Retrieval of Forest Parameters from Multi-polarimetric and Multi-frequency Interferometric SAR Data

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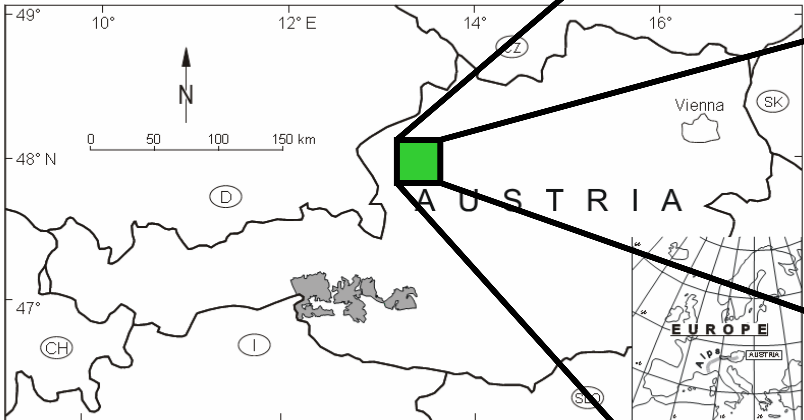
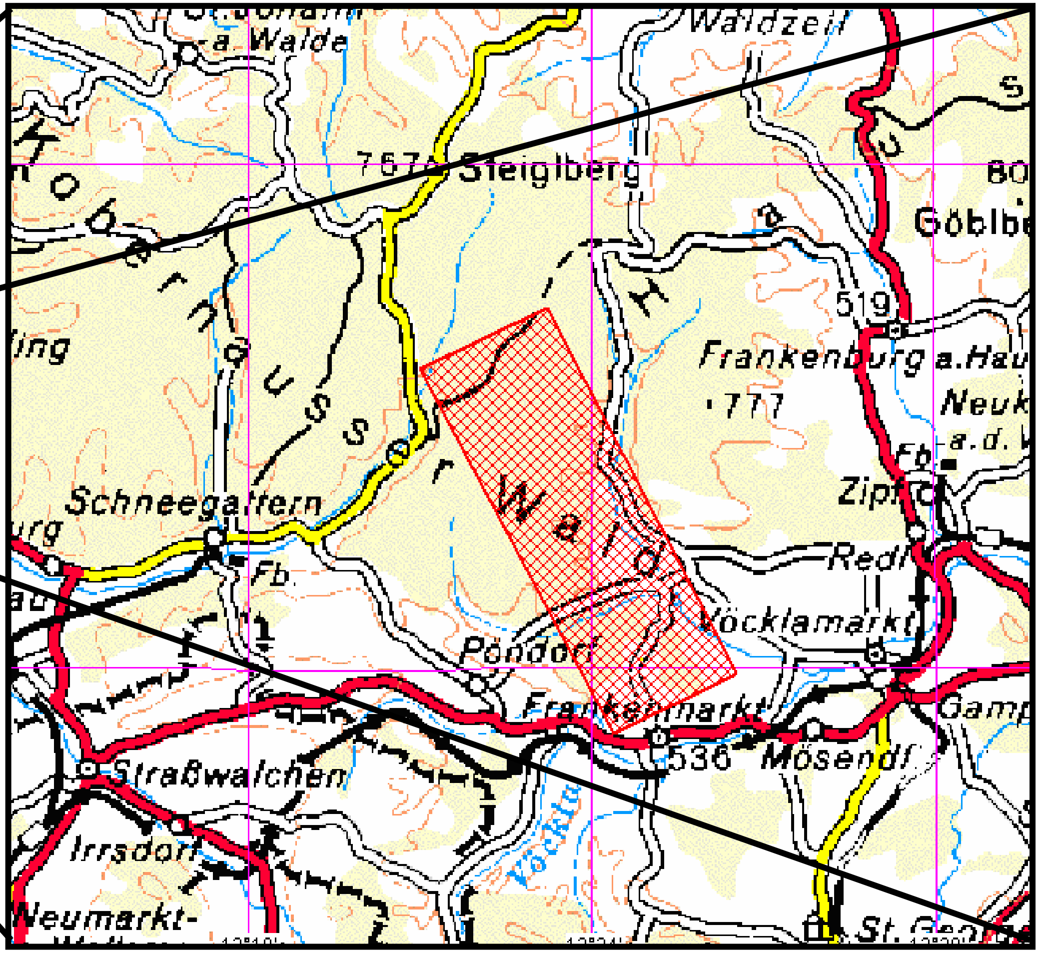
Test site "Kobernausser Wald"

