Tandem-X

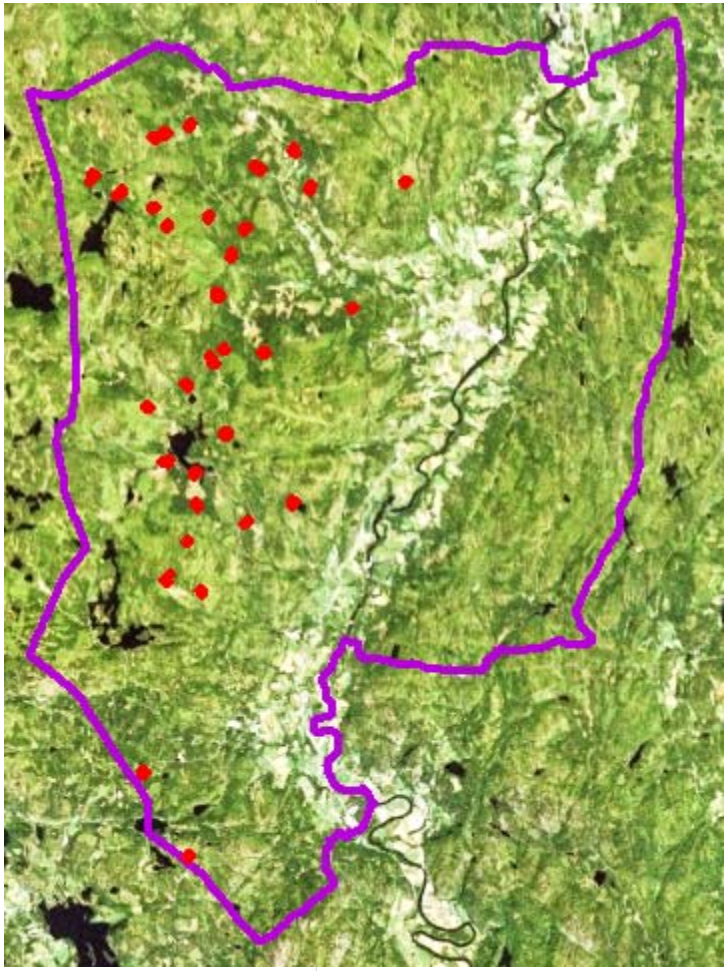
Svein Solberg, Rasmus Astrup

Norwegian forest and landscape institute

4th TanDEM-X Science Team Meeting
10-14 June 2013
German Aerospace Center (DLR)

