Algorithms to Track the Migration of Birds Along the US East Coast

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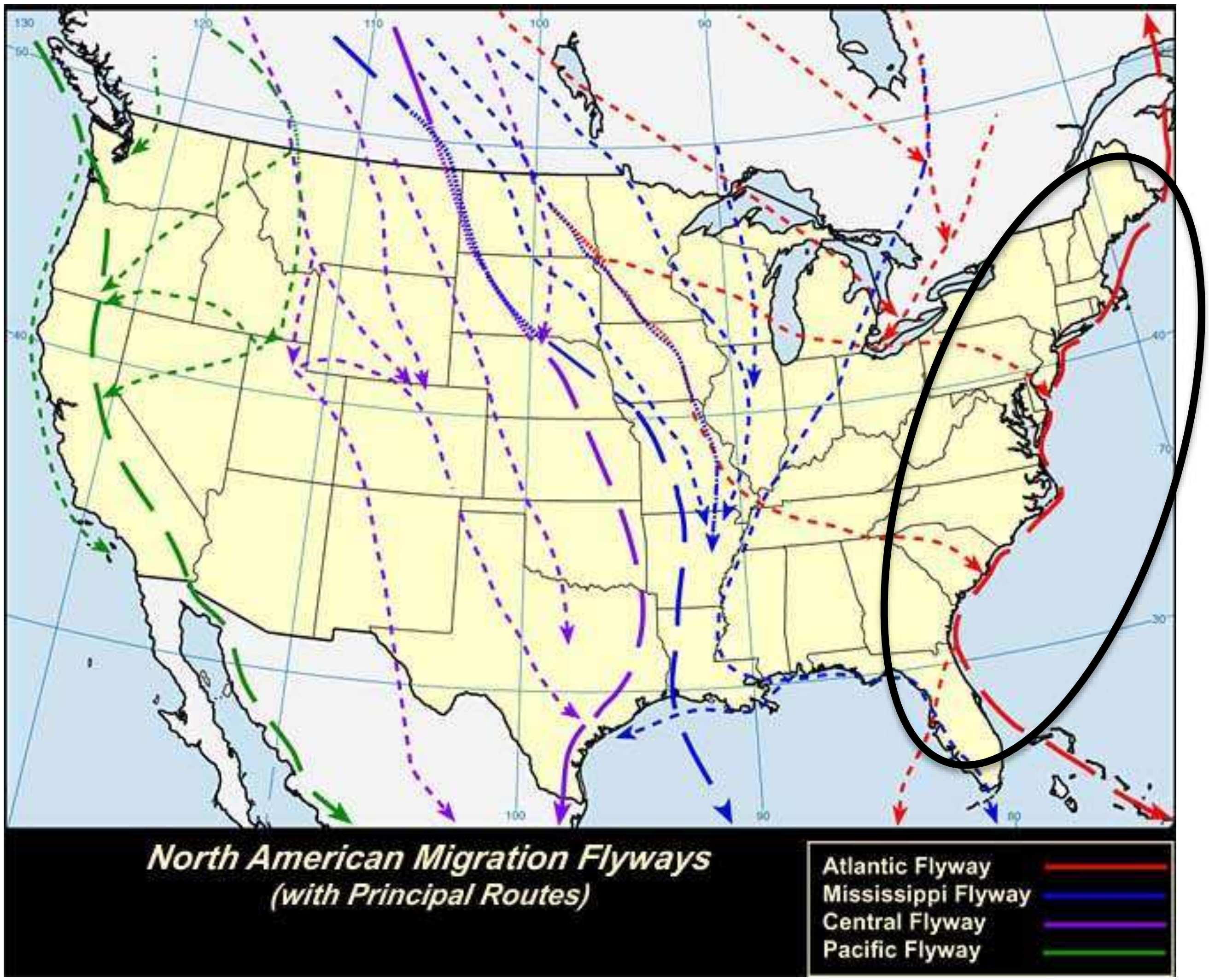
Presentation Outline

- Present the motivation for the study
- Provide an overview of the radar mosaicking method
- Discuss the algorithm
- Show results from the analysis
- Summary & Conclusions

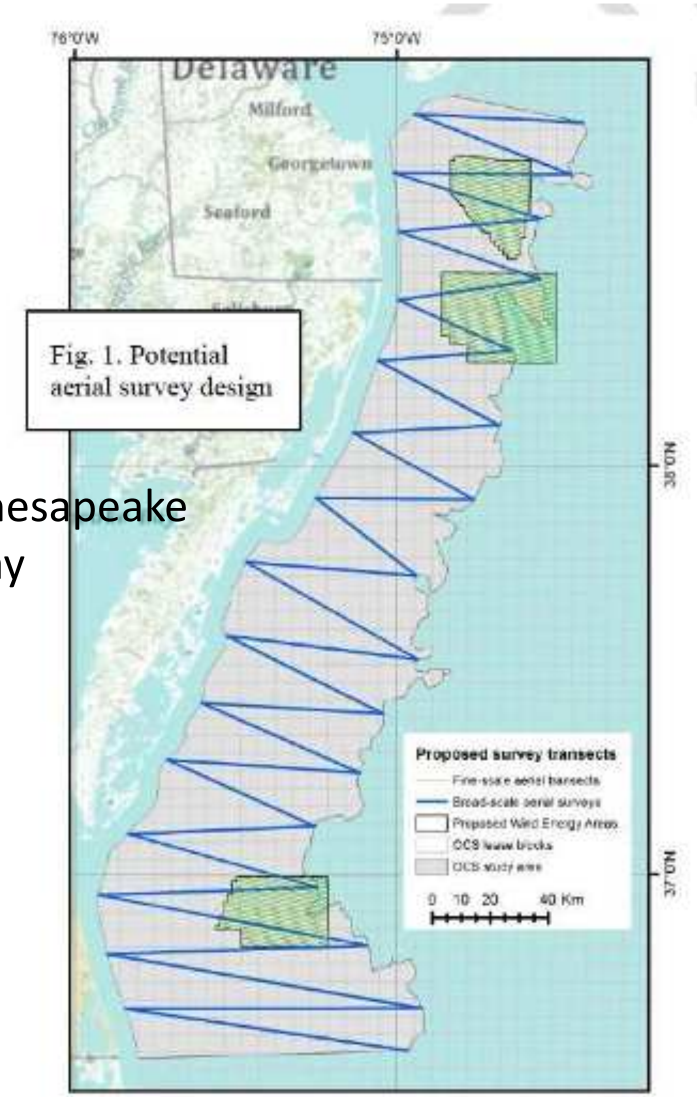
Motivation of the Study

Migratory Flyways in the US



Offshore Wind Farm Assessment Study Funded by the US Dept. of Energy

- Study the density and movement of wildlife across spatial and temporal scales on the mid-Atlantic outer continental shelf
- Various ground based and modeling approaches to be used in the study, but here we only consider the use of operational weather radar
- Shown to the right is the study region being considered (expanded view provided on next slide)

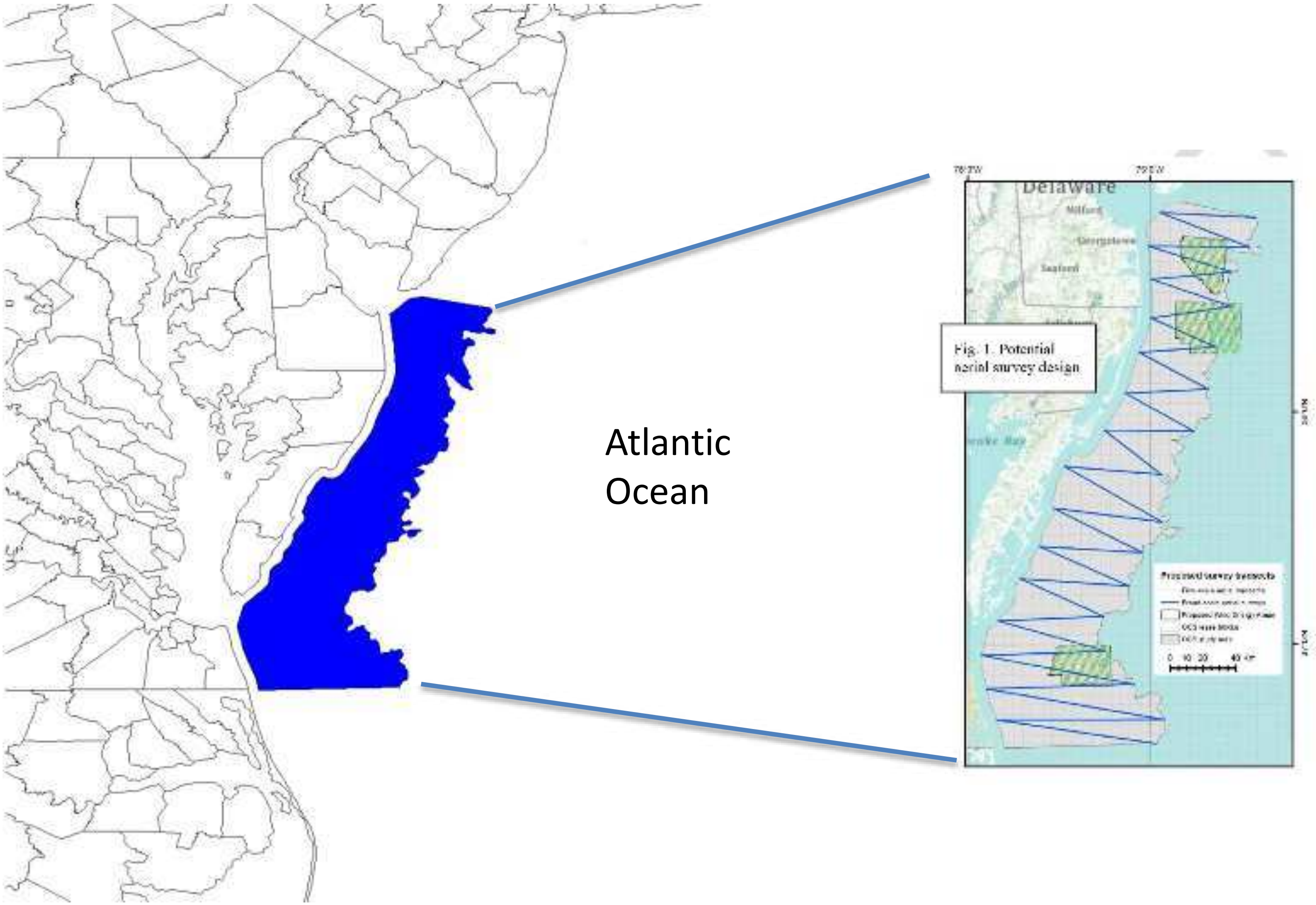


Chesapeake Bay

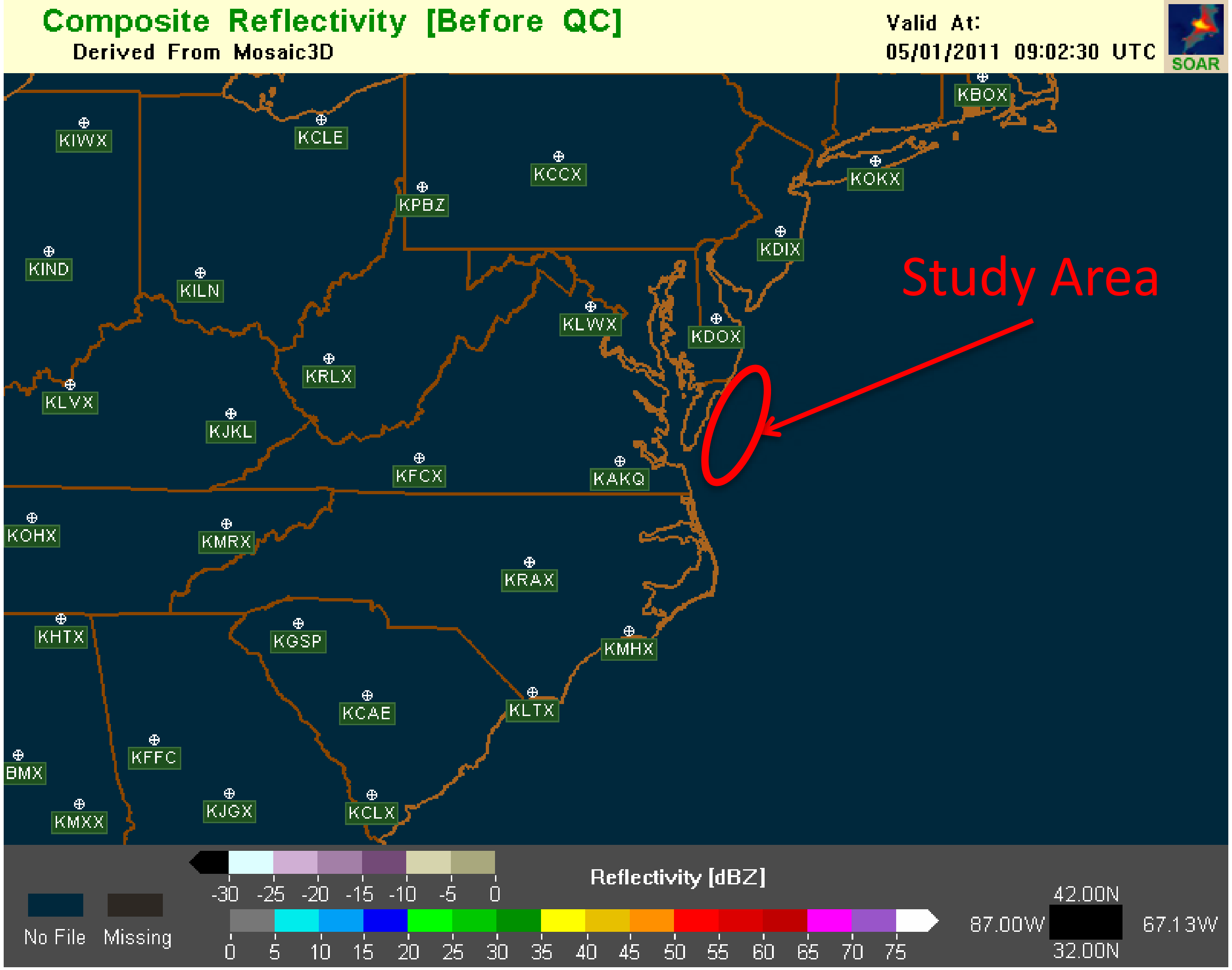
Offshore Wind Farm Assessment Study Funded by the US Dept. of Energy

