Assessment of the quality of digital surface and canopy height models over forests derived from TanDEM-X interferometry

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EUFODOS

European Forest Downstream Services - Improved Information on Forest Structure and Damage

- FP7 project; duration: January 2011 to the end of 2013
- Use of GMES (Global Monitoring for Environment and Security) data to develop forest downstream services

Role of Felis within Eufodos

- Partnership with GAF AG and SUK Thüringen Forst (Service and competence center of the public forest agency of Thuringia, Germany)

Main goals of Felis is to evaluate new sensor data capabilities for:

- Storm damage detection with TerraSAR-X, TanDEM-X and RapidEye
- Bark beetle damage detection with RapidEye

Purpose of this study

The idea: detection of storm damages by detecting changes in the height of the vegetation.

The approach chosen here: Evaluation of the quality of TanDEM-X derived surface models and of processing options using height models detected by LIDAR.

Storm damages lead to a reduction of the vegetation height.

Broken and thrown trees still lay on the ground after the storm event, Thus the height difference does not comprised the total vegetation height. In the majority of storm damages it exceeds at least 10 meters. Thus using TanDEM-X the detection of vegetation height differences of 10 m or more needs to be secured

Test site Karlsruhe

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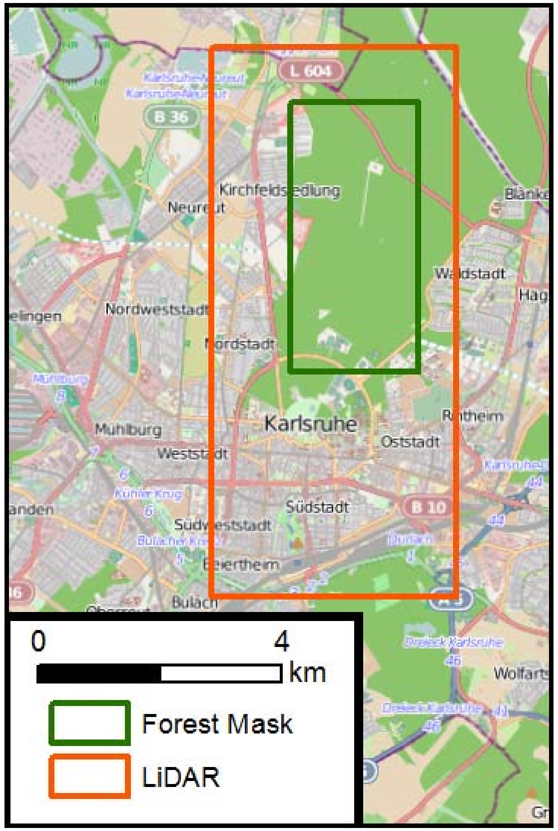
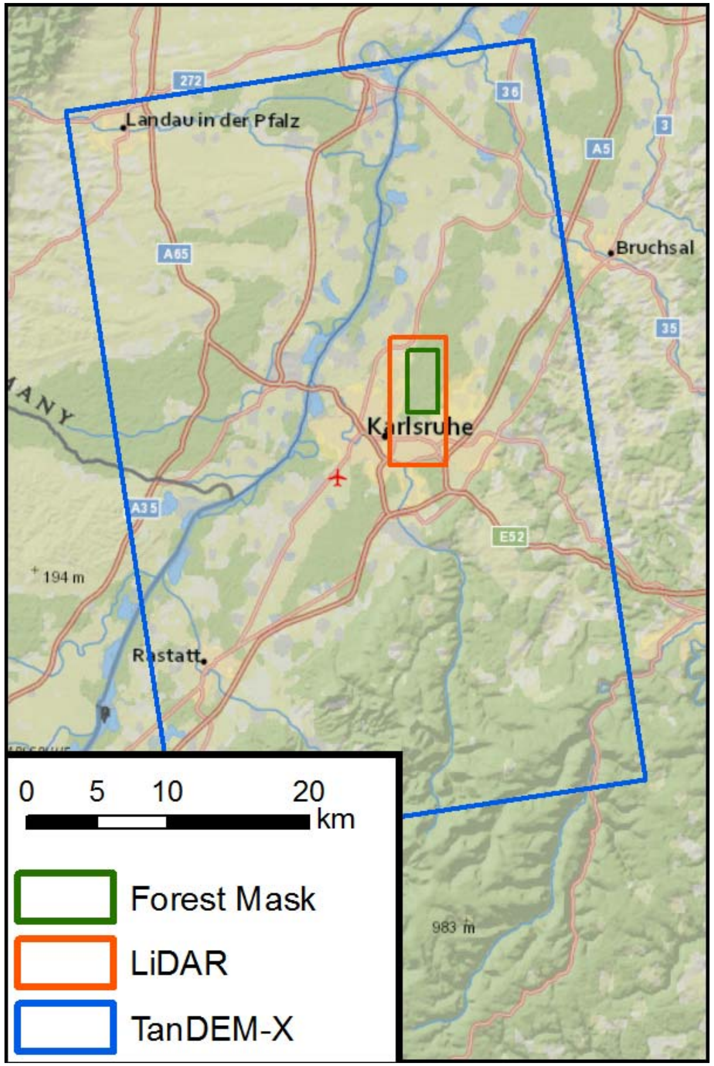
- North of the city center
- Flat terrain
- Main tree species: Pine & Oak





