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AMS SHORT COURSE REVIEW
NEXRAD APPLICATIONS AND THE MEDIA
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Jeff S. Waldstreicher
Scientific Services Division
Eastern Region Headquarters
Bohemia, New York

On June 20, 1990, the American Meteorological Society sponsored a short course on NEXRAD Applications for the media. This workshop, which preceded the 20th AMS Conference on Broadcast Meteorology, was intended to give the broadcast meteorological community a better understanding of NEXRAD and its potential to improve forecasts and warnings. Around 110 members of the broadcast community attended the short course.

The presentation consisted of a thorough overview of NEXRAD and is capabilities. Topics included: basic doppler principles; the NEXRAD system hardware; Doppler interpretation and applications; and the NEXRAD Information Dissemination Service (NIDS). The broadcasters received the full spectrum of NEXRAD information--its capabilities and limitations--including the results of the IOT&E II.

The following are summaries of each of the sessions (note that some of this information was derived from conversations with the speakers between sessions):

1. The Physics of Doppler
Donald Burgess

(Don is the Technical Manager for the Forecast Applications Research Group, National Severe Storms Laboratory (NSSL), Norman, Oklahoma.)

This presentation began with an overview of different components of the NEXRAD system. Don then proceeded to discuss the "Doppler Dilemma," which is the tradeoff between unambiguous range and velocity interval. This problem is related to the pulse repetition frequency (PRF). NEXRAD will utilize a low PRF to "map" the locations of all echoes (especially those at far ranges since this maximizes the unambiguous range). A higher PRF will be used to actually generate the base data (reflectivity, velocity, spectrum width). This higher PRF will have a specific unambiguous range (approximately 230 km for the standard NEXRAD PRF) that corresponds to the maximum distance a pulse can travel and be reflected back to the radar before the next pulse is transmitted. The far edge of this "trip" will appear purple on the NEXRAD velocity displays, which will signify range folded velocities.

Velocity data from echoes detected beyond this maximum unambiguous range (beyond 230 km) will be superimposed on the data from the "first trip" (within 230 km). The NEXRAD algorithms will detect this, blanking out those range gates as range folded (displayed as purple). For example, the velocity information from an echo located 270 km west of the radar will be interpreted by the radar as being located 40 km west of the radar. The NEXRAD algorithms will then blank out this data as range folded. This could have major operational significance if another echo, especially a potential severe storm, happened to be located 40 km west of the radar (in the blanked out area). If significant echoes are "hiding" in range folded areas, the PRF will have to be changed. This topic will be covered in depth at the NEXRAD residency course.

There was some concern on the part of the broadcasters about this situation. They were reassured that the radar operators will be fully trained to recognize and deal with this problem. While the broadcasters recognized that they will be somewhat "at the mercy of the radar operators," they were hopeful that the NWS staff would remain open to dialogue in such situations.

The other end of the doppler dilemma is the unambiguous velocity interval. For a given PRF, a certain range of radial velocities can be uniquely determined. Velocities above this interval will be aliased. This means that if the unambiguous velocity interval is +/- 32 m/s, an actual radial velocity of +40 m/s (away from the radar) would be interpreted by the radar as -8 m/s (toward the radar). NEXRAD has a very effective dealiasing algorithm, which will sense that the -8 m/s is aliased, and it will correctly interpret the velocity data in the velocity-based algorithms such as mesocyclone and TVS. One current limitation, however, is that the velocity products are restricted in regard to the number of velocity intervals that can be displayed. The current NEXRAD software load will display all velocities within the unambiguous velocity interval. Dealiased velocities, such as the +40 m/s above, will be displayed as a value greater than the unambiguous velocity interval (e.g., >+32 m/s). A method is currently being developed, however, to allow the operator to select his own velocity display scale. While the number of displayable intervals will still be fixed, the range of displayed velocities and the "width" of each display interval can be adjusted. For example, this will allow the operator to weight the scale toward inbound (-) or outbound (+) velocities depending on the situation. This feature will be incorporated in the full-production model software load.

After the discussion of the doppler dilemma, Don then presented a very thorough lesson on doppler velocity interpretation. His lecture included many examples of both idealized and actual velocity patterns for features such as veering/backing, convergence/divergence, and rotation. One interesting feature that will be available in the NEXRAD system is the capability to subtract out storm motion from the overall velocity field. This can be done over the entire field or for individual storms. This should provide some valuable information about storm relative flows.

