A SAR TECH

STEREO RESEARCH CONTRACT Nr SR/00/04

“ADVANCED SAR REMOTE SENSING TECHNIQUES”

Annual STEREO & VG Workshop, 9 May 2003

CONTENTS

I.
PROJECT OBJECTIVES AND ORGANIZATION

END-TO-END REMOTE SENSING SYSTEM

R

PRE-PROCESSING

POST-PROCESSING

Acquisition

Data = $h_a[\xi]$

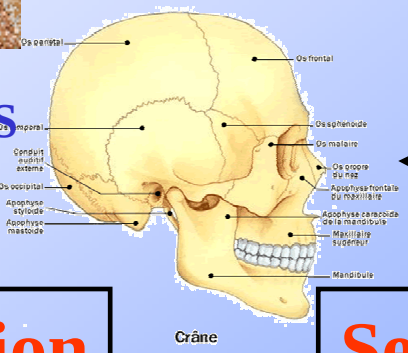
Reconstruction

$\hat{\xi} = h_a^{-1}[\text{Data}]$

-Denoising
-Pattern recognition
-Change detection
-etc

PHYSICS

$\xi(x,y)$



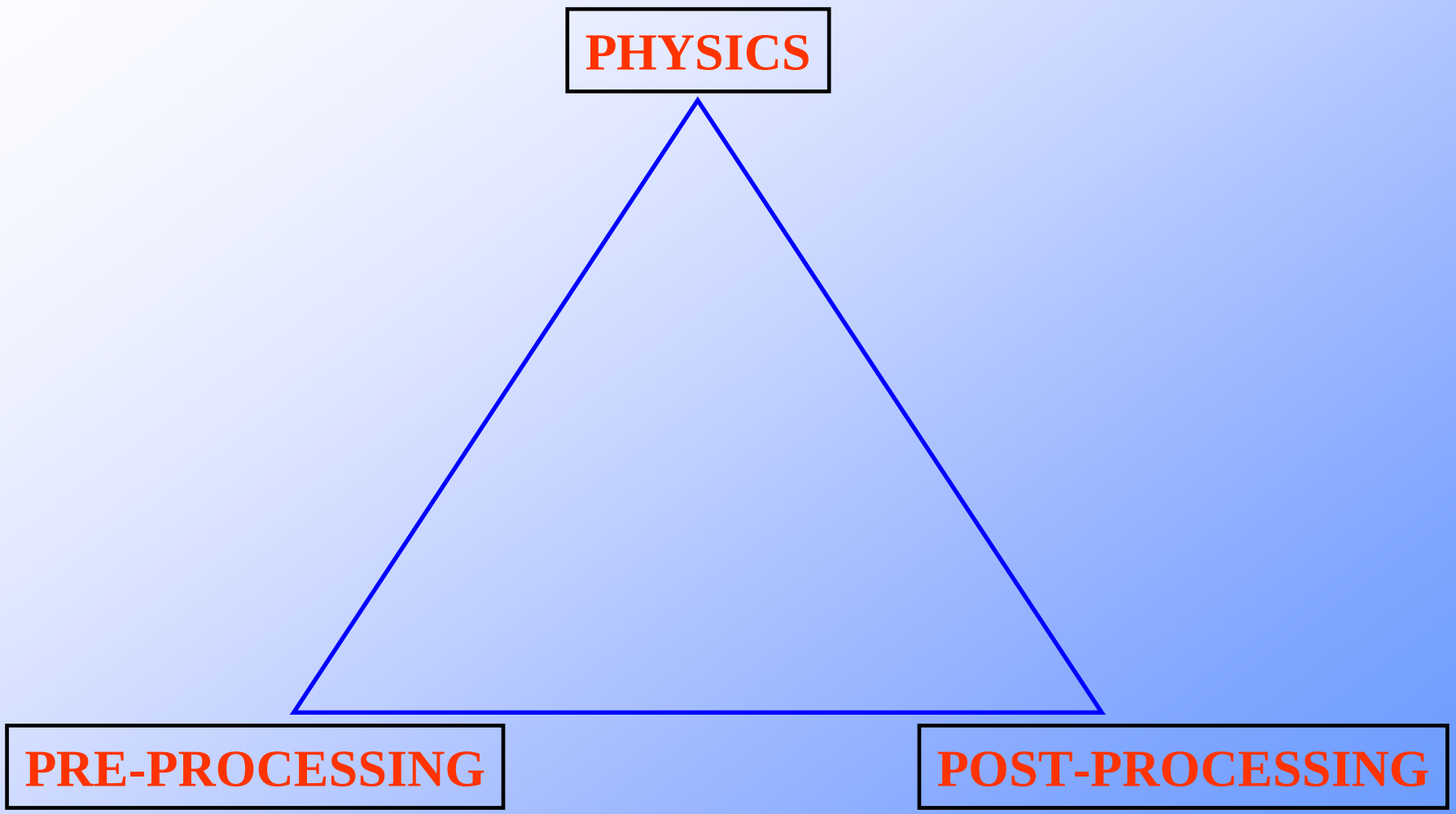
Crâne

Object function

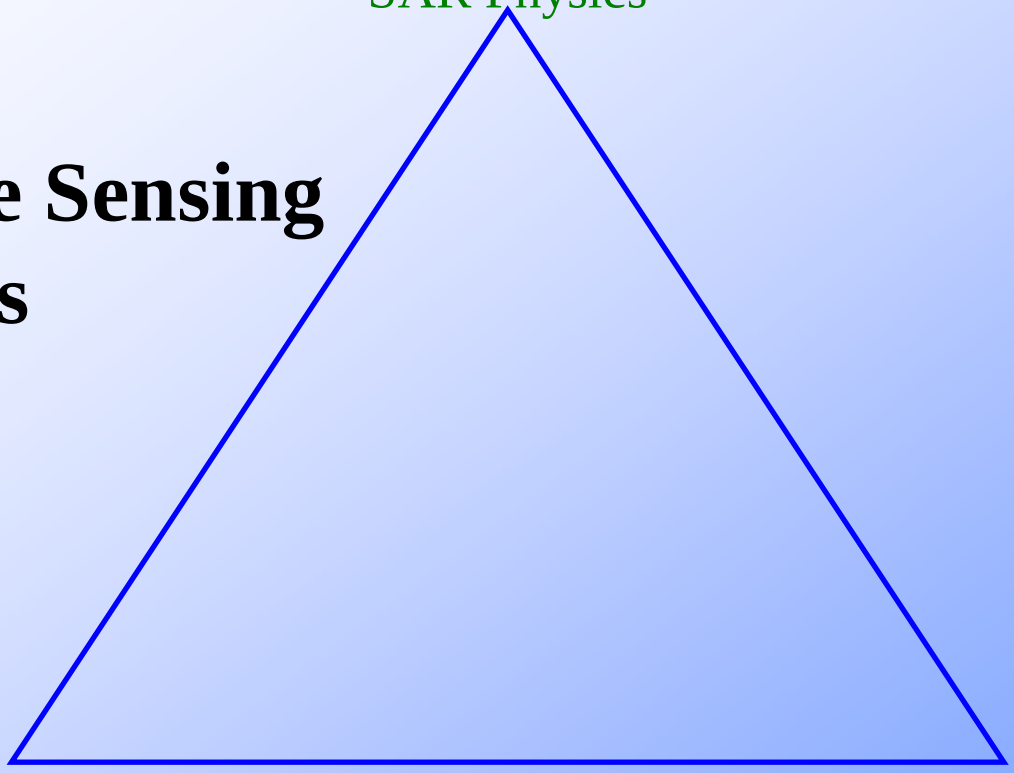
Sensor

Processing chain

3 BASIC INTERRELATED INGREDIENTS :



Advanced
SAR Remote Sensing
TECHniques



OBJECTIVES

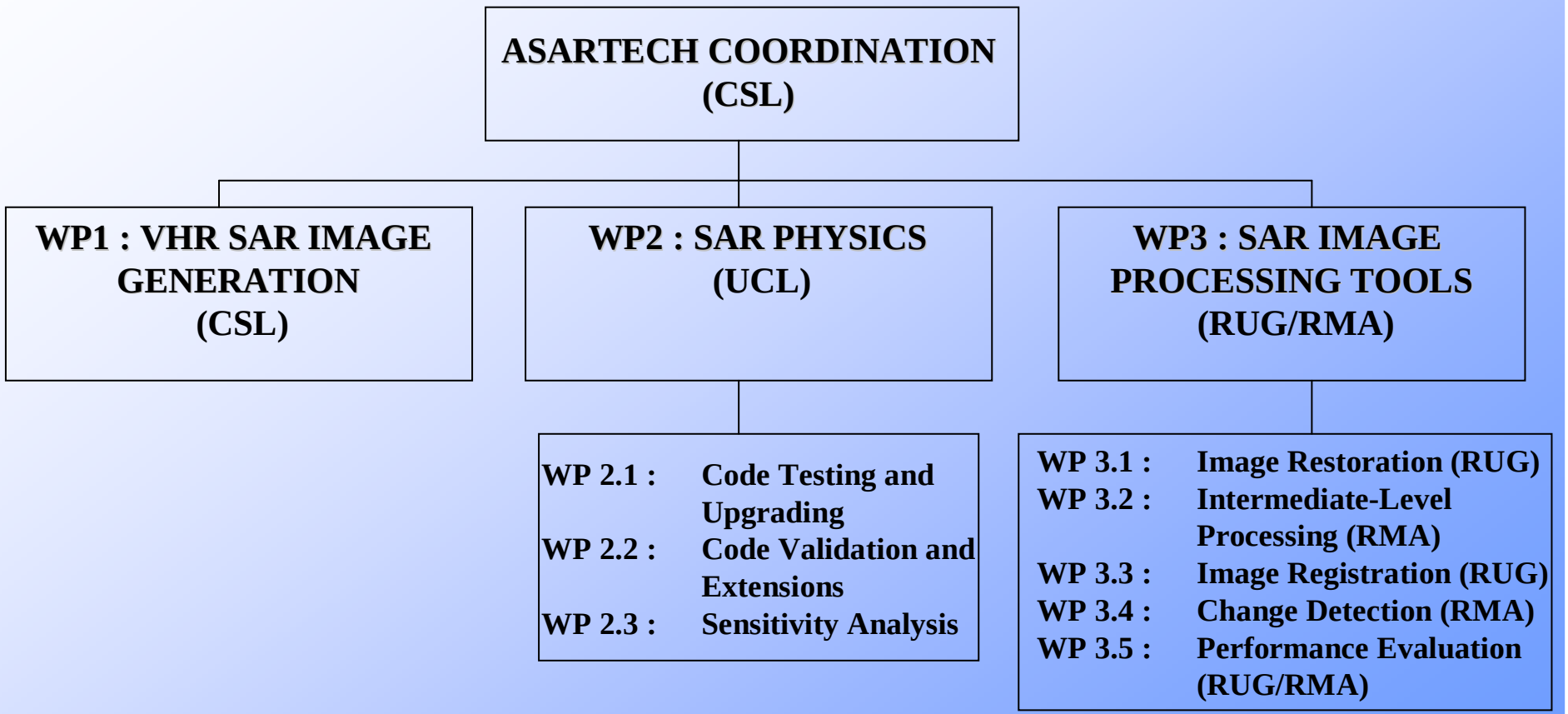
To develop and validate *advanced pre- and post-processing techniques for Synthetic Aperture Radar (SAR) remote sensing*, incl. :

1. ***Very high-resolution SAR image generation*** **:**
