Hungry hurricanes

This year's hurricane season wrought havoc – loss of lives, homes and businesses. For the USGS researchers the storms also had a saving grace in the form of data that will be used to enhance storm prediction capabilities and stave the future losses that Gulf Coast states might experience from storms in the future. **Kristen M Kusek** reports

Ah, life by the sea. The fresh breezes, bright sun, and silky sand between your toes. While just the mere sound of the phrase 'Gulf coast living' practically washes away tension and enables one to draw a deeper, slower breath, this summer in Florida proved that coastal living can also cause tension of a horrid kind, especially if your 'permanent residence' washes out to sea with the lick of one storm.

Gulf coast living this past hurricane season was anything but relaxing. More than 100 deaths were blamed on the suite of storms that hit Florida and other Gulf coast states this storm season (June-November), according to news reports.

One after another, the state of Florida was clobbered with five storm systems within a two-month period, said Asbury 'Abby' Sallenger, an oceanographer with the United States Geological Survey's Center for Coastal and Watershed Studies in St. Petersburg, Florida. There was one tropical storm system Bonnie and a whopping four hurricanes with seemingly benign names: Charley, Frances, Ivan and Jeanne.

Although the massive rebuilding effort is well underway, the state still shows signs of having been beat up this year: highway signs bent in half as if they were made of cardboard, oak-lined streets now bare and exposed, blue tarps in place of roofs.

'The Florida coastline is malleable,' Sallenger said, not to mention vulnerable, a difficult fact to accept for those who want to live as close to the sea as possible and might not think that the coastline actually moves.

