Radar Camouflage Assessment from Airborne Platforms

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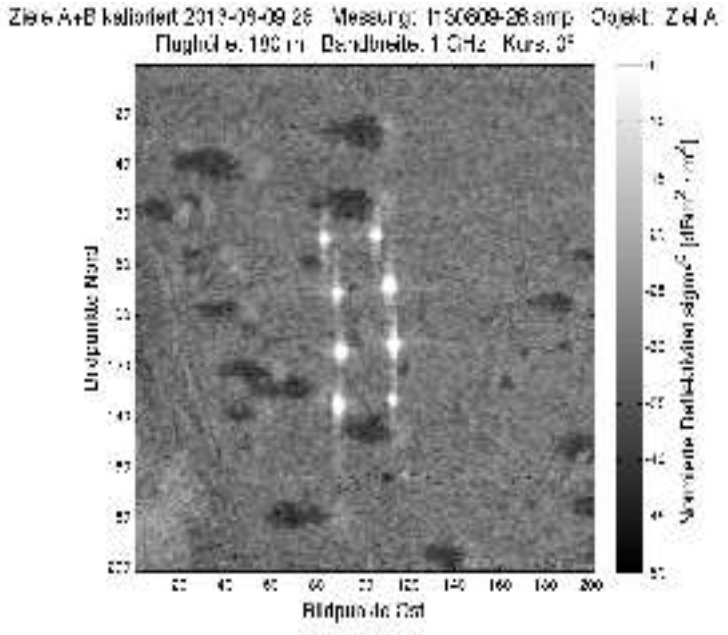
Bad Reichenhall, 22.10.2015

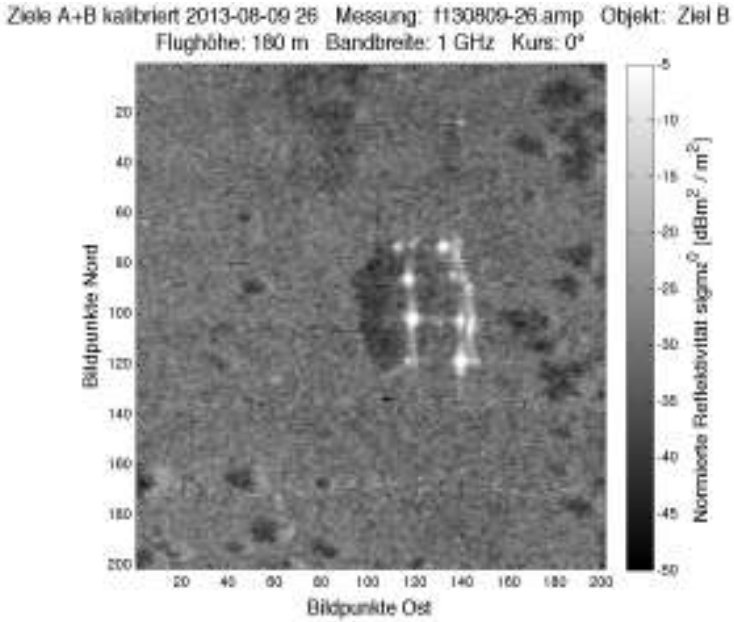
Fraunhofer FHR

Agenda

- Wanted: A Radar Camouflage Measure
- SAR Principle
- Change Detection Methods
- Delphin + MIRANDA SAR Platform Improvements
- Measurement campaigns results
- Summary and Outlook

In Search of a Radar Camouflage Measure





- Two extended targets across SAR scenes
- E.g. Camouflaged vs. original
- What is the effect of the camouflage material?

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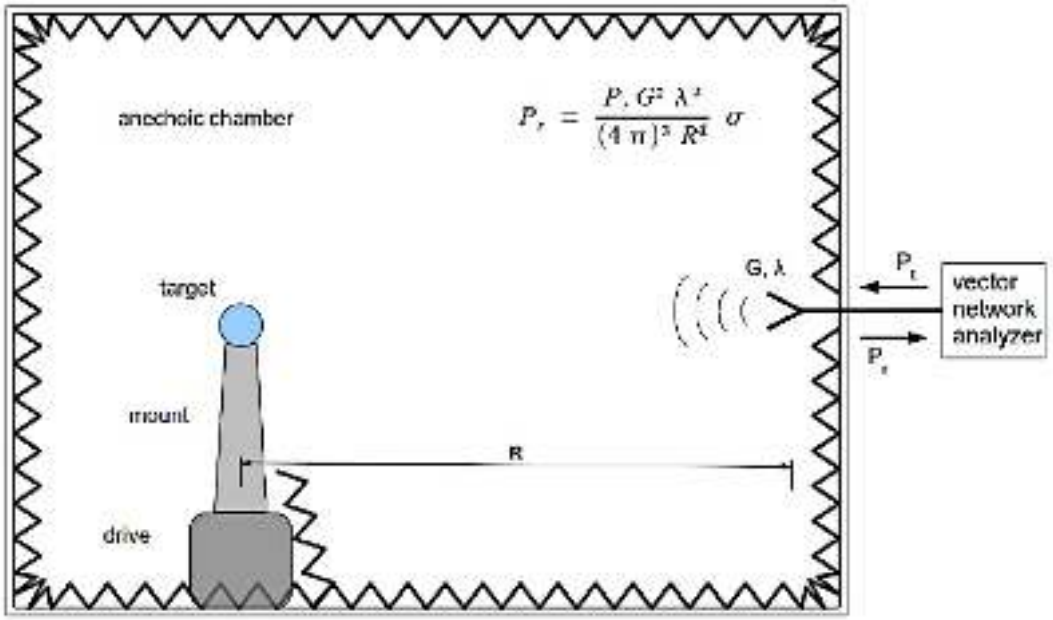
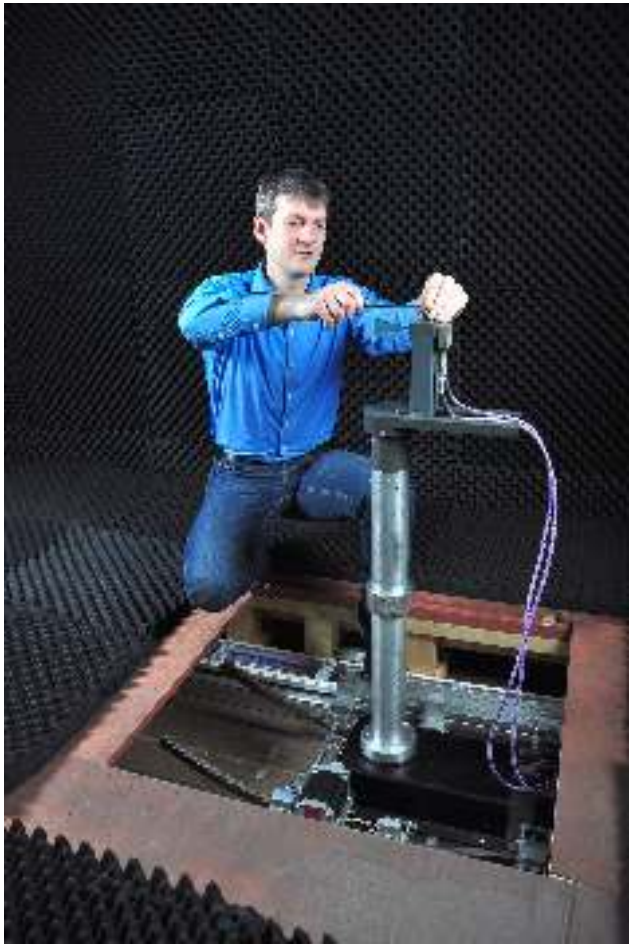
In Search of a Radar Camouflage Measure

- Radar Cross Section available
- ISAR (and SAR) provide approximations of RCS
- Dependent on
  - Aspect angle
  - Resolution





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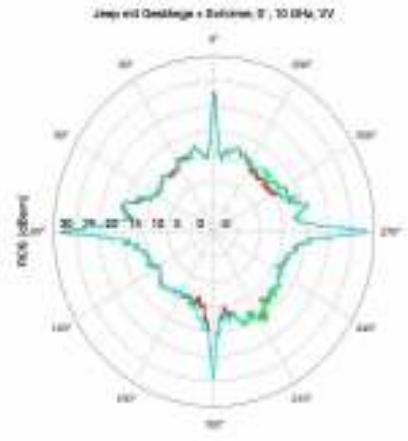
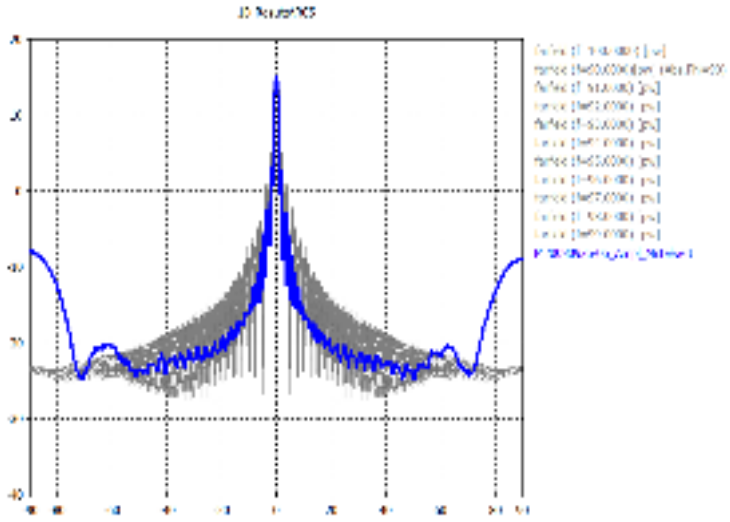
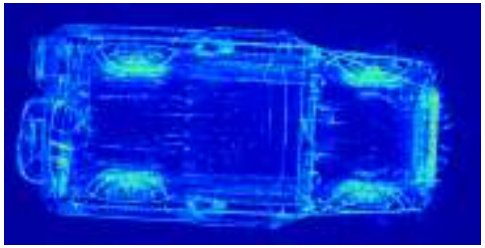
In Search of a Radar Camouflage Measure