Forest test site:
Kobernausser Wald

Area Size: 3km x 9km





Geographic Coordinates:
UL: 13°19'E / 48°04'N
LR: 13°25'E / 48°00'N

E-SAR data acquisition

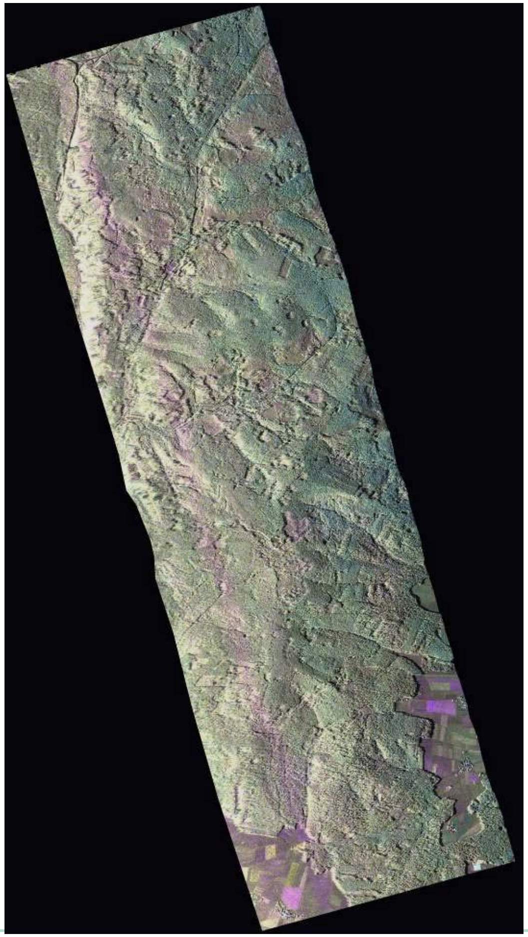
- Flight campaign on 11.05.2004
- Two corner reflectors installed

Frequency	Polarisation	Data Type	Pass	Baseline
X-band	HH/VV	SLC & Intensity	Single	0.5 m
L-band	HH/HV/VH/VV	SLC & Intensity	Dual	10 m
P-band	HH/HV/VH/VV	SLC & Intensity	Dual	20 m

E-SAR data acquired over Kobernausser Wald test site

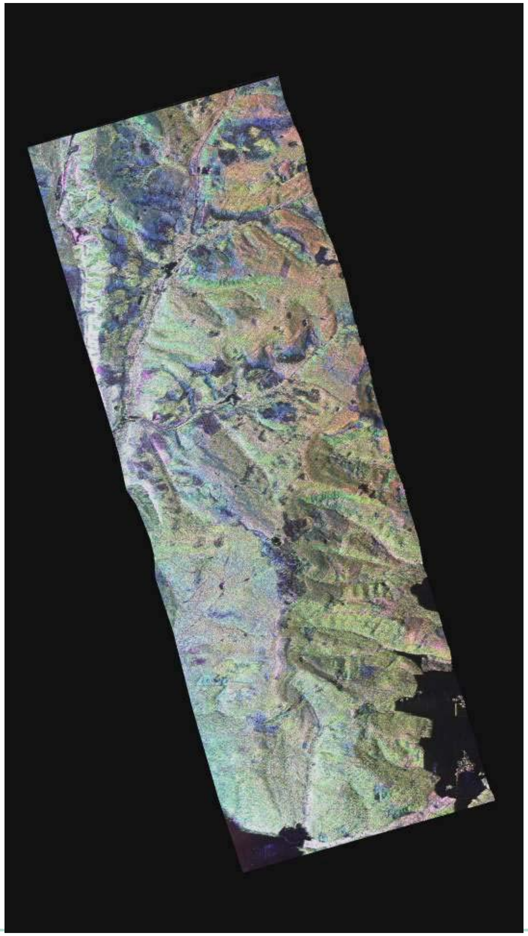
E-SAR data acquisition

X-band HH, HV, HH/VV



L-band HH, HV, VV

P-band HH, HV, VV



Basic methodologies

- Polarimetry
  - Use intensity (coherence) of backscattered signal
  - Empirical models
- Interferometry
  - Use phase of interferometric signal
  - Established technique
- Polarimetric SAR interferometry
  - Use complex coherency
  - Random Volume over Ground model (RVoG)

