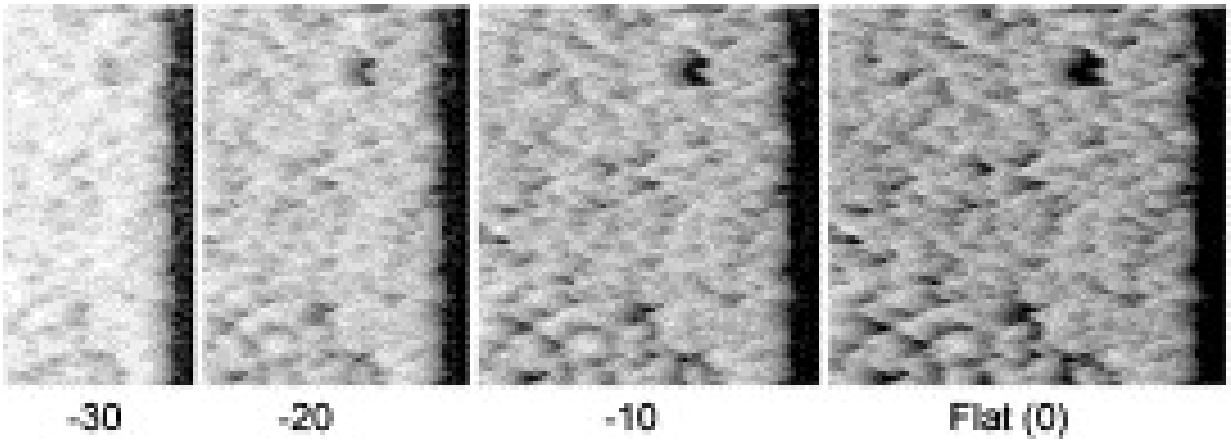
Interferometric X-band SAR for monitoring of forest biomass: correction of topographic effects

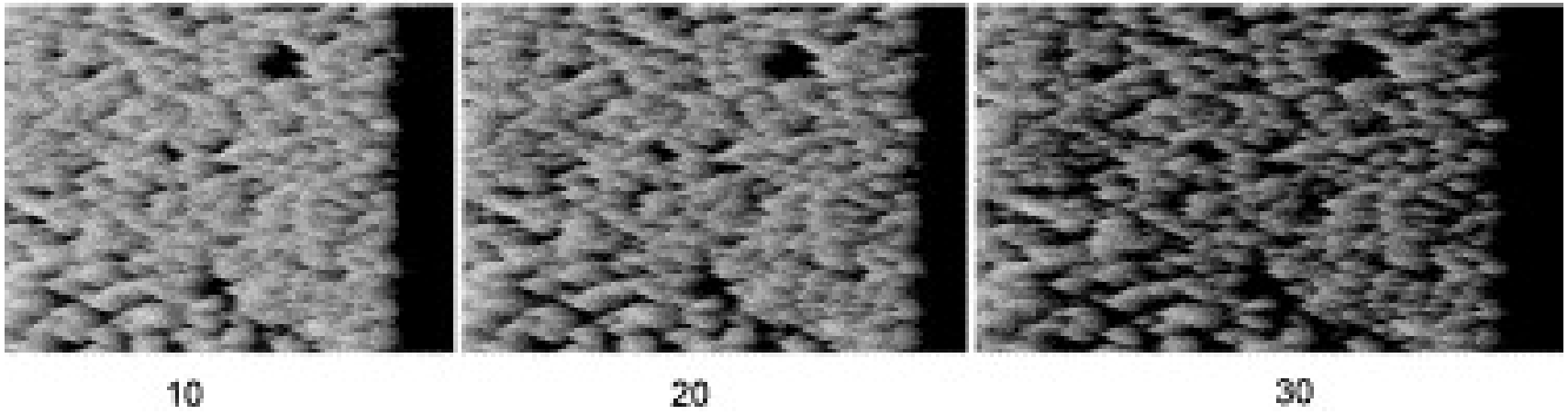
Holger Lange and Svein Solberg

Norwegian Forest and Landscape Institute, Ås, Norway

1. InSAR tree heights and local incidence angle: displacements, forshortening, layover, shadows
2. An explicit geometric correction for topographic distortions
3. Consequences for height and biomass estimates: a case study

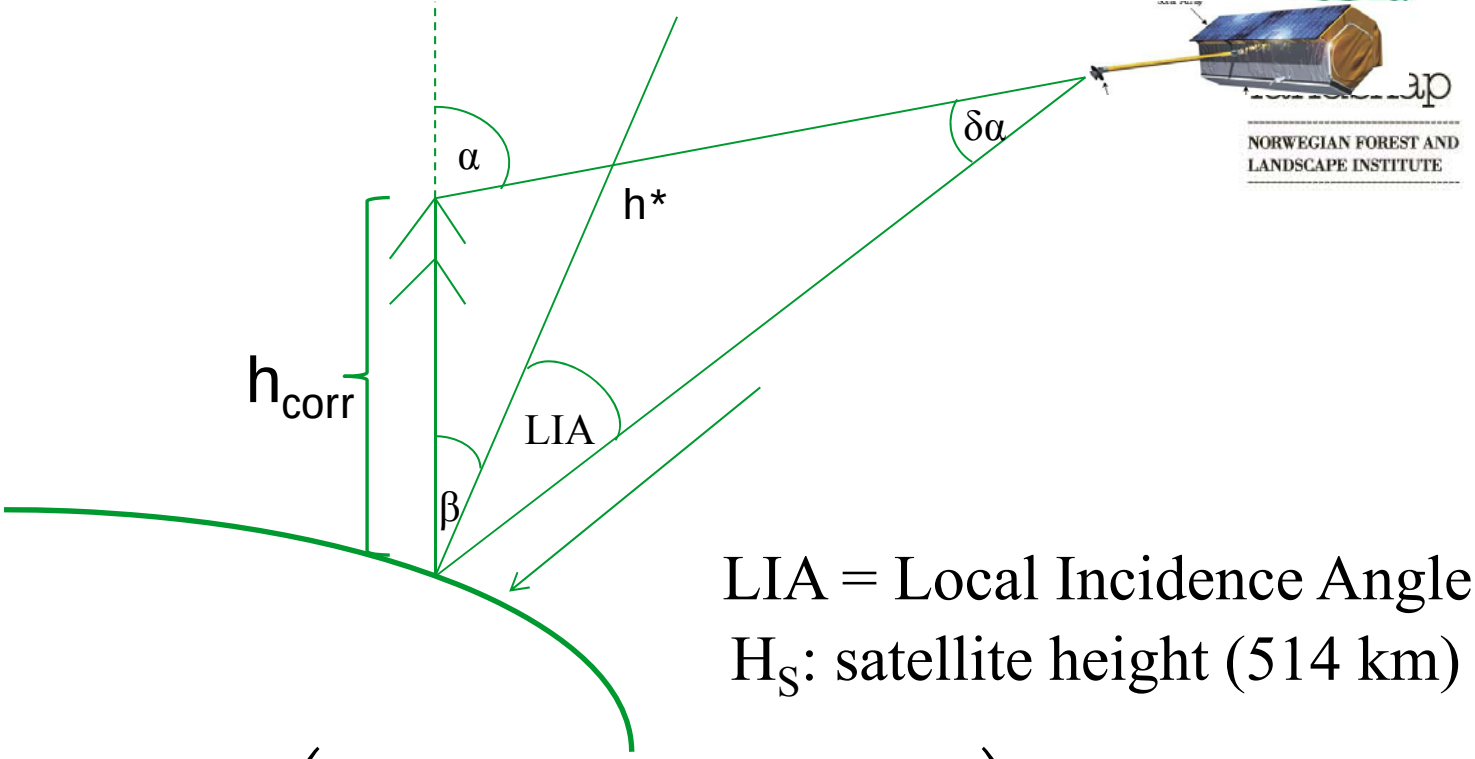
Impact of incidence angle: simulation of radar images





