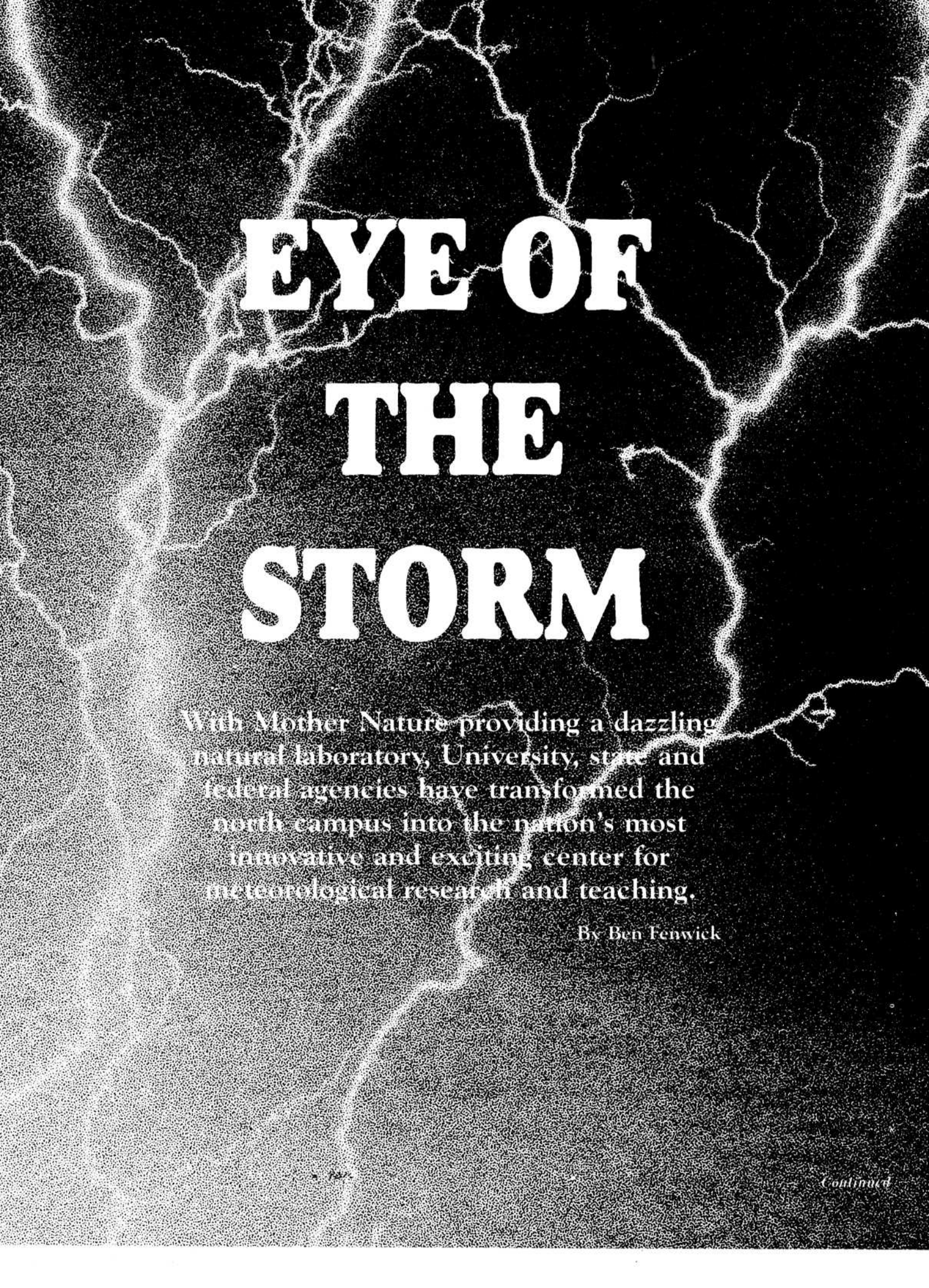


EYE OF THE STORM

With Mother Nature providing a dazzling natural laboratory, University, state and federal agencies have transformed the north campus into the nation's most innovative and exciting center for meteorological research and teaching.

