

RADAR ORNITHOLOGY 102

WSR-88D (NEXRAD), Marine Radar, Thermal Imaging

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A major environmental risk to wildlife from wind development is the possibility of collision mortality. To accurately assess this risk one must know the following :

- The exposure of wildlife to the factor (the number of birds and bats that will be flying through the turbine field at altitudes where collisions are possible)
- The avoidance behavior of the wildlife (how often do birds and bats change flight directions to avoid turbines)
- The relationship between exposure and measures of mortality.



Information Requirements for Assessment

- When do bird/bat movements occur over the project area (during the year and during 24-hours)?
- What is the altitudinal distribution of birds/bats flying over the project area?
- What are the densities of birds/bats at different altitudes?

To answer these questions one must be able to detect, quantify, and measure the altitudes of birds/bats aloft, and radar and thermal imaging can provide the necessary information.



Three approaches can be used to obtain the required data:

- **WSR-88D (NEXRAD)** provides information on movements within 124 nautical miles (NM) for a single radar station as well as regional and national scale for multiple radar sites.
- **High-resolution (marine) radar** provides information on movements between 30 m and 14 km depending on power of radar, antenna configuration, pulse length, and size of target.
- **Thermal imaging** can detect individual birds/bats out to a maximum range of 2 km.



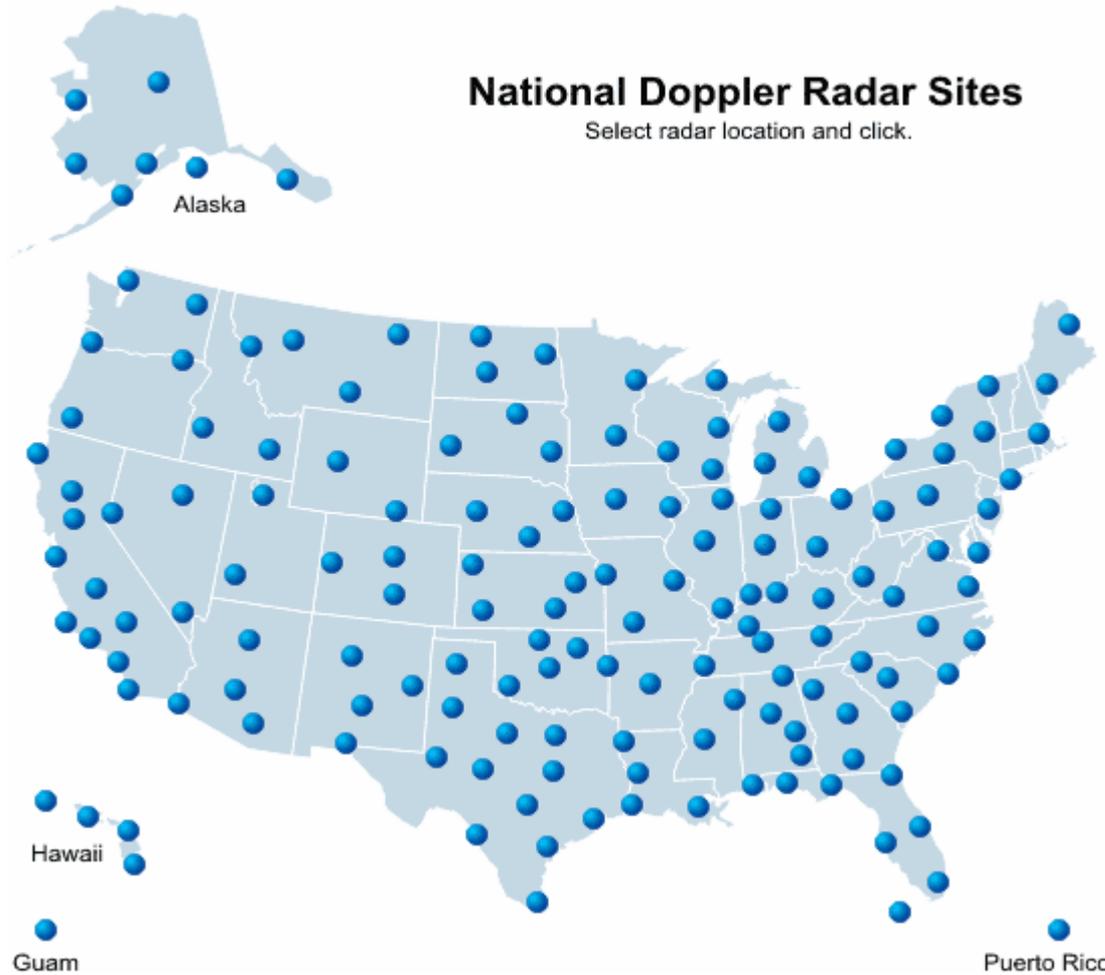
WSR-88D (NEXRAD)

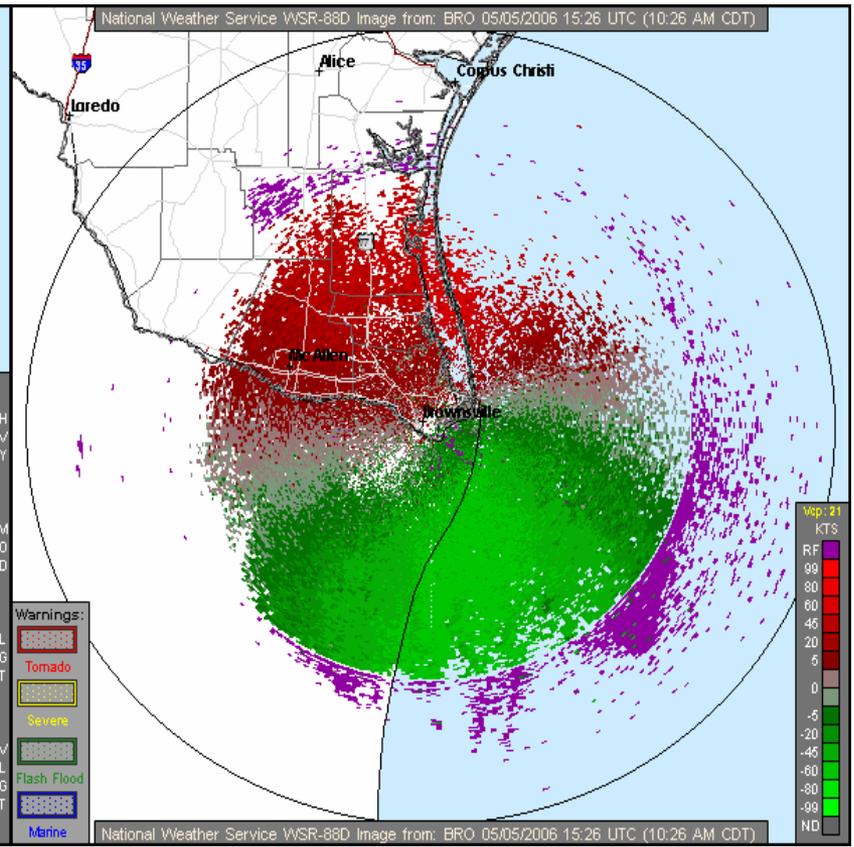
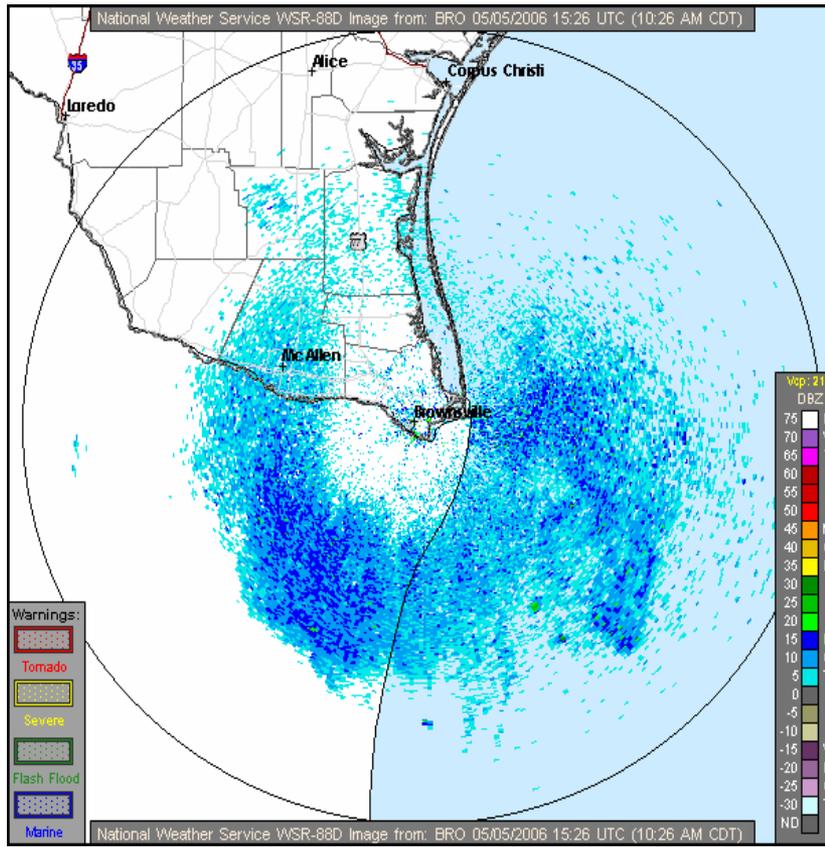
- WSR-88D (Weather Surveillance Radar, 1988, Doppler) or NEXRAD (for Next Generation Radar) is the Doppler weather radar that is located throughout the United States, Alaska, Hawaii, and Puerto Rico.
- WSR-88D (NEXRAD) provides information on movements within 124 nautical miles (NM) for a single radar station as well as regional and national scale for multiple radar sites.



National Doppler Radar Sites

Select radar location and click.



