Coastal Change Hazards During Extreme Storms Investigated With Airborne Topographic Lidar

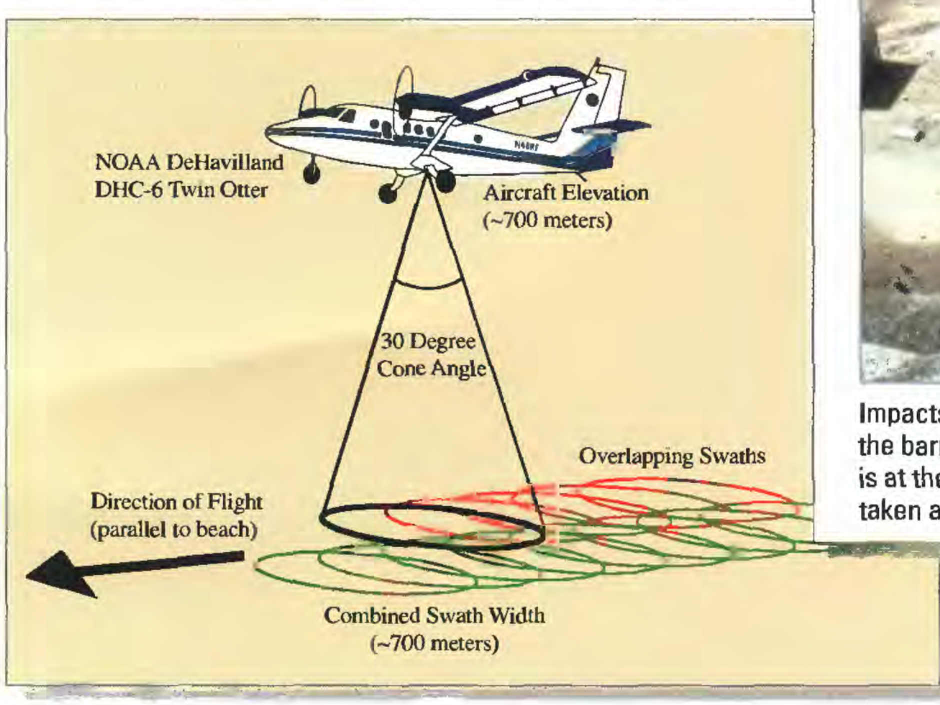
Coastal change, such as beach and dune erosion that occurs during hurricanes and severe winter storms, poses significant hazards to buildings and infrastructure that are constructed too close to vulnerable shorelines. Societal costs, in dollars spent and threats to lives, can be staggering.

Resource managers must be able to predict where and how much coastal change will occur during an extreme storm in order to locate new construction and infrastructure landward of coastal change hazards. Developing this predictive capability requires quantifying how different coastal regions respond to extreme storms and determining what causes the observed spatial patterns of change.

The US Geological Survey (USGS) and National Aeronautics and Space Administration (NASA) are jointly investigating coastal change hazards with the ultimate objective of improving predictive capabilities. The cornerstone of our effort is to use airborne topographic lidar to acquire pre- and post-storm topography to quantify changes to beaches and dunes.

Airborne lidar has only recently been applied to coastal change investigations. Lidar stands for 'light detecting and ranging,' similar to radar, which stands for 'radio detecting and

Impacts to Topsail Island, NC, during Hurricane Fran in 1996. A new inlet was cut across the barrier island. The Atlantic Ocean is at the bottom of the photograph and the back bay is at the top. The upper photo was taken prior to Hurricane Fran and the lower photo was taken afterward. Note the same house marked by the arrow in each photo.