Available Data

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- TanDEM-X
  - Acquisition Date 2011-12-17
  - Acquisition Mode Stripmap (30 x 50 km) Bistatic Mode
  - Polarisation HH
  - Resolution ~ 4 m
  - Baseline 220,61 m
  - 2 PI Ambiguity height 34,44 m
- SRTM (~ 90 m)
- LiDAR First and Last Pulse Data
  - Flight Date 2009-08
  - Covered area 3 x 9 km
  - → DSM (Resolution 1 m)
- Forest Stand Data from forest GIS
  - Tree species & age
  - Annual harvesting in m³ (2007 to 2012)

TanDEM-X Interferometry Processing

1. Baseline Estimation
2. Interferogram Generation
   - Multilooking Options
     1 to 4 looks tested
3. Interferogram Flatening
   - Synthetic phase
     generation (SRTM)
4. Interferogram Filtering
5. Phase Unwrapping
6. Geocoding & Resampling
   to 5 m

Interferogram Filtering

The filtering of the flattened interferogram enables to generate an output product with reduced phase noise.

Two filters were tested:

- **Boxcar filter** with a fixed window size (5x5)
- **Adaptive filter** with an adjusted window size and shape depending on the local coherence values
  → longer computing time but better preserving of interferometric fringe patterns

Interferogram Filtering

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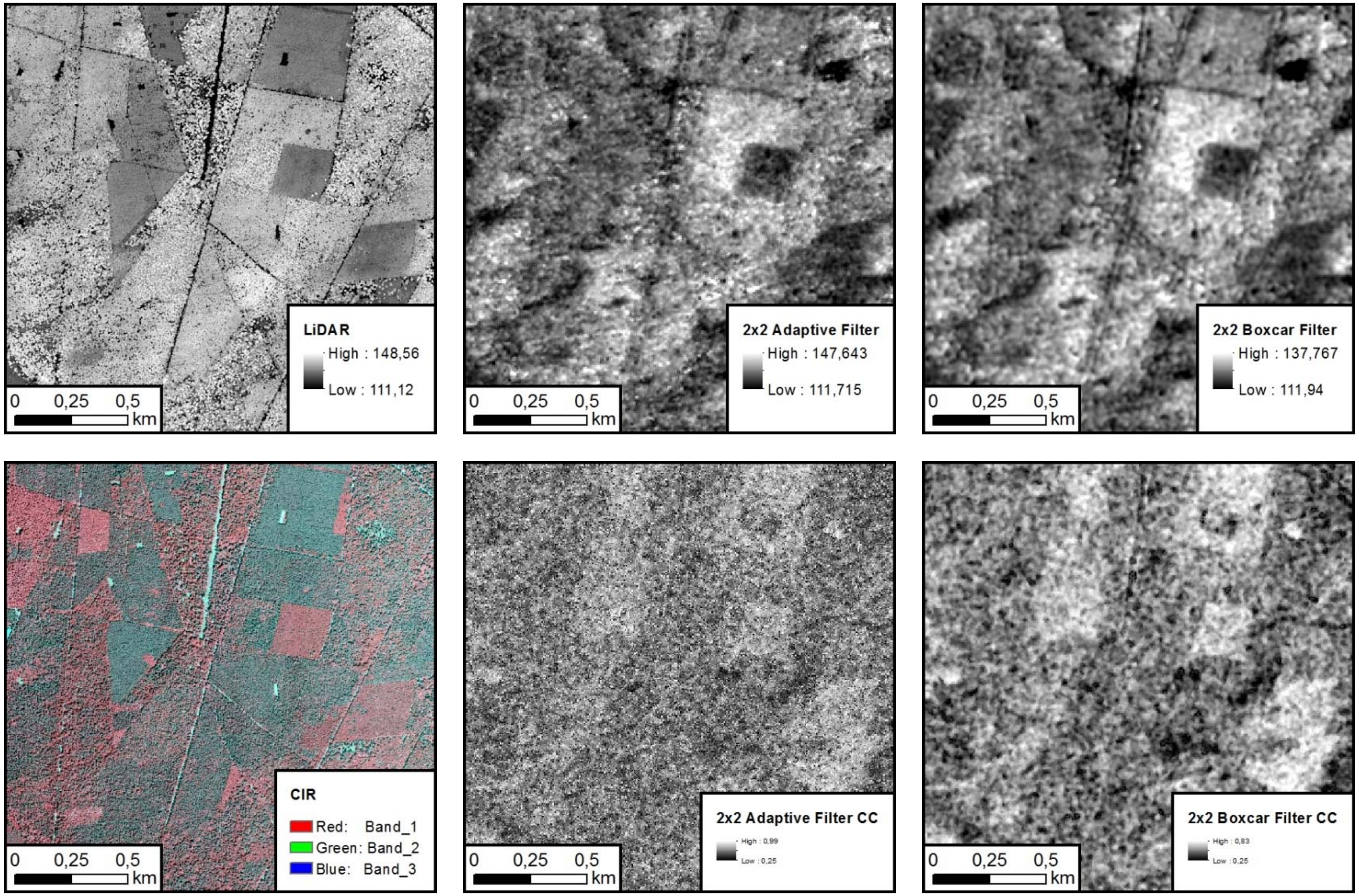