Study Area

Offshore Wind Farm Assessment Study Funded by the US Dept. of Energy



The Use of Radar to Study the Offshore Area

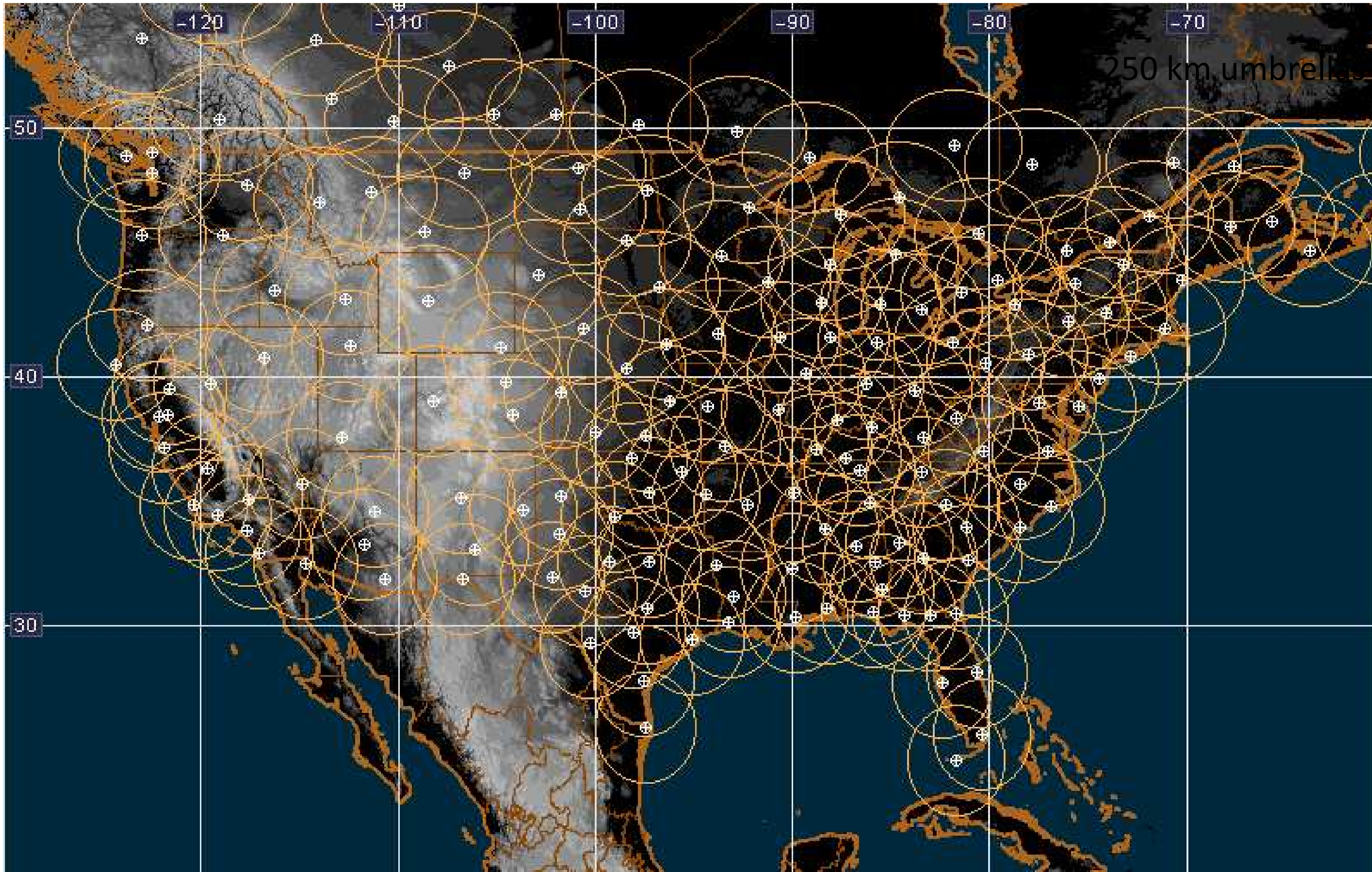


Motivation: Overview

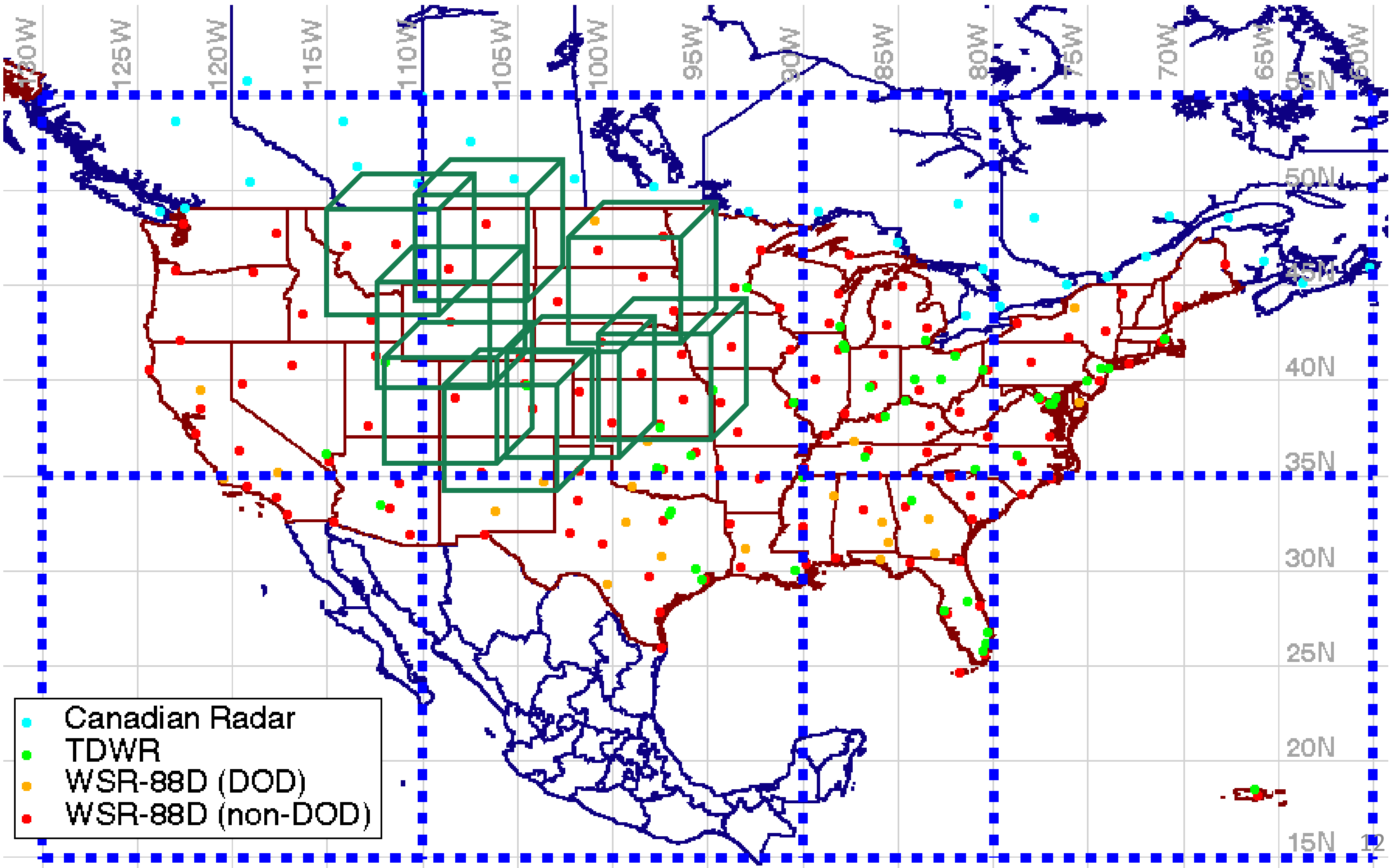
- The overall task is to access the potential impact of offshore wind farms located off the east coast of the US (near the Chesapeake Bay) on birds
- Part of the analysis includes the use of data from NEXRAD (network of S-band weather radars operated by the US weather service)

