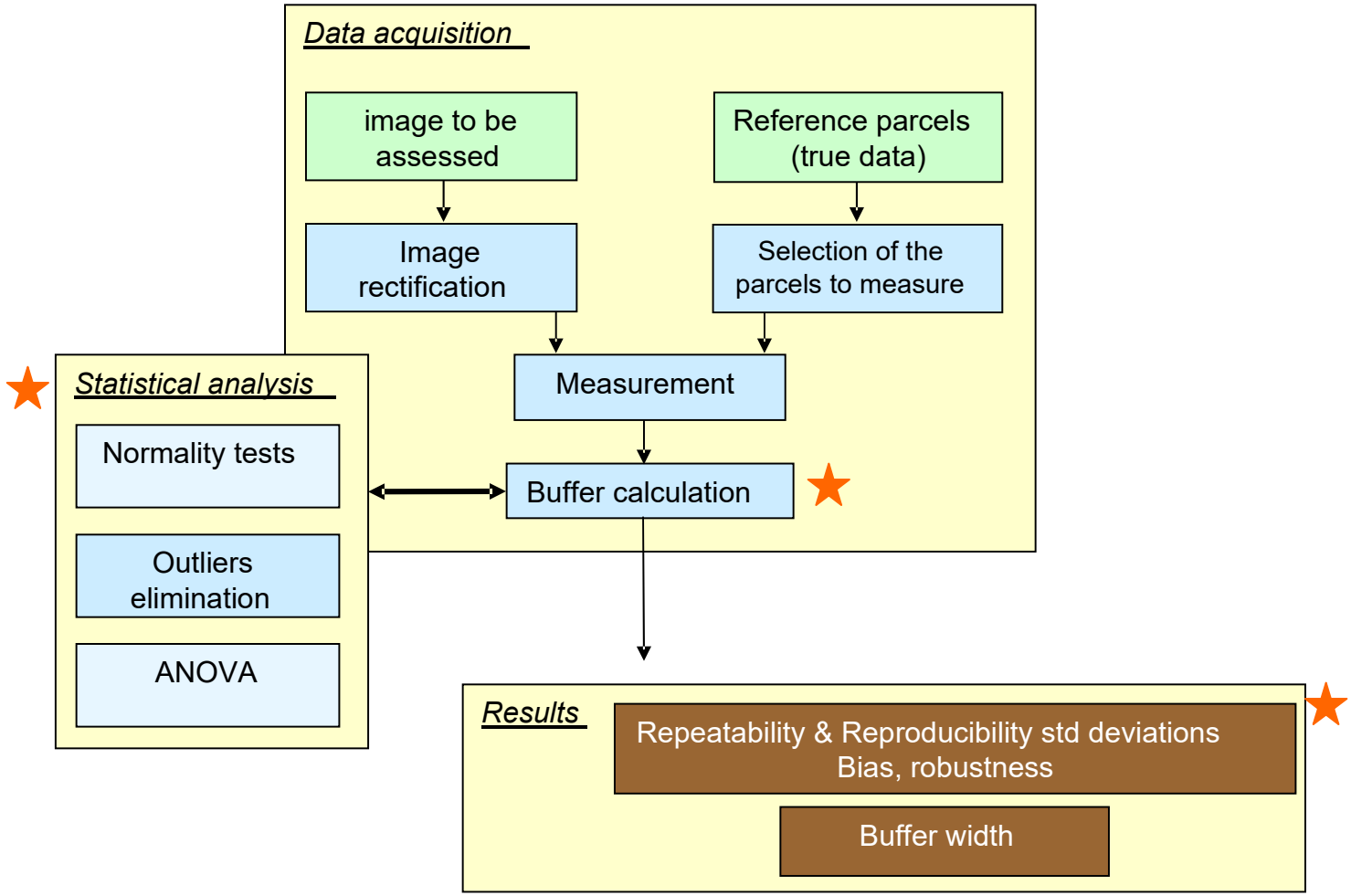
Assessment of the area measurement on satellite images

Methodology and Study cases

Outline of presentation

- ¾ Methodology for determining the buffer width of a given sensor
- ¾ Example based on VHR SAR images
- ¾ Current/future tests: Cartosat-1, TerraSAR-X

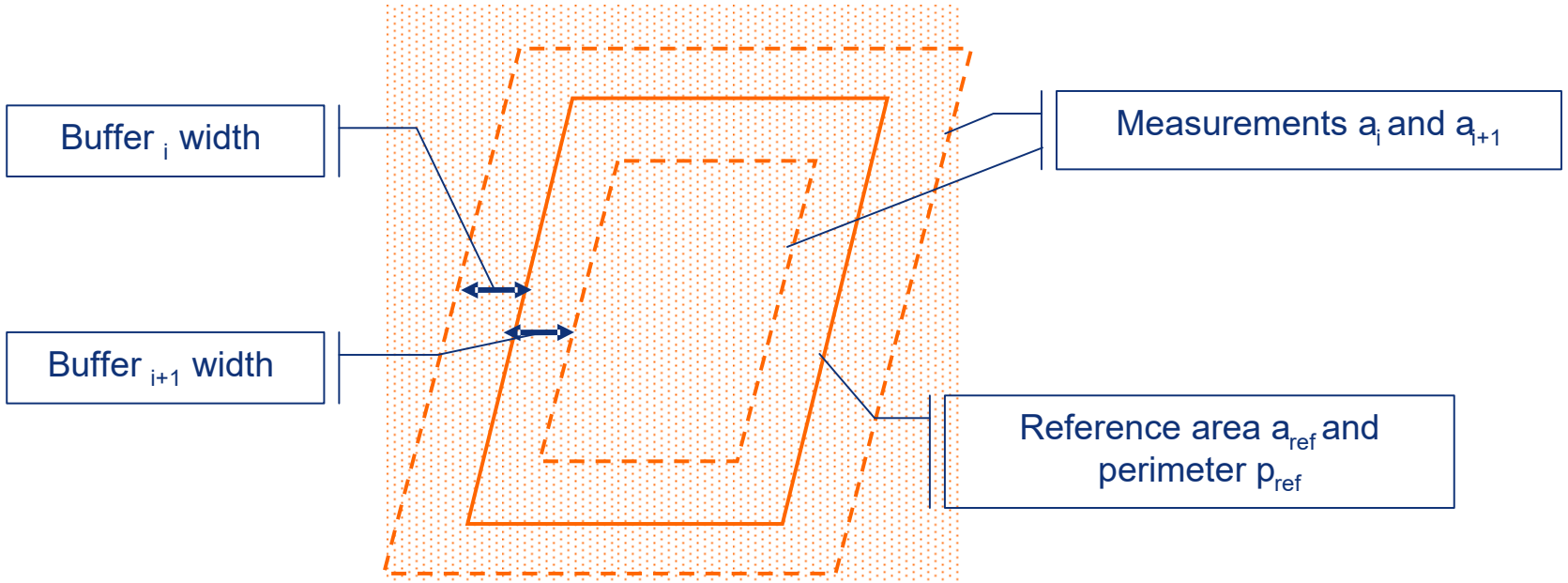
Workflow of the accuracy assessment of parcel area measurement