LiDAR Processing

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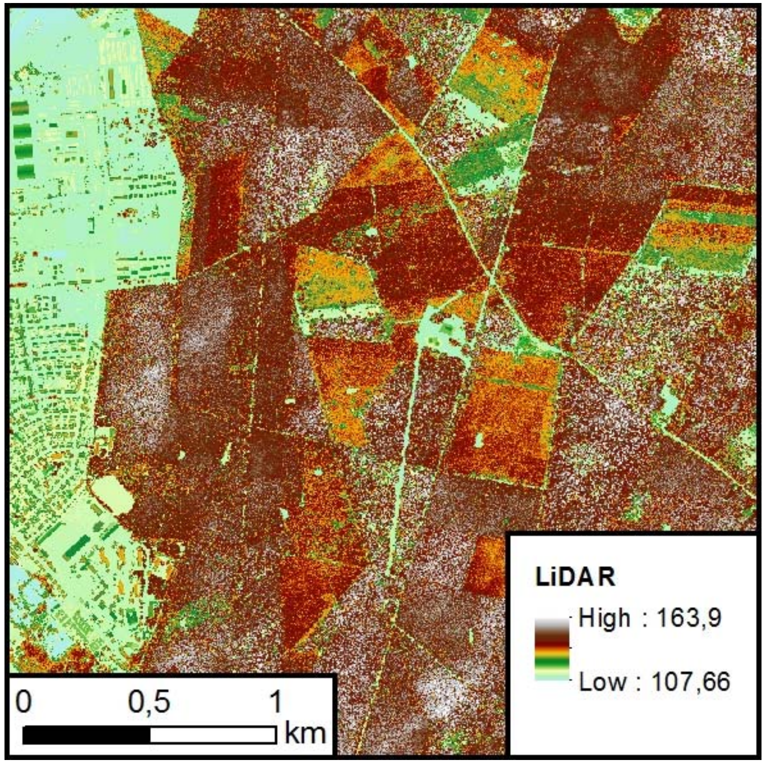
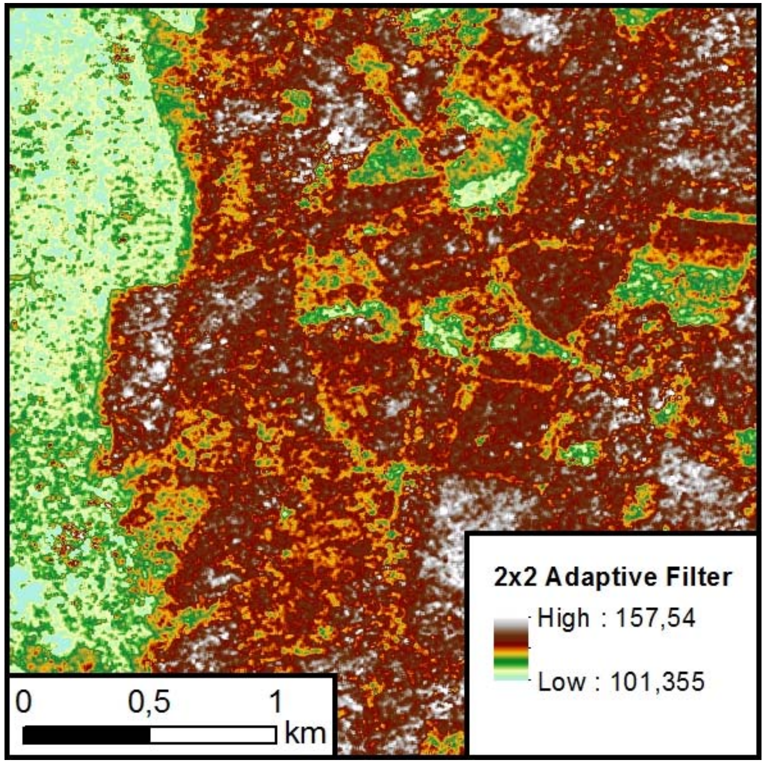
Use of an algorithm to exclude minimum values for better comparability with radar, resulting in Digital Surface Model with a 1 m resolution

LiDAR



2x2 Looks Adaptive Filter



Forest height Validation

Height validation on areas with homogenous vegetation:

A) Forest GIS data are used to prepare forest plots where forest type is homogeneous:

- Buffered with **-**10 meters (made smaller) to eliminate border effects
- Classified into classes :
  - 4 species classes: Oak, red oak, pine and douglas fir
  - 4 age classes

10-40	young age
41-80	middle age
81-130	old age

B) 10 test sites outside of the forest were delineated on agricultural land

Utilisation: Per such plot:

- calculation of the mean height based on LIDAR and TandemX separately
- Determination of the difference in mean height

