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Validation of methods for measurement of land parcel areas

FINAL REPORT

draft

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Content

1. Introduction

Aim of the project is elaboration of validation methods for measurement of land parcels areas. 2 measurement experiments were performed in the project: remote sensing (RS) and GPS. RS experiment was made at AGH - UST Kraków, and GPS at UWM Olsztyn. The experiment was prepared and statistical analyzed at USI Gembleux. We had three meetings during the project's duration: two in AGH -UST Kraków and one at UWM Olsztyn. The following persons took part in all meetings: B.Hejmanowska, S.Oszczak, R.Palm, A.Ciećko (UWM Olsztyn) and S.Kay. During the meeting in Olsztyn we visited two GPS test sites.

RS and GPS measurements were postponed and we had not enough time to prepare the final report, so we submit only draft vesion.

Report is composed of 8 chapters and Appendix. In chapter 2 made a review of existing approaches and discuss the Polish experience in the possibility of adapting cadastre regulations. The chapter might be improved.

Chapters 3: 4, 5 and 6 are almost complete but some information can be added if necessary after final meeting.

In chapter 7 discussion concering accuracy estimation on the basis of buffer and point position error are presented. This chapter can be removed or developed if needed.

Because of a short time it was not possibly to change ideas between authors of the report before the final meeting. Therefore the proposal of validation method for measurements of land parcel area (chapter 8) is planned for elaboration during 2 weeks after meeting.

Detailed statistical data are annexed in the appendix.

Other electronic data are attached to the report (data base of RS and GPS measurements).

2. Review of existing approaches to validation of measurement methods

2.1 Review of approaches in IACS (JRC)

The following information are extracted from: “Technical tolerances for On the Spot checks”

Technical tolerance is applied to estimation available difference between the declared and measure during control land parcel area. Tolerance may be defined by buffer or percentage of measured area on 95% probability level.

Tab 1. Area measurement tolerance for maps and ortophotomaps

Map scale	Pixel size [m]	Tolerance [%]	Tolerance [m]
1: 10 000	1	5	1.5
1: 5 000	0.5	2.5	0.75
1: 2 500	0.25	1.25	0.4

Tab 2. Area measurement tolerance for direct measurements

Map scale	Tolerance [%]	Tolerance [m]
GPS standalone	-	1.25
Geodetic surveying	2	0.35
Wheel, tape	2 (up to 50m) or 5	0.4

Remote sensing control: “measurement tolerance of any parcel may not exceed either 5% of the parcel area or perimeter buffer of 1.5m”.

The following information is extracted from “On-the-spot checks of area according to articles 15-23 of Commission regulation (ec) no 419/2001”.

“According to Article 22 of Regulation 2419/2001, agricultural parcel areas shall be determined by any appropriate means defined by the competent authority which ensure measurement of a precision at least equivalent to that required for official measurements under the national rules. Furthermore, the competent authority shall set a tolerance margin taking account of the measuring method used, the accuracy of the official documents available, local factors such as slope and shape of parcel”.

- The method of measurement should be adapted to the expected agricultural parcel size in the region concerned. The technical tolerance in relation to each declared parcel should not exceed 5% of the agricultural parcel area measured. Alternatively, a technical tolerance based on a perimeter buffer of up to 1,5 m may be used.
- Instead of the 5 % or 1,5 m buffer described above, an absolute tolerance of 0,02 ha may be applied to take account of errors in rounding.

- The maximum technical tolerance for each agricultural parcel measured should not exceed in absolute terms 1.0 ha.
- For preliminary measurements on LPIS documents, the area measured should not exceed the official area (land registry, LPIS reference areas).

According to Article 18(3) of Regulaltion 2419/2001, the extent and scope of the sample shall be extended appropriately if the checks on the initial sample cases reveal irregularities. The Commission services take the view that the following should, in general, be considered as being appropriate:

- \- if an over-declaration of more than 3% of the area is determined in the measurement of the sampled agricultural parcels for a specific crop group, the sample should be extended to include all the remaining parcels of the crop group concerned.
- \- if an over-declaration of more than 30% of the overall area is determined in the measurement of the sampled agricultural parcels, the sample shall be extended to include all the remaining parcels of the aid application concerned.

2.2 Review of approaches in cadastre (Poland)

2.3 Techical specification

Accuracy of cadastre parcel measurement is described by technical regulation [G5, 2003], technical guidelines [G 5.4, 1992] and publication [Maps for law tasks, splitting and merging of real estate, 1993]:

(1) $$\Delta P = 0.001 \cdot P + 0.2 \cdot \sqrt{P})$$

(2) $$\Delta P = 0.4 \cdot \sqrt{2P} \cdot \sqrt{\frac{1+K^2}{2K}}$$

(3) $$\Delta P = 0.001 \cdot P + 0.0002 \cdot M \cdot \sqrt{P})$$

(4) $$\Delta P = 2 \cdot (0.002 \cdot P + 0.2 \cdot \sqrt{P})$$

where:

ΔP – allowed discrepancies between area in cadastre and area measured in control measurement [m^2],

P – land parcel area [m^2].

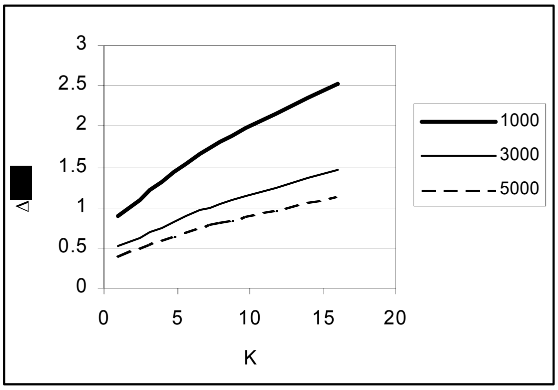


Fig. 1. Relationship between ΔP/P and elongation factor (K) for area: 1000, 3000, 5000 m^2 [%]) – formula(2)

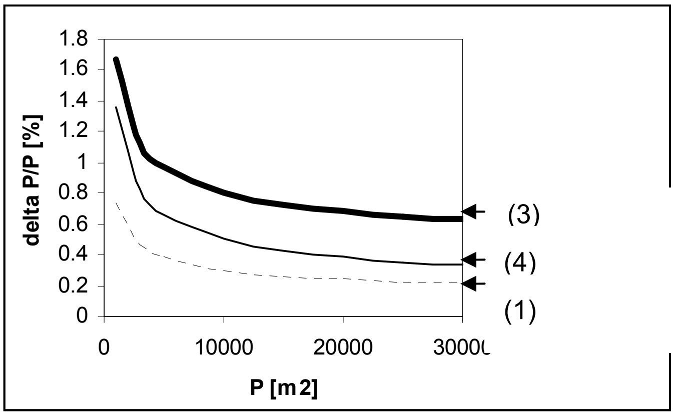


Fig. 2. Relationship between ΔP/P and elongation factor (K) for area: 1000, 3000, 5000 m^2 [%] – formula: (1), (3), (4)

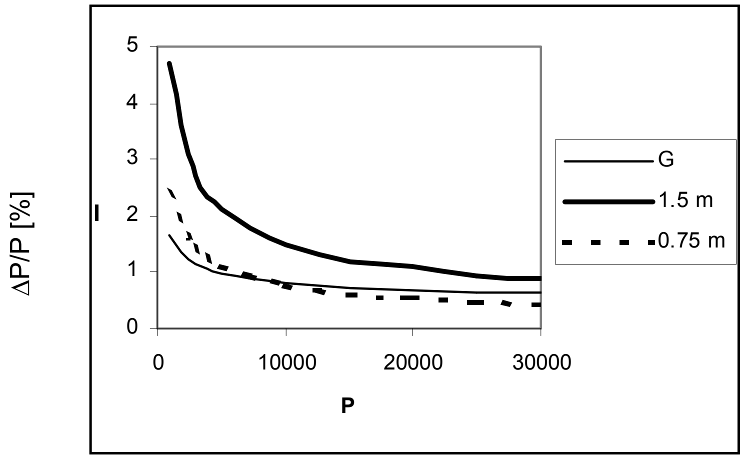


Fig. 3. Relationship between the relative area discrepancies (ΔP/P) and area(P); G – formula (3) and Gauss formula assuming m_{pkt} = 1.5m and 0.75m

Let us input to formula (1) parcel area of 0.1 ha. We obtained allowed area discrepancy of 7.3 m^2. If we apply inversely formula from Gauss (5) (invert to formula: (23) in chapter 5.3.1) we obtained point position error m_{pkt} = +/- 0.1m. It is not possible to measure land parcel area without stones.

(5) $$m_{pkt} = 2\sqrt{2}m_p \sqrt{\sum_{i=1}^{n} \frac{1}{(y_{i+1} - y_{i-1})^2 + (x_{i-1} - x_{i+1})^2}}$$

Usually, regulations applied in surveying, concern the case that we have stones on the parcel edges. Therefore the accuracy limits for surveying are very rigor and couldn't be adapted in IACS control procedure.

3. Steps in the statistical analysis of a precision experiment

3.1 Introduction

ISO 5725-2 gives the "basic method for the determination of repeatability and reproducibility of a standard measurement method". It is typically designed for interlaboratory experiments in order to estimate repeatability and reproducibility of measurement methods for chemical contents for example. But it can also be used for other purposes.

Hereafter we explain how we propose to analyze the data collected through an experiment for validation of methods for measurement of land parcel areas with respect to the standard norm.

First of all, we present the typical experimental design and the principles of statistical data analysis used for the estimation of repeatability and reproducibility (part 3.2), then we give a short description of the statistical tools used in order to identify and treat outliers or other irregularities in the data (part 3.3), and we explain how these tools are used in a step-by-step procedure (part 3.4

3.2 Layout of the precision experiment and overview of statistical analysis

3.2.1 Layout of the experiment

In a typical basic interlaboratory experiment, samples from q batches of materials representing q different levels of the content to be measured are sent to p laboratories which each obtain n replicate results under repeatability conditions at each of the q levels.

For a given method of area measurement (GPS device, orthophoto), several land parcels are measured on different days by different operators.

3.2.2 Critical examination of the results

In a typical interlaboratory experiment, critical examination of the data is based on a "pooling factor": the observations are grouped according to this factor and the mean and the standard deviation within a given group is compared to the means and the standard deviations within the other group. The statistical tools used for critical examination of the data are described in part 3.4.

In typical interlaboratory experiments, the pooling factor is the factor "laboratory" because in each laboratory replicated results are obtained under repeatability conditions.

In the experiment for validation of method for measurement of land parcels areas described in part 4, we have two factors: the factor day and the factor operator. The question is: which factor should be considered for pooling the data ?

The answer to this question depends on the method of measurements. For remote sensing methods, we expect that the factor "day" does not have an important effect on the results and measurements made by an operator on several days can be considered as made under repeatability conditions. As a consequence, the data should be pooled by operators. On the other hand, for GPS measurements, we expect the factor "day" to be a more important source of variation than the factor operator. So we consider that measurements made the same day by several operators are measurements made under repeatability conditions and the data are pooled by days.

3.2.3 Variance components, repeatability and reproducibility

As explained in part 1.2.2, the observations for a given parcel are allocated in groups according to a pooling factor which is the factor "day" for GPS observations and the factor "operator" for remote sensing data.

A one-way analysis of variance (random model) is performed on each column which contents the observations made on a given land parcel. This analysis of variance gives the mean square value between groups MS_{group} and the mean square within groups, MS_r The mean square within groups is an estimation of the between replicates variance $\hat{\sigma}_r^2$:

(6) $$\hat{\sigma}_r^2 = MS_r .$$

and the between groups variance between groups $\hat{\sigma}_{group}^2$ is given by the equation :

(7) $$\hat{\sigma}_{group}^2 = \frac{MS_{group} - MS_r}{n} .$$

It may happen that the number of replicates varies from one group to another due to technical problems or because of discarding some results considered as outliers when using statistical tests are used (see point 3.4). So the experimental design is no longer a balanced uniform-level experiment. In this case, the value of n in formula ((7)) should be replaced by n':

(8) $$n' = \left(n_.^2 - \sum_{i=1}^{p} n_i^2 \right) \left[n_. (p-1) \right].$$

In this formula, n_i is the number of replicates for level i (i = 1, …, p) of the pooling factor and $n_.$ is the total number of results for the land parcel :

(9) $$n_{.} = \sum_{i=1}^{p} n_i \,.$$

Should MS_{group} be smaller than MS_r, formula ((7) would give a negative value for the between groups variance. In this case, the between groups variance is set to zero.

The variance components are related to the repeatability variance and reproducibility variance: the repeatability variance is the between replicates variance and the reproducibility variance is the sum of the between groups variance and the within groups variance:

(10) $$\hat{\sigma}_R^2 = \hat{\sigma}_{group}^2 + \hat{\sigma}_r^2 \,.$$

3.2.4 Establishing a functional relationship between precision values and the characteristics of the parcels

When analysing data from interlaboratory, the repeatability and reproducibility variance sometimes vary with the mean level of content. If so, the relationship should be determined. This can be done by fitting regression equations, for example a straight line or an exponential relationship.

For the land parcel measurement methods, the values of repeatability and reproducibility are expected to vary from one parcel to another, due to the characteristics of the parcels. The relation between precision and size, shape or environmental conditions should be analyzed by means of statistical tools : plots and summaries, analysis of variance or regression.

The analysis should be performed not only on repeatability and reproducibility standard deviations but also on transformations of these values: standard deviation divided by the perimeter of the parcel, standard deviation divided by the true area error (obtained by Gauss formula assuming a given error on vertices measurements).

3.3 Statistical tools for critical examination of the data

3.3.1 Preliminary considerations

The first stage of the analysis of the data is the critical examination of the data in order to identify and treat outliers or other irregularities and to test the suitability of the model.

Outliers are original data or derived data that deviate so much from the comparable data that they are considered irreconcilable with the other data. They are taken into consideration in a similar way to the treatment of missing data.

To apply ISO 5725-2 for detection of outliers, the observations are pooled into groups according a pooling factor. In a typical interlaboratory experiment, this pooling factor is the factor "laboratory". As explained in par 3.2.3, we propose to consider the factor "operator" for remote sensing observations and the factor "days" for GPS observations as the pooling factor.

When several unexplained abnormal results occur at different land parcels for the same level of the pooling factor level then this level of the pooling factor may be considered to be an outlier having too high value a within variance (between replicates) and/or to large a systematic error in the level of its measurement results. It may be reasonable to discard some or all of the data from such an outlying level of the pooling factor.

Several statistical tools are used in order to identify outliers and outlying levels of the pooling factor. These tools are described hereafter (points 3.3.2, 3.3.3, 3.3.4) and the way they are used in the step-by-step procedure of statistical analysis is given in point 3.4.

3.3.2 Mandel’s h and k statistics

For a given land parcel, the statistics h and k are computed for each level of the pooling factor. The between-group consistency statistic, h, is given by the following formula:

(11) $$h_i = \left(\bar{y}_i - \bar{\bar{y}}\right) \Big/ \left[\sum_{i=1}^{p} \left(\bar{y}_i - \bar{\bar{y}}\right)^2 \Big/ (p-1) \right].$$

In this formula p is the number of levels of the pooling factor, $\bar{y}_i$ is the mean value for level i of the pooling factor and $\bar{\bar{y}}$ is the grand mean for the parcel:

(12) $$\bar{y}_i = \frac{1}{n_i} \sum_{k=1}^{n_i} y_{ik} \quad \text{and} \quad \bar{\bar{y}} = \frac{1}{n_.} \sum_{k=1}^{p} \sum_{i=1}^{n_i} y_{ik} .$$

For level i, h_i is a measurement of the standardized distance of the mean value observed for the level from the general mean.

The within-group consistency statistic, k compares the within standard deviation for level i to the mean value of the within standard deviation of each level:

(13) $$k_i = \sqrt{\frac{\hat{\sigma}_i^2}{\tilde{\sigma}^2}} .$$

where $\hat{\sigma}_i^2$ is the within variance for level i and $\tilde{\sigma}^2$ is the arithmetic mean of all within variances:

(14) $$\hat{\sigma}_i^2 = \sum_{k=1}^{n_i} \left(y_{ik} - \bar{y}_i\right)^2 \Big/ \left(n_i - 1\right)$$

and

(15) $$\tilde{\sigma}^2 = \frac{1}{p} \sum_{i=1}^{p} \hat{\sigma}_i^2 .$$

If all levels have a constant number of replicates ($n_i = n$ for all i), then $\tilde{\sigma}^2$ is the repeatability variance.

Statistics h and k are calculated for each parcel (k = 1, …, q) and therefore noted h_{ij} and k_{ij}.

These statistics are then plot, in order of the level of the pooling factor, in groups for each parcel. Lines are drawn on the h and k plots. Theses lines correspond to critical values (at 1 % level and at 5 % level), given in X [2000].

Examination of h and k plots may indicate that specific levels of the pooling factor exhibit patterns of results that are markedly different from the others in the study. This is indicated by consistently high or low between replicates variation and/or extreme mean values for a given level across many parcels. Notice that ISO 5725-2 does not provide a statistical test by which suspected operators may be judged. The h and k plots are only a graphical consistency technique. The decision of discarding a level is left to the statistical expert.

3.3.3 Cochran's test

The COCHRAN's test is designed to check if it can be assumed that the variances between replicates are equal for each level of the pooling factor in a given land parcel.

Let $\hat{\sigma}_1^2, \ldots, \hat{\sigma}_p^2$ be the variances between replicates for level i in a given land parcel and $\hat{\sigma}_{max}^2$ the largest variance. The Cochran's test statistics C is:

(16) $$C = \hat{\sigma}_{max}^2 \Big/ \sum_{i=1}^{p} \hat{\sigma}_i^2 .$$

If the test statistic C is less than or equal to its 5 % critical value, the item tested is accepted as correct.

If the test statistic is greater than its 5 % critical value, but smaller than or equal to its 1 % critical value, then the item tested is called a straggler and is indicated by a single asterisk. If the test statistic is greater than its 1 % critical value, the item tested is called a statistical outlier and is indicated by a double asterisk. The critical values are given in X [2000].

Cochran's criterion applies strictly only when all the variances are derived from the same number of replicates ($n_i = n$). In actual cases, this number may vary due to missing or discarded data. If the variation in the number of replicates is limited it can be ignored and Cochran's criterion is applied using for n the number of replicates occurring for the majority of operators.

3.3.4 Grubbs' test for one outlying observation

Given a set of n data arranged in ascending order $x_{[1]}, x_{[2]} \ldots, x_{[n]}$ with mean $\bar{x}$ and standard deviation $\hat{\sigma}$. Let :

(17) $$G1_{min} = \frac{\bar{x} - x_{[1]}}{\hat{\sigma}} \quad \text{and} \quad G2_{max} = \frac{x_{[n]} - \bar{x}}{\hat{\sigma}}.$$

$G1_{min}$ and $G2_{max}$ are the standardized distances from the mean for the largest and the smallest values.

Let G1 be the largest of the two values:

$$G1 = \max\left[G1_{min}, G1_{max}\right].$$

The extreme value ($x_{[1]}$ if $G1 = G1_{min}$ or $x_{[n]}$ if $G1 = G1_{max}$) is called a straggler and is indicated by a single asterisk if G1 is greater than its 5 % critical value and less than or equal to its 1 % critical value. It is called an outlier and is indicated by a double asterisk if G1 is greater than its 1 % critical value. Critical values are given in X [2000].

3.3.5 Grubbs' test for two outlaying observations

The aim is to check if the two largest observations, $x_{[n-1]}$ and $x_{[n]}$, or the two smallest observations, $x_{[1]}$ and $x_{[2]}$, may be considered as outliers.

Let SS be the sum of squares for all the n observations:

(18) $$SS = \sum_{i=1}^{n}\left(x_i - \bar{x}\right)^2 \quad \text{with} \quad \bar{x} = \frac{1}{n}\sum_{i=1}^{n} x_i .$$

Let SS' be the sum of squares after having discarded the two largest observations:

(19) $$SS' = \sum_{i=1}^{n-2}\left(x_i - \bar{x}'\right)^2 \quad \text{with} \quad \bar{x}' = \frac{1}{n-2}\sum_{i=1}^{n-2} x_i ,$$

and SS'' the sum of squares after having discarded the two smallest observations :

(20) $$SS'' = \sum_{i=3}^{n}\left(x_i - \bar{x}''\right)^2 \quad \text{with} \quad \bar{x}'' = \frac{1}{n-2}\sum_{i=3}^{n} x_i .$$

Let

(21) $$G2_{max} = \frac{SS'}{SS} \quad \text{and} \quad G2_{min} = \frac{SS''}{SS},$$

and define G2 as the smallest of the two values :

(22) $$G2 = \min\left(G2_{min}, G2_{max}\right).$$

The two observations related to G2 ($x[1]$ and $x[2]$ if $G2 = G2_{min}$ or $x[n-1]$ and $x[n]$ if are called straggler and are indicated by a single asterisk if G2 is smaller than its 5 % critical value and larger than or equal to its 1 % critical value. They are called outliers and are indicated by a double asterisk if G2 is smaller that its 1 % critical value. Critical values are given in X [2000].

3.4 Step-by-step procedure of analysis

3.4.1 Preliminary considerations

ISO 5725-2 gives the different steps of the statistical analysis of the data. We explain hereafter the main steps which lead to the determination of repeatability and reproducibility for each land parcel.

The analysis of the data begins with a visual inspection of the data for any obvious irregularities or erroneous data. These obvious discordant data may be corrected if possible or immediately discarded.

The Mandel's h and k plots are then prepared (see point 3.3.2).These plots may indicate the suitability of the data for further analysis, the presence of any outlying values or outlying level of the pooling factor. However no definite decisions are taken at this stage but are delayed until the statistical tests for outliers have been performed.

In the next stage, the numerical techniques described in point 3.3.3, 3.3.4 and 3.3.5 are used for the identification of outliers. The procedure of identification of outliers is explained in details in point 3.4.2 and 3.4.3. All the observations identified at this step as outliers are reported as well the reason why they are considered as outliers.

After discarding the outliers the analysis of variance, is calculated, the variance components are estimated and repeatability on reproducibility standard deviations are obtained as explained in point 3.2.1. Then the repeatability and reproducibility standard deviations are analyzed in order to determined how the variation of these values may be explained by the characteristics of the land parcels (see point 3.2.4).

3.4.2 Identifying outliers

Identification of outliers is done by the following steps.

1) Cochran's C statistic is computed for the level of the pooling factor showing the largest variance (between replicates). If this statistic is smaller than the 5 % critical value, go to step 5.

2) If the C statistic is larger than the 5 % critical value, the observations for the level with the largest variance are carefully examined in order to identify possible outliers which inflate the variance between replicates. This identification is based on the GRUBBS' tests as described in point 1.4.3 hereafter. If observations are identified as outliers, they are discarded and COCHRAN's test is applied again (back to step 1).

3) If no outlier is identified at step 2 and if the COCHRAN's C statistic is larger than the 5 % critical value but smaller than or equal to the 1 % critical value, go to step 5.

4) If no outliers is identified at step 2 and if the COCHRAN's C statistic is larger than the 1 % critical value, all the observations for the level of the pooling factor showing the largest variance are discarded and COCHRAN's test is applied again (back to step 1).

5) If, possibly after having discarded outliers, the COCHRAN's C statistic is smaller than or equal to the 1 % critical value, the means for each level of the pooling factor are carefully examined in order to identify outlying means. This identification is based on the GRUBBS' tests as described in point 1.4.3 hereafter. If mean values are identified as outliers, all the observations related to the level with an outlying mean are discarded.

3.4.3 Application of Grubbs' tests

We have already presented the Grubbs' tests (point 3.2.3and 3.2.4). The first test, called hereafter Grubbs/1, checks whether or not the largest or the smallest observation should be considered as an outlier. This test is based on the statistic G1. The second test, called hereafter Grubbs/2, checks whether or not the two largest or the two smallest observations should be considered as outliers. The associated statistic is G2.

The identification of outliers is performed on the observations related to the level of the pooling factor where COCHRAN's test has shown the variance between replicates variance to be suspect (point 3.4.2 step 2). It is also performed on the means per level (point 3.4.2, step 5).

If an individual observation is identified as an outlier (significant at 1% level), the observation is discarded. If a mean value is identified as an outlier (significant at 1% level) all the observations for the given level are discarded.

In the two situations the following procedure is used.

The GRUBBS/1 test is applied.

1) If the G1 statistic is smaller than or equal to the 1% critical value, go to step 6.

2) If the G1 statistic is larger than the 1% critical value, the extreme observation or mean is discarded and the Grubbs/1 test is applied again at the other extreme observation or mean

(if the extreme value discarded is the maximum, then look at the minimum; if the extreme value discarded is the minimum, then look at the maximum).

3) If the G1 statistic for this second Grubbs/1 test is smaller than the 1% critical value, the detection of outliers is stopped.

4) If the G1 statistic for this second Grubbs/1 test is larger than the 1% critical value, the observation or mean is discarded and the detection of outliers is stopped.

5) If no outlier has been identified by Grubbs/1 test, the Grubbs/2 test is applied.

6) If the G2 statistic is larger than or equal to the 1% critical value, the detection of outliers is stopped.

7) If the G2 statistic is smaller than the 1% critical value, the two largest (if G2 is related to the largest) or the two smallest (if G2 is related to the smallest) observations or means are discarded. The Grubbs/2 test is applied again at the other extreme (if the two largest observations or means have been discarded, the test is applied to the two smallest observations or means; if the two smallest observations or means have been discarded, the test is applied to the two largest observations or means). If the G2 statistic for the second Grubbs/2 test is larger than or equal to the 1% critical value, the detection of outliers is stopped.

8) If the G2 statistic for the second Grubbs/2 test is smaller than the 1% critical value the two observations or means are discarded and the detection of outliers is stopped.

3.4.4 Coding the results of the statistical tests

Three variables are defined in order to code the results of the statistical tests for the observations identified as outliers. These variables, called COCHRAN, GRUBBBS/1 and GRUBBS/2, are related to COCHRAN's test, to GRUBBS' test for one outlying observation and to GRUBBS test for two outlying observations.

The following codes are used:

COCHRAN: code related to the result of COCHRAN's test:

- 0 : statistic smaller than the 5% critical value,
- 1 : statistic larger than the 5% critical value but smaller than or equal to the 1% critical value,
- 2 : statistic larger than the 1% critical value.

GRUBBS/1: code related to the result of GRUBBS' test for one outlying observation:

- 0 : statistic non significant at level of 1%,

- 1 : statistic significant at the level of 1%, for a test performed on the observations within a given level of the pooling factor,
- 2 : statistic significant at the level of 1% for a test performed on the observations within a given level of the pooling factor and after having already identified one extreme value as an outliers,
- 10 : statistic significant at the level of 1% for a test performed on the mean values for the levels of the pooling factor,
- 20 : statistic significant at the level of 1% for a test performed on the mean values for the levels of the pooling factor and after having already identified one extreme mean as an outlier.

GRUBBS/2 code related to the result of GRUBBS' test for two outlying observations:

- 0 : statistic non significant at level of 1%,
- 1 : statistic significant at the level of 1%, for a test performed on the observations within a given level of the pooling factor,
- 2 : statistic significant at the level of 1% for a test performed on the observations within a given level of the pooling factor and after having already identified two extreme values as outliers,
- 10 : statistic significant at the level of 1% for a test performed on the mean values for the levels of the pooling factor,
- 20 : statistic significant at the level of 1% for a test performed on the mean values for the levels of the pooling factor and after having already identified two outlying means.

4. Detailed presentation of the validation approach to be applied

4.1 Assumption of the validation experiment

Validation experiment detailing two example applications based upon a GPS system and a VHR orthoimage system

4.2 Description of the parcel set

36 parcels were measured. Parcels were characterized by different size, shape and measurement's conditions. Different amount of operators and repetitions are applied for RS and GPS. For RS we have 12 operators and 3 repetitions, for GPS we have 23 operators and 2 repetition. Detailed description of the issue: teams, operators and repetitions are presented below.

4.2.1 Size

For the RS and GPS measurements the following parcel size was chosen:

- S : small (0.3 – 0.5 ha)
- M : medium (0.8 – 1.2 ha)
- L : large (2.4 – 4 ha)

4.2.2 Shape

Parcel compactness: whilst it is easier to comprehend the description of a parcel in terms of its ratio width: length, in practical terms this cannot be calculated. It was agreed therefore to work with the Shape Factor (SF) = $(\text{perimeter}/4)^2$ / parcel area. The thresholds to be used for the categorization of reference parcel (>1:3, 1:3 to 1:6, <1:6) are parcel ratio 1:3 gives an SF = 1.33, and the ratio of 1:6 gives an SF 2.04.

- S1 : form factor – level 1 < 1:3
- S2 : form factor – level 2 < 1:6
- S3 : form factor – level 3 > 1:6

4.2.3 Measurement's conditions

In the experiment parcels are measured in good and bad conditions:

- GOOD : good conditions

- BAD : bad conditions.

Good and bad conditions were understood in different way for RS and GPS measurements.

4.3 Measurement workflow

Measurements are prepared according ISO 5725: “basic method for determination of repeatability and reproducibility a standard measurement method” (ISO 5725-1), regarding very carefully predefined measurement conditions, especially the parcel sequences measured by each operator in all experiment period. Besides parcels were completed according assumption that they should be independent, so they must have own border, not sharing it with other one.

4.4 Control procedure

Before measurements operators were short trained and precisely instructions were them provided. Main recommendations are placed for each kind of measurements and full version of it was prepared in Polish and is attached as an appendix.

Measurements are controlled and gross errors (mainly mistakes of chosen parcel to measuring) are currently corrected.

5. Detail description of two example applications, based upon a GPS system and a VHR orthoimage system

5.1 Design of experiments – remote sensing

5.1.1 Initial phase

Preparing the main experiment we performed sample tests. 3 Operators performed measurements on 2 scale orto using 2 software: Microstation (Bentlley) and Geomedia (Intergarph). 41 parcels were measured 3 or 4 times. Measurements in Microstation need writing calculated in MS area and perimeter on the paper. In Geomedia all values are stored in file. Therefore for the main experiment Geomedia was chosen as a GIS software tool and other than measured in initial phase parcel set was prepared.

5.1.2 Main experiment

RS land parcel area measurements were performed on 3 kinds of ortofotomaps in different scales. 36 test land parcels were measured by 12 operators 3 times on each ortofotomaps Generally 3888 RS measurements are performed. Cadastre parcel is assumed as a reference parcel in land parcel measurements. Reference parcels were digitized on screen on the cadastre maps and land parcels on the ortho using GIS software: GeoMedia Professional (Intergraph). Results of measurements were automatically gathered in file, graphical and descriptive information were saved in one file.

12 operators were chosen to the experiment: 6 skilled and 6 unskilled. Test parcels are composed from one or more land parcels because assumption of ranges of parcels' size and shape. Completing the parcels sets was complicated under assumption that test parcels should:

- be composed from one cadastre parcel or more cadastre parcels without necessity to correct it
- fulfilled précised measurements conditions (bad and good border) and
- be characterized by the same measurements conditions on all ortho scales.

Parcel for measurements was marked uniquely on the screen but operators didn't know any cadastre borders.

Two kinds of parcels are chosen concerning the border conditions: good and bad. Parcel of good border condition means parcel edge easy to interpreted by operator (good contrast and strong brightest, color changes). Bad border condition means mainly trees along the edge.

Implementation the same conditions for all parcels on all ortophotomap were very difficult and in pair cases not possible to fulfill (ex. Fig. 4).

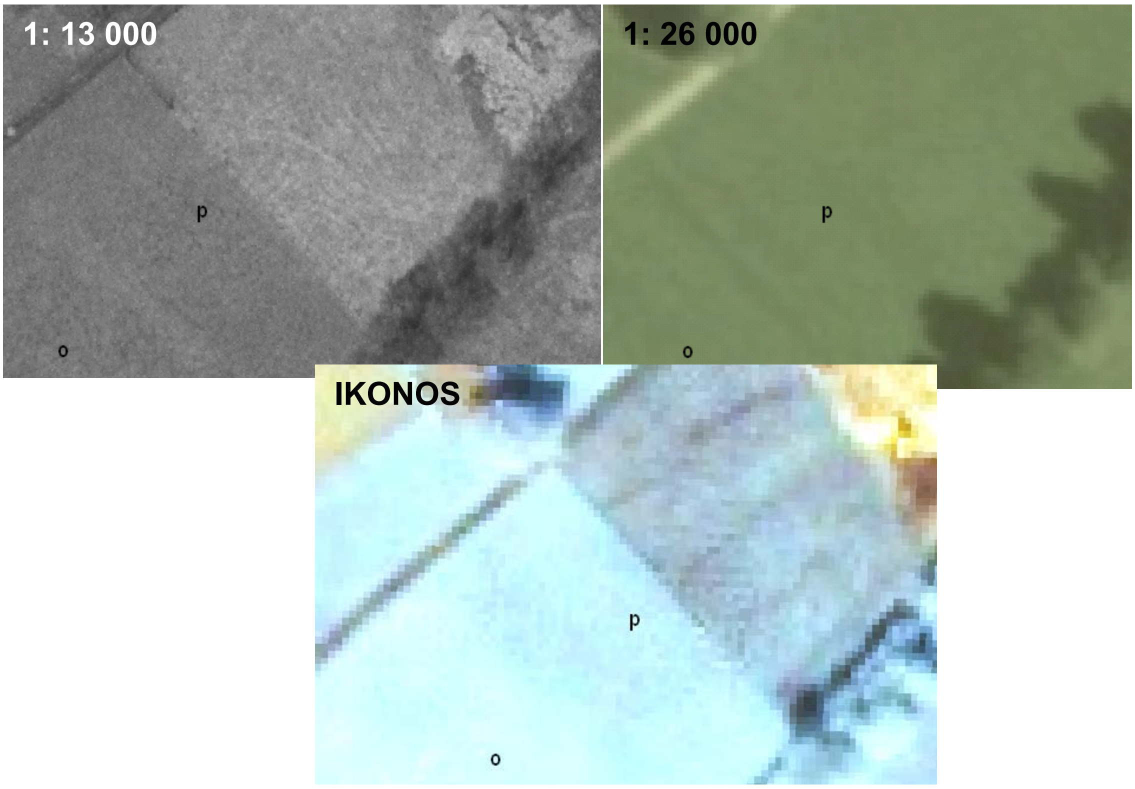


Fig. 4. Comparison of border condition on 3 ortophoto

5.1.3 Cadastre parcels as reference parcels

For the project 49 cadastre map sheets in national coordinate system 2000 were obtained from ARMA (Agency of Restructuring and Modernization of Agriculture in Poland). Reference parcels were digitized on the screen using Geomedia drawing tools (ex. snaping to the middle of line, or vertex). Parcels were defined by as minimum points as possible, only necessary edge breaks are noticed. Test parcels could be composed by one cadastre parcel (Fig. 5) or by few one (Fig. 6). It was not possible to choose cadastre parcels of so defined M or L size because of generally small parcels (or bigger than L) on the south of Poland.

Than area and perimeter of reference parcels were calculated in GeoMedia.

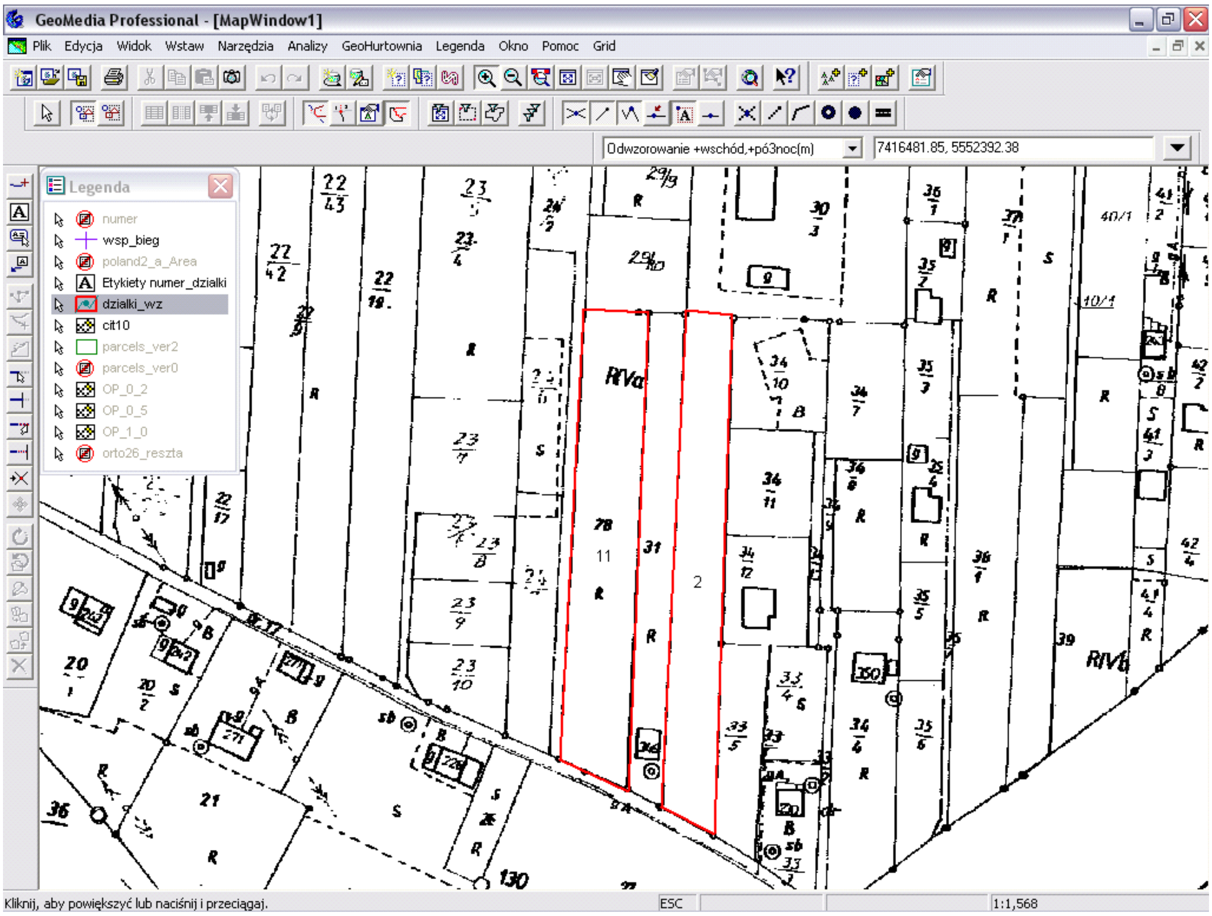


Fig. 5. Raster cadastre map – one cadastre parcel=one test parcel

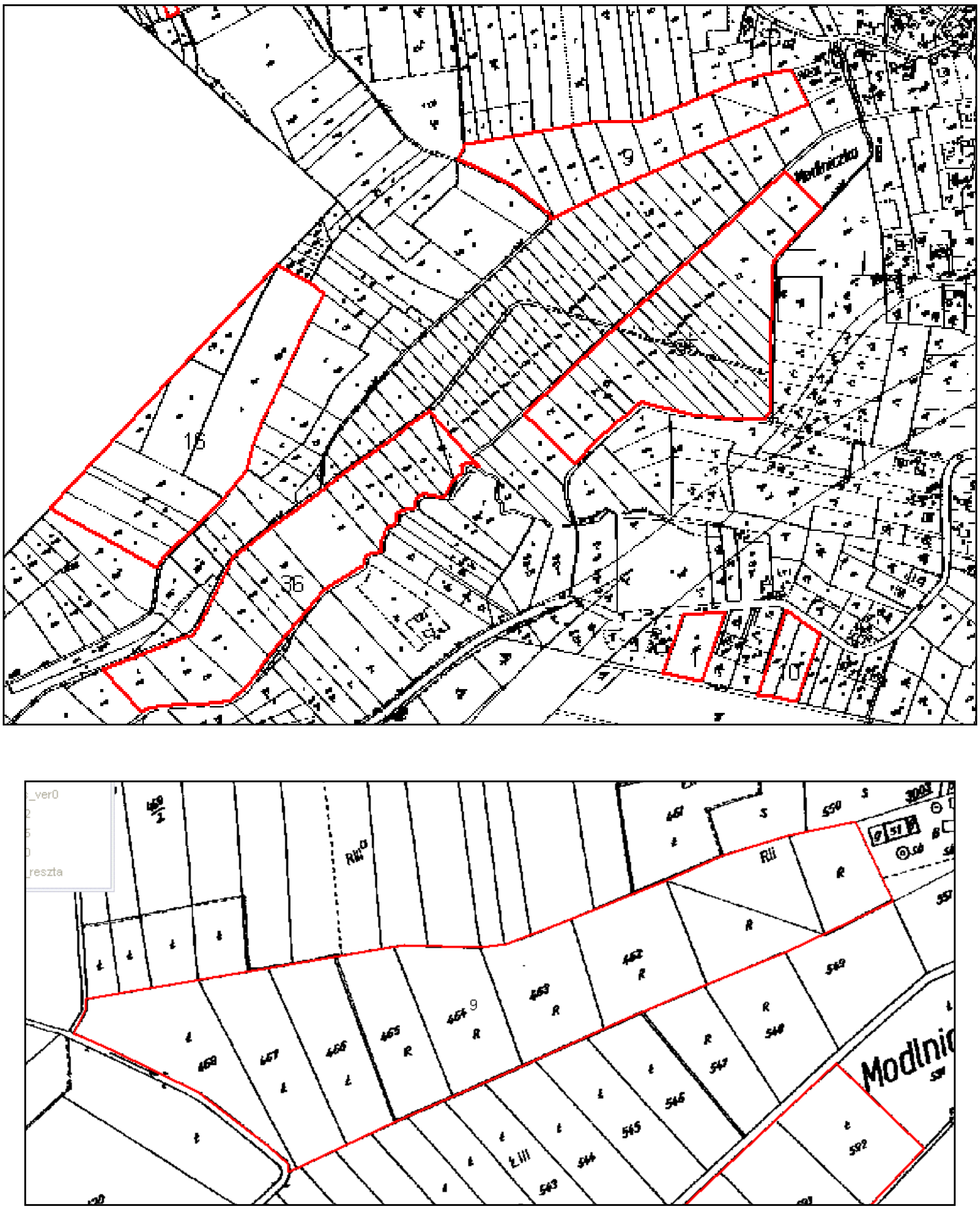


Fig. 6. Raster cadastre map – few cadastre parcels=one test parcel

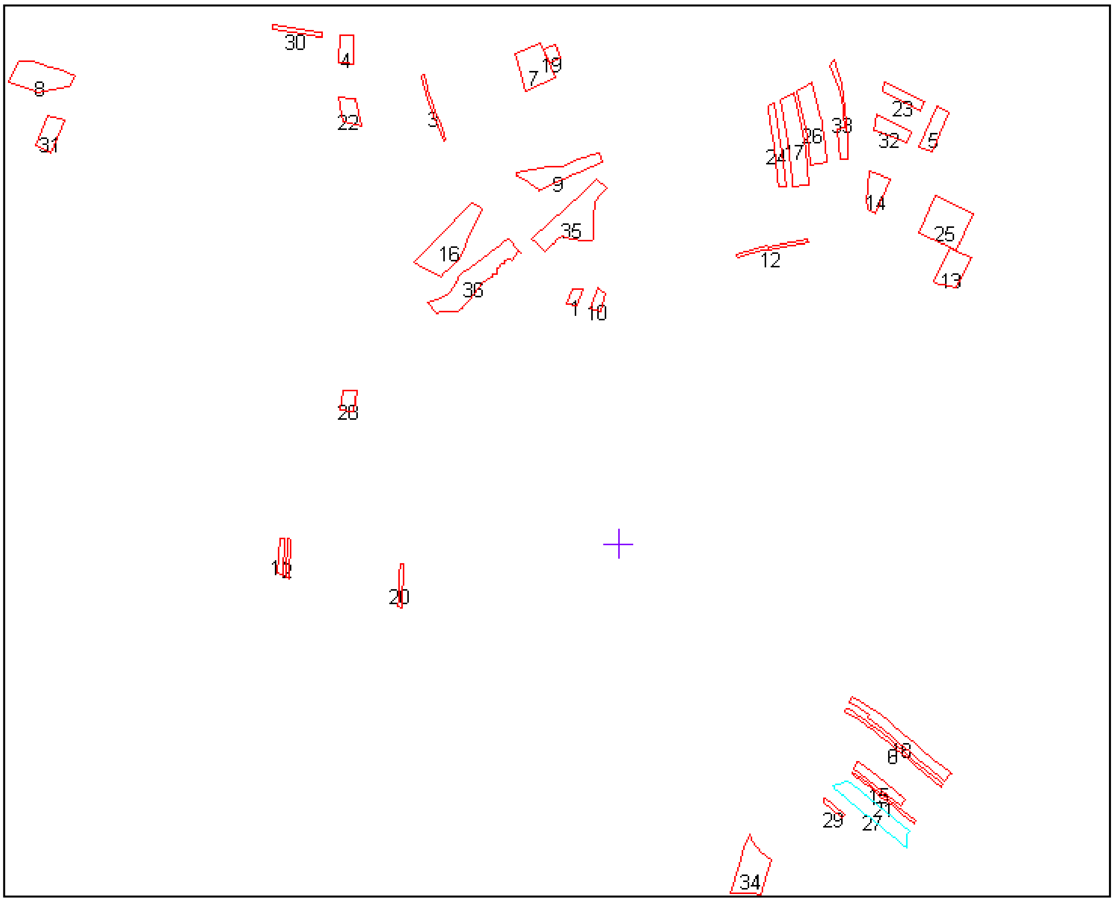


Fig. 7. Set of reference parcels composed by cadastre parcels

Tab 3. List of reference parcels

IDENT	REPLIC	BORDER	SIZE	SHAPE	AREA_REF	PERIM
1	A	GOOD	S	S1	3,431.80	248.7
2	A	GOOD	S	S2	3,179.50	394
3	A	GOOD	S	S3	4,081.80	650.9
4	A	GOOD	M	S1	8,450.70	388.6
5	A	GOOD	M	S2	12,387.30	519.5
6	A	GOOD	M	S3	8,567.10	1,150.40
7	A	GOOD	L	S1	23,511.30	623.3
8	A	GOOD	L	S2	27,960.70	711.4
9	A	GOOD	L	S3	24,503.30	897.9
10	A	BAD	S	S1	4,145.90	276
11	A	BAD	S	S2	3,856.80	375.6
12	A	BAD	S	S3	4,785.90	712.6
13	A	BAD	M	S1	17,747.00	546
14	A	BAD	M	S2	12,768.20	490.3
15	A	BAD	M	S3	10,955.00	635.3
16	A	BAD	L	S1	41,745.40	951

17	A	BAD	L	S2	30,883.10	965.7
18	A	BAD	L	S3	24,143.00	1,229.70
19	B	GOOD	S	S1	3,795.70	247.2
20	B	GOOD	S	S2	3,446.30	433.2
21	B	GOOD	S	S3	3,722.30	750.5
22	B	GOOD	M	S1	8,807.90	396.8
23	B	GOOD	M	S2	8,832.40	483.7
24	B	GOOD	M	S3	11,658.10	815.4
25	B	GOOD	L	S1	33,676.90	734.1
26	B	GOOD	L	S2	27,455.10	876.3
27	B	GOOD	L	S3	26,106.50	959.9
28	B	BAD	S	S1	5,710.50	307.5
29	B	BAD	S	S2	2,338.70	277.7
30	B	BAD	S	S3	4,312.30	501.5
31	B	BAD	M	S1	12,334.10	471.2
32	B	BAD	M	S2	10,420.60	468
33	B	BAD	M	S3	10,862.40	1,005.20
34	B	BAD	L	S1	28,543.40	746.9
35	B	BAD	L	S2	43,349.60	1,054.30
36	B	BAD	L	S3	41,087.00	1,170.60

5.1.4 Applied remote sensing imagery

During the experiment following RS imageries were applied:

- Panchromatic ortofotomaps from airborne photos of 1:13 000 (OP_0_2)
  - obtained from ARMA
  - pixels size: 0.2 m
- Color ortophotomaps from airborne photos of 1: 26 000 (OP_0_5)
  - Obtained from Centre of Surveying and Cartographic Documentation in Malopolska Region http://mapy.wrotamalopolski.pl/wrotamalopolski.htm
  - Pixel size: 0.75 m
- IKONOS pansharpening natural color composition (OP_1_0)
  - Pixel size: 1m

Test area is located near Krakow (commune: Zabierzów, on the north-east from Krakow).

Fig. 8. Panchromatic ortofotomap from airborne photos of 1:13 000

Fig. 9. Color ortophotomaps from airborne photos of 1: 26 000

Fig. 10. IKONOS pansharpening natural color composition

5.1.5 Technical specifications for operators – RS

Two kinds of operators participate in the experiment: skilled and unskilled. Operators (OP1, OP3, OP4, OP5) are working at Department of Photogrametry and Remote Sensing Informatics at AST – AGH Kraków. They are photogrammetry specialists (PH) or GIS. Operator OP2 is diploma student of our specialization (10th semester). Two unskilled operators (OP7 and OP8) are junior students on the 2nd and 4th semester of technical (surveying) and economy study (Academy of Economy, AE). Two others (OP9, OP10) are AST-AGH senior students of technical studies (not surveying). Last two (OP11, OP12) graduated in technical studies (not surveying), Tadeusz Kościuszko Cracow University of Technology (TKCUT).

Tab 4. List of operators

Operators skilled	Name	education	Operators unskilled	Name	education
OP1	Marta Borowiec	PH	OP7	Małgorzata Borowiec	AE student

OP2	Piotr Czajkowski	PH	OP8	Piotr Tokarczyk	AST - AGH student Surveying
OP3	Wojciech Drzewiecki	GIS	OP9	Anna Głowienka	AST – AGH student
OP4	Adam Boroń	PH	OP10	Dariusz Nowak	AST – AGH student
OP5	Andrzej Wróbel	PH	OP11	Hubert Wąsek	TKCUT graduate
OP6	Wladysław Mierzw	PH	OP12	Adam Szryniawski	TKCUT graduate

Operators had short lecture about the background of the project. The idea of measurements was presented, especially background of parcels' sequences to be measured.

Operators were trained in Geomedia software. Each operator obtained for each day prepared files:

- list of parcels to be measured on which orto (Fig. 11)
- geoworkspace: *.gws,
    - with configured ready to display images
    - number of all parcels (without reference parcels)
    - letters marking parcels building reference parcel (Fig. 12)
- warehouse: *.mdb
    - empty feature class – in the feature class operator digitized parcels according list of parcels to be measured on which orto

After measured, each operator each day provided the results, which were controlled and after control could obtain the data for next day.

