Airborne Polarimetric Doppler Phased Array Weather Radar

Vivek, Wen-Chau Lee, Eric Loew, Adam Karboski , Christopher Burghart and Turing Eret
National Center for Atmospheric Research
Earth Observing Laboratory
vivek@ucar.edu

Presentation at FARE Future: Emerging Technologies
September 21, 2023

Science Driver and Motivation

A fundamental challenge in observational meteorology is to measure concurrent 3D winds and precipitation characteristics

Why concurrent 3D winds and precipitation characteristics measurements?

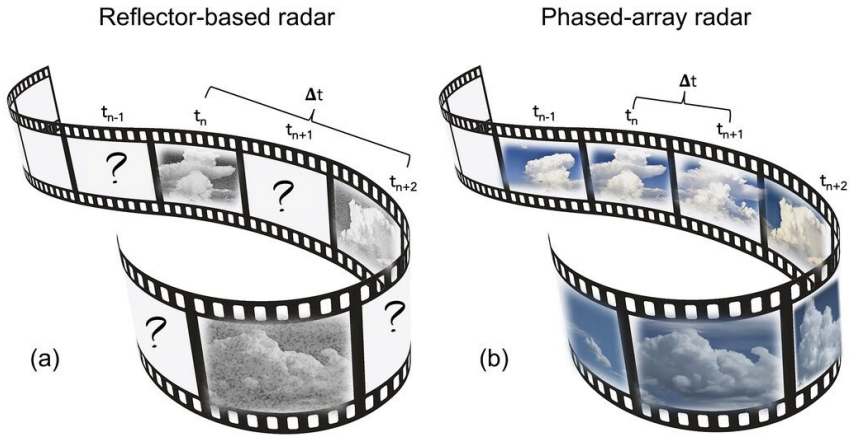
1. Microphysics is a poorly understood link in the nonlinear chain of dynamics (circulation) and thermodynamics.
2. Improved representation of microphysics-dynamics coupling in numerical models lets us better quantify storm predictability and reduce uncertainty in climate system models.

Why airborne dual-Doppler, dual-polarization, precipitation radar?

1. None of existing single observing facility/platform (ground-based, shipborne, or spaceborne) measures concurrent 3D winds and microphysical properties.
2. Weather and climate hazards often have their origins over the ocean (e.g., tropical cyclones) or complex terrain (orographic precipitation) not reachable by ground-based fixed and/or mobile radars.
3. Ability to follow a storm.

