

Transcript

Q: This is Jinny Nathans, AMS archivist, on April 19, 2018, and I'm here with Peter Black doing a quick interview at the Hurricanes and Tropical Meteorology Conference, and Peter's going to give us some information on a topic of his own choosing. Thank you.

A: OK, Jinny, well, thanks a lot. I guess I could start at the very beginning and just mention how I got into this field.

Q: That would be perfect.

A: It all began, for me, with Hurricane Carol in the Boston area, 1955. I think it was '55.

Q: I knew I was hearing a bit of a Boston accent.

A: (laughter) Yeah, I'm afraid I got (inaudible) by a little speech impediment that I was born with. No matter where I've lived, it just kind of followed me around for the last 70 years or so. But that was really the beginning. I was 12 years old then, and that was such a spectacular event. My mother was absolutely petrified. My dad, I think, was off on a business trip someplace. But for me it was out of fascination, to witness the power of nature, and even as a little kid then, I remember thinking, well, how can nature create such an incredible event like this? And rather than fear, it was fascination and excitement, was my initial reaction.

I remember when the eye came over our area and the sun came out, I went running outside to see, wow, what happened here, and the thing that I remember so distinctly was the smell of wood, just broken trees, and it just hits you like this pungent aroma that has always been like a reminder of a catastrophe. I wasn't thinking about the fact that we only had five minutes before the back side of the eye wall came over, so my mother came screaming out after me, grabbed me by the shoulder and dragged me back in the house again, and then the worst part of the storm hit and the place was just shaking on its foundations, and then I got a little scared. (laughter) Saying, oh my God, what's going to happen here?

So I got a feeling and a flavor for the excitement and the fascination of hurricanes, along with the fear that people feel when they're actually on the ground involved in these things. So that stuck with me. I had been a weather nut since I was born, practically. I remember being fascinated by northeasters there in the Boston area. My dad was transferred to New York City for a couple of years, and we had a blizzard down there one winter that was absolutely fascinating. I was glued to the window the whole time. That was back in the late forties. I must have been about six years old. That was my earliest conscious remembrance of being interested in the weather.

So it was kind of my hobby, and I was fascinated all through high school, and when it came time to go to college, first of all, I wanted to go to meteorology school. Second, I wanted to go someplace where I could learn something about tropical storms. That didn't really materialize too much right away, but I was fortunate enough to have some absolutely mentors early on. One was Oscar Tanenbaum, who was the meteorologist-in-charge of the Boston office then. I corresponded with him. Ken Spengler – I remember writing him saying, hey, how can I join the

American Meteorological Society? And I think that was 1956, and I've been a member since then, although I think all the records somehow have been lost in an AMS file somewhere.

Q: Not quite all. (laughter)

A: (laughter) But Ken was just always – I remember thinking, why would he be interested in me? And I was just a kid then. But he invited me to AMS headquarters, which was on Joy Street then, and always he gave me this feeling of, the AMS is a family, which what I always felt my whole life. This is a big family, and we're all in this together.

Lautzenheiser was the climatologist at Massachusetts, and he actually came out to the house and offered to make me an informal weather observer, so my dad helped me out, and we built a weather shelter for the backyard, and I started taking temperature and wind observations (laughter) with the Weather Bureau then. And then when I went to school in St. Louis, St. Louis University, I was fortunate enough my freshman year to be taken under the wing of Ed Brooks, who was the son of the founder of the AMS.

Q: Charles Franklin Brooks.

A: Absolutely, yeah. So I was always being fascinated by all the memos of Charles Brooks at the AMS headquarters there and saying, well, gee, it was his son that really helped me out and also instilled in me this desire that one thing I should always try to do throughout my career in the future then was to mentor other young scientists and students, and I've kept that as an absolutely rewarding, fascinating goal throughout my entire life, and I've been fortunate enough to have the opportunity to mentor a number of students at I think 12 or 15 or so different universities around the country. I was never in the university as a professor but always as an advisor to various students at different stages of their careers, and in the laboratory as well.

So that was kind of my early years that helped me get started in this field and really helped to mature this fascination with the weather and hurricanes that I just felt like I was born with. I don't know where it came from. My brother always felt really bad that he didn't know what he wanted to do when he was 12 years old, and he thought maybe something was wrong with him (laughter), but he went on to be a dentist, and the two of us were the first doctors or Ph.D.s in the family. My dad was the first of our family to go to college, at MIT, by the way. But those mentorships, although I wasn't conscious of the effect at the time, just had a huge impact on my life.

