USE OF GPS WITHOUT DIFFERENTIAL CORRECTION ON YIELD MAPPING

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ABSTRACT

The use of differential correction for improving the quality of GPS signal in precision agriculture has been a necessity because of the magnitude of positioning errors. Recently GPS suffered a significant improvement after selective availability was turned off. It has been observed that ordinary receivers are offering good positioning signal without correction. In North America and in Europe, public differential correction is being offered for free and in other parts of the World farmers still have to deal with privat services for differential signal. This work deals with the quality comparison of yield maps from GPS versus DGPS receivers. Field tests were conducted collecting data with a yield monitor with DGPS and an extra set of data of position collected with GPS. Maps were created and correlated, resulting in up to 78% correlation coefficient. As cost on precision agriculture is a big issue on adoption trend, it may be an option for farmers to cut costs.

Keywords: yield map, differential correction, yield monitor

INTRODUCTION

Recent uses of Global Navigation Satellite Systems (GNSS) in agriculture has created a new reality in the field. Farmers are gradually being involved and increasing their dependence on GNSS that have been available for more than ten years. The most important and used is the GPS also known as NAVSTAR (Navigation Satellite Time And Ranging). It is operated by the Department of Defense of the United States of America. The former Soviet Union also produced an equivalent system, called GLONASS, today administered by Russia. Both use a constellation of satellites with similar operation. Local triangulation positioning systems have been also used and are composed by radio towers and a rover receiver (Molin, 1998).
For applications in precision agriculture, Stafford (1996) suggests that the accuracy of positioning should be at least 30 m for variable application of fertilizers and of 10 m for yield mapping, due to the resolution of the equipment involved.

The positioning obtained with a GPS receiver integrates several sources of errors and the most usual way to reduce those errors is by using the technique of DGPS or GPS with differential correction (Goering and Han, 1993). Different correction methods available are presented by Molin (1998). In countries like Brazil, presently the only systems available are local towers for post processing or on real time by radio or by continental networks with signal transmitted through communication satellites.

Other sources of correction signals have appeared recently. The United States of America and the European Community are developing their differential correction, both using a system similar to the privet nets of continental differential correction by satellite. WAAS or "Wide Area Augmentation System" of The United States of America and EGNOS or "European Geostationary Navigation Overlay Service" already broadcast experimental public signal. WAAS is composed of 25 terrestrial stations and its priority is the civil aviation. EGNOS, initiated in 1998, is broadcasting experimentally and should be fully effective in 2003. Besides contemplating GPS users, it also works with GLONASS signal. Receivers of low cost, compatible with those systems, are available in the market and will allow a quick popularization of some agricultural activities because of the drastic reduction of cost on investment and operation. For users in South America, however, that signal will have limited use, at least for some years. Even if it is possible to tune in the signal of the communication satellite, the differential correction will have been generated at very large distances, with terrestrial stations in other continents.

In the beginning of May of 2000, the American government turned off the selective availability, a degradation of GPS signal quality. Until then, according to Divis (1996), a receiver of civil use, receiving frequency L1 (1575.42 MHz), offered theoretical accuracy of 100 m horizontal and 156 m vertical. In consequence, more recently new and revolutionary autonomous correction systems were announced. They are internal algorithms that use the position of GPS constellation satellites to produce their own correction.

The end of selective availability resulted in significant accuracy improvement on low cost receivers that are promising more selective applications. This work was developed with the purpose of comparing receivers with and without differential correction for yield mapping of cereals.

**MATERIAL AND METHODS**

One field of approximately 28.7 ha (field 1) was selected for data collection in 2001 and another field of 17.2 ha (field 2) in 2002, both in Paraná State, Southern Brazil at coordinates of approximately 24.6637 south and 49.8678 west. Those fields are part of a precision agriculture research project and have been monitored intensively by ABC Foundation, a cooperative research organization.

Corn on field 1 was harvested in April, 2001 and soybean was harvested in April 2002, both with an AGCO MF 34 combine equipped with FieldStar® yield monitoring system and a Racal GPS receiver model Land
Star MK 4 - G12 L (Racal®), with real time differential correction through satellite, also from Racal. In the same machine a GPS receiver Garmin model GPS III Plus (Garmin®) with external antenna was used in 2001 and a GPS receiver Brunton was used in 2002, both connected to a hand computer HP Jornada 548 (Hewlett Packard®), equipped with the navigation program Farm Site Mate (FarmWorks Software®).