Study area



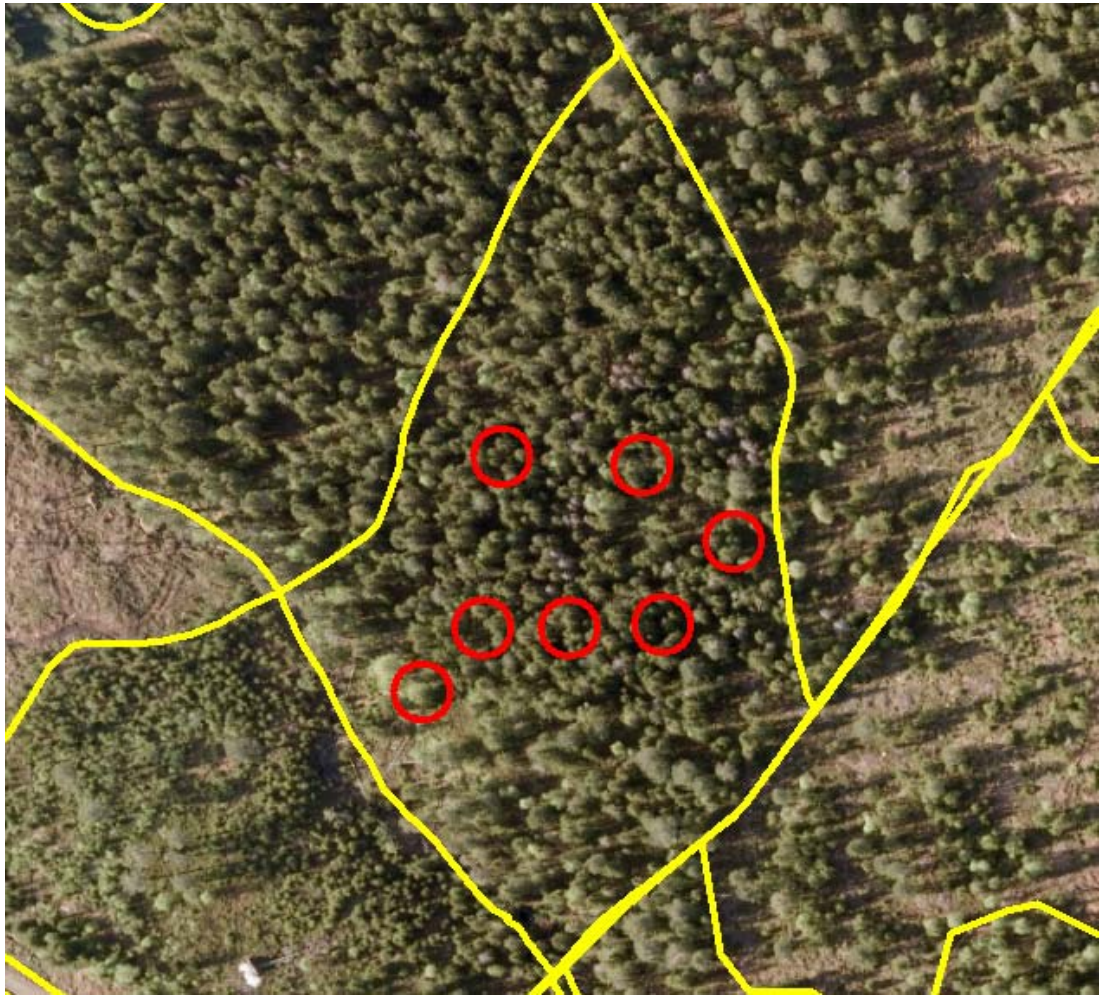


skog+ landskap

NORWEGIAN FOREST AND LANDSCAPE INSTITUTE

Study design

192 plots, 7 plots within selected spruce dominated stands



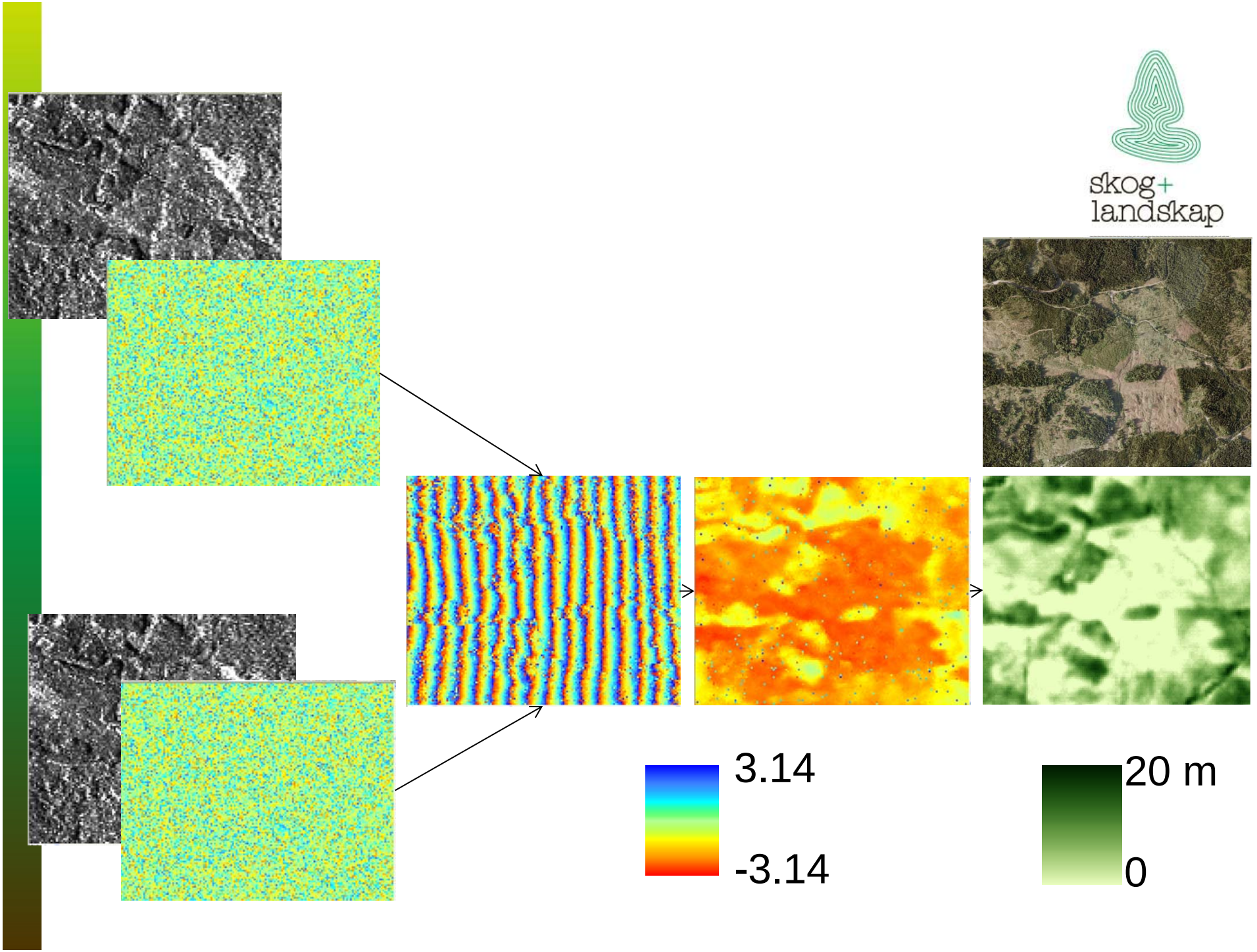
skog+ landskap

NORWEGIAN FOREST AND LANDSCAPE INSTITUTE

Processing CoSSC -> Insar height

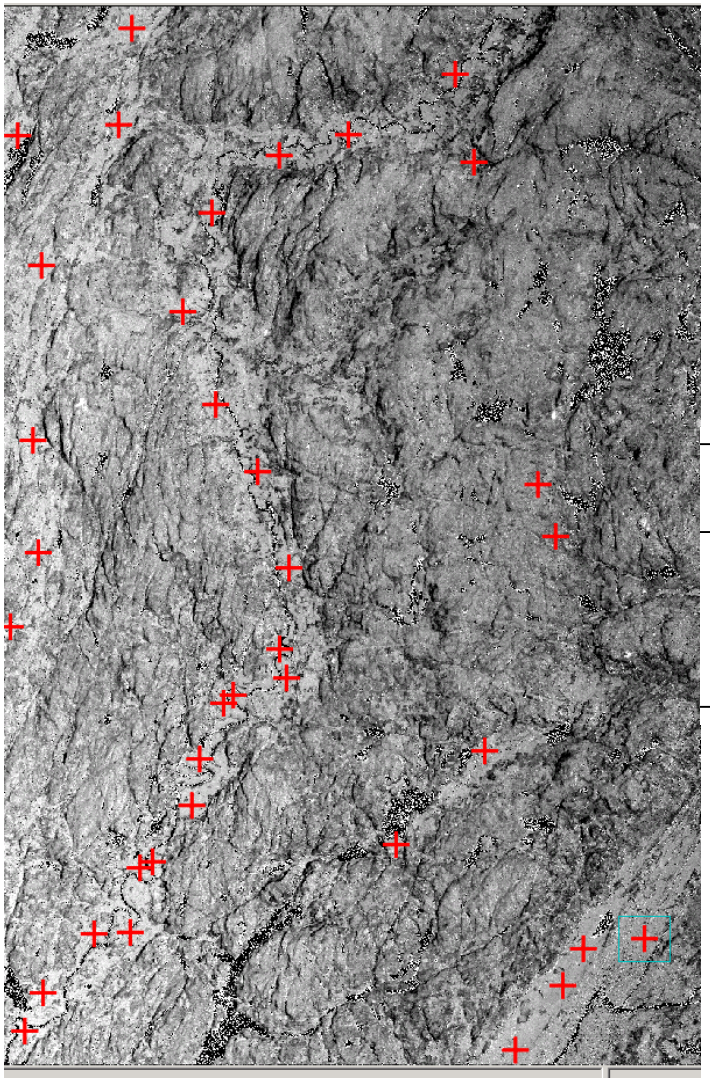
skog+ landskap
NORWEGIAN FOREST AND LANDSCAPE INSTITUTE

- Interferogram generation
- Removal of range and topograhy dependent phase diffs
- Phase noise filtering
- Phase offset and ramp removal
- Phase unwrapping
- Phase to height conversion and geocoding
- Subtraction of DTM


