

# Examples of Polarimetric and Non-Polarimetric Signatures of Bat Emergences

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Schweizerische Vogelwarte )



# Presentation Outline

- Introduction to the Brazilian free-tailed bat (*Tadarida brasiliensis*)
- Polarimetric observations of bats at X-band
- Modeling of radar backscatter from bats
- Polarimetric observations of bats using NEXRAD (polarimetric & non-polarimetric)
- Summary

# Brazilian Free-Tailed Bat

# Brazilian Free-Tailed Bat (in words)

- Medium sized bat (11-14 g) with a wing span of 30-35 cm
- Found in the western United States, south through Mexico, Central America and into northern South America
- Prefer to roost in caves but will also roost in attics, under bridges, or in abandoned buildings
- Most migrate to Central America and Mexico during the winter
- Aerial insectivores: consume large amounts of moths and other insects
- Largest known colony is Bracken Cave near San Antonio, Texas ... some estimates place up 20 million bats there at times

# Brazilian Free-Tailed Bat (in pictures)



Location of Bracken and Frio Caves



Foraging



Range of Brazilian free-tailed bats

# X-Band Observations of Bats

# Using ~~Storm~~ Biology Chasing Radars to Study Brazilian Free-Tailed Bats

- Frio Cave in central Texas hosts a large number (several million) Brazilian Free-Tailed bats
- On different occasions we have taken 2 different polarimetric X-band weather radars to Texas to study these bats
- Motivation was to investigate the emergence features of the bats, investigate their nocturnal foraging behavior, and to provide a base data set for comparison with observations from NEXRAD



# Mobile Radars



RaXPoL



NOXP

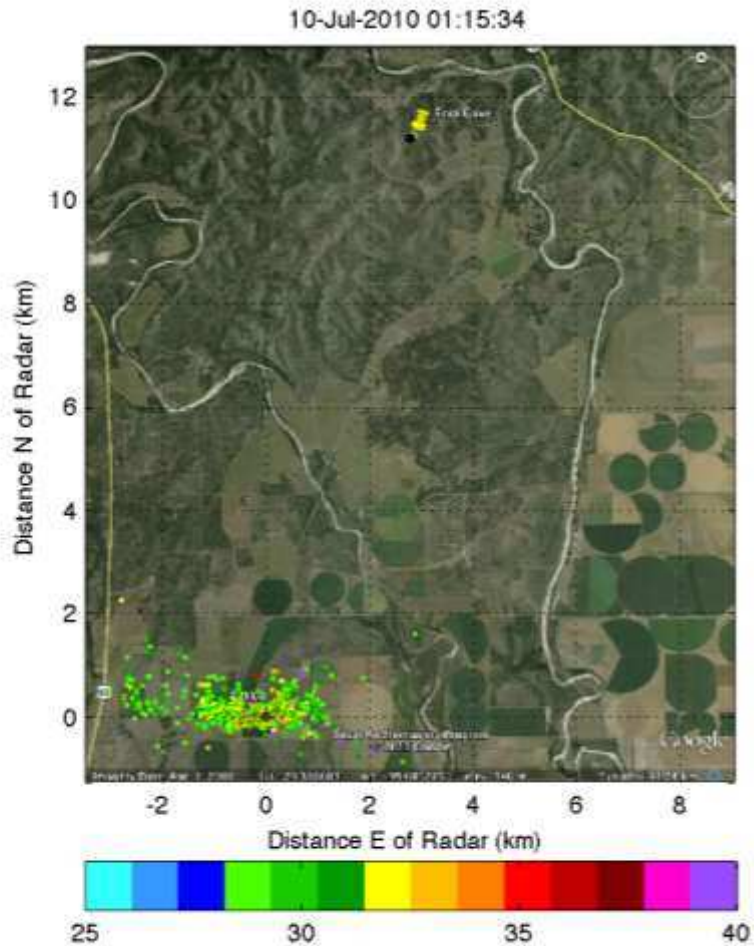
RaXPoL: OU Radar

NOXP: NOAA NSSL / OU Radar

Both are X-band (3-cm wavelength), Dual-polarization weather radars

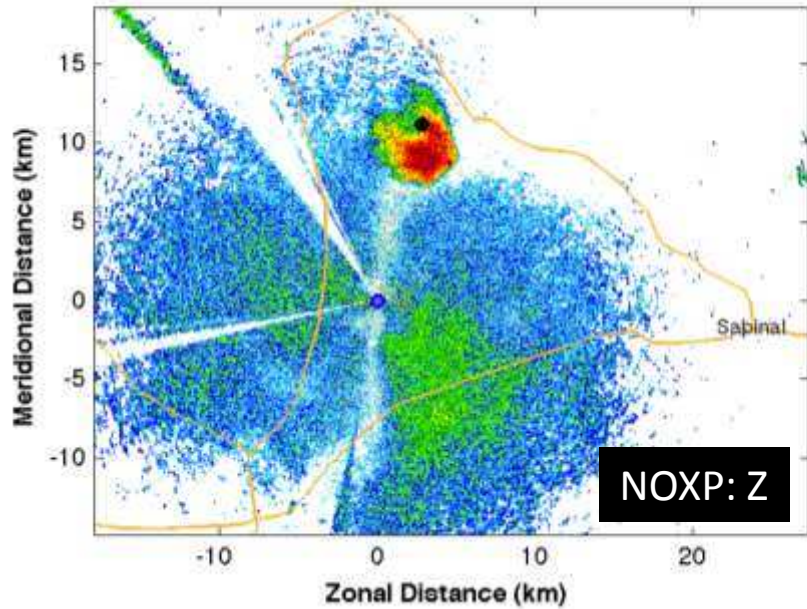


# Observations of Bat Emergence from Frio Cave Using X-Band Radar

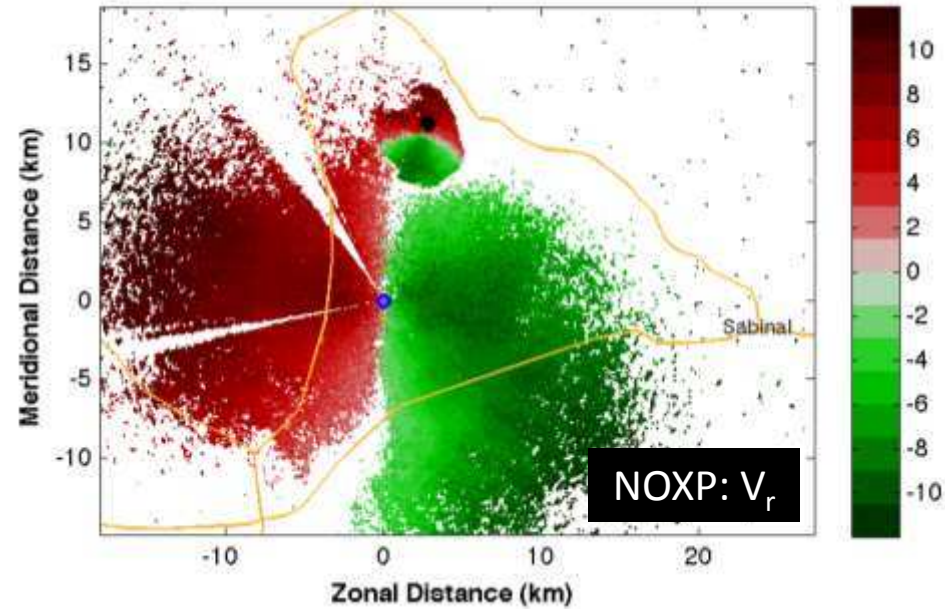


# Frio Cave, Texas: July 10, 2010 01:35 UTC (20:35 LT)

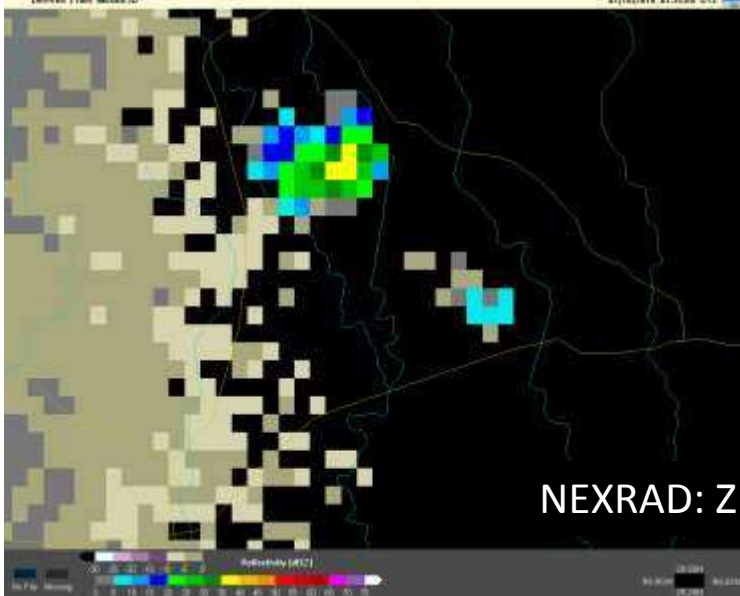
Reflectivity (dBZ) - 10-Jul-2010 01:34:06 UTC El=2.97 °



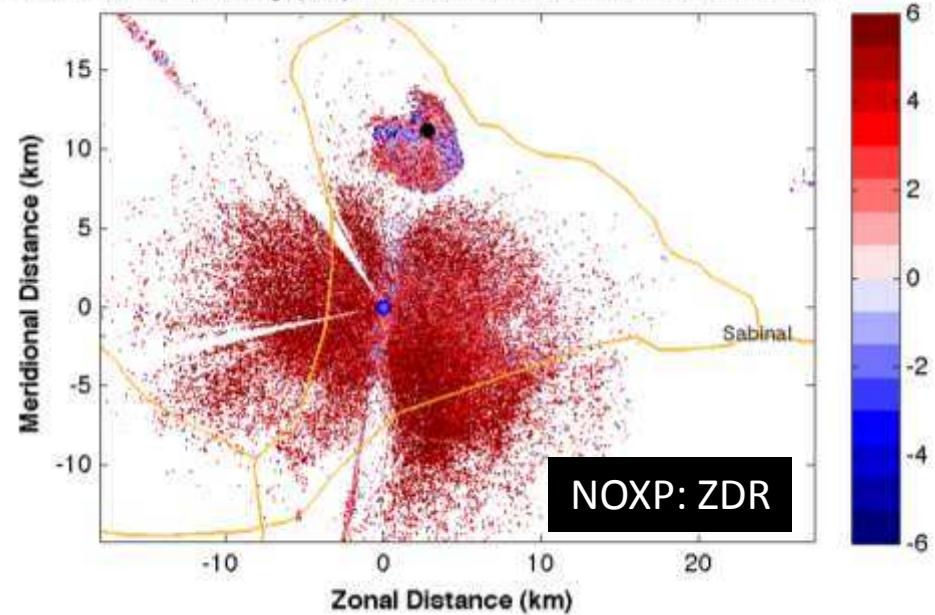
Velocity (m/s) - 10-Jul-2010 01:34:06 UTC El=2.97 °