The navigation software was configured to register time, so both files could be aligned by the time column, making yield readings equivalent for the same time at the specific location given by each of the GPS receivers. The original yield data were submitted to a filtering process with criterion that allowed the elimination of points with unlikely values, as well as points with location problems, according to Gimenez and Molin (2000). Each file related to one field generated two yield maps (with and without differential GPS) and were used for a correlation analysis.

The frequency of data collection on the yield monitor was set for collecting one point every two seconds. The same was established for the hand computer on the first year and for every second on the second year. As the time alignment not always coincided, there was a loss of part of the points between the file with coordinates with differential correction and that without differential correction.

As the positioning error can be lessened by the interpolation, maps were generated with cells of 5, 10, 20 and 30 m, always using as interpolator the inverse distance (Moore, 1998). All the pairs of maps were used for analysis of correlation of yield values among the cells of same coordinates to evaluate the degree of likeness among the two treatments (with and without differential correction) using SSTollbox (SST Development Group®).

RESULTS AND DISCUSSION

The representation of the combine paths registered by the yield monitor with GPS equipped with differential correction and by the GPS without correction connected to the hand computer is presented on Figure 1. It is possible to observe the visual difference on alignment between both kinds of GPS signal. Deviations are observed, however there is a regularity of parallelism among combine passes, with certain concentration of lines on the GPS without differential correction map. On the first year (field 1) the combine was equipped with a 4.8 m wide head (6 corn rows) and on the second year (field 2) its grain head was 5.20 m wide.

The correlation values among yields on each cell with and without differential correction, after the interpolation by the inverse distance, is presented on Table 1, as function of the size of the cells. It is observed that there was a good reproduction of the information contained in the conventional yield map (using GPS with differential correction). Loss of information had decreasing tendency (growing correlation coefficient) by increasing the size of the cell from 5 to up to 20 m on field 1 and from 5 to 30 m on field 2, indicating a trend on dispersion caused by the lack of accuracy of GPS without differential correction.

The two maps for each field, with and without differential correction, after interpolation using inverse distance and 10 m cells are presented on Figure 2.
Figure 1. Maps of the combine paths registered by the yield monitor GPS with differential correction - DGPS (left) and by the GPS without differential correction connected to the hand computer – GPS (right), for both, field 1 (above) and field 2 (below).
**Figure 2.** Interpolated maps with 10 m cells with differential correction – DGPS (left) and without differential correction – GPS (right), for both, field 1 (above) and field 2 (below).

The two maps of each field present plenty of visual likeness. There were some positioning errors that caused distortions but under the point of view of definition of management units with low yield variability, it can be
inferred that the areas with highs or lows are basically the same on both maps, with a good visualization of the yield zones.

<table>
<thead>
<tr>
<th>Cells size (m)</th>
<th>Field 1</th>
<th>Field 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>0.73</td>
<td>0.64</td>
</tr>
<tr>
<td>10</td>
<td>0.75</td>
<td>0.64</td>
</tr>
<tr>
<td>20</td>
<td>0.78</td>
<td>0.66</td>
</tr>
<tr>
<td>30</td>
<td>0.74</td>
<td>0.69</td>
</tr>
</tbody>
</table>

Table 1. Correlation coefficients among yield cells with and without GPS differential correction after the interpolation using inverse distance, in function of the size of the cells.

The fields used in this study are relatively small and it is expected that the method here tested of using GPS without differential correction can be applied in larger areas and if the objective is to detect zones with yield similarities, the evidences indicate that there is a great potential for its use. That should represent a significant reduction in the cost, both on investment and on operation, in the mapping generation, especially in countries like Brazil where differential correction and receivers are highly expensive, what represents an important limitation for adoption of precision agriculture practices by farmers. The cost for obtaining a yield map would fall at about 50 to 60%.

CONCLUSION

Based on the data here analyzed it is possible to affirm that yield maps obtained with GPS receivers with satellite differential correction were reproduced with up to 78% of correlation by using a low cost GPS receiver without differential correction. Because of that, the direct cost of obtaining yield maps as information for a better managing strategy can be reduced significantly.

REFERENCES


