Exploring the Potential Pol-InSAR Techniques at X-Band: First Results & Experiments from TanDEM-X

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

**July until October 2010**

**Alternating Bistatic**
- one satellite transmits and both satellites receive simultaneously
- small along-track displacement required for Doppler spectra overlap
- requires PRF and phase synchronisation
- transmitter alternates between PRF pulses
- provides three interferograms with two baselines in a single pass
- enables precise phase synchronisation, calibration & verification

**Standard DEM Mode**

**Temporal baseline: 2-3 sec (20-30Km Across Track separation)**
Teneriffa (2x bistatic) Coherence
87m HoA ($k_z \approx 0.075$) vs. 25m HoA ($\approx 0.27$)
Different Geometries
TSX-TDX Monostatic Mission Phase

Test Site Mawas / Borneo

24.07.2010  HH Pol / Baseline: 38m
04.08. 2010 HH Pol / Baseline: 35m
06.09.2010  HH Pol / Baseline: 54m
TSX-TDX Monostatic Mission Phase

Test Site Mawas / Borneo

24.07.2010 HH Pol  Baseline: 38m

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Pursuit Monostatic

- both satellites transmit and receive independently
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Bistatic

- one satellite transmits and both satellites receive simultaneously
- small along-track displacement required for Doppler spectra overlap
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Alternating Bistatic

- transmitter alternates between PRF pulses
- provides three interferograms with two baselines in a single pass
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Standard DEM Mode

200-500m Across Track separation
First Bistatic Dual Pol-InSAR Data Takes

Dual-Pol HH-VV Stripmap

Test Site Location: OP
InSAR Mode: Bistatic
Temporal Baseline: 0.7 sec
Vertical Wavenumber: 0.1
First Bistatic Dual Pol-InSAR Data Takes

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

Test Site Location: OP

InSAR Mode: Bistatic

Temporal Baseline: 0.3 sec

Vertical Wavenumber: 275 m

First Bistatic Dual Pol-InSAR Data Takes
First Bistatic Dual Pol-InSAR Data Takes

Dual-Pol HH-VV Stripmap
Test Site Location: OP
InSAR Mode: Bistatic
Temporal Baseline: 0.7 sec
Vertical Wavenumber: 0.1 m
Krüger National Park

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

Amplitude HH

Coherence HH

DEM (200-450m)

Dual-pol: / HH-VV, Incidence: 40deg, kz=0.1
TanDEM-X: Dual-Pol InSAR: First Bistatic Data Takes

Test Site: Wallerfing, Germany

04.05.2011

26.05.2011
TanDEM-X: Dual-Pol InSAR: First Bistatic Data Takes
Coherence Tomography

Volume Coherence

\[ \tilde{Y}_{\text{Vol}}(f(z)) = e^{ik_z z_0} \frac{\int_{0}^{h_v} f(z) \, e^{ik_z z} \, dz}{\int_{0}^{h_v} f(z) \, dz} \]

Fourier Legendre Series:

\[ f(z') = \sum_{n} a_n P_n(z') \quad \text{where} \quad a_n = \frac{2n + 1}{2} \int_{-1}^{1} f(z') P_n(z') \, dz' \]
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
PCT Profiles
PCT Coefficients: Ascending

Single Baseline Coeff: Half vs Full Baseline

Dual vs Single (Half Baseline)

Dual vs Single (Full Baseline)
PCT Coefficient Maps
PCT Coefficients

Height versus A1 plot

Height versus A2 plot
Summary

• Volume decorrelation effects at X-band over a variety of forest conditions … combined with Pol-InSAR sensitivity (coherence & phase center location).
  - Classification;
  - Forest Height;
  - Structure characterisation.

• Data quality and Mission Scenario allow the scientific investigation of Pol-InSAR:
  - Dual-Pol (HH&VV or HH&HV) Standard Mode
  - Quad-Pol (Campaign): performance critical at large look angles (>40deg)
  - Baseline diversity: - 2 Baselines Globally (Single-pol, kz=.13 and kz=.17);
    - Alternating bistatic mode;
    - Incidence angle diversity (Dual-/Quad-pol).

The challenge: To understand & model high resolution X-band Pol-InSAR data, invert physical parameters and generate information products.
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