Synthetic Aperture Radar Activities at UM-FERI

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Outline of presentation

- Educational activities
- Research activities
  - SAR data modeling using texture models
  - SAR data categorization
  - Detection of wet zones using SAR data and Ground Penetrating (GPR) data
  - Ground Synthetic Aperture Radar

Projects

1996-2000: Compression of complex-valued – focused - SAR data

- **Colaboration with German Aerospace Center**
  - **Developed Wavelet based encoder**

2004-2005 Marie Curie felllowship at German Aerospace Center, Oberpffafenhofen

DAAD Fellowships in 2009 and 2012

Projects:

2005-2007: Remote sensing laboratory, MORS

2007-2009: Complex-valued scene classification, ARRS

2009-2011: Detection of wet zones using SAR, DEM

2011-2013: Scene categorization, DLR

2009-2014: Monitoring of hydropower station‘s canal using georadar, DEM

2012-2013: Localization accuracy using GPS and SAR data

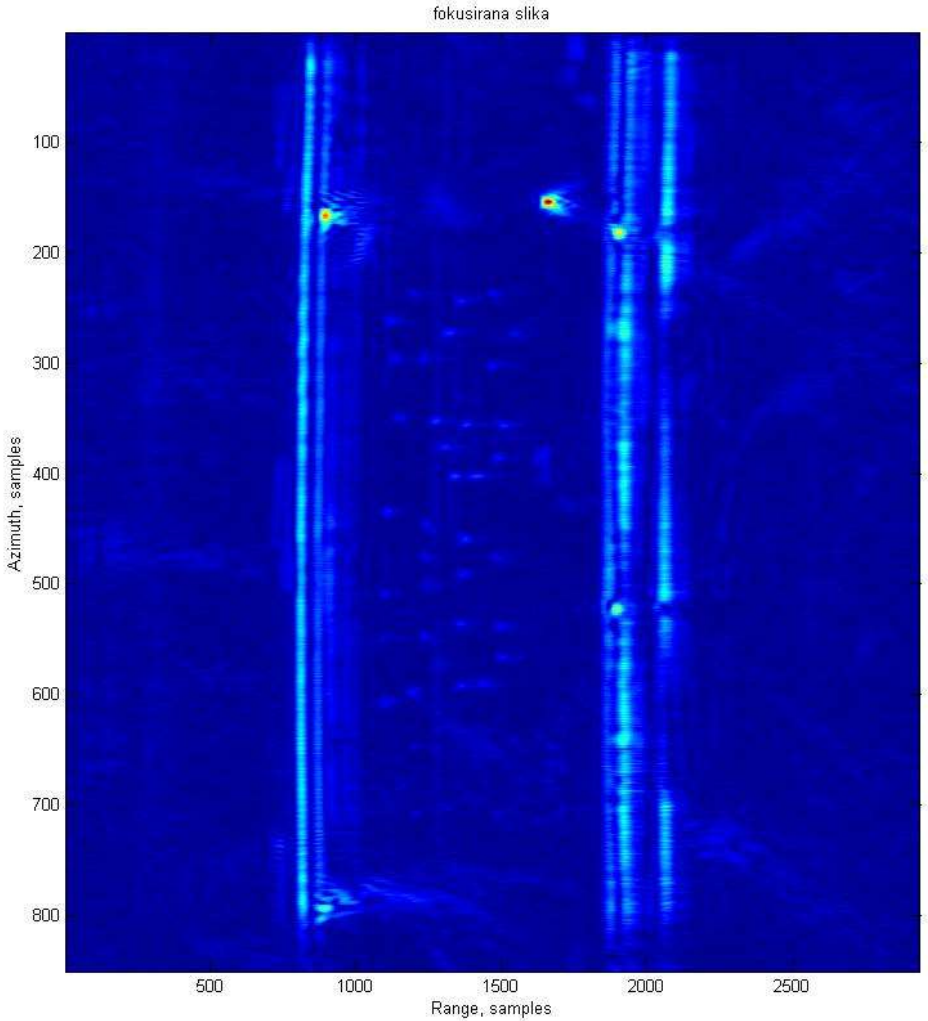
2013-2015: EU projects and computer vision projects

