

Agricultural parcels measurement on VHR SAR images

GeoCAP Action

Outline of presentation

Introduction

Methodology of the area measurement on SAR images: features recognition and delineation

Results achieved on TerraSAR-X and CosmoSkyMed images

Conclusions, recommendations

Introduction

Objective of the study

- to identify agricultural parcels
- to assess the measurement accuracy on VHR SAR images

Why we need to assess the area measurement accuracy?

- VHR SAR data as a new source of info
- CwRS uses 1.5m x GSD (pixel size)
- To find the tolerance

How to determine the tolerance?

- def.: acceptable discrepancy between 2 independent area measurements
- **reproducibility limits** the ability of a measurement to be accurately reproduced by someone else working independently

Determination of the tolerance

Tolerance = Reproducibility limit

Reproducibility limit R (ISO 5725*): the value less than or equal to which the absolute difference between two test results obtained under reproducibility conditions may be expected to be with a probability of x% (here 95%).

$$R = f * \sigma_R * \sqrt{n}$$

For normal distribution at 95% probability level, f is 1.96 and $f*\sqrt{2}$ then is 2.8. The simple “rule of thumb” is applied

$$\Rightarrow R = 2.8 * \sigma_R$$

σ_R (or s_R) is the standard deviation under reproducibility conditions: same method, different operators and conditions

*ISO 5725 (1994) “Accuracy (trueness and precision) of measurement methods and results”

7.4.5.1 The repeatability variance is

$$s_{rj}^2 = \frac{\sum_{i=1}^p (n_{ij} - 1) s_{ij}^2}{\sum_{i=1}^p (n_{ij} - 1)} \quad \dots (20)$$

7.4.5.2 The between-laboratory variance is

$$s_{Lj}^2 = \frac{s_{dj}^2 - s_{rj}^2}{\bar{n}_j} \quad \dots (21)$$

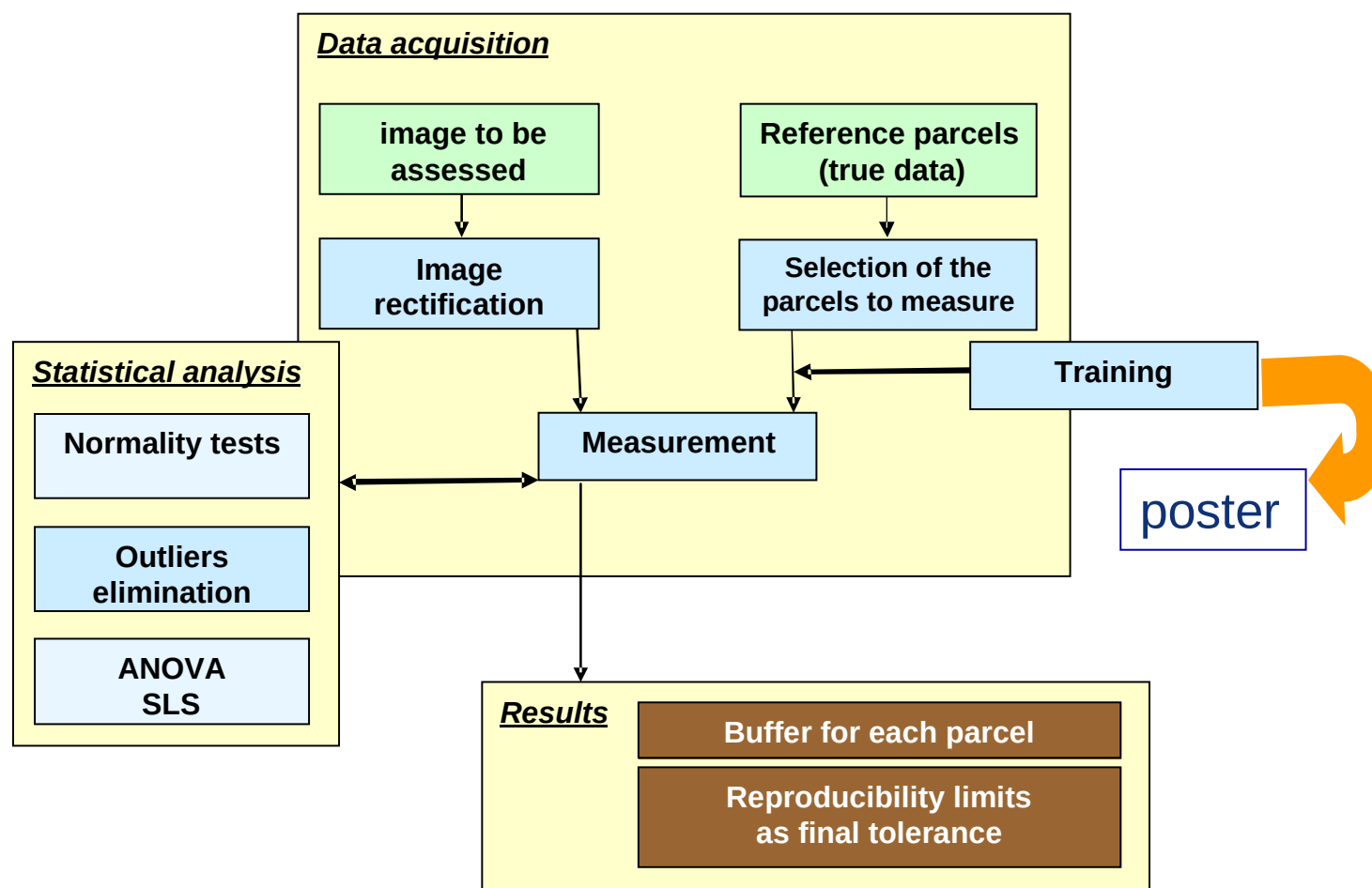
where

$$\begin{aligned} s_{dj}^2 &= \frac{1}{p-1} \sum_{i=1}^p n_{ij} (\bar{y}_{ij} - \bar{\bar{y}}_j)^2 \\ &= \frac{1}{p-1} \left[\sum_{i=1}^p n_{ij} (\bar{y}_{ij})^2 - (\bar{\bar{y}}_j)^2 \sum_{i=1}^p n_{ij} \right] \quad \dots (22) \end{aligned}$$

and

$$\bar{n}_j = \frac{1}{p-1} \left[\sum_{i=1}^p n_{ij} - \frac{\sum_{i=1}^p n_{ij}^2}{\sum_{i=1}^p n_{ij}} \right] \quad \dots (23)$$

Workflow of the accuracy assessment of parcel area measurement



Examination of the images

VHR X band SAR programmed data over agricultural test sites
in south France

1 site was covered with SpotLight mode data (4 TerraSAR, 2 Cosmo)

42 parcels on site

1 site was covered with StripMap colour comp (1 image of TerraSAR)

79 parcels on site

Reference areas & perimeters: derived from orthophoto
(ADS40, 0.5m GSD) acquired in May 2003

Independent operators, 3 repetitions, orthophoto as auxiliary material

TerraSAR-X

Mode	No	Image file	Incidence angle	Orbit direction	Date Time	Polarization	Approx. GSD	Cell size
SpotLight	1	VV_HSL_1405	34.46	descending	2008-05-14 05:53	VV single	1x1m	1x1m
	2	VV_HSL_2105	52.49	ascending	2008-05-21 17:41	VV single	1x1m	1x1m
	3	HH_SL_0604	47.16	descending	2008-04-06 05:44	HH dual	2x2m	1x1m
	4	cc_SL_0604	47.16	descending	2008-04-06 05:44	Dual: HH, VV, HH-VV	2x2m	1x1m
StripMap	5	cc_SM_1103	42.42	ascending	2008-03-11 17:33	Dual: HH, VV, HH-VV	6x6m	3x3m

