COVER: Satellite view of Hurricane Andrew as it approaches south Florida. The storm was to be the worst natural disaster (in terms of dollar damage) in U.S. history. Photograph courtesy of Roger Edwards, National Hurricane Center, Coral Gables, FL.

Storm Track is a non-profit publication intended for the scientist and amateur alike who share an avid interest in the acquisition and advancement of knowledge concerning severe or unusual weather phenomena. It is published bi-monthly in Lewisville, Texas. David Hoadley founded the publication in 1977 and Gene Rhoden designed the current cover. Anyone interested in copies of back issues should contact the editor.

Persons are encouraged to submit articles to STORMTRACK. Papers should be double-spaced and contain proper English. Photographs should be loose or lightly taped. High contrast photographs are preferred. Diagrams should be clear and legible. All articles will be reviewed by the editor.

The following subscription rates are effective January 1, 1992: U.S. First Class mail $12/year, Canada $14/year, and England/Japan $20/year. The new rates will include two issues per year with either a color cover or additional pages of text. Individual issues are now $2/copy. Back issues are available by year, or the complete 14 year set (1978-1991) can be purchased for $80. To subscribe or renew, send a check or money order payable ONLY to Tim Marshall, 1336 Brazos Blvd., Lewisville, Texas 75067.

STORM TRACK CLASSIFIEDS

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PHOTOS/SLIDES WANTED: I am looking for some severe thunderstorm photographs or slides for my new book: "Severe Thunderstorm Handbook". This book will be published next year. All materials will be handled and returned with care. Acknowledgements will accompany each published photograph and royalties will be offered. Contact Tim Vasquez at 217-892-9233 weekends or evenings.

1991 KANSAS TORNADO HIGHLIGHTS: A 1-1/2 hour VHS videotape summarizing the editor's best chase season ever. You'll see 14 tornadoes over three chase days. On April 26th, two tornadoes were filmed near Wichita, KS including one that went on to strike Andover. On May 16th, you'll watch a repeat performance in the same area. See violent motion of one tornado close-up in excellent light with the camera mounted on a tripod. Then, ten tornadoes in a row were witnessed near El Dorado, KS on May 26th along the Kansas turnpike. What a show! Just send $30 postpaid to Tim Marshall, 1336 Brazos Blvd., Lewisville, Texas 75067.
I. SHORT COMMENTARIES

HAS MOTHER NATURE GONE MAD? Since our last issue, three major hurricanes have struck United States territories. Typhoon OMAR struck Guam about the same time Hurricane ANDREW blasted south Florida. Then Hurricane INIKI struck Kauai, Hawaii. All of these storms reached category 4 status at some time in their lives. The increased storm activity has left many people wondering if our climate has changed. Some people blame El Nino, the warm pacific ocean current, for the storms. More heat applied to the ocean surface leads to more storms, they say. I've also heard other persons say that Mount Pinatubo caused the storms since more ash in the sky led to more condensation nuclei (rhyme). Finally, the other day I heard that it was the accumulation of electromagnetic smog over our cities that causes more storms. Enough is enough already! It is a human fallacy to believe that these storms must somehow be related to some other natural phenomena. Years ago, folks blamed the atomic tests in Nevada for storms. Why not accept it was mother nature going about her business. This time, the land just got in the way!

IS THERE TOO MUCH RELIEF? After Hurricane Andrew struck south Florida, relief efforts were slow to materialize. Initially, officials did not realize the extent of damage as power lines were down, and roads were blocked. In the weeks that followed the storm, hundreds of relief groups (large and small) headed for south Florida. When I visited south Florida to assess the damage, I soon realized there plenty of relief groups around. There was the military, all sorts of church groups, and other specialty groups too numerous to mention. I saw mountains of bottled water, hundreds of volunteers, more food than an army could eat, and heaps of clothing piled on the ground. Within hours the clothes were soaked by heavy rains and they had to be bulldozed and burned. Empty tents were everywhere. At first, there was too little relief, and now there is too much.

ANDREW WAS MY FRIEND! A lot of people hated Andrew, but Andrew was my friend. I spent a lot of time watching him grow. Many people complained he was too small, but that didn't bother me. I knew that one day his strength would make up for his small size. Ok, so he was too predictable, a fault of many who travel in life's fast lane. He didn't like Florida much, just passed through it on his way to Louisiana. I never realized how alive he was until just before his death. I stayed up on his last night alive, watching him slow down and lose strength. He seemed to sense his own demise as he paused at the water's edge. In a way it was sad to see him die.