2016- Expression of interests H2020 Space Information Day, Ljubljana

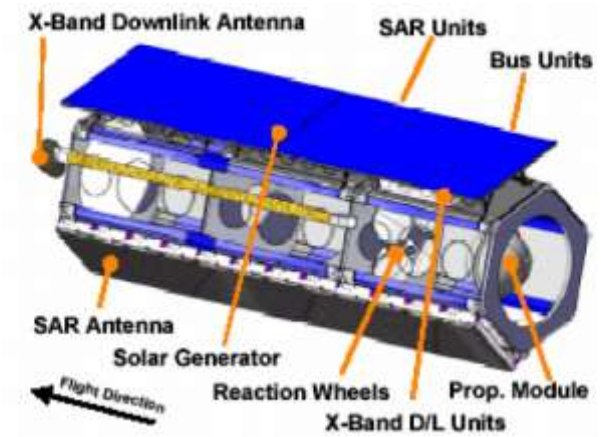
Educational activities

Ultrasonic SAR built by students

Focused image

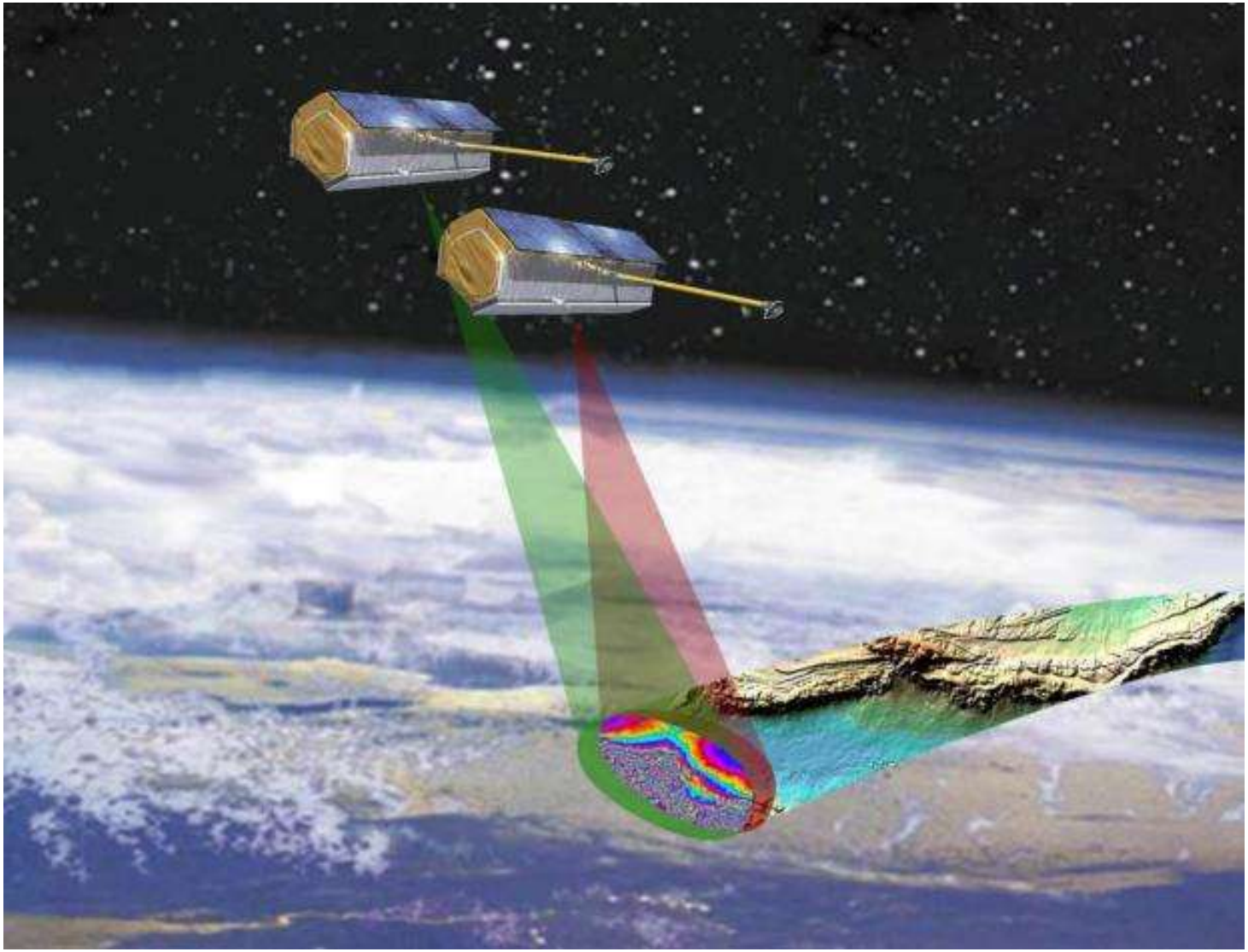


Synthetic Aperture Radar satellite – TerraSAR-X (june 2007)

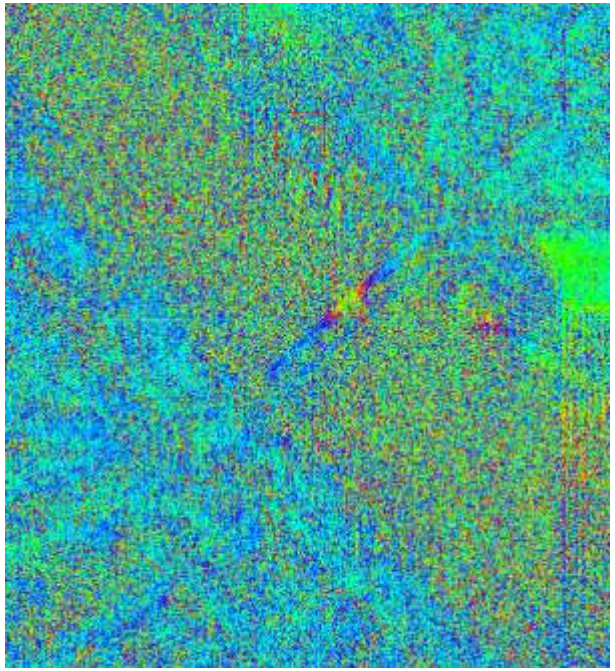


Height 5.0 m
Weight 1.230 kg
incl. payload mass 394 kg
SAR Antenna 4.8 m x 0.7 m x 0.15 m
Resolution 1 m @ 5 x 10 km Scene
Power consumption 800 W average
Data storage 256 Gbit Data
transmission 300 Mbit/s X-Band
Repetition rate 11 days
Life time 5 years
Altitude 514 km
Repeat Cycle 11 days
Max. Resolution 1 m (HR spotlight)

Tandem-X (2010)



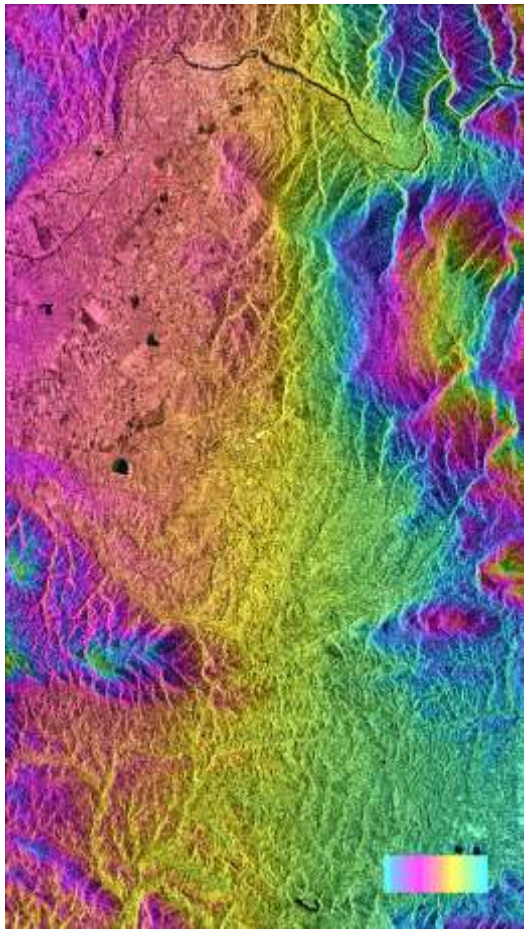
Repeating pass interferometry using TerraSAR-X, Doris