- RCS not directly applicable
  - modified clutter background
  - worst case estimate
    - sum or maximum







Radar Camouflage Assessment

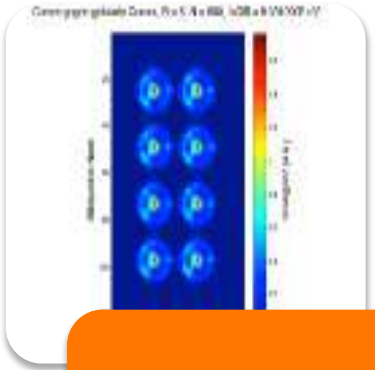
Improve-ments

Data
- SAR
- ISAR
- RCS
- Simulations
- EOSAR blends

Methods

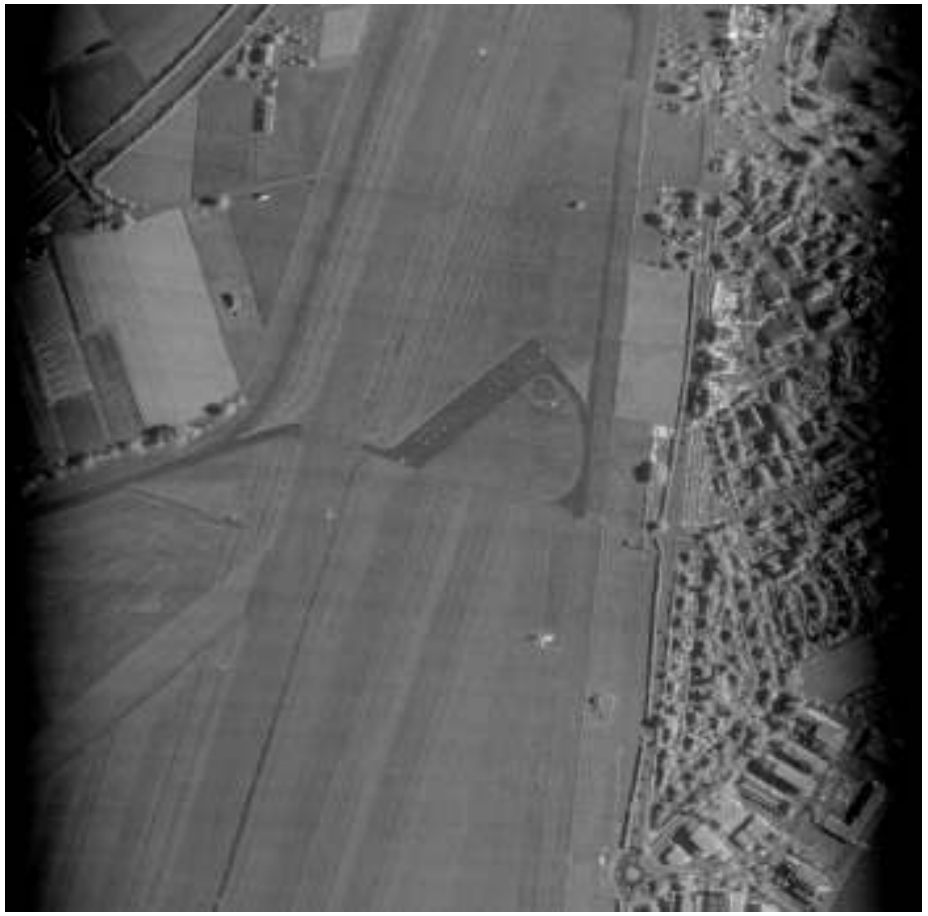
Estimators
- Noncoherent
- Coherent

Tests



Camouflage Measure

Airborne SAR Principle



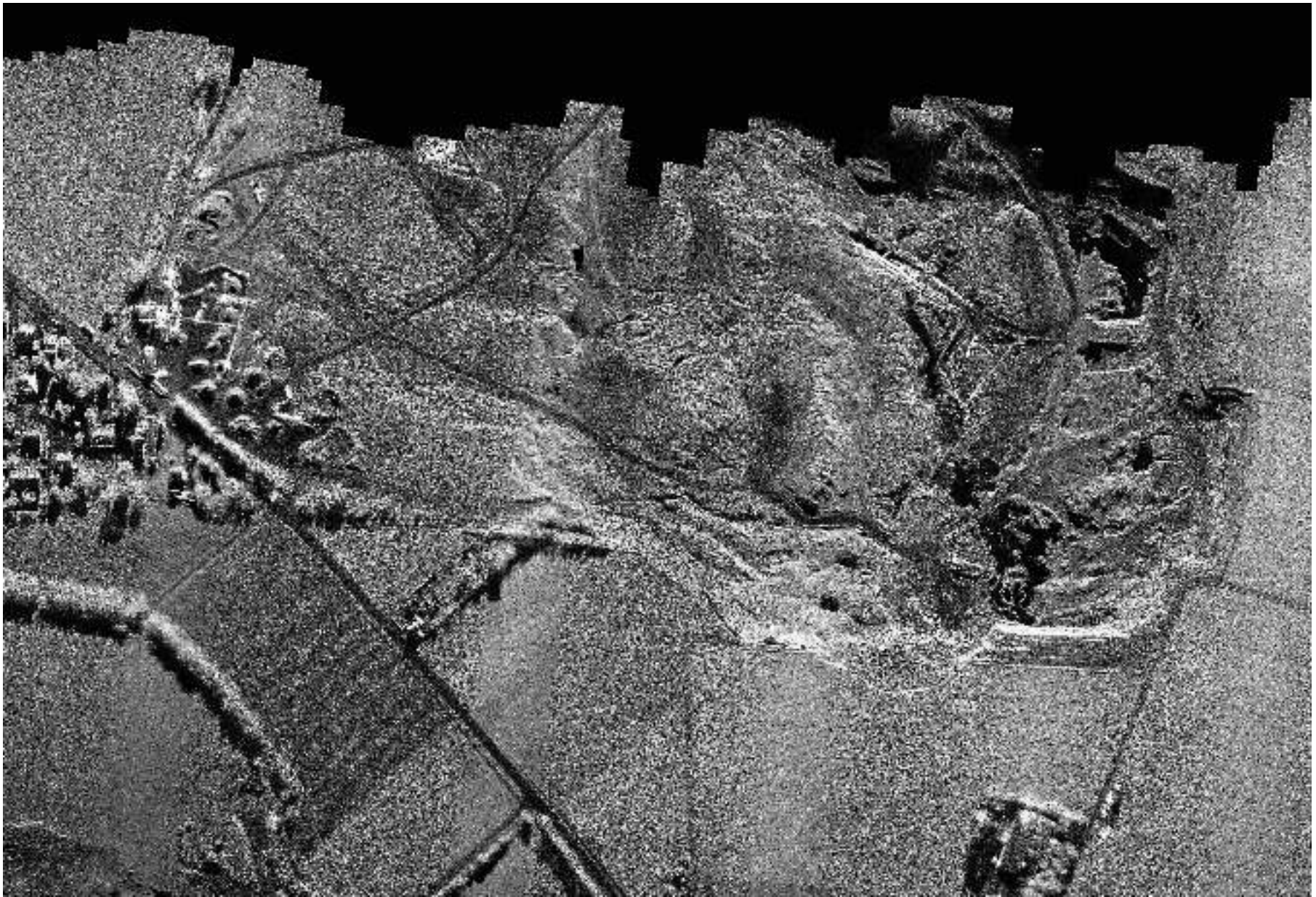
Large Scale Change Detection
Clay Pit Leimersdorf