Composite Reflectivity [Before QC]



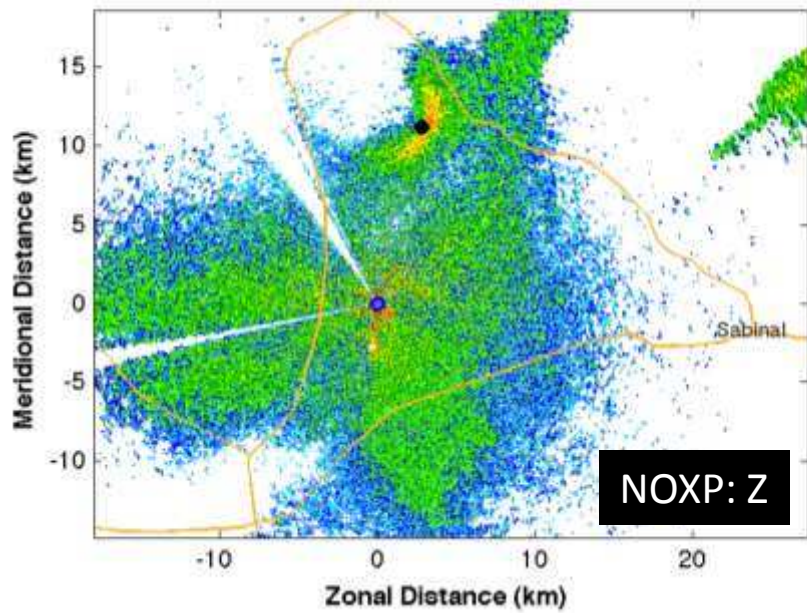
Differential reflectivity (dB) - 10-Jul-2010 01:34:06 UTC El=2.97 °



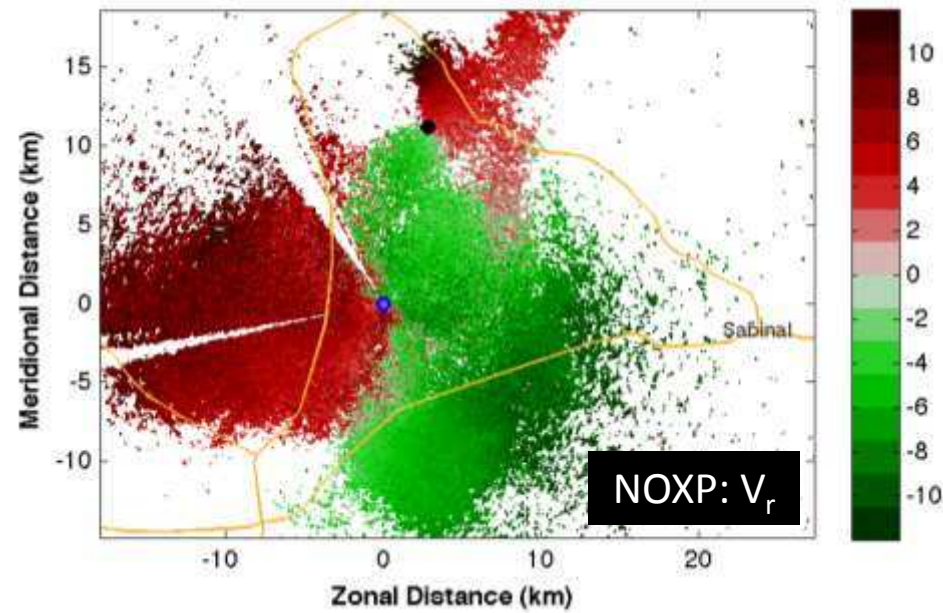


# Frio Cave, Texas: July 10, 2010 02:10 UTC (21:10 LT)

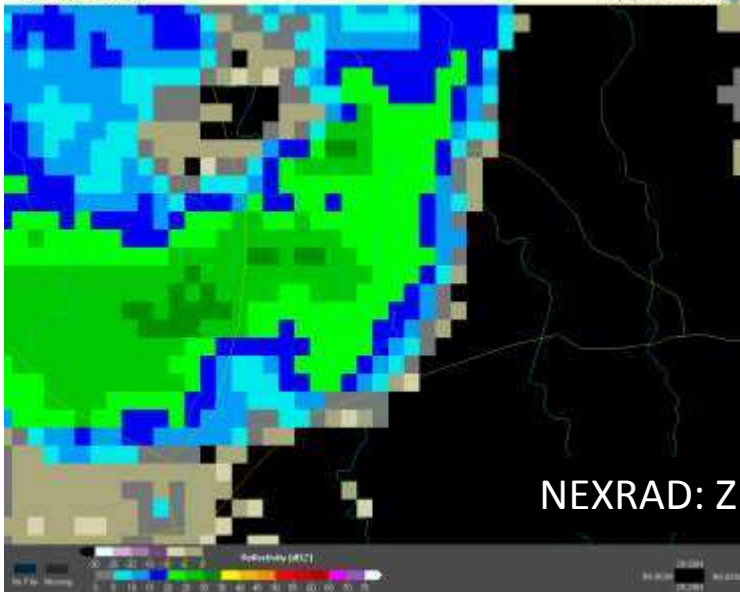
Reflectivity (dBZ) - 10-Jul-2010 02:09:10 UTC EI=2.99 °



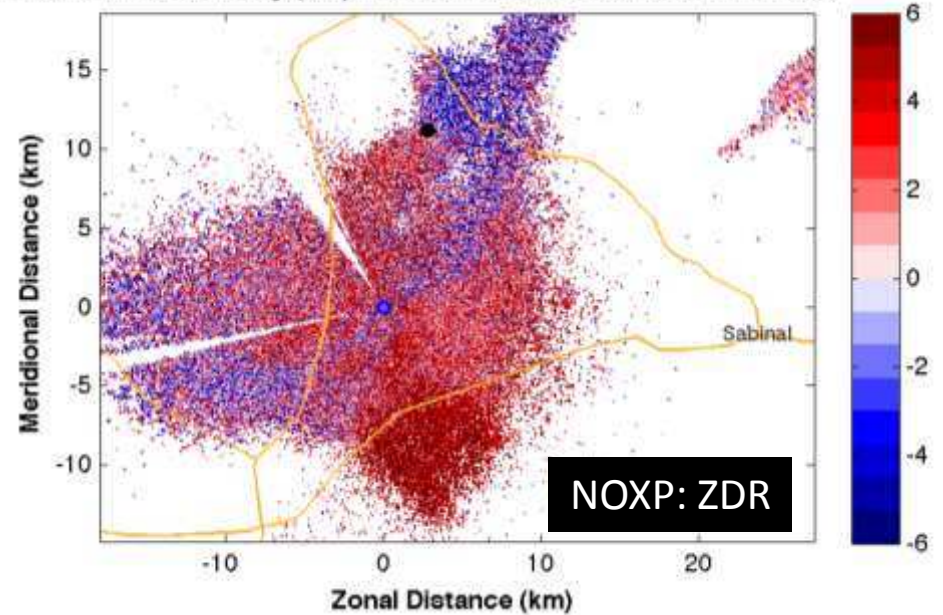
Velocity (m/s) - 10-Jul-2010 02:09:10 UTC EI=2.99 °



Composite Reflectivity [Before QC]