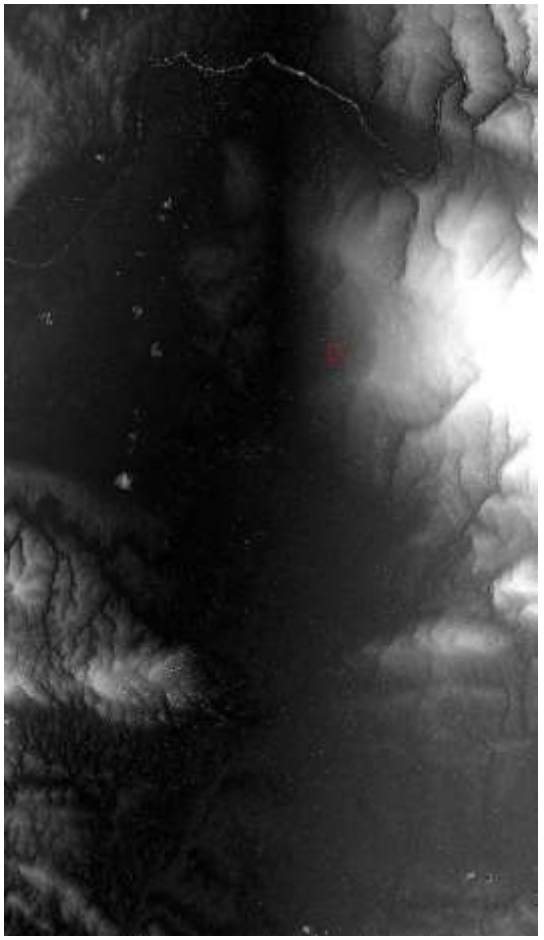


11 days difference, Paris, January 11th and 22nd 2010

DEM of Maribor

- **DEM processing chain using DORIS (today SARscape, NEST)**

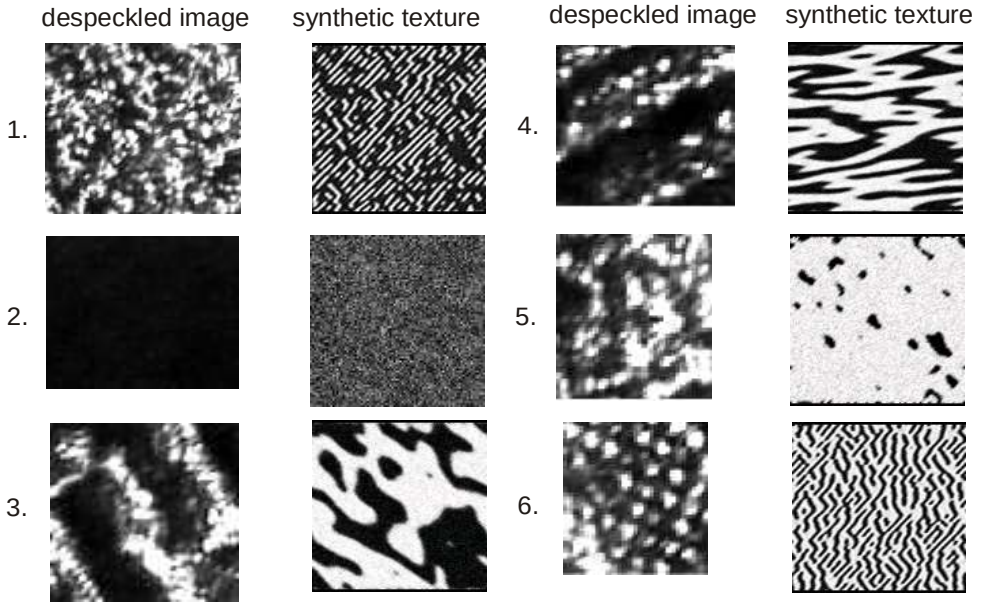




SAR research activities

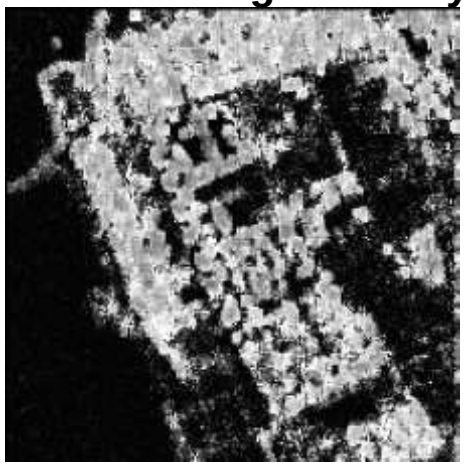
Image Information Mining

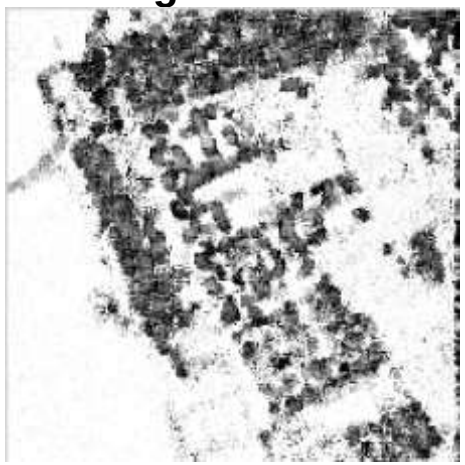
Model based approach MAP estimate (despeckled image) and texture parameter θ

