

Bruce Melton is a civil engineer and environmental researcher working at the forefront of scientific outreach on climate change. He grew up in Texas, on the Gulf Coast, and now resides in Austin. Bruce has reported on climate change from Greenland, Alaska, the American Rockies and now the Gulf Coast. For this story, he camped for three nights at a deserted McDonald's on the Galveston seawall, filing his journal story from the parking lot of the University of Texas Medical Branch, through their guest wireless Internet connection.

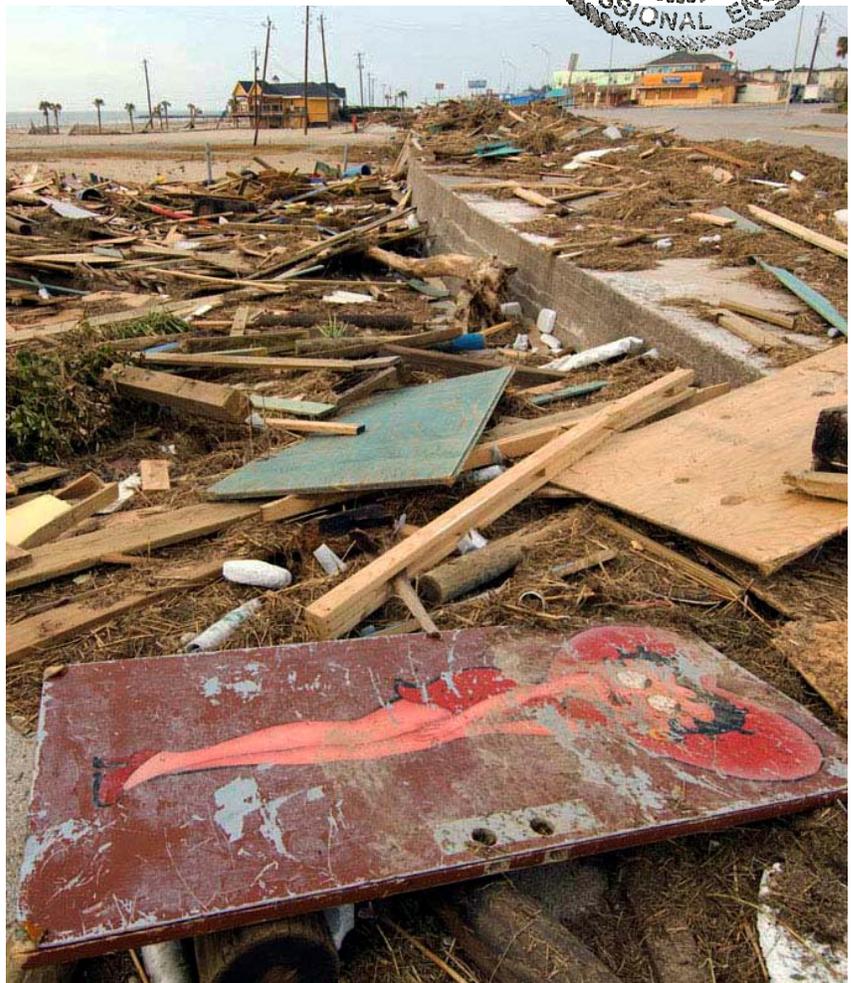
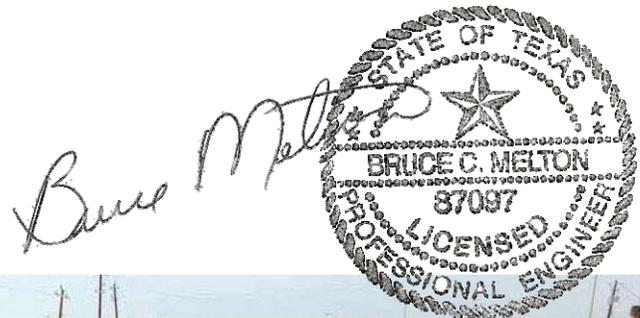
Hurricane Ike: Category 2 Hurricanes and Climate Change

Galveston Island
Wednesday, September 17, 2008
11 pm

I arrived after dark. It took a while to get here. Two of the six checkpoints I met with turned me away. The last 40 miles were driven in the dark. The roads were mostly cleared, but power lines hung low. The debris piles on the roadsides were getting larger as I neared the Island. The city was an eerie place without electricity.

Boats lined Interstate 45. There were few people on the road other than emergency, law enforcement and utility crews. Two lanes were cleared in each direction on the causeway. Piles of debris higher than the truck in places continually lined the road, even in the center between the northbound and southbound lanes. The headlights illuminated nothing but boats and wreckage.

Galveston was deserted and dark. The floodwaters had all drained away. The smell was like an old abandoned house with a bad leaky roof and broken windows.



Machinery had pushed the debris aside to allow vehicle passage. A pleasure boat was laying in the median. It was fairly easy to move about except in the sea wall area. Here, debris was piled along every roadside like snow drifts after a big blizzard. Power was on at the University of Texas Medical Branch Campus on the east end. It looked like the only lit place on the island.

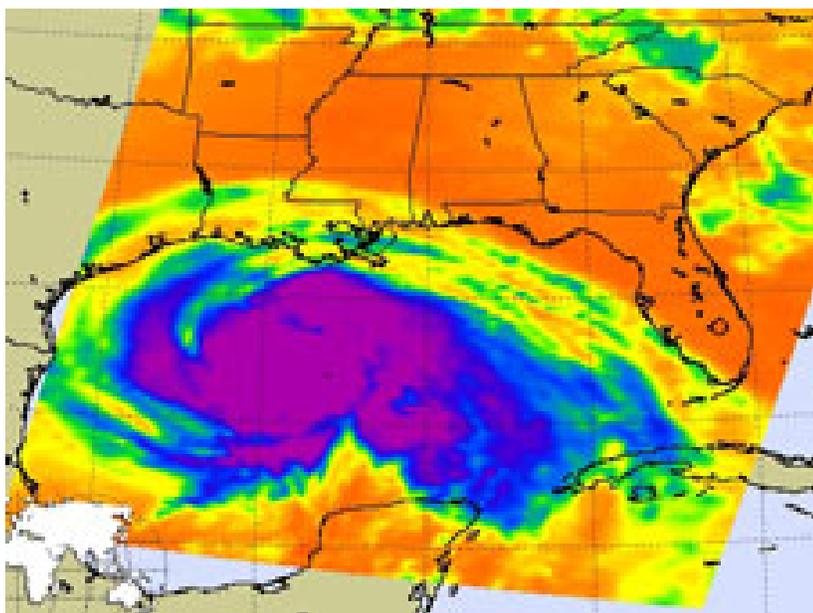
Scientists have been warning us for decades that hurricanes will become bigger and more intense on a warmer planet. Hurricane Ike was a prime example of what they have been saying. I always thought they meant we would have to add a category 6 to the Saffir-Simpson scale, but they also meant that Cat 2 storms will become larger and more intense.