From: Sun et al. (2002), RSE

Topographic correction

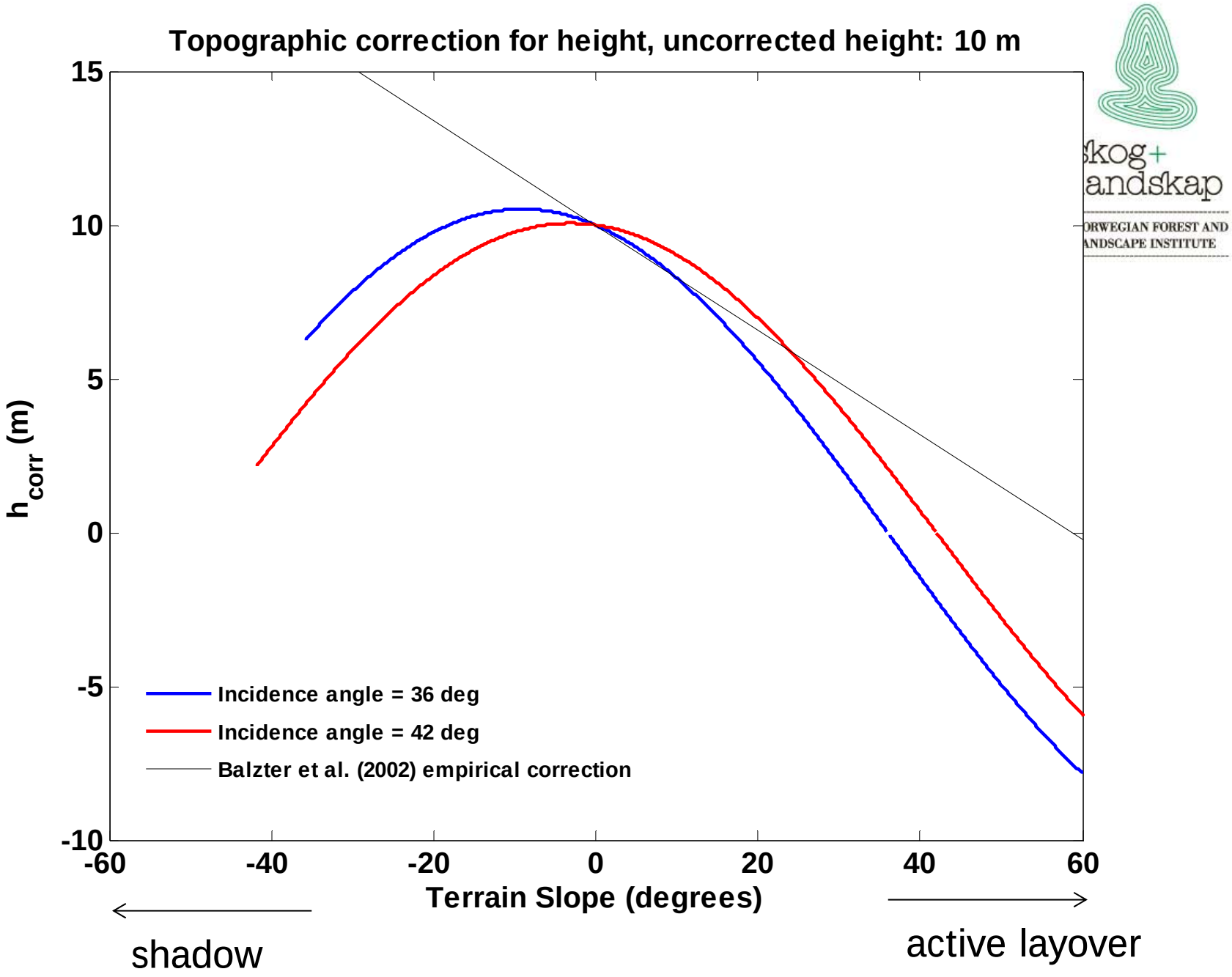


LIA = Local Incidence Angle

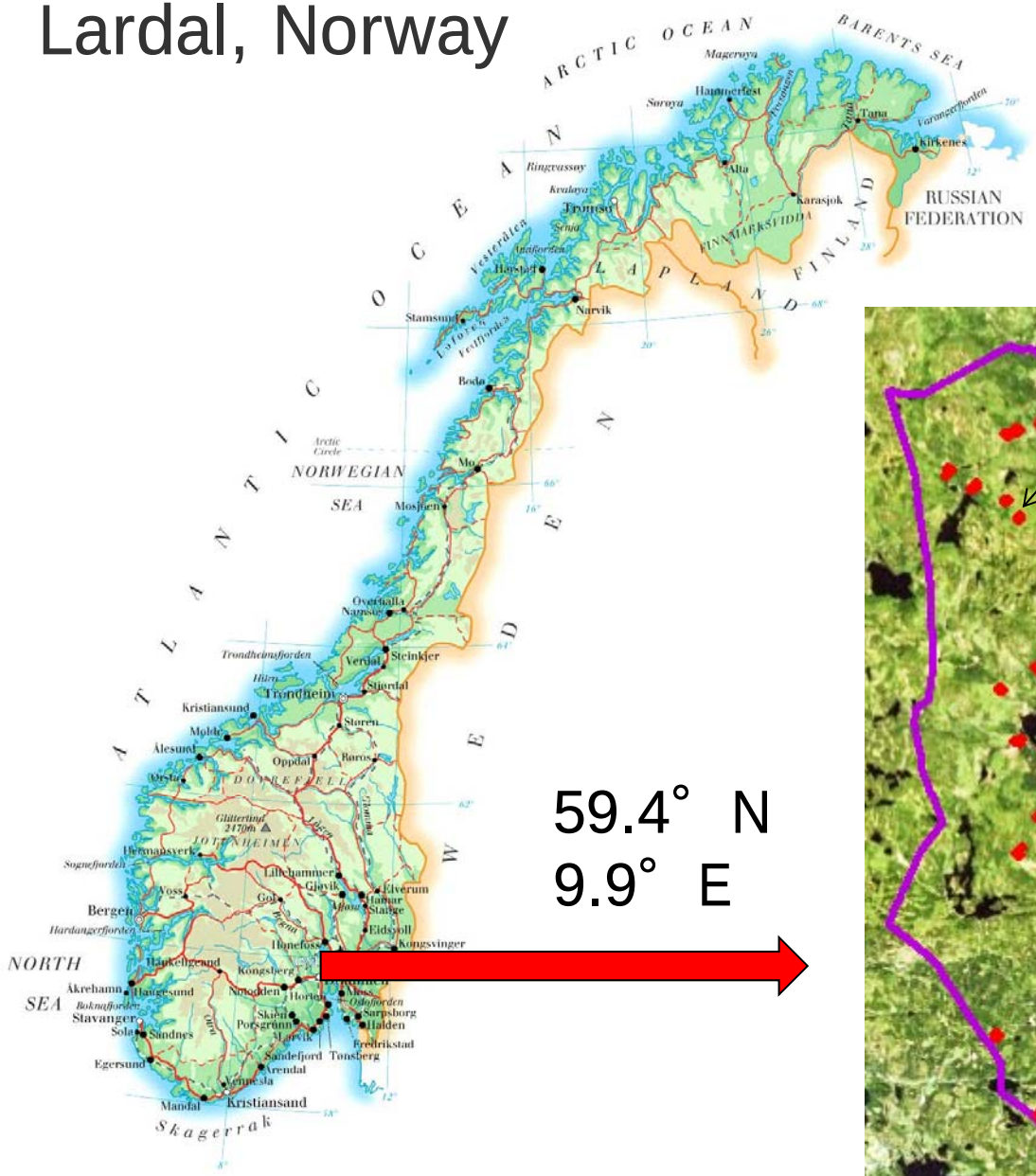
H_S: satellite height (514 km)

$$\delta\alpha = \beta - \alpha + \tan^{-1}\left(\left(1 - \frac{h^*}{H_S}\right)\tan(LIA - \delta\alpha)\right)$$

$$h_{corr} = h^* + H_S\left(\frac{\tan(LIA)}{\tan(LIA - \delta\alpha)} - \frac{\tan(\alpha + \delta\alpha)}{\tan\alpha}\right)$$