skog+
landskap
3.14
-3.14
20 m
0

Removing phase offset and ramp with GCPs in high coherence areas

skog+ landskap
NORWEGIAN FOREST AND LANDSCAPE INSTITUTE



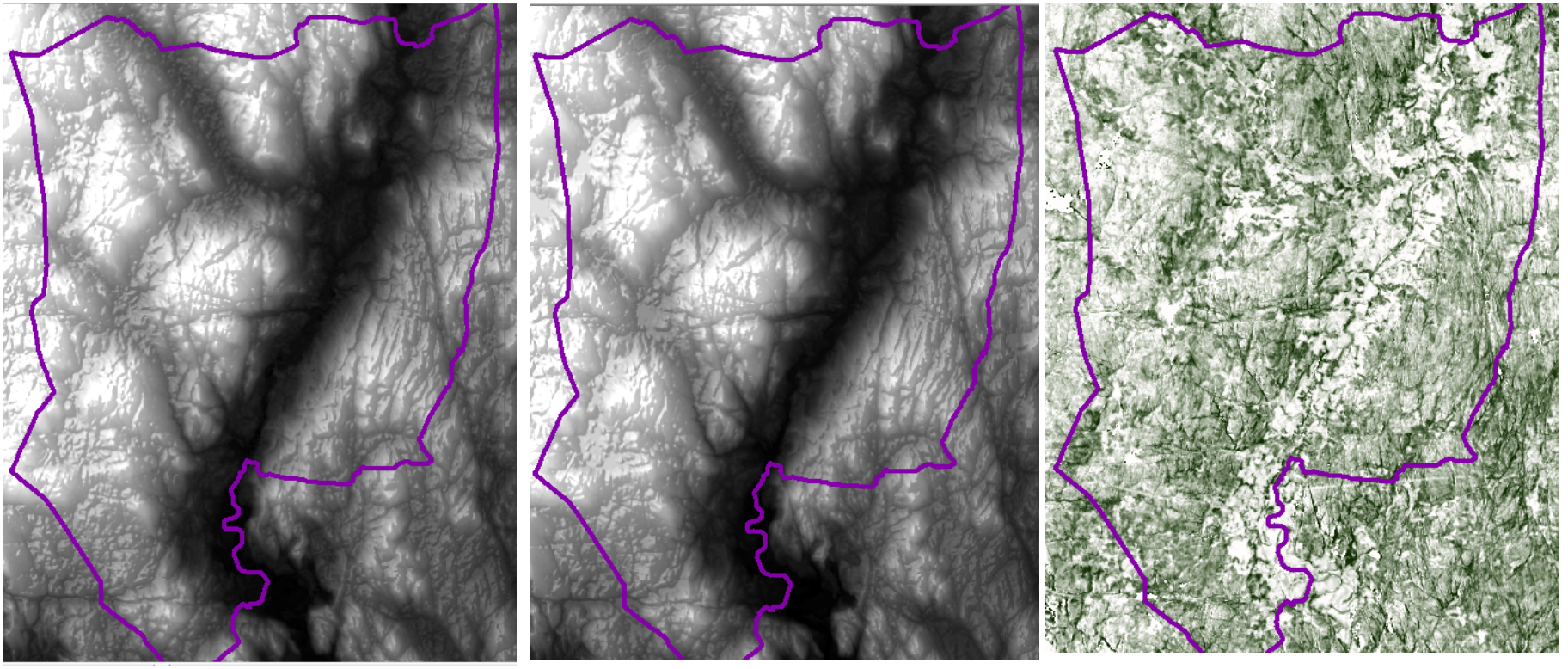
$$\Delta\varphi = k_0 + k_1\,\mathrm{RG} + k_2\,\mathrm{AZ}$$

Acquisition	k_0	k_1	k_2	RMSE
Ascending	-2.749480	-0.000048	-0.000013	0.9 m
Descending	1.488414	-0.000093	0.000028	2.2 m

skog+ landskap

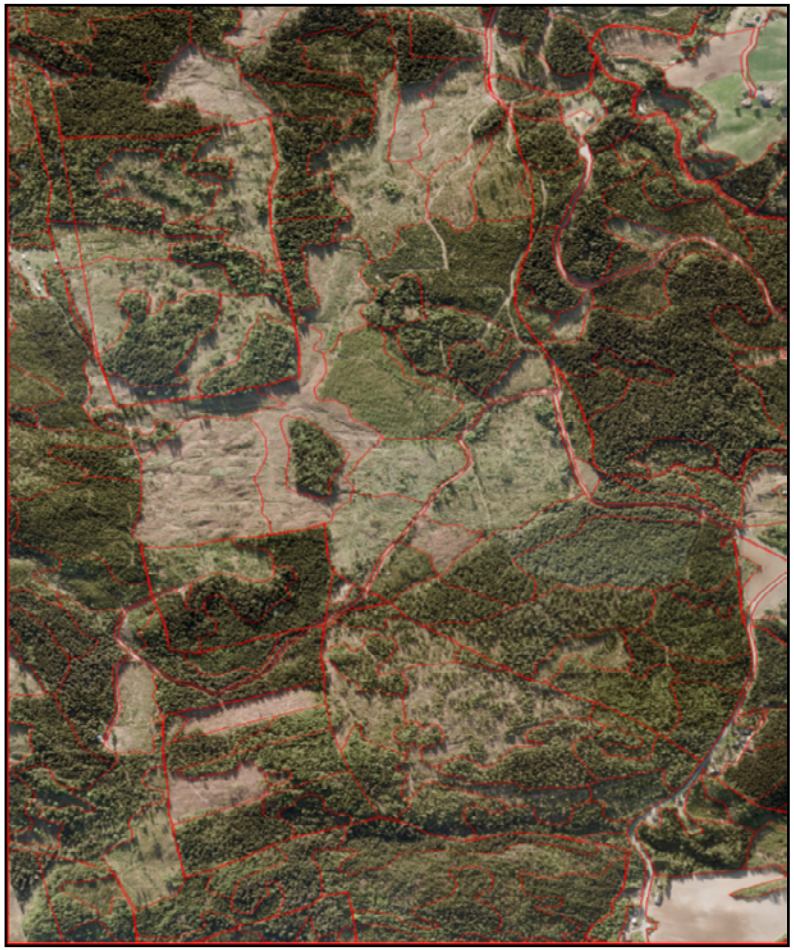
NORWEGIAN FOREST AND LANDSCAPE INSTITUTE