   A Spotlight SAR processor

2. ***SAR Physics*** **:**
   A Polarimetric Radiative Transfer Model and associated computer code for the realistic simulation of polarimetric radar (and SAR) observation of rough soils, vegetated areas and forested areas.

3. ***SAR image processing tools*** **:**
   Efficient processing tools that could be included in GIS systems and take into account the SAR image generation process and the scattering physics, with specific interest on image restoration, intermediate-level image processing, image registration and change detection.

NETWORK AND WBS



II.
PROJECT STATUS

- **On track**
- **First Steering Committee Meeting 29 Nov. 2002**

  Successful

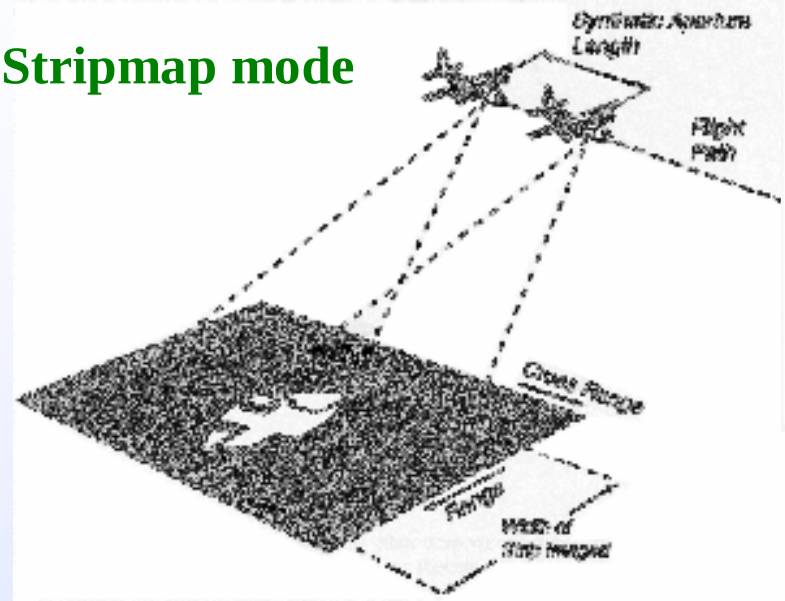
  Recommendations to be reviewed (next progress report) and implemented

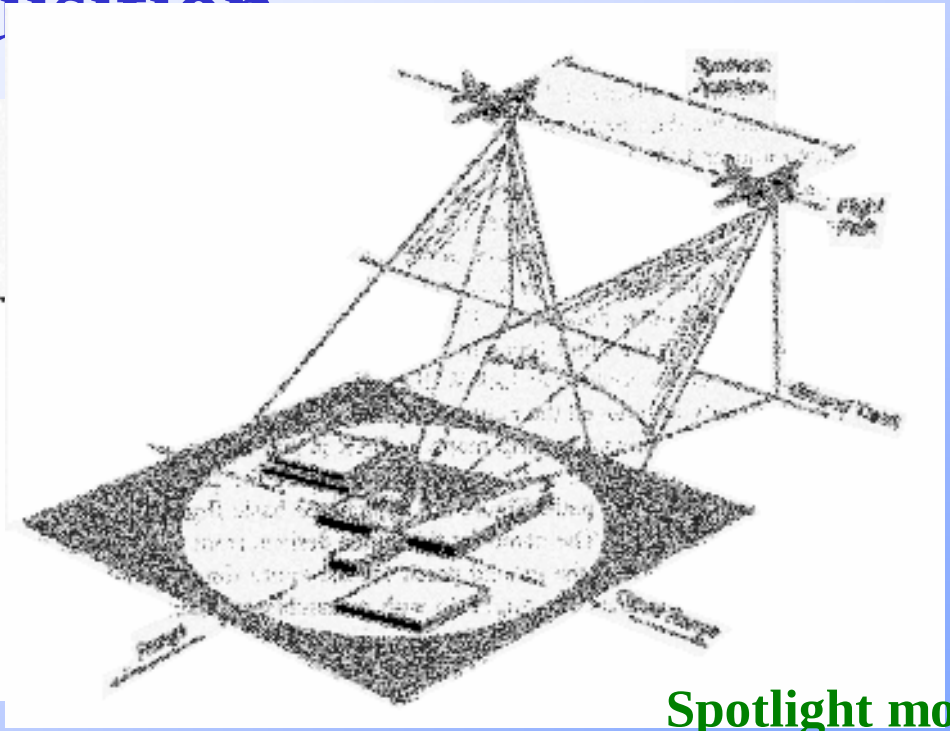
III.
TASK PRESENTATIONS

WP 1 : VHR SAR Image Generation (CSL)

