

ALOS-PalSAR & TanDEM-X Acquisitions for Forest Disturbance & Degradation Mapping

Florian Kugler¹, Kostas Papathanassiou¹, Irena Hajnsek², Shane Cloude³

¹Microwaves and Radar Institute (DLR-HR) German Aerospace Center (DLR)

Deutsches Zentrum für Luft- und Raumfahrt e.V. in der Helmholtz-Gemeinschaft

eV

²Institute of Environmental Engineering, ETH Zürich

³AEL Consultants, Scotland, UK



Combination and Synergies of TanDEM-X and ALOS-PalSAR data

K&C Initiative

An international science collaboration led by JAXA

ALOS

- The availability of two different enough frequencies provides a sensitivity to different vertical structure parameters / frequencies;
- The structural sensitivity of the single-pass interferometric coherence allows detect vertical structur disturbances (degradation) before these become visible in the L-band images;
- The high spatial resolution of TanDEM-X is crucial when it comes to detection of small scale disturbances (down to single trees ?);
- The hi-res DEM provided by TanDEM-X can be used to interpretation ambiguities in the interpretation of single- dual or even quad-pol L-band data;
- The higher sensitivity of L-band to higher biomass levels than the one at X-band is critical for interpreting/investigating high(er) biomass forest conditions;
- The availability of fully polarimetric data at L-band provides a significant interpretation and quantification advantage.

Objectives

K&C Initiative

An international science collaboration led by JAXA

ability to detect small scale changes in forest environments

ALOS

- ability to detect forest biomass changes at high spatial resolution
- the determination of forest structure and sensitivity to (vertical) structure changes
- Evaluation of the potential to combine ALOS-PalSAR and TanDEM-X acquisitions for forest disturbance & degradation mapping;
- Development and implementation of an appropriate methodology;
- Demonstration (and if possible validations) on a limited number of selected test sites/cases.

Results from Phase I

the state of the

Level of Temporal **Decorrelation (42** days) Collapses **Height Inversion**



Vertical

Wave

Number

 K_{z}

0.1130

Dihedral

Coherence

0.608

0.505

Surface

Coherence

0.401

0.405

Volume

Coherence

0.243

0.246

Spatial

baseline

[m]

662.016

Date

2007. 02. 15

2007.04.02

ΗH

VV



Coherence

Interferometric Coherence scaled from 0(black) to 1 (white)

TanDEM-X Data Acquisition Modes

Pursuit Monostatic



Alternating Bistatic



- both satellites transmit and receive independently
- susceptible to temporal decorrelation & atmospheric disturbances
- no PRF and phase synchronisation required (backup solution)



- one satellite transmits and both satellites receive simultaneously
- small along-track displacement required for Doppler spectra overlap
- requires PRF and phase synchronisation

Standard DEM Mode

transmitter alternates between PRF pulses

- provides three interferograms with two baselines in a single pass
- enables precise phase synchronisation, calibration & verification

Temporal baseline: 2-3 sec (20-30Km Across Track separation)

Location TanDEM-X data sets



Deutsches Zentrum DLR für Luft- und Raumfahrt e.V. in der Helmholtz-Gemeinschaft

(temperate riverine forest)







Test Site: Krycklan, Sweden







Interferometric Coherence: HH



Deutsches Zentrum DLR für Luft- und Raumfahrt e.V. in der Helmholtz-Gemeinschaft

Temporal Decorrelation



DLR für Luft- und Raumfahrt e.V. in der Helmholtz-Gemeinschaft

TanDEM-X Data Acquisition Modes

Pursuit Monostatic



- both satellites transmit and receive independently
- susceptible to temporal decorrelation & atmospheric disturbances
- no PRF and phase synchronisation required (backup solution)





- one satellite transmits and both satellites receive simultaneously
- small along-track displacement required for Doppler spectra overlap
- requires PRF and phase synchronisation

Standard DEM Mode

Alternating Bistatic



- transmitter alternates
 between PRF pulses
- provides three interferograms with two baselines in a single pass
- enables precise phase synchronisation, calibration & verification

Bistatic

Dual-Pol HH-VV Stripmap Test Site Location: OP InSAR Mode: Bistatic Temporal Baseline: 0.?sec Vertical Wavenumber: 0.1 Date: 10th February 2011

ANDEM





Dual-Pol HH-VV Stripmap Test Site Location: OP InSAR Mode: Bistatic Temporal Baseline: 0.?sec Vertical Wavenumber: 0.1







Dual-Pol HH-VV Stripmap Test Site Location: OP InSAR Mode: Bistatic Temporal Baseline: 0.?sec Vertical Wavenumber: 0.1m Date: 10th February 2011

ANDEM





Riverine Deciduous Forest Isar Germany 12.4.2011



Riverine Deciduous Forest Isar Germany 04.05.2011



Riverine Decidous Forest Isar Germany 15.05.2011



BioSAR II: Krycklan, Sweden

Forest heights: Up to 30m - (Mean ~ 17m)

Biomass range: Up to 220t/ha - (Mean ~ 90t/ha)

Pine, Spruce, Birch & Mixed stands.