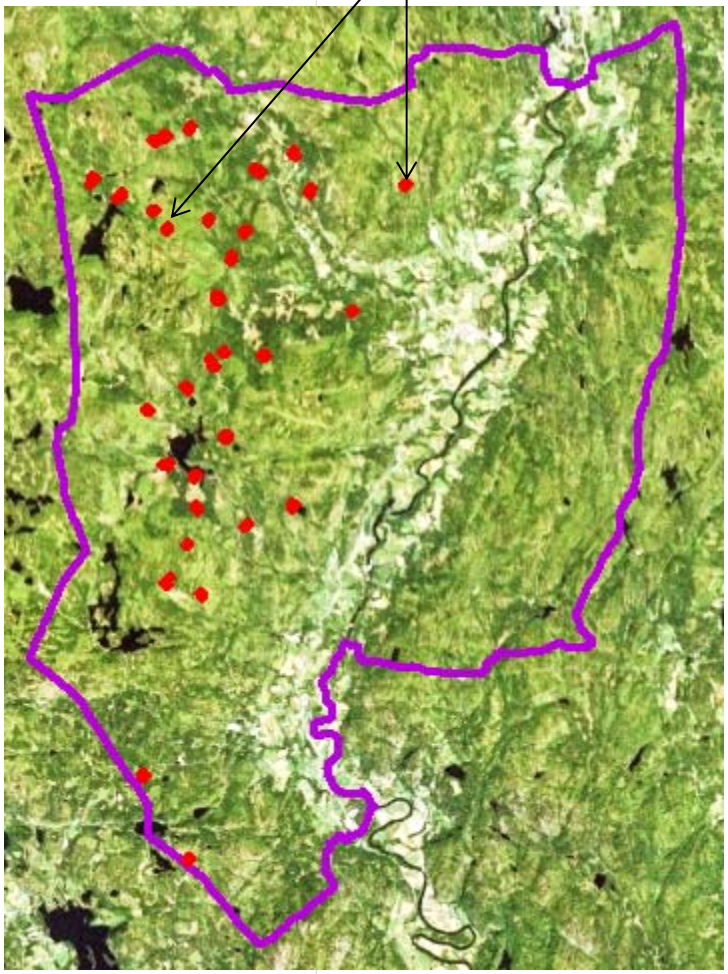

Topographic correction for height, uncorrected height: 10 m
15
10
5
0
-5
-10
h_{corr} (m)
-60
-40
-20
0
20
40
60
Terrain Slope (degrees)
Incidence angle = 36 deg
Incidence angle = 42 deg
Balzter et al. (2002) empirical correction
shadow
active layover

Lardal, Norway



59.4° N
9.9° E

Field plots



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Case study and procedure

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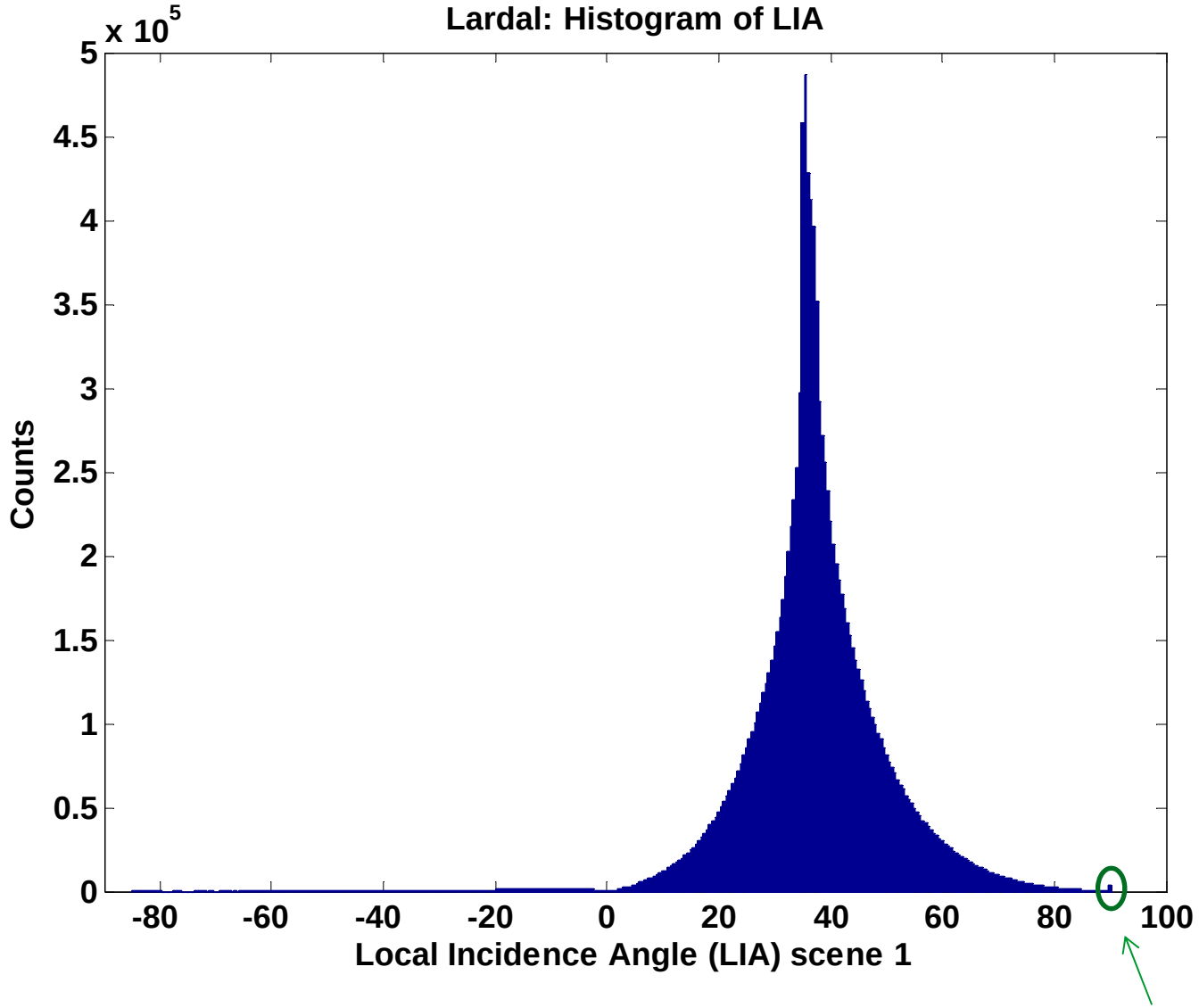
- Two Tandem-X acquisitions:
  - Ascending, right-looking, 23.7.2011: «Scene 1»
  - Descending, right-looking, 1.9.2011: «Scene 82»
- Processing of InSAR DSM as in the previous talk
- Subtraction of a Lidar-based DTM to generate (interferometric) heights
- Conversion to biomass using linear model from previous talk
- Calculation of Local Incidence Angles using SarScape
- Correction and comparison
- Conclusions