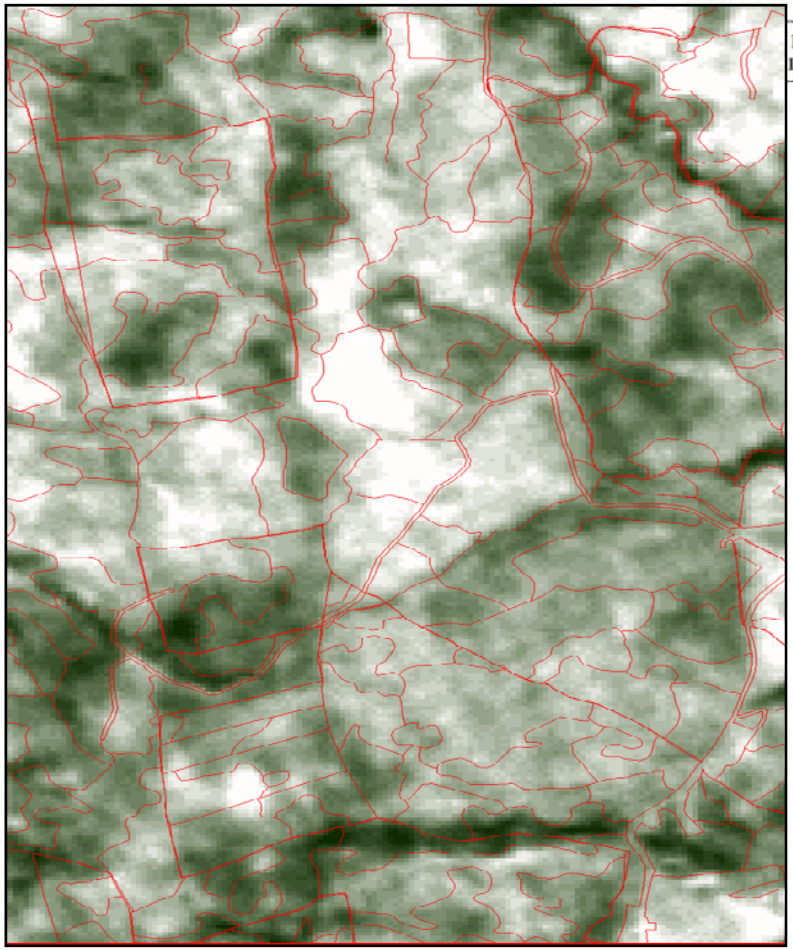
Tandem-X DEM - LiDAR DTM = InSAR height



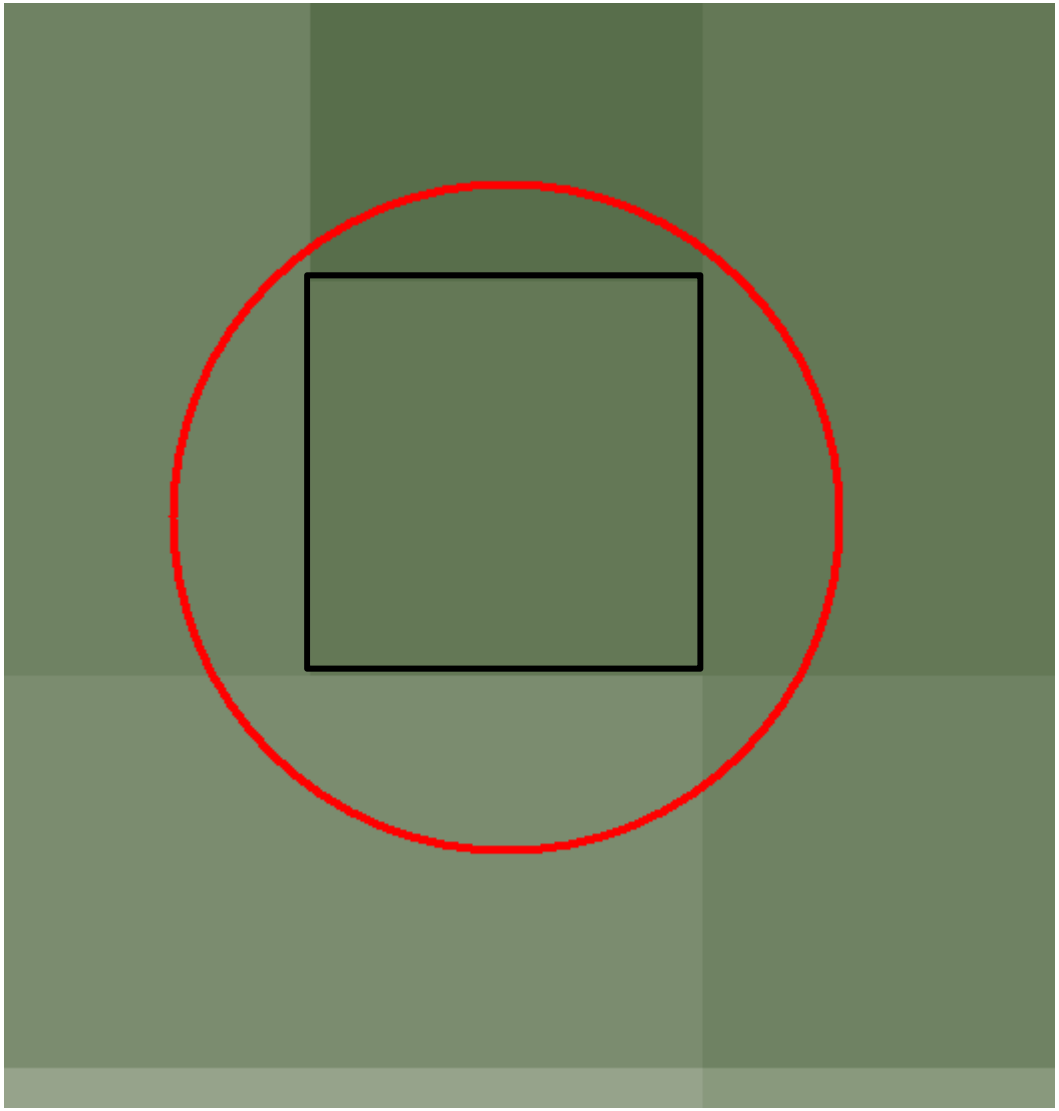
skog+
landskap

FOREST AND
INSTITUTE





Each plot – nearest 10m x10m pixel

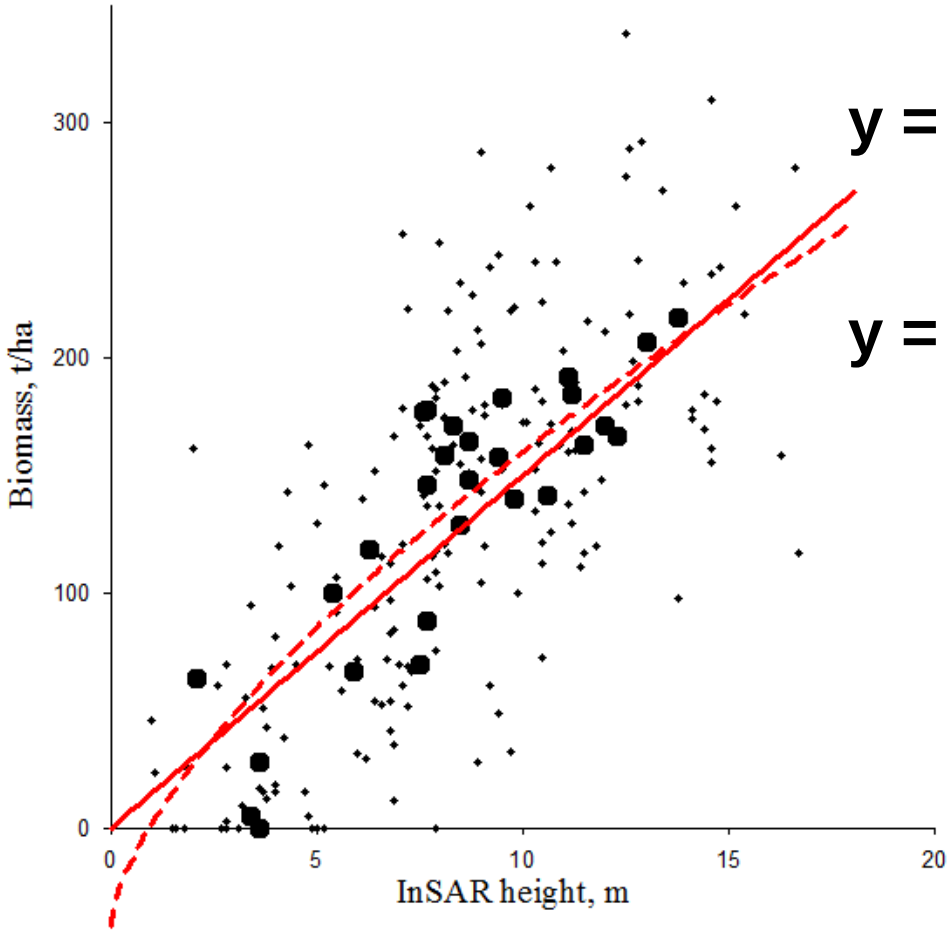


skog+ landskap

NORWEGIAN FOREST AND LANDSCAPE INSTITUTE

Curvilinear vs linear fit

skog+ landskap
NORWEGIAN FOREST AND LANDSCAPE INSTITUTE



$$y = 14x + \sigma + \varepsilon$$

$$y = 41x^{0.66} - 40 + \sigma + \varepsilon$$

TDX interferometry and TSX radargrammetry almost identical

skog+ landskap