Don then proceeded to discuss some of the other products that will be available in NEXRAD. Spectrum width will have three primary uses. First, spectrum width can be used as a data quality indicator. Very high values of spectrum width often indicated poor data which should be distrusted. The other two uses of spectrum width will involve locating boundaries and areas of turbulence, both of which display as moderately high values.

The Velocity Azimuth Display (VAD) algorithm was discussed. In addition to the VAD display, data from the VAD algorithm will be used to calculate kinematically derived (from convergence/divergence calculations) vertical motion. Next, the mesocyclone algorithm was discussed. Currently, the algorithm utilizes height continuity in determining the presence of a mesocyclone. In the future, time continuity will also be incorporated in the algorithm.

Finally, the Weak Echo Region (WER) product was presented. The WER zooms in on a 50 X 50 km section if the screen and displays multiple elevation scans in a "stacked plate" format. Unfortunately, the current NEXRAD software load only allows for three levels of reflectivity to be displayed. WSFO DEN and PROFS have had success utilizing a more detailed version of this product on the DAR^{3}E workstation ("Two Examples of Operational

Tornado Warnings Using Doppler Radar," by Larry Dunn, February 1990, **Bulletin of the American Meteorological Society**). Fortunarely, future NEXRAD software loads will have this more detailed WER product, as well as a velocity WER product (these may have to come at the expense of lesser used products due to current processing limitations).

2. The NEXRAD System's Concepts and Capabilities - Basic NEXRAD Products

Ron Alberty

(Ron is the Director of the NEXRAD Operational Support Facility (OSF), Norman, Oklahoma.)

This presentation with an announcement that the official (formal) name for the new doppler radar system is no longer "NEXRAD" but has been changed to "WSR-88D." Ron then proceeded to use the term NEXRAD several dozen times during his presentation by force of habit (it is also easier to say (and write) than WSR-88D).

Ron began by discussing the NEXRAD network and its coverage. Ron straight-forwardly said that while the capabilities of NEXRAD may have been initially somewhat oversold (statements about mesocyclone/TVS detection at 350 km ranges should be obviously ridiculous), NEXRAD will be an extremely valuable tool in improving all weather services. Ron proceeded to show the operational ranges for the NEXRAD products as will as the beam height and widths. The effective ranges of the mesocyclone and TVS algorithms (as well as all other velocity algorithms) are 230 km. These limitations are inherent to the velocity data limitations discussed earlier by Don Burgess. TVS signatures of course, will rarely (if ever) be detected at 230 km ranges because they are features that are smaller than the 4 km beam width at this range. Mesocyclones can be, and already have been, detected at a 230 km range.

Ron then proceeded to show a number of NEXRAD products. One very interesting case involved a base reflectivity display in which the intersection of a cold front and a dry line over Oklahoma is clearly visible. A copy of this display is Figure 1, which is more impressive in color. An appropriate analogy for the Eastern Region would be a cold front intersecting a sea-breeze front. Figure 2 is an attempt to simulate what an operational WSR-57 would have displayed by showing only reflectivities greater than 11 dBZ. Note that the skies over Oklahoma at this time were completely clear. Over two hours later, the intersection of these two boundaries produced a thunderstorm that dropped baseball-sized hail! (This cases is included in the NEXRAD training slide set being presented at each WSFO by the Eastern Region NEXRAD Training Team. A copy of this slide set will be provided to all Eastern Region NEXRAD Program Leaders as an additional training resource.)

Following Ron's presentation, questions and concerns were raised regarding the performance of the NEXRAD system during last summer's IOT&E-II. Ron responded that there are two ways a test like the IOT&E-II could be successful. The first would be for the system to work perfectly. The second is to find as many "bugs" as possible and have them fixed as soon as possible. The IOT&E-II team found over 50 problems, all of which have been corrected. Note that in many cases, the IOT&E-II team intentionally operated the radar in an incorrect or faulty manner, which of course lead to increased radar down time as evident by the test's statistics. Since the correction of the problems discovered will lead to a superior and more reliable system once operationally deployed, it would appear that the IOT&E was a success.

3. The Transition from the Present Radar Dissemination System to the NEXRAD Information Dissemination Service (NIDS)

Vico Baer

(Vico works for the Office of Systems Operations (OSO), Silver Spring, Maryland, and is responsible for the implementation of the NIDS.)