«Global» Incidence Angle at the center: 36.05 deg



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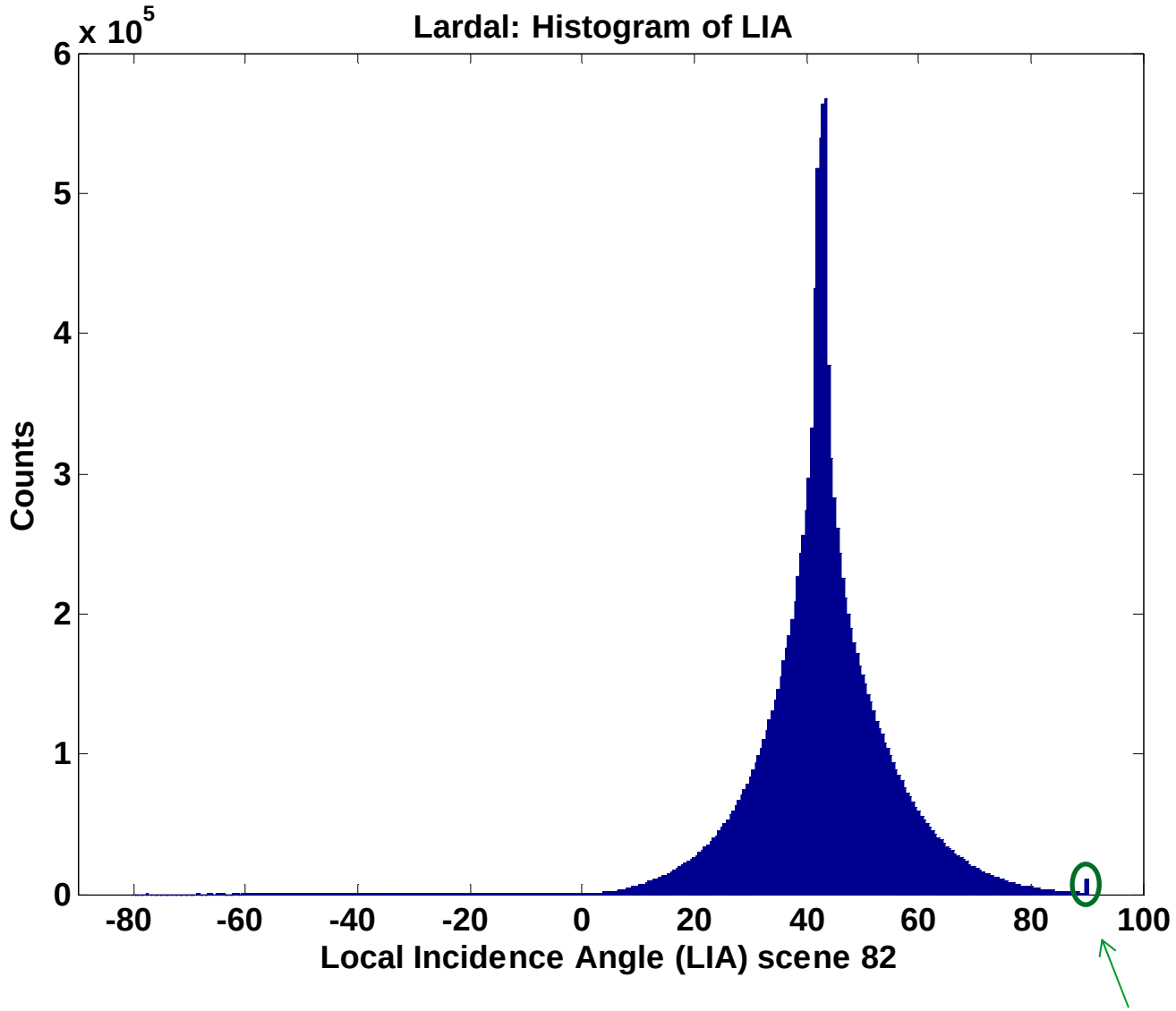
Shadow areas

«Global» Incidence Angle at the center: 42.7 deg



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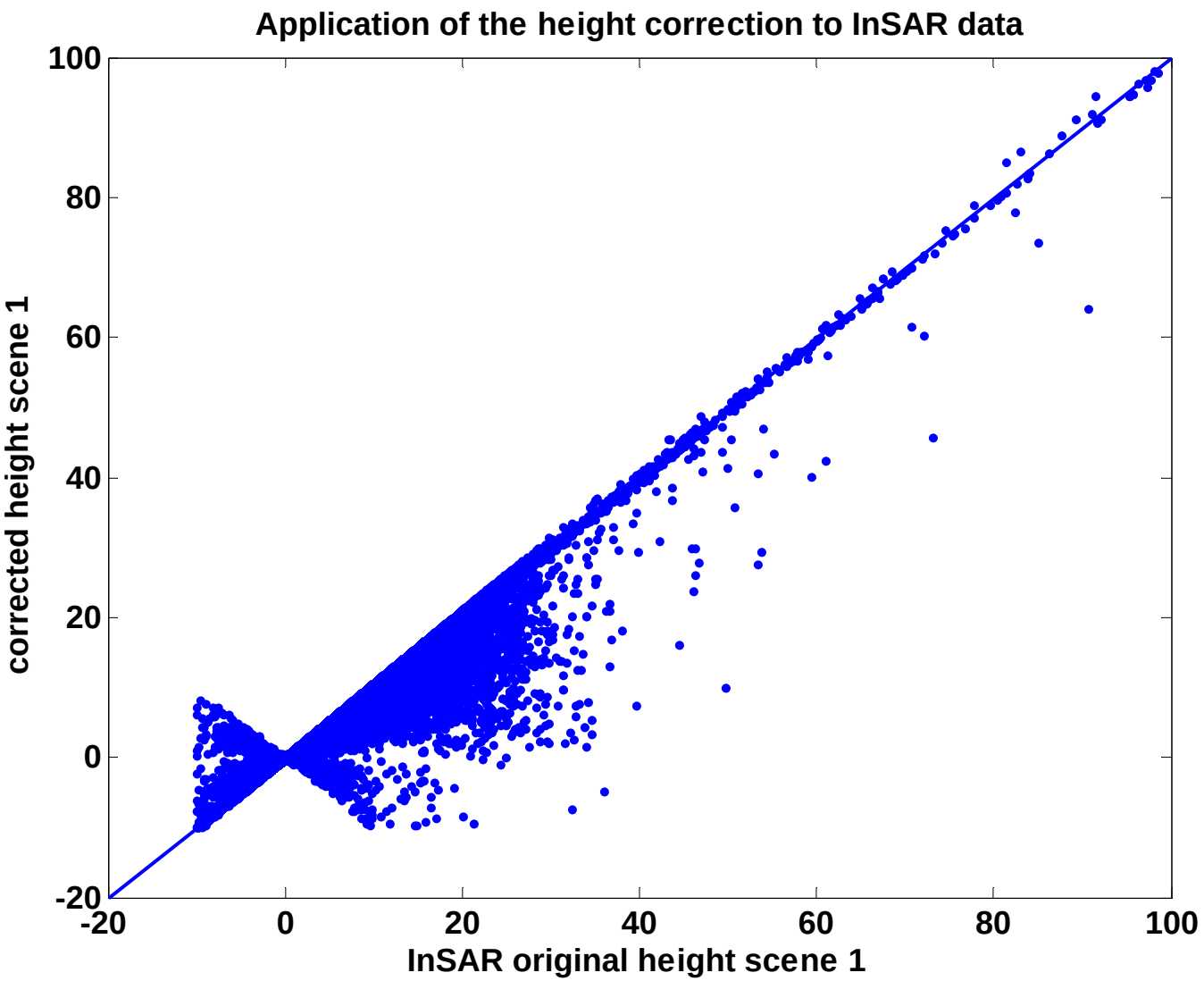
Shadow areas