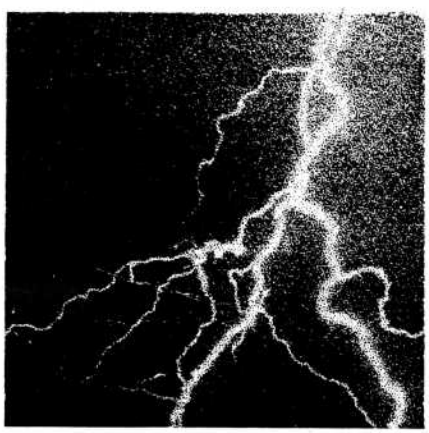
By Ben Fenwick

Continued

Eye of the Storm

A storm is brewing at the University of Oklahoma. All the signs are there. Drive into Swearingen Research Park at OU's north campus, just past the intersection of Robinson and Flood streets in Norman. Spot the radar domes and instrument towers.

The area seems quiet, but it is an impending quiet, like the calm before a tornado strikes. The streets have names like Einstein, Newton and Mendel — echoes in the halls of science. Although older buildings remain, dating from the days when north campus was a Navy base, new structures dominate the south side, the Weather Center and the National Severe Storms Laboratory buildings among them. Inside each, scientists are hard at work, peering at the screens of coolly-analytical workstations linked to hosts of



computers including supercomputers.

The storm is there. It's an academic storm that is sweeping the world of weather research and forecasting.

Some of these north campus scientists may work for the National Weather Service, others for the FAA, Air Force, the state of Oklahoma—or all of the above. But one thing is certain: they all work with the University of Oklahoma and for the future. Nationally, OU's Weather Center is becoming synonymous with weather forecasting and research, and the research could affect the way we all live and work.

The Weather Center is an amalgamation of eight different federal, state and university entities. Located within the OU Energy Center on the main campus are: the School of Meteorology (SOM), the Center for Analysis and Prediction of Storms (CAPS), the Cooperative Institute for Mesoscale Meteorological Studies (CIMMS), the Geosciences Computing Network (GCN), the Oklahoma Climatological Survey (OCS). The north campus elements of the Weather Center include the National Weather Service Forecast Office (NWSFO), the Next Generation Radar (NEXRAD) Support Facility, and the National Severe Storms Laboratory (NSSL).

The various Weather Center agencies employ more than 200 scientists, technicians and teaching faculty. Many of the 230 or more graduate and undergraduate students who study there are also on the payroll.

Claude Duchon, the director of the School of Meteorology and 20-year faculty member, said the Weather Center has seen exponential growth through the 1980s.

"The big changes occurred in the '80s," he says. "I think it was a function of the kind of people here."

But even though the center's greatest amount of growth happened during that decade, Duchon explains that the sudden swell was the result of work done for at least two decades prior. For the most part, it started with the desire of the National Severe Storms Laboratory, established in the early 1960s, to work with students at the School of Meteorology, and vice-versa. The site for NSSL was chosen by the federal government to be near OU, an effort to take advantage of both the proximity of a university and the "natural laboratory" of Oklahoma's weather.

"There is a lot of interesting weather in Oklahoma," Duchon says. "That always has been of national interest. When the Cooperative Institute for Mesoscale Meteorology was funded, it produced a natural, three-way tie between OU, CIMMS and the NSSL."

Present throughout all the development was the School of Meteorology, acting as the clearing-house to bring together all the components of what has become the Weather Center.

The prototype Next Generation Radar on OU's north campus represents technology for a new era in meteorological research.

"I think of the school as the hub of the program," Duchon says. "We are the educational arm. We educate and train the students; they go out to the other parts of the center. A lot of people channel back and forth through us."

"One thing that is clear is that new technology is very exciting to young people in this country," says James F. Kimpel, dean of the OU College of Geosciences, which oversees the Weather Center operations. "Weather research is attractive to high school students and college students with engineering and science backgrounds. We've been able to take advantage of that."

With 160 undergraduates, the OU School of Meteorology enjoys the largest undergraduate enrollment of any meteorology program in the country, and meteorology attracts the

ABOVE: Offices of the National Weather Service and NEXRAD are located in the Weather Center Building on the north campus. RIGHT: Meteorology school director Claude Duchon, left, graduate students Greg Wilk and Spencer Piel and technical assistant Tim Hughes take readings from a unique instrument to measure longwave and shortwave radiation, precipitation, air and surface temperatures, humidity at two levels and wind speed and direction.

