Crowdsourced Contributions to the Nation's Geodetic Elevation Infrastructure

volunteer GPS observers enhance United States' nationwide positioning framework

William Stone, National Oceanic & Atmospheric Administration (NOAA) – National Geodetic Survey (NGS)

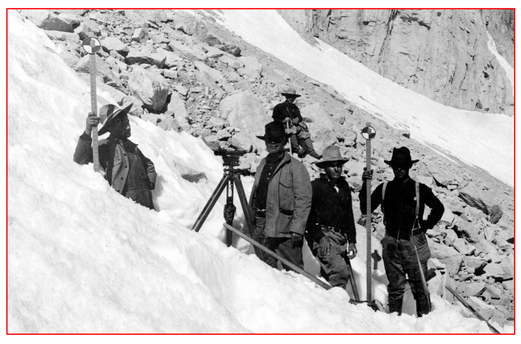

Figure 1. 1905 U.S. Geological Survey leveling party surveying in arduous, high-elevation conditions on Mt. Whitney, Sierra Nevada, CA.

NOAA's National Geodetic Survey provides the official United States spatial positioning infrastructure – the National Spatial Reference System (NSRS). The elevation (orthometric height) component of NSRS has historically been developed from precise – but labor intensive and costly – differential leveling surveys (Fig. 1). Recently, properly executed Global Navigation Satellite System (GNSS) (including GPS) surveys have been able to meet elevation requirements for many applications, particularly when performed in accordance with NGS Height Modernization guidelines. GNSS surveys inherently utilize ellipsoid heights, which can be combined with a geoid model to produce elevations (orthometric heights) (Fig. 2). NGS is collaborating nationwide with geospatial professionals who collect and share their GPS field observations at NGS-published vertical control stations (bench marks (BM)) to bolster future NGS geoid modeling efforts, thereby enhancing the ability to produce accurate GNSS-derived elevations anywhere. These crowdsourced "GPS on Bench Marks" contributions play an important role in enhancing today's elevation infrastructure, improving future geoid models, and preparing for the next generation of national geodetic datums.

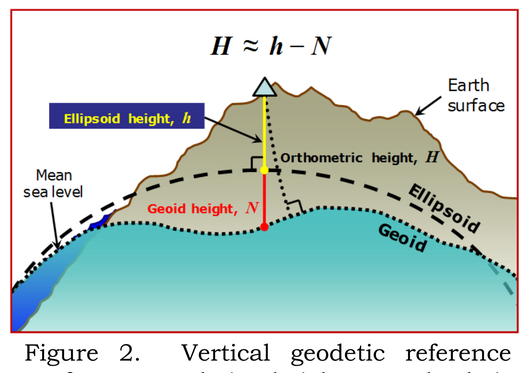

Figure 2. Vertical geodetic reference surfaces, geodetic heights, and their relationships.

Wanted: GPS on Bench Marks...

Why?

GPS on BMs (Fig. 3) play a fundamental role in transforming U.S. Gravimetric Geoid 2012 (USGG2012), a gravimetric geoid model built primarily from terrain and gravity data, to GEOID12A (Fig. 4), a hybrid geoid model relating North American Vertical Datum 1988 (NAVD88) elevations (orthometric heights) to North American Datum 1983 (NAD83) ellipsoid heights. GPS on BMs link together the two height systems.

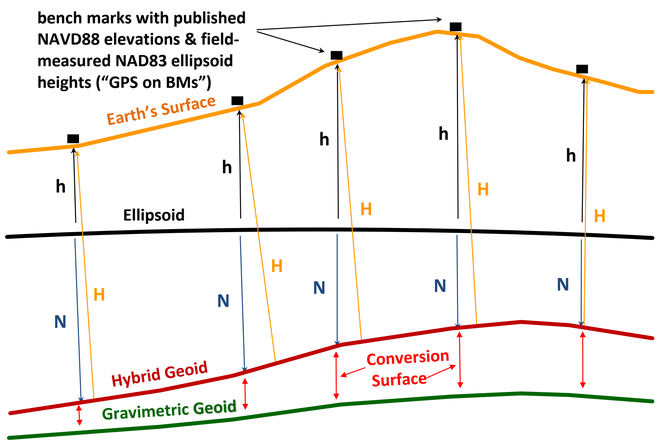

Figure 3. Conversion from gravimetric to hybrid geoid models. GPS-derived ellipsoid heights (h) field-measured at BMs with published NAVD88 elevations (H) produce a conversion surface to modify the gravimetric geoid heights (N) and transform USGG2012 to GEOID12A.