Spotlight SAR Acquisition

Stripmap mode



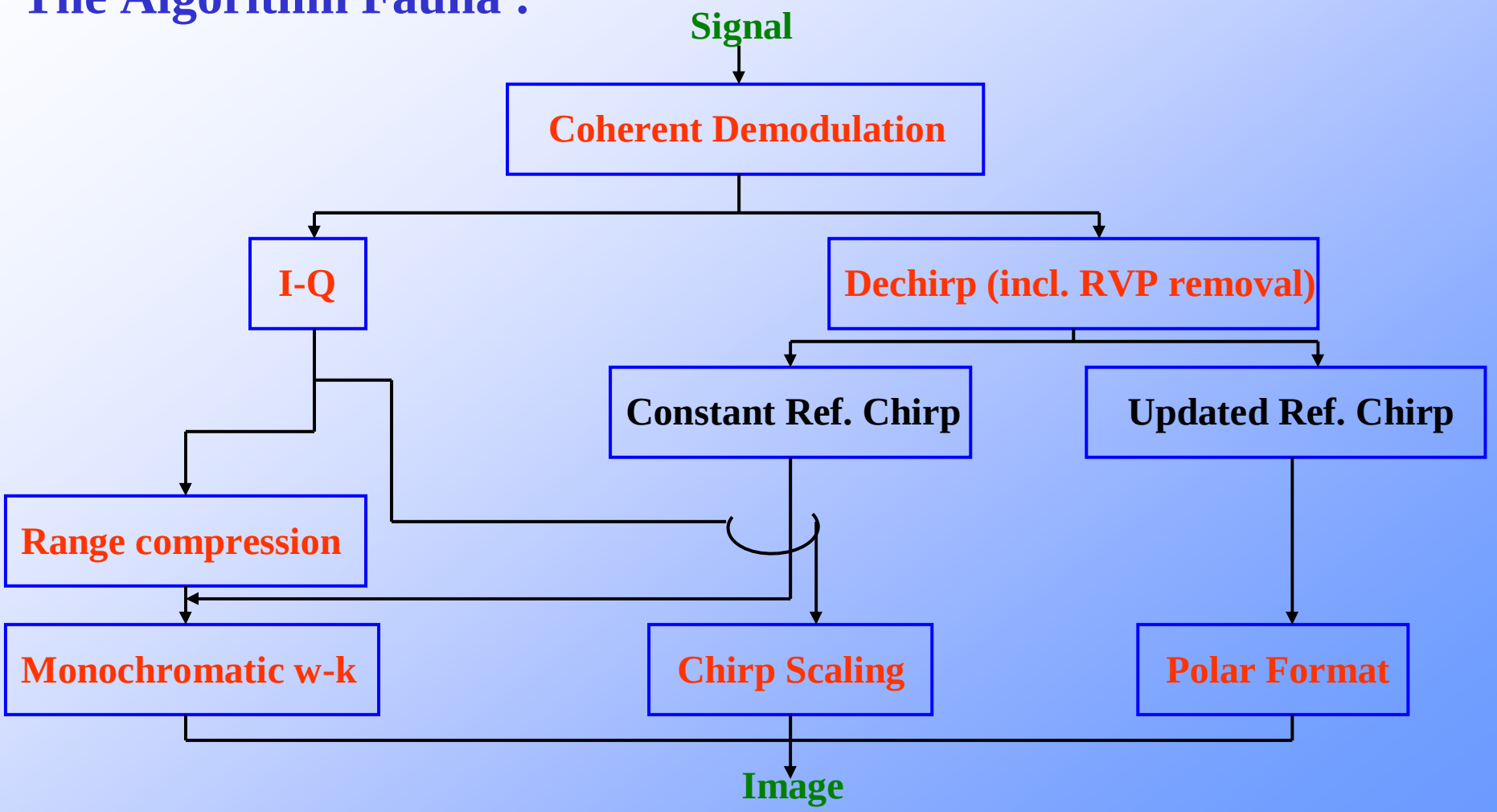


Spotlight mode

Driver

Basically all Stripmap processing schemes are adaptable to Spotlight case *mutatis mutandis*

The Algorithm Fauna :



Status

1) Theory of Spotlight SAR processing

- **Spotlight SAR acquisition equation and PTR** **DONE**
- **Spotlight SAR reconstruction equation and algorithms** **DONE**
- **Algorithm(s) selection** **IN PROGRESS**

2) Processor design and coding

3) Processor validation on

- **Simulated point target data**
- **SIR-C raw data set.**

WP 2 : SAR Physics (UCL)

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UCL is current busy with finish Task 1 and start Task 2.

Task 1: Testing and correction of the code "**POLSAR**"

- Increased reliability of the code

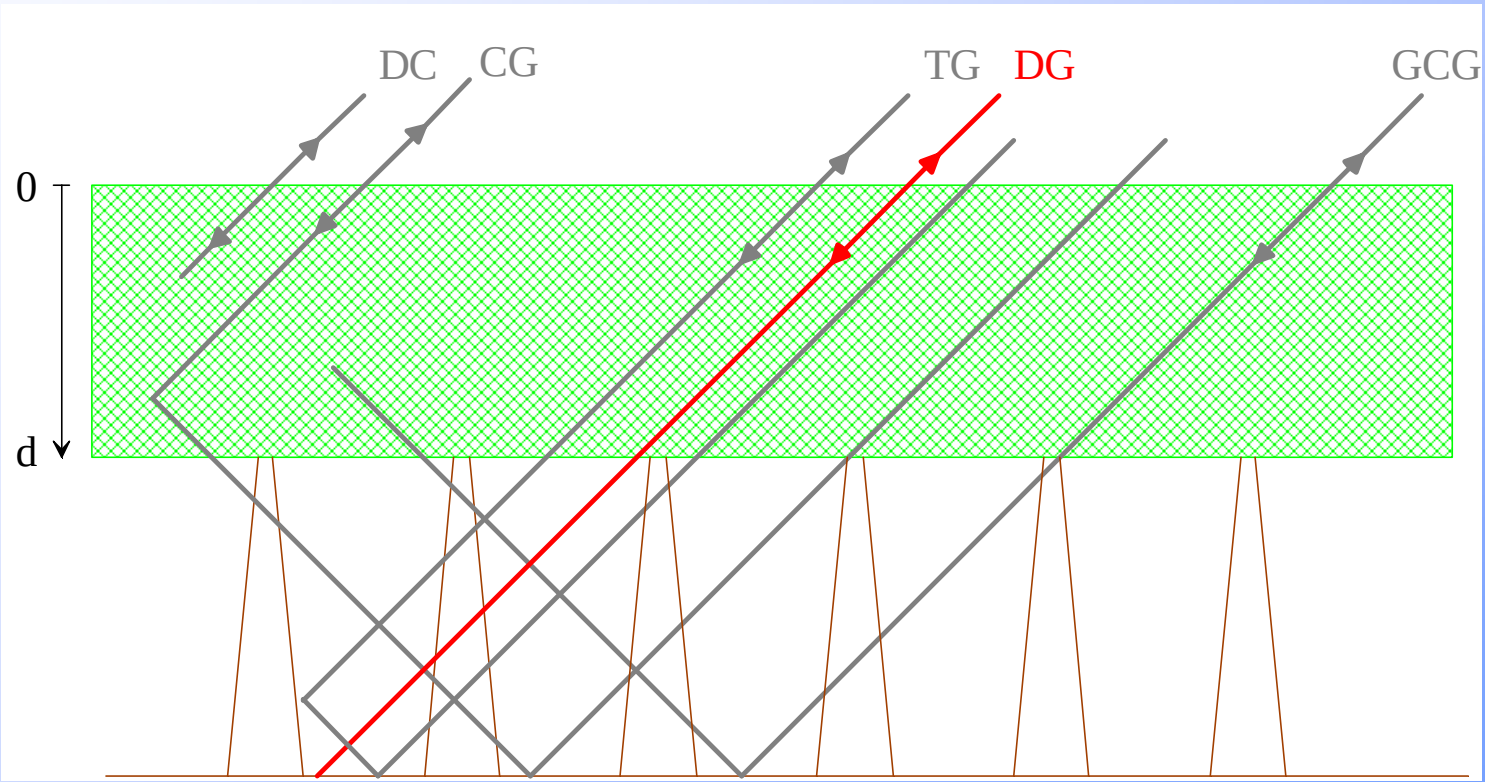
Task 2: Validation and extension of the code

- More realistic modelisation of natural elements

Task 3: Extended and systematic sensitivity analysis

- Determination of the more relevant parameters

UCL model for vegetated areas and *the 5 backscattering* contributions.



UCL uses I.E.M. Fung's model for bare soil contribution.