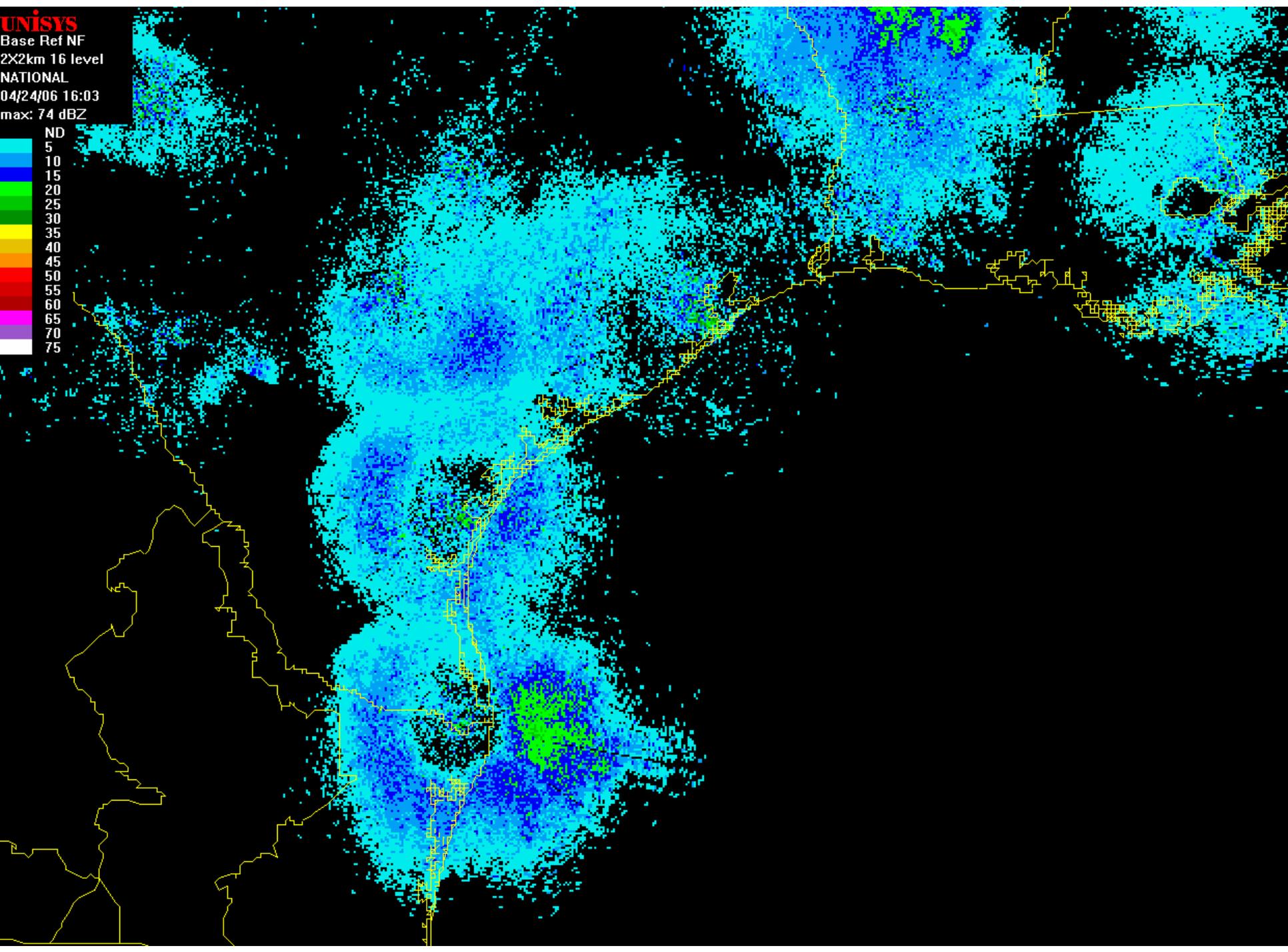


Base Reflectivity Image, Brownsville, TX Base Velocity Image, Brownsville, TX



UNISYS

Base Ref NF
2X2km 16 level
NATIONAL
04/24/06 16:03
max: 74 dBZ



UNISYS

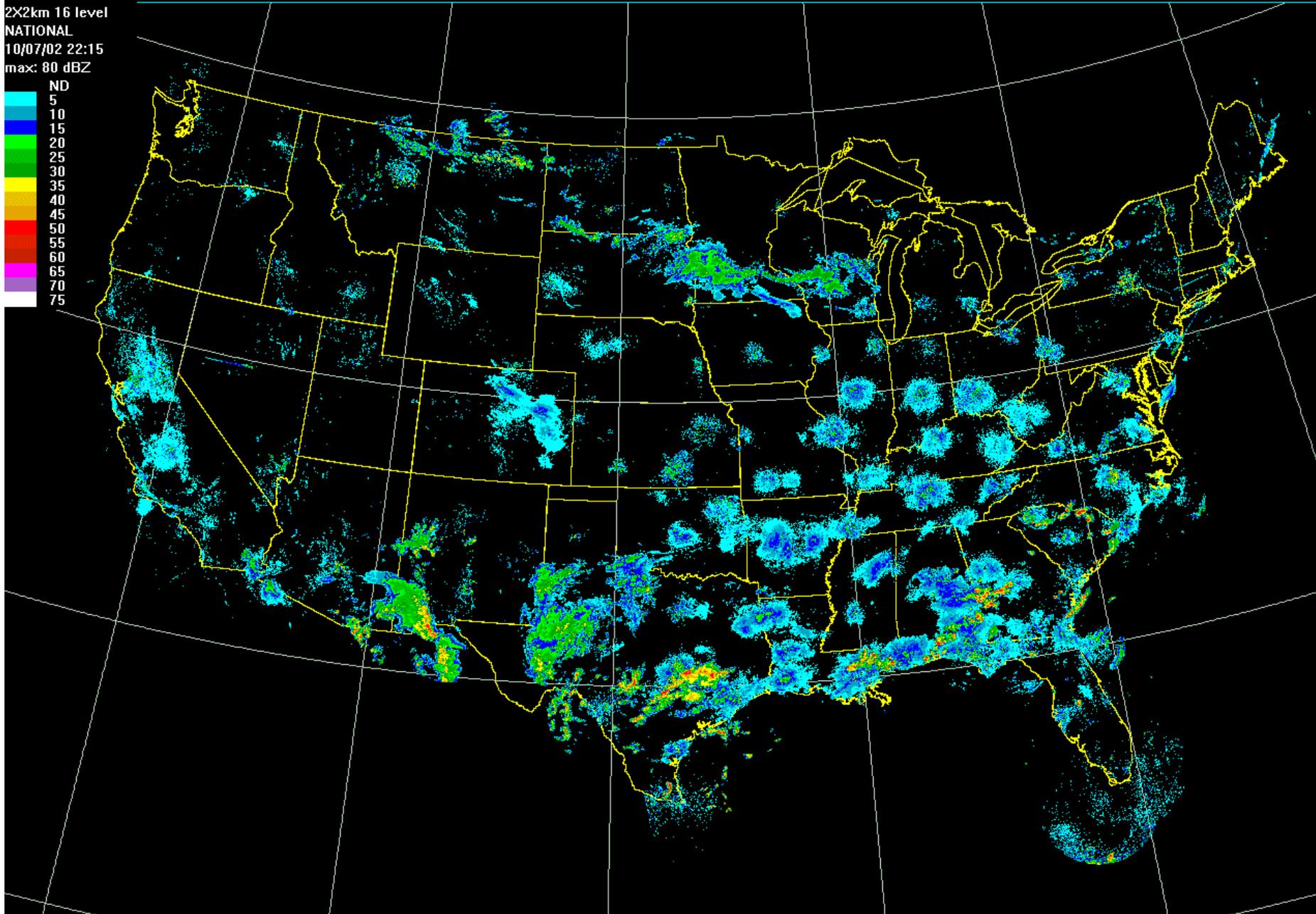
Base Ref NF

2X2km 16 level

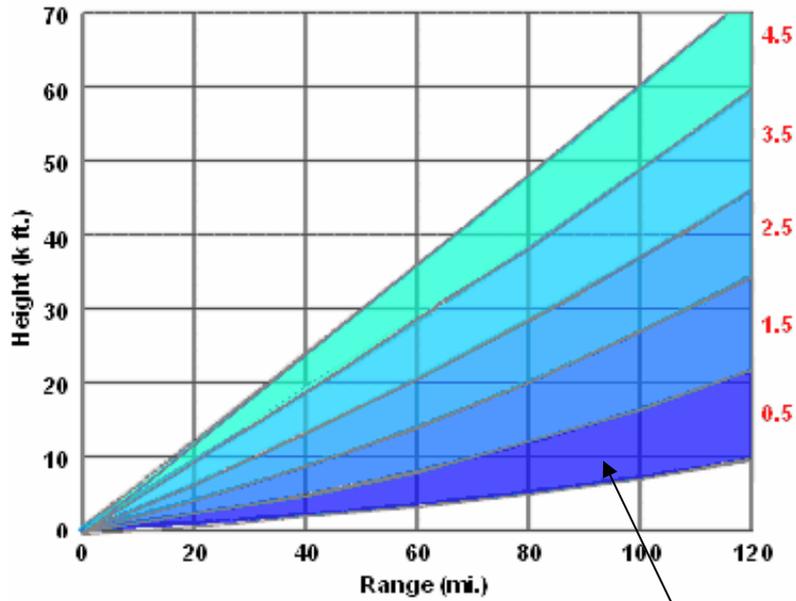
NATIONAL

10/07/02 22:15

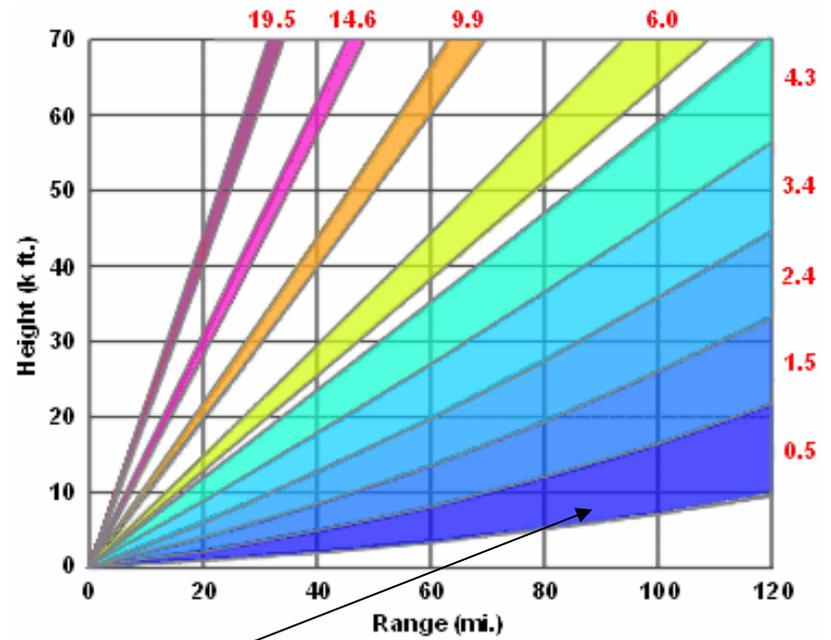
max: 80 dBZ



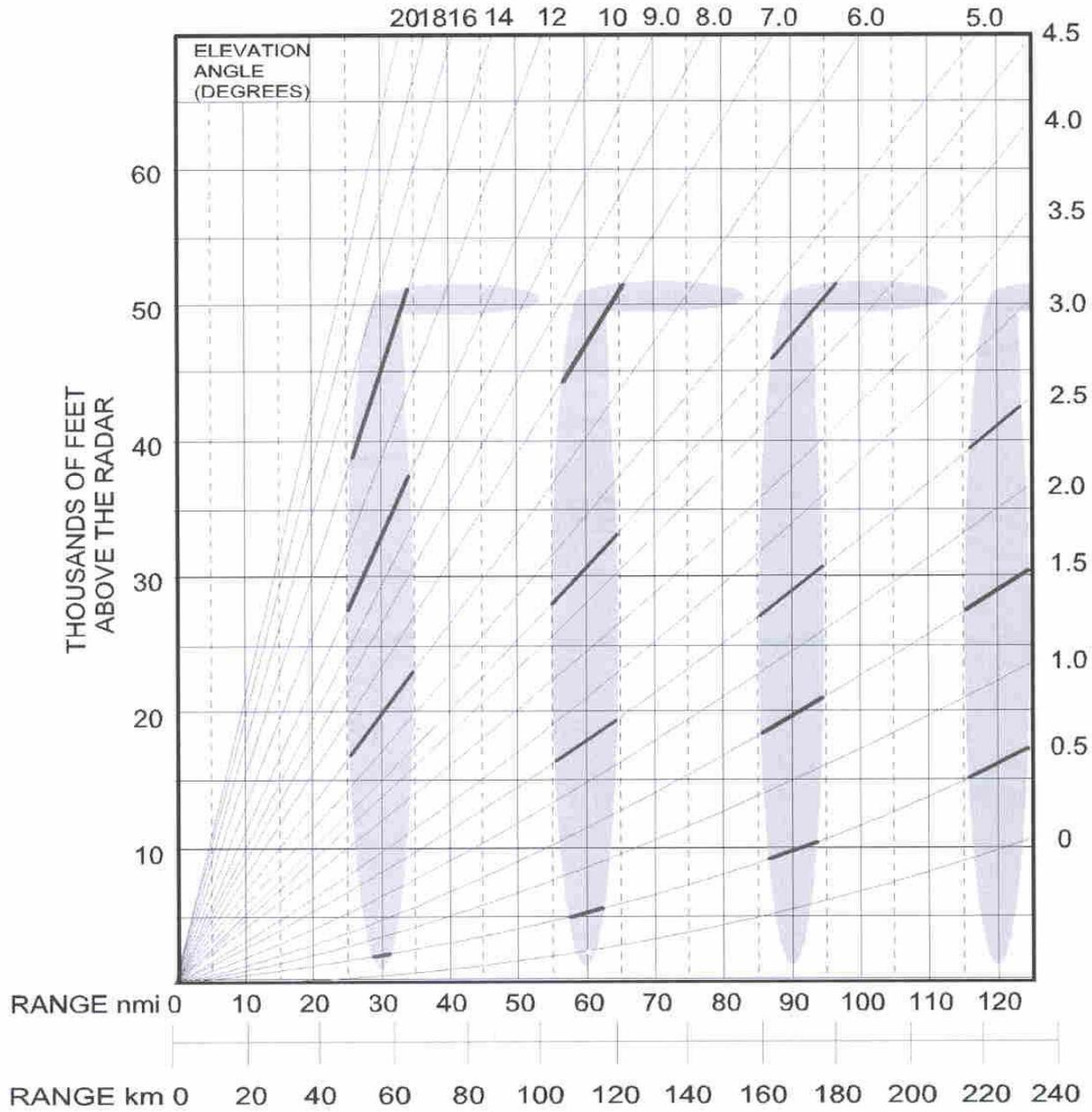
clear air mode



precipitation mode



lowest antenna tilt 0.5 degrees

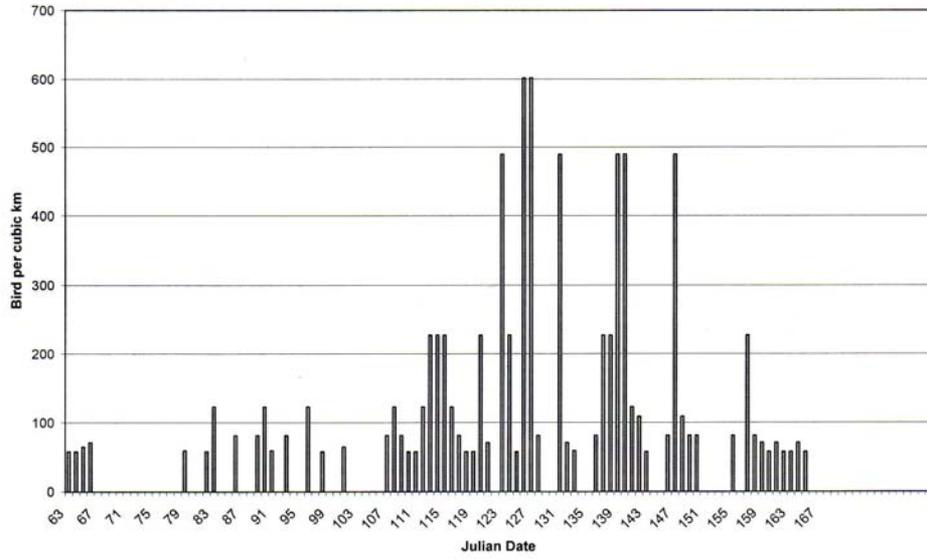