NORWEGIAN FOREST AND LANDSCAPE INSTITUTE

TerraSAR-X radargrammetry: Biomass = 16CHM + σ + ε,

Stand level: Var(σ) = 23 t/ha, RMSE = 42%

Plot level: Var(ε) = 55 t/ha, RMSE = 18%

Tandem-X interferometry: Biomass = 16CHM + σ + ε,

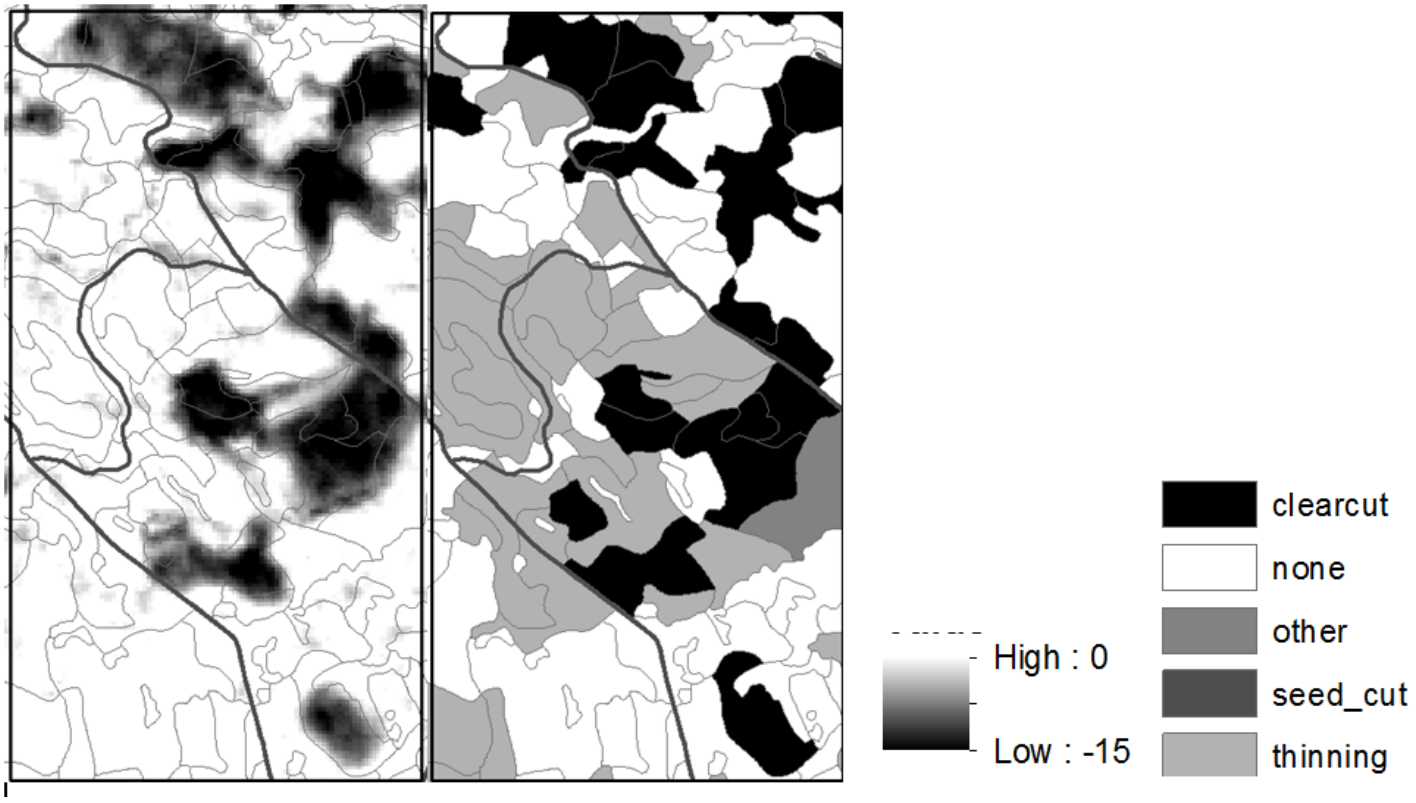
Stand level: Var(σ) = 25 t/ha, RMSE = 38%

Plot level: Var(ε) = 51 t/ha, RMSE = 19%

Detection of clear cuts, Lardal, Norway, 2000 - 201

skog+ landskap
NORWEGIAN FOREST AND LANDSCAPE INSTITUTE

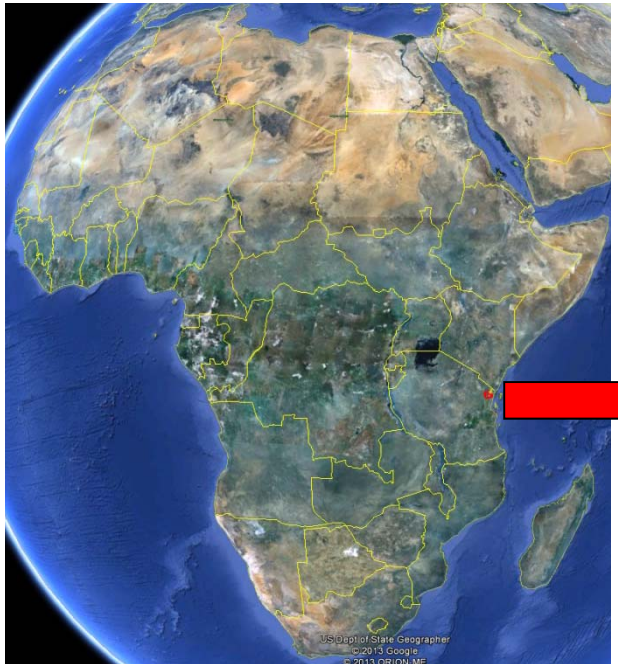
Redusert overflatehøyde og registrerte hogster hos Fritzøe