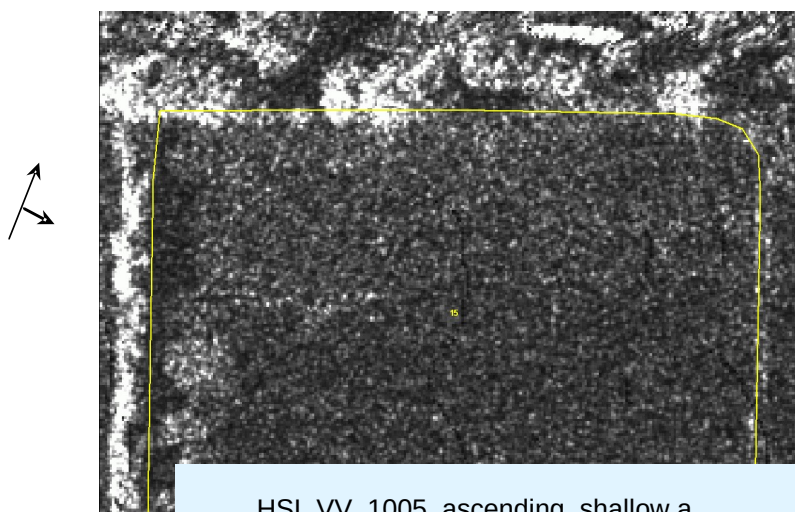
CosmoSkyMed

SpotLight	6	CSK_1207	40.83	descending	2008-07-12 17:56	HH single	1x1m	1x1m
	7	CSK_1407	55.40	ascending	2008-07-14 05:58	HH single	1x1m	1x1m

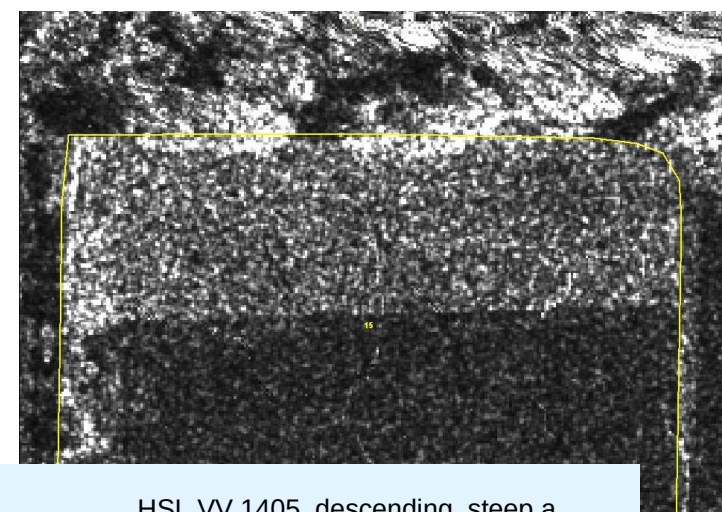
All TerraSAR-X data were processed and provided by Infoterra GmbH and CosmoSkyMed data by Agenzia Spaziale Italiana

Area measurement methodology

- Photointerpretation key for the most common features
- Self-training course
- Measurement instruction
 - First measurement on orthophoto (parcels memorized by operator)
 - ortho as auxiliary materials for SAR interpretation

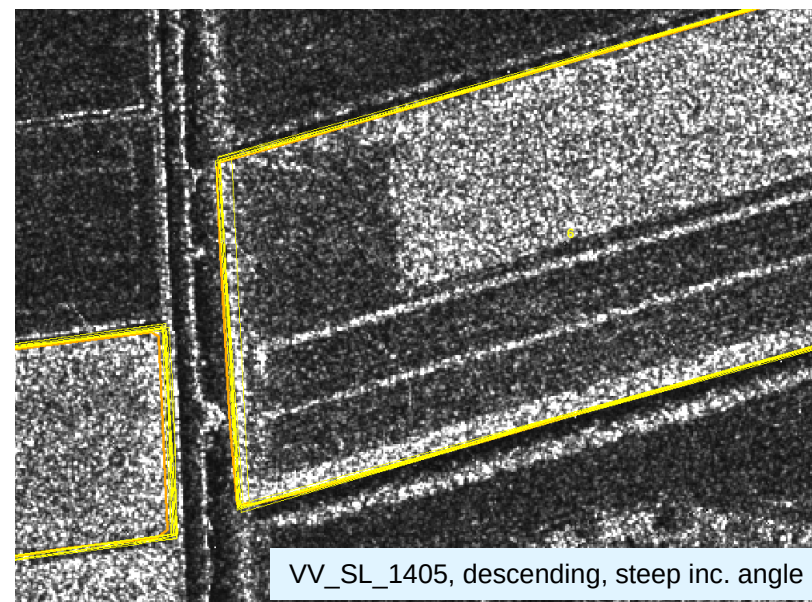
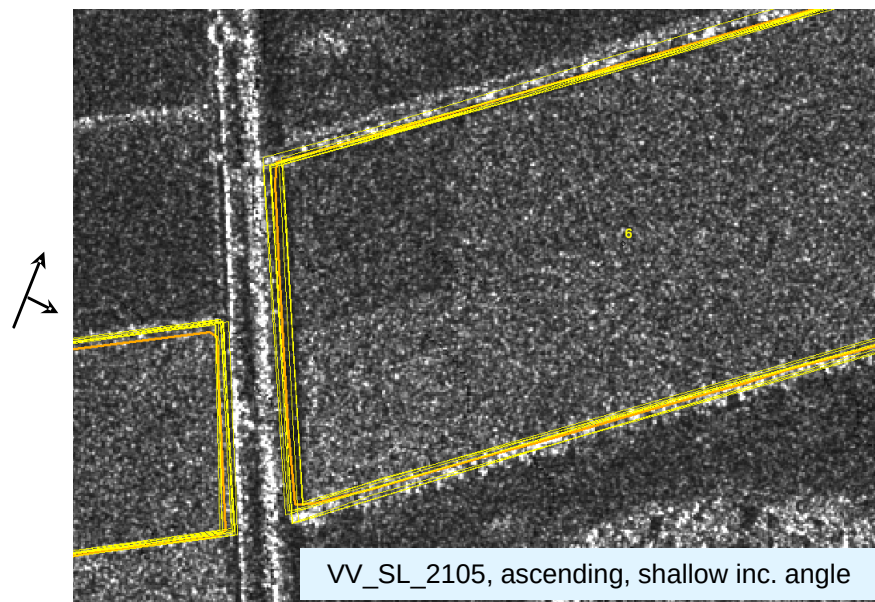
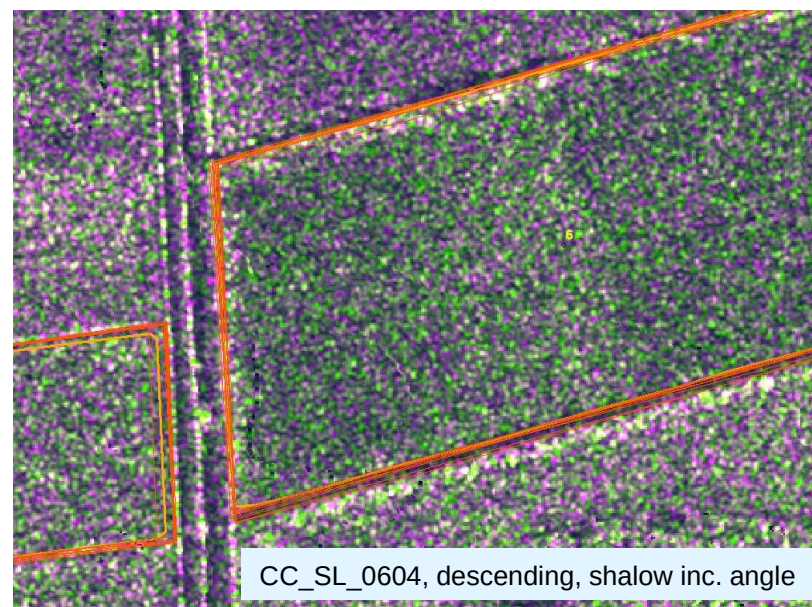


HSL VV_1005, ascending, shallow a.

