Site-Specific Management Guidelines

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Selecting a DGPS for Making Topography Maps

Summary

The CEO of your company decides he wants you to start offering precision farming services. Based on this mandate, you purchase a **code**-phase differentially corrected global positioning system (DGPS), and you use it for grid sampling, applying variable rate fertilizers, and yield monitoring. After a while you notice that your competitor is superimposing soil nutrient, pH, and yield information on topography maps, and is thereby improving his ability to identify management zones (**Figure 1**). Based on the need to stay competitive, you decide to use your code-phase DGPS system, purchased for locating soil sample grid points, to develop topography maps. After spending $5,000 to attend a geographic information systems (GIS) training workshop for a week, you develop your first topography map (**Figure 2**). Why doesn't it look like your competitor's maps? What went wrong?

In order to answer this question, it is important to point out that differential correction does not guarantee absolute accuracy because different receivers and sampling approaches have different accuracies. Typically, a **carrier**-phase DGPS is more accurate and expensive than a **code**-phase DGPS.

DGPS receiver impact on vertical error

To demonstrate the impact of receiver type and sampling approach on vertical error, an experiment was conducted. In this experiment, 200 points were surveyed to determine relative elevation using a laser. Then, elevations at these points were measured using two different sampling approaches, real-time kinematic (RTK), or moving and real-time stop-and-go (RTSG). Using RTK, the elevation measurements were collected as the DGPS system was driven over the field. Using RTSG, the elevational information was collected by stopping at the sampling point, waiting until the elevation was determined, and then driving to the next point. The systems tested were a Leica single frequency **carrier**-phase DGPS (Leica Inc., Norcross, Georgia) DGPS and an Omnistar (Omnistar Inc., Houston, Texas) **code**-phase DGPS. Details about the DGPS receivers are provided in **Table 1**.

Table 1. Sensors and types of DGPS used in the experiment.

DGPS	Phase	Model Number	Approximate cost
Leica	Carrier	Leica SR9400	$25,000+
Omnistar	Code	Omnistar 6300A	$ 4,000

The Leica RTSG and RTK **carrier**-phase DGPS elevational information was highly correlated to the relative field elevations (**Figure 3**) and the errors were less than 1.4 inches. The stop-and-go and kinematic (moving) sampling approach had similar errors. This is significant because the kinematic sampling approach required much less time to sample a field than the stop-and-go approach.

The relative elevations measured using RTK code phase DGPS were also correlated to the relative elevations (**Figure 4**). However, correlation coefficients were much lower than those observed for the **carrier**-phase receiver. When the experiment was repeated, different results were obtained. The regression equations between the measured (y) and surveyed (x) elevations for experiments 1 and 2 were:

$$y = -4.42 + 1.29\,(x) \quad r=0.82^{**}$$
$$y = 5.86 + 0.70\,(x) \quad r=0.78^{**}$$

respectively, where y was elevation value measured by the RTK **code**-phase DGPS and x was the surveyed elevation. The fact that the slopes and y intercepts changed indicated that on date 1 the slopes were steeper and valleys deeper than actually measured, while on date 2 the Omnistar flattened the landscape. The RTK **code**-phase DGPS had a vertical error of 33 inches.

Differences between **carrier** and **code**-phase DGPS are more apparent when topography maps from the two systems are compared (**Figures 1 and 2**). Because **code**-phase DGPS has been mounted on combines, multiple elevational data sets are available for many fields. The question arises, "Can elevational information from these