For a given parcel, the knowledge of its reference area and reference perimeter allow to translate the error on the area into a buffer width using:

$$B_i = \frac{(a_i - a_{ref})}{p_{ref}}$$

where:
B_i – buffer width for i measurement
a_i – measured area for i measurement
a_{ref} - reference area of the parcel
p_{ref} – reference perimeter of the parcel



Determination of buffer tolerance

Tolerance: acceptable discrepancy between 2 independent measurements

Tolerance = Reproducibility limit

Reproducibility limit R (ISO 5725, 1994): the value less than or equal to which the absolute difference between two test results obtained under reproducibility conditions: (same method, different operators and conditions) may be expected to be with a probability of x% (here 95%).

$$R = \sqrt{2}\, x1.96\, x\, s_{Rj} = 2.8\, x\, s_{Rj}$$

Where s_{Rj} is the standard deviation under reproducibility conditions

Critical difference – comparison with reference value for more than 1 operator

$$CD = \frac{1}{\sqrt{2p}} \sqrt{(2{,}8\sigma_R)^2 - (2{,}8\sigma_r)^2 \left(1 - \frac{1}{p} \sum \frac{1}{n_i}\right)}$$

p – no of operators
n – no of observations

Statistical analysis

¾ **Statistical determination of sample size**
assuming infinite population size, 95% of confident with 5% of accuracy and based on results from previous study (stdev) – around 200 parcels

¾ **Normality tests:** Shapiro-Wilk's, Anderson-Darling's tests, etc.

¾ **Outliers elimination:** Grubb's and Cochran's tests

¾ **Analysis of variance:** ANOVA

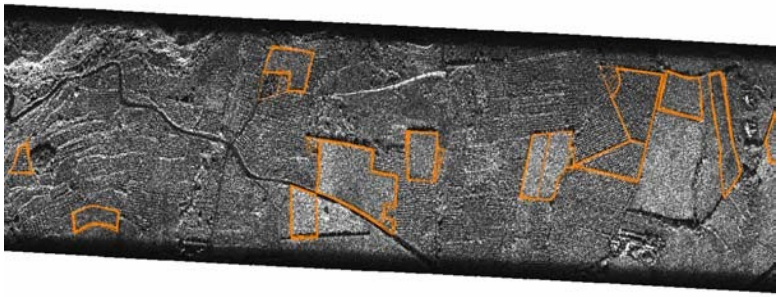
¾ **Calculation of reproducibility** according to ISO 5725 (1994)
"Accuracy (trueness and precision) of measurement methods and results"

Example of buffer width determination on simulated VHR SAR images

¾ Objective of study was identifying agricultural parcels and assessing the measurement accuracy on VHR SAR images

¾ Airborne VHR X band SAR data in the frame of the ORFEO programme were provided by CNES over 4 agricultural sites in France

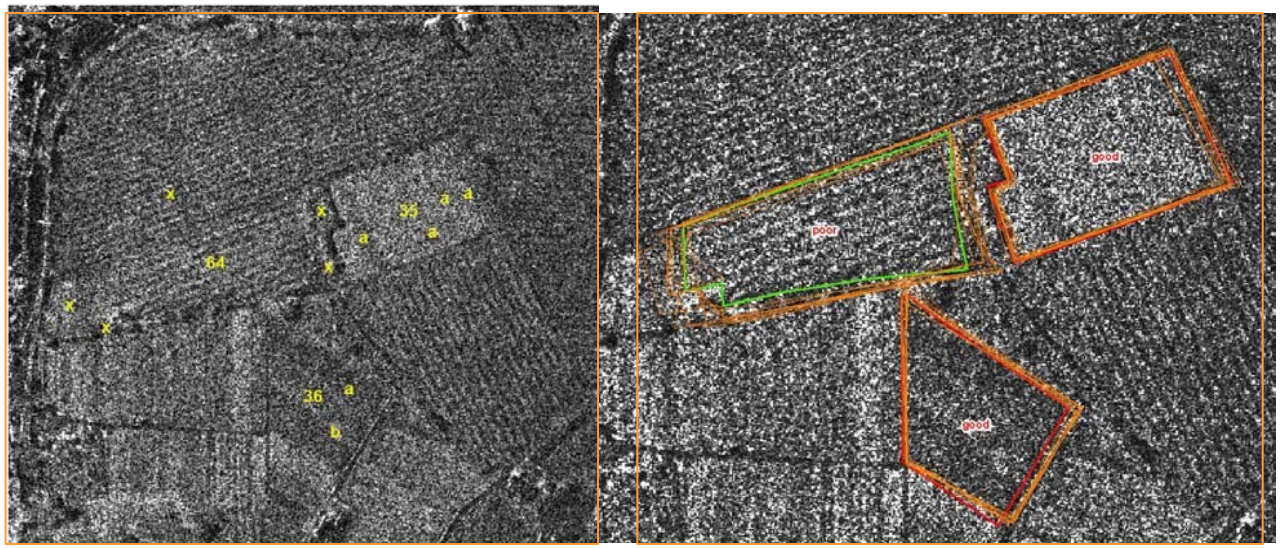
¾ 3 from 4 sites were covered with 1m B&W data (VV) from 2002-04,
one site was covered with 2m colour comp data (HH, VV, VH, HV) from 2002