This presentation described the NEXRAD Information Dissemination System (NIDS). NIDS will be the avenue through which the broadcast and private sectors receive NEXRAD information. Each NEXRAD will have four NIDS ports (113 NWS and 24 DOD radars). The plan calls for four NIDS "providers" to ensure fair market competition. The four NIDS providers will sign a reimbursable agreement, prorated on a per site basis to cover the direct costs by the sites for providing the service. These costs include a $107K one time cost and an annual recurring cost of $190K.

All providers must offer a minimum service that includes an "unaltered" NIDS External User Products set from any and all sites. Table 1 contains the list of products planned for initial NIDS implementation. Providers are strongly encouraged to offer value-added services such as derived or composite products. Note that the NEXRAD radar coded message will not be distributed.

Proposals from NIDS providers have been received by Weather Service Headquarters, and selection of the four providers is expected in mid-July. Many of the broadcasters wanted to know who (or at least how many) companies submitted proposals. Given the stage of the selection process, however, this information could not be revealed. This was the only information withheld from the broadcasters during the entire course!

One problem that arose from discussions was an apparent confusion on the part of the broadcasters as to the dates when information will become available from each NEXRAD. There are three important dates associated with each NEXRAD site. These are:

Delivery Date - This is the date when the NEXRAD equipment will be delivered. Since this has been the most publicized date, many broadcasters equate this as the date when data will become available.

Acceptance Date - This is the date when the NEXRAD equipment is ready for local operational use (time is needed after installation for check-out, ground clutter mapping, training, etc...). This will typically occur about 6 months after NEXRAD delivery. Data will not yet be disseminated to external users until the staff has had an opportunity to work with the radar and ensure there are no problems with the data.

Commissioning Date - This is the date when the radar data becomes available to external users. This will typically occur approximately 9 months after the delivery date.

The date of greatest impact to the broadcasters would be the Commissioning Date. The NIDS is scheduled to be implemented in mid-1991, which is about the time the first radar (Twin Lakes, Oklahoma), will be commissioned.

4. Real-Time NEXRAD Applications I

Carl Bullock

(Carl is the AWIPS-90 Program Manager at PROFS, Boulder, Colorado.)

Carl's presentation focused on several case studies where doppler radar data was effectively used in real-time forecast problems, especially on the DAR^{3}E workstations at WSFO Denver. Carl showed several cases where boundaries, which were subsequently the focus for severe convection, were tracked using Doppler radar.

One other extremely interesting case was the "1990 Denver Blizzard." During March, 1990, a storm tracked slowly across southern Colorado in response to a large cut-off upper low. Conventional analysis and satellite information indicated an area of warmer, dryer air rotating around this upper low would move into the Denver area. Doppler radar (as well as profiler data), indicated a cold-air damming pattern was setting up. The Doppler velocity fields indicated colder air was moving southward parallel to the mountains along the foothills. When this occurs, the air advecting from the east is forced up and over this cold dome of air dammed up against the mountains. This pattern was recognized by the forecasters at WSFO Denver, and they were able to update the forecasts. Instead of the snow ending, Denver received up to 2 feet of snow (with over 3 feet in the foothills) and blizzard conditions. Similar applications should provide extremely valuable information for summer and winter Eastern Region forecast problems.

5. Real-Time NEXRAD Applications II

Robert Tibi

(Bob is the DAR^{3}E/Norman Hydrologic Program Manager for PROFS, Boulder, Colorado.)

This presentation focused on NEXRAD's hydrometeorologic capabilities and applications. The Precipitation Processing System (PPS), which generates one-hour running, three hour running, and running storm total precipitation accumulations, was presented. In addition, the Flash-Flood Potential System (FFP) was described. This system will provide short-term (up to one hour) forecasts of precipitation and flash flood potential. The flash flood potential will be presented in the form of "critical rainfall probabilities."

Bob presented a case of flash flooding in Greeley, Colorado, which is north of Denver (northeast of Boulder). The performance of the hydrometeorologic algorithms was traced throughout the duration of the event. The algorithms accurately depicted the location of the maximum rainfall and the rainfall rates (observed and projected). The total rainfall observed from this system exceeded 8 inches!

6. NEXRAD Experiences at Norman, Oklahoma

Kenneth Crawford

(Ken, the former Oklahoma Area Manager, is currently Director of the Oklahoma Climatological Survey, and an Associate Professor in Meteorology at the University of Oklahoma.)