So I guess what I had in mind to talk about – I could drone on here for hours, I think, on this subject. But just going to relay – maybe we have enough time – there's a couple of stories that are linked together of especially fascinating and intense experiences on a couple of hurricane flights. I could back up a little bit and mention how I happened to get involved in hurricanes to begin with. I was fortunate enough one summer to, just on a whim, drive up to the University of Chicago, actually to the weather office up there, looking for something to do for the summer, and Dorothy Bradbury, who was an assistant to Dr. Ted Fujita at the time – he was right next to the Weather Bureau – she told me to go next-door and that Professor Fujita was looking for somebody to help him out during the summer.

And so I went over there, and he says, oh, yeah, we can even pay you. I said, you can pay me? (laughter) So I worked with him for a couple of summers helping to put together some of these photos and – he had this incredible catalog of photographs of tornado damage that he'd gotten started on with the tornado surveys. So one thing led to another, and I wound up applying to graduate school at the University of Chicago and got accepted, even got a pretty nice fellowship at the time, but Fujita offered to give me an office, and he didn't have to pay me then because I got the fellowship that he suggested I apply for.

And it all worked out, though, so even though – students there at the time – we were given a little office in the attic of this old Victorian house at the University of Chicago, which a number of the professors were in, which made it really actually pretty fascinating, too, that we worked in this big, Gothic building that the rest of the department was involved with. Professor Fultz and Professor Braham – they were on other parts of the campus in a more traditional university setting, but Fujita and even Dr. Pettersson, who was there the first year I was there – I wanted to go to work for either one of those two gentlemen, but he was in the process of retiring, so Pettersson was only there for about six months when I got up there.

Anyway, the ambiance was fascinating. The Weather Bureau actually was in one of these old Victorian houses, too, right next-door, so that was kind of neat. I could always go see what was going on with the local weather, just take a break and go next-door. And then Professor Platzman was behind us in another one of these old Victorian buildings, which happened to have been the building that Carl Rossby occupied when he was there, when the Chicago School was going full-bore.

I kind of got in just on the tail end of the so-called Chicago School – Herbert Riehl, Joanne Simpson, (inaudible) – a whole group of what became very famous people. They had kind of moved on by that time. Bill Gray had just graduated I think a year and a half ahead of me, and I wound up getting to know him, and he was another incredible person that helped me maintain interest in not only severe storms – got me more involved in hurricanes. And we became the best of friends ever since then. That would have been 1964, '65. So, as with many, many other people in our profession that were honoring Bill today, in fact, with his contributions, it's almost impossible to do a proper job of that, because he affected so many people like myself. I never was his student, just a friend, but he always, always supported stuff that I was trying to do. We'd get into arguments, and Bill would come up alongside and said, OK, Pete, let's see what you got to say today. (laughter)

Anyway, that was kind of the early beginnings. And I remember once, I think my second year at Chicago, Fujita said, you know, we got a new grant for doing studies of hurricanes, which was a little side interest besides doing the tornado studies. And he said, you're going to be my hurricane man. How would you like to go to Miami for a summer job? And I said, oh, well, that sounds interesting. (laughter) So I got hooked. He sent me down there. I got on a couple of hurricane flights. And I had an offer later on to go to work at NCO when NCO was just being formed as well, and it was an unbelievable set of opportunities there. Either one was going to be a win-win. But after flying on the storms, I decided, I'm going to Miami. (laughter)

So I went down there, and I wound up working for Fujita for five years, and he wasn't very anxious to graduate his students. We were good, inexpensive labor at the time. And I was kind of not terribly motivated to move ahead with a Ph.D. at the time. So I accepted an offer to go to work down in Miami after a couple of summers there, and that was an offer I couldn't refuse.

So once I got down there, after three years, I remember Harry Hawkins, who was Jeff Hawkins's dad there, one of the students I was able to mentor and help out – I met him when he was seven years old and followed his career along. But Harry said, you know, it's your turn to go back to school. And I said, my turn? Yeah, he said. We have a sort of government scholarship that young scientists can apply for, and we've got nobody else except yourself that's qualified to apply for these. And I said, I don't want to go back to school. I'm tired of (laughter) the university. He sat down. He says, OK, let me tell you something. Just think of it this way – it's a business proposition. You're going to make money off of this. We're going to pay your way. We're going to pay for your books, your tuition. You're going to (inaudible). And we pay you a stipend to pay for the living expenses up there. And he said, if nothing else, you're going to make money, so just don't argue with me and do it. (laughter)

So I did. One thing led to another, and I qualified for the Ph.D. exam. I wound up a year later leaving Penn State with everything but my thesis, so I wound up having to procrastinate a number of years, but I was finally able to finish the thesis work under Rick Anthes up there, and I regarded that as a union card.