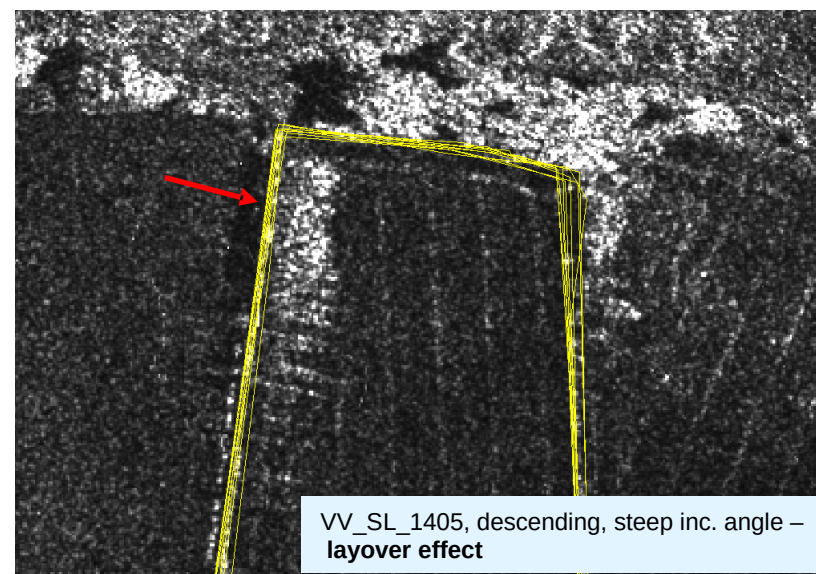
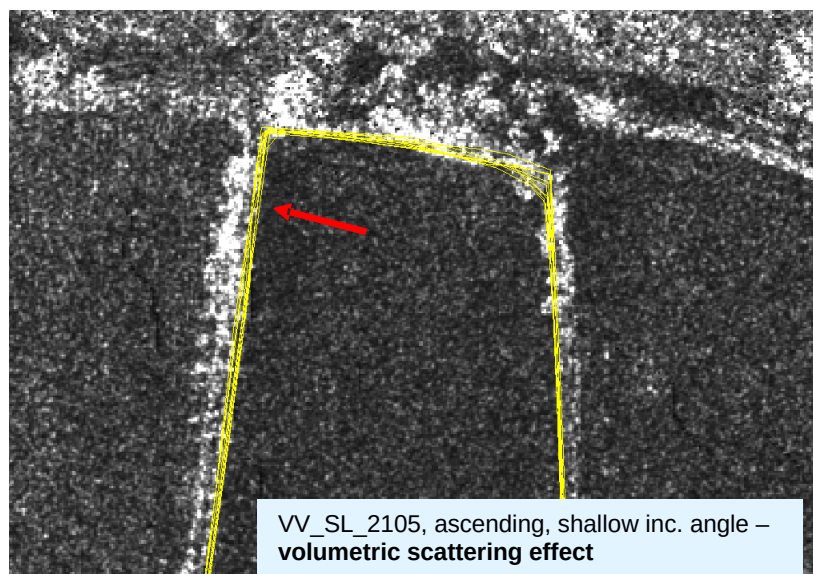
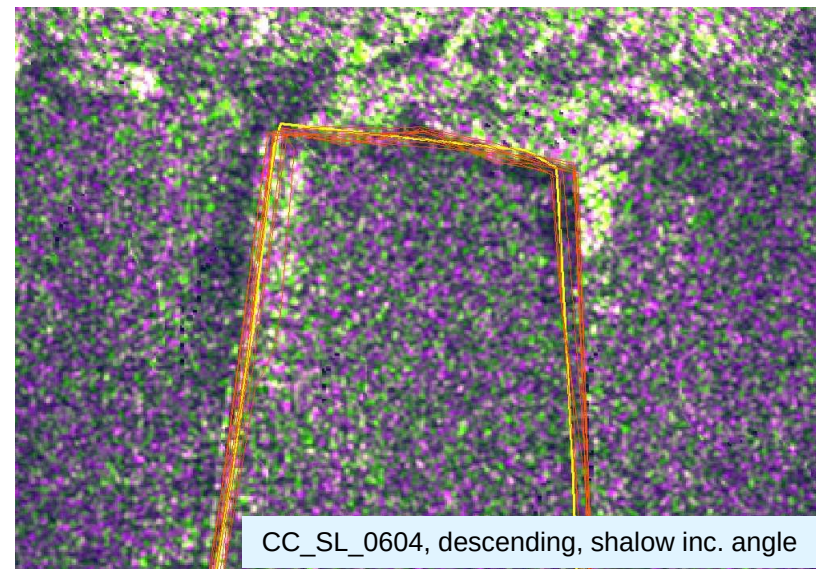


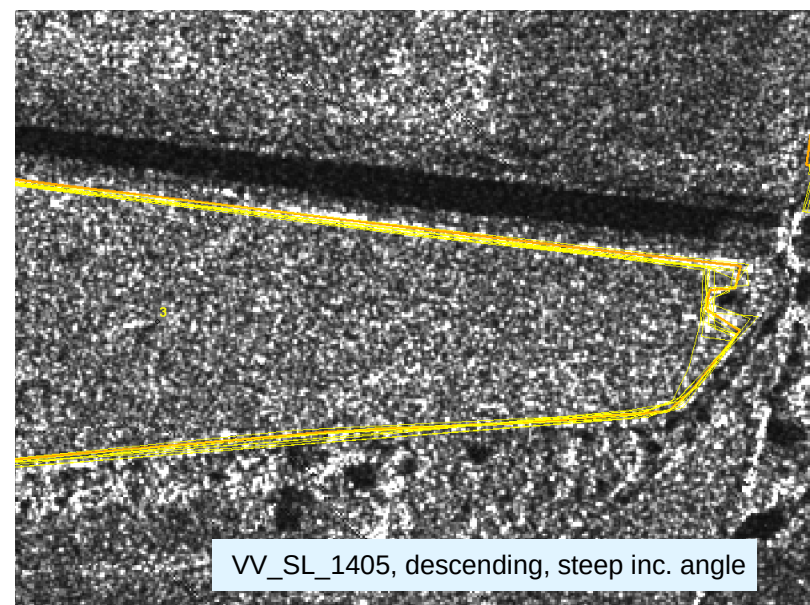
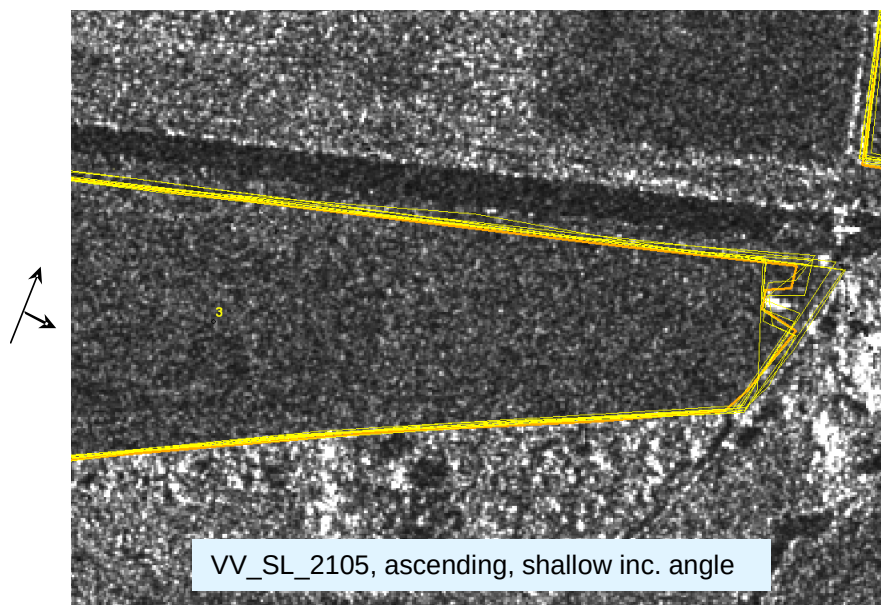
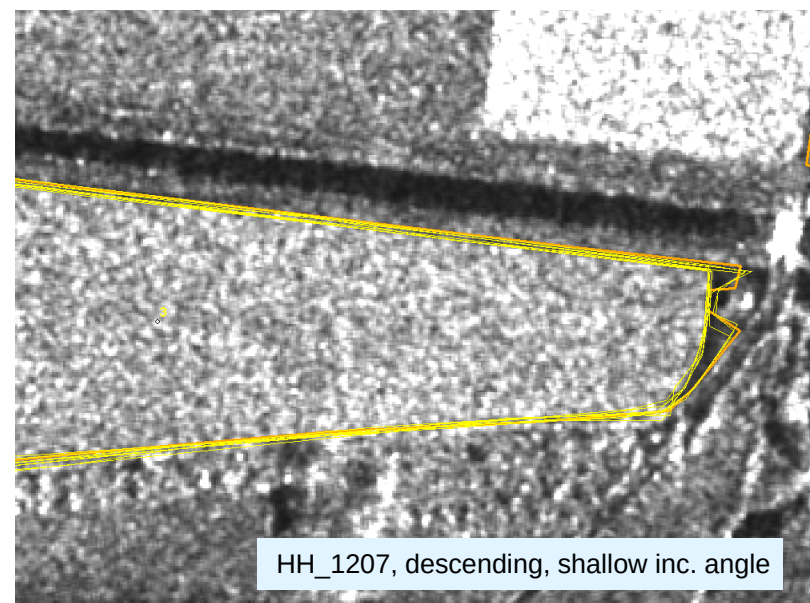
HSL VV 1405, descending, steep a.