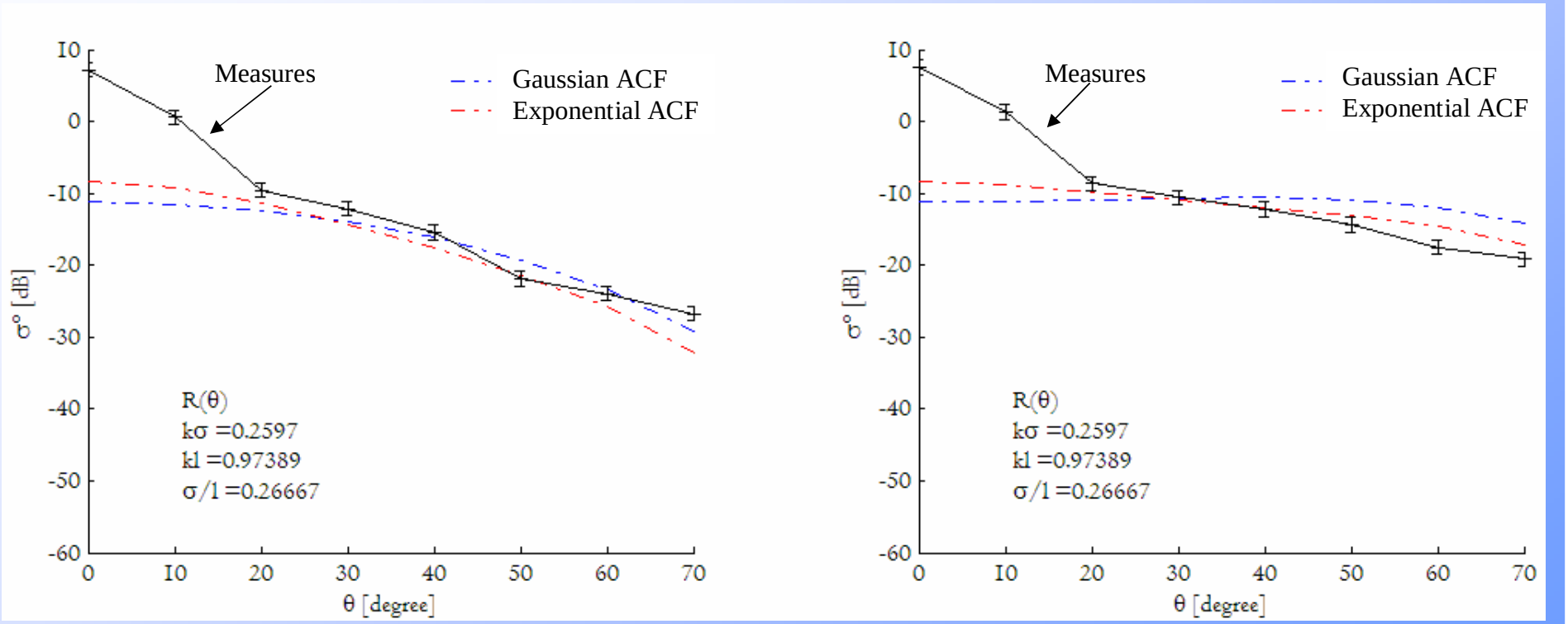
The bare soil backscattering (DG) needs to be better characterized.

The initial model was developed to study the backscattering of forests.

The contributions of the soil in this case was negligible.

Now for the low vegetation the bare soil contribution is important.

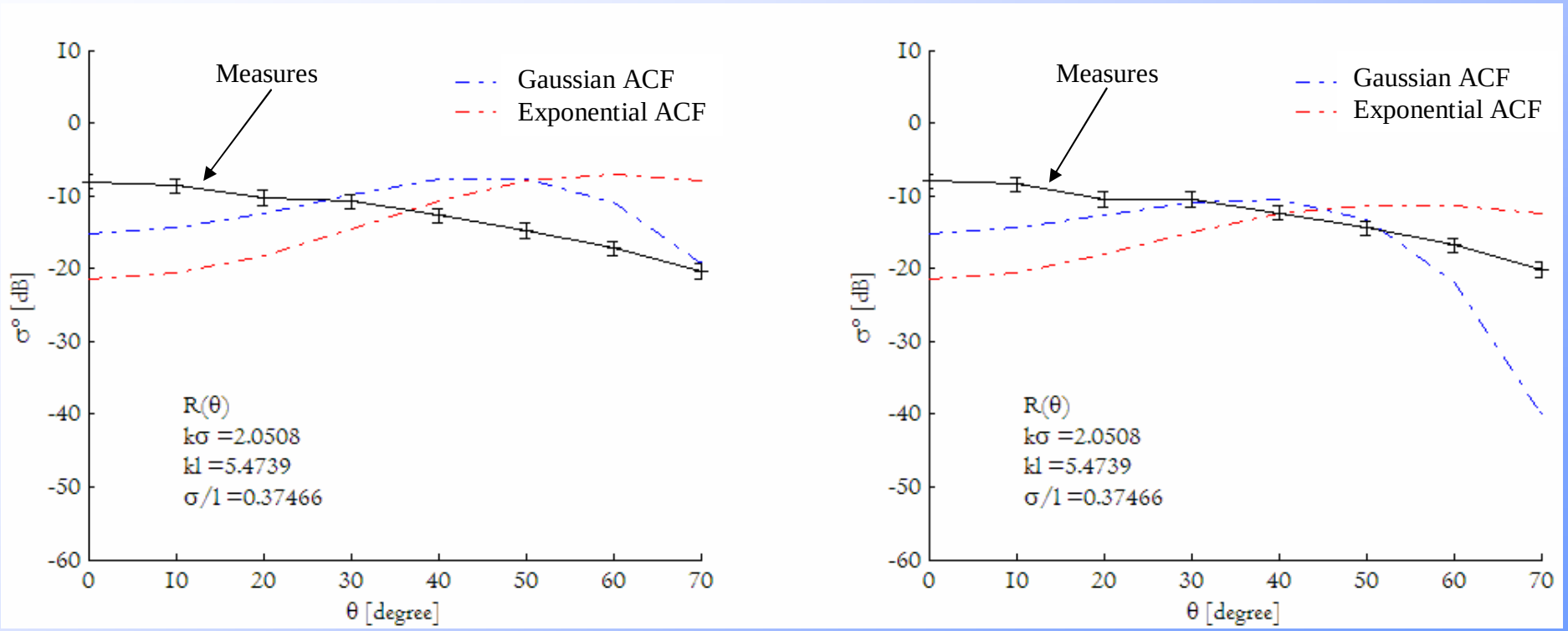
Validation of the DG contribution: a "*good*" example.



Niederried 14 August 86 Pol HH 3,1 Ghz

Niederried 14 August 86 Pol VV 3,1 Ghz

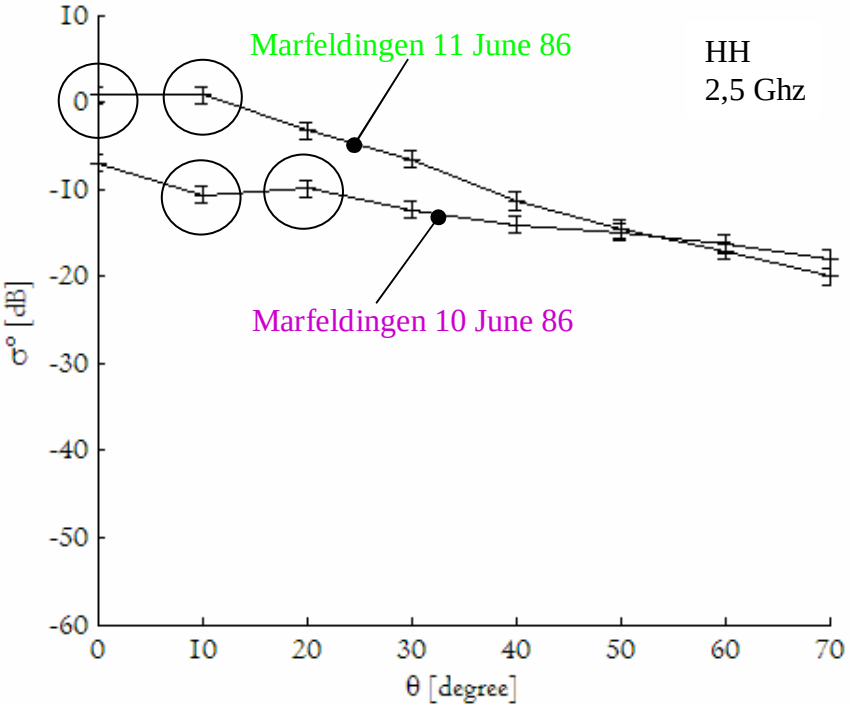
Validation of the DG contribution: a "*bad*" example.