But along the way, I wound up being involved in some of the early hurricane flights on various aircraft. My initial job there was to be a radar operator on the old DC-6, and then I wound up somehow or other being promoted to work with the Navy and fly with the WC-121 aircraft during STORMFURY, which was just an absolutely fascinating experience. But since we've got a limited amount of time here, I'll skip forward to after the post-Storm-Fury era, where we were becoming more focused on hurricane flights to document the intensification of hurricanes.

At that time, there were only a few of us that were available to actually fly the flights as flight meteorologists. One of the early flights that I got involved in was a flight into Hurricane Gladys in 1975, actually September 29, 1975, in which we were hoping we would be able to document the development of a weak hurricane into a strong (inaudible) was forecast to intensify. But it turned out to be a flight we almost didn't come back from. Turned out to be, and still was, one of the most unusual hurricanes I ever flew in, because a couple things happened. First, on the way inbound on the first leg – the storm was northeast of the Bahamas, by the way, and we were flying out of Miami – we had a power failure on the aircraft and lost power to the main instruments on that first penetration. So the pilot says, look, I've never flown a storm that I haven't been able to get into. My instruments are still working in the cockpit. Let's just keep on going.

So he descends down below cloud base. We'd lost our ability to get real-time winds at flight level, so he said, let's go down below cloud base. We'll do this like the Navy does and fly into (inaudible) by looking at the streaks on the ocean from the waves. So I guess we went down to about 900 feet and flew in, and as we got in closer to the center, we encountered this really, really strong turbulence. The winds were only about 60 or 70 knots at the time. It wasn't a

particularly intense storm. But it became like night, black as could be, and I remember as we got in towards the center, the strangest thing was, initially, it looked like we couldn't find the center.

But just about the time that the pilot and the flight director in the cockpit were getting kind of concerned, the winds dropped. In about 10 seconds they dropped from 80 knots to zero. And the wind direction changed by I think almost 90 degrees at the same time, and all of a sudden there was no air flowing over the wings. It happened so quickly. So the pilot reaction was that both the pilot and the copilot were looking outside the cockpit. They were looking at the sea surface to try to figure out, what's the wind direction? And in the meantime we hit this really strong downdraft in this supposedly calm area at the center. So the plane started dropping, losing altitude. So the pilot pulled back on the stick too much, and with that sudden change in the wind and no air flowing over the wings, the aircraft stalled, and I could feel in the back of the plane it began fluttering like a leaf, and I said, this is not good.

Meantime, we found ourselves in the middle of what appeared to be a violent thunderstorm. It was constant lightning. We had no lights because of the power failure in the back of the plane. The aircraft was beginning to flutter. And then I remember a colleague of mine was sitting next to me, Duncan Ross (sp?), who's since passed away. He was an oceanographer. In this situation, I heard over the intercom the infamous words that I hope to never hear again. It was basically, oh, shit. And we were out of control. Basically there was no airplane, no control.

And in the back of the airplane where I was, we were getting ready to launch one of these AXBTs, so we were sitting there holding this thing in our hand and trying to figure out, well, when's a good time to do this. But then it became a question of, are we going to make it out of here? And all of a sudden we felt the plane lurch forward, and at the same time, we hit this big updraft. It felt like being plastered into the seat in the back there. But at the same time we experienced total vertigo. We didn't know which was up and which was down. And it felt like the airplane was all of a sudden lurching downward into the ocean.

And I figured, oh, God, you know – that was probably the scariest moment of my life, even up to then and since then, because I knew we'd started out at only – I think by the time we hit this point where we could feel the fluttering of the aircraft, we were down to around 700 feet. That was the last altitude I'd heard from the pilot. And not being able to see anything in the back – it was black. It was 2:00 in the afternoon, but it was black as night, and the only time I could see anything was in the lightning flashes. But that's when we were – I just – OK, when are we going to hit the water?

And so we waited a couple of minutes, and nothing happened, and then we broke out into the clear and hit this huge updraft. It was like the hand of God reached out and took that aircraft and just scooped it up into the sky. And that got enough air flowing over the wings so that the pilots were able to level out the aircraft. It was a huge mistake that was made to pull the stick back and try to climb out to begin with, because the cardinal rule is just keep plane level no matter what, but it was as hair-raising for the flight crew as it was for us in the back, and myself in particular, where this was I think maybe the 20th flight. I hadn't done too many flights at that time. Certainly I'd never experienced anything like this.

So we got flying again. We got the aircraft back up to just below the cloud base, about 900 feet, and flew out to the northeast, and then our pilot, my good friend Fred Worly (sp?), says, you know, I've never flown a hurricane where I can't find the center. We're going to go back and try to do this again. I said, you're going to do what? (laughter) So he turned the airplane around. We were in about 70-, 80-knot winds again. Turned the airplane around and started to fly back towards the center. And again, we flew into what appeared to be a violent thunderstorm. This time we experienced really intense turbulence, and the plane was just bouncing all over the place.