Sallenger's progressive coastal survey programme – a

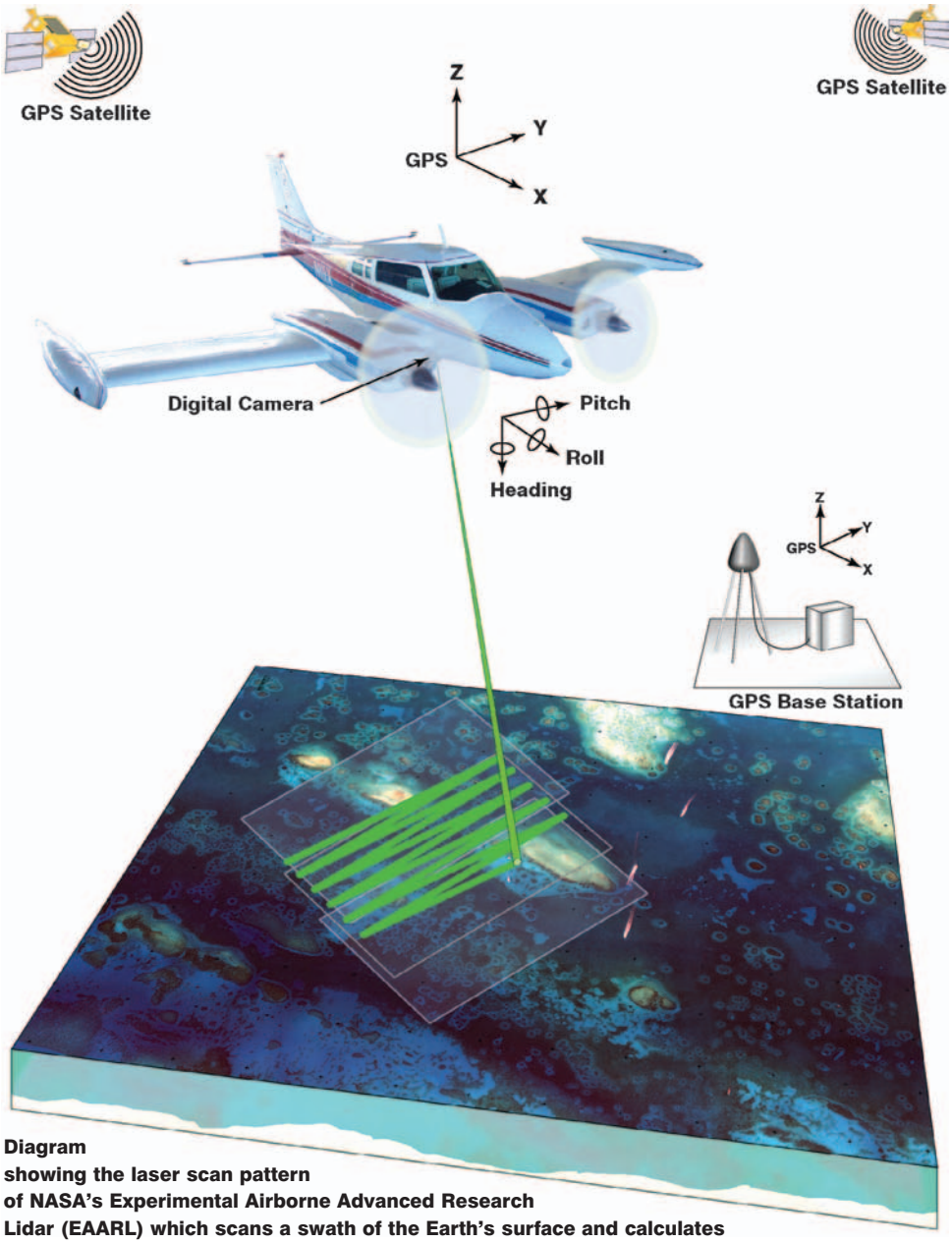


Diagram showing the laser scan pattern of NASA's Experimental Airborne Advanced Research Lidar (EAARL) which scans a swath of the Earth's surface and calculates ground elevation. Lidar stands for light detecting and ranging [source USGS]

along Gulf Coast

cooperative effort between the USGS, NASA and Army Corps of Engineers – ramped up its efforts in response to this year's unusually active hurricane season, which just wrapped up for this year, much to the relief of weary residents who packed and unpacked, fled and returned to their homes too many times to count.

'Because the storms were on top of us this year, we had the added concern of our own homes and our own safety,' said Sallenger, whose team of six or seven regularly logged 6 or 7-day weeks when the storms made landfall. The last time a single state was hit by four storms in one season was in the late 1800s (Texas), Sallenger said. 'We've had a very active summer and a very good team of folks working on this'.

Devastation

There is no questioning the absolute devastation – loss of lives and homes and trees and businesses and more – wrought by this year's hurricane season. For the USGS researchers, however, the storms also had a saving grace in the form of data that will be used to enhance storm prediction capabilities and stave the future losses that Florida and other Gulf coast states might experience from storms in the future.

'Usually it would take about four to five years to collect this kind of data set,' said Sallenger. 'The storms came one after another, and there was more diversity in these storms in terms of what they did to the coastline.' That means there's a lot to learn from the data sets, a highlight of which are gobs of 'photo pairs' — images taken before and after the storm — that underscore Sallenger's statement about the coastline being malleable.

'This is exciting scientifically because we're looking at forces that are just awesome, and trying to understand them enough so that we can predict them,' Sallenger said.

Karen Morgan is a USGS coastal geologist on Sallenger's team. 'It's been an absolute wild ride,' said Morgan, 'and as busy a year as I've ever seen it.'

While it didn't register the highest winds or greatest storm surge, in terms of coastal change it was Ivan that dealt the greatest blow to the Gulf coast. In fact, although Ivan only registered as a marginal category 2 by the time it hit shore, it was the worst storm in terms of coastal change in the last few decades.

'Ivan is something the coastal change folks will be talking about for decades to come,' Sallenger said.

The team counted about 87 houses gone after Ivan between the mouth of Mobile Bay, Alabama and the Florida border. Several hundred houses were lost in total.

'The volume of sand that got moved was incredible – about 3-4ft of sand were moved for miles,' Morgan said, recalling the scene as if it were yesterday. She was responsible for taking thousands of oblique photographs of the battered coastline, which the team posted on the USGS website for all to view within a couple days of taking them.

'It looked like a major winter storm, only the snow wasn't

Hurricane	Category	Landing date	Landing area	Description
Charley	4	August 13	Southwest Florida coast	Moved 'like a knife'; had the most intense winds of any of the storms, but it moved quickly — at about 20+ miles per hour — and it was small and narrow. It carved new inlet in North Captiva Island on the west central Florida coast.
Frances	2	September 5	Florida central east coast	'Frances seemed to prepare the coast for a sucker punch. Then Jeanne came through and really clobbered it,' Sallenger said.
Ivan	3	September 16	Near Gulf Shores, Alabama	'Ivan is something the coastal change folks will be talking about for decades to come,' Sallenger said.
Jeanne	3	September 25	Florida central east coast	'Having a storm hit in exactly the same place within a couple weeks is phenomenally unlikely,' Morgan said.

melting (because it was sand!),' she said, explaining that lobes of sand filled the canals lining the Pensacola Beach area in particular, even to the point of enabling one to walk on the sand across the canal. 'I should know, I took something like 809 pictures of this area alone.'