Green cover

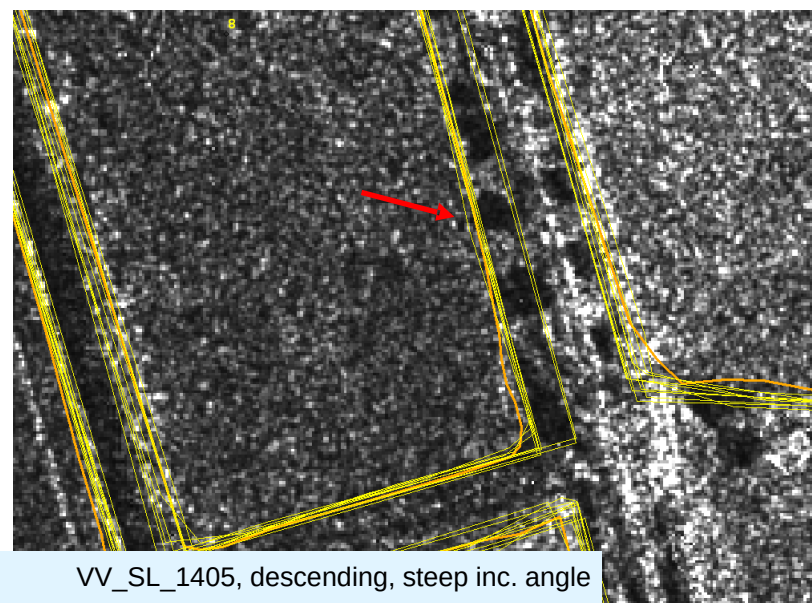
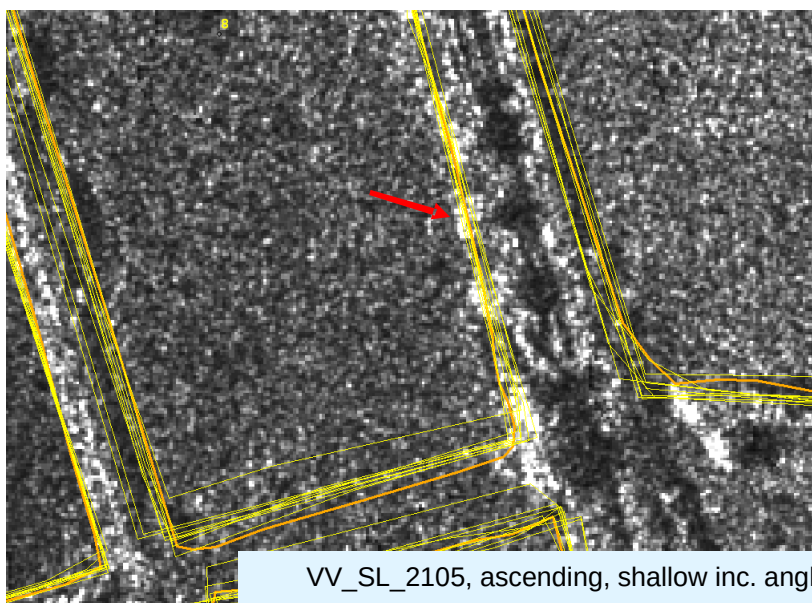
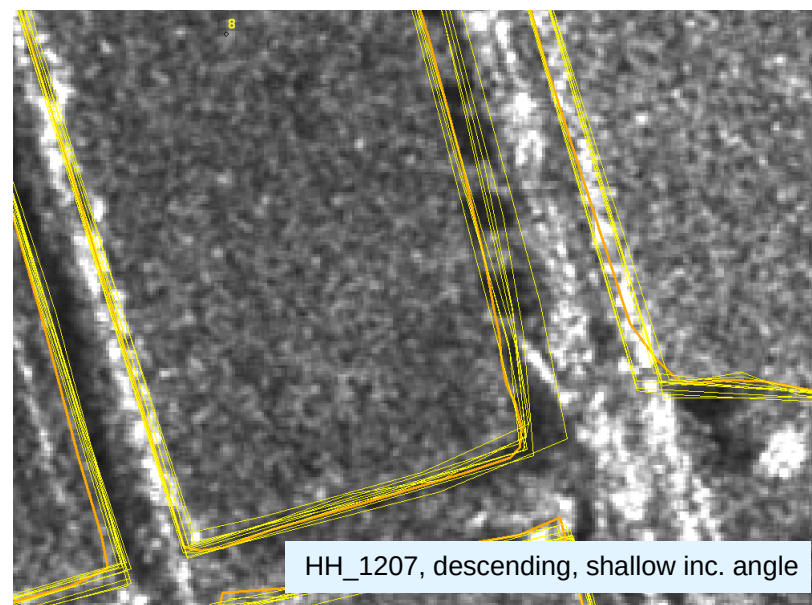