And finally Fred says, well, maybe we're going to pass on this one. So we turned the plane around again. We never got back to the center. But he turned around. We headed back out to the northeast, and we came out into this surreal environment where you could look off out the window – it had cleared up – and saw this gigantic roll cloud. It looked like we were getting ready to fly into one of these gigantic supercells. It turned out that's indeed what we had just flown through, a tornadic supercell thunderstorm that had developed a tornado cyclone, which we had flown through. Turns out the calm area in the center was less than a mile and a half across. The winds decreased down to zero and back up to 80 knots in just a few minutes.

So we detoured around this roll cloud. It turned out it was fairly harmless, but it looked so ferocious, just this black line of clouds. So we detoured around the roll cloud and got out northeast of the center, and the pilot says, you know, I think we'd better go back home and see if we have any damage (inaudible) the storm. So we got out of there and headed back and survived the experience OK.

But a couple of days later, when we were back home, I began looking at some of the initial data, and turns out that the typical ASP (sp?) that we flew at was around 220 knots, and the first thing I saw was that our ASB (sp?) had plummeted to like 90, and looking at the trace of the aircraft altitude during that period when it was so pitch-black and we had vertigo and so on – was decreasing at a rate that we would have hit the water at nine seconds more if we had not hit that updraft. That updraft got air flowing over the wings again, and they were able to level out and fly out of there. So I got more scared then (laughter) realizing that I was nine seconds away from never coming back again.

Q: Wow. How long did the whole incident take?

A: I think it was about 40 minutes, from the time we first entered the storm from the southwest, from the time we had that power failure and the lights went out, and a few minutes later we got into this supercell, and it just was pitch-black for about 20 minutes as we descended. It got a little brighter when we got below the clouds. Basically you could see the streaks on the ocean surface. That gave me a little sense of orientation. But then as we got to the center, it's like the lights just went out, with no lights inside the airplane. That's the thing. I had to think, wait a minute, it's the middle of the day, and I can't even see the ocean's surface, what I thought was 900 feet away from us. (laughter)

So I guess it was about 40 minutes. And we did that turn going back to the center, and then finally he made the decision to get out of there and fly along that wall of cloud. I have some

fascinating photographs that I took. When I got back I showed them to Fujita later that summer, and he did some magic with his artistic abilities to enhance the old 35mm photos. Anyway, I have that one memento of that roll cloud that we flew through and also was able to check the satellite photos, and sure enough we were right underneath these huge, overshooting turrets (sp?). There's the cauliflower tops on top of the outflow layer of the storm, and they had just developed in the matter of 10, 15 minutes while we were out there. And subsequently, the storm did develop – I didn't fly it again. I was pretty nervous. But they did fly a flight the next day and found the winds were up to about 120 knots, and a beautiful eye developed, and there was an incredible development. But an experience that, like I say, I'll never forget. I can still see myself sitting at that station in the back of the airplane next to my friend and colleague, Duncan Ross, one of the engineers behind us holding this AXBTs, which were the ocean-sensing instruments that we'd just started using. He says, when should I drop? And I told him, hold on. Just hold on. (laughter) He was afraid it was going to go flying out of his hands and hit somebody.

Anyway, that was the one experience, and I'll maybe wrap it up here, but another experience that I could talk about, perhaps, is the Hurricane Hugo flight in 1989, which was the second flight that was a near-death experience. You probably already heard about that from Hugh Willoughby and some of the other folks.

Q: Just a little bit, yes. (laughter) I have just one question. How long was it before you actually flew again after this?

A: I remember coming home, and my wife then just said I was white as a sheet. I actually didn't fly the next flight that was into the mature hurricane, and that was I think the last flight of the season. It actually turned out that that was the last flight for the DC-6, because it was just before we got the P-3s, and we actually got the first P-3 in '75 that flew an earlier storm. So we didn't fly anymore that year, and the aircraft was retired the next season. We had the second P-3, and I began flying on the P-3 after that. And I remember thinking that the P-3 is such a strong, powerful, turboprop airplane, we're never going to have this problem again, because we always have the engines running wide open all the time. You just change the pitch of the prop, and the plane gets up and goes. And so I think, well, if we ever get into this problem again, the pilots will be able to get us out. It's a strong, powerful new airplane. In 1989, we found that wasn't the case, but we had 14 years before we found that that aircraft also had its limitations in the face of Mother Nature there.