Present throughout all the development was the School of Meteorology, the clearing-house to bring together all the components of the Weather Center.

largest out-of-state undergraduate enrollment to OU. Three current students in the OU program are National Merit Scholars. A roster of 70 graduates places the school second or third nationally in graduate enrollment.

Many students work their way through college in weather research projects at the center. Graduates and undergraduates alike work for the National Oceanic and Atmospheric Administration and other agencies that eventually could hire them.

"These are very good students," Kimpel says. "We get the students in the top 25 percent of the list."

In addition to acting as a kind of lightning rod to students, the center also attracts outside funding.

"If you look at the whole operation, we bring about $15 million annually into the state's economy," Kimpel says. "We've put together the critical mass that lets us compete head-to-head with other universities for more research funding."

Since 1989, the various organizations in the Weather Center have received millions in private donations and outside research grants, far surpassing the state money received.

Among the numerous incidents of private support is more than half a million dollars in discounts from the Digital Equipment, Stardant and Recognition Concepts corporations to upgrade computer equipment in its nerve center, the Geosciences Computer Network. Additionally, the W. M. Keck Foundation provided $350,000 to the GCN.

In another grant, CAPS was awarded 450 hours of computer time for research on MIT's Cray-2, the world's most powerful computer system. Each hour is worth approximately $1,000.

How did this highly regarded center of research and education evolve at the University of Oklahoma?

"Frankly, the concept was copied from the Energy Center," Kimpel says.

The Energy Center was designed to bring under one roof all energy-related disciplines to allow students and faculty to work, learn and research together.

Continued

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"The people in meteorology started thinking big," Kimpel recalls. "Well, if OU can have an Energy Center, we could do something like that in the weather business. The Weather Center idea was put together in 1981."

The National Severe Storms Lab was already on the north campus, and the meteorology school was located on the main campus. Faculty members reasoned that if these units were to begin a formal working relationship, a larger, more coherent entity could be created. Since OU's meteorology school works on both basic and applied research problems, the meteorologists saw merit in combining a theoretical center with an operational center, where weather forecasting is an everyday occurrence. So, Kimpel says, the school simply made a phone call to the National Weather Service Forecast Office, then located in Oklahoma City.

"We decided—rather naively—that we'd like to move the National Weather Service Forecast Office to north campus," Kimpel says. "About four years later, after involving a few hundred people — the U.S. Congress, the Senate, and the Department of Commerce — it happened."

That move was made in 1985, giving OU's weather program a new dimension and an impetus for growth.

Now, the mix allows OU meteorology students to interact on a daily basis with the scientists in the National Weather Service and the National Severe Storms Laboratory. Not only can researchers see how their work comes into practical use, but the relationship also provides the NWS and NSSL with benefits as well. And, some NWS and NSSL scientists don teaching robes, taking to the OU meteorology classrooms what they have learned in their professional activities.

"We like to think of the Weather Service Forecast Office as our teaching hospital," notes Kimpel.

Kenneth C. Crawford, who was with the National Weather Service office in Norman for 27 years and left federal service after becoming the Oklahoma area manager for the National Weather Service, made the switch to academia permanent. Crawford is now an associate professor in OU's School of Meteorology and director of the Oklahoma Climatological Survey.

Capt. Jeff Fornear demonstrates a principal user processor, a workstation for the NEXRAD program, for visitors from the National Science Foundation.

The Oklahoma Climatological Survey was created by the Oklahoma Legislature in 1982 as a dual research and service organization to provide state officials with statistics on Oklahoma's climate. OCS conducts research as well on basic scientific problems relating to climate change and other environmental concerns.

Crawford's experience has been valuable in teaching and in developing another ambitious project, the Oklahoma MesoNet. If approved for funding by the U.S. Department of Energy, the project would be a joint effort of OU and Oklahoma State University, with OSU providing agricultural expertise for the project.