SAR interferometry

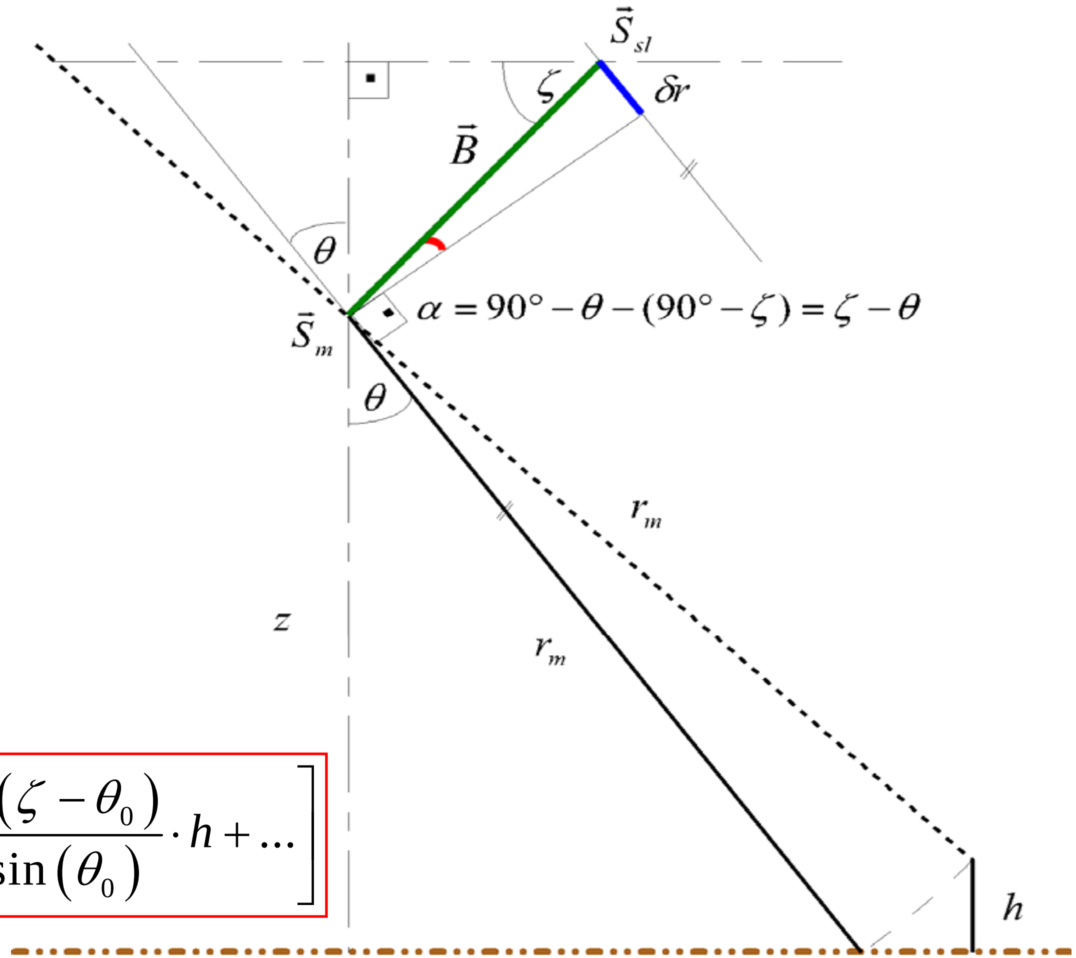
Approximation

$$\delta r = B \cdot \sin(\zeta - \theta)$$

$$\cos(\theta(h)) = \frac{z-h}{r} = \cos\theta_0 - \frac{h}{r}$$

$$\delta r(h) = B \cdot \sin(\zeta - \theta_0) + \frac{B \cdot \cos(\zeta - \theta_0)}{r \cdot \sin(\theta_0)} \cdot h + \frac{B \cdot \cos(\zeta)}{2r^2 \sin^3 \theta_0} \cdot h^2 + \ldots$$

$$\phi_{abs}(h) = \frac{4\pi B}{\lambda} \cdot \left[\sin(\zeta - \theta_0) + \frac{\cos(\zeta - \theta_0)}{r \cdot \sin(\theta_0)} \cdot h + \ldots \right]$$



InSAR products at P-band

Amplitude

Coherence

Wrapped Interferogram

Interferometric height

Polarimetric SAR Interferometry

Random Volume over Ground model*

h_V = tree height
φ_0 = ground topography
σ = mean volume extinction
m = ground to volume scattering amplitude
γ = complex interferometric coherence
[M] = scattering model operator

$$\begin{bmatrix} h_V \\ \exp\left(\Im\varphi_0\right) \\ \sigma \\ m_1 \\ m_2 \\ m_3 \end{bmatrix} = \left[M\right]^{-1} \begin{bmatrix} \tilde{\gamma}_1 \\ \tilde{\gamma}_2 \\ \tilde{\gamma}_3 \end{bmatrix}$$

*K. P. Papathanassiou and S. R. Cloude: Single-baseline polarimetric SAR interferometry. *In IEEE Transactions Geoscience Remote Sensing*, Vol. 39, No. 11, 2352-2363, 2001.