Blick Aktuell, 29.03.2015

Der Karweiler Krater beunruhigt die Bürger

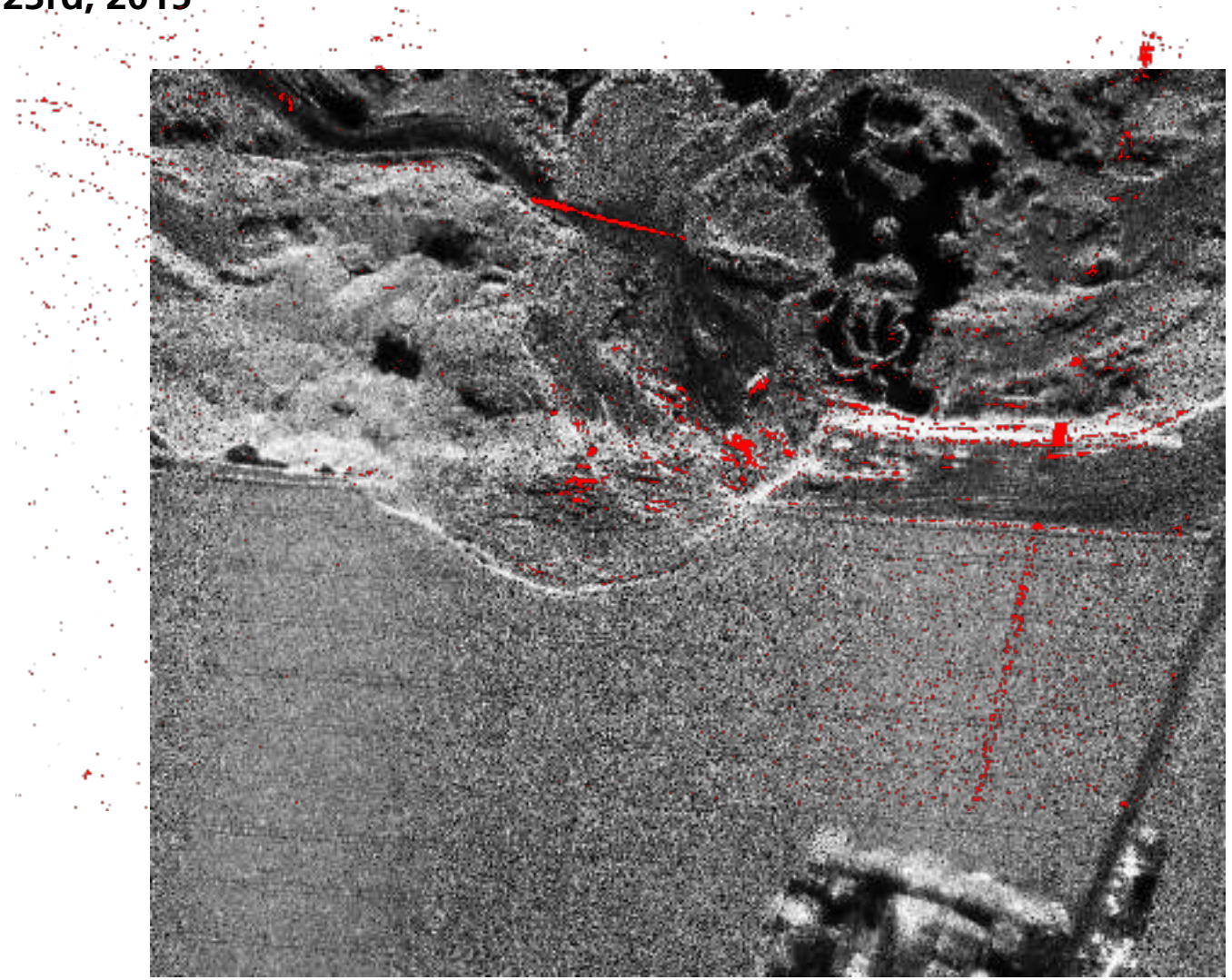
35 GHz MIRANDA SAR image

April 23rd, 2015

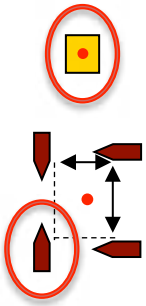


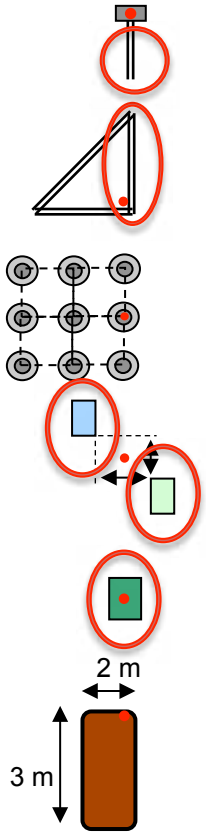
Change Detection of Brim Region, n = 1

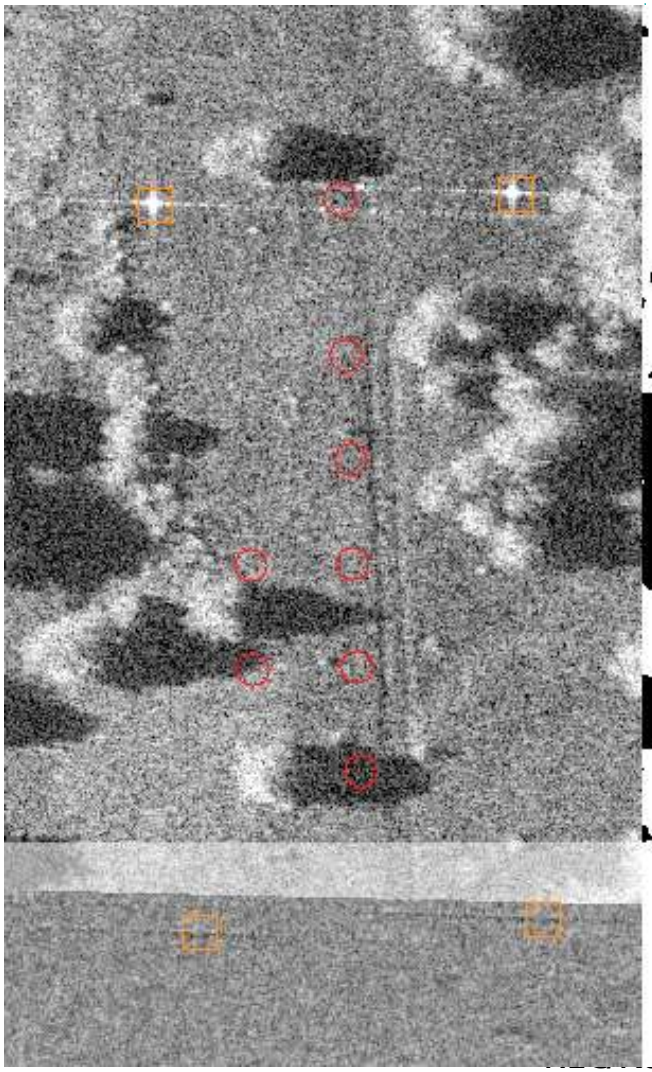
April 23rd, 2015

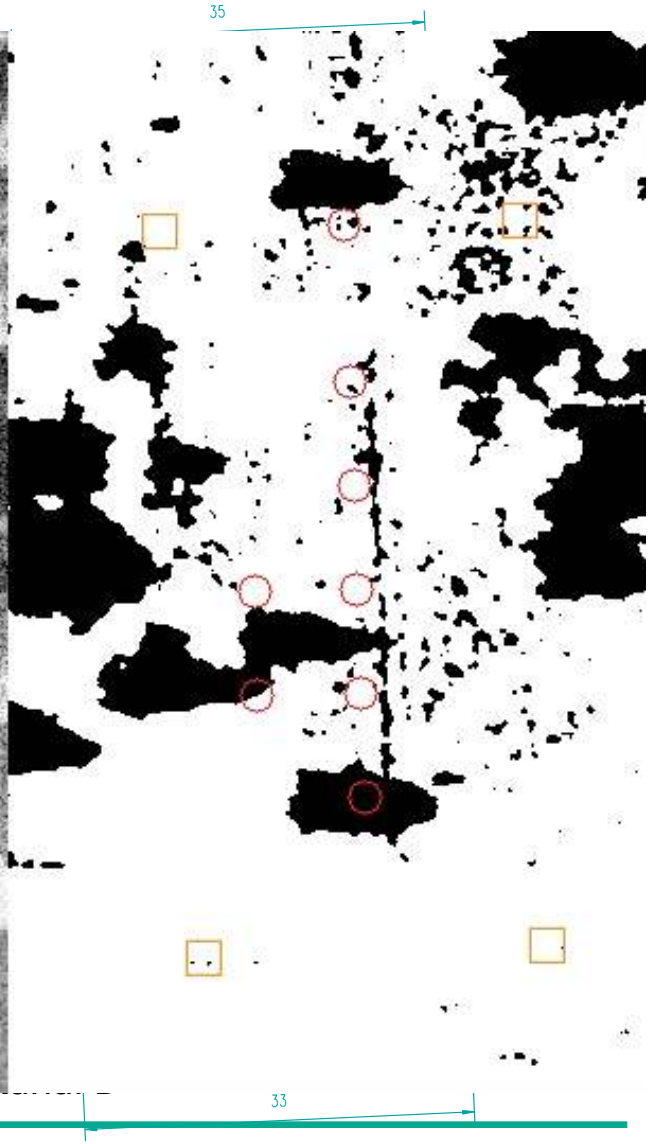


Change Detection (Storkow 2010)