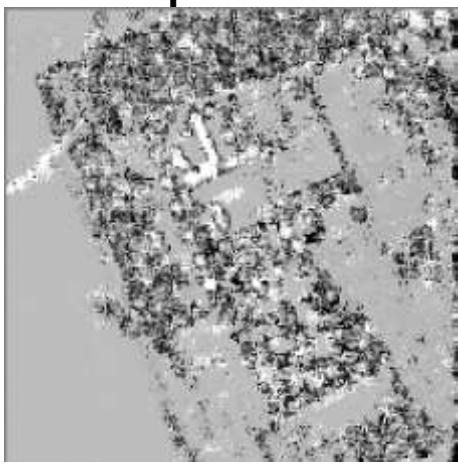


MAP Estimate

Real images and synthetic generated form texture parameters

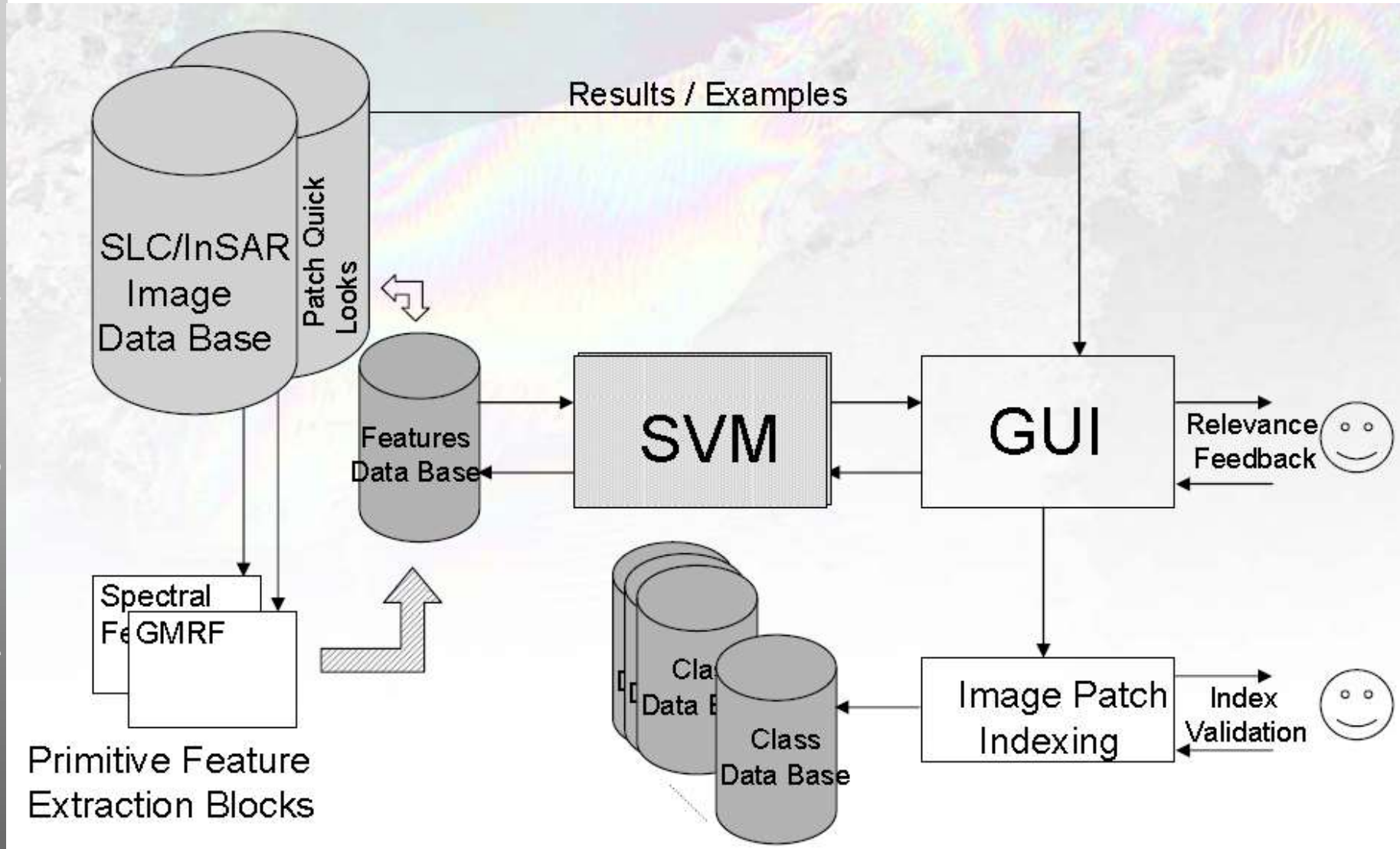


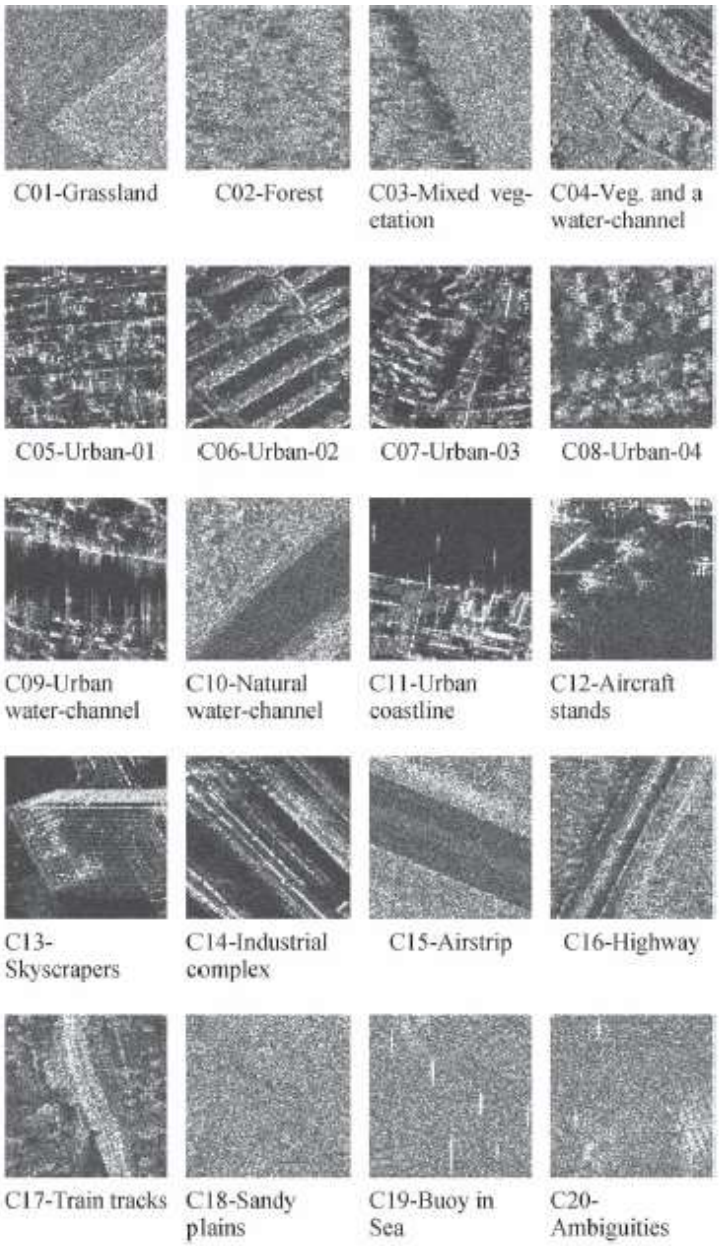


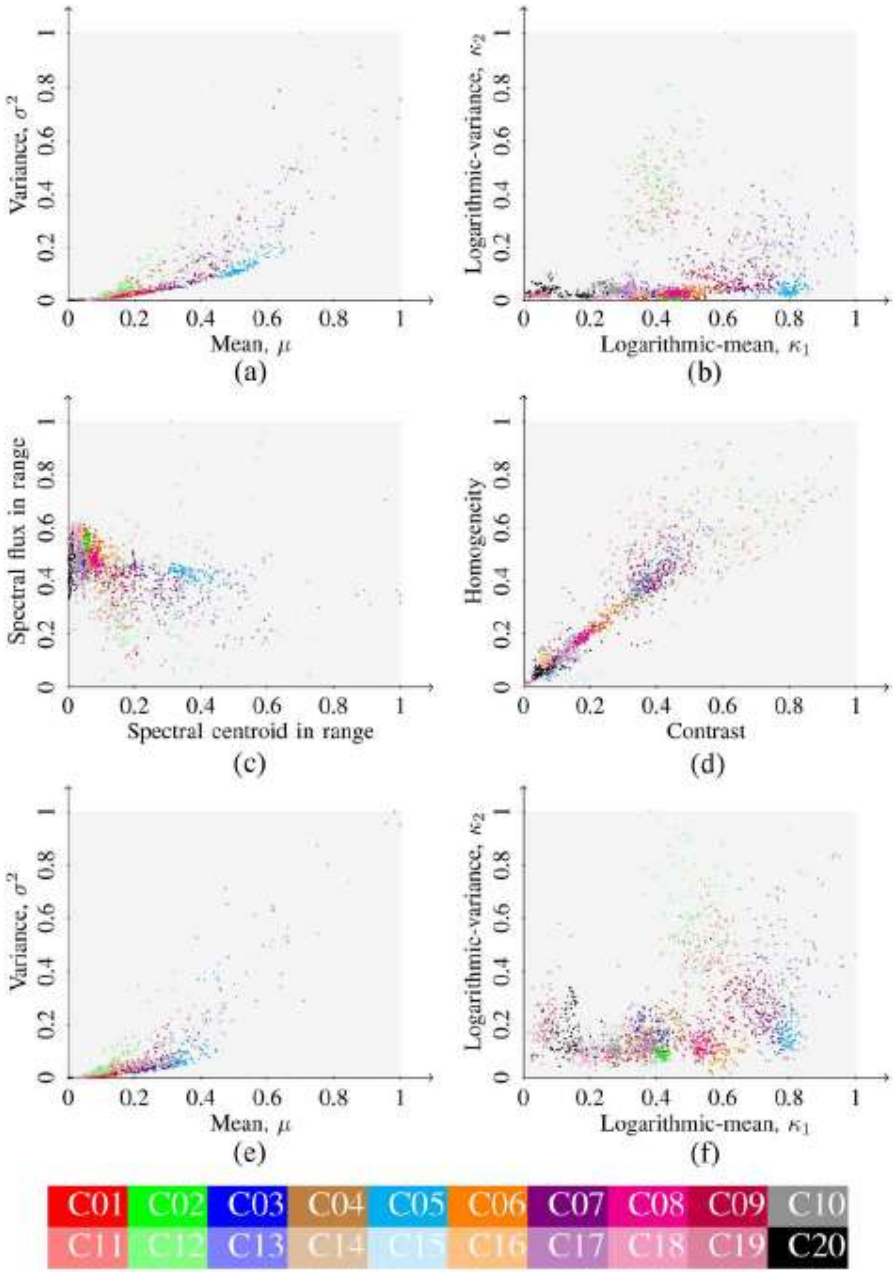


SAR research activities

SAR data categorization

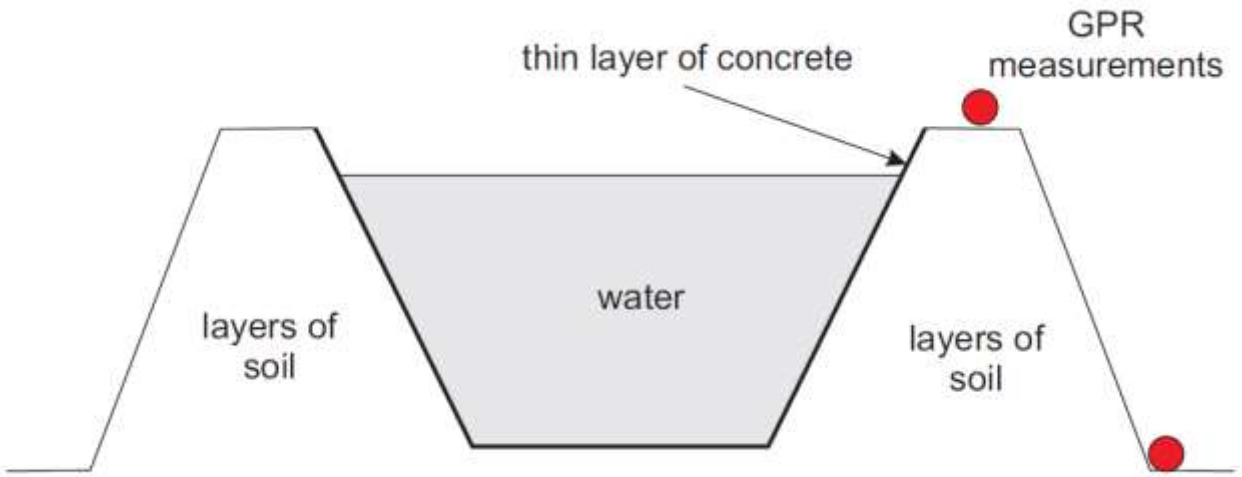

Results / Examples
SLC/InSAR Image Data Base
Patch Quick Looks
Features Data Base
SVM
GUI
Relevance Feedback
Spectral
GMRF
Primitive Feature Extraction Blocks
Class Data Base
Image Patch Indexing
Index Validation



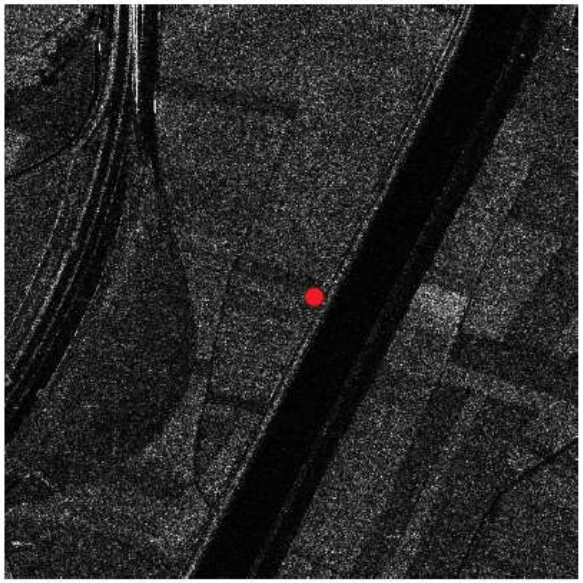


Soil moisture estimation using SAR and wet zones detection using Ground Penetrating Radar

Monitoring Hydro-power station‘s canal



In-suite data



SAR data

Soil moisture estimation using SAR data

$$\sigma^0 \approx C\sigma^0_{veg} + (1-C)\sigma^0_{soil}$$

$$\sigma^0_{veg}(\theta) = \frac{K_s \cos(\theta)}{2K_e}\left[1-\exp(-2K_e \sec\theta)\right] = \frac{1}{2}\omega_v \cos(\theta)\left[1-T^2(\theta)\right]$$

$$\sigma^0_{soil}(\theta) = \frac{|\Gamma(\theta)|^2}{2s^2\cos^4\theta}\exp\left(\frac{-\tan^2\theta}{2s^2}\right)$$

$$J(x) = \|y - Tx\|_2^2 + \lambda_1^2 \|x\|_m^m + \lambda_2^2 \left\|\nabla |x|\right\|_m^m$$