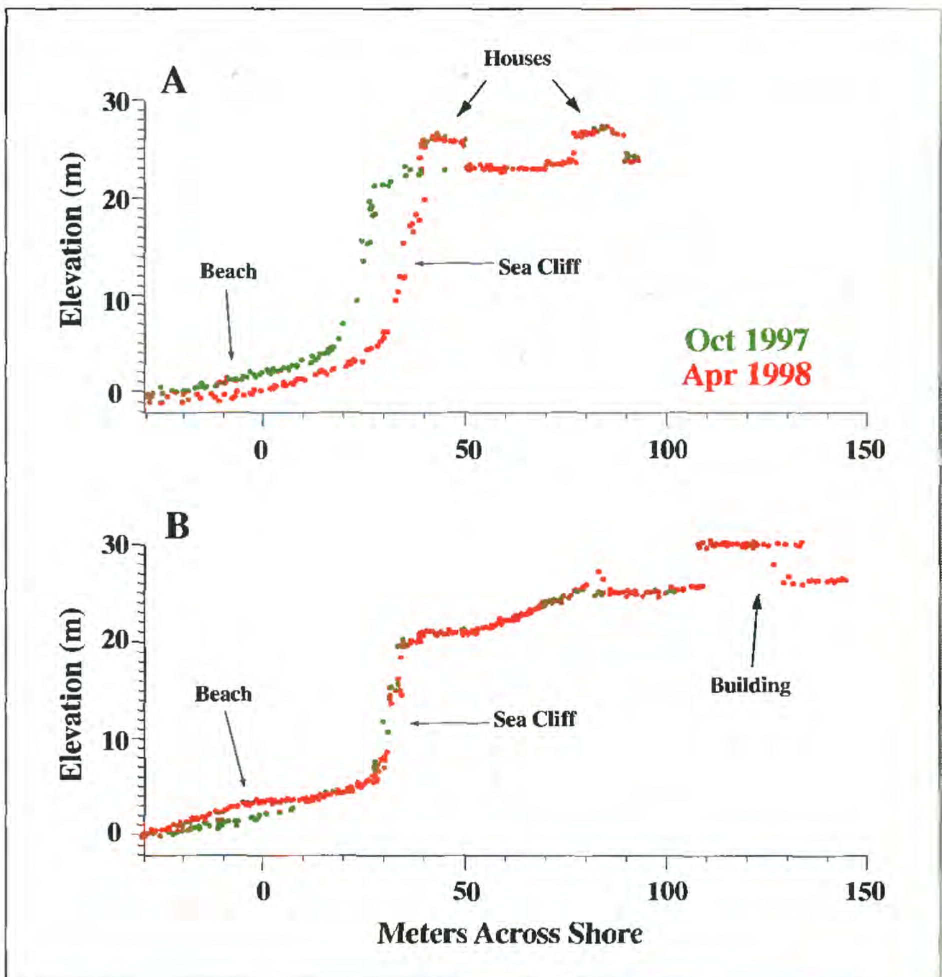


Elliptical scan pattern of a NASA lidar, called Airborne Topographic Mapper or ATM. Lidar surveys topography of beaches and coasts with unprecedented data density and quality.

