Evaluation of Interferometric Radar Tree Mapping Parameters using Tree Grouping Approach

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ABSTRACT

Radar 3D-tree mapping is important for monitoring of certification for sustainable natural forest management (SFM). Evaluation of interferometric radar tree mapping parameters and tree plot parameter measurements is the primary objective in this paper. To achieve this objective, the objects (trees) grouping approach was evaluated using available buffering techniques in Geographic Information Systems (GIS) software. Results showed that along with aerial photo interpretation and Ikonos tree shadow approach were not comparable with the results derived from radar tree mapping algorithm, however using tree grouping approaches the results showed qualitative similarity tree patterns. This evaluation concludes that the tree grouping of tree mapping parameters could have spatial pattern similarity to the tree grouping of field measurements, aerial photo interpretation, and Ikonos tree shadow. The positive implication is that further technique of tree aggregation can consider this evaluation as additional remarks along with the forest tree structure analysis.

Keywords and phrases**:** Synthetic Aperture Radar (SAR), Interferometric

1.0 INTRODUCTION

1.1. Background

The shape of a tree is defined by its branching architecture and leaf geometry (Ustin, *et al*., 1994). The structure of tree canopy is important for input of radiation scattering at microwave wavelength. Varekamp (2001) assumed that the tree crown is an isotropic random scattering volume consisting of many independent scatterers per resolution cell. Varekamp and Hoekman (2000) concluded that C-band was accurate enough to assess the validity of interferometric Synthetic Aperture Radar (InSAR) image simulation approach as a tool for testing tree map inversion algorithms and as a tool for comparing system designs for tree mapping.

Hoekman and Varekamp (2001) investigated the use of InSAR for individual 3D-tree mapping. They developed an algorithm that could map a 3D individual tree, which would be very important for certification purposes and to detect illegal logging activities. The information requirement for timber certification based on ITTO recommendation, however, needs dynamic inventory on the timber production information.

Several validations for 3D individual tree mapping have been done in East Kalimantan (Prakoso and Suryokusumo, 2000) and Jambi (Bos, 2002). Temporary conclusion is that further validation technique can be introduced, e.g. SAR image simulation from radar plot and tree grouping validation. Therefore, this paper is intended to show qualitative validation results using the tree grouping approach.

1.2. Objective

The objective of this study is an evaluation of interferometric radar tree mapping parameters and tree plot parameter measurements using the tree-grouping approach.

1.3. Structure of the Paper

The structure of the paper consists of:
- Introduction
- Materials and Method
- Results and Discussions
- Conclusion and Recommendation

2.0. MATERIALS AND METHOD

2.1. Materials

This study uses data of Airborne DOSAR of August 1996 and the study area is located in East Kalimantan and Jambi, Indonesia (Figure 1). The fieldwork activities have been done in year 1999 and 2000. The latest fieldwork has been done in the study area in July 2002 along with Global Positioning Systems (GPS) measurement.

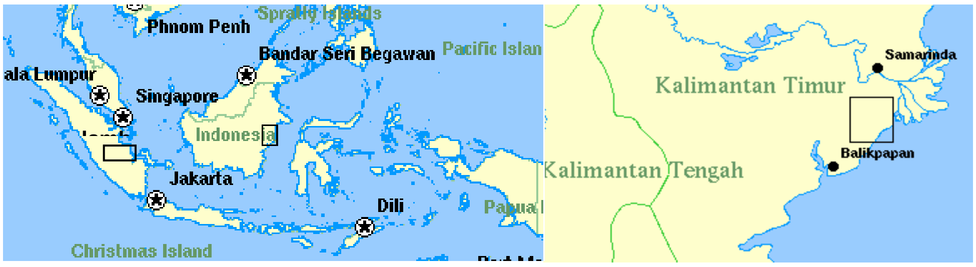


Figure 1. The location of study area

2.2. Method

In this paper or this study, the point of departure is an individual tree level up to a group of trees or groups of trees. This study also uses the 3D-tree-aggregation-mapping algorithm developed by Dr. Hoekman, Wageningen University (Figure 2).

