STORM SURGE

The US Climate Resilience Toolkit (2017) defines storm surge as abnormally high water levels generated by severe storms that can produce sea levels much higher than normal high tide, resulting in extreme coastal and inland flooding. If storm surges coincide with high tide, they can raise water levels by 20 ft (6 m) or more above mean sea level. As a result of global sea level rise, storm surges that occur today are 8 in (0.2 m) higher than they would have been in 1900. By 2100, storm surges will happen on top of an additional 8 in to 6.6 ft (0.2 to 2 m) of global sea level rise.

Hurricane Sandy, the largest Atlantic hurricane on record, made landfall on October 29, 2012, and generated a storm surge along a long swath of the US Atlantic coastline. The barrier islands were breached in a number of places and beach and dune erosion occurred along most of the Mid-Atlantic Coast. As a part of the National Assessment of Coastal Change Hazards Project, the USGS collected post-Hurricane Sandy oblique aerial photography and lidar topographic surveys to document the changes that occurred as a result of the storm. Comparisons of post-storm photographs to those collected prior to Sandy's landfall were used to characterize the nature, magnitude, and spatial variability of hurricane-induced coastal changes. Analysis of pre- and post-storm lidar elevations was used to quantify magnitudes of change in shoreline position, dune elevation, and beach width (Sopkin and others, 2014).

The USGS assessed the morphological impacts of Hurricane Sandy on the beach and dune system at Fire Island National Seashore, Long Island, New York. Fire Island National Seashore is a east–northeast to west–southwest trending barrier island on the southeast side of central Long Island. Ocean Bay Park and Old Inlet are located in the western and eastern portions of the Fire Island National Seashore (Figure 15-38).

At the height of the storm, a record significant wave height of 9.6 m was recorded at the wave buoy offshore of Fire Island (Hapke and others, 2013). During the storm, beaches were severely eroded and dunes extensively overwashed. Fire Island was breached in three locations, and the coastal infrastructure, including many private residences, was heavily damaged.

The Hurricane Sandy storm surge washed over the dunes at Ocean Bay Park, an urbanized barrier island, resulting in the transport of large volumes of sand inland from the beach system, a severe decrease of dune height, and significant property damage. The May 21, 2009 pre-storm oblique photograph looking northwest from the ocean toward the interior bay shows the intact housing, infrastructure, and trees at Ocean Bay Park (Figure 15-39A). A wide beach with sand dunes is established along the seaward side of Ocean Bay Park. The post-storm aerial photograph reveals that overwash from the beach and narrow dunes along the ocean shoreline carried sand inland and towards the bayside of the island (Figure 15-39B). The morphological changes due to the storm surge were quantified with lidar (Plate 52A). Sand was removed from a 50-m wide swath of the beach and dunes. The sand beach and dunes were severely eroded with topographic elevation reduced by up to 3.5 m. The surge deposited sand toward the interior of the island. Some sites accumulated over 2 m of sand.

Breaching of the barrier island occurred at several locations along Fire Island, including at Old Inlet, an unpopu-