Pol-InSAR products at P-band

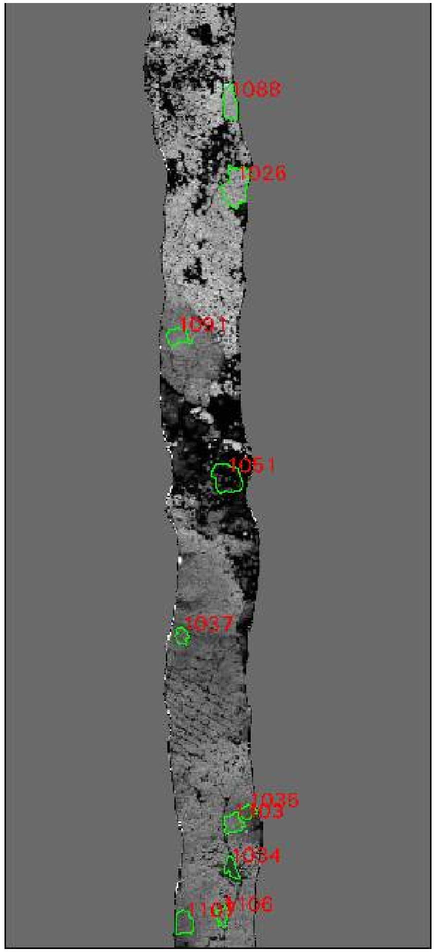
Ground phase φ_0

Vegetation layer height h_V