A USGS press release described it well:

'The barrier islands exposed to Ivan's strongest winds – for example, the communities of Gulf Breeze and Orange Beach, Ala., that were located in the storm's right front quadrant – are low lying. The dunes rise up only several metres, insufficient to have contained the increase in sea level of Ivan's storm surge,' said Abby Sallenger, USGS oceanographer. 'The Gulf spilled across the islands in a strong current capable of transporting massive amounts of sand landward, undermining buildings and roads, and opening new island breaches. On top of the surge, breaking waves nearly as tall as the water caused deep, eroded dunes and battered structures.'

The highest storm surge caused by Ivan was 'something like 3m or more on the open coast,' recalled Sallenger.

This summer also marked the first time that the USGS took a stab at issuing warnings in anticipation of where the storms were projected to go. For example, a press release sent out prior to Ivan's landfall went like this:

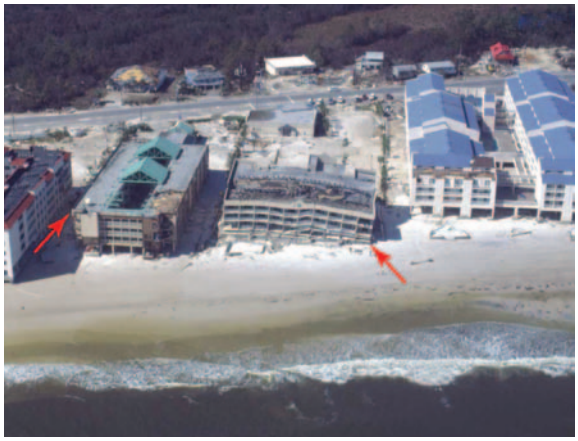
'As of the 11:00am National Hurricane Center forecast, the barrier islands from Louisiana to the panhandle of Florida are within the cone of uncertainly for the path of Hurricane Ivan.' Maps provided by the USGS indicated worst-case scenarios in terms of storm surge depending upon the strength of the hurricane.

'We were a little nervous about doing this,' Sallenger said, 'because it is still an 'experimental project'.

Lidar warning system

Sallenger has worked with the 'experimental' part of it since the late 1990s (see Panel)

Before and after: Breach through Barrier Island, Pine Beach, Al. The island was severed by a breach that may have developed as the back bay drained excess water following the peak of the storm surge, although the breach could have been initiated by waves and surge from the Gulf side
[source USGS]



Before and after: The lower two floors of this five-story building in Romar Beach, Al, collapsed and the third floor has fallen to ground level. Erosion in front of the buildings undermined pools and walkways, and perhaps the buildings themselves. Note the sandy overwash deposits that were driven landward between the buildings by storm waves and currents
[source USGS]

The experimental technology 'tour de force' in this case is Lidar, which stands for Light Detecting And Ranging.

Lidar is a NASA technology that enables scientists to study topography and quantify elevation (eg, the amount of sand along a coastline). It is basically a scanning airborne laser altimeter, Sallenger said. As the aircraft flies along the coast, a laser altimeter scans a swath of the Earth's surface that is several hundred metres wide. It calculates an estimate of the ground elevation every few square metres. Ideally in the coastal change studies scientists collect 'before' and 'after' Lidar data, Sallenger said.

Contrary to the 'old' traditional method of beach profiling 'where graduate students are often the ones surveying every kilometre in single lines, but doing it that way gives you data that are ten times lousier,' Sallenger said, 'with Lidar you fly for a couple of hours, survey an area three football fields wide, hundreds of kilometres of coastline in total, and with far better accuracy. The spatial coverage it provides is astounding'.

This year the USGS team also had storm surge data which, combined with the Lidar information, made for a pretty good data set, said Sallenger. 'We took it as far as we could,' he said. Eventually the team would like to combine it with wave data to make the data set even more robust.

Sallenger said his team at the USGS has already learned a great deal from this year's storm activity and the data collected. They'll be busy for quite some time, he said, but 'the take-home message right now is this: It's easy to say "Don't build on the coast",' he said, 'but the real message is that all barrier islands are not the same. There are some places on the coastline that are far more stable, and others that are much more vulnerable. There are places were we shouldn't even pitch a tent let alone a five-story condo,' he said. 'We want to be able to identify where the most vulnerable areas are, and we want to get this information to the decision-makers – the state and county governments.'

'And before you rebuild in the same location, make sure you do it right,' he added.

Morgan issued a succinct warning, short on words but strong in passion: 'This sort of thing will happen again. …You cannot stop these things. You have to get out of their way.'

Brief History of Lidar

Lidar has been used generally since the mid 1980s. Its initial primary purpose was to assist scientists in their study of the ice sheets in the Arctic. Once introduced to the technology by a colleague, Sallenger saw the application for beaches. 'I couldn't believe the detail you could see in the beach front,' he said. The USGS has used lidar since the late 1990s when Sallenger's team did El Nino work on the west coast of the United States.