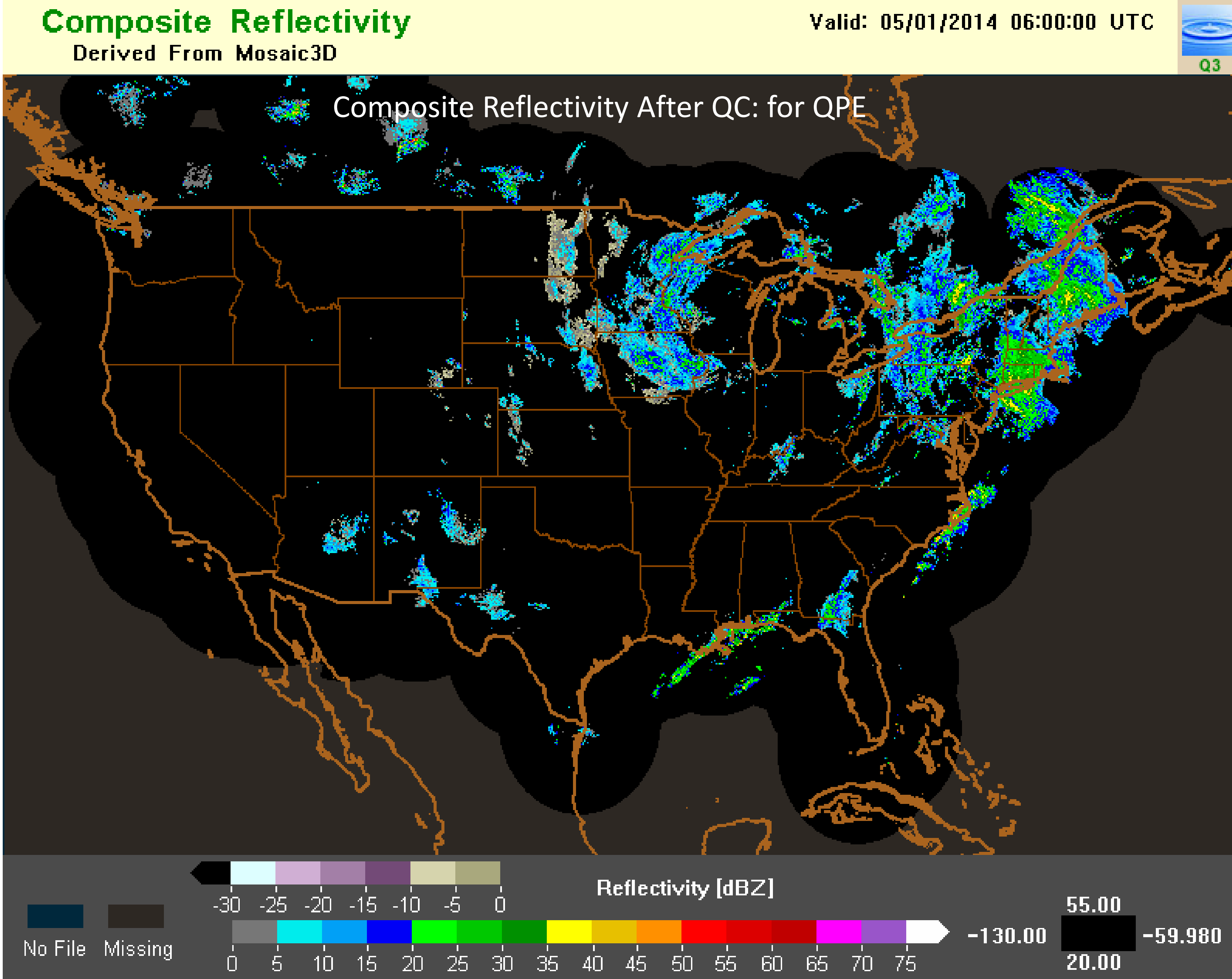
Radar Mosaicking

US NEXRAD & Canadian Radar Networks



3-D CONUS Radar Mosaic




Composite Reflectivity
Derived From Mosaic3D
Valid: 05/01/2014 06:00:00 UTC
Q3
Composite Reflectivity After QC: for QPE
Reflectivity [dBZ]
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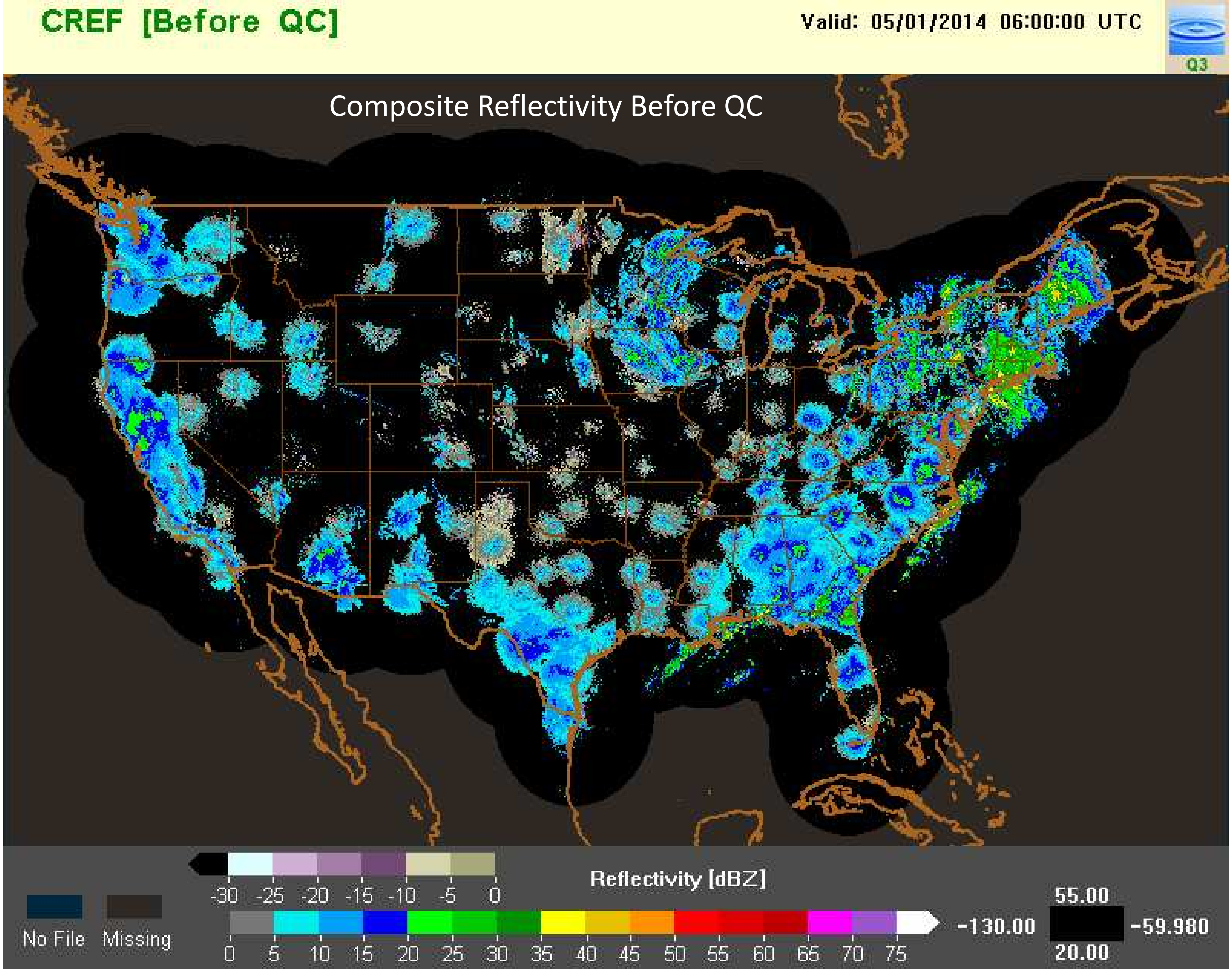
-130.00
-59.980
20.00


CREF [Before QC]
Valid: 05/01/2014 06:00:00 UTC
Q3
Composite Reflectivity Before QC
Reflectivity [dBZ]
-30 -25 -20 -15 -10 -5 0
0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75
No File
Missing
-130.00
55.00
-59.980
20.00

Composite Reflectivity (CREF) Data Raster

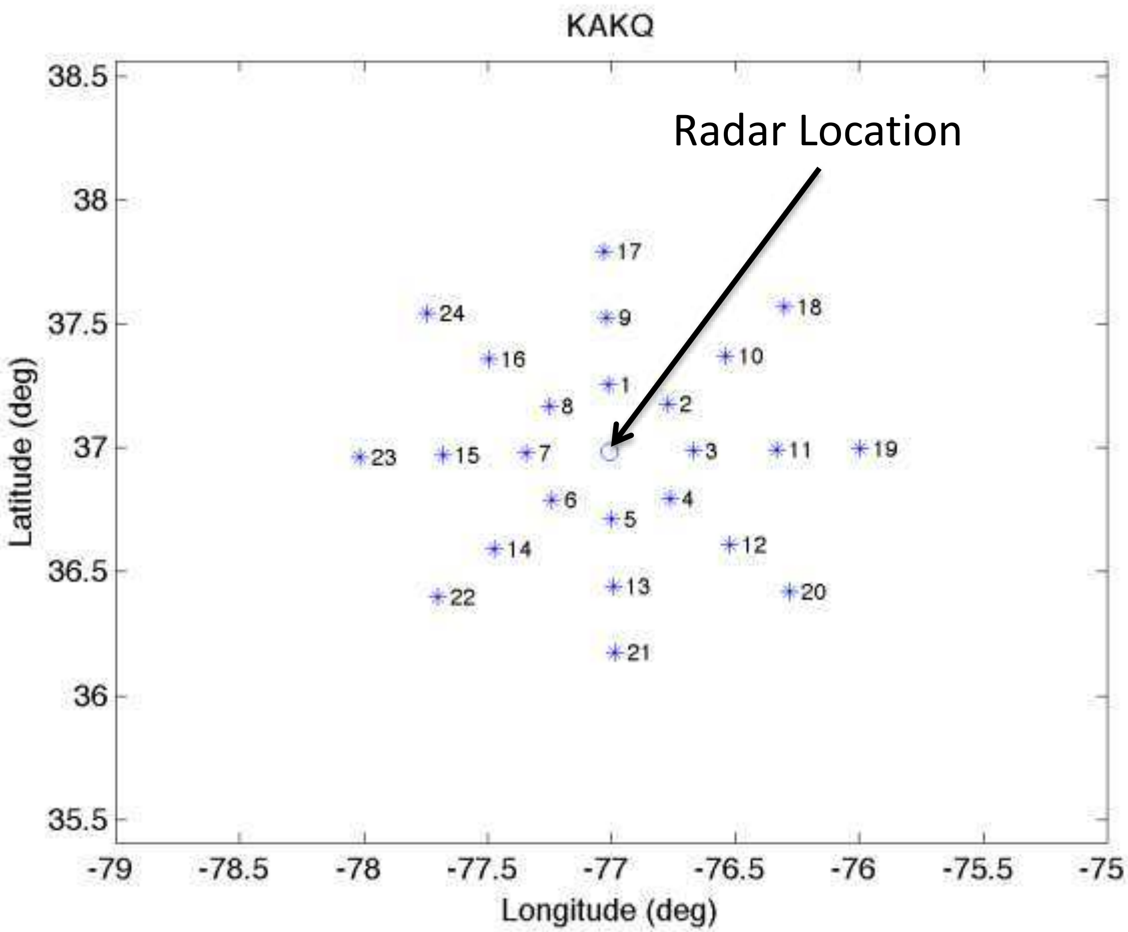
- CREF data for the Continental US (CONUS) have typically had spatial and temporal resolutions of 0.01° x 0.01° (approximately 1 km^2) and 5 min, respectively – but this is changing.
- CREF data have been quality controlled (QC'ed) to remove non-meteorological signals.
- CREF data before QC are also available (UNQC_CREF)
- The UNQC_CREF data contain biological scatter (bioscatter) but also clutter, sunspikes, chaff echoes, radio interference, and such

Radar Mosaicking: Overview

- Data from NEXRAD, some terminal Doppler weather radars (TDWR), and some Canadian weather radars are merged to form contiguous 3-D representations of atmospheric phenomena
- Two products of the processing are CREF and UNQC_CREF, which are 2-D projections of the radar signal strength (composite reflectivity) onto the surface.
- CREF and UNQC_CREF data available as a GeoTIFF raster
- Each pixel in the raster covers 1 km^2 (1 km x 1 km)
- A new raster is available every 5 minutes

Algorithm Development

Create Rings of Points Around a Particular Radar Site



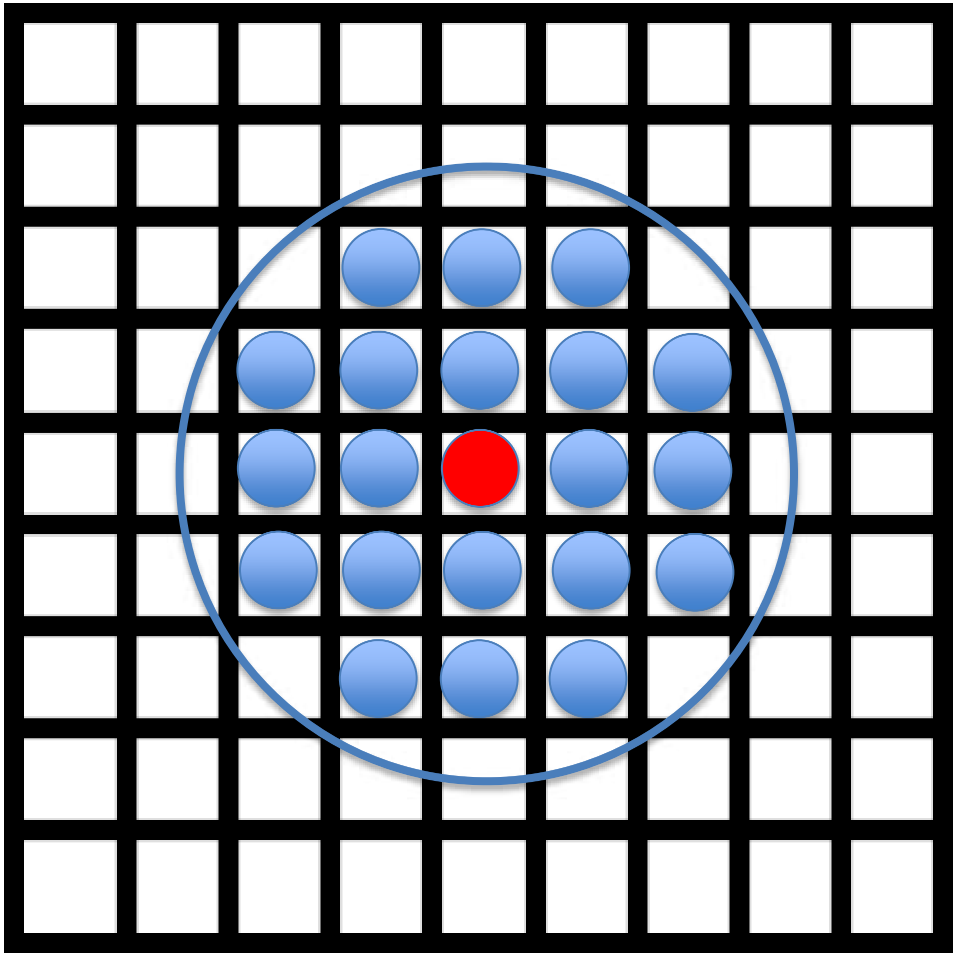
Rings located at distances of 30, 60, and 90 km from the radar site

Each ring contains 8 points

Bounding box used by GRASS (GIS software) to define a region within the from the composite reflectivity raster