So by the following season, I was ready to get up and go and do it again. I wasn't going to call it quits at that stage just because of a scary incident. Lots of people almost die from different things, but we didn't, so – (laughter) the second one, though – I stopped flying for about a year after the Hugo experience. That was really horrifying. (laughter)

Q: Do you want to talk a little bit about that?

A: Well, maybe since Hugh's already talked about it I could mention that a little bit. The Gladys flight, I think most of the flight crew has passed away now. My colleague scientist that was on the plane next to me died about 10 years ago. Billy Lewis (sp?), who was the radar guy on that flight, died about 15 years ago. I think maybe the flight director, John Ritchie (sp?), may still be

alive, but he's the only one I know. The flight crew has all passed on. So not too many people know about that. And that is one case – I had still saved a lot of those records, plots of the aircraft altitude, the airspeed and so on to show. I don't know. It was one of those things – a combination of a little afraid to go back and revisit that for a while, procrastination and (laughter) whatever. I've hung on to a lot of the analyses and plots that I did then, including some of the radar photos and the satellite photos. So now that I'm retired for real, that's one thing I really want to do, is go back and write up a report on that one, because that's one that was never written up by anybody because of the issues with pilot error and so on that nobody else really wanted to talk about very much.

Q: Go ahead and talk about Hugo, because what Hugh mentioned was that you would probably talk about Hugo. (laughter) He referred (sic) to you, and you're saying he already did it. But your story would be different.

A: You know, I was thinking – it's late now, but four of us on that flight are here at the meeting – myself, Frank Marks, Hugh Willoughby and Jeff Mastis (sp?), who was the flight director, and he was the fall guy for that flight. He was the flight director. He worked for AOC (sp?), and the rest of us were scientists. But that flight – we called it the A-Team. For some reason we had all the top scientists on that one flight. The other aircraft, the other P-3, was flying at a higher altitude, but everybody wanted to be on the flight where we did the low-level flight there.

Q: Tell us your story, and if I can get the four of you in a room, I'll do it.

A: Yeah. I've always thought, we've never all gotten together and rehashed our individual recollections, because they're all different, and each of us, I think, had the same experience that it was such a traumatic experience. It was one of those things like being in a car accident where, second by second, the images of the impending crash, in my case anyway, were burned into my brain. It's like a movie. It's like photographs that were – minutes turned into hours, seconds seemed to be minutes, and I can still remember exactly where I was and what was going on during the really traumatic part of that flight. So maybe I can go ahead and just have a few recollections of what happened there.

We were flying out of Barbados, but it all began with a briefing at the Weather Office there. The satellite imagery in those days was not very good, and the only thing we had from the Weather Office at that time was facsimile copies of the satellite images. So it didn't look like much of a storm. It looked like maybe a strong tropical storm that had the potential to develop again. So we got quite interested in the potential for, again, being able to document the development of a storm in the main development area just northeast of Barbados. So the estimates (inaudible).

The other thing was that neither the Air Force nor any of the NOAA aircraft had flown that storm yet, so there had not been any actual measurements of winds or minimum pressures or anything, only satellite estimates, and the satellite images were pretty poor, even in Washington at NHC, where they were doing the satellite, the Dvorak estimates of the peak intensities. So we decided that it looked like it was about 60 or 70 knots peak wind and was forecast to slowly intensify. We were saying, well, maybe it'll be 80 or 90 by the time we get out there three hours later. So that was the environment that we were kind of expecting.

And we had designed a flight pattern to fly at I think three different levels – down low at 1,500 feet, mid-levels around 700 millibars, and then we were going to do a high-level flight at 500 millibars. Eventually the flight pattern that we decided on – we were going to start flying high, start with a high flight to burn off fuel at the high level first before we went down low. But then we got to thinking, well, you know, if this thing really does develop, and it gets rough, the flight crew – they're not going to want to go down low if it gets to be more than hurricane-force strength.

So we said, well, let's go in low first, and we'll get the low-level portion of the flight done first and see what happens. Well, that turned out to be a really bad mistake on several accounts. The storm was not far away. It was only a few hundred miles from Barbados. The other thing we had always felt was that if we as scientists were proposing to do something really stupid, the flight crew would catch it and not allow us to do it. Well, turns out we had more experience than the new flight crew. The pilot – this was his third hurricane flight. The flight director was a young guy, Jeff Mastis. He'd only had a couple of storms that he flew into as well. So we didn't realize that we should have been the responsible people to think about all these details.

But going in low – actually, we went in at about 1,200 feet, and we wanted to get, again, below cloud base. We'd had a new instrument, the (inaudible) microwave radiometer that I was still trying to document with photos of the sea state so we could correlate percent of the area covered by foam and breaking waves with the signal that we were using to interpret wind speed. So we thought, this will be a good opportunity. We'll get down low and maybe get some 70-, 80-knot winds that we can compare.