THE BATTLE OF THE WINDS! As Andrew's winds died, a battle of a different sort began to brew. Many people in south Florida left homeless by Andrew, turned their shock into anger when they realized their homes were built poorly. How would you feel if your destroyed home never met the local building code? What if you found out that many construction details were absent or inadequate? Developers and builders insist that Andrew was an "act of God", a storm so powerful that nothing could escape destruction. Obviously, that's not true. Many engineers are saying that the destruction in south Florida was caused by winds less than 120 mph (code value), however, some meteorologists are saying the winds were 175 mph. Juries will have to decide if builders or mother nature is to blame. My fear is that if homes did not meet building codes during normal times, how in the world are they going to meet codes during the massive rebuilding-boom!
Andrew formed in classic Cape Verde fashion from an African wave, becoming a depression on 16 August and a tropical storm on the 17th. From the 18th through the 21st, an upper level low ESE of Bermuda had drawn Andrew north, buffeting it with shear and reducing it to a 1015 mb system with tropical storm-force gradient winds in the northeast quadrant. Most of the upper low moved NE and became caught up in higher-latitude westerlies, leaving Andrew trapped south of a strong deep-layer ridge, with no place to go but west and nothing to do but deepen — fast. Andrew became a hurricane early the 22nd, then bombed 72 mb in 36 hours, becoming a 922 mb borderline Category 4/5 hurricane by midday 23 August. Andrew cruised due W, weakening to 941 mb across the Bahamas. In its short passage over the Straits of Florida, the eye shrunk, cloud tops cooled fast, and the eyewall solidified. When Andrew hit land near Homestead FL, it was a tightly wound little Category 4, with 1-minute sustained winds of about 145 mph gusting to 175 mph, peak surge of 16.9 ft in Biscayne Bay, and a pressure of 926 mb. [By contrast, the lowest pressure at Miami International Airport was 992 mb, meaning a 66 mb gradient over 20 miles!] In terms of pressure, Andrew was the 3rd-strongest landfall in U.S. history, behind only Camille (1969) and Labor Day (1935). Andrew crossed Florida and the Gulf of Mexico, oscillating several times in intensity, before final landfall as a Category 3, WSW of Morgan City LA on the 26th. It also spawned several tornadoes with 2nd landfall, including a killer near Laplace LA. Preliminary death and damage estimates are 54 and $15-30 billion respectively, making Andrew the most expensive U.S. disaster ever.

I had been in 3 tropical storms (Alicia, Marco, and Fabian), but Andrew was my first hurricane. What an introduction! As I said so stupidly but accurately on my video, "This was clearly not a trivial event." I tracked the storm from noon to midnight Sunday at NHC, using our NEXRAD PUP (a Doppler radar workstation) to plot center fixes, and watching with increasing awe as the long-awaited Big One motored our way. During the day, the cirrus on the eastern horizon evolved to dense cirrostratus, and the first outer band moved across with a nice lightning display around sunset. The eye became well-defined on radar, as it came within range of both the WSR-57 on our roof and the WSR-88D (NEXRAD) antenna in Melbourne. Satellite, radar, and airplane fixes had Andrew pegged on a rigid westerly course. The computer models came in, unanimously taking Andrew across Dade County shortly before dawn. Meteorologists and media alike braced for disaster with an eerie mix of eager anticipation and resignation to impending doom. By the time I left, Andrew was deepening again, and it was obvious we were going to be sledgehammered by a strong category-4 hurricane.

The streets of South Miami were deserted as I drove home; I was relieved to see that everybody was taking this seriously. With no hurricanes since 1965, and a population of around 2.5 million (mostly newcomers) from all over the nation and the world, the reaction by the public of Dade County to the warnings was amazing and outstanding. Tanja and I took a macabre little walk around our Dadeland neighborhood at 12:30, an hour before the first serious inner band, speculating on what effects 120+ mph eyewall easterlies would have on each sign, tree, and building we saw...including our own apartment complex! We had a north wind about 10 mph, lightning from the band offshore, and no rain.

My storm-induced adrenalin rushes had allowed my only 3 hours’ sleep in 2 days, but I still could force only an hour’s nap before I woke up and heard the first good gusts outside. No way was I going to sleep through a millisecond of this! I made sure my video camera was ready to go -- oddly, the same one I bought from Jim Leonard, before he left for Guam due to Miami’s hurricane drought. Our windows were boarded up, of course, so I was outside on semi-protected 2nd- and 3rd-floor hall balconies, shooting by the lights around the
complex. By 4:30, the eye was 15-20 miles SSE of me over Biscayne Bay, and we still had power and TV! The winds outside were gusting well over 100 mph by then, and I was out on those balconies filming away and hoping it wasn't too dark for video.

Green-blue flashes of exploding transformers lit the sky, while that famous howl of the winds drove horizontal rain sheets past me faster than I could track them. On video I said, "This is still not as strong as a couple thunderstorm outflows I've been in." Seconds later, I ate those words; I heard boards, branches and glass breaking somewhere not far away in a gust too strong to estimate, but way over 120 mph. I saw shingles and other small objects flying past, but it was too dark to catch them on video. The building shook some, above the constant structural vibration. I stuck my left hand past the plane of the balcony wall for a few seconds, risking amputation by airborne missiles to feel the sting of rain and winds like I had never seen. I was in the eyewall! At 4:45, with the center of the eye 15 miles almost due south and about to make landfall, the power finally failed -- no more video 'til dawn. I went back in and took shelter with Tanja in the bathroom, in case the south-facing windows blew in anyway in the NE part of the eyewall, turning our possessions into deadly projectiles. One final foray out the front door greeted me with 50 mph winds and flying tree leaves -- in the adjoining INNER hallway!

Meanwhile, 2 miles further north (and further from Andrew's eye), NHC was rocking, literally. The din of the storm was audible to all inside, and the swaying of the building was readily felt on the 6th floor. That floor has metal hurricane shutters, but a window still busted out. A gust of 164 mph slammed the rooftop anemometer, before it was blasted away by another gust. Suddenly, a deep BOOM rocked the building, silencing everyone... The radar had been torn from the roof! Somehow, generator power and computer links held throughout the storm, allowing NHC and WSFO Miami to issue every single warning and statement without interruption. Several meteorologists from South Dade were working with nerves of steel, devoted to their mission while knowing their homes were being obliterated.