Differential reflectivity (dB) - 10-Jul-2010 02:09:10 UTC EI=2.99 °

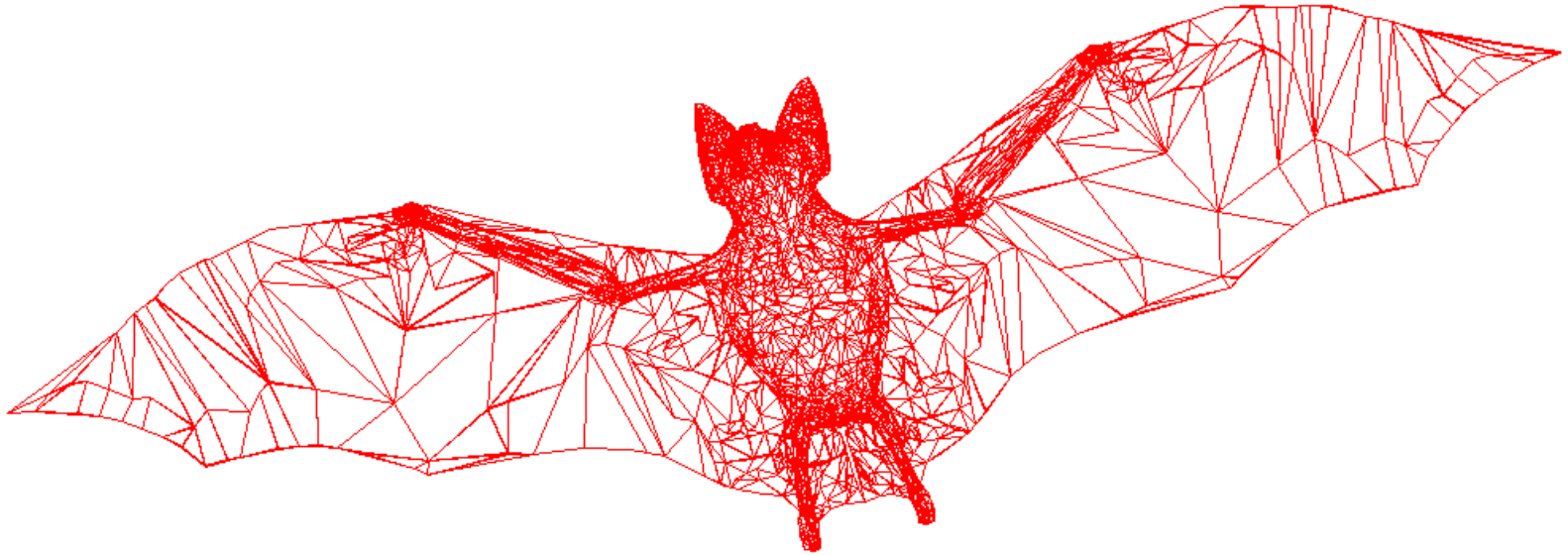


# Modeling of Radio-Wave Backscatter from Bats

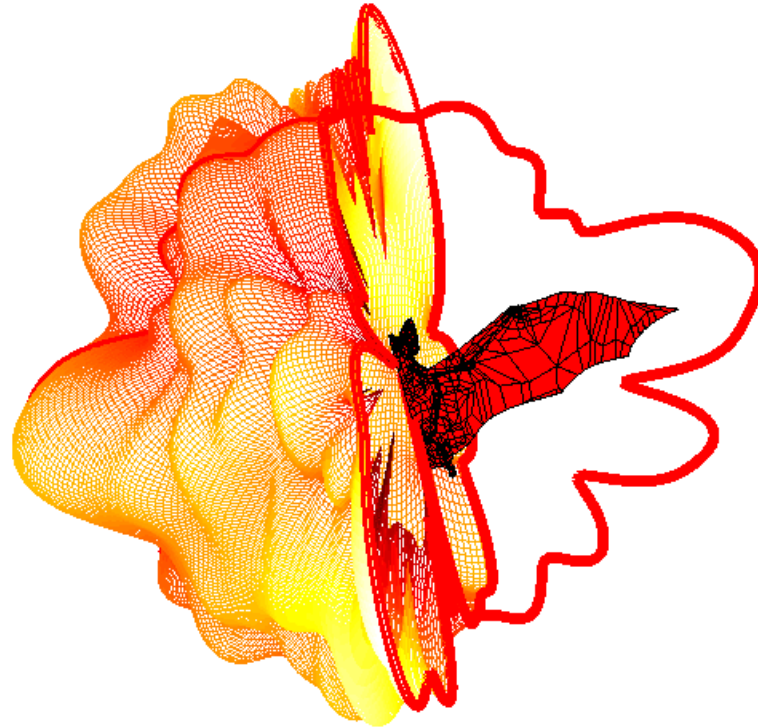
# RCS Modeling: Method of Moments

- Aim is simulate the radar cross section (RCS) of an object of interest using numerical models
- Construct a “plate model” of the object with each plate being characterized by a given complex dielectric constant
- Use the computer model to solve the integral equation form of Maxwell’s equations for each plate and determine the resulting surface induction currents
- Calculate the electromagnetic field generated from the cumulative contributions of the induction currents
- The result is used to find the RCS of the object

# Plate Model of the Brazilian Free-Tailed Bat

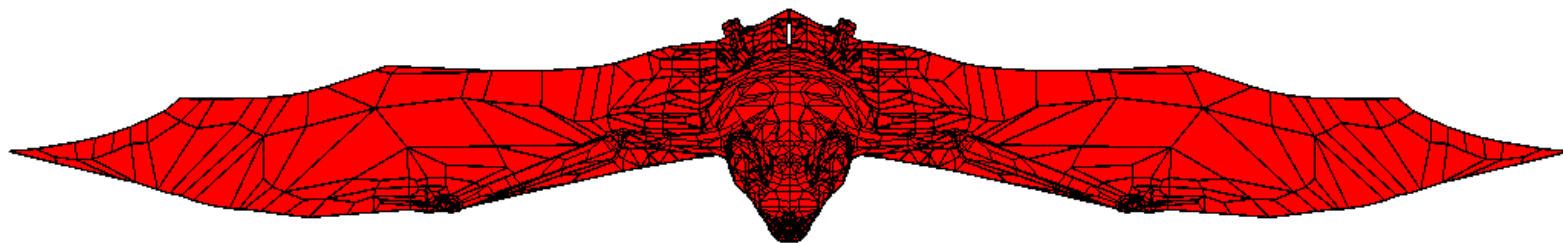


# RCS Calculated for the Brazilian Free-Tailed Bat

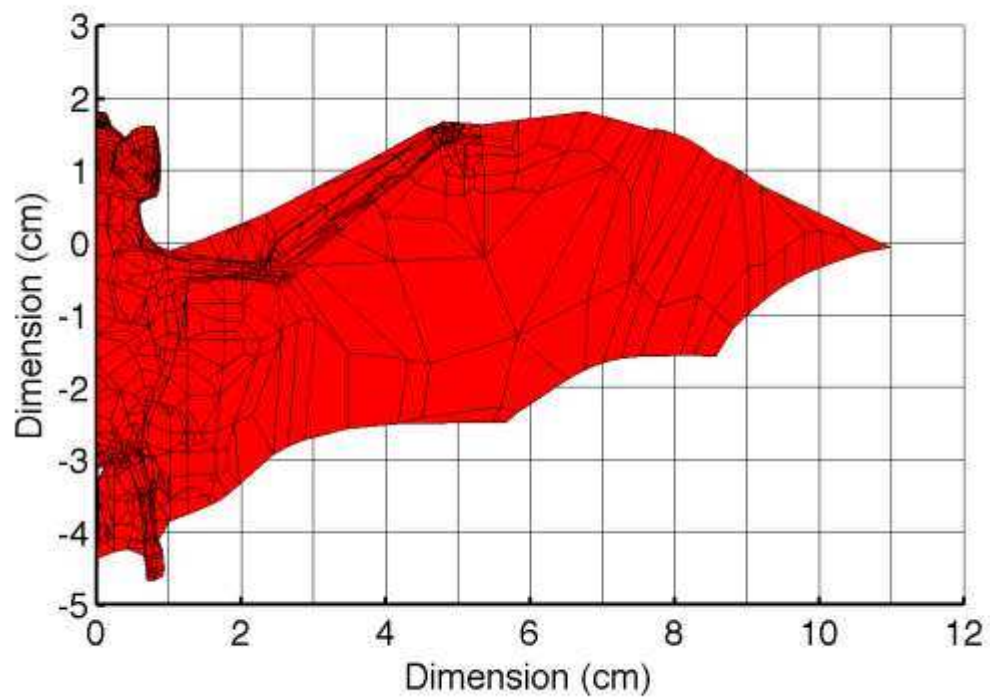




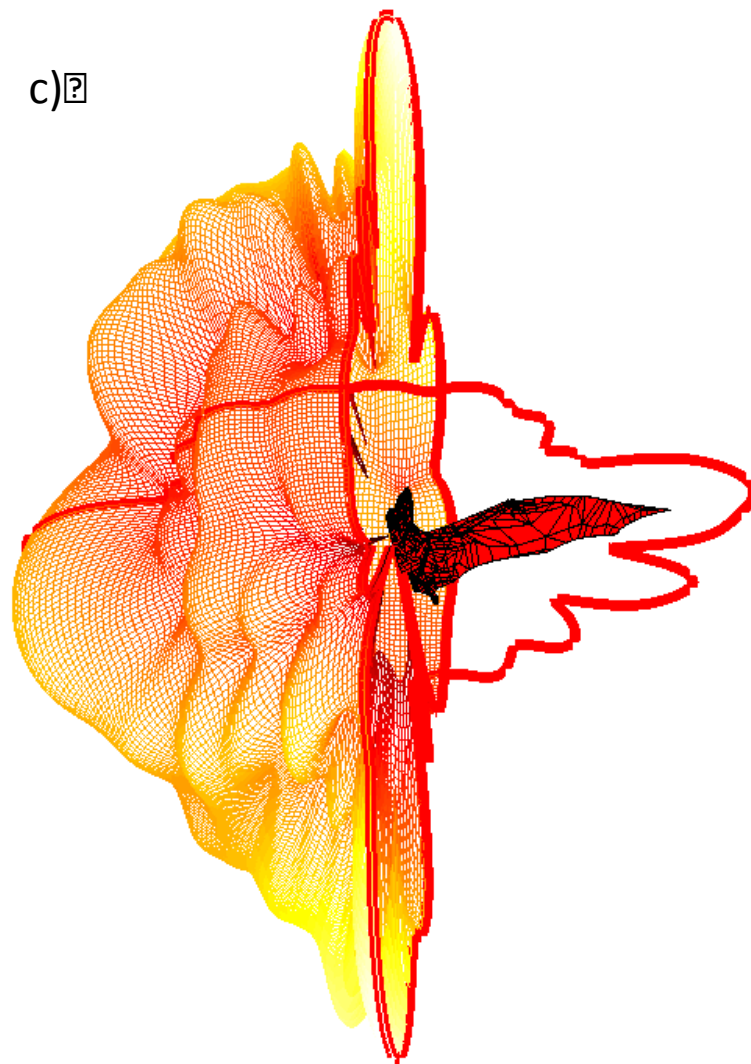
a)



b)