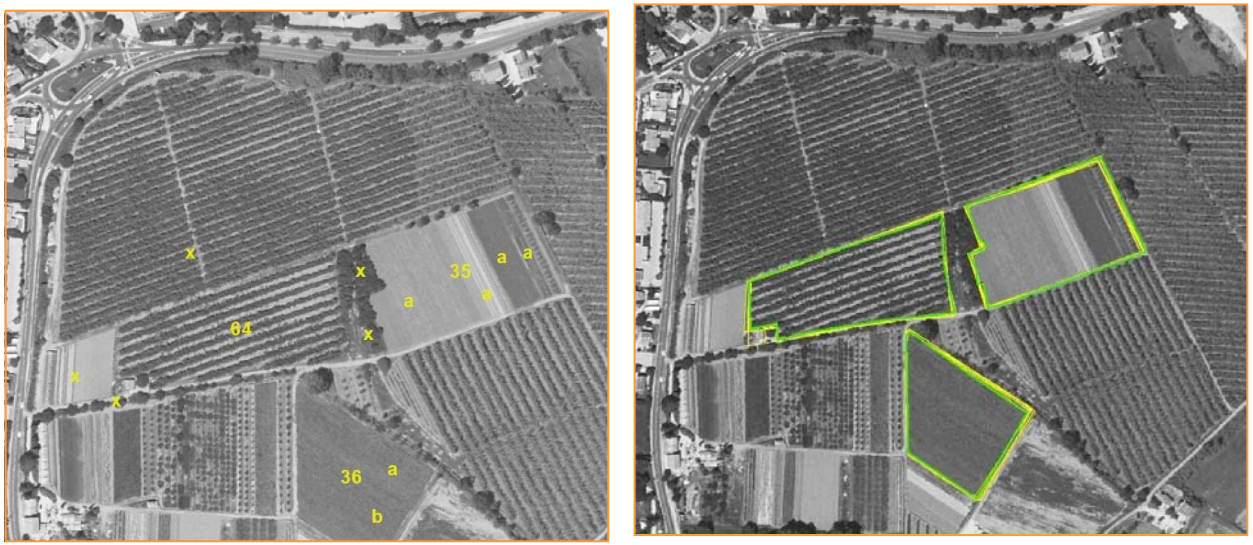
¾ Reference areas & perimeters: derived from orthophotos (1m B&W) acquired over 2001-2004; orthos also used as reference for the geometrical correction of the VHR SAR

¾ All parcels falling on the frame of the SAR images were measured on the orthophotos and on the VHR SAR data