Saffir-Simpson Category	Maximum Wind Speed (mph)	Storm Surge (feet)
Cat 1	74-95	3 to 5
Cat 2	96-110	6 to 8
Cat 3	111-130	9 to 12
Cat 4	131-155	13 to 18
Cat 5	156+	19+

Ike was an odd hurricane in ways beyond its large size. His ground level wind speed never actually caught up with what the Hurricane Hunter aircraft reported at elevation and they new and understood this by using dropsonds, or weather observatories on parachutes that measured wind speed as they fall from the airplane. This issue was widely acknowledged in the hurricane forecast discussions. The highest measured actual ground level wind speed was 102 mph and the highest modeled wind speed from NOAA's Atlantic Oceanographic and Meteorological Laboratory was 101 mph. This means that Ike was weaker than the average Category 2 storm, yet Ike's storm surge was up to fifteen feet high with widespread areas of ten to twelve foot high surge. The normal surge for a weak Category 2 storm is six feet. This means that the actual surge was two to three times larger than normal. Ike's storm surge was, according to the Saphir-Simpson Scale, that of a major Category 4 hurricane.

Camp was in the McDonald's parking lot at Stewart Beach. A wall of debris blocked beach access. Law enforcement was keeping a close eye on everything. My pass had been checked twice now; law enforcement personnel were very helpful and professional and were guarding this crippled city well.

The atmosphere here was intense with the piles of debris looming in the unnatural darkness in the middle of town. It was mercifully cool after an early autumn cold front. The smell of mold was almost tolerable. The mosquitoes were only terribly bad.



Nothing moved last night except local officers, County Sheriff and DPS. A house cat meowed pitifully in the debris on the beach in the distance. The refreshing breeze did not belong at the edge of the deserted McDonald's parking lot. The surf was surreal in the faint moonlight beyond the huge debris field. That forlorn cat's meowing literally began to fill me with fear. Was it: meooooooooow... meooooooooow... meooooooooow... or hellllllllp... hellllllllp... hellllllllp? Was there a person out there? This was the fifth night after the storm, was it possible? I got my flashlight and stumbled off into the debris and almost immediately

stepped on a board full of nails. Luckily the nails did not penetrate the sole of my boot and I lurched on.

Drawing closer to the cat, it was obvious that it was just a poor storm ravaged cat. Deep relief flooded over me... I hoped the cat was ok. It was foolhardy to press on further into the dangerous debris field. I never heard the cat again. A disaster reporter once said that that he always brought cat food along on these assignments. Hmm... make note to self.

Ike's physical size was described as huge and freakishly large with a tropical storm wind field at landfall that spread over 500 miles along the Gulf Coast. NASA said that Ike was twice as big as a normal hurricane.

This is our future on a warmer planet. This is not alarmism this is a true alarm. One may argue today that this storm was or was not caused by mankind's global warming pollution, but scientists universally agree that a warmer planet will produce conditions that are suitable for producing significantly larger and more intense hurricanes. Scientists also universally agree that our planet is warming and that it will continue to warm at a faster rate than anything we have seen in the prehistoric past and that within this century, possibly by 2050, it will be warmer than it has been in three million years. They agree that it will be warmer than it has been since there was no permanent polar ice on the planet and sea level was 200 feet higher.

The Director of NASA's Goddard Institute for Space Studies, the U. S. Government Climate Modeling agency and arguably one of the greatest climate scientist alive, describes all of this very clearly in a paper titled *Scientific reticence and sea level rise*. This paper can be found on Dr. Hansen's website at Columbia University or here <http://www.iop.org/EJ/abstract/1748-9326/2/2/024002/>

09/18/08 Thursday

7:30 am

First light and thankfully, the debris piles adjacent to my abandoned parking lot are not as big as they appeared last night, but the ones along the road are even larger than my imagination dreamed in my

restless sleep. What a mess. The breeze from the surf smells not of salt. Every kind of object imaginable was piled deep and wide, some places overhead; from a child's toy dump truck to a door with a beautiful life-size painting of Betty Boop. Was this from the Balinese?



Coffee from the camp stove helped. The procession of disaster response vehicles, law enforcement, fire and emergency response vehicles began again.

A local pedaled up on his bike. I asked him the standard greeting: "How'd you do?" He had three-foot deep water downstairs in his home on 19th street. The waves came in the house. He described his downstairs as "looking like everything had been inside of a washing machine, sheetrock down and

furniture and personal possessions destroyed.” From the outside, there was no sign of the extreme damage inside.

Another local said that this was much worse than hurricane Alicia, a Category 3 storm in 1983. The storm surge peaked at ten to twelve feet along the seawall with Ike. In Alicia, storm surge peaked at five to eight feet.

Alicia in 1983 was the last major hurricane to hit Galveston. It rated a Category 3 on the Saffir-Simpson scale with 115 mph winds, a five to twelve foot storm surge and \$5.83 billion in damages in 2007 dollars. Ike's insured losses, revised as of September 22 are \$8 to \$12 billion onshore and \$4 to \$6 billion offshore and including National Flood Insurance Program losses could total between \$20 and \$25 billion.

Because the national insurance industry refused to issue new policies along the Gulf Coast after Katrina and Rita in 2005, the state run Texas Windstorm Insurance Association has had to take up the slack. It remains to be seen if their \$2.5 million insurance pool can find enough extra money to cover the losses from Ike.