At first glimmer of light, with hurricane-force gusts in departing inner bands, I was out filming the storm and its effects. Damage was relatively light where I live, mostly uprooted or snapped trees, a few missing windows, and chunks of roof missing. My complex was solidly built, and luckily, my apartment proper was almost unscathed. Tanja had parked her car in the Dadeland Mall parking garage a block away, and I needed an excuse to get out in Andrew and do some filming before it left. Camcorder wrapped in a trash bag, I went to the garage and drove her car out, only to find every route but one blocked by fallen lines, trees, light poles, and even railing from the elevated Metrorail tracks. Filming the whole time, I drove around the neighborhood, while dodging dangling light standards and debris of all kinds. All east-facing windows were blasted out of a 20-story building located 4 blocks from my apartment. Several miles further south in the Goulds, Redlands, and Cutler Ridge neighborhoods, then down into Homestead and Florida City, devastation was much worse; that was what you saw on national TV. During subsequent days, I filmed damage in those areas, choosing my routes carefully so I wouldn't impede relief efforts.

I was back at work again at noon Monday for the first of 2 more 12-hour shifts, tracking Andrew as it headed for Louisiana. The NEXRAD from Houston, over 200 miles away, showed the eye in crisp detail as it moved ashore for the last time. For a storm maniac like me, it was the ultimate excitement, a memory for all time. Only a 1.5-mile wide F5 monster tornado could rival this, and I didn't have to go anywhere to chase Andrew! My personal jollies were contrasted, though, by all the suffering everywhere around me. I'm ready for another one, but only on a recon flight or chasing somewhere else. Imagine trying to chase a 20-mile wide F3 through a major urban area at 5 am; that's what Andrew was!
IN THE HEART OF A KILLER STORM  by Warren Faidley

As the jet lifted off the runway, I sat back in my seat, closed my eyes, and took a deep breath. For over ten years, I had carefully planned this moment. Like an athlete in training, I envisioned the awaiting events numerous times and even pondered the dangerous possibilities. But this was reality, my job, and there was no turning back. My eight hour flight from Tucson, Arizona to Miami, Florida allowed me plenty of time to remember all of the recent hurricane scenarios where storms either stalled, died, or turned away from Florida. But, Hurricane Andrew's westward trek remained constant, and there was little doubt in my mind that a monster hurricane was going to hit south Florida.

As a photographer who makes his living chasing severe weather, I have encountered hundreds of storms, some of them quite violent. However, I knew that chasing a powerful hurricane would be different. The tornadoes I have chased were viewed from the outside looking in, and I usually had control over the situation. But chasing a hurricane required putting yourself inside the heart of the storm; there was little control.

Andrew was still a tropical storm on Friday, August 21 when I made the initial decision to intercept it. Forecasters were predicting that Andrew would strengthen and pass over south Florida during the daylight hours on Monday, which caught my attention from a photographic point of view. All of the recent major hurricanes, including Hugo, made landfall at night providing limited photographic opportunities.

Early Saturday morning, I made my final decision to intercept Andrew and called my travel agent. I completed the final check of my "hurricane pack"; a waterproof bag filled with safety, survival and photographic equipment. When I arrived in Miami late Saturday night, one of the first things I did was purchase three gallons of drinking water, a three day supply of food, two cans of flat-fix, all which proved to be very important. Motel rooms were few and far between as people left coastal areas and moved inland. But I found a room, though it was difficult to sleep knowing that Andrew was headed my way.

I awoke Sunday morning to the sound of a television in an adjacent room with a reporter noting evacuation orders. I filled the sink with water, then left my room to get a newspaper and breakfast at the local Denny's. Bold headlines on the Miami Herald read: "Bigger, Stronger, Closer", referring to Andrew. I overheard a man saying that the hurricane was "no big deal" adding that he had been through "a number of them". By mid morning, lines were already forming at gas stations & grocery stores. One enterprising man was on the side of the road selling candles.

My next stop was the National Hurricane Center in Coral Gables where I met Steve and Mike, veteran hurricane chasers who have a similar passion for storms. We discussed Andrew and several locations where we could safely photograph the storm. After surveying the coast, we decided to ride out Andrew in a parking garage near the Dinner Key Marina in Coconut Grove. The sturdy steel reinforced concrete building was built like a fortress. "Fort Andrew" someone quipped. The interior was well protected with thick concrete walls. Exterior walls were mostly solid concrete with large square openings that offered safe vantage points for taking pictures. From this building, we could see almost 360 degrees around. A building to our south did offer some blocking protection from the onslaught of flying debris expected from the marina. Our seven-story garage was located about two hundred yards from the marina.

Late Sunday afternoon was exceptionally peaceful. A few people strolled along the boardwalk; schools of fish darted about the calm waters in the marina. There were a few clouds and small thunderstorms to the southwest, but there was no discernible sign of danger. Throughout the early nighttime hours, we carefully
monitored the radio and television broadcasts. Every hour, Dr. Robert Sheets, Director of the National Hurricane Center, would give updates on Andrew. Hurricane Andrew was now a category 4 storm. Its forward motion increased such that it was now expected to strike during the early morning hours. This was a major setback for a photographer who needed daylight to shoot pictures. I tried several times to take a nap, but it was no use as the winds were increasing. Like sentries awaiting an advancing army, we all took turns looking out from our borrowed fortress over the Miami skyline searching for the earliest signs of Andrew.

Florida Light and Power decided to leave the electricity on until the power lines were destroyed. This provided us with an early warning system as arcing powerlines gave notice of approaching high winds. The bursts of light also helped us see in the pitch black darkness. Line arcing and related transformer explosions became increasingly more intense as the evening progressed. The sound of the wind overcame even the car alarms that were going off at a steady rate throughout the garage. Steve and I took an anemometer (wind measuring device) and held it outside the fourth floor. Gusts to 65 mph made it very laborious to hold the meter even with both hands.