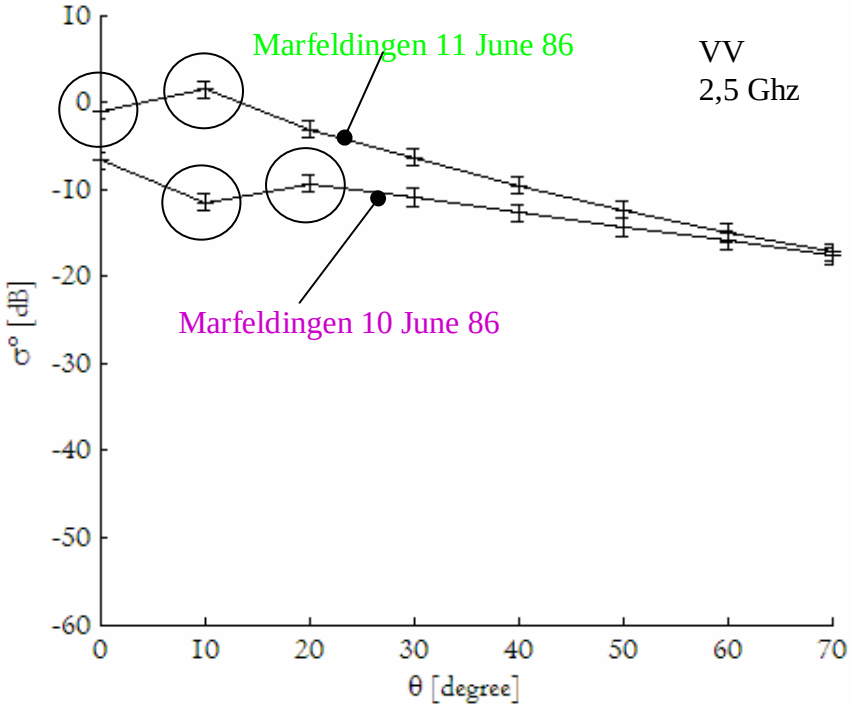


Suberg 26 April 88 Pol HH 7,2 Ghz

Suberg 26 April 88 Pol VV 7,2 Ghz

The validation process depends on the "*reliability*" of the measurements.



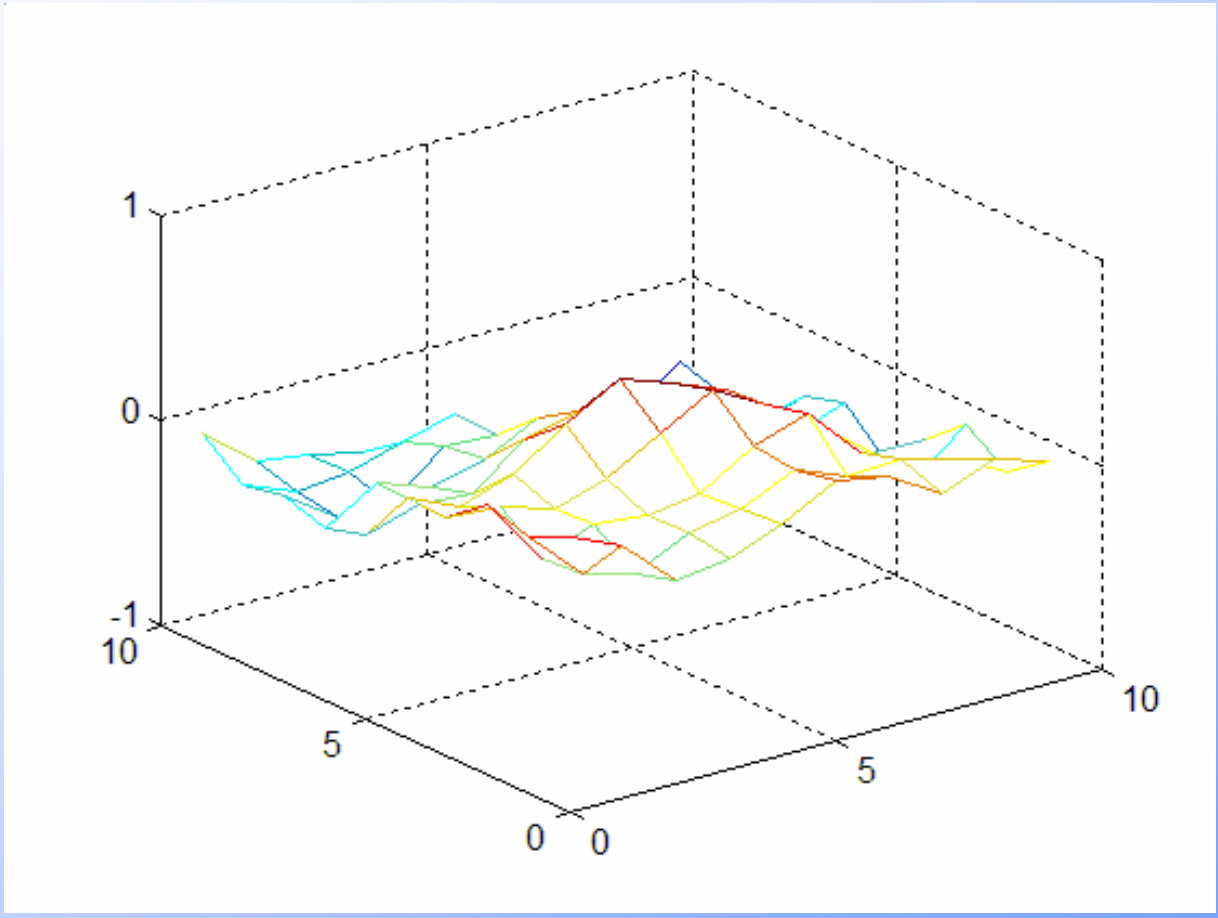


Tsol [°C]	mv %	θ g/cm3	sand %	clay %	RMSh [cm]	lcorr [cm]
17.4	31	0.88	23	27	0.70	1.35
24.3	17	0.88	23	27	0.70	1.35

$\varepsilon_{R\,SOIL}$ = 18.40-j 5.47

$\varepsilon_{R\,SOIL}$ = 8.42-j 0.72

Another way to validate the model: to study 3D numerical surface.



Temporal planning.

U.C.L.												
Year	2002				2003				2004			
Trimester	1	2	3	4	1	2	3	4	1	2	3	4
2.1												
2.2												
2.3												

WP3: SAR Image Processing Tools (RUG/RMA)

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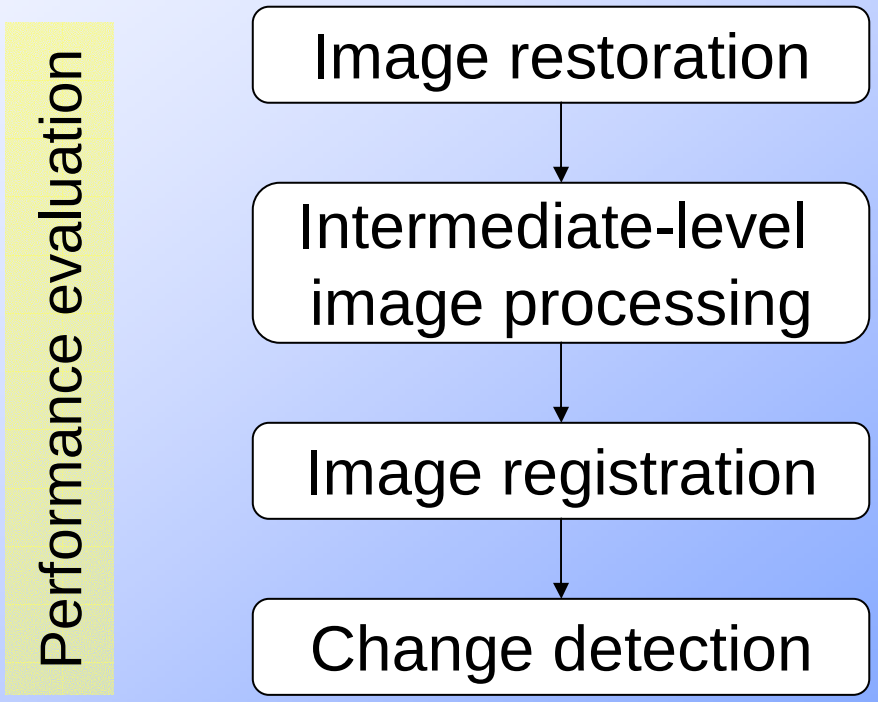
SAR Image Processing Tools



WP3.1: Image restoration (RUG)