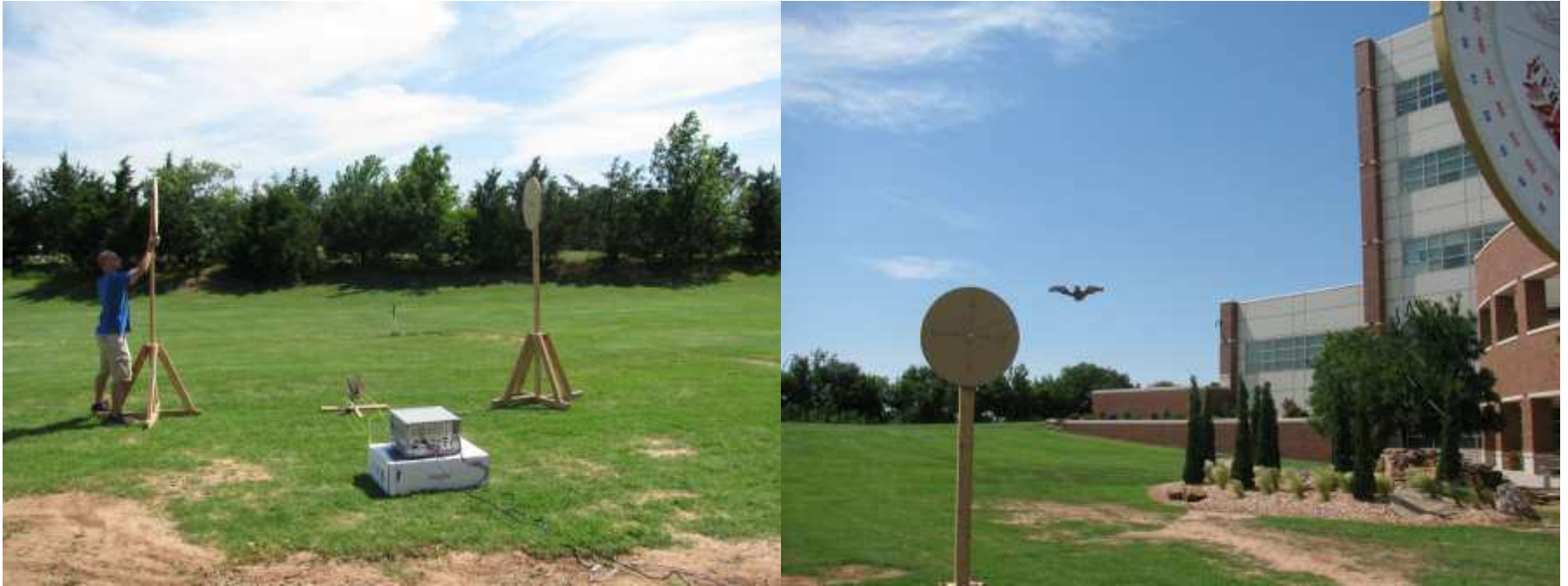


c)





# Field Measurements / Model Validation



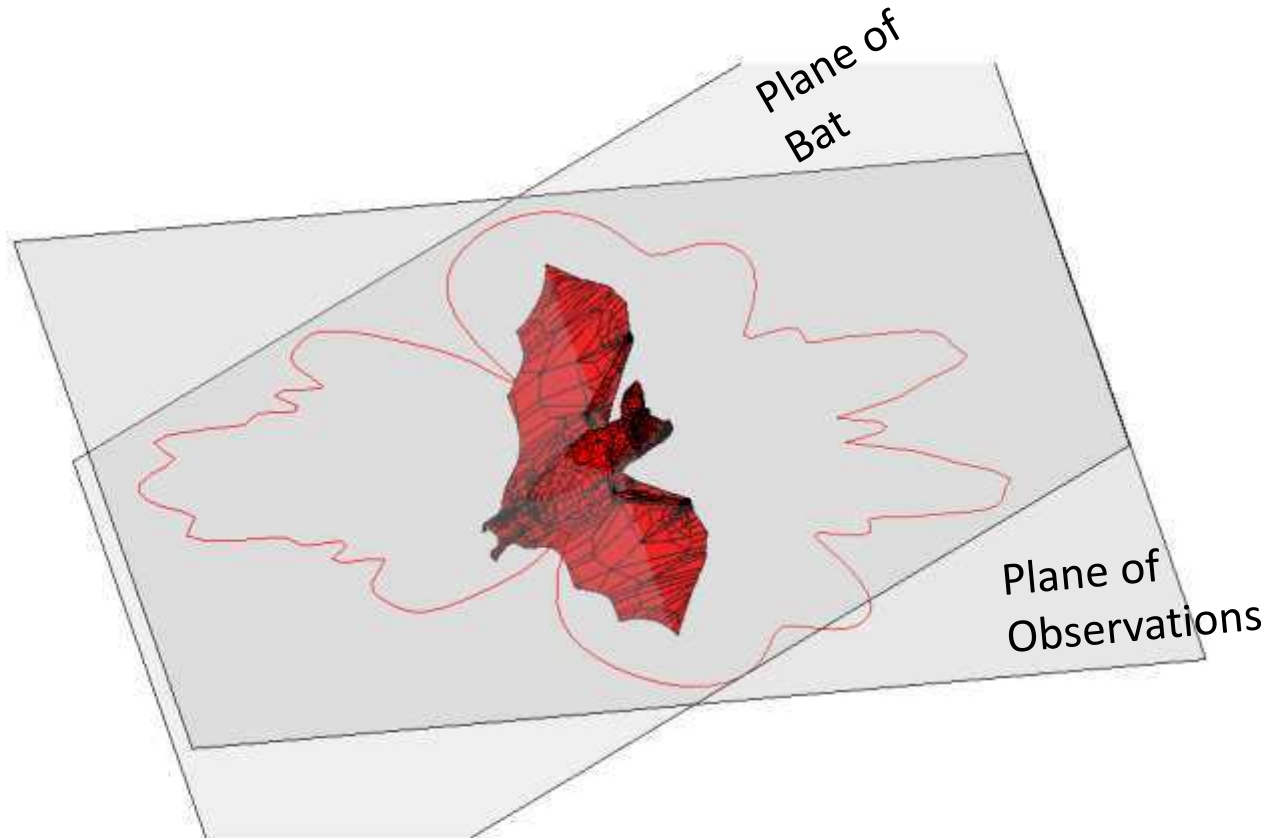
Dual-polarization RCS measurements of a deceased Brazilian free-tailed bat at X-band. The mounting frame allows for measurements across  $360^\circ$  along a single plane of the bat.

# Field Measurements / Model Validation

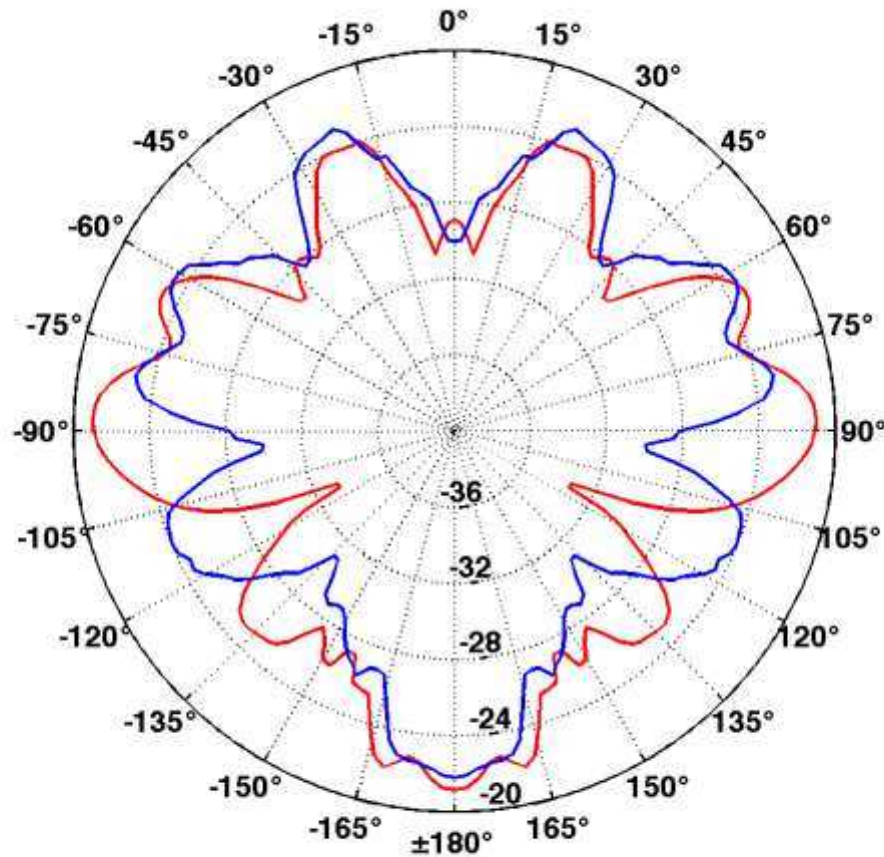


Bistatic measurements were made using two polarimetric horn antennas (left) and an Agilent Network Analyzer (right).

# Orientation of Bat During Validation



# Comparison of RCS Values (dBsm) Valid for X-band



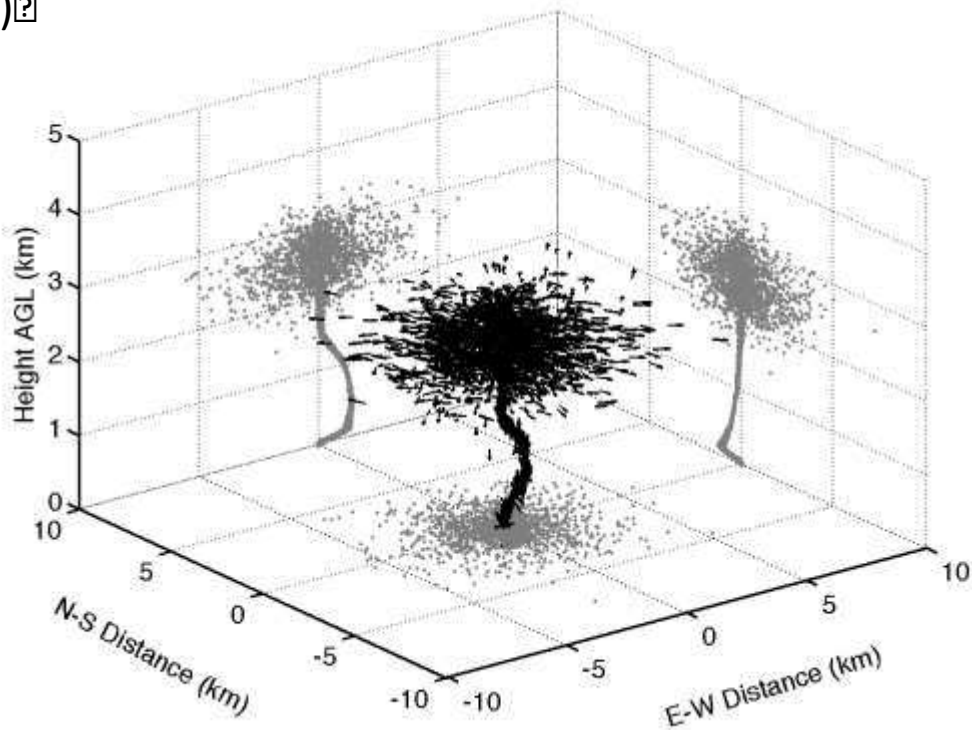
Modeled values  
shown in red

Measured values  
shown in blue

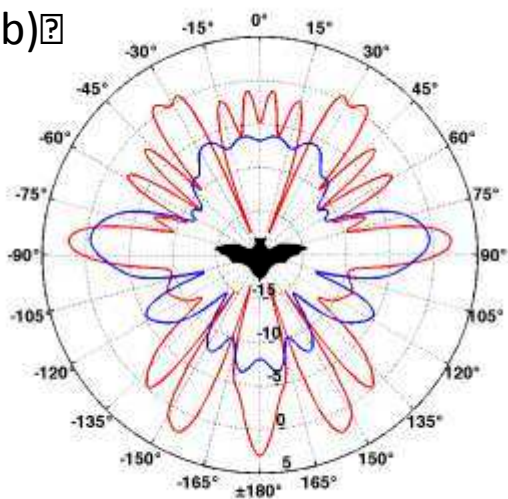


a) ?