			OPERATOR_1
DAY_1			
	10	OP_1_0	
	22	OP_0_2	
	3	OP_0_2	
	6	OP_1_0	
	20	OP_0_5	
	30	OP_0_2	
	36	OP_1_0	
	35	OP_0_5	
	26	OP_0_5	
	17	OP_0_2	
	25	OP_0_2	
	28	OP_0_5	
	16	OP_0_2	
	12	OP_0_5	
	32	OP_1_0	
	15	OP_1_0	
	14	OP_1_0	
	33	OP_1_0	
	27	OP_0_5	
	18	OP_1_0	
	4	OP_0_5	
	31	OP_1_0	
	2	OP_0_2	
	19	OP_0_5	
	34	OP_0_5	
	11	OP_0_5	
	8	OP_0_2	
	5	OP_0_5	
	29	OP_1_0	
	7	OP_1_0	
	23	OP_1_0	
	24	OP_1_0	
	1	OP_0_2	
	21	OP_0_2	
	13	OP_0_5	
	9	OP_1_0	

Fig. 11. List of parcels to be measured on which orto

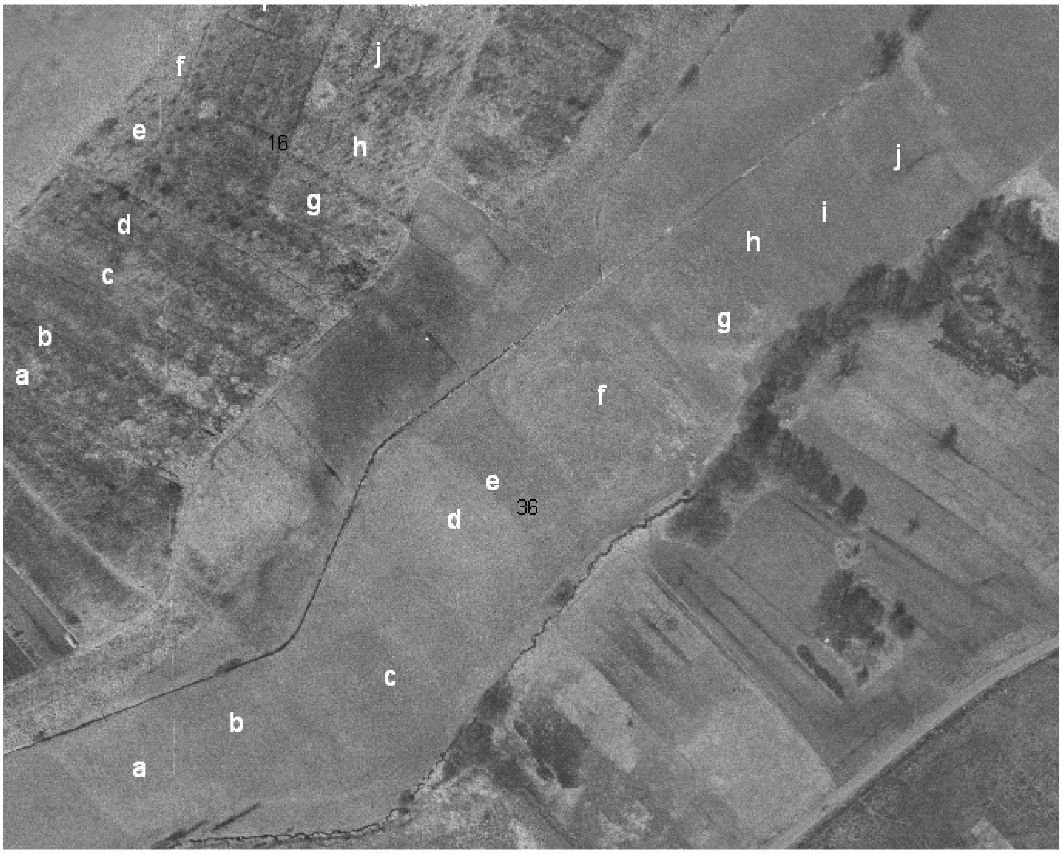


Fig. 12. Letters marking parcels building reference parcel

5.1.6 Data gathering

Data were gathered in separate files for each operator and each day. Than data were controlled, eventually corrected by operator and files from all operators were combined to one file for one day. File *.mdb contains attribute (parcel number, day, operator and ortho) and graphic (coordinates of parcel vertexes).

Tab 5. Example of *.mdb file

ID1	Geometry1	numer	dz_pom	op	ortho	Geometry1_sk
1		32	4	1		1blrGgQp
2		6	4	1		1blrGgV
3		13	4	1		1blrGgq
4		22	4	1		1blrGgF
5		10	4	1		1blrGgjR
6		11	4	1		1blrGglp
7		21	4	1		1blrGgw
8		9	4	1		1blrGgl
9		5	4	1		1blrGgq
10		28	4	1		1blrGgf

Finally all files from 9 days were combined to one file, area and perimeter were calculated. The file is on the attached CD.

5.1.7 Data export for statistical analyses

Data preparation for statistical analysis was provided automatically using macro in Excel, (Fig. 13, Fig. 14). EXP3PARCEL_MACRO.xls is on the attached CD.

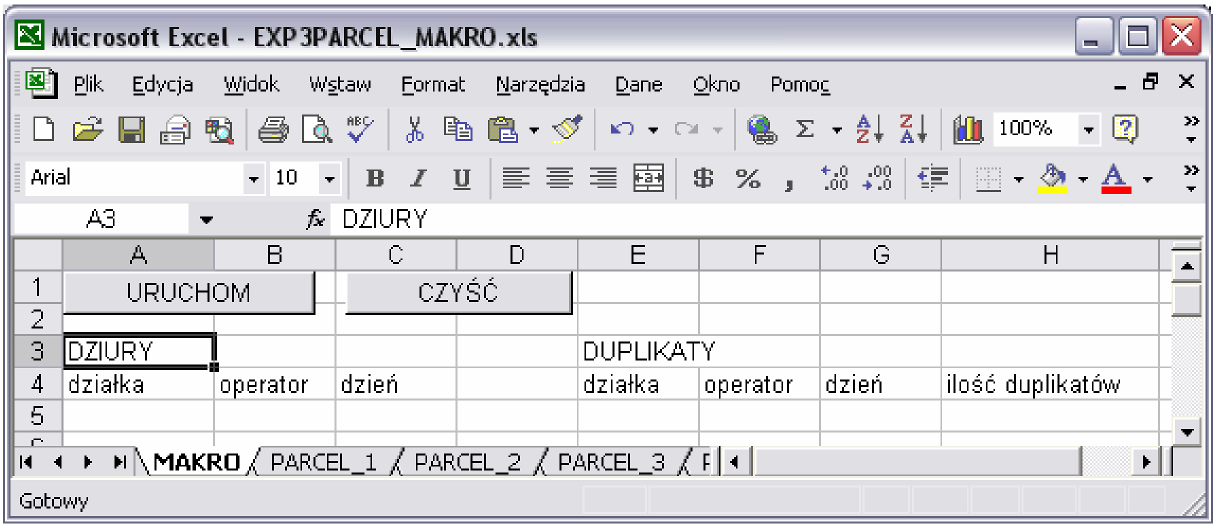


Fig. 13. Macro

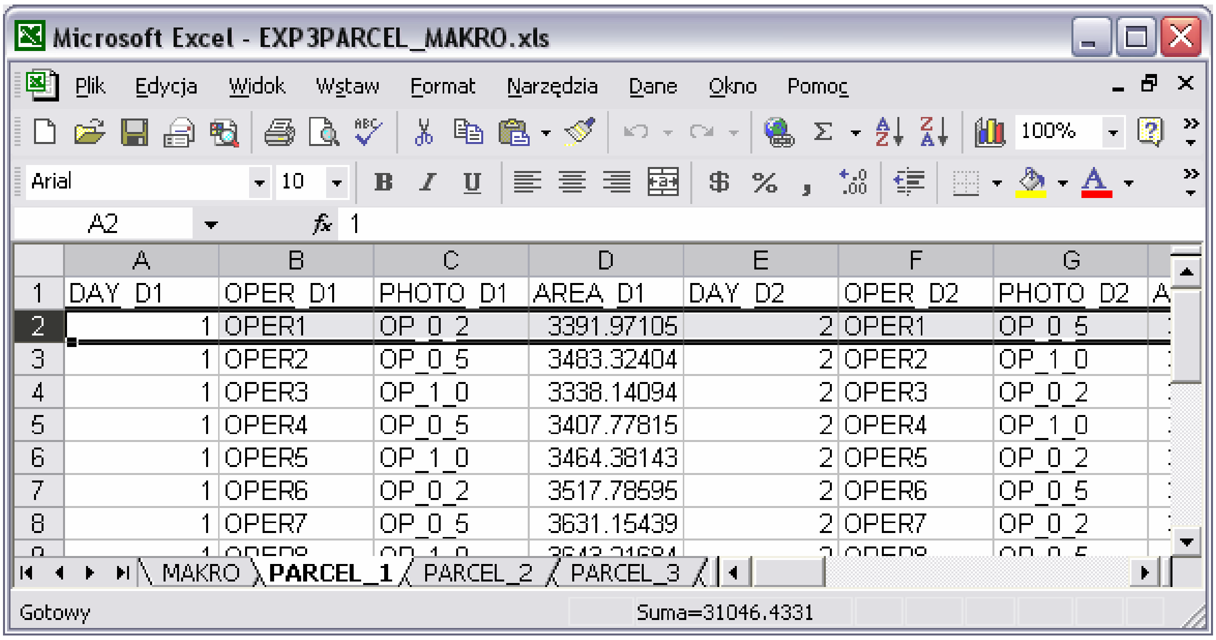


Fig. 14. Automatic fulfilled xls fields

5.2 Design of experiments – GPS

5.2.1 Introduction

During kick off meeting the preliminary decisions concerning GPS measurements were made. It was agreed that GPS measurement test would be performed by the University of Warmia and Mazury in Olsztyn in the Chair of Satellite Geodesy and Navigation. The GPS part of the project was supervised by **Prof. Stanisław Oszczak, PhD** and **Adam Ciećko, PhD**.

This was a very important task and also very difficult. Since, according to decisions made at the meetings total number of parcels was 36, an area of about 80-100 hectares was needed. Obviously no farmer would allow establishing hundreds of stakes on his field; therefore an airfield in Gryzliny (about 25 km from Olsztyn) was taken into consideration. It appeared to be a very good object, flat and vast area, free form electromagnetic fields. Nevertheless it appeared to be too small; especially there was a lack of obstructed (close to the woods) fields. After establishing of 27 parcels in the airfield and surroundings, a new object was strongly needed.

The large field of wasteland was found in Stawiguda and selected as second object. This area is rather hilly and irregular. There was an electrical line in the close neighborhood of the parcels as well as the GSM mast within the sight.

5.2.2 Reference parcels

According to the agreements made at the meetings the parcels were established in the field and marked with wooden stakes. The stakes on the corners were 1 meter long and the stakes about 35cm long were placed every 15-20 meters along the borders. Each parcel had its own color of stakes, which was especially important when the borders of 2 parcels were close to each other.

It was agreed that no border can be the same for 2 parcels; the minimum distance between two borders was set to 20 meters. In peculiar situations an intersection of the borders was acceptable. In several cases (especially for the obstructed parcels) the intersection was inevitable. <u>Altogether over 850 stakes were used!</u>

5.2.2.1 Design of reference parcels

The graphical presentation of the parcels is given in the Figures Fig. 16 and Fig. 17.

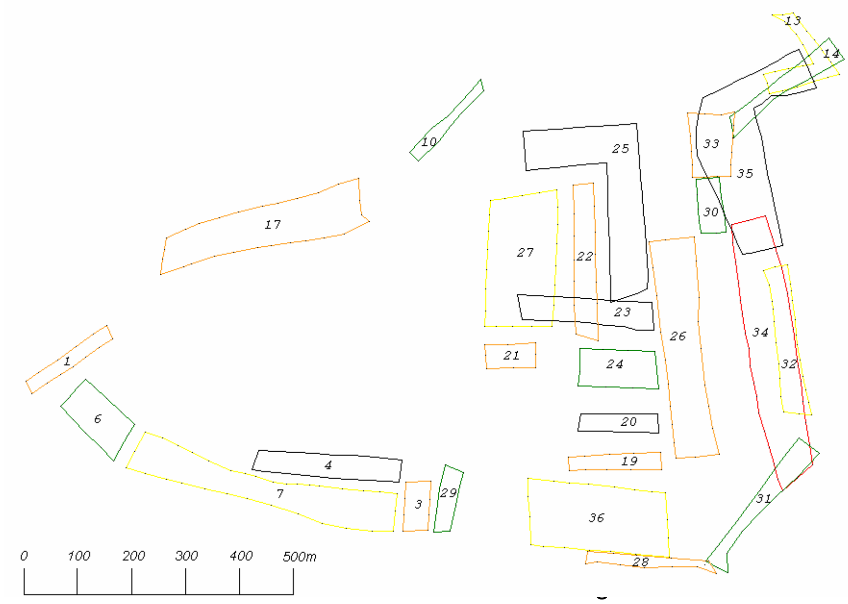


Fig. 16. Test object in the airfield in Gryźliny

Fig. 17. Test object in Stawiguda

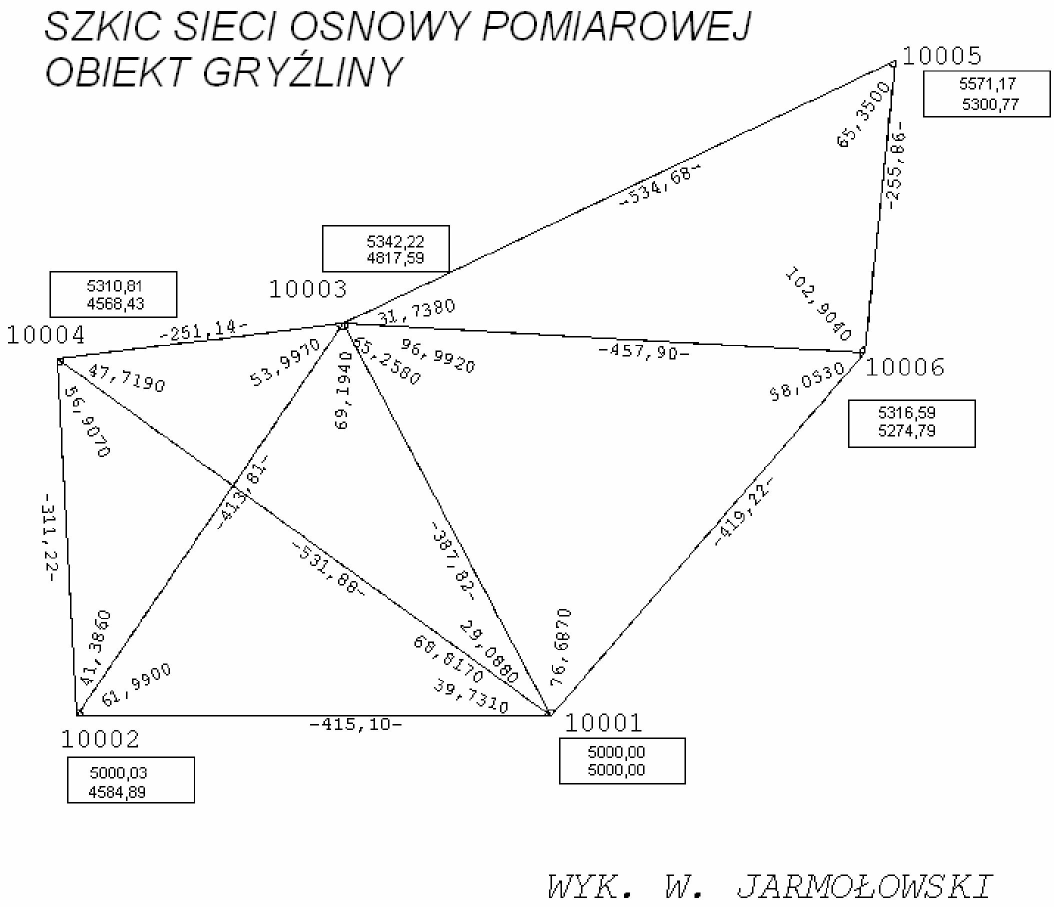
5.2.2.2 Geodetic measurements of reference parcels

The network was referred to Polish geodetic network POLREF. The coordinates of the parcels were calculated in Polish reference system 2000/21. The field work and calculation concerning preparation phase of experiment were made by the team of workers and PhD students of Chair of Satellite Geodesy and Navigation under leadership of **Wojciech Jarmołowski, MSc.**

The preparation phase of the test objects (marking the parcels and total station measurements) **took 2 weeks of hard work.** The reference values of the 36 parcels are given below:

Tab 6. Reference parcels – Total station measurements

IDENT	REPLIC	BORDER	SIZE	SHAPE	AREA_REF [ha]	PERIM [m]
1	A	GOOD	S	S1	0.4840	416.85
2	A	GOOD	S	S2	0.4079	378.56
3	A	GOOD	S	S3	0.4250	275.21
4	A	GOOD	M	S1	1.1217	617.79
5	A	GOOD	M	S2	1.2506	594.56
6	A	GOOD	M	S3	0.9641	412.34
7	A	GOOD	L	S1	2.9678	1145.47
8	A	GOOD	L	S2	2.8344	999.51
9	A	GOOD	L	S3	2.9342	736.62
10	A	BAD	S	S1	0.3690	413.54
11	A	BAD	S	S2	0.3882	358.33
12	A	BAD	S	S3	0.4229	287.38
13	A	BAD	M	S1	0.7056	569.08
14	A	BAD	M	S2	0.7740	576.82
15	A	BAD	M	S3	1.0274	438.40
16	A	BAD	L	S1	3.3783	1038.56
17	A	BAD	L	S2	2.8458	935.47
18	A	BAD	L	S3	2.9569	748.93
19	B	GOOD	S	S1	0.4856	400.96
20	B	GOOD	S	S2	0.4928	359.66
21	B	GOOD	S	S3	0.4112	278.42
22	B	GOOD	M	S1	1.1290	650.74
23	B	GOOD	M	S2	1.1463	593.68
24	B	GOOD	M	S3	1.0049	428.96
25	B	GOOD	L	S1	3.1311	1075.00
26	B	GOOD	L	S2	3.0116	979.18
27	B	GOOD	L	S3	3.0878	737.41
28	B	BAD	S	S1	0.4233	522.25
29	B	BAD	S	S2	0.4016	306.44
30	B	BAD	S	S3	0.4635	293.72
31	B	BAD	M	S1	0.9028	669.58
32	B	BAD	M	S2	1.1362	648.04
33	B	BAD	M	S3	0.9012	397.16
34	B	BAD	L	S1	3.9512	1113.94
35	B	BAD	L	S2	3.9169	1055.88
36	B	BAD	L	S3	3.0999	758.10



5.2.3 Applied GPS system

It was stated that equipment owned by University of Warmia and Mazury in Olsztyn can be used in the tests. These were:

- 4 Thales Mobile Mapper receivers
- 4 Satcon receivers
- 1 Garmin GPSMap 76S receiver

It was also mentioned that an extra Garmin receiver can be obtained from Polish dealer of Garmin - EXCEL Systemy Nawigacyjne Sp. Jawna, ul. Monte Cassino 24, 70-467 SZCZECIN, http://www.garmin.pl.

It was said that the receivers of one kind should have the same options, firmware and accessories. Garmin and Thales receivers were updated using firmware obtained from WebPages. Satcon GPS receivers (Ricaline 6010) were sent to Germany to the manufacturer of SatconSystem to upload the newest firmware.

Short description of the receivers chosen for the experiment is given in Appendix 10.

5.2.4 GPS measurements team

Field measurements were made by each of the team independently. Operators were divided to skilled and unskilled. The operators were selected from the students of Geodesy and Land Management Faculty, Specialization: Geodesy and Satellite Navigation. The full list of the observers is given below:

TEAM	STATUS	IDENT	NAME
TEAM_1	Unskilled	OPER_11	Paweł Klockowski
	Unskilled	OPER_12	Daniel Leleniewski
	Unskilled	OPER_13	Joanna Janowiec
	Skilled	OPER_14	Zinkiewicz Daniel
	Skilled	OPER_15	Arkadiusz Przesmycki
	Skilled/Leader	OPER_16	Rafał Gregorczyk
TEAM_2	Leader	-	Marcin Uradziński
	Unskilled	OPER_21	Marcin Gryszko
	Unskilled	OPER_22	Wojciech Augustyniak
	Unskilled	OPER_23	Michał Czajkowski
	Skilled	OPER_24	Przemysław Wasilczyk
	Skilled	OPER_25	Łukasz Grądzki
	Skilled	OPER_26	Tomasz Gronostajski
TEAM_3	Leader	-	Arkadiusz Tyszko
	Unskilled	OPER_1	Andrzej Pawlak
	Unskilled	OPER_2	Radosław Cecot
	Skilled	OPER_3	Paweł Ronowicz
	Skilled	OPER_4	Maciej Rudziński
TEAM_4	Leader	-	Arkadiusz Tyszko
	Unskilled	OPER_5	Jakub Rojek
	Unskilled	OPER_2	Radosław Cecot
	Skilled	OPER_6	Mirosław Depta
	Skilled	OPER_4	Maciej Rudziński

5.2.5 Experimental design

After the second meeting the final experimental design was established. Two experiments were carried out on 36 land parcels (18 parcels for each experiment).

5.2.6 Material

5.2.6.1 Land parcels

The 36 different land parcels are measured. These parcels are selected according to:

- size : 3 levels (labelled 1, 2, 3)
- shape : 3 levels (labelled 1, 2, 3)
- border : 2 levels (labelled 1, 2)
- replication : 2 levels (labelled 1, 2).

5.2.6.1.1 Size

- S : small (0.3 – 0.5 ha)
- M : medium (0.8 – 1.2 ha)
- L : large (2.4 – 4 ha)

5.2.6.1.2 Shape (ratio of width:length)

- S1 : form factor – level 1 < 1:3
- S2 : form factor – level 2 < 1:6
- S3 : form factor – level 3 > 1:6

5.2.6.1.3 Border

- GOOD : good conditions (open horizon)
- BAD : bad conditions (obstructions by the trees)

5.2.6.1.4 Replic

- A : first replication (parcels allocated to experiment 1)
- B : second replication (parcels allocated to experiment 2)

5.2.7 Instruments

The10 instruments are available. They are of the following makes

- Garmin (2 instruments): G1, G2 – one borrowed from EXCEL Systemy Nawigacyjne
- Thales (4 instruments): T1, T2, T3, T4
- Satcon (4 instruments): S1, S2, S3, S4

It was agreed that all observations will be downloaded on PC. The exception was the Garmin instrument which can store results of only 10 parcels and the download speed is very limited. Garmin results were only written down in the field notes.

5.2.8 Teams of operators

The 20 operators are allocated to 4 teams.

- Team 1 : 6 operators (3 skilled + 3 unskilled) using instruments : G1, T1, S1

- Team 2 : 6 operators (3 skilled + 3 unskilled) using instruments : G2, T2, S2
- Team 3 : 4 operators (2 skilled + 2 unskilled) using instruments : T3, S3, T4, S4
- Team 4 : 4 operators (2 skilled + 2 unskilled) using instruments : T3, S3, T4, S4

5.2.9 Designs

5.2.9.1 Introduction

The 36 land parcels are allocated to two sets, set 1 and set 2, according to the level of replication: parcels of replication level equal to 1 are allocated to the set 1 (18 parcels) and parcels of replication level equal to 2 are allocated to set 2 (18 parcels).

Two separate designs are proposed. Experiment 1 is designed for the first set of 18 parcels and experiment 2 is designed for the second set of 18 parcels.

- parcels 1-18 experiment 1 (team 1 and 2),
- parcels 17-36 experiment 2 (team 3 and 4).

Experiment 1 gives 1944 independent results and experiment 2 gives 1728 results. So, all together 3672 GPS measurements will be available.

5.2.9.2 Experiment 1

5.2.9.2.1 Material

Experiment 1 is designed for the 18 land parcels of set 1. This experiment is carried out by team 1 and team 2. Three instruments are used by each team. They are labelled G1, T1 and S1 for team 1 and G2, T2 and S2 for team 2. Only one team makes measurements in a given land parcel.

5.2.9.2.2 Experimental design for a given land parcel

The same design is used for each land parcel. So the design is replicated 18 times. We first give the design for a given land parcel then, we will consider the whole experiment.

Suppose that team 1 is allocated to land parcel 1. On this land parcel, and on a given day each operator makes the measurement with each instrument. So 6 x 3 = 18 results are obtained on this given day. The same measurements are repeated on day 2, day 3, day 4, day 5, day 6. So, for parcel 1, 18 x 6 = 108 measurements are made.

5.2.9.2.3 Measurements of all the land parcels

The design described for a given land parcel is repeated on each of the 18 land parcels. Since two teams are available, each team will perform the measurements on 9 parcels, during 6 days.

Measurement days have to be independent but there is no need to measure during 6 days in a row.

5.2.9.3 Experiment 2

5.2.9.3.1 Material

Experiment 2 is designed for the 18 land parcels of set 2. This experiment is carried out by team 3 and team 4, with four instruments, labelled T3, S3, T4 and S4.

5.2.9.3.2 Experimental design for a given land parcel

The same design is used for each land parcel. So the design is replicated 18 times. We first give the design for a given land parcel. Then we consider the whole experiment.

On a given land parcel and a given day each operator makes the measurement with each instrument. So, 4 x 4 = 16 results are obtained on this given day. The same measurements are repeated on day 2, day 3 and day 4, day 5, day 6. So, for a given land parcel 16 x 6 = 96 measurements are made.

5.2.9.3.3 Measurement of all the land parcels

The design described for a given parcel is repeated on each of the 18 land parcels. The measurements are made during a time period of 12 days (6 days – team 1 and 6 days – team 2), 9 parcels have to be measured on a first period of six days and 9 parcels have to be measured on a second period of six days. Measurement days have to be independent but there is no need to measure during 12 days in a row.

5.2.10 Order of measurements.

The order of the parcel measurements for each of the days is random. It was stressed that given order can not be changed. Also order of measurements for each given parcel was random and can not be changed. This is also a very important factor for observers to keep them vigilant and prevent from boredom. The order of measurements for each day for every team is given below:

team 1					
DAY_1	DAY_2	DAY_3	DAY_4	DAY_5	DAY_6
10	6	14	10	14	3
13	3	17	7	4	1
7	1	4	13	17	6
1	14	13	14	3	7
3	4	10	17	6	10
6	17	7	4	1	13
14	13	1	1	10	4
17	10	3	6	13	17
4	7	6	3	7	14
team 2					
DAY_1	DAY_2	DAY_3	DAY_4	DAY_5	DAY_6
9	16	18	11	8	15
5	12	8	5	18	16
11	15	2	9	2	12
15	18	11	8	16	5
12	2	9	18	15	11
16	8	5	2	12	9
8	5	16	16	5	18
2	9	15	15	11	8
18	11	12	12	9	2

team 3					
DAY_1	DAY_2	DAY_3	DAY_4	DAY_5	DAY_6
19	36	31	32	32	19
20	26	26	23	29	24
24	31	36	29	23	20
36	20	32	36	20	23
26	19	23	26	24	29
31	24	29	31	19	32
32	32	20	24	36	26
23	29	24	19	26	36
29	23	19	20	31	31
team 4					
DAY_1	DAY_2	DAY_3	DAY_4	DAY_5	DAY_6
35	33	21	27	34	35
25	28	25	34	27	25
21	22	35	30	30	21
22	25	34	28	25	27
28	21	30	33	21	30

33	35	27	22	35	34
27	30	33	35	33	33
30	34	28	21	22	28
34	27	22	25	28	22

5.2.11 Technical specifications for operators GPS

Before the actual measurements short training and written instructions were given to the observers. In the instructions, each of the observers got detailed:

- Information about parcels
- Information about instruments
- Description of experiment 1 and 2
- Detailed explanation of field measurement
- Naming of the parcel files
- Schedule of measurements

The full text of instructions (in Polish) is given in appendix 10.3.

Due to unstable EGNOS performance it was agreed to perform all the measurements without the EGNOS corrections. The EGNOS option was switched off in each of the receivers.

Special filed notes tables were prepared for each of the teams. The results (area measured and perimeter) were noted in the field. The graphical example of field measurement is presented in Fig. 19.

Fig. 19. Parcel measurement. Team_4.

Very often the field measurements were performed in unfavorable weather conditions. There was also totally unexpected problem with the tear gas which was used by the police practicing some tactical maneuvers, nearby our test objects (Fig. 8)

One day observation took about 10-12 hours, each of the operators walked along the borders on a single day about 20 kilometers!

Altogether the total distance walked by the operators during GPS measurements of all teams exceeded 2250 km!!!.

Fig. 20. . Parcel measurement. Police tactical exercises can be seen in the background

5.2.12 Data gathering

5.2.12.1 Detailed information about experiment 1

Operators unskilled: **11, 12, 13** (team_1), **21, 22, 23** (team_2). Operators skilled: 14, 15, 16 (team_1), 24, 25, 26 (team_2). Working days for teams 1 and 2 were the same and they were:

- Day_1 – 20. 04. 2005
- Day_2 – 22. 04. 2005
- Day_3 – 25. 04. 2005
- Day_4 – 26. 04. 2005
- Day_5 – 27. 04. 2005
- Day_6 – 28. 04. 2005

All parcels were prepared according to given instructions.

Parcels measured by team_1 (1, 3, 4, 6, 7, 10, 13, 14, 17) are located in airfield in Gryźliny.

Parcels measured by team_2 (2, 5, 8, 9, 11, 12, 15, 16, 18) are located in the second object in Stawiguda.

5.2.12.2 Detailed information about experiment 2

Operators unksilled: **1, 2** (team_3), **5, 2** (team_4). Operators skilled: **3, 4** (team_3), **6, 4** (team_4). Operators **2 and 4** were working in both **team 3** and **team 4.**

Working days:,

Team 3:

- Day_1 – 20. 04. 2005
- Day_2 – 22. 04. 2005
- Day_3 – 25. 04. 2005
- Day_4 – 26. 04. 2005
- Day_5 – 27. 04. 2005
- Day_6 – 28. 04. 2005

Team 4:

- Day_1 – 05. 05. 2005
- Day_2 – 06. 05. 2005
- Day_3 – 09. 05. 2005
- Day_4 – 10. 05. 2005
- Day_5 – 12. 05. 2005
- Day_6 – 13. 05. 2005

All parcels were prepared according to given instructions.
Parcels measured by both team_**3** (19, 20, 23, 24, 26, 29, 31, 32, 36) and **team_4** (21, 22, 25, 27, 28, 30, 33, 34, 35) are located in airfield in Gryźliny.

The test objects were visited by the contactors of the project on 11th of May 2005 – Fig. 21. There was also a meeting with the operators and team leaders on the same day .

Fig. 21. Inspection in the field by the project's contractors.

5.2.13 Data preparation for statistical analyses

After the field measurements all collected data were entered from the filed notes into a spreadsheet. The entered data were double checked and special spreadsheets were prepared for further calculation.

All the observation files (from Thales and Satcon) collected during measurements were downloaded to the PC, sorted and prepared for further analyses.

5.3 Coefficient calculations for accuracy estimations

5.3.1 Backgrounds

Accuracy estimation was based on point position error using following formulas (Hejmanowska B. 2003, Bogaert P., Delinc´e J., Kay S. 2005):

(23) $$m_p = m_{pkt} \sqrt{\sum_{i=1}^{n} \frac{(y_{i+1} - y_{i-1})^2 + (x_{i-1} - x_{i+1})^2}{8}}$$ (BH)

(24) $$m_P = m_{pkt}\sqrt{\frac{1}{2}\sum_{i=1}^{n}(r_i^2 - r_i r_{i+2}\cos(\alpha_{i+2}-\alpha_i))}$$ (BDK)

where:

m_P – area error,

m_{pkt} – point position error

x, y – Cartesian coordinate of parcel vertices

r, α – polar coordinate of parcel vertices.

n – number of parcels vertices.

Generally we can write:

(25) m_P= m_{pkt} Area_error_cofficient

Area_error_coefficient calculated from Cartesian coordinates is almost always the same as calculated from polar coordinates. In some cases (very coincidence geometry, 2 points very near each other on vertex) formula (24) gives bad results.

All analysis was performed assuming m_{pkt} = 1, it means that only Area_error_coefficient was calculated. For calculation own software was used.

5.3.2 Workflow

Area_error_coefficients are calculated using own prepared software:

- Area error calculation xy.exe – version1 for formula ((23)
- Area error calculation xy_polar – version2 for formulas: ((23) and (24)

To apply the software data preparation is needed. Area_error_coefficients are calculatede on the basis of reference parcels. From GIS software: GeoMedia, coordinate of reference parcels are exported to text file (see 05.3.2.1.1). Than polar coordinates are calculated (see 5.3.2.1.2). Finally Area_error_coefficients are calculated (see 5.3.2.1.3).

5.3.2.1 Preparing text files for calculations.

5.3.2.1.1 The file of Cartesian coordinates calculations

Parcels are described in object model, it means that parcel are identified by ID and x,y coordinate of each vertices. Land parcel is an polygon, so the first point and the last one has the same coordinates (X_0,Y_0).

ID

X_0 Y_0

....

X_0 Y_0

1

7417724.0295 5553736.2709

7417772.4838 5553741.0013

7417744.2319 5553661.0135

7417700.3765 5553669.8735

7417724.0295 5553736.2709

2

7416418.7351 5552595.3742

7416435.2316 5552593.7601

7416428.7019 5552411.8346

7416409.9633 5552421.0627

7416418.7350 5552595.3727

7416418.7351 5552595.3742

File for measurements:

- AGH CD\Area error calculation\AGH_xy.txt
- UWM CD\Area error calculation\ UWM_xy.txt

5.3.2.1.2 Polar coordinates calculation

Cartesian coordinates can be easily recalculated into polar coordinate system:

- AGH CD\Area error calculation\AGH_polar_calculation.xls
- UWM CD\Area error calculation\UWM_polar_calculation.xls

7417936.2	5552573.07				
1				1	
7417724.03	5553736.27	-212.1705	1163.2009	-0.18042	1182.393
7417772.48	5553741	-163.7162	1167.9313	-0.13927	1179.35
7417744.23	5553661.01	-191.9681	1087.9435	-0.17465	1104.75
7417700.38	5553669.87	-235.8235	1096.8035	-0.21179	1121.869
7417724.03	5553736.27	-212.1705	1163.2009	-0.18042	1182.393

File of polar coordinates:

- AGH CD\Area error calculation\ AGH_polar.txt
- UWM CD\Area error calculation\ UWM_polar.txt

5.3.2.1.3 Area_error_coefficient calculation

Area_error_coefficient was calculated applying following software:

- Area error calculation xy.exe for calculation of area error coefficient based on Cartesian coordinates

- Area error calculation xy_polar.exe for calculation of area coefficient based on polar coordinates

Tab 7. Area error coefficient AGH

Tab 8. ID AREA BH BH/A BDK

Id	Pole[m2]	Blad[m2]	BladWzgl[%]	BladBieg[m2]
1	3431.78	63.9	1.862	63.9
2	3179.49	126.87	3.99	2144.81
3	4081.83	123.79	3.033	123.79
4	8450.68	83	0.982	83
5	12387.27	146.03	1.179	146.03
6	8567.1	155.27	1.812	155.27
7	23511.33	150.22	0.639	150.22
8	27960.71	119.61	0.428	119.61
9	24503.28	141.59	0.578	141.59
10	4145.92	71.84	1.733	71.84
11	3856.83	116.65	3.025	2191.88
12	4785.93	155.46	3.248	155.46
13	17747	127.14	0.716	127.14
14	12768.24	112.04	0.878	112.04
15	10955.06	162.78	1.486	162.78
16	41745.43	195.93	0.469	195.93
17	30883.16	185.27	0.6	185.27
18	24143	171.54	0.711	171.54
19	3795.68	61.86	1.63	61.86
20	3446.28	114.11	3.311	114.11
21	3722.3	110.9	2.979	110.9
22	8807.86	94.41	1.072	94.41
23	8832.43	142.61	1.615	142.61
24	11658.05	203.32	1.744	203.32
25	33676.91	183.52	0.545	183.52
26	27455.06	163.69	0.596	163.69
27	26106.52	197.21	0.755	197.21
28	5710.47	78.14	1.368	78.14
29	2338.73	58.81	2.514	58.81
30	4312.32	151.34	3.509	151.34
31	12334.07	123.88	1.004	123.88
32	10420.59	121.75	1.168	121.75
33	10862.41	155.03	1.427	155.03
34	28543.4	134.34	0.471	134.34
35	43349.56	158.69	0.366	158.69
36	41087.04	130.99	0.319	130.99

Tab 9. Area error coefficient UWM

Tab 10. ID AREA BH BH/A BDK

Id	Pole[m2]	Blad[m2]	BladWzgl[%]	BladBieg[m2]
1	4840.33	77.62	1.604	77.62
2	4078.53	58.42	1.432	58.42
3	4249.97	58.17	1.369	58.17
4	11217.49	95.3	0.85	95.3
5	12505.57	91.8	0.734	91.8
6	9640.73	74.53	0.773	74.53
7	29677.78	141.76	0.478	141.76
8	28343.55	135.38	0.478	135.38
9	29342.36	98.96	0.337	98.96
10	3689.74	77.63	2.104	77.63
11	3882.17	67.56	1.74	67.56
12	4229.26	48.81	1.154	48.81
13	7056.18	79.22	1.123	79.22
14	7740.37	83.94	1.084	83.94
15	10273.58	79.47	0.774	79.47
16	33783.29	120.98	0.358	120.98
17	28458.24	123.05	0.432	123.05
18	29569.13	90.53	0.306	90.53
19	4855.66	83.8	1.726	83.8
20	4927.9	71.73	1.456	71.73
21	4111.65	63.46	1.543	63.46
22	11289.99	113.72	1.007	113.72
23	11463.02	102.57	0.895	102.57
24	10049.25	89	0.886	89
25	31310.78	130.69	0.417	130.69
26	30115.77	147.26	0.489	147.26
27	30878.09	107.72	0.349	107.72
28	4232.64	104.72	2.474	104.72
29	4016.29	67.83	1.689	67.83
30	4634.89	54.45	1.175	54.45
31	9027.64	109.93	1.218	109.93
32	11361.55	91.12	0.802	91.12
33	9012.34	67.55	0.75	67.55
34	39512.02	135.04	0.342	135.04
35	39169.17	116.85	0.298	116.85
36	30998.68	117.82	0.38	117.82

6. The statistical analysis of a trial datasets

6.1.1 Remote sensing

6.1.1.1 Critical examination of the data

The method proposed in ISO 5725-2 and described in part 3.3 is used to identify outliers and other irregularities.

The pooling factor is the factor "operator". Each photo has been examined by each operator on three different days. So, the observations are allocated into 1296 groups (12 operators × 36 parcels × 3 photos). The 36 observations related to a given photo of a given parcel (12 operators × 3 days) are analyzed separately. So the identification of outliers and other irregularities is repeated 108 times (36 parcels × 3 photos).

Out of 1296 groups, 28 are identified as outliers (2,16 %). For each of these groups, all the observations are discarded (84 observations). Most of these groups are identified by COCHRAN's test (22 groups), due to too large standard deviation within repetitions for a given operator. Only six groups are identified by GRUBB's tests, due to too extreme mean values for one or two operators.

For operator 2 and operator 11, five groups (among 108 groups) are discarded. For operators 3, 6, 8 and 12, three groups are discarded. For the other operators, two or less than two groups are discarded.

Regarding the photos, 10 groups for photo OP_0_2, 6 groups for photo OP_0_5 and 12 groups for photo OP_1_0 are identified.

For parcel 24, four groups are discarded. For parcel 5 and parcel 17, three groups are discarded and for the other parcels only two or less than two groups are identified.

The complete list of all the 84 observations that are discarded is given in Appendix **Błąd! Nie można odnaleźć źródła odwołania.**.

Figures: Fig. 22-Fig. 25give to boxplots of the h_i and k_i values defined by MANDEL, before and after discarding these observations. The definition of h_i and k_i values are given in part 3.3.2. Let us recall that h_i is a measurement of the standardized distance of the mean value observed for the operator i from the general mean of all observations for a given parcel and a given photo, and k_i is the ratio of the within operator i standard deviation to the mean value of the within standard deviation of all operators.

The h_i plots show that operator 11 often overestimates and that operator 12 often underestimates the area of the parcels. Comparing the boxplots drawn before and after discarding 84 observations shows that there are slightly less extreme values after having discarded these observations.

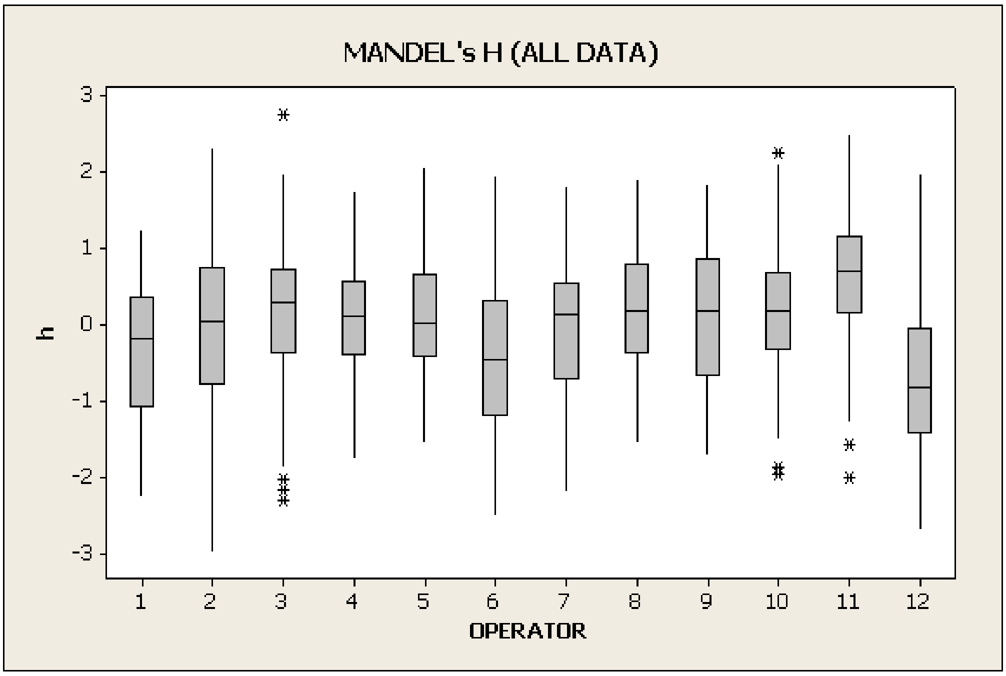


Fig. 22. Boxplot of MANDEL's h_i values as a function of operators (before discarding observations).

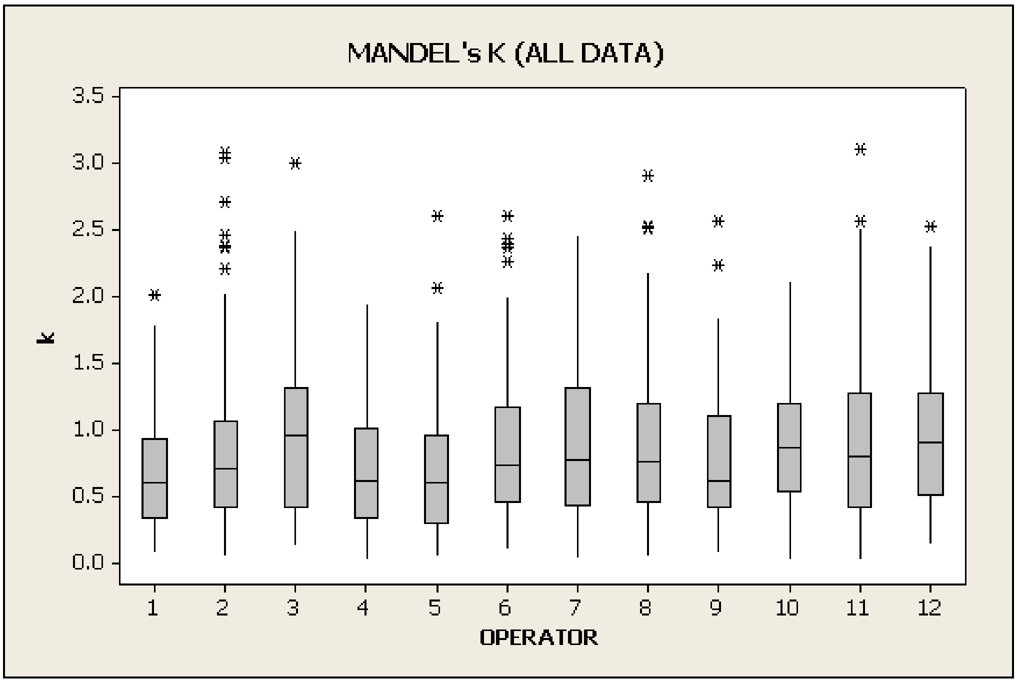


Fig. 23. Boxplot of MANDEL's k_i as a function of operators (before discarding observations).

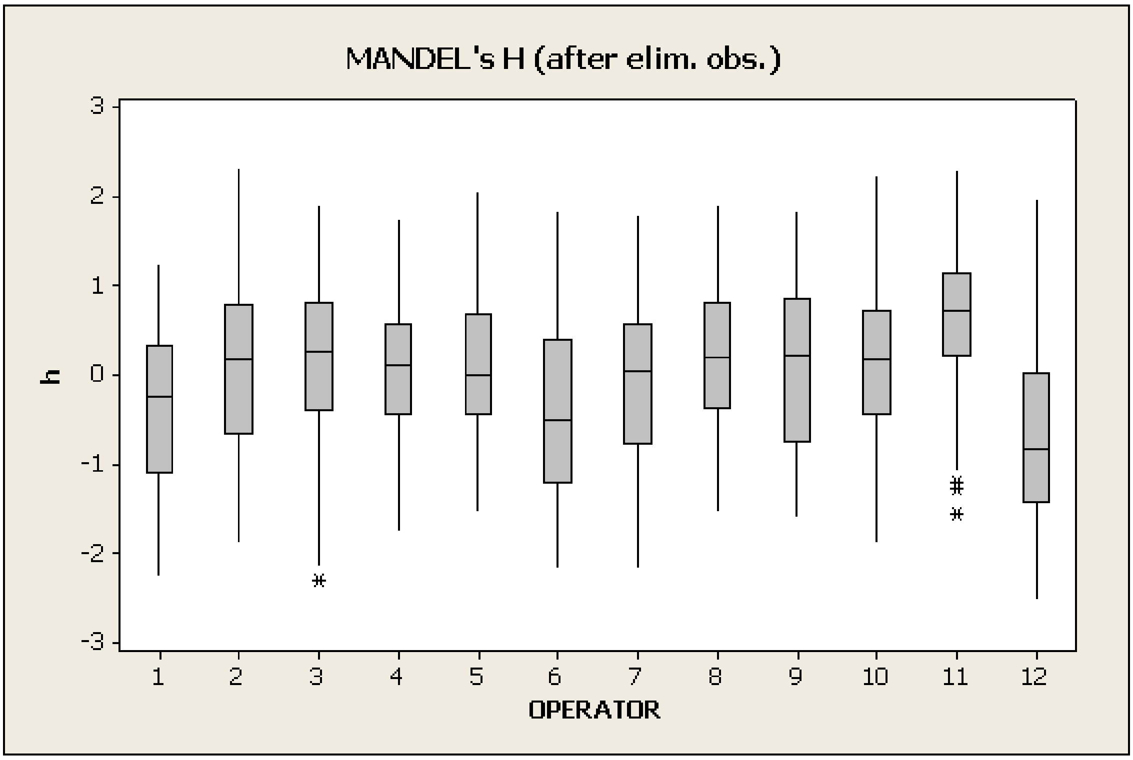


Fig. 24. Boxplot of MANDEL's h_i values as a function of operators (after a discarding 84 observations).

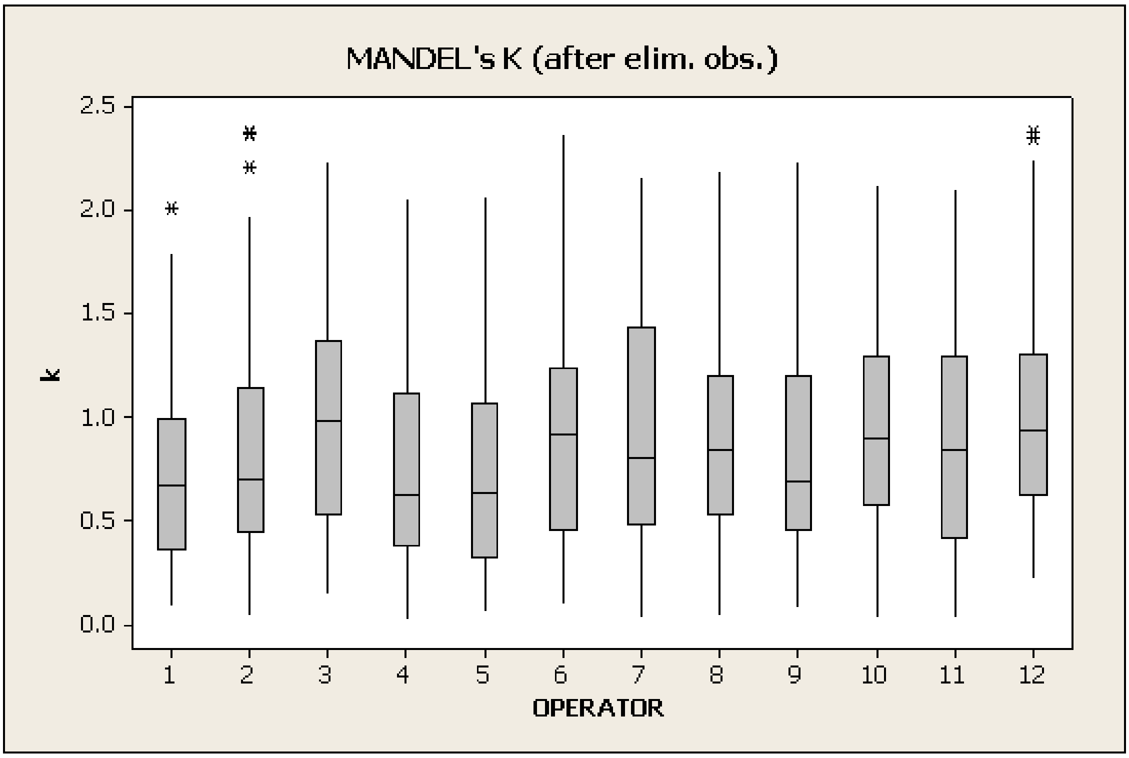


Fig. 25. Boxplot of MANDEL's k_i values as a function of operators (after discarding 84 observations).

The k_i plots show that variability does not vary between operators and that discarding observations reduces the range of the values of k_i. No difference between skilled operators (operator 1 to operator 6) and unskilled operators (operator 7 to operator 12) is visible from these plots.

As a conclusion of this critical examination of observations, we propose to discard all the identified observations by ISO 5725-2 procedure (84 observations) and we consider that no operator shows a special pattern giving us a reason to discard him or her.

6.1.1.2 Individual relative errors

Figures : Fig. 26-Fig. 29 give the distributions of the errors (in percent). Fig. 26 and Fig. 27 give the differences between observations and reference areas, in percent of the reference areas for all data (Fig. 26) and after discarding 84 observations (Fig. 27) :

(26) relative error = 100 (observation – reference area)/reference area.

Fig. 28 and Fig. 29 give the differences between observations and the general mean (of all observations made on the parcel), for all the data (Fig. 28Fig. 29) and after discarding 84 observations (Fig. 29):

(27) relative error = 100 (observation – general mean)/general mean.