Results for agricultural land

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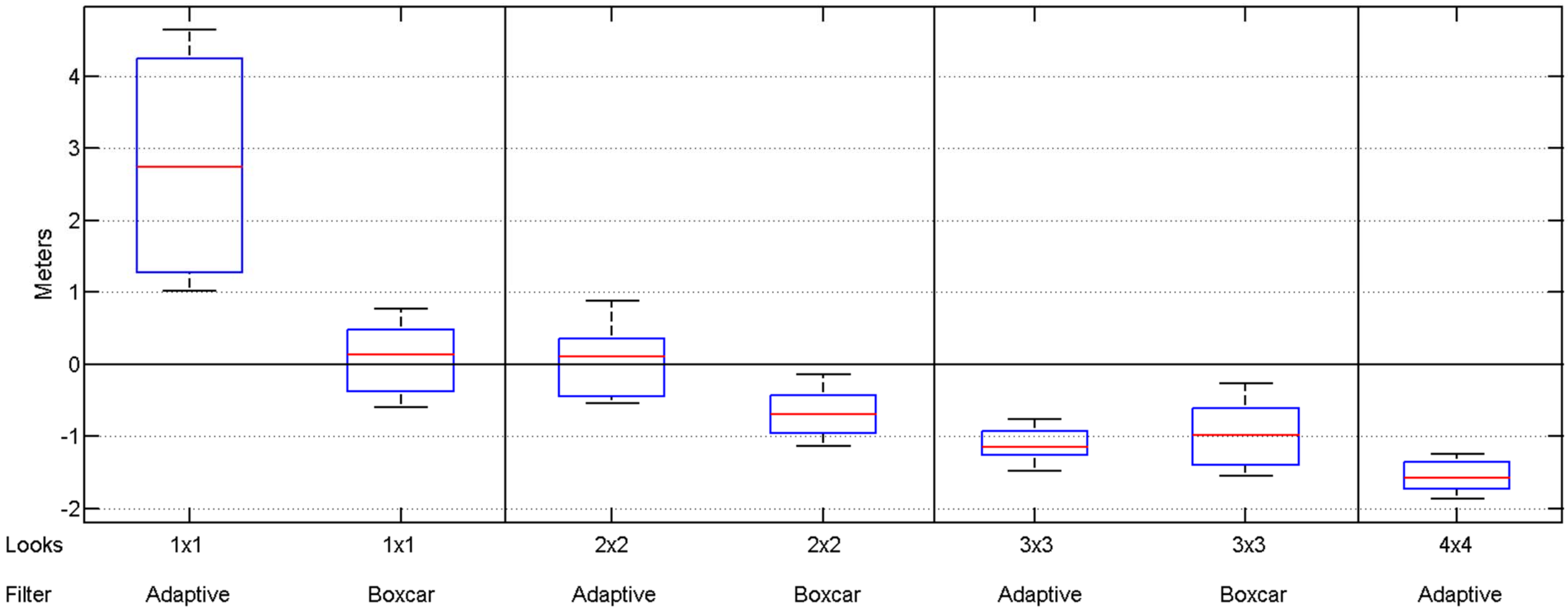

Results for different forest types