09/18/08 Thursday

10:30 am

The University of Texas Medical Branch looks little affected, at least from the outside. There are a few broken windows, and those are boarded already. The parking lot is littered with debris. There are a few power lines down and a fallen light pole here and there.



I grew up on the coast. Back in the old days we just boarded up for a Cat 2 storm and hunkered down. But today, with our mega population centers, things are different. The extended lack of services caused by this hurricane would create extremely unlivable conditions if the population were still in place here. The winds may have produced normal damage for this intensity of a storm, but an unexpectedly large and widespread storm surge produced damage much more severe than a Cat 2 storm.

Scientists have been warning us that hurricanes would grow more intense on a warmer planet. This is because hurricanes feed off of warm ocean waters. Scientists agree that that as the ocean waters warm, like they have been doing more rapidly in the last ten to fifteen years, hurricanes will become bigger and more intense. Even though science moves slowly, and statistics take time to accumulate, Hurricane Ike appears to be an example of strengthening of hurricanes caused by global warming.

09/18/08 Thursday

2 pm

The Strand was a giant mud hole. Strong easterly winds drove all the mud out of Galveston Bay into the most historically valuable part of this great little city. Bay mud never smells good, and the water looks like it was at least waist deep inside the buildings.

There were only two doors open on the Strand. It is ghostly here because of the mandatory evacuation. I was able to stop my truck in the middle of the Strand to take pictures. Not a vehicle drove up.

Utility crews were out in force downtown. Linemen were even repairing house connections. Most of the downed trees have been cleared from the streets or at least pushed to the side. I even saw a couple of chipper trucks. Major structural damage was not often apparent; but quite disturbing to note, almost all of the homeowners I talked to had significant damage inside of their homes.

The huge piles of floodwater ruined personal items; furniture, appliances and carpet were just starting to appear on the curbsides. There were very few people in town. The evacuation order was put back into effect today after the aborted attempt at "look and leave". There was just too much damage to let the population of Galveston return safely.

The press was not being allowed onto West Galveston Island beyond the seawall.

Cyclogenesis is the science of hurricane formation. This is one of the rocket science-like areas of weather forecasting. Hurricane forecasters have developed excellent computer models to tell them where a hurricane is going to go, but the intensity forecast of those storms has advanced much less in the last couple of decades. One of the reasons for this is the enormously complicated climate of our planet. Far-reaching events like El Nino in the southern Pacific Ocean have significant effects on hurricane formation and intensity as far away as the Atlantic Ocean.

Blaming increased hurricane intensity on climate change is still a disputed topic because of these complicating factors. The dispute centers around scientific analysis of course, but only a handful of climate scientists disagree with the majority position that man-caused climate change is affecting hurricane strength right now.

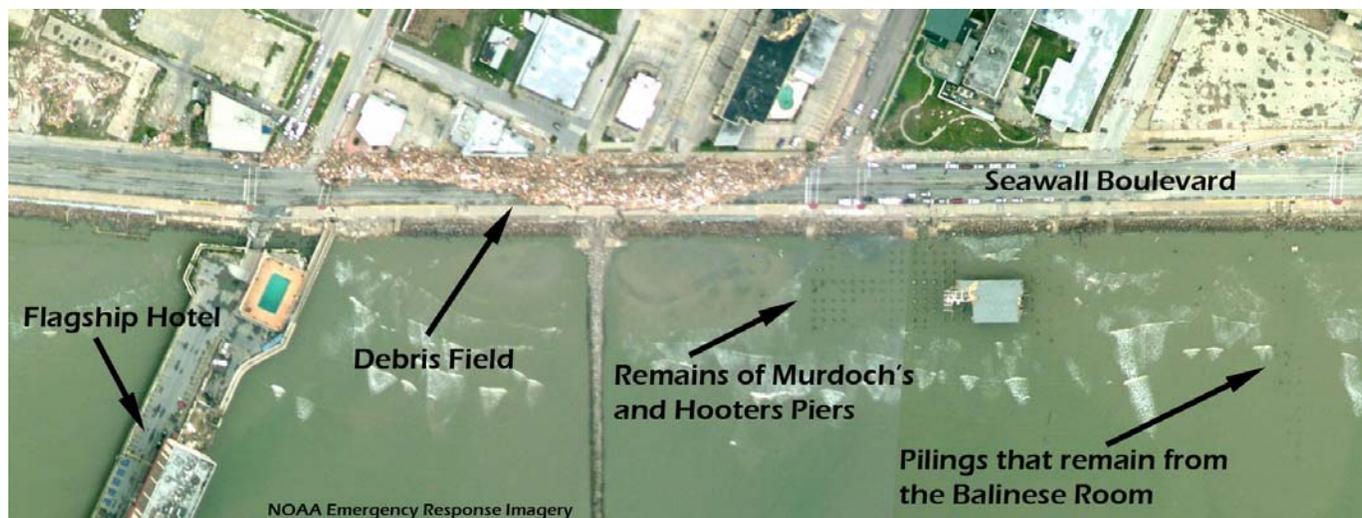
The dissenters are a few very well respected "old-guard" hurricane specialists who continue to see the traditional "natural cycles" as being the recent cause of hurricane intensity changes.

Climate science however is progressing at an extremely rapid pace. Today, there are 1,000 times more scientific papers being published about climate science per year than there were twenty years ago. The majority of the climate scientists today think that this knowledge speaks differently to them than it does to those few established specialists who see natural cycles as being the cause of the bigger and more intense hurricanes.



The largest piles of debris in town were just south of the Hotel Galvez. All of the businesses on stilts over the Gulf were destroyed except for the Flagship Hotel. The debris field completely filled Seawall Boulevard and in places it was over ten feet deep and extended for several blocks.

I talked with a fellow who rode the storm out in a house just behind the Galvez Hotel and he said he heard extremely loud crashes at the height of the storm in the middle of Friday night. Apparently this was when The Balinese, Murdoch's and Hooters (all on stilts over the Gulf) were washed away and were slammed into the seawall by the twenty-foot plus waves. The Balinese Room of course was the infamous illicit gambling house and nightclub of the 1930's, that was made recently famous by the ZZ Top song titled The Balinese.