Ken discussed his experiences with NEXRAD as Meteorologist-In-Charge/Area Manager at WSFO Norman. He led the audience through two case studies where NEXRAD was used operationally at WSFO Norman. Ken presented the first case, while the second case included audience participation. These two cases are also included in the NEXRAD Training Slide Set. Ken's presentation was similar to his outstanding seminar presented at WSFO Washington earlier this year, which was videotaped. Eastern Region SSD is in the process of making copies of this videotape, which will be distributed in the near future.

One important idea discussed by Ken involves the impact NEXRAD will have at other offices. WSFO Norman amassed some very impressive verification statistics for 1989. Their false alarm ratio dropped from around 80% in the early 1980's to 20% in 1989. The point stressed by Ken is that this improvement did not occur overnight. It took a rigorous, in-house training program to help develop the skills necessary to utilize NEXRAD to make skillful warning decisions. In addition, WSFO Norman developed a database of almost 3,000 telephone contacts in its 50 county area of warning responsibility since 1983 in an effort to provide the ground-truth necessary to verify the radar observations. The key idea is that stations should not expect an immediate jump in the skill of their warnings with the installation of NEXRAD. Rather, a "learning curve" should be anticipated. Many stations have already taken significant steps up this learning curve with local research and training programs, and improving spotter programs.

One product that received much discussion during Ken's presentation was the use of Vertically Integrated Liquid (VIL) product. The VIL product displays a calculated amount of liquid water contained in a vertical column over 4 X 4 km radar grids. VIL is calculated using a reflectivity-liquid water relationship integrated over the depth of a storm. Large VIL values may imply strong updrafts that are often associated with severe storms. The presence of hail in a storm often results in inflated reflectivity returns, which will result in higher VIL's. While the presence of hail may somewhat invalidate any direct assumptions made regarding a reflectivity to liquid water relationship, hail-inflated VIL's are still excellent indications of severe storms.

The RADAP-II system has been used to calculate VIL's for several years at many locations. Findings at WSFO Norman indicate VIL is an outstanding indicator of severe weather if used properly. Research at Norman has indicated that severe-weather producing VIL's vary with season, with lower VIL's producing severe weather during cool seasons and higher VIL's during the mid-summer. WSFO Norman has been able to develop seasonal thresholds for VIL, although frequently the most effective means for utilizing VIL's is to use the VIL associated with the first report of severe weather on a given day as a "threshold of the day."

Several offices, especially WSFO Pittsburgh, have found similar results utilizing VIL's, although their actual thresholds differ from those found at WSFO Norman due to different atmospheric regimes (differences have also been found by using RADAP-II systems in other locations such as Florida). WSFO Charleston has developed an innovative program to database severe weather reports together with calculated VIL's (as well as other parameters). This database will serve as an excellent resource for local studies and, possibly, for the algorithm tailoring that will be necessary at many NEXRAD locations.

7. Combined Satellite and Radar Applications - Making All the Pieces Fit

Michael Mogil

(Mike is the Chief of the Training and Information Services Branch, NESDIS, Camp Springs, Maryland.)

This presentation involved combining satellite and radar information to better evaluate and understand the atmospheric wind flow. Mike showed numerous examples from a wide geographic area (Mike's presentation had an international flavor) of how satellite information can be used to evaluate various wind fields. The audience was encouraged to imagine how NEXRAD could be used to add even more information to the clues the satellite provided. Among the numerous features examined were: land/sea breezes, terrain induced flows, flow around islands, and fog/stratus.

As you can see, the broadcasters were presented with a wealth of information. These summaries were prepared from the actual presentations, conversations with numerous individuals between presentations, and a 300+ page notebook of reference material, which was provided to all of the participants. There was a tremendous willingness on the part of the broadcasters to work with the NWS in utilizing doppler technology to provide the best possible forecast and warning service. Effective warnings must be effectively disseminated. The broadcast community has an important role to play in association with the modernized National Weather Service. Sharing information about NEXRAD, as well as other advancements in the science, will help strengthen the bond between your office and the media, which should result in improved weather services for everyone.