Row trees on the border

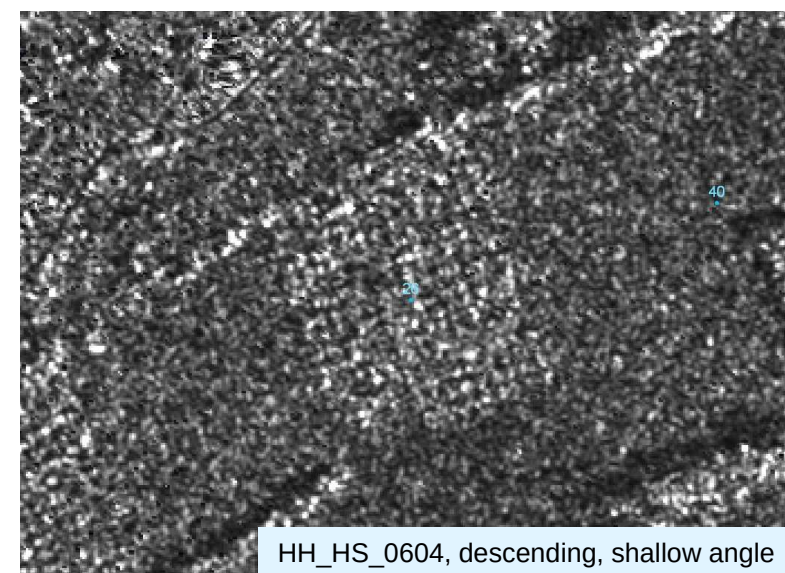
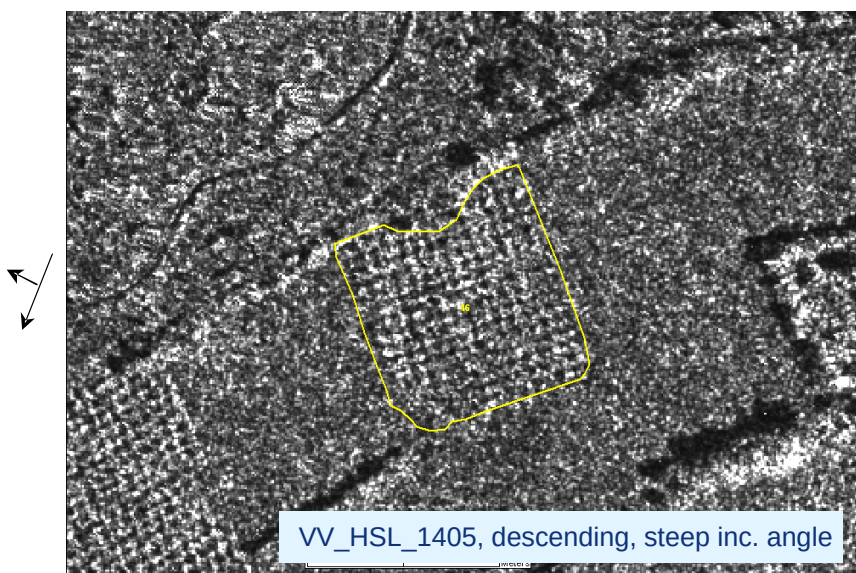
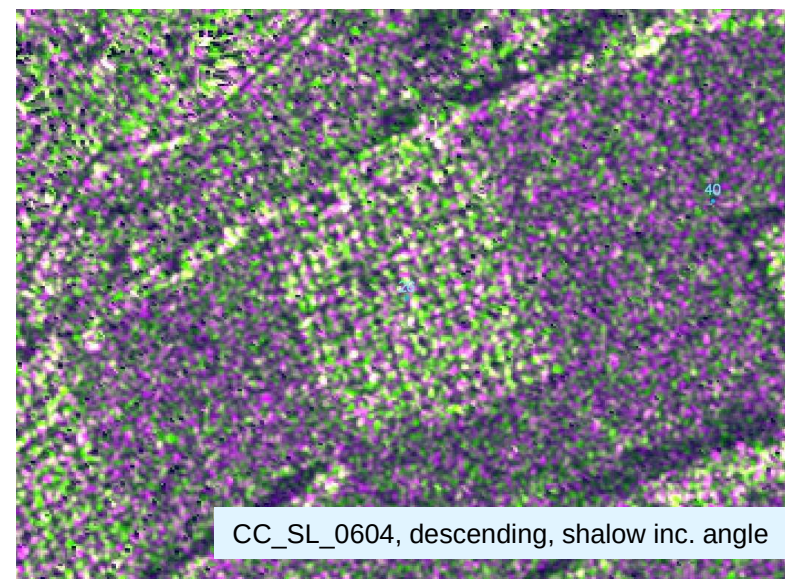
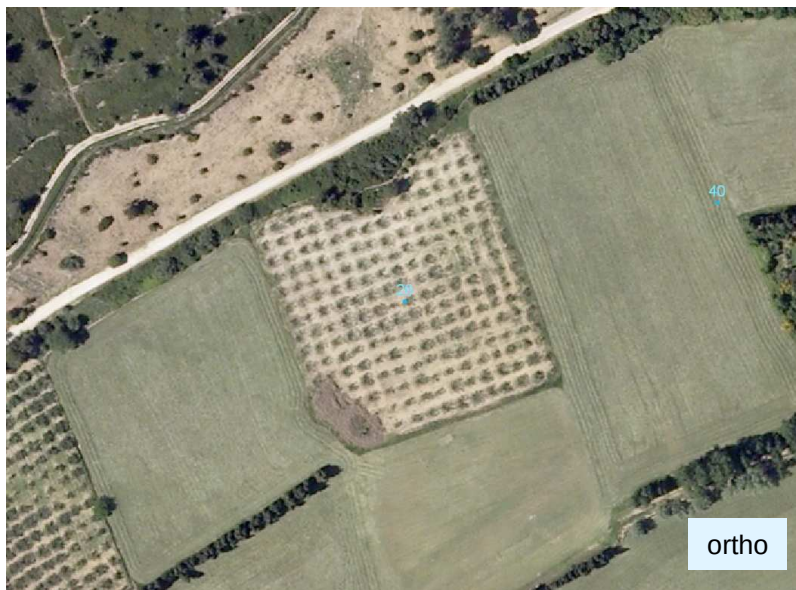




Trees, paths



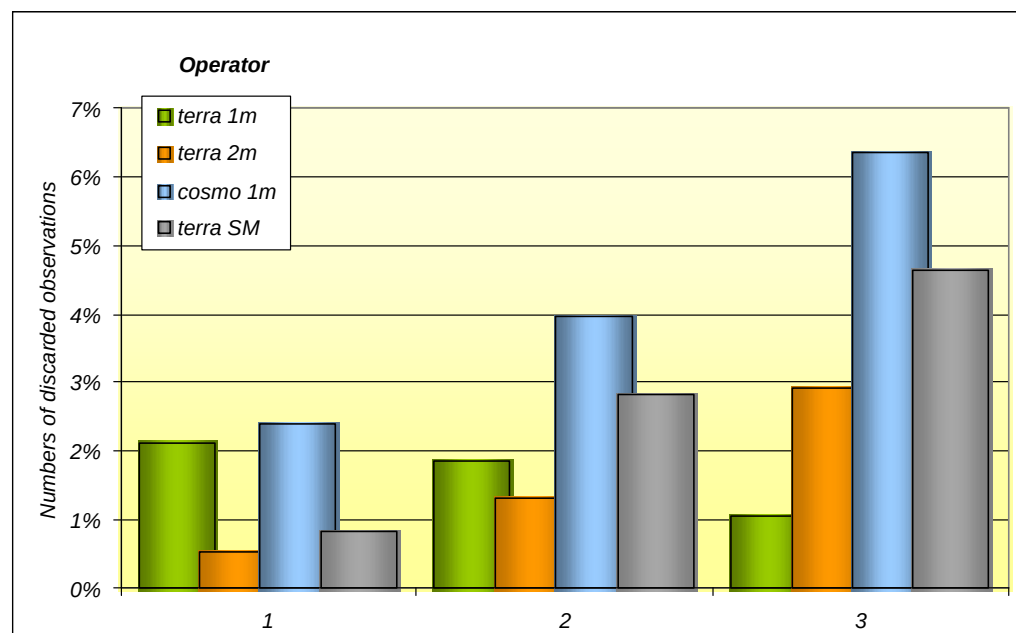
Olive trees



Outliers detection

- Grubbs, Cochran tests
- more outliers on StripMap image, less on color SL
- the outliers distribution according to operators, shape and size of parcels