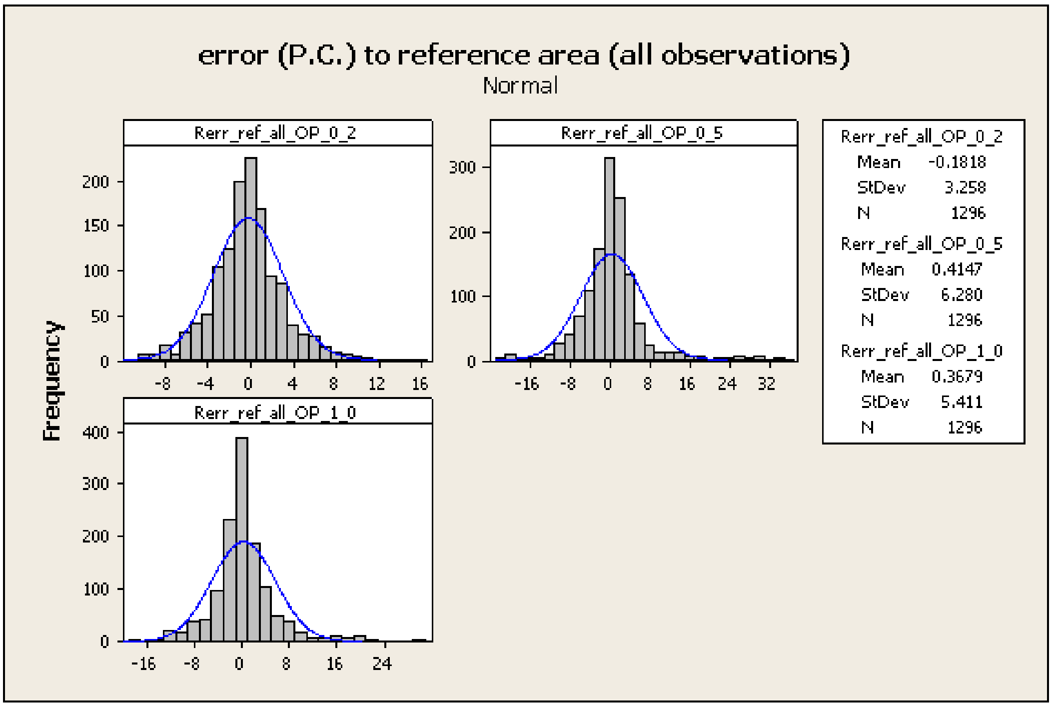


Fig. 26. Histogram of the errors (in percent) to reference area for all observations.

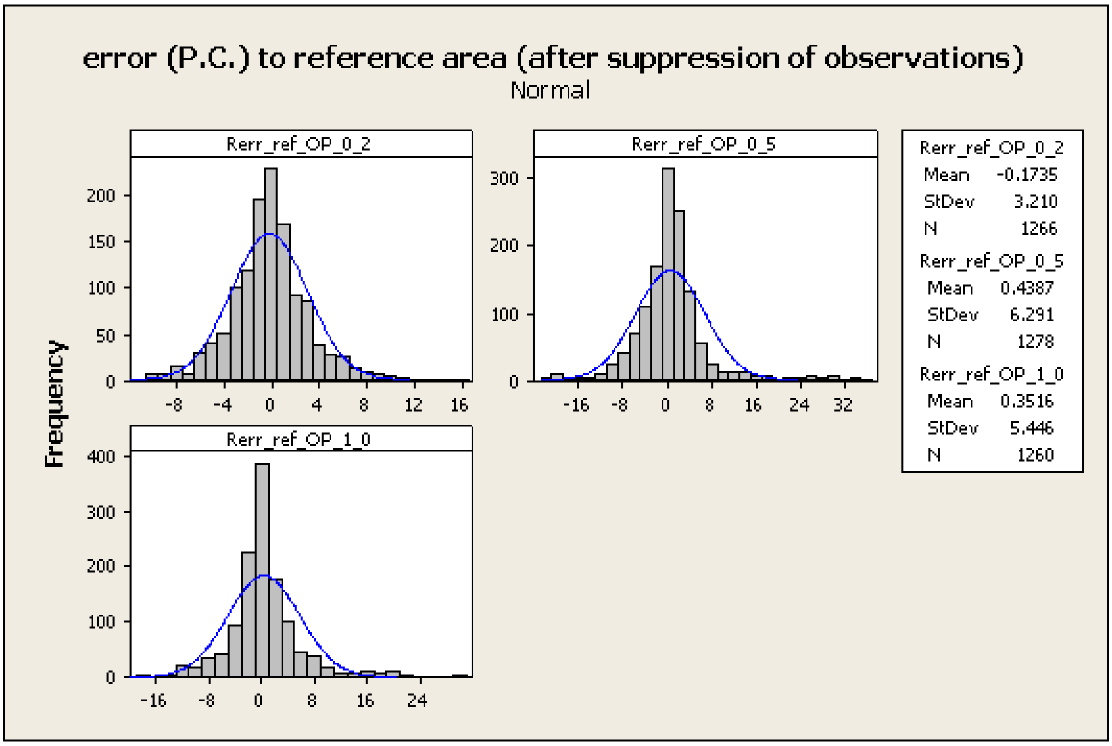


Fig. 27. Histogram of the errors (in percent) to reference area after discarding 84 observations.

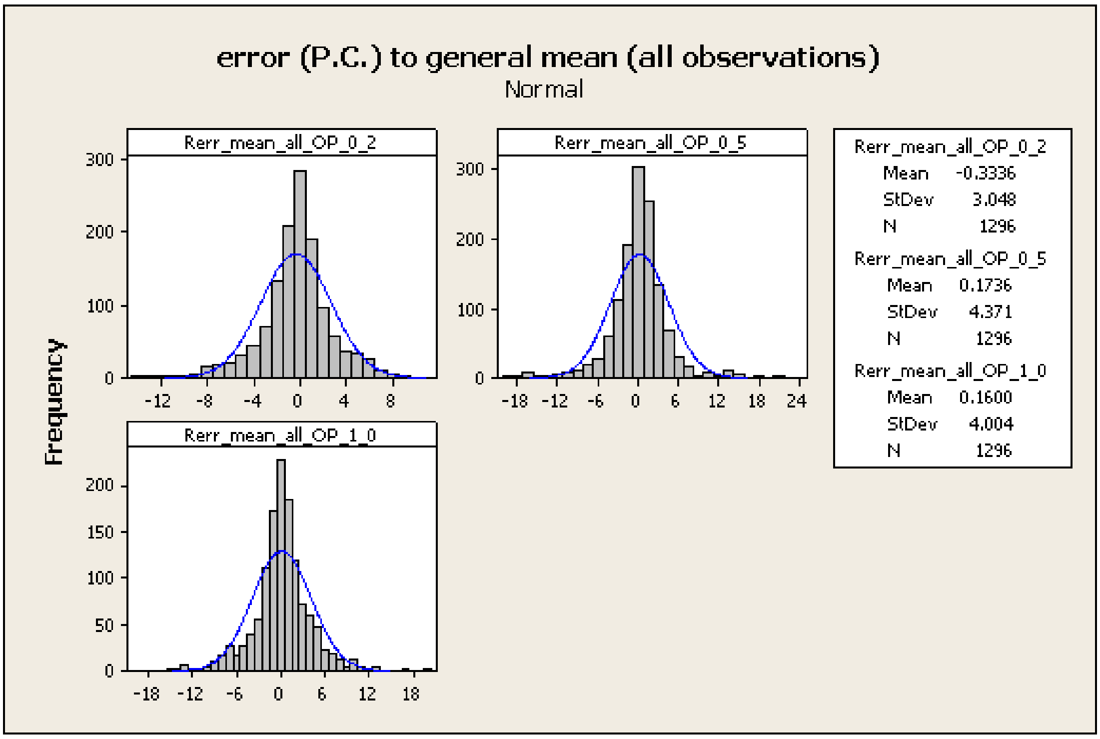


Fig. 28. Histogram of the error (in percent) to the general mean for all observations.

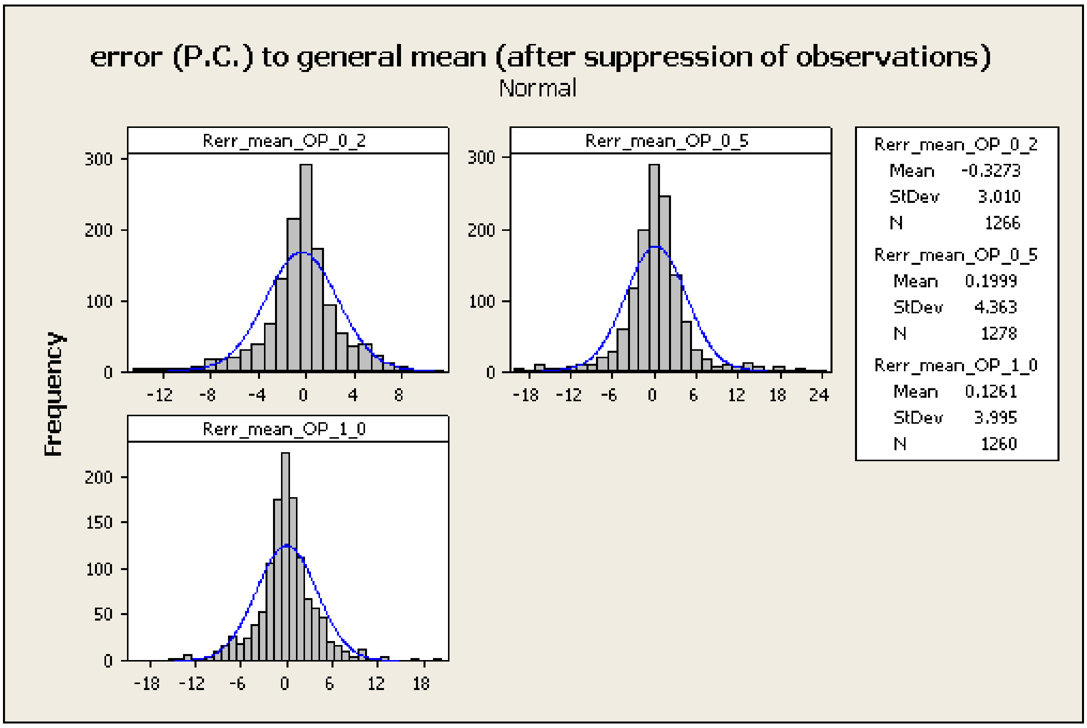


Fig. 29. Histogram of the error (in percent) to the general mean after discarding 84 observations).

Table: Tab 11 gives the percentage of observations with a (absolute) relative error less than a given value. The errors are computed as follows, after discarding 84 observations :

(28) (absolute) relative error = 100 | observation – general mean | /general mean.

From this Tab 11, we can see, for example, that 76.3 percents of observations for photo OP_0_2 show a deviation from the mean smaller or equal to 3 percents. For photos OP_0_5 and OP_1_0, the percentages are 68.4 and 71.0.

Tab 11. .Cumulative percentages of observations as a function of the error (%).

Error (%)	OP_0_2	OP_0_5	OP_1_0
1	40.9	30.2	34.3
2	63.2	52.0	57.2
3	76.3	68.4	68.3
4	83.7	79.3	76.8
5	89.1	85.9	83.4
6	93.4	89.1	88.1
7	95.7	91.9	91.6
8	97.6	93.6	93.9
9	98.8	94.3	95.6
10	99.0	95.0	96.7

6.1.1.3 Bias of the methods

For each kind of photo and for each parcel, the ratio between the general mean and the reference area is computed. These ratios are given in table: Tab 12. Fig. 29gives the histograms of the ratios.

The 95 % confidence intervals are :

- 0.9905 – 1.0061 for photo OP_0_2,
- 0.9860 – 1.0228 for photo OP_0_5,
- and 0.9886 – 1.0181 for photo OP_1_0.

The interval includes the value 1 for each photo. So, we can conclude that the mean value of the ratio for the 36 parcels is not significantly different from 1 and, consequently, we conclude that there is no bias.

Tab 12. Mean values of the observations and ratios mean value/reference area.

Parcels	OP_0_2	OP_0_5	OP_1_0	OP_0_2/Ref	OP_0_5/Ref	OP_1_0/Ref
1	3527	3539	3415	1.028	1.031	0.995
2	3103	3019	2877	0.976	0.949	0.905
3	3931	4046	4147	0.963	0.991	1.016
4	8373	8691	8379	0.991	1.028	0.992
5	12344	12296	12400	0.996	0.993	1.001
6	8519	8503	8740	0.994	0.993	1.020

7	23727	24113	23643	1.009	1.026	1.006
8	28167	28054	28146	1.007	1.003	1.007
9	24199	23773	24293	0.988	0.970	0.991
10	4096	4163	4161	0.988	1.004	1.004
11	3904	4042	3703	1.012	1.048	0.960
12	4896	4549	5009	1.023	0.951	1.047
13	17485	17618	17330	0.985	0.993	0.976
14	13233	13069	13532	1.036	1.024	1.060
15	10880	10934	10966	0.993	0.998	1.001
16	42018	41883	41962	1.007	1.003	1.005
17	30732	30480	30750	0.995	0.987	0.996
18	23767	24412	23519	0.984	1.011	0.974
19	3757	3420	3713	0.990	0.901	0.978
20	3231	3201	3296	0.937	0.929	0.957
21	3836	4571	3934	1.031	1.228	1.057
22	8488	8910	8722	0.964	1.012	0.990
23	9192	8828	9441	1.041	1.000	1.069
24	11263	11767	11488	0.966	1.009	0.985
25	33434	33877	33867	0.993	1.006	1.006
26	27934	28318	28503	1.017	1.031	1.038
27	25918	26097	25826	0.993	1.000	0.989
28	5493	5313	5228	0.962	0.930	0.915
29	2347	2521	2280	1.003	1.078	0.975
30	4420	4625	5023	1.025	1.072	1.165
31	12323	11877	12392	0.999	0.963	1.005
32	10592	10596	10759	1.016	1.017	1.032
33	10672	10057	10780	0.982	0.926	0.992
34	28853	28818	28803	1.011	1.010	1.009
35	44148	44609	43523	1.018	1.029	1.004
36	41643	41688	41043	1.014	1.015	0.999

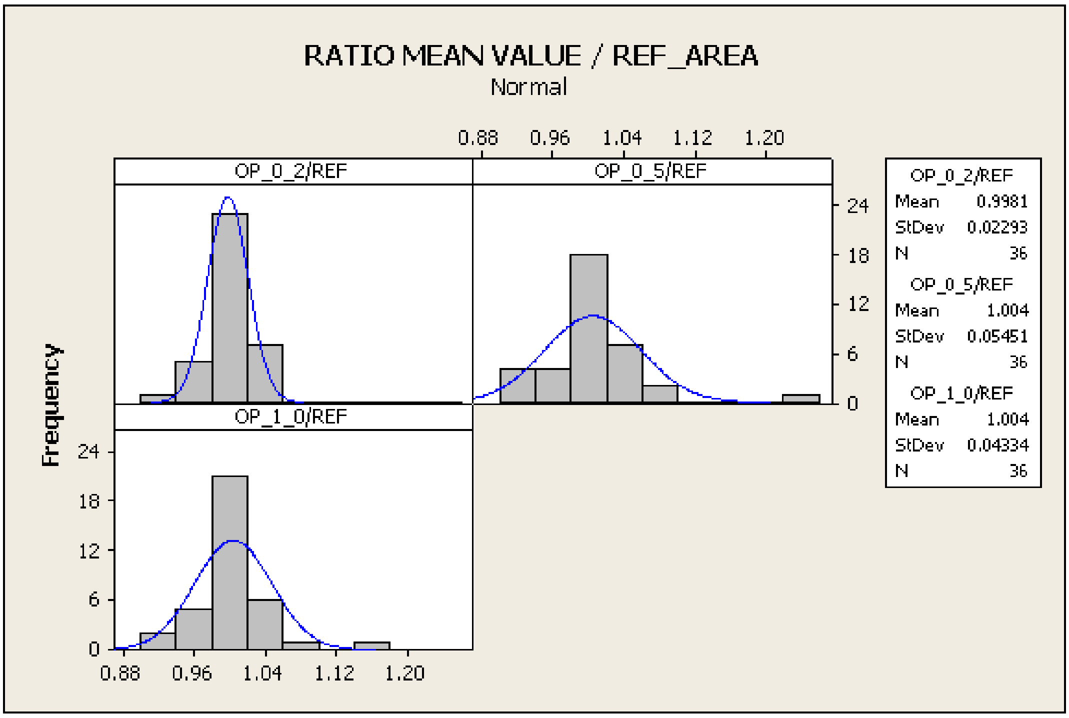


Fig. 30. Histogram of the ratios mean value/reference area.

6.1.1.4 Variance components and reproducibility

For each parcel and each photo, a one-way analysis of variance has been performed and the variance components have been estimated.

The "between groups" variance, $\hat{\sigma}^2_{group}$ is the variance between operators and the "within groups" variance $\hat{\sigma}^2_2$ is the variance of the replicates related to the days. The negative estimations have been set to zero. The sum of these two variances gives the reproducibility variance $\hat{\sigma}^2_R$.

Tables: Tab 13 - Tab 15 give the variance components and the reproducibility for each parcel (labelled Bop Wop and Repr). The variance components have also been expressed in percentage of the reproducibility.

Tab 13. Between operators and within operators variance components for photo OP_0_2.

Parcels	Bop	Wop	Repr	B %	W %
1	4489	1990	6479	69	31
2	1697	5434	7131	24	76
3	4128	8382	12510	33	67

4	1888	4556	6444	29	71
5	476	7459	7935	6	94
6	26815	44033	70848	38	62
7	8754	25011	33765	26	74
8	25419	39227	64646	39	61
9	0	78806	78806	0	00
10	5862	1511	7373	80	20
11	1224	3715	4939	25	75
12	347	11595	11942	3	97
13	23012	44759	67771	34	66
14	366624	19111	385735	95	5
15	13315	11356	24671	54	46
16	42552	207909	250461	17	3
17	21813	37203	59016	37	63
18	23435	35076	58511	40	60
19	2614	2940	5554	47	53
20	2158	1409	3567	60	40
21	13039	7842	20881	62	38
22	4756	3554	8310	57	43
23	8202	20663	28865	28	72
24	11100	16915	28015	40	60
25	21886	59121	81007	27	73
26	31725	137286	169011	19	81
27	0	25875	25875	0	100
28	25927	9115	350427	4	26
29	5471	8617	14088	39	61
30	6555	23439	29994	22	78
31	22619	49952	72571	31	69
32	79557	47442	126999	63	37
33	6738	26712	33450	20	80
34	4835	26681	31516	15	85
35	365159	93815	458974	80	20
36	789033	1229667	2018700	39	61

Tab 14. Between operators and within operators variance components for photo OP_0_5.

Parcels	Bop	Wop	Repr	B %	W %
1	1327	2075	3402	39	61
2	1221	5744	6965	18	82
3	8496	7292	15788	54	46
4	1432	5780	7212	20	80
5	3101	25141	28242	11	89
6	26771	48659	75430	35	65

7	14089	16965	31054	45	55
8	5080	36584	41664	12	88
9	44472	91484	135956	33	67
10	3112	2042	5154	60	40
11	7167	24079	31246	23	77
12	9972	26069	36041	28	72
13	10807	92152	102959	10	90
14	171704	86784	258488	66	34
15	0	198238	198238	0	100
16	42984	107560	150544	29	71
17	20759	24711	45470	46	54
18	83554	132507	216061	39	61
19	45112	61881	106993	42	58
20	833	15774	16607	5	95
21	8390	78472	86862	10	90
22	7756	19575	27331	28	72
23	0	36925	36925	0	100
24	29455	36732	66187	45	55
25	16033	65374	81407	20	80
26	46384	101562	147946	31	69
27	55734	48185	103919	54	46
28	4642	13286	17928	26	74
29	2984	11903	14887	20	80
30	0	34615	34615	0	100
31	5161	43056	48217	11	89
32	33614	86381	119995	28	72
33	146023	196957	342980	43	57
34	4052	23725	27777	15	85
35	390111	482784	872895	45	55
36	394015	258499	652514	60	40

Tab 15. Between operators and within operators variance components for photo OP_1_0.

Parcels	Bop	Wop	Repr	B %	W %
1	5562	10824	16386	34	66
2	11878	8470	20348	58	42
3	1737	6505	8242	21	79
4	1851	6949	8800	21	79
5	2351	24166	26517	9	91
6	0	94566	94566	0	100

7	5643	19383	25026	23	77
8	17891	21405	39296	46	54
9	31148	105430	136578	23	77
10	4675	7121	11796	40	60
11	6786	6476	13262	51	49
12	0	20199	20199	0	100
13	57717	102911	160628	36	64
14	201004	769499	970503	21	79
15	4817	24707	29524	16	84
16	37251	81219	118470	31	69
17	783	36320	44155	18	82
18	10989	39413	50402	22	78
19	2832	1458	4290	66	34
20	0	14307	14307	0	100
21	4996	59327	64323	8	92
22	16014	19270	35284	45	55
23	10656	32730	43386	25	75
24	0	43779	43779	0	100
25	167346	77959	245305	68	32
26	4290	27800	32090	13	87
27	2769	48204	50973	5	95
28	3741	33350	37091	10	90
29	7781	24838	32619	24	76
30	44287	68772	113059	39	61
31	14539	38020	5255	28	72
32	49120	110929	160049	31	69
33	29420	42533	71953	41	59
34	19380	72390	91770	21	79
35	630789	145386	776175	81	19
36	483447	173678	657125	74	26

The average proportions of "between" and "within" variance components, for each kind of photo are:

- 38 % between and 62 % within for OP_0_2,
- 29 % between and 71 % within for OP_0_5,
- 29 % between and 71 % within for OP_1_0.

Several transformations of the reproducibility have also been computed:

- the reproducibility standard deviation, $\hat{\sigma}_R$ (labeled SDev);

- the reproducibility coefficient of variation (standard deviation divided by the reference area of the parcel, labeled CoefVar);
- he buffer (standard deviation divided by the perimeter of the parcel);
- the standard deviation divided by a constant (labeled HB) depending on the parcel geometry; this constant is the factor which is multiplied by the point position error to give the area error.

The results are given in tables: Tab 16 - Tab 18.

For these four variables, the boxplots are given by types of "size", "shape" and "border". These plots, given in appendix **Błąd! Nie można odnaleźć źródła odwołania.**, show that :

- the standard-deviation increases with size;
- the coefficient of variation decreases with size;
- the buffer and the ratio standard deviation/HB seem only to be slightly related to size;
- shape has not an important influence;
- border is a important factor.

Generally speaking, the border has an effect on the median and on the variability of all variable.

Buffer is the transformation for which the results are the least influenced by the characteristics of the parcels. For this reason, buffer is the best parameter for describing variability.

Tables: Tab 19 - Tab 21 give the results of several attempts of modeling the buffer.

Tab 16. Transformations of the reproducibility variance for photo OP_0_2.

Parcels	SDev	Buffer	CoefVar	SDev/HB
1	80	0.324	0.023	1.260
2	84	0.214	0.027	0.666
3	112	0.172	0.027	0.904
4	80	0.207	0.009	0.967
5	89	0.171	0.007	0.610
6	266	0.231	0.031	1.714
7	184	0.295	0.008	1.223
8	254	0.357	0.009	2.126
9	281	0.313	0.011	1.983
10	86	0.311	0.021	1.195
11	70	0.187	0.018	0.602
12	109	0.153	0.023	0.703
13	260	0.477	0.015	2.048
14	621	1.267	0.049	5.543
15	157	0.247	0.014	0.965
16	500	0.526	0.012	2.554

17	243	0.252	0.008	1.311
18	242	0.197	0.010	1.410
19	75	0.301	0.020	1.205
20	60	0.138	0.017	0.523
21	145	0.193	0.039	1.303
22	91	0.230	0.010	0.966
23	170	0.351	0.019	1.191
24	167	0.205	0.014	0.823
25	285	0.388	0.008	1.551
26	411	0.469	0.015	2.512
27	161	0.168	0.006	0.816
28	187	0.609	0.033	2.396
29	119	0.427	0.051	2.018
30	173	0.345	0.040	1.144
31	269	0.572	0.022	2.175
32	356	0.761	0.034	2.927
33	183	0.182	0.017	1.180
34	178	0.238	0.006	1.321
35	677	0.643	0.016	4.269
36	1421	1.214	0.035	10.847

Tab 17. Transformations of the reproducibility variance for photo OP_0_5.

Parcels	SDev	Buffer	CoefVar	SDev/HB
1	58	0.235	0.017	0.913
2	83	0.212	0.026	0.658
3	126	0.193	0.031	1.015
4	85	0.219	0.010	1.023
5	168	0.323	0.014	1.151
6	275	0.239	0.032	1.769
7	176	0.283	0.007	1.173
8	204	0.287	0.007	1.707
9	369	0.411	0.015	2.604
10	72	0.260	0.017	0.999
11	177	0.471	0.046	1.515
12	190	0.266	0.040	1.221
13	321	0.588	0.018	2.524
14	508	1.037	0.040	4.538
15	445	0.701	0.041	2.735
16	388	0.408	0.009	1.980
17	213	0.221	0.007	1.151
18	465	0.378	0.019	2.710
19	327	1.323	0.086	5.288
20	129	0.297	0.037	1.129

21	295	0.393	0.079	2.658
22	165	0.417	0.019	1.751
23	192	0.397	0.022	1.347
24	257	0.316	0.022	1.265
25	285	0.389	0.008	1.555
26	385	0.439	0.014	2.350
27	322	0.336	0.012	1.635
28	134	0.435	0.023	1.714
29	122	0.439	0.052	2.075
30	186	0.371	0.043	1.229
31	220	0.466	0.018	1.773
32	346	0.740	0.033	2.845
33	586	0.583	0.054	3.778
34	167	0.223	0.006	1.241
35	934	0.886	0.022	5.888
36	808	0.690	0.020	6.167

Tab 18. Transformations of the reproducibility variance for photo OP_1_0.

Parcels	SDev	Buffer	CoefVar	SDev/HB
1	128	0.515	0.037	2.003
2	143	0.362	0.045	1.124
3	91	0.139	0.022	0.733
4	94	0.241	0.011	1.130
5	163	0.313	0.013	1.115
6	308	0.267	0.036	1.981
7	158	0.254	0.007	1.053
8	198	0.279	0.007	1.657
9	370	0.412	0.015	2.610
10	109	0.394	0.026	1.512
11	115	0.307	0.030	0.987
12	142	0.199	0.030	0.914
13	401	0.734	0.023	3.152
14	985	2.009	0.077	8.793
15	172	0.270	0.016	1.056
16	344	0.362	0.008	1.757
17	210	0.218	0.007	1.134
18	225	0.183	0.009	1.309
19	65	0.265	0.017	1.059
20	120	0.276	0.035	1.048
21	254	0.338	0.068	2.287
22	188	0.473	0.021	1.990
23	208	0.431	0.024	1.461
24	209	0.257	0.018	1.029

25	495	0.675	0.015	2.699
26	179	0.204	0.007	1.094
27	226	0.235	0.009	1.145
28	193	0.626	0.034	2.465
29	181	0.650	0.077	3.071
30	336	0.670	0.078	2.222
31	229	0.487	0.019	1.851
32	400	0.855	0.038	3.286
33	268	0.267	0.025	1.730
34	303	0.406	0.011	2.255
35	881	0.836	0.020	5.552
36	811	0.692	0.020	6.189

Tab 19. Modeling buffer for OP_0_2.

All	Buffer = 0.370 (0.263)
Good border	Buffer = 0.263 (0.091)
Bad border	Buffer = 0.478 (0.331)
All	Buffer = 0.256 + 0.000007 Ref_Area (0.250)
Good border	Buffer = 0.197 + 0.000005 Ref_Area (0.078)
Bad border	Buffer = 0.358 + 0.000007 Ref_Area (0.326)

Tab 20. Modeling buffer for OP_0_5.

All	Buffer = 0.441 (0.247)
Good border	Buffer = 0.373 (0.250)
Bad border	Buffer = 0.509 (0.230)
All	Buffer = 0.413 + 0.000002 Ref_Area (0.249)
Good border	Buffer = 0.398 + 0.000002 Ref_Area (0.257)
Bad border	Buffer = 0.465 + 0.000003 Ref_Area (0.234)

Tab 21. Modeling buffer for OP_1_0.

All	Buffer = 0.447 (0.331)
Good border	Buffer = 0.330 (0.130)
Bad border	Buffer = 0.565 (0.424)
All	Buffer = 0.418 + 0.000002 Ref_Area (0.335)
Good border	Buffer = 0.302 + 0.000002 Ref_Area (0.132)
Bad border	Buffer = 0.572 + 0.000000 Ref_Area (0.437)

The first three lines in these tables give the general mean and the means for parcels with good and bad border. The next lines show regression equations giving the buffer as a function of reference area. The related scatter plots are given in figures: Fig. 31 - Fig. 33. For each model the (residual) standard deviation is given in parentheses.

For all types of photo the factor "border" is important buffer is larger for parcels with bad border and, except for photo OP_0_5, the standard deviation is larger for parcels with good border.

Whether or not it is useful to take into account the size as a second factor depends on the kind of photo. For photos OP_0_5 and OP_1_0 using the reference area in addition to the factor "border" does not improve the model. For photo OP_0_2, the introduction of the reference area into the model slightly decreases the residual standard deviation (from 0,091 to 0,078 for parcels with good border and from 0,331 to 0,326 for parcels with bad border).

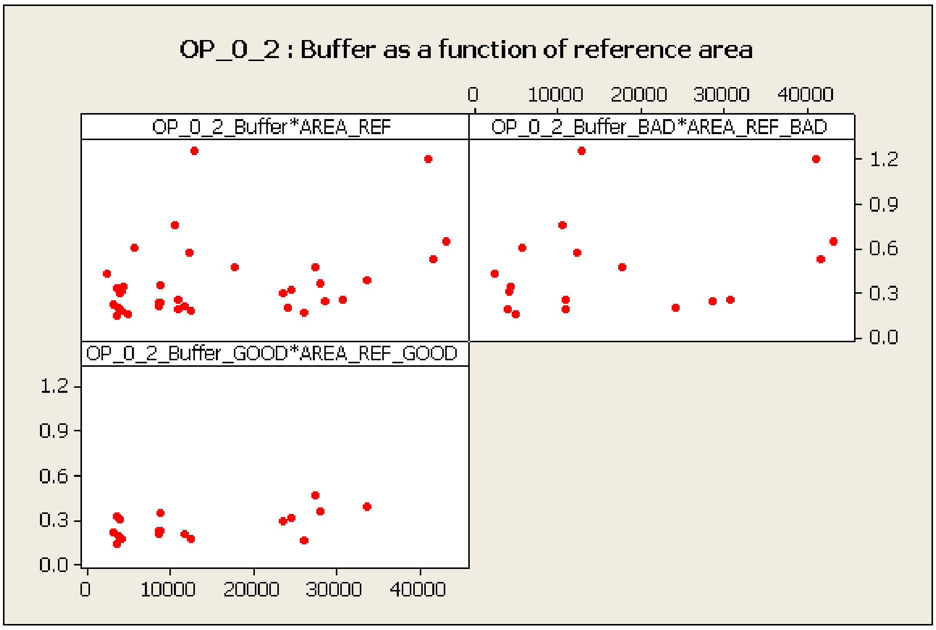


Fig. 31. Buffer as a function of reference area for photo OP_0_2.

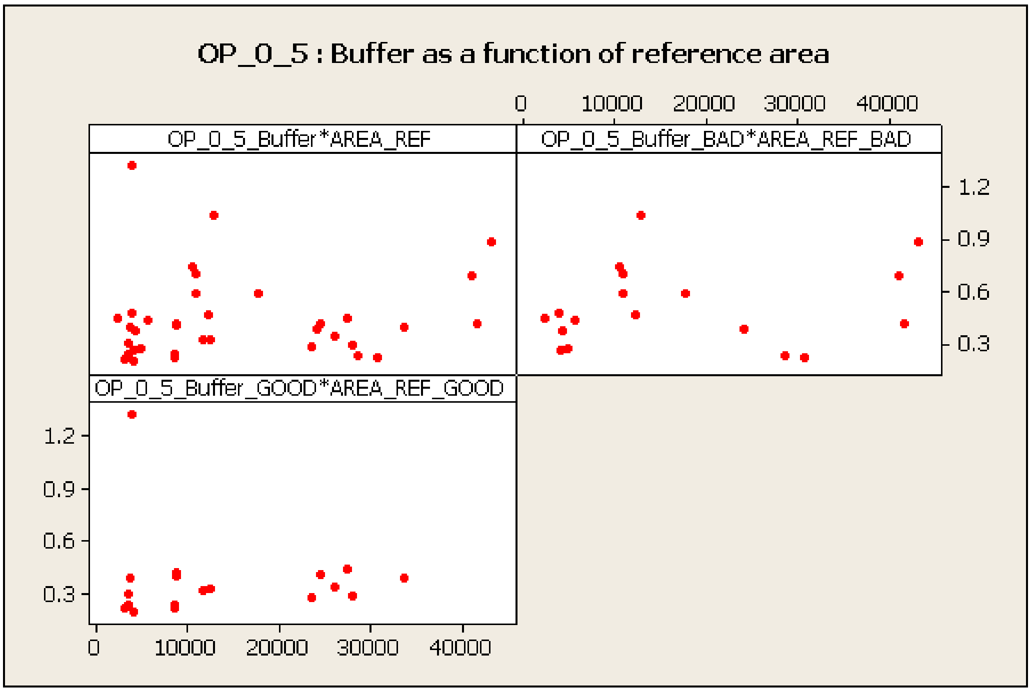


Fig. 32. Buffer as a function of reference area for photo OP_0_5.

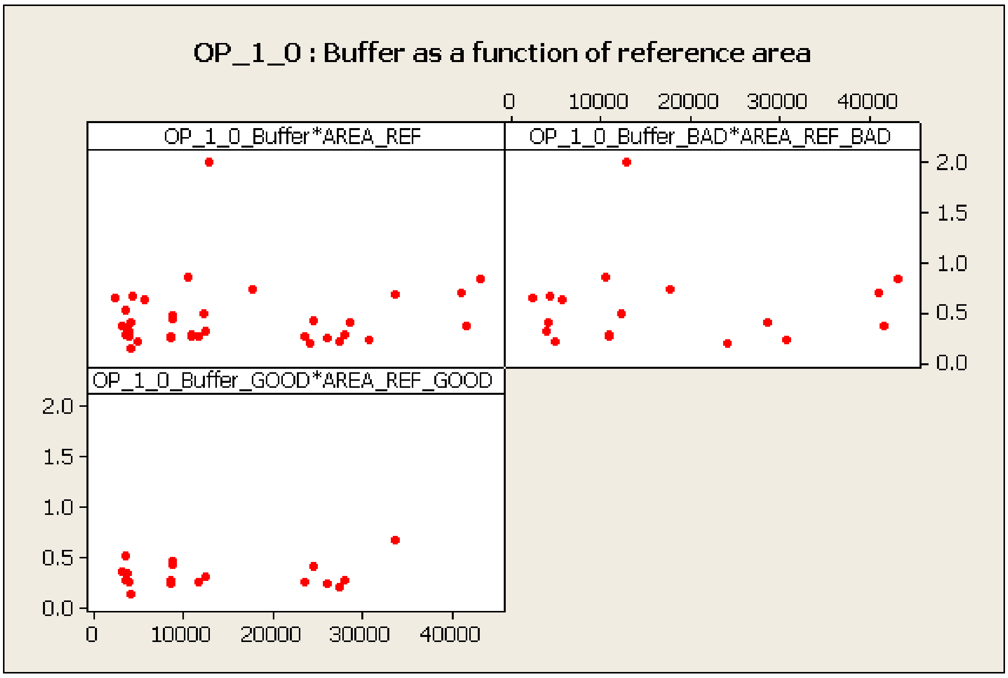


Fig. 33. Buffer as a function of reference area for photo OP_1_0.

6.2 GPS

6.2.1 Experiment A

6.2.1.1 Critical examination of the data

When using ISO 5725-2, the pooling factor is the factor day. Each parcel has been examined by six operators on six different days. The observations are allocated into 324 groups (6 days × 18 parcels × 3 instruments). The 36 observations related to a given instrument of a given parcel (6 groups × 6 operators) are analyzed separately. So the identification of outliers and other irregularities is repeated 54 times (18 parcels × 3 instruments).

Among the 1944 observations, 121 are identified as outliers (6,1 %). Most of them (90) are identified by COCHRAN's test, due to large standard deviation within repetitions for a given day, and 30 are identified by GRUBB's tests due to too extreme mean values for one or two days.

The number of observations identified for a given day vary from 8 (day 4) to 31 (day 1). Regarding the instruments, the numbers of identified observations are as follows 30 observations for GARMIN, 47 observations for SATCON and 44 observations for THALES.

For parcels 1, 4, 5, 6, 13, 14 and 16, the number of observations that are identified lies between ten and twenty. One to ten observations are discarded for parcels 3, 7, 11, 12 and 17.

The complete list of all the 121 observations that are identified is given in appendix **Błąd! Nie można odnaleźć źródła odwołania.**.

Figures: Fig. 34 - Fig. 37 give the boxplots of the h_i and k_i values, defined by MANDEL, before and after discarding these observations. These figures do not exhibit a special pattern and we consider that no day should be discarded.

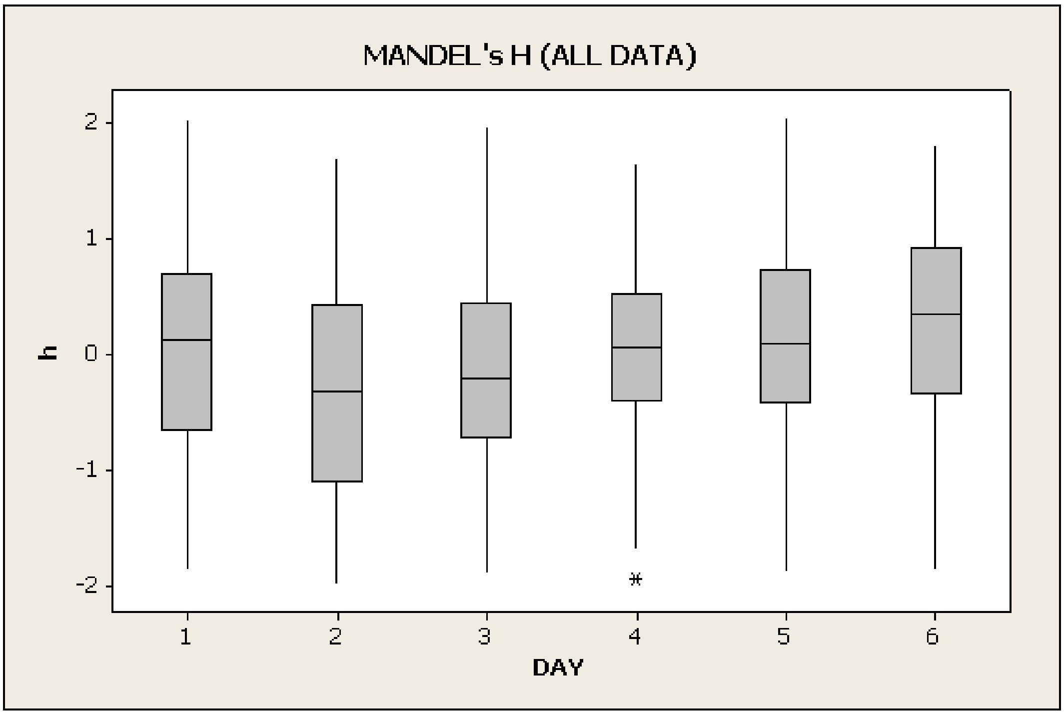


Fig. 34. Experiment A – Boxplot of MANDEL's h_i values as a function of days (before discarding observations).

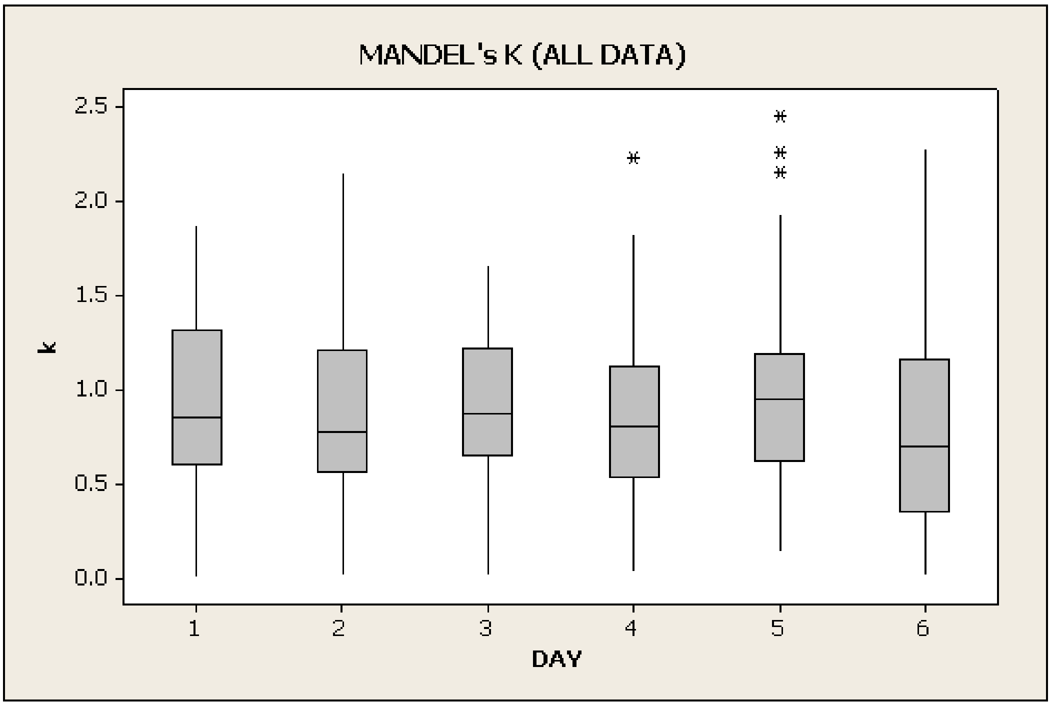


Fig. 35. Experiment A – Boxplot of MANDEL's k_i values as a function of days (before discarding observations).

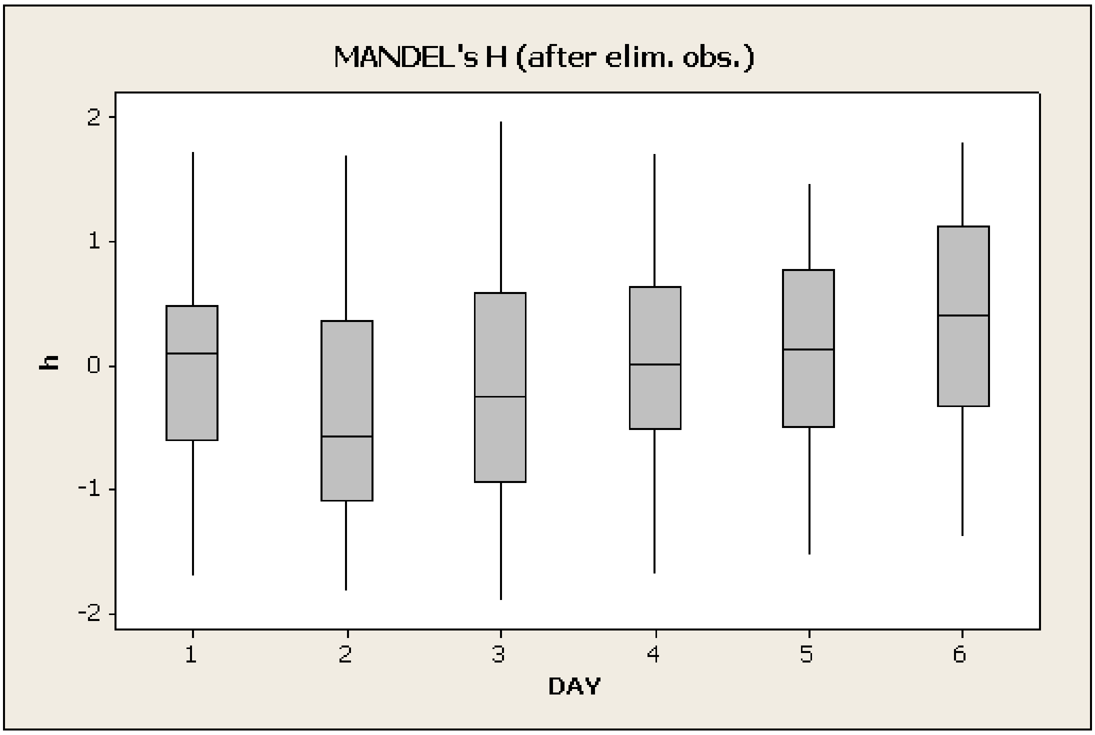


Fig. 36. Experiment A – Boxplot of MANDEL's h_i values as a function of days (after discarding 121 observations).

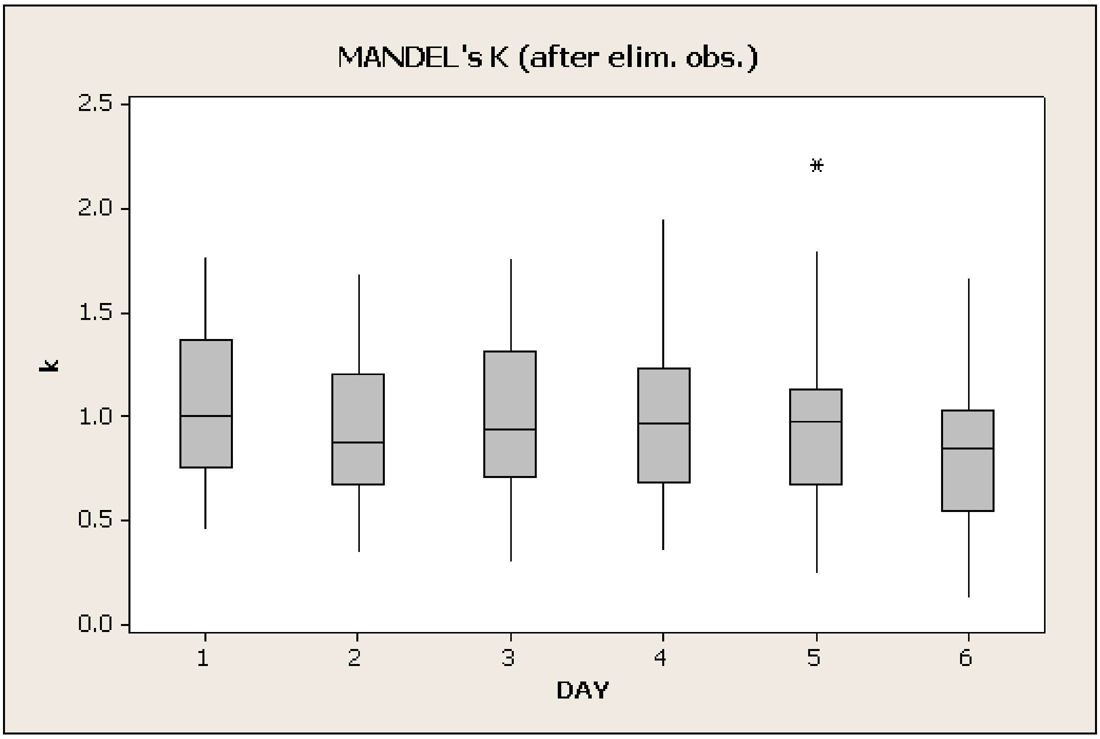


Fig. 37. Experiment A – Boxplot of MANDEL's k_i values as a function of days (after discarding 121 observations).

6.2.1.2 Individual relative errors

Figures: Fig. 38 - Fig. 41give the distributions of the errors (in percent). Figures: Fig. 38 and Fig. 39 give the differences between observations and reference areas, in percent of the reference areas for all data (Fig. 38) and after discarding 121 observations (Fig. 39):

(29) relative error = 100 (observation – general mean)/reference area.

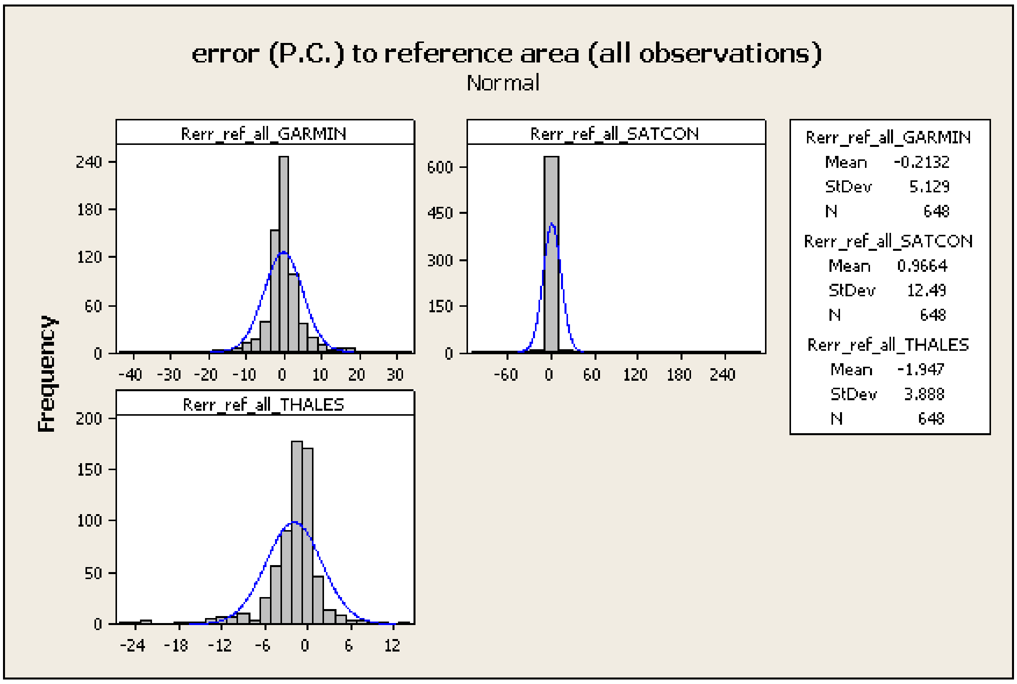


Fig. 38. Experiment A – Histogram of the errors (in percent) to reference area for all observations.