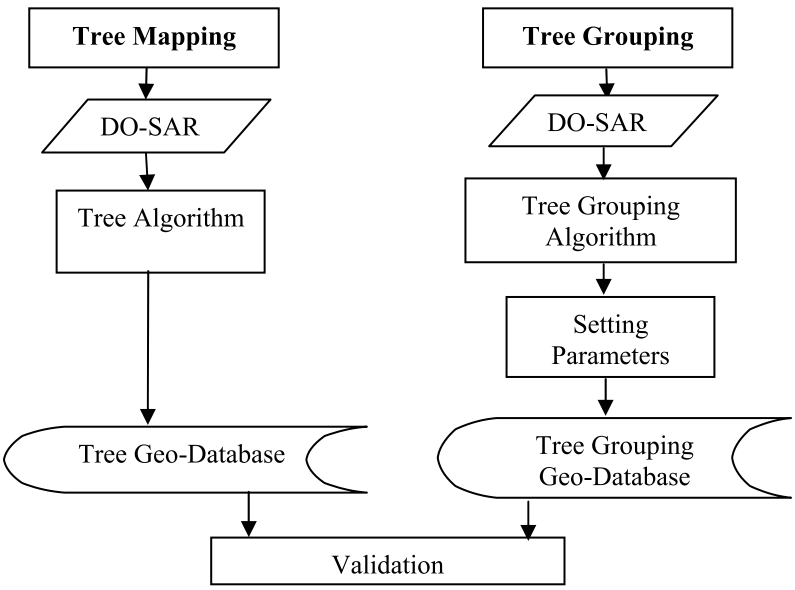


Figure 2. Flowchart of Forest Structure Analysis in DO-SAR images

3.0. RESULTS AND DISCUSSIONS

3.1. 3D-Tree Mapping and Forest Plots

The 3D-tree mapping was run on the Beratus, East Kalimantan and Silva Gama, Jambi DO-SAR data and these results were compared to the 6 Ha Radar Plot. The 6 Ha Radar Plot contains complete information, e.g. contour of the land, x,y,z coordinates of tree trunk, local-species-genus- family identification, tree height, diameter at breast height, height of first branch, height of periphery, canopy radii of 8 compass directions at periphery that these data can be visualized in 3D look alike from any direction as well as from above views (Prakoso and Suryokusumo, 2000). Results showed several difficulties to be compared in a qualitatively way. Difficulties are found because a certainty about the real tree-trunk or tree-stem position is being questioned. This uncertainty could be resolved at least to convince that the tree seen in DO-SAR was the tree found in the fieldwork and the use of GPS including compass and measuring tapes were very helpful. Obviously, there could be differences by time (1996 and 1999, 2002) and by the viewing, e.g. fieldworkers see from below and In-SAR sees from above (Figure 3 and 4).

Bos (2002) tried to test the height comparison between 3D-tree mapping results and plot data using Siegel/Tukey test in Jambi. The test showed that only one plot has a significant difference in the distribution of height measured by both methods. The poor results could be caused by a slight different position of plots and pure secondary forest was measured in the field. The significant plot was a transition from secondary forest to a rubber forest.

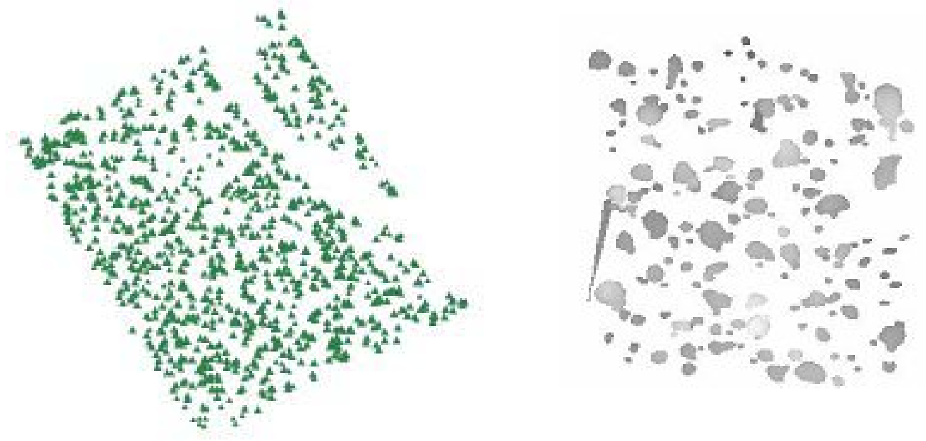


Figure 3. Example of Forest Survey Data Visualization and Beratus 3D-Tree Mapping Geo-database