For each point, a prescribed number of pixels from the raster are examined

Assigning CREF Pixels From the Raster

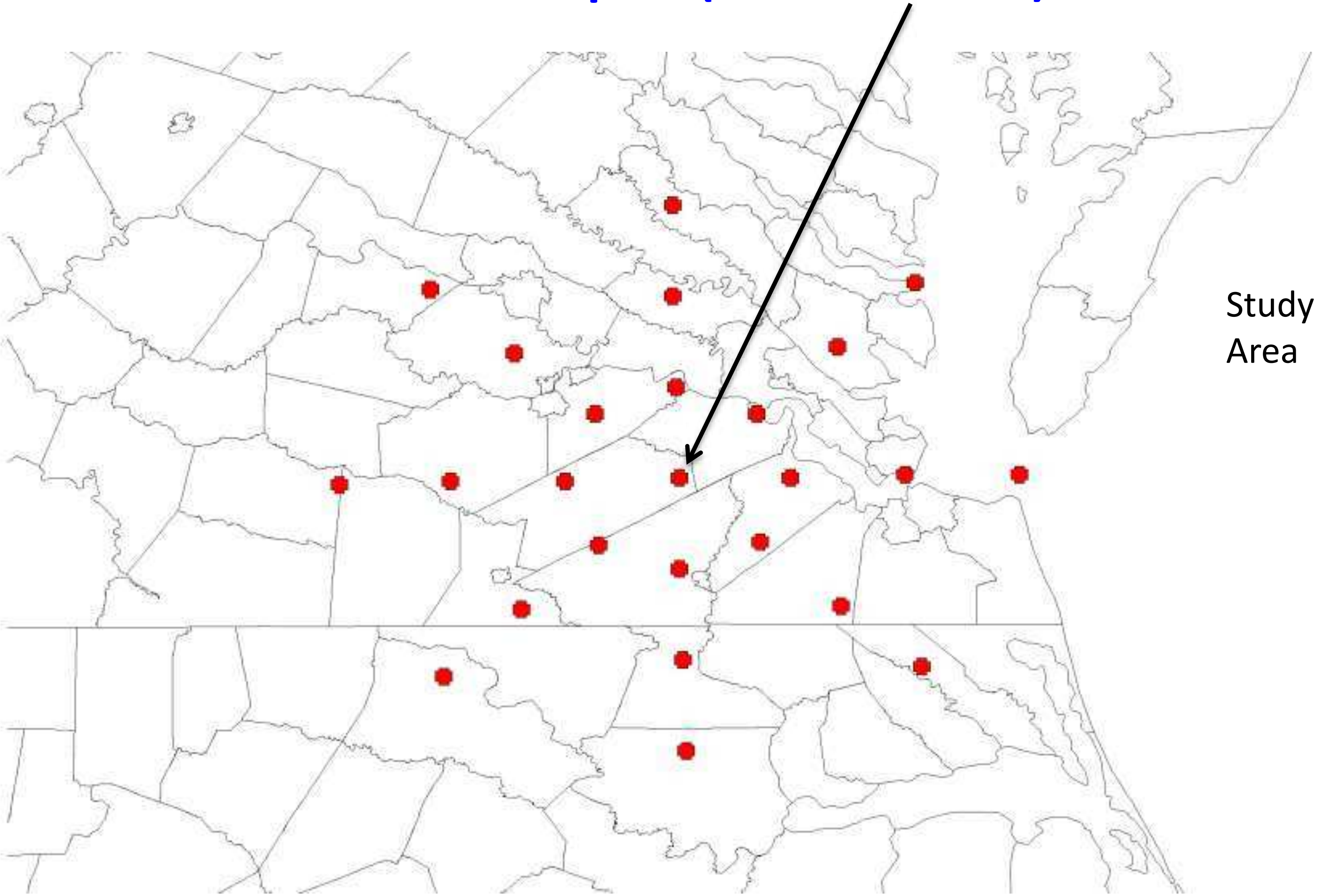


Find the pixel in the raster of the CREF and UNQC_CREF data corresponding to a particular point on the ring (shown here as a red 'dot').

Use GRASS to "grow" the area around the point

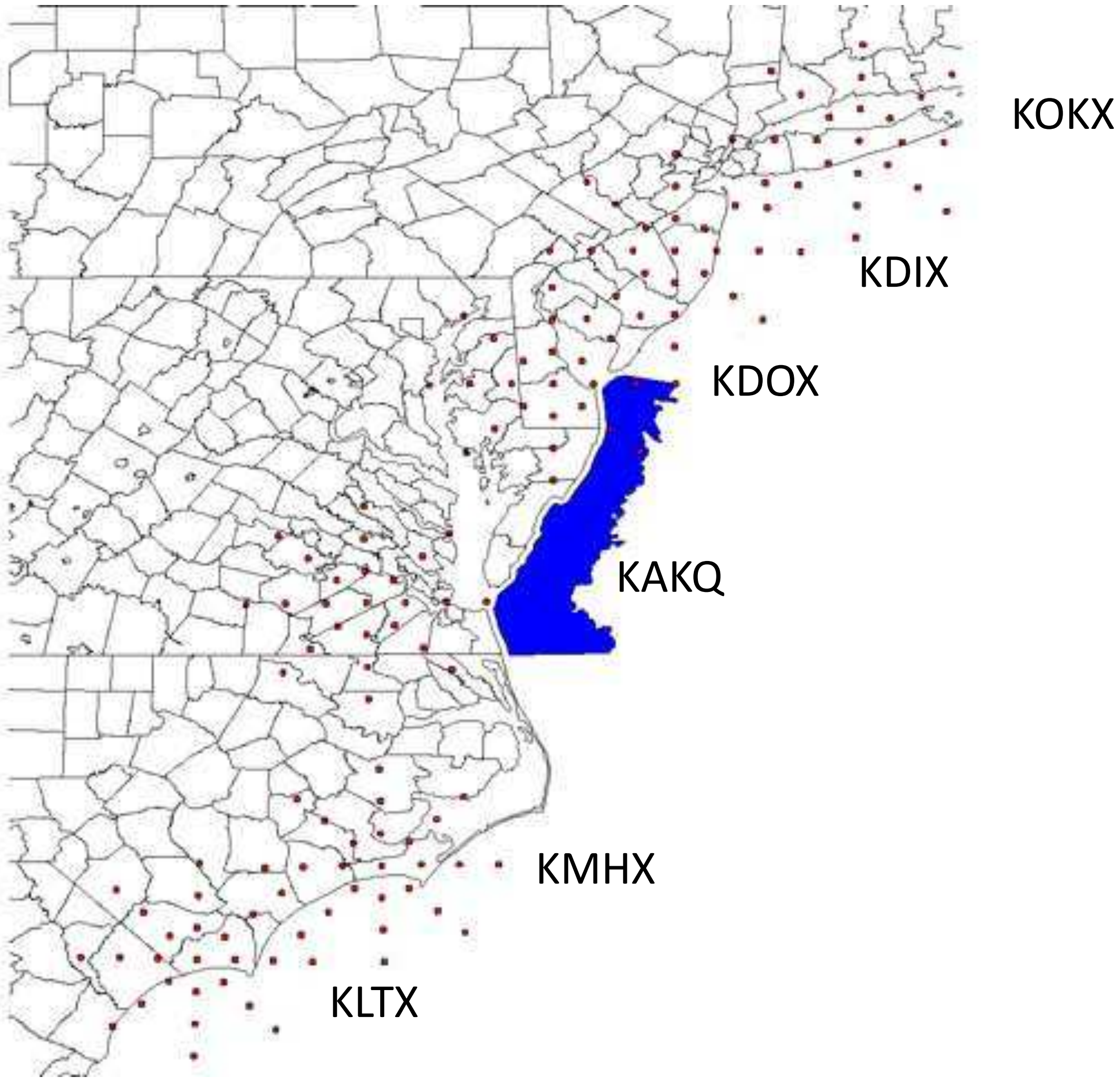
Use the resulting pixels (here 21) in the raster for a univariate analysis of the reflectivity values

Rings and Points Projected onto the Landscape (for KAKQ)



Study Area

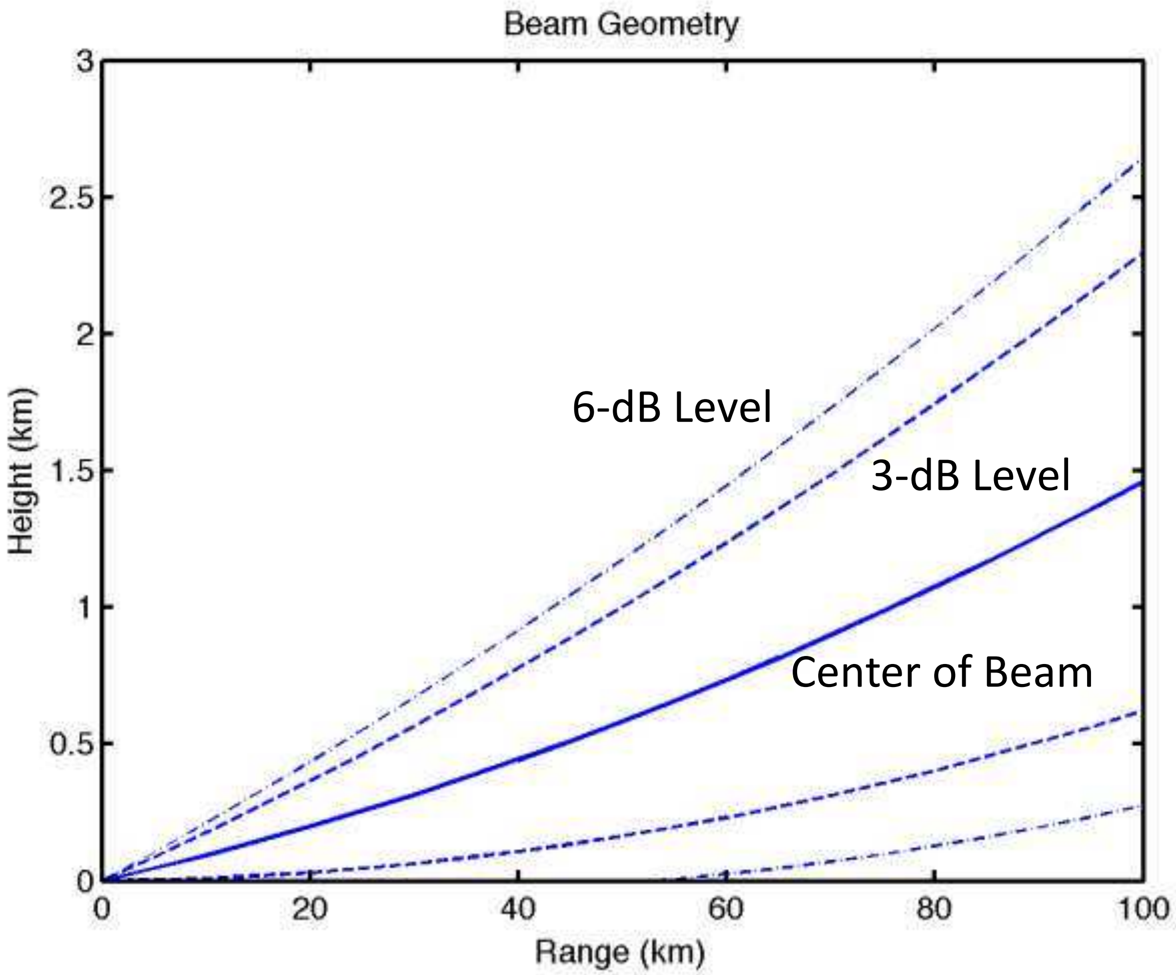
Location of the 144 NEXRAD Radar Data Collection Points



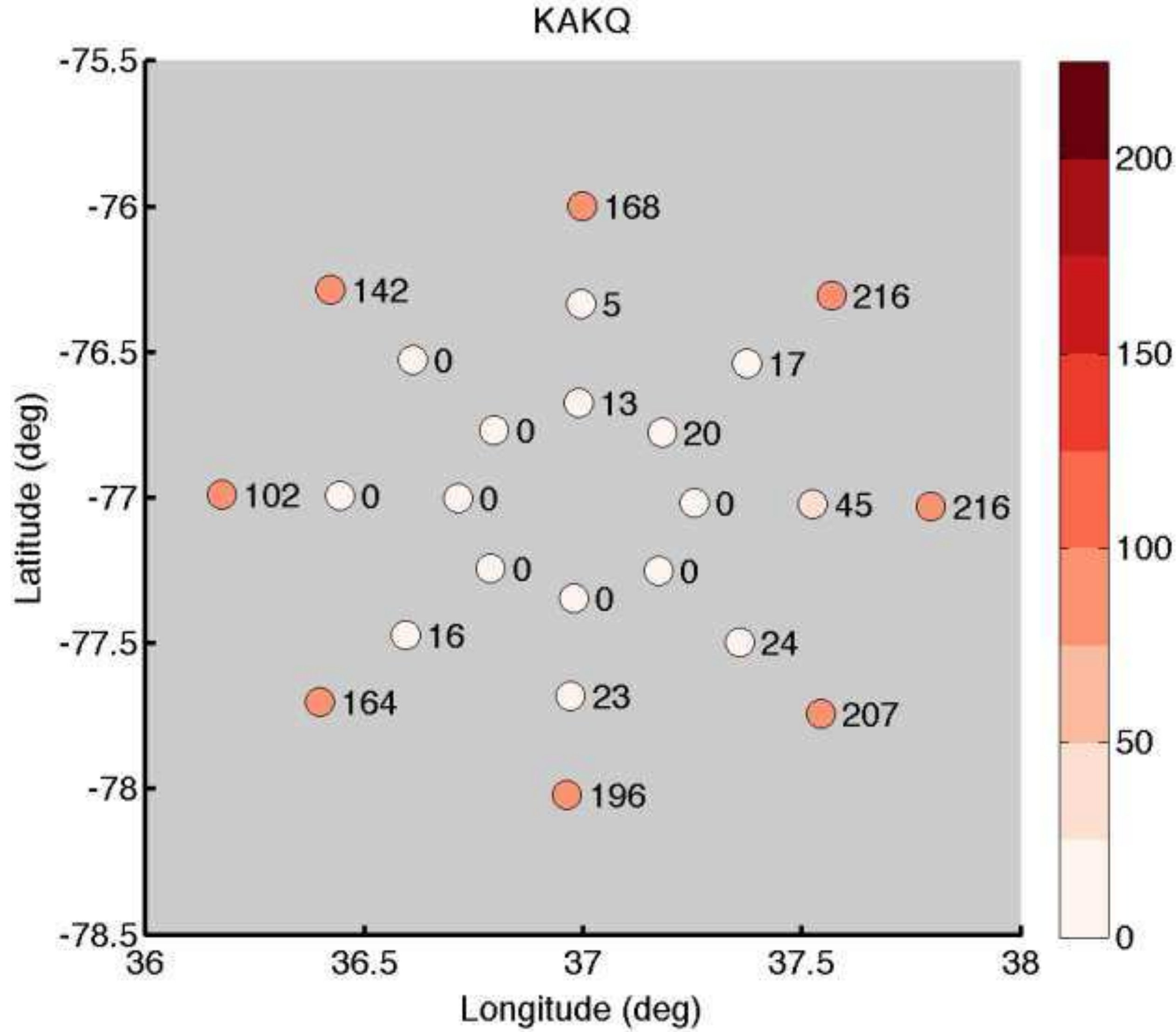
Preliminary Data Analysis

- Perform a univariate analysis on the collection of 21 reflectivity values for each of the 144 (6 radars x 24 points) clusters for both the CREF and UNQC_CREF data
- Results of the **univariate analysis** (sum, mean, max, min, standard deviation, number of pixels used) are saved
- A filtered version of the UNQC_CREF data is created by discarding those values for which there is a corresponding signal in the CREF data – that is only data with no “weather contamination” are considered