Around 4 a.m., the real wrath of Andrew bore down upon us. Windows from surrounding buildings imploded, sending shards of glass everywhere. I don't recall being cut, but I glanced at my arm and saw blood. A small piece of glass was imbedded in my arm. Occasionally, a very loud "thud" was heard. I could only guess that it was the sound of some building roof being torn apart. At this point my senses were on red alert, a type of awareness that I have experienced a number of times while in dangerous situations. Although the data from your senses of sight, sound, feeling, and taste are being processed so quickly, I somehow slowed down the events in my mind so I could deal with them in a rational and timely manner. The flip side of this was panic, which I avoided.

The infamous "hurricane wail" other people have described was unreal. The sound of the wind howling through the garage was wicked enough, but when it was mixed with breaking glass and crashing debris, it permeated my memory like a had song. To me, it was more like a devil's scream. The winds increased to such a force that any attempt to walk passed an open area in the garage was impossible. Exposing just half of your body to the blast of wind would take your breath away.

My journey from the fourth level to the ground level was an adventure by itself. I entered the stairwell and proceeded downstairs. While exiting the building, I almost made a fatal mistake. I allowed the basement door to close behind me, but quickly realized this, and lunged for the closing door. Just as the door slammed shut, I smashed against it hitting my head and nearly knocking myself out. After regaining my senses, I reached to open the door, but there was no handle or knob! It was pitch black and I was stuck. I expected to be carried off in a flood of water from the storm surge. Fortunately, I felt the partially exposed locking mechanism and with a pinch, I was able to open the door. Rainwater poured down the elevator shafts and stairwells. Emergency lights flickered on and off in an eerie fashion. Pipes from the fire sprinkling system swayed, some crashed to the floor. Paint had been stripped from those pipes that faced the wind. One pipe had fallen across a row of cars.

Over five hours Andrew pounded us with everything it had. Around 6:30 a.m., a faint blue tint could be detected in the sky signaling a rising sun. The dim morning light was welcomed. Less than one hour after sunrise, Andrew was history. We found the floor of our fortress covered with all sorts of debris. Many boats in the marina were seriously damaged or washed ashore. Totally exhausted, wet, bruised, and cut, I sat for a moment on the edge of the broken marina and sighed. The images once envisioned were now reality. But most important of all, it was great to be alive.
Sloshing through the storm surge (Warren Faidley)

Fort Andrew parking garage (Warren Faidley)

Chasers brave the early morning squalls (Warren Faidley)

Palm fronds sway in the wind (Warren Faidley)
ANDREW AFTERMATH  by Tim Marshall

Hurricane Andrew struck southern Florida on August 24, 1992 and entered southern Louisiana on August 26, 1992. After the storm passed, Rich Herzog and I spent five days in southern Florida and Louisiana surveying the damage. Our task was to assess the performance of various buildings and to see how well or not how well they were built. We also wanted to gain better insight on the magnitudes of winds and water levels during the storm. During our survey, we visited the National Hurricane Center in Coral Gables, Florida and the National Weather Service in Slidell, Louisiana. These folks helped us a great deal and we thank them. Their information combined with our own is presented in the following summary.

A. HURRICANE ANDREW CHRONOLOGY

Hurricane Andrew could be traced back to an easterly wave that developed in North Africa during the second week in August, 1992. A tropical depression formed along the wave when it was about halfway between Africa and the easternmost islands of the Caribbean (11 degrees north, 38 degrees west) on August 17, 1992. Thunderstorms organized around the center of a low pressure system and the storm strengthened to tropical storm status later that day. It was at that time the name "Andrew" was assigned to the storm.

Tropical Storm Andrew moved rapidly along a west-northwest course but fluctuated in strength over the next four days as it encountered bands of upper level wind shear. The storm exited this area and began gathering strength on August 21, 1992. At 5am, on August 22, 1992, the storm reached hurricane status; the winds increased rapidly as the central pressure dropped.

Hurricane Andrew moved steadily west along 25.4 degrees north latitude during the next day. The lowest barometric pressure (27.23 in. or 922 mb.) was recorded at 12:48pm on August 23, 1992, when the center of the storm was positioned east of the Bahamas. The hurricane had reached the upper end of category 4 status on the Saffir-Simpson scale. Maximum flight level winds (10,000 ft.) were measured as high as 195 miles per hour or 170 knots.

Around 6pm on August 23, 1992, the eye of Hurricane Andrew passed the northern end of Eleuthera Island in the Bahamas. A surface reporting station recorded a maximum wind gust of 120 mph as the eye wall passed. The height of this wind instrument above the ground was unknown. Reconnaissance reports indicated the hurricane had a "double eye" structure for a few hours. Hurricane Andrew weakened slightly as it passed through the Bahamas and the central pressure rose to 941mb.

On the morning of August 24, 1992, Hurricane Andrew struck south Florida. The eye passed over Elliott Key located on the western end of Biscayne Bay. Fowey Rocks Buoy, located east of Elliott Key, reported northerly winds sustained at 141 mph (123 knots) with a peak gust of 169 mph (147 knots) at 4:00 am as the eye wall passed. Sea level pressure was 967 mb. Data transmission ceased after that time. The height of the wind instrument was 143 feet (43 meters) above sea level.

Around 4:30am, the eye of Hurricane Andrew was centered over Biscayne Bay. High storm surges occurred from near Turkey Point to as far north as Miami. Seawater inundated numerous homes along the coast. Key Biscayne was submerged during the storm. The highest storm surge was over 16 feet NGVD in Derring and Saga Bays. Many boats moored at Black Point and Coconut Grove marinas were damaged or destroyed.