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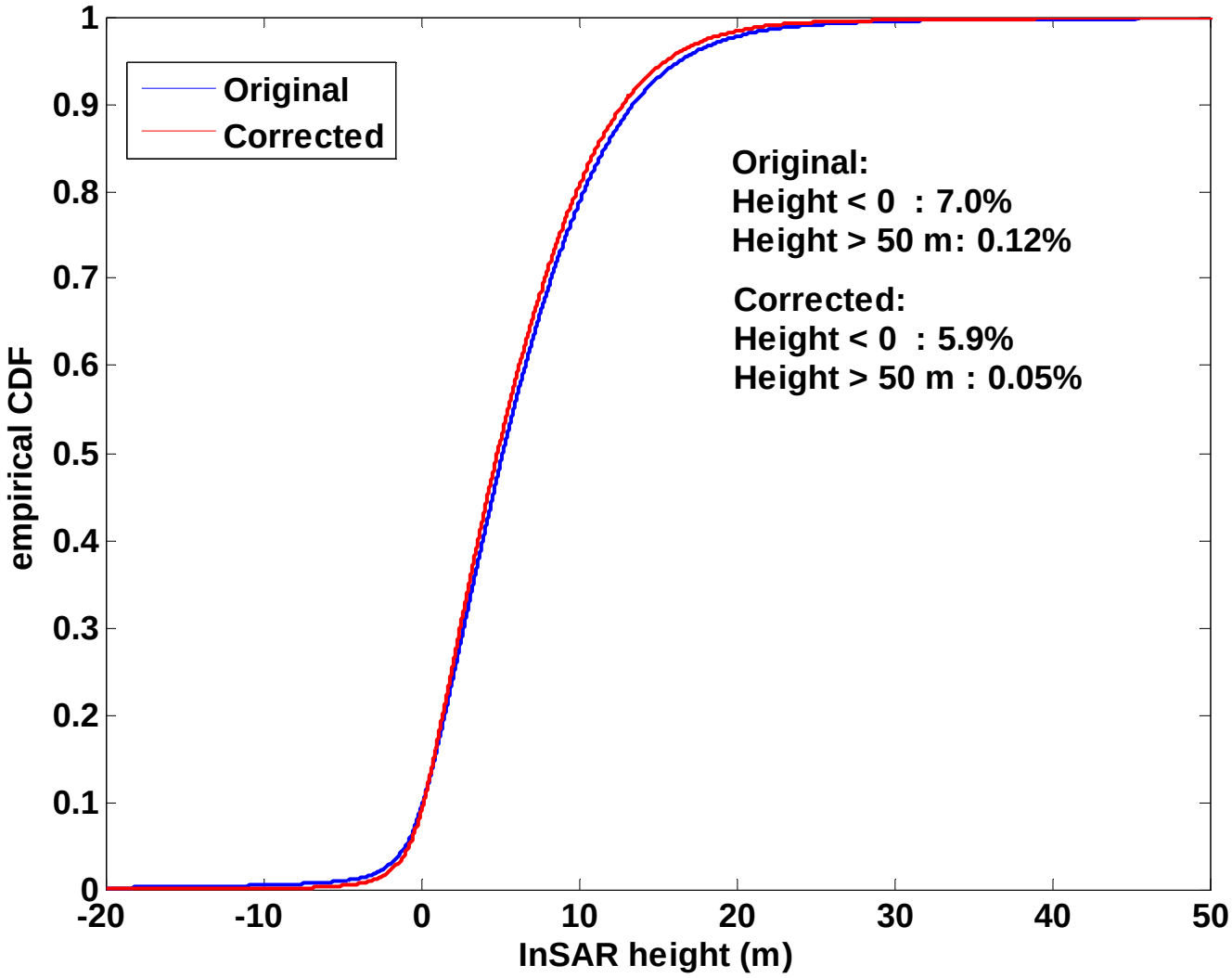

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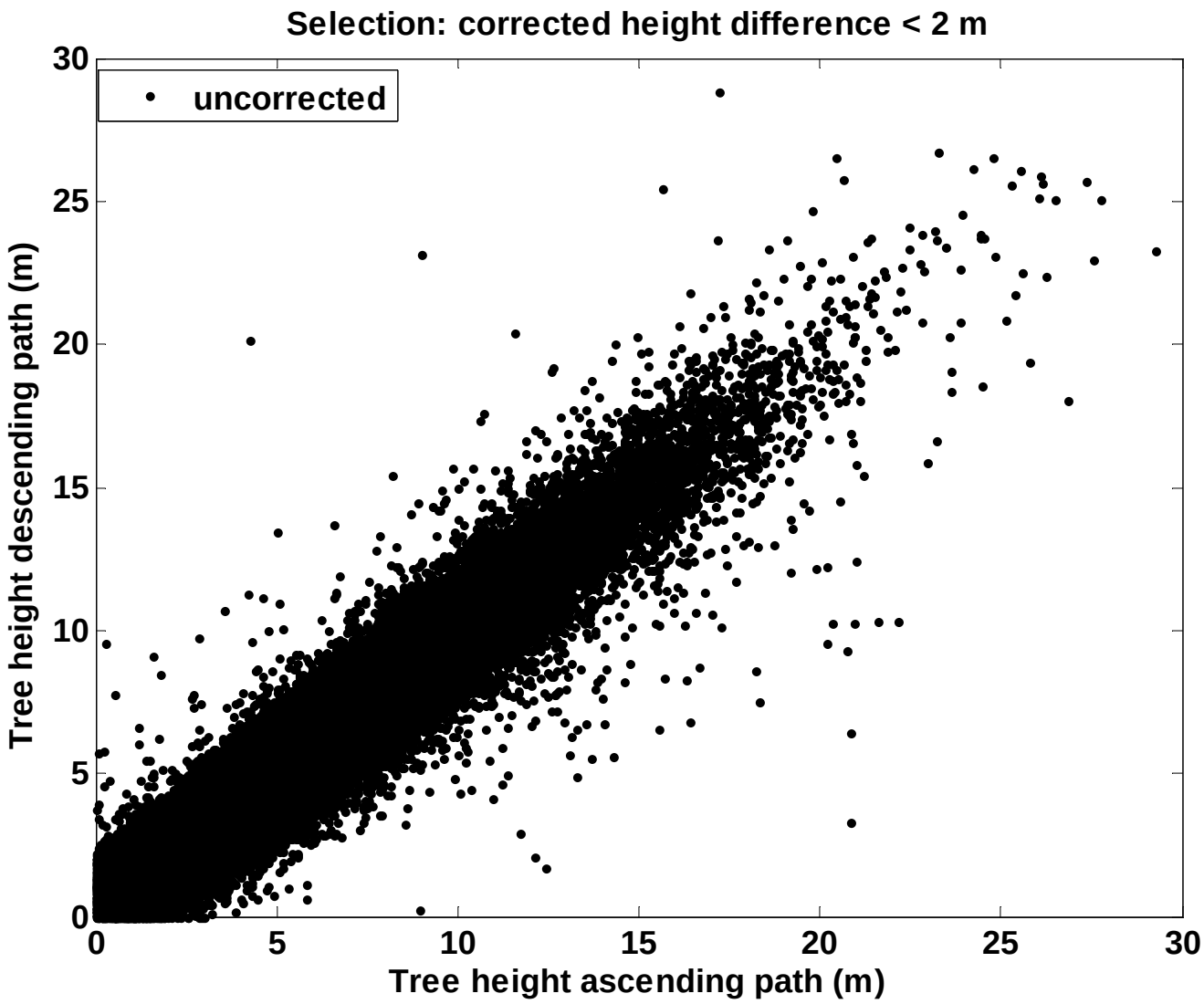