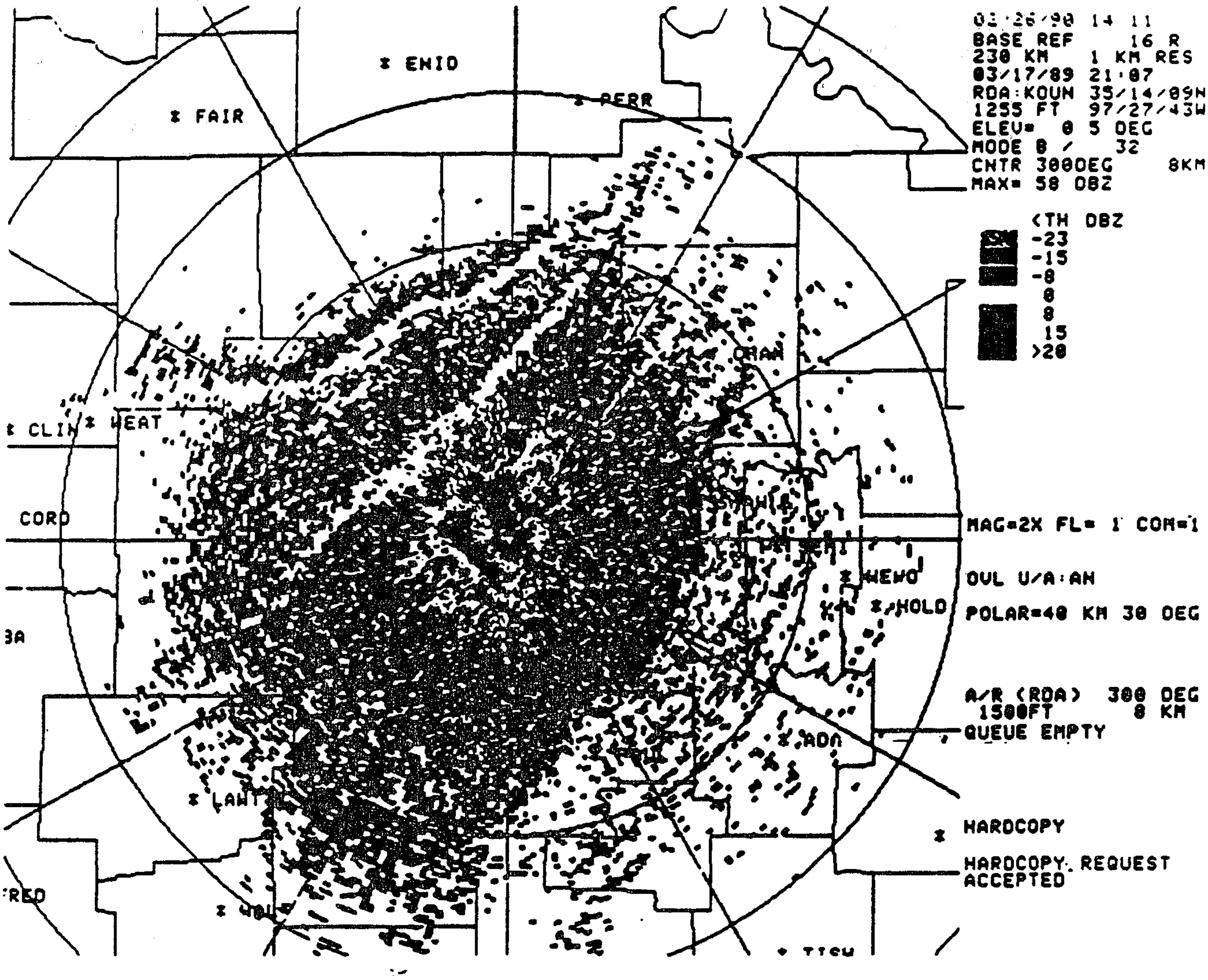

Figure 1 WSR-88D Base Reflectivity product with cold front and dryline evident in reflectivities down to -8 dBZ. (3/17/89 2107 Z)