Height Coverage of Lowest Beam Assuming Flat Terrain (4/3 Earth Model)



Radar Height Coverage Taking Terrain Into Consideration



Algorithm Development: Overview

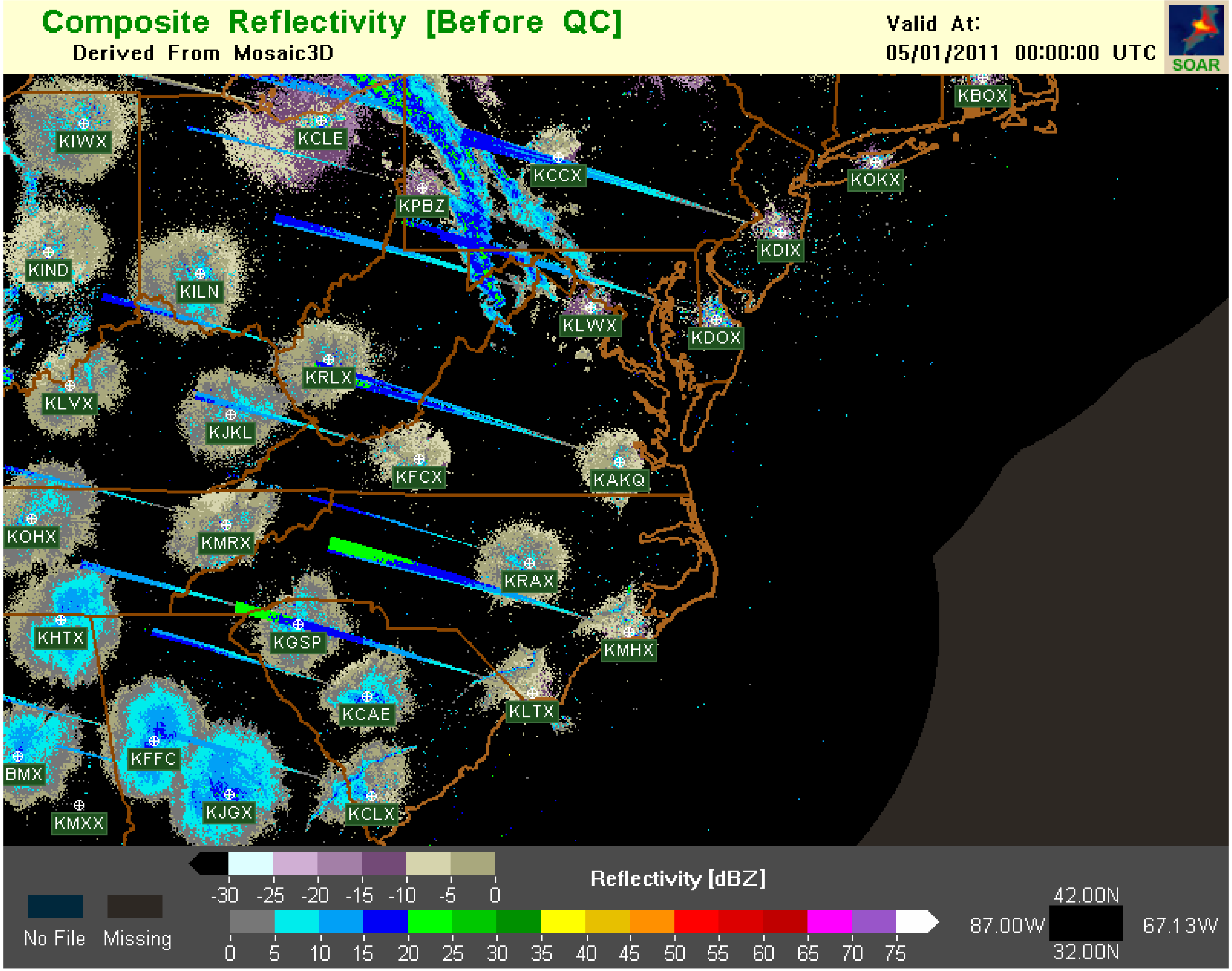
- We examine 144 locations, each corresponding to an area of 21 km^2) located across the eastern US
- CREF and UNQC_CREF data for these regions are evaluated using univariate analysis
- Statistics from the univariate analysis for filtered (only using times when no weather is present) UNQC_CREF data are investigated
- Height coverage is taken into consideration based on distance from the radar site and topography

Results

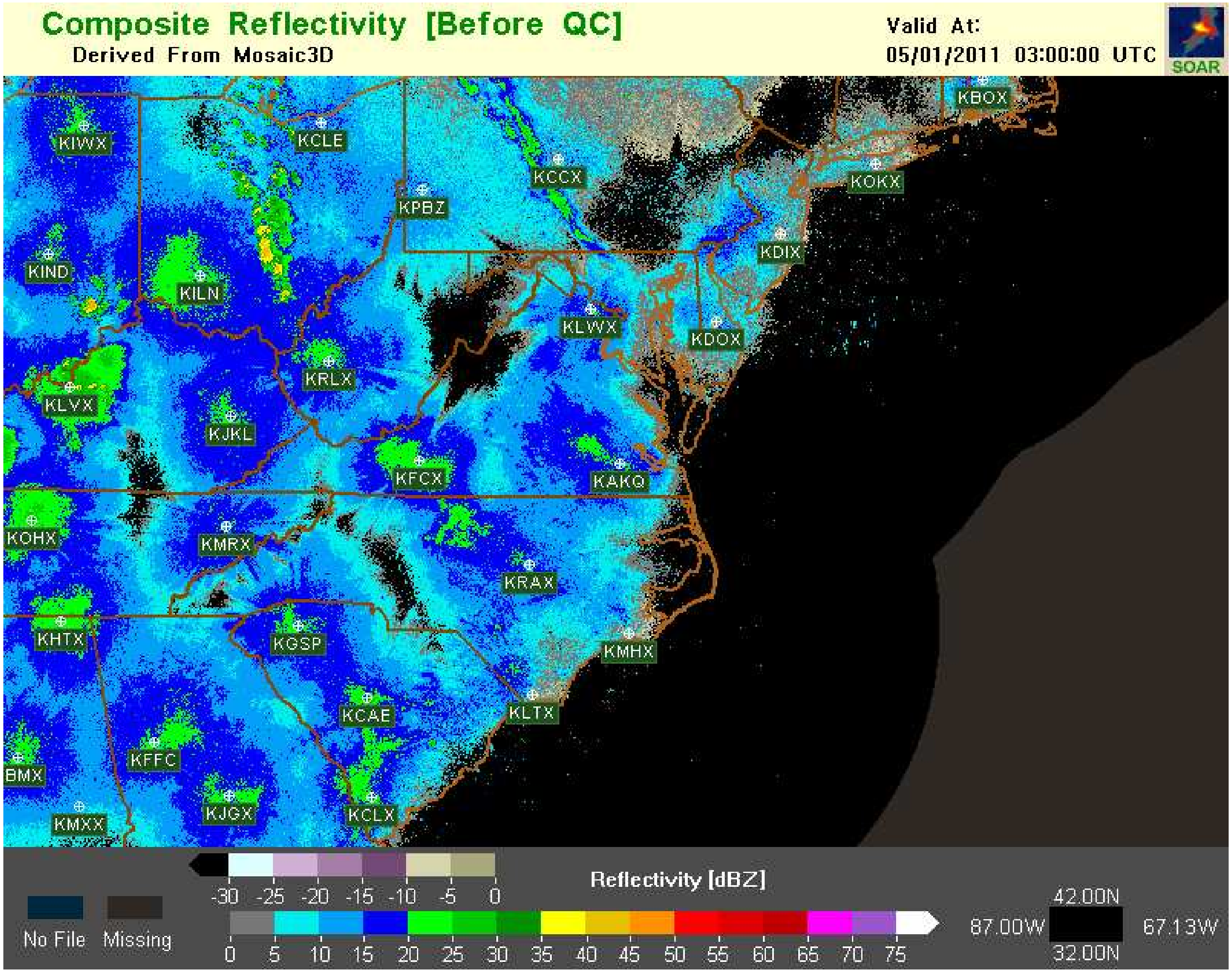
Periods of Investigation

- We are focusing on the months of May (spring migration) and September & October (fall migration) over several years
- Moreover, we are focusing on the periods during the day corresponding to
  - Local sunset ± 1 hour
  - Local sunrise ± 1 hour
  - Local midnight (midpoint between sunset and sunrise) ± 3 hours
- Local sunset and sunrise are calculated for each radar domain and for each day using the convention of civil twilight (sun is located 6° below the horizon)