09/18/08 Thursday

5pm

Curfew is fast approaching. A \$2,000 fine and a trip to the mainland is in store for violators, so I headed off towards my camp in the abandoned McDonald's parking lot next to Stewart Beach. By the way, the McDonald's only suffered minor superficial damage and all of the windows there remained intact. However, the side of the parking lot facing the surf was eroded almost down to sea level; about eight feet. The dumpster pad and the drive through order stations were also destroyed.



On the way back to camp it appeared that there were some relatively large, strange looking boats approaching the beach from the Gulf. I stopped at the gathered crowd and discovered that the Navy was landing. There were three landing craft circling just offshore and one landing craft unloading a big green truck into five feet of water in the surf. This was a real live military landing!

Splashing ashore were a half a dozen trucks, a couple of Humvees, a bulldozer, a bucket loader and a troop of soldiers. They all filed off in procession and set up camp adjacent to my abandoned McDonald's parking lot. How about that...



This evening there seemed to be a good twenty-block area east of the UT Med School where power was back on. The shredded apartment parking cover was not picked up. The brick walls blown off of the nearby apartments remained partially in the street and two telephone or power lines still hung down in an intersection, but the power was back on. The recovery had to start somewhere.

The rattling of bulldozer tracks shattered the evacuated silence of Galveston at some point in the middle of the night. I feared that the Navy was taking down one of the partially destroyed buildings on Stewart Beach, but couldn't see, and was not about to join the mosquitoes for a look. Sleep was difficult even without the clatter... what could they have been doing?

08/19/08 Friday

7:30 am

All of the partially destroyed buildings on Stewart Beach were still in place after the midnight bulldozing episode last night - the debris fields too... I had no idea what that bulldozer had been up to during the night. Further inspection found dozer tracks all around the military camp, but no sign of cleanup. Coffee from my camp stove sure was good.



I missed the press conference today, it was held at 10 am instead of noon like yesterday.

This must have been what it felt like to be a local and to have remained on the island. No news. No television. No paper, and very few neighbors to spread the word.

One of the rumors I heard yesterday afternoon was that martial law had been declared. At that point it was not certain if it was true or not, so what do you do? Better pay attention to curfew time and not get kicked off of the island and thrown in jail as well.



There seemed to be no shortage of folks with lots of damage in downtown Galveston. Here the damage was mostly to the inside furnishings and possessions of homes from floodwaters. Those floodwaters almost completely ruin every single item they contact. A few things could be saved, but salt water is especially hard on belongings.

Two different individuals told me today that they had received only minor damage to their homes, and even though one was an upstairs apartment, this was good news. Good news was a little short on the Island today. Another local related how he worked at a parts counter for one of the destroyed marinas along the causeway. What was he going to do for a living now?



West Galveston Island was opened to reporters today. There has certainly been a hurricane blast through down here. The damage on west Galveston looks worse than anywhere else on the island, even though it was on the lee side of the storm. Thankfully the projected 20-foot plus storm surge never developed. West Galveston Island would have looked like Bolivar Peninsula that took the most damaging quadrant

of the storm full force – total devastation.

All of the homes on the west side of the Island, literally thousands of them, are built on stilts. The living areas are generally 10 feet or more off the ground to protect them from hurricane storm surge.

The Category 4 sized storm surge from Ike created extensive damage. Most of the homes here have walled in areas below the living quarters that are, or were, used for storage. These areas were hit very

hard by the surge. Fully half of the homes had their first floors completely bombed out by water, wind and waves.



When the Galveston seawall was built the top was seventeen feet above sea level. Today the top is fourteen feet four inches above sea level. Subsidence can account for about one and a half feet of this sea level rise. The rest is from an increase in sea level.

Between 1996 and 2005, ice discharge from Greenland

doubled. Ice melt on Greenland in 2007 beat the 2005 record by 10% and the 2008 figures is said to be greater still. Antarctica has long been considered to be a place where ice discharge was less than or equal to ice gain from snowfall, in other words, that Antarctica had no effect on sea level rise because of more snow than melt.

New gravity detecting satellites, 100 times more accurate than the previous satellites, that are now used to analyze ice mass have shown that Antarctica is not at all a place where snowfall outpaces melt, at least not anymore. It appears that about a decade ago a switch was flipped in Antarctica. As of 2006, Antarctic ice discharge had caught up with Greenland's and will likely pull ahead soon.

The doubling and then redoubling of discharge in Greenland was not at all anticipated in the computer models, and in Antarctica, this event was not forecasted to happen for 100 years. As recently as the 2001 Intergovernmental Panel on Climate Change report.



08/19/08 Friday

1 pm

Total destruction was limited to just those beach homes immediately on the beach. Some were completely washed away. In places the ground was swept



clean and all of that debris must have been deposited into West Bay. About four feet of sand was eroded from the beach and for several hundred feet inland.

The utility crews were out in force on West Galveston Island. A main power transmission line that extends the length of the island took a lot of damage. Most of the repair to this line was complete already; dozens of those really big metal power poles were replaced by hundreds of men in hundreds of utility vehicles and bucket trucks.

The evacuation order was still in effect and there were very few to almost no residents on this side of the island. There were thousands of beach homes here. All of them were damaged, some seriously. The roadsides were strewn with personal items, lumber, home furnishings and shredded vegetation.

The one homeowner I could find to talk with said that their place and a couple of others that he had checked for friends received little damage in the living areas, but down below the damage was almost complete. Superficially there was a tremendous amount of damage to roofs, siding and especially the stairs on every home. They all had stairs to reach their second floor living areas, many of which are now destroyed. The devastation of the first floors of these homes is startling. The best news of the day: the 10-foot plus surge kept floodwaters beneath most of the homes living areas.

The storage areas under the homes were generally demolished. Cars and golf carts and boats and freezers alike had floated off, landing askew in odd places. Walls were blown out or completely gone. Above the ground floor storage areas, the most damage was done to homes closer to the beach. These homes were basically shredded. Siding was ripped away. Concrete floors disintegrated. Stairs, decks and porches floated off or were dismantled board by board from the relentlessly pounding waves.

Another striking thing to see here was the lack of a beach. The ten to twenty foot waves were breaking right through the front row of beach homes. Sand dunes lined at least a third of West Galveston Island before the storm. All of these dunes were



completely washed away. Major hurricanes usually take the dunes out completely, but not weaker storms. The dunes are Mother Nature's last line of defense on the coast. Once they are gone, the interior is open to destruction. These are not common things to see with weaker than average Category 2 hurricane.

