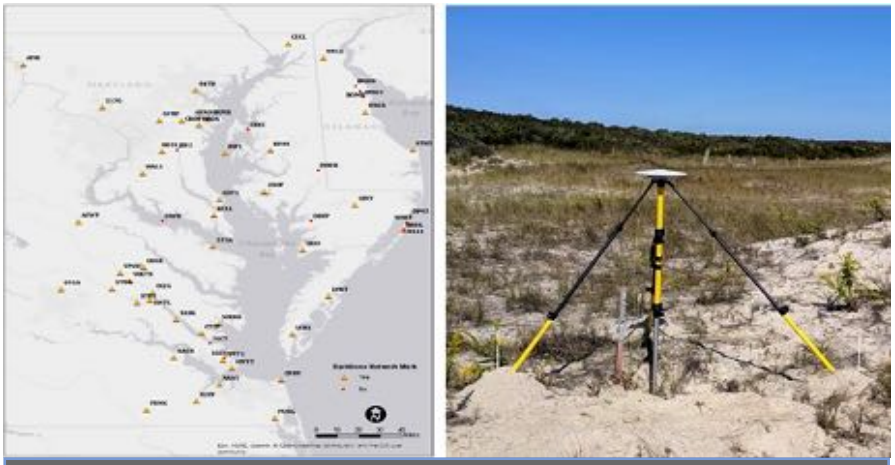
National Geodetic Survey

NOAA's National Geodetic Survey (NGS) provides the framework for all positioning activities in the Nation. The foundational elements of latitude, longitude, elevation, and shoreline information impact a wide range of important activities. NGS' mission is to define, maintain and provide access to the National Spatial Reference System to meet our nation's economic, social, and environmental needs. Included below are six highlighted scientific projects by NGS researchers and their partners.

Understanding the Role of Human-induced Subsidence in Affecting Sea-level Rise Hotspots in the Chesapeake Bay



Map showing locations of bench marks monitored as part of the Chesapeake Bay Regional VLM Project (left). GPS monitoring on Assateague Island National Seashore (right).

The Chesapeake Bay is experiencing some very high rates of local sea-level rise (up to 4.8 mm/yr), and the rates are variable throughout the region. Presumably, these variations are due to differences in local vertical land motion (VLM), with subsidence being a leading cause. Unfortunately, we do not have a good handle on the spatial variations in VLM, and the last authoritative study was published back in the early 1970's. In 2019, a coalition of scientists from Federal, academic and state institutions began a 5-year research project attempt to tease out a VLM signal across the entire Chesapeake Bay area using annual GPS measurements spanning from the mouth of the Bay to Delaware Bay, from the coastal barrier islands of Assateague to the Shenandoah Mountains.

FY20 Accomplishment(s): From October 5-20, 2019 (FY20), NGS, along with its collaborators, successfully obtained an average of 66 hrs of GPS data across 54 sites; the data and metadata have been published at https://www.unavco.org/data/doi/10.7283/M6D3-T837.

