OPERATIONAL OBSERVATIONS OF ATYPICAL METEOROLOGICAL FEATURES USING THE WSR-88D

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1. INTRODUCTION

The Weather Surveillance Radar - 1988 Doppler (WSR-88D) provides invaluable information on a variety of meteorological phenomena. The high sensitivity of the WSR-88D allows for the observation of phenomena that were not observable with previous WSR's. Precipitation phase, land-sea breeze circulations and clouds are examples of phenomena that are now observable by the WSR-88D. The detection of these features has an enormous impact on forecast operations.

2. PRECIPITATION PHASE DETECTION

The delineation between frozen and liquid precipitation is routinely observed on weather radars as a band of enhanced reflectivity referred to as "the bright band." When frozen precipitation melts as it falls, a region of water-covered ice is produced. The water-covered ice is the cause of the enhanced reflectivity. Stewart and King (1990) describe the structure of the bright band.

When the radar is located on the cold (snow) side of a precipitation phase change line, the bright banding commonly appears as a line of higher reflectivity on lower radar elevation angles. When the radar site is located on the warm (rain) side, the bright band commonly appears as a circular ring of enhanced reflectivity around the radar.

A commonly occurring phenomenon in areas of precipitation phase change is precipitation banding that usually results in enhanced precipitation rates. In regions of warm advection, slantwise convection can cause banded precipitation that appears similar in reflectivity fields to bright bands associated with phase change. Discriminating between bright bands and precipitation banding in the reflectivity field data can be difficult.

The correct interpretation of banded echoes is critical to short-term forecasting. Examination of WSR-88D data from three winters along the mid-Atlantic coast has shown that 1) bright bands produce higher reflectivity values than precipitation bands, 2) bright bands propagate more slowly than precipitation bands, and 3) bright bands are typically narrower than precipitation bands. An example appears in Fig. 1.

The detection of bright bands using the WSR-88D is a critical element in the development of a snowfall accumulation algorithm. Any advanced rainfall accumulation algorithm will depend on detection of and compensation for bright banding that results in greatly overestimated rainfall amounts.

3. LAND-SEA BREEZE CIRCULATIONS

In a coastal regime, land-sea breeze circulations cause abrupt wind shifts and temperature gradients, particularly in spring. Recognizing and forecasting these circulations is critical to writing accurate forecast products. Both public temperature forecasts and aviation terminal

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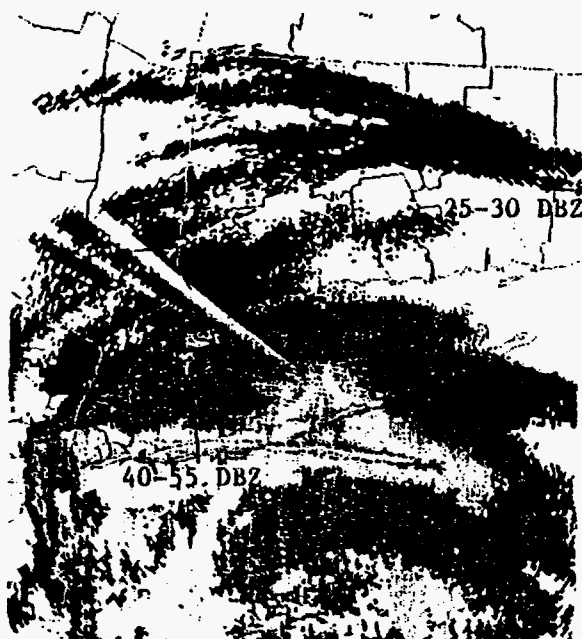
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FIG. 1. Base reflectivity from the
KOKX (Upton, NY) WSR-88D at 1352 UTC
on 4 February 1995 at the 0.5°
elevation angle. The 40-55 dBZ east-
west line represents a bright band
and the 25-30 dBZ east-west bands are
the result of slantwise convection.

forecasts of wind direction improve
dramatically when forecasters
recognize land-sea breeze
circulations. Aviation operations
benefit from accurate anticipation of
runway use changes.