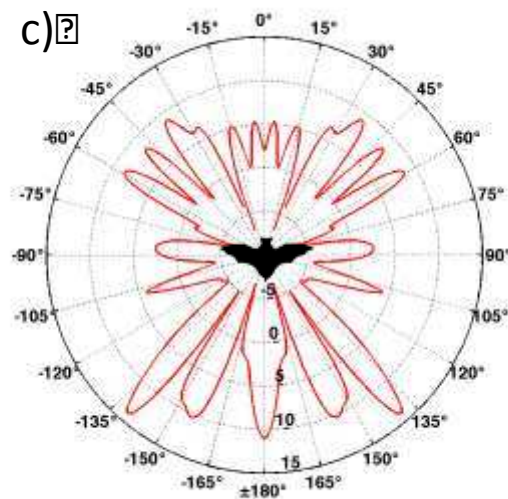
## Simulated Bat Emergence



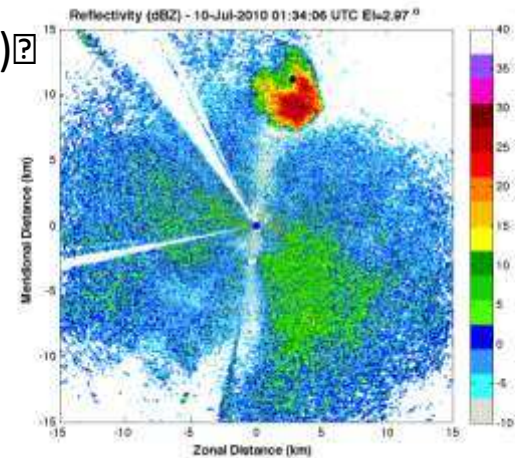
b) ?



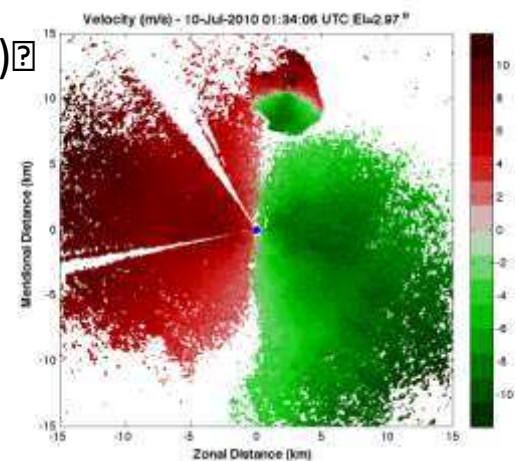
c) ?



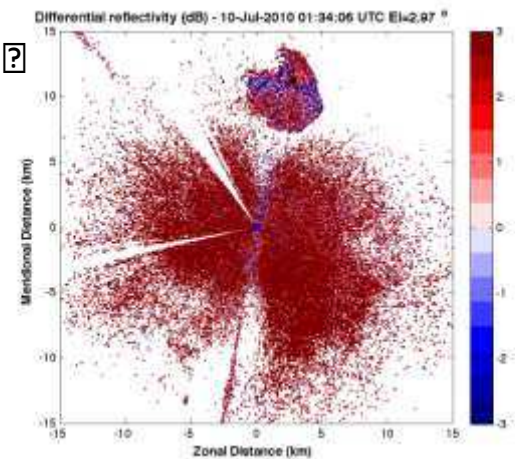
d) ?



e) ?

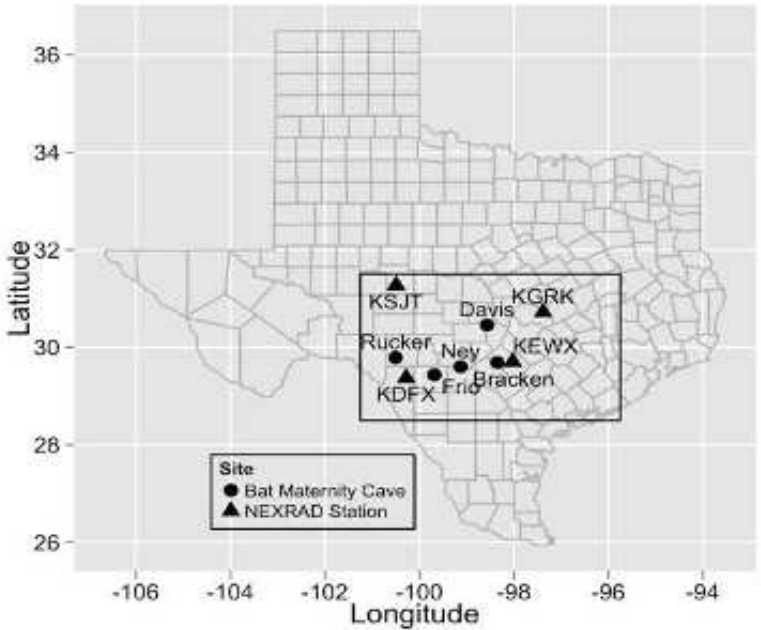


f) ?