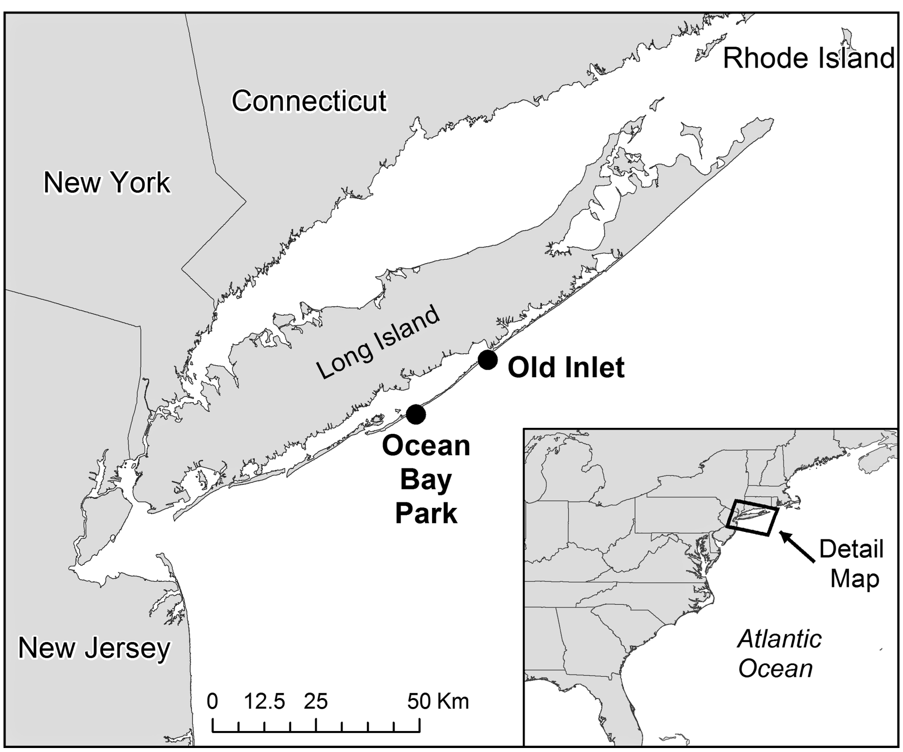


Figure 15-38 Location map for pre- and post-storm lidar survey maps at Fire Island, New York.

lated barrier island, where volume loss and shoreline retreat are apparent (Figure 15-40). A road across the island was destroyed during the storm surge and a new inlet was created. A fishing shack remained standing despite the breach. The lidar pre- and post-storm DEMs clearly show that the breach cut through 4-m high sand dunes (Plate 53). Beach and sand dunes outside of the breach and along the seaward side of the island were eroded with a decrease in elevation while the interior of the island accumulated up to approximately 2.5 m of sand washed over the island during the surge.

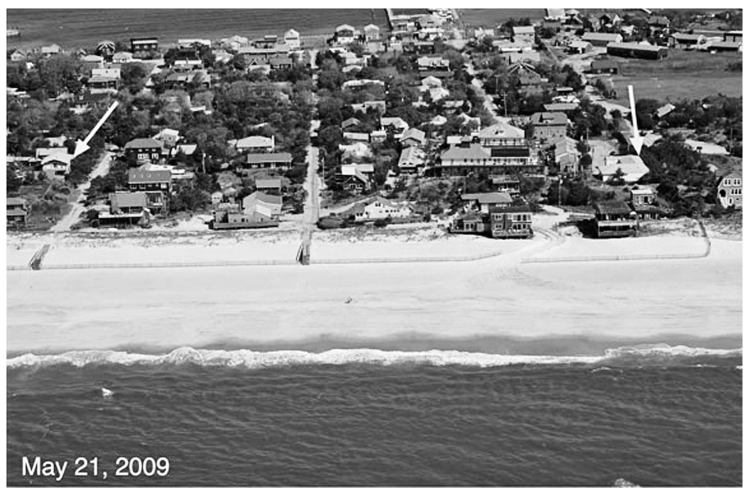
Hapke and others (2013) summarize the morphological changes at Fire Island. The beaches and dunes on Fire Island were severely eroded during Hurricane Sandy, and the island breached in three locations on the eastern segment of the island. The lidar measurements and fieldwork documented a landward shift of the upper portion of the beach that averaged 19.7 m, but varied substantially along the coast. The elevation of the shoreline was lowered by as much as 3 m. Shoreline change was highly variable, but the shoreline prograded during the storm by an average of 11.4 m due to the deposition of material eroded from the upper beach and dunes onto the lower portion of the beach. The beaches and dunes lost 54.4% of their pre-storm volume, and the dunes experienced overwash along 46.6% of the island. The inland overwash deposits account for 14% of the volume lost from the beaches and dunes, indicating that the majority of material was moved offshore. Hurricane Sandy reduced the topographic elevation of the barrier island, leaving the island vulnerable to future storms.