$$\sigma^o = Mx$$

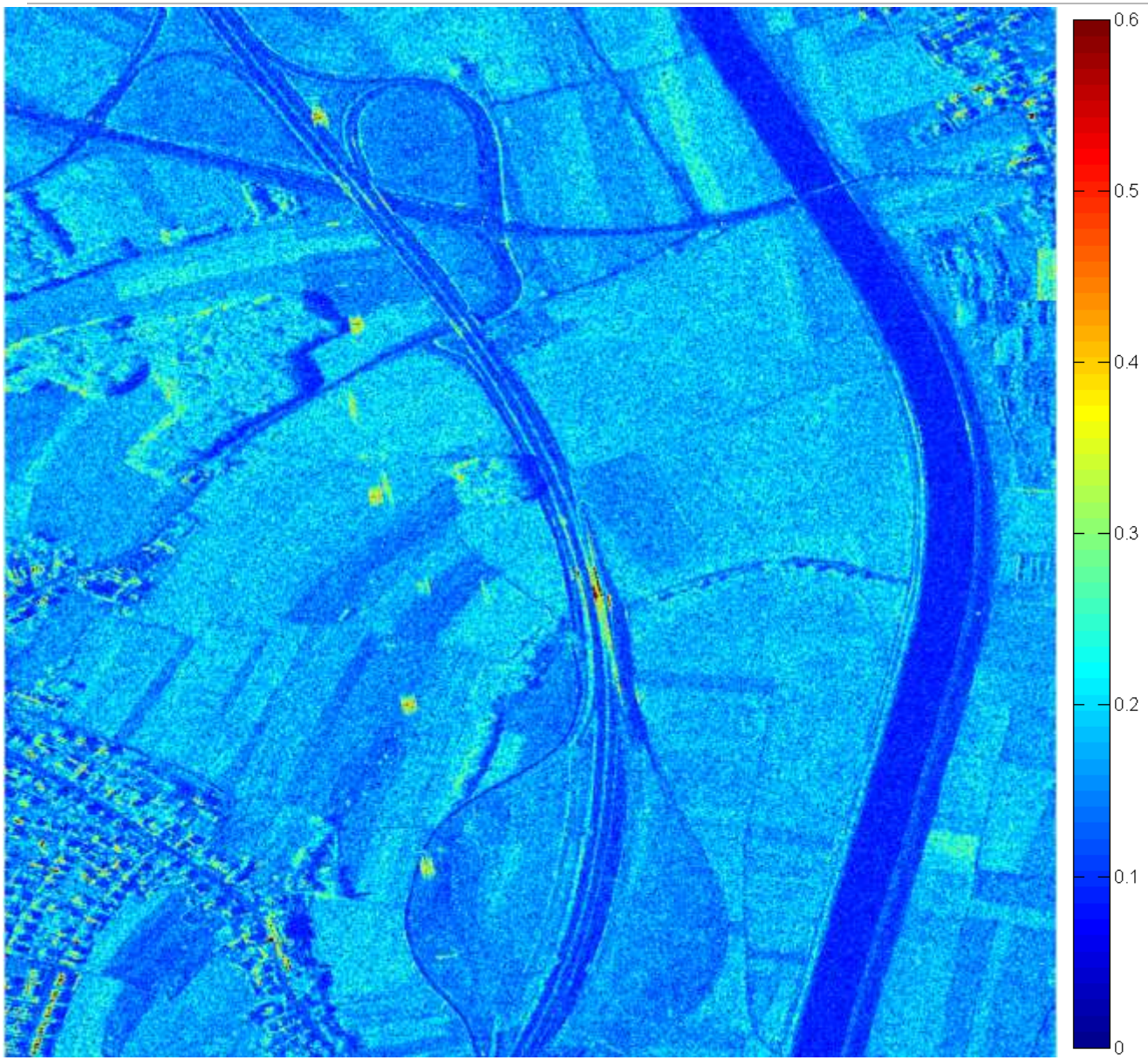
$$diag(M) = \left[\frac{1}{2}\omega_v \cos(\theta)\left[1-T^2\right] \quad \frac{1}{2\cos^4\theta} \quad -\frac{\tan^2\theta}{4\cos^4\theta} \quad \frac{\tan^4\theta}{16\cos^4\theta}\right]$$

$$x^T = \left[C \quad \frac{(1-C)|\Gamma(\theta)|^2}{s^2} \quad \frac{(1-C)|\Gamma(\theta)|^2}{s^4} \quad \frac{(1-C)|\Gamma(\theta)|^2}{s^6}\right]$$

$$\varepsilon_s = \sin^2(\theta) + \left(\frac{\sqrt{|\Gamma(\theta)|}+1}{\sqrt{|\Gamma(\theta)|}-1}\right)^2 \cos^2(\theta)$$

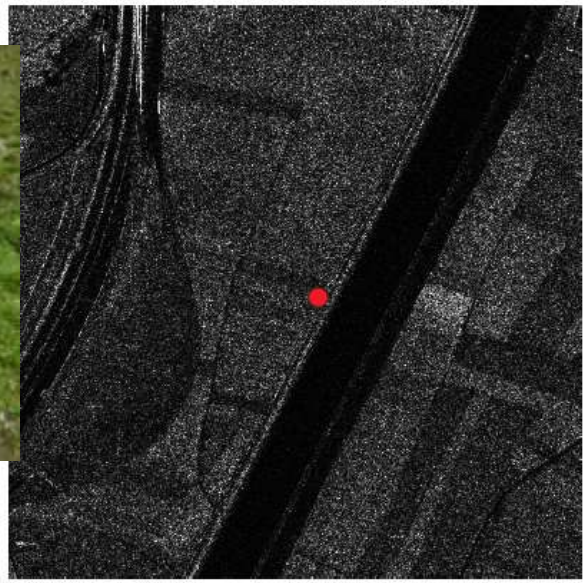
$$\hat{x}^{(n+1)} = \hat{x}^{(n)} - \gamma\left[H\left(\hat{x}^{(n)}\right)\right]^{-1} \nabla J\left(\hat{x}^{(n)}\right)$$

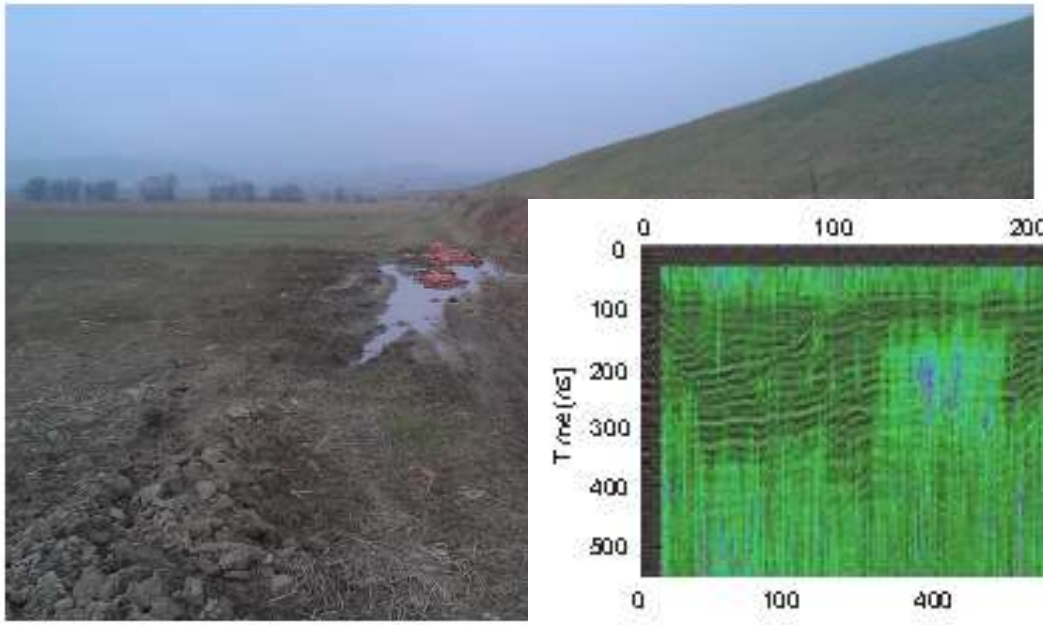
$$m_v = -5{,}3\cdot 10^{-2} + 2{,}92\cdot 10^{-2}\cdot\varepsilon_s - 5{,}5\cdot 10^{-4}\cdot\exp\left(2\log(\varepsilon_s)\right) + 4{,}3\cdot 10^{-6}\cdot\exp\left(3\log(\varepsilon_s)\right)$$

