Biological Scatterers as Indicators of Boundary Layer Structure

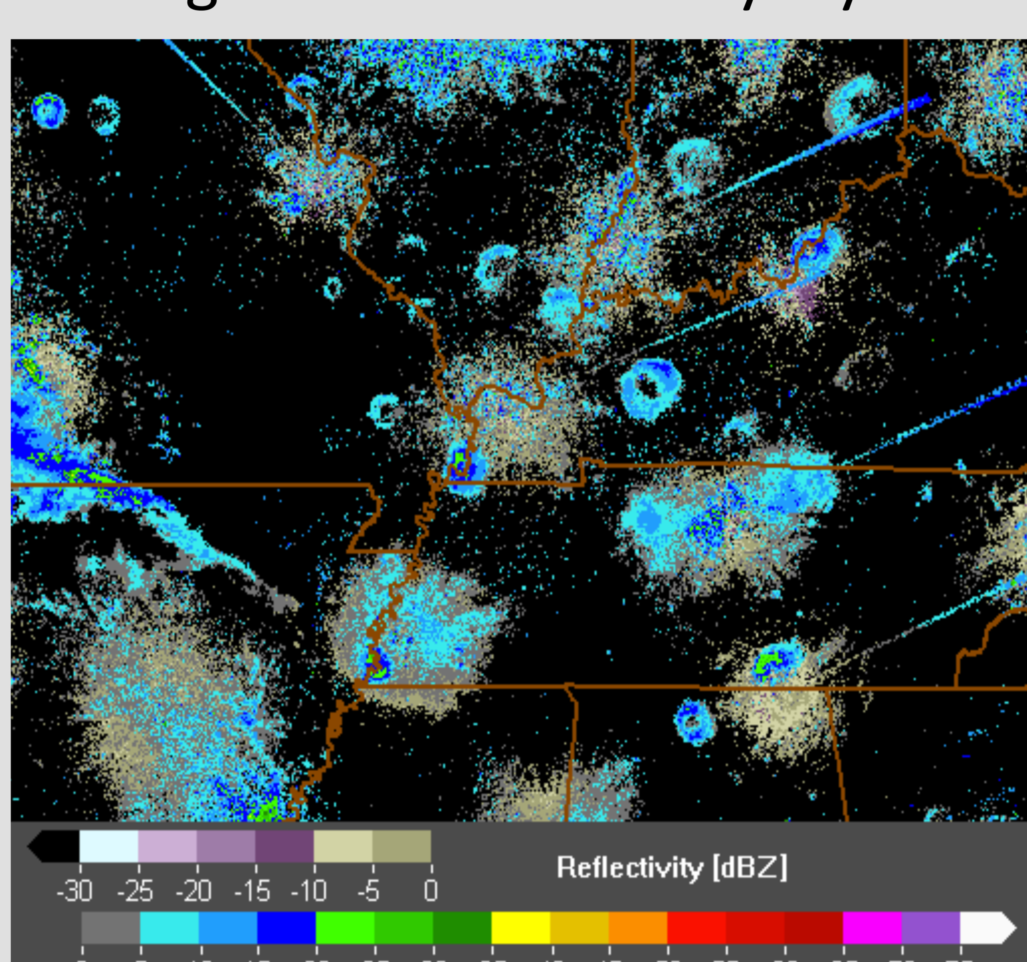
Phillip Stepanian[1], Jeffrey Kelly[2], and Phillip Chilson[1]

[1] Advanced Radar Research Center and School of Meteorology, University of Oklahoma, Norman, OK, USA

[2] Oklahoma Biological Survey and Department of Biology , University of Oklahoma, Norman, OK, USA