FIRE

Images acquired at night with the Day/Night Band of the VIIRS instrument onboard the NASA/NOAA Suomi NPP satellite capture low-light emissions under varying illumination conditions with 370 m spatial resolution (Blumenfeld, 2019). The Day/Night Band detects light in a range of wavelengths from green to NIR and uses filtering techniques to observe dim signals such as city lights, gas flares, auroras, wildfires, and reflected moonlight (Cole and others, 2012). Each Suomi NPP Day/Night Band has a swath width of

FIGURE 15-39 Ocean Bay Park, Fire Island, New York. The view is looking northwest across Fire Island towards Great South Bay. The white arrows in each image point to the same features. See Plate 52. From Sopkin and others (2014, Figure 32).

A. Oblique pre-storm aerial photograph.



B. Oblique post-storm aerial photograph.

3,040 km (Chapter 11), enabling regional scenes that can provide nighttime images of many fires. These images are available generally within three hours of acquisition.

The Day/Night Band images effectively track nighttime fire fronts across large areas on a daily basis, informing emergency response teams and residents in harm's way of the fire front's size, shape, and direction(s) of movement. Day/Night Band images were acquired around 2 AM on the nights of December 4 through 8, 2017 of the huge Thomas Fire in Ventura County (Figure 15-41). Fierce Santa Ana winds, very low humidity, and dried out vegetation caused the front of the Thomas Fire to rapidly spread outward and toward the west during the five days, scorching terrain across an area greater than 35 km across.

The image in Figure 15-41B is a portion of the Day/Night Band scene acquired on December 4, approximately 16 hours before the Thomas Fire started. The white arrow points to the location of a brushfire that was reported at 6:28 PM on December 4, approximately 30 km northeast of Ventura (O'Neal, 2017). Figure 15-41C was acquired two hours before the fire had consumed 31,000 acres with over 150 structures destroyed and 27,000 people evacuated. The bright glows in the center of Figure 15-41C show the hot spots along the fire front. On December 6 (Figure 15-41D), the fire had three hot spots and had reached the coast. On December 7 (Figure 15-41E), the fire evolved into a two-pronged front: the southern front moving along the coast and the northern front tracking west in the mountains northeast of Santa Barbara. A few hours later the fire had burned 96,000 acres with over 400 homes lost. The December 8 image shows two long fire fronts in the mountains and some hotspots near the coast (Figure 15-41F). By December 8 the Thomas Fire had scorched 150,000 acres and is estimated to have cost $17 million (O'Neal, 2017).

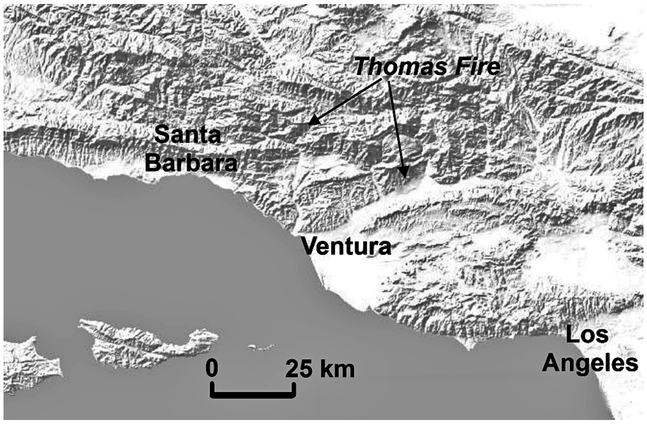
The Suomi NPP Day/Night Band images supplement higher spatial resolution and daytime visible and reflected IR images by filling the nighttime gap with regional daily coverage of evolving fire fronts. The Suomi NPP MWIR bands (3.75 μm and 4.05 μm) also provide fire temperatures (Bachmeier, 2017). The large, wind-driven Thomas Fire was very hot: the maximum recorded temperature on December 5 was 434.6°K (161.6°C or 322.6°F).