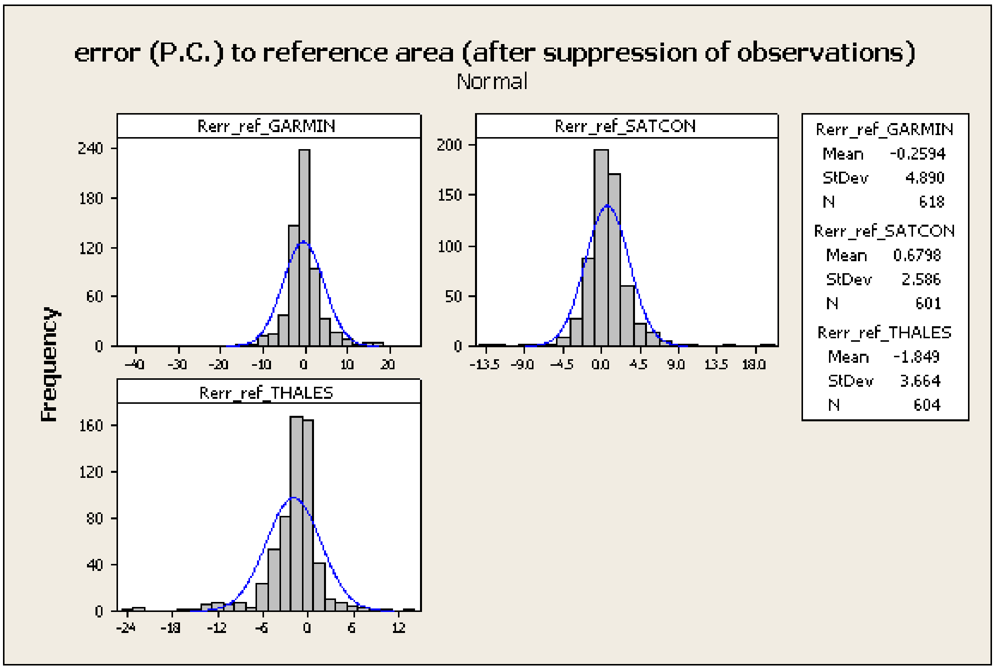


Fig. 39. Experiment A – Histogram of the errors (in percent) to reference area after discarding 121 observations.

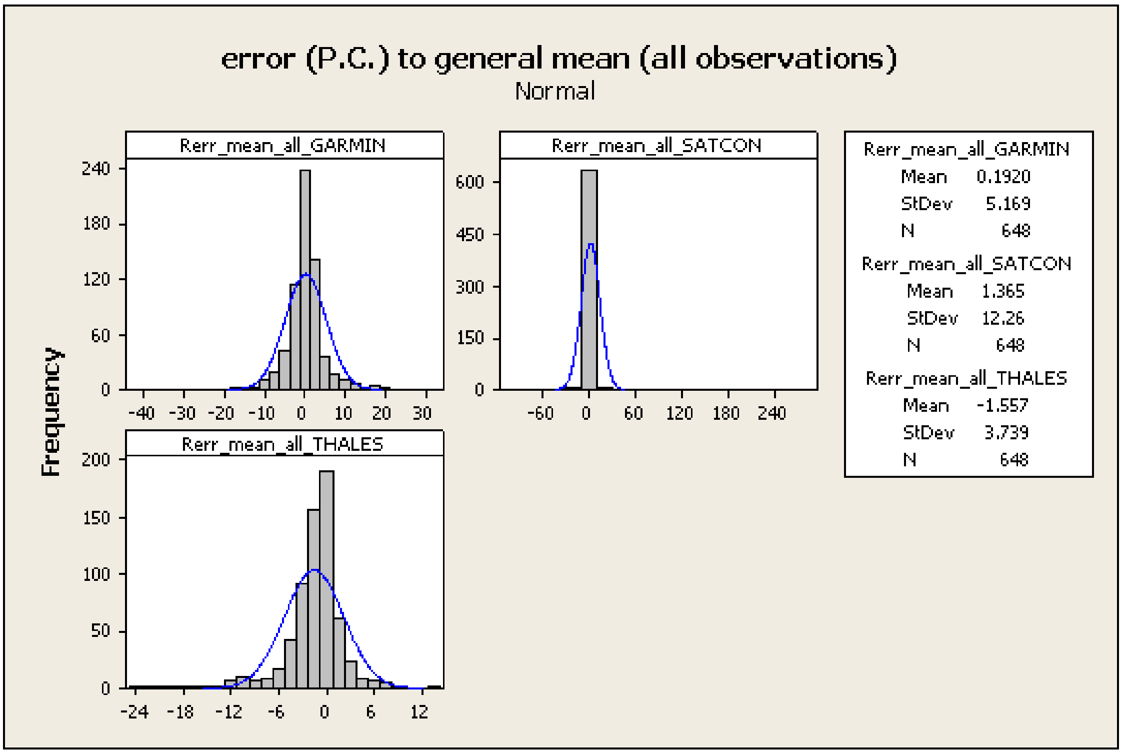


Fig. 40. Experiment A – Histogram of the errors (in percent) to the general mean for all observations.

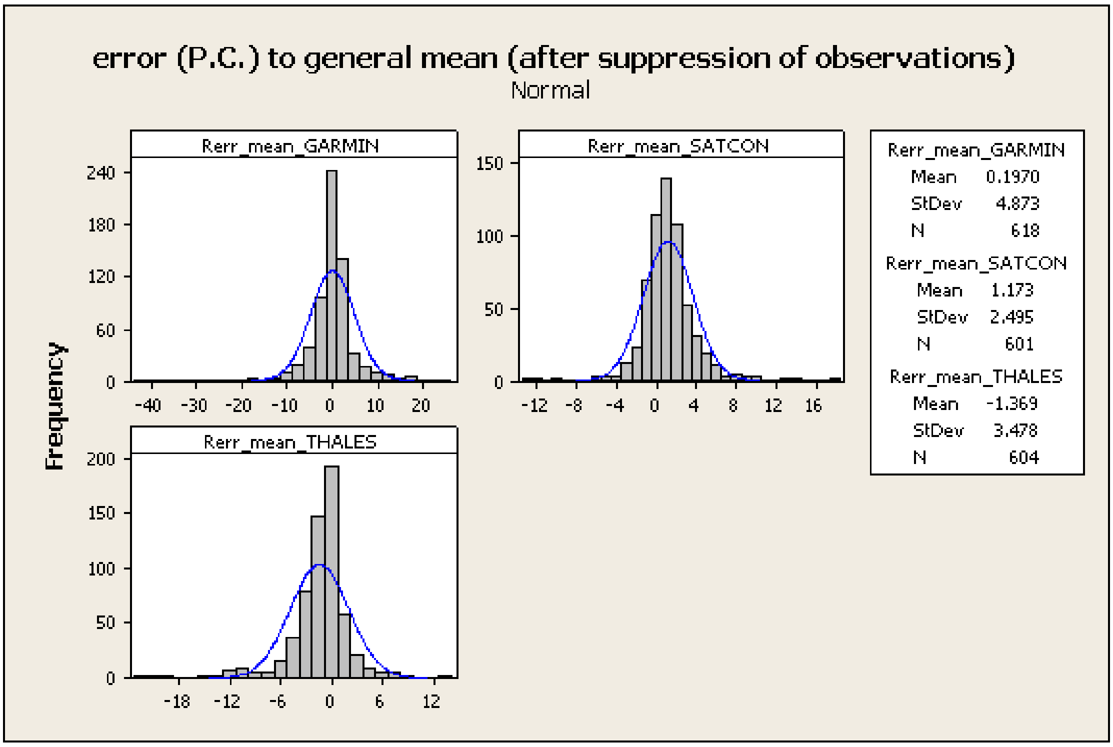


Fig. 41. Experiment A – Histogram of the errors (in percent) to the general mean after discarding 121 observations.

Figures:Fig. 40 and Fig. 41 give the differences between observations and the general mean (of all observations made on the parcel), for all the data (Fig. 40) and after discarding 121 observations (Fig. 41) :

(30) relative error = 100 (observation – general mean)/general mean.

Table: Tab 22 gives the percentage of observations with a (absolute) relative error less than a given value. The errors are computed as follows, after discarding 121 observations:

(31) (absolute) relative error = 100 | observation – general mean | /general mean.

From this Tab 22, we can see, for example, that 68.8 percents of observations for GARMIN show a deviation from the mean smaller or equal to 3 percents. For SATCON and THALES, the percentages are 82.4 and 75.2.

Tab 22. Experiment A - Cumulative percentages of observations as a function of the error (%).

Error (%)	GARMIN	SATCON	THALES
1	30.1	39.4	39.6
2	54.2	66.6	63.9
3	68.8	82.4	75.2
4	79.5	89.7	84.4
5	84.3	93.7	88.7
6	87.4	96.5	92.1
7	90.3	97.3	93.9
8	92.1	98.3	95.0
9	94.0	98.7	95.5
10	95.6	99.2	96.2

6.2.1.3 Bias of the instruments

For each instrument and for each parcel, the ratio between the general mean and the reference area is computed. These ratios are given in Tab 23. Figure Fig. 42 gives the histograms of the ratios.

The 95 % confidence intervals are :

- 0.9910 – 1.0039 for GARMIN,
- 1.0014 – 1.0126 for SATCON,
- and 0.9741 – 0.9900 for THALES.

The interval includes the value 1 only for GARMIN. So, we can conclude that the mean value of the ratio for the 18 parcels is significantly different from 1 for SATCON and THALES : SATCON overestimates the reference areas and THALES underestimates the reference areas.

Tab 23. Experiment A – Means values of the observations and ratios mean value/reference area.

Parcels	GARMIN	SATCON	THALES	G/Ref	S/Ref	T/Ref
1	4912	4942	4827	1.015	1.021	0.997
2	3918	4140	4017	0.961	1.015	0.985
3	4257	4330	4198	1.002	1.019	0.988
4	11468	11277	11156	1.022	1.005	0.994
5	12463	12648	12400	0.997	1.011	0.992
6	9574	9728	9598	0.993	1.009	0.996
7	29409	29675	29380	0.991	1.000	0.990
8	28341	28434	27956	1.000	1.003	0.986
9	29047	29400	29108	0.990	1.002	0.992
10	3687	3813	3680	0.999	1.033	0.997
11	3885	3957	3801	1.001	1.019	0.979
12	4196	4219	3952	0.992	0.997	0.934
13	7090	6963	6936	1.005	0.987	0.983
14	7759	7695	7404	1.002	0.994	0.957
15	10346	10301	10002	1.007	1.003	0.974
16	33223	33904	33309	0.983	1.004	0.986
17	28223	28547	27876	0.992	1.003	0.980
18	29643	29553	28613	1.002	0.999	0.968

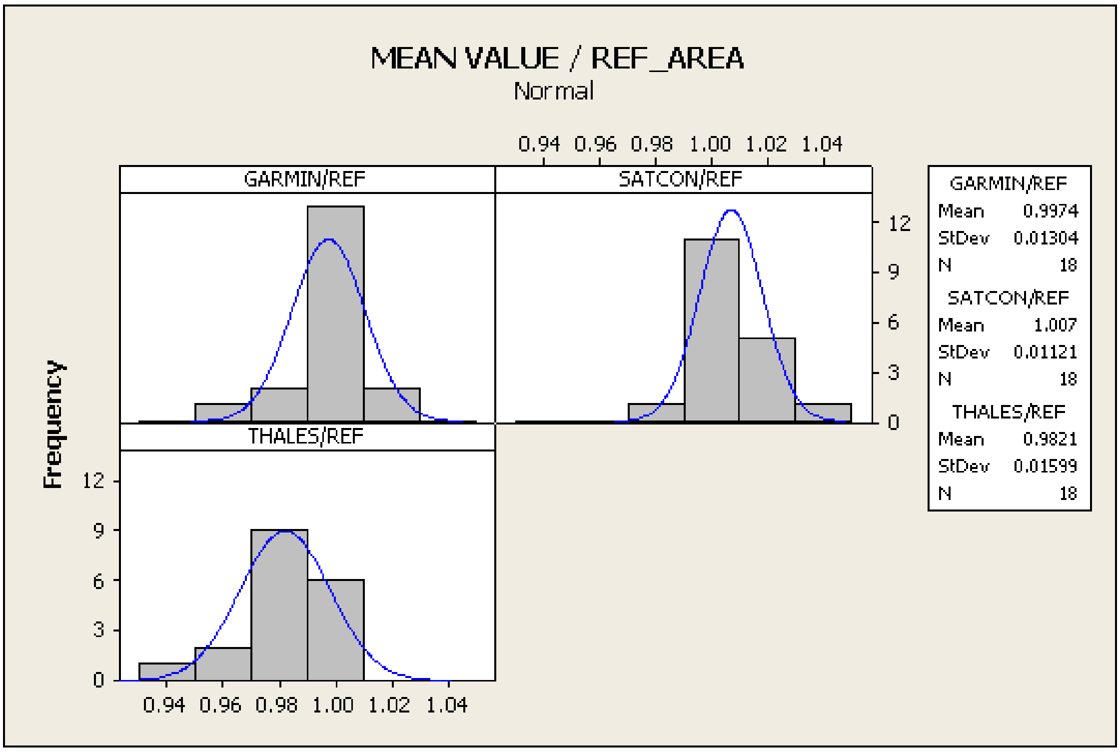


Fig. 42. Experiment A – Histogram of the ratios mean value/reference area.

6.2.1.4 Variance components and reproducibility

For each parcel and each instrument, a one-way analysis of variance has been performed and the variance components have been estimated.

The "between groups" variance $\hat{\sigma}^2_{group}$ is the variance between days and the "within groups" variance $\hat{\sigma}^2_2$ is the variance of the replicates related to the operators. The negative estimations have been set to zero. The sum of these two variances gives the reproducibility variance $\hat{\sigma}^2_R$.

Tables: Tab 24 -Tab 26 give the variance components and the reproducibility for each parcel (labeled Bdays, Wdays and Repr). The variance components have also been expressed in percentage of the reproducibility.

Tab 24. Experiment A – Between days and within days variance components for GARMIN.

Parcels	Bdays	Wdays	Repr	B%	W%
1	48804	30776	79580	61	39
2	0	197376	197376	0	100
3	0	83796	83796	0	100
4	6374	90547	96921	7	93
5	0	235040	235040	0	100
6	17864	32320	50184	36	64
7	26276	85549	111825	23	77
8	0	1215955	1215955	0	100
9	38279	653476	691755	6	94
10	0	33659	33659	0	100
11	46724	6085	102809	45	55
12	8686	40658	49344	18	82
13	0	11104	11104	0	100
14	0	54207	54207	0	100
15	0	209965	209965	0	100
16	53260	1464739	1517999	4	96
17	0	280013	280013	0	100
18	53518	446849	500367	11	89

Tab 25. Experiment A – Between days and within days variance components for SATCON.

Parcels	Bdays	Wdays	Repr	B%	W%
1	7438	13490	20928	36	64
2	0	14222	14222	0	100
3	0	2510	2510	0	100

4	8350	18619	26969	31	69
5	0	43597	43597	0	100
6	8581	5627	14208	60	40
7	107861	83703	191564	56	44
8	0	02186	102186	0	100
9	0	54124	54124	0	100
10	6447	40317	46764	14	86
11	407	11745	12153	3	97
12	0	12239	12239	0	100
13	1936	17428	19364	10	90
14	0	79307	79307	0	100
15	6960	22811	29771	23	77
16	0	170634	170634	0	100
17	42914	54785	97699	44	56
18	7934	63213	71147	11	89

Tab 26. Experiment A – Between days and within days variance components for THALES.

Parcels	Bdays	Wdays	Repr	B%	W%
1	54	10348	10402	1	99
2	0	17451	17451	0	100
3	0	13395	13395	0	100
4	0	43191	43191	0	100
5	0	44069	44069	0	100
6	1455	2055	3510	41	59
7	100	100483	100583	0	100
8	0	176693	176693	0	100
9	13624	64603	78227	17	83
10	4510	40417	44927	10	90
11	0	18607	18607	0	100
12	0	107023	107023	0	100
13	7790	7059	14849	52	48
14	0	139054	139054	0	100
15	0	225536	225536	0	100
16	36400	226260	262660	14	86
17	26211	245473	271684	10	90
18	11507	1022631	1034138	1	99

The average proportions of "between" and "within" variance components, for each instrument are :

- 12 % between and 88 % within for GARMIN,
- 16 % between and 84 % within for SATCON,

- 8 % between and 92 % within for THALES.

Several transformations of the reproducibility have also been computed :

- \- the reproducibility standard deviation (labelled SDev);
- \- the reproducibility coefficient of variation (standard deviation divided by the reference area of the parcel, labelled CoefVar);
- \- the buffer (standard deviation divided by the perimeter of the parcel);
- \- the standard deviation divided by a constant (labeled HB) depending on the parcel geometry; this constant is the factor which is multiplied by the point position error to give the area error.

The results are given in tables: Tab 27 - Tab 29.

Tab 27. Experiment A – Transformations of the reproducibility variance for GARMIN.

Parcels	SDev	Buffer	CoefVar	SDev/HB
1	282	0.677	0.058	3.625
2	444	1.174	0.109	7.567
3	289	1.052	0.068	4.964
4	311	0.504	0.028	3.281
5	485	0.815	0.039	5.283
6	224	0.543	0.023	2.992
7	334	0.292	0.011	2.358
8	1103	1.103	0.039	8.176
9	832	1.129	0.028	8.388
10	183	0.444	0.050	2.367
11	321	0.895	0.083	4.759
12	222	0.773	0.053	4.536
13	105	0.185	0.015	1.331
14	233	0.404	0.030	2.750
15	458	1.045	0.045	5.759
16	1232	1.186	0.036	10.182
17	529	0.566	0.019	4.284
18	707	0.945	0.024	7.808

Tab 28. Experiment A – Transformations of the reproducibility variance for SATCON.

Parcels	SDev	Buffer	CoefVar	SDev/HB
1	145	0.347	0.030	1.859
2	119	0.315	0.029	2.031
3	50	0.182	0.012	0.859
4	164	0.266	0.015	1.731
5	209	0.351	0.017	2.275
6	119	0.289	0.012	1.592
7	438	0.382	0.015	3.087
8	320	0.320	0.011	2.370

9	233	0.316	0.008	2.346
10	216	0.523	0.059	2.790
11	110	0.308	0.028	1.636
12	111	0.385	0.026	2.259
13	139	0.245	0.020	1.758
14	282	0.488	0.036	3.326
15	173	0.394	0.017	2.169
16	413	0.398	0.012	3.414
17	313	0.334	0.011	2.531
18	267	0.356	0.009	2.944

Tab 29. Experiment A – Transformations of the reproducibility variance for THALES.

Parcels	SDev	Buffer	CoefVar	SD ev/HB
1	102	0.245	0.021	1.311
2	132	0.349	0.032	2.250
3	116	0.421	0.027	1.985
4	208	0.336	0.019	2.190
5	210	0.353	0.017	2.288
6	59	0.144	0.006	0.791
7	317	0.277	0.011	2.237
8	420	0.421	0.015	3.117
9	80	0.380	0.010	2.821
10	212	0.513	0.057	2.734
11	136	0.381	0.035	2.025
12	327	1.138	0.077	6.680
13	122	0.214	0.017	1.539
14	373	0.646	0.048	4.405
15	475	1.083	0.046	5.969
16	513	0.493	0.015	4.235
17	521	0.557	0.018	4.220
18	1017	1.358	0.034	11.224

For these four variables, the boxplots are given by types of "size", "shape" and "border" in appendix **Błąd! Nie można odnaleźć źródła odwołania.**. These plots show that :

- he standard-deviation increases with size;
- the coefficient of variation decreases with size;
- the buffer and the ratio standard deviation/HB seem only to be slightly related to size.

Buffer is the transformation for which the results are the least influenced by the characteristics of the parcels. For this reason, buffer is the best parameter for describing variability.

Tables: Tab 30 - Tab 32 give the results of several attempts of modeling the buffer.

Tab 30. Experiment A – Modeling buffer for GARMIN.

All	Buffer = 0.763 (0.322)

Good border	Buffer = 0.810 (0.322)
Bad border	Buffer = 0.716 (0.334)
All	Buffer = 0.671 + 0.000006 Ref_Area (0.324)
Good border	Buffer = 0.836 + 0.000002 Ref_Area (0.344)
Bad border	Buffer = 0.538 + 0.000012 Ref_Area (0.316)

Tab 31. Experiment A – Modeling buffer for SATCON.

All	Buffer = 0.344 (0.081)
Good border	Buffer = 0.308 (0.058)
Bad border	Buffer = 0.381 (0.086)
All	Buffer = 0.338 + 0.000000 Ref_Area (0.083)
Good border	Buffer = 0.272 + 0.000002 Ref_Area (0.055)
Bad border	Buffer = 0.396 + 0.000001 Ref_Area (0.099)

Tab 32. Experiment A – Modeling buffer for THALES.

All	Buffer = 0.517 (0.338)
Good border	Buffer = 0.325 (0.090)
Bad border	Buffer = 0.709 (0.389)
All	Buffer = 0.465 + 0.000004 Ref_Area (0.346)
Good border	Buffer = 0.299 + 0.000002 Ref_Area (0.094)
Bad border	Buffer = 0.627 + 0.000006 Ref_Area (0.409)

The first three lines in these tables give the general mean and the means of parcels with good and bad border. The next lines show regression equations giving the buffer as a function of reference area. The related scatter plots are given in figures: Fig. 43 - Fig. 45. For each model the (residual) standard deviation is given in parentheses.

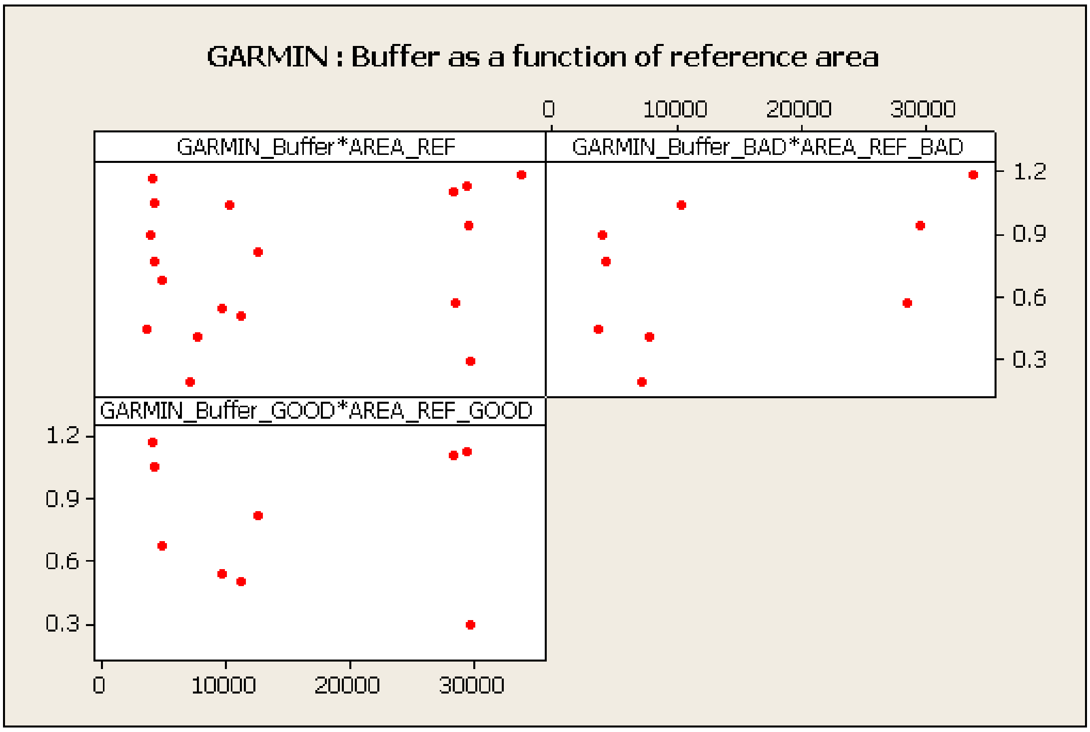


Fig. 43. Experiment A – Buffer as a function of reference area for GARMIN.

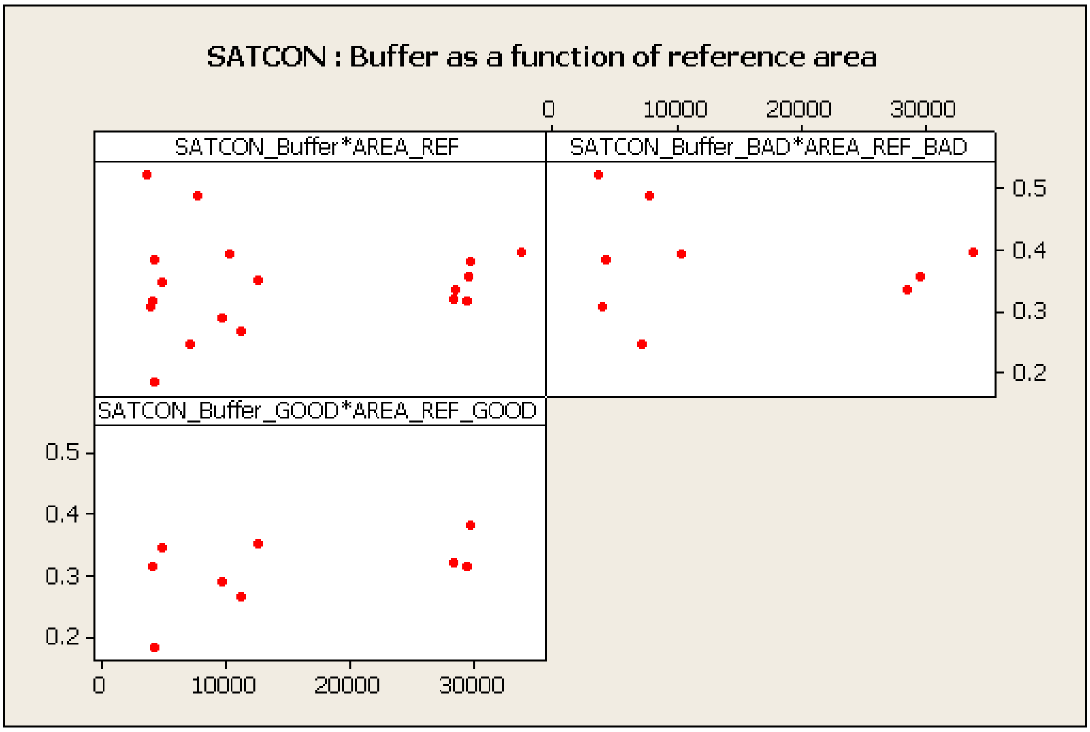


Fig. 44. Experiment A – Buffer as a function of reference area for SATCON.

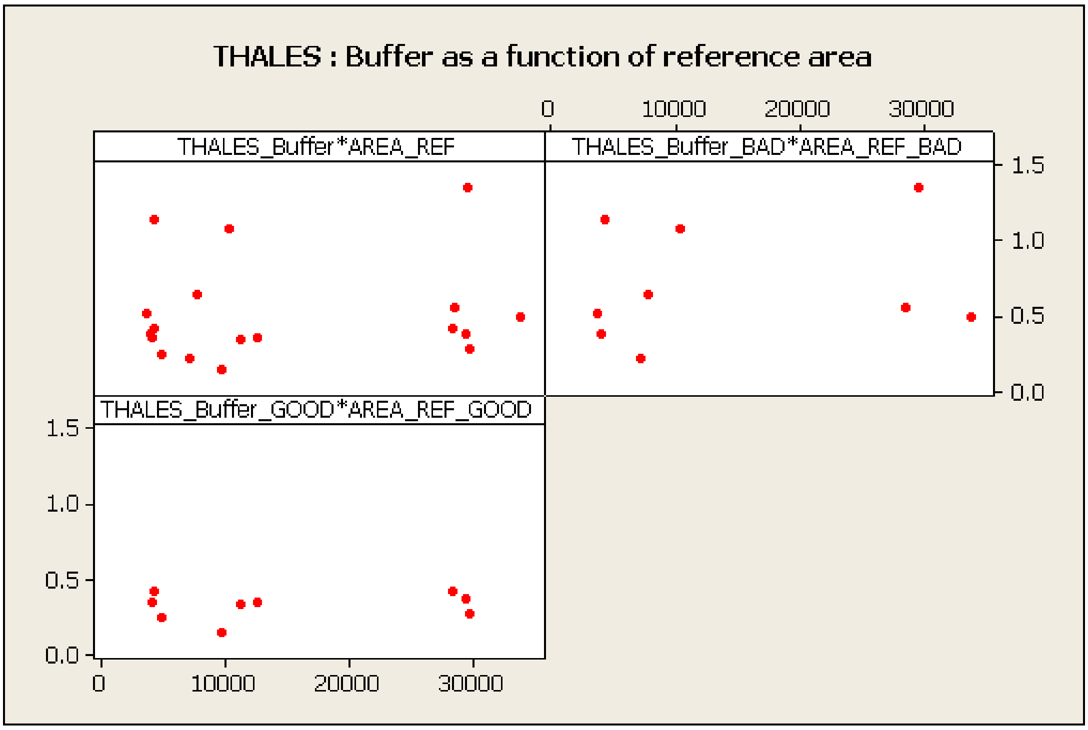


Fig. 45. Experiment A – Buffer as a function of reference area for THALES.

For GARMIN, the factor "border" and the factor "Reference area" are not significant. For SATCON and THALES, the factor "border" is significant but the factor "Reference area" is not significant.

6.2.2 Experiment B

6.2.2.1 Critical examination of the data

When using ISO 5725-2, the pooling factor is the factor day. Each parcel has been examined by four operators on six different days. The observations are allocated into 432 groups (6 days × 18 parcels × 4 instruments). The 24 observations related to a given instrument of a given parcel (6 days × 4 operators) are analysed separately. So the identification of outliers and other irregularities is repeated 72 times (18 parcels × 4 instruments).

Among the 1728 observations, 99 are identified as outliers (5,7 %). Most of them (78) are identified by COCHRAN's test, due to large standard deviation within repetitions for a given day.

For day 2, 21 observations are identified; for days 3, 4 and 5 from 10 to 15 observations are identified and for days and 6 only 4 and 6 observations are identified.

For the two SATCON instruments, 36 and 35 observations are identified; 12 and 16 for the two THALES.

Concerning the parcels, parcels 19, 26, 28 and 33 have from 11 to 20 outliers and parcels 21, 23, 25, 27, 29, 31, 32 and 36 have from 1 to 10 outliers.

The complete list of all the 99 observations that are identified is given in appendix **Błąd! Nie można odnaleźć źródła odwołania.**

Figures 25 to 28 give the boxplots of the h_i and k_i values, defined by MANDEL, before and after discarding these observations. Figure 27 shows that the means of the groups for day 4 are often smaller than the means for the other days. Nevertheless, we propose not to discard this day.

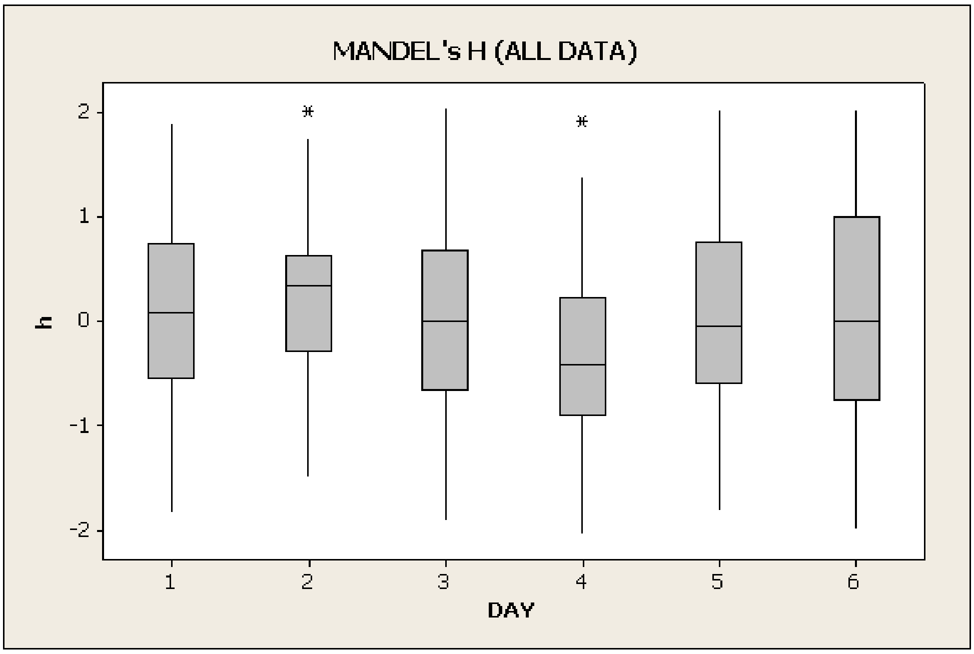


Fig. 46. Experiment B – Boxplot of MANDEL's h_i values as a function of days (before discarding observations).

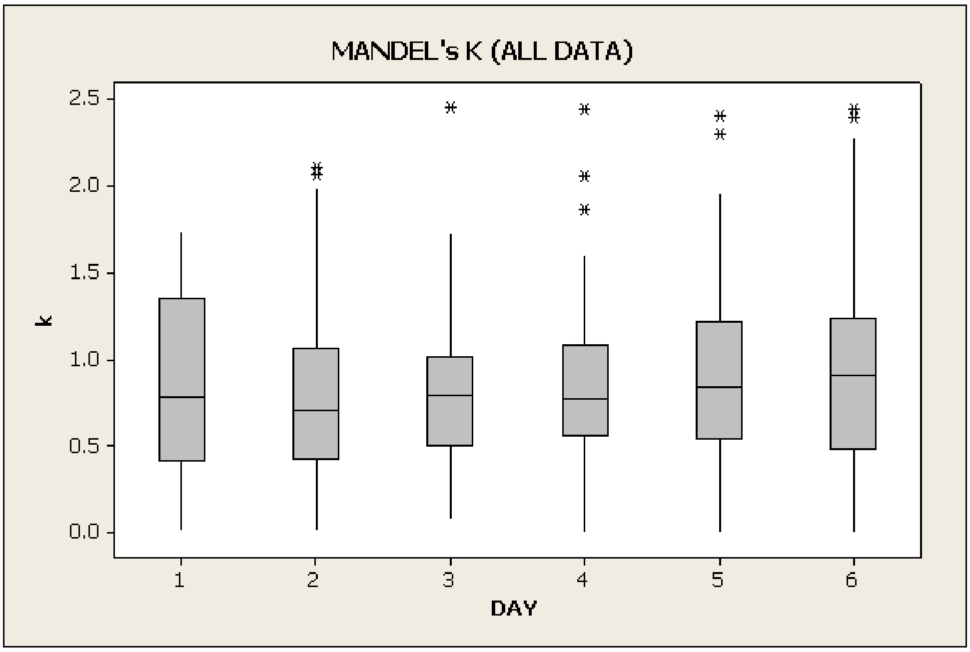


Fig. 47.

Fig. 48. Experiment B – Boxplot of MANDEL's k_i as a function of days (before discarding observations).

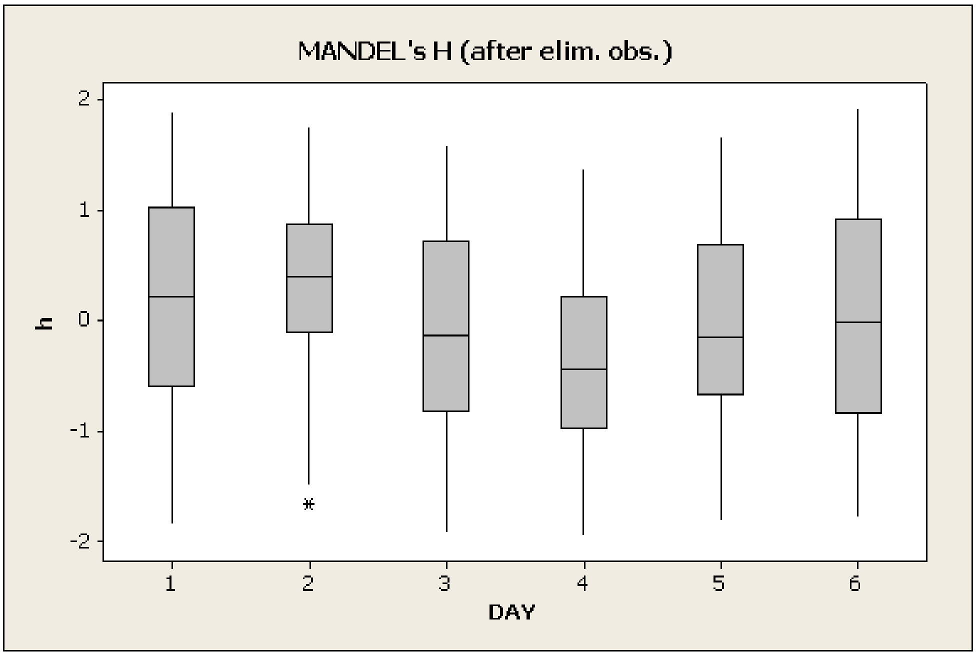


Fig. 49. Experiment B – Boxplot of MANDEL's h_i values as a function of days (after a discarding 99 observations).

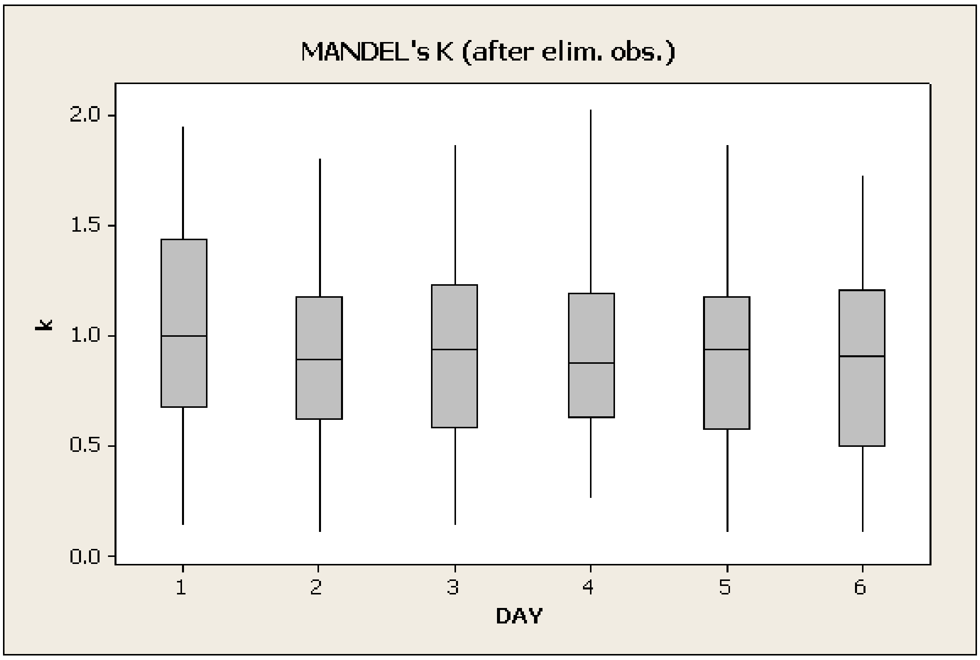


Fig. 50. Experiment B – Boxplot of MANDEL's k_i values as a function of days (after discarding 99 observations).

6.2.2.2 Individual relative errors

Figures: Fig. 51 - Fig. 54 give the distributions of the errors (in percent). Figures: Fig. 51, Fig. 52 give the differences between observations and reference areas, in percent of the reference areas for all data (Fig. 53) and after discarding 99 observations (Fig. 54) :

(32) relative error = 100 (observation – reference area)/reference area.

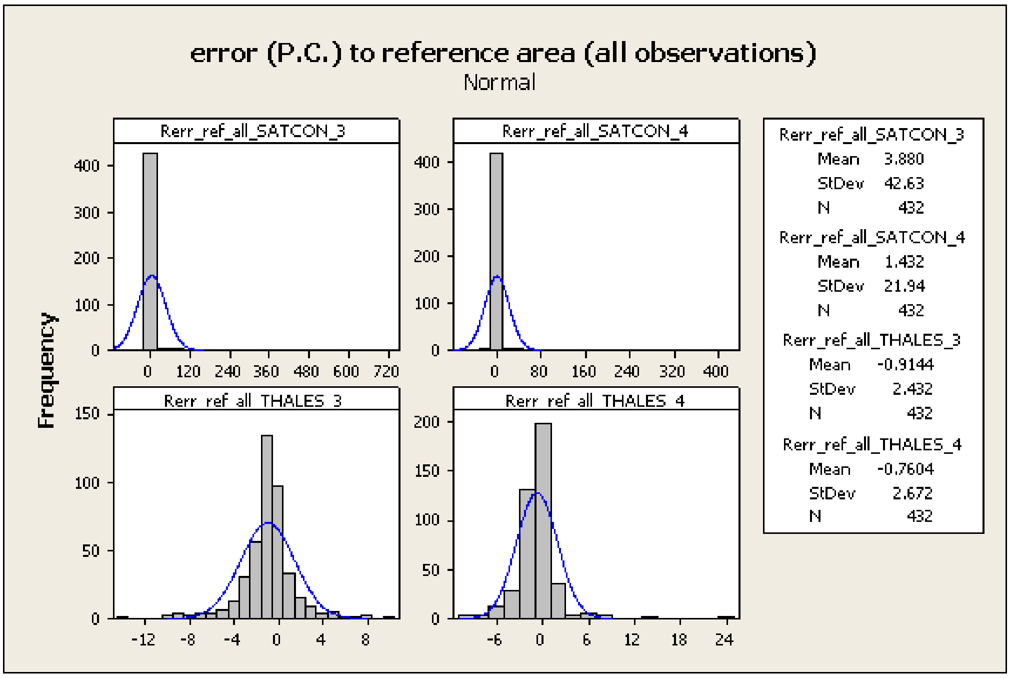


Fig. 51. Experiment B – Histogram of the errors (in percent) to reference area for all observations.

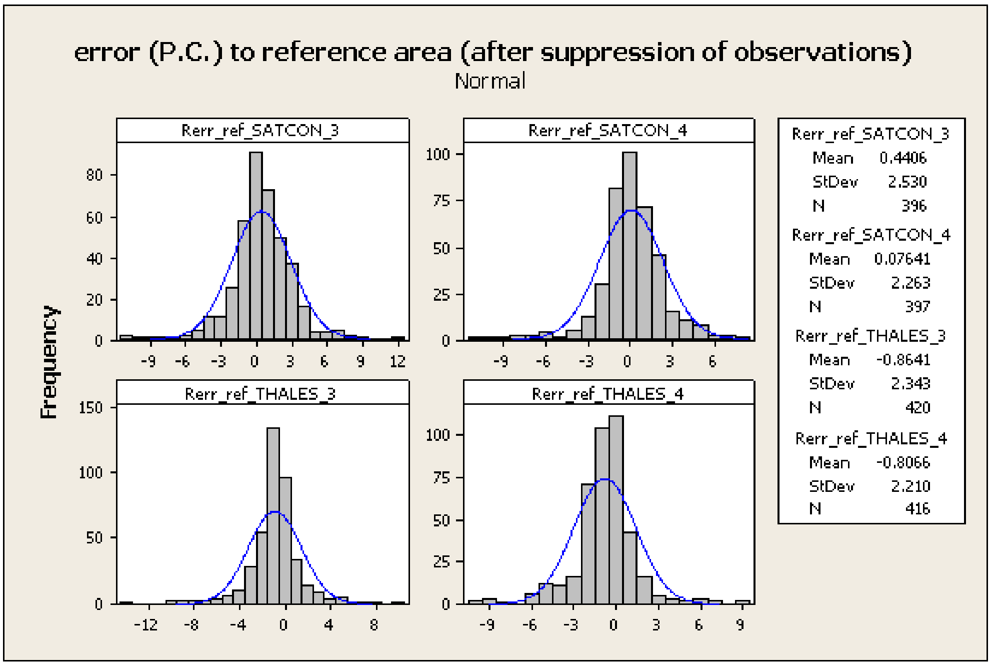


Fig. 52. Experiment B – Histogram of the errors (in percent) to reference area after discarding 99 observations.

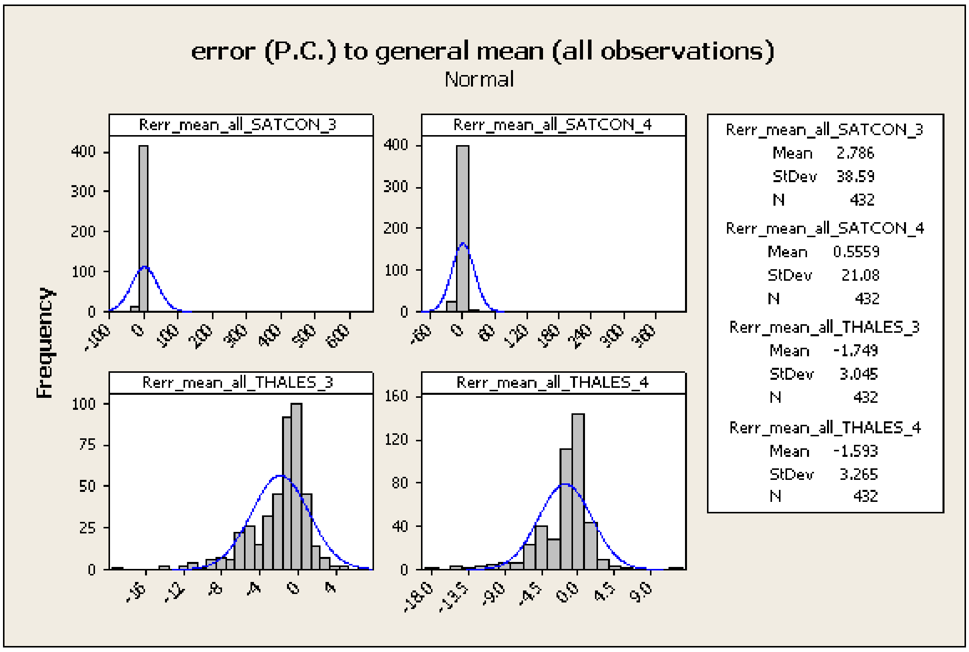


Fig. 53. Experiment B – Histogram of the error (in percent) to the general mean for all observations.

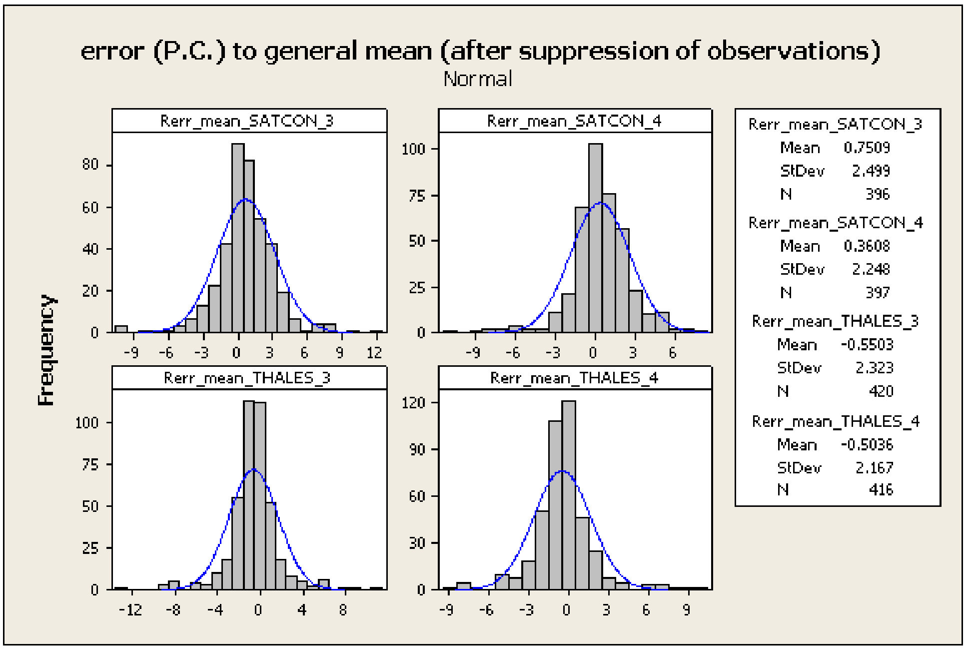


Fig. 54. Experiment B – Histogram of the error (in percent) to the general mean after discarding 46 observations).

Figures: Fig. 53, Fig. 54 give the differences between observations and the general mean (of all observations made on the parcel), for all the data (Fig. 53) and after discarding 46 observations (Fig. 54) :

(33) relative error = 100 (observation – general mean)/general mean.

Table: Tab 33 gives the percentage of observations with a (absolute) relative error less than a given value. The errors are computed as follows, after discarding 99 observations :

(34) (absolute) relative error = 100 | observation – general mean | /general mean.

From this table, we can see, for example, that 80.3 percents and 87.2 percents of observations are smaller or equal to 3 percents for the two Satcon instruments. For the two Thales, the percentages are 87.4 and 88.2.

Tab 33. Experiment B – Cumulative percentages of observations as a function of the error (%).

	SATCON		THALES	
Error (%)	S3	S4	T3	T4
1	40.4	47.1	51.9	49.0
2	65.2	74.6	74.5	78.1
3	80.3	87.2	87.4	88.2
4	90.7	91.7	92.1	92.8
5	95.0	94.0	94.1	95.0
6	96.2	97.2	96.2	96.6
7	97.2	98.2	97.1	97.6
8	97.9	99.2	97.9	98.3
9	98.7	99.5	99.3	99.3
10	99.2	99.8	99.5	100.0

6.2.2.3 Bias of the instruments

For each instrument and for each parcel, the ratio between the general mean and the reference area is computed. These ratios are given in table: Tab 34. Figure Fig. 55 gives the histograms of the ratios.

The 95 % confidence intervals are :

- 0.9984 – 1.0091 for SATCON S3,
- 0.9954 – 1.0060 for SATCON S4,
- 0.9862 – 0.9967 for THALES T3,
- and 0.9880 – 0.9961 for THALES T4.

The confidence interval includes the value 1 only for Satcon. So, we can conclude that the mean value of the ratio for the 18 parcels is not significantly different from 1 for Satcon but is significantly different from 1 for Thales : there is no bias for Satcon but Thales underestimates the reference areas.

Tab 34. Experiment B – Mean values of the observations and ratios mean value/reference area.

