FRINGE 2015 WORKSHOP

Advances in the Science and Applications of SAR Interferometry and Sentinel-1 InSAR Workshop

TanDEM-X InSAR time series data in forest cover mapping in boreal zone

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• Interferometric coherence interpretation from thematic mapping viewpoint

\[ \tilde{\gamma} = \tilde{\gamma}_{\text{temporal}} \cdot \tilde{\gamma}_{\text{SNR}} \cdot \tilde{\gamma}_{\text{spatial}} \]

• Forest layer causes decorrelation, relevant theory for forest-layer-parameters inversion is in mature state.
• However, not many suitable satellite instruments for forestry
• Data are accumulated and can be used:
  – monitoring changes (e.g., bi-temporal)
  – Improving stability, retrieval, resolution etc
  – Memorizing ”temporal signatures” for further interpretation (analysis, classification)
Study focus

• Two case studies to access utility of multitemporal TanDEM-X InSAR for improved characterization of boreal forest

• Specific objectives
  – Study seasonal variability of SPC in the forest layer for characterizing forest cover (differentiating primary forest classes)
  – Capability of multitemporal TDX InSAR for forest parameter retrieval (forest tree height)

• Two study sites with different reference data
Test site and data

• Kirkkonummi
Test site and data

- Kirkkonummi

Test site area

44 land cover classes

Delineation of 3 primary forest classes:
- Deciduous forest on mineral soil,
- Coniferous forest on mineral soil,
- Mixed forest

<table>
<thead>
<tr>
<th>Acquisition Date</th>
<th>Acquisition Time</th>
<th>Effective Baseline (m)</th>
<th>Polarizations</th>
<th>Min. Incidence Angle</th>
<th>Max. Incidence Angle</th>
<th>Orbit Direction</th>
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Temporal dynamics

- Coherence magnitude

Average coherence was highest for deciduous forest and lowest for coniferous forest.

Differentiation of forest classes is problematic
Temporal dynamics

Coherence phase

- Methodology
  - External DEM for topographic phase removal
  - Ground DEM matching with $\text{abs(Y)} > 0.95-0.98$
  - Investigating co-pol channels
  - Potential for model based inversion (e.g., RVoG)?
Temporal dynamics

- SPC height and location in the forest layer centre
Temporal dynamics

- VV-pol SPC height was larger than HH-pol.
- VV-pol relative location of SPC to the treetop was higher compared to HH-pol.
- September acquisition had least difference between HH and VV.
- Higher temporal variation at HH-pol compared to VV-pol.
- Coniferous forest exhibited more stable behavior across the season.
- Mixed forest peculiarity attributed to structure composition and density.
Test sites and data

- Hyytiälä forestry station
Test sites and data

- Hyytiälä forestry station

Test site area

Stand-wise forest inventory

TanDEM-X data

6 May 2011
20 August 2012
24 June 2013
27 July 2013
Tree height retrieval

- 10km x 11km site, 55 stands size >2 ha
Tree height retrieval

• How to combine them?
  – Accumulation of results from several scenes and averaging
  – Scene by scene retrieval followed by multiple regression

RMSE=3.3 m, R2=0.58  RMSE=3.3 m, R2=0.57  RMSE=4.2 m, R2=0.32  RMSE=3.4 m, R2=0.55
Fusion approach

1. Mask of training forest stands
2. Forest stand inventory data
3. Mask of validation forest stands

- Training data
- Validation data

- InSAR data
- Training individual models
  - Individual models
- Training multiple model
  - Multi-date model

Tree height estimation
Tree height map
Validation
Fusion approach

Ensemble averaging vs. Multiple regression

RMSE=3.2 m, R2=0.61

RMSE=3.0 m, R2=0.65
Conclusions

• Potential for forest classes differentiation is limited, further investigation needed with longer baselines.
• Tree height retrieval with RMSE about 3 meters.
• Multitemporal aggregation increased stability and accuracy. Other approaches could be tested.
• Scenarios in absence of reference data or reference DEM need attention. Model-based approaches? Nonlinear models? Validity of underlying assumptions should be checked.