WSR-88D (NEXRAD)

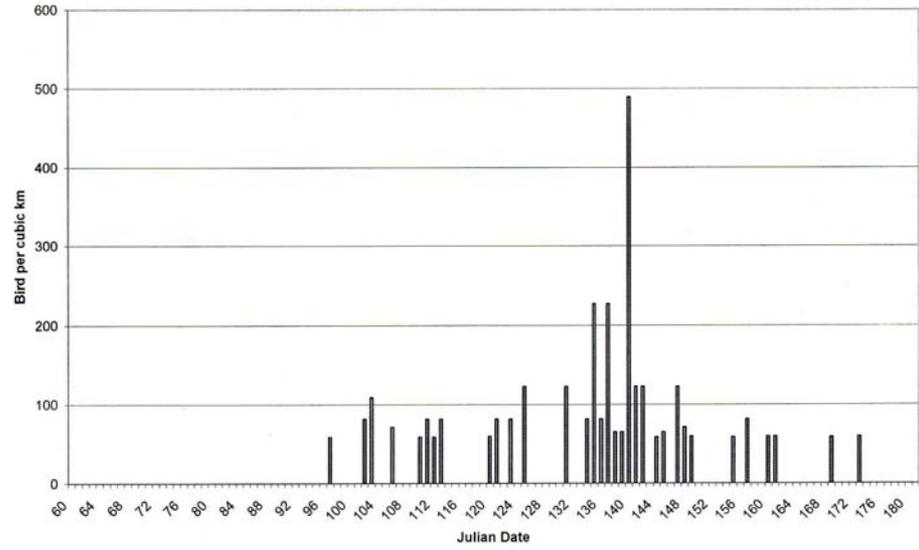
- Although NEXRAD can't detect low flying birds/bats, it can document the quantity of migration that could be compressed to lower altitudes when weather conditions force migrants to fly at low altitudes, and it can document the locations of important bird/bat roost sites.
- Provides several years of baseline information that documents the variation in temporal patterns of bird/bat activity in the atmosphere (hour-to-hour, day-to-day, spring vs. fall, and year-to-year) over land and over water.