Hilly Terrain / Steep local slopes



Test Site: Krycklan, Sweden

in der Helmholtz-Gemeinschaft



Test Site: Krycklan, Sweden



Deutsches Zentrum DLR für Luft- und Raumfahrt e.V. in der Helmholtz-Gemeinschaft

Penetration Depth @ X-band



Pol-InSAR Coherence Region



Pol-InSAR Phase Difference



the state of the second s

DLR Dutsches Zentrum für Luft- und Raumfahrt e.V. in der Helmholtz-Gemeinschaft





6m

0m





Forest Height Estimation: 1 Pol + DEM





Forest Height Estimation: 2 Pol



Dual-Pol HH-VV Stripmap Test Site Location: OP InSAR Mode: Bistatic Temporal Baseline: 0.?sec Vertical Wavenumber: 0.1 Date: 10th February 2011

ANDEM





ALOS Comparision of different acquistions dates: Pauli Image



30th June 2006

2nd April 2007

20th August 2008

Polarimetric Decompostion: Surface (blue), Dihedral (red), Volume(green) Power



30th June 2006

2nd April 2007

20th August 2008

Polarimetric Decompostion: Surface (blue), Dihedral (red), Volume(green) Normalized Power



30th June 2006

2nd April 2007

20th August 2008

Comparision ALOS PALSAR vs. TanDEM-X



ALOS 20th August 2008 Pauli

TanDEM-X 2nd February 2011 Dual-pol colour composite

TanDEM-X 2nd February 2011 Amplitude HH

Comparision ALOS PALSAR vs. TanDEM-X



ALOS 20th August 2008 Pauli

ALOS 20th August 2008 Decompostion

TanDEM-X 2nd February 2011 Phase centre difference

Summary

- 3 seconds temporal baseline can decorrelate interferometric coherence dramatically (in case of X-band)
- Single Pol TanDEM-X data (VV) are sensitive to forest height (with a priori ground phase r²=0.91, RMSE = 1.58)
- Dual Pol TanDEM-X data (HH, VV) allow forest height estimation without any a priori information at least for boreal forests as found in Krycklan test site (r²=0.86, RMSE = 2.02)
- ➤ ALOS PalSAR sees similar features as TanDEM-X -> Synergies
- ALOS PalSAR could serve as a reference for the interpretation of up to date TanDEM-X data
- Changes in the data may appear due to seasonal effects, but also from other origin

Test Site and required Data

K&C Initiative

An international science collaboration led by JAXA

Borneo, Central Kalimantan, Centre coordinate: lat= - 2.20770, long = 114.45625

ALOS PALSAR K&C strip data FBD (HH+HV) and

if possible Quad Pol (HH HV VH VV) data

Additional test sites

ALOS

Extra test sites will be selected in agreement with the ALOS K & C initiative group

Data sets with proofed changes in forest conditions are preferred

TanDEM-X data can be accordingly acquired

Proposal relies on Single pass TanDEM-X data and ALOS PalSAR archive data

Deliverables

K&C Initiative

An international science collaboration led by JAXA

ALOS

- D1 (KO+12Months): <u>Technical note</u> on the potential to combine ALOS-PalSAR & TanDEM-X acquisitions for Forest Disturbance & Degradation Mapping based on test case analysis;
- D2 (KO+24Months): <u>Technical note</u> describing the proposed methodology for combining PalSAR & TanDEM-X acquisitions for Forest Disturbance & Degradation Mapping;
- D3 (KO+36Months): <u>Technical report</u> on the demonstration of Forest Disturbance & Degradation Mapping from combined ALOS-PalSAR and TanDEM-X acquisitions.
- ✓ D4 (KO+48Months): <u>Technical report on the analysis of</u> multi-annual Forest Disturbance & Degradation Dynamics.
- → TanDEM-X data (DEM's) for several test sites



ALOS-PalSAR & TanDEM-X Acquisitions for Forest Disturbance & Degradation Mapping

Florian Kugler¹, Kostas Papathanassiou¹, Irena Hajnsek², Shane Cloude³

¹Microwaves and Radar Institute (DLR-HR) German Aerospace Center (DLR)

> Deutsches Zentrum für Luft- und Raumfahrt e.V. in der Helmholtz-Gemeinschaft

²Institute of Environmental Engineering, ETH Zürich

³AEL Consultants, Scotland, UK



Krüger National Park



- Savanna forest
- Single trees no closed canopy
- Tree heights up to 20m



Deutsches Zentrum für Luft- und Raumfahrt e.V. in der Helmholtz-Gemeinschaft