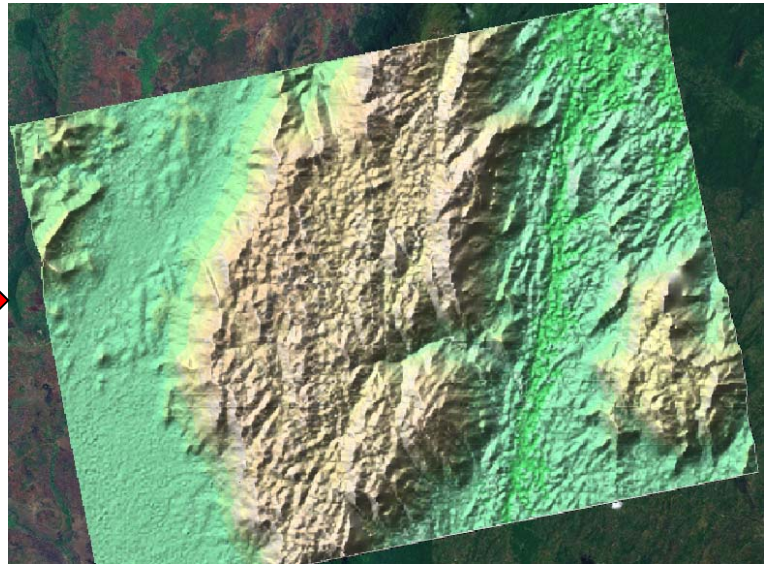
Part of the study area (1km x 2km) with changes from February 2000 to September 2011. Negative changes in InSAR DSM from the X-band SRTM to Tandem-X (left), and the stand-wise loggings recorded by the forest owner (right).

Tropical forests, Tanzania

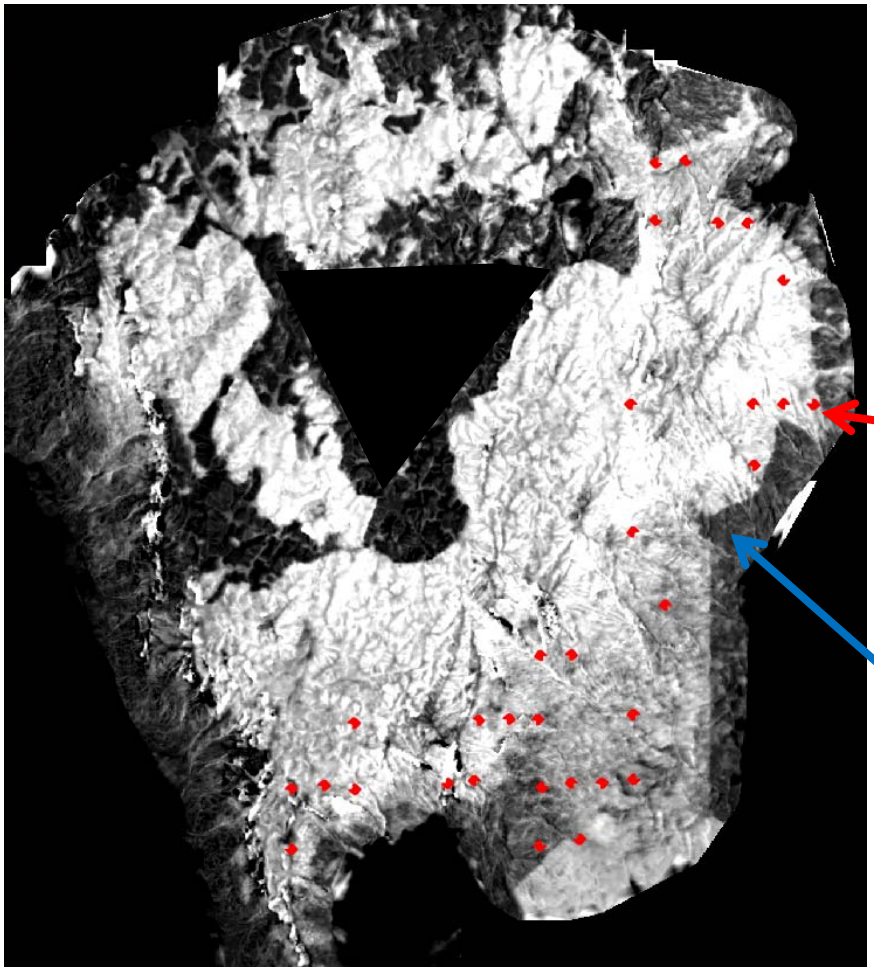
skog+ landskap
NORWEGIAN FOREST AND LANDSCAPE INSTITUTE