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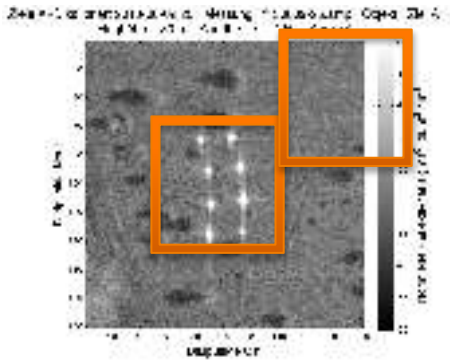
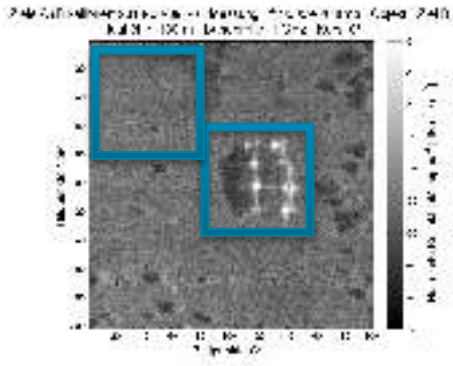
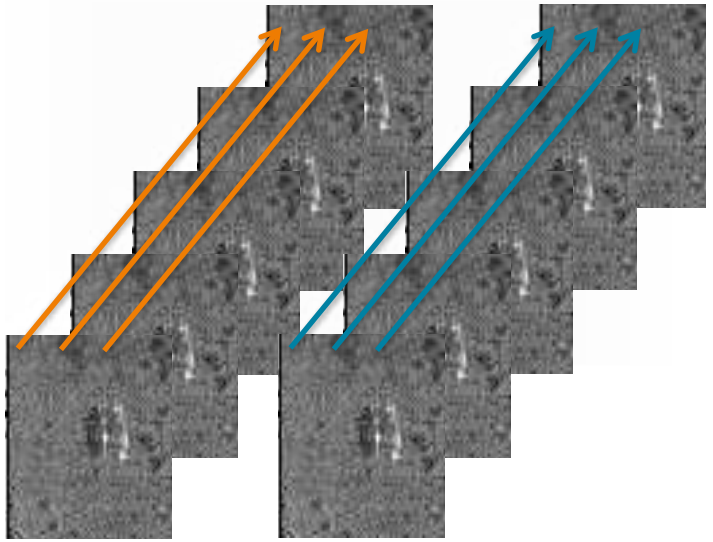
Informational Difference as a Change Detection Method

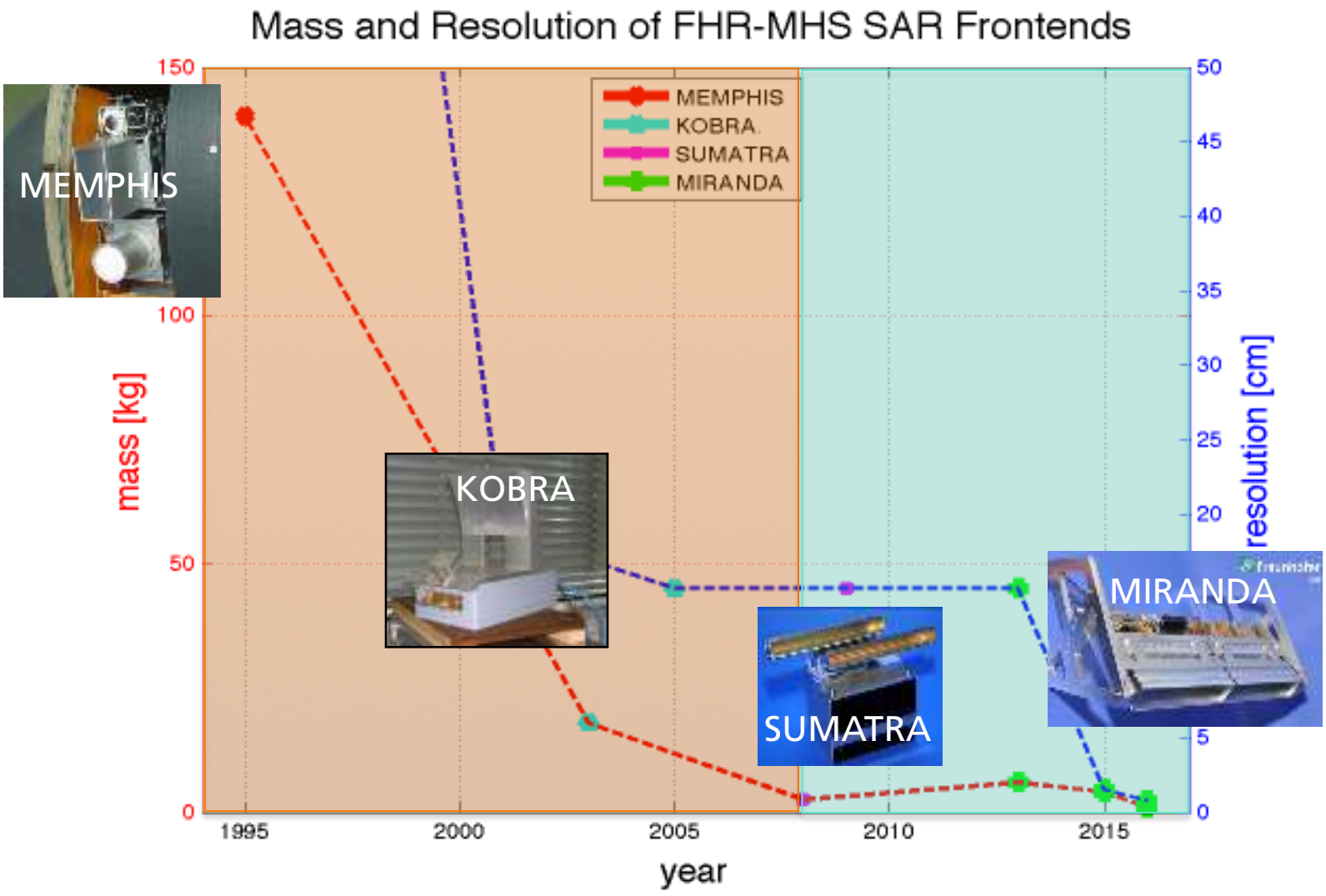
- $InDiff = \Sigma\ 1/2\ (1/\delta_{12} + 1/\delta_{22})\ (\mu_1 - \mu_2)^2 + ((\delta_1 / \delta_2) - (\delta_2 / \delta_1))^2$
- developed for IR data in two shapes:
  - InDiff on n = 1 pairs
  - InDiff on n > 1 sets
- SAR scene simulations suggest sets of n ≥ 10
- adaption of our SAR capabilities for the Storkow 2014 campaign







Progress of SAR – Systems



Fraunhofer FHR

SAR Platform: Microlight ‚Delphin‘

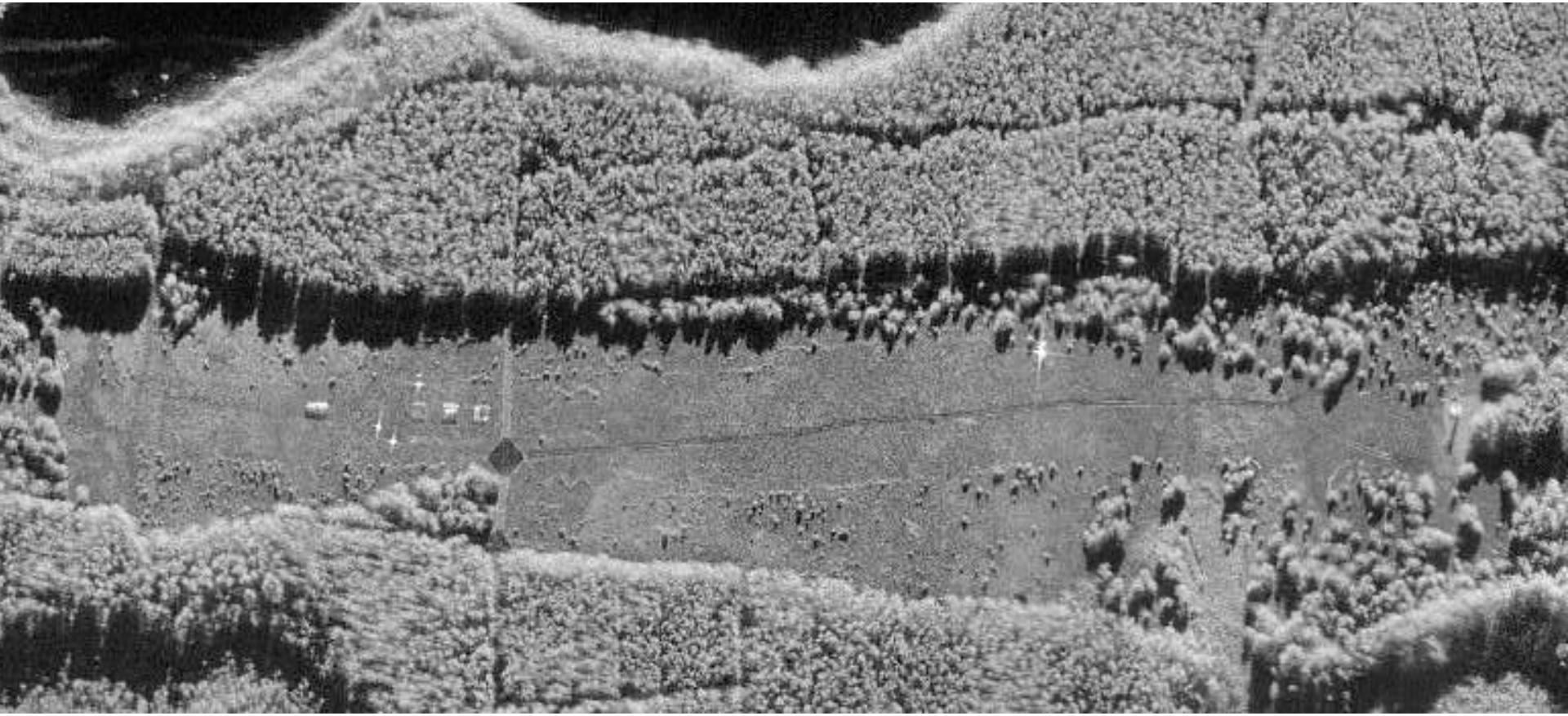
Parameter	Value
Weight	320 kg
Payload	150 kg
Power supply	200 W
Voltage	12 V / 24 V
Range	~1000 km
Wing spread	9.4 m
Velocity	~35 m/s
Depression angle	adjustable (typ. 30°)