A. Oblique pre-storm aerial photograph.

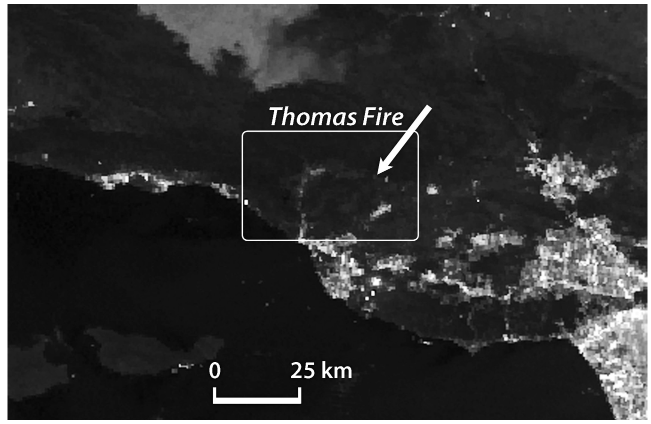
B. Oblique post-storm aerial photograph.

Figure 15-40 Old Inlet, New York. The view is looking northwest across Fire Island toward Great South Bay. The island breached during Hurricane Sandy, creating a new inlet. Despite the breach, a fishing shack (white arrow) remained standing. See Plate 53. From Sopkin and others (2014, Figure 34).

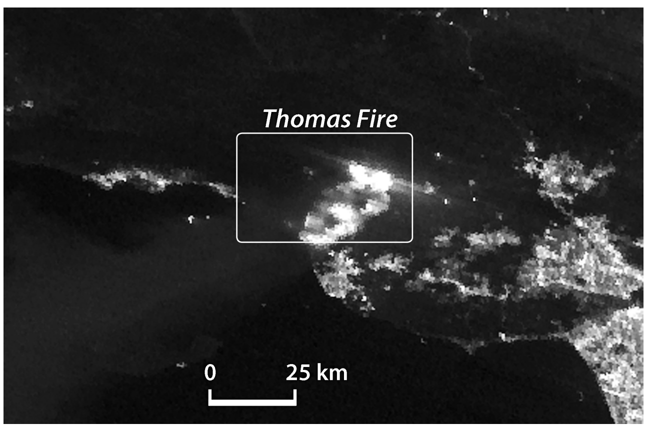
A. Location map. The general area of the Thomas Fire burn scar is highlighted by two arrows.



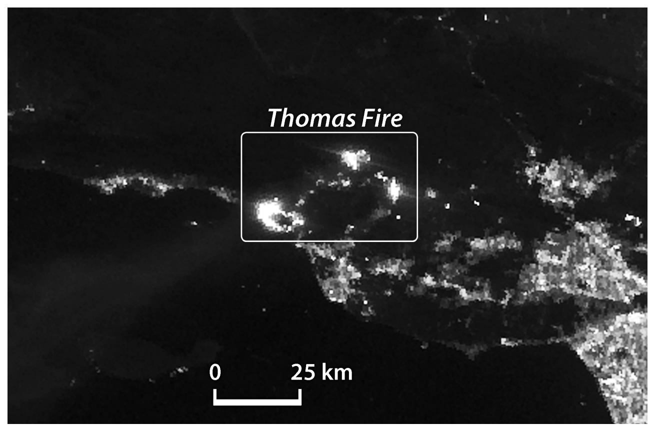
B. December 4, 2017.