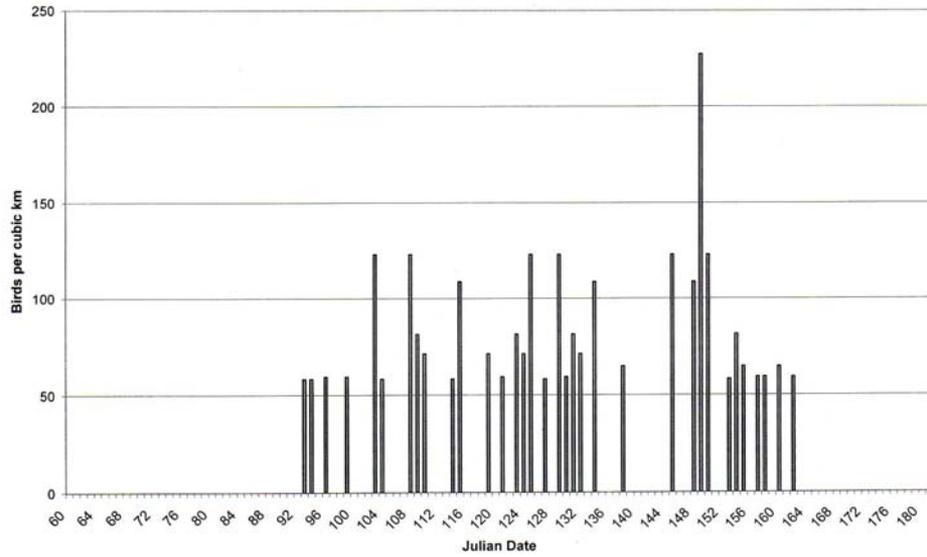
Spring 2000



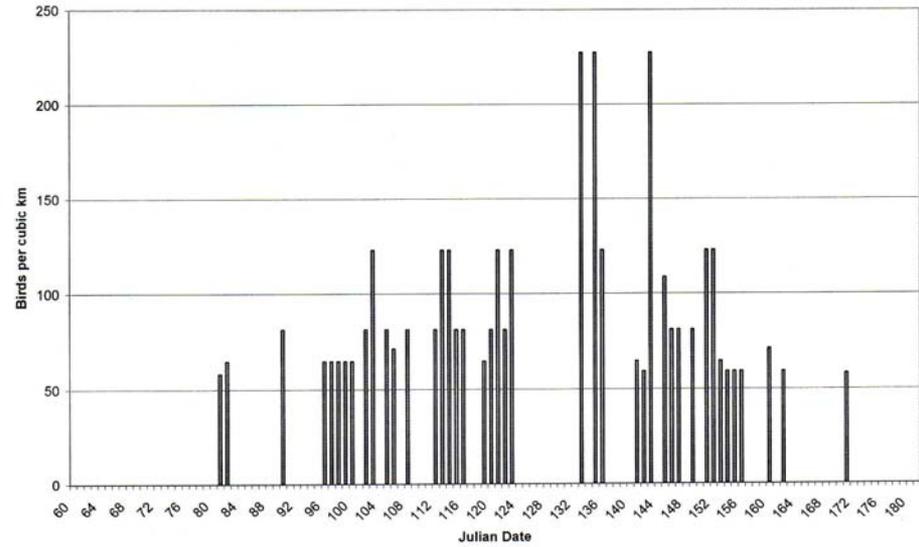
Spring 2002



Spring 2001

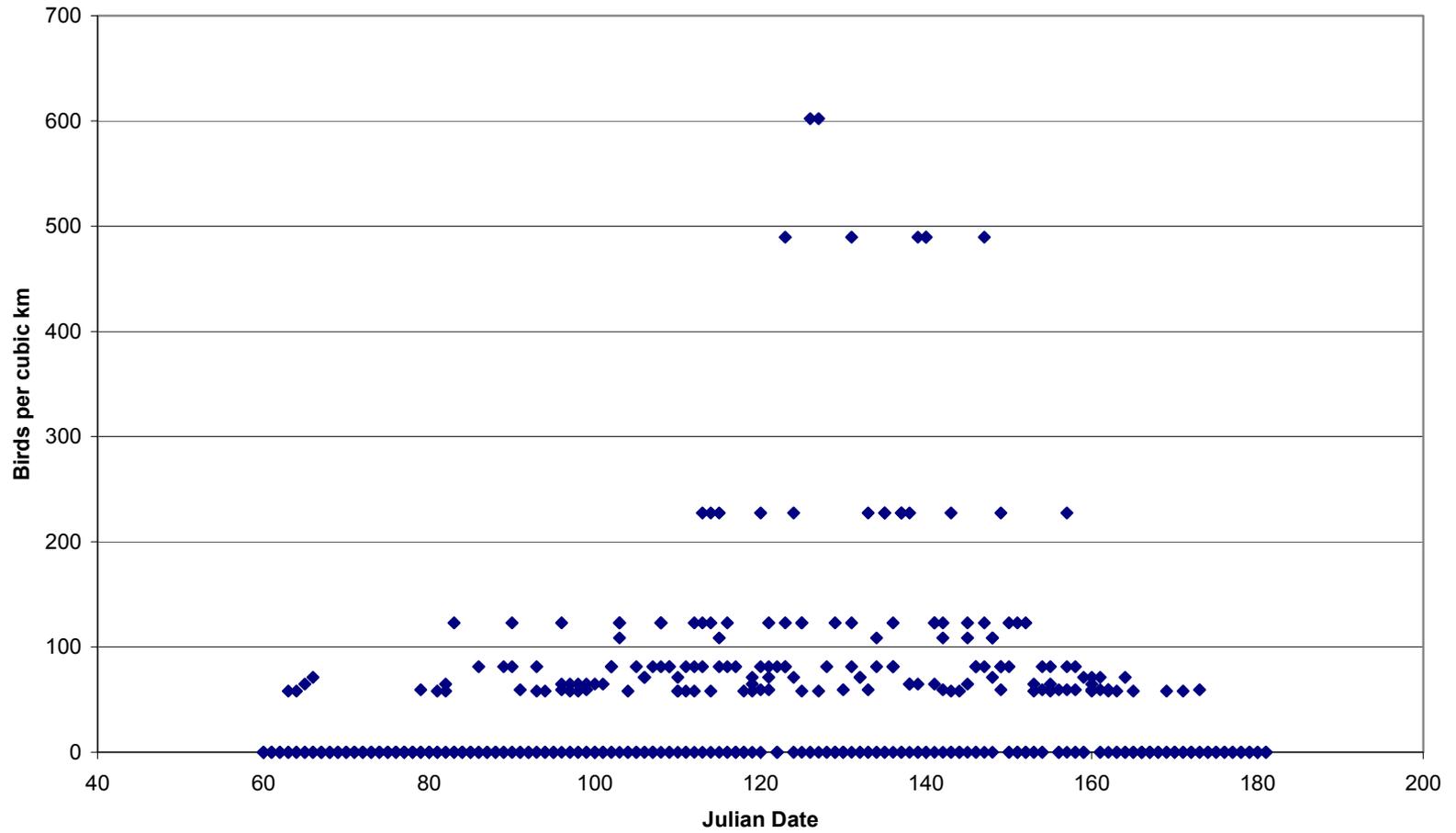


Spring 2003

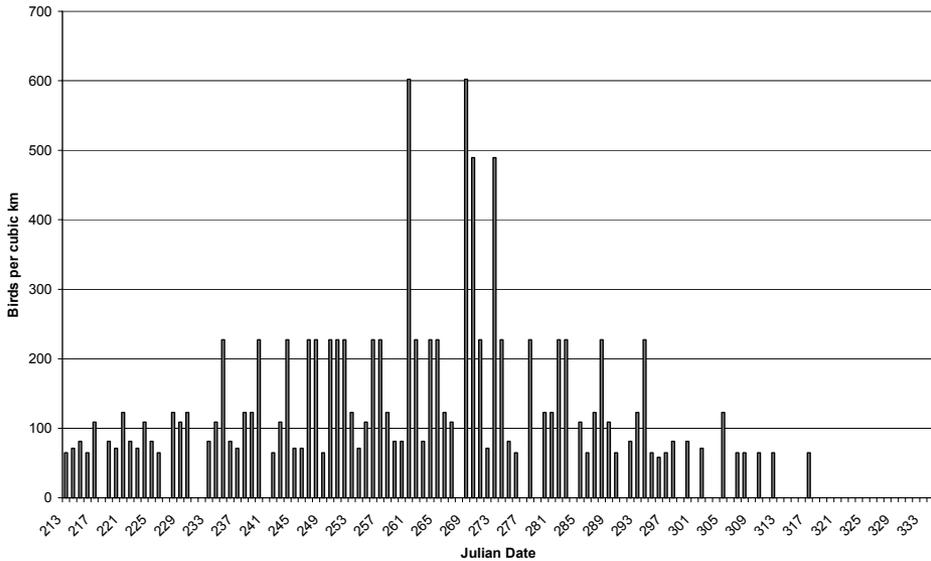


Grand Forks, ND

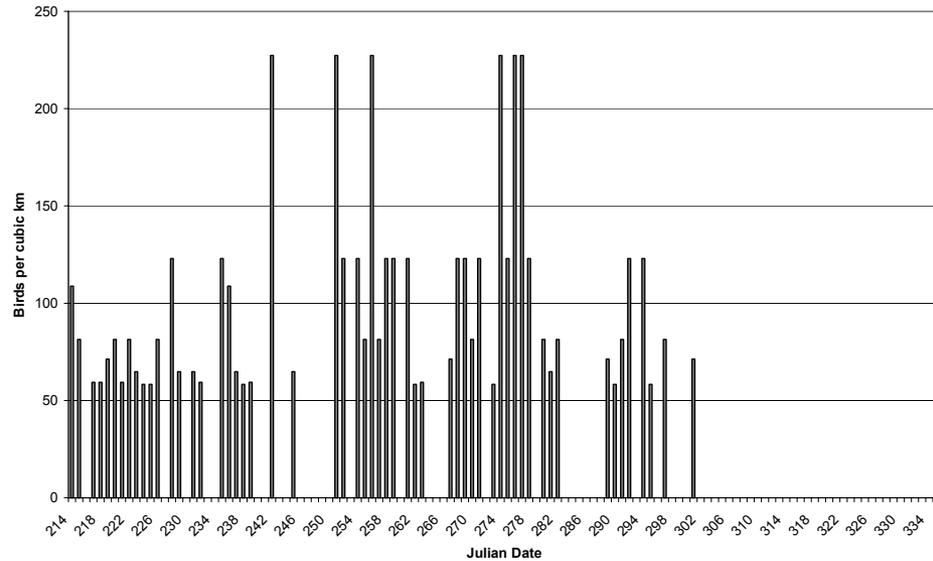
Spring Brd Migration, Grand Forks, ND
2000-2003