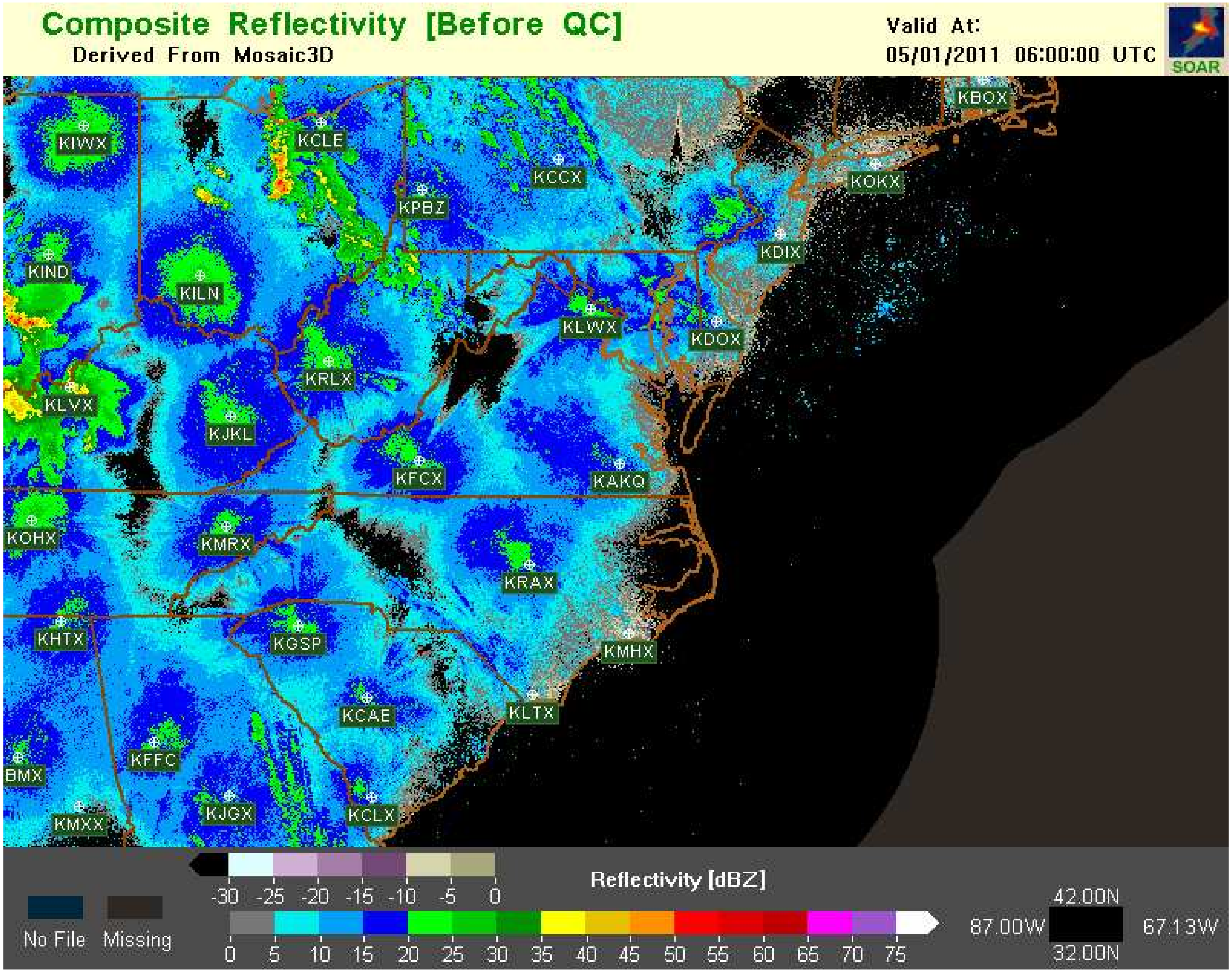
01 May at 00 UTC



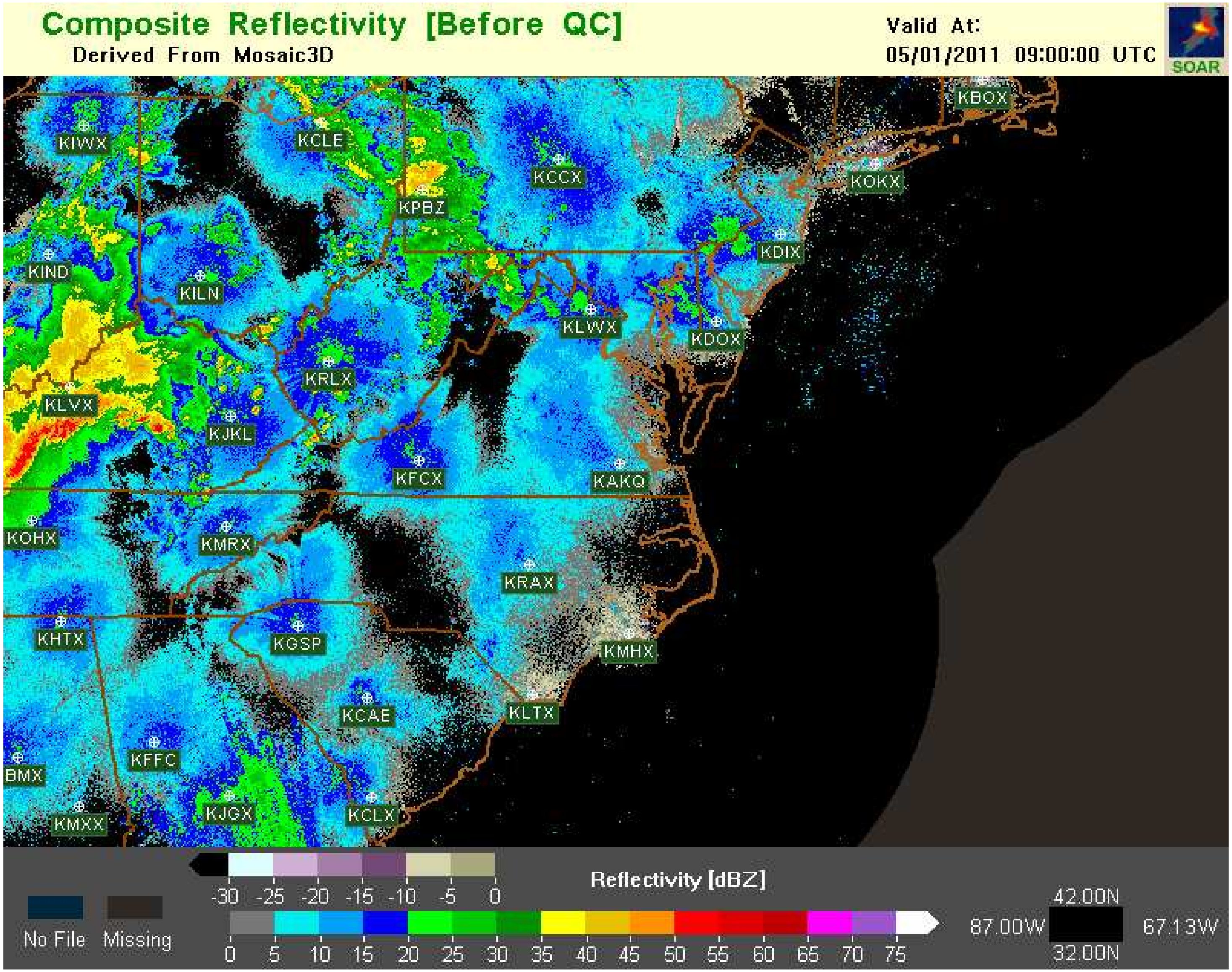
01 May at 03 UTC



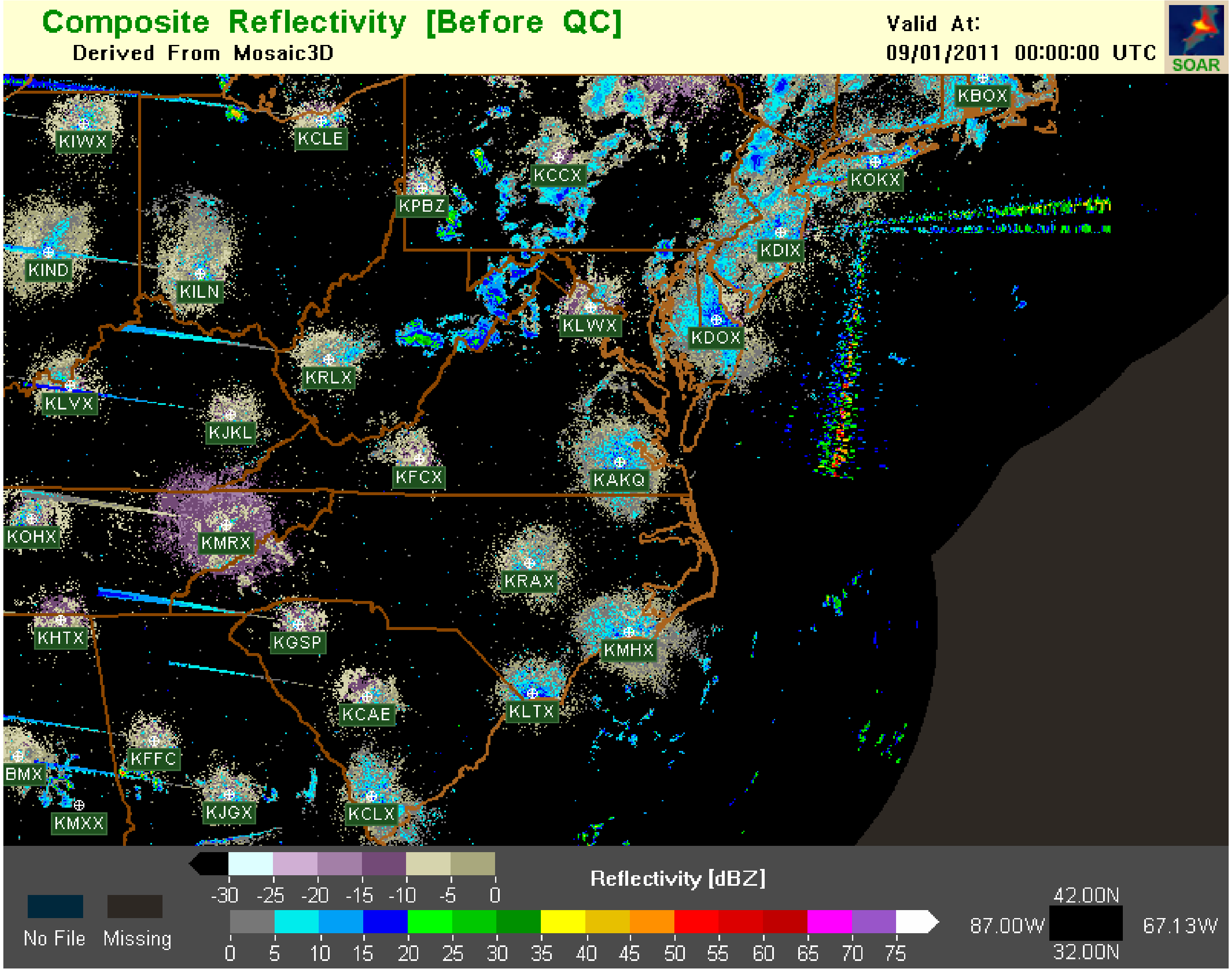
01 May at 06 UTC



01 May at 09 UTC



01 September at 00 UTC



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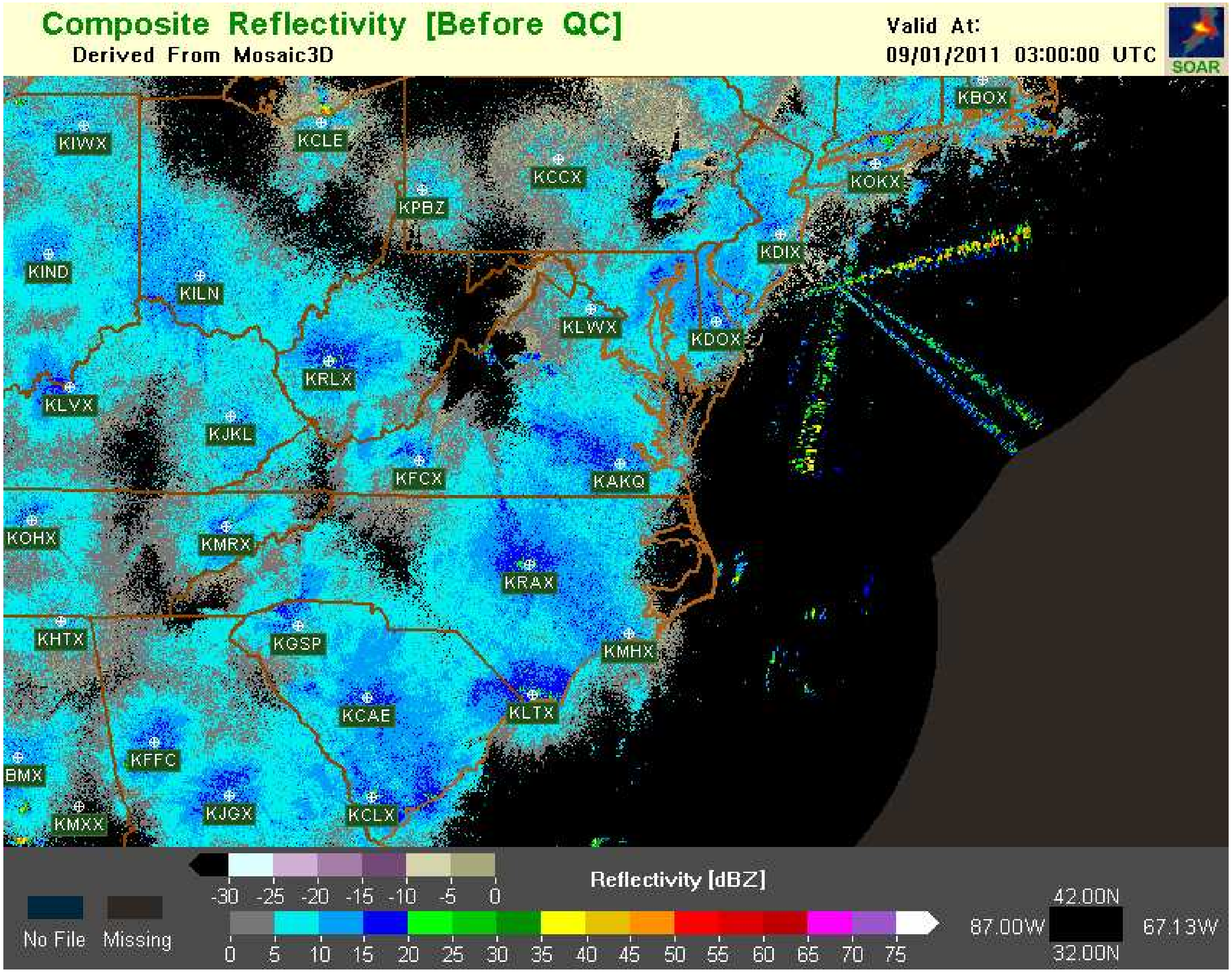

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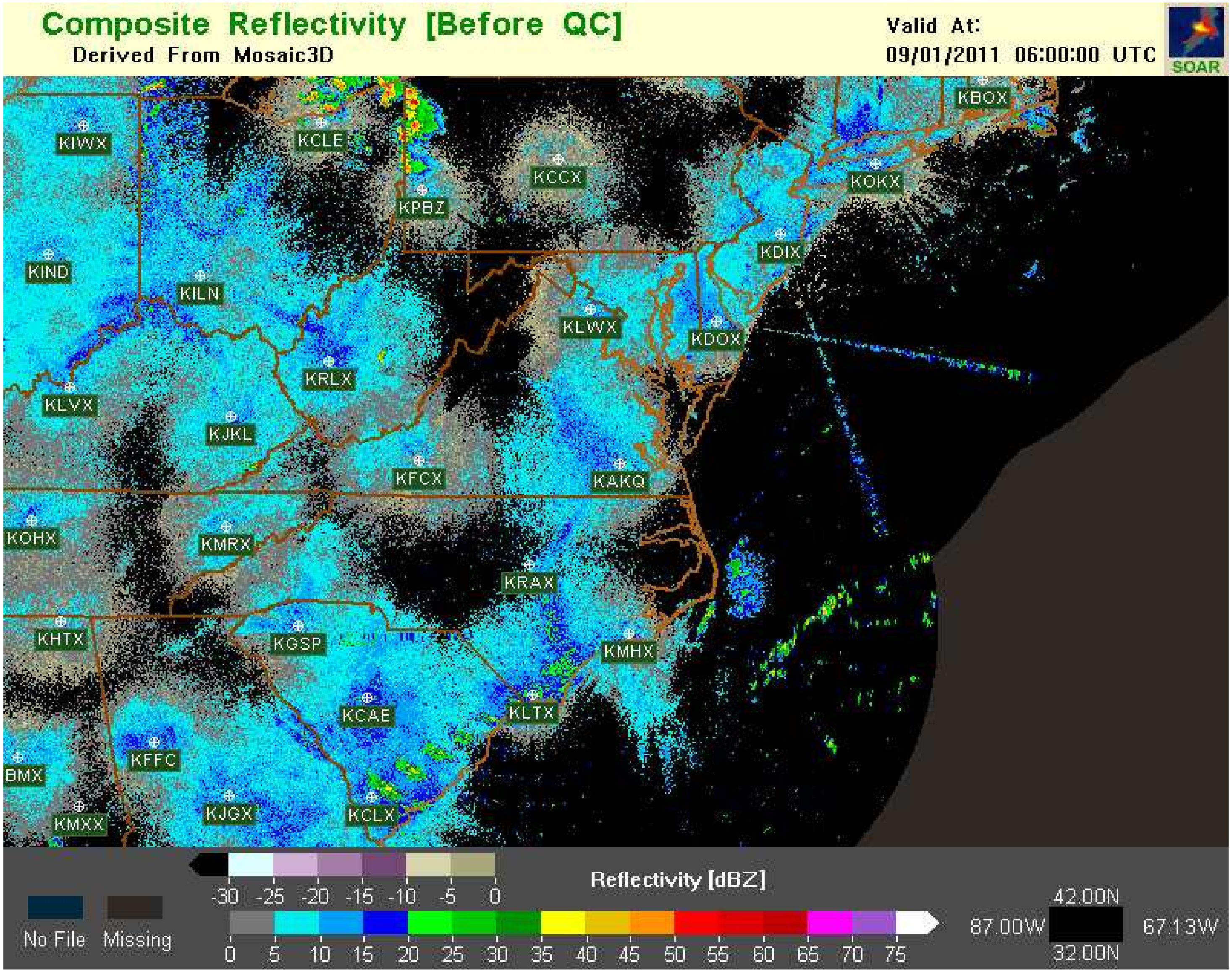