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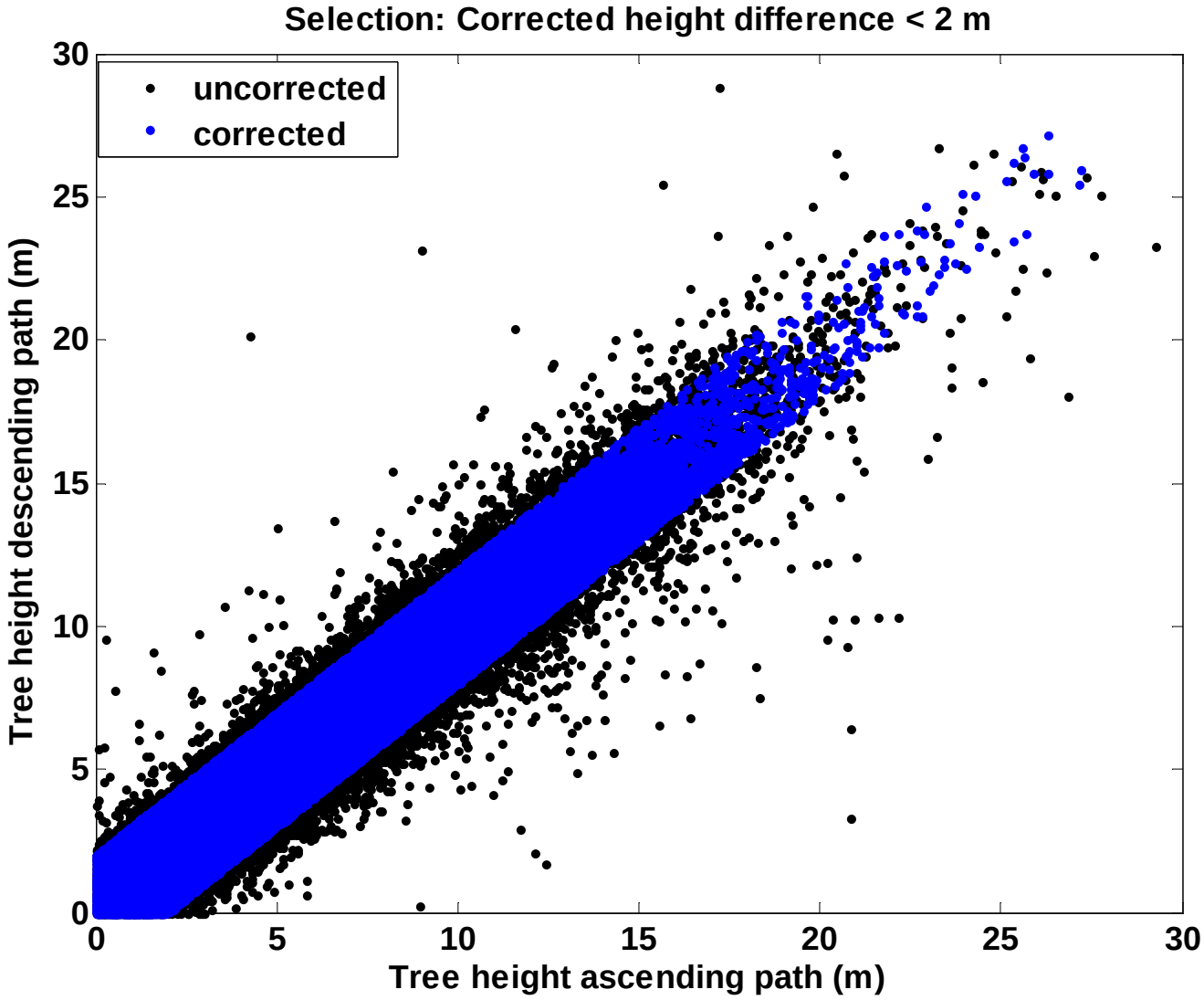

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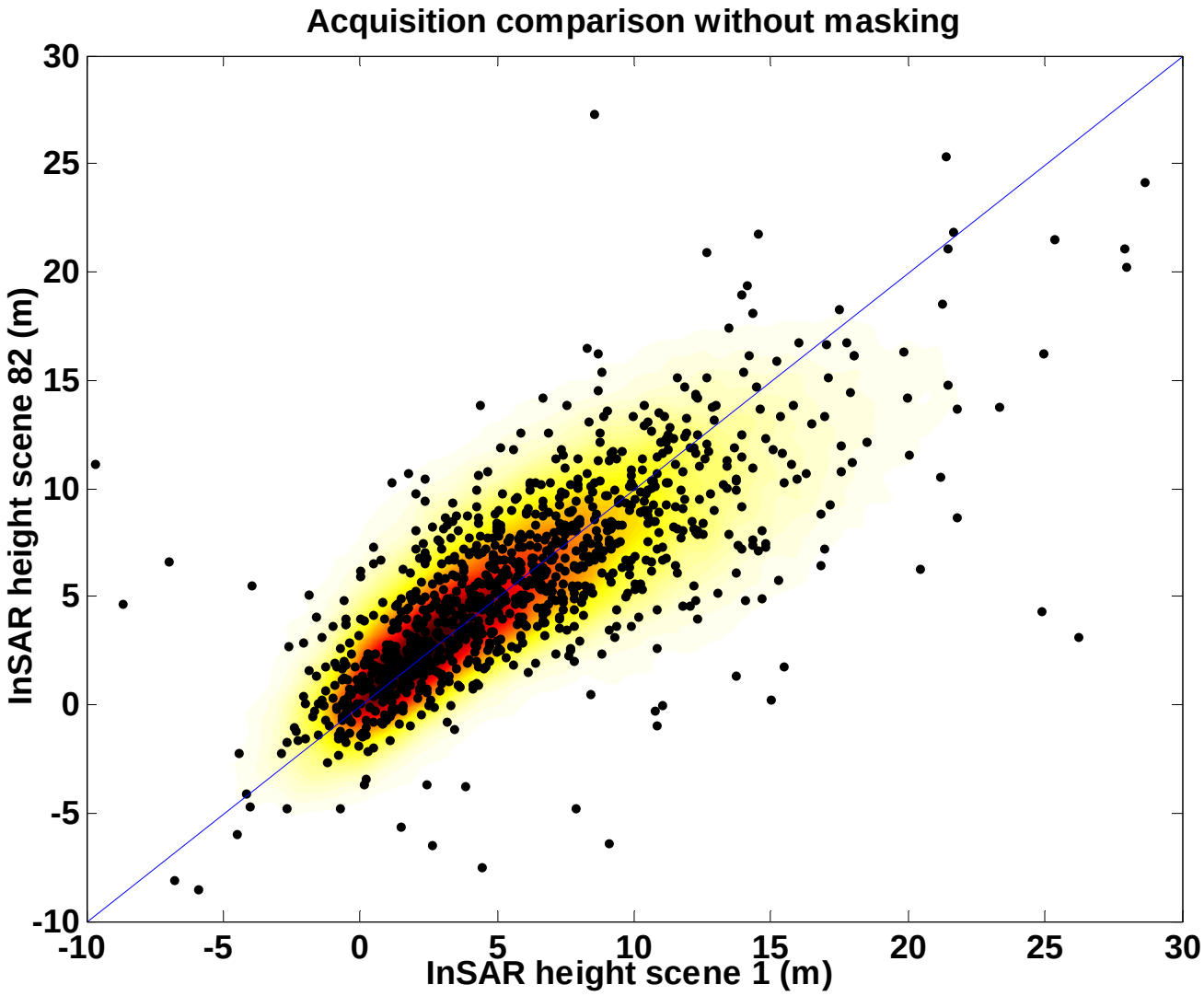
The full truth (almost...), uncorrected