The wind during Hurricane Ike on West Galveston Island blew offshore. This was the "weak" side of the hurricane. The power poles, the ones that were not broken off, lean towards the beach. The major wind damage was on the sides of the homes "away" from the beach. These are things to remember about hurricanes and climate change. There are no good hurricanes, and what were once weak hurricanes may now become much more damaging, especially as our planet continues to warm.



"Publish or Perish" is a common phrase from academia that can be used to show how the results of climate change research have been reported conservatively by scientists.

The end product of the scientist's work is a paper published in a scholarly journal describing the results of the research. To get a paper published, the scientist's work must be approved by what is called a "jury of peers". This is basically a review committee that deems whether or not the scientist's work is "good enough" for publication. This process is similar to writers getting their work published – it is not an easy task to complete.

As time progresses, continued scientific investigation can reveal new results that may contradict previous work. If a scientist is proven wrong too many times, the scholarly journals will no longer consider that scientist's work as worthy of publication, and the saying "publish or perish" becomes true. This scientist can then no longer publish his or her papers and their academic career perishes.



Scientists are smart people however. They reduce the likelihood of being proven wrong by being conservative in their reports. They use their writing skills to minimize the possibility of being proven wrong by using words like may or might instead of shall. They say could instead of will. They know how to use statistics to say that there is only a probability of something happening instead of proclaiming that it is so.

To keep their jobs, scientists consistently understate their findings. This has become painfully evident in the latest report from the Intergovernmental Panel on

Climate Change. Even before their report came out it was being outpaced by climate change. Greenland, Antarctica, Arctic sea ice, methane, carbon dioxide emissions and sea level rise are all outpacing the results of climate science published by researchers.

It is about twenty miles from Galveston to San Louis Pass. The Pass ends the developed area of Galveston and separates Galveston Island from the Surfside Beach Peninsula. Much of the way the road was lined with tall piles of debris and sand pushed aside to make way for the utility crews. The further from Galveston I drove the worse things seemed to be. This was counter-intuitive to what one would normally think, as the eye of the storm centered downtown Galveston. Likely it was because the eye of the storm never crossed this part of the island and greater winds prevailed for longer down here. The eye wall passed directly over the west end of the island, where-as the northern parts of the island had a two-hour reprieve while the huge eye passed overhead.

One of the last photo stops I made I saw what I believed to be a homeowner on what was left of the eroded beach in front of a few particularly hard hit beach houses.

Because there were very few civilians on the ground, I went over to talk. I found this person was an employee of one of the utility companies sent here to help repair. Hearing this I immediately asked if he was a person that I could ask for permission to interview some of the linemen heroes (these guys are great – they bring the power back!). He said no and then spilled his story.

It seems that he was a public relations employee and it was his job to keep reporters away from the work crews *and*, he had been following me for some time just to fulfill his job! I didn't quite believe him, so after the third or fourth time I made him repeat his story, I was convinced. This was a great guy doing his job while I was doing mine. Both of us being responsible about the way we were behaving.



Some days, even in the depths of a major hurricane cleanup, it is great to be alive.

08/19/08 Friday

4pm

The end of my day's journey down the island was in sight. This is the San Louis Pass Bridge where Chocolate Bay joins the Gulf of Mexico. On my trip down from my home in Austin I had heard that the road from Galveston Island to Freeport, along

Surfside Beach, had been washed out.

The mile-long bridge over the pass was intact and this far down the island, there were almost no people, no checkpoint, nothing. The utility crews had not made it this far yet. The relatively new twelve-plexes

and high-end beach homes on this end of the island looked to have sustained almost no damage. There were very few broken windows and almost none of the first floor areas had been washed out; likely testimony to new, more strict building codes.



The bridge was in good shape and once on the other side it was apparent that virtually no one had been there. There are about one hundred beach homes on the south side of the bridge and the homes being older here; there was some damage and debris consisting of the usual boats on the road and such.

A half-mile from the bridge enormous, thirty-foot long, five-foot deep potholes started appearing on the shoreward side of the road. The giant surf of the storm, on top of the surge, had washed out these huge sinkholes swallowing portions of the road. The power of water is incredible. What a sight this must have been during the storm. Driving here was just a little bit unnerving.

Another half mile and two-dozen of these giant potholes later and I came upon the real road damage. For at least a couple of miles the road was complete destroyed and in its place were storm cuts where the sea had attempted to reach the bay behind the barrier island. These cuts were up too several hundred feet wide and two deep to guess.

This was once my home beach when I grew up south of Houston. It is not like it was back then anymore.



There was once a beach here, and sand dunes and salt grass. The road was never far from the dunes. Ike took care of that for us. Now the surf was within a couple of hundred feet of where the road once was, and the dunes were completely washed away!

There was a trail that ran off into the salt marsh on the bay side of the now non-existent road - where emergency vehicles and law enforcement had been driving - so I put her in four wheel drive and took off. Two trucks with County

officials were on this stretch of trail. We stopped to talk, they told me a little news from Surfside Beach and I told them a little news from Galveston. None of us new much about what was going on then.

It sounds like there was trouble at the village of Surfside too, but curfew was approaching and I needed to get back to camp at the deserted McDonalds parking lot.

Bolivar Peninsula, Crystal Beach, High Island, Gilchrist: these areas were hardest hit by Ike. As of this writing information is still trickling out. Unfortunately, there is very little to say as the devastation is almost complete.

The heavily damaged bridge at Rollover Pass is the only access by road to the area. The Bolivar Ferry is only running for law enforcement and emergency vehicles. Two of the three landings were damaged and of course power is out. Electricity will likely be out for several more weeks.



Galveston allowed residents back on the island Wednesday almost two weeks after the storm, but residents of West Galveston Island could only “look and leave” between six am and six pm. People in Galveston were coming home to almost complete destruction inside of their homes because of flooding. More than eighty percent of the homes in downtown Galveston were flooded to some extent.