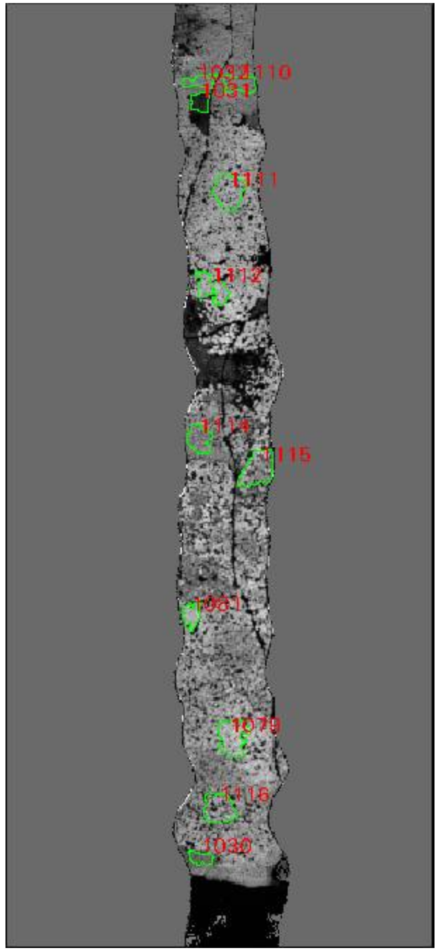
Extinction σ

Laser scanner reference DHMs

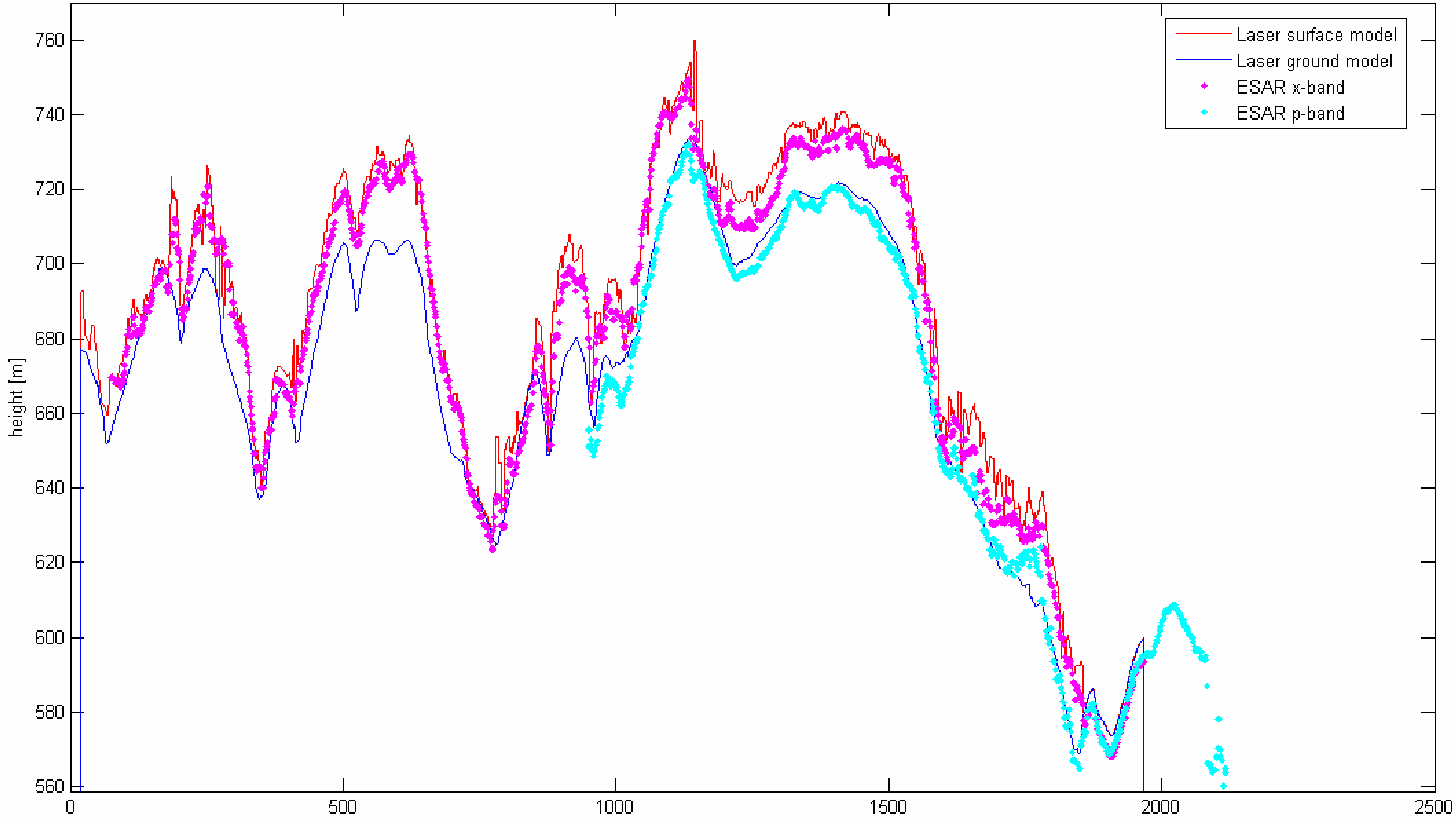