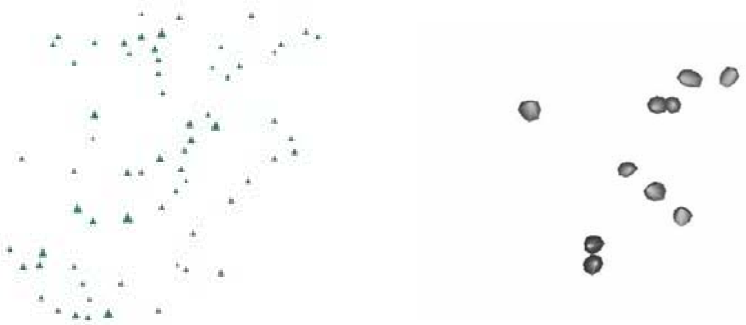
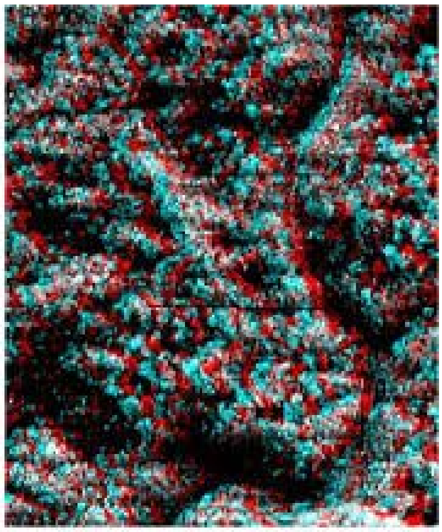


Figure 4. Example of Forest Survey Data Visualization and 3D-Tree Mapping Geo-database in Jambi

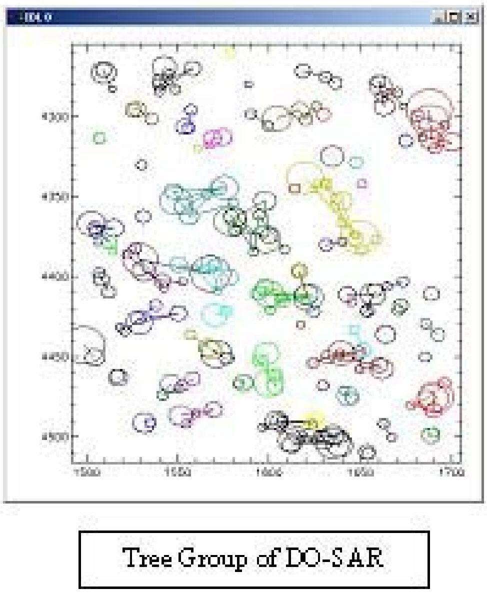
3.2. Tree Grouping Validation

A group of tree could be grouped based on the close distance among tree canopies in 2D or in 3D. Plots that have been established are dominated by Dipterocarpaceae that tends to clump (Smits, 1994). In addition, young *Shorea leprosula* of Dipterocarpacea found to be needed shades (Omon, 2002). These are the reasons that tree grouping can be used for In-SAR tree mapping validation. The 2D-tree grouping tries to create groups based on buffering technique of tree point feature, which representing an average radius of tree canopies. The 3D-tree grouping tries to accommodate a real world situation when within a group would consist of big trees and several small trees in between. The concept of network limits one tree not to have more than one link to other trees. Qualitatively, this 3D-tree grouping approach on an intact secondary forest showed a slight difference result with the 2D-tree grouping approach that based on a fixed buffering, e.g. a canopy radius is assumed 6 meter (Figure 5 and 6).

Tree Group of Radar Plot



Anaglyph of DO-SAR



Tree Group of DO-SAR

Figure 5. The 3D- tree group and tree group using buffering technique with tree height as weighting factor

