Knowledge transfer through Citizen Science using the example of a forest inventory campaign

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Background - Overall

- Paramount goal of EO: Collect data to boost understanding of biophysical processes and relationships on Earth for making wise decisions
- Data collection should include all means of observations: spaceborne, airborne, unmanned aerial vehicles (UAV), *in situ*, citizen scientists

Background - Forestry

- Precise inventory data of particular interest
- LiDAR: utilized to detect single trees and tree heights (in some Scandinavian countries inventories supported by LiDAR by default)
- Most European countries execute regular and country-wide LiDAR acquisitions
- Instead of LiDAR UAV/SfM (structure from motion) based point clouds can be used
- BUT: stem diameter cannot be measured using airborne LiDAR or UAV/SfM data
- Straightforwardness of dbh (diameter at breast height) measurements → appropriate citizen science exercise!

Fig.1. Scheme of integrative EO including observations based on in situ measurements, UAVs, planes, satellites, citizen scientists.

The Test Site Roda-Forest

- 15 km to the SE of Jena, Germany (Thuringia), see Figure 2
- Planted and intensively managed forest, dominant species: spruce and pine
- AOI located in the southern part of the Roda Forest (500 m × 250 m), it features gentle terrain
- During the past two years the forest affected by several stressors such as storm events, long drought periods (spring 2018 and 2019, summer 2018), and bark beetle attacks
- Forest management activities were conducted in June 2019 to remove stressed and affected trees and for thinning

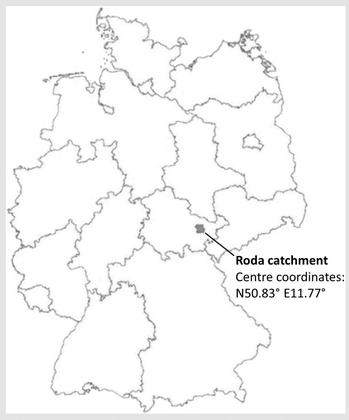

Fig. 2. Location of test site Roda-Forest

Field Data Acquisition by Citizens

- Citizens were "gathered" from a university lecture for forthcoming Geography teachers
- Hands-on learning and data collection for science and forestry → "win-win"
- Common planning of campaign
- Test of a new approach for improved positioning under challenging GNSS conditions (offset correction using Bluetooth low energy beacons – BLE)
- Tree coordinates delineated from terrestrial laser scanner (TLS) data
- Acquired parameters: stem circumference, species, will the tree be logged (those trees had a mark), other describing parameters
- Two campaigns: one before (May) and one after (July) the management action (cross validation, check which trees were logged)

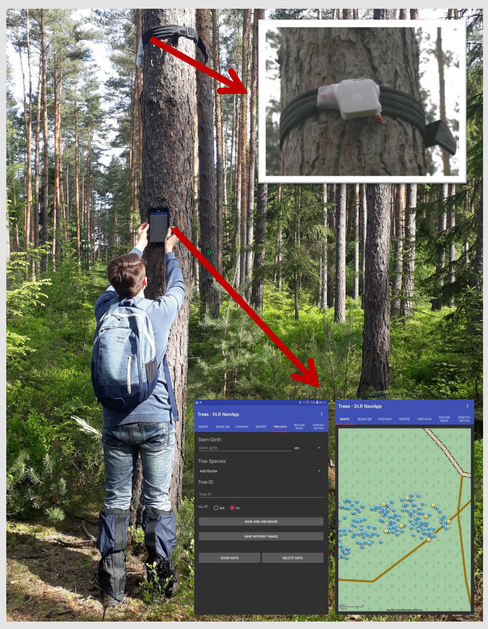

Fig. 3. Data collection by students using a specially developed App (Android). The position of the BLE (top right) was used to compute the offset between GNSS (global navigation satellite system) and true position

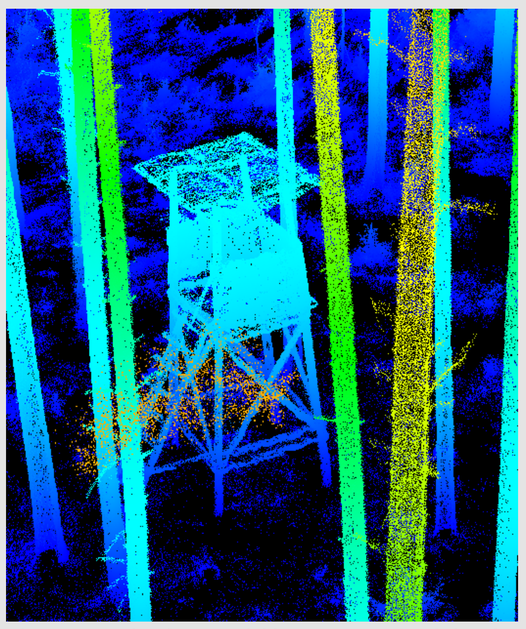

Fig. 4. Example of terrestrial laser scanner (TLS) data by J. Baade. This TLS dataset provides the basis for the tree and BLE positions

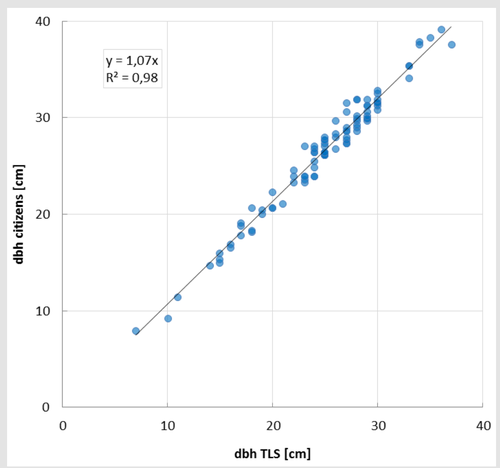

Fig. 5. Comparison of stem diameters at breast height (dbh) from TLS data against measurements from citizens (data from a former campaign). Accordingly, high accuracy can be achieved if the correct trees are identified within a forest.