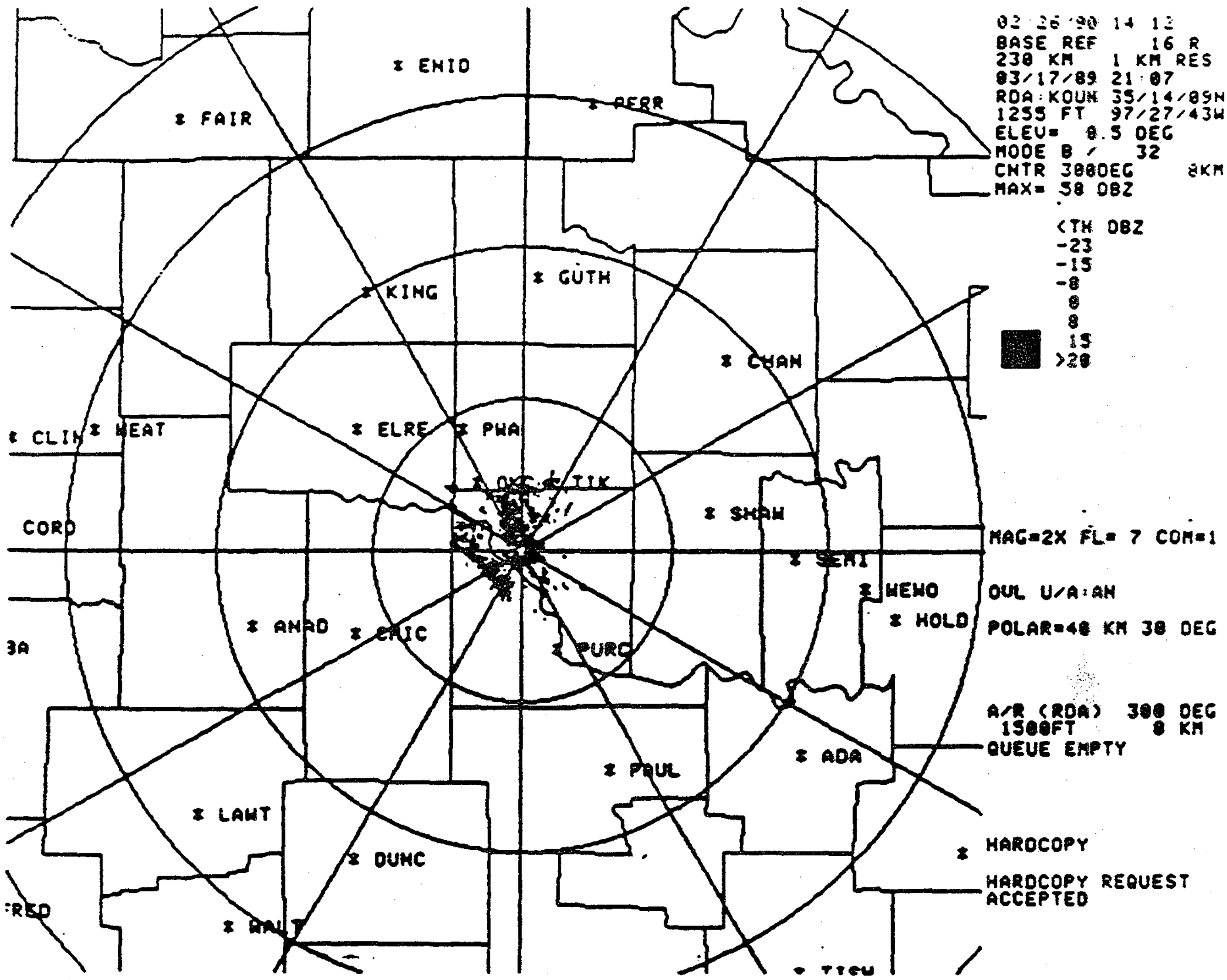

Figure 2. WSR-88D Base Reflectivity product (same date and time as shown in Figure 1). Only reflectivities greater than 11 dBZ are shown to illustrate what an operational WSR-57 would have displayed.

TABLE 1. NIDS Product Suite Planned for Initial Implementation

NIDS EXTERNAL USER PRODUCTS

Planned for Initial Implementation:

- Reflectivity (2 Tilts) 1x1 Km, 16 data levels 230 Km Range
- Composite Reflectivity 4x4 Km, 16 data levels 460 Km Range
- Echo Tops
- Vertical Integrated Liquid (VIL)
- Surface Rainfall Accumulation
    - 1-Hr Running Total
    - 3-Hr Total (once per hour)
- Storm Total Rainfall
- Hourly Digital Rainfall Array Product
- Radial Velocity (2 Tilts) 1x1 Km, 16 data levels 230 Km Range
- Velocity Azimuth Display (VAD) Winds (Time vs. Height)
- Layer Composite Reflectivity