Northern part



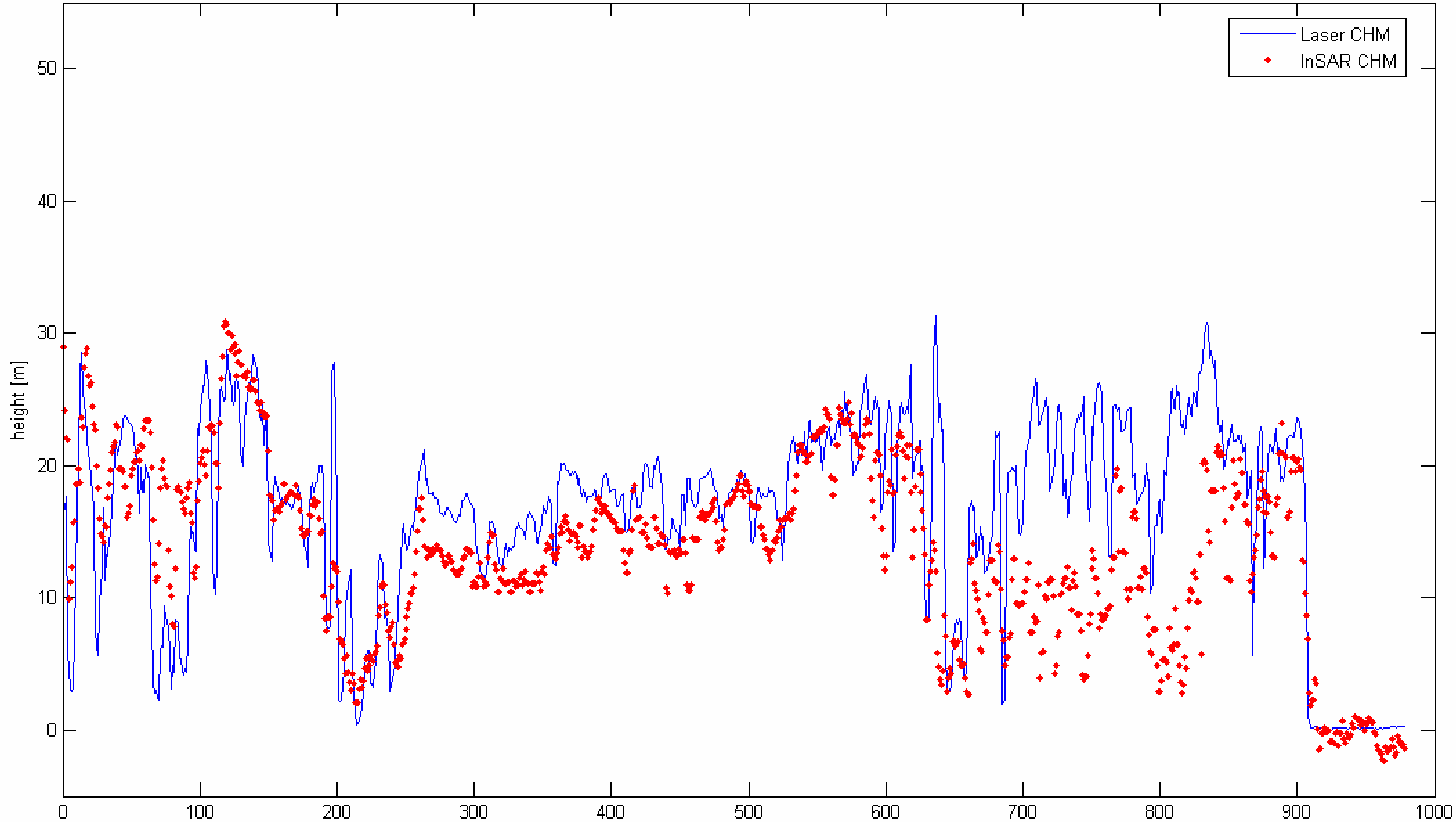
Southern part



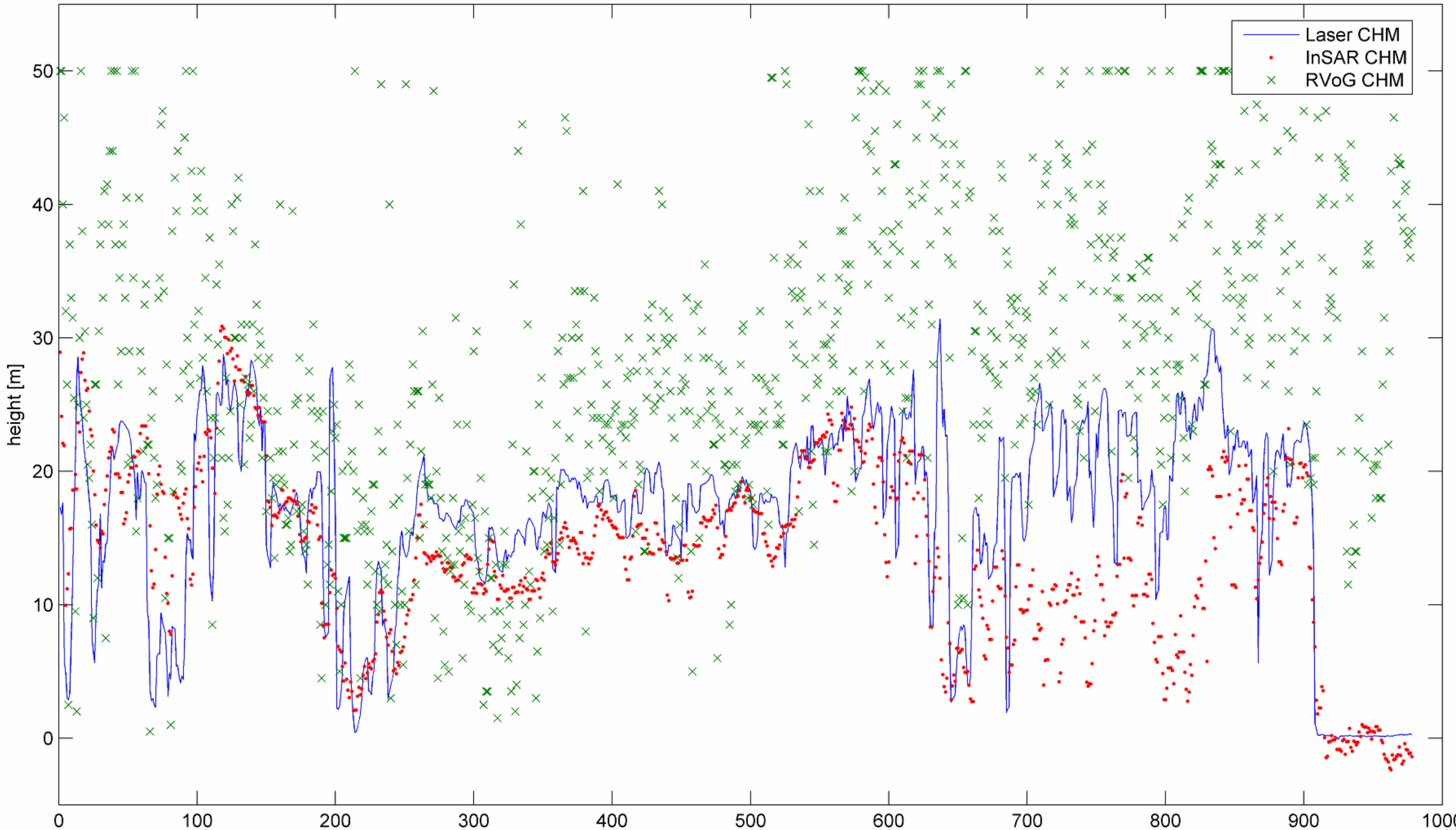