5.3° S
38.9° E



InSAR height and field plots

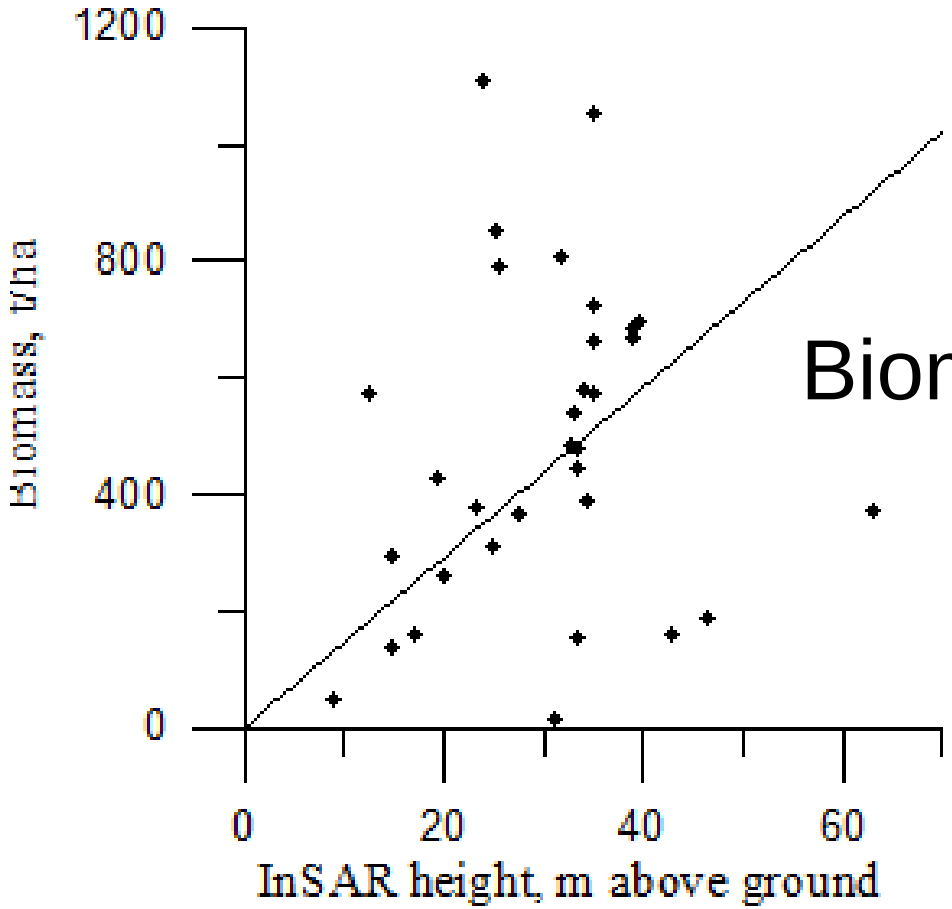


- InSAR height 0-40m above ground
- Field plots

Partly logged area

Biomass model with InSAR Amani, Tanzania

skog+ landskap
NORWEGIAN FOREST AND LANDSCAPE INSTITUTE

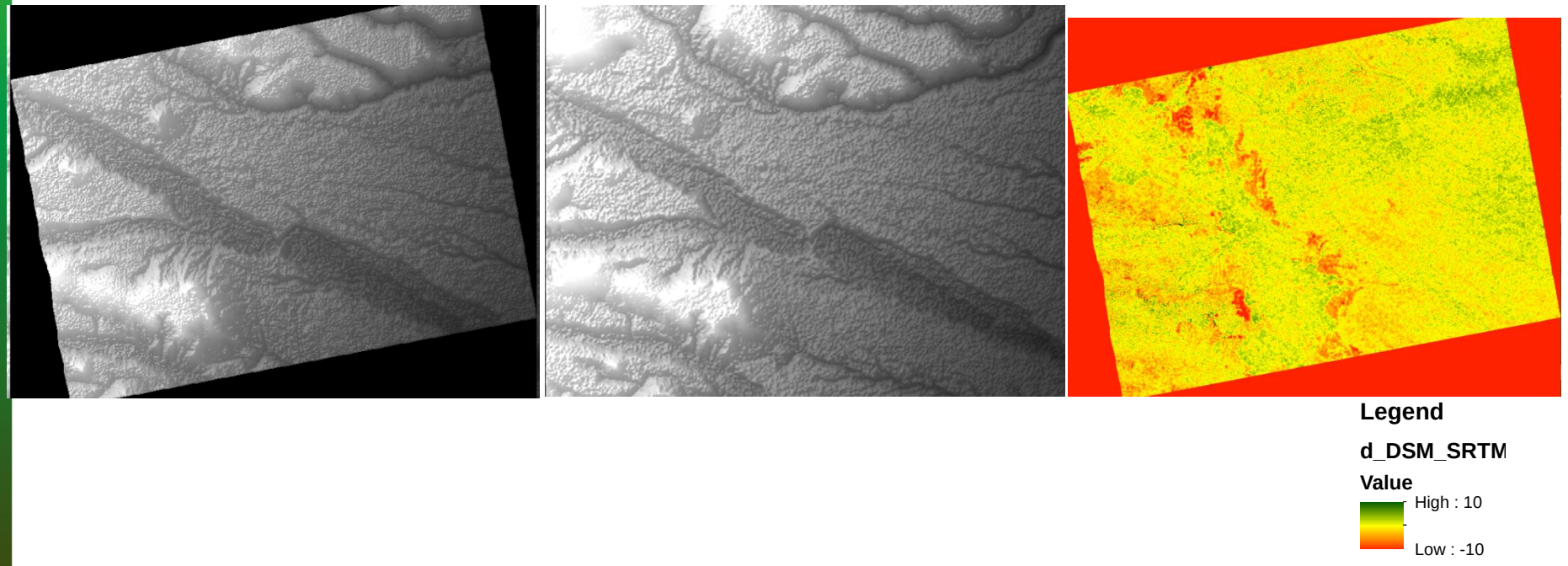


$$\text{Biomass} = 14.6 * H_{InSAR}$$

Change detection 2000 – 2011 savannah forest

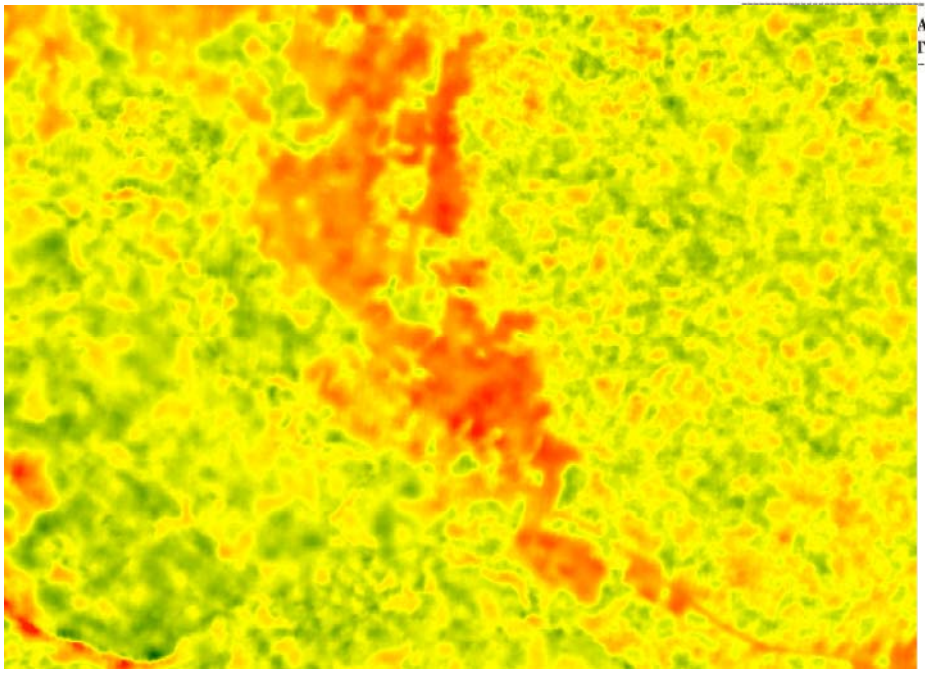
skog+ landskap
NORWEGIAN FOREST AND LANDSCAPE INSTITUTE