Measurement

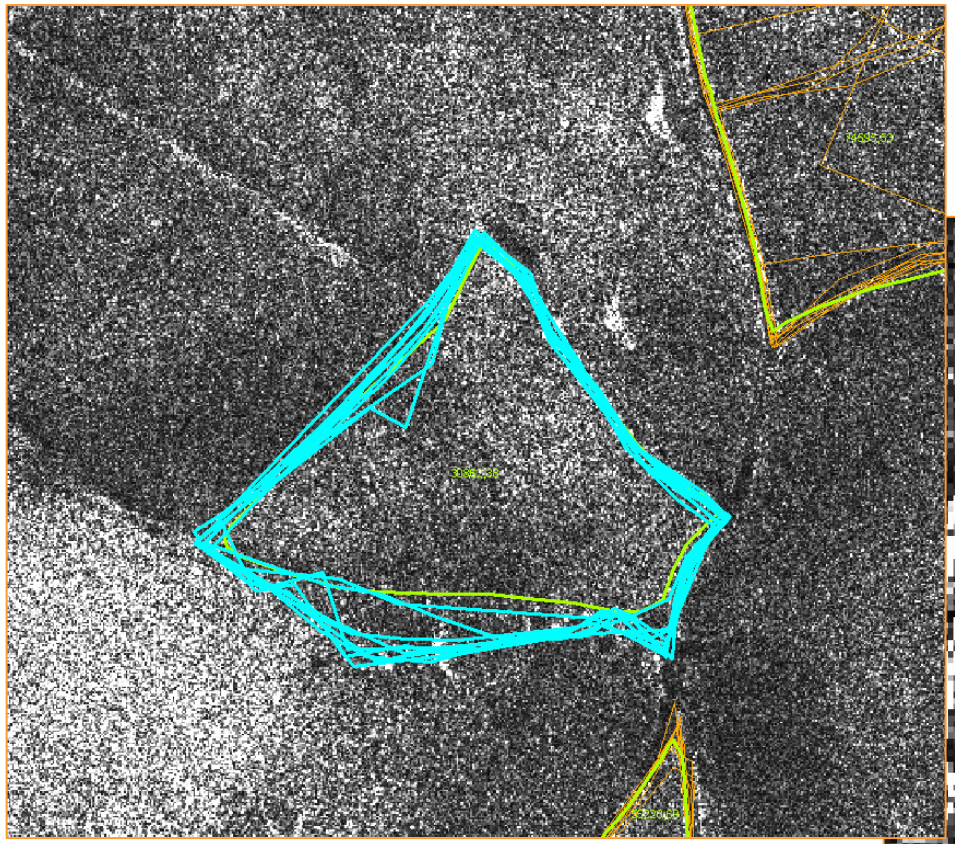


VHR SAR
1m

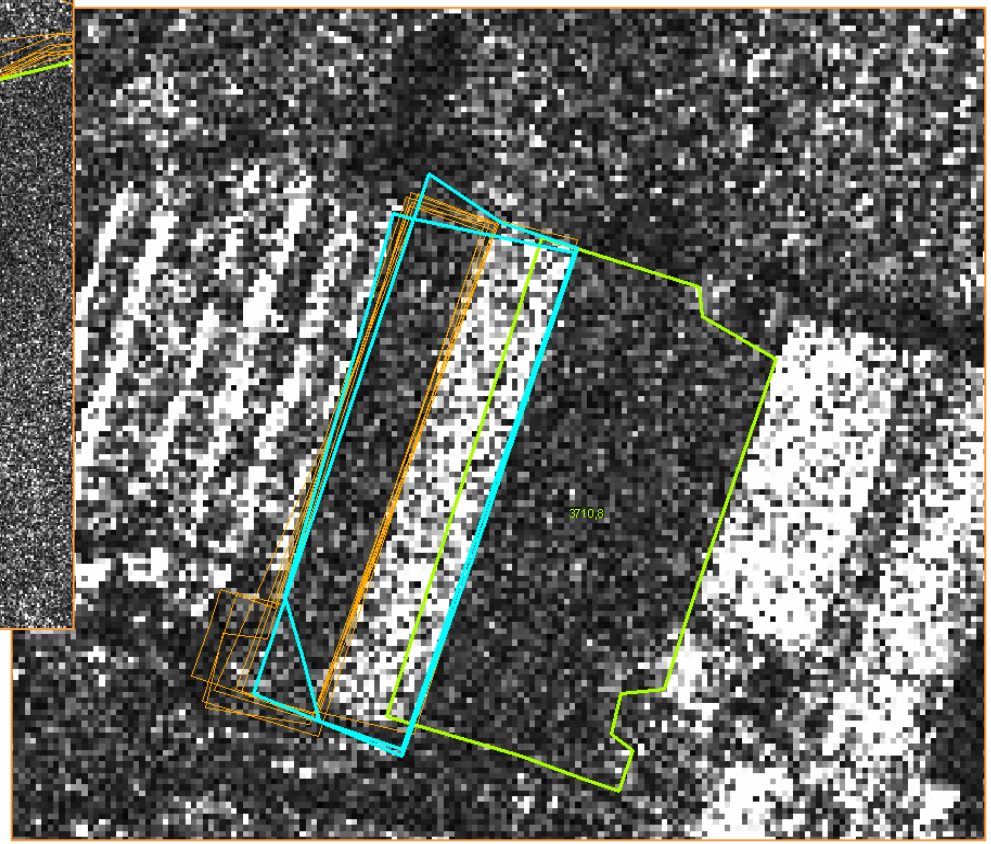


ORTHOPHOTO
1m

Outliers - examples

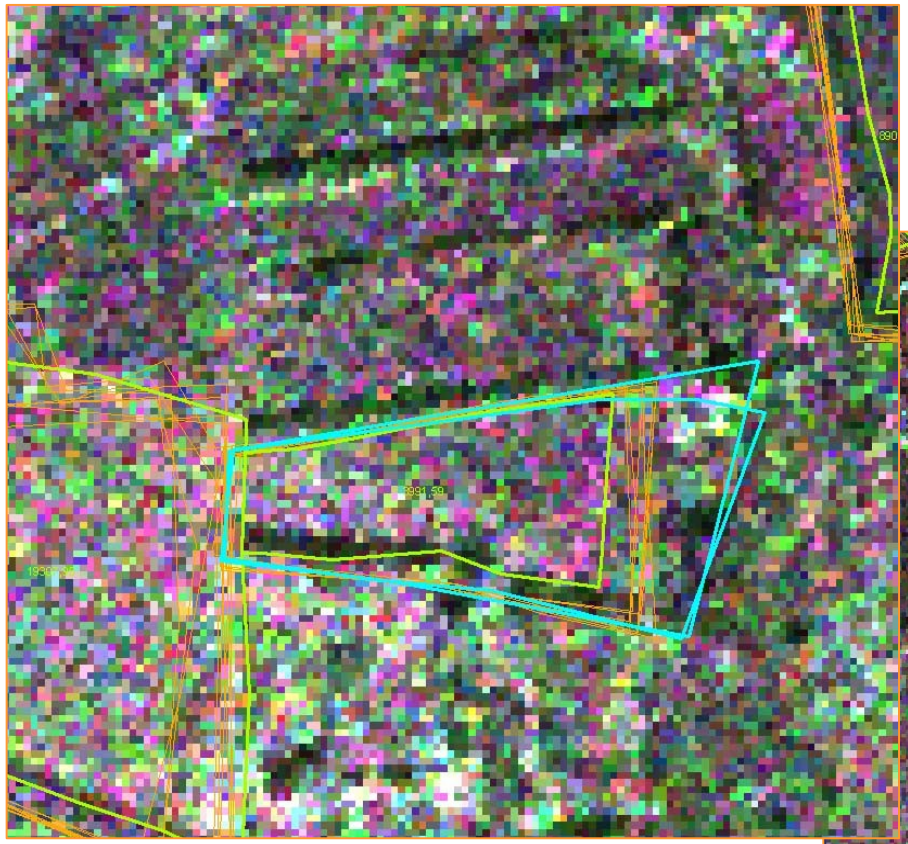


SAR 1m

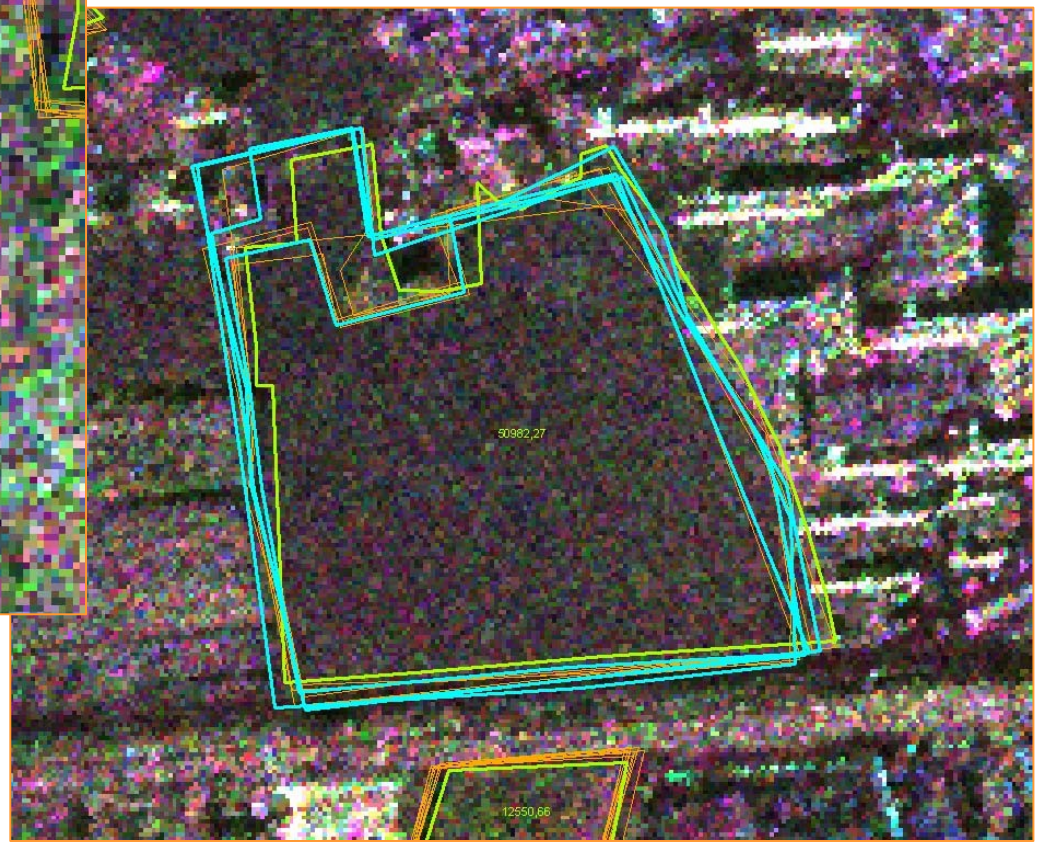


- Boundary not clear
- Different objects measured