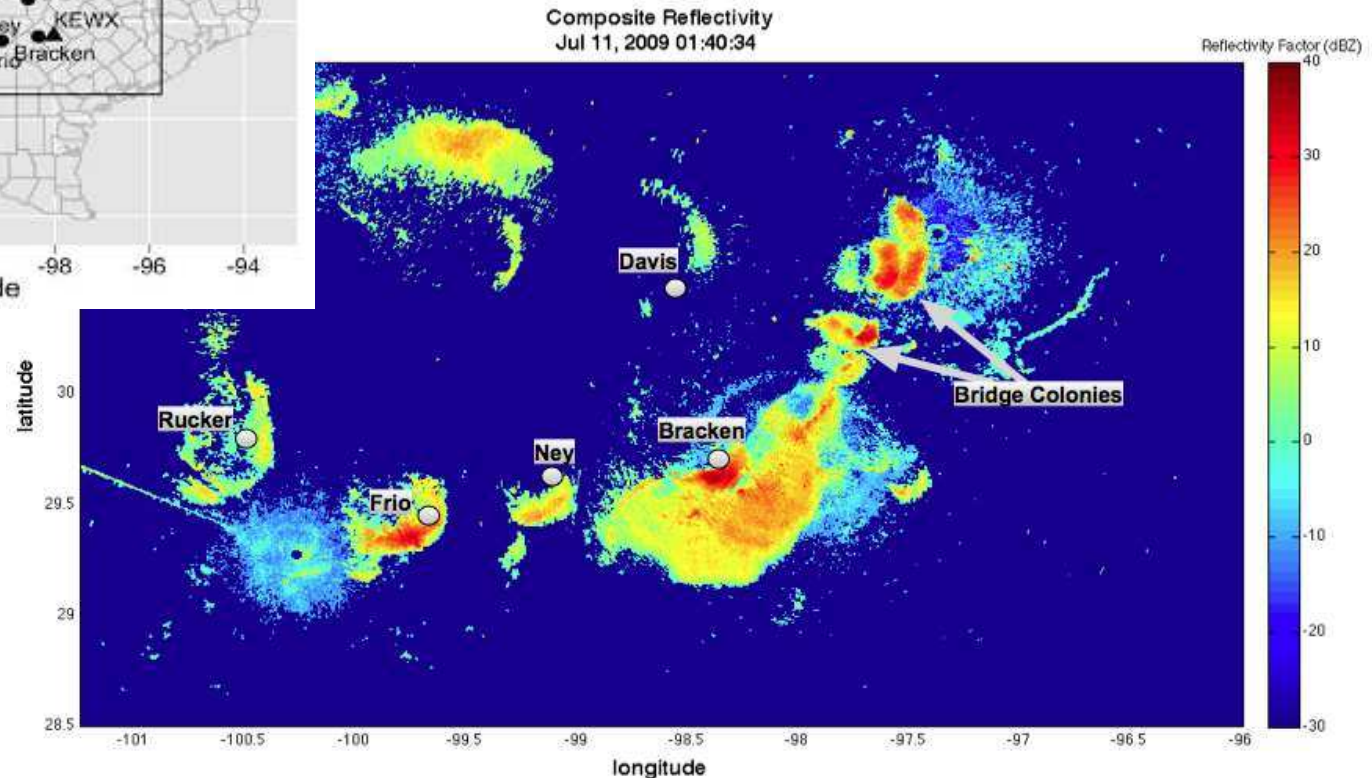


# NEXRAD Observations of Bats

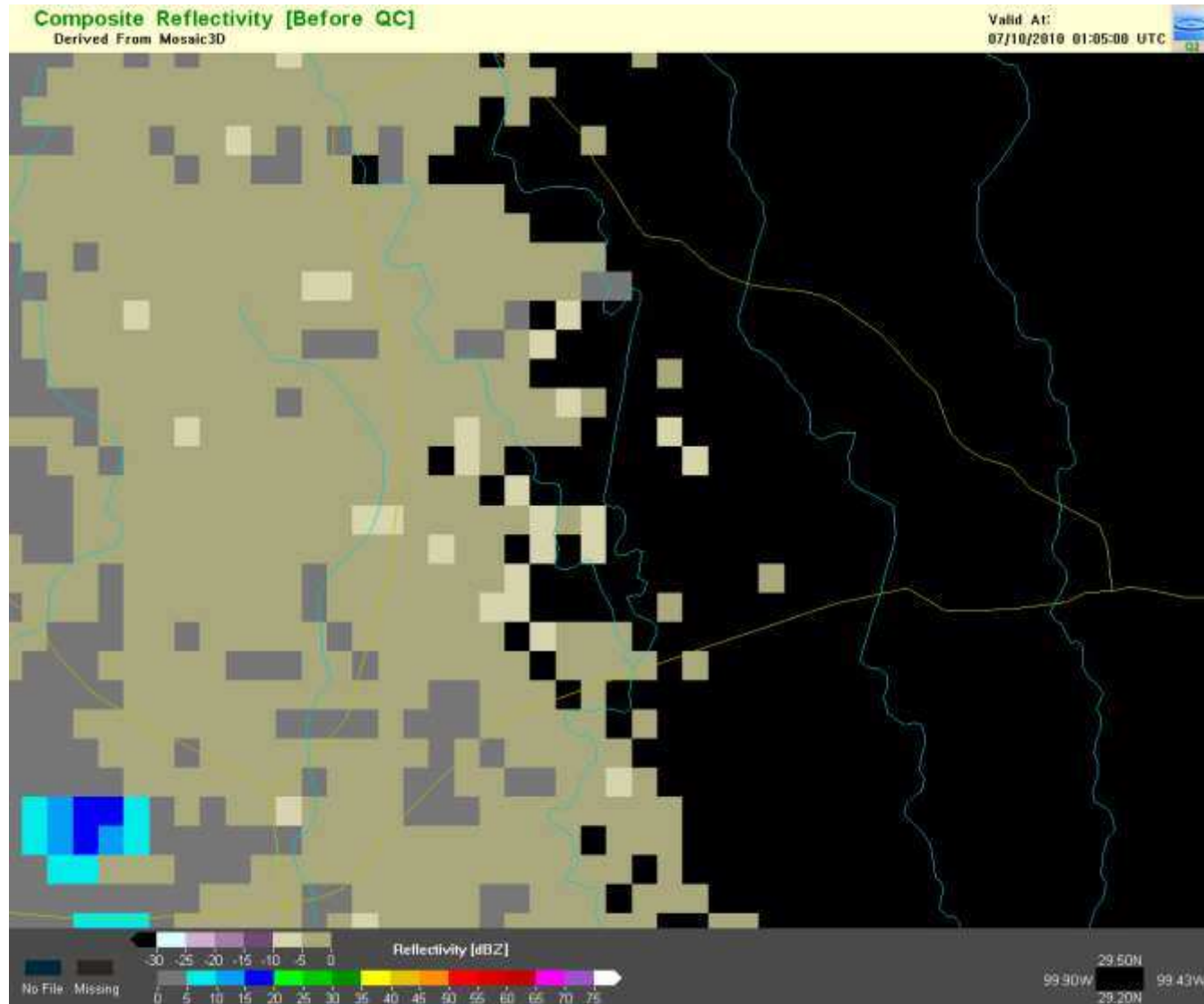
# Bat Emergences Seen on NEXRAD



- Many bat colonies in central Texas
- Shown here are a few as detected by NEXRAD during the maternity season

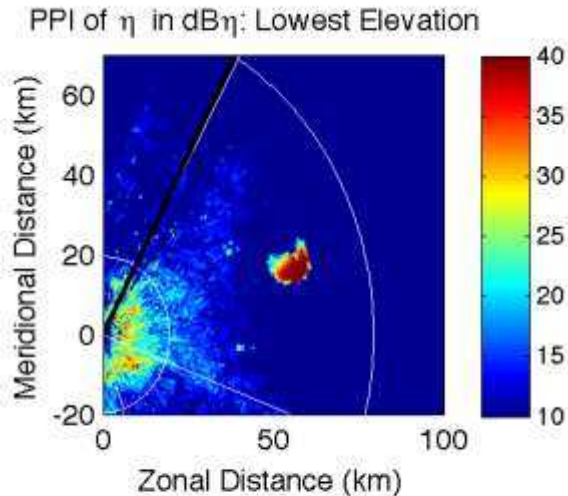


# Frio Emergence as Seen on NEXRAD: UNQC\_CREF Data





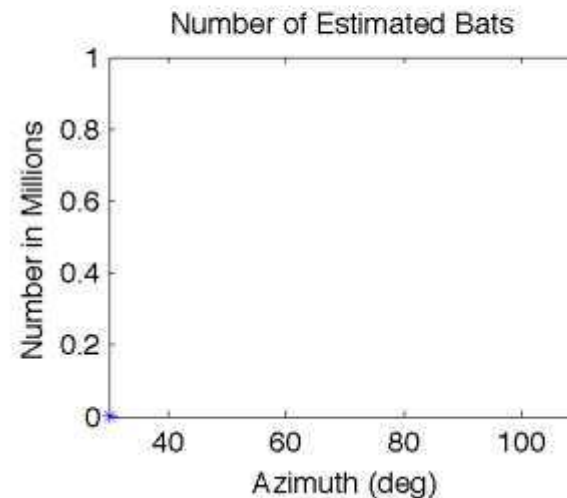
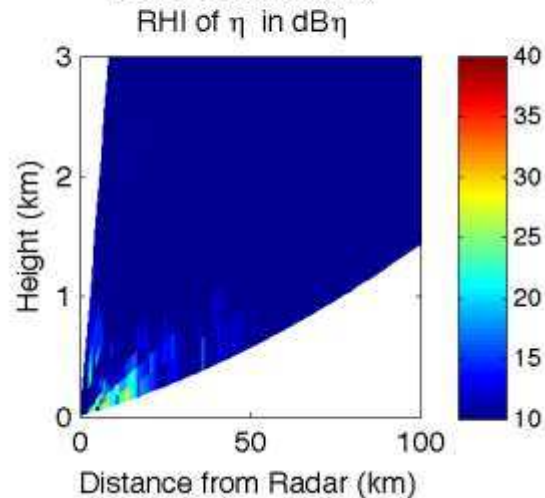
# Frio Cave Emergence as Seen with NEXRAD Level II Data



2010-07-10T01:34:26Z

KDFX

VCP: 212



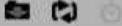
The following images show emergences of Brazilian free-tailed bats as seen by NEXRAD

Data are for 03 July 2014 at 20:50 local time

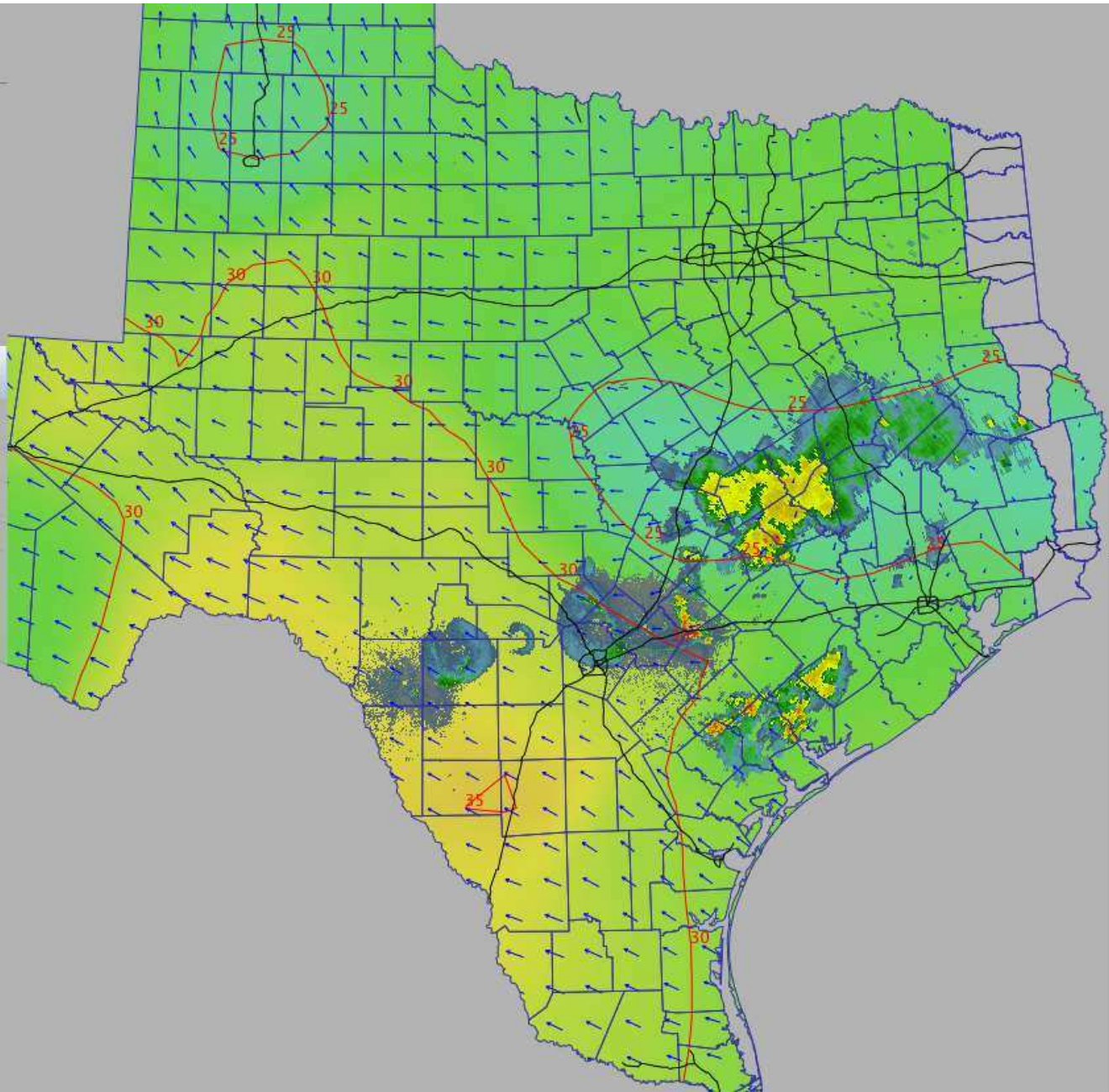
Images have been created using Level III data  
using a common meteorological software  
package: WeatherScope