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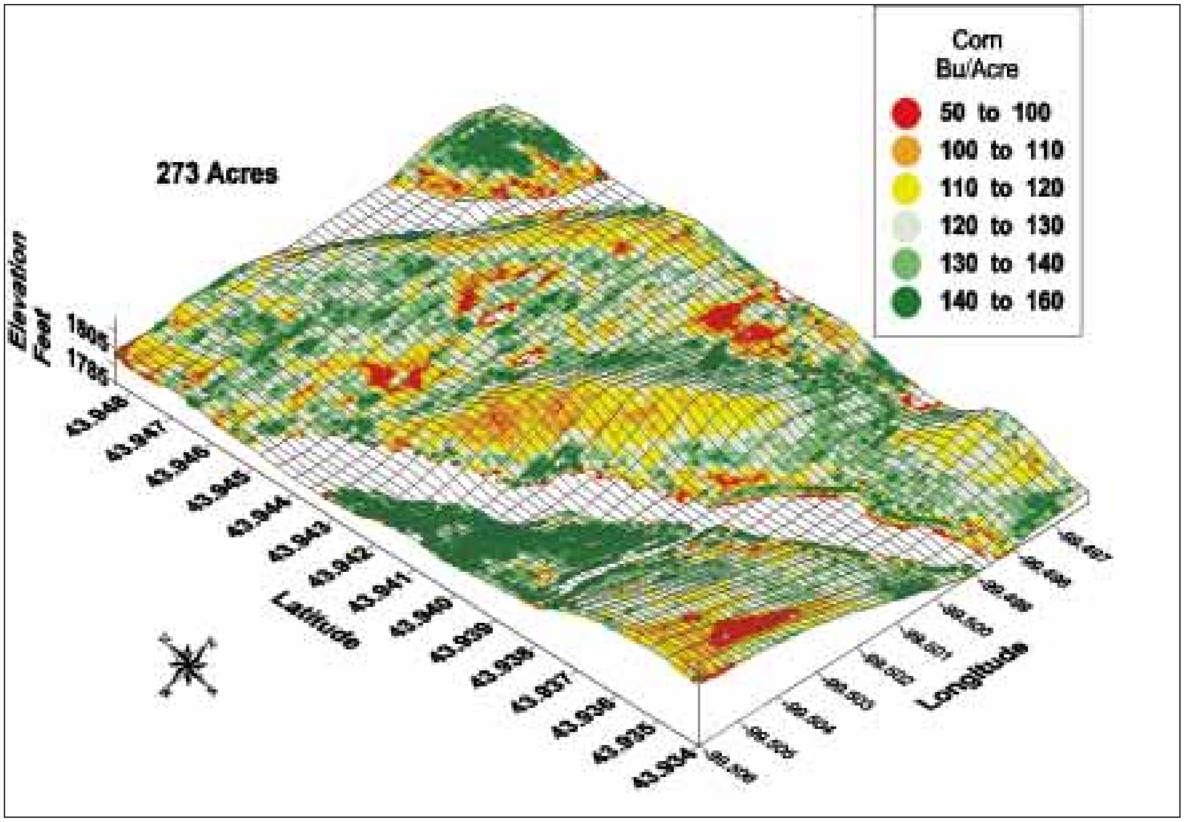

Figure 1. **The competitor's yield map superimposed on topography map generated from a real-time kinematic carrier-phase DGPS.**