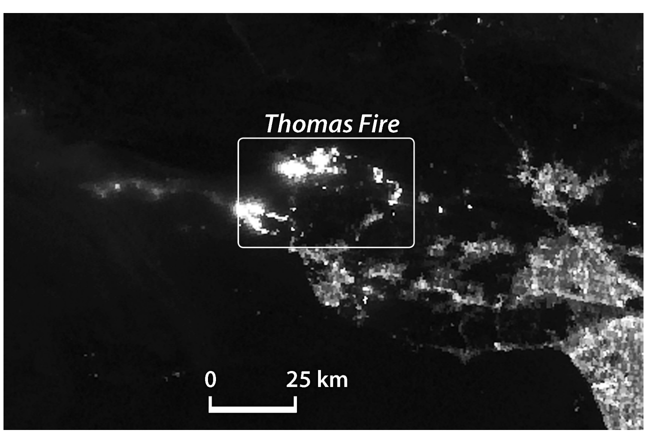
C. December 5, 2017.



D. December 6, 2017.



E. December 7, 2017.



F. December 8, 2017.

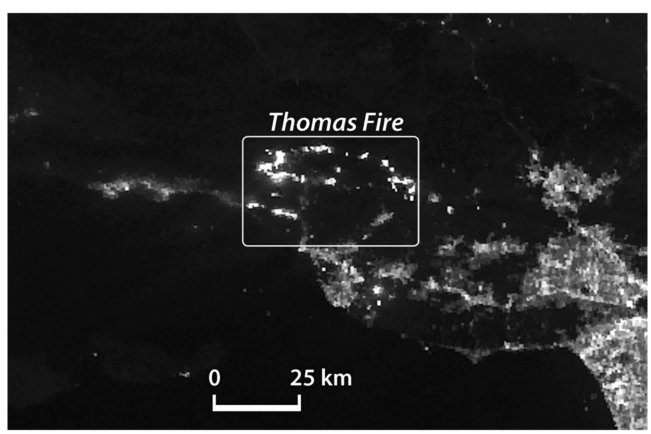
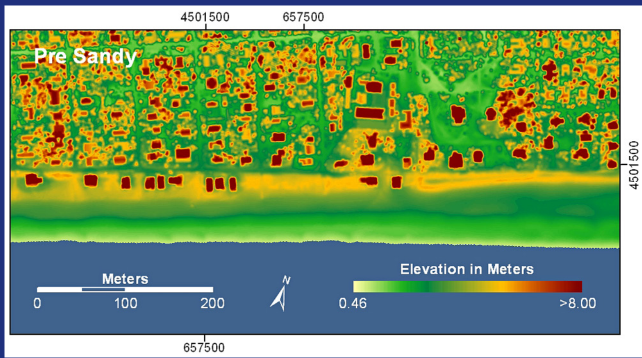
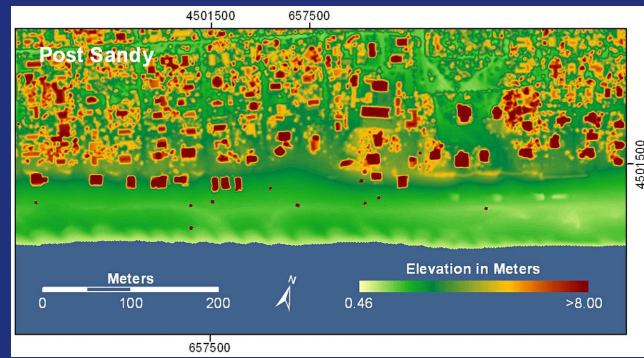


FIGURE 15-41 Suomi NPP Day/Night Band images of the Thomas Fire in southern California. From NASA Earth Observatory (2017).