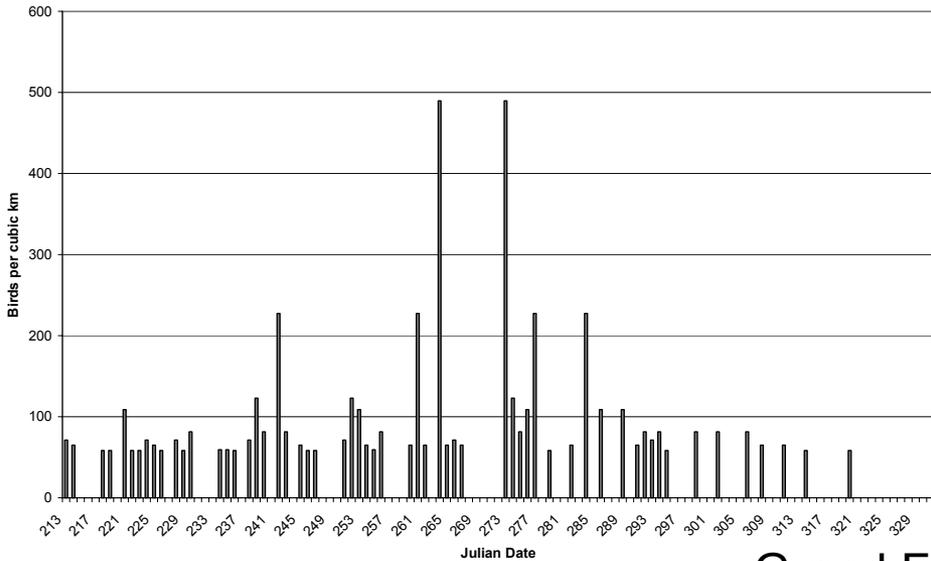
Fall 1999



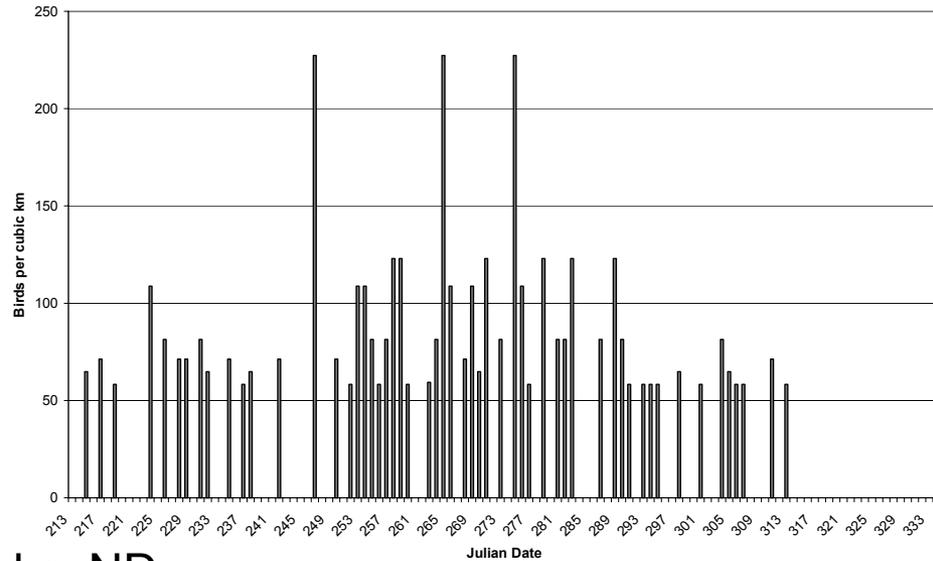
Fall 2000



Fall 2001

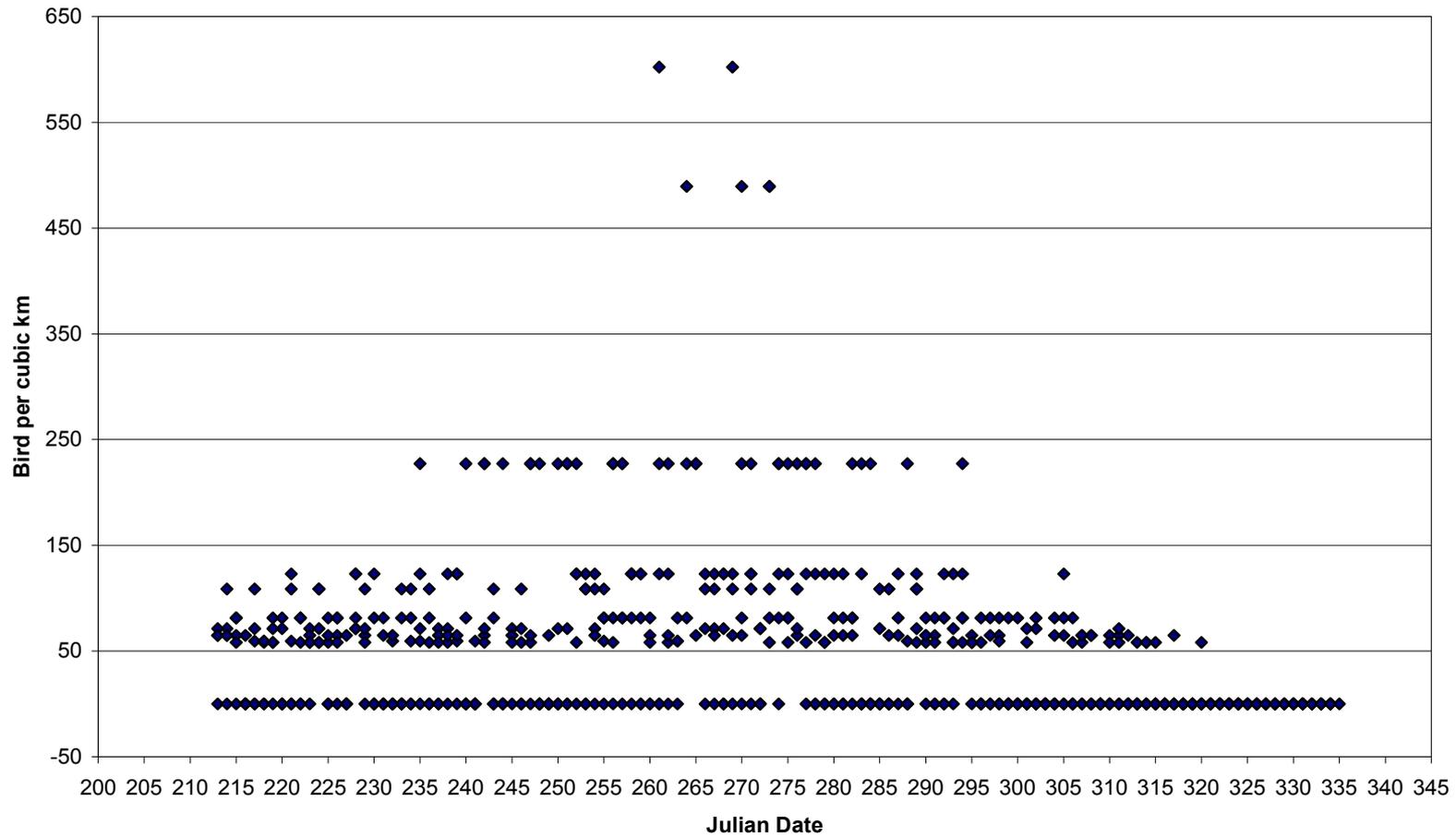


Fall 2002



Grand Forks, ND

Fall Migration at Grand Forks, ND
1999-2003



WSR-88D (NEXRAD)

- Although the download process can be rather tedious, Level 2 and Level 3 data for most stations have been archived at National Climatic Data Center since about 1995 and can be obtained at no cost.
- More details on Level 2 & 3 NEXRAD data can be found at <http://lwf.ncdc.noaa.gov/oa/radar/radarresources.html>



HIGH-RESOLUTION (MARINE) RADAR

- **High-resolution (marine) radar** provides information on movements between 30 m and 14 km depending on power of radar, antenna configuration, pulse length, and size of target.
- These units can provide information on target density and altitudinal distribution and are used widely in pre-construction studies of bird and bat movements over proposed projects.
- More post-construction studies are needed to quantify collision mortality with respect to exposure





Mobile Avian Radar System (MARS)

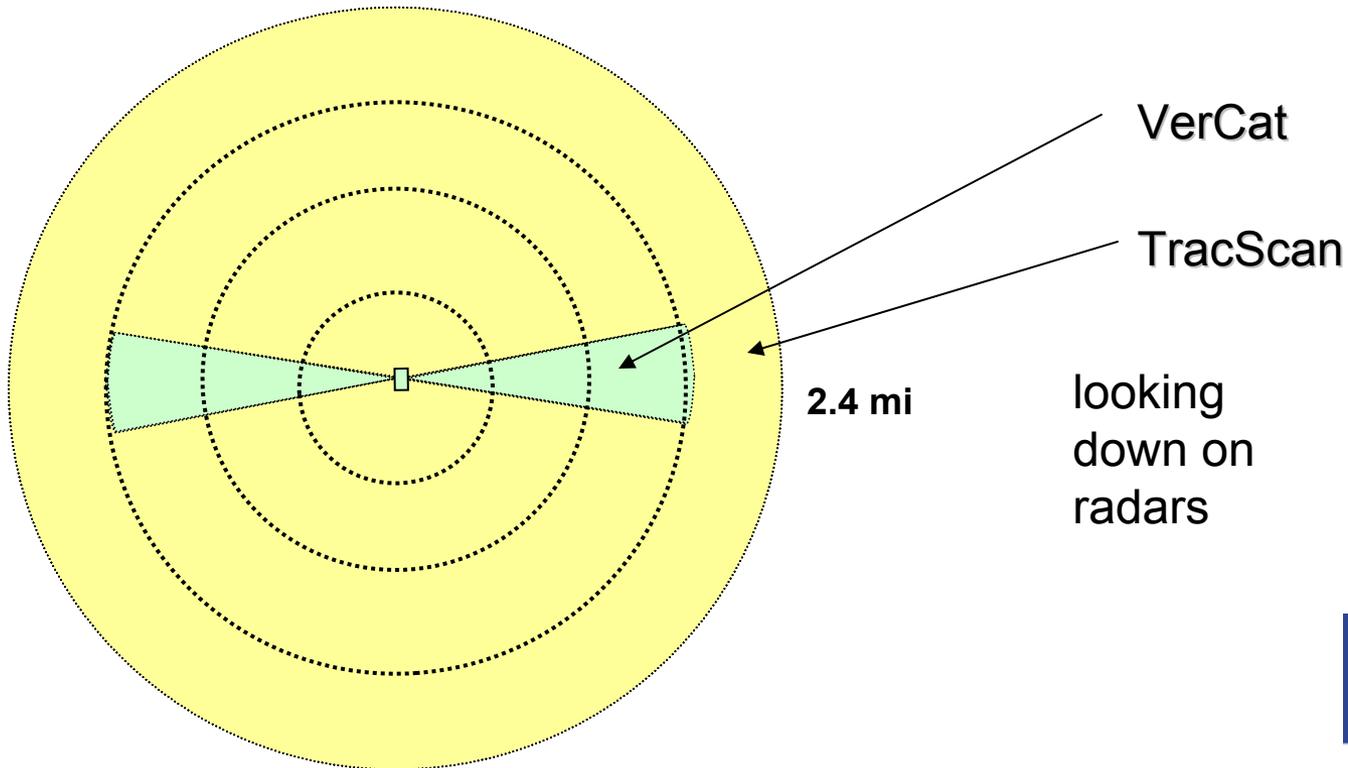
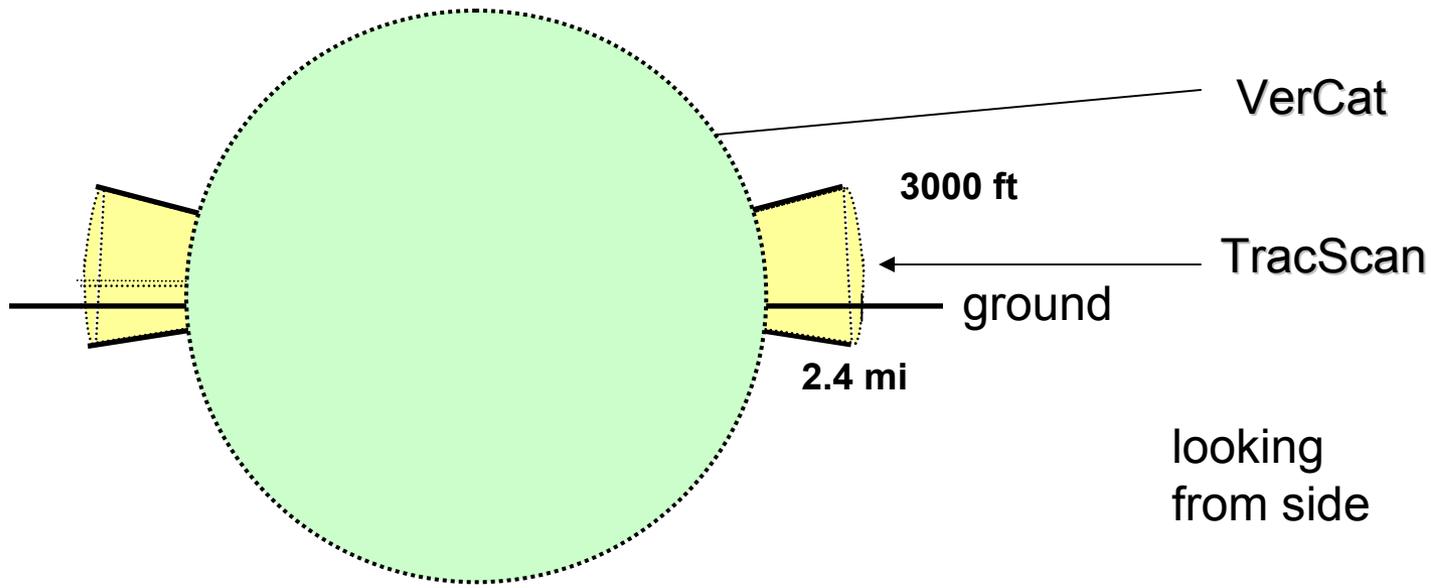
Dual radar system for bird detection