Parcels	S3	S4	T3	T4	S3/Ref	S4/Ref	T3/Ref	T4/Ref
19	4846	4869	4884	4865	0.998	1.003	1.006	1.002
20	5006	4956	4905	4915	1.016	1.006	0.995	0.997
21	4167	4109	4054	4077	1.013	0.999	0.986	0.991
22	11318	11366	11177	11229	1.002	1.007	0.990	0.995
23	11605	11600	11404	11428	1.012	1.012	0.995	0.997
24	10074	10056	9987	10014	1.003	1.001	0.994	0.997
25	31541	31242	31156	31155	1.007	0.998	0.995	0.995
26	30100	30166	29854	29942	0.999	1.002	0.991	0.994
27	31029	30741	30685	30720	1.005	0.996	0.994	0.995
28	4113	4078	4324	4268	0.972	0.963	1.022	1.008
29	4079	4039	3927	3972	1.016	1.006	0.978	0.989
30	4670	4627	4599	4571	1.008	0.998	0.992	0.986
31	9145	9154	8794	8786	1.013	1.014	0.974	0.973
32	11226	11316	11129	11138	0.988	0.996	0.980	0.980
33	9076	9048	8869	8843	1.007	1.004	0.984	0.981
34	39485	39529	39025	39239	0.999	1.000	0.988	0.993
35	39121	39164	38785	38718	0.999	1.000	0.990	0.988
36	31274	31296	30800	30806	1.009	1.010	0.994	0.994

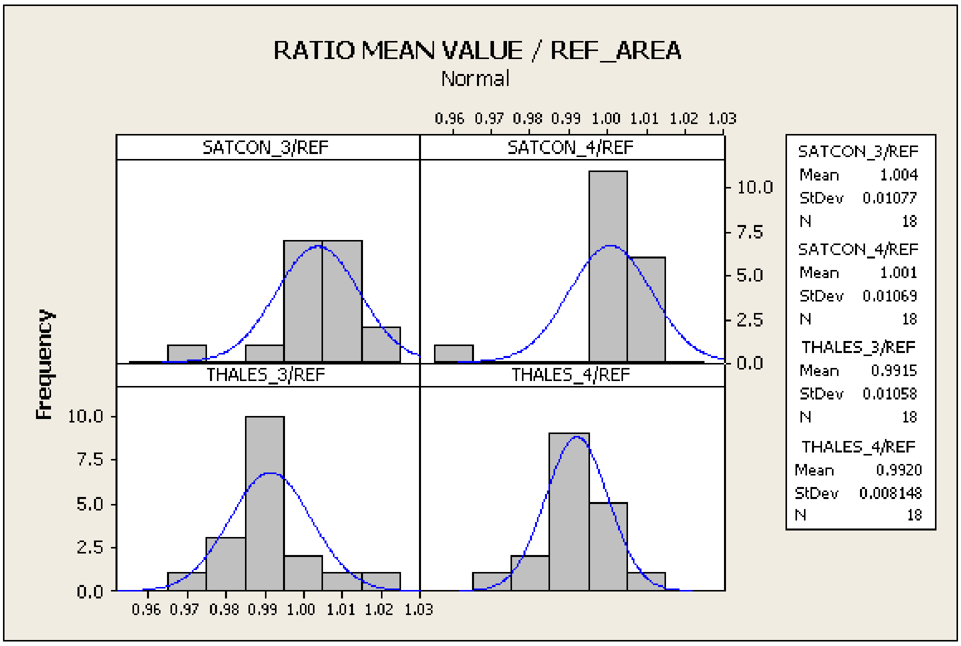


Fig. 55. Experiment B – Histogram of the ratios mean value/reference area.

6.2.2.4 Variance components and reproducibility

For each parcel and each instrument, a one-way analysis of variance has been performed and the variance components have been estimated.

The "between groups" variance, $\hat{\sigma}^2_{group}$ is the variance between days and the "within groups" variance $\hat{\sigma}^2_2$ is the variance of the replicates related to the operators. The negative estimations have been set to zero. The sum of these two variances gives the reproducibility variance $\hat{\sigma}^2_R$.

Tables: Tab 35 - Tab 38 25 give the variance components and the reproducibility for each parcel (labeled Bdays, Wdays and Repr). The variance components have also been expressed in percentage of the reproducibility.

Tab 35. Experiment B – Between days and with days variance components for SATCON S3.

Parcels	Bdays	Wdays	Repr	B%	W%
19	0	13845	13845	0	100
20	0	22049	22049	0	100
21	5418	5788	11206	48	52
22	37030	16295	53325	69	31
23	0	52109	52109	0	100
24	6868	19884	26752	26	74
25	25174	110779	135953	19	81
26	4133	64206	68339	6	94
27	23976	67531	91507	26	74
28	30881	25888	56769	54	46
29	7464	14803	22267	34	66
30	0	5475	5475	0	100
31	0	112566	112566	0	100
32	0	147559	147559	0	100
33	0	13054	13054	0	100
34	0	471700	471700	0	100
35	56153	75416	131569	43	57
36	152190	36218	188408	81	19

Tab 36. Experiment B – Between days and with days variance components for SATCON S4.

Parcels	Bdays	Wdays	Repr	B%	W%
19	10688	24965	35653	30	70
20	0	10493	10493	0	100
21	4	3176	3180	0	100
22	21121	41848	62969	34	66
23	17452	71156	88608	20	80
24	133	18795	18928	1	99
25	0	71196	71196	0	100

26	0	123494	123494	0	100
27	8222	16968	25190	33	67
28	5223	28134	33357	16	84
29	2428	8086	10514	23	77
30	4449	2652	7101	63	37
31	0	98173	98173	0	100
32	21254	26725	47979	44	56
33	0	10271	10271	0	100
34	104278	148502	252780	41	59
35	85227	86626	171853	50	50
36	169135	81463	250598	67	33

Tab 37. Experiment B – Between days and with days variance components for THALES T3.

Parcels	Bdays	Wdays	Repr	B%	W%
19	1216	4043	5259	23	77
20	539	2826	3366	16	84
21	0	1657	1657	0	100
22	0	80232	80232	0	100
23	0	25239	25239	0	100
24	783	8601	9385	8	92
25	3	38518	38521	0	100
26	0	76707	76707	0	100
27	0	22507	22507	0	100
28	0	35349	35349	0	100
29	0	19986	19986	0	100
30	2244	11651	13895	16	84
31	0	88757	88757	0	100
32	32097	116971	149068	22	78
33	0	19307	19307	0	100
34	112774	647387	760161	15	85
35	62052	85679	147731	42	58
36	0	43735	43735	0	100

Tab 38. Experiment B – Between days and with days variance components for THALES T4.

Parcels	Bdays	Wdays	Repr	B%	W%
19	0	12432	12432	0	100
20	1232	4885	6117	20	80
21	1989	1189	3178	63	37
22	8388	29183	37571	22	78
23	0	13700	13700	0	100

24	264	6761	7025	4	96
25	41922	92164	134086	31	69
26	1052	23983	25035	4	96
27	12998	31029	44027	30	70
28	20625	38062	58687	35	65
29	0	6211	6211	0	100
30	5830	6438	12268	48	52
31	0	87026	87026	0	100
32	69028	98924	167952	41	59
33	1262	6725	7987	16	84
34	0	119474	119474	0	100
35	82125	214796	296921	28	72
36	0	31552	31552	0	100

The average proportions of "between" and "within" variance components, for each instrument are :

- 23 % between and 77 % within for SATCON S3,
- 23 % between and 77 % within for SATCON S4,
- 8 % between and 92 % within for THALES T3,
- 20 % between and 80 % within for Thales T4.

Several transformations of the reproducibility have also been computed:

- he reproducibility standard deviation (labelled S Dev);
- the reproducibility coefficient of variation (standard deviation divided by the reference area of the parcel, labelled CoefVar);
- he buffer (standard deviation divided by the perimeter of the parcel);
- the standard deviation divided by a constant (labelled HB) depending on the parcel geometry; this constant is the factor which is multiplied by the point position error to give the area error.

The results are given in tables: Tab 39 - Tab 42.

Tab 39. Experiment B – Transformations of the reproducibility variance for SATCON S3.

Parcels	SDev	Buffer	CoefVar	SDev/HB
19	118	0.293	0.024	1.400
20	148	0.413	0.030	2.064
21	106	0.380	0.026	1.668
22	231	0.355	0.020	2.033
23	228	0.385	0.020	2.223
24	164	0.381	0.016	1.827
25	369	0.343	0.012	2.821
26	261	0.267	0.009	1.775
27	303	0.410	0.010	2.812

28	238	0.456	0.056	2.305
29	149	0.487	0.037	2.184
30	74	0.252	0.016	1.362
31	336	0.501	0.037	4.230
33	114	0.288	0.013	1.683
34	687	0.617	0.017	5.125
35	363	0.344	0.009	3.107
36	434	0.573	0.014	3.674

Tab 40. Experiment B – Transformations of the reproducibility variance for SATCON S4.

Parcels	SDev	Buffer	CoefVar	SDev/HB
19	189	0.471	0.039	2.247
20	102	0.285	0.021	1.424
21	56	0.203	0.014	0.889
22	251	0.386	0.022	2.209
23	298	0.501	0.026	2.899
24	138	0.321	0.014	1.537
25	267	0.248	0.009	2.041
26	351	0.359	0.012	2.387
27	159	0.215	0.005	1.476
28	183	0.350	0.043	1.767
29	103	0.335	0.026	1.500
30	84	0.287	0.018	1.551
31	313	0.468	0.035	2.847
32	219	0.338	0.019	2.412
33	101	0.255	0.011	1.493
34	503	0.451	0.013	3.752
35	415	0.393	0.011	3.551
36	501	0.660	0.016	4.237

Tab 41. Experiment B – Transformations of the reproducibility variance for THALES T3.

Parcels	SDev	Buffer	CoefVar	SDev/HB
19	73	0.181	0.015	0.863
20	58	0.161	0.012	0.806
21	41	0.146	0.010	0.641
22	283	0.435	0.025	2.493
23	159	0.268	0.014	1.547
24	97	0.226	0.010	1.082
25	196	0.183	0.006	1.501
26	277	0.283	0.009	1.881
27	150	0.203	0.005	1.395
28	188	0.360	0.044	1.819
29	141	0.461	0.035	2.069
30	118	0.401	0.025	2.169

31	298	0.445	0.033	2.707
32	386	0.596	0.034	4.251
33	139	0.350	0.015	2.047
34	872	0.783	0.022	6.507
35	384	0.364	0.010	3.293
36	209	0.276	0.007	1.770

Tab 42. Experiment B – Transformations of the reproducibility variance for THALES T4.

Parcels	SDev	Buffer r	CoefVa	SDev/HB
19	111	0.278	0.023	1.327
20	78	0.217	0.016	1.087
21	56	0.202	0.014	0.888
22	194	0.298	0.017	1.706
23	117	0.197	0.010	1.140
24	84	0.195	0.008	0.936
25	366	0.341	0.012	2.801
26	158	0.162	0.005	1.075
27	210	0.285	0.007	1.951
28	242	0.464	0.057	2.344
29	79	0.257	0.020	1.153
30	111	0.377	0.024	2.038
31	295	0.441	0.033	2.680
32	410	0.632	0.036	4.512
33	89	0.225	0.010	1.317
34	346	0.310	0.009	2.579
35	545	0.516	0.014	4.668
36	178	0.234	0.006	1.504

For these four variables, the boxplots are given by types of "size", "shape" and "border" in appendix **Błąd! Nie można odnaleźć źródła odwołania.**. These plots show that :

- the standard-deviation increases with size;
- the coefficient of variation decreases with size;
- the buffer and the ratio standard deviation/HB seem only to be slightly related to size.

Buffer is the transformation for which the results are the least influenced by the characteristics of the parcels. For this reason, buffer is the best parameter for describing variability.

Tables: Tab 43 - Tab 46 give the results of several attempts of modeling the buffer.

Tab 43. Experiment B – Modeling buffer for SATCON S3.

All	Buffer = 0.408 (0.110)
Good border	Buffer = 0.359 (0.050)
Bad border	Buffer = 0.457 (0.134)

All	Buffer = 0.383 + 0.000002 Ref_Area (0,112)
Good border	Buffer = 0.374 + 0.000001 Ref_Area (0.052)
Bad border	Buffer = 0.410 + 0.000003 Ref_Area (0.136)

Tab 44. Experiment B – Modeling buffer for SATCON S4.

All	Buffer = 0.363 (0.116)
Good border	Buffer = 0.332 (0.107)
Bad border	Buffer = 0.393 (0.122)
All	Buffer = 0.331 + 0.000002 Ref_Area (0.116)
Good border	Buffer = 0.375 + 0.000003 Ref_Area (0.109)
Bad border	Buffer = 0.315 + 0.000005 Ref_Area (0.107)

Tab 45. Experiment B – Modeling buffer for THALES T3.

All	Buffer = 0.340 (0.165)
Good border	Buffer = 0.232 (0.089)
Bad border	Buffer = 0.448 (0.154)
All	Buffer = 0.302 + 0.000002 Ref_Area (0.167)
Good border	Buffer = 0.220 + 0.000001 Ref_Area (0.095)
Bad border	Buffer = 0.405 + 0.000003 Ref_Area (0.159)

Tab 46. Experiment B – Modeling buffer for THALES T4.

All	Buffer = 0.313 (0.128)
Good border	Buffer = 0.242 (0.060)
Bad border	Buffer = 0.384 (0.141)
All	Buffer = 0.303 + 0.000001 Ref_Area (0.132)
Good border	Buffer = 0.220 + 0.000001 Ref_Area (0.062)
Bad border	Buffer = 0.391 + 0.000000 Ref_Area (0.150)

The first three lines in these tables give the general mean and the means of parcels with good and bad border. The next lines show regression equations giving the buffer as a function of reference area. The related scatterplots are given in figures: Fig. 56 - Fig. 59. For each model the (residual) standard deviation is given in parentheses.

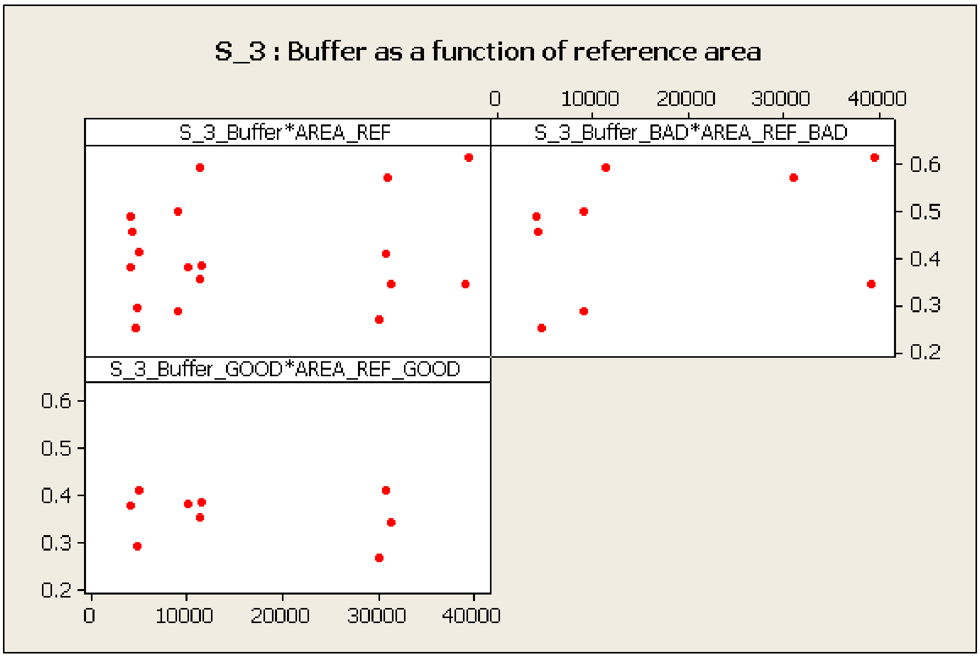


Fig. 56. Experiment B – Buffer as a function of reference area for SATCON S3.

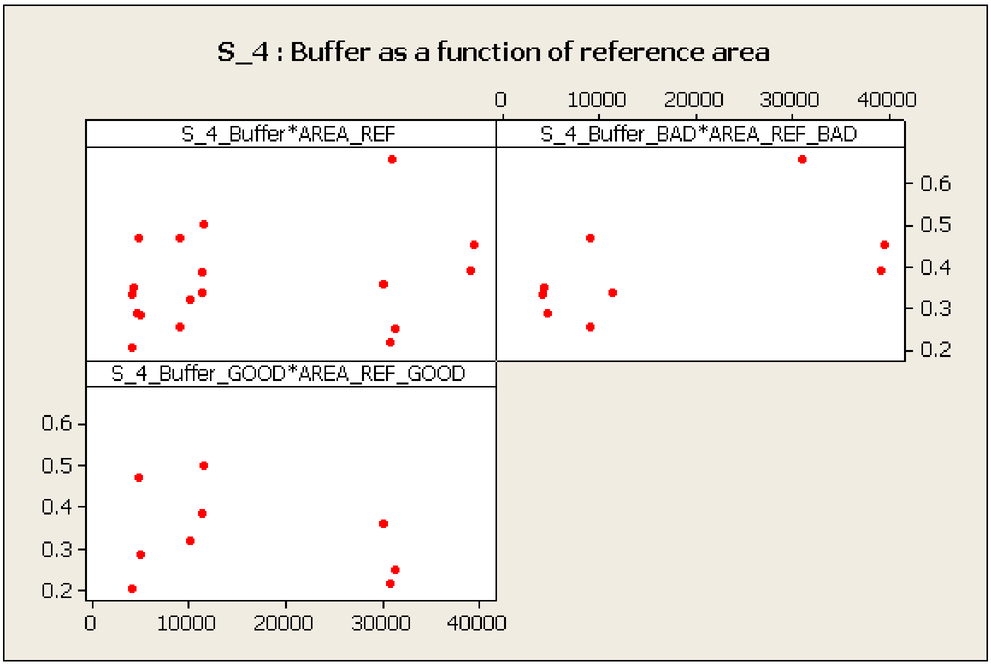


Fig. 57. Experiment B – Buffer as a function of reference area for SATCON S4.

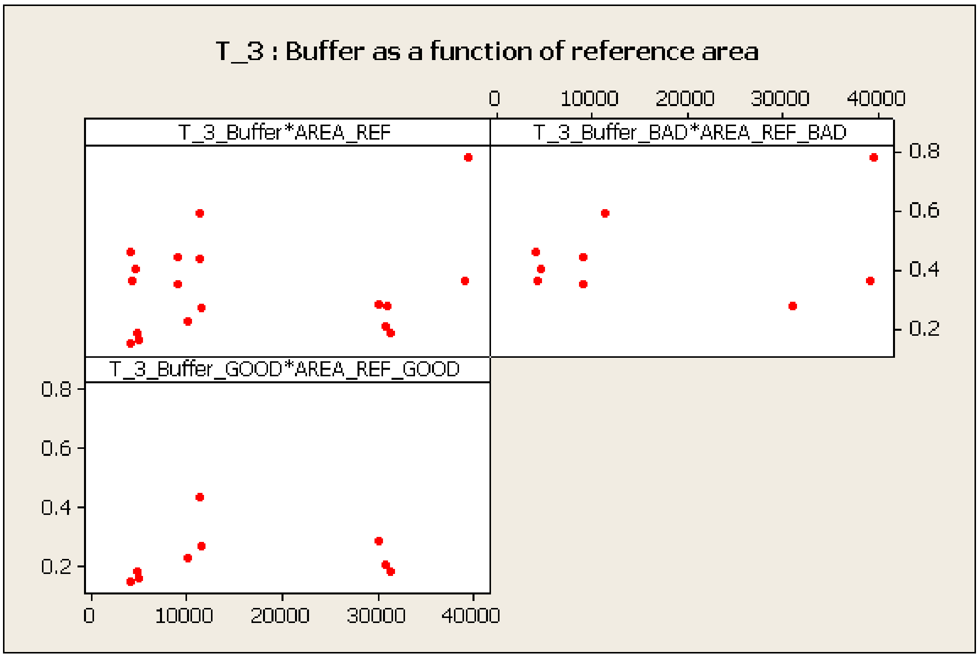


Fig. 58. Experiment B – Buffer as a function of reference area for THALES T3.

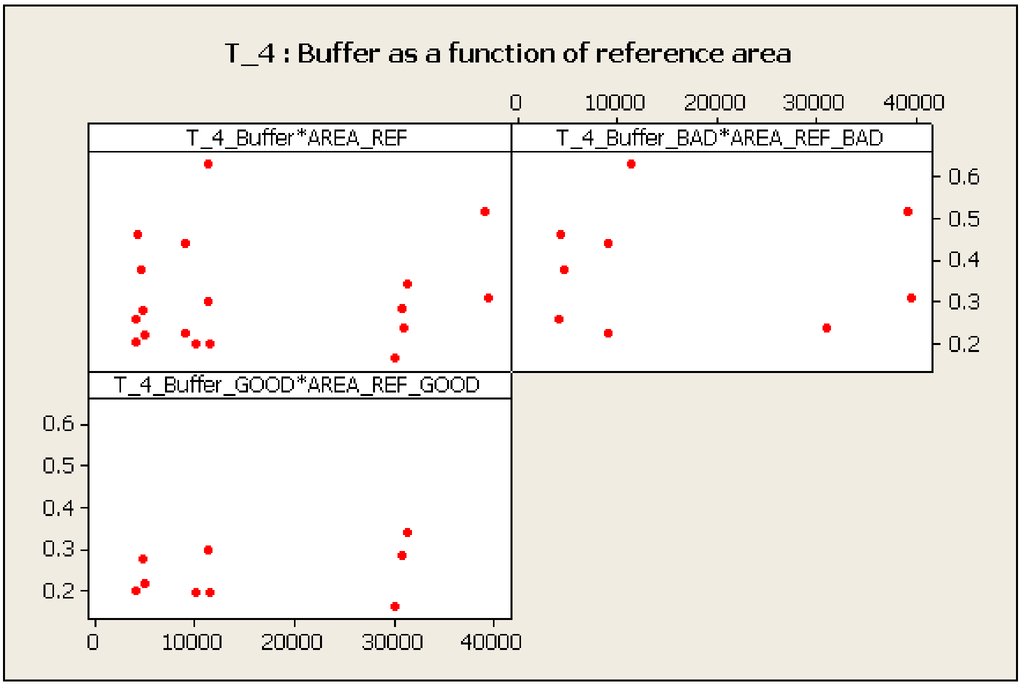


Fig. 59. Experiment B – Buffer as a function of reference area for THALES T4.

For SATCON S3 and S4, the factor "border" and the factor "Reference area" are not significant. For SATCON and THALES T3 and T4, the factor "border" is significant but the factor "Reference area" is not significant.

7. Point position error – discussion

Buffer width and point position error are compared in the chapter. RS analyses are performed on the base of data from chapter 6.1.1. Relationships between point position error and parcel area are presented for good and bad conditions on the diagrams: Fig. 60 - Fig. 65.

Tab 47. Average point position error

	Average m_{pkt}	σ of m_{pkt}
OP_0_2	1.24	0.55
OP_0_5	1.78	1.08
OP_1_0	1.52	0.60

Tab 48. Average buffer width

	Average buffer width	σ of buffer width
OP_0_2	0.26	0.09
OP_0_5	0.38	0.25
OP_1_0	0.33	0.40

Let us analyze diagrams: Fig. 60 - Fig. 65 and put the offset from formula on diagram to the table.

Tab 49. Offset from diagrams: Fig. 60 - Fig. 65

	offset (good)	offset (bad)
OP_0_2	0.83	0.95
OP_0_5	1.68	1.58
OP_1_0	1.28	1.95

Assuming accuracy of parcel edge recognition of 0.5m we can calculate point position error for measured ortho, assuming nominal RMS for each ortho.

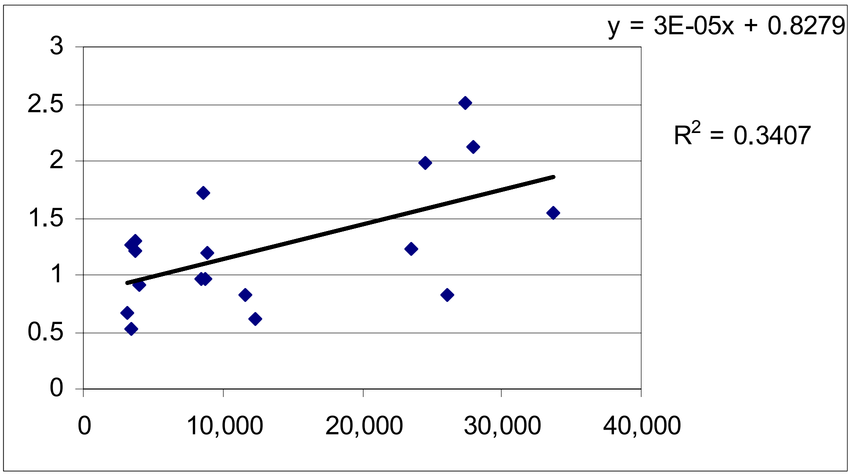
Tab 50. A'priori point position error

	Ortho RMS	Resultant RMS)
OP_0_2	0.75	0.90
OP_0_5	1.5	1.58
OP_1_0	2.5	2.55

It follows from the table: Tab 50 that having assumed a'priori ortho RMS and accuracy of parcel edge recognition, we can estimate minimum RMS in the case of OP_0_2 and OP_0_5 and overestimate of OP_1_0. This other option is that nominal RMS of OP_1_0 were badly estimated.

7.1 Remote Sensing – good border

7.1.1 OP_0_2 - good



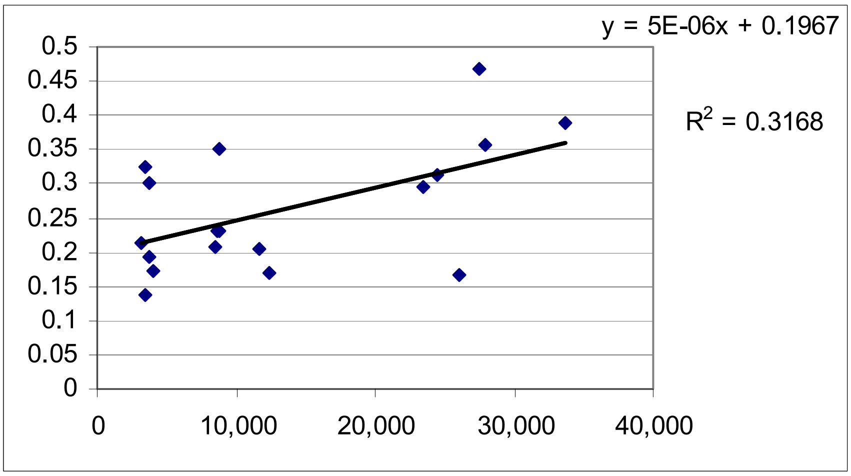
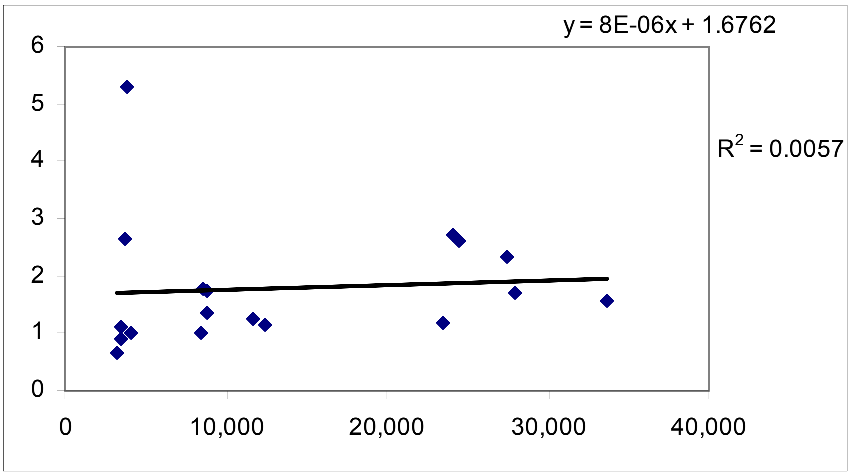


Fig. 60. OP_0_2 – good (error of point position -above, buffer width – below)

7.1.2 OP_0_5 - good



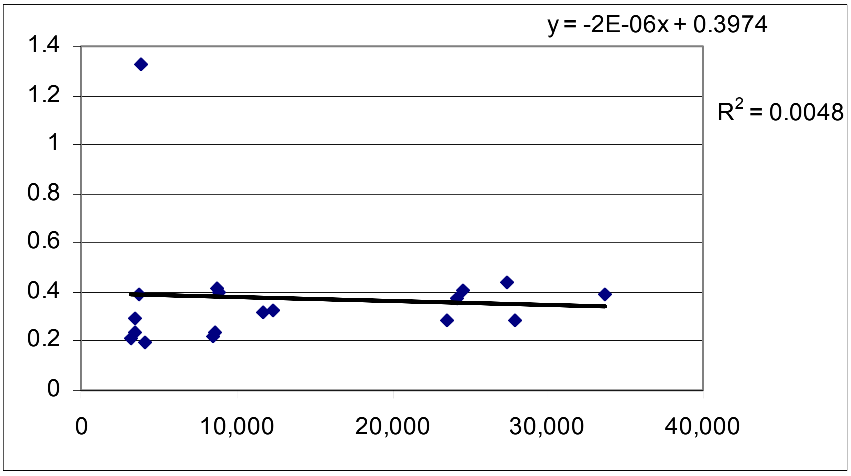


Fig. 61. OP_0_5 – good (error of point position -above, buffer width – below)

7.1.3 OP_1_0 - good

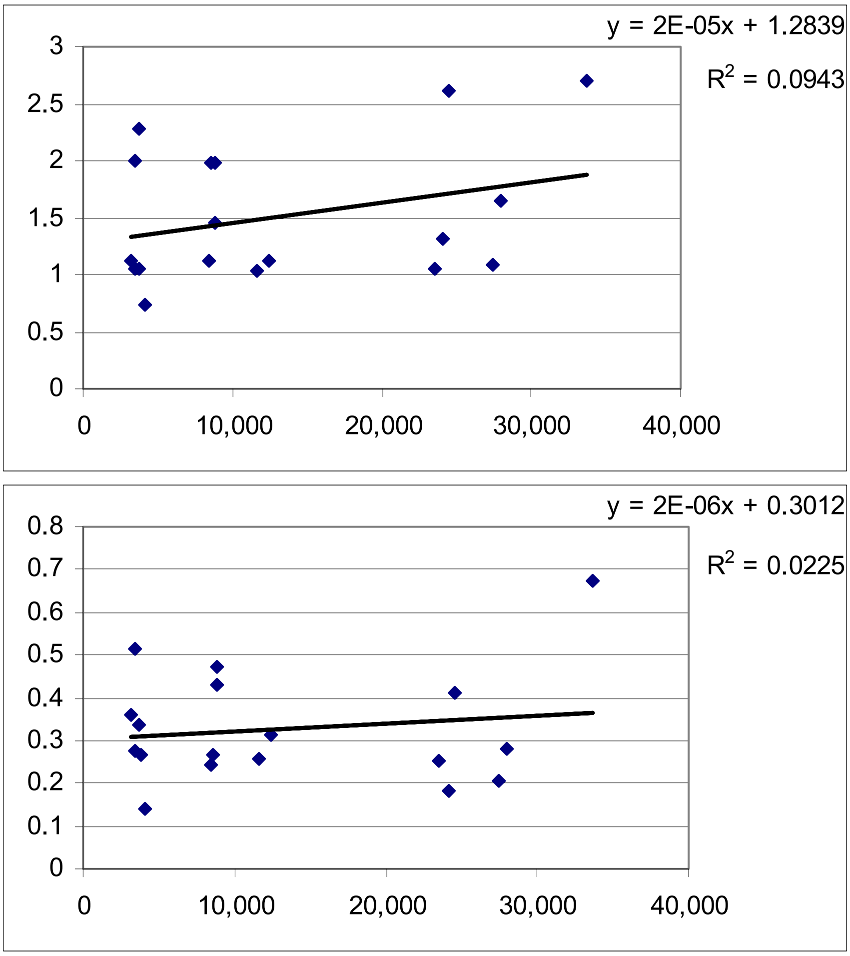
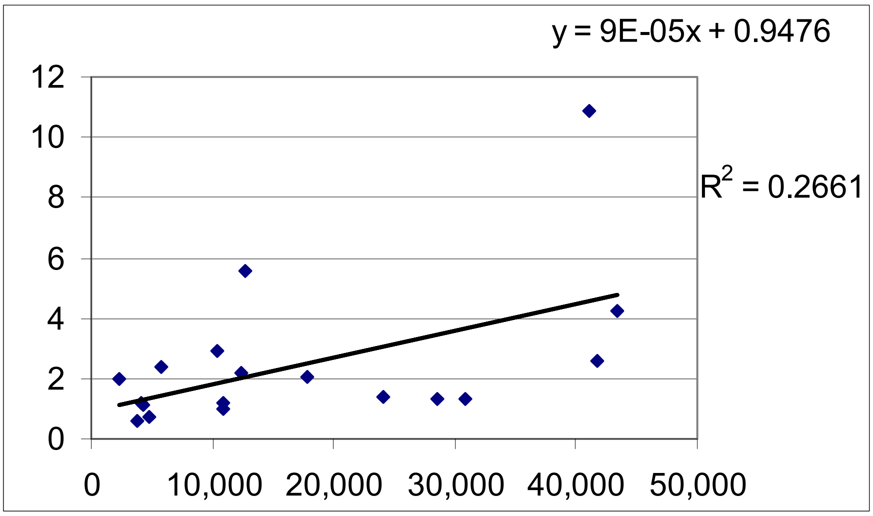


Fig. 62. OP_1_0 – good (error of point position -above, buffer width – below)

7.2 Remote sensing – bad border

7.2.1 OP_0_2 - bad



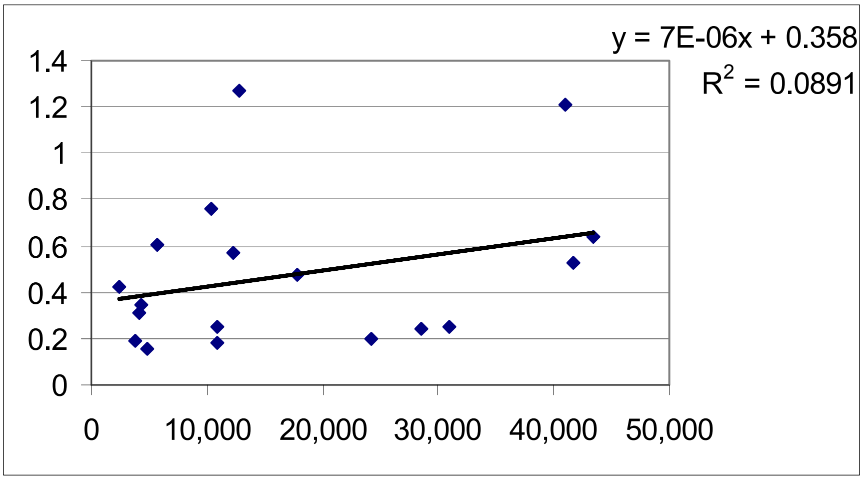
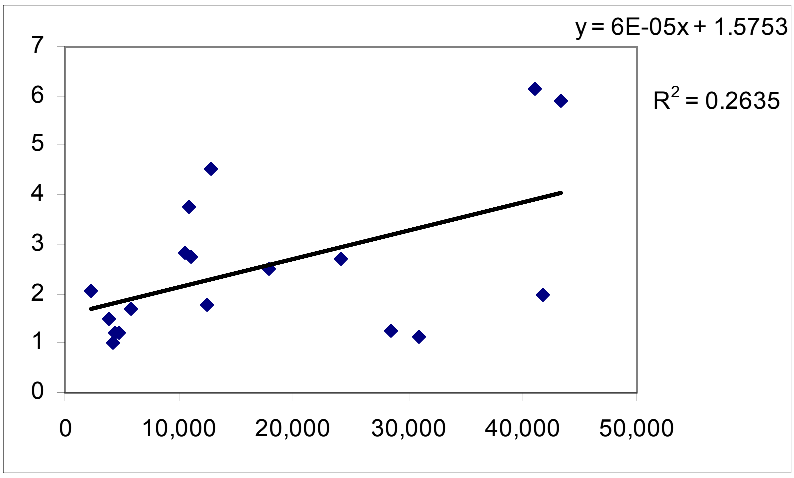


Fig. 63. OP_0_2 – bad (error of point position -above, buffer width – below)

7.2.2 OP_0_5 - bad



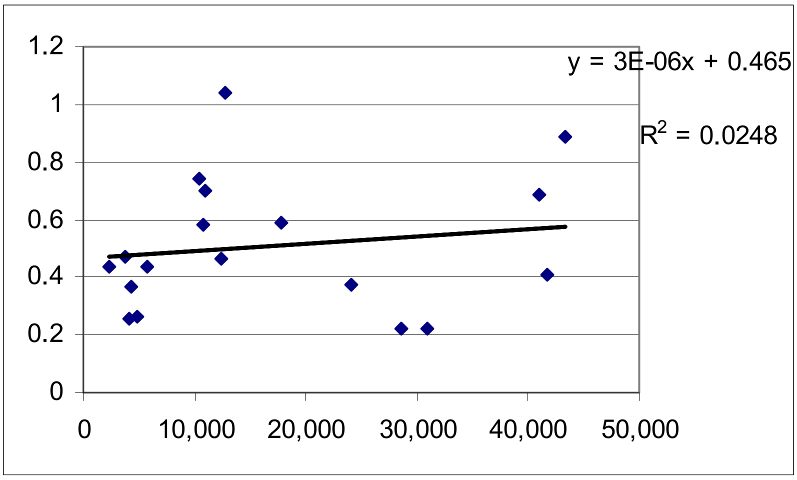
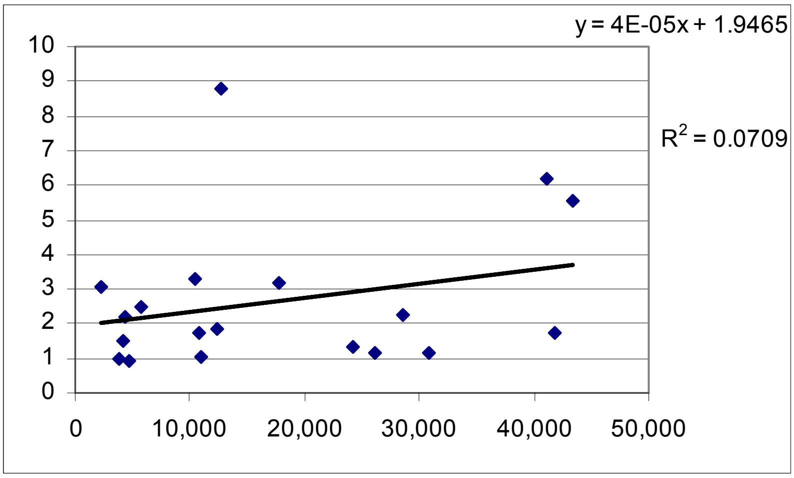


Fig. 64. OP_0_5 – bad (error of point position -above, buffer width – below)

7.2.3 OP_1_0 - bad



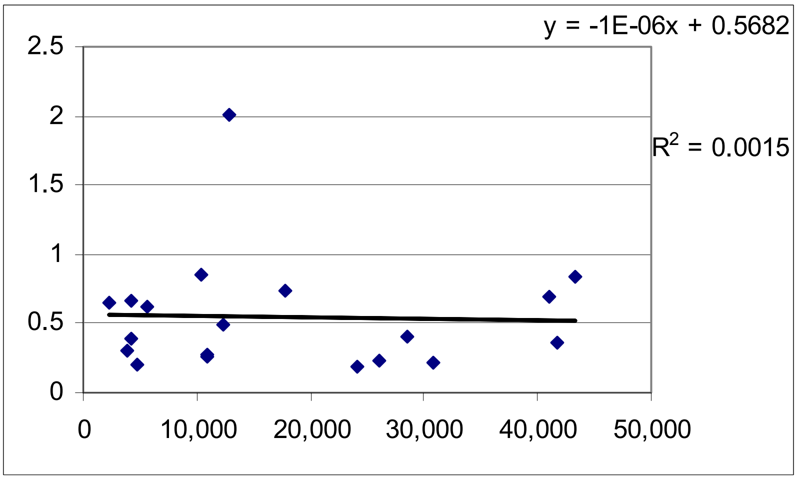


Fig. 65. OP_1_0 – bad (error of point position -above, buffer width – below)

7.3 GPS – example

Relationships between buffer width and point position error and parcel area are compared for chosen data in the chapter (experiment A, Garmin and Satcon), (Fig. 66,Fig. 67). Point position error strongly depends on amount of vertex of parcel border. All analysis performed for GPS data based on reference parcel defined by stakes (each 20m). In real GPS measurements we have more points than stakes therefore point position error calculated on the basis of the reference parcel doesn't represent real point position for GPS measurement (Tab 51).

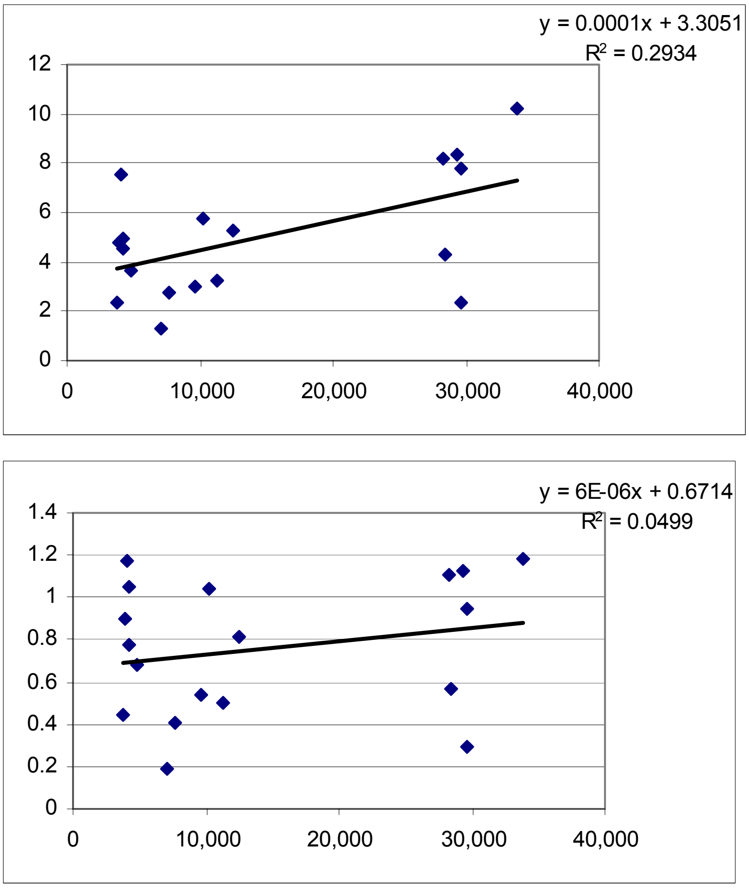
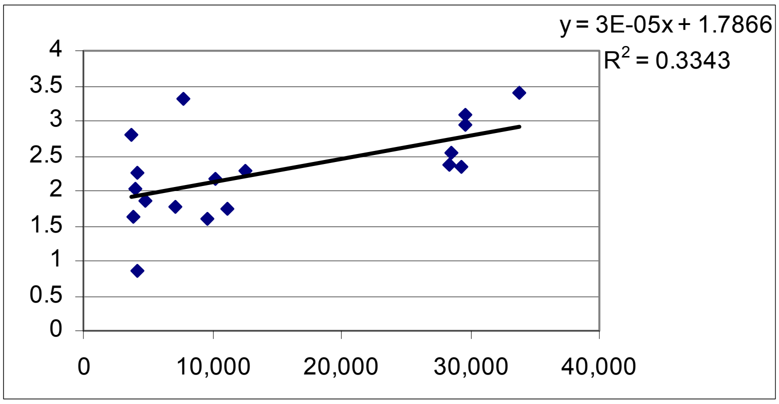


Fig. 66. Experiment A – Garmin (error of point position -above, buffer width – below)



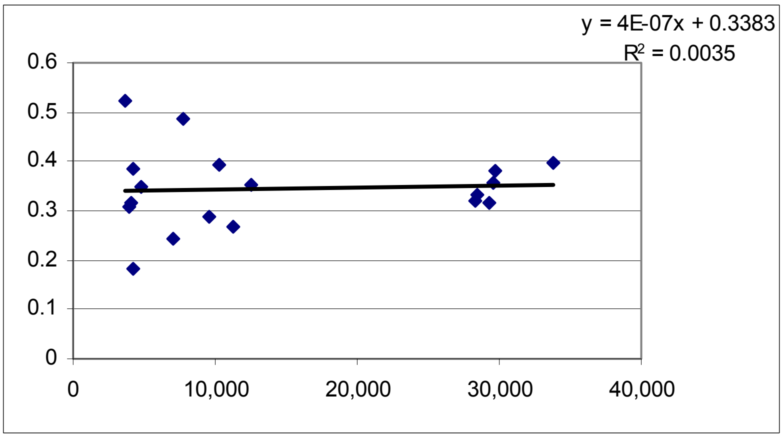


Fig. 67. Experiment A - Satcon (error of point position -above, buffer width – below)

Tab 51. Comparison error of point position calculated for reference parcel and real GPS measurements.

Parcel No	HB	Garmin SDev/HB	Satcon SDev/HB
2 reference	58.42	7.567	2.031
5 reference	91.8	5.283	2.275
2 real	16.46	26.97	7.22
5 real	20.72	23.41	10.086

8. Proposal for validation of measurement of land parcel area

The method for validation of measurement of land parcel area will be elaborated in two weeks basing on the JRC approach [Kay S., Spruyt P. 2002, Soruyt P. 2004] and the results of the project..

8.1 Design of experiment

8.2 Work flow of measurements

8.3 Data preparation

8.4 Statistical outlier identification

8.5 Parcel area error calculation

9. Bibliography

1) Bogaert P., Delinc´e J., Kay S. 2005 – “Assessing the error of polygonal area measurements: a general formulation with applications to agriculture” – Institute of Physics Publishing, Measurements Science Technology, 16 (2005), 1170-1178

2) Hejmanowska B., 2003 – „Data inaccuracy in geographic system – propagation of DTM and ortophotomaps in the spatial analysis”, – Geodesy 40, Publishing of Geodesy and Environmental Engineering, Polish Academy of Science, Kraków

3) Kay S., Spruyt P. 2002 - JRC GPS validation scheme (ref. JRC IPSC/G03/P/SKA/ska D(2002)(1092))

4) Spruyt P., 2004 - JRC Protocol for reference field-measurement (ref. JRC IPSC/G03/P/PSP/psp D(2002)(1108))

5) Kay S., 2003 - JRC Technical Information Document: Technical tolerances for On the Spot checks (ref. JRC IPSC/G03/P/SKA/ska D(2003)(1576))

6) Note on the use of stand-alone GPS for parcel measurement (ref. JRC IPSC/G03/SKA/OLE D(2002)(1087))

7) DG-AGRI Guidance for on-the-spot checks of area and area measurement (ref. AGRI-2254-2003), Working Document No. AGRI/2254/2003 replacing working document VI/8388/94 rev. 6 of 17/12/1999, on-the-spot checks of area according to articles 15-23 of commission regulation (ec) no 2419/2001

8) **2. ISO standards**:

- ISO 5725 “Accuracy (trueness and precision) of measurement methods and results”
  - Part 1 „General principles and definitions”
  - Part 2 “Basic method for the determination of repeatability and reproducibility of a standard measurement method”
  - Part 3 “Intermediate measures of the precision of a standard measurements method”

10. Appendix GPS

10.1 GPS instruments

10.1.1 Thales – Mobile Mapper

10.1.1.1 Navigation features:

- 4MB RAM, internal (removable) memory card type SD: 16MB (optionally 32 or 64 MB)
- Data collection software „Mobile Mapper Field" + postprocessing software „MobileMapper Office"

Agriculture: operation planning, development of reports on crops or areas requiring chemical fertilising, area borders, roads

10.1.1.2 "Mobile Mapper Field" software

The software combines GIS data collection capability and all navigation capabilities. The GIS data collection options include the following:

- Object description (attributes)
- Support for point, line, and area recording
- Offset capability for unavailable points measurement
- Measurement capabilities' nesting, e.g. measurement of additional points in the course of line measurement
- Repeated object measurement option for quick recording of objects with the same attributes
- Map tools enabling collection of additional data (water depth, chemical compounds concentration, etc.) needed for vector map generation

10.1.1.3 "Mobile Mapper Office" software

The software is a package of applications for connecting a MobileMapper receiver with a GIS system. The software options include the following:

- Attribute library build-up
- GIS data display and editing
- GIS data and base map downloading to Mobile Mapper receiver
- Map mapping definition
- Data display in other reference system

- Data export to .SHP, .MIF, and .DXF formats

10.1.1.3.1 Receiver operating features:

- Capable of receiving DGPS correction and WAAS/EGNOS signal
- 12 independent GPS channels
- Initialisation: so called „cold start” < 2 min., „warm start” < 1 min, „hot start” < 15 sec.
- Interval: 1or 2 seconds
- Real time accuracy with WAAS (RMS): Horizontal: < 3 m (10 ft) 2DRMS (95%)
- Interfaces: Serial port NMEA (option to configure forwarded sentences), RTCM 104 – external port for differential correction receipt from base station
- Antenna: built-in, option to connect an external antenna

10.1.1.3.2 Physical features (Fig. 68):

- Weight: 0.22 kg
- Size: 16.5 cm H x 7.3 cm W x 3 cm D
- Illuminated colour display: 5.6 cm H x 3.9 cm W (2.2 in H x 1.6 in. W)
- Display resolution: 120 x 160
- Illuminated keypad: 12 keys
- Power supply: 2 internal AA type batteries
- Battery life: 8 hours with illuminated display and Li-ion battery at 25°C; 16 hours with no illumination
- Option to connect external power supply via serial port
- Operating temperature: -10°C to 60°C
- Storage temperature: -20°C to 70°C
- Waterproof : IEC-529 IPX7 Standard (can withstand immersion for 30 min at 1m depth)
- Shockproof: can withstand fall from 1.5 m elevation on a hard surface

Fig. 68. Thales Mobile Mapper receiver.

10.1.1.4 Satconsystem – PalmArea

10.1.1.4.1 Basic features of a Satconsystem - PalmArea unit consisting of the following components (Fig. 69):

- GPS receiver - Rikaline GPS 6010
- SONY palmtop with PalmArea version 2.60 software
- external battery
- receiver/palmtop connecting cable, power supply cable, external battery and palmtop rechargers, and palmtop/PC connecting cable via USB port
- FarmGovs PC application enabling transfer of recorded data to a PC and visualisation, measurement simulation, printing, etc. thereof.

Fig. 69. Satconsystem - PalmArea unit.

10.1.1.5 GPS receiver Rikaline GPS 6010

10.1.1.5.1 Physical features:

- Waterproof up to 1 m depth
- Power consumption 70mA (3.3V)
- Autonomous positioning accuracy 25 m (95%) CEP
- Autonomous positioning accuracy 0.1 m/s
- Differential positioning accuracy (EGNOS or DGPS) 1-5 m (95%) CEP
- Differential velocity accuracy 0.05 m/s
- Size: 59.3 x 50.2 (47.1) x 19.7 mm
- (W x D x H) inch2.33 x 1.98 (1.85) x 0.78
- Weight: 103g
- Measurement L1, C/A code
- 12 channels
- option EGNOS and DGPS

- hot start 8 sec
- warm start 38 s
- cold start 45 s
- measurement interval 1 s
- operating temperature -40 ~ 85°C
- storage temperature -55 ~ 100°C

10.1.1.5.2 PalmArea v. 2.51 (Palmtop SONY) software

The software is preinstalled on the palmtop type computer. The software is capable of determining plot position, area, and perimeter, as well as data recording. There are four main modes of the software operation available:

- measurement and recording of plot perimeter (point recording hold-up, recorded point delete, mean position on-the-spot record, plot border offset setup)
- visualisation of measured areas on built-in map and recording of terrain barriers (waypoints),
- setting out (signalling of presence within certain distance) of predefine points, e.g. sewerage well in field, stones, etc., used in agriculture (this feature was not tested under this study),
- computation of area, perimeter, max. DOP indicator, max. movement speed, distance covered, measurement time, number of points measured.

The settings include: minimum velocity for point recording, minimum DOP indicator, map grid interval, known point warning radius, „offset" and measurement interval, as well as metric/English measurement system swap.

The antenna connection may be altered (e.g. via memory card pocket), as well as data transfer to PC in 4 formats (satcon, fieldstar, arcview, txt). EGNOS system satellite corrections receiving is set up in this software version as the default mode.