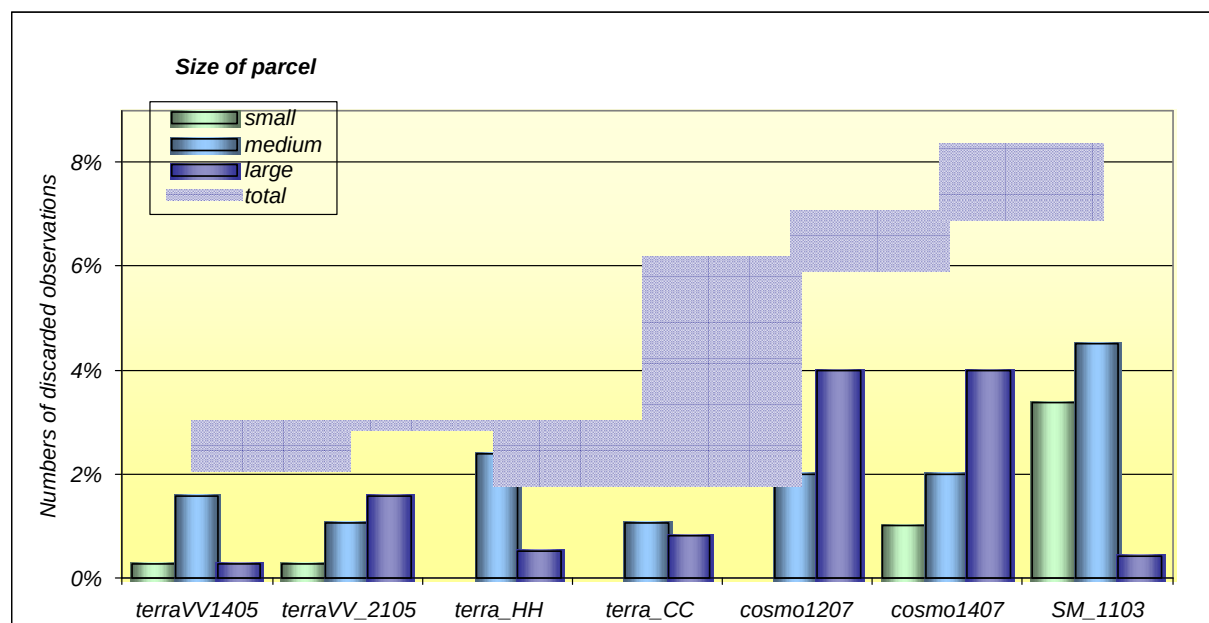
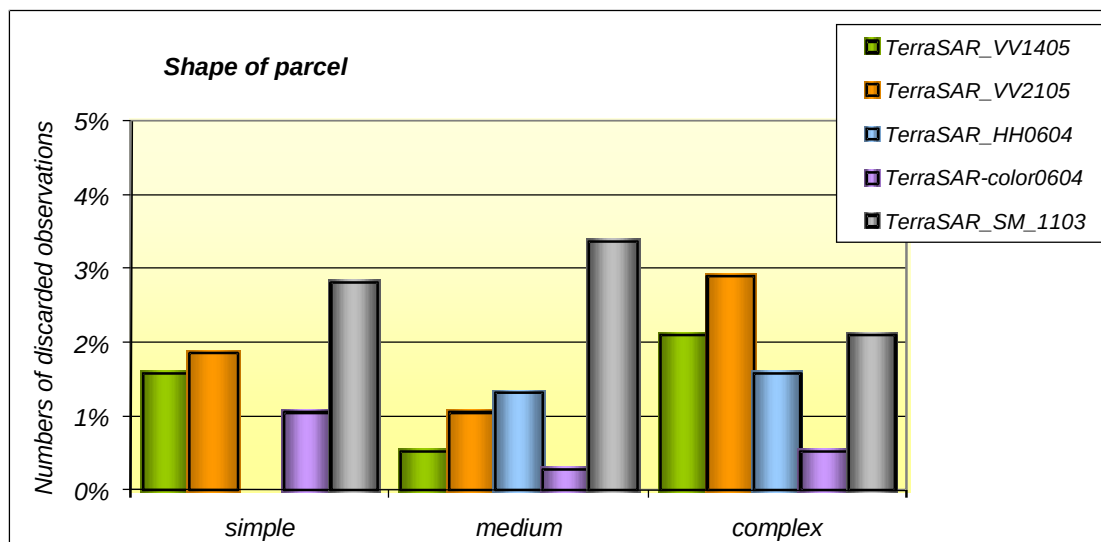
image	No of outliers	%
Terra_VV1405	8 (378)	2%
Terra_VV2105	11 (378)	3%
Terra_HH0604	11 (378)	3%
Terra_CC0604	7 (378)	2%
Cosmo1207	21 (378)	6%
Cosmo1407	27 (378)	7%
SM_CC1103	59 (711)	8%
total	144 (2979)	5%



- more outliers for complex-shape parcels

- more outliers on StripMap image for small and medium parcels and less for large