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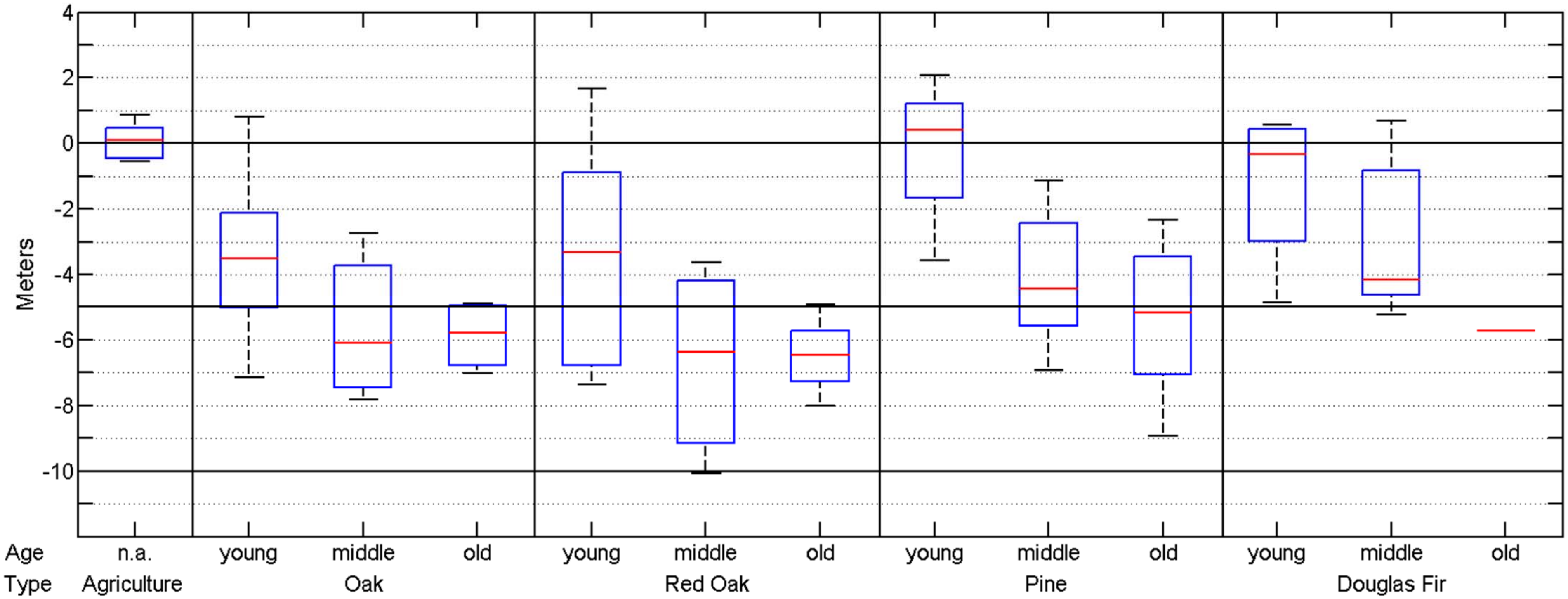
TanDEM-X data processed with 2x2 Looks and Adaptive Filter