MIRANDA
mmW Radar with Analog and Digital Data Acquisition

Parameter	Value
Type	FMCW-Radar
Center-Frequency	35 GHz
Max. Bandwidth	1 GHz
Range resolution	15 cm
Output power	33 dBm / 40 dBm
Dimensions	80 mm x 350 mm x 150 mm
Weight	5 kg
Power consumption	25 W @ 12 V
Depression angle	30°
Opening angle	3.3° x 15°
Altitude	300 m – 2000 m
Distance	600 m – 4200 m
Swath width	300 m – 2200 m

Current Storkow Campaign, n ≥ 10

- altitudes 400, 600, 800 m
- headings 0°, 180°



Camouflage Difference Campaign at FHR

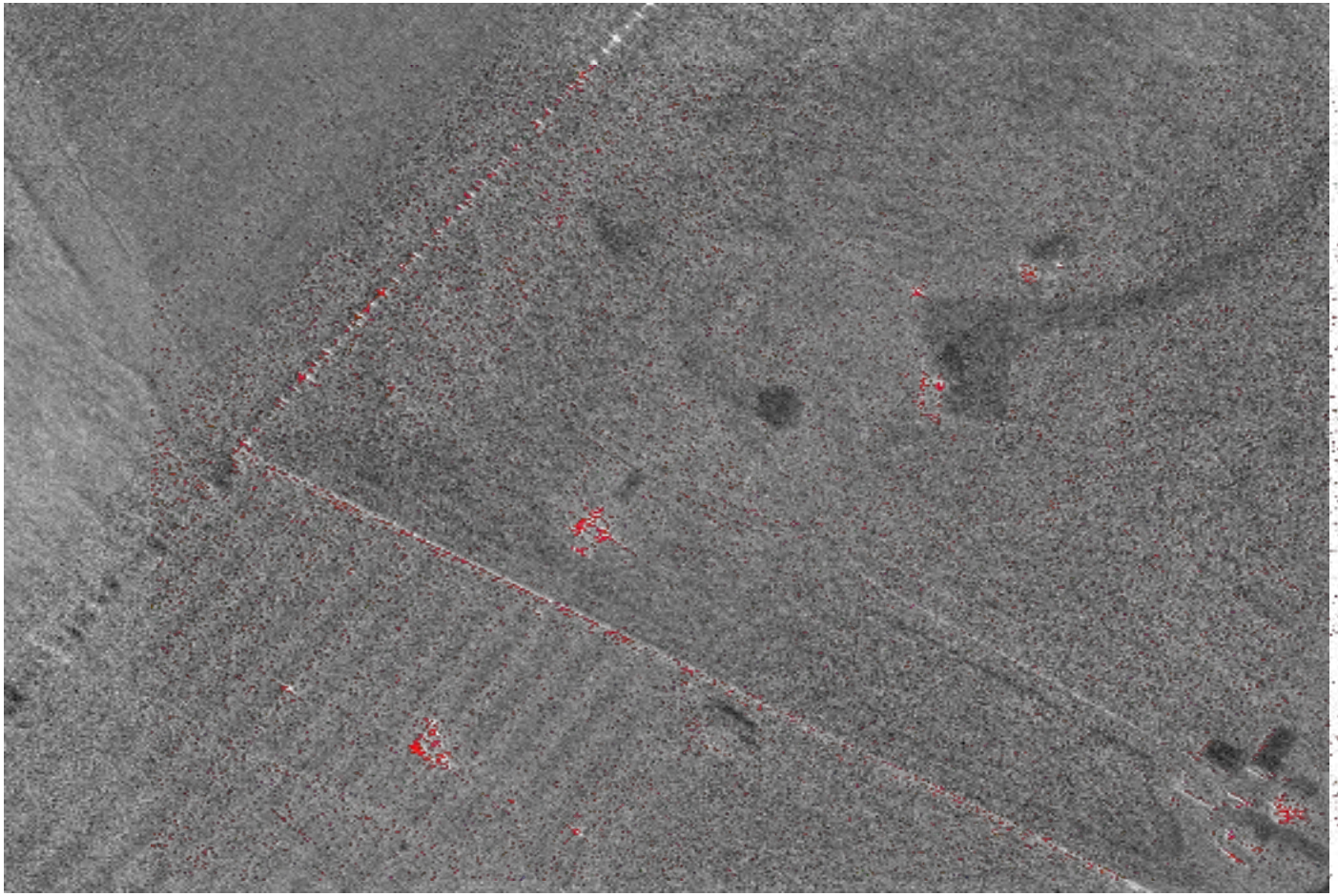
August 5th, 2015

Complete MIRANDA 35 GHz SAR Scene

August 5th, 2015

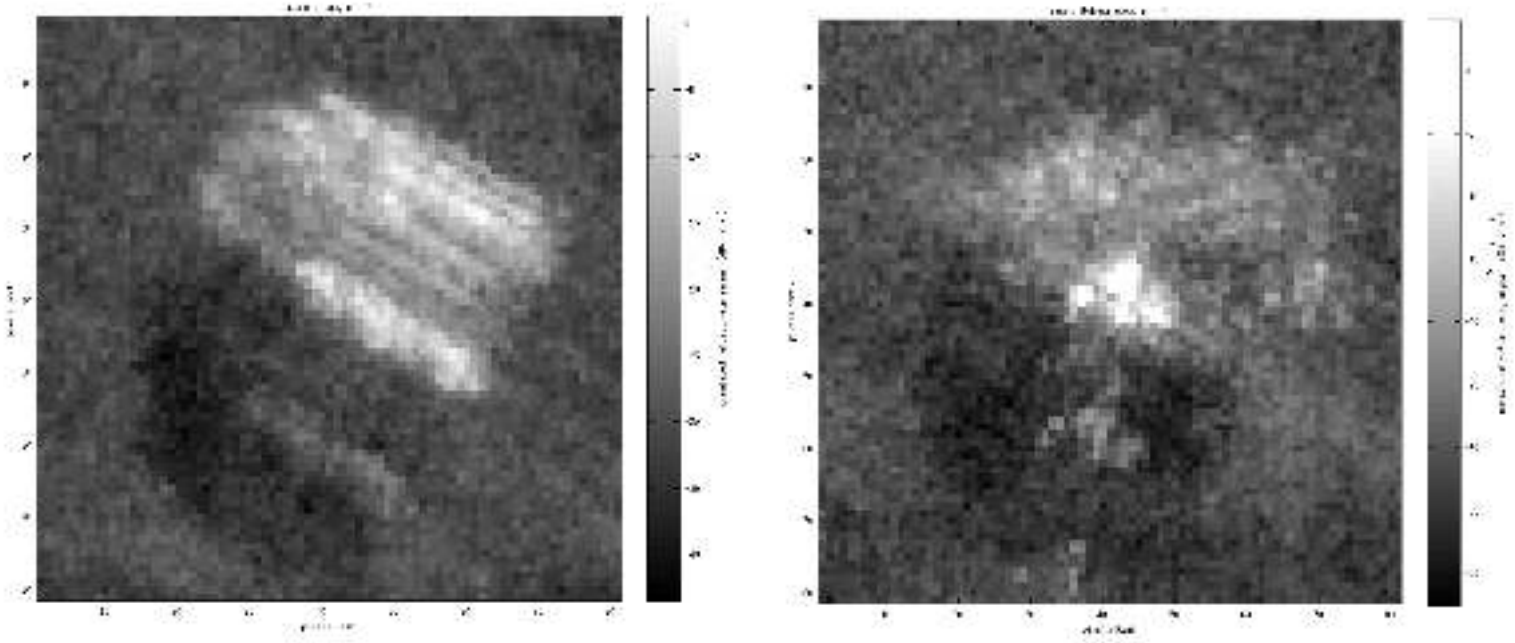
MIRANDA 35 GHz SAR Scene Close-Up

Changes within Test Area, n = 1

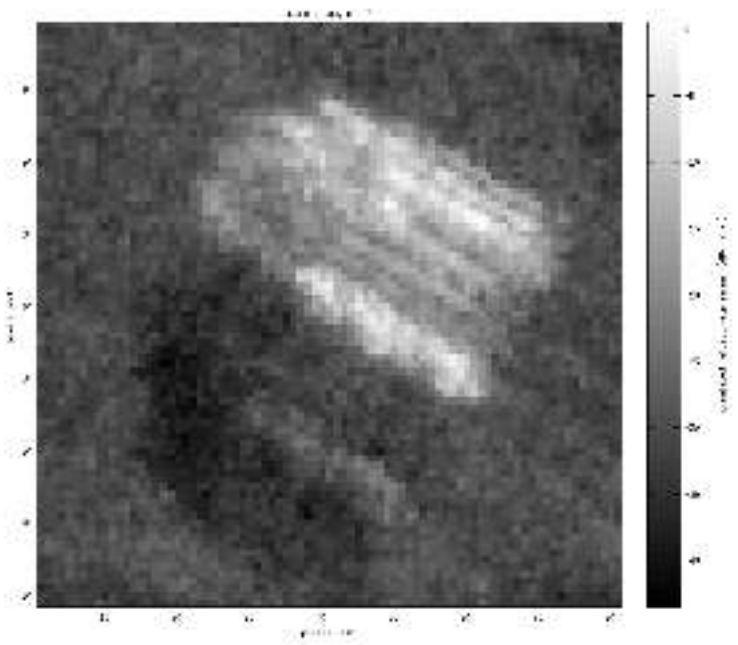


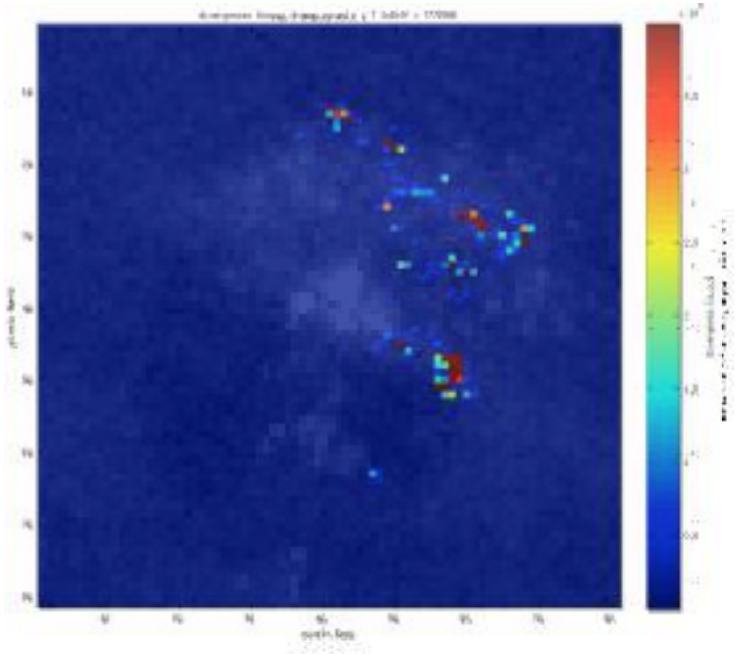
Repositioned Vehicle

InDiff of Vehicle, n = 7



InDiff of Vehicle, n = 7

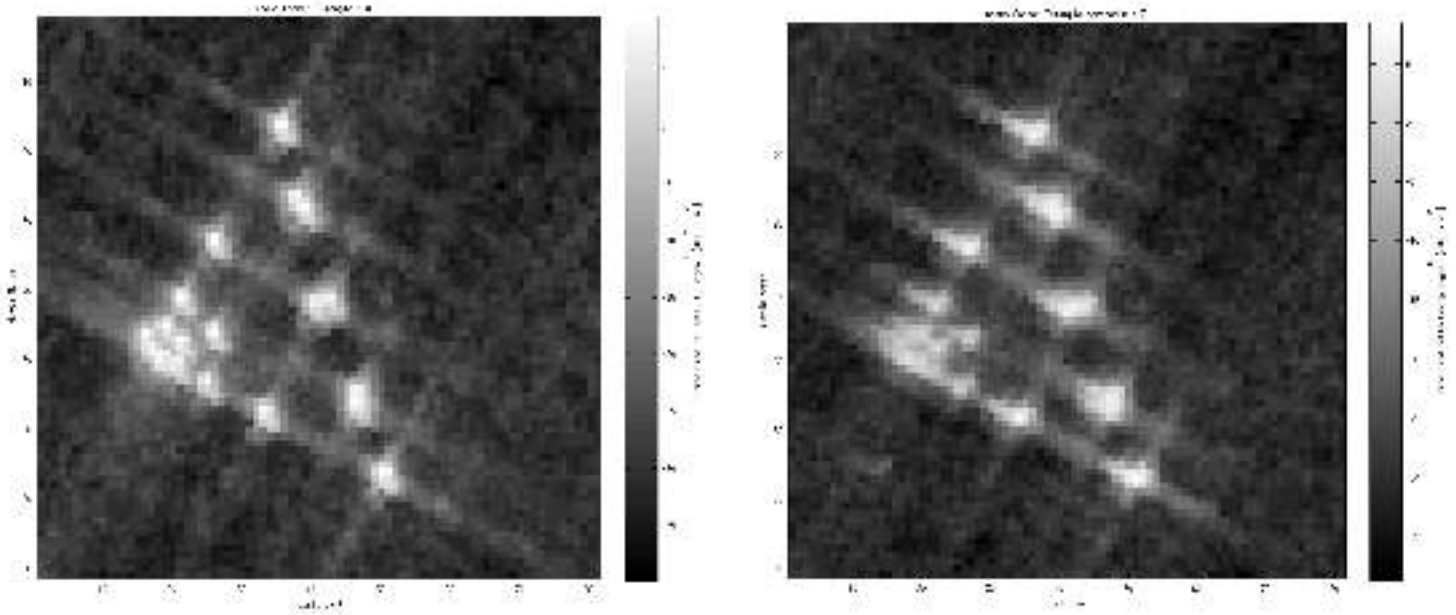