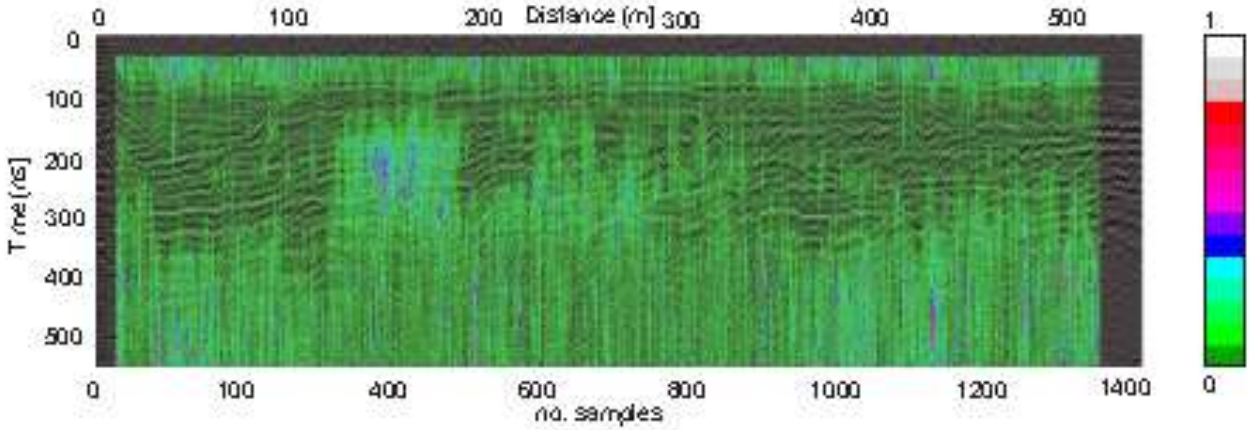


- **Data: 2.12.2011**
- **Incidence angle: 45,87°**
- **VV polarization**
- **Descending orbit**
- **Chirp bandwidth: 300 MHz**
- **Soil moisture cca. 15,8% in 28,8%**