Mean height difference versus Coherence

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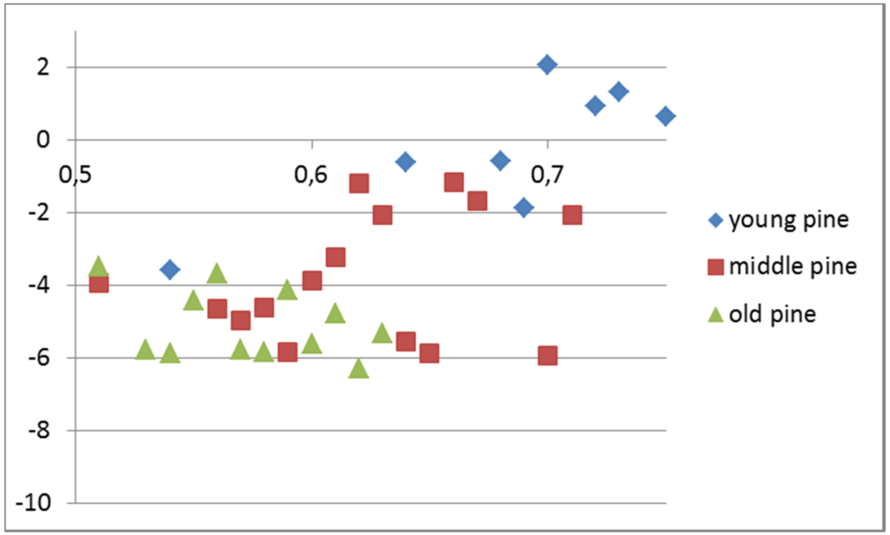