A. Before (May 2012) Hurricane Sandy.



B. After (November 2012) Hurricane Sandy.



C. Elevation changes.

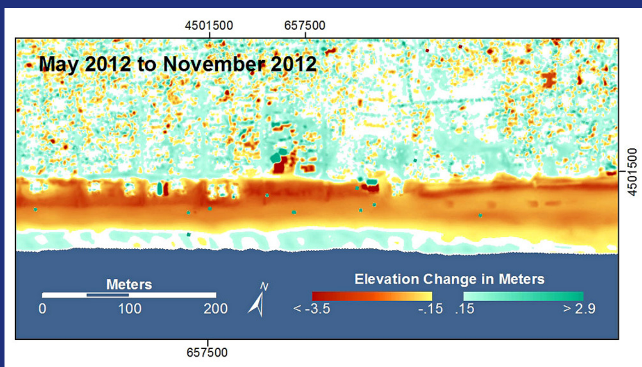
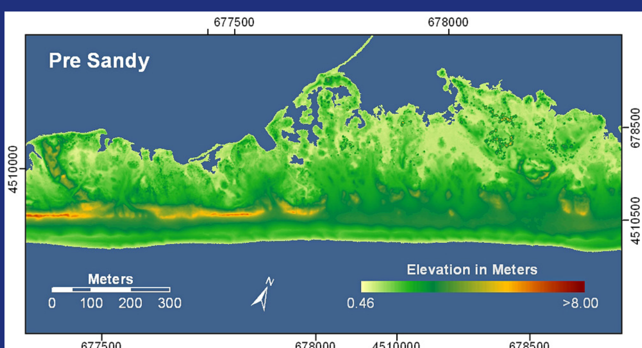
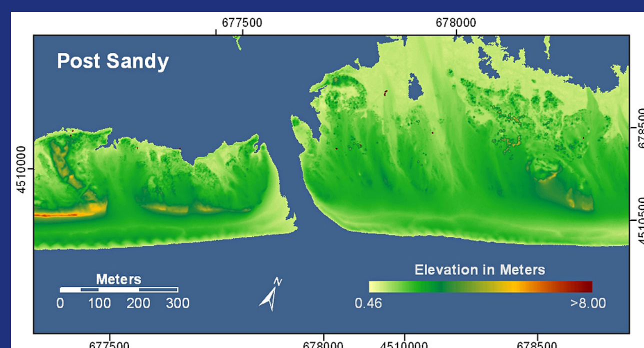


PLATE 52 (CHAPTER 15) Three-dimensional lidar topography of a populated area at Ocean Bay Park, Fire Island, New York (Figure 15-39). From K. L. Sopkin, H. F. Stockdon, K. S. Doran, N. G. Plant, K. L. M. Morgan, K. K. Guy, and K. E. L. Smith. 2014. *Hurricane Sandy: Observations and Analysis of Coastal Change* (Open-File Report 2014-1088). Washington, DC: US Geological Survey.

A. Before (May 2012) Hurricane Sandy.



B. After (November 2012) Hurricane Sandy.



C. Elevation changes.

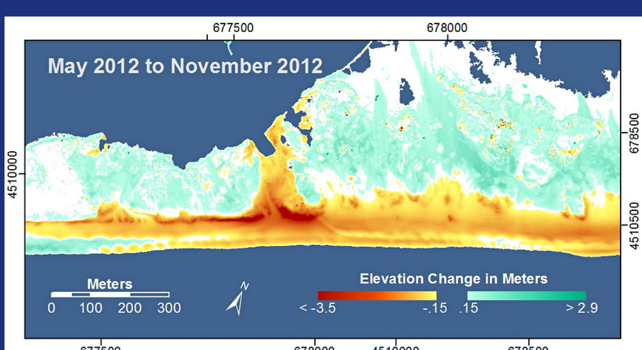


PLATE 53 (CHAPTER 15) Three-dimensional lidar topography of an unpopulated island at Old Inlet, Fire Island, New York (Figure 15-40). From K. L. Sopkin, H. F. Stockdon, K. S. Doran, N. G. Plant, K. L. M. Morgan, K. K. Guy, and K. E. L. Smith. 2014. *Hurricane Sandy: Observations and Analysis of Coastal Change* (Open-File Report 2014-1088). Washington, DC: US Geological Survey.