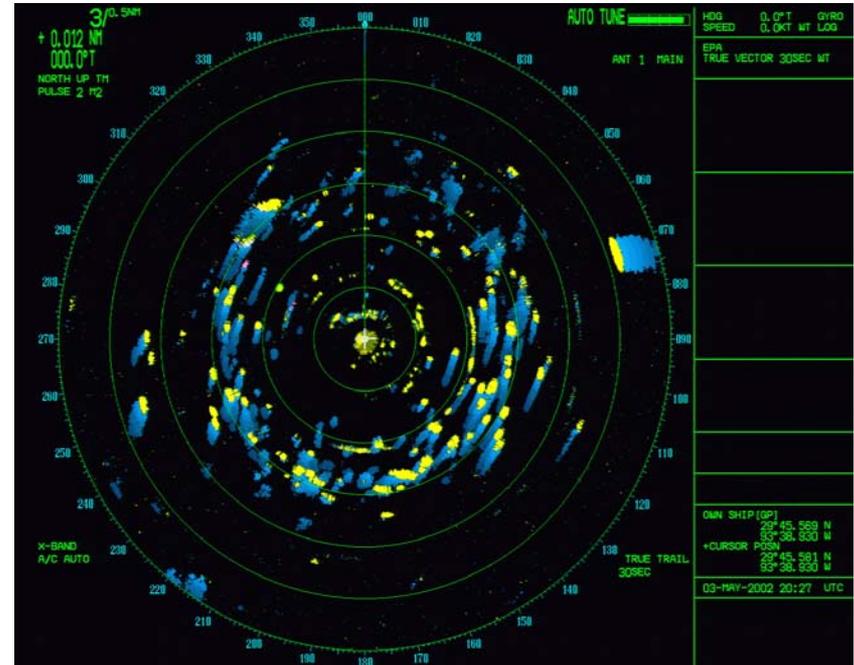
TracScan provides horizontal surveillance and tracks targets reporting position, speed, direction, and echo strength. S-band for “seeing beyond” precipitation

VerCat provides vertical surveillance and records altitude and size of echo. X-band for finer altitude resolution

24 x 7 radar operations

On-board weather station





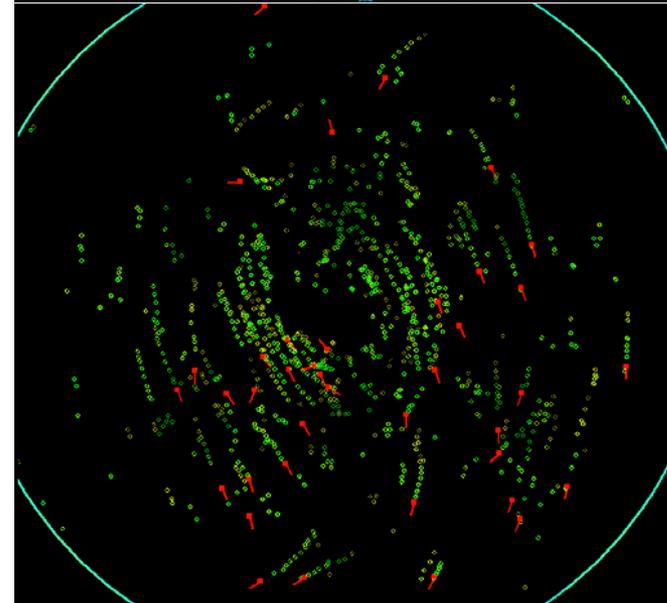
BIRD RAD

FURUNO FR-2155BB

Frequency: X-band 9415 MHz \pm 30 MHz

Output power: 50 kW

Parabolic antenna (4°) beam width



eBIRD RAD with Accipiter®
Digital Processor

Sicom
Systems Ltd.



THERMAL IMAGING AND VERTICALLY POINTING FIXED-BEAM RADAR

- **Thermal imaging** can detect individual birds/bats out to a maximum range of 2 km.
- The combination of thermal imaging (TI) and fixed vertical-beam radar (VERTRAD) enables the determination of
 - » altitude of movement
 - » direction of movement
 - » flock size



THERMAL IMAGING AND VERTICALLY POINTING FIXED-BEAM RADAR

- Radiance 1 (Raytheon Amber, Ca.)
 - Detector array 256 x 256 (65,536 elements) Indium antimonide (InSb)
 - Spectral Bandpass 3 μm to 5 μm
 - Display Resolution 640 x 482 full screen
 - 60 frames per second
 - With a 100-mm lens, the field of view is 5.57° (horizontal screen dimension) and 4.19° (vertical screen dimension).

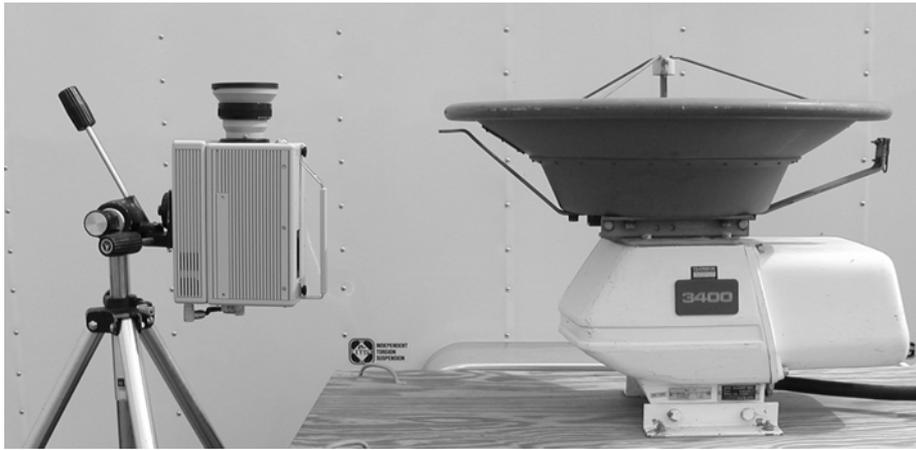


THERMAL IMAGING AND VERTICALLY POINTING FIXED-BEAM RADAR

- Pathfinder Model 3400 marine radar (Raytheon Inc., Manchester, NH)
 - replaced the typical open array antenna with a parabolic antenna (61 cm diameter) that produced a beam width of 4°
 - The vertically-pointing antenna sat on top of a transmitter-receiver (TR) unit connected to a display unit (178 mm cathode ray tube) and rectifier by cables
 - transmitter frequency was 9410 ± 30 MHz (3-cm wavelength) with a peak power output of 5kW; minimum range of detection of 25 m.

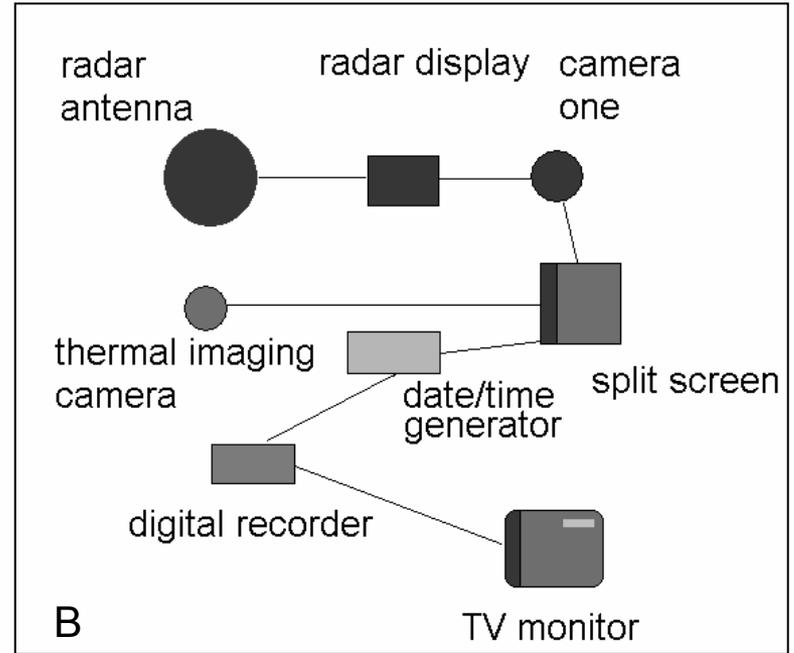






A TI camera

VERTRAD antenna



B





153:153:25

153:153:25

5-01-03 THU

11:02:51 PM

I

I

LIVE



153.153.25

153.153.25

5-01-03 THU

11:02:34 PM

I

I

LIVE

THERMAL IMAGING AND VERTICALLY POINTING FIXED-BEAM RADAR

- We used a video peak store (VPS) to make time exposures of target tracks in the video record of the TI and developed criteria to distinguish birds, foraging bats, and insects based on characteristics of the tracks in the VPS images and the altitude of the targets.
- We also enhanced the video frames to maximize detection of weak radiance signals from high flying birds.