Landfall of the eye occurred around 5:00am just east of Homestead Air Force Base. The eye diameter was approximately 15 miles across and extended from SW 216th street to the southern end of Florida City. The northern end of the eye wall...
reached SW 88th street. The National Hurricane Center, located in Coral Gables, Florida, was on the northern edge of the eye wall. They reported a maximum sustained wind of 138 mph (120 knots) with a peak gust of 164 mph (143 knots) at 4:50 am before the wind instrument was destroyed. The height of the wind equipment was approximately 200 feet above ground level. Miami International Airport reported a maximum sustained wind of 86 mph (75 knots) with a peak gust of 115 mph (100 knots) from the east around 5:50 am. The height of the wind equipment was approximately 33 feet (10 meters) above the ground.

It took about three hours for Hurricane Andrew to traverse southern Florida. Towns of Homestead, Naranja, Leisure City, Goulds, Princeton, Cutler Ridge, and Florida City sustained heavy damage to buildings. Moderate building damage occurred in the communities of Perrine, Howard, and Kendall. Minor damage to buildings occurred north of 104th Street. By 8:00 am, the eye of Andrew was located over Big Lostman’s Bay on the west coast of Florida in Everglades National Park. The storm had weakened to category 3 status, and the barometric pressure had risen to 29.91 in./951mb.

When Hurricane Andrew entered the Gulf of Mexico, it re-intensified to category 4 status. However, the storm never recovered its pre-Florida landfall intensity. The lowest barometric pressure recorded while the storm was over the Gulf of Mexico was 27.52/936mb at 4:00 pm on August 25, 1992. Approximately two hours later, Hurricane Andrew slowed and started to curve northwestward towards the south-central Louisiana coast. Central barometric pressures continued to rise, and Hurricane Andrew gradually lost strength. The storm was downgraded to category 3 status prior to landfall on the Louisiana coast.

As Hurricane Andrew approached Louisiana, an isolated storm on one of Andrew's rainbands spawned a tornado that traveled west-northwestward through Laplace, Louisiana. The tornado damage path was 9 miles long and about 150 yards wide. The tornado was rated F3 on the Fujita damage scale. Damage to homes was more severe in the tornado than hurricane-caused damage to similarly constructed homes in Louisiana. The tornado lasted ten minutes beginning around 8:10 pm.

The eye of Hurricane Andrew skirted the coast along Vermillion Bay for several hours until curving northward and coming ashore near Burns Point, Louisiana around 3 am on August 26, 1992. Slow forward movement of the storm and close proximity of the eye wall over marshland caused the hurricane to weaken; central pressures rose and the hurricane was downgraded to category 2 status just after landfall. Rising pressures in the core of the storm led to lower wind speeds and storm surges inland in comparison to when the storm struck Florida. Consequently, the damage-causing potential of the storm was less in Louisiana than in Florida. The eye of Hurricane Andrew eventually passed over Franklin, Louisiana just after sunrise. Towns of Morgan City, Berwick, and Patterson were located east of the eye and sustained the most severe wind damage. Only minor damage occurred in towns of Lafeyette, Baton Rouge, and Houma.

The Morgan City Power Plant reported a maximum sustained wind of 92 mph (80 knots) with peak gust of 108 mph (94 knots) at 3:05 am from the south. The height of the wind equipment was approximately 50 feet above the ground. The highest reported storm surge was 9 feet NGUD at the Marine Conservatory at Cocodrie, Louisiana. Andrew continued northeastward and was downgraded to a tropical storm during the afternoon on August 26, 1992 when the center of circulation was between Baton Rouge and Lafayette.

B. AERIAL DAMAGE SURVEY IN FLORIDA

An aerial damage survey was conducted on September 5, 1992 over southern Florida. The survey began at the Miami International Airport. We made several east-west
traverses south of the Miami airport from Tamiami Airport to Coral Gables southward to Florida City. Cities of Coral Gables, Kendall, Howard, Perrine, Cutler Ridge, Naranja, Leisure City, Homestead, and Florida City were included within the aerial survey. Our final traverse extended from Ocean Reef Key northward to Key Biscayne. We made the following observations from our aerial survey:

1) RESIDENCES: Most of the damage to residences occurred south of an east-west line extending through Tamiami airport. The damage primarily involved loss of roof coverings that were tiles and composition shingles. Concrete masonry residences performed well. We saw few failures with these buildings. Damage to these structures ranged from F0 to F1 on the Fujita scale. There were certain subdivisions which sustained more building damage than adjacent developments. These residences had wood-framed walls and roof structures. Homes in certain subdivisions sustained damage up to F3 on the Fujita scale, however, we do not feel the wind velocities were F3 intensity.

2) METAL BUILDINGS: Severe damage occurred to large metal buildings. Many hangers at Tamiami airport and Homestead Air Force Base were destroyed. However, smaller metal buildings fared much better, especially if their large doors faced a direction opposite of the oncoming wind. Mobile homes were destroyed and several mobile home parks south of 104th street sustained severe damage.

3) MISCELLANEOUS: Water towers remained intact in each community we visited. Only a few television and radio towers were downed by the storm. Many light standards remained intact. From items that were damaged as well as items not damaged, we estimated the maximum (sustained) wind velocities between 120 and 130 mph in eye wall areas.

C. GROUND SURVEY OF FLORIDA

A ground damage survey was conducted throughout south Florida south of an east-west line extending through Tamiami airport. We paid close attention to details that involved fastening roof coverings, decking, roof trusses, and gable ends. The types of fasteners (nails or staples) and roof connections (metal straps or hurricane clips) were noted.