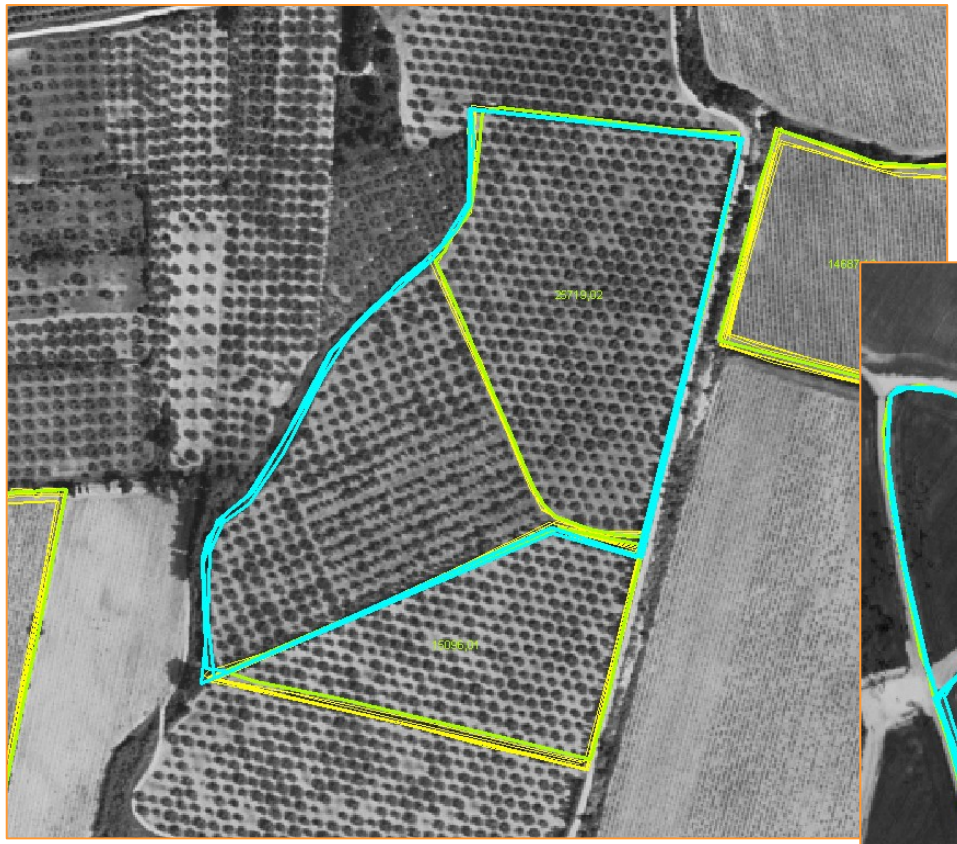
Outliers - examples



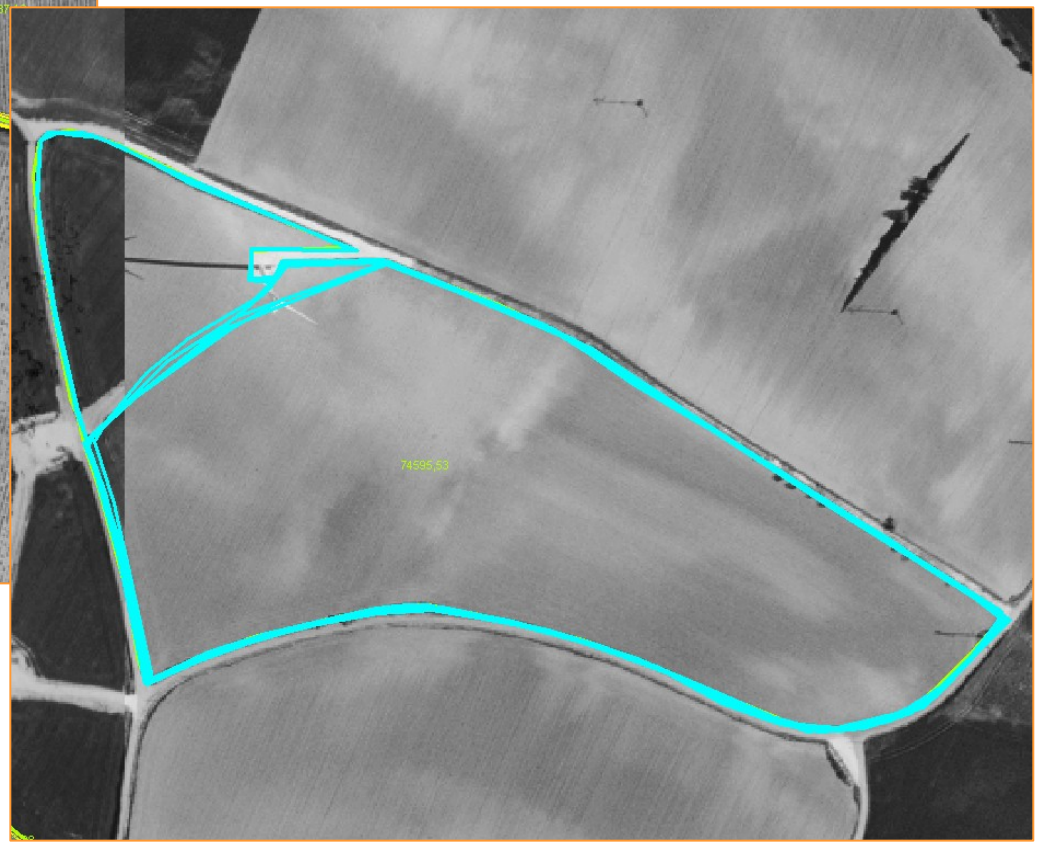
SAR 2m



Outliers - examples

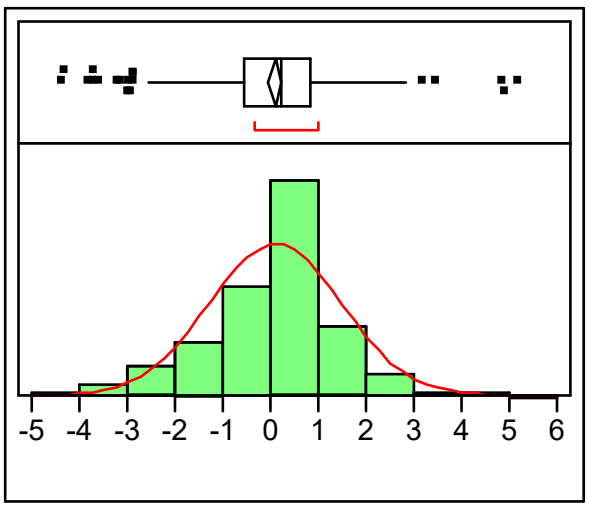


ORTHOPHOTO 1m

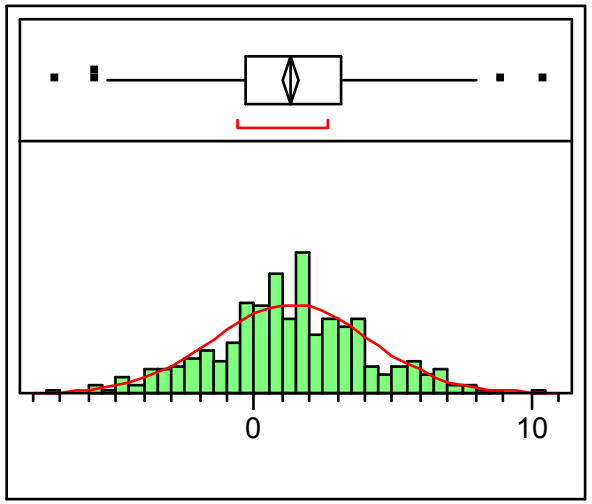


Distribution of the calculated buffers