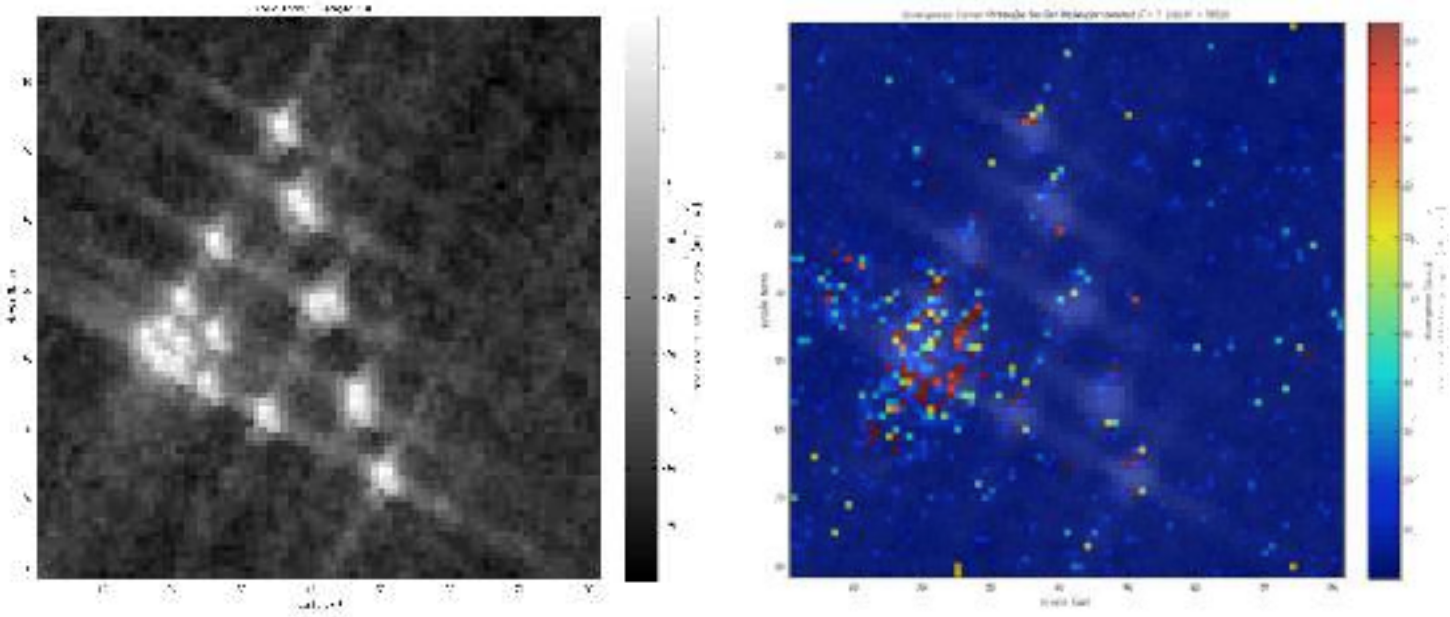
- InDiff = $7.8*10^6$

Triangle of Corner Reflectors

InDiff of Corner Triangle, n = 7



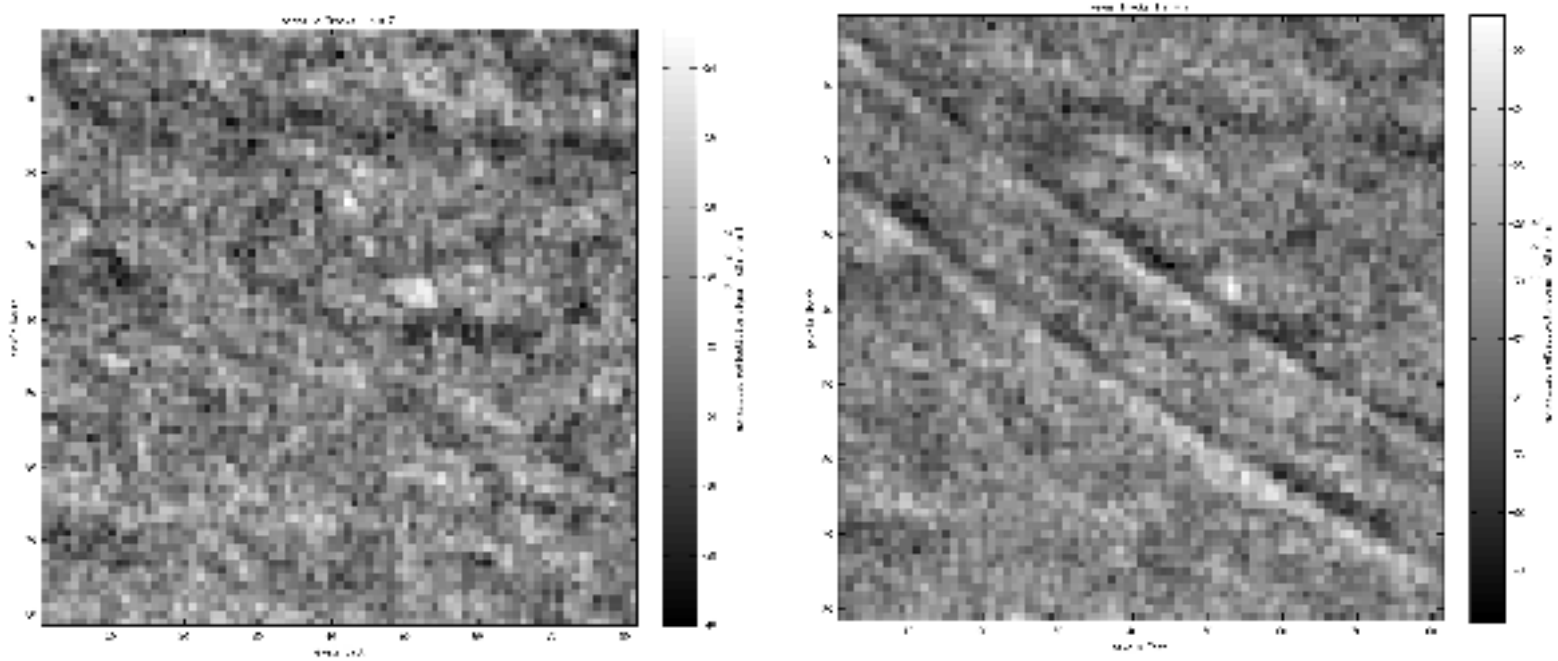
InDiff of Corner Triangle, n = 7



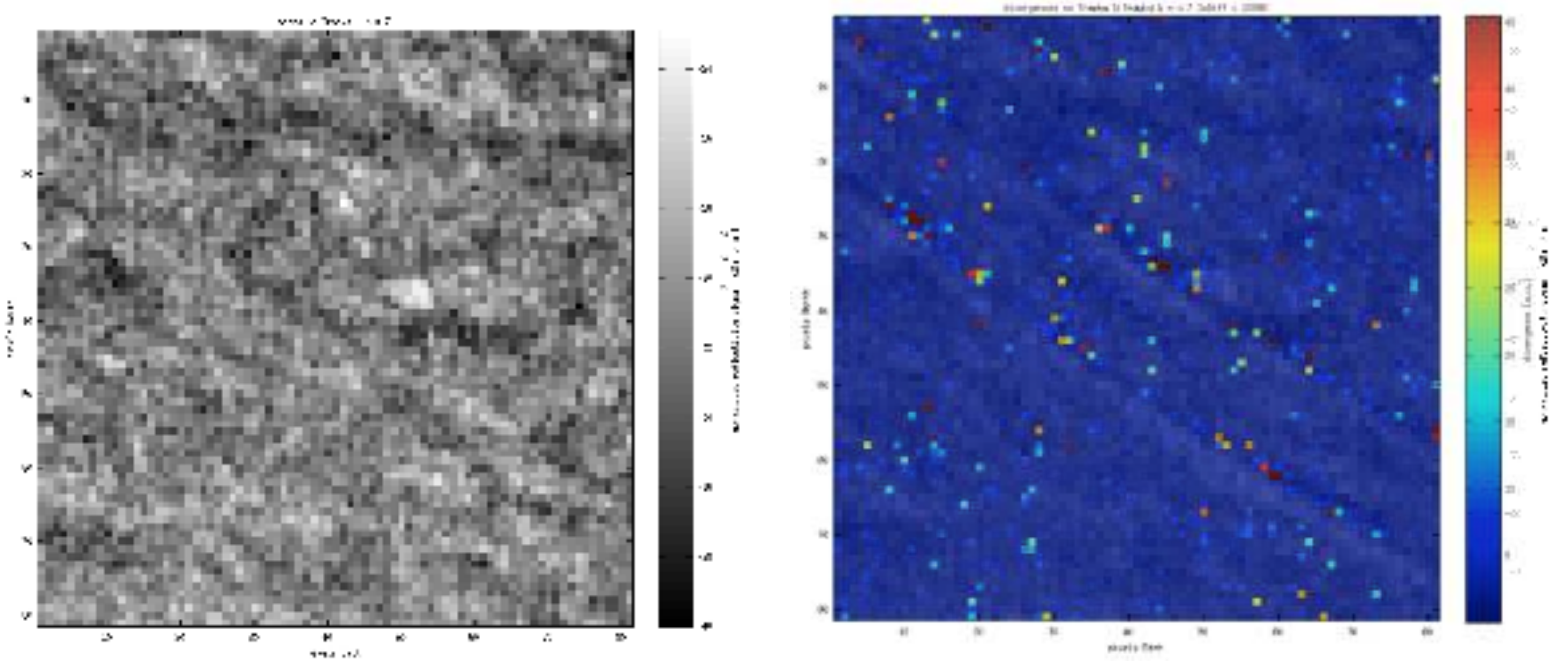
- InDiff = $5.7*10^4$

Vehicle Tracks

InDiff of Vehicle Tracks, n = 7



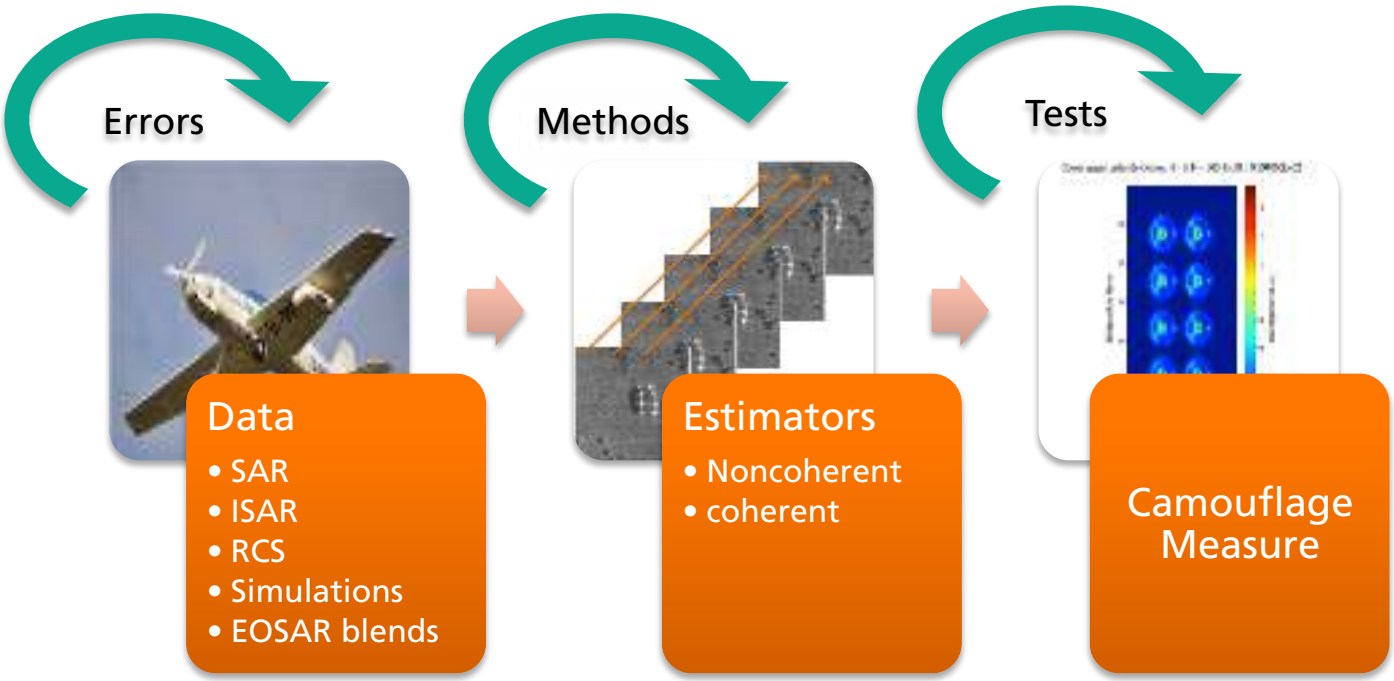
InDiff of Vehicle Tracks, n = 7



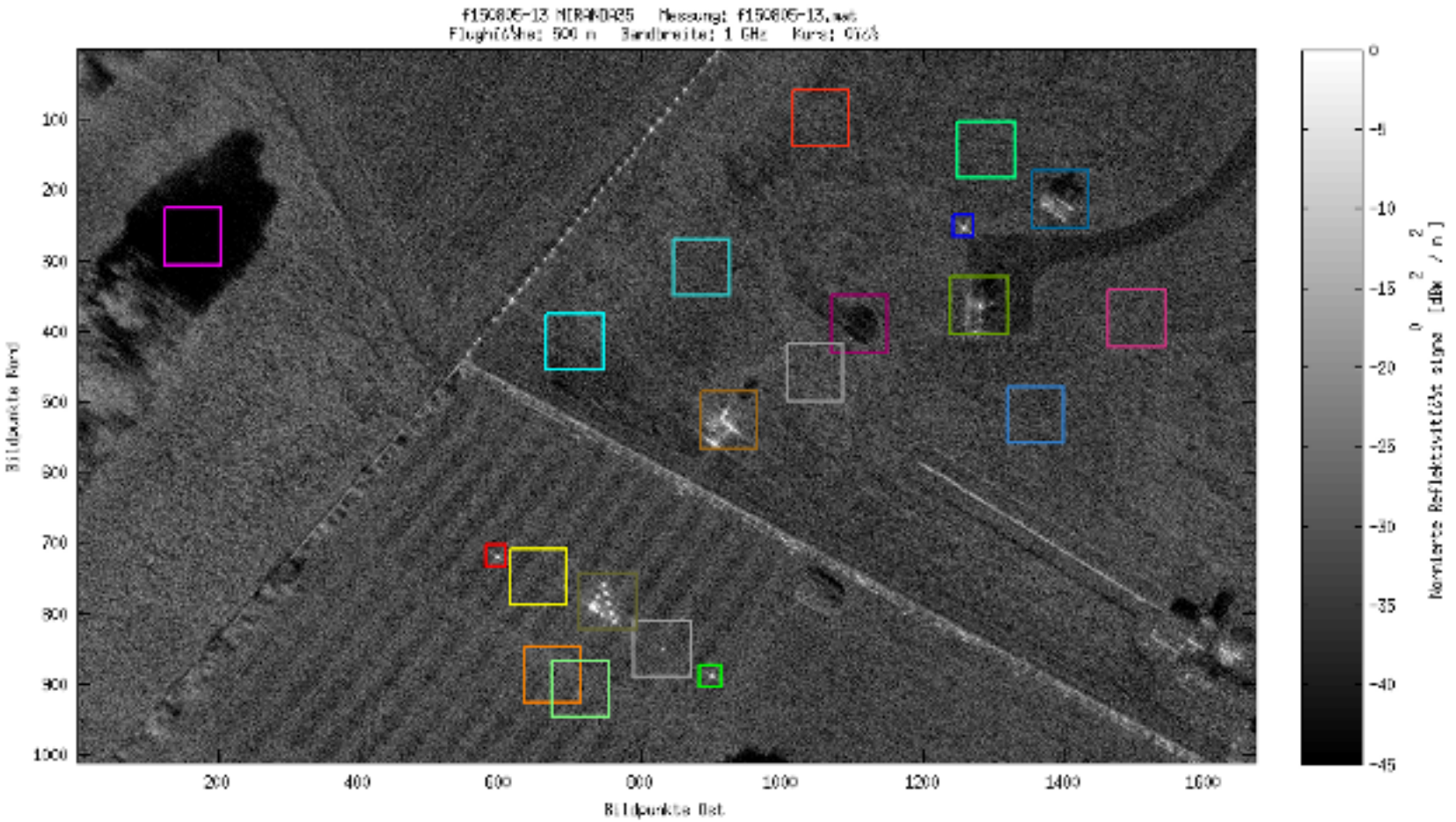
- InDiff = $1.1*10^4$

