Computers & Geosciences 42 (2012) 28–36

Contents lists available at SciVerse ScienceDirect

Computers & Geosciences

journal homepage: www.elsevier.com/locate/cageo

A simple, interactive GIS tool for transforming assumed total station surveys to real world coordinates – the CHaMP transformation tool

Joseph M. Wheaton [a,*], Chris Garrard [b], Kelly Whitehead [c], Carol J. Volk [c]

[a] Department of Watershed Sciences, Utah State University, 5210 Old Main Hill, Logan, UT 84332-5210, USA
[b] Remote Sensing GIS Lab, Utah State University, 5210 Old Main Hill, Logan, UT 84332-5210, USA
[c] South Fork Research, Inc. 44842 SE 145th St, North Bend, WA 98045, USA

ARTICLE INFO

Article history:
Received 8 December 2011
Received in revised form
1 February 2012
Accepted 3 February 2012
Available online 17 February 2012

Keywords:
Control network
Topographic surveying
Coordinate transformation
Geophysical monitoring
Affine transformation
Columbia habitat monitoring program

ABSTRACT

Increasingly, geoscientists and biologists are monitoring the natural environment with total station and terrestrial laser scanning surveys. Due to the remote nature of many of the sites monitored (e.g., streams, rivers, glaciers, etc.) the surveys are often done in unprojected, Cartesian, local, assumed coordinate systems. However, without the survey data projected in real world coordinates the range of possible analyses is limited and the contextual power of existing imagery, elevation models, and hydrologic layers can not be exploited. This requires a transformation from the local assumed to the real world coordinate systems. We present a simple interactive interface, as an ArcGIS Add-In, that allows a user to transform unprojected total station data into real-world coordinates using three benchmark coordinates, which can be collected from a hand-held GPS (available at http://ctt.joewheaton.org/). Unlike most transformations built into GIS programs, our tool uses an affine transformation (simple shift and rotate) to preserve the precision and relative accuracy of the total station survey, while leveraging the absolute positional accuracy of the hand-held GPS to place one's data approximately in real world coordinates for GIS overlay purposes. The user can quickly visually inspect between six and twelve transformation options, while comparing the residual error estimates to interactively choose the most reasonable transformation. The tool provides an easy-to-use, cost-effective workflow, which facilitates the sharing and visualization of precise total station survey data in real world coordinates through a webGIS or virtual globes (e.g., Google Earth, NASA Whirlwind). The tool has been tested and was used by 12 crews to transform topographic total station surveys of 364 sites into real world coordinates as part of the Columbian Habitat Monitoring Program (CHaMP).

1. Introduction

Total station surveys are a widely used method to survey topography (USACE, 2007), with applications ranging from traditional land surveying (Kizil and Tisor, 2011) to landform evolution monitoring (Lane and Chandler, 2003). In the geosciences, repeat total station surveys have proved useful in monitoring morphodynamic evolution (i.e., geomorphic change detection) of rivers (Lane et al., 1994; Fuller et al., 2003; Merz et al., 2006), glaciers (Nainwal et al., 2008), beaches (Delgado and Lloyd, 2004; Baptista et al., 2011) and mass wasting of hillslopes (de Sanjose-Blasco et al., 2007; Mackey et al., 2009). Similarly, in the biological sciences total stations are now becoming standard tools in monitoring streams and rivers by fisheries biologists (Bouwes et al., 2011), riparian ecologists (Marquardt et al., 2010) and stream ecologists (e.g., Walters et al., 2003). Both in the geosciences (Tooth, 2006; Chien and Keat Tan, 2011) and biological sciences (Butler, 2006), there is increasing demand to collect spatially explicit data that can be visualized in GIS and shared in any of a number of common webGIS platforms (e.g., Google Earth, Google Maps, Bing Maps, Mapquest, etc.). Even though the vast majority of these new geoscience and biology practitioners lack formal training in surveying and may only have basic training in GIS, their appreciation for and need to make their own data spatially explicit is increasing (Brown, 2006; Udell, 2008).

Unfortunately, most such practitioners lack the abilities and/or tools to transform their precise total station data (and terrestrial laser scanning data) to an accurate real world location, without degrading the high relative accuracy and precision of the survey data (Sheppard and Cizek, 2009). Since many total station surveys are now undertaken in remote and/or undeveloped localities (e.g., deep canyon gorges, alpine glacial valleys), there is often not an established local control network tied to a projected real world coordinate system (PRWCS). Thus, many of these surveys

* Corresponding author. Tel.: +1 435 797 2465; fax: +1 435 797 1871.
E-mail address: Joe.Wheaton@usu.edu (J.M. Wheaton).