5556 m

4630 m

3704 m

2778 m

1852 m

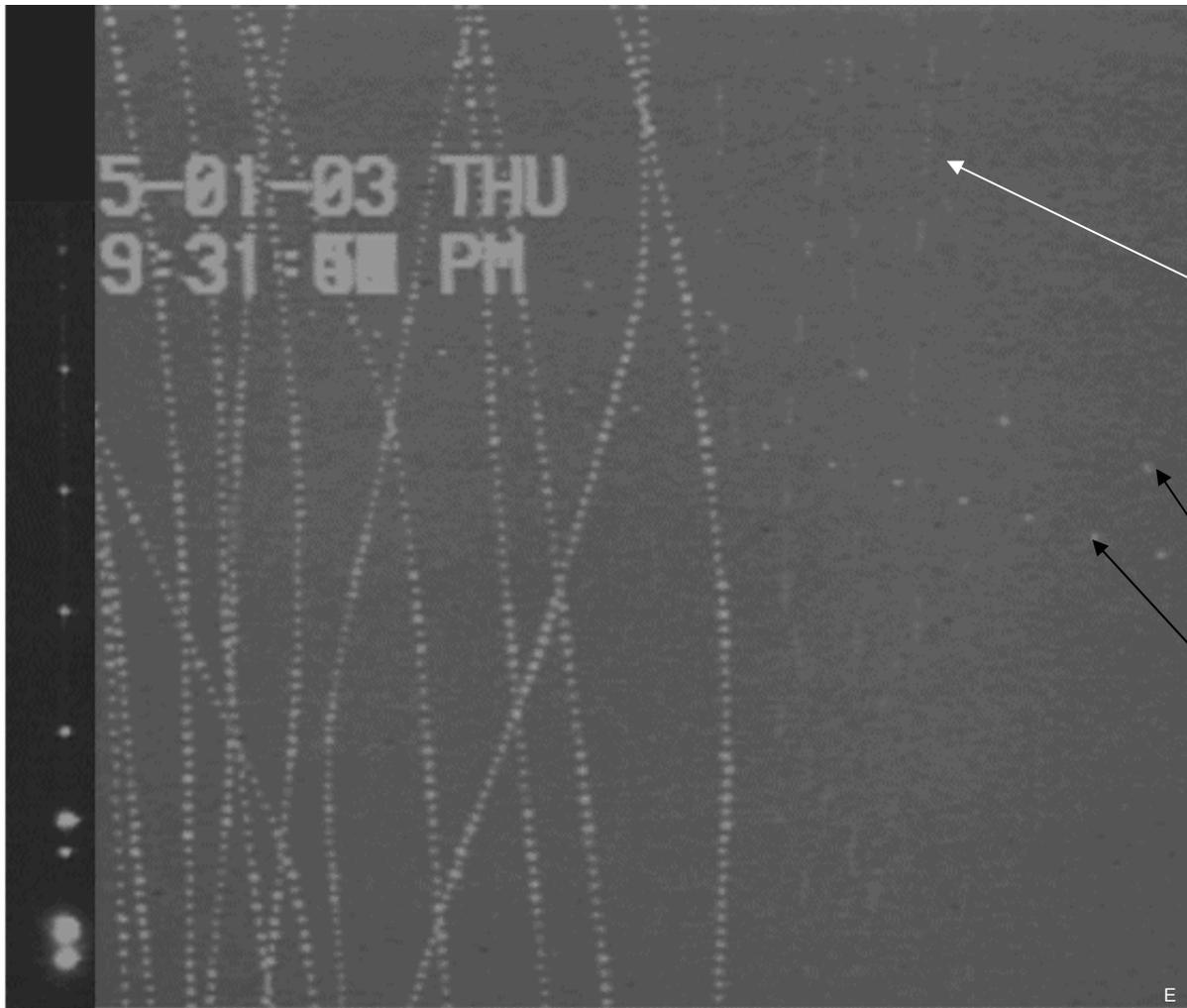
926 m

surface

5-01-03 THU
9:31:01 PM

HIGHER
FLOCK

INSECTS



B

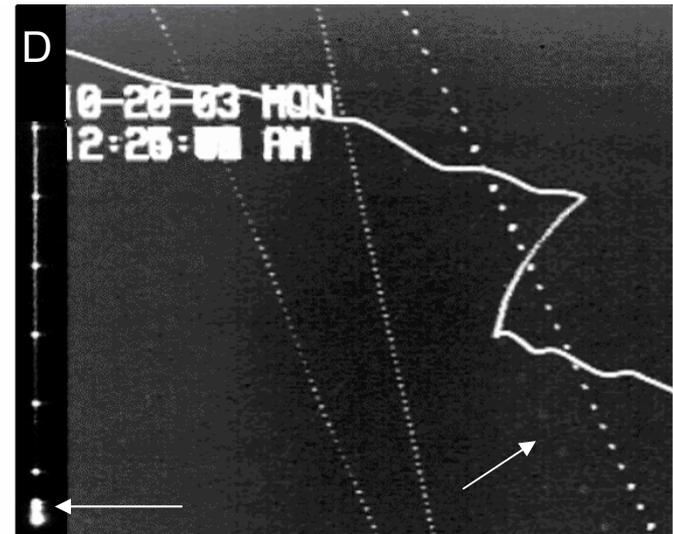
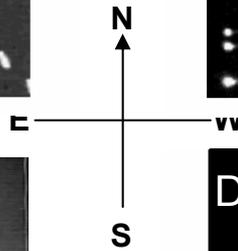
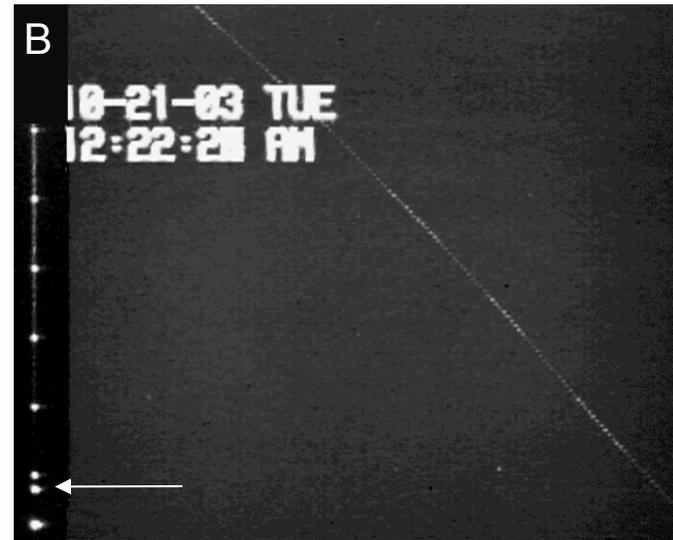
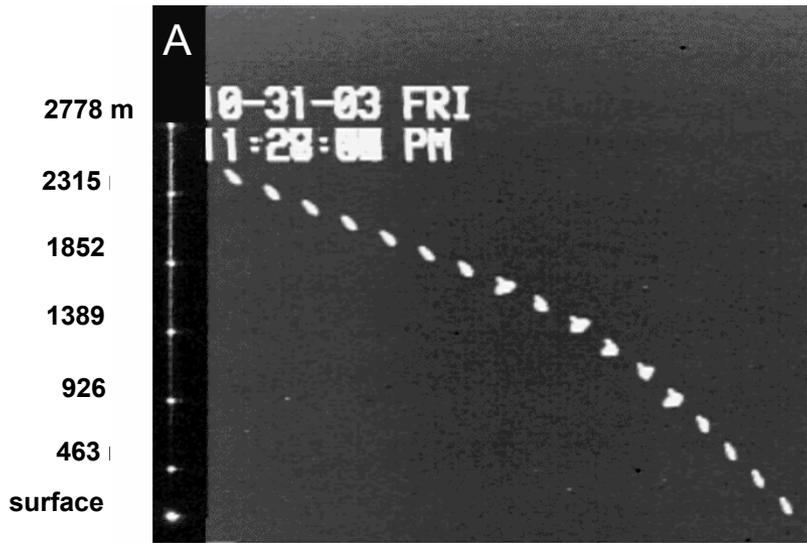
5-01-03 THU
9:31 PM

Enhanced Image

THERMAL IMAGING AND VERTICALLY POINTING FIXED-BEAM RADAR

Discrimination of Targets:

- Insects produce relatively weak thermal signatures that do not show modulation. Many more insect targets at lower altitudes.
- Birds produce relatively strong thermal signatures that show distinct modulation that is in keeping with their wing beat.
- Bats that are foraging show strong thermal signatures that show distinct modulation when flying fast, but modulation pattern is obscured when flight is slow. Foraging bats show sharp turns and non-linear flight.
- Bats and birds in linear migratory flights are nearly impossible to discriminate unless flying at very low altitudes (< 25 m).