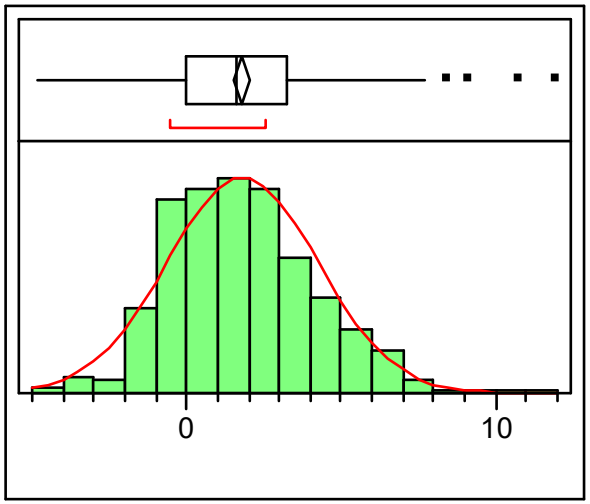
For each parcel and image type, 9 area measurements (3 operators x 3 repetitions)



ORTHO buffers

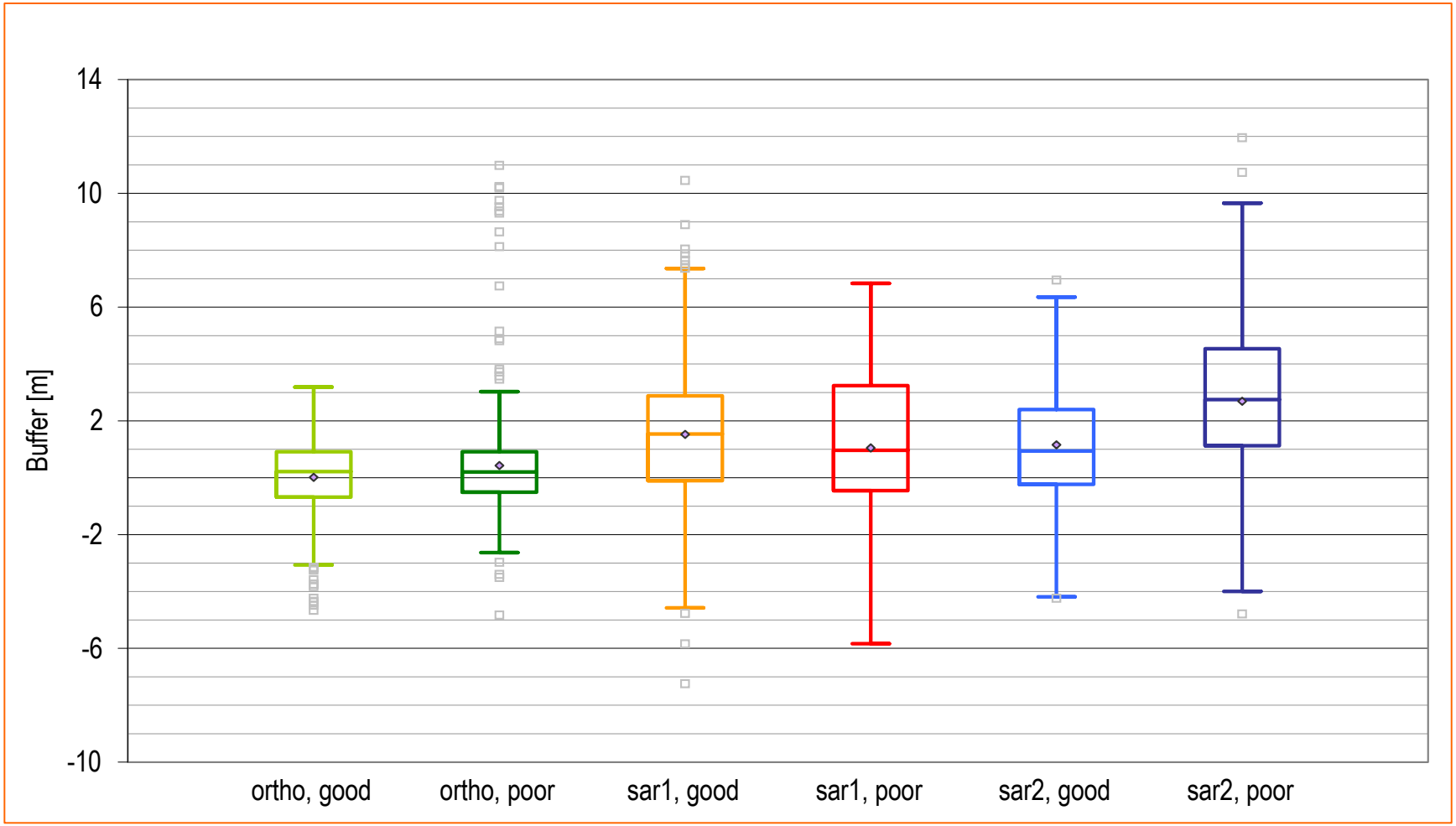


SAR1 buffers



SAR2 buffers

Box plots of the buffer values as a function of image type and parcels visibility