The WSR-88D identifies land-sea
breeze circulations as relatively
narrow regions of enhanced
reflectivity. A typical case in
which the land-sea breeze circulation
is seen in the reflectivity data from
the WSR-88D is shown in Fig. 2. This
is a constant altitude (0.5 km)
display of reflectivity from the KOKX
WSR-88D at 1800 UTC on 16 June 1995.
The Interactive Radar Analysis
Software (IRAS) (Priegnitz 1995) was
used to produce the image. One
circulation is evident over Long
Island with another along the coast
of Connecticut. The horizontal width
of the reflectivity band varies from
the limit of resolution of the radar
(about 1 km) to about 5 km. It
extends upward about 1 km above the
surface (not shown). The
reflectivity is on average 12 dBZ on
Long Island west of the radar and
also in Connecticut; over the south
fork of Long Island, the reflectivity
is 20 dBZ or higher. The
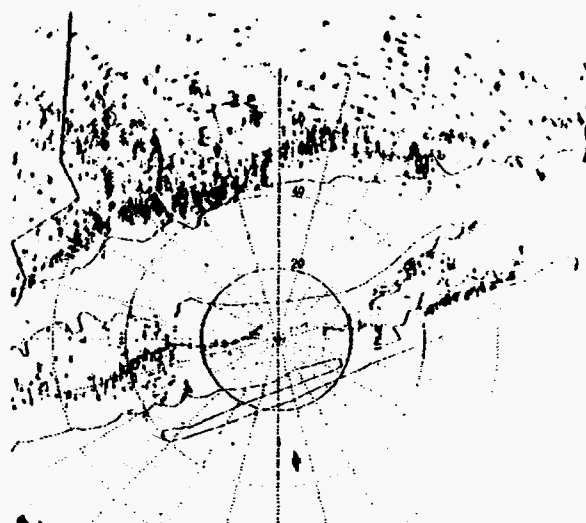reflectivity line represents the

FIG. 2. Base reflectivity from the
KOKX (Upton, NY) WSR-88D at 1800 UTC
16 June 1995 at a constant altitude
of 0.5 km. Range circles are labeled
in kilometers.

"leading edge" of the circulation
where strong baroclinicity exists and
is commonly referred to as the "sea
breeze front." Doppler radial
velocity measurements can further
define the circulations.

Initial formation of separate
circulations over Long Island and
Connecticut is typical. The Long
Island "front" usually advances
northward in the late afternoon,
crossing Long Island Sound and
merging with the Connecticut "front."
Observations at surface-based
observing stations have often
confirmed the passage of the "front."

It is likely that a combination
of targets causes the returns:
insects (Sauvageot and Despaux 1996),
refractivity variations, aerosols,
suspended particulate matter, etc.
When the front is over Long Island
Sound, the echoes are significantly
weaker. This suggests that
terrestrial particulate matter has
been lost and that any refractivity
variation has diminished. The
remaining reflectivity is likely
caused by aerosols generated at the
water surface.

4. DETECTION OF CLOUDS

It is possible to detect water
and ice clouds with the WSR-88D. The
remote observation of clouds is
important to both forecasters and
researchers. Of particular interest
are stratus clouds and fogs, which

are observable in reflectivity data. In addition, algorithms to detect parameters such as cloud thickness, cloud fraction, cloud base height and cloud top height are under development.

While precipitation typically produces reflectivity values of 20 to 60 dBZ, clouds and fog generally produce reflectivities of -30 dBZ or lower. Figure 3 shows estimates of typical reflectivity factors for stratocumulus clouds and drizzle. Table 1 shows estimates of reflectivity for several different cloud types.
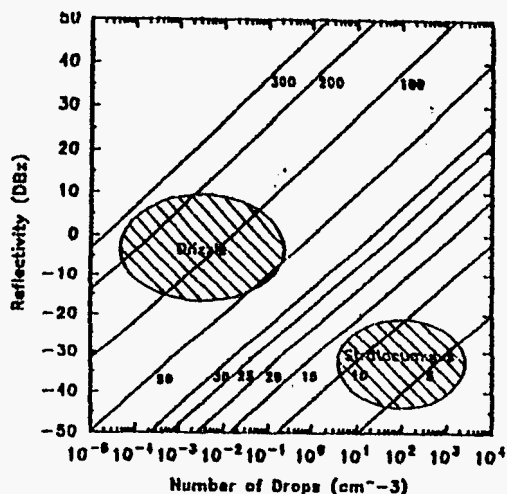
FIG. 3. Reflectivity (dBZ) versus droplet density (cm⁻³) and droplet radius (μm). The labeled diagonal lines are isopleths of equal droplet radius and the hatched areas represent typical values for droplet number density and droplet radius taken from aircraft measurements (Miller 1994).

4.1 *Minimum Detectable Signal*

To determine if the WSR-88D is sensitive enough to detect clouds, the Minimum Detectable Signal (MDS) of the radar must be calculated from examination of the radar equation (Doviak and Zrnic 1984). The MDS for any range can be calculated if the radar constant is known. The MDS for the WSR-88D is shown in Fig. 4 for the long and short pulse widths used in the "clear air mode" volume coverage patterns 31 and 32. If clouds have an average reflectivity value of -30 dBZ, then from figure 4 it can be seen that clouds are detectable to a range of around 15 km

using the 1.57 μs short pulse and to around 30 km using the 4.57 μs long pulse.