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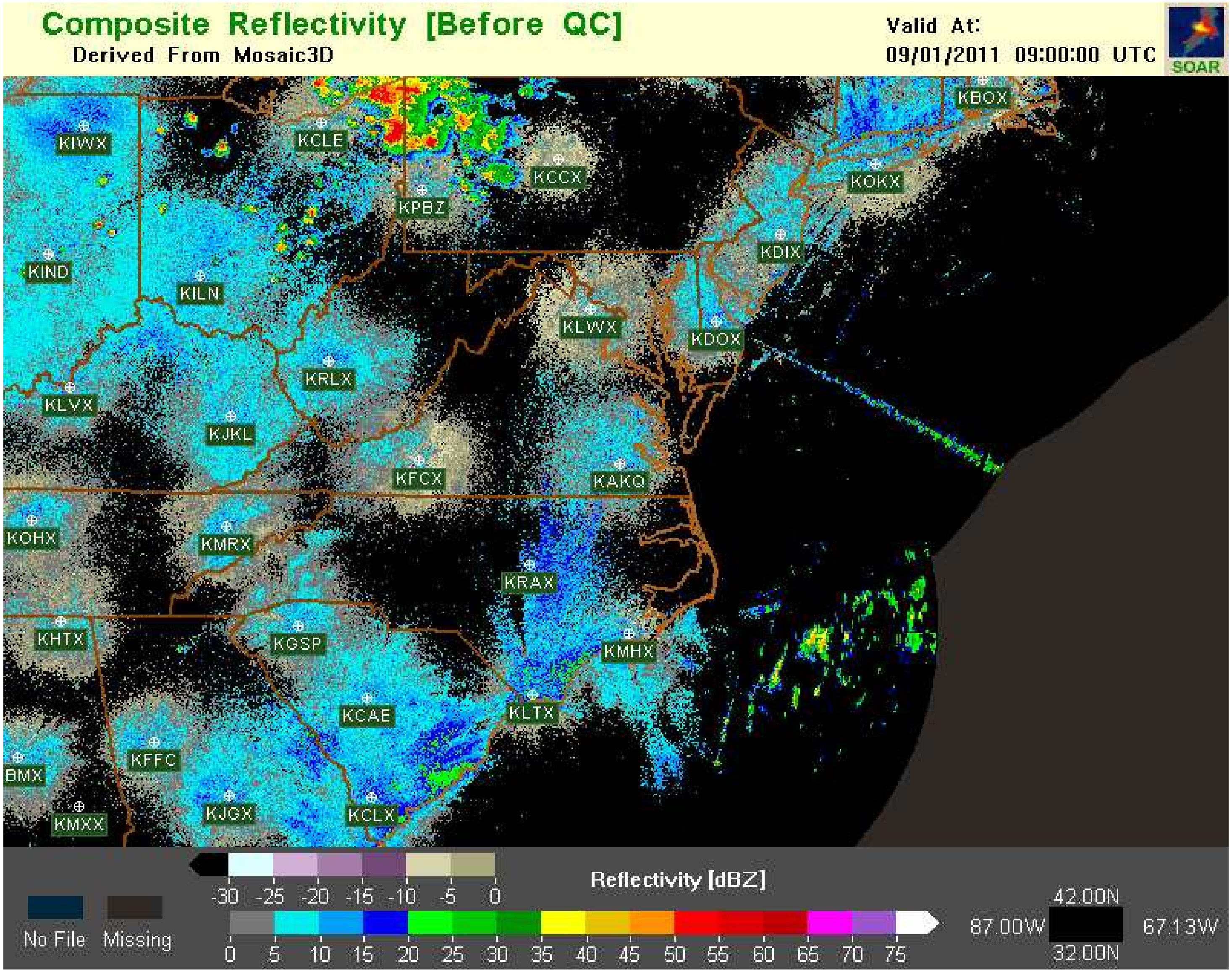
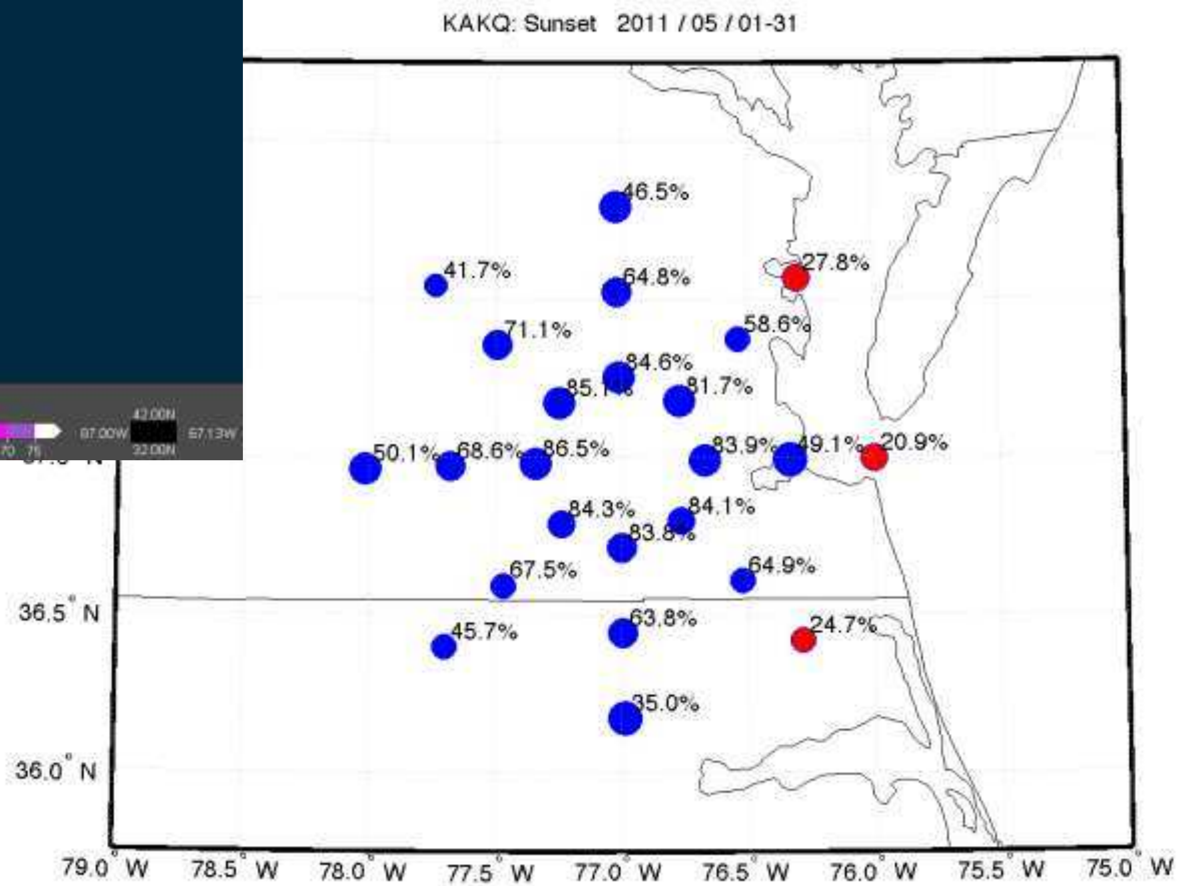
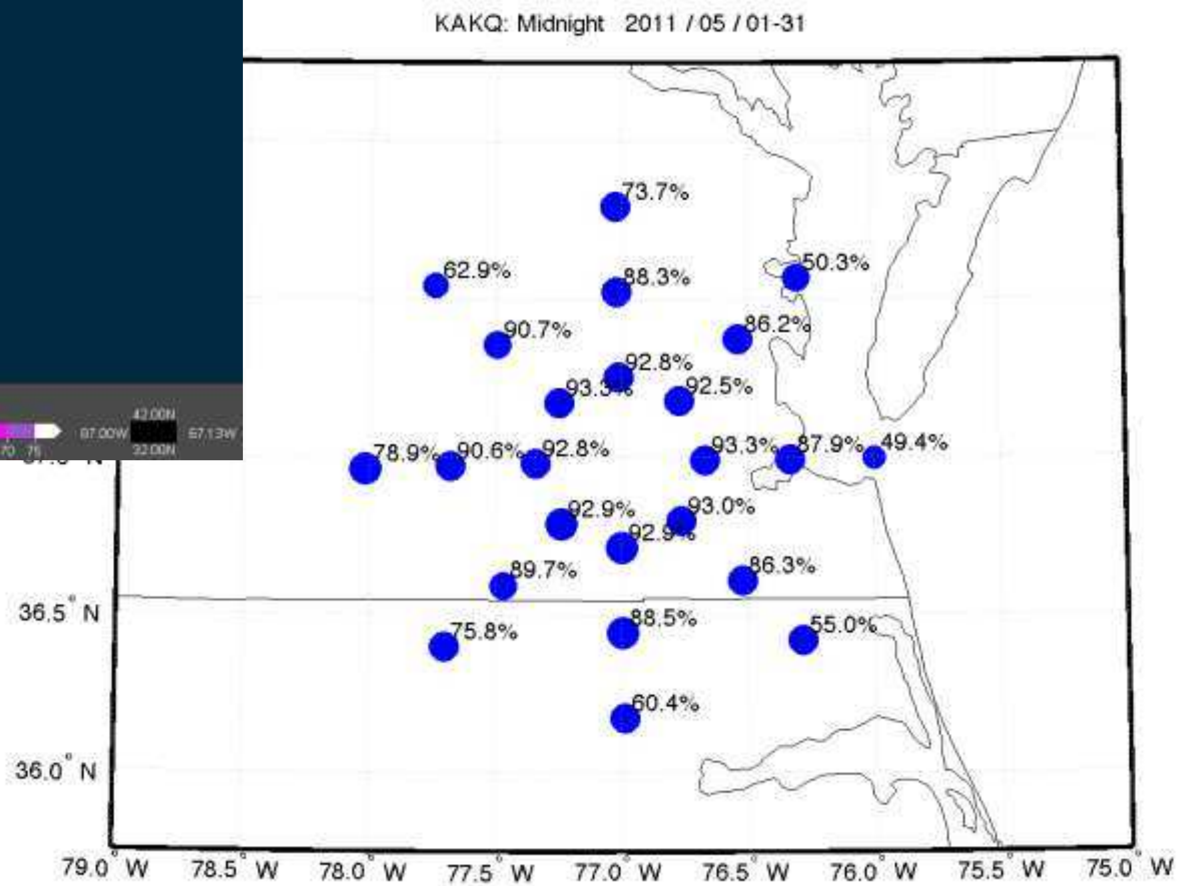


