Geoid Slope Validation Survey 2017

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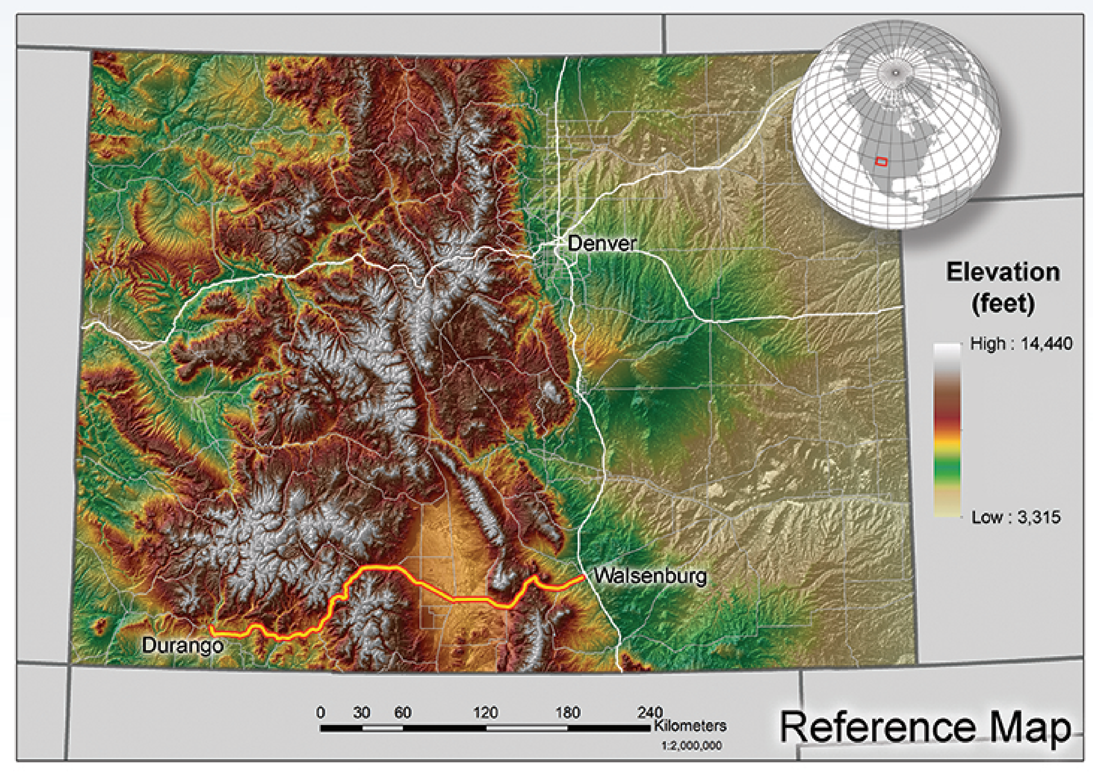
Who is NOAA/NGS?

The National Oceanic and Atmospheric Administration (NOAA) is the nation's oldest scientific agency dating back to 1807 when Thomas Jefferson created the Survey of the Coast. This agency was created to help the United States of America (US) increase commerce by providing maps of the land, shore and waterways to assist shipping, (the main form of trade), and avoid shipwrecks. In 1970 the U.S. Coast and Geodetic Survey and its primary operations of providing geodetic coordinates, tides, and nautical charts were integrated into NOAA. NOAA's mission is Science, Service and Stewardship: to understand and predict changes in climate, weather, oceans, and coasts; to share that knowledge and information with others; to conserve and manage coastal and marine ecosystems and resources.

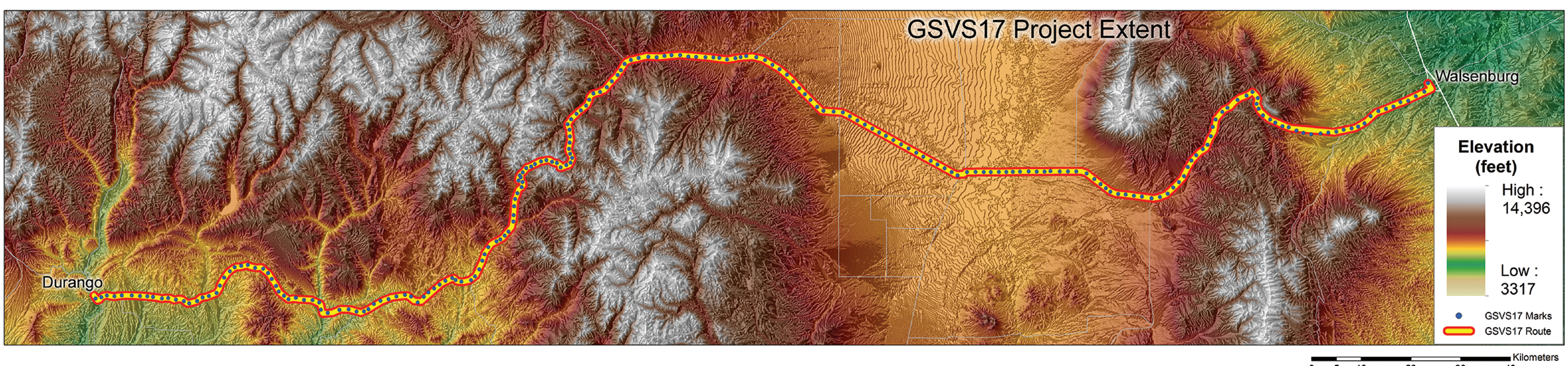
The National Geodetic Survey (NGS) is a program office within NOAA's National Ocean Service. NGS defines the location and elevation framework for the US and all its territories by developing the official US reference frames, datums and geoid models used for positioning. NGS' mission is to define, maintain and provide access to the National Spatial Reference System (NSRS) to meet our nation's economic, social, and environmental needs. One critical component of the NSRS is the determination of "height" --specifically ellipsoid height, orthometric height, geopotential and dynamic height -- for any point in the United States or its territories. These geoid slope validation surveys will greatly assist NGS in providing more accurate geoid models for determining or computing heights.