1) ROOFING: Many concrete tile roofs sustained severe damage as the tiles were not well secured to the roofs. Tiles laid on mortar patties installed over rolled roofing performed poorly. Typically, failure initiated between the tile and the mortar or between the roll roofing and the roof deck. The result was numerous tile missiles which caused additional damage to buildings downwind. Tiles nailed to wooden battens also performed poorly. In many instances the tiles were lifted over the fastener head leaving the nailed battens intact. In these instances, the fastener heads were smaller in diameter than nail holes in the tiles!

Three-tab shingle roofs sustained severe damage. Many homes were completely stripped of shingles. Shingle roofs that were stapled performed worse than roof shingles that were nailed. In many instances, the staples were installed incorrectly on the shingle with crowns oriented up and down (vertically) instead of along the width of the shingle (horizontally).

2) ROOF TRUSSES: Premanufactured wooden roof trusses had little to no lateral bracing and cascaded (like falling dominoes) when the roof decking was removed. This problem was evident even when metal straps were used to secure the ends of the trusses to the top plates. Wood-framed gable ends and exterior walls were lightly nailed to other framing members. Numerous failures were noted when the nailed connections pulled loose.
D. GROUND SURVEY IN LOUISIANA

A ground damage survey was conducted throughout south-central Louisiana extending south and west of a line from Grand Isle to Houma to Lafayette. We assessed the performance of residential structures, metal buildings, and wooden commercial facilities paying close attention to connection details. The following observations were made from our ground survey:

1) RESIDENCES: Most of the damage to residences occurred in a line from Morgan City to Franklin to Cypremort Point. Conventional wood-framed structures survived with little or no damage except on Cypremort Point where damage up to F2 intensity was observed. Failure occurred when homes were impacted by flying debris (metal boathouses). Gable ends failed in some instances, otherwise, most of the damage was confined to various roof coverings.

2) MOBILE HOMES: Mobile homes performed poorly. Many failures initiated when the stapled connections between the walls and floors as well as the roof trusses and walls had pulled loose. There were no metal straps between roof/wall and wall/floor members. Walls pivoted becoming horizontal as the roof covering tore loose. Mobile homes that were not tied down properly had rolled or flipped over on their sides. Maximum wind velocities probably did not exceed 100 mph.
SELECTED WIND SPEED AND STORM SURGE MEASUREMENTS

A preliminary report of Hurricane Andrew offers a glimpse into the statistics of Andrew's wind and water forces. Wind measuring instruments were rendered inoperable in many places, making data unavailable.

**WIND SPEEDS**

- **Number in small type indicates the greatest gust.**
- The number in wind type is sustained wind speed of at least one minute. in miles per hour.

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<td>Fowey Rocks</td>
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<td>Nort' Hurricane Center</td>
<td>10.0</td>
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<tr>
<td>7</td>
<td>Virginia Key</td>
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</table>

*Instruments failed after this measurement, so speeds could be higher.*

**STORM SURGE DEPTH**

- Site 10m main used for comparison

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<tr>
<th>Site</th>
<th>Surge Depth</th>
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</tr>
<tr>
<td>20</td>
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**SOURCE:** NOAA, National Hurricane Center
Andrew closes in on south Florida

Andrew in the Gulf on the 24th

Andrew closes on Louisiana
Devastated mobile home park in Homestead, FL (Tim Marshall and Rich Herzog)

Mobile home cleared to the floor (Tim Marshall and Rich Herzog)

Stapled wall/floor (Tim Marshall and Rich Herzog)

Lightly stapled roof trusses pulled loose (Tim Marshall and Rich Herzog)

Ground view of mobile home park (Tim Marshall and Rich Herzog)
Damage to concrete tile roof (Tim Marshall and Rich Herzog)

Cemented tile thrown by Andrew (Tim Marshall and Rich Herzog)

Wedding picture among broken tiles (Tim Marshall and Rich Herzog)

Whole roof coverings were removed (Tim Marshall and Rich Herzog)

Stapled shingle roofs performed poorly (Tim Marshall and Rich Herzog)

Misapplied staples - should have been parallel to chalk line (Tim Marshall and Rich Herzog)
Skeletal remains of roof structures indicated wood deck problems (Tim Marshall and Rich Herzog)

Garage door blew inward causing south wall to blow outward (Tim Marshall and Rich Herzog)

Full and half sheets of plywood decking lightly stapled to roof (Tim Marshall and Rich Herzog)

Gable ends fell outward as they were minimally attached to roof (Tim Marshall and Rich Herzog)

Water-soaked ceilings fell when roof coverings were removed (Tim Marshall and Rich Herzog)

Full sheet of plywood with roof shingles still attached. (Tim Marshall and Rich Herzog)
No bracing in attic allowed roof trusses to fall like dominoes (Tim Marshall and Rich Herzog)

Only three nails held this second story wall in place (Tim Marshall and Rich Herzog)

Wall simply fell outward when studs were pulled from bottom plate (Tim Marshall and Rich Herzog)

Base of wall where studs were pulled from bottom plate (Tim Marshall and Rich Herzog)

Metal straps at top of wall held trusses in place as they rotated (Tim Marshall and Rich Herzog)

Metal straps at base of wall kept it from failing (Tim Marshall and Rich Herzog)
Two-story steel boathouse collapsed at Black Point Marina trapping boats (Tim Marshall and Rich Herzog)

Water mark from storm surge at Black Point Marina (Tim Marshall and Rich Herzog)

Boats tossed about by 12 foot storm surge (Tim Marshall and Rich Herzog)

Poorly attached wall was peeled back on this condominium complex near Deering Bay (Tim Marshall and Rich Herzog)