Analysis along profile



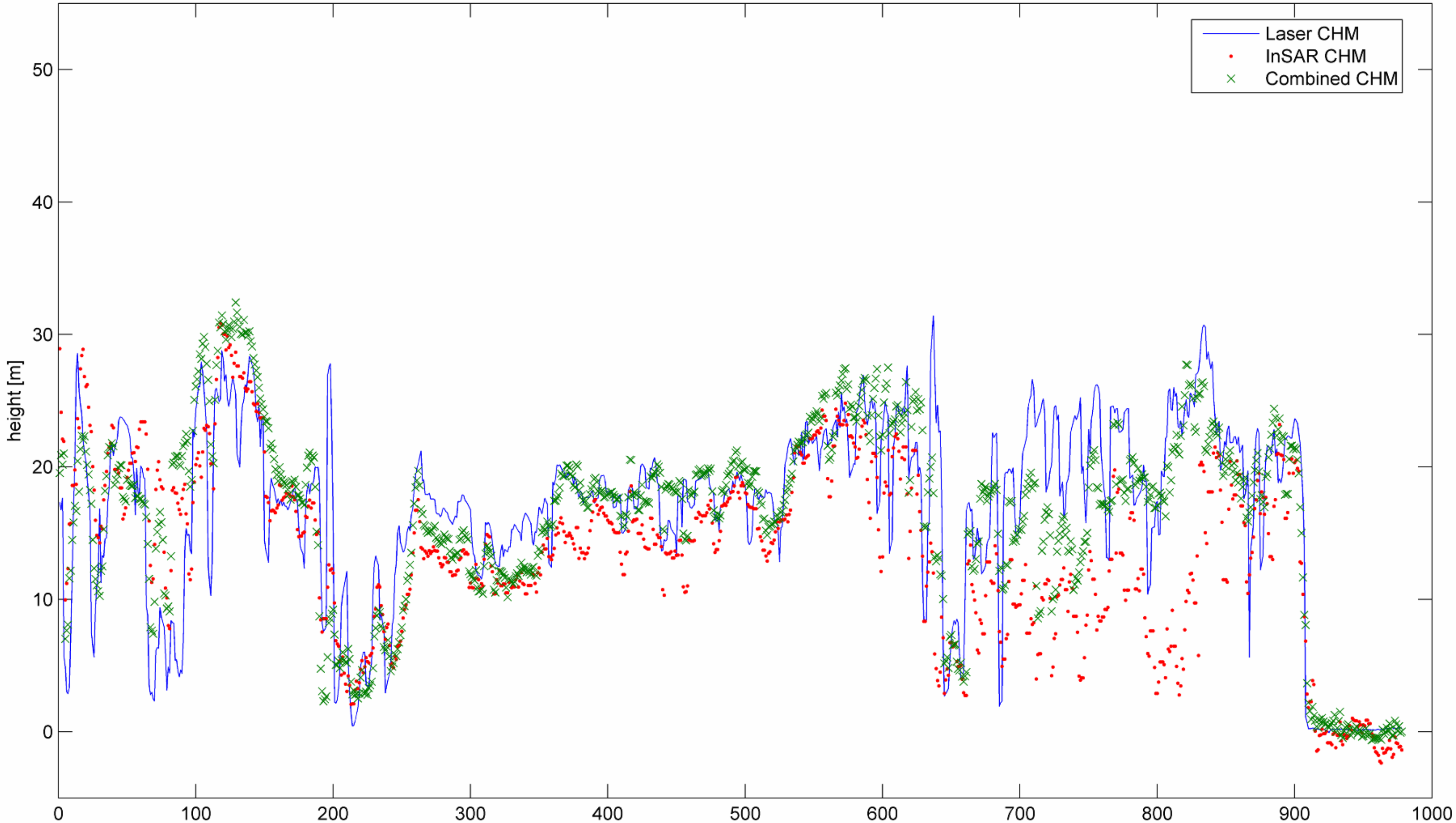
InSAR canopy height model (CHM)