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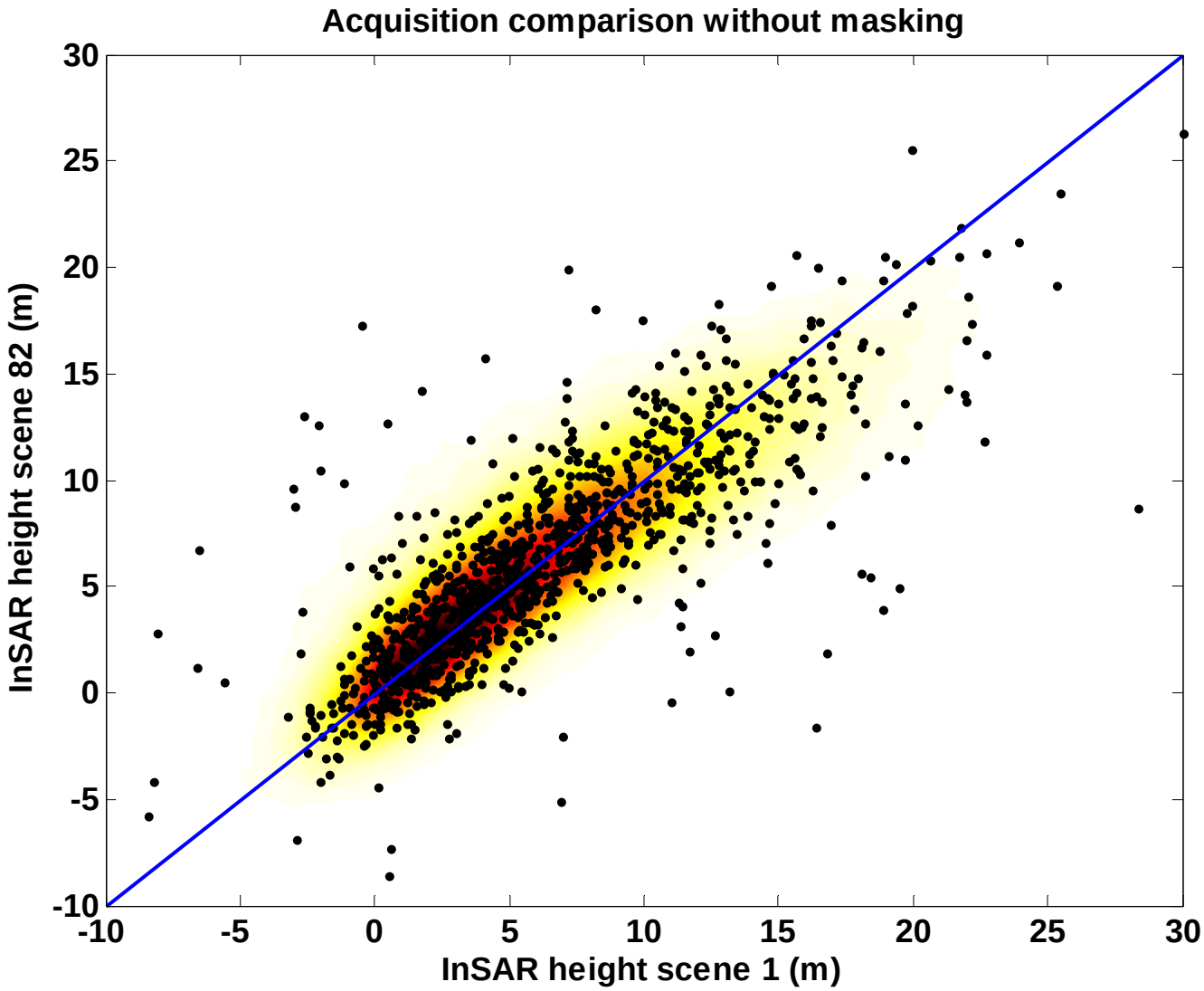

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Height differences before correction

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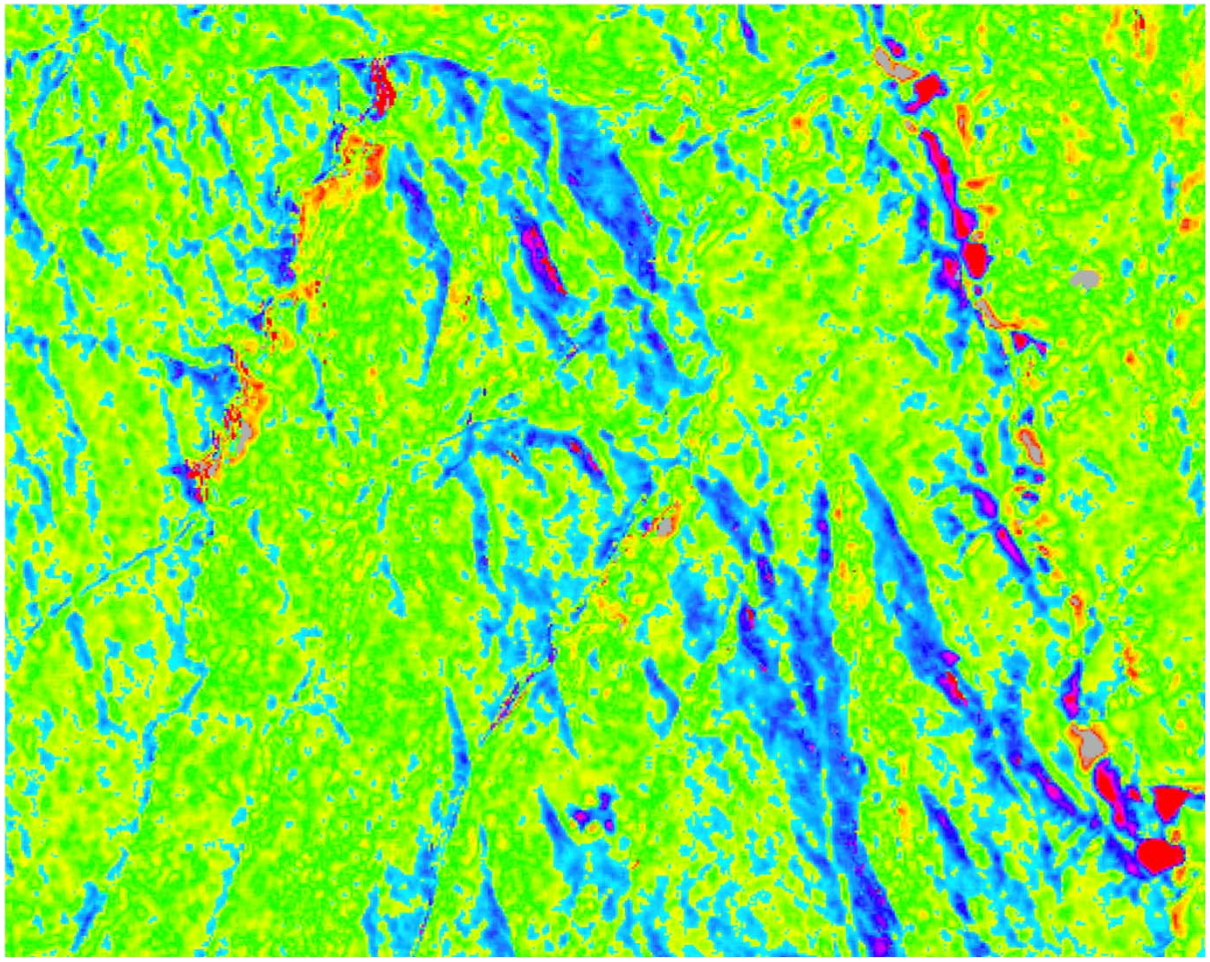