Data fusion GPR and SAR data

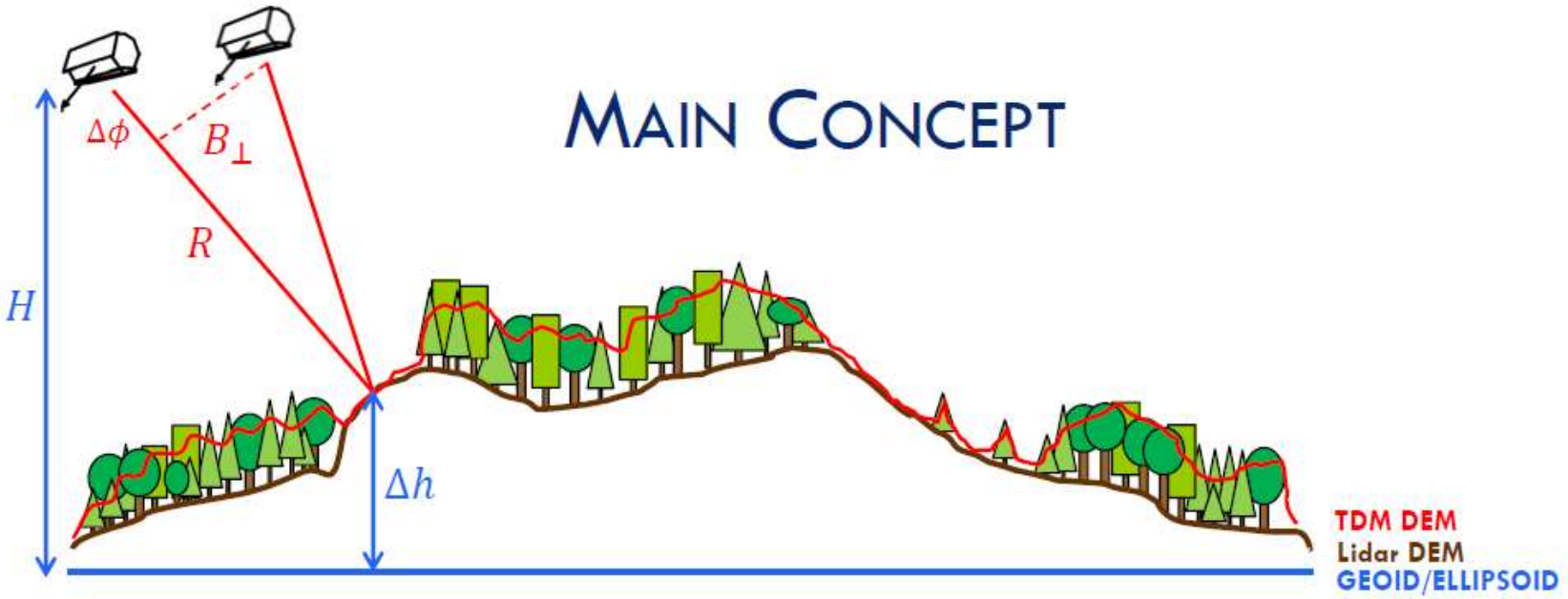






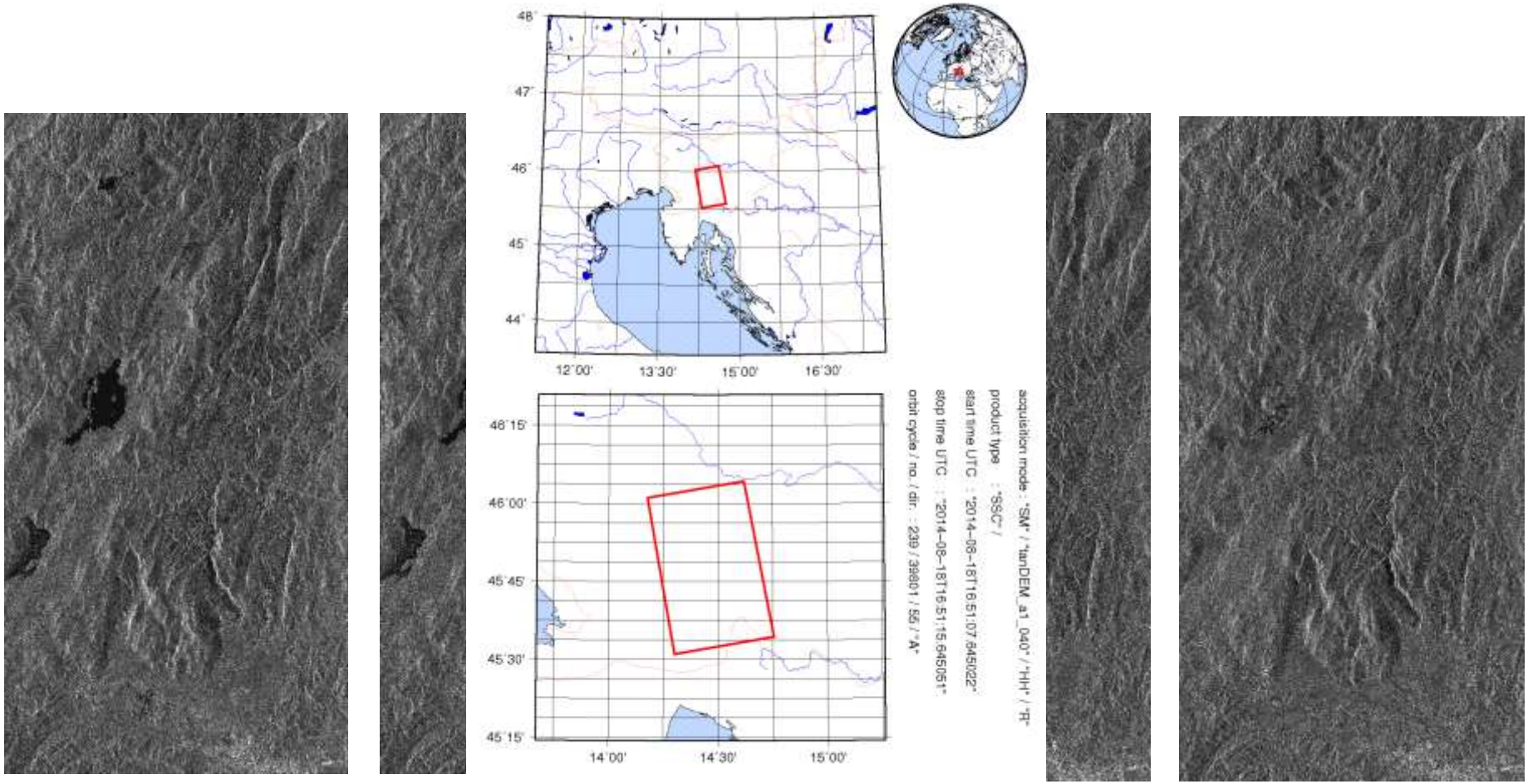
Change detection using DEM

Change detection using DEM



Maciej Soja at all, „Forest Canopy Mapping from Tandem-X Interferometry and High Resolution Lidar DEM“, Tandem-X Meeting, 2013

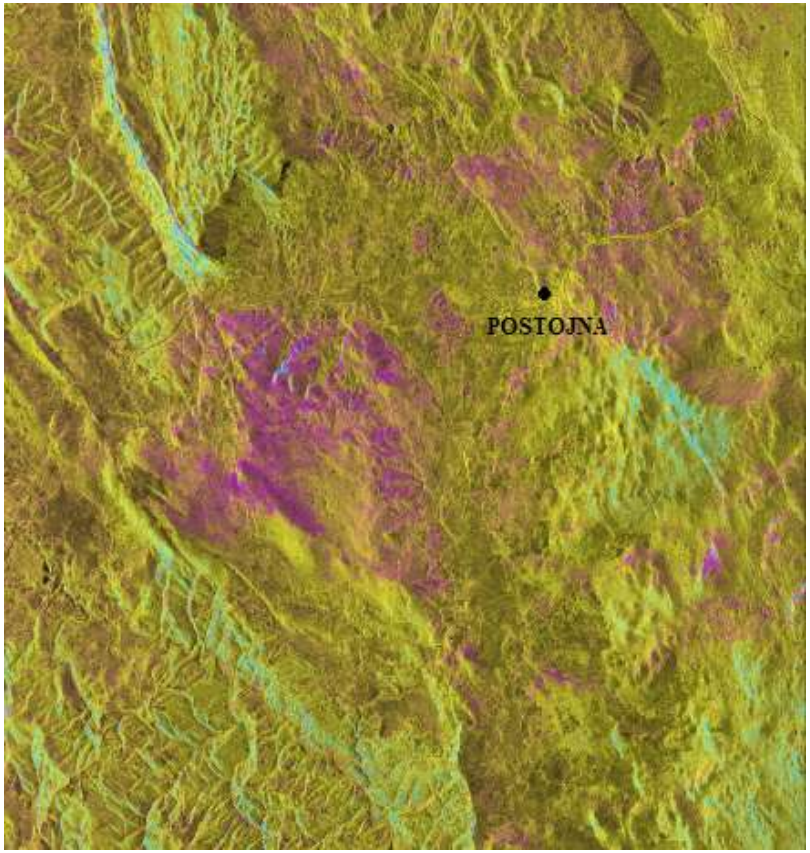
Tandem-X



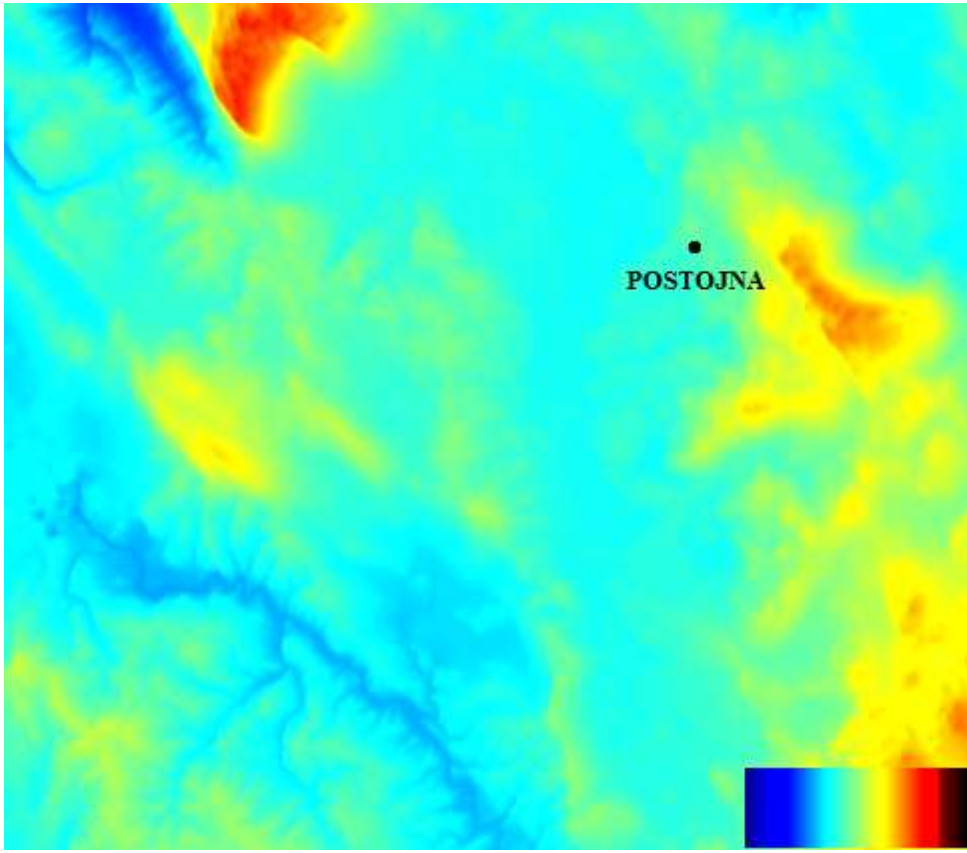
Tandem-x, April 2013

Tandem-x, August 2014

DInSAR



Phase difference



Unwraped phase

Miniature Ground Synthetic Aperture Radar

- **Developing localization techniques using USRP**
- **Building Ground Synthetic Aperture Radar**
  - **Bandwidth 800 MHz**
  - **Under development**