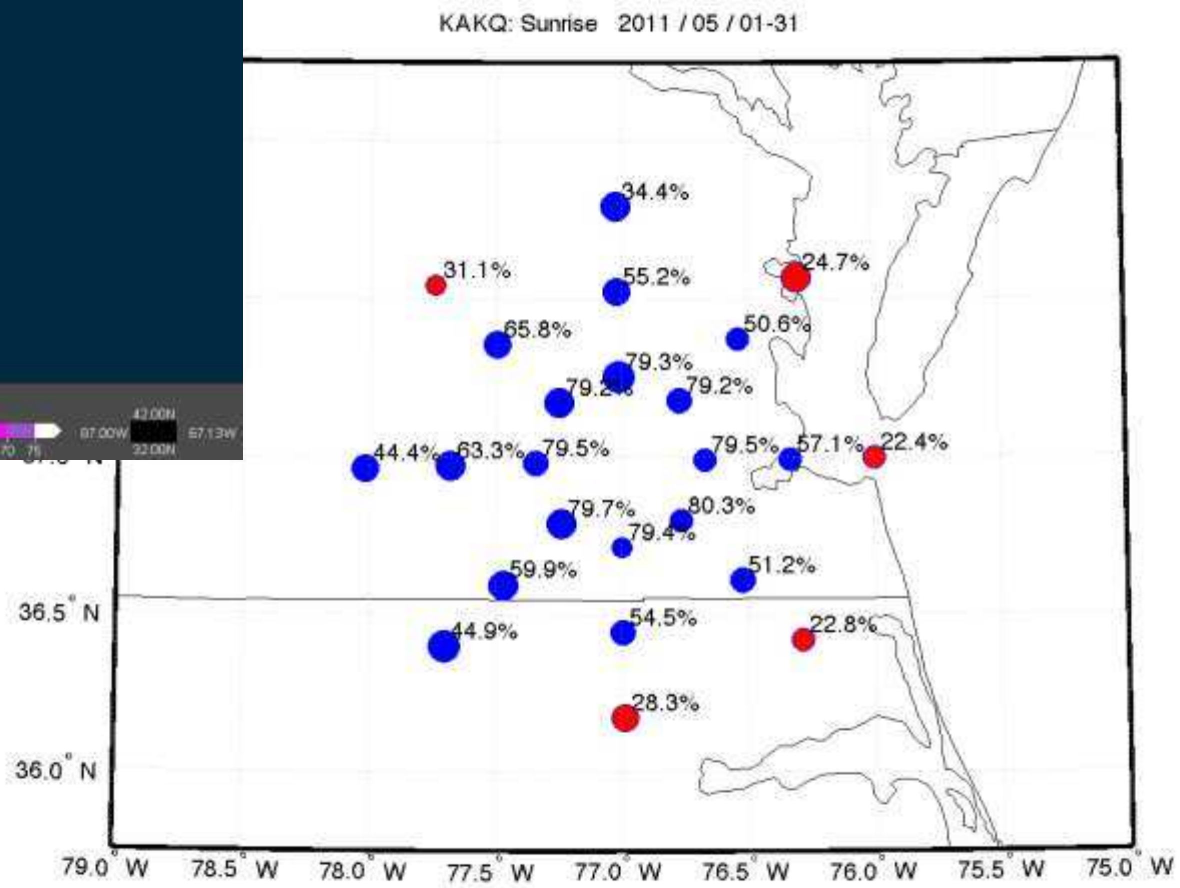
KAKQ: May for Sunset



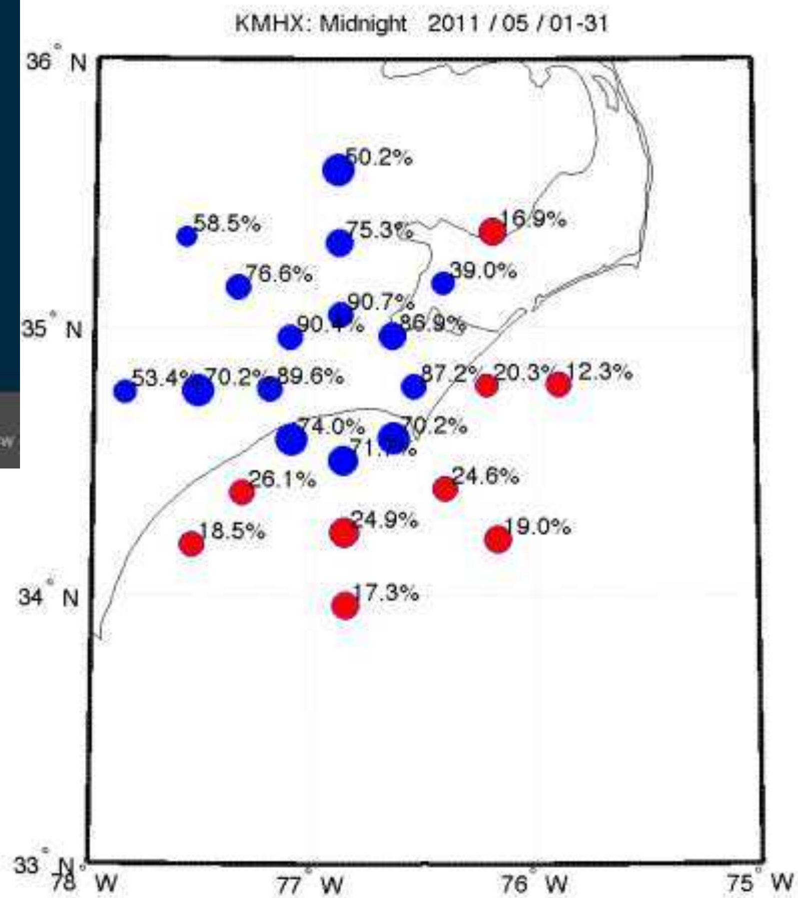
KAKQ: May for Midnight



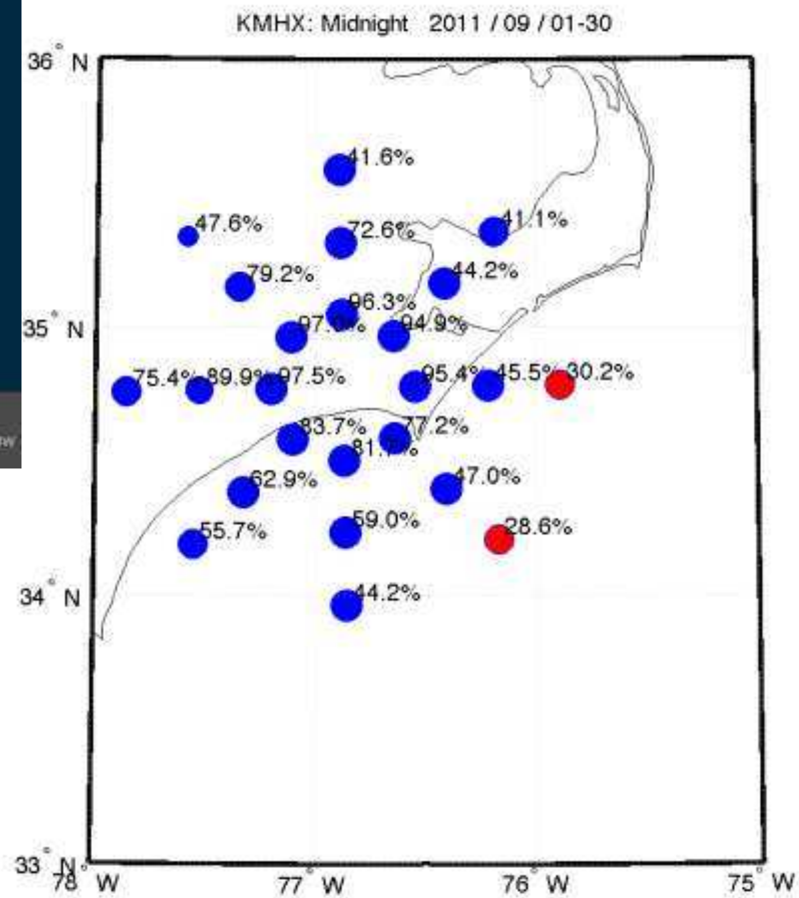
KAKQ: May for Sunrise



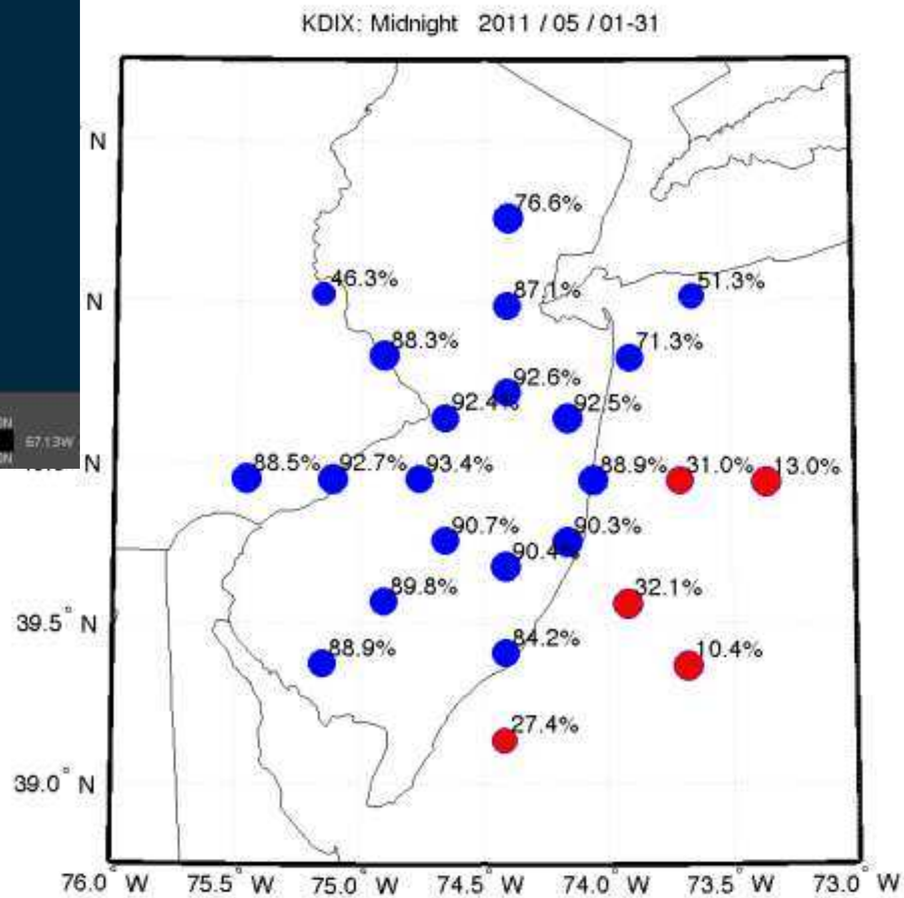
KMHX: May for Midnight



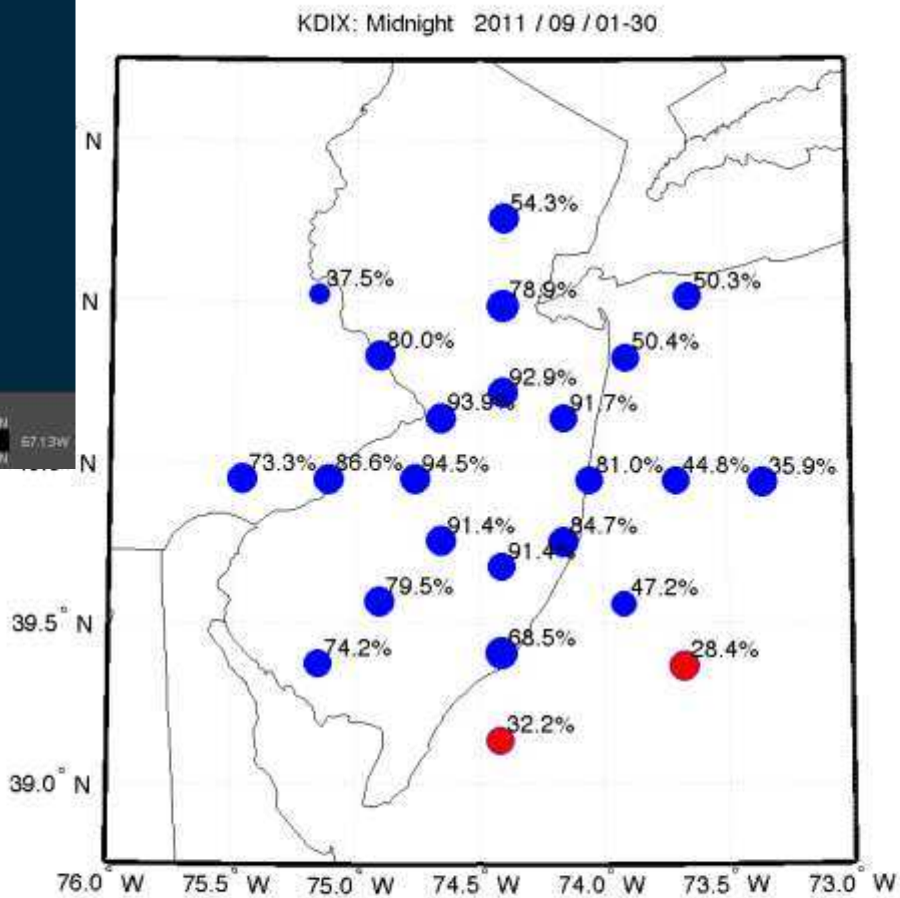
KMHX: September for Midnight



KDIX: May for Midnight



KDIX: September for Midnight



Results: Overview

- Data for 2011 during spring (May) and fall (September and October) have been analyzed – additional years are being processed
- During spring, migrating birds appear to stay over land areas
- During fall migration more biological activity was detected over the Atlantic Ocean

Summary & Conclusions

Conclusions

- Weather radar is being used to investigate migration of birds along the Easter Seaboard of the United States
- An algorithm was developed, which allows us to investigate migration traffic in the vicinity of various NEXRAD installations
- We have partly addressed the topic of whether an absence of signal implies an absence of biological scatter … but not extensively

On-going and Future Work

- Monthly averages of the data may be too long. Likely some biological questions will require less averaging. We are looking into this.
- Refine the graphical representation used in the figures
- Refine how how the fraction of bioscatter is calculated
- Relate the average values to potentially meaningful biological parameters

Acknowledgements

- Study being funded by the US Department of Energy
- Also participating in the study are
  - Evan Adams & Kate Williams – Biodiversity Research Institute
  - Victoria Ford & Jeff Kelly – University of Oklahoma

Hic sunt dracones