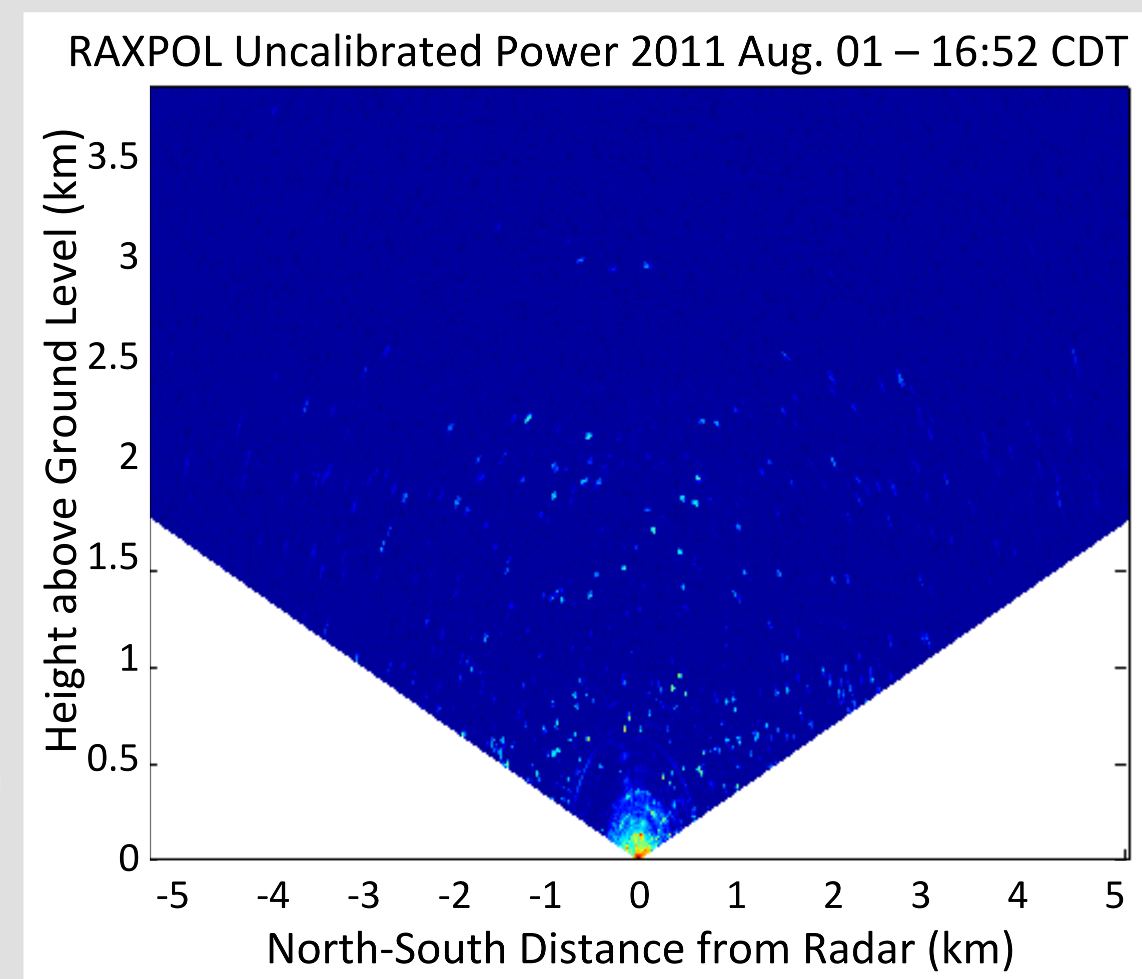
The national network of weather surveillance radars routinely records non-meteorological signals in the atmospheric boundary layer. It is often assumed that some of these scatterers - such as dust, chaff, and small insects - act as passive tracers that reveal atmospheric motions. The remaining signals are typically considered clutter, with no meteorological use. The behavior of aerial organisms - even large, active flyers - are motivated in part by atmospheric features and boundary layer structures. Understanding the relationships between the bulk behavior that is observed by radar and underlying atmospheric conditions can yield boundary layer information from otherwise useless data.

Purple Martins (*Progne subis*) are migratory birds that forage for aerial insects on the wing. In preparation for the southward migration in fall, large aggregations of purple martins form across the United States as thousands of individuals gather into spatially isolated colonies. Through the summer and early fall, these birds spend the nights in densely packed roosts. Shortly before dawn each morning, these colonies take part in a mass exodus as the birds disperse to forage for the day. These daily exodus events are a common observation at many NEXRAD sites. As the birds spread across the region, they remain a significant contributor to so-called clear-air radar scatter throughout the boundary layer.



Left: A NEXRAD CREF (non quality controlled) depicting the widespread, regional exodus of purple martin colonies following sunrise.