Summary

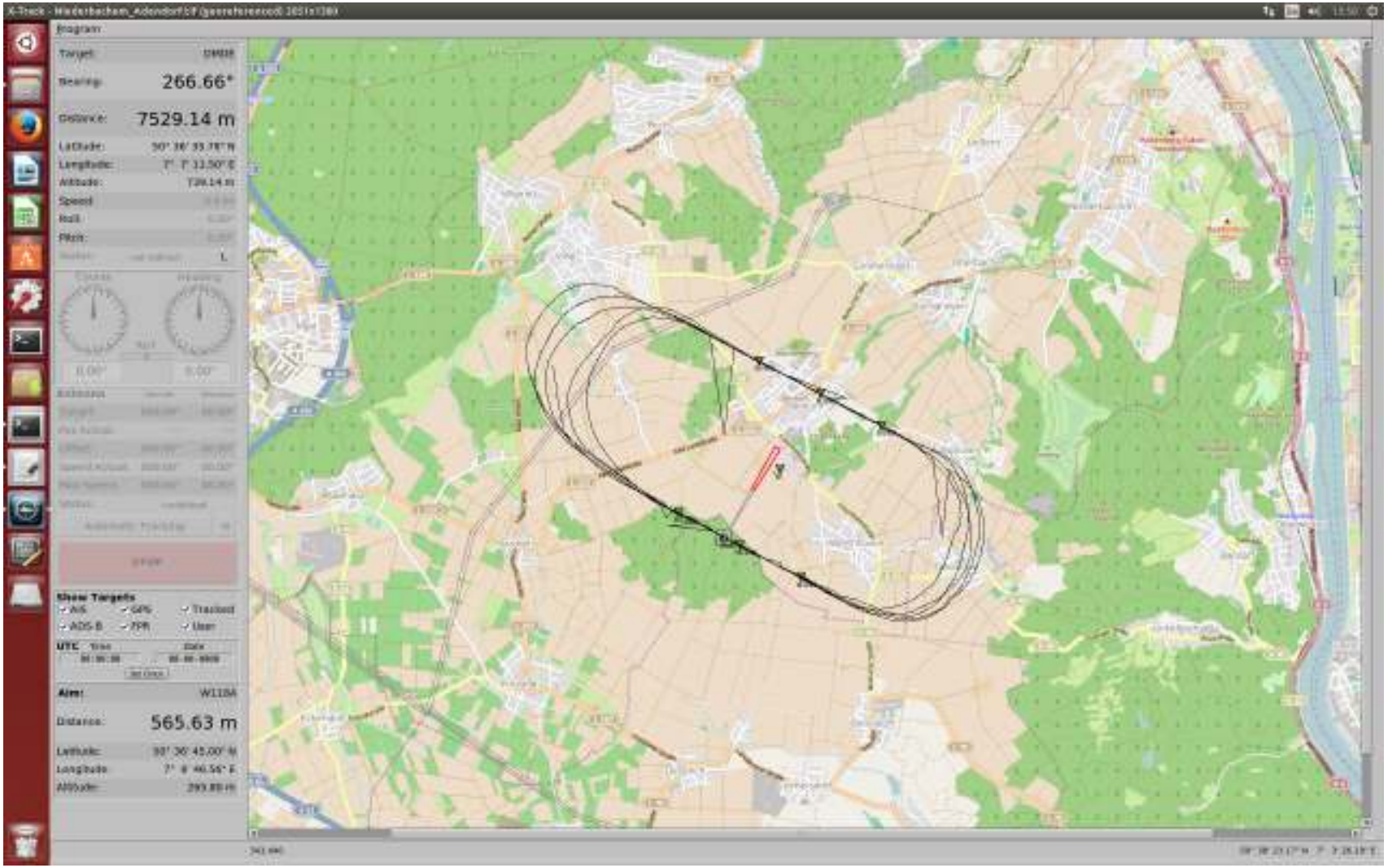
- Camouflage measure: not RCS, but in agreement
- Change detection and Radar camouflage measure parallelism
- Learning curve for FHR Radars and operators
- Results from current campaigns at FHR and Storkow



CUDA Acceleration of SAR Processor



Improved Flight Repetition Accuracy



Outlook

- more Radar bands
- Polarization
- Coherent methods
- SAR platform improvements
- Test of camouflage measure with observers