The MesoNet would plant approximately 100 weather mini-stations statewide, linked through a computer network used currently only by the Oklahoma Department of Public Safety. Information, including flood and storm warnings, could be relayed to any of more than 213 computer bases in local police stations.

Continuous data on soil and air temperature, rainfall, wind, humidity and soil moisture would be made available and could be used to save the state more than $20 million annually in energy, irrigation and agricultural costs. Some of the station-gathered data also could be combined with radar data through the Weather Center's computer system to compare the different readings for research purposes. The availability of collected data to the state's high schools for teaching and science projects would be an additional payoff.

But Weather Center activities also range to the theoretical. Howard Bluestein, a professor in the School of Meteorology, hopes to discover how tornadoes begin and how to accurately measure the speed of the air moving within them, something that only can be estimated now.

With an experimental portable Doppler radar developed at Los Alamos National Laboratory, but through research funded by OU Associates grants and the National Science Foundation, Bluestein and a handful of graduate students peer into the center of tornadoes in a way never done before.

"This is the first time this type of radar has been used," he says. "With this radar, we can get close to the situation a number of times every year."

"One of the major goals of this center is to build new numerical models capable of predicting weather on the scale of a single thunderstorm."

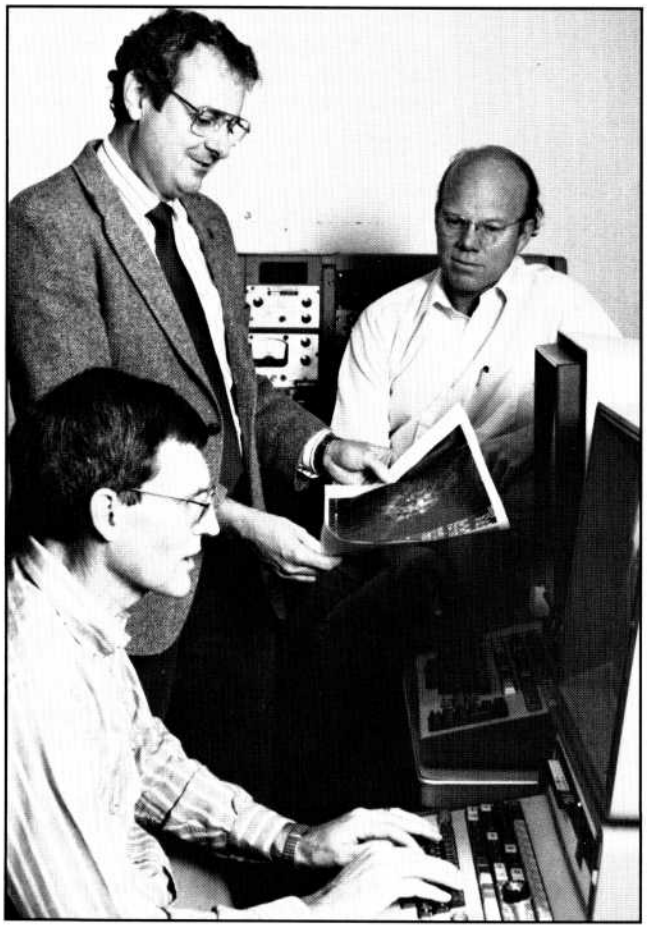
Rarely, if ever, even in Oklahoma, does a tornado come close enough to larger conventional radar facilities to register the type of readings Bluestein wants. Large radars can, however, detect and track tornadoes up to hundreds of miles away. When the National Weather Service's radar picks up a tornado within a few hundred miles of Norman, Bluestein and his students run out in a van to intercept it.

This spring, they got "lucky" when they were able to intercept a tornado-bearing wall cloud and try out their new radar. The cloud eventually formed a funnel. Bluestein says this is the first time he has been able to get a usable reading.

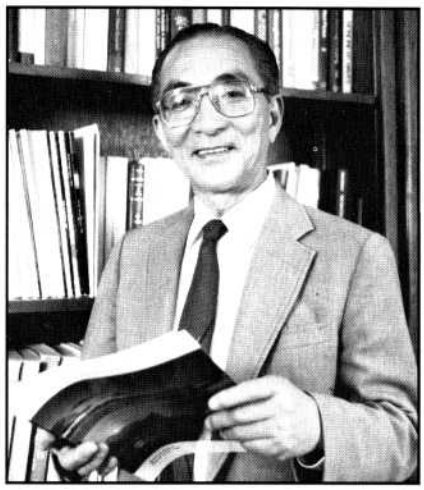
"While we were obtaining the data, a funnel formed, but it didn't touch down," Bluestein says. "We got a videotape and some still photographs. We hope to find out where it formed within the wall cloud."