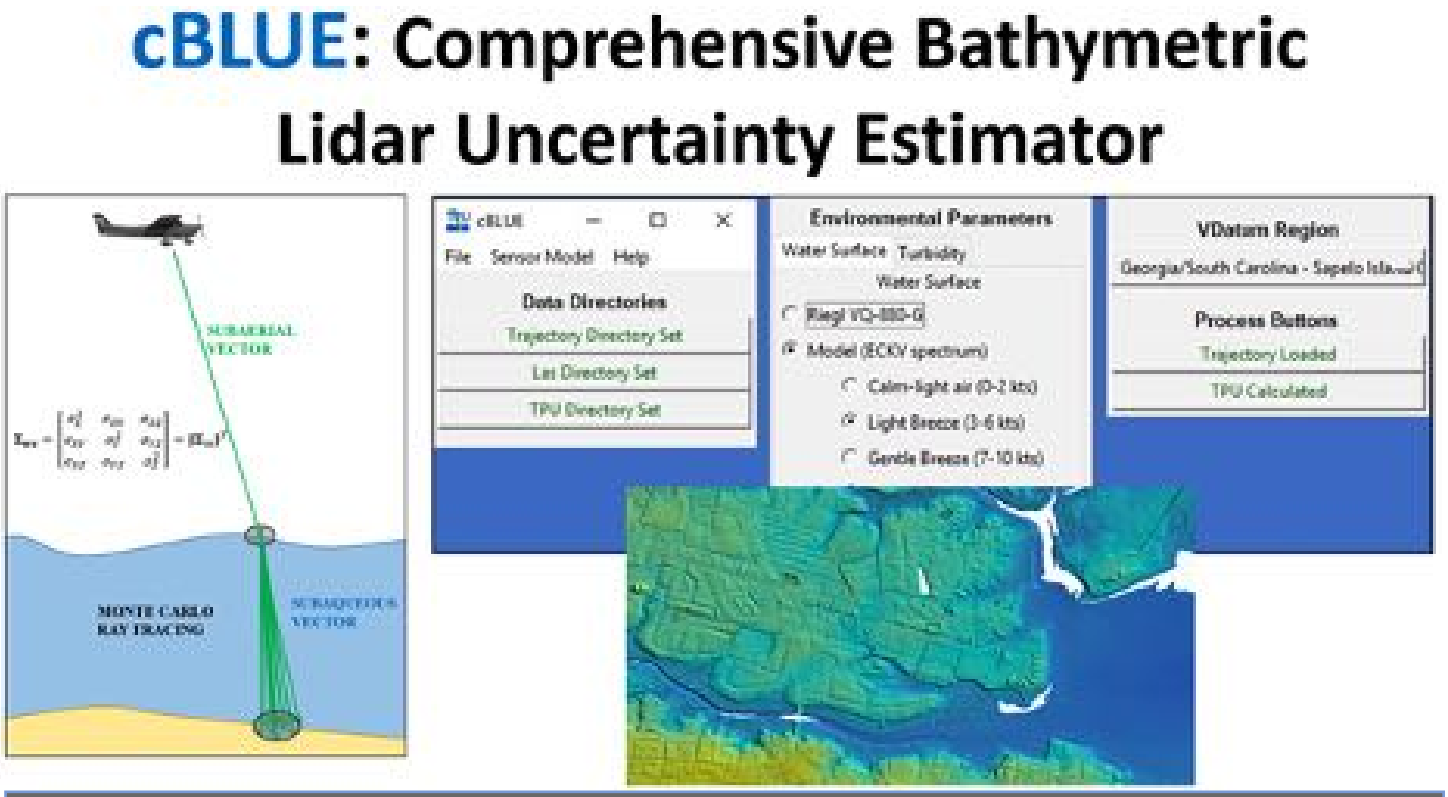
Press Release URLs:

https://www.ngs.noaa.gov/web/news/chesapeake-bay-sea-level.shtml

https://www.usgs.gov/centers/cba/science/new-crowd-sourcing-will-contribute-study-land-subsidence-and-sea-level-rise?qt-science_center_objects=0#qt-science_center_objects

Understanding and Estimating Total Propagated Uncertainty for NGS lidar sensors

Starting in 2016, National Geodetic Survey (NGS) began research efforts with Oregon State University (OSU) and the Center for Coastal and Ocean Mapping/Joint Hydrographic Center, University of New Hampshire (CCOM/JHC, UNH) toward the development of robust total propagated uncertainty (TPU) models. These TPU models cover the range of NGS and Joint Airborne Lidar Bathymetry Technical Center of Expertise (JALBTCX) topo-bathy lidar systems and facilitates operational use of topo-bathy lidar in the lidar community and Coast survey by providing a level of uncertainty (via cBLUE app shown below) to improve informative decisions based on the multi-use of the data. In turn, this aids NOAA in obtaining survey data in challenging, nearshore areas, including shoreward of the navigation area limit line (NALL). Additionally, the enhanced use of topo-bathy data will contribute directly to NOAA's Integrated Ocean and Coastal Mapping (IOCM) initiatives, by providing data that can simultaneously support coastal science and coastal zone management needs.