Results

Type of image	orthophoto	sar1	sar2
Sample size (nb of parcels)	714	314	366
Mean value = Bias [m]	0,20	1,32	1,81
Repeatability standard deviation (s_r) [m]	1,61	2,79	2,42
Reproducibility standard deviation (s_R) [m]	1,78	2,85	2,46
Reproducibility limit (R=2,8 x s_R) [m]	**4,98**	**7,97**	**6,89**
Critical Difference [m]	1,68	2,58	2,22

Reasons:

- High bias
- Ref area was not measured with requested precision
- Object recognition errors
- Difference in dates of images
- The assumption of normality?

Conclusions from study on VHR SAR

¾ 60 to 75% of the parcels are mutually recognised on both orthophotos and VHR SAR data

¾ Image type and resolution are the main factors affecting the parcels measurement accuracy

¾ Similar accuracy observed despite the resolution difference between 1m SAR B&W images and 2m SAR colour compositions suggests compensative effect of multipolarized information on lower resolution

¾ Estimated buffer tolerances (4.81m on 1m SAR, 4.14m on 2m SAR) are higher than the maximum 1.5m requested by the actual EU regulation

¾ Compared to optical data, the uncertainty of the measurement (as bias and robustness) and the ability to repeat and reproduce the measurement are lower for both kinds of radar data

On-going study on Cartosat-1

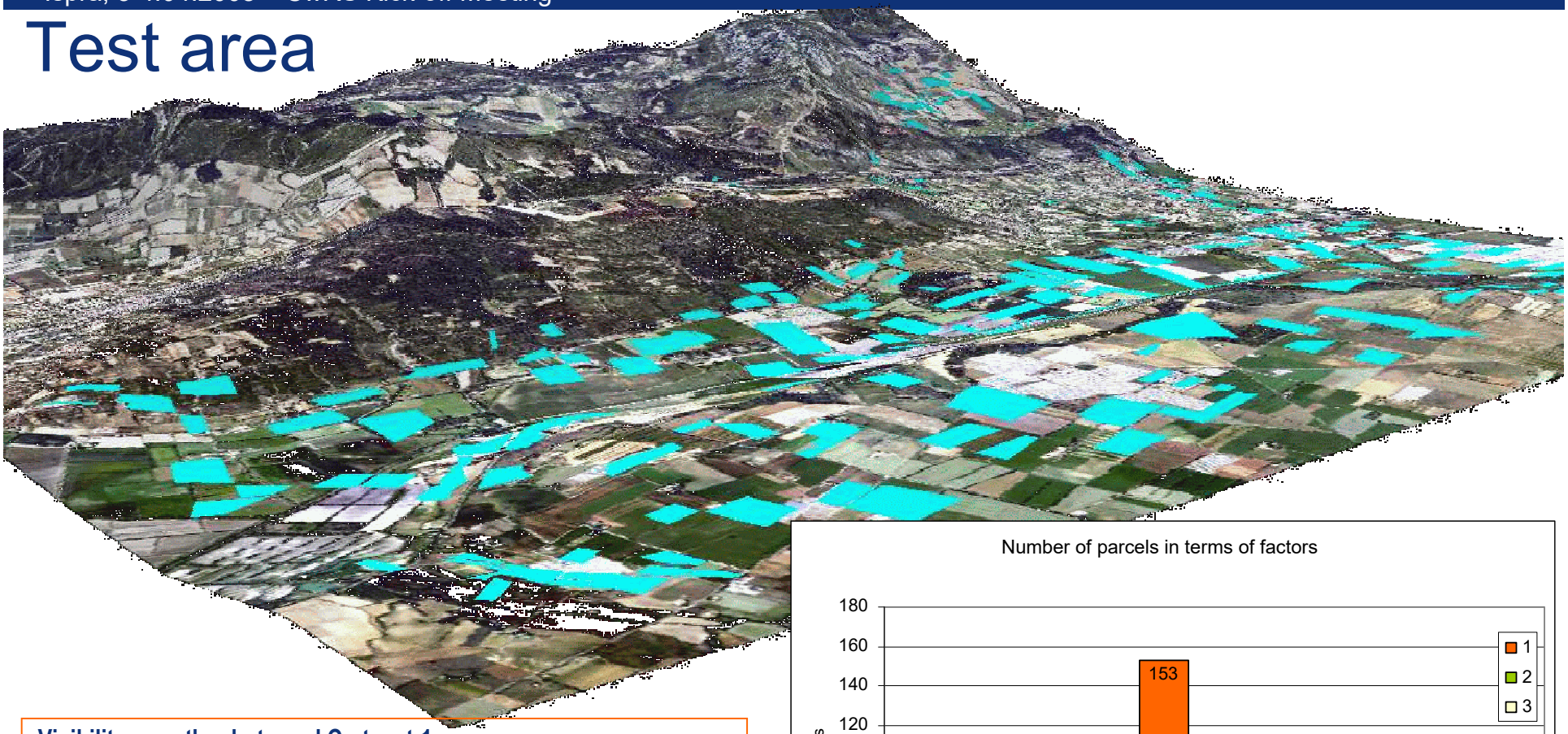
¾ The main objective of this study is to assess the measurement accuracy of agricultural parcel area on Cartosat-1 panchromatic imagery (0.5-0.85µm) with 2.5m of GSD at nadir

¾ Two pairs of Cartosat-1 images: aft (-5deg pitch angle) and fore (+26deg) were acquired on 31.01.2006 over Maussane, a 10kmx10km area in Southern France (perm crops, pastures, some arable crops)

¾ Reference image: UltraCamD data (RGB, 0.5m) from May 2005

¾ 185 selected parcels falling on the frame of Cartosat-1 images were digitized on the orthophoto and are measured on the Cartosat-1 by 3 operators x 3 repetitions