- Speckle noise hinders the interpretation of image content
- Standard speckle filters blur the image

Image restoration: a multiresolution approach

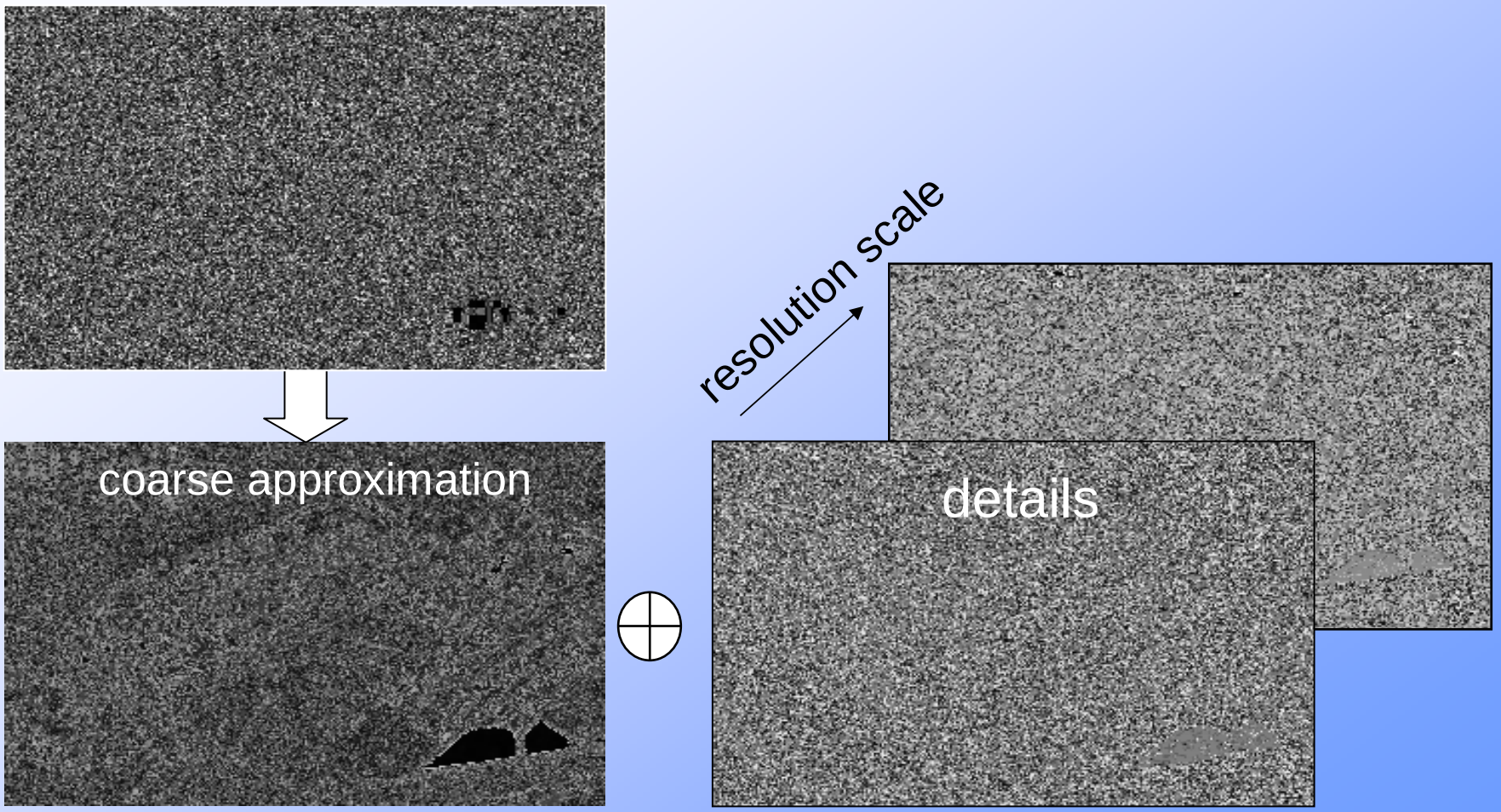
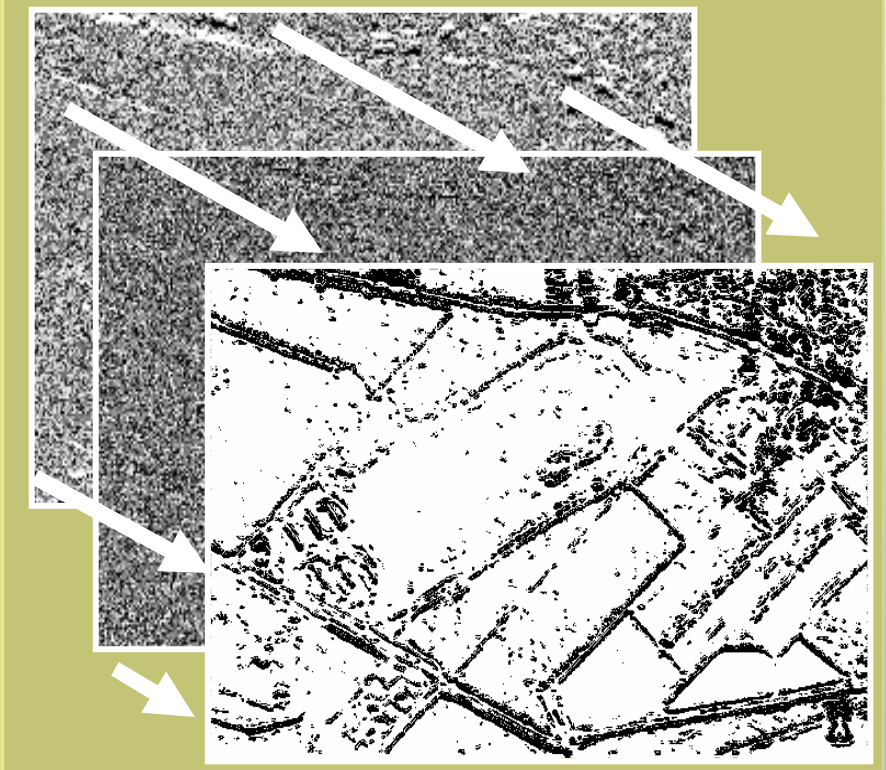