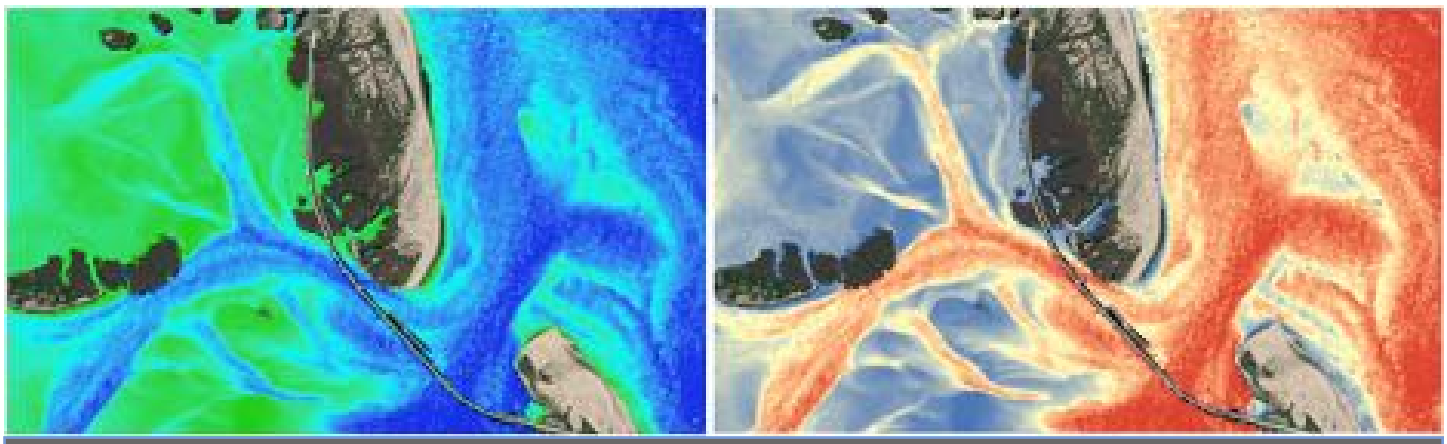


cBLUEApp Module (top right) was created using topo-bathy lidar (middle image) TPU model research (schematic on top left) by Oregon State University (OSU) and the Center for Coastal and Ocean Mapping/Joint Hydrographic Center, University of New Hampshire (CCOM/JHC, UNH) for use by NGS.

FY20 Accomplishment(s): Incorporated research to create cBLUE, first phase of testing complete and now in use operationally at NGS for Riegl VQ-880-G topo-bathy lidar surveys.

Peer reviewed journal article: Eren et al. 2019 *Photogrammic Engineering and Remote Sensing* https://www.ingentaconnect.com/content/asprs/pers/2019/00000085/00000008/art00011;jsessionid=i5midxo2i62m.x-ic-live-01

Applying New Research and Automating Satellite-Derived Bathymetry



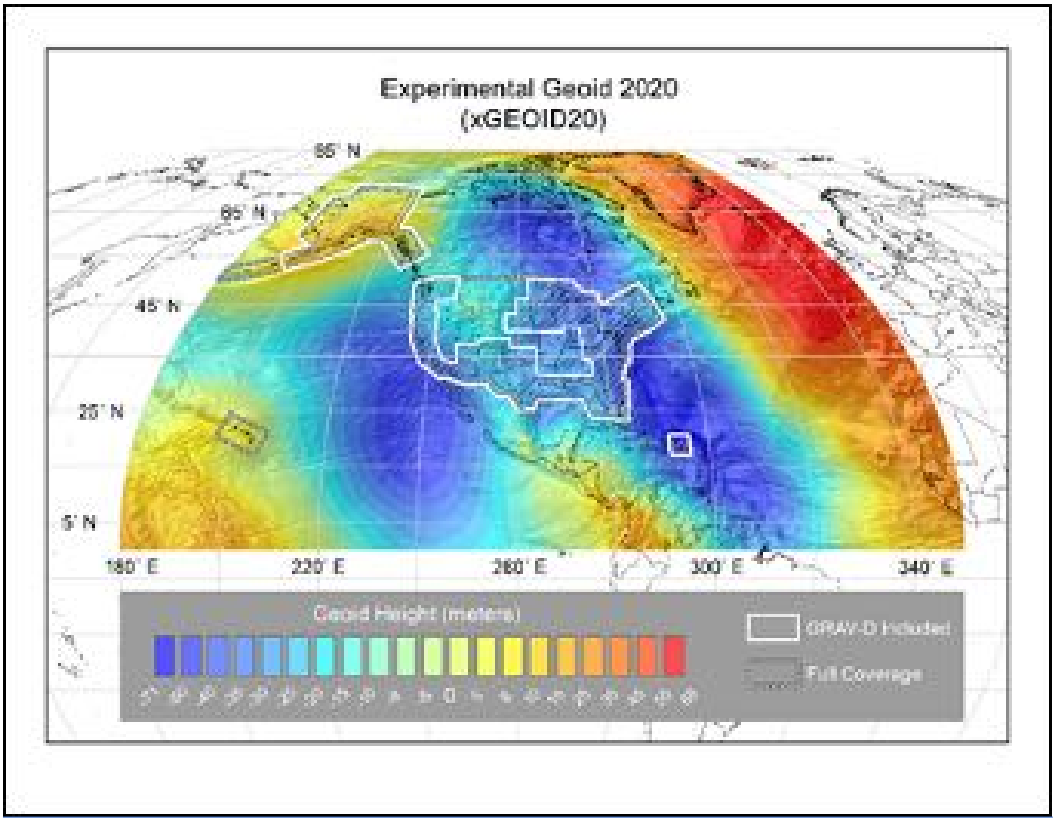
Oregon SDB created Inlet (Oct 2020) using NGS' new pre-alpha SatBathy tool v1.0 based on research from NCCOS.