So I said I wanted to sit in the back of the plane by the bubble window, which was back just behind the (inaudible) station on the aircraft across from the radar, where all the instruments are, and so they gave me the seat right by the bubble window in the back of the airplane. And so I remember coming into the storm, seemed like the winds rose to 60 knots and just stayed at 60 knots for 15, 20, 30 minutes and were not increasing so much, but I remember looking at the radar, and it looked like this tiny little doughnut. I said, you know, this doesn't look too good. I don't know if we want to fly into here at the low level.

And then I finally told the flight director, you know, I think maybe we ought to climb up to 5,000 feet, 850 millibars, at least get above that, and he said, nah, we'll just hang in there. This doesn't look all that bad, because the far part of the eye wall – looked more like a crescent-shaped eye wall. The northeast side, which is normally the strongest, he said, is open. And says, well, the reason it's open, I think, is because the V-flow (sp?) activity, the convectors (sp?) clouds are so intense that the signal is being attenuated, so I said, I think it's really bad, and the V-flow activity values are up around 50 dBZ, which would normally indicate hail. So that was so strong just in that forward quadrant that we were approaching.

So we kind of talked back and forth about this, and I expected the pilots to chime in and say – in fact, I asked the pilots, well, what do you think? You want to fly through this? He said, oh, yeah, man, I've got 5,000 hours on P-3s. No problem. I said, yeah, 5,000 hours on the P-3 but only about 10 in a hurricane. (laughter) Which I didn't realize at the time, either. So we talked back and forth and back and forth, and finally the pilot said, it's too late. We're getting too close to the

edge of the eye wall. We just got to keep the plane level and fly through this, and trying to climb would be more dangerous by the time we got through this back-and-forth discussion, so I just – OK.

And the winds, gradually, as we got into the outer edge of the eye wall, just slowly increased up to 70, 75, 80, and then in a space of about two or three minutes, the winds increased from 80 to about 120, and we began to get into some really wicked turbulence where the plane was bouncing around and moving from side to side, and then all of sudden it's like the plane got hit by a sledgehammer. We hit an updraft, which later we found out was like 20 meters per second, and followed that within a few seconds with an almost equally strong downdraft where everything on the airplane just went flying, even stuff that was bolted down. The coffee pot came loose. Chaos was breaking out.

And then there was a rapid succession of three of these couplets of updrafts and downdrafts, and finally there was this updraft, and then the downdraft that followed it sounded like the plane was hit by a giant sledgehammer. There was just this bang, and the plane just dropped like a rock and tilted on its side. It felt like the plane was going to roll over. And then it all of a sudden got shoved sideways. In that moment, I thought we were all dead – just the plane was going to come apart.

And what happened in the next moment was, there was a flash of flame from the inboard engine on the right side where I was sitting, and this huge ball of fire just went shooting by the window like arm's length away. If I could stick my arm outside the window, I would have been able to touch it. Our program manager, Jim McFadden, was sitting next to me, and I said, Jim, I think we're in trouble.

And then I heard over the headset – Jim didn't have a headset. That was another thing. There was a headset missing on that station, and I said, Jim, the engine's on fire. And so he grabbed the headset off my head and started talking to the pilots and so on. That's when pretty much sheer terror took over on my part for a moment there, and I said, OK, this is it. And they said, well, we got the fire out, he said. They pulled the bottle that's inside the engine, and they were able to feather the prop (sp?) and put out the fire. But we were still just inside the eye wall. The winds during all this spiked up to 180, which is like 200 miles an hour – 180 knots – and then dropped to about 10 or 20.

So it was almost like a rerun of that Gladys flight, with the sudden change in the wind, except it was a completely different – the plane in this case being a turboprop had a different reaction. Flying in like that, there were those high winds. The pilot has to turn the plane into the wind to keep the aircraft going straight towards the eye, but the plane – in this case, it was like a 50-degree angle to the direction we were traveling, so the plane was pointed this way, off to the left, and the plane was moving forward when all of a sudden the wind dropped, and we're in this crazy attitude coming into the eye and losing altitude again, and that's when all of a sudden – the winds were still like 130, 140, and the eye opened up, and it was a magnificent sight for a moment on my side, so I started taking photos of the sea state, because I got to concentrate on something. (laughter)

So it turns out at that moment, though, the pilots realized, we've got this 50-degree drift angle, and we're heading back into the eye wall in less than a minute if he didn't do something. So he had to turn the plane, make a right turn, which caused the wing to dip on the right side, as you would expect. But that stalled the wing. But the wing on the other side was still providing some lift. But they began losing altitude, and I remember just concentrating on taking photos, 35mm photos, and I just was looking through the camera lens at the ocean's surface, and it kept getting clearer and clearer and clearer, and then I looked up and I said, what's going on here?