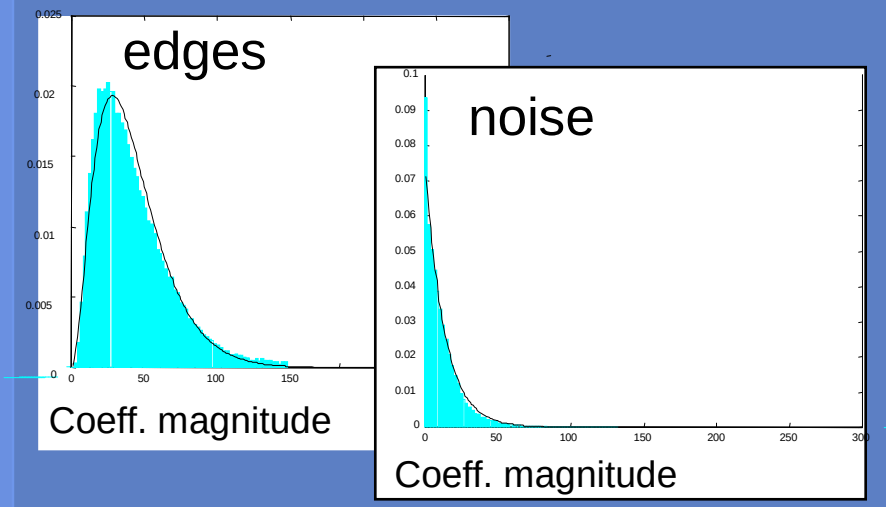
Image restoration

Multiscale analysis



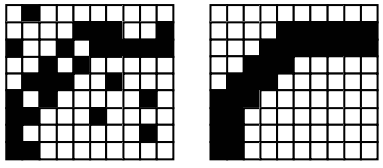
Preliminary classification

Statistical characterization



Spatial context modeling

edge geometry



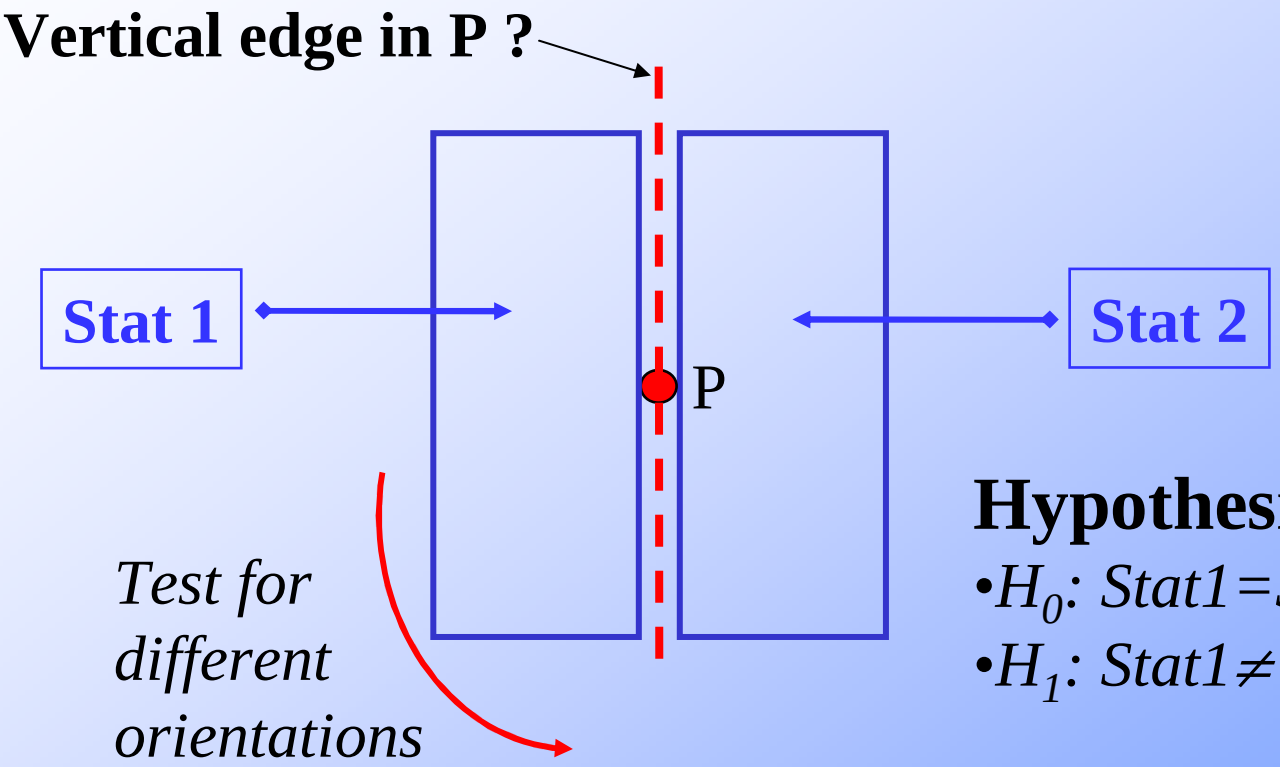
Markov Random Field models

Image restoration: despeckling results

WP3.2: Intermediate-Level Image Processing (RMA)

- **SAR edge detection**
  - single- and multi-channel images
  - edge completion
- **SAR regional analysis**
  - multi-channel texture analysis and region segmentation

Principle of edge detection in SAR



Hypothesis Test:

- H_0: *Stat1 = Stat2 (no edge)*
- H_1: *Stat1 ≠ Stat2 (edge)*

Multi-Channel Data (e.g. Polarimetric Data) → ***Multi-Variate Hypothesis Tests***

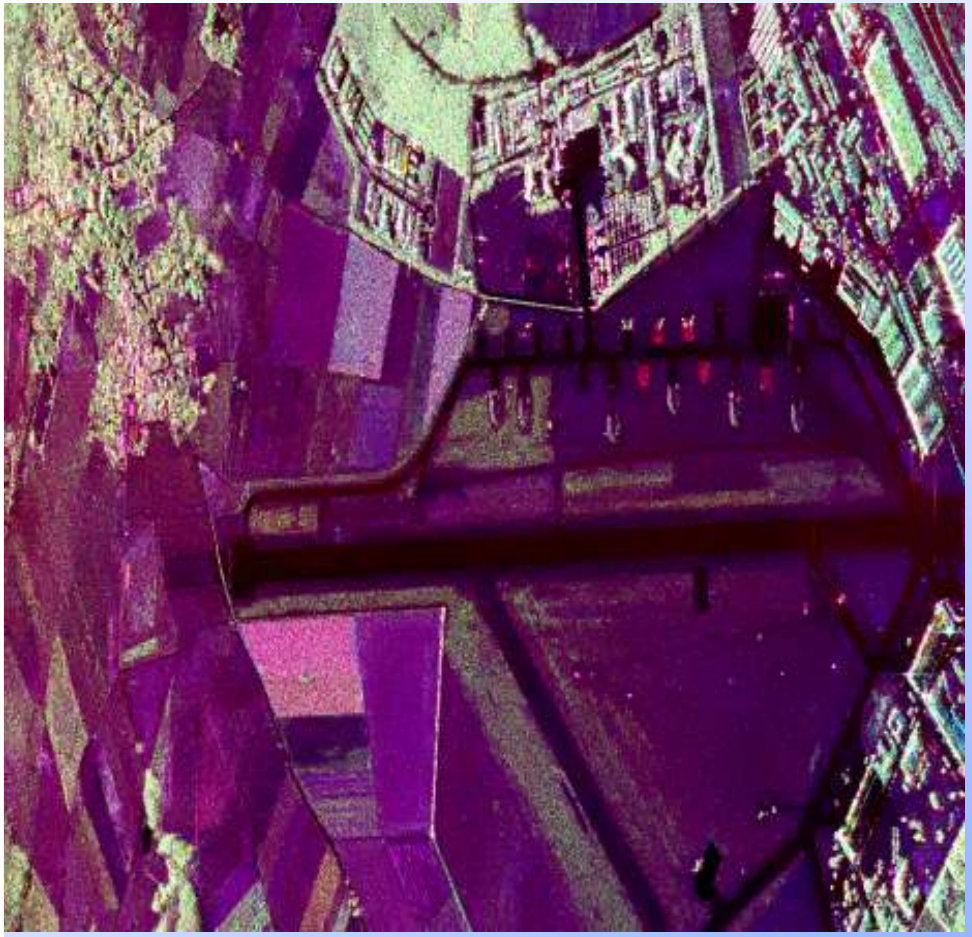
Synergy between denoising and line detection