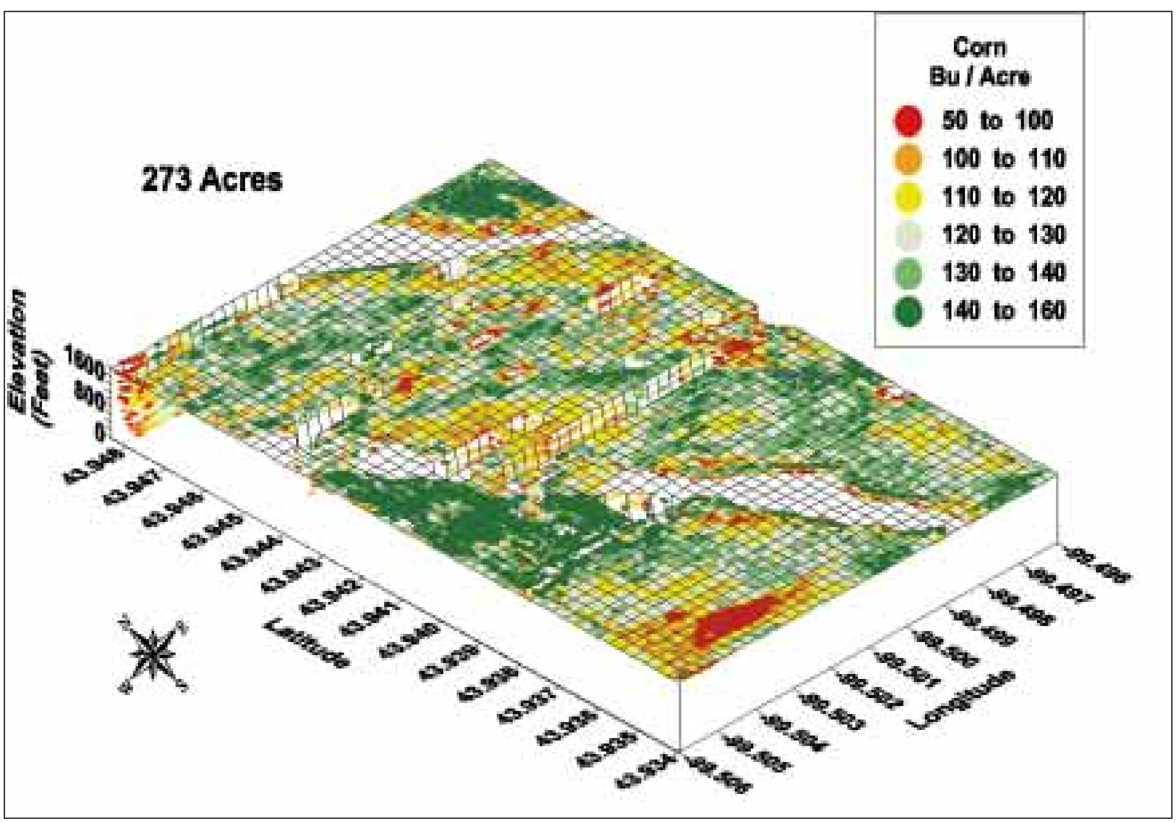

Figure 2. **Your yield map superimposed on a topography map generated from real-time kinematic code-phase DGPS.**

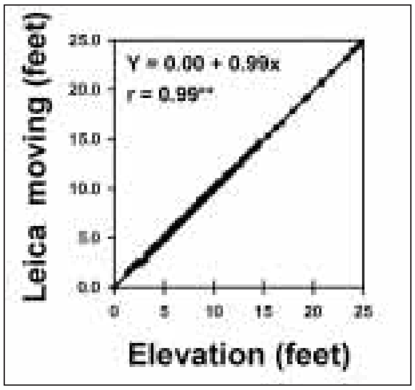

Figure 3. The relationship between elevation measured by laser and elevation measured by a RTK carrier**-phase DGPS.**

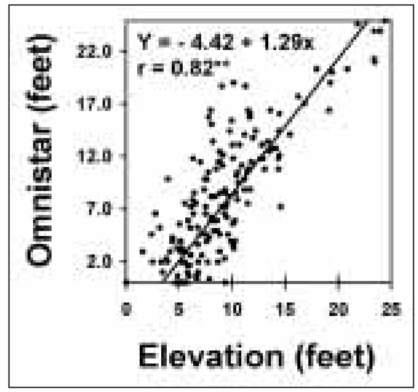

Figure 4. The relationship between elevation measured by laser and elevation measured by a RTK code**-phase DGPS.**

data sets be averaged to produce useful topographic maps?" The magnitude of the Omnistar vertical error was reduced by averaging the relative elevation of a point taken one day with values collected on different days. This approach reduced vertical errors. However, even after six measurements, the errors were still large. In a practical sense, averaging reduces error and will eventually provide useful maps, but it will take time and money to develop the maps. The development of high quality topography maps should be considered as a one time expense. Once developed, the maps can be used for planning field drainage and identification of nutrient management zones.

In comparing the **code** and **carrier**-phase systems, several points became apparent. These include:

1. **Carrier**-phase DGPS (Leica) had much smaller elevational errors than the **code**-phase DGPS;
2. **Code**-phase DGPS (Omnistar) had large errors in the vertical direction even when averaged with other values;
3. The setup time for the **code**-phase (Omnistar) was less than five minutes, while the setup time for the **carrier**-phase (Leica) was between one to two hours;
4. Omnistar required less than an hour of training while the Leica required several days;
5. The Omnistar or other similar equipment using **code**-phase information can be used for located sample points, while highly accurate **carrier**-phase systems should be used for developing topography maps;
6. **Code** and **carrier**-phase systems do not duplicate, but complement, each other;
7. The Leica single frequency carrier-phase RTSG and RTK sampling approaches had similar errors in the vertical direction.
8. **Carrier** and **code**-phase systems are continuously being improved. When purchasing a new system, you should ask the salesman what the vertical accuracy is. ■

The use of trade names is for the convenience of the reader and does not imply endorsement by South Dakota State University.

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