10.1.1.5.3 FarmGovs P.C. software

The software enables visualisation of measured plots separately or jointly on a common map using data in the SATCON format, as well as:

- recovery of measurement data such as: date, measurement start and end time, initial measurement point position, average measurement velocity, perimeter, number of points measured;
- concurrent visualisation of one plot or multiple plots, in different scales, as well as print in built-in format, with additional information;
- display of locations, registered points, accelerated or real time simulation of measurement route;
- software communication with GPS device;
- entering additional description of measured plot;

- number of options for soil sample planning (acidity, mineral resources, etc.), soil map development etc., used in agriculture (this feature was not tested under this study).

Both programs, FarmGovs and PalmArea, were appraised as very simple and user-friendly, popular tools (for many users, including farmers).

10.1.2 Garmin – GPS Map 76S

10.1.2.1 Navigation features:

- Internal memory: 24MB for data from MapSource series software.
- Waypoints: 500 with symbol and name
- Automatic search of the nearest points
- Search of waypoints and map elements after name and off list
- 10 warning points
- Covered route record: automatic recording of up to 5000 points – option to save up to 10 tracks
- Routes: 50 reversible to 50 points each and MOB and TracBack features
- Co-ordinate systems: over 100 + option to define by user
- Position display formats: Lat/Lon, UTM/UPS, Maidenhead, MGRS, Loran TDs and other, also option to define by user
- Built-in electronic compass and barometer

10.1.2.2 Receiver operating features:

- Capable of receiving DGPS correction and WAAS/EGNOS signal
- 12 channels (capable of concurrent tracking of up to 12 satellites)
- Initialisation: „cold start" ca. 45 sec., „warm start" ca. 15 sec.
- Interval: 1 or 2 seconds
- 10 warning points
- Accuracy: autonomous operation: < 15 meters, 95%; WAAS: < 3 meters, 95%
- Interfaces: Serial port supporting GARMIN, GARMIN DGPS, NMEA (option to configure forwarded sentences), RTCM 104, and text formats
- Antenna: built-in, quad-helix, option to connect an external antenna: MCX connection

10.1.2.3 Physical features (Fig. 70):

- Size: 6,9x15,7x3,6 cm
- Weight: 218g
- Display: 4,1x5,6 cm, illuminated, resolution 180x240 px, 4 grey grades
- Waterproof: as per IPX7

- Operating temperature: -15 to 70°C
- Power supply: 2 x AA alkali battery or external 10-40 V DC
- Battery life: up to 16 hours / 2xAA
- Accuracy: autonomous operation: < 15 meters, 95%; WAAS: < 3 meters, 95%
- Interfaces: Serial port supporting GARMIN, GARMIN DGPS, NMEA (option to configure forwarded sentences), RTCM 104 and Text formats
- Antenna: built-in, quad-helix, option to connect an external antenna: MCX connection

Fig. 70. Garmin GPSMap 76S receiver.

10.2 GIS of GPS measurements reference parcels

Reference parcels for GPS measurements was input into GIS system (Geomedia) in local coordinate system.

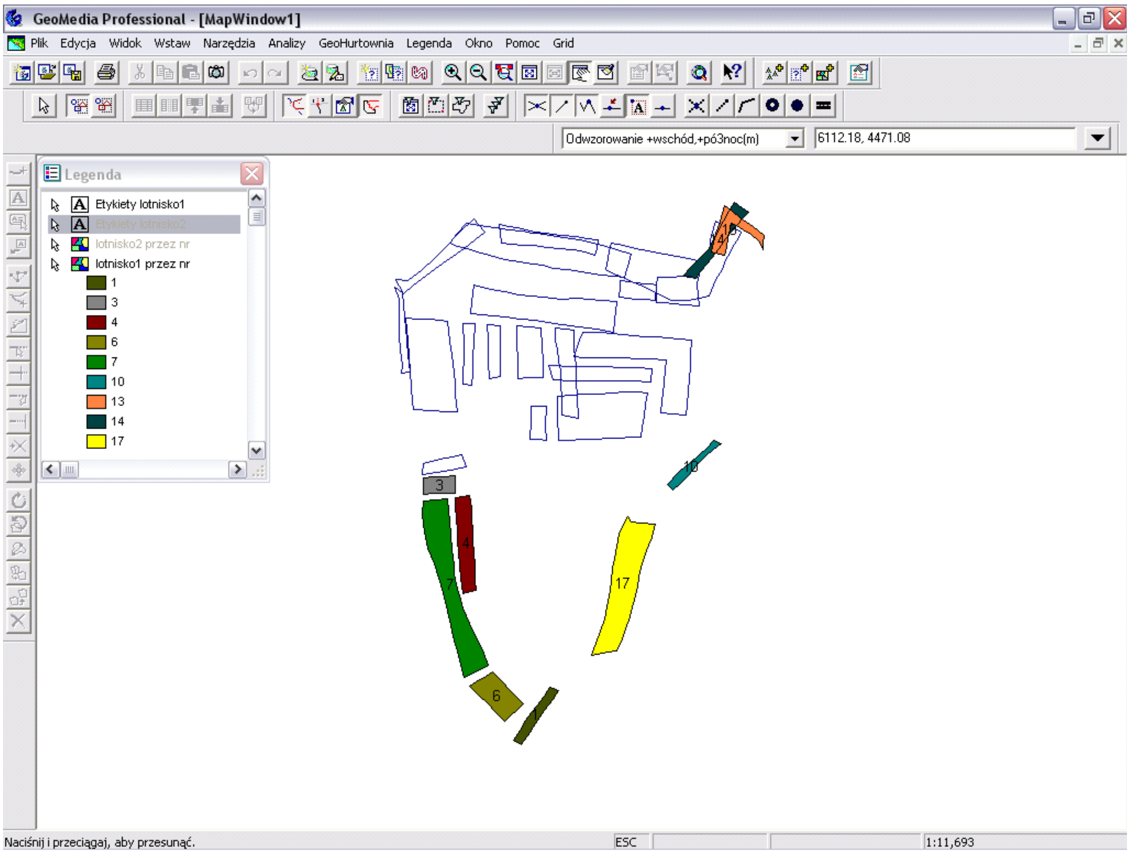


Fig. 71. “Lotnisko1”

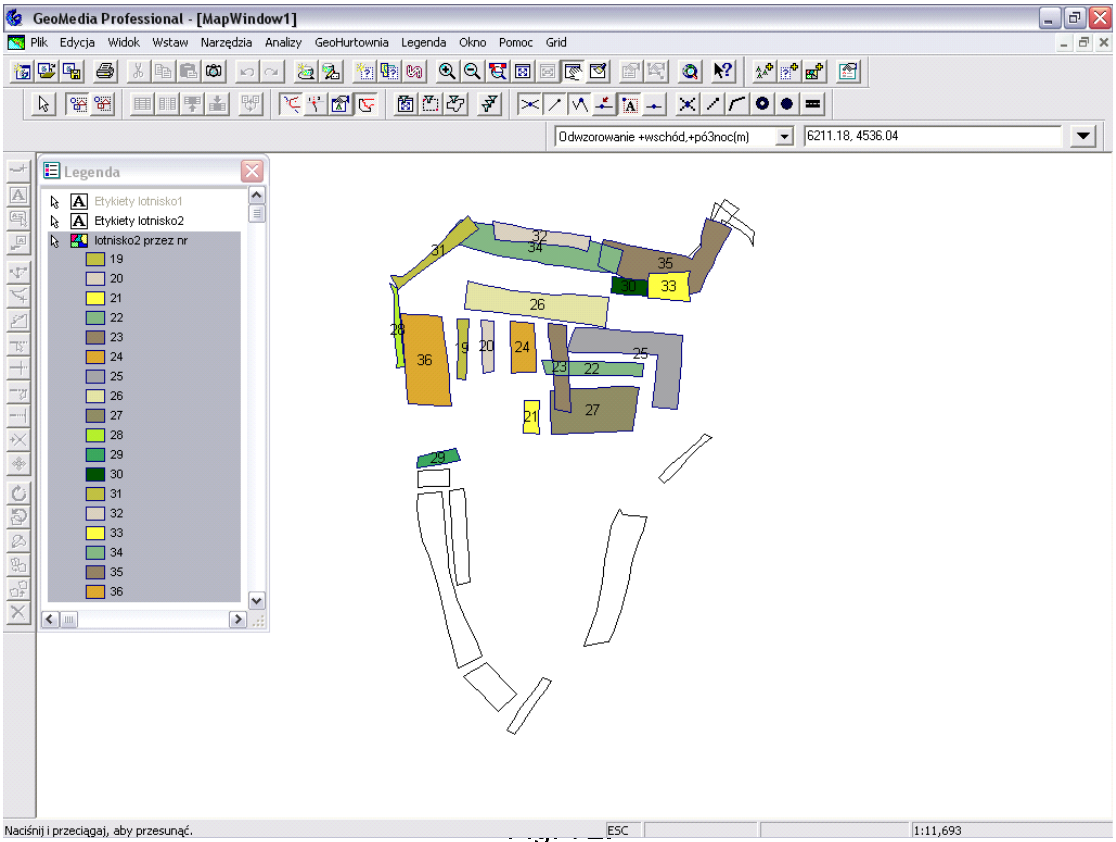


Fig. 73. “Lotnisko 2”

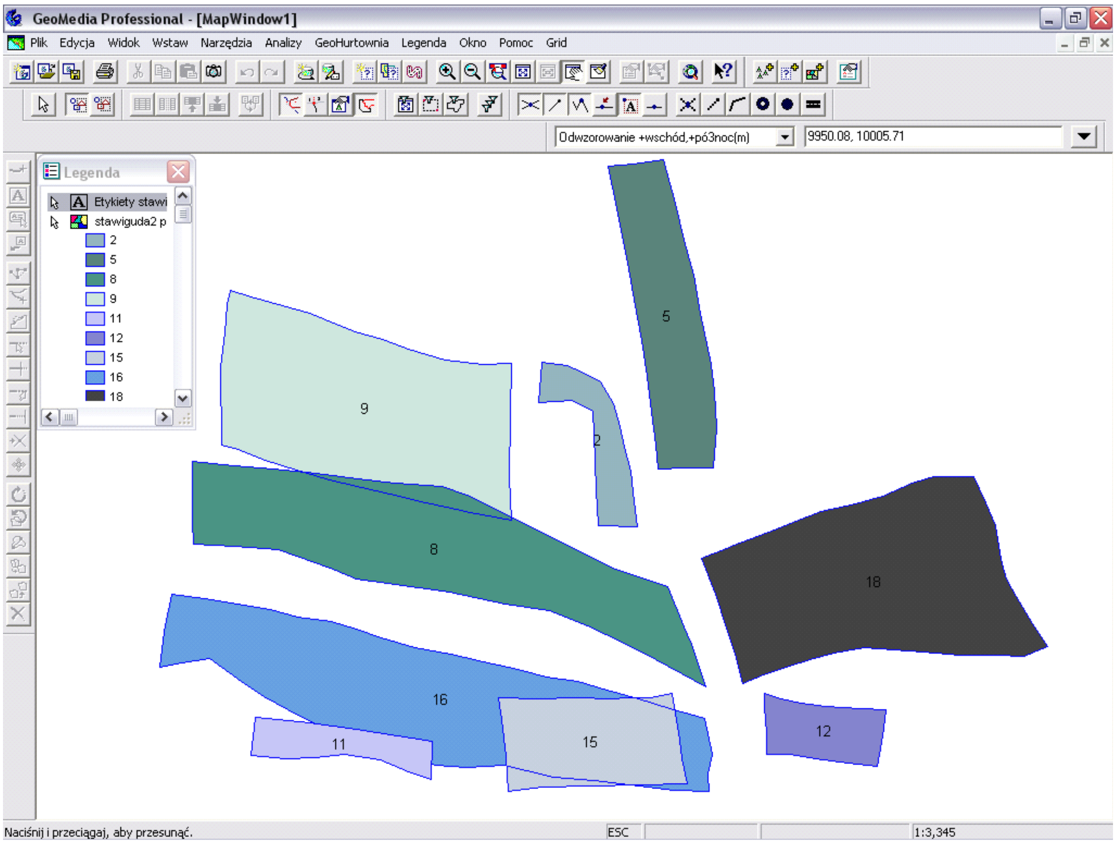


Fig. 74. “Stawiguda

10.3 Instruction for operators (in Polish) - OPIS EKSPERYMENTU

10.3.1 Podstawowe dane

10.3.1.1 Działki rolne

36 różnych działek rolnych bierze udział w eksperymencie. Działki pogrupowano w zależności od:

- wielkości : 3 poziomy (oznaczone 1, 2, 3)
- kształtu : 3 poziomy (oznaczone 1, 2, 3)
- zasłon : 2 poziomy (oznaczone 1, 2)
- powtórzenia : 2 poziomy (oznaczone 1, 2).

10.3.1.2 Instrumenty

10 następujących instrumentów bierze udział w eksperymencie. Podczas eksperymentu każdy zespół posiada swoje instrumenty, którymi nie wymienia się między sobą. Każdy

z poszczególnych typów instrumentów posiada tę samą wersję oprogramowania jak również dokładnie te same ustawienia. Wszystkie instrumenty pracują z wyłączoną opcją EGNOS. Interwał pomiarowy 1 sekunda. Wszystkie pomiary z wyjątkiem odbiorników Garmin rejestrujemy i zgrywamy do komputera.

- Garmin (2 instruments): G1, G2
- Thales (4 instruments): T1, T2, T3, T4
- Satcon (4 instruments): S1, S2, S3, S4

10.3.1.3 Zespoły pomiarowe

20 operatorów jest przydzielonych do 4 zespołów. Każdy z operatorów otrzyma swój numer, który pozostaje niezmienny.

- Zespół 1 : 6 operatorów (3 skilled + 3 unskilled), instrumenty : G1, T1, S1
- Zespół 2 : 6 operatorów (3 skilled + 3 unskilled), instrumenty : G2, T2, S2
- Zespół 3 : 4 operatorów (2 skilled + 2 unskilled), instrumenty : T3, S3, T4, S4
- Zespół 4 : 4 operatorów (2 skilled + 2 unskilled), instrumenty : T3, S3, T4, S4

10.3.2 Pomiary

Każda z 36 wytyczonych działek ma swój numer, który nie ulega zmianom podczas pomiarów. Działki są podzielone na dwie części (po 18), zgodnie z założeniem o 2 poziomach powtórzenia. Każdy z dwóch zestawów 18 działek bierze udział w niezależnym eksperymencie:

- działki 1-18 eksperyment 1 (zespół 1 i 2),
- działki 17-36 eksperyment 2 (zespół 3 i 4).

Eksperyment 1 daje nam 1944 niezależnych pomiarów, a eksperyment 2 – 1728 pomiarów, co łącznie da nam 3672 obserwacji.

10.3.3 Eksperyment 1

Eksperyment 1 jest prowadzony na działkach 1-18 przez zespoły 1 i 2, przy czym każdy z zespołów ma losowo przydzielonych 9 działek na których przez 6 dni wykonuje pomiary. Każdego dnia zespół dokonuje pomiaru 9 działek.

Każdego dnia kolejność pomiaru 9 działek jest inna – zgodna z podanym harmonogramem, którego należy się trzymać.

Na każdej z działek każdy z 6-ciu operatorów dokonuje pomiaru każdym z 3-ech odbiorników. Zatem 3 pomiary (trzema różnymi odbiornikami) są prowadzone jednocześnie – operatorzy idą jeden za drugim w odstępie ok. 10 m, w tym czasie 3 pozostałych operatorów odpoczywa. Na każdej z działek jest wykonywanych 6x3=18 obserwacji; 18x9=162 pomiary dziennie.

Proszę zwrócić uwagę na kolejność pomiarów, która jest inna każdego dnia dla każdej z działek i ma być prowadzona zgodnie z dostarczonym schematem.

10.3.4 Eksperyment 2

Eksperyment 2 jest prowadzony na działkach 19-37 przez zespoły 3 i 4, przy czym każdy z zespołów ma losowo przydzielonych 9 działek na których przez 6 dni wykonuje pomiary. Każdego dnia zespół dokonuje pomiaru 9 działek. Zespoły 3 i 4 pracują tymi samymi instrumentami i nie mogą wykonywać swoich pomiarów równolegle.

Każdego dnia kolejność pomiaru 9 działek jest inna – zgodna z podanym harmonogramem, którego należy się trzymać.

Na każdej z działek każdy z 4-ech operatorów dokonuje pomiaru każdym z 4-ech odbiorników. Zatem 4 pomiary (czterema różnymi odbiornikami) są prowadzone jednocześnie – operatorzy idą jeden za drugim w odstępie ok. 10 m. Na każdej z działek jest wykonywanych 4x4=16 obserwacji; 16x9=144 pomiary dziennie. Proszę zwrócić uwagę na kolejność pomiarów, która jest inna każdego dnia dla każdej z działek i ma być prowadzona zgodnie z dostarczonym schematem.

W eksperymencie 2 operatorzy nie odpoczywają podczas pomiarów, ale też pomiary w ciągu dnia zabiorą im mniej czasu.

10.3.5 Szczegółowe uwagi dotyczące pomiarów polowych.

Pomiar pojedynczej działki zaczynamy każdego dnia w tym samym ustalonym przez kierownika punkcie. Poruszamy się zgodnie z ruchem wskazówek zegara. Granica działek jest wyznaczona jednoznacznie przez paliki drewniane. Mierzymy linie łączące poszczególne paliki.

Po pomiarze każdy z operatorów zapisuje swoje wyniki pomiarów na kartce (pole i obwód), dodatkowo kierownicy zespołów po każdej serii zapisują na kartce wyniki każdego z operatorów. Każdego dnia dane będą zgrywane, a wyniki przepisywane do specjalnie utworzonej bazy danych. Każdy z kierowników odpowiada za dane swojego zespołu

Odbiorniki ręczne (Thales, Garmin) trzymamy pionowo w prawej dłoni na minimum wysokości ramion. Odbiornik GPS systemu Satcon podczas pomiarów umieszczamy na głowie. Należy pamiętać, że pomiarowi podlega trajektoria odbiornika, a nie ścieżka przejścia.

10.3.5.1 Thales

Dla każdej mierzonej działki zakładamy niezależny „job” o nazwie w formacie: „d1p02”, gdzie:

- d1 – day 1,

- p01 – parcel 02.

Wybieramy feature library o nazwie odpowiedniej dla zespołu: team1_2 oraz team3_4.

Podczas pomiaru każdy z operatorów wybiera obiekt odpowiadający jego przypisanemu numerowi np. operator 1, operator 2, etc. Każdy z operatorów ma przypisany kolor, który dla każdej działki jest taki sam.

10.3.5.2 Satcon

Dla każdej mierzonej działki każdy z operatorów zakłada nowy zbiór (field) o nazwie w formacie: „d1p02o4", gdzie:

- d1 – day 1,
- p01 – parcel 02,
- o4 – operator 4

10.3.5.3 Garmin

Przed każdym pomiarem stojąc w punkcie początkowym kasujemy zapis śladu, po wykasowaniu niezwłocznie rozpoczynamy pomiar. Po dojściu do punktu początkowego zapisujemy ślad (wybieramy godzinę zakończenia pomiaru) i odczytujemy właściwości śladu. Dokładnie zapisujemy pole powierzchni i obwód pamiętając, że nie będzie później możliwości sprawdzenia poprawności spisanych wyników (nie zgrywamy danych).

Tab 52. Kolejność pomiaru działek w poszczególnych dniach dla zespołów 1 i 2:

team 1					
DAY_1	DAY_2	DAY_3	DAY_4	DAY_5	DAY_6
10	6	14	10	14	3
13	3	17	7	4	1
7	1	4	13	17	6
1	14	13	14	3	7
3	4	10	17	6	10
6	17	7	4	1	13
14	13	1	1	10	4
17	10	3	6	13	17
4	7	6	3	7	14
team 2					
DAY_1	DAY_2	DAY_3	DAY_4	DAY_5	DAY_6
9	16	18	11	8	15
5	12	8	5	18	16
11	15	2	9	2	12
15	18	11	8	16	5
12	2	9	18	15	11
16	8	5	2	12	9

8	5	16	16	5	18
2	9	15	15	11	8
18	11	12	12	9	2

Tab 53. Kolejność pomiaru działek w poszczególnych dniach dla zespołów 3 i 4:

team 3

DAY_1	DAY_2	DAY_3	DAY_4	DAY_5	DAY_6
19	36	31	32	32	19
20	26	26	23	29	24
24	31	36	29	23	20
36	20	32	36	20	23
26	19	23	26	24	29
31	24	29	31	19	32
32	32	20	24	36	26
23	29	24	19	26	36
29	23	19	20	31	31

team 4

DAY_1	DAY_2	DAY_3	DAY_4	DAY_5	DAY_6
35	33	21	27	34	35
25	28	25	34	27	25
21	22	35	30	30	21
22	25	34	28	25	27
28	21	30	33	21	30
33	35	27	22	35	34
27	30	33	35	33	33
30	34	28	21	22	28
34	27	22	25	28	22

11. Appendix - Area error coefficient calculation

11.1.1 Remote Sensing

11.1.1.1 Input data: Cartesian and polar coordinate:

X	Y	R	α
1			1
7417724	5553736	1182.393	-0.18042
7417772	5553741	1179.35	-0.13927
7417744	5553661	1104.75	-0.17465
7417700	5553670	1121.869	-0.21179
7417724	5553736	1182.393	-0.18042
2			2
7416419	5552595	1517.629	-1.5561
7416435	5552594	1501.111	-1.55701
7416429	5552412	1516.096	1.464246
7416410	5552421	1533.788	1.471528
7416419	5552595	1517.629	-1.5561
7416419	5552595	1517.629	-1.5561
20			20
7416935	5552483	1004.932	1.480932
7416953	5552481	987.2297	1.477635
7416944	5552283	1033.366	1.286029
7416927	5552284	1049.674	1.291646
7416929	5552322	1037.986	1.326053
7416930	5552347	1031.025	1.350178
7416932	5552382	1022.541	1.382803
7416932	5552402	1018.261	1.402178
7416934	5552434	1012.15	1.432529
7416935	5552483	1004.932	1.48093
7416935	5552483	1004.932	1.480932
3			3
7417031	5554713	2323.415	-0.4
7417045	5554715	2320.123	-0.39403
7417060	5554660	2263.092	-0.39736
7417070	5554627	2228.87	-0.39935
7417081	5554596	2196.528	-0.40012
7417106	5554535	2130.243	-0.40026
7417115	5554513	2106.264	-0.40055
7417128	5554472	2063.26	-0.40232
7417147	5554422	2010.237	-0.40352
7417136	5554418	2010.719	-0.4095
7417112	5554482	2079.008	-0.40784
7417091	5554535	2136.253	-0.40659
7417061	5554609	2216.302	-0.40576
7417048	5554657	2265.926	-0.40298
7417031	5554713	2323.415	-0.4

21			21
7419007	5551520	1501.941	-0.79383
7419010	5551528	1498.464	-0.79884
7419017	5551524	1506.772	-0.80039
7419032	5551514	1523.528	-0.80234
7419059	5551493	1557.877	-0.80511
7419079	5551478	1582.276	-0.80674
7419089	5551470	1595.376	-0.80755
7419109	5551454	1620.619	-0.80873
7419126	5551441	1642.821	-0.81014
7419167	5551409	1694.664	-0.8132
7419185	5551394	1717.125	-0.81409
7419211	5551372	1751.697	-0.8154
7419244	5551346	1792.962	-0.81736
7419272	5551325	1828.429	-0.81912
7419300	5551303	1863.184	-0.82083
7419294	5551294	1865.036	-0.81526
7419239	5551337	1796.528	-0.81167
7419203	5551366	1749.483	-0.80942
7419169	5551393	1706.862	-0.80739
7419138	5551419	1665.962	-0.80548
7419113	5551439	1634.423	-0.80383
7419091	5551456	1606.886	-0.80214
7419069	5551473	1578.761	-0.80002
7419045	5551492	1548.575	-0.79766
7419026	5551506	1525.187	-0.79573
7419014	5551515	1510.348	-0.79449
7419007	5551520	1501.941	-0.79383
4			4
7416678	5554900	2645.889	-0.49573
7416691	5554900	2639.108	-0.49148
7416724	5554899	2622.733	-0.48061
7416725	5554857	2585.568	-0.48772
7416725	5554831	2562.202	-0.49256
7416724	5554805	2539.459	-0.49743
7416724	5554781	2518.721	-0.50191
7416725	5554767	2506.214	-0.50435
7416684	5554771	2530.018	-0.51775
7416669	5554774	2539.522	-0.52237
7416655	5554776	2548.616	-0.52654
7416662	5554902	2654.274	-0.50055
7416678	5554900	2645.889	-0.49573
6			6
7418978	5551807	1293.627	-0.9366
7418985	5551820	1291.603	-0.94788
7419007	5551807	1316.234	-0.94998
7419031	5551792	1344.932	-0.95107
7419051	5551778	1369.341	-0.95148
7419069	5551765	1391.445	-0.95137
7419088	5551752	1414.694	-0.95129
7419120	5551727	1455.065	-0.95065
7419138	5551714	1477.62	-0.95017
7419146	5551708	1487.737	-0.94994
7419181	5551678	1533.613	-0.94728
7419213	5551652	1574.18	-0.94558

7419251	5551619	1624.22	-0.94296
7419289	5551586	1674.727	-0.94038
7419323	5551558	1718.677	-0.93878
7419351	5551535	1754.511	-0.93791
7419384	5551509	1796.611	-0.9368
7419409	5551488	1829.249	-0.93589
7419427	5551474	1851.72	-0.93552
7419418	5551462	1852.017	-0.92715
7419344	5551522	1756.281	-0.92955
7419301	5551558	1701.078	-0.93111
7419258	5551594	1644.765	-0.93305
7419212	5551633	1584.859	-0.93555
7419176	5551663	1538.455	-0.93745
7419134	5551696	1484.654	-0.93901
7419106	5551718	1449.542	-0.93949
7419069	5551745	1403.175	-0.93944
7419037	5551768	1363.55	-0.93925
7419012	5551785	1333.855	-0.93872
7418978	5551807	1293.627	-0.9366
7			7
7417466	5554815	2290.843	-0.20688
7417578	5554867	2321.474	-0.15513
7417647	5554704	2150.131	-0.13474
7417512	5554646	2115.777	-0.20191
7417492	5554729	2201.023	-0.20337
7417466	5554815	2290.843	-0.20688
25			25
7419317	5553997	1983.055	0.77001
7419393	5554164	2157.13	0.741408
7419559	5554084	2217.825	0.821011
7419484	5553919	2051.249	0.854925
7419317	5553997	1983.055	0.77001
8			8
7415145	5554685	3500.133	-0.92318
7415194	5554782	3521.673	-0.89274
7415228	5554779	3493.184	-0.88735
7415246	5554778	3478.434	-0.8841
7415273	5554771	3453.297	-0.88095
7415325	5554755	3402.767	-0.8746
7415359	5554745	3370.568	-0.87042
7415384	5554737	3345.915	-0.86747
7415409	5554726	3320.217	-0.86523
7415429	5554718	3299.848	-0.86312
7415446	5554710	3281.138	-0.86161
7415426	5554670	3271.141	-0.87491
7415421	5554666	3272.213	-0.87683
7415374	5554655	3301.554	-0.88845
7415341	5554649	3322.958	-0.89613
7415308	5554643	3345.341	-0.90366
7415277	5554639	3367.192	-0.91042
7415271	5554639	3372.125	-0.91135
7415267	5554640	3375.899	-0.91189
7415145	5554685	3500.133	-0.92318
11			11
7416383	5552596	1553.433	-1.55611

7416406	5552595	1530.79	-1.55668
7416398	5552427	1544.776	1.475948
7416374	5552438	1567.78	1.484382
7416383	5552596	1553.433	-1.55611
7416383	5552596	1553.433	-1.55611
29			29
7418878	5551388	1513.801	-0.67157
7418881	5551401	1505.675	-0.67823
7418882	5551411	1498.186	-0.68319
7418894	5551402	1512.425	-0.68558
7418919	5551381	1544.579	-0.68962
7418931	5551372	1559.701	-0.69139
7418976	5551333	1618.645	-0.69783
7418964	5551317	1623.238	-0.68594
7418924	5551351	1570.693	-0.67972
7418906	5551367	1547.546	-0.67688
7418892	5551378	1530.012	-0.67451
7418878	5551388	1513.801	-0.67157
12			12
7418477	5553897	1430.434	0.387549
7418618	5553937	1524.485	0.463533
7418620	5553929	1519.121	0.467209
7418805	5553967	1642.889	0.557195
7418808	5553953	1631.87	0.563327
7418691	5553931	1553.981	0.507453
7418656	5553925	1531.529	0.489501
7418624	5553917	1509.868	0.473145
7418623	5553922	1513.565	0.470811
7418614	5553920	1507.561	0.466132
7418599	5553916	1497.236	0.458599
7418482	5553882	1417.784	0.395014
7418477	5553897	1430.434	0.387549
24			24
7418621	5554573	2113.459	0.329825
7418649	5554586	2135.21	0.340464
7418685	5554361	1938.916	0.396675
7418698	5554261	1852.187	0.423882
7418703	5554208	1805.436	0.438499
7418671	5554206	1790.467	0.422967
7418668	5554248	1827.548	0.411796
7418648	5554397	1957.972	0.372206
7418632	5554507	2055.49	0.345218
7418621	5554573	2113.459	0.329825
10			10
7417841	5553742	1172.47	-0.08111
7417857	5553731	1160.695	-0.06848
7417880	5553715	1142.946	-0.04889
7417853	5553637	1067.052	-0.0778
7417826	5553643	1075.462	-0.10285
7417809	5553646	1080.353	-0.11785
7417809	5553646	1080.466	-0.11795
7417841	5553742	1172.47	-0.08111
28			28
7416673	5553275	1445.25	-1.06354
7416736	5553272	1388.759	-1.04372

7416726	5553180	1353.667	-1.10607
7416664	5553186	1412.442	-1.12174
7416673	5553275	1445.25	-1.06354
30			30
7416351	5554944	2852.447	-0.58939
7416526	5554919	2737.147	-0.54121
7416554	5554915	2719.556	-0.53326
7416579	5554911	2703.754	-0.52596
7416579	5554897	2691.745	-0.52858
7416579	5554893	2687.187	-0.52925
7416570	5554894	2693.058	-0.53202
7416348	5554926	2838.446	-0.5937
7416351	5554944	2852.447	-0.58939
13			13
7419458	5553928	2037.426	0.843436
7419522	5553898	2066.465	0.874664
7419555	5553883	2082.456	0.890187
7419486	5553741	1940.756	0.924878
7419451	5553750	1918.307	0.910244
7419426	5553756	1902.345	0.899823
7419406	5553761	1889.891	0.89117
7419383	5553773	1879.471	0.87816
7419382	5553773	1878.982	0.878194
7419399	5553805	1912.692	0.870912
7419458	5553928	2037.426	0.843436
14			14
7419086	5554276	2054.615	0.593895
7419185	5554243	2084.946	0.641948
7419116	5554086	1918.32	0.662101
7419079	5554102	1908.587	0.641791
7419074	5554154	1947.768	0.623912
7419076	5554178	1968.049	0.617552
7419079	5554213	1998.652	0.608635
7419081	5554229	2012.962	0.605182
7419084	5554253	2034.534	0.599117
7419086	5554276	2054.615	0.593895
22			22
7416652	5554616	2412.741	-0.56135
7416678	5554613	2396.712	-0.55245
7416697	5554611	2385.131	-0.54629
7416729	5554605	2363.083	-0.53598
7416755	5554486	2247.985	-0.55326
7416701	5554498	2286.689	-0.57056
7416676	5554502	2304.101	-0.57864
7416652	5554616	2412.741	-0.56135
5			5
7419395	5554572	2475.19	0.630416
7419452	5554546	2487.704	0.655103
7419375	5554368	2300.398	0.675733
7419315	5554390	2280.676	0.649333
7419395	5554572	2475.19	0.630416
32			32
7419107	5554461	2221.469	0.555061
7419119	5554539	2294.082	0.541784
7419279	5554456	2312.775	0.619232

7419259	5554411	2264.484	0.623985
7419138	5554454	2231.742	0.568418
7419107	5554461	2221.469	0.555061
23			23
7419147	5554640	2395.386	0.529773
7419158	5554681	2436.723	0.525316
7419339	5554597	2462.653	0.60598
7419320	5554553	2415.774	0.60996
7419147	5554640	2395.386	0.529773
26			26
7418757	5554642	2226.276	0.377647
7418782	5554659	2250.484	0.38518
7418801	5554671	2268.992	0.391091
7418822	5554687	2291.537	0.396757
7418861	5554537	2170.871	0.440266
7418869	5554502	2142.729	0.450646
7418875	5554475	2121.138	0.458451
7418879	5554444	2095.399	0.466644
7418885	5554394	2053.413	0.480438
7418895	5554316	1989.185	0.503013
7418819	5554306	1944.707	0.471295
7418809	5554390	2015.736	0.448035
7418795	5554478	2089.705	0.423487
7418785	5554524	2128.032	0.410371
7418757	5554642	2226.276	0.377647
33			33
7418930	5554786	2426.083	0.422065
7418949	5554717	2371.178	0.441431
7418959	5554675	2337.606	0.453026
7418969	5554625	2297.168	0.466178
7418978	5554559	2242.413	0.483024
7418984	5554497	2190.486	0.498731
7418987	5554432	2135.179	0.5146
7418989	5554395	2104.365	0.52414
7418991	5554371	2084.855	0.530391
7418993	5554334	2053.188	0.540439
7418974	5554334	2043.783	0.53272
7418958	5554330	2032.765	0.526815
7418938	5554472	2147.039	0.485547
7418974	5554477	2168.107	0.499102
7418969	5554536	2218.209	0.48447
7418966	5554566	2243.209	0.476913
7418958	5554607	2276.717	0.465638
7418947	5554660	2319.423	0.451096
7418936	5554692	2343.249	0.440668
7418903	5554762	2393.117	0.415997
7418930	5554786	2426.083	0.422065
34			34
7418537	5551247	1455.66	-0.42553
7418548	5551225	1480.912	-0.42599
7418555	5551211	1496.402	-0.42626
7418568	5551190	1520.98	-0.42869
7418575	5551180	1532.518	-0.43031
7418581	5551172	1542.502	-0.4316
7418591	5551162	1555.93	-0.43457

7418615	5551142	1584.254	-0.44301
7418623	5551136	1592.855	-0.44555
7418637	5551128	1606.554	-0.45157
7418623	5551083	1640.308	-0.43176
7418601	5551017	1691.816	-0.40369
7418586	5550971	1729.088	-0.38527
7418557	5550972	1717.678	-0.36998
7418528	5550973	1705.859	-0.354
7418507	5550974	1698.152	-0.3429
7418477	5550975	1686.923	-0.32653
7418448	5550977	1676.653	-0.31046
7418498	5551129	1549.287	-0.3708
7418514	5551179	1508.771	-0.39265
7418537	5551247	1455.66	-0.42553
35			35
7417691	5554105	1550.938	-0.1587
7417630	5554049	1507.346	-0.20439
7417541	5553965	1447.317	-0.27634
7417557	5553951	1428.705	-0.26843
7417600	5553908	1376.698	-0.24702
7417622	5553933	1395.339	-0.22683
7417647	5553954	1411.123	-0.20659
7417659	5553965	1419.048	-0.19668
7417670	5553974	1425.799	-0.18777
7417676	5553977	1428.354	-0.18343
7417680	5553978	1428.181	-0.18055
7417692	5553974	1422.415	-0.17286
7417717	5553968	1411.904	-0.15602
7417734	5553965	1406.739	-0.14453
7417768	5553962	1398.641	-0.12047
7417816	5553958	1390.553	-0.08662
7417822	5553966	1397.149	-0.08201
7417823	5554035	1466.256	-0.07733
7417824	5554071	1502.488	-0.07485
7417826	5554134	1564.564	-0.07033
7417828	5554140	1570.575	-0.06877
7417833	5554148	1578.015	-0.06513
7417853	5554170	1598.989	-0.05192
7417881	5554199	1626.799	-0.03397
7417838	5554240	1669.882	-0.05859
7417760	5554167	1604.02	-0.11027
7417714	5554126	1568.392	-0.14232
7417691	5554105	1550.938	-0.1587
16			16
7417000	5553859	1590.337	-0.62936
7417023	5553846	1566.069	-0.62225
7417057	5553827	1531.583	-0.6117
7417122	5553790	1464.376	-0.58926
7417130	5553802	1469.932	-0.58024
7417140	5553812	1473.257	-0.57114
7417158	5553830	1478.225	-0.55443
7417172	5553842	1481.622	-0.54221
7417198	5553868	1490.477	-0.51841
7417224	5553902	1507.371	-0.49208
7417232	5553930	1528.68	-0.47904

7417242	5553955	1546.709	-0.46516
7417263	5553999	1576.926	-0.44118
7417297	5554070	1628.179	-0.4035
7417313	5554102	1651.124	-0.3873
7417295	5554115	1670.159	-0.39397
7417260	5554134	1701.179	-0.40887
7417110	5553975	1627.431	-0.53247
7417000	5553859	1590.337	-0.62936
9			9
7417472	5554253	1742.864	-0.26987
7417466	5554255	1746.297	-0.27233
7417473	5554267	1756.173	-0.26714
7417473	5554272	1760.598	-0.26621
7417618	5554296	1752.344	-0.18257
7417628	5554298	1751.96	-0.17689
7417665	5554297	1744.71	-0.15617
7417677	5554298	1744.509	-0.14895
7417709	5554310	1752.119	-0.13032
7417755	5554329	1765.278	-0.10278
7417783	5554341	1774.733	-0.0867
7417815	5554351	1781.675	-0.0681
7417848	5554357	1786.585	-0.04961
7417866	5554319	1747.126	-0.04029
7417814	5554295	1725.869	-0.07087
7417774	5554278	1712.654	-0.0946
7417733	5554260	1699.489	-0.11995
7417686	5554239	1685.038	-0.14933
7417623	5554212	1668.353	-0.18855
7417572	5554187	1654.977	-0.22209
7417571	5554192	1659.341	-0.22182
7417561	5554200	1669.318	-0.22649
7417528	5554226	1702.558	-0.24223
7417486	5554247	1733.093	-0.26278
7417472	5554253	1742.864	-0.26987
36			36
7417155	5553711	1380.32	-0.60162
7417162	5553714	1378.795	-0.59633
7417168	5553721	1381.162	-0.58957
7417186	5553755	1399.671	-0.56595
7417201	5553785	1417.769	-0.54519
7417210	5553801	1426.893	-0.53408
7417224	5553814	1430.554	-0.5214
7417252	5553836	1435.79	-0.49643
7417284	5553859	1441.688	-0.46979
7417315	5553882	1448.802	-0.44343
7417335	5553897	1453.607	-0.42609
7417356	5553912	1459.197	-0.40919
7417375	5553925	1464.377	-0.39365
7417392	5553938	1469.559	-0.37935
7417408	5553951	1475.413	-0.36583
7417433	5553968	1482.962	-0.34654
7417478	5553918	1420.609	-0.32854
7417490	5553904	1403.827	-0.32315
7417481	5553910	1412.316	-0.32826
7417474	5553908	1412.638	-0.33341

7417471	5553907	1412.606	-0.33586
7417472	5553902	1407.472	-0.33645
7417470	5553898	1404.018	-0.33832
7417465	5553893	1401.388	-0.34292
7417461	5553889	1399.213	-0.34645
7417455	5553878	1390.605	-0.3531
7417452	5553873	1386.899	-0.35631
7417450	5553871	1385.71	-0.35861
7417441	5553873	1390.804	-0.36429
7417432	5553873	1394.581	-0.37023
7417425	5553873	1396.648	-0.37447
7417419	5553870	1395.694	-0.37931
7417418	5553866	1392.78	-0.38133
7417418	5553861	1388.16	-0.38286
7417417	5553858	1386.396	-0.38411
7417406	5553856	1387.949	-0.39227
7417397	5553853	1388.599	-0.39865
7417396	5553845	1382.203	-0.40126
7417392	5553839	1377.7	-0.40616
7417387	5553837	1378.057	-0.40966
7417384	5553836	1377.979	-0.4123
7417382	5553832	1375.127	-0.41447
7417382	5553828	1372.258	-0.41569
7417378	5553821	1367.343	-0.42018
7417378	5553817	1363.169	-0.42154
7417379	5553810	1356.808	-0.42344
7417374	5553808	1356.623	-0.427
7417369	5553807	1357.696	-0.43075
7417365	5553806	1358.549	-0.43395
7417362	5553803	1357.758	-0.43664
7417359	5553801	1356.2	-0.43927
7417358	5553793	1350.581	-0.44278
7417355	5553790	1348.543	-0.44574
7417313	5553765	1344.76	-0.48211
7417252	5553692	1311.46	-0.54875
7417229	5553660	1296.881	-0.57694
7417221	5553651	1293.159	-0.5857
7417207	5553641	1292.938	-0.59925
7417198	5553637	1295.009	-0.60646
7417182	5553636	1303.401	-0.61725
7417140	5553634	1326.352	-0.64363
7417121	5553633	1336.635	-0.65561
7417113	5553630	1339.858	-0.66166
7417105	5553625	1340.898	-0.66831
7417060	5553674	1406.998	-0.67232
7417106	5553692	1392.993	-0.63835
7417155	5553711	1380.32	-0.60162
27			27
7418985	5551489	1508.002	-0.76875
7419009	5551470	1538.281	-0.77135
7419236	5551286	1829.028	-0.79031
7419270	5551260	1871.874	-0.79334
7419265	5551250	1875.379	-0.78737
7419261	5551240	1879.29	-0.78249
7419258	5551232	1882.945	-0.77826

7419257	5551227	1885.565	-0.77588
7419256	5551221	1889.873	-0.77332
7419258	5551214	1895.706	-0.77148
7419257	5551200	1905.21	-0.76618
7419262	5551183	1920.696	-0.76156
7419241	5551197	1896.308	-0.75908
7419219	5551216	1867.303	-0.75701
7419164	5551260	1797.605	-0.75166
7419091	5551318	1705.841	-0.74373
7419060	5551343	1665.793	-0.7403
7419023	5551373	1619.402	-0.73606
7419005	5551388	1596.017	-0.73396
7418980	5551409	1562.94	-0.731
7418947	5551437	1520.562	-0.72744
7418937	5551447	1506.545	-0.72622
7418920	5551463	1482.856	-0.72504
7418929	5551468	1485.775	-0.73196
7418942	5551472	1491.17	-0.74008
7418955	5551474	1498.745	-0.74786
7418965	5551477	1503.271	-0.75371
7418985	5551489	1508.002	-0.76875
18			18
7418998	5551847	1286.418	-0.97103
7419012	5551874	1283.101	-0.99482
7419047	5551854	1322.79	-0.9964
7419089	5551825	1374.082	-0.99522
7419141	5551786	1438.994	-0.99247
7419182	5551754	1491.304	-0.98921
7419246	5551703	1572.193	-0.9842
7419302	5551656	1645.18	-0.97933
7419330	5551631	1681.993	-0.97642
7419386	5551585	1754.098	-0.97241
7419422	5551553	1802.464	-0.96946
7419463	5551521	1854.561	-0.96759
7419453	5551512	1850.995	-0.96034
7419443	5551500	1850.334	-0.95188
7419434	5551487	1850.131	-0.94336
7419362	5551545	1757.969	-0.94639
7419313	5551586	1693.783	-0.94873
7419286	5551609	1658.844	-0.95061
7419243	5551646	1602.749	-0.95381
7419227	5551659	1581.447	-0.95489
7419198	5551683	1543.827	-0.95631
7419152	5551721	1484.353	-0.95948
7419127	5551740	1453.236	-0.96049
7419104	5551757	1424.917	-0.96103
7419078	5551776	1392.799	-0.96155
7419087	5551788	1393.239	-0.97203
7419046	5551817	1343.141	-0.9729
7419015	5551837	1305.99	-0.9722
7418998	5551847	1286.418	-0.97103
15			15
7419015	5551540	1493.562	-0.80716
7419029	5551578	1478.118	-0.83248
7419045	5551569	1495.622	-0.83472

7419127	5551505	1599.903	-0.83971
7419253	5551404	1760.654	-0.84481
7419228	5551373	1763.43	-0.822
7419113	5551466	1616.133	-0.81608
7419045	5551519	1529.594	-0.81076
7419015	5551540	1493.562	-0.80716
17			17
7418679	5554599	2157.466	0.351394
7418723	5554623	2196.078	0.366443
7418743	5554633	2212.072	0.373214
7418765	5554545	2138.986	0.397684
7418777	5554483	2086.68	0.41464
7418793	5554380	2000.083	0.442698
7418803	5554297	1929.921	0.466024
7418810	5554217	1861.242	0.488462
7418793	5554215	1851.856	0.480917
7418735	5554207	1818.872	0.454869
7418732	5554232	1840.293	0.447401
7418727	5554297	1896.563	0.430338
7418711	5554408	1991.726	0.399454
7418703	5554459	2035.802	0.386416
7418679	5554599	2157.466	0.351394
31			31
7415324	5554532	3265.019	-0.92752
7415400	5554511	3191.972	-0.91817
7415339	5554363	3154.378	-0.96757
7415265	5554392	3232.064	-0.973
7415324	5554532	3265.019	-0.92752
19			19
7417596	5554834	2286.26	-0.1494
7417652	5554859	2304.03	-0.12373
7417672	5554795	2238.055	-0.11854
7417620	5554775	2224.58	-0.14246
7417596	5554834	2286.26	-0.1494

11.1.1.2 RS output file

Id	Pole[m2]	Blad[m2]	BladWzgl[%]	BladBieg[m2]
1	3431.78	63.9	1.862	63.9
2	3179.49	126.87	3.99	2144.81
3	4081.83	123.79	3.033	123.79
4	8450.68	83	0.982	83
5	12387.27	146.03	1.179	146.03
6	8567.1	155.27	1.812	155.27
7	23511.33	150.22	0.639	150.22
8	27960.71	119.61	0.428	119.61
9	24503.28	141.59	0.578	141.59
10	4145.92	71.84	1.733	71.84
11	3856.83	116.65	3.025	2191.88
12	4785.93	155.46	3.248	155.46
13	17747	127.14	0.716	127.14
14	12768.24	112.04	0.878	112.04
15	10955.06	162.78	1.486	162.78

16	41745.43	195.93	0.469	195.93
17	30883.16	185.27	0.6	185.27
18	24143	171.54	0.711	171.54
19	3795.68	61.86	1.63	61.86
20	3446.28	114.11	3.311	114.11
21	3722.3	110.9	2.979	110.9
22	8807.86	94.41	1.072	94.41
23	8832.43	142.61	1.615	142.61
24	11658.05	203.32	1.744	203.32
25	33676.91	183.52	0.545	183.52
26	27455.06	163.69	0.596	163.69
27	26106.52	197.21	0.755	197.21
28	5710.47	78.14	1.368	78.14
29	2338.73	58.81	2.514	58.81
30	4312.32	151.34	3.509	151.34
31	12334.07	123.88	1.004	123.88
32	10420.59	121.75	1.168	121.75
33	10862.41	155.03	1.427	155.03
34	28543.4	134.34	0.471	134.34
35	43349.56	158.69	0.366	158.69
36	41087.04	130.99	0.319	130.99

11.1.2 GPS

11.1.2.1 Input data: cartesian and polar coordinate:

x	y	r	α
	19		19
5136.89	4888.26	2816.136	0.722929
5080.36	4889.01	2853.296	0.73796
5034.91	4889.01	2884.07	0.749619
4996.73	4887.99	2910.958	0.758981
4965.34	4886.96	2933.39	0.766503
4963.24	4912.31	2916.649	0.77305
4994.48	4914.1	2893.629	0.765755
5040.62	4916.37	2860.189	0.754676
5084.7	4918.78	2828.401	0.743906
5134.75	4920.43	2793.523	0.731122
5136.89	4888.26	2816.136	0.722929
	20		20
5131.67	4956.19	2769.082	0.740573
5095.66	4957.37	2792.642	0.750375
5060.07	4958.29	2816.364	0.759841
5031.53	4959.34	2835.343	0.767394
4982.1	4960.51	2869.049	0.780077
4987.18	4992.19	2843.017	0.786644
5020.88	4992.56	2818.995	0.778294
5057.4	4992.33	2793.642	0.768927
5090	4992.02	2771.296	0.760396

5129.52	4991.71	2744.435	0.749884
5131.67	4956.19	2769.082	0.740573
	21		21
4903.09	5077.74	2844.664	0.828825
4861.2	5077.58	2875.789	0.838627
4811.73	5075.89	2913.885	0.849545
4810.32	5100.32	2898.876	0.856195
4808.03	5121.15	2887.007	0.862165
4851.7	5120.3	2854.552	0.851983
4903.76	5123.47	2813.465	0.840646
4902.97	5103.2	2827.611	0.835491
4903.09	5077.74	2844.664	0.828825
	22		22
4972.13	5416.37	2572.963	0.90779
5010.3	5420.62	2540.344	0.899861
5011.54	5377.89	2566.167	0.886518
5012.86	5329.99	2595.7	0.871897
5014.17	5288.42	2621.646	0.859436
5016.24	5235.79	2654.758	0.84391
5016.93	5197.47	2679.866	0.833053
5019.05	5127.98	2725.55	0.813662
4977.17	5140.74	2747.488	0.827508
4974.86	5193.24	2713.959	0.842327
4974.6	5238.51	2684.23	0.854976
4975	5277.01	2658.819	0.865804
4974.95	5322.88	2629.365	0.879103
4975.14	5362.82	2603.923	0.89087
4972.13	5416.37	2572.963	0.90779
	23		23
5122.41	5147.25	2637.807	0.792057
5090.2	5148.09	2660.246	0.800786
5066.53	5153.6	2673.481	0.808429
5031.08	5156.42	2697.301	0.818262
5001.65	5161.74	2715.254	0.827101
4970.55	5163.09	2737.317	0.835156
4921.81	5165.64	2771.958	0.847638
4878.44	5166.84	2803.835	0.858195
4869.58	5213.41	2780.394	0.872952
4933.29	5209.44	2734.483	0.856868
4974.28	5207.14	2705.16	0.846304
5019.27	5204.72	2673.26	0.834471
5066.15	5200.95	2641.279	0.821494
5118.56	5198.63	2604.755	0.807136
5120.58	5174.37	2620.142	0.799915
5122.41	5147.25	2637.807	0.792057
	24		24
5130.73	5037.76	2710.084	0.761138
5082.75	5039.46	2742.182	0.774235
5033.74	5041.09	2775.519	0.787271
4982.28	5042.97	2810.9	0.800666
4984.58	5070.54	2790.114	0.807185
4985.48	5113.38	2760.005	0.818172