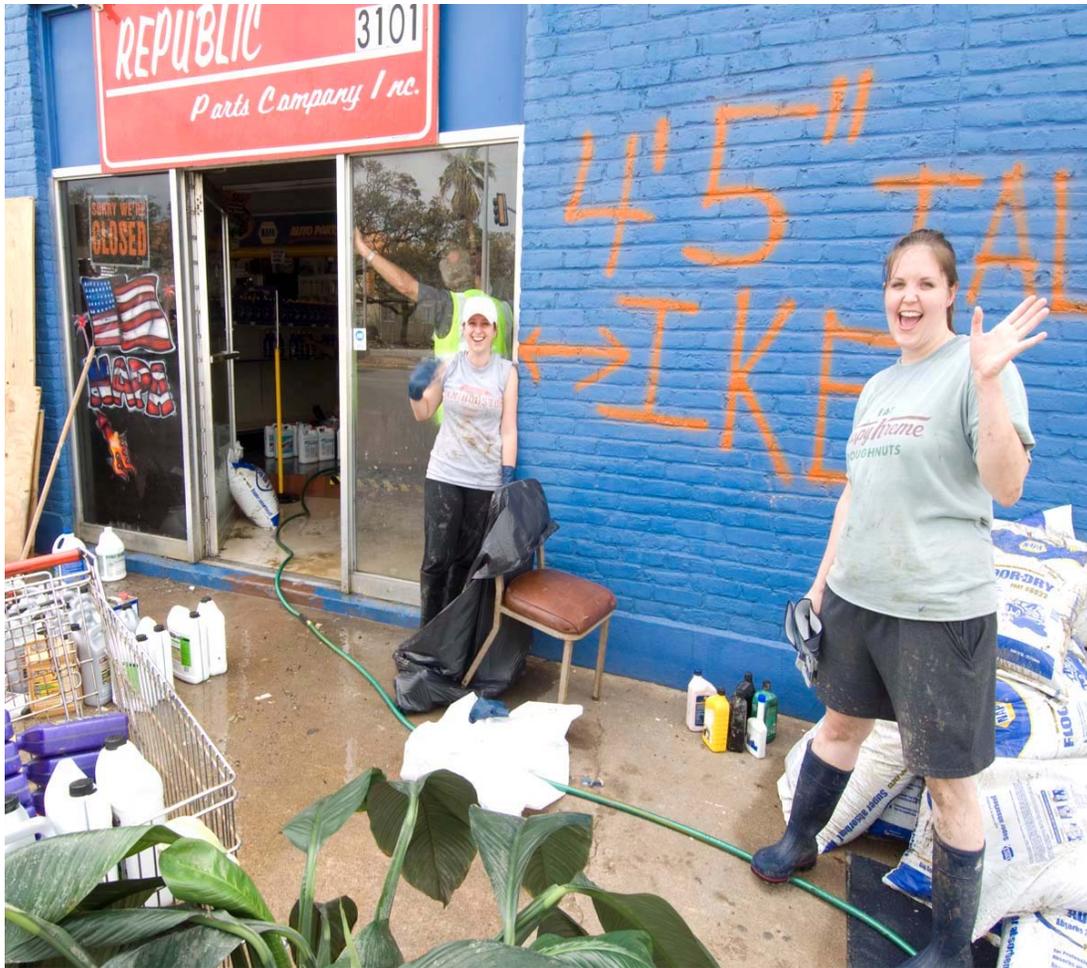
Salt water flooding is worse than fresh water flooding. Most flood damaged items are much more difficult to salvage because of the corrosive nature of salt water.

Because it has been eleven days since the water rose, mold will be a major problem as well. Any flood



water exposed sheetrock will have to be removed, and much of the remaining first floor sheetrock will also be contaminated. Electrical wires, outlets and fixtures in flooded homes may be affected if submerged. It's doubtful that any appliances can be salvaged after salt water submersion. Maybe a few wardrobes can be salvaged. Saltwater flooded automobiles will certainly be difficult to salvage.

Even though electricity and gas lines are operational on most parts of the island, most homeowners will need their electric meters and their gas meters certified by an electrician or plumber because of possible salt water corrosion – before these utilities can be restored to the individual homes. Inspection will cost one to two hundred dollars or more each. Up to 17,000 gas meters may need to be replaced.



The aftermath of a major hurricane is tremendously difficult to overcome. The challenge for our generation today, is that more and more hurricanes will produced catastrophic damage because they will become even larger and more powerful as our planet continues to warm.

A Wake Up Call (Dr. Bill Chameides. 2005)

"While it is not possible to determine to what extent global warming may have contributed to the destruction wrought by a single storm such as Katrina, the evidence is mounting that tropical storms have already become more destructive as a result of global warming, and that global warming will be an increasingly significant factor exacerbating the destruction caused by hurricanes in the coming decades."

(Dr. Bill Chameides, Chief Scientist, Environmental Defense Fund, Member of the U.S. National Academy of Sciences, and has been named a National Associate of the National Academies. He is also an American Geophysical Union Fellow, and has received the American Geophysical Union's Macelwane Award. Dr. Chameides has served as editor of the Journal of Geophysical Research and is the author or co-author of more than 120 scientific publications and five books. He received his doctorate from Yale University, 09/27/2005)

Links and References and Supplemental Information:

NASA Hurricane Advisory Archives

http://www.nasa.gov/mission_pages/hurricanes/archives/2008/h2008_ike.html

Insurance Journal

<http://www.insurancejournal.com/news/southcentral/2008/09/22/93925.htm>

NOAA Hurricane Ike Emergency Response Imagery

<http://ngs.woc.noaa.gov/ike/IKE0000.HTM>

The Galveston County Daily News

<http://galvestondailynews.com/story.lasso?ewcd=4e3343785698fb28>

Intergovernmental Panel on Climate Change Third Assessment (TAR): Summary for Policy Makers, 2001

<http://www.ipcc.ch/>

Intergovernmental Panel on Climate Change Fourth Assessment: Summary for Policy Makers, 2007

<http://www.ipcc.ch/>

Rignot, et. al., Recent Antarctic ice mass loss from radar interferometry and regional climate modeling, *Nature, Geoscience* January 2008

Hanna, et. al., Increased Runoff from Melt from the Greenland Ice Sheet: A Response to Global Warming, *Journal of Climate* Jan 2008.