Starting in 2016, National Geodetic Survey (NGS) began collaboration efforts between the National Centers for Coastal Ocean Science (NCCOS) and the Office of Coast Survey (OCS) to create a user friendly Satellite Derived Bathymetry (SDB) tool that would provide consistent and quick results utilizing new research from Dr. Isabel Cabellero and Dr. Richard Stumpf. Since 2016, progress has been made to incorporate "a robust atmospheric correction, a multi-scene compositing method to reduce the impact of turbidity and a switching model to improve mapping in shallow water" to improve Dr. Stumpf, et al.'s 2003 SDB algorithm. In tandem to this effort, NGS has been working with NCCOS to develop a framework and began developing the NOAA SatBathy tool.

FY20 Accomplishment(s): NGS began creating the framework and creation of the SatBathy tool.

Peer reviewed journal article: Caballero & Stumpf 2020 *Remote Sensing:* https://www.mdpi.com/2072-4292/12/3/451

The Experimental Geoid 2020



Display of the Experimental Geoid 2020 (xGEOID 2020). Image credit: NGS, NOAA.

Starting in 2014, the National Geodetic Survey (NGS) began publishing a series of experimental geoid models annually. These models contain the gravity data from the latest satellite gravity models, the terrestrial gravity and most importantly, the airborne gravity from the Gravity for the Redefinition of the American Vertical Datum (GRAV-D) project. These experimental geoids have been developed to demonstrate the geoid improvements provided by the addition of GRAV-D data and by refining the geoid computation methods. The experimental geoid models provide a preliminary but increasingly-accurate view of the changes expected from the upcoming North American-Pacific Geopotential Datum of 2022 (NAPGD2022). The experimental geoid 2020 is the first model computed jointly by scientists at NGS, the Canadian Geodetic Survey, and the National Institute of Statistics and Geography in Mexico.

FY20 Accomplishment(s): NOAA worked with the Canadian Geodetic Survey and the National Institute of Statistics and Geography in Mexico to combine gravity data sets, to make the best geoid possible for North America, Hawaii, the Caribbean, Central America, and beyond.

Project URL:
https://beta.ngs.noaa.gov/GEOID/xGEOID20/

Geoid Determination in Mountainous Terrain

Ground truth surveys along US160 in southern Colorado. Setting up a geodetic GPS antenna for horizontal positioning

In a few years, NOAA NOS will modernize the nation's height system. Instead of measuring heights inland from a "mean sea level," heights will be measured relative to a constant geopotential surface known as the "geoid," a model of the shape of the Earth under the influence of its gravity and rotation. By providing the shape of this undulating surface everywhere, the new system allows surveyors to use GPS receivers to determine precise heights anywhere. In the Journal of Geodesy, NGS describes a ground-truth test of the geoid-based system in Colorado, demonstrating that it has a relative accuracy of better than 5 cm in mountainous terrain—a worst case scenario for geoid determination. When combined with earlier Texas and Iowa surveys (which demonstrated better than 2 cm accuracy in smoother terrain), these results indicate the new national height system will provide accurate elevations everywhere, with approximately 10X better accuracy.

> **FY20 Accomplishment(s):** Peer reviewed article published in the *Journal of Geodesy* demonstrating the relative accuracy of the ground truth techniques and various experimental models.
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> Peer reviewed journal article: van Westrum et al. 2021 *Journal of Geodesy:* https://link.springer.com/article/10.1007/s00190-020-01463-8

Total Station Astrogeodetic Control System (TSACS)

The Total Station Astrogeodetic Control System (TSACS) being tested with with a Leica TS60 robotic total station in Silver Spring, Maryland. The various components can be viewed using the URL below.

The National Geodetic Survey developed the Total Station Astrogeodetic Control System (TSACS), a system for measuring the direction of gravity with astronomical observations. The TSACS directs a robotic total station to measure the deflection of the vertical (DOV) by imaging stars. The deflection of the vertical indicates how much the direction of gravity has been shifted by local mass anomalies, like mountains. As DOV defines which way is up, measuring it in the field will be crucial for verifying the level surface that will define NGS's future geopotential height system. The TSACS will also find use in establishing precise orientations and bridging classical and modern geodetic observations. Its automated observation sequence can measure deflections of the vertical to better than ±0.2 arcseconds in as little as 15 minutes.

FY20 Accomplishment(s): Developed and tested a system for measuring deflections of the vertical by imaging stars with a robotic total station.

Project Presentation URL:
https://www.ngs.noaa.gov/web/science_edu/presentations_library/files/aguf2020_-_ryan_hardy.pdf