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doi:10.1016/j.cageo.2012.02.003

are done from an unprojected Cartesian local assumed coordinate system (UCLACS). For the generally short (i.e., <1–2 km) spatial extents of total station surveys, using a UCLACS will often suffice for applications like change detection monitoring where the most important things are that the control network and same coordinate system (UCLACS or PRWCS) are used consistently. However, as GIS has become more of an everyday tool in the geosciences for visualization, contextualization, modeling and analysis of topographic data (Lane and Chandler, 2003), there is an increasing demand for such surveys to be in PRWCS (e.g., biodiversity

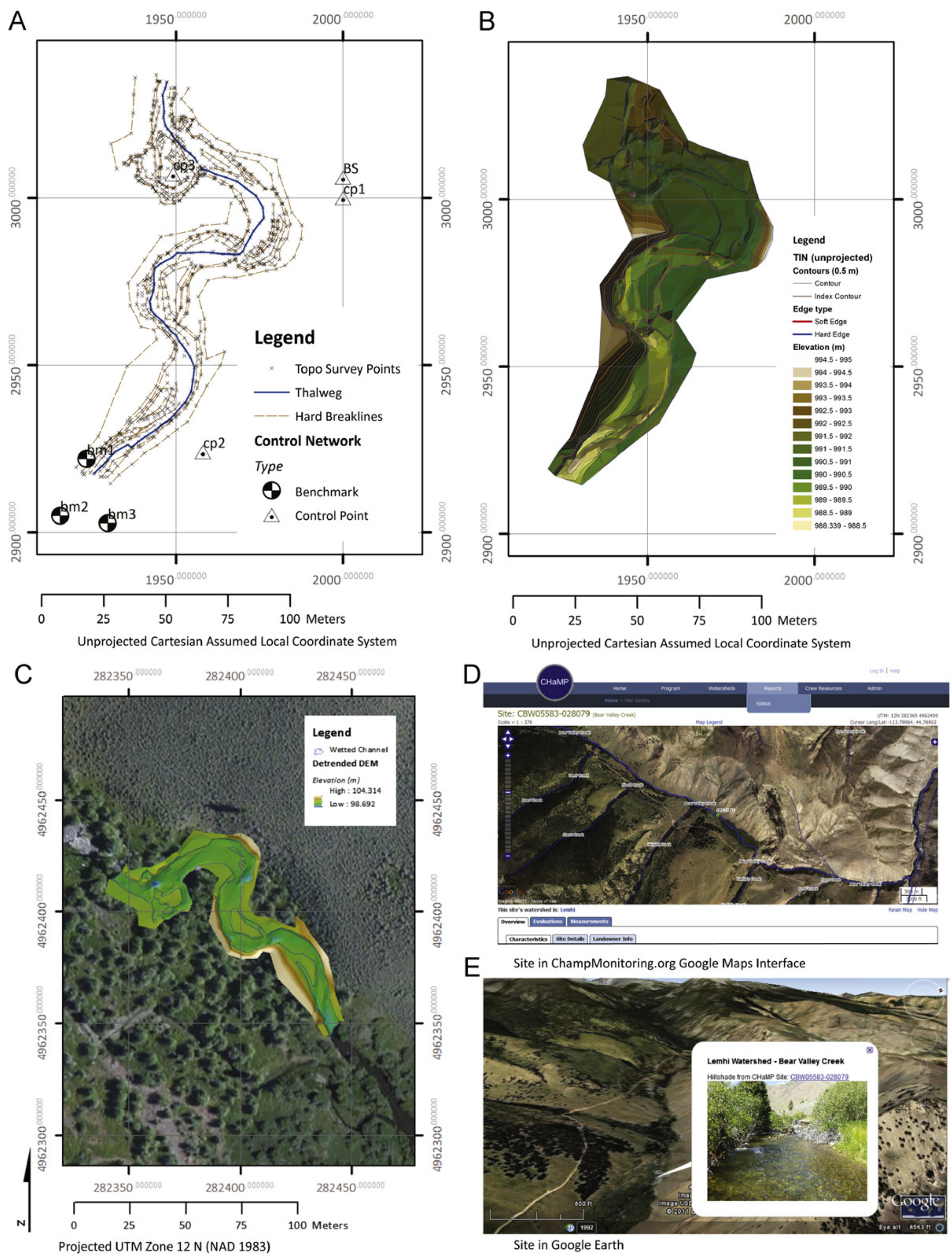

Fig. 1. The value of total station data being projected in real world coordinates. (A) Raw total station data in an assumed coordinate system is not that informative as there is little context to accompany it. (B) A derived product, like this TIN, may be recognizable and useful, but still lacks basic context. (C) When the data is transformed into real world coordinates, we can overlay it with other layers in a GIS enabling spatial associations to be made by visual inspection as well as facilitating a broader range of spatial analyses. (D) and (E) finally, projected data can be easily shared as KML for visibility in webGIS applications (D) or Google Earth (E). Data from CHaMP site CBW05583-028079 on Bear Valley Creek in the Lemhi Watershed (available at: http://www.champmonitoring.org/Site/Details/3592).