Jul 3, 2014

20:50 CDT



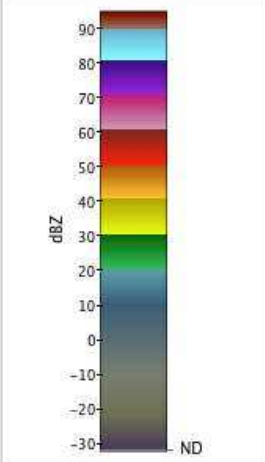
- Texas
- Limited access highways
- Texas County borders
- Winds at 10 meters  
20:00 CDT
- Air temperature  
20:00 CDT
- KEXX - NOQ  
20:47 CDT
- KDFX - NOQ  
20:49 CDT
- Air temperature  
20:00 CDT



Inspector

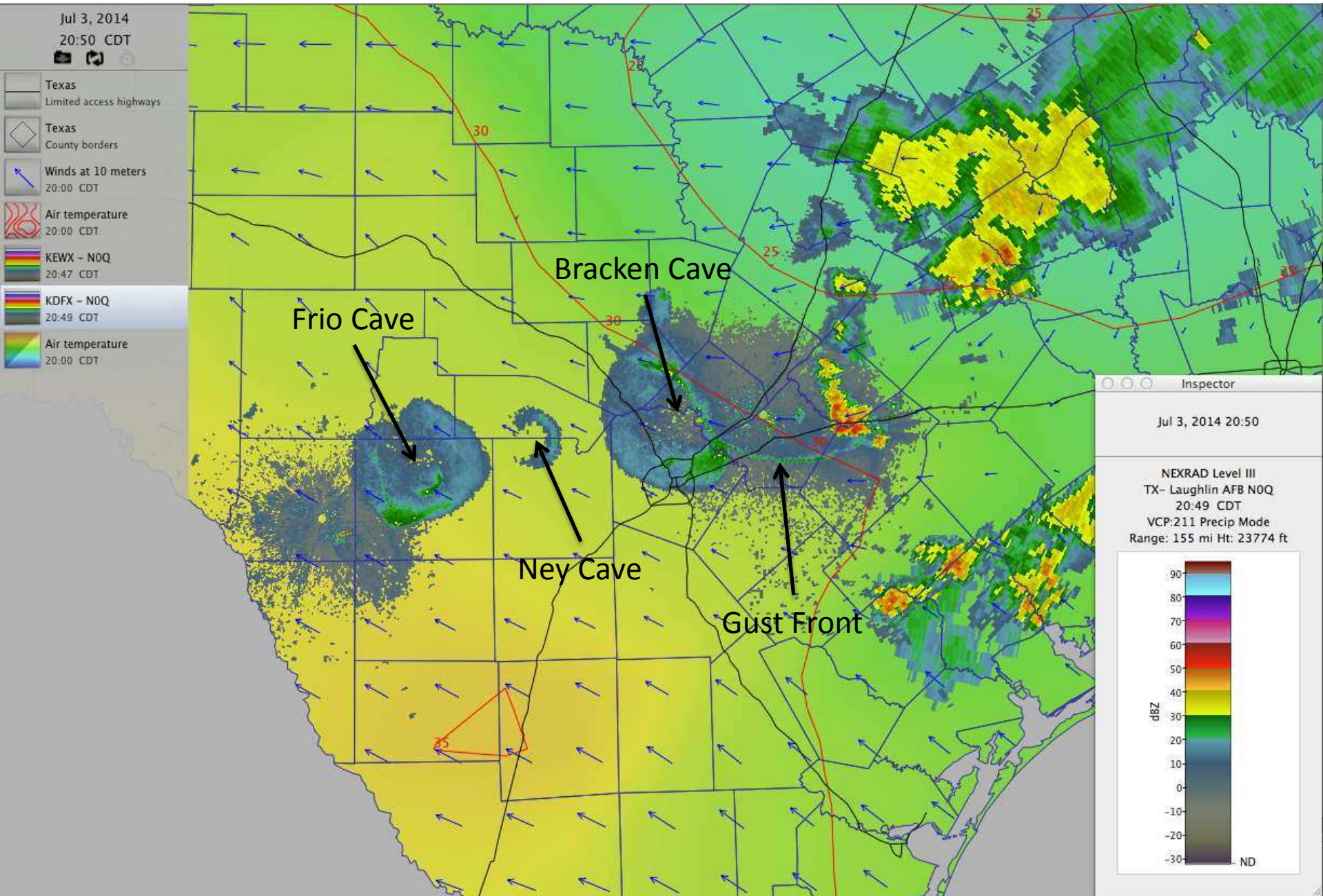
Jul 3, 2014 20:50

NEXRAD Level III  
TX- Laughlin AFB NOQ  
20:49 CDT  
VCP:211 Precip Mode  
Range: 519 mi Ht: 190565 ft