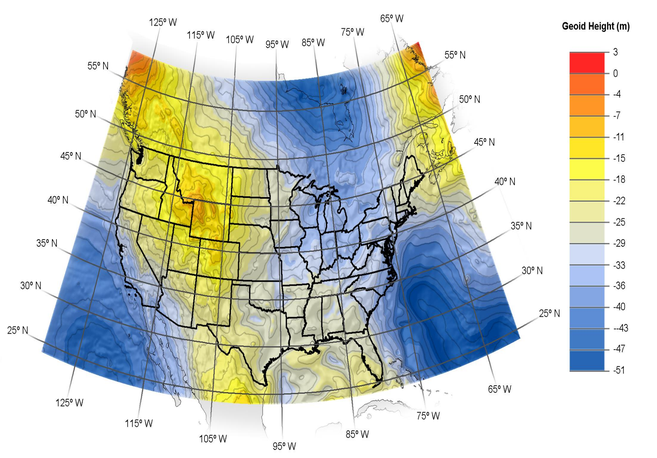

Figure 4. GEOID12A hybrid geoid model for CONUS. GEOID12A characterizes the height offset (geoid undulation) between the geoid reference surface (i.e. zero elevation) for NAVD88 and the NAD83 reference ellipsoid. GEOID12A supports the conversion between NAD83 ellipsoid heights and NAVD88 elevations.

Where?

The existing GPS on BM coverage varies considerably across the nation (Fig. 5) as does the accuracy of GEOID12A (Fig. 6). GPS on BMs come from two sources – marks that are published in the NGS Integrated Database (IDB) and that are shared in the Online Positioning User Service (OPUS) Database (OPUS-DB). NGS offers various tools to research where GPS on BMs are most needed (Fig. 7). More GPS on BMs are need in many regions.

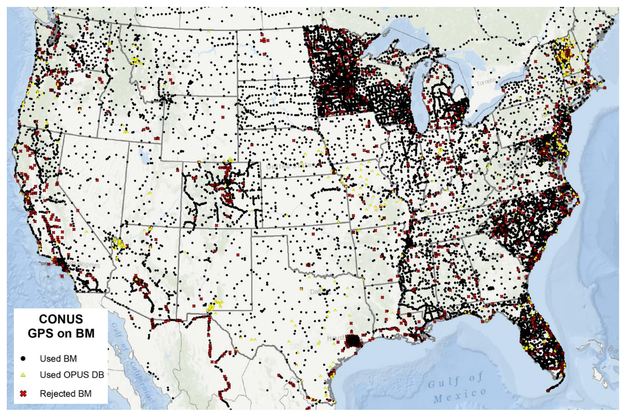

Figure 5. CONUS GPS on Bench Marks. Shown are 24,000 geodetic control stations from the NGS IDB ("Used BM") and the OPUS-DB ("Used OPUS DB") used to transform USGG2012 to GEOID12A.

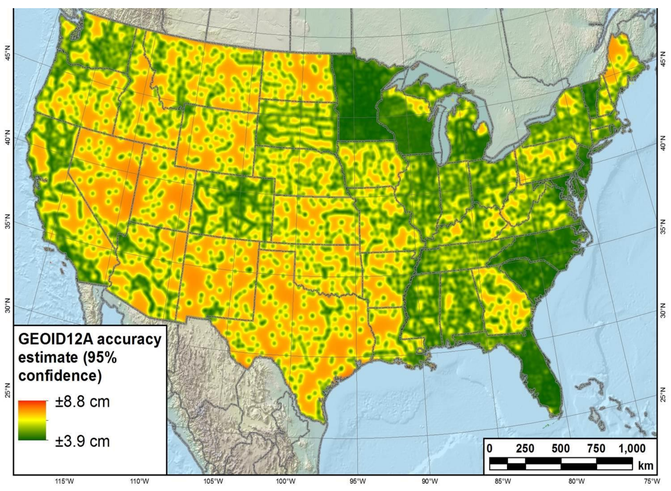

Figure 6. GEOID12A accuracy estimate displayed with DSWorld software. Accuracy is based on distribution of GPS on BM occupations and is suggestive of where additional GPS on BM measurements are needed.