The tornado touched down in the western Oklahoma town of Shattuck. Although buildings were damaged, no one was killed, largely because the town had adequate warning from the National Weather Service. Perhaps Bluestein's research may one day even improve upon the current safety margin for tornado warnings.

Although not quite as gripping, another kind of research ongoing at the Center for the Analysis and Prediction of Storms, or CAPS, may lead to discoveries that also can save lives and money.



National Severe Storms Laboratory director, Robert Maddox, left, and John Lewis, chief of the meteorological research group, stop at a workstation manned by meteorologist Carl Hane, seated.



Known worldwide for his work on variational objective analysis, George Lynn Cross Research Professor Yoshi K. Sasaki joined the OU faculty in 1961.

In 1988, CAPS was one of only 11 programs selected from among 323 applying nationwide to receive multimillion dollar funding from the National Science Foundation. Since then, the original $4.9 million has been doubled with private matching funds, Kimpel says. Originally funded for five years, CAPS may receive an additional $20 million or more over a 10-year period if the NSF decides to continue its support. Douglas Lilly is the intellectual and administrative leader of CAPS.

CAPS deputy director Kelvin Droegemeier recently was awarded the Presidential Young Investigator Award for his work in building computer models of storm activity.

"One of the major goals of this center is to build new numerical models capable of predicting weather events on the scale of a single thunderstorm," says Droegemeier. "We're looking at redefining forecast methodology."

For Droegemeier, this redefinition takes on the form of computer prediction models. Droegemeier and the others in CAPS are creating complex computer programs that simulate dangerous weather conditions such as thunderstorms, tornado clouds or other phenomena. They hope to build a three-dimensional model which, when fed readings from the extremely

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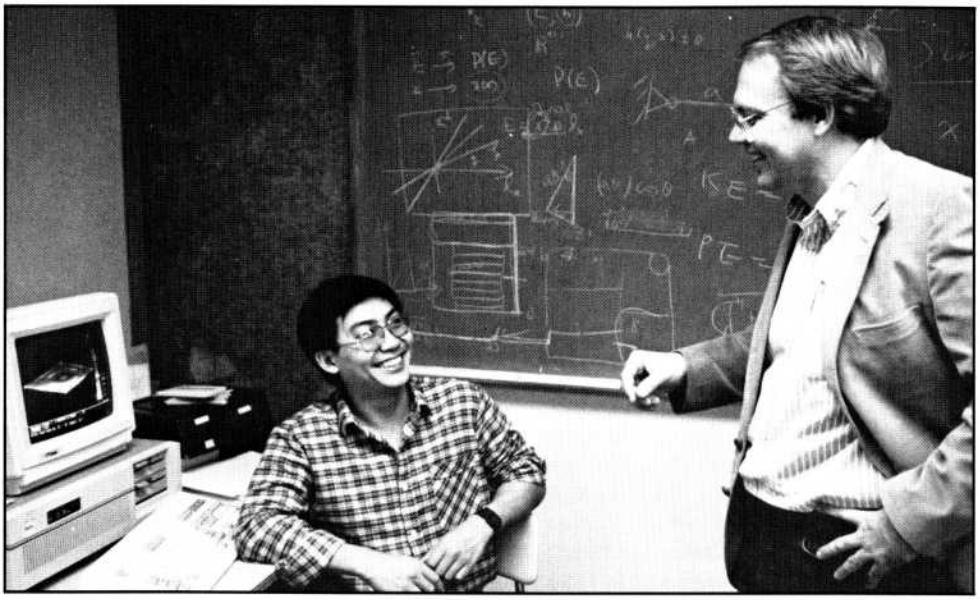
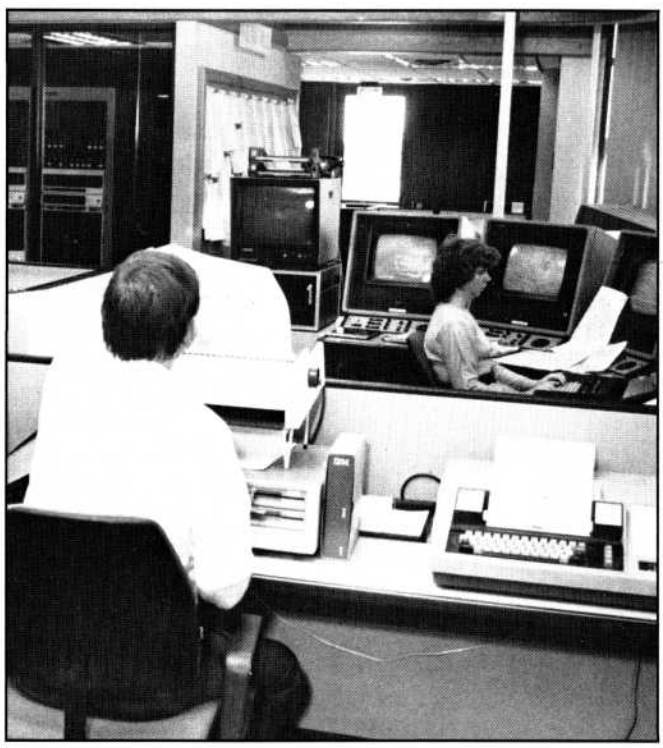