Height differences after correction

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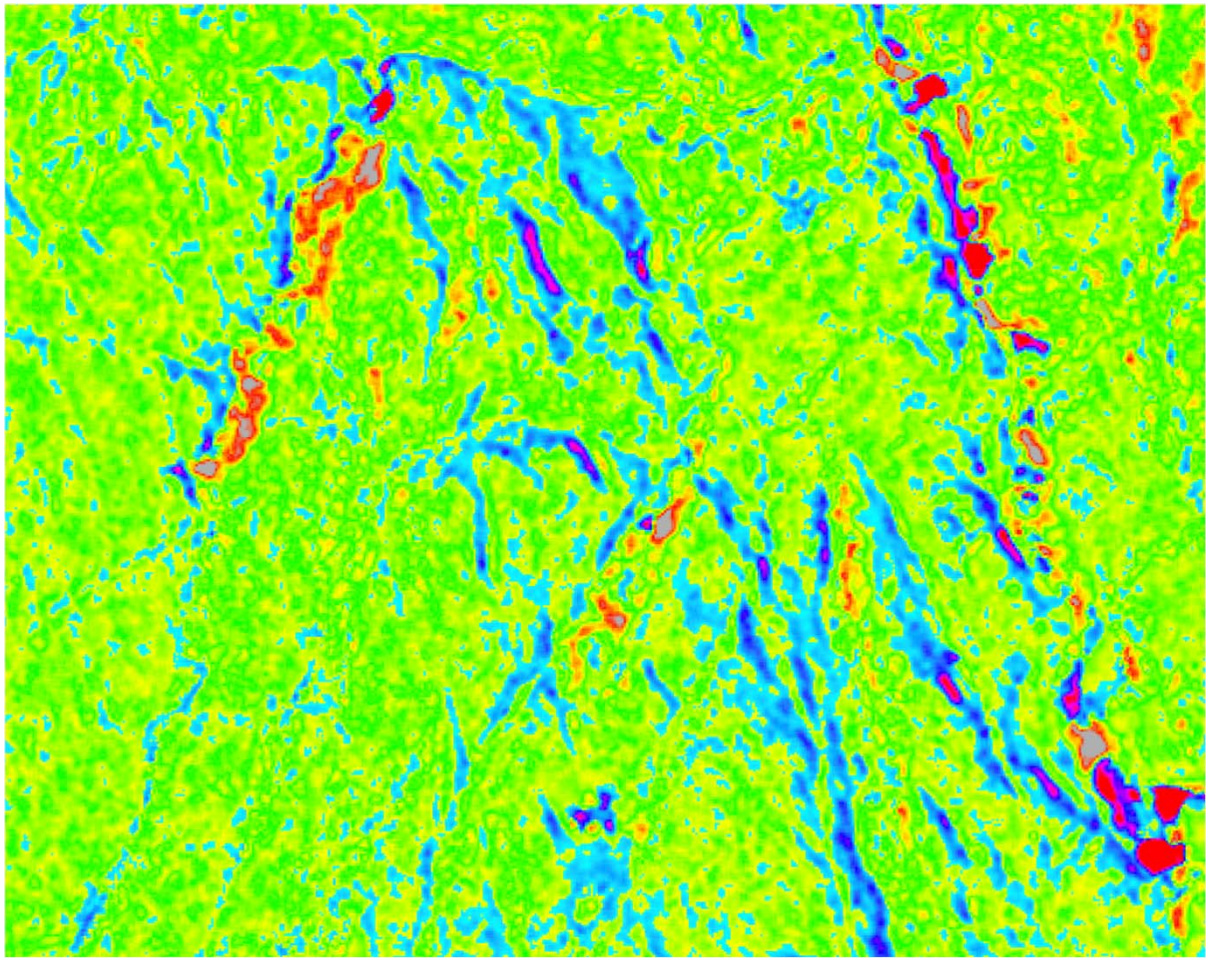

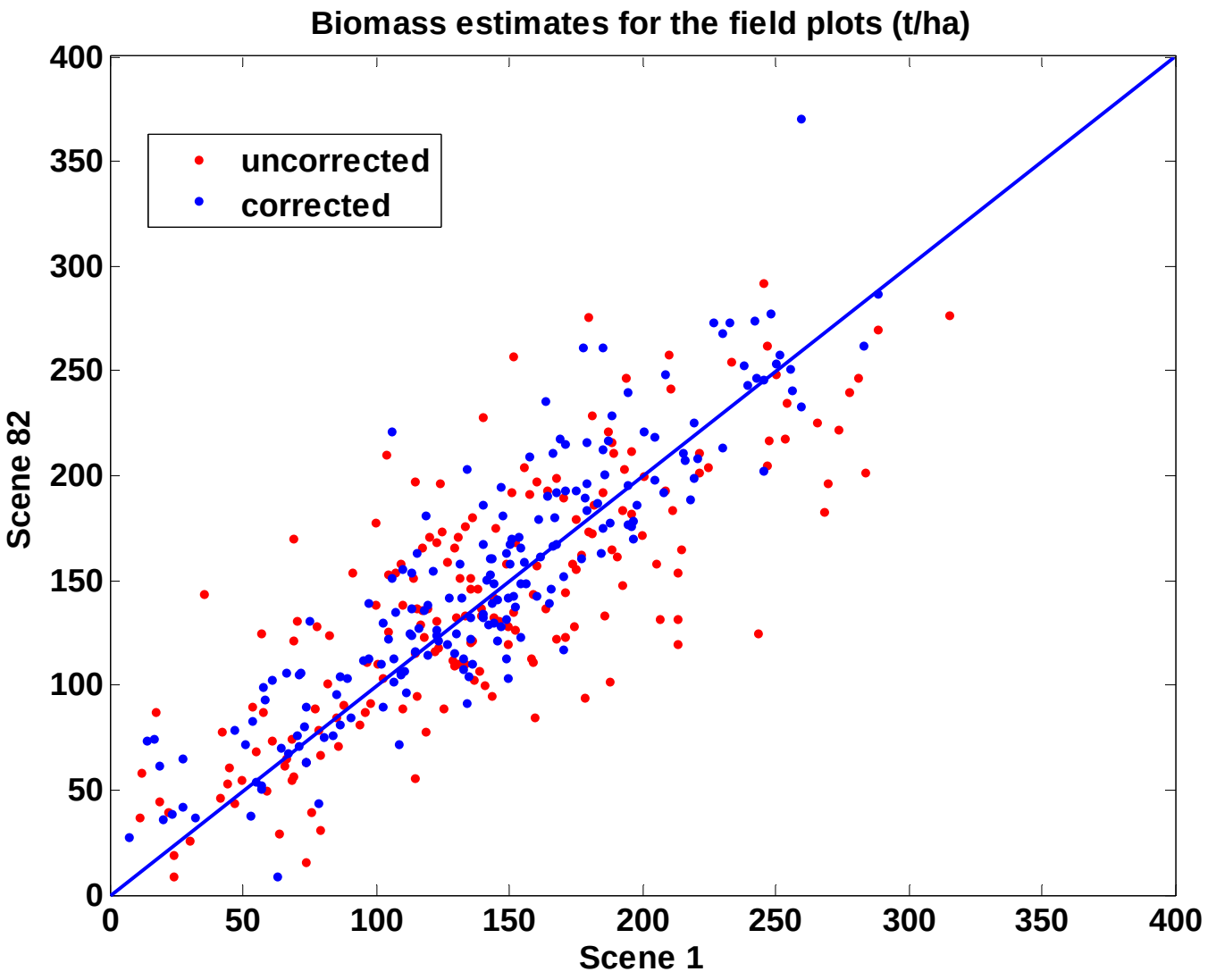

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Biomass estimates from the field sites

(Biomass values in tons/ha; mean values, n=192)

	uncorrected	corrected	% Deviation
Scene 1	143.8	137.4	-4.5
Scene 82	147.0	139.5	-5.1
Difference	3.2	2.1	66.7
% Difference	2.2	1.5	

The difference between the scenes is reduced to 2/3 through the correction

Biomass estimates from the whole scene

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(Biomass values in tons/ha; mean values;
> 10^7 pixels)

	uncorrected	corrected	% Deviation
Scene 1	124.3	107.2	-13.8
Scene 82	112.1	101.6	-9.4
Difference	12.2	5.6	52.0
% Difference	10.3	5.4	

The difference between the scenes is reduced to 1/2 through the correction

Conclusions

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- Topographic correction is important in rugged terrain, less important in almost flat areas
- Leads to mostly reduced tree height estimates
- Comparison between different scenes is improved
- Biomass corrections in the 10% region for the case study
- Improvements:
  - discern between near range and far range for the global incidence angle
  - Take into account local aspect, i.e. the full 3D information
  - Use SAR DSM for calculation of LIA, not Lidar DTM