Overpeck, Paleoclimatic evidence for future ice sheet instability and rapid sea level rise, *Science*, March 2006

Grace: Gravity Recovery and Climate Experiment

<http://www.csr.utexas.edu/grace/>

Leatherman, Greenhouse Effect and Sea Level Rise: A Challenge for This Generation, Chapter 5: Coastal Geomorphic Responses to Sea Level Rise Galveston Bay, Texas, 1984.

Hansen, Scientific reticence and sea level rise *Environmental Research Letters*, May 24, 2007.

Knutson and Tuleya, Increased hurricane intensities with CO2 induced warming as simulated using the GFDL hurricane prediction system, *Climate Dynamics*, 1999.

Palmen, E. H., On the formation and structure of tropical cyclones. *Geophysica*, University of Helsinki, Vol. 3, 1948.

Gray, W.M., A global view of the origin of tropical disturbances and storms, *Monthly Weather Review*, Volume 96, 1968.

Gray, W.M., Hurricanes: Their formation, structure and likely role in the tropical circulation, *Meteorology Over Tropical Oceans*, 1979.

Goldenberg et. al., The recent increase in Atlantic hurricane activity: causes and implications, *Science*, Volume 293, July 2001. Emanuel, Anthropogenic Effects on Tropical Cyclone Activity, Position Paper on Tropical Cyclones and Climate Change, Kerry Emanuel, Program in Atmospheres, Oceans and Climate, Massachusetts Institute of Technology, January 2006

Three day hurricane forecast becomes more accurate with better environmental modeling, *NOAA Magazine*, January 2002

Knutson and Tuleya, 2004, Impact of CO2-Induced Warming on Simulated Hurricane Intensity and Precipitation: Sensitivity to the Choice of Climate Model and Convective Parameterization, *Journal of Climate*, Volume 17, No. 18, September 2004

Emanuel, Increasing destructiveness of tropical cyclones over the past 30 years, *Nature*, Volume 436 August 2005.

Bryden, et. al., Slowing of the Atlantic meridional overturning circulation at 258N, *Nature*, Volume 438, December 2005.

Webster, et. al., Changes in tropical cyclone number, duration, and intensity in a warming environment, Science, September 2005.

Trenberth, Kevin, Uncertainties in Hurricanes and Global Warming, Science, Volume 17, June 2005.

Hoyos, Cury, et. al., Deconvolution of the Factors Contributing to the Increase in Global Hurricane Intensity, Science, Volume 312, April 2006.

Kerr, Richard, Is Katrina a harbinger of still more powerful hurricanes? Science, Volume 309, September 2005.

Sheets, The National Hurricane Center - past present and future, Weather and Forecasting Volume 5, 1990.

Levitus, Warming of the world ocean, Science, Volume 287, March 2000.

Jones, P.D., et. al., Adjusting for sampling density in grid box land and ocean surface temperature time series, Journal of Geophysical Research, volume 106, 2001.

Neumann, C.J., B.R. Jarvinen, C.J. McAdie, and J.D. Elms (1993): Tropical Cyclones of the North Atlantic Ocean, 1871-1992.

Landsea, A climatology of intense (or major) Atlantic hurricanes, Monthly Weather Review, 1993.

Comments by William M. Gray (Colorado State University) on the recently published paper in Science by Webster, et al., titled "Changes in tropical cyclone number, duration, and intensity in a warming environment" (September 2005, Vol. 309, pp. 1844-1846.

Max Mayfield, Director, NOAA's National Weather Service Tropical Prediction Center / National Hurricane Center, U.S. Department of Commerce Oversight Hearing on "The lifesaving role of accurate hurricane prediction" before the Committee on Commerce, Science and Transportation Subcommittee on Disaster Prevention and Prediction, United States Senate, September 20, 2005.

Pielke, Hurricanes and global warming, American Meteorological Society, November 2005.

The image below reflects the actual ground speed wind velocity of the land falling Hurricane Ike. The maximum observed wind speed was 102 mph. The maximum modeled wind speed was 101 mph (89 and 88 knots respectively). Ref: Maximum Wind Contours, NOAA Atlantic Oceanographic and Meteorological Laboratory

http://www.aoml.noaa.gov/hrd/Storm_pages/ike2008/wind.html

Powell, M. D., S. H. Houston, L. R. Amat, and N. Morisseau-Leroy, 1998: The HRD real-time hurricane wind analysis system. J. Wind Engineer. and Indust. Aerodyn. 77&78, 53-64