ABOVE: OU mathematics professor Luther W. White, here with graduate student Yusheng Feng, provides a solid mathematical foundation for the development of the CAPS models. RIGHT: At work at the National Weather Service Forecast Office are hydrologist Eldon Beard, left, and Liz Quoetone, instructor for the NEXRAD training unit. FAR RIGHT: National Severe Storms Laboratory Building on OU's north campus.

advanced NEXRAD, can fast-forward them in a simulation to show what weather conditions will develop in the hours ahead. Models that simulate weather conditions already exist, but none are so advanced to be able to predict what the weather is going to be.

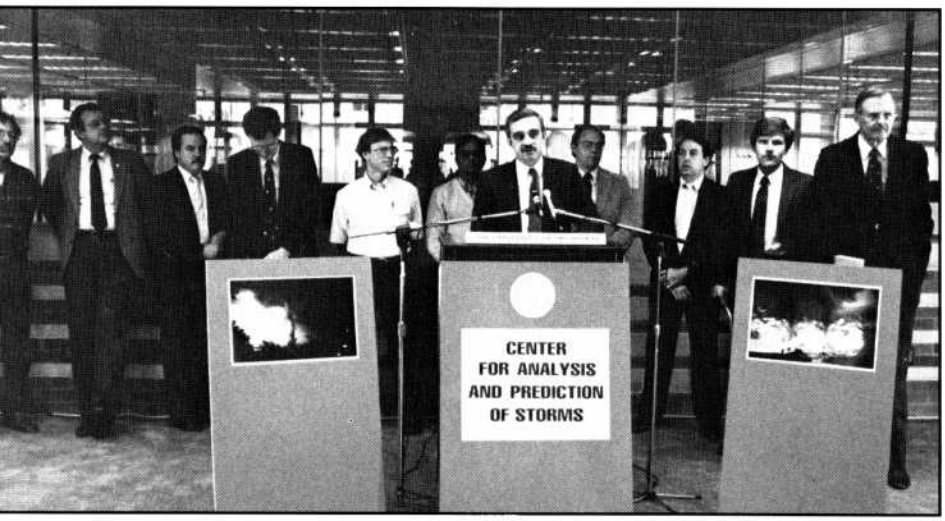
"The models we've been running for 15-to-20 years are very appropriate for simulating events," Droegemeier explains. "But not for predicting them. You can't take one, turn it on in the morning and hope to have a reasonable forecast by the afternoon."