We were falling. We were losing altitude as the plane was turning. And it kept turning and turning and turning. I said, whoa. Why don't we straighten out and make a left turn? But the pilot was so concerned with getting the airplane into the eye and away from the eye wall that he did a complete 360, and all during that time the airplane was falling. And then it dawned on him – we've got to make a left turn. We got to I think around 400 feet, something like that, and we got into this left turn finally. And then things stabilized.

In the following I don't know how many minutes, I remember during this chaos when we hit these updrafts, Hugh Willoughby was sitting in the single seat on the other side of the aisle. His computer, which was in front of Jim McFadden right next to me – he was in the seat across the aisle – that had this metal strap tying it down to the table. It broke loose. It was an HP, one of the original HP laptops that came out, and we brought the HPs because they were heavy and a real solid machine. But this thing broke loose and went almost through the overhead. It cut through the canvas, broke a bunch of the wiring in the ceiling, and then came crashing down like this far from Hugh. I don't think he still realizes how close he came to being dead at that point, because if that had hit him – the plane was in an updraft the next second. This thing just crashed to floor right next to him. I remember watching in slow motion.

At the same time, I watched the life raft get yanked – there was a couple of passenger seats just ahead of the door. Hugh was just behind the door. The passenger seats were forward of the door. And under those passenger seats was the 20-man life raft that was supposed to save us if we ever did crash into the ocean, which is kind of a joke. We had lots of training on how to do that, which was lots of fun at the time, but that life raft – in slow motion, it came out from under the seats as the plane got jerked to the side, and then as we hit the downdraft, it just went sailing up into the ceiling, hit the overhead, broke all the wires and conduit, and actually what prevented it from doing more damage was this handrail we had on the aircraft that went the length of the aircraft. If you happened to be standing or walking around and hit a sudden updraft, you could always grab that handrail, and the idea was you would prevent yourself from getting hurt. Of course everybody was buckled in in this case.

But that life raft hit that area up there where the handrail was located and put this huge dent in this – I don't know what that pipe was made out of, but it was like solid steel, and it bent it by about 20 degrees, and then the life raft came crashing back down into the aisle, and fortunately it didn't hit anybody either. And that was a souvenir that we had for the rest of our careers. We left that dent in the handrail on that airplane, and I think they still, when they refurbished the plane last year, left that original handrail there on that aircraft just to remind everybody about this particular incident.

So we all survived pretty good, and later, once everybody recovered from that initial shock and realized we weren't going to die in that moment, everybody just scrambled to – first reaction was to dump fuel. We had to make the airplane lighter. What made that so dangerous was that we had a full load of fuel, and the plane was heavy, and the pilot, once he'd started circling in the eye with these left turns, couldn't really climb. We were down there. He got up to 700 feet or so, and he couldn't climb. The engines were starting to overheat, and he had to level out, and the airplane began sinking back to the surface again.

So our first job – they pulled the switch on dumping fuel, but we could only dump fuel out of the wings. We had fuel in the fuselage also, and you couldn't get rid of that. So they were dumping fuel. We immediately got busy throwing everything we could out of the AXBT tube where we launched this instrument for measuring the ocean temperatures. We threw all the AXBTs out one after the other and any kind of equipment, anything at all that would fit through that tube. We were just tossing stuff out left and right and trying to lighten the airplane as much as we could.

And that helped just enough so that, during these circles in the eye, we were able to slowly climb up to about 1,000 feet, and then the engine would overheat again and we sunk back down to about 800 feet and then climbed back up again. What happened next was, deicing boots on the props that, when flying high, prevents the prop from having ice build up on the propellers – it's this black rubber material with heating coils inside. Of course that wasn't a problem for us then, but the remaining engine, the outboard engine on that right side, began vibrating. The whole wing started vibrating, and the plane began vibrating.

And so the pilot yelled back at me, keep an eye on that outboard engine and tell me what's going on, and I said, it looks like one of the prop blades – something is protruding from it. He said, well, that's the deicing boot. So this went on for like a half an hour, and the vibration kept getting worse and worse, and he says, if I have to shut that engine down, we're done.

So the pilot was on the verge of shutting the engine down, not knowing whether there was going to be a mechanical problem or whatever. He didn't want the engine to explode. And then all of a sudden the deicing boot flew off. I was glued to that thing, and I saw the thing just fly off. And then the vibrations stopped, and everybody took a deep breath.