Large span double-tee building collapsed in Cutler Ridge, FL (Tim Marshall and Rich Herzog)
Aerial view of Tamiami Airport -- most of the metal hangars and planes were destroyed (Tim Marshall and Rich Herzog)

Columns rotated inward as center of hangar collapsed -- note loss of sheet metal walls (Tim Marshall and Rich Herzog)

Close-up view of column base showing pulled anchors and broken concrete foundation (Tim Marshall and Rich Herzog)

Airplane draped over tree at Tamiami Airport (Tim Marshall and Rich Herzog)
IT JUST TAKES ONE GOOD DAY

by David Hoadley

Chase '92 was only moderately successful for this chaser, but one good day salvaged an otherwise minimal season. As Tim Marshall noted in the last Storm Track, almost everything that could go wrong did. There were several opportunities, but the atmosphere had a mind of its own. I flew out for a rare, quick weekend chase April 18-19 in Texas but came away empty handed, despite two days in the middle of tornado watches - and one a High Risk!

I returned to the chase from May 15-26 and June 4-14. That's right, I came home one day early, before the outbreak of the 15th in Kansas. Since a Moderate Risk for widespread tornadoes the day before had not verified, movement of the trough now seemed unsure, and my annual leave was used up - I started for home that Sunday evening. (Sometimes you do have to act like a responsible person). Of course, Monday began a three day 150+ tornado outbreak, and I was miserable for weeks after!

My first severe weather this year was a distant tornado and funnel 20-25 miles southwest of Fort Stockton, Texas on May 24. I would have driven closer, as at least two other chasers did, but misjudged the proximity of the storm base to a secondary road just ahead of it. I saw several small funnels over the next few weeks but nothing to compare with the excitement of slithering down a mud slick road in suburban Texoma.

Having met Warren Faidley south of Springfield, Colorado at the end of a fruitless June 5th chase, we went charging south to the next day's expected storms in west Texas. In the lead, I missed the turnoff onto southwest US 54.

But, no problem, we continued down a local street to the cemetery south of town and turned west on the paved road back to the highway. WRONG! Oh, it headed due west alright but was soon no longer paved. We failed to duly regard a slowly moving vehicle a mile ahead, in the late evening light, with caution lights flickering -- until it slid completely off into the ditch. At that point, we were already committed several hundred feet down this mud slide. Warren and I counseled over the CB what to do but decided it best to continue west - and by all means keep moving. So for an interminable 20 minutes or so, I fought continuously to keep the crown of the road and maintain a 2-3 MPH crawl. It was virtually impossible to drive straight! I simply aimed straight, began sliding sideways, corrected and oversteered, returned to straight and slid to the other side. We passed the stranded vehicle at its luckless roadside stop -- up to its hubcaps. Drawing on every driving skill I had, including many icy trips over Dakota highways, I managed - with great relief - to lead our little caravan to pavement, carrying an extra 40 pounds of mud in the wheel wells. Warren's cheerful CB reply once we were clear: "Hey, let's do that again!"
Fortunately, this misadventure was more than offset by the main show on June 7 southwest of Roswell, New Mexico. The cell wasn't much to look at on satellite, and the tornado drew only one line in the Midland newspaper the next day. However, it made my trip!

I started from Midland that morning with a forecast for southeast New Mexico. As I approached Carlsbad, small Cbs were building to the northwest over Roswell. I drove north to Artesia and then west. Ironically, I had stopped in the little town of Hope (!), when the radio interrupted with a tornado watch. I was right in the middle and on the west side of the box. The cell to my west was the only good one within 100 miles, so I went for it. (As I left, I thought how often others chase "with hope," but I had actually started there.) Good fortune held on the chase road which was US 82 to Alamogordo. One of the few good roads in eastern New Mexico, it was parallel to and just south of the action. The storm base eventually opened up with a clear notch and a white column gradually appeared through the rain on the northwest side of the notch. At first I thought it was a towering cumulus but then said to myself, "Hey, no tcu comes almost to the ground." Then I thought it might be a hail shaft. But, "Hey, hail shafts don't turn like that." It was, of course, a large tornado - almost 1/3 of a mile wide and rotating like a great white stove pipe. The condensation base was never visibly in contact with the ground, and I saw no suction vortices or dust swirls beneath. However, it was over wet, rocky terrain and a slight valley obscured full view. Intermittent ground contact from damaging tornadic winds was likely. It became visible about 5:26 PM CDT, imbedded in rain, and much clearer after several more minutes as the rain core moved east. It turned magnificently in space in a great, slow dance of power and majesty. Lightning bolts occasionally struck the ground around, framing it in dramatic bursts of energy.

After it roped out 20 minutes later, I drove to the west side of Hope and stopped for one last look. A westbound State trooper pulled up to ask what I had seen. I gave a full report and said it was unlikely to make any more tornadoes, noting the diminished inflow bands, less organized base and increased core rainfall.

In any case, I said the old rotation center was now several miles north of town, and it was no longer in danger. His shoulders sagged with a great sigh as he said, "Whew! That's a relief! These things drive me crazy." He turned around and drove into town. I passed where he had stopped next to several anxious Hope citizens studying the skies. They crowded around for his report and - perhaps - my second-hand reassurance (Another small community service from the chaser brigade to offset our sometimes irresponsible image).
I encountered yet another State trooper during a brief taping of hail bouncing on the highway east of Hope. I reassured him I wasn’t completely crazy and he continued east. When I reached Artesia, I stopped at the first convenience store to phone home. When I finished and turned about, the second trooper was sitting in his car next to me—also wanting “more input.” The Hope storm base was approaching and still looked dark and foreboding. I reassured him about Artesia and said I was going south towards Carlsbad, since I thought more storms were likely there. He thanked me and I left.