5028.83	5111.71	2729.68	0.806869
5073.79	5109.3	2699.08	0.794701
5125.3	5107.5	2663.842	0.780673
5130.73	5037.76	2710.084	0.761138
	25		25
4885.96	5443.75	2625.087	0.936218
4883.55	5474.56	2608.894	0.946277
4879.54	5516.61	2587.817	0.960365
4907.11	5518.53	2564.165	0.954816
4946.29	5521.35	2530.638	0.94678
4980.39	5523.7	2501.657	0.939578
5012.27	5526.04	2474.597	0.932739
5046.1	5528.6	2445.965	0.925341
5089.7	5531.94	2409.242	0.915562
5095.02	5462.15	2448.251	0.891633
5097.55	5430.99	2465.99	0.881156
5100.59	5398.55	2484.432	0.870304
5103.5	5367.22	2502.535	0.859983
5106.01	5334.22	2522.305	0.849419
5108.57	5303.57	2540.744	0.839695
5110.26	5276.79	2557.454	0.831458
5111.15	5246.78	2577.118	0.822621
5110.03	5224.06	2593.444	0.816494
5089.87	5215.45	2614.042	0.819374
5042.5	5198.2	2660.505	0.826792
5041.64	5228.89	2640.455	0.835564
5041.27	5270.44	2613.044	0.847453
5040.63	5302.38	2592.498	0.856852
5038.8	5339.61	2569.669	0.868268
5037.66	5375.24	2547.67	0.879231
5036.21	5413.44	2524.608	0.891253
5034.7	5458.62	2497.65	0.905704
5006.27	5455.76	2521.832	0.911769
4969.42	5452.12	2553.27	0.919479
4942.41	5449.88	2576.15	0.925144
4915.18	5447.27	2599.509	0.930645
4885.96	5443.75	2625.087	0.936218
	26		26
5163.55	4909.05	2782.916	0.720687
5160.52	4938.15	2763.134	0.728461
5157	4971.53	2740.682	0.737528
5153.6	5006.84	2716.961	0.747194
5148.6	5047.35	2690.822	0.758788
5144.24	5091.43	2662.045	0.77137
5135.18	5143.64	2631.278	0.787672
5127.71	5211.22	2589.441	0.808204
5120.92	5264.11	2558.174	0.824988
5113.01	5312.07	2531.766	0.841023
5144.09	5315.13	2506.629	0.833666
5197.5	5320.41	2463.743	0.820681
5200.41	5275.47	2492.494	0.806694
5205.83	5208.67	2535.332	0.78619

5205.65	5162.52	2568.273	0.773523
5210.52	5112.61	2600.861	0.758776
5216.76	5045.27	2645.924	0.739552
5225.24	5005.58	2669.735	0.727186
5231.32	4965.43	2695.868	0.7156
5243.82	4916.89	2724.613	0.700449
5198.91	4912.39	2757.18	0.711851
5163.55	4909.05	2782.916	0.720687
	27		27
4818.13	5388.83	2712.273	0.934738
4846.54	5391.94	2687.61	0.929389
4877.67	5397.07	2659.637	0.923932
4909.63	5402.03	2631.189	0.918115
4941.77	5407.82	2602.181	0.912382
4943.77	5376.33	2619.997	0.902408
4943.48	5343.26	2640.845	0.892648
4942.2	5308.07	2664.051	0.882663
4939.73	5266.38	2692.61	0.871285
4938.36	5231.41	2716.297	0.861759
4936.44	5194.25	2742.082	0.851929
4932.68	5154.16	2771.45	0.841937
4895.56	5154.07	2799.308	0.850744
4859.54	5154.58	2826.154	0.859285
4829.65	5154.89	2848.658	0.866219
4808.72	5154.8	2864.694	0.870927
4809.3	5183.46	2845.871	0.878499
4810.89	5223.37	2819.329	0.889036
4811.97	5259.4	2795.919	0.898799
4813.34	5297.08	2771.537	0.909131
4815	5330.77	2749.646	0.918427
4816.39	5361.85	2729.778	0.927166
4818.13	5388.83	2712.273	0.934738
	28		28
5223.75	4718.24	2891.625	0.661466
5238.31	4694.61	2901.444	0.652503
5203.74	4707.93	2912.067	0.664713
5156.66	4708.74	2940.71	0.677484
5105.63	4706.13	2974.975	0.6903
5060.54	4711.6	2999.713	0.703051
5017.55	4716.12	3024.271	0.714862
4996.47	4713.53	3040.079	0.71954
4999.22	4737.38	3020.359	0.724059
5046.88	4733.16	2992.197	0.711193
5090.54	4729.44	2966.729	0.699225
5154.34	4723.62	2930.592	0.681284
5223.75	4718.24	2891.625	0.661466
	29		29
4734.54	4896.69	3091.314	0.822497
4768.7	4883.45	3075.465	0.811784
4762.73	4857.67	3097.572	0.807073
4754.86	4822.91	3127.359	0.800785
4744.36	4774.31	3168.85	0.792081

4713.58	4771.43	3192.842	0.79821
4719.38	4811.3	3160.955	0.805962
4725.16	4851.73	3128.891	0.814006
4734.54	4896.69	3091.314	0.822497
	30		30
5209.48	5327.1	2450.42	0.819346
5206.99	5350.72	2436.187	0.827128
5204.56	5372.45	2423.329	0.834407
5202.84	5399.47	2406.549	0.843205
5201.6	5427.89	2388.676	0.852436
5243.84	5430.9	2355.031	0.841593
5246.11	5411.64	2366.224	0.834884
5248.09	5394.15	2376.54	0.82887
5250.6	5375.72	2387.192	0.822468
5253.97	5352.9	2400.325	0.814546
5256.86	5328.92	2414.756	0.806501
5238.17	5328.01	2428.908	0.811555
5209.48	5327.1	2450.42	0.819346
	31		31
5219.84	4718.8	2893.587	0.662651
5241.32	4745.1	2859.638	0.662387
5258.78	4768.75	2830.252	0.662662
5277.49	4794.23	2798.654	0.662992
5296.16	4819.5	2767.246	0.663295
5318.27	4849.81	2729.75	0.66375
5347.58	4889.37	2680.532	0.664229
5370.26	4919.64	2642.716	0.664533
5391.64	4948.08	2607.144	0.664804
5429.69	4918.5	2607.396	0.646319
5389.68	4875.2	2666.066	0.648518
5348.88	4838.69	2719.827	0.652366
5319.85	4807.59	2762.167	0.653882
5287.12	4773.35	2809.258	0.655716
5258.03	4733.68	2858.438	0.65532
5259.94	4697.3	2886.215	0.647114
5240.36	4706.3	2890.916	0.654395
5219.84	4718.8	2893.587	0.662651
	32		32
5363.29	4994.98	2588.228	0.684605
5358.41	5024.35	2568.659	0.693307
5356.82	5057.81	2544.041	0.702193
5354.38	5084.39	2525.396	0.709729
5350.38	5123.6	2498.424	0.72117
5345.89	5162.5	2472.344	0.732923
5344.44	5186.38	2455.625	0.739868
5342.61	5201.04	2446.058	0.744462
5336.65	5231.14	2428.085	0.754667
5326.61	5258.86	2414.913	0.765559
5347.45	5265.74	2395.533	0.761277
5371.38	5269.03	2376.691	0.754943
5375.45	5232.88	2400.391	0.743388
5377.21	5220.92	2408.023	0.739488

5380.04	5202.73	2419.597	0.733558
5384.61	5166.17	2443.853	0.722152
5387.38	5139.06	2462.446	0.714031
5388.92	5120.37	2475.598	0.708617
5393.82	5092.1	2493.972	0.699748
5399.2	5061.91	2513.713	0.690376
5404.3	5037.32	2529.5	0.68263
5409.33	5013.5	2544.88	0.675192
5415.47	4990.68	2558.926	0.667745
5392.56	4992.27	2571.934	0.675122
5363.29	4994.98	2588.228	0.684605
	33		33
5272.09	5552.03	2254.394	0.873317
5270.33	5527.67	2271.456	0.865594
5268.34	5503.67	2288.591	0.858172
5266.85	5478.23	2306.424	0.850249
5266.28	5455.1	2322.176	0.842926
5265.78	5433.69	2336.845	0.836228
5240.62	5432.54	2356.342	0.843023
5216.16	5431.51	2375.341	0.849549
5194.77	5430.74	2391.952	0.855212
5193.61	5454.08	2377.586	0.862941
5192.2	5479.05	2362.505	0.871359
5190.08	5507.7	2345.798	0.881287
5185.99	5551.07	2321.644	0.896822
5217.09	5549.14	2298.644	0.887722
5247.18	5546.59	2277.011	0.878512
5272.09	5552.03	2254.394	0.873317
	34		34
5370.43	5214.53	2417.313	0.739779
5373.96	5192.54	2431.238	0.732609
5380.82	5149.33	2459.009	0.718782
5388.75	5094.04	2495.758	0.701803
5390.85	5081.11	2504.297	0.697829
5395.11	5053.09	2523.119	0.689399
5399.97	5015.22	2549.401	0.67848
5405.73	4975.75	2576.681	0.667125
5411.85	4933.9	2605.953	0.655344
5417.18	4897.77	2631.481	0.64537
5388.75	4872.02	2669.162	0.648076
5361.86	4849.23	2703.574	0.650917
5353.71	4871.33	2691.005	0.658303
5345.39	4898.79	2674.475	0.667045
5337.4	4928.68	2656.051	0.676371
5327.63	4960.01	2637.874	0.686694
5318.08	4993.52	2618.171	0.697629
5313.42	5023.82	2598.045	0.706496
5308.27	5049.25	2582.126	0.714407
5301.85	5081.04	2562.444	0.724428
5299.58	5114.07	2539.323	0.733718
5292.21	5141.65	2523.888	0.743204
5287.24	5177.34	2501.127	0.754323

5283.77	5202.09	2485.543	0.762159
5279.85	5235.69	2464.083	0.772725
5273.77	5273.76	2441.265	0.785395
5269.87	5310.13	2418.473	0.79717
5267.06	5342.9	2397.72	0.807766
5297.07	5350.68	2370.702	0.801389
5329.95	5359.52	2340.992	0.79433
5342.57	5320.78	2359.418	0.778868
5351.36	5290.29	2375.105	0.767216
5359.41	5263.65	2388.817	0.757049
5370.43	5214.53	2417.313	0.739779
	35		35
5307.61	5559.86	2222.203	0.865751
5314.4	5535.67	2232.825	0.855529
5322.29	5505.79	2246.636	0.843185
5328.77	5471.7	2264.666	0.830041
5333.57	5438.98	2283.369	0.818047
5339.96	5407.96	2300.07	0.806305
5347.4	5372.45	2319.484	0.793035
5354.63	5339.43	2337.677	0.7808
5362.25	5304.2	2357.533	0.767986
5340.82	5299.05	2376.154	0.772968
5300.61	5290.84	2410.219	0.782532
5286.34	5288.01	2422.301	0.785886
5276.51	5312.42	2412.124	0.795925
5266.76	5334.21	2403.95	0.805239
5255.08	5359.47	2395.012	0.816223
5243.64	5385.96	2385.356	0.8276
5229.17	5416.38	2375.645	0.84115
5217.33	5440.66	2368.429	0.852124
5202.64	5472.62	2358.685	0.866424
5201.19	5496.52	2344.391	0.874593
5200.87	5522.32	2328.177	0.883184
5207.06	5552.34	2304.42	0.891546
5213.5	5579.61	2282.343	0.89907
5230.57	5586.03	2264.993	0.896598
5246	5593.59	2248.223	0.89494
5269.65	5606.04	2221.989	0.892654
5286.92	5615.8	2202.42	0.891185
5314.72	5627.7	2173.333	0.887405
5335.64	5638.26	2150.449	0.88507
5354.33	5649.51	2128.862	0.883601
5371.36	5659.33	2109.47	0.882078
5392.34	5669.48	2086.829	0.879444
5401.25	5650.33	2092.274	0.869677
5410.09	5631.49	2097.769	0.860096
5419.19	5609.22	2105.524	0.84926
5424.39	5597.28	2109.543	0.843382
5392.2	5589.09	2139.086	0.850529
5367.07	5582.49	2162.359	0.8559
5339.91	5582.61	2182.864	0.864099
5323.98	5569.06	2203.777	0.864116

5307.61	5559.86	2222.203	0.865751
	36		36
5151.57	4726.05	2930.451	0.682541
5089.18	4731.71	2965.868	0.700069
5043.04	4735.61	2992.851	0.712699
5002.64	4738.96	3016.91	0.723557
4957.07	4743.15	3044.164	0.735688
4917.45	4746.18	3068.667	0.745923
4894.84	4748.19	3082.588	0.751752
4891.37	4800.22	3047.188	0.764245
4889.2	4838.97	3020.849	0.77364
4888.66	4872.44	2997.377	0.781572
4936.49	4866.94	2967.831	0.768827
4966.27	4864.14	2949.23	0.760909
5000.47	4860.83	2928.168	0.751671
5048.53	4855.42	2899.562	0.738288
5086.04	4850.37	2878.22	0.727468
5118.65	4846.8	2859.327	0.718119
5143.68	4845.28	2844.071	0.71114
5147.65	4796.28	2878.816	0.698986
5149.93	4760.9	2904.536	0.690547
5151.57	4726.05	2930.451	0.682541
	2		2
10023.58	9947.78	4222.729	0.798091
10051.78	9943.82	4240.217	0.803403
10068.75	9942.36	4251.436	0.806421
10088.33	9936.46	4261.523	0.8106
10104.6	9933.14	4271.048	0.813789
10123.15	9927.99	4281.027	0.817639
10141.45	9917.6	4287.318	0.822326
10148.93	9902.5	4282.554	0.826098
10154.03	9890.17	4277.965	0.829026
10156.87	9869.82	4266.344	0.832992
10124.33	9866.68	4240.2	0.828378
10125.73	9894.17	4259.86	0.823845
10117.66	9911.03	4265.431	0.819659
10099.61	9912.41	4253.2	0.816526
10076.63	9912.63	4236.634	0.812774
10053.89	9913.76	4220.929	0.808875
10023.93	9915.63	4200.601	0.80363
10023.58	9947.78	4222.729	0.798091
	5		5
10070.66	9964.37	4268.072	0.803009
10071.34	9987.32	4284.532	0.799265
10071.86	10009.38	4300.313	0.795672
10104.91	10012.03	4325.828	0.800581
10133.8	10010.04	4345.232	0.805539
10155.82	10007.69	4359.518	0.809427
10197.11	9998.41	4383.147	0.817459
10227.42	9993.2	4401.759	0.823033
10256.34	9985.9	4418.071	0.828695
10286.36	9977.98	4434.921	0.834586

10321.91	9968.95	4455.306	0.841446
10318.52	9943.7	4435.983	0.845181
10316.06	9923.61	4420.831	0.848211
10281.41	9930.41	4399.427	0.841843
10237.53	9939.67	4373.015	0.83358
10203.14	9946.08	4351.953	0.827178
10174.65	9951.35	4334.613	0.821833
10145.17	9955.83	4316.135	0.816422
10123.52	9958.24	4302.042	0.812568
10089.51	9962.8	4280.567	0.806331
10070.66	9964.37	4268.072	0.803009
	8		8
9927.71	9991.42	4185.699	0.774635
9941.79	9985.32	4191.213	0.778054
9974.32	9972.43	4204.987	0.785716
9989.25	9930.05	4185.786	0.795399
10033.25	9840.27	4155.447	0.818242
10049.27	9808.31	4145.438	0.826511
10055.82	9787.7	4136.34	0.831249
10059.2	9750.13	4113.626	0.83855
10062.41	9719.43	4095.565	0.844649
10066.5	9685.41	4076.132	0.851556
10069.94	9650.7	4055.951	0.858553
10073.37	9618.33	4037.481	0.865176
10076.78	9584.22	4018.055	0.872189
10057.51	9584.29	4003.364	0.86908
10027.9	9584.96	3981.231	0.86415
10009.3	9585.77	3967.631	0.860951
10007.82	9619.02	3988.264	0.854386
10004.86	9654.07	4009.148	0.847308
9989.87	9697.18	4026.674	0.836819
9980.9	9718.14	4034.111	0.831472
9976.82	9750.27	4052.831	0.824935
9970	9793.89	4077.588	0.815943
9960.33	9839.82	4102.211	0.806172
9955.27	9875.81	4123.579	0.799024
9942.76	9906.86	4136.384	0.791535
9928.35	9936.46	4147.051	0.784015
9915.57	9962.91	4156.848	0.777345
9893.12	10002.91	4169.846	0.766779
9927.71	9991.42	4185.699	0.774635
	9		9
10029.15	9845.18	4155.815	0.816706
10046.8	9843.73	4167.708	0.819858
10063.64	9843.1	4179.606	0.822718
10113.75	9843.84	4216.973	0.830672
10156.48	9844.73	4249.218	0.837299
10155.18	9821.96	4233.039	0.84109
10159.26	9790.71	4215.328	0.847261
10167.34	9760.9	4201.739	0.853851
10175.43	9739.21	4193.641	0.859017
10181.91	9717.4	4184.353	0.863976

10188.81	9699.95	4178.306	0.868224
10196.62	9680.42	4171.694	0.873007
10203.2	9657.9	4162.322	0.878168
10209.73	9632.21	4151.011	0.883936
10215.63	9615.41	4144.954	0.887972
10204.25	9613.03	4134.627	0.886682
10180.85	9610.91	4115.174	0.883488
10152.52	9607.51	4091.148	0.879737
10090.29	9608.76	4044.196	0.869691
10086.04	9621.44	4049.147	0.866621
10077.49	9643.65	4057.072	0.861084
10069.87	9669.64	4068.302	0.855018
10061.94	9695.71	4079.501	0.84892
10055.66	9722.44	4092.522	0.843004
10049.92	9745.89	4103.891	0.837807
10043.49	9770.14	4115.399	0.832382
10039.22	9791.61	4126.735	0.827838
10034.61	9811.53	4136.854	0.823538
10029.15	9845.18	4155.815	0.816706
	11		11
9848.75	9780.59	3980.836	0.797506
9853.38	9751.54	3963.931	0.803566
9858.92	9718.16	3944.847	0.810632
9863.96	9680.01	3922.336	0.818566
9868.83	9636.24	3896.145	0.827623
9837.48	9632.42	3870.52	0.822869
9834.97	9660.73	3887.999	0.817092
9836.1	9684.14	3904.878	0.812919
9838.42	9708.63	3923.43	0.808792
9833.96	9737.38	3940.124	0.802732
9824.25	9760.97	3949.6	0.796728
9818.17	9779.32	3958.118	0.792339
9848.75	9780.59	3980.836	0.797506
	12		12
9888.32	10050.6	4201.018	0.75808
9876.32	10051.31	4193.293	0.755886
9855.77	10052.68	4180.225	0.752084
9838.64	10053.17	4168.9	0.749003
9838.55	10072.15	4182.759	0.745897
9835.08	10092.17	4195.139	0.742051
9832.48	10112.42	4208.337	0.738344
9830.9	10126.76	4217.893	0.735778
9829.1	10142.83	4228.615	0.732912
9843.35	10145.71	4240.298	0.734956
9860.16	10148.13	4253.38	0.737506
9875.1	10149.95	4264.784	0.739812
9875.88	10130.07	4250.65	0.7431
9877.43	10100.72	4230.138	0.748064
9879.67	10081.22	4217.394	0.751599
9883.85	10064.09	4207.759	0.755105
9888.32	10050.6	4201.018	0.75808
	15		15

9888.29	9975.84	4147.028	0.77047
9884.02	9958.38	4131.535	0.772671
9884.21	9940.48	4118.87	0.775738
9884.01	9926.15	4108.512	0.778145
9884.1	9898.14	4088.673	0.78297
9883.72	9866.06	4065.728	0.78847
9884.03	9834.28	4043.609	0.794098
9866.46	9836.43	4032.608	0.790664
9836.96	9840.04	4014.246	0.784856
9808.3	9842.22	3995.593	0.779395
9811.47	9869.83	4017.498	0.775126
9813.02	9909.5	4047.008	0.76854
9814.95	9987.79	4104.977	0.755621
9835.15	9983.9	4116.034	0.759841
9850.08	9981.75	4124.777	0.762824
9888.29	9975.84	4147.028	0.77047
	16		16
9808.17	10005.48	4113.238	0.751472
9822.75	10004.8	4122.71	0.754169
9838.58	10008.29	4136.103	0.756381
9867.3	10002.26	4151.503	0.762409
9875.4	9973.77	4136.573	0.768582
9883.95	9947.94	4124.017	0.774426
9890.95	9922.3	4110.648	0.780005
9897.39	9898.81	4098.532	0.785153
9901.26	9873.07	4083.117	0.79028
9907.49	9849.64	4071.111	0.795446
9913.52	9821.92	4056.086	0.801368
9919.83	9794.77	4041.8	0.807279
9925.2	9766.25	4026.032	0.813319
9933.07	9738.13	4012.512	0.819758
9940.04	9718.25	4004.088	0.824575
9946.33	9697.68	3994.789	0.829425
9950.08	9670.39	3979.19	0.83512
9956.16	9648.32	3968.94	0.840271
9960.62	9621.07	3954.147	0.846156
9965.13	9594	3939.649	0.85206
9968.65	9567.65	3925.011	0.857703
9938.18	9561.63	3898.057	0.853757
9909.41	9557.81	3873.894	0.84962
9912.97	9575.85	3888.496	0.846741
9916.44	9598.41	3906.067	0.843002
9897.52	9624.15	3909.192	0.834866
9885.57	9643.38	3913.307	0.829174
9869.62	9672.43	3921.301	0.820964
9863.51	9685.36	3925.665	0.817493
9850.85	9717.49	3938.54	0.809343
9839.15	9749.4	3952.211	0.801456
9829.24	9782.84	3968.475	0.793666
9827.64	9808.37	3985.284	0.788817
9829.48	9838.17	4007.638	0.783865
9819.68	9879.55	4030.187	0.774894

9817.43	9911.96	4051.842	0.768901
9809.07	9977.85	4093.71	0.756241
9808.17	10005.48	4113.238	0.751472
	18		18
9896.06	10033.64	4194.06	0.7622
9902.99	10050.35	4210.936	0.760651
9910.29	10071.75	4231.482	0.758414
9915.33	10088.57	4247.165	0.756552
9920.97	10107.98	4265.162	0.754389
9925.66	10132.59	4286.328	0.751255
9923.6	10156.65	4302.543	0.747088
9921.21	10180.3	4318.307	0.74296
9919.39	10210.31	4339.231	0.737973
9918.79	10239.72	4360.633	0.733334
9917.98	10262.45	4377.007	0.72972
9925.72	10282.17	4396.871	0.728042
9945.03	10269.33	4400.195	0.73326
9967.16	10256.36	4405.442	0.738963
9981.08	10248.13	4408.762	0.742554
9996.77	10243.66	4416.102	0.745856
10024.07	10239.88	4431.909	0.750959
10043.82	10231.31	4439.167	0.755529
10064.37	10221.77	4446.365	0.760364
10064.6	10204.14	4433.767	0.763142
10064.46	10188.97	4422.719	0.76549
10059.36	10171.66	4406.712	0.767377
10048.26	10147.86	4381.884	0.769325
10041.32	10121.83	4358.377	0.772336
10036.47	10097.36	4337.486	0.775472
10028.39	10076.35	4316.836	0.777542
10019.87	10054.62	4295.383	0.779678
10010.59	10030.95	4272.038	0.782028
10004.14	10015.44	4256.493	0.783521
9997.58	9999.9	4240.859	0.785011
9968.6	10011.4	4228.607	0.778241
9941.38	10020.37	4215.964	0.772149
9919.56	10027.08	4205.597	0.767319
9896.06	10033.64	4194.06	0.7622
	6		6
4118.36	4905.01	3562.7	0.94217
4095.1	4929.14	3567.479	0.951475
4067.52	4956.74	3574.122	0.962242
4043.18	4980.45	3580.694	0.971561
4020.59	5005.85	3585.18	0.980966
4034.17	5020.73	3565.622	0.982315
4051.98	5041.36	3539.363	0.98437
4067.38	5056.94	3517.917	0.985637
4083.1	5041.57	3513.368	0.979518
4106.34	5019.61	3506.453	0.970624
4133.59	4995.3	3497.875	0.960489
4158.44	4971.51	3491.308	0.950826
4146.42	4952.26	3512.287	0.948353

4129.75	4924.75	3541.892	0.944787
4118.36	4905.01	3562.7	0.94217
	1		1
3966.8	5029.07	3617.301	0.994572
3955.78	5051.98	3614.147	1.001549
3980.32	5068.65	3584.492	1.001776
4014.44	5092.39	3542.957	1.002232
4048.91	5117.48	3500.402	1.00297
4080.68	5139.94	3461.539	1.003504
4106.84	5155.95	3430.874	1.003342
4116.8	5131.81	3435.546	0.995859
4091.95	5114.95	3465.569	0.995675
4066.63	5096.46	3496.873	0.995177
4043.56	5080.15	3525.104	0.994858
4021.02	5064.38	3552.597	0.99459
3995.79	5048.25	3582.542	0.994652
3966.8	5029.07	3617.301	0.994572
	7		7
4645.85	4844.2	3192.099	0.82935
4641.41	4810.89	3217.942	0.822648
4638.47	4774.71	3244.802	0.815092
4599.64	4773.81	3273.782	0.823026
4551.46	4779.05	3305.748	0.834099
4505.73	4788.79	3333.292	0.845481
4461.97	4805.59	3355.15	0.85788
4412.41	4821.87	3382.288	0.871105
4367.82	4834.75	3408.325	0.882422
4329.07	4844.06	3432.484	0.891688
4288.27	4853.29	3458.59	0.901175
4246.16	4863.29	3485.565	0.910923
4216.23	4871.17	3504.468	0.917935
4177.94	4881.94	3528.484	0.926952
4142.23	4891.18	3551.615	0.935068
4158.93	4922.99	3519.325	0.939523
4178.12	4958.39	3482.984	0.944477
4210.64	4946.42	3463.773	0.936174
4238.94	4933.66	3448.654	0.928329
4264.78	4920.49	3435.956	0.920754
4296.05	4905.16	3420.482	0.911653
4336.89	4886.84	3399.647	0.900035
4363.91	4880.56	3382.454	0.893616
4382.73	4875.65	3370.9	0.888982
4414.81	4865.19	3352.704	0.88053
4440.33	4861.91	3335.167	0.874899
4459.16	4861.08	3321.272	0.871073
4483.38	4859.24	3303.972	0.865926
4501.95	4857.3	3291.112	0.861821
4543.26	4853.44	3262.406	0.852679
4582.57	4849.28	3235.671	0.843717
4613.7	4847.32	3213.792	0.836822
4645.85	4844.2	3192.099	0.82935
	4		4

4388.75	4923.56	3336.2	0.898995
4419.9	4922.19	3312.735	0.892819
4457.93	4920.01	3284.582	0.88504
4492.41	4917.91	3259.311	0.877842
4527.88	4915.96	3233.357	0.87037
4558.05	4914.23	3211.473	0.863903
4587.52	4912.85	3190.024	0.857574
4620.18	4910.48	3166.96	0.850261
4654.39	4906.28	3144.129	0.842078
4648.7	4865.65	3175.541	0.833726
4624.74	4866.89	3192.494	0.839058
4587.72	4869.36	3218.497	0.847314
4557.3	4871.32	3240.071	0.853983
4525.73	4873.09	3262.784	0.860749
4494.13	4875.68	3285.136	0.867617
4457.29	4878.64	3311.426	0.875493
4422.49	4882.31	3335.891	0.883021
4399.92	4885.09	3351.606	0.887937
4376.85	4887.86	3367.796	0.892897
4388.75	4923.56	3336.2	0.898995
	3		3
4708.43	4866.06	3131.293	0.821002
4707.24	4832.59	3155.062	0.813495
4705.48	4804.56	3175.654	0.807462
4703.12	4775.32	3197.633	0.801365
4657.36	4774.77	3231.039	0.811096
4658.72	4804.24	3209.821	0.817461
4660.43	4835.54	3187.236	0.824257
4661	4865.8	3166.343	0.83115
4708.43	4866.06	3131.293	0.821002
	17		17
4594.48	5349.81	2917.131	0.969527
4546.75	5326.2	2969.856	0.972063
4510.45	5319.37	3003.727	0.976996
4476.94	5313.48	3034.828	0.981565
4448.09	5309.2	3061.217	0.98564
4412.03	5304.64	3093.838	0.990849
4386.95	5300.46	3117.125	0.994137
4342.39	5292.75	3158.733	0.999782
4306.27	5285.43	3193.107	1.003967
4263.16	5271.26	3237.103	1.007425
4249.62	5265.27	3251.75	1.008092
4205.92	5250.21	3296.763	1.011299
4210.4	5279.69	3277.398	1.018197
4213.59	5296.99	3265.628	1.022194
4217.63	5319.04	3250.724	1.027333
4252.81	5334.55	3212.597	1.025803
4277.9	5345.09	3185.68	1.024549
4314.61	5356.97	3148.153	1.021716
4350.67	5367.84	3111.735	1.018648
4396.26	5378.57	3067.327	1.01383
4424.18	5382.92	3041.348	1.010192

4460.27	5391.79	3006.088	1.006307
4500.14	5402.33	2966.791	1.002119
4536.27	5418.85	2927.456	1.000228
4573.43	5429.96	2890.202	0.996519
4576.91	5388.77	2909.884	0.983984
4579.01	5361.43	2923.372	0.975799
4594.48	5349.81	2917.131	0.969527
	10		10
4669.32	5478.36	2783.426	0.992403
4687.59	5498.19	2757.295	0.994803
4710.18	5521.83	2725.484	0.997563
4740.25	5546.21	2687.001	0.999116
4763.75	5571.46	2653.59	1.002327
4783.7	5592.6	2625.407	1.005022
4800.53	5613.32	2600.106	1.00828
4806.9	5592.51	2605.9	1.000221
4786.64	5572.79	2633.608	0.998074
4765.72	5550.08	2663.508	0.995165
4745.74	5528.05	2692.271	0.99234
4723.13	5496.88	2728.279	0.987305
4684.17	5461.05	2780.546	0.984271
4669.32	5478.36	2783.426	0.992403
	13		13
5337.79	5586.44	2181.993	0.866064
5332.59	5606.63	2172.956	0.874693
5326.65	5622.71	2167.263	0.882144
5348.35	5628.33	2146.957	0.877742
5373.31	5633.18	2124.692	0.871992
5398.65	5638.5	2101.905	0.866174
5418.28	5642.08	2084.655	0.861383
5410.19	5658.8	2079.979	0.870016
5399	5676.95	2076.936	0.88017
5386.24	5698.08	2073.455	0.891946
5364.83	5720.92	2076.012	0.906985
5343.17	5733.06	2085.719	0.917968
5362.85	5733.19	2070.041	0.912243
5382.47	5736.13	2052.747	0.907526
5407.43	5702.36	2054.3	0.887091
5420.12	5686.46	2054.607	0.87719
5434.76	5666.59	2056.2	0.865207
5450.68	5645.82	2057.716	0.852506
5467.64	5622.17	2060.714	0.838448
5445.8	5617.08	2080.386	0.843648
5420.8	5610.75	2103.304	0.849301
5389.61	5599.9	2133.925	0.855137
5362.68	5591.18	2159.998	0.860271
5337.79	5586.44	2181.993	0.866064
	14		14
5270.2	5505.4	2286.053	0.858213
5267.51	5527.12	2273.961	0.866214
5264.42	5543.88	2265.507	0.872734
5281.38	5556.55	2244.371	0.872202

5304.49	5574.55	2215.099	0.871714
5317.5	5584.85	2198.512	0.871492
5334.63	5598.26	2176.771	0.871141
5354.67	5614.37	2151.065	0.870872
5373.08	5627.75	2128.365	0.870108
5392	5642.08	2104.664	0.869517
5413.43	5659.45	2077.084	0.86925
5432.04	5676.19	2052.065	0.869628
5448.59	5690.87	2029.949	0.869894
5460.21	5672.61	2032.958	0.859343
5475.83	5651.22	2035.265	0.846371
5450.61	5636.63	2063.828	0.849175
5422.74	5621.32	2094.877	0.852477
5398.59	5606.89	2122.562	0.854847
5370.12	5593.17	2153.063	0.858718
5344.21	5575.61	2184.154	0.860383
5318.36	5551.45	2219.507	0.859726
5296.89	5530.78	2249.265	0.858993
5270.2	5505.4	2286.053	0.858213

11.1.2.2 GPS output file

Id	Pole[m2]	Blad[m2]	BladWzgl[%]	BladBieg[m2]
1	4840.33	77.62	1.604	77.62
2	4078.53	58.42	1.432	58.42
3	4249.97	58.17	1.369	58.17
4	11217.49	95.3	0.85	95.3
5	12505.57	91.8	0.734	91.8
6	9640.73	74.53	0.773	74.53
7	29677.78	141.76	0.478	141.76
8	28343.55	135.38	0.478	135.38
9	29342.36	98.96	0.337	98.96
10	3689.74	77.63	2.104	77.63
11	3882.17	67.56	1.74	67.56
12	4229.26	48.81	1.154	48.81
13	7056.18	79.22	1.123	79.22
14	7740.37	83.94	1.084	83.94
15	10273.58	79.47	0.774	79.47
16	33783.29	120.98	0.358	120.98
17	28458.24	123.05	0.432	123.05
18	29569.13	90.53	0.306	90.53
19	4855.66	83.8	1.726	83.8
20	4927.9	71.73	1.456	71.73
21	4111.65	63.46	1.543	63.46
22	11289.99	113.72	1.007	113.72
23	11463.02	102.57	0.895	102.57
24	10049.25	89	0.886	89
25	31310.78	130.69	0.417	130.69

26	30115.77	147.26	0.489	147.26
27	30878.09	107.72	0.349	107.72
28	4232.64	104.72	2.474	104.72
29	4016.29	67.83	1.689	67.83
30	4634.89	54.45	1.175	54.45
31	9027.64	109.93	1.218	109.93
32	11361.55	91.12	0.802	91.12
33	9012.34	67.55	0.75	67.55
34	39512.02	135.04	0.342	135.04
35	39169.17	116.85	0.298	116.85
36	30998.68	117.82	0.38	117.82

12. Appendix - Statistical analysis.

12.1.1 Remote sensing

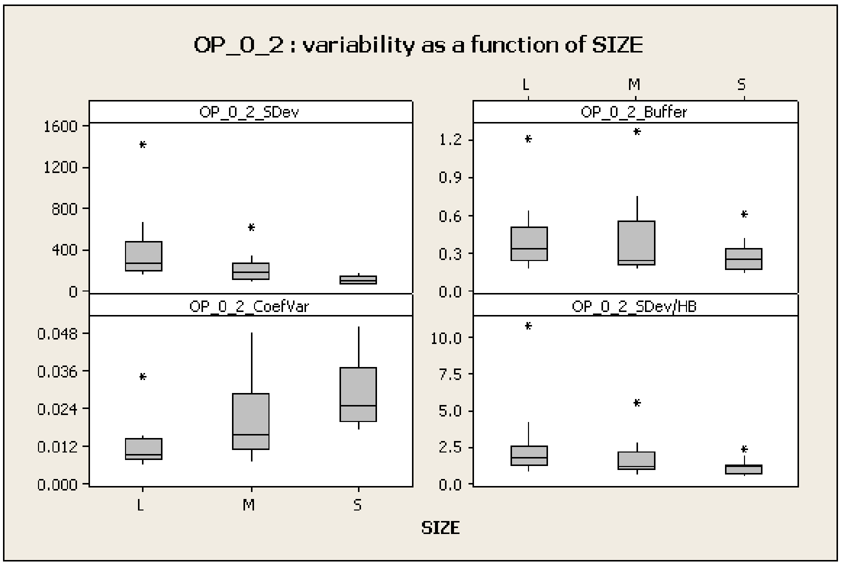
12.1.1.1 List of discarded observations for remote sensing data. Explanation of the codes used in column COCHRAN's, GRUBBS/1 and GRUBBS/2 is given in part 3.4.3.

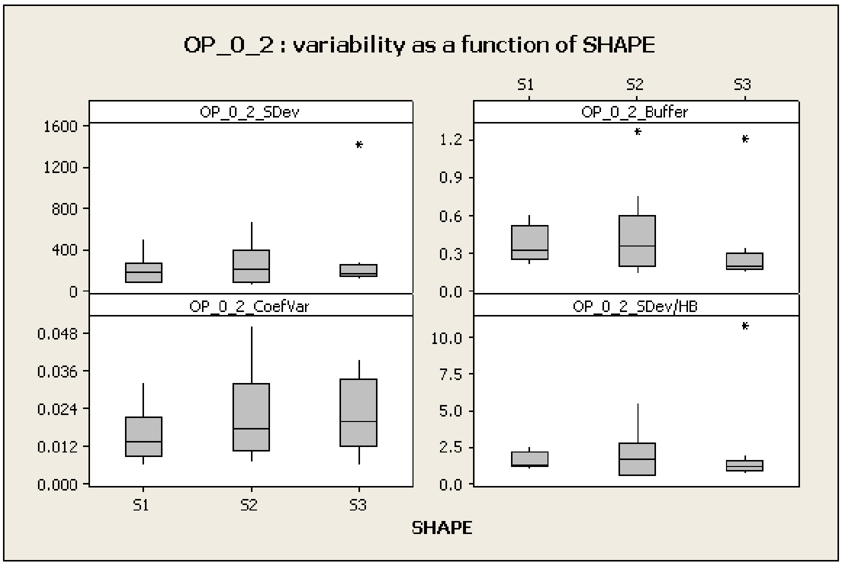
Row	Parcel	Photo	Operator	Data	COCHRAN	GRUBBS/1	GRUBBS/2
1	1	OP_0_2	3	3587.3	2	0	0
2	1	OP_0_2	3	3592.7	2	0	0
3	1	OP_0_2	3	3320.5	2	0	0
4	1	OP_0_5	3	3127.1	2	0	0
5	1	OP_0_5	3	3626.5	2	0	0
6	1	OP_0_5	3	3540.1	2	0	0
7	5	OP_0_2	2	11791.6	0	0	10
8	5	OP_0_2	2	12148.0	0	0	10
9	5	OP_0_2	2	12139.0	0	0	10
10	5	OP_0_2	12	11969.9	0	0	10
11	5	OP_0_2	12	12106.5	0	0	10
12	5	OP_0_2	12	12277.1	0	0	10
13	5	OP_0_5	2	11019.2	2	0	0
14	5	OP_0_5	2	12129.9	2	0	0
15	5	OP_0_5	2	12184.7	2	0	0
16	7	OP_0_5	8	23169.2	2	0	0
17	7	OP_0_5	8	24375.5	2	0	0
18	7	OP_0_5	8	24284.7	2	0	0
19	8	OP_1_0	2	28370.6	2	0	0
20	8	OP_1_0	2	26967.1	2	0	0
21	8	OP_1_0	2	28295.7	2	0	0
22	8	OP_1_0	10	28538.7	2	0	0
23	8	OP_1_0	10	27316.0	2	0	0
24	8	OP_1_0	10	28214.4	2	0	0
25	9	OP_0_2	12	23124.9	0	10	0
26	9	OP_0_2	12	23826.4	0	10	0
27	9	OP_0_2	12	23773.0	0	10	0
28	10	OP_0_5	9	4433.0	2	0	0
29	10	OP_0_5	9	4131.2	2	0	0
30	10	OP_0_5	9	4165.1	2	0	0
31	14	OP_0_2	11	14026.0	2	0	0
32	14	OP_0_2	11	12537.4	2	0	0
33	14	OP_0_2	11	12291.8	2	0	0
34	15	OP_1_0	6	10420.8	2	0	0
35	15	OP_1_0	6	11021.9	2	0	0
36	15	OP_1_0	6	9993.1	2	0	0
37	16	OP_1_0	12	41982.3	2	0	0
38	16	OP_1_0	12	40869.2	2	0	0
39	16	OP_1_0	12	42884.5	2	0	0
40	17	OP_0_2	2	30622.2	2	0	0
41	17	OP_0_2	2	28464.6	2	0	0

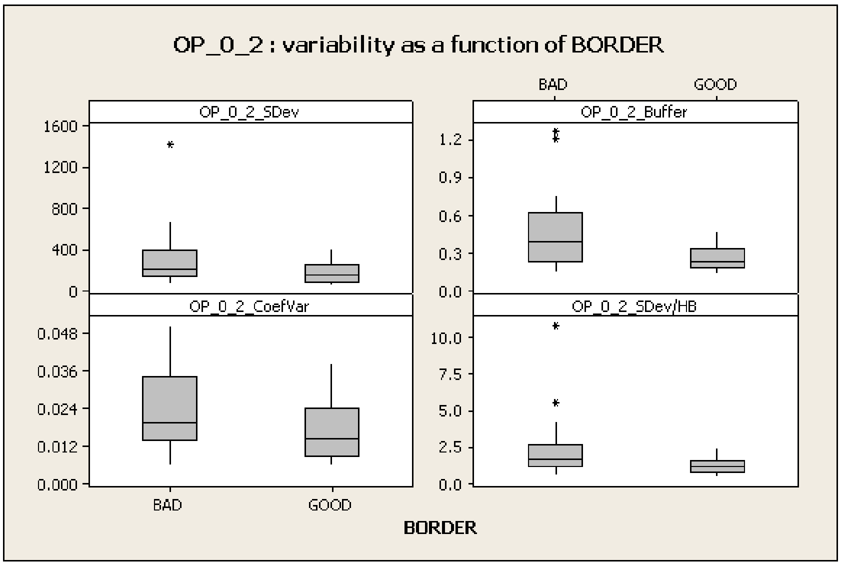
42	17	OP_0_2	2	28455.7	2	0	0
43	17	OP_0_5	2	30379.2	2	0	0
44	17	OP_0_5	2	27987.9	2	0	0
45	17	OP_0_5	2	27978.5	2	0	0
46	17	OP_0_5	4	30657.3	2	0	0
47	17	OP_0_5	4	30380.9	2	0	0
48	17	OP_0_5	4	31448.2	2	0	0
49	19	OP_1_0	7	3511.1	2	0	0
50	19	OP_1_0	7	3781.5	2	0	0
51	19	OP_1_0	7	3851.1	2	0	0
52	19	OP_1_0	11	3896.8	2	0	0
53	19	OP_1_0	11	3721.3	2	0	0
54	19	OP_1_0	11	3645.5	2	0	0
55	24	OP_0_2	11	11575.1	2	0	0
56	24	OP_0_2	11	11498.8	2	0	0
57	24	OP_0_2	11	12326.8	2	0	0
58	24	OP_1_0	8	12409.6	2	0	0
59	24	OP_1_0	8	11383.6	2	0	0
60	24	OP_1_0	8	12864.4	2	0	0
61	24	OP_1_0	7	12502.3	0	0	10
62	24	OP_1_0	7	12077.8	0	0	10
63	24	OP_1_0	7	11954.4	0	0	10
64	24	OP_1_0	11	12186.8	0	0	10
65	24	OP_1_0	11	11840.1	0	0	10
66	24	OP_1_0	11	12010.2	0	0	10
67	26	OP_0_2	3	29276.4	0	10	0
68	26	OP_0_2	3	29207.2	0	10	0
69	26	OP_0_2	3	30009.4	0	10	0
70	26	OP_1_0	11	28004.9	2	0	0
71	26	OP_1_0	11	28869.0	2	0	0
72	26	OP_1_0	11	27690.3	2	0	0
73	28	OP_0_2	8	5156.3	2	0	0
74	28	OP_0_2	8	5813.1	2	0	0
75	28	OP_0_2	8	5612.0	2	0	0
76	35	OP_0_2	6	44723.3	2	0	0
77	35	OP_0_2	6	42498.5	2	0	0
78	35	OP_0_2	6	43028.6	2	0	0
79	35	OP_1_0	6	42661.7	2	0	0
80	35	OP_1_0	6	44609.9	2	0	0
81	35	OP_1_0	6	42378.7	2	0	0
82	36	OP_1_0	5	40934.5	2	0	0
83	36	OP_1_0	5	42951.4	2	0	0
84	36	OP_1_0	5	44050.3	2	0	0

12.1.1.2 Boxplots of four transformations of the reproducibility as a function of size, shape and border for RS measurements

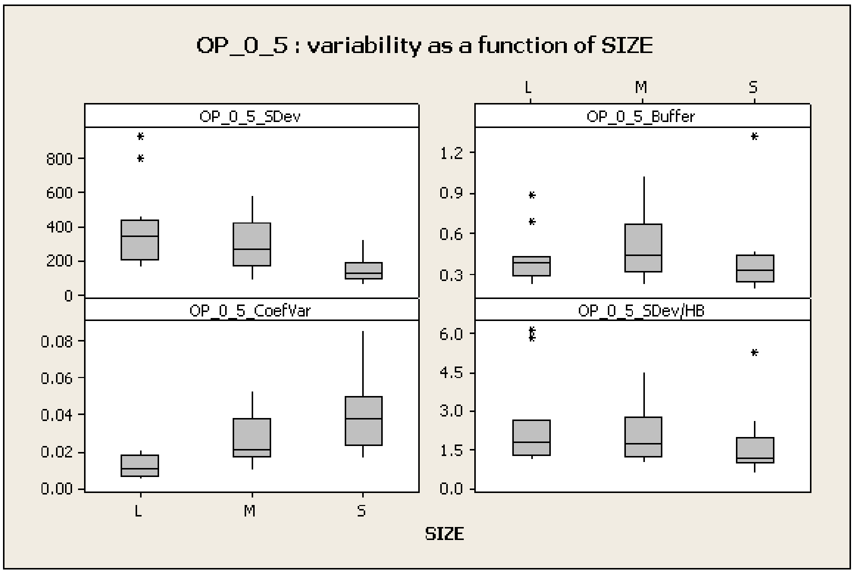
12.1.1.2.1 OP_0_2

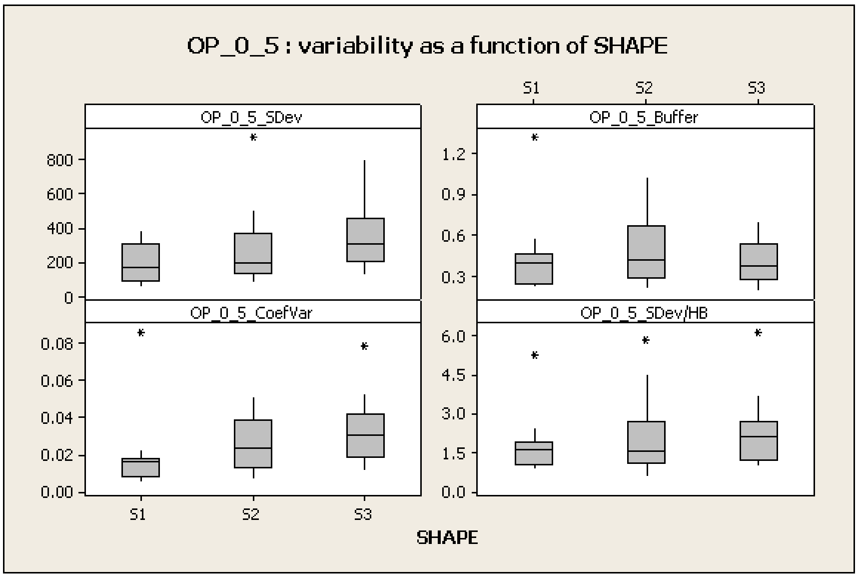


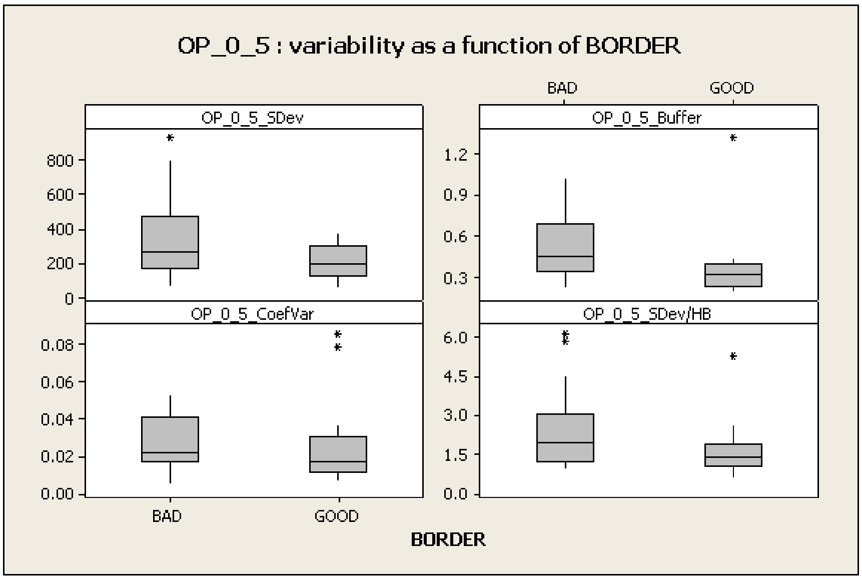



OP_0_2 : variability as a function of BORDER
OP_0_2_SDev
OP_0_2_Buffer
OP_0_2_CoefVar
OP_0_2_SDev/HB
BAD
GOOD
BORDER

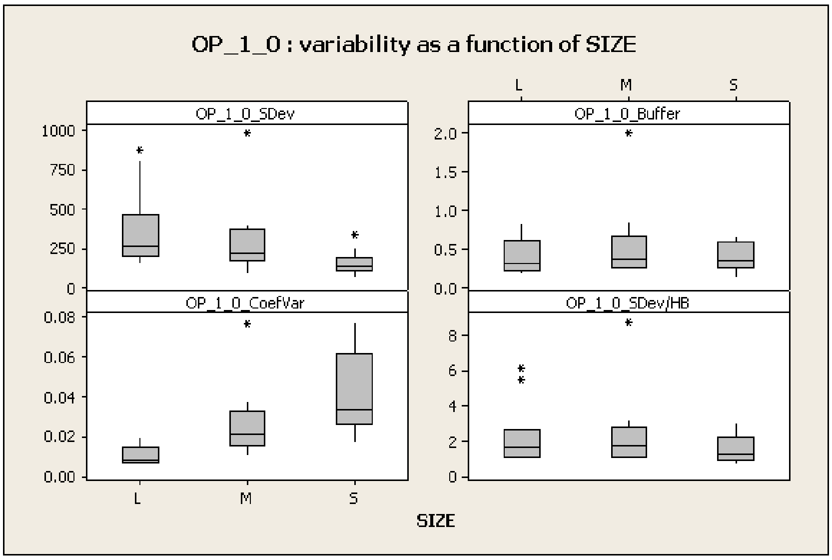
12.1.1.2.2 OP_0_5

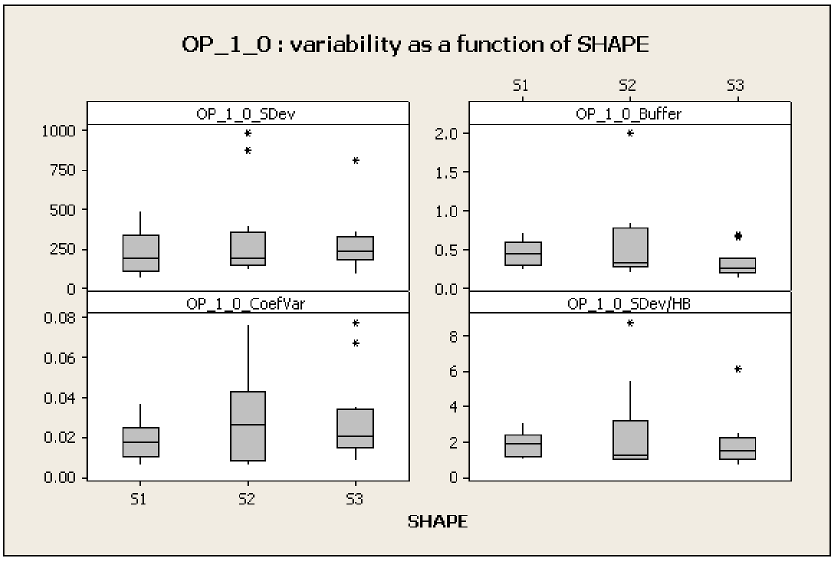

OP_0_5 : variability as a function of SIZE
OP_0_5_SDev
OP_0_5_Buffer
OP_0_5_CoefVar
OP_0_5_SDev/HB
L
M
S
SIZE

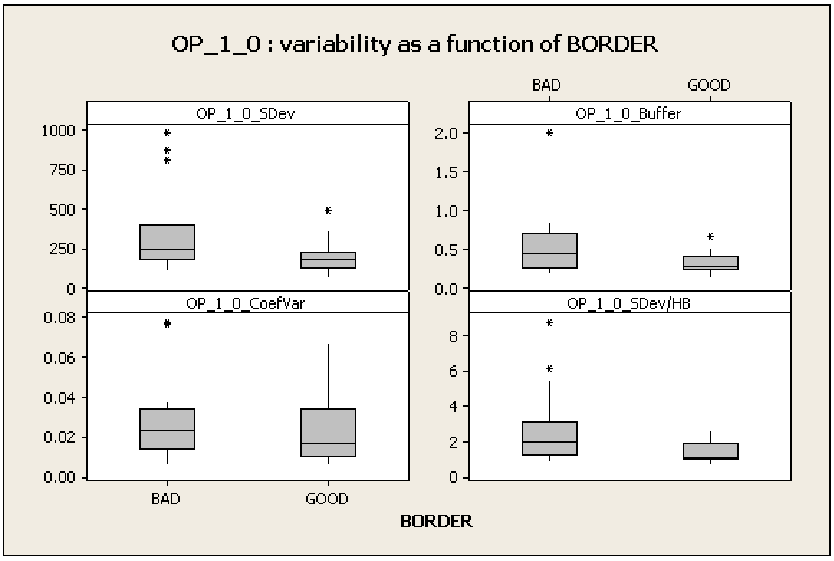

OP_0_5 : variability as a function of SHAPE
OP_0_5_SDev
OP_0_5_Buffer
OP_0_5_CoefVar
OP_0_5_SDev/HB
S1
S2
S3
SHAPE


OP_0_5 : variability as a function of BORDER
OP_0_5_SDev
OP_0_5_Buffer
OP_0_5_CoefVar
OP_0_5_SDev/HB
BAD
GOOD
BORDER

12.1.1.2.3 OP_1_0


OP_1_0 : variability as a function of SIZE
OP_1_0_SDev
OP_1_0_Buffer
OP_1_0_CoefVar
OP_1_0_SDev/HB
L
M
S
SIZE


OP_1_0 : variability as a function of SHAPE
OP_1_0_SDev
OP_1_0_Buffer
OP_1_0_CoefVar
OP_1_0_SDev/HB
S1
S2
S3
SHAPE



12.1.2 GPS – experiment A

12.1.2.1 List of discarded observations for experiment 1. Explanation of the codes used in column COCHRAN, GRUBBS/1 and GRUBBS/2 is given in part 1.4.3.