But that was probably almost, if not more, scary than the original turbulence coming through the eye wall, because it's like your brain was behind the actual event, but in this case we could see what was going on, and it was like, OK, when's it going to happen? Are we going to just lose the engine and glide into the ocean or what? And I remember myself thinking, is this what plane crash victims feel like before they die? (laughter)

But then after that, the Air Force was inbound at 10,000 feet to do a normal reconnaissance, and when they heard what was going on with the aircraft they came down to our altitude and flew out ahead of us, and they said, well, look, we're going to see if we can find a soft spot in it, because we had to turn the radars off on the airplane. That was another thing. We were afraid that the fuel that was being dumped – if the radars were still operating, there was any kind of a spark, we'd just be incinerated. So all the electronic equipment was turned off. Again, it reminded me of

the Gladys flight where there was a power failure and everything went out. But in this case, the lights were still on, and it was daylight, and we were out in the eye there, and that was bright sunshine, so it was a different situation in that regard.

So the Air Force came down and said, the last view we had on our radar was this solid doughnut of high reflectivity, and there was no weak spot. We couldn't see any weak spots at all. The Air Force said they thought that this northern eye wall – the reflectivity was not quite as strong on their radar, and they said, look, you guys can't go around in circles forever. By the time that they'd come down and decided what to do, we'd been in the eye circling for two hours. And going through these cycles of climbing out a couple of hundred feet and then falling back 100 feet, climbing another couple of hundred feet – and finally we got up to about – I think it was three or 4,000 feet, a relatively comfortable altitude, when the Air Force guys' – it's now or never. This thing is an intensifying storm.

So they said, we'll go out ahead of you, and you follow us, and we'll tell you if it appears dangerous. So they flew out ahead of us, and we turned to follow them, and I was thinking, again, this is going to be the end of it, because they radioed back and said, the winds are 170 knots, but he said, there's almost no turbulence. So I said, really? So we flew behind them. So sure enough, winds got up to about 175 knots, but it was smooth. It was just smooth as can be. And we flew out to the northeast, and we got out of it.

And circled around the perimeter of the storm and came back to Barbados. It only took us like 30 minutes to get back on the ground there. And a number of people when they got off the plane just kissed the pavement, and one of the engineers on the plane got off the airplane, and he walked straight to the terminal building, and he said, I want the next ticket out of here. (laughter) He bought his own ticket back to Miami and never flew again.

Myself, I said, well, I think I'm done for a while, too. So I said I wasn't going to fly anymore that year, and I didn't. But again, the next year was a new year, a new season. A lot of the trauma had faded. And I said, we know what happened, and I've just got to get back in the game again. So I did. Some of the other guys – the flight director – actually, our lab director, Bob Burpee at the time, he says, you've got to get back on the horse. You've got to conquer the fear. So he and Frank Marks and a couple of others flew the next flight, and I said, I can't do it. (laughter)

So we all had different reactions and different impressions, and it was something that took Frank and I 10 years before we could write the full story of that flight. We had lots of arguments about how to do it, when to do it and so on and so forth, but finally we published a paper in Monthly Weather Review about the story with all the data that we could have and wrote a scientific article, and none of the background stuff that I've just talked about here was in that, but at least the situation was documented.

And it turned out to be what we call the eye wall mesovortex that we flew through and which we have seen hundreds of times since then in satellite images. These mesovortices form in rapidly intensifying storms. And again, like Gladys, it was flying where the tornado cyclone, the rotating main thunderstorm – and the only thing that's missing in the hurricane case is the little hook that produces a tornado. But it almost scales, so when you compare the eye wall mesovortex with the

eye wall, the eye wall is a bigger vortex than – in the Midwest we have the tornado cyclone and then the very tiny tornado attached to the hook. The mesovortex in the hurricane is like the hook. And the tornado, which had a scale – and it was about five miles across. But we could document – there was a huge pressure drop right in the eye wall where the center of that circulation was. The perturbation of the wind was about 50 knots higher than it would have been if it wasn't for that vortex. And the wind gradient at the edge of that vortex – to see the wind go from 185 meters per second and 190 knots down to 20 in the space of six second of flight time – we fly at about seven miles a minute or so – so just in the space of a few miles, that wind gradient took place.

So we were able to document that structure really well and got some really good science out of that, but we never flew low like that again, and that was kind of how that went. (laughter)

Q: Thank you. That was really fascinating. And to hear those two stories at the same time was really something – some similarities and some very, very different –

A: Yeah. I'm sure that story would be different if I sat down tomorrow and told it again, but basically that is a reproduction of those images that are still in my brain. (laughter)

Q: Well, you made those flights come alive. (laughter) Thank you.

A: (laughter) OK. All righty.

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