Pol-InSAR canopy height model

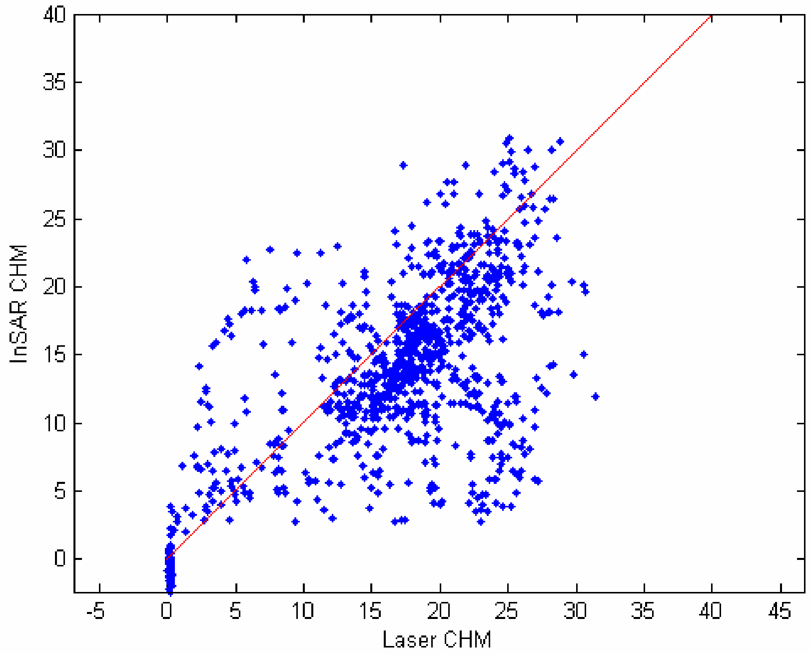


Combined canopy height model



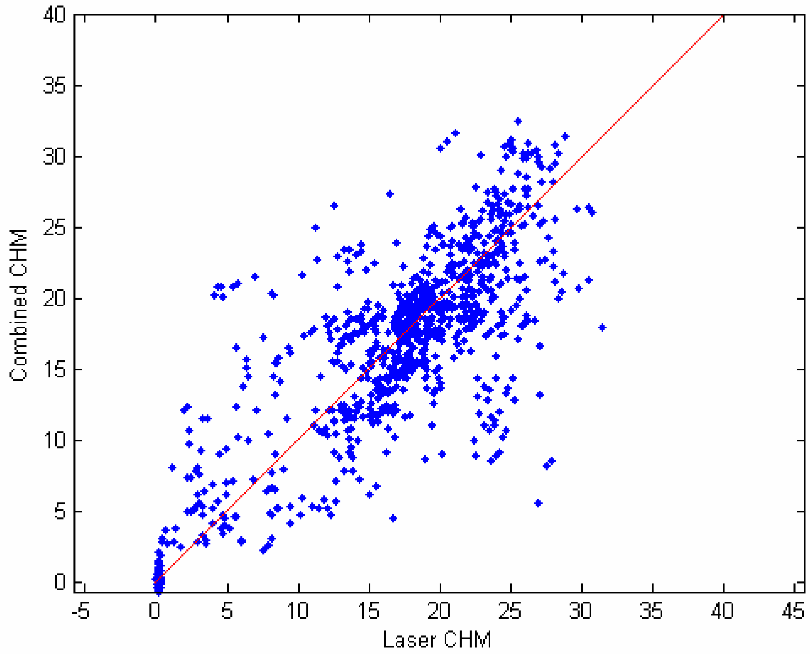
Correlation

Interferometry



Correlation Coefficient: 0.64

Combination



Correlation Coefficient: 0.81

Discussion and outlook

- Pol-InSAR
  - Only L- or P-band necessary
  - Preliminary results
- InSAR
  - Difference X-band DSM and P-band DTM
  - Penetration of P-band to ground not sufficient
- Combination
  - Best results with X-band DSM and reference DTM
  - Upcoming TerraSAR-X mission