ORIGINAL image

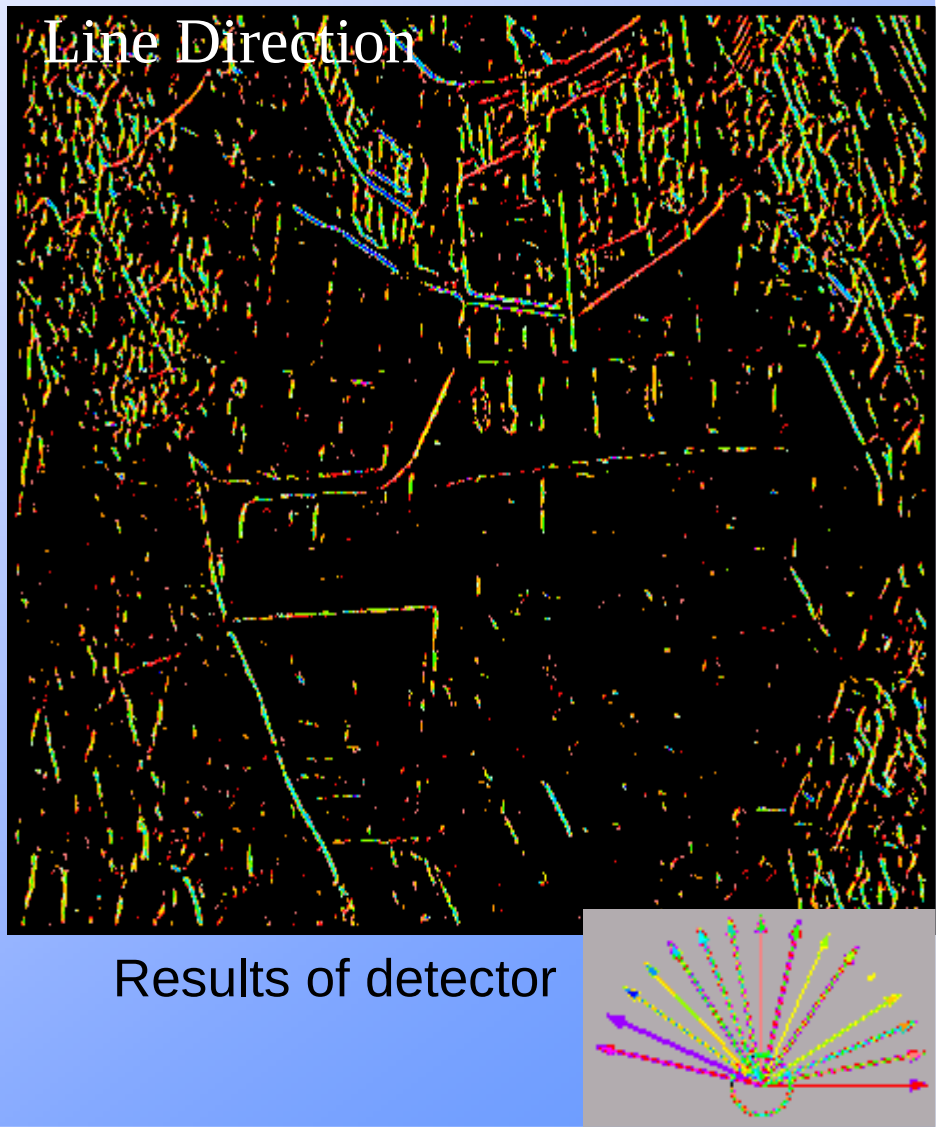
Using ORIGINAL image

Using DENOISED image

Line detection after Speckle Reduction



Speckle Reduced SAR image
(L-band, full-polarimetric)

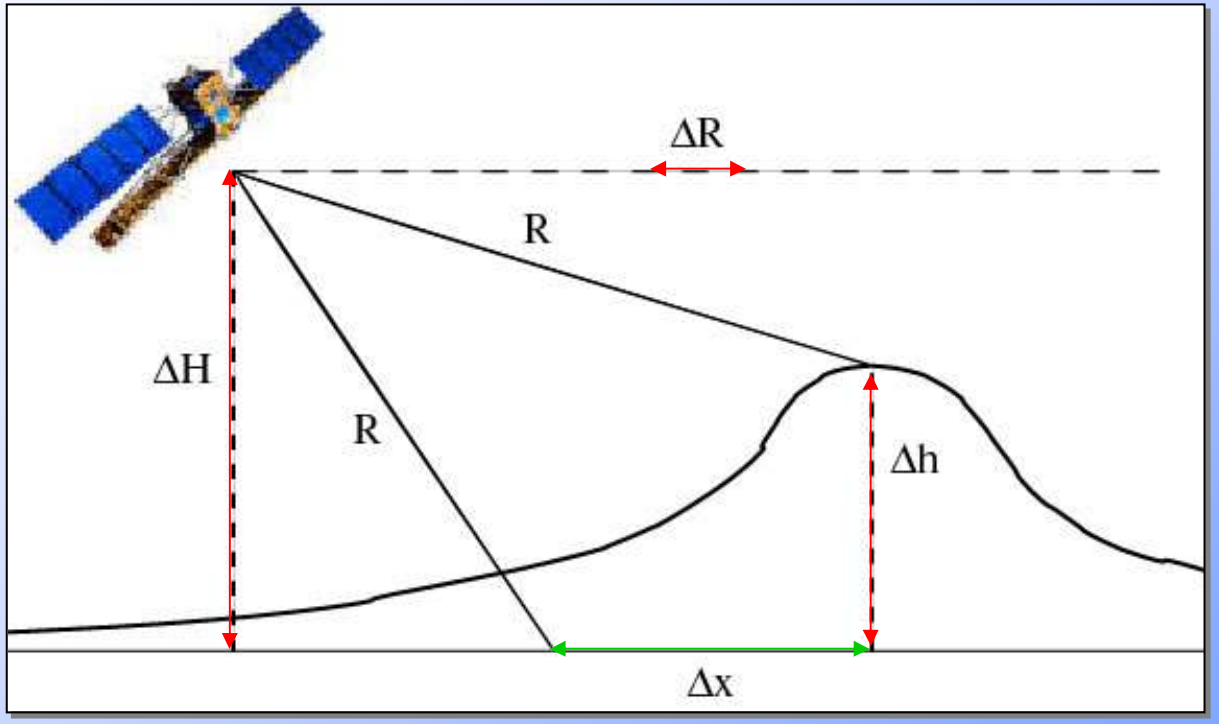


Results of detector

WP3.3: Image Registration (RUG)

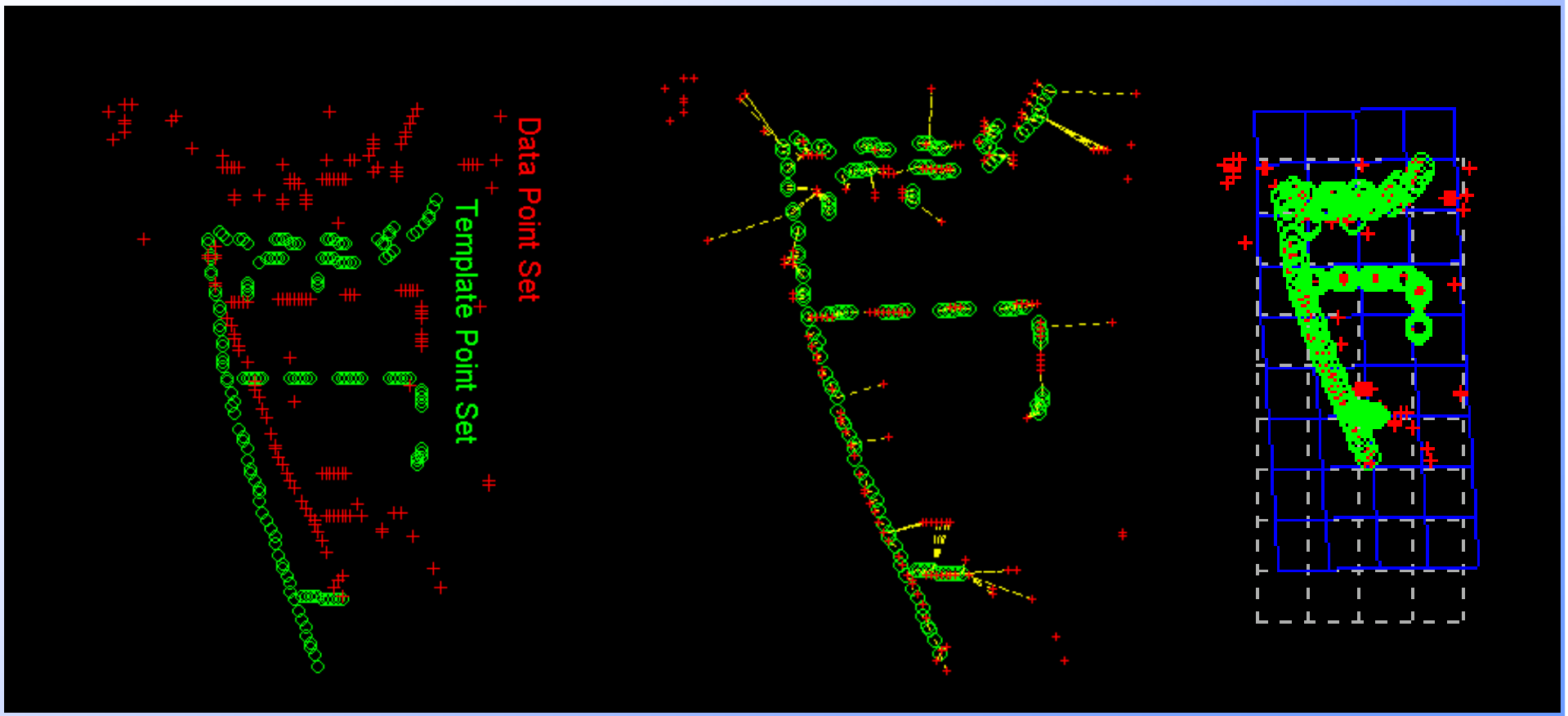
- **Error analysis** on SAR geometry
- **Object based registration** of multisensor images
  - Comparing image with vector information
  - Compensation of allowable distortions due to e.g. terrain
  - Detection of distortions due to changes
- **Spline based registration** - models affine transformations and compensates distortions

Error analysis on SAR geometry



Per-pixel estimation of positional accuracy
due to SAR geometry and spatial transformation

Spline-based registration



SAR Image Processing Tools: status