Unregistered

153 153 25
153 153 25

10-17-83 FRI

10:17:39 PM

C

10

Li

Unreg

Live

Unregistered

10/17/03

10:17:40

10-17-03 FRI

10:17:40 PM

C

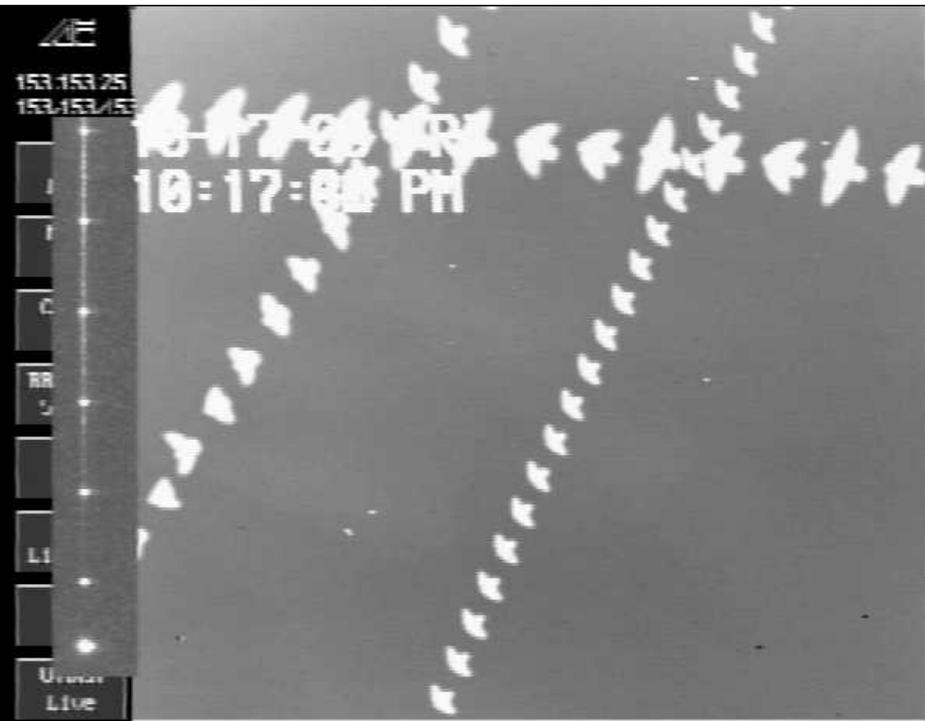
DN

S

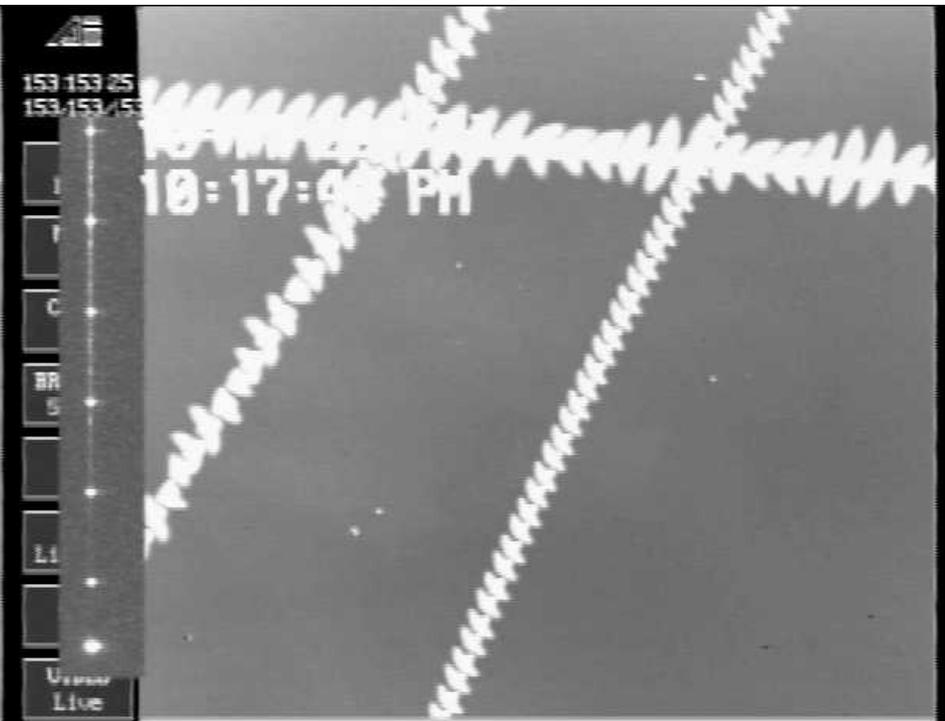
Li

Version

1.00



every other frame



every frame

Tree Swallows

Unregistered

9-26-00 TUE

1:14:33 AM

953 153 25



Live

Unregistered

9-26-08 TUE

1:14:33 AM

10/10/08

10/10/08

10/10/08

10/10/08

10/10/08

10/10/08

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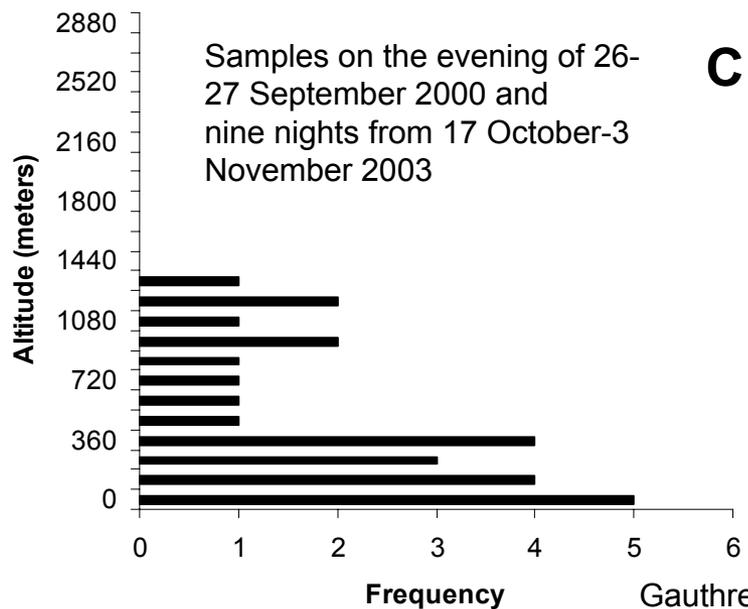
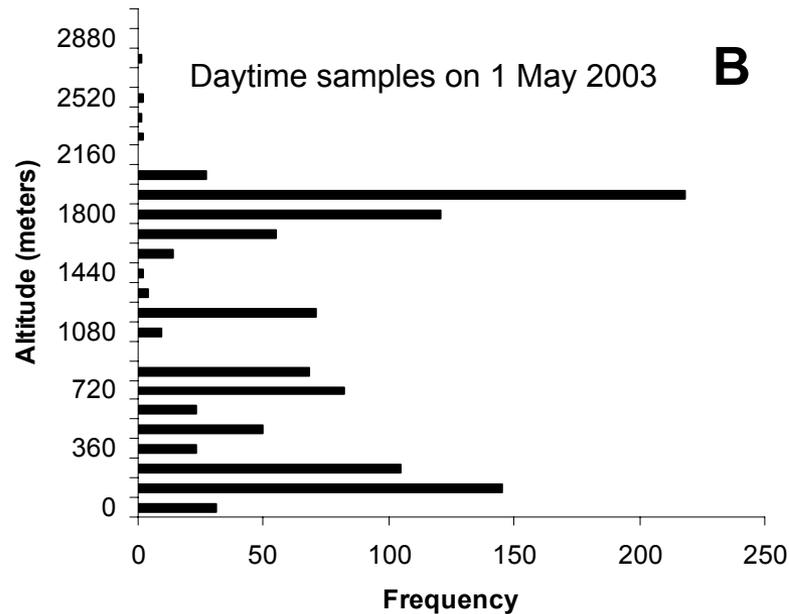
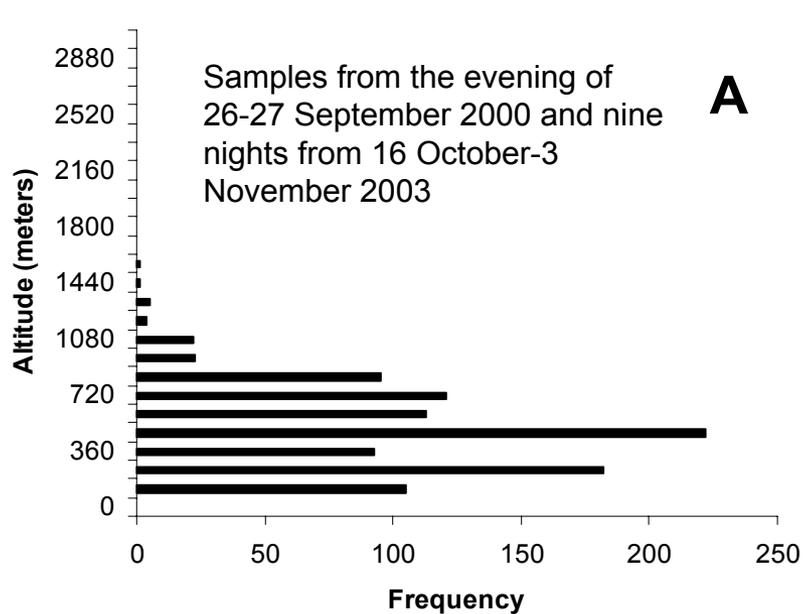


every other frame



every frame

bat in linear flight



THERMAL IMAGING AND VERTICALLY POINTING FIXED-BEAM RADAR

Disadvantages:

- TI Cameras are costly (\$ 50-\$ 75 K)
- They cannot be used to see small targets through heavy cloud and precipitation
- The TI/VERTRAD system samples a narrow cone directed vertically (4.19°) when configured to detect higher altitude targets
- Analysis of data can be time consuming, but algorithms are being developed to automate analysis



THERMAL IMAGING AND VERTICALLY POINTING FIXED-BEAM RADAR

Advantages:

- TI cameras detect the thermal radiance of the target and do not require any target illumination as is the case for image intensifiers.
- TI cameras can be used to identify sources of radar echoes at greater distances than image intensifiers.
- TI/VERTRAD systems are portable and can be deployed in many different topographies



THERMAL IMAGING AND VERTICALLY POINTING FIXED-BEAM RADAR

- The TI camera works equally well during daytime and nighttime observations and best when skies are clear, because thermal radiance from cloud heat often obscures small targets.
- The VERTRAD/TI system is a valuable tool for measuring accurate bird migration traffic rates (the number of birds crossing 1609 m [1 statute mile] of front per hour) for different altitudinal strata above 25 m.



THERMAL IMAGING AND VERTICALLY POINTING FIXED-BEAM RADAR

- The technique can be used to estimate the potential risk of migrating birds colliding with man-made obstacles of various heights (e.g., communication and broadcast towers and wind turbines)—a subject of increasing importance to conservation biologists.



Acknowledgements

- Much of my work with NEXRAD, marine radar, and thermal imaging was accomplished with support from the Legacy Resource Management Program of the Department of Defense. The Department of the Navy also assisted in the development of BIRD RAD and eBIRD RAD
- Carroll Belser, Donald van Blaricom, and John Livingston assisted in all phases of this work
- I wish to thank the organizers and sponsors of this conference for inviting me and supporting my travel