I stopped in Carlsbad at 9:10 CDT to make another call home and just ahead of a turbulent storm base. I was in a motel lobby, when the lights suddenly went out and hard, gusting winds swirled up just outside. I glanced up at the approaching front, as I raced to the car to avoid the coming deluge. As I cleared the east side of town, now almost black with cloud mass and heavy rain, I heard a radio report of a tornado in Carlsbad that had damaged several buildings, while I was there! But I had not seen it (if ever it was real). At that point, I was 15 miles east in hard, driving rain and had no interest in turning back. After an hour of plowing water, I broke clear at Hobbes. Among other memories of this interesting day was how fast a clear air mass at 6PM could change in 3 hours to cover all of south-eastern New Mexico with heavy rain and strobe lightning. Also, I recall a trooper in Artesia, who may still be wondering what ever happened to the Virginia stranger who went to Carlsbad one evening in June.

Isolated cumulonimbus “Cb” with pulsing anvil in southeast New Mexico. Photograph by Dave Hoadley.
The Severe Supercell Thunderstorm is noted not only for its relative infrequency and intensity, but also for its relative isolation from other storms in a particular region. Because of these traits, it can be argued that the statistical odds of multiple severe supercells striking the same geography over a short time period are low. Yet, on the evening of April 28, 1992, the western portion of the Dallas-Fort Worth Metroplex was hit by three consecutive severe supercells in just over four hours. Each supercell intensified in almost the exact same location and followed a surprisingly similar path. Together, the storms triggered some of the most expensive hail damage in Texas history, testifying to the costly vulnerability that urban areas can have to major meteorological events. Big hail storms occurred quite frequently across the plains during the Spring of 1992, but only occasionally did they infringe upon heavily populated areas. April 28 was one of those occasions. Three separate supercells brought three separate hail storms. For storm enthusiasts, the sky became a repeat performance, but, for a lot of urban residents, the sky became a repeat offender.

On the evening of April 28, a warm front was situated along the northern and eastern portions of North Central Texas, roughly from west of Tyler, Texas to near Wichita Falls. Southerly surface winds were pumping hot and humid air across North Central Texas at speeds often gusting over 30 mph. The upper level flow was strong from the Northwest, and temperature transitions across the frontal boundary were as much as 25 degrees in places. A tornado watch had been issued for the area, good up until midnight, but as of 7:00 p.m., the Dallas-Fort Worth area skies were cloudless. Along the border of Clay and Montague Counties, east of Wichita Falls, the skies were not so clear. The first in a series of three supercells was intensifying along the frontal boundary and sliding Southeast. As the storm entered Wise and Denton Counties to the immediate northwest of the Dallas-Fort Worth area, it became severe. A tornado touched down in Pelican Bay, Texas as the storm began entering the outskirts of Fort Worth, and golfball size hail showered the western boundary of the region.

Mammatus formations on the leading edge of the storm had a classic supercell look. Lightning was also very frequent, but the most alarming site may have been the wall cloud that hovered over western Fort Worth during the passage of the supercell. Waymon Meeks photographed the feature as it moved over Fort Worth's Carswell Air Force Base. This was the same wall cloud that had produced the tornado several minutes earlier. The inflow produced no further wind damage, but did fuel a lot of hail. As the supercell progressed south, it dropped baseball size hail on the City of Cleburne, Texas, and produced straight line winds reported up to 100 mph.

Meanwhile, another surprise was moving into Wise and Denton Counties to the northwest, one that the region will remember for a while. A second supercell had intensified along the same Clay and Montague County border and slid southeast, reaching severe status. Cloud tops were 55,000 feet. Skies had cleared after passage of the first storm, and winds again became southerly. The second supercell entered the Fort Worth area around 11:30 p.m., and brought its most severe impact around midnight. Baseball size hail pounded thousands of residences in southeastern Fort Worth and southwestern suburban Arlington, Texas. News reports in Dallas-Fort Worth have now estimated the damage to be in excess of 400 million dollars, making it one of the most costly hailstorms in both Texas and U.S. history. Three months later, the city landfill at Arlington, Texas was still accepting roofing waste resulting from the hailstorm -- on the order of 400 to 500 tons per day (Fort Worth Star Telegram, 7-29-92).

The "one-two punch" of these supercells was impressive, but the evening wasn't over. A third severe supercell was trailing only 50 miles behind the second. This particular cell actually had a longer history than the previous two. It started much earlier in the evening in southwestern Oklahoma, becoming tornadic before sunset. As it progressed southeasterward toward the Texas border, it weakened -- only to reach the now infamous border area between Clay and Montague Counties and fire up again. It entered Wise and Denton Counties, triggering the third round of severe thunderstorm warnings of the evening. Its movement into Dallas and Fort Worth brought more wind and hail -- only 90 minutes after the second supercell had left holes in roofs and windows.

April 28, 1992 was a great study in severe supercell development, as well as a demonstration of the impact that they can have on urban areas. Certainly, as urban areas across the country continue to expand and occupy a greater proportion of the total land area, the odds of severe weather impacting urban activities will continue to rise. On this particular evening, perhaps over 2 million people were exposed to severe weather. The three storms combined to produce a 50-mile wide swath of hail -- many people getting hit more than once. A powerful supercell laboratory was conducted multiple times in one evening and in one geography. It was a night when both hail and insurance claims ended up going through the roof.
Inflow area of first supercell (Waymon Meeks)

Relative storm paths (4/28/92)

Lightning illuminates second supercell (Scott Rae)