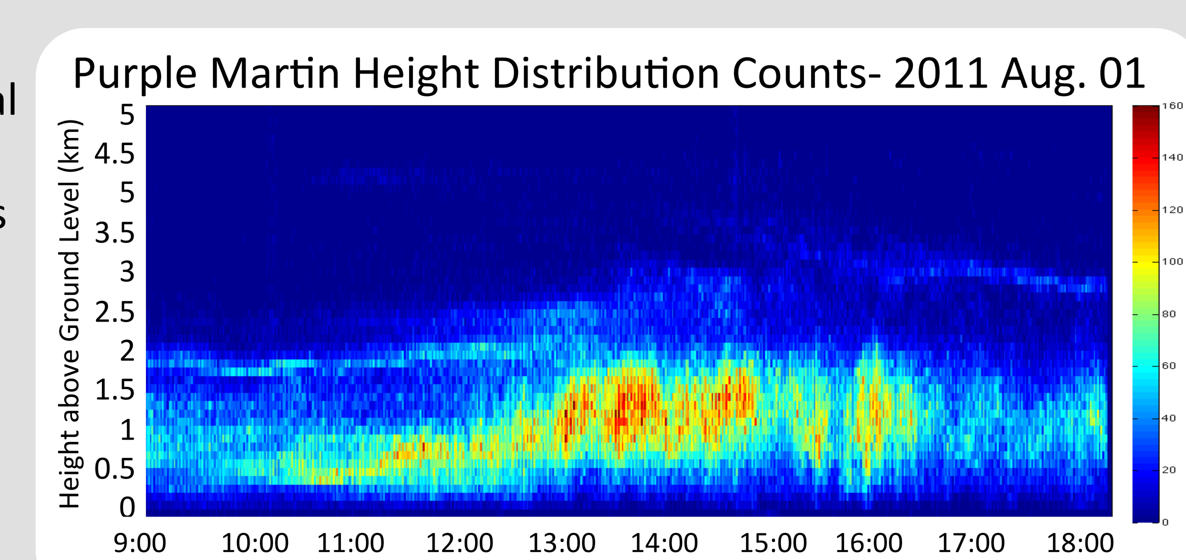
Below: A mature male purple martin



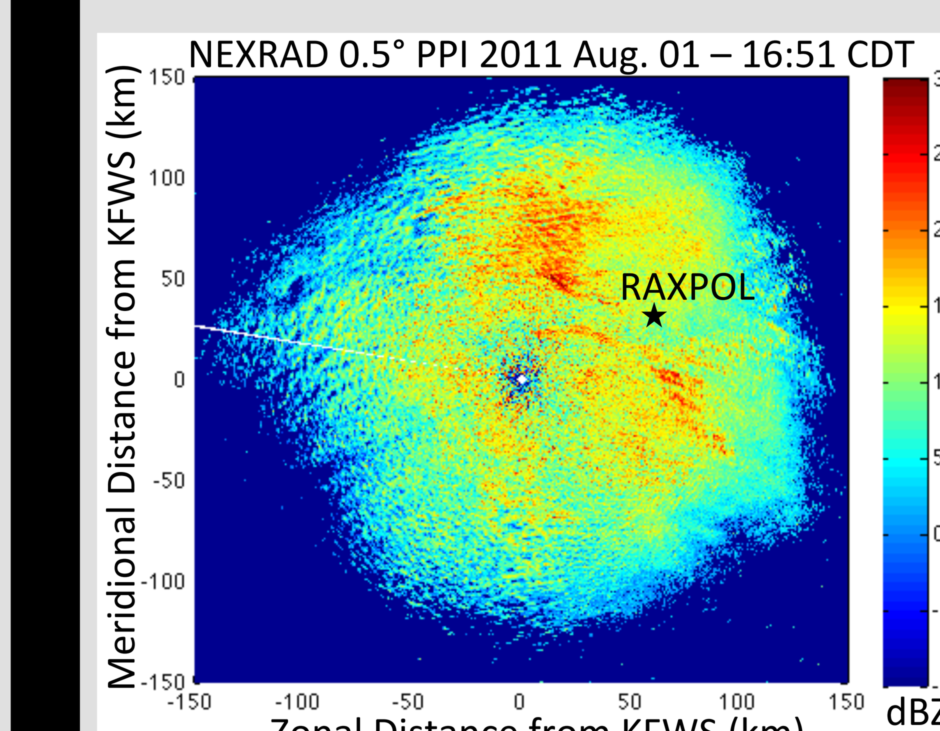
Right: An RHI of uncalibrated power from RAXPOL in Garland, TX. Birds appear as point scatterers. Ground observations confirm that birds are primarily purple martins. Each RHI completed in 14 seconds, yielding high temporal resolution.

To explore the interactions between bird behavior and boundary layer structure, a mobile X-band radar (RAXPOL) was deployed at the site of a major roost in Garland, TX. Continuous RHIs were taken from 09:00-18:00 CDT. Martin height distributions throughout the day track with boundary layer growth, and show interactions with thermals. It is possible that thermals advect insects on which the birds feed.

Right: The temporal evolution of bird height distributions obtained from RAXPOL RHIs. Fluctuations in the early afternoon suggest thermal structures.



Comparing these RAXPOL observations to NEXRAD data shows agreement between the locations of the point scatterers (RAXPOL) and biological volume scatter (NEXRAD). This suggests that radio-wave echoes from foraging insectivorous birds can be used to reveal atmospheric features in the boundary layer, e.g., proxies for boundary layer depth, locations of thermal plumes, and times of convective boundary layer development and decay.



Left: The lowest PPI of reflectivity factor from the Dallas, TX NEXRAD site (KFWS) with the location of RAXPOL marked with a star. Patterns within the clear-air signals suggest boundary layer thermal structures. Limited ground observations at the RAXPOL site support the theory that active flyers, i.e., purple martins, are responsible for much of the clear-air scatter.

Right: The projection of NEXRAD reflectivity factor values onto RAXPOL nominal resolution volume locations. The strong correlation between these constructed RHI images and the RAXPOL RHIs further support that purple martins are the dominant source of the reflectivity signals in the NEXRAD PPI above.