UAV Data

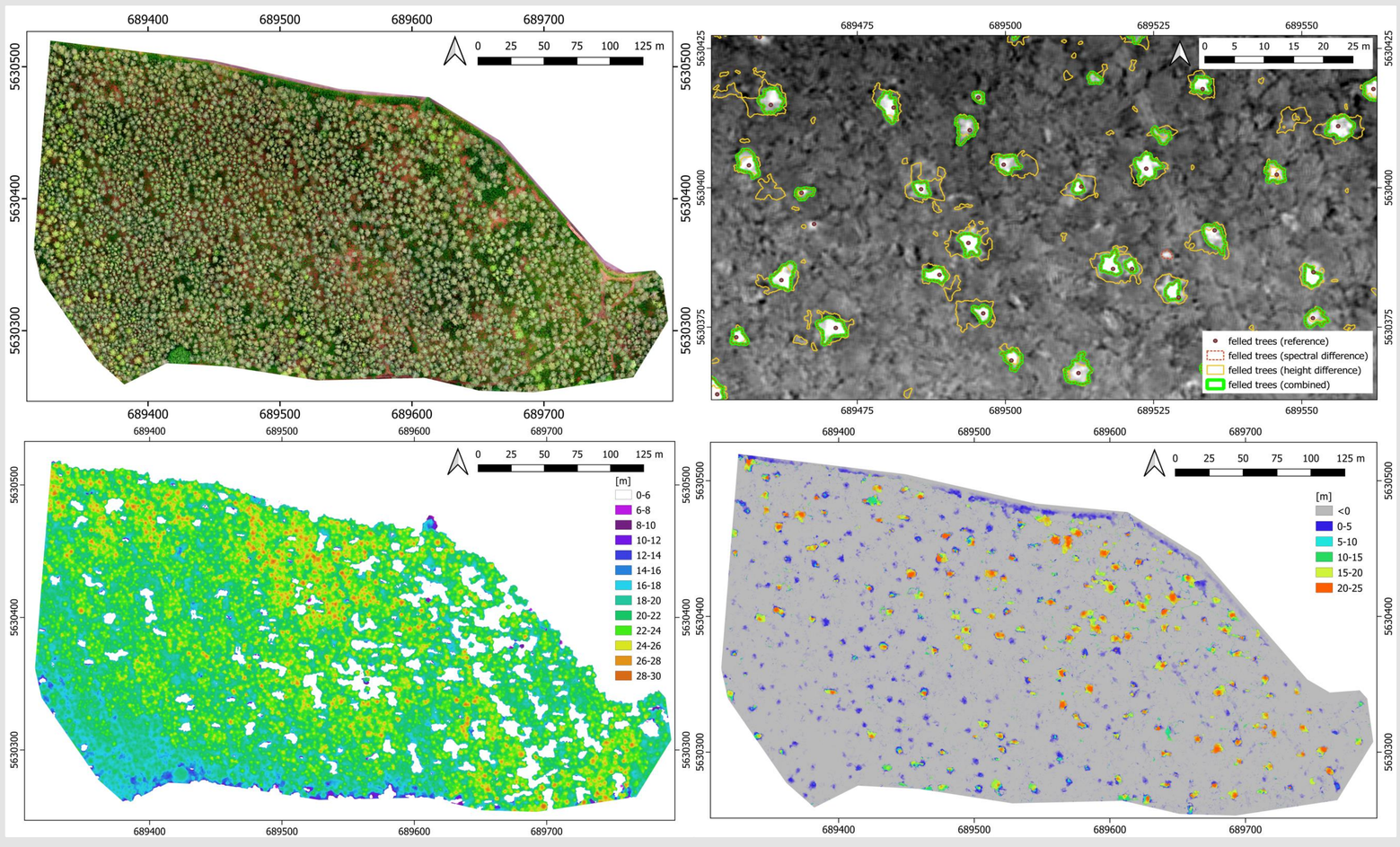

Fig. 6. In parallel to the field campaigns UAV campaigns with the RTK version of DJI`s Phantom 4 Pro were conducted. The conditions were calm and the illumination was diffuse (overcast). The UAV data was used to compute very high resolution image mosaics (top left, data from May) and normalized digital surface models (nDSM, bottom left). Based on the nDSM single tree heights can be delineated. As the RTK function delivers data with very high positional (XYZ) accuracy, difference images can be directly computed such as spectral differences (e.g. using the green channel, top right) or elevation differences (bottom right), which enables the automated detection of logged trees.

Integration of Field and UAV data

- UAV data allow for detection of single trees and measurement of their heights
- Furthermore, detection of logged trees is feasible
- Cross-check of field data (dbh) collected before and after management action revealed high agreement
- Based on dbh and tree height tree-wise stem volume can be computed
- This includes stem volume of logged trees
- This kind of information is of extreme value for radar satellite based research

Summary & Outlook

- This study provides an example for the great value of including citizens in research in order to test new acquisition tools, to collect data or to extend existing educational concepts
- If properly designed, citizen science projects will enable a win-win situation in which the benefit for the citizens can be achieved in many different ways
- To be successful in the latter point, science on citizen science is needed

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