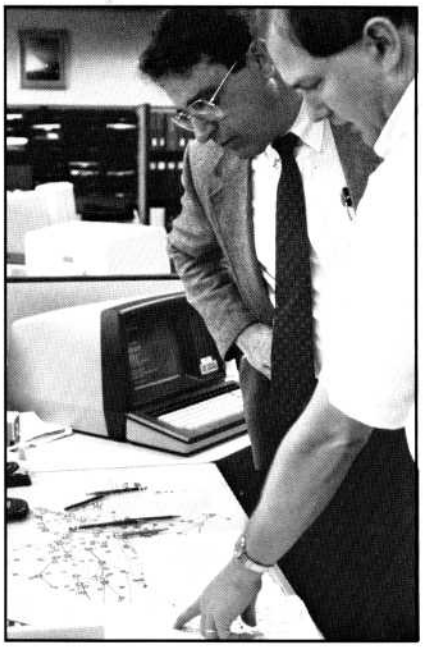
The kind of forecasting models Droegemeier wants to produce would be so accurate that a forecast would not be just "a possibility of widely scattered showers in the area this afternoon" but more like "a storm will hit the southern two-thirds of Oklahoma City in two hours."

Droegemeier hopes they also will be able to predict what is now an unpredictable event: wind shear. Wind shear is an abrupt, sometimes violent, change in wind direction. Not only can it cause turbulence, but wind shear even can wreck planes flying close to

the ground, taking off or landing. One source claims that wind shear plays a part in as many as 30 percent of all the fatal plane crashes in the United States.

One way the problem could be solved is to connect an advanced weather model computer to the airport's radar system and use it to predict the weather conditions around the airport. Another solution would mount a special computer on board the plane to run prediction models, based on condi-





ABOVE LEFT: Geosciences Dean James F. Kimpel, flanked by many of the principal players in the Weather Center, announces the $4.9 million NFS grant to CAPS. ABOVE RIGHT: Former OU student Craig Goff, left, now with the FAA in Atlantic City, gets a Weather Center update from the National Weather Service's David Imy.

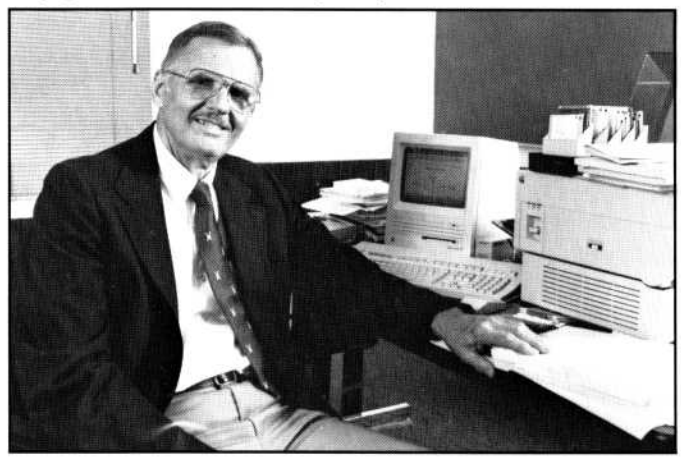
tions in front of the plane as they are monitored by the plane's radar. Both methods are still on the horizon but could prove beneficial to air travelers in the future.

To make these models work, Droegemeier and the other researchers, using the Geosciences Computing Network, interface with powerful supercomputers that can handle the amount of information currently required to run such a model. Often, these supercomputers, such as the Cray-2 at MIT, are based in other states.

"CAPS is a national center with a national mission," Droegemeier says. "We incorporate many groups from the outside. We can't do everything, so we turn to other national centers and groups in the country when we are developing new techniques."

But Droegemeier says none of the models or techniques could work without the new technology represented by NEXRAD. NEXRAD is able to collect data ranging from the size of raindrops to the flow of the wind, to the degree of detail necessary for the kinds of calculations being conducted at CAPS.

It can be said that NEXRAD, the Next Generation Radar, is the Weather Center's eyes and the centerpiece of Norman's weather program. The radar program, which eventually will place 165 radar units nationwide, was approved by Congress for $71 million in funding in fiscal year 1990 and $114 million in fiscal year 1991. NEXRAD's parent company, the UNISYS Corporation, has been contracted for $359 million in federal funding for the system through 1996. The new radar is taking the place of World War II-era radars currently used by weather forecasters to see oncoming storms.



