Supertyphoon Tip

Shattering all records.. The Atlantic Ocean has never known anything as severe as some of the tropical cyclones that occasionally roam the western Pacific. The worst of these storms was Supertyphoon Tip, which set the record for the lowest sea-level pressure ever observed on Earth. Debi Iacovelli Tropical Weather Specialist Cape Coral, Florida Tim Vasquez Weather Graphics Technologies Norman, Oklahoma four-engine turboprop reconnaissance aircraft, known as the WC- 130 "Hercules," lifted off the runway. It headed across many miles of vast ocean and penetrated the east side of a strong typhoon. Bob Korose, who is now the assistant Chief, Aerial Reconnaissance Coordination, All Hurricanes (CARCAH), at the National Hurricane Center in Coral Gables, Florida, was at the controls. "As you approach a storm, you're always putting the wind on your left wing, so that you're approaching perpendicular to the wind flow," he said. "As you get closer to the center of the storm you can pick up the eye on the radar. You head on in based on the radar and the windflow data that you're receiving. Generally you just go in as straight as you can, unless you're able to take advantage of a weak spot in the typhoon." But this storm called for different tactics. "It's a solid wall cloud, so there's no easy way in. As you head for the eye, you constantly have to make corrections for the winds. You're getting blown sideways at 150 mph, or even more than that, so you have a lot of correction. In other words, the nose of your aircraft isn't pointing to where you are going. You see on the radar that the eye is right straight ahead of you, but actually Continued on Page 5 you point off to the left side as you're going in because you have such a drift to the right from the crosswinds spinning into the storm." On this day, Supertyphoon Tip smashed all records for the lowest recorded pressure inside any tropical storm on Earth. Not only was its 870 mb (25.69" of mercury) pressure reading unprecedented, Tip had one of the largest circulation patterns on record: 1380 miles (2220 km) in diameter. A hurricane this size in the Gulf of Mexico would cover everything from Guatemala to Kentucky, and Mexico City to the Bahamas! (Note: The size of the circulation pattern in a tropical cyclone is determined by the diameter of the highest closed isobar associated with the tropical cyclone.) "Tip was a big storm," remembers Korose, "I mean big in surface area. When it was at its peak, it stretched halfway between Guam and the Philippines. That's about 1500 miles (2400 km). The outflow from the storm pretty much covered most of that area." Lt. Commander George Dunnavan was also on the missions that flew into Tip. He agreed. "It was a little bit strange because not only was it a supertyphoon, but it also had a huge wind radii on it. That's what was so interesting about it. It covered everything from the Philippines over to Guam, and from southern Japan all the way to the equator. The 30 kt (55 km/h) wind radius was something like 600 miles (965 km) on it. It also had an extremely warm eye temperature-86 degrees F (30 degrees C) at 700 mb (about 1 mile up in the storm). I don't think I've ever seen anything over 88 degrees F (31 degrees C) in a tropical cyclone." Tropical storm winds are classified as winds of 30 knots (55 km/ h) or greater. While these extended over 600 nm (1100 km) out from Supertyphoon Tip, 50 kt (93 km/h) winds were over 150 nm (280 km) in radius. If Hurricane Andrew of 1992 had a similar wind structure, its swath of destruction would have enveloped most of southern Florida from the Keys northward to West Palm Beach! Aloft, reconnaissance reports indicated that 700 mb winds of 105 kts (194 km/h)

existed more than 120 nm (220 km) from the center of Tip during 13-17 October. Looking at the birth of this monster storm, we find that on 4 October a reconnaissance aircraft was sent to investigate a tropical disturbance near Truk. They discovered a closed surface circulation with maximum observed surface winds of 25 kts (46 km/h), and a minimum sea-level pressure of 1003.9 mb (29.65"). The disturbance became Tropical Depression 23 on 5 October at 0000 UTC. The Joint Typhoon Warning Center (JTWC) in Guam issued the first tropical cyclone warning, since reconnaissance missions discovered that surface winds had increased to tropical storm strength. The depression became Tropical Storm Tip on 6 October at 0000 UTC. The initial erratic movement of Tropical Storm Tip and its failure to intensify