TABLE 1. Characteristics of various clouds and estimated reflectivity factors. The abbreviation "Sc" indicates stratocumulus (Miller, 1994).

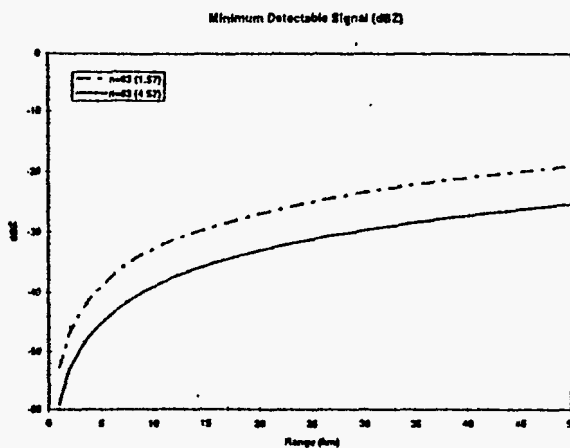| CLOUD TYPE	Droplet Number Density (cm⁻³)	Droplet Radius (μm)	Liquid Water Content (g kg⁻¹)	Reflect. Factor (dBZ)
Maritime Cumulus (1)	10	15	0.4	-22
Continent. Cumulus (1)	50	5	0.4	-44
Hawaiian Orographic (1)	10	20	0.2	-14
Marine Sc Nicholls (2)	40	11.5	.5	-22
Marine Sc Albrecht (3)	40-100	9-6	.1-.15	-28,-35
Marine Sc Slop/Platt (4)	30-40	7-12	.1-.4	-22,-40
CA Rad. Fog (5)	60	9.5	.2	-25
Marine Sc Drizzle (2) 300 m	.001	100	.003	-12

FIG. 4. Graph showing MDS for the WSR-88D's volume coverage pattern 31 (4.57 μs pulse width) and volume coverage pattern 32 (1.57 μs pulse width). The number of samples per radial is 63 for both.

4.2 *Example*

Figure 5 shows a WSR-88D reflectivity pattern from 23 February 1996. This pattern was made using an

elevation angle of 1.5°, a pulse width of 4.57 μs, and 63 samples per radial (volume coverage pattern 31). On this day, low clouds were observed over the region with fog and drizzle located to the southeast of the radar. A circular pattern of reflectivities in the -24 to -32 dBZ range is observed. The outer edge of this circular area represents the loss of detectability due to receiver noise (MDS). The inner edge represents the lowest height at which echoes are observed and is comparable to cloud base height. From these data, efforts are being made to further quantify the characteristics of the cloud field in the vicinity of the radar.
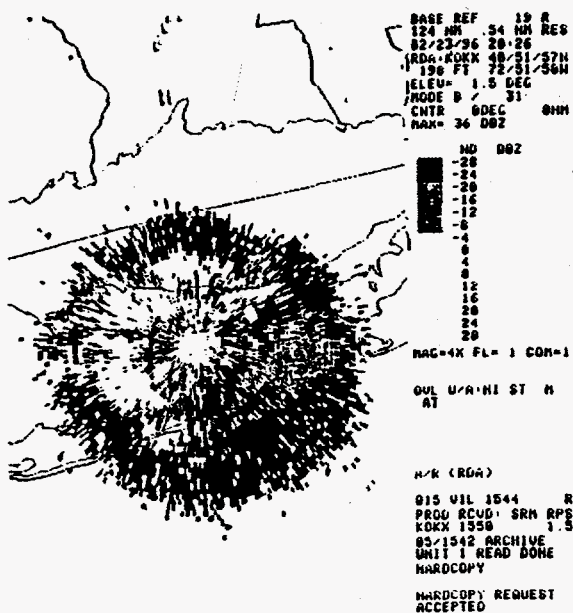

FIG. 5. Base reflectivity from the KOKX (Upton, NY) WSR-88D at 2026 UTC on 23 February 1996 for the 1.5° elevation angle. The region of -24 to -28 dBZ reflectivities depicts stratus clouds; the -8 to -23 dBZ reflectivities represents an area of drizzle.

5. CONCLUSION

The WSR-88D network is a unique meteorological observing resource. The system has proven an invaluable tool in the severe weather warning process (Bieringer and Ray 1996). However, the detection of non-severe features including clouds, land-sea breeze circulations, and precipitation phase can also affect the accuracy of both public and aviation forecasts. The WSR-88D is a powerful observing platform that can be integrated with other active and passive remote observing systems to depict a more detailed four dimensional structure of the atmosphere. Operational meteorologists should attempt to assure that the WSR-88D is used such that non-severe features are detected and integrated into the forecast process.

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6. ACKNOWLEDGMENTS