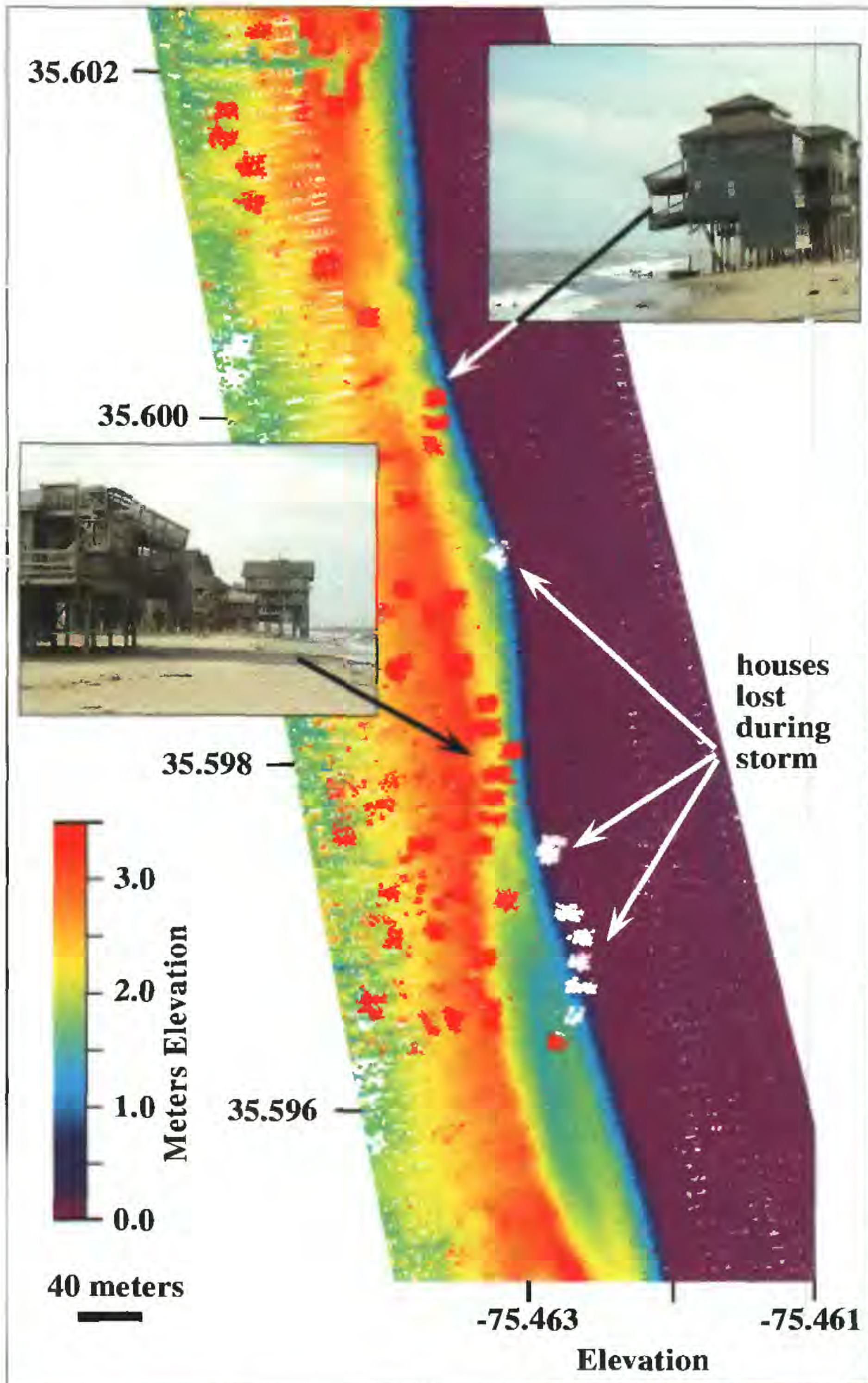
ranging.' As the aircraft flies over the coast, the lidar scans a 350-m-wide swath of the earth's surface, acquiring an estimate of surface elevation every few square meters. Each estimate is based on a laser pulse of light that is very accurately timed from when it leaves the instrument to when it is reflected back to the aircraft from the earth's surface. Knowing the position of the aircraft, using the Global Positioning System (GPS), and the speed of light, the topography of the Earth's surface can be accurately mapped.

Lidar surveys of coastal areas before and after a storm allows detailed comparison and quantification of changes. Traditional USGS topographic sheets do not have sufficient resolution to be useful for comparing coastal elevations, especially over brief time periods of high-energy events. With its rapidity of acquisition and very high data density, lidar is revolutionizing the quantification of storm-induced coastal change.

In addition to the lidar data, USGS acquires GPS-controlled pre- and post-storm aerial oblique imagery (video and still photography) to document coastal changes and to assist in interpreting results of the lidar surveys. After particularly severe storms, USGS deploys ground crews to document coastal change in detail, and to acquire high-resolution GPS surveys to verify airborne lidar data.



Cross sections, cut across beaches and cliffs, derived from Airborne Topographic Mapper data from October 1997 and April 1998 near Pacifica, CA, shows El Niño storm impacts. The cliff in the upper profile retreated nearly 15 m whereas only several hundred meters away the cliff in the lower figure was stable. Deciphering the causes of this spatial variability is a major research objective. Each cross-section shows individual laser spot elevations that fall within a 2-m-wide strip oriented approximately shore normal. Note that the dimensions of buildings are clearly revealed by the lidar data.



This sample of lidar data shows beach topography of Rodanthe, NC, after hurricane Dennis; houses are high elevation, red, rectangles. (Ocean is shown in purple.) Before and after the storm lidar surveys were compared to detect the lost houses (shown in white).

Investigations of the impacts of El Niño storms on the west coast, and hurricanes and extreme winter storms in the southeast, have quantified extreme coastal changes (see figures) and have tested hypotheses for how the changes occurred. Understanding the causes allows USGS scientists, and our cooperators in other agencies and universities, to improve our capabilities to predict the location and magnitude of storm-induced coastal change hazards.

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