was caused by the interaction of the storm with weak but extensive circulation patterns associated with Tropical Storm Roger, just to its west. Roger quickly sped northwestward, generating heavy rains and tides in the Tokyo area. Although it rapidly lost its influence over Tip, Tip still did not intensify. On October 9, as Tip was heading toward Guam, reconnaissance aircraft found that the sea-level pressure in the storm had only dropped to 995 mb (29.38") with surface wind speeds of 40 kts (74 km/h). Upper-level maps showed that a tropical upper-level trough (technically known as a TUTT) was to the north of Tip, interfering with its ability to vent its upperlevel outflow. This caused mass to accumulate within the storm. Tip was forecast to pass directly over the center of the island of Guam, but radar positions and recon reports from Andersen Air Force Base showed the storm had actually passed 28 miles (45 km) south of the island. Stations located in southern Guam recorded sustained surface winds of only 48 kts (89 km/h) with gusts to 64 kts (118 km/h), but in some locations they reported over 9 inches (228 mm) of rain. Supertyphoon Tip Continued from Page 4 Continued on Page 6 Supertyphoon Tip Tip officially reached typhoon strength after passing south of Guam later on 9 October. It moved into an area of strong, upper-level divergence that was covering most of the Western Pacific, so being in favorable conditions allowing mass to be removed from Tip. It was vented into the surrounding upper atmosphere, thus intensifying the storm. Surface pressures in the typhoon dropped tremendously, falling 92 mb (2.7") to 898 mb (26.51") between the 9th and 11th of October. The storm reached supertyphoon strength during this period (maximum sustained surface winds of 130 kts [241 km per hour] or greater) and maintained supertyphoon strength for the next 54 hours while moving northwest between 3 to 7 knots. Tip's highest measured windspeed of 165 kts (190 mph) was measured during this period, along with gusts that exceeded 200 mph. The most intense tropical cyclones on Earth develop in the Western Pacific because of the long journey over warm ocean waters. Statistics show that about 30 typhoons develop annually, and some of these are bound to explode into intense storms. Lt. Col. Charles Holliday, in a Monthly Weather Review article published by the American Meteorological Society (AMS) about rapidly deepening typhoons, showed where explosive deepening usually occurs in the western Pacific. The area that Holliday came up with was right where Tip was. Rapid deepening of a tropical cyclone (as established by Lt. Col. Charles Holliday and Professor Aylmer Thompson) is "greater or equal to 42 mb (1.24") in 24 hours." Tip's central sea-level pressure dropped 59 mb (1.74") during one 27-hour period. Bob Korose remembered this well. "Tip blew up in only a couple of days. It came across Guam as a tropical storm, but then the conditions got perfect and it exploded. The central pressure just dropped like a rock. It had good conditions as far as seasurface temperatures, and upper air. Evidently there was tremendous

outflow above the storm, so it developed. There was nothing to inhibit it." This huge tropical cyclone had a circulation pattern which extended from the surface through 500 mb and higher. "Tip had a strange structure," said George Dunnavan. "One of the ARWOs (Aerial Reconnaissance Weather Officers) who flew into the typhoon remarked to me that normally when they're flying in the 700 mb (flight level) range, there's a big drop in the height of the surface as you penetrate the eyewall. I remember the ARWO telling me that one thing curious about Supertyphoon Tip was that on the record-setting flight when they were flying the 700 mb surface all the way from Guam, it was a gradual slope all the way into the center of the system. They thought it was rather strange, because usually once you cross the eyewall of a typhoon it's an abrupt change in everything. In fact, if you look at the windspeed and temperature profile data on Supertyphoon Flo (a supertyphoon in the Western Pacific in September 1990), you'll see that once you get inside the eye the wind drops off just in a matter of seconds. The temperature structure changes once you get inside the eyewall as well. It's usually very abrupt. They set the reconnaissance aircraft on autopilot during the 700 mb penetration and it will try to fly at a pressure level making the altitude adjustment. So usually when you penetrate the eye and the 700 mb surface changes radically, the airplane is going to drop and try to stay on that surface. But that didn't happen with Tip." Bob Korose knew this flight would be different. "We were on a WC-130 plane out of the 54th weather recon squadron, Anderson AFB, Guam. We normally have a crew of 6 people on the reconnaissance aircraft, but there were extra people in training on that flight. There were at least eight of us. I was one of the pilots on that crew. In the cockpit was the pilot, an instructor pilot, the co-pilot, the navigator, an aerial reconnaissance weather officer, and the flight engineer. We had an idea that we would be setting a record that day. We knew that the old record had been 876 mb (25.87") set by Typhoon Rita, and we knew from the previous mission the pressure was pretty close to Rita's. It Continued on Page 7 Supertyphoon Tip Continued from Page 5 August 1998 7 Supertyphoon Tip looked like the storm had continued to intensify, so there was a good chance that we would set a record." As the crew of the WC-130 flew toward Tip, many aboard did not know what they would find. "In a way, every storm that you approach you're a little apprehensive, because you're not sure what you will encounter," explained Korose. "Each storm is a little different, and the dynamics of the system are always changing. Sometimes they're real turbulent, sometimes they're real smooth. Sometimes you get a lot of rain, sometimes you can see a lot visually. Everyone on board was a little excited with the possibility that we were going to be the crew that would set a new record low pressure recorded in a tropical storm." The eyewall of a hurricane is a ring of big thunderstorms enclosing the eye. But in strong typhoons the eyewall can present a formidable hazard for pilots trying to reach the center of the storm. What surprised Korose was how smooth the penetration into Tip's eyewall was. "Being that it was such a big storm, I thought, 'Boy, it was going to be rough!' But what I found out later, after flying into storms for four years out there, was that the roughest storms were usually the ones that were changing character-they were intensifying or weakening, due to the meteorological dynamics taking place inside the storm. Supertyphoon Tip was at its maximum intensity, so there was very little change going on inside the storm. There wasn't nearly as much turbulence as I would have expected. The wall cloud itself was only 10 miles wide, so the penetration time at 180 kts ground speed (3 miles a minute) was a little over 3 minutes. Going through the eyewall we got some real heavy rain and were bounced

around a little bit, but nothing out of the ordinary." As the crew of the WC-130 reconnaissance aircraft broke through the eyewall, they were curious what the ocean's surface would look like. "As we were approaching the outside of Tip there was a lot of cloudiness, but once we broke into the eye, it cleared up," said Korose. "It was blue skies and sunshine. We could look back under the wall cloud from inside the eye and observe the sea surface. Once a typhoon's winds get above 130 kts (241 km/ h), you really can't tell much of a difference with the surface of the water. It's just totally white, because the surface is blown into spray. It's hard to see where the air ends and the sea starts." Even though ships in the western Pacific were giving wide berth to Tip, they were still encountering gale-force winds in 25-foot swells 200 to 300 miles (320 to 480 km) from the storm's center. When asked for his observations inside the eye of Tip, Korose replied, "Some eyewalls you see look like a stadium; in other words the tops of the clouds around the eye are narrower at the bottom and wider at the top. But this one was straight up and down and really tall. Some typhoons seem higher in altitude than other ones. Inside Tip it looked like a wall; just a mass of dark clouds with bright sunshine above. At night it was stars above, and sometimes you'd see lightning that lit up the wall cloud. Tip's eyewall was totally circular, with no gaps or breaks in it. It was solid all the way around." Supertyphoon Tip had "spiral striations in the wall cloud, and it looked like a double helix spiraling from the base of the wall cloud to the top, making about two revolutions around the eye in climbing," as was reported from the ARWO aboard the recon mission. When asked about this, Dunnavan said, "That means Tip had some pretty violent vertical motion in it. What it looks like is a spiral staircase that spirals around the eye. The air, once it gets into the eyewall, is going to be spiraling up to the top of the eyewall before it spins away from the storm at about 100 mb (53,000 feet) or higher. The more pronounced this striation, the more intense the tropical cyclone. With eyewalls, they talk about the 'stadium effect' and the 'fishbowl effect'. Sometimes, if you get a real intense tropical cyclone, the eyewall shape will be like a fishbowl. It will bow out so that it will be narrower at the top than it is at the middle or the bottom, and the upper-level clouds kind of Continued on Page 8 Supertyphoon Tip Continued from Page 6 Supertyphoon Tip overhang a little bit into the eye. What causes this overhang is probably the vertical motion bringing up a lot of clouds (the eyewall), and you're also getting a lot of subsidence (downward motion) taking place in the eye, which is going to heat the air up and dissipate clouds. So clouds sometimes spill back over into this subsiding air before they dissipate." A mid-level trough moving from China towards Japan on 17 October caused Tip to weaken in size and strength and begin recurvature northward under the influence of increased mid-level southwesterlies. Its outer rain bands brushed the Philippines, dumping copious amounts of precipitation over the mountains of northern Luzon, but the storm moved northward and passed within 35 nm (65 km) of Kadena AFB on Okinawa. The weather station there reported sustained winds of 38 kts (70 km/h) with gusts to 61 kts (113 km/h). On 19 October, Typhoon Tip weakened to a tropical storm and made landfall on the Japanese island of Honshu about 70 miles (110 km) south of Osaka. Rapidly caught up in the prevailing westerlies, it came onshore with forward speeds in excess of 45 kts (78 km/h). Flooding from the typhoon became the main threat. At a joint U.S.-Japanese military training center near Tokyo, flooding breached a fuel-retaining wall which led to a fuel storage fire which killed 13 and injured 68. Throughout Japan, a total of 42 people died, while 71 were missing and 283 injured. More than 22,000 homes were flooded,

and 600 landslides ravaged the countryside. Out at sea, eight ships were grounded or sunk by Tip, and 44 fishermen were dead or unaccounted for. The Chinese freighter Ying Shan went aground off Cape Erimo, Hokkaido, and broke in two by the pounding of the mountainous seas, while gusty winds delayed the rescue of its 46 crew members. The remnants of Tip maintained winds of 50 kt (93 km/h) until 21 October, when it moved east of Kamchatka toward Alaska. Back in the U.S., Bill Rogers and Grete Waitz won the New York Marathon. Spent and exhausted, they collapsed after the race. And over the Bering Sea, the remnants of once-Supertyphoon Tip became extra-tropical and dissolved quietly into history books. Missions flown out of Andersen Air Force base into Typhoon Tip numbered upwards to 40, which made it one of the most closely watched tropical cyclones of all time. Many associated with this reconnaissance effort felt privileged to have been an eyewitness to the beauty and the strength that is rarely seen in such magnitude, and some even described Tip as the most incredible storm they had ever seen. "You're in awe any time you get in those storms," said Korose. "Even though they seem small on satellite pictures compared to the overall weather patterns, they're still awesome as far as the power and the strength of them." Acknowledgements: We would like to thank Bob Korose, Lt. Commander George Dunnavan, Kevin Shaw, John Diercks, John Pavone, Dr. Hugh Willoughby, and Jack Beven for their kind assistance. Note: The record low sea-level pressure of 870 mb (25.69" of mercury) set by hurricane Tip on October 12, 1979, still stands as the lowest sea-level pressure ever recorded. Professional affiliations of some people mentioned in the article may have changed since it was written in 1993. References: Dunnavan, G.M. and Diercks, J.W., 1980: An Analysis of Supertyphoon Tip (October 1979). Monthly Weather Review, AMS, Vol. 108, pages 1915-1923. Holliday, C.R. and A.H. Thompson, 1979: Climatological Characteristics of Rapidly Intensifying Typhoons. Monthly Weather Review, AMS, Vol 107, pages 1022-1034. Joint Typhoon Warning Center, 1979: Annual Typhoon Report 1979. Naval Oceanography Command Center, Guam, Mariana Islands, 72-77, 175-177. Rough Log, North Pacific Weather (October and November 1979), 1980: Mariners Weather Log, January 1980, pages 70-77.h Supertyphoon Tip Continued from Page 7