Tandem-X 2011 - SRTM DEM 2000 = Canopy height change



Clear-cuts, savannah forest

skog+ landskap



7 km

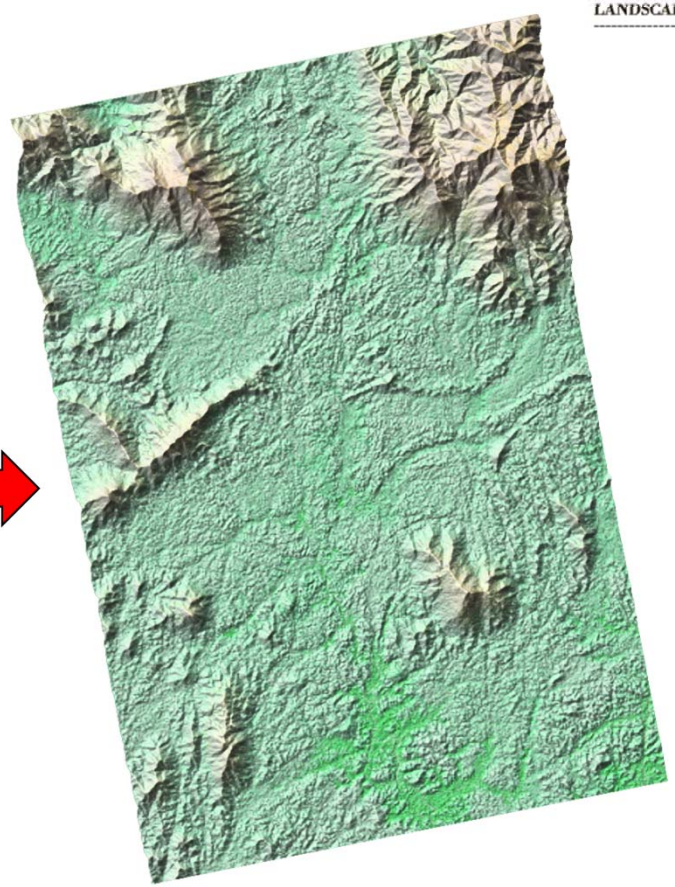
High : 10

Low : -10

Tropical forest, Central Kalimantan, Indonesia

skog+ landskap
NORWEGIAN FOREST AND LANDSCAPE INSTITUTE

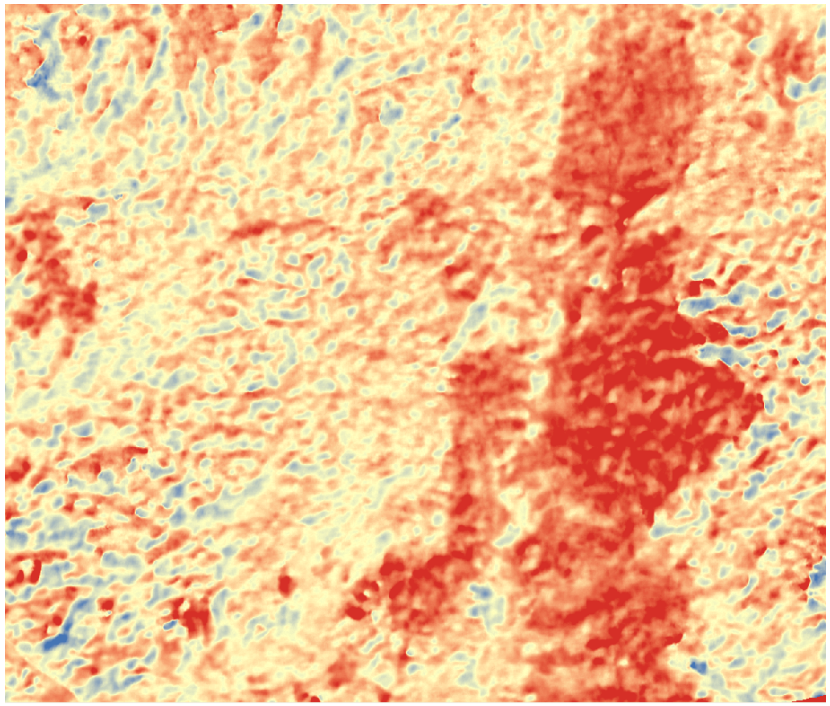
1.0° S
112° E



Detection of careful logging in Central Kalimantan, Indonesia

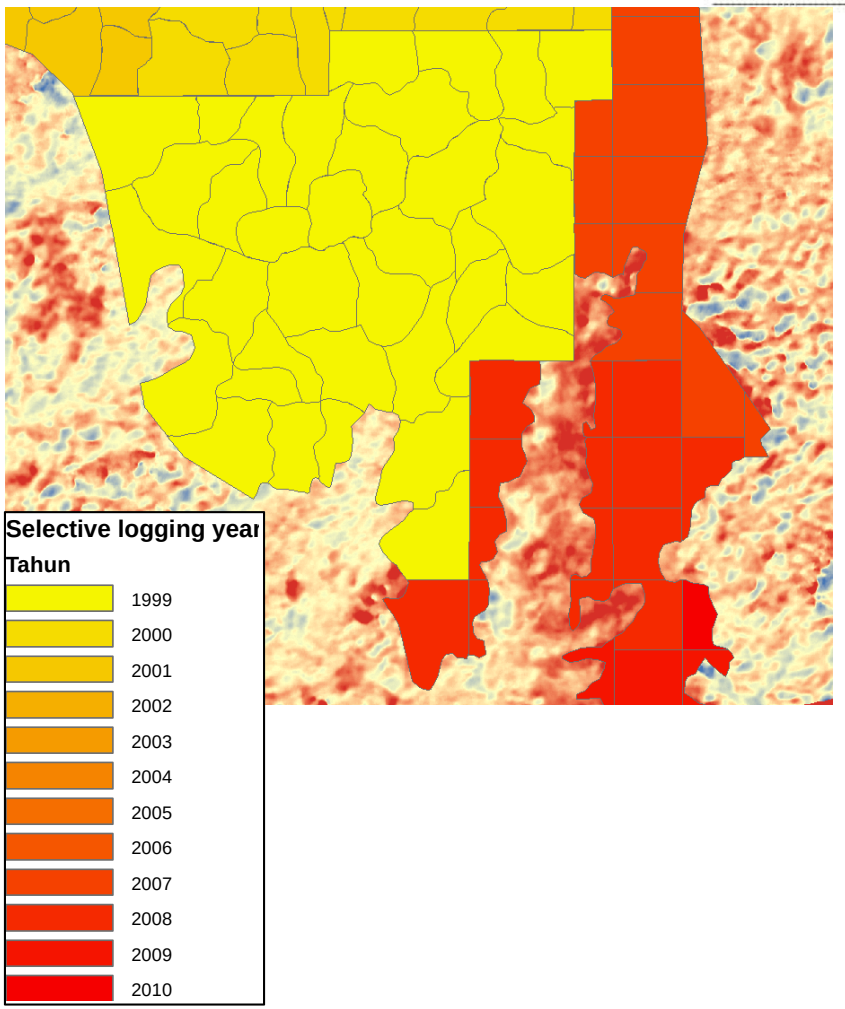
skog+ landskap
NORWEGIAN FOREST AND LANDSCAPE INSTITUTE

Change in InSAR height
from SRTM 2000 to Tandem-X 2011



Red = ca 20-30 m decrease

Forest loggings recorded by
SBK during 1999 - 2010



Selective loggings are detectable

skog+ landskap
NORWEGIAN FOREST AND LANDSCAPE INSTITUTE

Conclusion

- Biomass can be estimated fairly accurate
- No tendency of saturation
- The relationship is linear, -> biomass changes can be estimated without a DTM

skog+ landskap
NORWEGIAN FOREST AND LANDSCAPE INSTITUTE