CAPS director Douglas K. Lilly, a faculty member since 1982, is a George Lynn Cross Research Professor and one of the nation's most respected research meteorologists.

NEXRAD is so sensitive that it can pinpoint a storm's location to within a county, in some cases to within one mile. It can provide resolution enabling forecasters to "see" wind shear. Researchers hope NEXRAD can be used to detect a tornado at birth, rather than at maturity, perhaps eliminating many of the false tornado warnings that have plagued forecasting in the past. It also can provide pinpoint rainfall estimates as rain falls.

The Weather Center was chosen as the site for NEXRAD's prototype unit, unveiled at north campus in October 1988. Since its start, the radar continually has been tested for accuracy by government officials. Its score: 91 out of a possible 100 points, a solid A on college exams.

Currently, 38 people work at the Norman NEXRAD facility, housed in the same building with the National Weather Service. That number is expected to reach 110 when the facility becomes fully operational as a training center.

At the unveiling of NEXRAD, with representatives present from the National Oceanographic and Atmos-

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RIGHT: Meteorology's tornado chaser, Howard Bluestein, right, and CIMMS' Robert Davies-Jones were on hand for the announcement of the CAPS grant. FAR RIGHT: The parallel processing research of S. Lakshmivarahan of electrical engineering applies to the CAPS goal of developing a new class of storm prediction models.

pheric Administration, the Federal Aviation Administration and the Air Force, U.S. Congressman Dave McCurdy predicted that projects like NEXRAD "will take Oklahoma into the future."

With each passing month, that future moves closer. National, if not international attention is focused on the Weather Center's successful combination of research and everyday forecasting; its melding of private, state and federal programs; its innovative in-house research; and its attraction for researchers from across the nation.

On April 4 and 5 of this year, the center hosted the National Science Foundation's Subcommittee on Atmospheric Research. The group consisted of representatives from the federal agencies present at the launching of NEXRAD, plus representatives from the Department of Interior, Department of Defense, Department of Agriculture, NASA and other areas with a concern for atmospheric research.

Chairman of the subcommittee, Eugene W. Bierly, commented, "We decided to come to Norman because of the mesoscale activities here. Norman is probably the center for mesoscale research in the United States."

Mesoscale is the term used to describe weather events from the size of one storm to perhaps a line of storms crossing an entire state. While other types of weather prediction techniques can encompass even global patterns, most of the events that impact human activities happen at the mesoscale, OU's specialty.

"The Weather Center has the people who are doing the research and thinking about the problems," Bierly explains. "They've got researchers like Droegemeier, with CAPS. Then they've got the people who get the warnings out. It's happening here because they talk together and know each other and because the research feeds into the operation."

Bierly says that the Weather Center is important in the National Science Foundation's plans. For instance, Bierly's committee is compiling a plan to increase funding in mesoscale research nationwide. The initiative will be put before President George Bush in December 1990.

If funded, the plan "will be a huge step forward, something meteorology hasn't done before," Bierly says. "The critical mass of people and programs here (at the Weather Center) are going to be important for future activities. It's going to help with the future of the initiative."

Although proud of its accomplishments in mesoscale meteorology, Duchon insists that the OU program does not intend to rest on its laurels. The study of climate change figures in the School of Meteorology's future. So, too, does hydrology, the study of the distribution of water over the earth's surface.

"Mesoscale meteorology will always be the strong card in our hand, as it should be," Duchon says. "But we are interested in moving into those other areas. In the coming years, we hope to have a broader perspective with additional opportunities for students."

Meanwhile, OU's Weather Center will continue to grow. Already, new faculty positions are being added in the areas of math, computer science and electrical engineering, Kimpel says. The OU Centennial Campaign has placed a high priority on the first endowed chair in meteorology in the country.

"Why does this mix work so well in Oklahoma?" Kimpel asks. "Two pieces of glue hold the Weather Center together. The first piece is the 40-to-50 Ph.D.-level scientists we have working in atmospheric research. They interact continually. The second piece of glue is the students. The student population in meteorology has doubled, even though the trend at other universities, and nationally, has been the other direction.

"That's what you get from consolidation: learning how to work with each other in productive ways. We're seeing the payoff now."