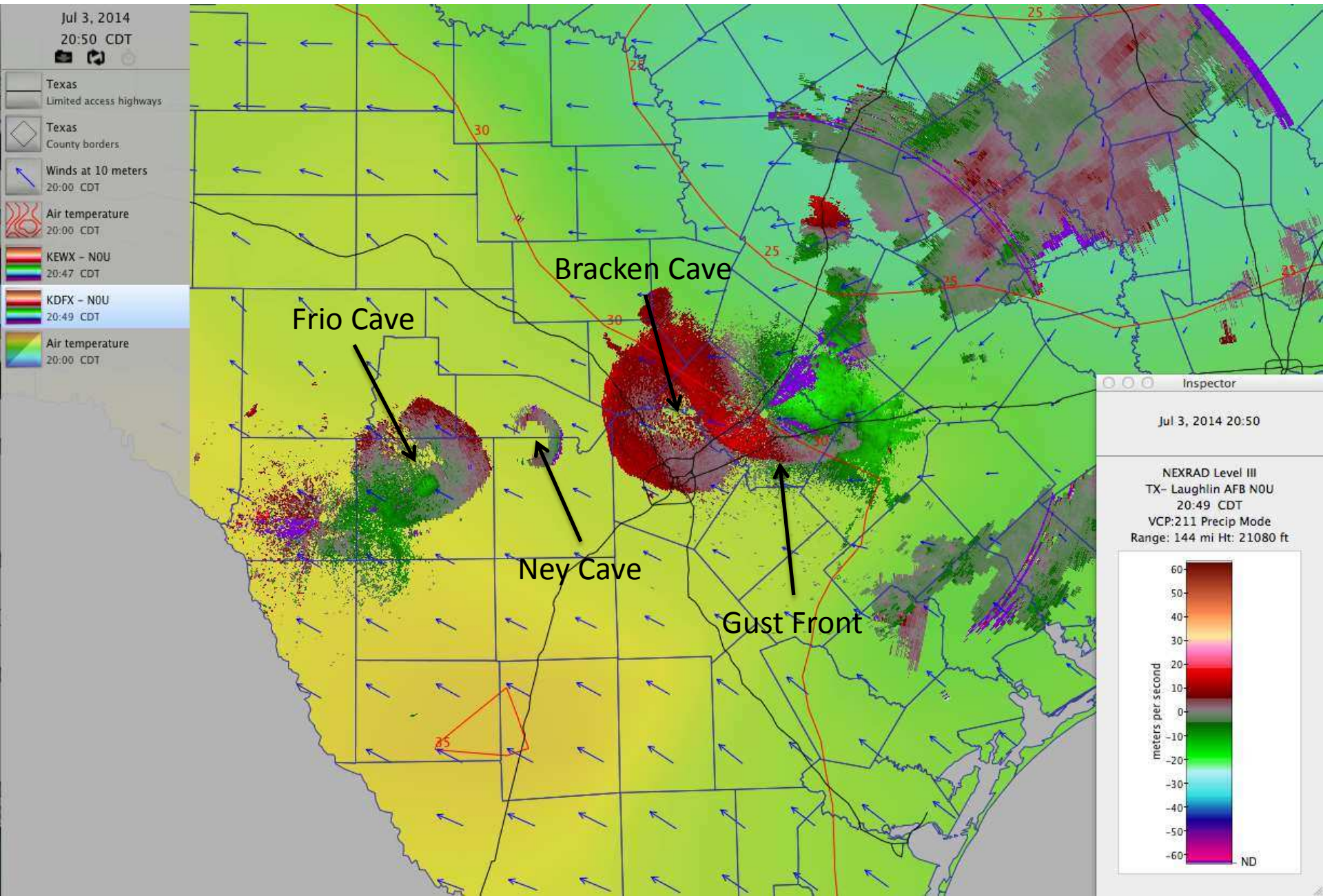


# Reflectivity (dBZ): Lowest Scan



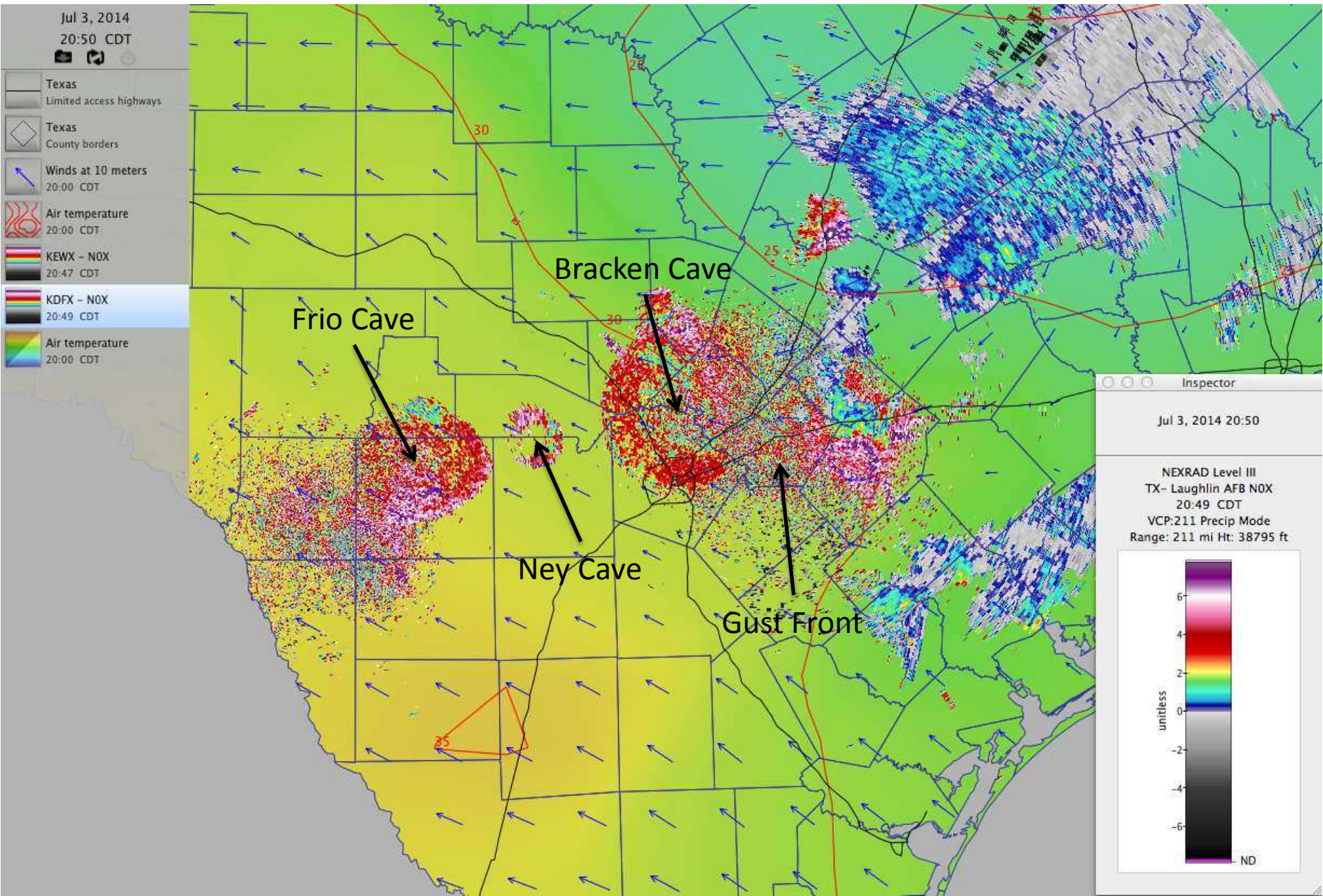


# Radial Velocity (m/s): Lowest Scan



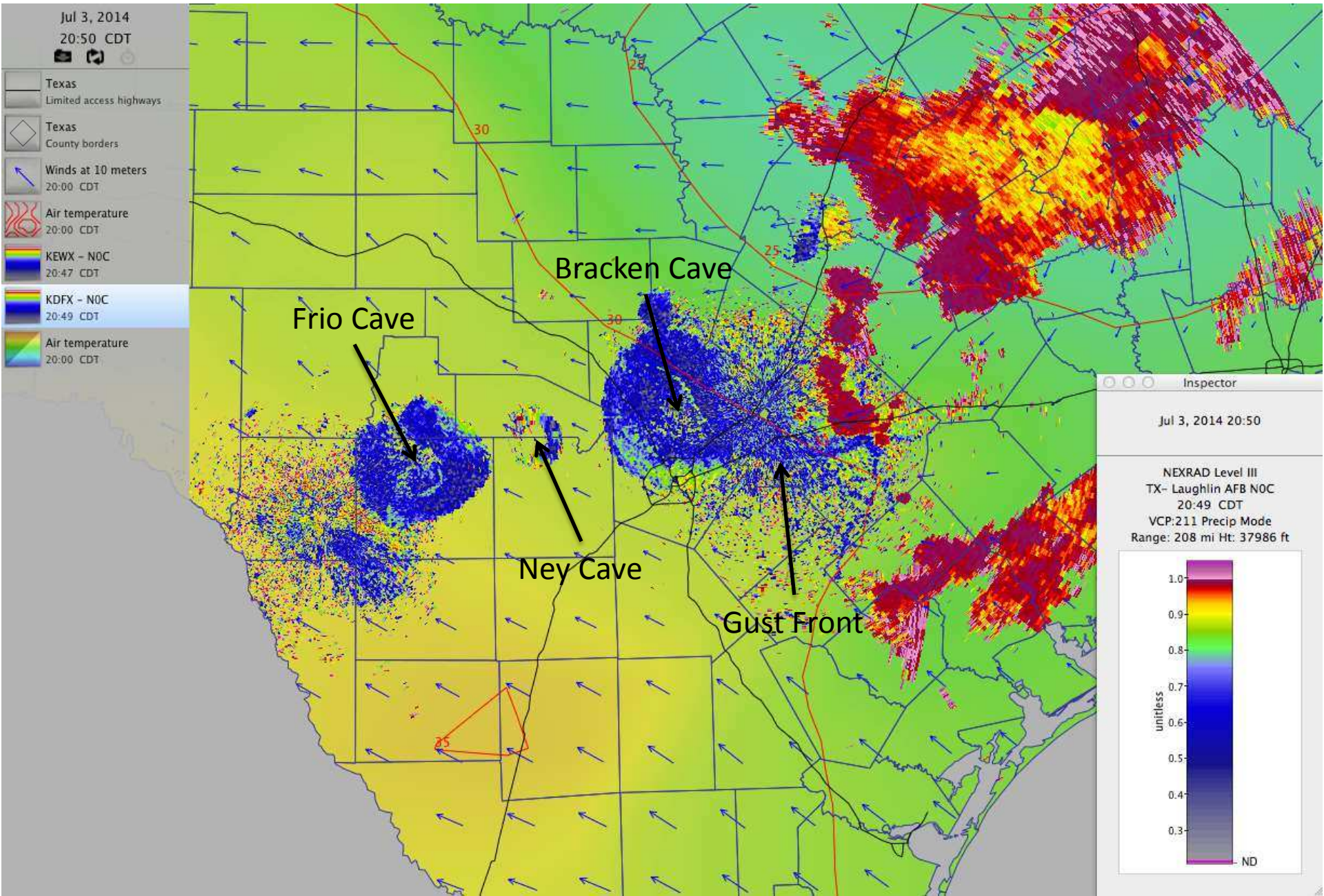


# Differential Reflectivity (dB): Lowest Scan





# Correlation Coefficient (unitless): Lowest Scan



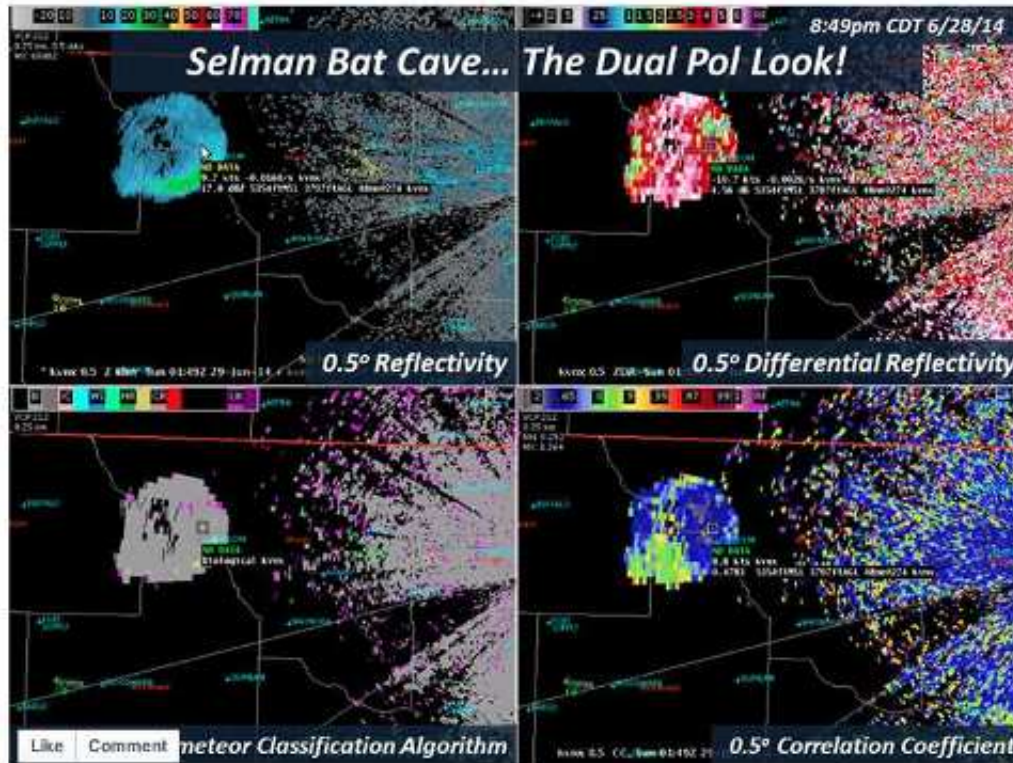
And finally an example from the National Severe  
Storms Laboratory as posted on Facebook:

Bat emergence from Selman Cave in Oklahoma  
28 June 2014 @ 20:49 local time  
as seen on KVNK



### Timeline Photos

Back to Album - US National Weather Service Norman Oklahoma's Photos - US National Weather Service Norman Oklahoma's Page  
 Previous · Next



US National Weather Service Norman Oklahoma

Weather Update... and Bat Update??? - June 28 9:23pm

Storm chances remain slim through the evening, but we are currently watching an isolated storm east of the Caprock in western Texas. So, those in far southwestern Oklahoma and parts of western north Texas may still see an isolated storm, small hail, up to penny sized would be the primary concern through midnight, but most of you will stay dry. Meanwhile... while watching radar tonight, we also caught Bats taking flight again! I know many of you have seen it, but this never gets old to us 😊 Enjoy, and don't forget, you can visit the Selman Bat cave too! <https://www.wildlifedepartment.com/wildlifemgmt/bats.htm>

Like · Comment · Share · June 28

Album: Timeline Photos

Shared with: Public

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# Summary & Conclusions

# Conclusions

- Radar is being used to study the behavior of Brazilian free-tailed bats
- Observations have been made at several roosts in Texas
- Polarimetric data can be used to
  - Discriminate between different types of volant animals and weather
  - Estimates of number densities of bats in the atmosphere
  - Determine orientation of animals in flight
- These results apply to other aggregating species such as swifts and swallows

# On-going and Future Work

- Perform more validation of the model using other radar observations at other frequencies
- Model other species of animals
- Integrate the results into a realistic radar simulator
- Other ideas?



# Acknowledgements

- Also participating in the study are
  - Djordje Mirkovic, Phil Stepanian, & Jeff Kelly (University of Oklahoma)
  - Winifred Frick (University of California – Santa Cruz)





Hic sunt dracones