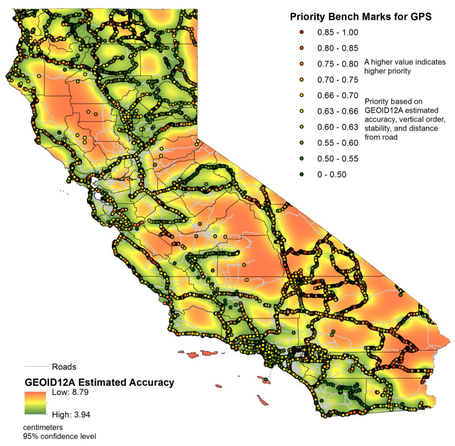

Figure 7. Candidate GPS on BM stations for California. NGS provides state-specific maps and lists of priority-ranked stations for GPS on BM occupation and sharing through OPUS, thereby helping collaborators identify where to target GPS on BM field efforts.

How?

GPS on BMs can be easily developed from four or more hours of survey-grade GPS measurements at 1st- and 2nd-order NAVD88 BMs, processed by OPUS with results shared to OPUS-DB, resulting in a publicly accessible solution (Fig. 8). Shared solutions will be retrieved and utilized in the next hybrid geoid model. Fig. 9 shows the current OPUS-DB solutions.

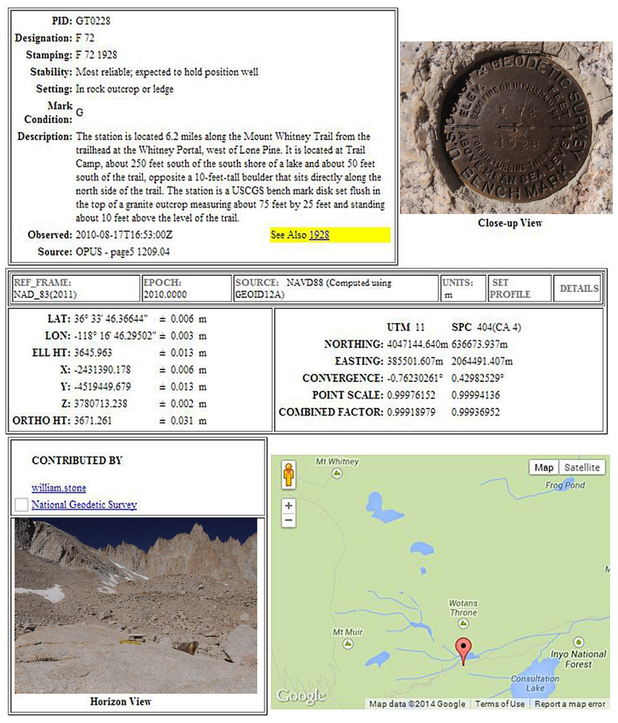

Figure 8. Sample shared OPUS solution report. OPUS offers an optional "sharing" into the NGS OPUS-DB (for GPS observation sessions and results meeting basic technical criteria), thereby making an OPUS solution available to the public and to further analysis by NGS and, if appropriate, for use in development of future hybrid geoid models. The solution depicted was shared by the author and is currently the highest elevation solution in the OPUS-DB, having been collected on the flank of Mt. Whitney, not far from the historical scene in Fig. 1.

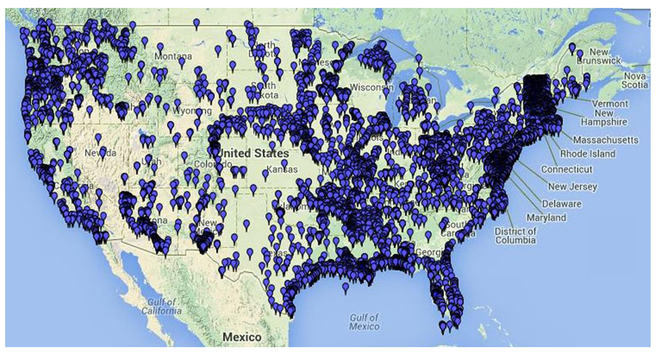

Figure 9. CONUS shared solutions (approx 8000, mid-2014) in the NGS OPUS-DB. Symbols indicate stations that were GPS-occupied and shared to the OPUS-DB, including many GPS on BMs.

For information & to get involved, please visit:

1. **NGS home page:**
   geodesy.noaa.gov
2. **Height Modernization GPS on BM Campaign page:**
   geodesy.noaa.gov/heightmod/2014GPSonBM.shtml
3. **Online Positioning User Service (OPUS):**
   www.ngs.noaa.gov/OPUS/

Or contact the author at william.stone@noaa.gov

All are welcome to participate in GPS on BMs!

Poster created July 2014
for
The Map Gallery
Esri International User Conference
2014