Row	Parcel	GPS	Day	Data	COCHRAN	GRUBBS/1	GRUBBS/2
1	1	SATCON	2	2127	2	1	0
2	1	SATCON	1	6260	2	0	0
3	1	SATCON	1	4844	2	0	0
4	1	SATCON	1	5085	2	0	0
5	1	SATCON	1	4739	2	0	0
6	1	SATCON	1	4970	2	0	0
7	1	SATCON	1	5137	2	0	0
8	1	SATCON	5	5690	2	1	0
9	1	THALES	5	4710	2	0	0
10	1	THALES	5	4477	2	0	0
11	1	THALES	5	4660	2	0	0
12	1	THALES	5	4100	2	0	0
13	1	THALES	5	4700	2	0	0
14	1	THALES	5	4960	2	0	0
15	3	SATCON	5	17	2	1	0
16	3	SATCON	3	6457	2	1	0
17	3	SATCON	4	5142	2	1	0
18	3	SATCON	1	3803	2	1	0
19	4	SATCON	1	11254	2	0	0
20	4	SATCON	1	11755	2	0	0
21	4	SATCON	1	11289	2	0	0
22	4	SATCON	1	11786	2	0	0

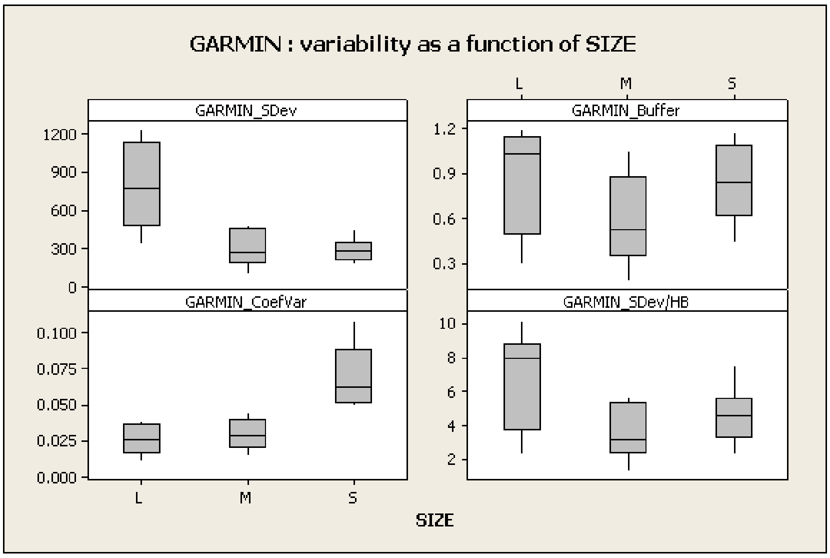
23	4	SATCON	1	12030	2	0	0
24	4	SATCON	1	12048	2	0	0
25	4	THALES	1	10950	1	10	0
26	4	THALES	1	11450	1	10	0
27	4	THALES	1	12030	1	10	0
28	4	THALES	1	11280	1	10	0
29	4	THALES	1	11090	1	10	0
30	4	THALES	1	11330	1	10	0
31	5	GARMIN	4	12530	2	0	0
32	5	GARMIN	4	12340	2	0	0
33	5	GARMIN	4	12830	2	0	0
34	5	GARMIN	4	12210	2	0	0
35	5	GARMIN	4	10970	2	0	0
36	5	GARMIN	4	16640	2	0	0
37	5	GARMIN	2	10290	2	0	0
38	5	GARMIN	2	12640	2	0	0
39	5	GARMIN	2	12830	2	0	0
40	5	GARMIN	2	12740	2	0	0
41	5	GARMIN	2	12530	2	0	0
42	5	GARMIN	2	14780	2	0	0
43	5	THALES	2	10260	2	0	0
44	5	THALES	2	12330	2	0	0
45	5	THALES	2	12220	2	0	0
46	5	THALES	2	11760	2	0	0
47	5	THALES	2	12370	2	0	0
48	5	THALES	2	12590	2	0	0
49	7	SATCON	4	24590	2	1	0
50	7	SATCON	3	27809	2	0	0
51	7	SATCON	3	29393	2	0	0
52	7	SATCON	3	29505	2	0	0
53	7	SATCON	3	30085	2	0	0
54	7	SATCON	3	30030	2	0	0
55	7	SATCON	3	29908	2	0	0
56	11	SATCON	6	4150	2	0	0
57	11	SATCON	6	3670	2	0	0
58	11	SATCON	6	3610	2	0	0
59	11	SATCON	6	4120	2	0	0
60	11	SATCON	6	4230	2	0	0
61	11	SATCON	6	4110	2	0	0
62	12	SATCON	6	3590	1	1	0
63	13	THALES	5	6300	2	0	1
64	13	THALES	5	5300	2	0	1

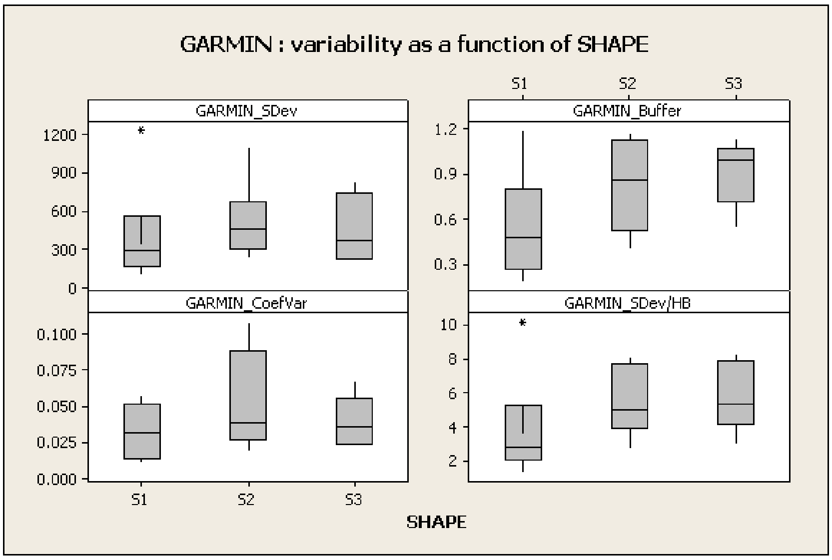
65	13	THALES	6	6860	2	0	0
66	13	THALES	6	6760	2	0	0
67	13	THALES	6	7080	2	0	0
68	13	THALES	6	6990	2	0	0
69	13	THALES	6	5800	2	0	0
70	13	THALES	6	7140	2	0	0
71	13	THALES	3	6920	2	0	0
72	13	THALES	3	6470	2	0	0
73	13	THALES	3	7130	2	0	0
74	13	THALES	3	6870	2	0	0
75	13	THALES	3	6850	2	0	0
76	13	THALES	3	7080	2	0	0
77	14	GARMIN	1	7291	0	0	10
78	14	GARMIN	1	7572	0	0	10
79	14	GARMIN	1	7143	0	0	10
80	14	GARMIN	1	7534	0	0	10
81	14	GARMIN	1	8228	0	0	10
82	14	GARMIN	1	7483	0	0	10
83	14	GARMIN	3	7554	0	0	10
84	14	GARMIN	3	7731	0	0	10
85	14	GARMIN	3	7502	0	0	10
86	14	GARMIN	3	7945	0	0	10
87	14	GARMIN	3	7522	0	0	10
88	14	GARMIN	3	7781	0	0	10
89	16	SATCON	5	128230	2	1	0
90	16	SATCON	2	34000	1	0	10
91	16	SATCON	2	33750	1	0	10
92	16	SATCON	2	33540	1	0	10
93	16	SATCON	2	34000	1	0	10
94	16	SATCON	2	33120	1	0	10
95	16	SATCON	2	34200	1	0	10
96	16	SATCON	6	33940	1	0	10
97	16	SATCON	6	33080	1	0	10
98	16	SATCON	6	33440	1	0	10
99	16	SATCON	6	33650	1	0	10
100	16	SATCON	6	33590	1	0	10
101	16	SATCON	6	33890	1	0	10
102	16	THALES	1	33350	2	0	0
103	16	THALES	1	32050	2	0	0
104	16	THALES	1	30620	2	0	0
105	16	THALES	1	33930	2	0	0
106	16	THALES	1	33420	2	0	0

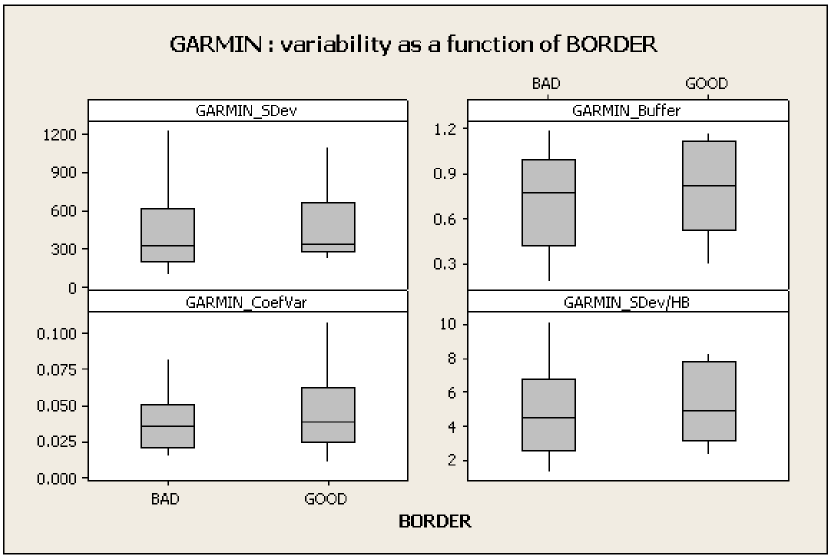
107	16	THALES	1	33570	2	0	0
108	17	SATCON	6	22311	2	1	0
109	17	SATCON	3	26660	2	1	0
110	6	GARMIN	2	10696	2	0	0
111	6	GARMIN	2	10137	2	0	0
112	6	GARMIN	2	9724	2	0	0
113	6	GARMIN	2	9427	2	0	0
114	6	GARMIN	2	9742	2	0	0
115	6	GARMIN	2	9725	2	0	0
116	6	THALES	5	9450	2	0	0
117	6	THALES	5	9850	2	0	0
118	6	THALES	5	9490	2	0	0
119	6	THALES	5	9930	2	0	0
120	6	THALES	5	9360	2	0	0
121	6	THALES	5	9430	2	0	0

12.1.2.2 Boxplots of four transformations of the reproducibility as a function of size, shape and border for GARMIN, SATCON, THALES

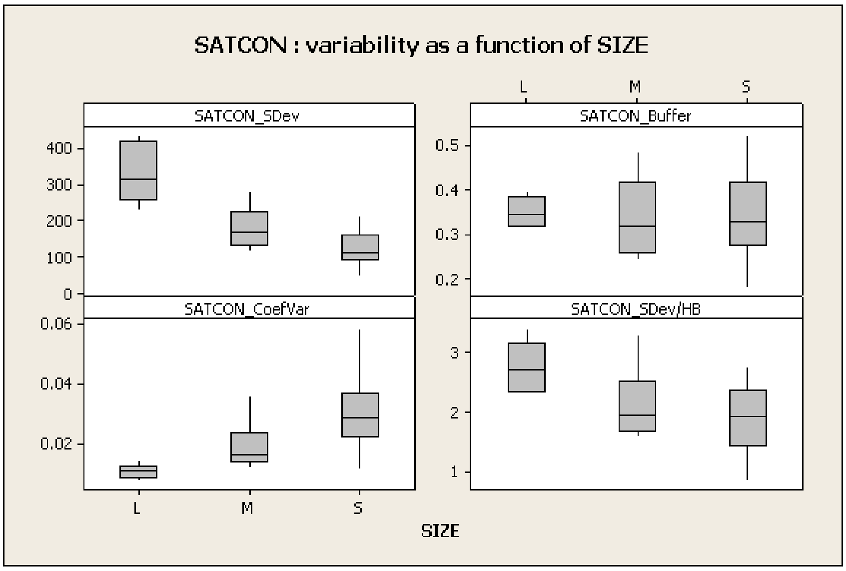
12.1.2.2.1 GARMIN

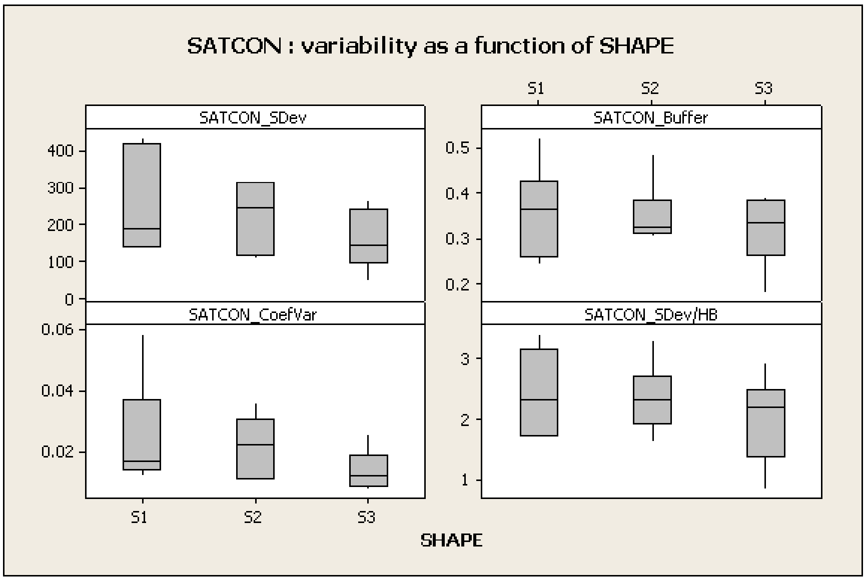


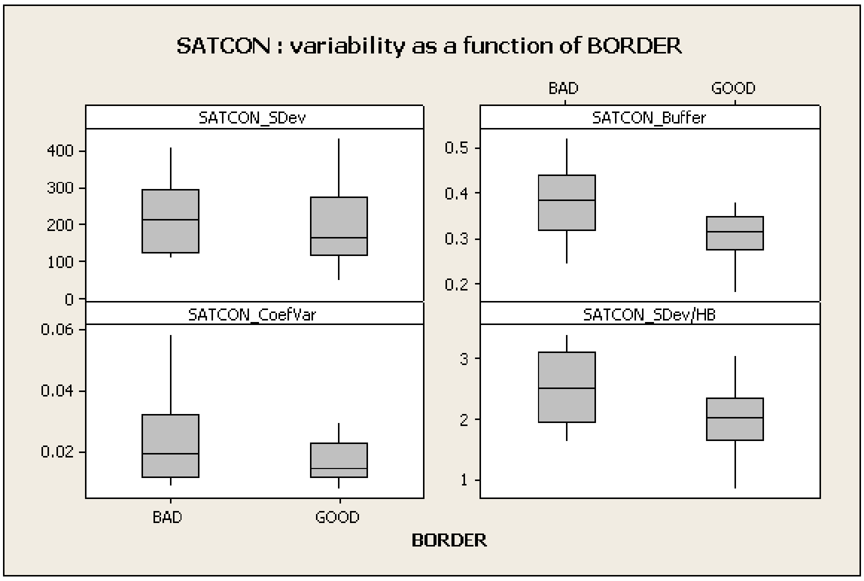

GARMIN : variability as a function of SHAPE
GARMIN_SDev
GARMIN_Buffer
GARMIN_CoefVar
GARMIN_SDev/HB
S1
S2
S3
SHAPE


GARMIN : variability as a function of BORDER
GARMIN_SDev
GARMIN_Buffer
GARMIN_CoefVar
GARMIN_SDev/HB
BAD
GOOD
BORDER

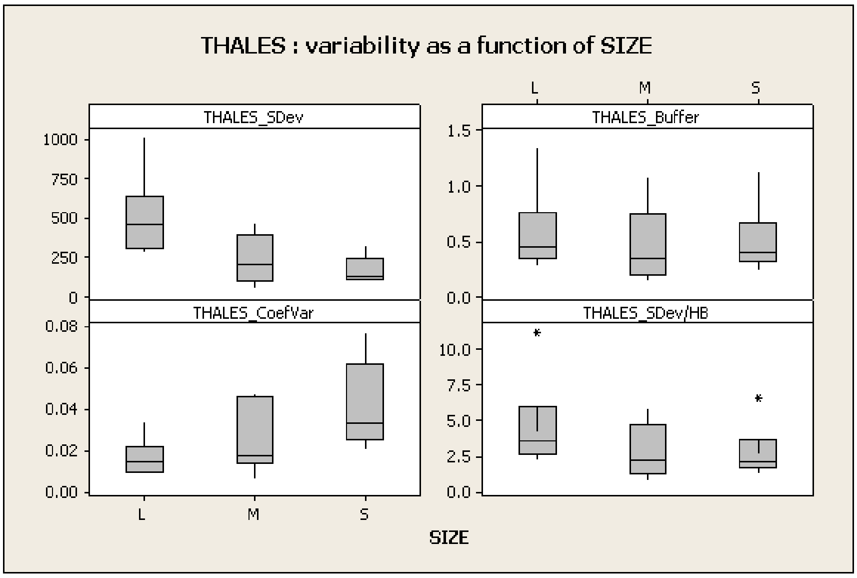
12.1.2.2.2 SATCON

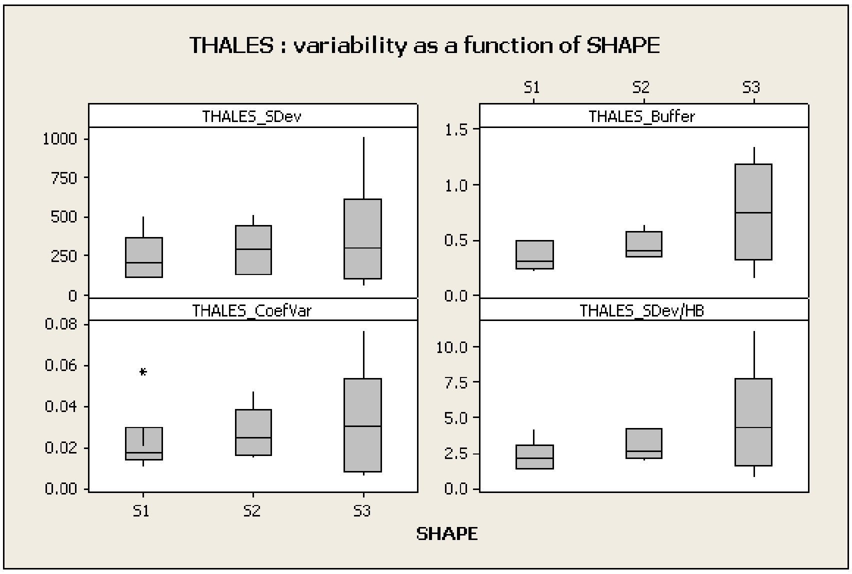


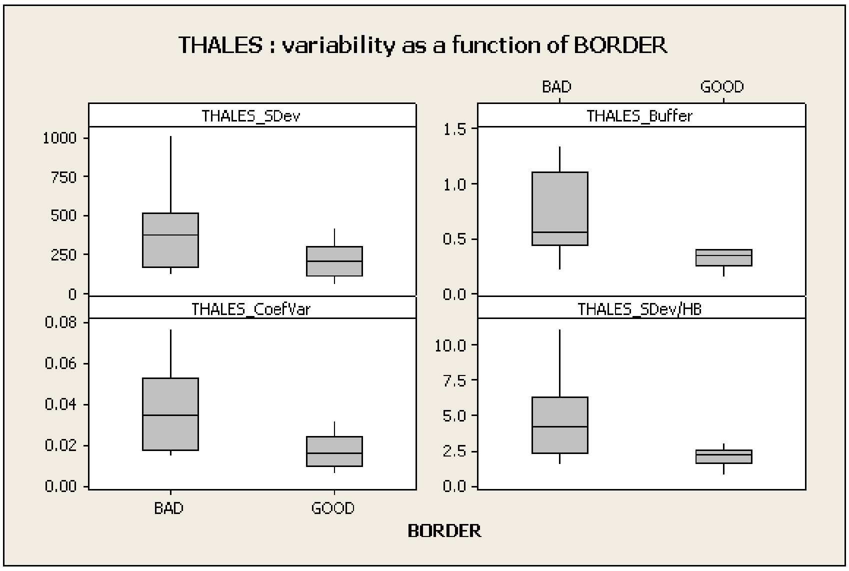




12.1.2.2.3 THALES







12.1.3 GPS measurement - experiment B

12.1.3.1 List of discarded observations. Explanation of the codes used in column COCHRAN, GRUBBS/1 and GRUBBS/2 is given in part 3.4.3

Row	Parcel	GPS	Day	Data	COCHRAN	GRUBBS/1	GRUBBS/2
1	19	SATCON_3	2	4992	0	0	10
2	19	SATCON_3	2	5029	0	0	10
3	19	SATCON_3	2	4959	0	0	10
4	19	SATCON_3	2	4746	0	0	10
5	19	SATCON_3	5	5043	0	0	10
6	19	SATCON_3	5	5051	0	0	10
7	19	SATCON_3	5	4841	0	0	10

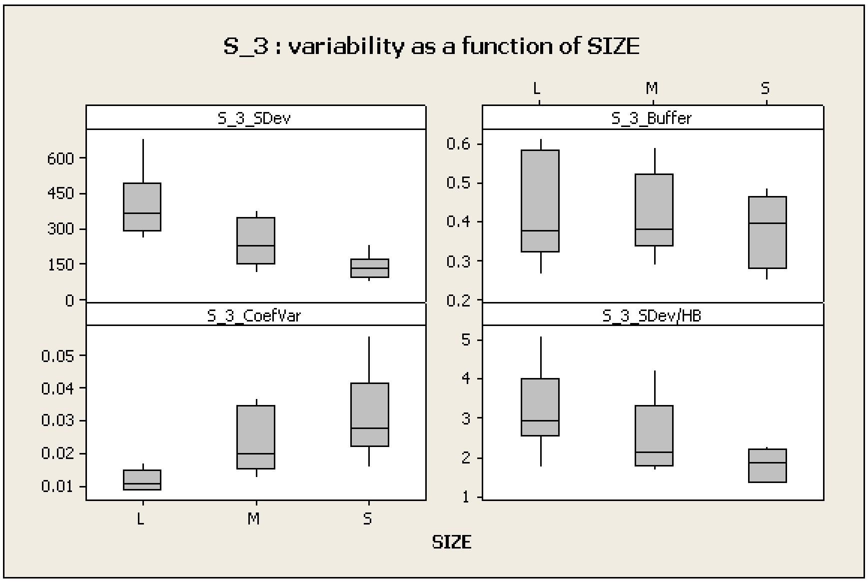
8	19	SATCON_3	5	5275	0	0	10
9	19	THALES_3	6	5230	2	0	0
10	19	THALES_3	6	4440	2	0	0
11	19	THALES_3	6	4500	2	0	0
12	19	THALES_3	6	4680	2	0	0
13	21	THALES_3	2	4020	2	0	0
14	21	THALES_3	2	4110	2	0	0
15	21	THALES_3	2	3830	2	0	0
16	21	THALES_3	2	4180	2	0	0
17	23	SATCON_3	6	9848	2	0	0
18	23	SATCON_3	6	9964	2	0	0
19	23	SATCON_3	6	11890	2	0	0
20	23	SATCON_3	6	11561	2	0	0
21	23	SATCON_4	6	13874	2	0	0
22	23	SATCON_4	6	13949	2	0	0
23	23	SATCON_4	6	11545	2	0	0
24	23	SATCON_4	6	10997	2	0	0
25	25	SATCON_4	4	14733	2	1	0
26	25	THALES_3	4	30340	0	10	0
27	25	THALES_3	4	30270	0	10	0
28	25	THALES_3	4	29990	0	10	0
29	25	THALES_3	4	30630	0	10	0
30	26	SATCON_3	6	32908	2	0	0
31	26	SATCON_3	6	32727	2	0	0
32	26	SATCON_3	6	27745	2	0	0
33	26	SATCON_3	6	28968	2	0	0
34	26	SATCON_4	6	23569	2	0	0
35	26	SATCON_4	6	24706	2	0	0
36	26	SATCON_4	6	40164	2	0	0
37	26	SATCON_4	6	41167	2	0	0
38	26	THALES_4	2	30090	2	0	0
39	26	THALES_4	2	30660	2	0	0
40	26	THALES_4	2	29330	2	0	0
41	26	THALES_4	2	30030	2	0	0
42	27	SATCON_3	3	183372	2	1	0
43	28	SATCON_3	5	34824	2	1	0
44	28	SATCON_3	2	8449	1	1	0
45	28	SATCON_3	4	7541	2	1	0
46	28	SATCON_3	3	6686	2	0	0
47	28	SATCON_3	3	4262	2	0	0
48	28	SATCON_3	3	4358	2	0	0
49	28	SATCON_3	3	4085	2	0	0

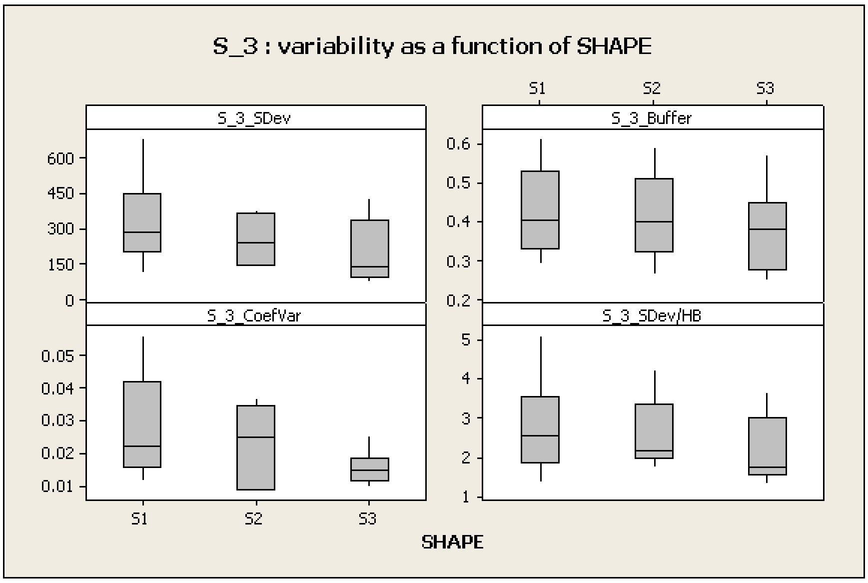
50	28	SATCON_4	5	9287	2	1	0
51	28	SATCON_4	3	5757	2	0	0
52	28	SATCON_4	3	4029	2	0	0
53	28	SATCON_4	3	4118	2	0	0
54	28	SATCON_4	3	3959	2	0	0
55	28	THALES_4	5	4020	2	0	0
56	28	THALES_4	5	4860	2	0	0
57	28	THALES_4	5	5290	2	0	0
58	28	THALES_4	5	4230	2	0	0
59	29	SATCON_4	6	4701	2	0	0
60	29	SATCON_4	6	4434	2	0	0
61	29	SATCON_4	6	4321	2	0	0
62	29	SATCON_4	6	4033	2	0	0
63	31	SATCON_4	6	9222	2	0	0
64	31	SATCON_4	6	8709	2	0	0
65	31	SATCON_4	6	6056	2	0	0
66	31	SATCON_4	6	9390	2	0	0
67	31	SATCON_4	3	8465	0	10	0
68	31	SATCON_4	3	8545	0	10	0
69	31	SATCON_4	3	9241	0	10	0
70	31	SATCON_4	3	9197	0	10	0
71	32	SATCON_3	4	11608	2	0	0
72	32	SATCON_3	4	11473	2	0	0
73	32	SATCON_3	4	14100	2	0	0
74	32	SATCON_3	4	11284	2	0	0
75	32	SATCON_4	6	12300	2	0	0
76	32	SATCON_4	6	12192	2	0	0
77	32	SATCON_4	6	11306	2	0	0
78	32	SATCON_4	6	11402	2	0	0
80	33	SATCON_3	2	9290	0	10	0
81	33	SATCON_3	2	9475	0	10	0
82	33	SATCON_3	2	9284	0	10	0
83	33	SATCON_4	3	47443	2	1	0
84	33	SATCON_4	1	8005	2	0	0
85	33	SATCON_4	1	9170	2	0	0
86	33	SATCON_4	1	9096	2	0	0
87	33	SATCON_4	1	8923	2	0	0
88	33	THALES_4	6	8250	2	0	0
89	33	THALES_4	6	8700	2	0	0
90	33	THALES_4	6	8790	2	0	0
91	33	THALES_4	6	8400	2	0	0
92	36	SATCON_3	2	31137	2	0	0

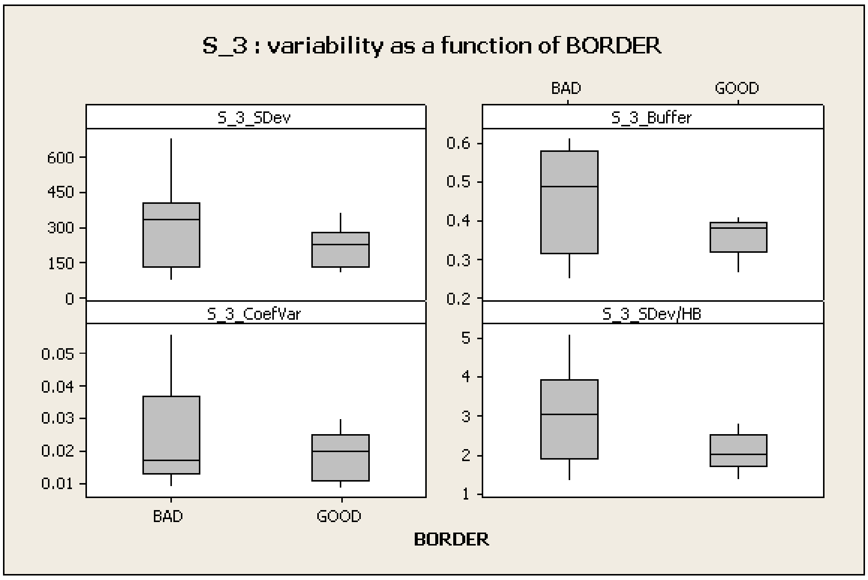
93	36	SATCON_3	2	30850	2	0	0
94	36	SATCON_3	2	30566	2	0	0
95	36	SATCON_3	2	31939	2	0	0
96	36	THALES_4	5	30730	2	0	0
97	36	THALES_4	5	31260	2	0	0
98	36	THALES_4	5	30100	2	0	0
99	36	THALES_4	5	30260	2	0	0

12.1.3.2 Boxplots of four transformations of the reproducibility as a function of size, shape and border for SATCON S3, SATCON S4, for THALES T3 and for THALES T4

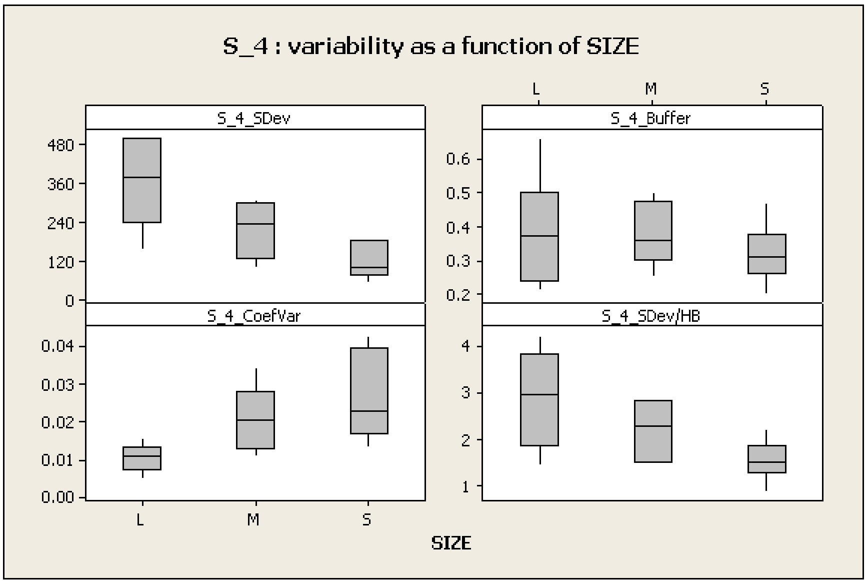
12.1.3.2.1 SATCON S3

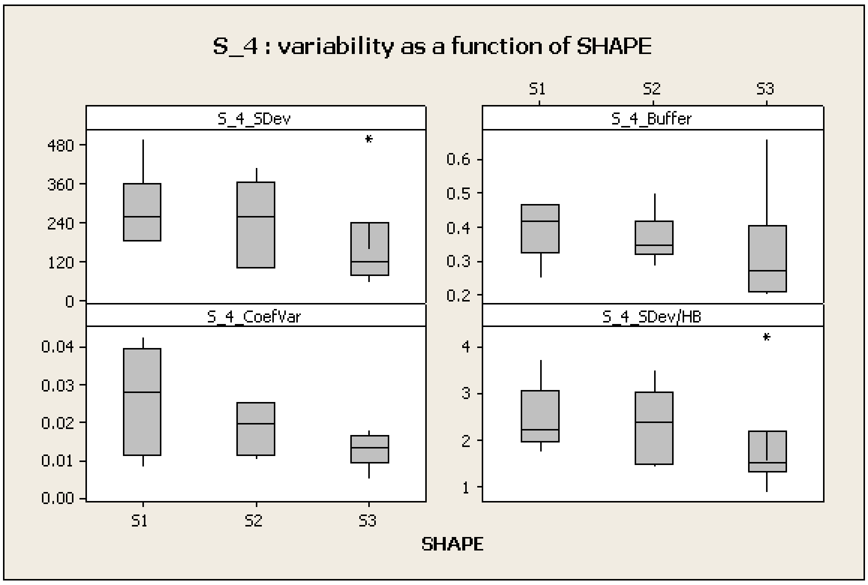


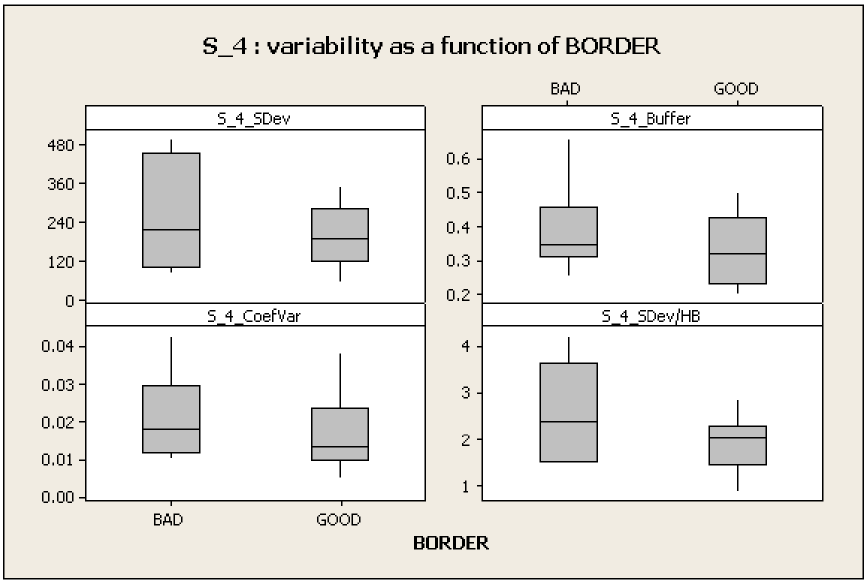

S_3 : variability as a function of SHAPE
S1
S2
S3
S_3_SDev
S_3_Buffer
S_3_CoefVar
S_3_SDev/HB
600
450
300
150
0
0.6
0.5
0.4
0.3
0.2
5
4
3
2
1
0.05
0.04
0.03
0.02
0.01
SHAPE



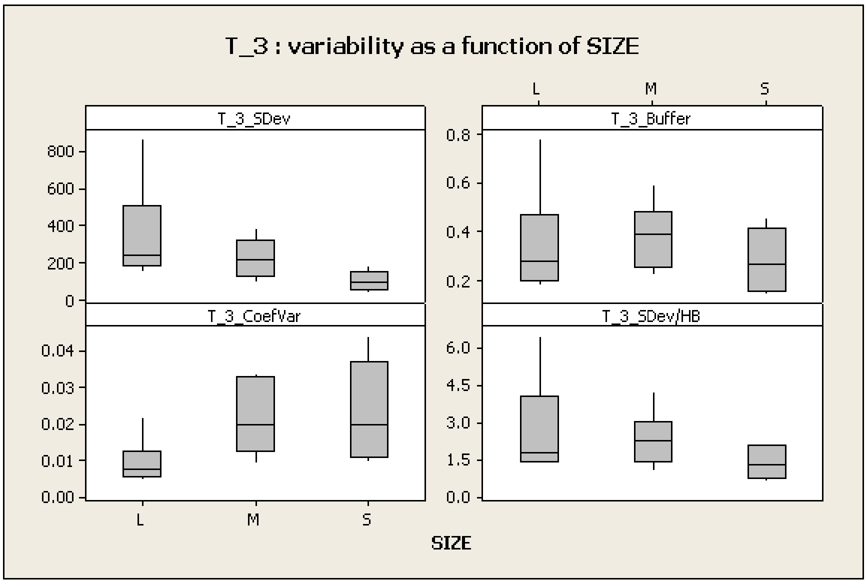
12.1.3.2.2 SATCON S4

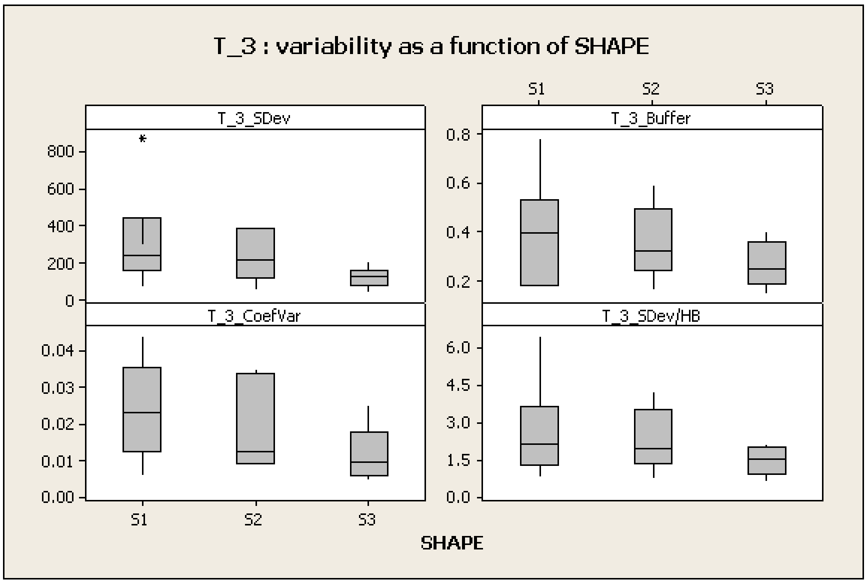


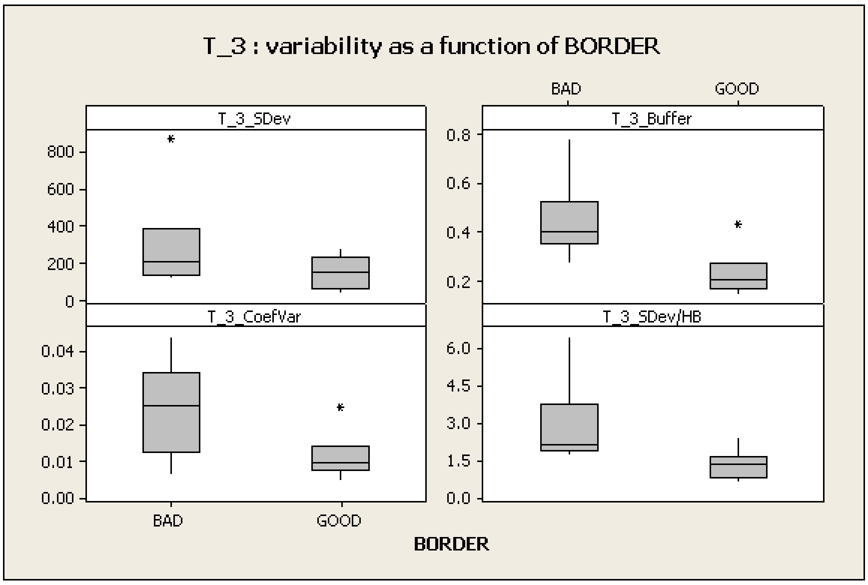




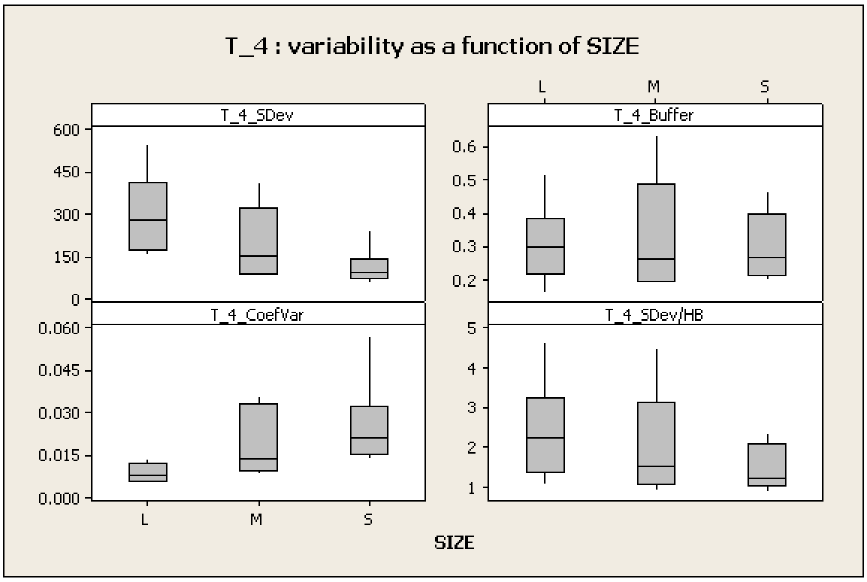
12.1.3.2.3 Thales 3

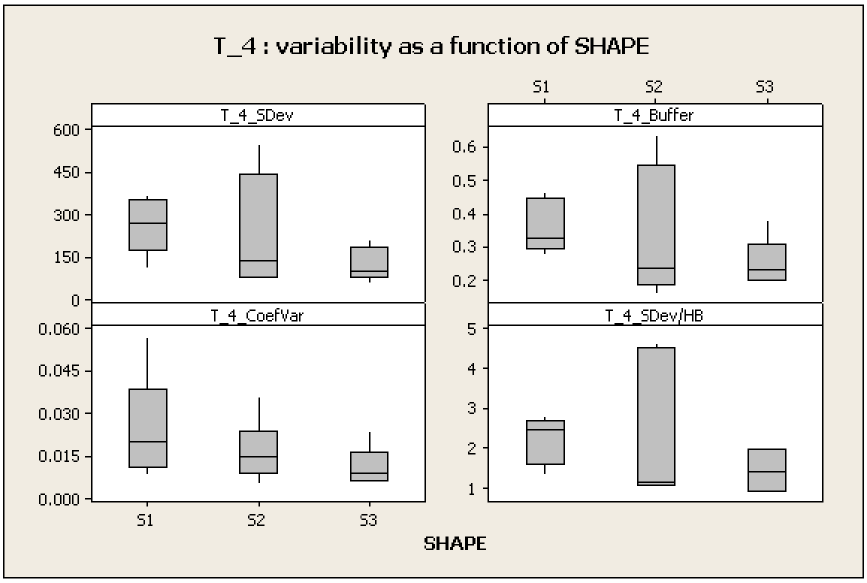

T_3 : variability as a function of SIZE
T_3_SDev
T_3_Buffer
T_3_CoefVar
T_3_SDev/HB
L
M
S
SIZE
0
200
400
600
800
0.2
0.4
0.6
0.8
0.00
0.01
0.02
0.03
0.04
0.0
1.5
3.0
4.5
6.0

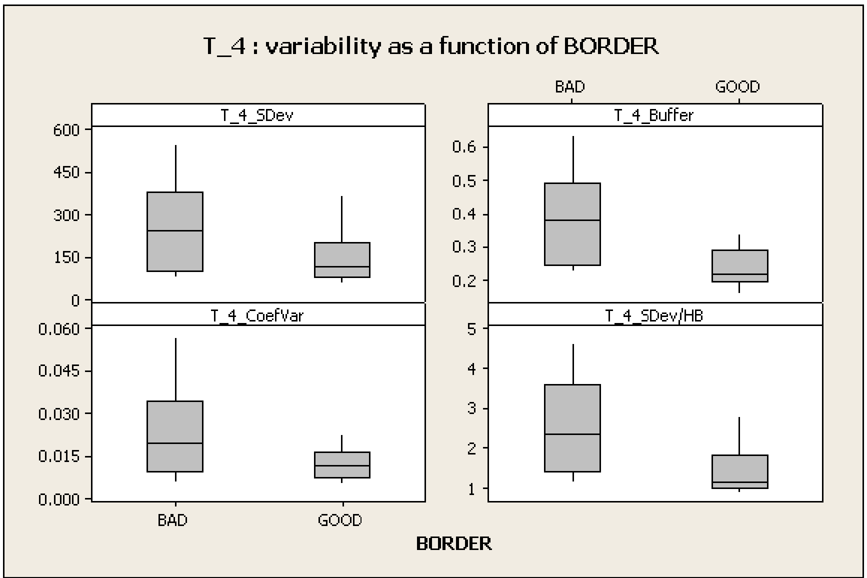

T_3 : variability as a function of SHAPE
T_3_SDev
T_3_Buffer
T_3_CoefVar
T_3_SDev/HB
S1
S2
S3
SHAPE
0
200
400
600
800
0.2
0.4
0.6
0.8
0.00
0.01
0.02
0.03
0.04
0.0
1.5
3.0
4.5
6.0

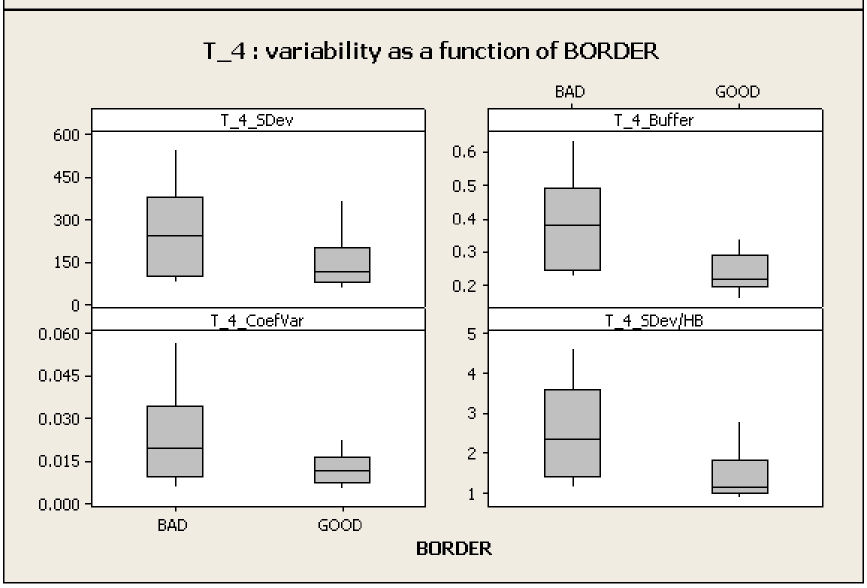


12.1.3.2.4 THALES T4




T_4 : variability as a function of SHAPE
T_4_SDev
T_4_Buffer
T_4_CoefVar
T_4_SDev/HB
S1
S2
S3
SHAPE


T_4 : variability as a function of BORDER
T_4_SDev
T_4_Buffer
T_4_CoefVar
T_4_SDev/HB
BAD
GOOD
BORDER


T_4 : variability as a function of BORDER
T_4_SDev
T_4_Buffer
T_4_CoefVar
T_4_SDev/HB
BAD
GOOD
BORDER