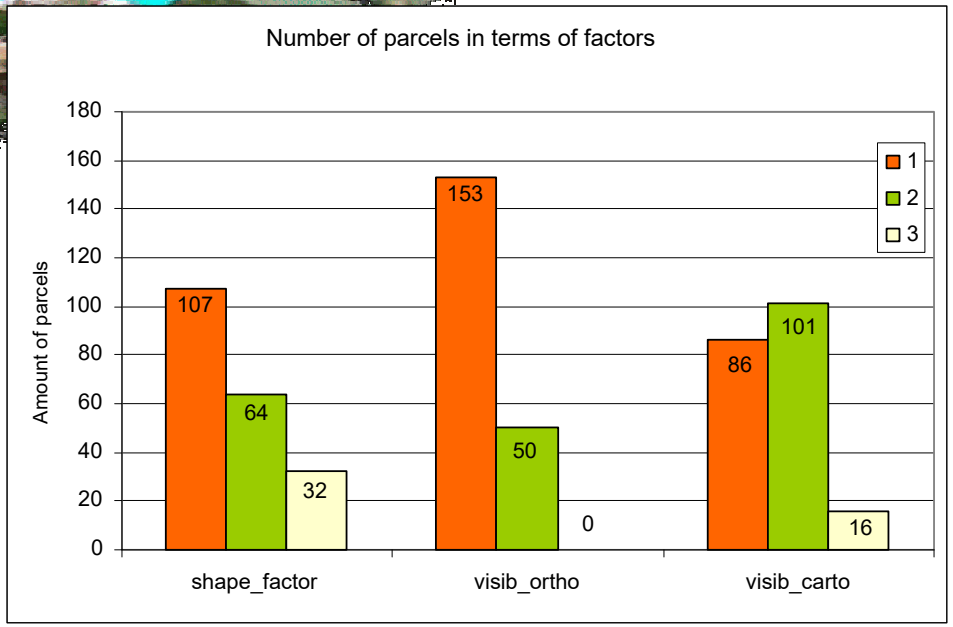
Test area

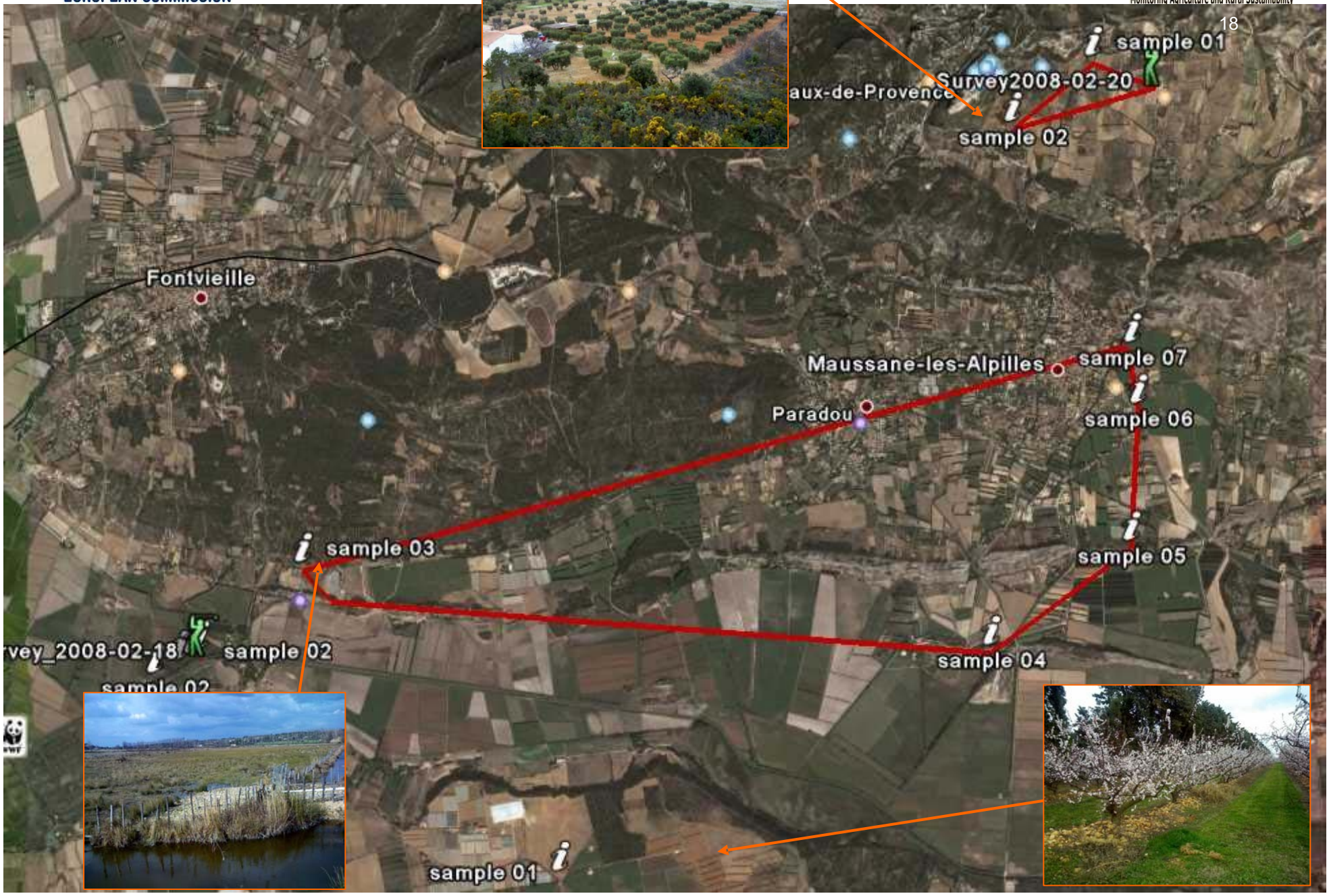


Visibility on orthophoto and Cartosat-1:
1. good – all the border is easy to recognize
2. poor – part of the border is hard to recognize and must be deducted
3. invisible – most or all the border is difficult to deduct

Shape:
1. simple – rectangular alike
2. medium – straight shape with small changes
3. complex – shapeless parcel

Land cover classes, area, operator, image mode




sample 01
Survey2008-02-20
aux-de-Provence
sample 02
Fontvieille
Maussane-les-Alpilles
sample 07
Paradou
sample 06
sample 03
sample 05
sample 04
sample 02
sample 01

Conclusion

③Methodology to calculate buffer width / validate area measurement for any sensor established

③Need to “run” it on various test areas with various sensors: TerraSAR X, F2, Eros A/B, WV1,…