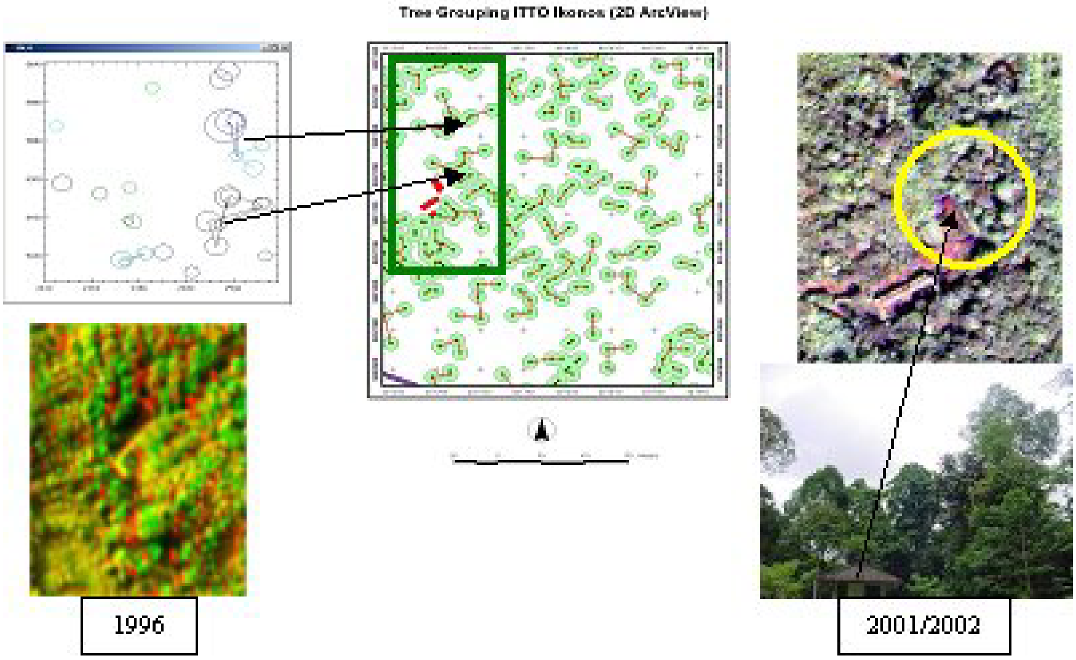


Figure 6. 3D tree grouping that based on user requirements on distance and difference tree height

Qualitatively, results showed that the validation used tree grouping approaches seemed to have similarities in tree patterns, but these should be checked furthermore. For the intact forest, Ikonos data would be sufficient enough for qualitative validation for 3D-tree mapping and the similar tree patterns could be seen (Figure 7).

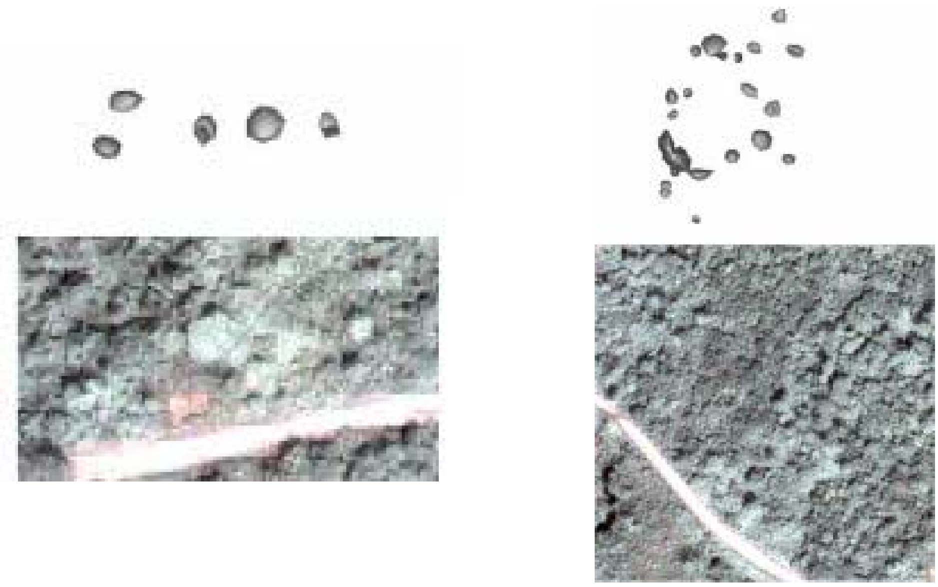


Figure 7. Two examples of 3D-tree mapping and Ikonos image

Currently, there are about 18 plots are being investigated to be used for SAR image validation, e.g. AirSAR. Fieldwork has been also done in July 2002 to improve the quality of the plots. For further research, our radar group would like to investigate the use different aggregation indexes (Pretszch, 1999 in Olsthoorn *et al.*, 1999) and the assessment of spatial similarity (Abdelmoty and El-Geresy, 2000 in Atkinson and Martin, 2000).

4.0. CONCLUSION AND RECOMMENDATIONS

The objective of this study is to investigate the tree grouping validation for 3D-tree mapping of DO-SAR data using tree-grouping approaches. The results showed that tree-grouping objects could be used for 3D-tree mapping of DO-SAR data in a qualitative way. Quantitatively, these results can support the clumped and shade requirements of Dipterocarpaceae.

Further investigations on developing tree grouping indexes and species or genus identification by SAR images would be important for the further quantitative validation approaches.

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