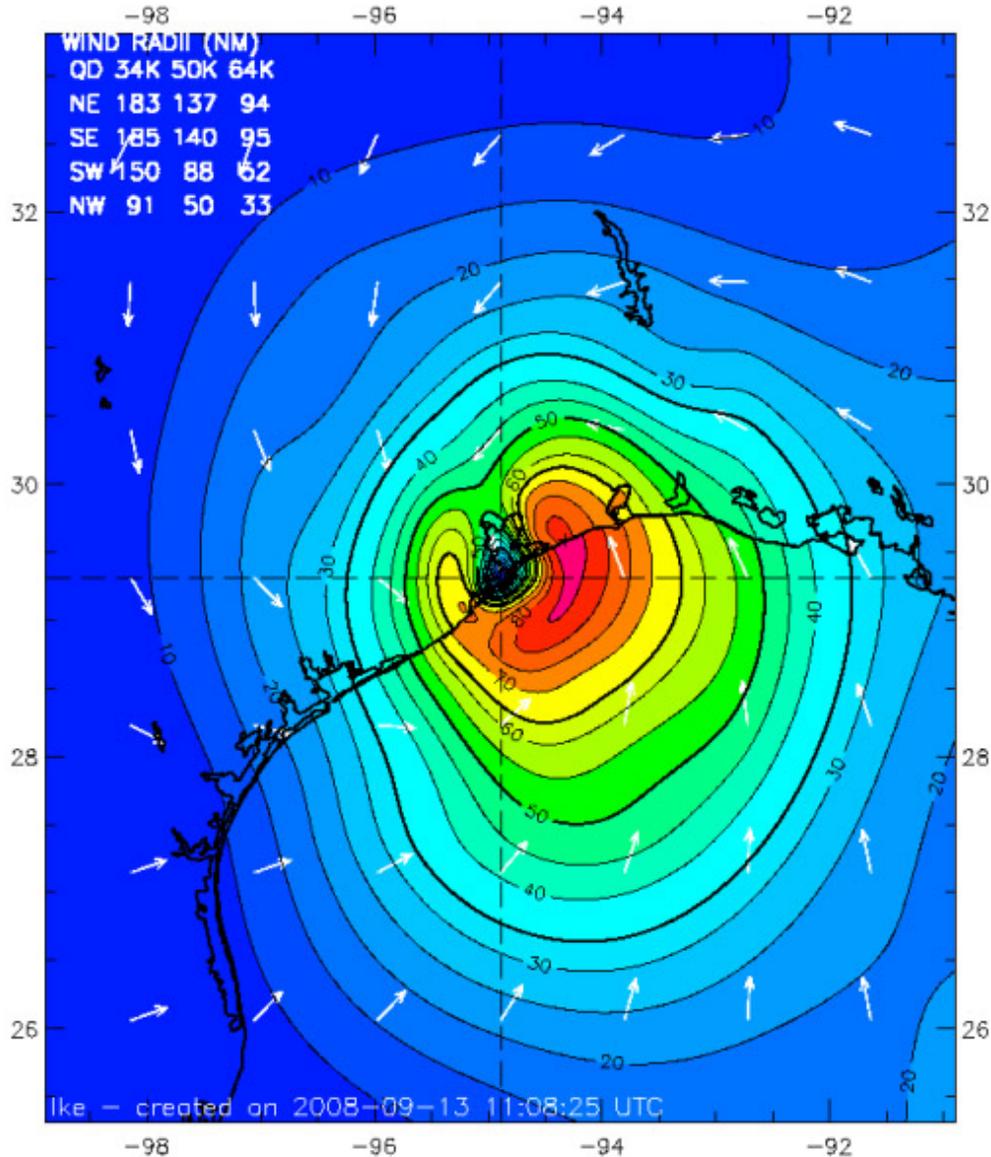
Hurricane Ike 0730 UTC 13 SEP 2008

Max 1-min sustained surface winds (kt)

Valid for marine exposure over water, open terrain exposure over land

Analysis based on GOES_SWIR from 0702 - 1002 z; CMAN from 0439 - 0959 z; MOORED_BUOY from 0430 - 0949 z;
ASOS from 0432 - 1030 z; GPSSONDE_SFC from 0431 - 0850 z;
SHIP from 0600 - 0900 z; METAR from 0430 - 1030 z;
FCMP_TOWER from 0434 - 1025 z; GPSSONDE_WL150 from 0431 - 0850 z;
WEATHER_FLOW from 0430 - 1030 z; BACKGROUND_FIELD from 0730 - 0730 z;
SFMR_AFRC from 0900 - 0956 z;

0730 z position interpolated from 0631 Vortex; mslp = 953.0 mb



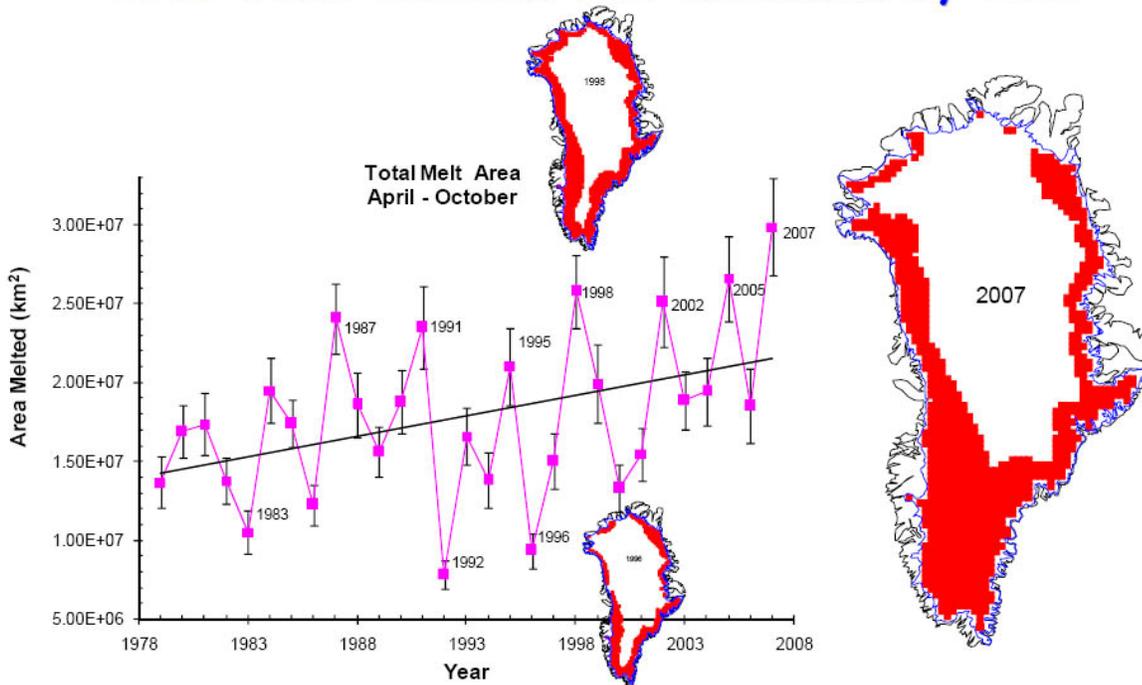
Integrated Kinetic Energy: for Winds > TS force: 70 TJ, for Winds > Hurricane Force: 26 TJ
Destructive Potential Rating(0-6) Wind: 3.0, Surge/Waves: 4.2

Observed Max. Surface Wind: 89 kts, 37 nm NE of center based on 0438 z SFMR_AFRC
Analyzed Max. Wind: 88 kts, 39 nm NE of center

Uncertainty -> mean wind speed error: 1.24 kt, mean direction error: -0.24 deg
rms wind speed error: 6.56 kt, rms direction error: 9.96 deg

Experimental research product of [NOAA / AOML / Hurricane Research Division](#)

Greenland Total Melt Area - 2007 value exceeds last maximum by 10%



Konrad Steffen and Russell Huff, CIRES, University of Colorado at Boulder

The Eastern End of Surfside beach where the Blue Water Highway crosses over to Galveston Island: