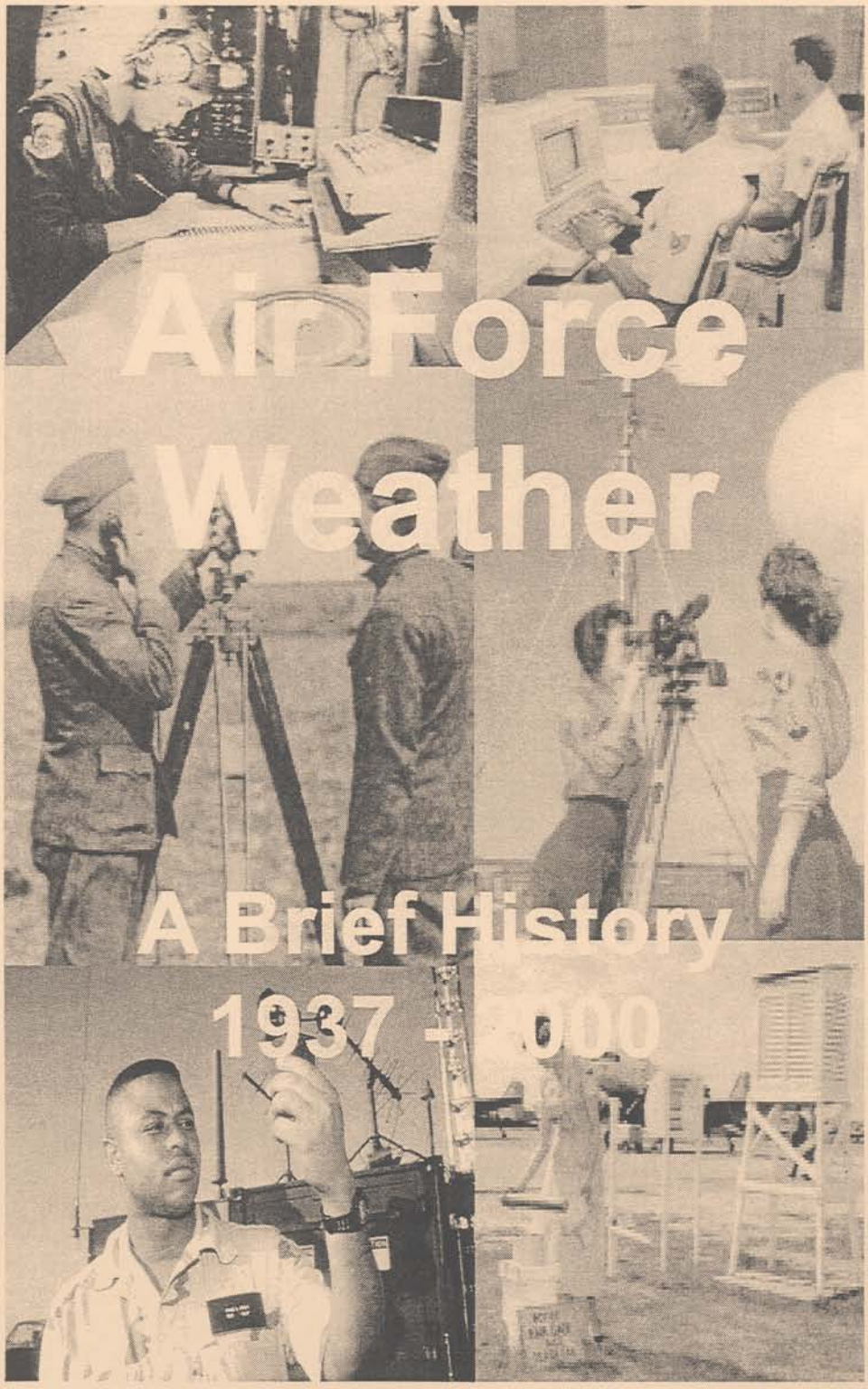

Air Force
Weather
A Brief History
1937 - 000

FOREWORD

This heritage pamphlet represents an era in Air Force Weather. As we enter a new century, we do so with the spirit of an explorer anticipating new challenges that await, while remembering the past. There have been many instances throughout time when military operations were impacted by weather. In Dr. Irving P. Krick's report on "Weather and War," in 1945, he talks about some of those events. A few of those examples are: the failure of Napoleon's Armies in Russia due to the onslaught of winter's cold, the damage wrought to the combined French and British Fleets in the Black Sea during the Crimean War around 1855 and the destruction of the Spanish Armada by an unforeseen storm. In addition, when four Prussian regiments were using gas warfare in World War I at Armentierres, they had the gas blow back in their faces when the wind shifted.

As we dedicate ourselves to preserving our past to ensure our future, I am reminded of a quote by General Dwight D. Eisenhower, "Neither a wise nor a brave man lies down on the tracks of history to wait for the train of the future to run over him." Sun Tzu once said "Know the enemy, know yourself, your victory will never be endangered. Know the ground, know the weather, your victory will be total."

With the Air Force Weather Agency making strides towards a brighter tomorrow, let us heed the words of Sir Winston Churchill, "the farther backwards you can look, the farther forward you are likely to see."

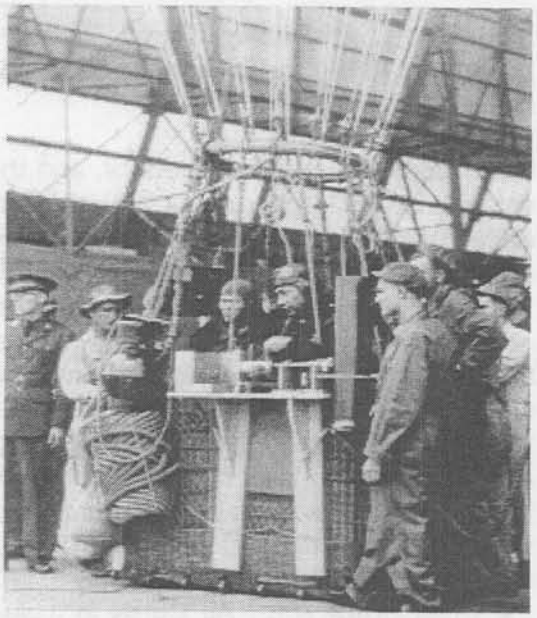
CHARLES W. FRENCH,
Colonel, USAF
Commander

Air Weather Service

A Brief History: 1937-2000

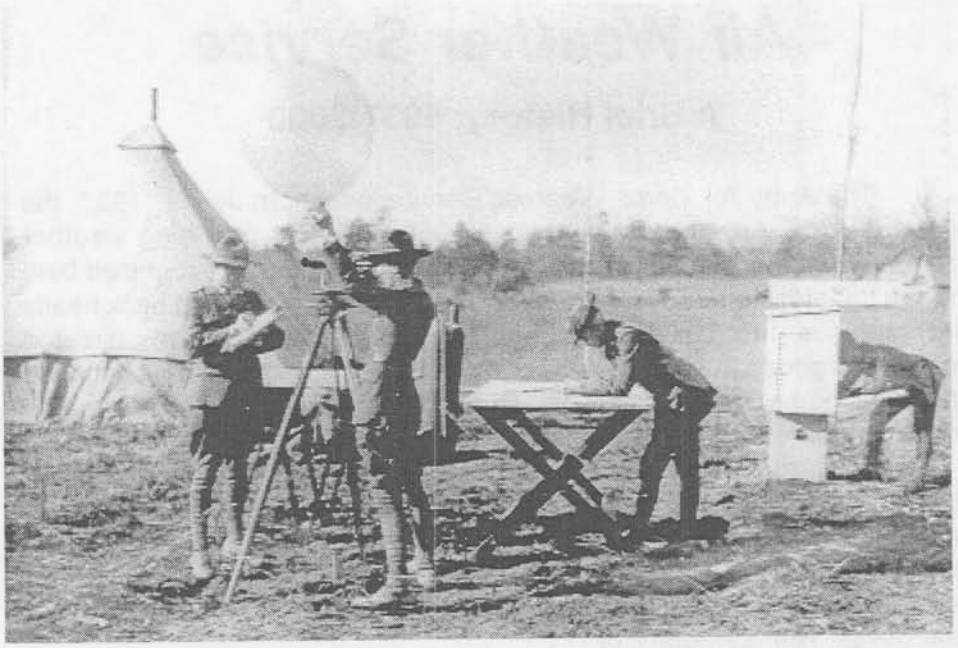
The Army Air Corps Weather Service was born July 1, 1937, the date the Army Air Corps assumed responsibility for providing weather services from the Signal Corps. While this is the officially recognized birth date, a better historical perspective can be achieved by looking back nearly two centuries. In 1814, the Surgeon General of the U.S. Army directed hospital surgeons to keep records of the weather, a tradition that continued and expanded with his successors. During those early days, the observer's only instruments were thermometers, wind vanes, and determination.

The importance of this early work was evident in 1842 when Congress established the position of "Meteorologist to the U.S. Government" and assigned it to the Surgeon General's Office. In 1870, Congress formally instructed the War Department to take meteorological observations at military stations to warn of approaching storms on the northern lakes and seacoasts. The Secretary of War assigned this task to the Army Signal Corps, which bore that responsibility for 20 years until Congress established the U.S. Weather Bureau in 1890. At this point, all of the military equipment and personnel transferred to this new agency. As a result, virtually no American military weather service existed from 1891 to 1917, however this changed again in 1917 with America's involvement in World War I.



The "father" of Air Weather Service, Capt Randolph P. "Pinkie" Williams (right) talks to his ground crew while in a balloon basket at Scott Field, Illinois in April 1935. Also in the basket is Capt Orvil A. Anderson.

A request for weather support from the Chief Signal Officer of the American Expeditionary Forces in France led to the creation of the Meteorological Section in the Army Signal Corps. By the end of the war, the Army had trained approximately 500 weathermen. While World



Members of the Army Signal Corps' Meteorological Section prepare for a PIBAL release near Pee Dee River, North Carolina during December 1927.

War I demonstrated the need for, and the potential of a military weather service, by 1935 only about 160 enlisted weathermen and about a half dozen officers remained. One of those remaining officers was a man who would bring about crucial changes...he was Capt. Randolph P. "Pinkie" Williams, later known as the "Father of Air Weather Service."

On July 1, 1935 a decision was made by the Chief Signal Officer of the Army to expand the Signal Corps' Meteorological Section. This decision was due in part to a number of studies and reports produced by Captain Williams. During this same year, a committee chaired by the Secretary of War recommended the Air Corps operate the weather service during times of war. Based on this recommendation, a reluctant Chief Signal Officer suggested the Meteorological Section of the Signal Corps be transferred to the Air Corps. Then on July 1, 1937, the Secretary of War directed the Chief of the Army Air Corps to assume responsibility for the military weather service. This marked the birth of Air Weather Service, then called the Army Air Corps Weather Service.

The Army Air Corps Weather Service started with 22 officers and approximately 280 enlisted personnel, of those, 180 transferred from the Signal Corps, while the other 100 were already on duty with the Army Air Corps. However another world war soon speeded up changes already in motion during the early days of the 1940s, so that by the time the United

States entered the war in December 1941, the weather service had grown to about 2,650 people. This explosive growth made the recruiting and training of weathermen a major challenge during the war years. The Army Air Corps opened a school for enlisted forecasters at Patterson Field, Ohio, in September 1937, and one for observers at Scott Field, Illinois, in September 1939, but by the spring of 1940 these two schools were consolidated at Chanute Field, Illinois. Also, prospective weather officers were sent to several universities to pursue studies in meteorology.

Shortly after entering the war, the Army Air Corps became the Army Air Forces (AAF), with the Weather Section remaining under the Office of the Chief of the Air Corps as part of its Training and Operations Division. The Army Air Forces Commander, General Henry H. "Hap" Arnold expanded the mission of Weather Service to include support to Army Ground and Support Forces, and by early 1945 the AAF Weather Service reached its peak strength of 19,000. These weather people operated 900 weather stations, with nearly 700 of them being located in 58 different countries. Weathermen served in all parts of the world from the ice caps of Greenland to the jungles of the Pacific. They set up stations alongside advanced airstrips; they accompanied the first wave of troops storming ashore on Pacific islands, and the Normandy beaches, and served in weather stations along the front lines. In some remote areas, they were the only military forces present. Members of the AAF Weather Service also helped prepare the critical weather forecasts preceding the D-Day invasion and the first atomic bomb missions. By the time the fighting stopped, the war had claimed the lives of 68 AAF Weather Service personnel — 30 officers and 38 enlisted men.

Throughout the war the AAF Weather Service experienced several confusing, high-level organizational changes. In 1942 and 1943 those changes included the weather command level at the Air Staff being elevated from Weather Section to Weather Directorate (due to taking responsibility for administering both fixed and mobile weather units) to Weather Division. In April 1943, the AAF activated a Weather Wing at the Pentagon, then moved it to Asheville, North Carolina, a month later. The wing served as a field headquarters with responsibility for managing the nine AAF Weather Service squadrons located in North America. There were also 10 weather squadrons assigned overseas. Then on July 1, 1945 AAF abolished the Weather Division at the Air Staff, redesignated the Weather Wing at Asheville as the AAF Weather Service, and then transferred all functions of both the Weather Division and the wing into this new organization. The AAF Weather Service commander remained in Washington, where he continued functioning as staff weather officer to the Commanding General, Army Air Force. At the end of World War II, the rapid demobilization of the American forces began, and by June 30, 1946, AAF Weather Service had

only 4,198 people remaining in its ranks. This, however, proved to be the post-war low, and by the end of 1948, the manning had increased again, reaching 8,300.

During the first three years following the end of World War II, the headquarters for AAF Weather Service moved three times. In January 1946, it was moved from Asheville to Langley Field, Virginia, then five months later relocated again, this time to Gravelly Point, Virginia, near Washington D.C. then on December 1, 1948 it moved across the Potomac River to Andrews Air Force Base, Maryland.

Under the terms of the AAF reorganization on July 1, 1945, the AAF Weather Service became a worldwide command reporting directly to the Commanding General, AAF. This arrangement gave recognition to the fact that satisfactory weather service seemed to demand a single functional manager and a separate centralized organizational structure that would cut across the domains of independent commanders. The AAF Weather Service's existence as an Air Force command did not last long, however. The Air Staff, in a measure designed to lessen the number of commands reporting directly to Headquarters AAF, assigned the Weather Service to the Air Transport Command (ATC) on March 13, 1946, and changed the organization's name to Air Weather Service. Although the reorganization ended the weather service's short tenure as an independent command, the new affiliation did not result in any significant changes to its basic worldwide organizational structure and relationships.

Captain Robert C. Miller and Major Ernest J. Fawbush issued the first tornado warning in March 1948.

In July 1947, Congress passed the National Security Act, which created a Department of Defense with the Army, Navy, and Air Force sub-departments. This move made the Air Force a separate military service distinct from the Army, with the AWS becoming part of the new Air Force. However, under the terms of an agreement signed March 15, 1947, between the Army and the Air Force, AWS continued providing meteorological services to the Army. Less

Aerial weather reconnaissance operations began in 1942 when the Army Air Force formed its first weather reconnaissance squadron and equipped it with WB-25s.

than a year later on June 1, 1948 AWS, along with three other specialized services, became part of the Military Air Transport Service (MATS) formed by combining ATC with elements of the Naval Air Transport Command.

The accomplishments of the AWS during the years immediately following World War II, included the rehabilitation of foreign national weather services, support of atomic testing, and the introduction of a system of weather centrals which provided a daily analysis of weather conditions throughout the northern hemisphere, and improvement of weather analysis and forecasting methods. In March 1948, it had also issued its first tornado warning. The AWS operational network coverage during those years included surface, upper air, radar, and detection data. The post-war years also saw AWS gaining an aerial weather reconnaissance capability.

Aerial weather reconnaissance operations actually started during the war. On August 16, 1942 the Army Air Force established its first weather reconnaissance squadron, equipping it with nine B-25s. The following summer these B-25s began flying the North Atlantic ferry route to Great Britain ahead of tactical aircraft transiting the ocean. In November 1943, "weather scout" missions began over Europe, using P-51 aircraft. The weather scouts flew to primary and secondary bomber targets, determining winds, cloud cover, and cloud height, then radioing the information back to the appropriate bomber strike force. These

weather scouts soon proved their worth.

The first actual aerial hurricane penetration occurred in July 1943, when Colonel Joseph B. Duckworth made an unauthorized flight from Texas over the Gulf of Mexico. During the Spring of 1944, there were four B-25 aircraft and crews assigned to the AAF Weather Service's Weather Wing for the purpose of conducting hurricane reconnaissance. The primary mission consisted of providing weather reports from storm areas, and determining their intensity, location, and extent of the disturbance. The first official, authorized flight into a hurricane took place September 10, 1944 on a reconnaissance mission out of Puerto Rico northward over the western Atlantic. Throughout the remainder of 1943, and through 1945, many other hurricane reconnaissance missions followed. Eventually B-17s took the place of the B-25.

Officially, the AAF Weather Service received the aerial weather reconnaissance mission at the time it became a part of ATC in March 1946. At this time Air Weather Service gained four additional weather reconnaissance squadrons to enhance their mission capability. In August 1946, the Air Staff ordered that all weather reconnaissance groups and squadrons be assigned to AWS. During the same year, AWS began receiving B-29 aircraft, replacing the B-17s it had inherited. By the end of 1948, AWS had a weather reconnaissance force consisting of one group and five squadrons, equipped with 91 aircraft, mostly RB-29s, and manned by 454 officers and 2,265 enlisted men. The reconnaissance fleet not only conducted routine weather and hurricane reconnaissance in the North Atlantic, Pacific, Arctic, and Caribbean areas, but also detected and tracked typhoons in the Pacific.

Of all the events AWS supported in the late 1940s, none was more significant, or more challenging, than the Berlin Airlift. The biggest challenge facing the Airlift, which lasted from June 1948 to May 1949, was the weather, which often times was adverse. Low clouds, fog, freezing rain, ice, and turbulence frequently hampered airlift operations. Exact ceiling and visibility forecasts were needed for daily operations, and special climatological studies and forecasts for operational planning purposes. Logistical aspects of the operation, such as maintaining a smooth flow of supplies from on-load to airlift bases, also required weather support. AWS met the challenge by concentrating its most experienced weathermen at air bases involved with the airlift and introducing new techniques, such as holding telephone conferences with airlift forecasters to discuss the weather situation and arrive at a composite forecast for the area.

Following the June 25, 1950 invasion of South Korea by the Communist forces of North Korea, President Harry Truman immediately decided to come to the aid of the South Koreans with American military forces. AWS personnel were among the first to enter the fight. On June

26, 1950, less than 24 hours after the North Koreans crossed the 38th parallel into South Korea, AWS conducted its first weather reconnaissance "Buzzard" flight over the country. The next day, the first detachment arrived in South Korea, and almost immediately began generating weather reports. During the next three years, AWS provided its extensive weather support to United Nations air and ground forces. They soon introduced the process of "pinpoint" forecasting for bomber targets. Also, for the first time in combat, they successfully used the principle of a weather central connected by radio to subordinate forecasting stations. Forecasts were made more difficult because the enemy controlled the areas to the west of South Korea, but with persistence and determination they gradually improved over time.

From the first day of the conflict, and throughout the war, AWS reconnaissance forces flew daily missions over the peninsula. During this period, the 512th Reconnaissance Squadron (redesignated the 56th Weather Reconnaissance Squadron in February 1951) flew approximately 750 missions from Yokota Air Base, Japan. Once again war increased the size of the organization with the strength of the unit rising from 8,800 on June 30, 1950, to a peak of nearly 12,000 by mid-1952. However, as hostilities ceased, the unit once again began to decline. By the time the armistice was signed, the fighting had claimed the lives of approximately 30 weather personnel.

1/Lt David H. Grisham, the first Air Weather Service members to lose his life during the Korean War, follows a PIBAL at a forward operating base in Korea during June 1950, while 2/ Lt John T. Gordon operates the theodolite.

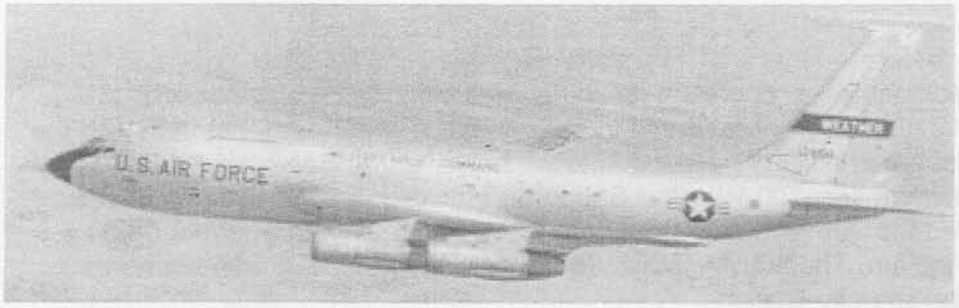
During 1952, in recognition of a growing need for specialized support, AWS reorganized its units located in the U.S. from a geographical basis to a functional one. Therefore, instead of having its weather units serving particular geographical regions, AWS aligned them according to the needs of the customers they supported. Thus it established weather groups to support the various major commands such as Strate-

gic Air Command (SAC), Tactical Air Command (TAC), Air Defense Command, Air Research and Development, Air Training Command, and Air Material Command. In another important organizational change in 1957, AWS closed the U.S. Air Force Weather Central at Suitland, Maryland (a suburb of Washington D.C.), which traced its origins to the Weather Research Center established in 1941 at Bolling Field, D.C. Those functions and resources were combined with those of SAC's Global Weather Center established at Offutt AFB in 1949. The new consolidated organization was called Air Force Global Weather Central (AFGWC). A significant location change occurred in 1958 when the Air Force moved Headquarters AWS from Andrews AFB to Scott AFB.

Throughout its history, AWS has constantly worked at expanding, improving, and modernizing its support. During the 1950s AWS began developing and placing increased emphasis upon centralized forecasting. In 1958, they started centralized terminal forecasting from the newly-created Kansas City Centralized Forecasting Facility. By the start of the next decade, the unit not only operated a worldwide weather central at AFGWC, but also a European weather central at High Wycombe in the United Kingdom, and a Pacific weather central at Fuchu, Japan. The organization finally received its first formal, comprehensive statement of Army weather requirements, which helped implement an effective Army support program. Three years later, in 1959, AWS, upon the authority of the Military Air Transport Service, activated its first two weather squadrons dedicated exclusively to support the Army.

There were many other initiatives to provide new and improved types of services in other areas as well during the late 1950s, and early 1960s. These included issuing severe weather warnings and creating three Automatic Weather Stations in the upper regions of the Northern Hemisphere, one in Greenland and two on Alaskan islands. In the same year a program was inaugurated to establish runway representative observing sites at air bases throughout the world. In 1960, AWS began using weather satellites, the very first one being launched by the United States in that year. This provided additional and more accurate weather products for use in providing weather information. Two years later, they issued their first solar forecasts.

Air Weather Service introduced the Weather Observing and Forecasting System in 1954, its first attempt at integrating all existing meteorological equipment, techniques, and display and communications facilities into one overall system. In 1957, Global Weather Central started using computers for processing weather data. The 1960s saw weather personnel bringing on-line a number of new equipment systems, some representing totally new technology, with others being upgraded versions of earlier equipment. These included such items as the first radar specifi-



WB-135s were first used for aerial weather reconnaissance during the mid 1960s. They became part of MAC's Aerospace Rescue and Recovery service in 1975.

cally designed for meteorological use, transmissometers, rotating beam ceilometers, and rocketsondes. These years also saw AWS weather reconnaissance squadrons receive new aircraft. The WB-50s began replacing the old, obsolete B-29s. Units began flying WB-47s in 1958, followed by WB-57s in 1961, then WC-130s in 1962. Although WC-135s were also being used in 1965, the WB-47s and WB-57s constituted the bulk of the reconnaissance fleet. The "W" prefix signified the aircraft were weather modified.

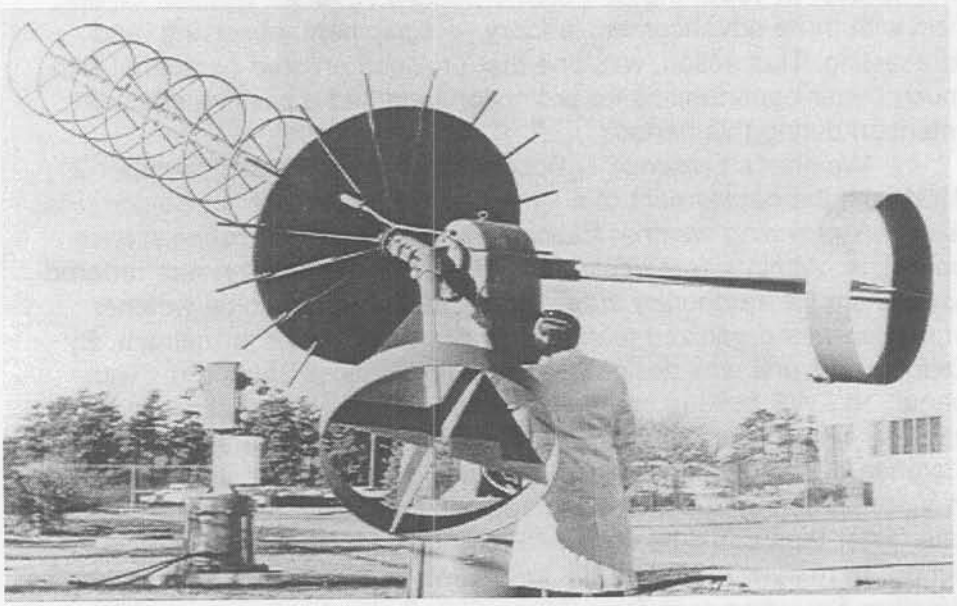
From the end of the Korean War in 1953 until the beginning of America's large-scale involvement in Vietnam in 1965, manning levels in the weather arena remained relatively stable, staying between 10,500 and 12,500. In 1956, the Air Force created a separate weather career field with three advancement ladders — equipment, observing, and forecasting. This action, was one that provided enlisted personnel with much better opportunities for promotion, and had a positive effect on retention during this period.

Weather's presence in Southeast Asia began on December 21, 1961 with the deployment of a single weather forecaster to Saigon. His task was providing weather forecasting for a RF-101 reconnaissance operation. Within a few weeks, a cadre of 23 weathermen was ordered to Vietnam for "temporary duty." In May 1962, a provisional weather squadron was organized to support military operations in Vietnam. By October this unit was designated the 30th Weather Squadron. Thus began an AWS buildup in the Southeast Asian theater that reached its peak six years later. Although the number of weather personnel did not increase during this time period, expanding U.S. participation in the war in Vietnam during 1965, led to increasing manpower requirements at a rate faster than could be filled with existing personnel. During a one-year period, from July 1965 through June 1966, authorizations for the 30th Weather Squadron rose from 238 to 560. By the beginning of 1968, AWS had approximately 600 people in Southeast Asia organized into one group (the 1st), three squadrons (the 5th, 10th, and 30th), 26 de-

tachments, six operating locations, and eight cadre weather teams. Weather personnel served in both Thailand and South Vietnam, with the 1st Weather Group Headquarters located at Tan Son Nhut Air Base near Saigon. The 5th Weather Squadron provided support to Army forces, and the 30th Weather Squadron to Air Force units throughout South Vietnam. The 10th Weather Squadron supported Air Force elements stationed in Thailand.

By 1966, American aircraft were flying 13,000 combat sorties monthly. In support of this effort, AWS troops issued thousands of target forecasts, reaching a peak of 29,488 during the last six months of 1966. Since experience in Southeast Asia dictated closer combat weather support to Army forces, AWS extended its services down to the brigade level instead of only to division level, as it had done prior to this point. One AWS unit commander described their task in Southeast Asia as, "finding out where the weather-sensitive decisions are being made, then concentrate support there." Weather support was such that General William C. Westmoreland, then the American commander in South Vietnam, remarked in 1967 that no other U.S. military commander had ever had the advantages of the outstanding weather support he had at his disposal.

For AWS weather people, the war in Southeast Asia was one of technological contrasts. Scientific sophistication permitted weather detachments in South Vietnam to receive pictures from TIROS VIII, an



Cloud cover photos taken by the TIROS satellite pass through this manually tracked 13-db heliz antenna.

earth-orbiting meteorological satellite, which was put into operation in January 1964. At the same time, combat weather teams, operating directly with the Army in the fields, had to be wary of such primitive weapons as concealed dirt pits lined with sharpened, poison-tipped bamboo splints.

Weather personnel played significant roles in many operations. In November 1966 the success of Operation Attleboro was due in part to accurate weather observations from one of our weather observation teams (OL 1, Det 26, 5th Weather Squadron) a unit that deployed with the 25th Infantry Division. During this campaign, round the clock observations were the norm at Phu Loi with observations in the base camp being prepared during daylight hours only. However, when the brigade command post deployed for action, a member of the AWS combat weather team, accompanied the force to take observations along the way. For this particular operation three observers were deployed along with the 2nd Brigade and two more were setup with forward command. Although the weather during this entire operation was generally poor, our weathermen, forecast it properly. Thus our forces knew what to expect and Maj. Gen. William E. DePuy and his staff were better able to reach decisions regarding troop and supply airlift. This helped lead to a Viet Cong force ultimately losing over 1,100 of its soldiers. For their efforts, every member of the observation team received the Bronze Star Medal.

Then during November 1970, the Son Tay raid took place. The raid called for five HH-53 helicopters to airlift 56 men into a Vietnamese prison camp to free American POWs. The weather was terrible that time of year, with several typhoons striking within an eight-week period. Then, with a tentative plan set for the raid to take place November 21, disaster struck when Typhoon Patsy hit November 18. With another cold front close at hand in the early hours of November 20, a two-man forecasting team advised Brig. Gen. Leroy Manor that "Patsy" would be ashore by the next day. After that, the weather would be so bad that another attempt could not be made for at least a month. General Manor talked with Maj. Keith Grimes, a combat weatherman with Special Operations, and determined that the raid should take place immediately. Even though the Son Tay Prison camp was empty, to many of the POWs, the raid was the greatest thing that could have happened to them during their incarceration. It brought hope to the POWs when, after hearing about the raid, they realized they had not been abandoned, and the United States was doing everything possible to get them back.

Weather reconnaissance forces played a critical role in the Southeast Asia conflict. Starting in August 1965, AWS WB-47s flew weather scout sorties from Guam to refueling areas in support of Strategic Air Command missions over Vietnam. These ended in the fall of 1969 at the direction of Headquarters Air Force. Meanwhile, in March 1967,

AWS began WC-130 flights over Vietnam from Udorn, Thailand. By the time these flights ended in January 1971, about 1,435 combat support missions were flown in the WC-130s.

Once the U.S. started its disengagement from Vietnam in 1969, AWS underwent a drawdown in Southeast Asia that was even more rapid than its buildup. The last weather unit in South Vietnam was inactivated on March 3, 1973, while the 10th Weather Squadron, located in Thailand, was inactivated on September 30, 1975. The last AWS unit of any kind in Southeast Asia, the 1st Weather Wing's Detachment 30, which was also based in Thailand, was officially inactivated on June 7, 1976. However, the last weather person assigned to Southeast Asia, departed the theater on May 21, 1976, exactly 14 years and six months after the arrival of the first one in Saigon. The Southeast Asian conflict resulted in the loss of more than 25 people working in weather related fields.

While the U.S. wound down its presence in Southeast Asia, AWS experienced a major force reduction of its own, driven to a large extent by the austere post-Vietnam military budget crunch. The drawdown started in 1969 with manning being cut by 757 people. For the next several years AWS manning continued its decline. During 1972 alone, AWS was reduced by 2,315 positions, while two wings, one group, and five squadrons were inactivated. Manning, which reached its peak at 11,624 on December 31, 1968, was slashed to 6,402 by the end of 1977, its lowest point since the end of the post-World War II demobilization in 1946. The drawdown finally ended in 1978, and for the first time in

When the 19 WC-130s and seven WC-135s were transferred to MAC's Aerospace Rescue and Recovery Service, it marked the end of AWS ownership and operation of weather reconnaissance aircraft.

As significant to the flying mission as weather is, measuring and monitoring equipment has always been located near the flightline on Air Force installations.

nearly a decade manning across the board was essentially steady.

Aerial weather reconnaissance operations also diminished during the period of January 1971 through the end of 1975, starting when the WC-130 missions over Vietnam ended. AWS adopted a "selective reconnaissance program" in 1971, greatly reducing its number of flying missions. In 1974 the Air Force retired the last of AWS's WB-57s and restricted its few WC-135 aircraft to air sampling missions. The following year it ended the aerial photo-mapping mission of the RC-130s. Then on September 1, 1975, the Air Staff transferred the entire AWS weather reconnaissance fleet, now reduced to 19 WC-130s and seven WC-135s, to Military Airlift Command's (MAC's) Aerospace Rescue and Recovery Service, thus ending almost 30 years of AWS ownership and operation of weather reconnaissance aircraft. However, the Air Staff did not terminate their aerial tropical storm reconnaissance mission, which AWS carried out by means of AWS aerial reconnaissance weather officers flying aboard aircraft assigned to the Aerospace Rescue and Recovery Service. On October 1, 1977 the Air Staff removed the weather equipment maintenance function — a function critical to the performance of its mission — from AWS and gave it, along with 875 personnel positions, to

the Air Force Communications Service.

Throughout the Vietnam War and the post-Vietnam era, AWS continued initiating new services and technologies, while modernizing its equipment. The Air Force launched the first satellite of the Defense Meteorological Satellite Program during 1965, providing AWS with a valuable new source of weather data in support of operations. Around that same time, they began expanding and upgrading space environmental support activities, especially in the areas of solar observing and forecasting. In 1965, they inaugurated a Solar Observing and Forecasting Network consisting of four solar observatories. The next year a Solar Forecast Center was established at Ent AFB, Colorado, and the world's first magnetometer network was created. A few years later, AWS started operating new solar optical and radio telescopes at its solar observatories in 1975 and 1978 respectively. In 1979, they took over operation of the Air Force Geophysical Laboratory's worldwide polarimeter network.

During these years, AWS created or introduced several new or upgraded systems in the computer and weather communications areas. In 1965, the organization implemented a high-speed (4,500 words per minute) Automated Weather Network, linking AWS's two overseas weather centrals with the Global Weather Central at Offutt AFB, which officially became Air Force Global Weather Central (AFGWC) in 1966. This made AFGWC the world's largest operational weather analysis and forecasting facility. Operation of the new Automated Digital Weather Switch began in 1969 at Carswell AFB, Texas, for the Automated Weather Network. Periodically, the computer systems were upgraded at AFGWC, as well as at the U.S. Air Force Environmental Technical Applications Center (formerly the Climatic Center), which moved from Washington, D.C., to Scott AFB, in 1975. The first segment of an upgraded weather communications system for the continental United States, the Meteorological Data System, became operational in 1976.

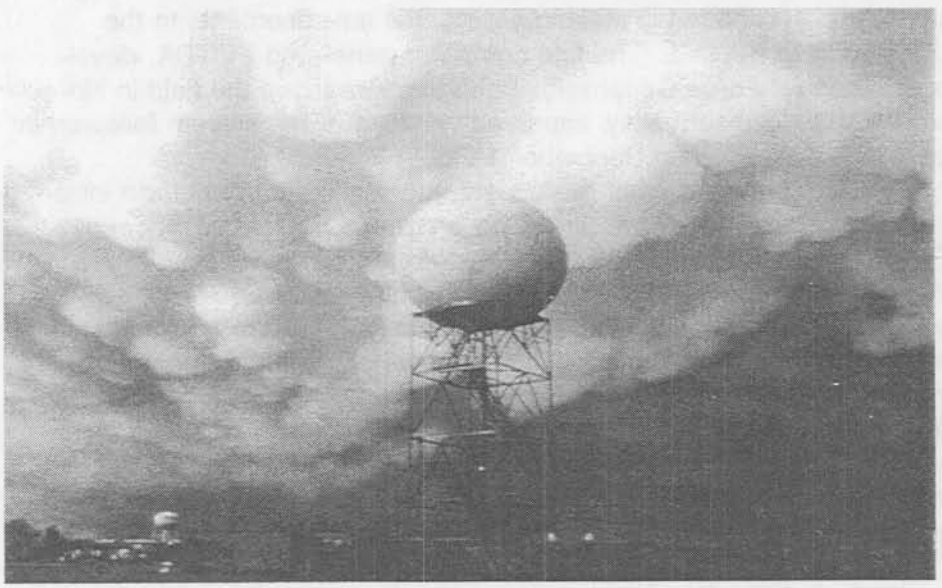
Prior to that, AWS recreated its Centralized Terminal Forecast Program in 1971, which required AFGWC to issue aerodrome forecasts for all weather units in the United States. Seven years later, having realized all of the contributions made by base weather stations to local forecasting, AWS returned responsibility for issuing terminal aerodrome forecasts for periods shorter than 24 hours to base weather stations, with limited duty stations being the one exception.

The years following Vietnam saw AWS continue its weather support of the U.S. Army, despite a limited number of people available for the mission. In 1979, the organization reconfirmed its commitment to furnish direct observing, forecasting, and staff weather officer support to each tactical Army echelon down through division, separate brigades, and armored cavalry regiments. During that same year, the National Guard Bureau, at the request of AWS, reassigned 29 Air National Guard

weather flights to the Air National Guard flight operations in support of Army Reserve and Guard units.

During the 1980s, modernization became the dominant theme for AWS. It pursued a major, across-the-board effort to modernize the way it performed its work by utilizing state-of-the-art technology unheard of only a decade or two earlier. This undertaking included the implementation of new techniques, and the acquisition of new meteorological equipment systems and capabilities based on this new technology. Also during this time, they initiated programs to replace obsolete systems still employing 1950s and 1960s technology, with updated versions that incorporated the more modern technology.

The top three initiatives on the AWS priority list during the 1980s were the Automated Weather Distribution System (AWDS), Next Generation Weather Radar (NEXRAD), and the Battlefield Weather Observation and Forecast System (BWOFS) programs. AWDS would bring weather operations facilities, particularly base weather stations, out of the age of manual operations, and into a new era of automation through the use of state of the art computer systems, plus provide display and communications technology for gathering, processing, and disseminating weather data. The NEXRAD program was a joint undertaking between the National Weather Service, AWS, and the Federal Aviation Administration. It replaced existing, unreliable weather radar with the new, highly auto-

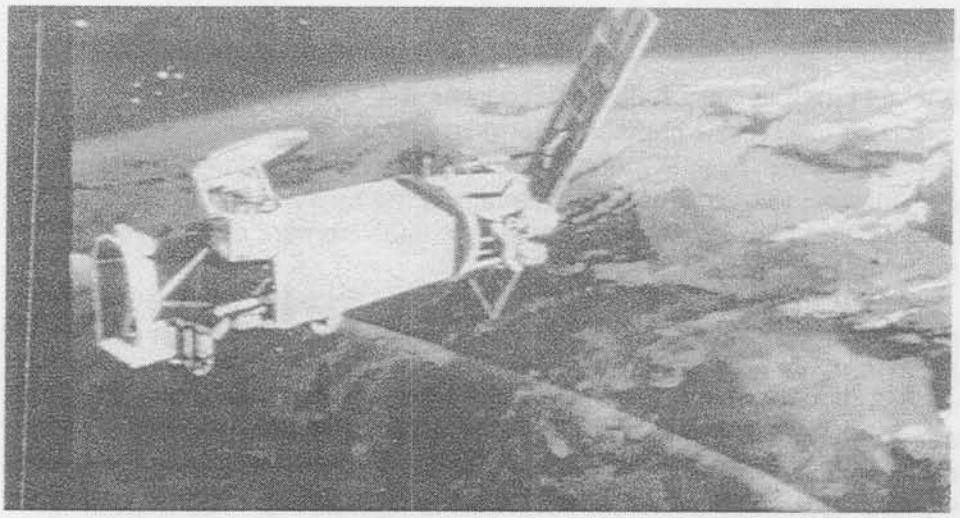


The NEXRAD weather radar program, a joint undertaking between Air Weather Service, the National Weather Service, and the Federal Aviation Administration, came on line late in the 1980s.

mated Doppler Weather Radar that vastly improved severe weather forecasting. The BWOFS program consisted of two parts: the Pre-Strike Surveillance Reconnaissance System (PRESSURS) and Electro-Optical Tactical Decision Aids (EOTDAs). PRESSURS was designed with the idea of making it possible to obtain weather data from behind enemy lines through the use of sensors aboard meteorological satellites and unmanned air vehicles. EOTDAs were essentially predictions of the performance of electro-optical, precision-guided weapons, and target acquisitions systems based on both weather and non-weather data. AWS's goal was automating the production of EOTDAs for both theater decision-makers and aircrews.

The AWDS, NEXRAD, and EOTDA programs made significant progress throughout the 1980s. The development of the PRESSURS program did not thrive. As a result, the Department of Defense decided to eliminate all full scale funding for the program, and by the end of 1988, the program was eliminated. The first prototype of the hardware for the NEXRAD program was delivered in October 1988, and after thorough testing, the Air Force awarded a full production contract for the radar. The AWDS program received its production go-ahead from the Air Force in April 1990, and in June, the contractor installed the first system at McGuire AFB, New Jersey. The system soon became operational, and was then officially accepted by AWS in January 1991. Meanwhile AWS, in concert with Air Force Systems Command and other Air Force major commands, succeeded in making substantial advancements to the EOTDA part of BWOFS. The first computer-generated EOTDA, developed by the Air Force Geophysics Laboratory, reached the field in November 1986. Subsequently, improved versions of the system followed in May 1989, then again in December 1990.

AWS launched other equipment acquisitions and upgrade initiatives throughout the decade, including programs needed to modernize AFGWC operations. In 1985 a new mainframe computer system along with a Cray supercomputer were purchased for AFGWC. They also acquired the Satellite Data Handling System (SDHS), linking together the interactive weather graphics and imagery system, with a high-speed data handling system. By 1986 SDHS had achieved full operational capability. Additionally AWS, in coordination with Air Force Communications Command, obtained a communications front-end processor, nearing full operational capability by the end of 1990. This combined all AFGWC communications functions into one automated data processing system. At this time, AWS also set programs in motion to upgrade equipment at the six solar observing sites of its Solar Electro-Optical Network, the successor to the Solar Observing and Forecasting Network. The organization obtained and installed 19 digital ionospheric sounders at strategic locations throughout the world as replacements for outdated analog



The Air Force launched the first satellite of the Defense Meteorological Satellite Program in 1965. Subsequent launchings have continually improved the system which was still in use at the end of the centuary.

sounders. They also began, and in some cases completed, several programs to procure new, small, fixed, and transportable meteorological and communications systems, while aggressively seeking to have additional weather sensors installed on meteorological satellites.

The 1980s saw AWS introduce new and better weather support services, including weather support to NASA's space shuttle operations in 1981. The organization also initiated programs to improve space environmental support systems. Then in 1983, it began working towards the construction of a Space Forecast Center where it could consolidate its space environmental support activities. By 1990, the physical-structure located at Falcon AFB (now Schreiver AFB), Colorado, was completed and the center soon reached operational status. In 1985, AWS initiated a program to acquire new and more sophisticated space environmental models. That same year, it began an attempt to secure manifesting for a weather officer on a space shuttle mission. This effort failed and was finally discontinued in November 1991. This was due largely to scheduling problems caused by a lack of resources, DOD prioritization, and other issues. During the 1980s, AWS expanded and enhanced its Army support, including support of its Special Operations Forces. In 1988, for example, it agreed to provide weather effects support to Army electro-optical systems, including for the first time, EOTDA support.

Weather personnel supported numerous U.S. contingency operations during the 1980s. These included Operation URGENT FURY, the invasion of the Caribbean island of Grenada in October 1983 to restore

order and democracy; Operation ELDORADO CANYON, the air strike against Libya in April 1986 to discourage that country's sponsorship of terrorism following a number of terrorist bombings throughout Europe and the Far East, and Operation JUST CAUSE, the military intervention in Panama in December 1989, leading to the capture and imprisonment of it dictator Manuel Noreiga, and the reestablishment of a democratic government.

Two significant and somewhat related changes occurred in the weather career field during the decade of the 1980's. The first came in April 1981, when AWS eliminated a separate enlisted weather observer career field created in the 1950s. They instead implemented a single career ladder system under which weather personnel began their careers as observers and later, after returning to school to take the weather technician's course, advanced to forecasters. The second change introduced a forecaster assistant program whereby select individuals took the observer and forecaster training courses in succession. Graduates of this program became "forecaster assistants" who, after on the job and other types of training in the field, could advance to fully certified forecaster status.

Although the AWS fleet of weather reconnaissance aircraft was

A member of the "Hurricane Hunters" prepares to release a dropsonde from a WB-50 into a hurricane to obtain information on the strength of the storm. This hurricane mission was turned over to the Air Force Reserves in 1991.

transferred to Military Airlift Command in 1975, it continued a close involvement with all the aerial reconnaissance issues and operations. By 1986, the Air Force became convinced that advances in meteorological satellite weather sensor technology, made weather reconnaissance flights by aircraft obsolete. Therefore, it proposed the termination of aerial weather reconnaissance. Congress, however, concerned about protecting U.S. coastal areas against hurricanes, especially in the eastern and southern coastal regions, mandated the Air Force to continue WC-130 weather reconnaissance flights over the western Atlantic-Caribbean-Gulf of Mexico and eastern Pacific areas. It did however, permit the Air Force to terminate aerial weather reconnaissance in the western Pacific region in October 1987. Four years of discussion took place among the Air Force, Congress, and other government agencies over the future of aerial weather reconnaissance. Finally, in October 1990, the Air Staff, in accordance with a Congressional directive, transferred the "Hurricane Hunters" from MAC's Air Rescue Service to the Air Force Reserve and stationed them at Keesler AFB, Mississippi, in June 1991.

As the last decade of the 20th Century dawned, it appeared AWS was entering another period during which it would diminish in size. The sudden and surprising collapse of the Communist regimes of Eastern Europe, and the end of the Cold War in 1989, coupled with pressure to reduce spending in the Federal budget, were all signs another drawdown had arrived.

However, before that could take place, a sudden and unexpected challenge arose. The invasion of Iranian forces across its southern border, and its subsequent annexation of Kuwait, soon led to the largest overseas deployment of weather personnel since the height of the Southeast Asia conflict in 1968. On August 7, 1990, President George Bush ordered American forces to deploy to Saudi Arabia, and by the 8th the first weather officer was in Dhahran. Thus began the AWS support of Operation DESERT SHIELD, the massive deployment of American and other United Nations forces into the Middle East region. Operation DESERT SHIELD became DESERT STORM on January 16, 1991, as the United Nations coalition kicked-off offensive operations aimed at driving Iraqi forces out of Kuwait. On February 27, its objectives complete, the coalition ceased all combat operations. The AWS deployment to DESERT SHIELD and DESERT STORM in support of U.S. Air Force and Army forces reached its peak of approximately 475 people in early February. The redeployment of these troops began shortly after the end of the hostilities. Although short in duration, the conflict resulted in the loss of three enlisted personnel.

Once the war was over, AWS personnel found themselves supporting a number of humanitarian and military operations over the next

Since its inception, one of the primary roles of Air Force weather personnel has been the support of Army forces in the field, both during deployments and exercises. A role that continues today.

few years. Among these operations were, SOUTHERN WATCH (Southwest Asia), NORTHERN WATCH and PROVIDE COMFORT (Turkey), PRODUCTIVE EFFORT/SEA ANGEL (Bangladesh), FIERY VIGIL (Philippines), PROVIDE HOPE (Russia), RESTORE HOPE and CONTINUE HOPE (Somalia), PROVIDE PROMISE (Bosnia-Herzagovina), SUPPORT DEMOCRACY and UPHOLD DEMOCRACY (Haiti), SUPPORT HOPE (Rwanda), plus ALLIED FORCES and SHINING HOPE (Kosovo)

Air Weather Service began a new era in history April 1, 1991, when reorganization within the Air Force saw the end of their 45-year status as a subordinate organization of MAC and its predecessors, and made it a field operation agency (FOA). As a FOA, it reported directly to the Air Staff through a Directorate of Weather recreated in the Office of the Deputy Chief of Staff for Plans and Operations. This Air Force action restored AWS to a position similar to that which it possessed prior to becoming part of Air Transport Command. Under this reorganization, the Directorate of Weather has responsibility for policies, plans, and resources for environmental support services while the focus of AWS is on operational weather support.

That change was just one of many that affected the organization

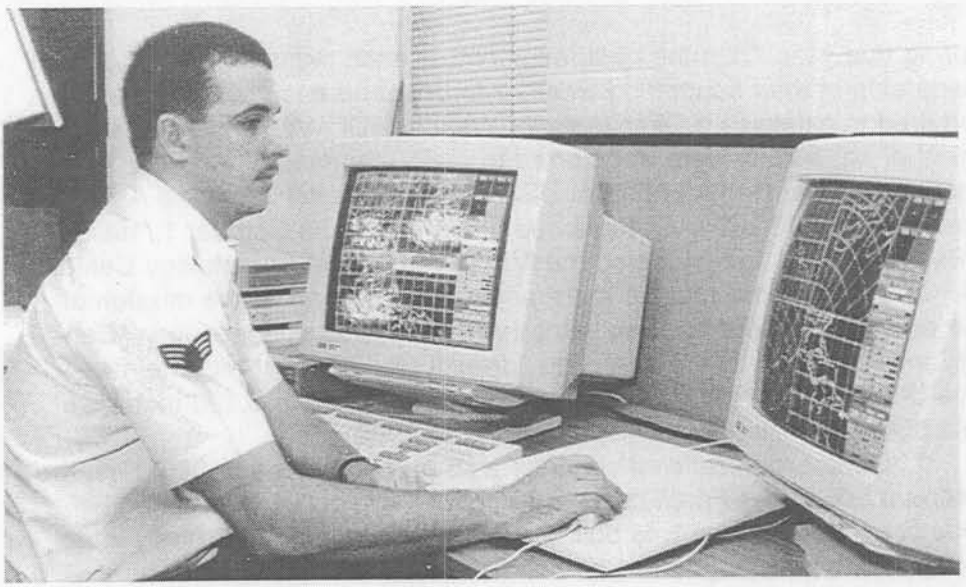
during that year. Over the next few months, each major command gained ownership of their supporting weather forces, and each of them was required to establish a Directorate of Weather (DOW). While entire weather squadrons were transferred to major commands, Air Force Global Weather Central and the USAF Environmental Technical Applications Center (USAFETAC) remained under AWS. On October 1, 1995, USAFETAC was redesignated the Air Force Combat Climatology Center (AFCCC), the name change more adequately describing the mission of the unit. Global Weather also went through a minor change when "Central" was changed to "Center." This "divestiture," coupled with the massive drawdown of military forces, saw AWS shrink from 5,100 members to 1,056 authorized positions by the end of 1995.

Other organizational changes also occurred during 1995. First the Secretary of the Air Force ordered the establishment of the Combat Weather Facility, which was built at Hurlburt Field, Florida. Shortly after, their name was changed to Combat Weather Center. The unit was tasked with a four-fold mission: develop, maintain, and conduct tactical training to improve wartime readiness of Air Force Weather people; conduct realistic combat weather exercises for integrating weather people into Air Force, Army, Special Forces, and joint forces; evaluate new and emerging concepts, techniques, and applications of technology to improve combat effectiveness; and transition improvements to operational forces.

As the Air Force's weather battle laboratory, CWC provides an institutional means of attaining the warfighters' goal of "owning the weather". The objective of "owning the weather" is to obtain capabilities that allow warfighters to exploit knowledge of the environment and its effect on the battlefield. This in turn, gives them a decisive advantage over the enemy. CWC brings together the Army, special operations forces, industry, and academia to evaluate new doctrine, tactics, technologies, and techniques and then quickly provides the most promising to Air Force weather people for use in the field.

The plan to integrate the command, control, communications and computers, and information management functions under one management level began to take shape. The office, designated as SC or the Communications/Information Office, would not be fully established until 1996.

Technology continued to be the cornerstone for improving the gathering of weather information. Started in 1965, the Defense Meteorological Satellite Program (DMSP) continued its successful mission with the launching of F-13, which joined its predecessors during 1995. For over 30 years DMSP satellites provided data on environmental features such as clouds, bodies of water, snow, fire, and pollution in the visual and infrared spectra for both military and civilian organizations.



A Senior Airman builds a satellite picture display based on information obtained from the Automated Weather Distribution System. First brought on line in the early 1980s, it was most recently updated in 1998.

A number of other weather systems saw the light of day during the late 1980s and the early 1990s. A few of those systems were the Transionospheric Sensing System, Digital Ionospheric Sounder System, Automated Surface Observation System, Automated Weather Distribution System, Meteorological Data Station-MARK IV-B, FMQ-13 Digital Wind Measuring System, Digital Temperature/Dew Point Measuring System, and Laser Beam Ceilometer, plus numerous space environmental systems. One of the more recent programs was the Very Small Aperture Terminal. Referred to as VSAT, this system is a small satellite dish that can be easily set up in the field to receive data.

New weather communications systems, as well as upgrades to systems still in use, also occurred during this time. Among them was a Weather Information Processing System, a Computer Front End Processor, the purchase of numerous personal computer systems, and the growth of the Local Area Network. Eventually AWS joined the Internet in 1996 when AFGWC posted its first web page and the Air Force Weather Information Network (AFWIN) went online. Through AFWIN, customers could receive visualizations, charts, and meteorological satellite products. This unclassified military Internet, known as NIPRNET, provides weather products to customers worldwide. A new program, called the Defense Weather Information Network (DWIN), helped alleviate network traffic from the Automated Weather Distribution System (AWDS). Once

online, DWIN provided graphic products and satellite images. AWDS, first created just a few years prior, was itself upgraded in early 1998.

In the midst of all the technological changes, came yet another change in the organizational structure. This occurred October 15, 1997 when Air Weather Service was redesignated as Air Force Weather Agency (AFWA), and subsequently moved from Scott AFB, Illinois to Offutt AFB, Nebraska, and merged with the Air Force Global Weather Center which was inactivated.

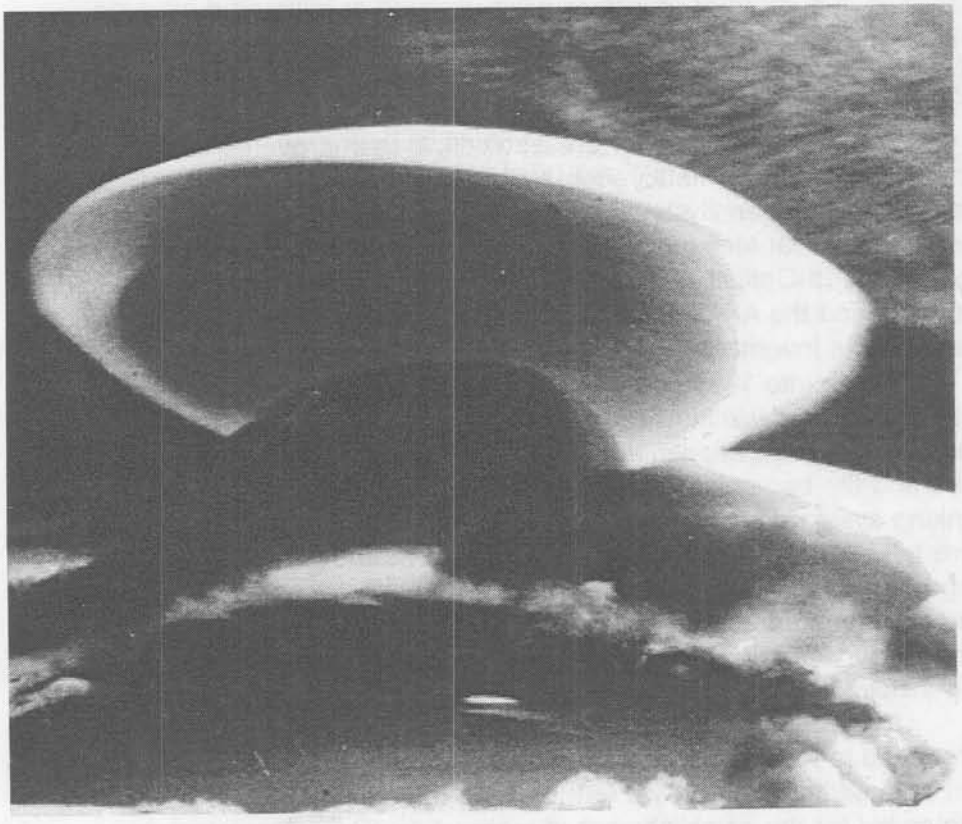
During the Gulf War, and through the years since that time, AWS continued its long-standing tradition of providing weather support to U.S. Army forces. While weather teams provided the basic weather support in tactical theaters (providing services similar to a base weather station), they also functioned at levels as high as division headquarters. To provide better assistance for warfighting commanders in a variety of scenarios, a number of programs were updated or initiated during the 1990s. They included an increase in Tactical Meteorological Equipment, an upgraded Tactical Forecast System Concept of Operations, and the development of a Survivable Enduring Weather Capability program. New or updated equipment items were also critical to improvements in the tactical weather area. Items such as the Transportable Automated Weather Distribution System, the Tactical Rawinsonde, Small Tactical Terminal, Tactical Meteorological Observing System, Tactical Weather Radar, Electro-Optical Tactical Decision Aids, Rapid Deployment Imagery Terminal, and the AN/GMQ 33 Transportable Cloud Height Detector were added to the inventory.

Going into 1999 one of the greatest challenges facing the computer technicians within AWS was the same thing worrying most of the world: What would happen when midnight arrived marking the end of 1999 and the beginning of 2000? Fears of crashing airplanes, satellites, banking systems, and anything else tied into computerized technology were talked about on television, radio and in the newspapers. However, long hours of hard work and dedication by AFWA computer personnel paid dividends and critical rollover dates, such as September 9, 1999, October 1, 1999, January 1, 2000 and February 29, 2000, passed with little incident.

In the final years leading up to the millennium, a new term was introduced to the men and women of weather: re-engineering. With the Air Force getting smaller, yet with growing operational requirements, this plan called for the establishment of regional Air Force Operational Weather Squadrons (OWS) around the world. These units would provide specialized weather data to meet the needs of units within their regions. By the end of the century OWS units were activated at Scott AFB, Illinois; Sembach AB, Germany; Davis-Monthan AFB, Arizona; Barksdale AFB, Louisiana; Shaw AFB, South Carolina; Elmendorf AFB, Alaska; and

Yongsan, South Korea. Other OWS units at Yokota AB, Japan, and Hickam AFB, Hawaii are expected to join the others early in the next century. Meanwhile, the space weather mission and its operations, which in 1994 had been transferred to Air Force Space Command, was once again placed under the AFWA umbrella during 1999.

Starting from their days in the Army Air Corps, and through more than 60 years of existence, dedicated service, and professionalism have been the hallmark of Air Force Weather. People, units, missions, technology, and even its service affiliation have changed during those years. Most of these changes will continue to occur well into the next century, which will dictate how weather people carry out their mission. However, if history is a measuring stick for success, then the people of this organization will be equal to any challenge well into the new millennium.



This unusual cloud formation, known as an Altocumulus Standing Linticular or Cap Cloud, will sometimes form over the top of a mountain, giving it the appearance of a giant flying saucer.

Fallen Comrades of Air Weather Service

Air Reconnaissance Personnel

1/Lt Otis A. Young, 1/Lt Jay A. Steinbrenner, 1/Lt John P. Trostel, T/Sgt Harry A. Holt, Maj Roy H. Bruns, Capt Cleo S. Maddox, Capt John C. Mays, 1/Lt James E. Shewey, 1/Lt Andrew J. Rooks, T/Sgt Clarence J. Hyatt, S/Sgt Harry N. Barker, S/Sgt Preston S. Treadway, Sgt James A. Sapp, Cpl Harry N. Carden, Cpl Robert D. Myrman, 1/Lt Walter Krueger, 2/Lt Vincent P. Gendusa, 2/Lt Robert J. Shaw, M/Sgt Frank P. Leach, Sgt Donald E. Parker, Cpl Francis X. Toland, Maj Sterling L. Harrell, Capt Donald M. Baird, Capt Frank J. Pollak, 1/Lt William D. Burchell, 1/Lt Clifton R.Knickmeyer, M/Sgt Edward H.Fontaine, A/1C Alton B. Brewton, A/1C William Colgan, A/1C Anthony J. Fasullo, A/3C Rodney E. Verrill, Maj Bruce Acebedo, Capt Guilford A. Hopkins, Capt Robert L. Kizer, Capt Leonard B. Winstead, 2/Lt August I. Lam, M/Sgt Edwin M. Fultz, T/Sgt George R. Shook, S/Sgt Elbert E. King, S/Sgt Hayden C. Shulz, S/Sgt Carlton J. Fose, Capt Charles F. Baker, Maj Dale Richardson, Cpt Leonard N Chapman, Jr., Capt Everett E. Dyson, 1/Lt William J. Wolters, Jr., 2/Lt Willaim W. Faustlin, M/Sgt Fred T. Gregg, Jr., T/Sgt Richard K. Brown, S/Sgt Ronald R. Ragland, A/3C Douglas W. Maxson, A/2C Melvin O. Lindsay, Capt Raymond Durr, Capt Dewey A. Keithly, Capt Leonard A. Klawa, Cpt Lawrence C Monies, 1/Lt Waylon H. Moseley, S/Sgt William A. Taylor, A/2C Gerald R. Arnn, A/2C John E. Hollis, A/2C Mose F. Thomas, Jr., Capt Harold W. Bales, Capt Robert E. Eichelberger, Capt William P. Spil, 1/Lt Robert E. McGough, 1/Lt Ralph L. Sampson, 2/Lt Bobby H. Spencer, M/Sgt Woodrow B. Russell, A/1C John W. Cramer, A/1C Donald D. Dodds, A/2C Robert C. Glenn, A/2C Thomas F. Patterson, A/3C Roger D. Sigman, Capt Albert J. Lauer, Capt Clyde W. Tefertiller, Capt Marcus G. Miller, 1/Lt Courtland Beeler III, 1/Lt Paul J. Buerkle, Jr., T/Sgt Delivan L. Gordon, S/Sgt Kenneth L. Tetzloff, S/Sg Kenneth L. Houseman, A/1C Randolph C. Watts, A/1C Bernard G. Tullgren, Capt John R. Willis, 1/Lt Robert W. Blanton, 1/Lt William L. Hesse, 1/Lt Howard S. Kelly, 2/Lt Lawrence K. Draper, M/Sgt Claude M. Burgess, M/Sgt James W. Fields, Jr., T/Sgt Vernon W. Powell, A/1C Edward L. Armstead, A/3C Alfred Campbell, Jr., A/3C Barney Jablonski,

Capt Paul H. Palmer, Capt Joseph W. Ivins, Lt Glenn Sprague, Lt Bobby Galbrecht, Maj Joseph M. Pair, Capt Carl R. Laffoon, Maj Conrad L. Lienhart, Capt Warren S. Hillis, T/Sgt Charles F. Heckman, Amn Terry J. Nirolis, Lt Col James B. McCravy, Lt Col James B. McCravy, Capt Harold "Pat" Moore, Jr., Maj Dale M. Mann, Capt Edward R. Bushnell, 1/Lt Gary Wayne Crass, 1/Lt Michael Patrick O'Brien, 1/Lt Timothy John Hoffman, TSgt Kenneth George Suhr, and Sgt Detlef Wolfgang Ringler.

World War II

Capt Robert M. Losey, Cpl Harold W. Borgelt, TSgt Daniel A. Dyer, PFC Sherman Levine, Pvt Richard E. Livingston, Cpl James M. Topalian, 1/Lt James H. Cooke, 1/Lt James W. Pflueger, Pvt George D. Cunning, Pvt Gordon S. Hart, Pvt Earl W. Wilson, 1/Lt Amos M Hutchinson, Jr., 1/Lt William E. Stodghill, MSgt Donald E. Tice, TSgt Ben Slobutsky, MSgt Raymond B.Orner, Jr., Capt Robert G. Aho, TSgt Herman C. Hudson, 2/Lt Raymond W. Pope, SSgt Everett N. Dietrich, 2/Lt Leland T. Harder, Jr., SSgt David W. Fogo, Maj William P. Conway, Jr., SSgt Russell E. Hill, Capt Edward P. McDermott, Capt John D. Root, Cpl Arthur H. Gill, Jr., 1/Lt J.J. Mann, Sgt Joseph H. Kimmell, Jr., 2/Lt John H. Macklin, MSgt Richard W. Stoodley, SSgt Charles H. Hammill, Cpl Robert P. Herbig, Sgt Louis J. Heller, Cpl Leonard S. Harrow, Col Joseph A. Miller, Jr., 2/Lt Robert L. Shaw, MSgt James K. Hastings, Sgt Myron Hirsfield, 2/Lt Harold G. Brink, Capt Jean W. Dixon, 2/Lt Elgin E. Fisher, 1/Lt Howard R. Henry, TSgt John F. Spellman, 2/Lt William C. Stillwell, Sgt Albert F. Whalen, Maj Frank T. Cox, Jr., 2/Lt Richard W. Beard, Jr., Cpl Walter A. Marsh, Jr, TSgt Walter C. Ahrens, 2/Lt Robert G. Kraybill, Cpl Carl E. Houston, 2/Lt Charles A. Cannon, Jr., SSgt William H. Hutchings, 2/Lt Charles H. Janssen, Jr., SSgt Frederick E. Keup, 1/Lt William L. Knowlan, MSgt Thomas W. Smith, 1/Lt Arthur J. Brestlin, Maj Jay Jacobs, TSgt Cletus G. Bice, 1/Lt Stanley Z. Abrams, SSgt Billy R. Isham, Maj Robert C. Kunz, F/O James M. Pyca, SSgt Alvin C. Schaefer, Capt Carl E. Rimmele, Sgt Harold E. Gstalder, Cpl John R. Waite, 1/Lt James A. Fuller, and Lt Walter R. Weston.

Korean War

Capt David H. Grisham, 1/Lt James M.Schooley, Jr., Capt Warren G. Harding, Capt Gerald L. Brose, Capt Bruce K. Nims, and TSgt Carl M. Spence.

Southeast Asia

Sgt Edward W. Milan, SSgt James C. Swann, SSgt Eduardo Garcia, Jr., and A1C Kenneth E. Baker, Jr.

Desert Shield/Desert Storm

MSgt Samuel Gardner, Jr., SSgt Marc H. Cleyman, and SSgt Rande J. Hulec.

AFWA History Office
Special Study
by
Lillian E. Nolan
John M. Murphy