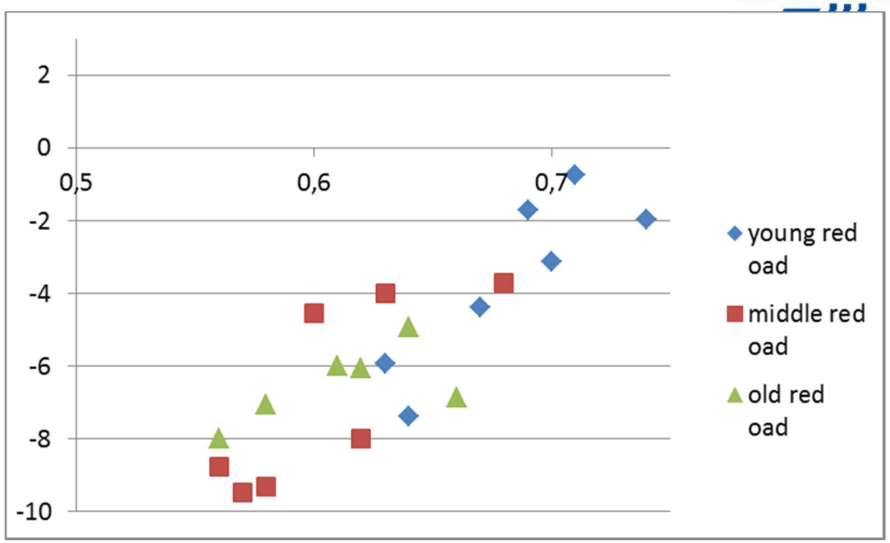

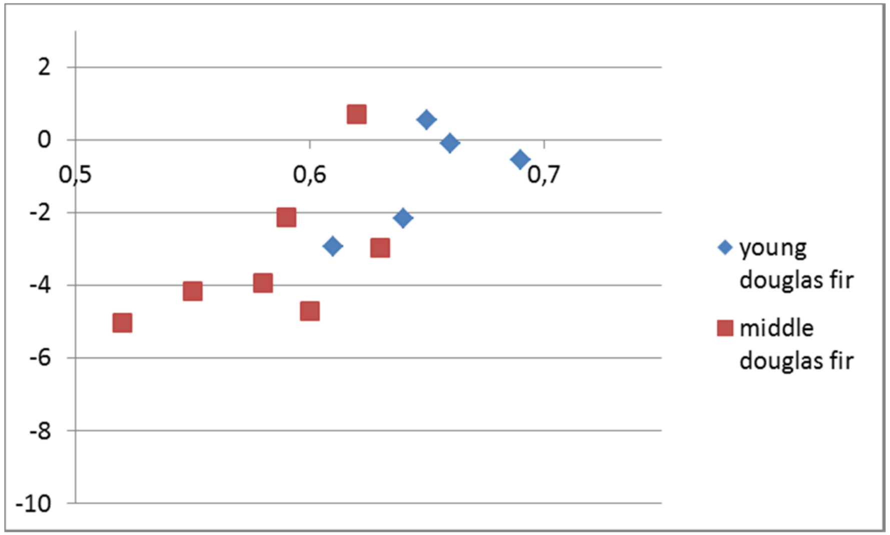

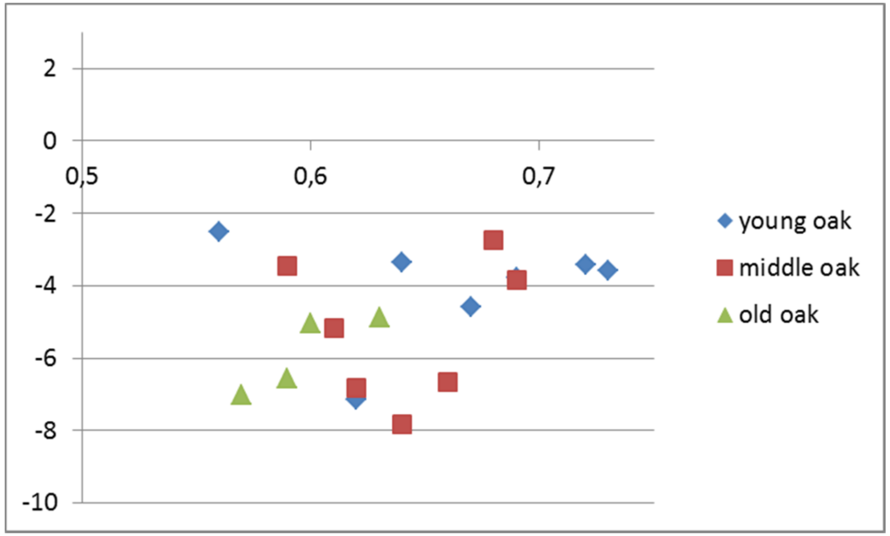

Conclusions

- TanDEM-X data processed with 2x2 Looks and the adaptive Filter provided the best results
- The mean height of conifer stands is increasingly underestimated with increased age, this might be due to more gaps in the canopy in older stands
- The mean height of broadleaf stands is underestimated for young stands, there is an high deviation in the height measurements. The middle and the old stands are more underestimated, the deviation decreases with higher age classes
- Coherence can be used as a measure of the accuracy of height measurements
- **Main conclusion**: Stand sites were never underestimated by more than 10 m → storm damages can be detected using the difference between LiDAR and TanDEM-X DSMs

Further research

- Comparison of Summer/Winter acquisition
- Use of different acquisition Mode
  (VHR with 1 m resolution)
- Segmentation of TanDEM-X data for gap detection