- no outliers on HH0604 for regular and small parcels

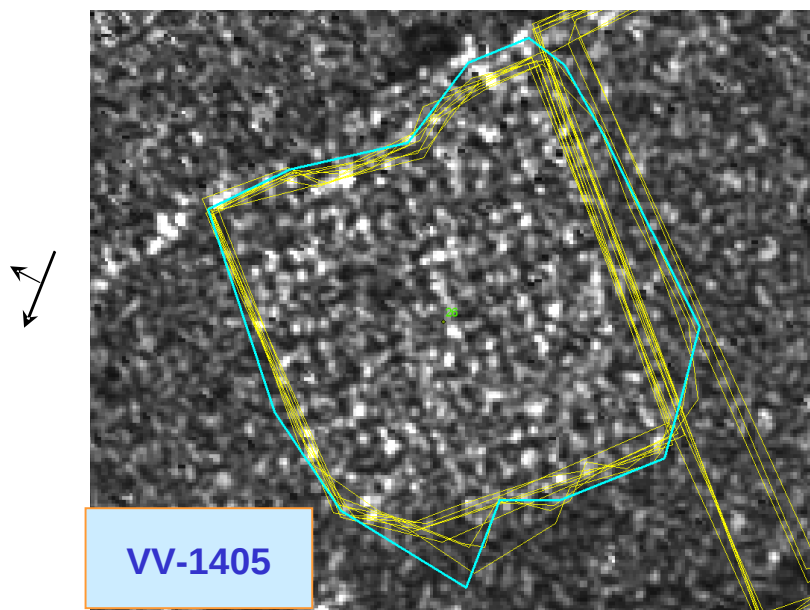


Outliers – examples

- Mistake of features interpretation
- Boundary not clear

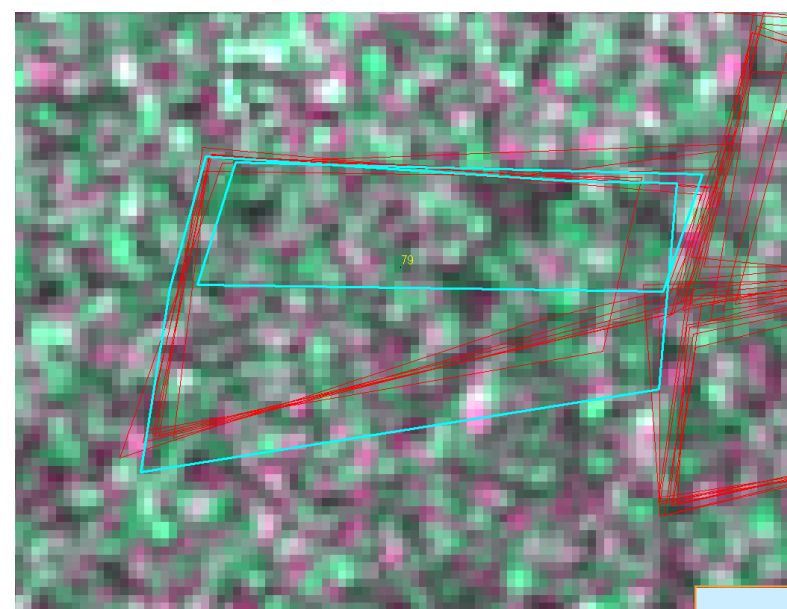


VV-2105

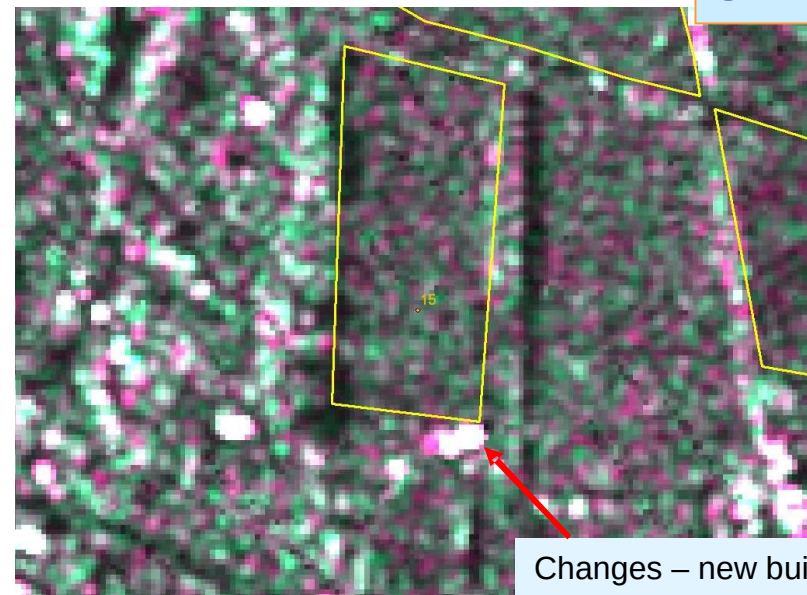


VV-1405





STRIP MAP



Changes – new buildings

Analysis of variance

Main factors effected buffer variation

1. incidence angle

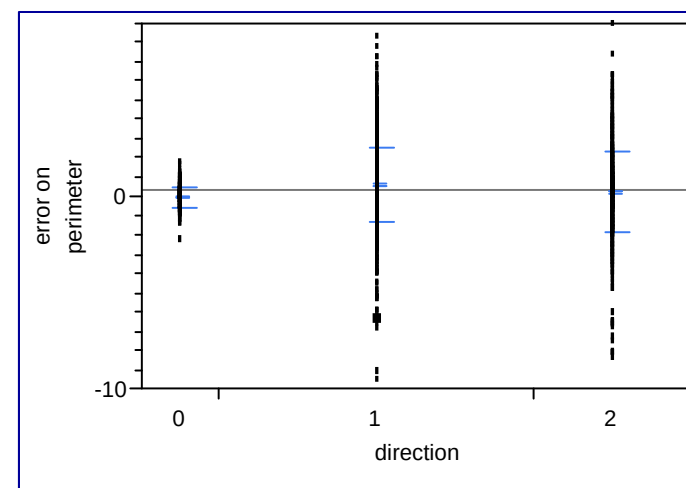
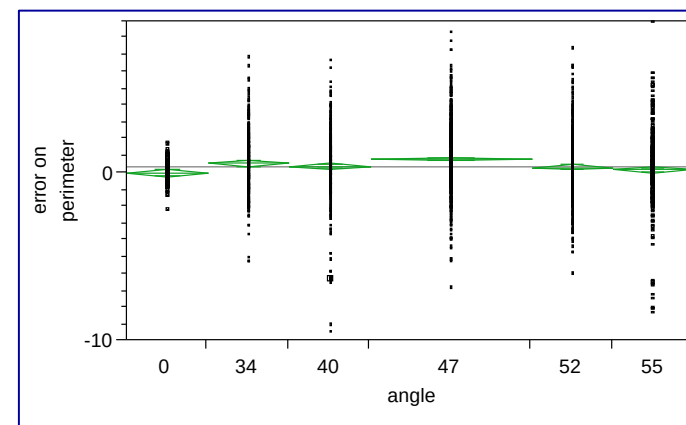
- shallow angle (47-55deg) results with overestimation
- steep angle (20-40deg) results with underestimation

2. orbit direction

- descending orbit results with overestimation
- ascending orbit results with higher variation

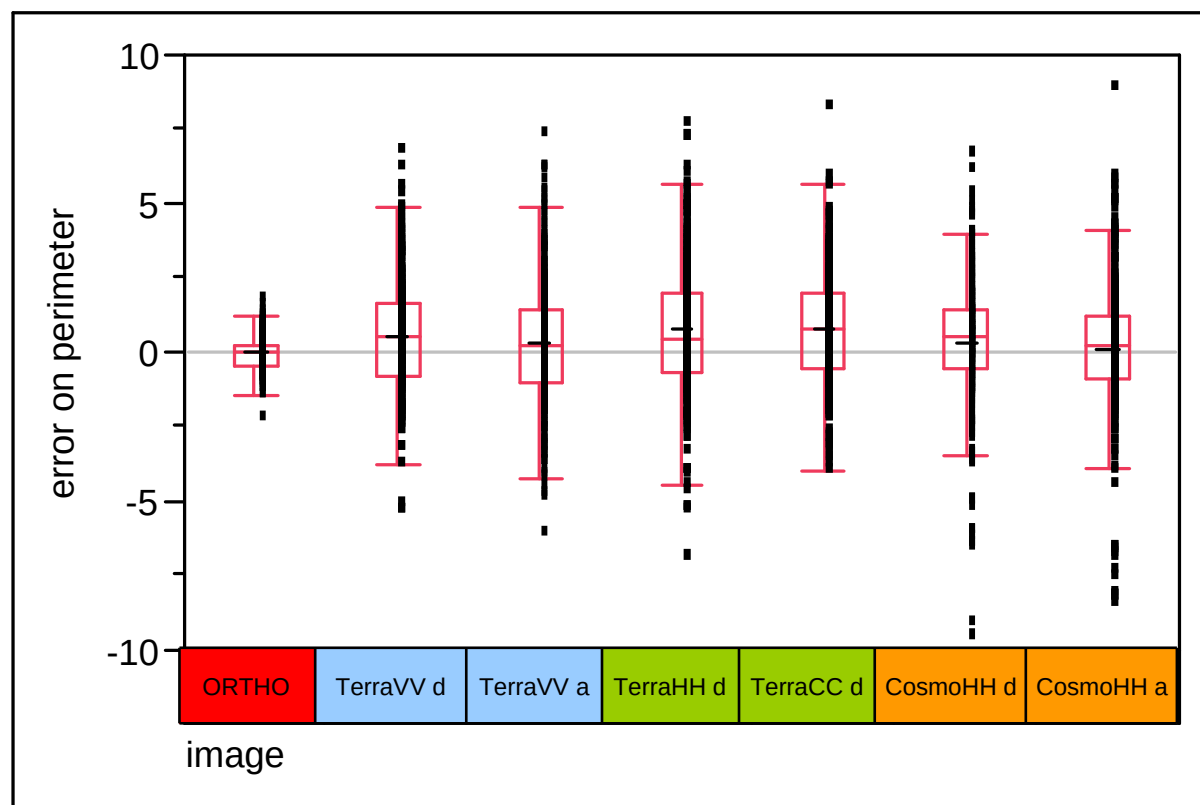
3. polarization

- VV results with higher variation
- Colour comp results with overestimation
- the same level of overestimation for both VV and HH