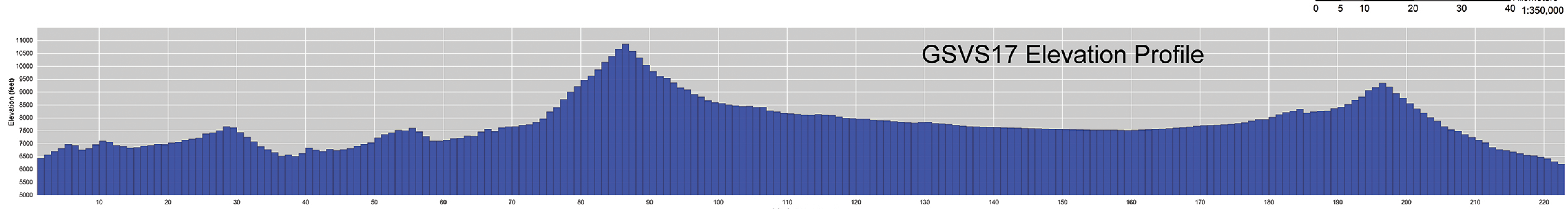


Validating the Geoid

NOAA's National Geodetic Survey (NGS) will be replacing the North American Vertical Datum of 1988 (NAVD88) in 2022 with the North American-Pacific Geopotential Datum of 2022 (NAPGD2022). To build towards the future, NGS has performed many surveys to evaluate how best to model the Earth for the United States and its territories. The purpose of the Geoid Slope Validation Surveys (GSVS) is to provide proof that adding airborne gravity data acquired for the Gravity for the Redefinition of the American Vertical Datum (GRAV-D) project will provide regional 1 cm differential geoid accuracy. NGS has conducted prior GSVS campaigns in Texas and Iowa (in 2011 and 2014), but the complex terrain of Colorado will make GSVS17 a likely worst-case scenario to evaluate geoid modeling.

The GSVS' are composed of four independent surveying methodologies; gravity, differential leveling, GPS, and observed deflections of the vertical (DOV) surveys. The objective of performing these surveys is to compare the geoid slope from co-located (temporally and spatially) GPS, leveling, DOV and terrestrial gravity measurements to the geoid slope of a gravimetric geoid created using the airborne gravity data. By performing independent measurements, NGS is working to validate through observation, not modeling and forecasting, to verify that the models are correct. The ultimate goal for the new reference frames and geopotential datum is to model the Earth as best as we can to allow users of the National Spatial Reference System (NSRS) to acquire an accurate position and elevation using GPS.





Gravity Observations

You might be surprised to learn that gravity is not the constant G we all learned in physics. Gravity is actually different at every location on the Earth and throughout the universe. Almost every geodetic measurement depends in a fundamental way on the Earth's gravity field. Most geodetic measuring instruments have a "bubble level" on them, which are used to level the instrument relative to the gravity field at the location where the observation is made. When level (or plumb), the instrument is then considered tangent to an equipotential surface – or aligned with the local direction of gravity – at the exact point of the instrument. For GSVS17 absolute gravity and vertical gravity gradients are measured on each bench mark, and this information is combined with leveling data to provide a direct measurement of the Earth's gravitational (geo)potential field.

Geodetic Leveling

Humans have been determining height differences by performing leveling dating back to ancient times where the Egyptians, Greeks, and Romans used it for constructing some of the major monuments that still exist today. Instruments and methodology have changed over the centuries; today differential leveling provides the most accurate, and precise means of determining height differences. Leveling uses two calibrated rods and an instrument (rotating telescope) making readings with the instrument in a locked position between the two rods and all of them plumb to the gravity field at their location. The difference between the readings is the height difference between the two rods. Leveling from Durango to Walsenburg was quite the effort, walking more than 450 miles with changes in elevation of about 4500 feet.

Global Positioning System (GPS)

The Global Positioning System (GPS) has revolutionized many industries around the world. While everyone knows that GPS is used to help determine your position on Earth, most people do not realize that at its core GPS is a network of satellites with very accurate clocks that are broadcasting time, not coordinates. Users can then get an accurate position when four satellites are in view to help determine X,Y,Z, and time. GPS provides a more accurate position in a fraction of the time and effort it took to determine latitude and longitude prior to its existence. The GSVS17 GPS Survey was composed of two crews operating 10 sets of equipment each. The GPS crews would set up equipment to collect data over two or more days providing a minimum of 24 and 16 hour sessions on each of the 223 GSVS marks.

Deflection of the Vertical (DOV)

The Deflection of the Vertical (DOV) is the angle between the true zenith (plumb line) and the line perpendicular to the surface of the reference ellipsoid. DOV's are caused by features such as mountains and underground geological features and are typically a few arc-seconds, but can reach an arc-minute of departure. Deflections are used to relate the orientation of a locally leveled instrument, such as a theodolite or total station, to a spatial reference system. For GSVS17 the ETH-Zurich CODIAC zenith camera system is being used to measure the DOV but looking at far away celestial objects (quasars). The DOV will provide the geoid slope at all 223 marks observed for GSVS17 which can be used to compare to slopes provided from combining gravity and leveling measurements. The DOV survey requires clear skies, which was challenging through the summer causing this survey to continue into September.

GIS in the Rockies, Denver, Colorado 2017

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