Buffer variation

image	GSD [m]	Bias [m]
ortho	0.5	-0.05
TerraVV_d	1.0	0.5
TerraVV_a		0.3
Cosmo_HH_d		0.4
CosmoHH_a		0.1
TerraHH_d	2.0	0.7
TerraCC_d		0.8

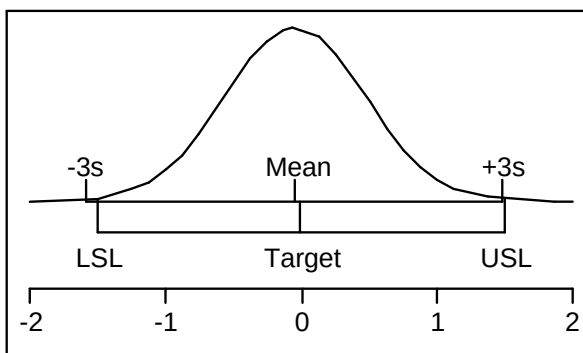


Further buffer analysis

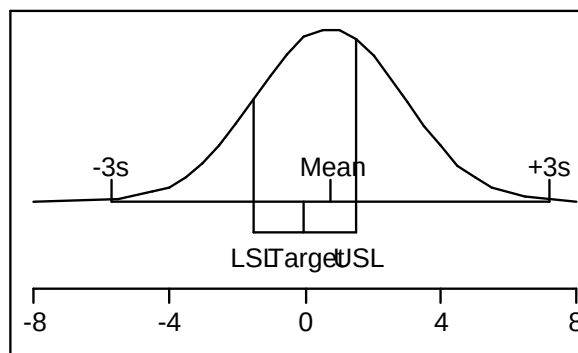
For specified limits 1.5m:

Total outside observations between 42% to 51% for SAR
while for ortho 0.4%

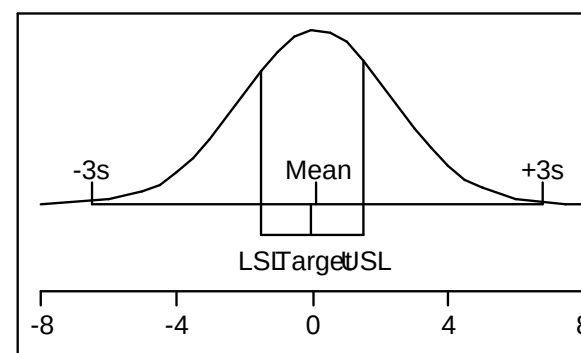
Capability: Ortho

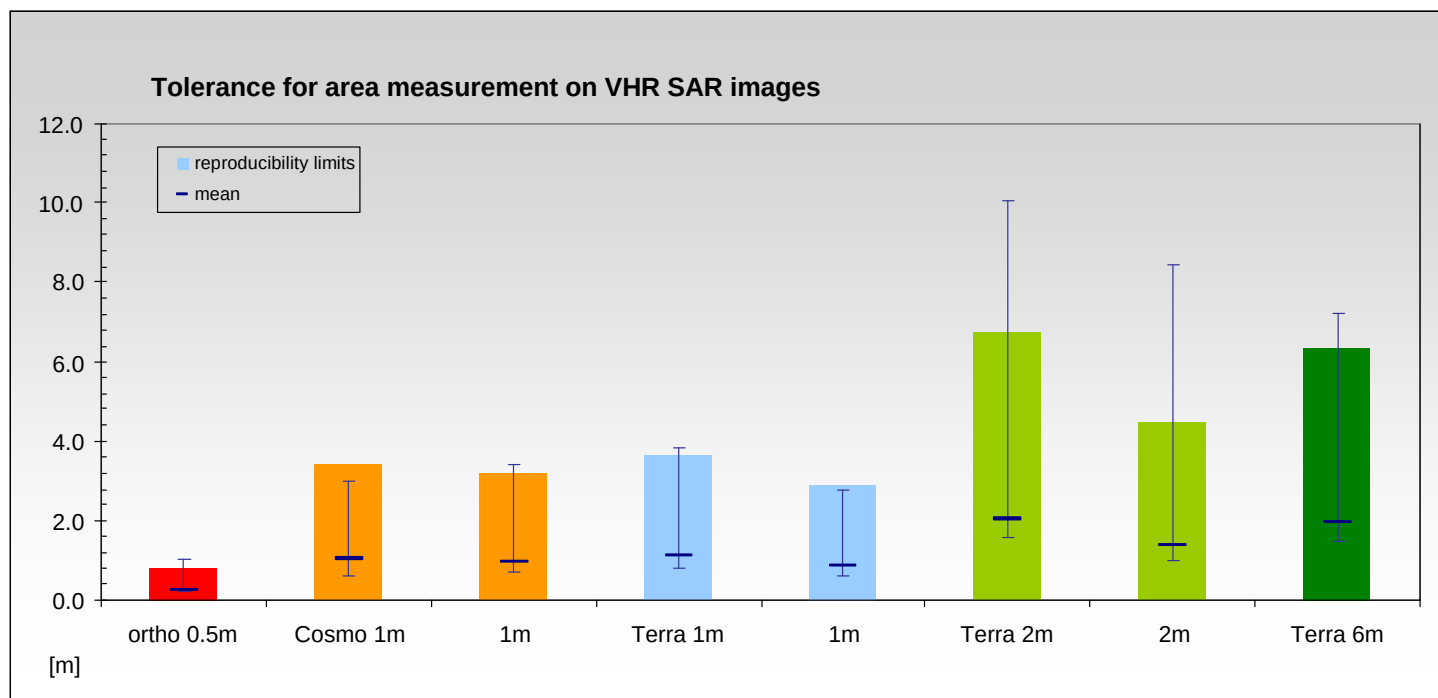


TerraSAR [2m]



CosmoSkyMed [1m]





buffer	ORTHO 05.2003	Single polarization				Dual polarization		Terra SM CC1103
		Cosmo HH1407	Cosmo HH1207	Terra HSL VV1405	Terra HSL VV2105	TerraSL HH0604	TerraSL CC0604	
Nb observ	360	345	357	370	367	365	371	652
Reproducibility limits [m]	0.81	3.41	3.19	3.66	2.89	6.71	4.50	6.35
Maximum buffer [m]	0.93	2.27	2.83	3.17	2.21	9.34	8.25	4.55
Min buffer [m]	0.04	0.48	0.31	0.40	0.28	0.55	0.45	0.54

Conclusions from study on SAR images

100% of the parcels are mutually recognised on both orthophoto and VHR SAR data

144 outliers out of almost 3000 observations (5%)

The same tolerance for both sensors: TerraSAR-X and CosmoSkyMed

Estimated tolerances: ~3m on 1m HSL, ~6,7m on 2m SL
are higher than the maximum 1.5m requested by the actual EU regulation

Compensative effect of multipolarized information on lower resolution:
~4,5m on colour SL (2m) and ~6,4m on colour SM (6m) image

Significant effects on buffer variability: incidence angle and orbit direction, no effect of polarization

Discussion and recommendations

Photointerpretation on VHR SAR more difficult than on optical images

- Advanced training on radar image nature
- Photointerpretation guidelines are necessary

Main problems not with parcels identification but with boundary delineation

- Difficulties with features recognition on the borders
- Features interpretation relating on image parameters

To achieve less variation and less overestimation, the images acquired under the shallow incidence angle and ascending direction are recommended

With regard to reproducibility limits the SAR tested images can be considered as secondary solution for CwRS in accordance with European CAP requirements