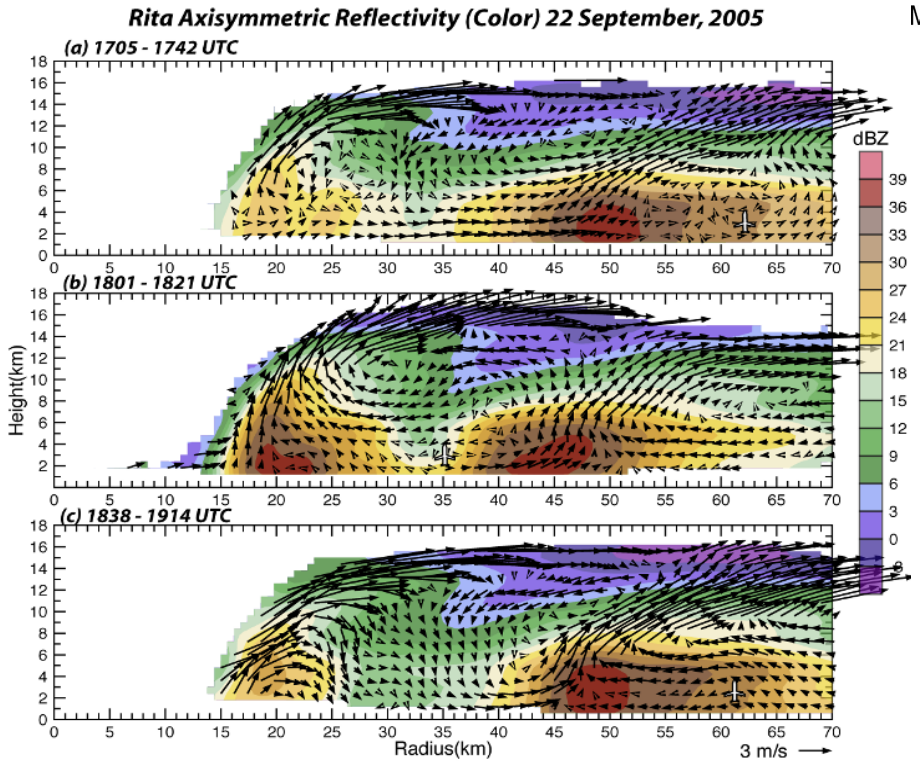
Background: Beam agility

- Steer the beam instantly: quickly switch scan
- Beam multiplexing: reduces std. deviation of radar measurements and scan time
- Adaptive scanning to focus on echoes of interest
- Fan beam transmission and multiple pencil -beam reception uses digital beamforming (DBF)

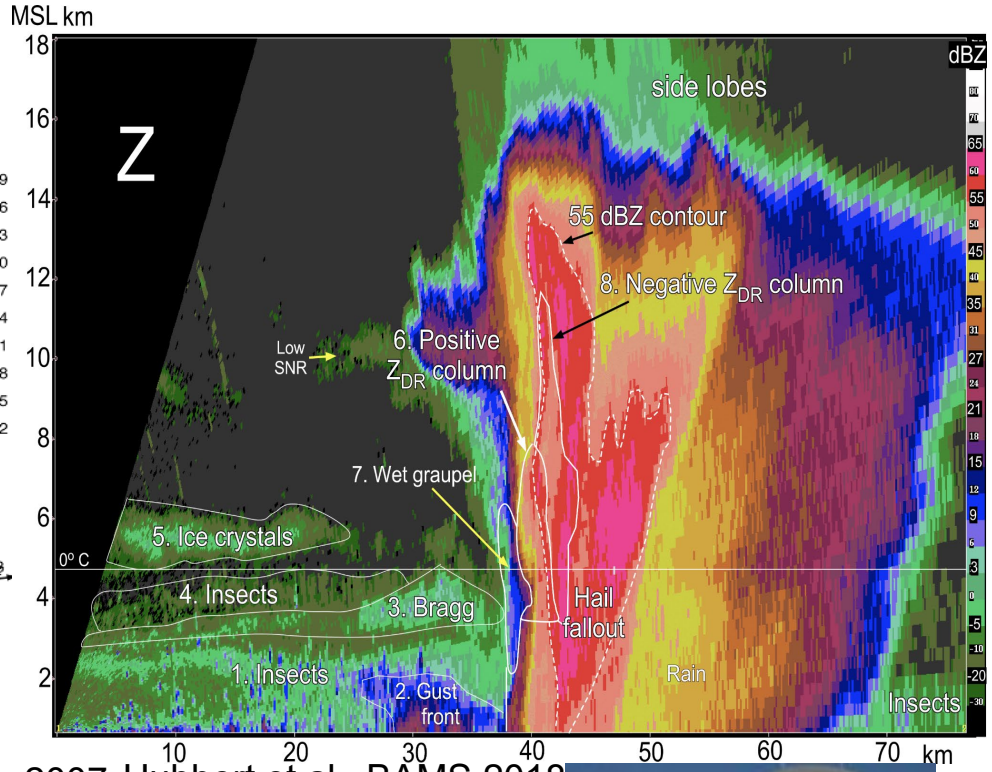


Kollias et al., BAMS 2022

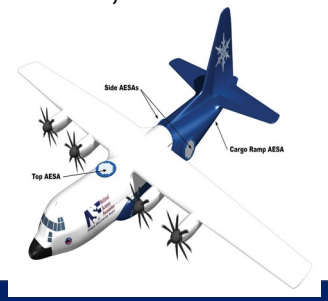
3-D Hurricane Winds & Hydrometeors in a Convective Storm



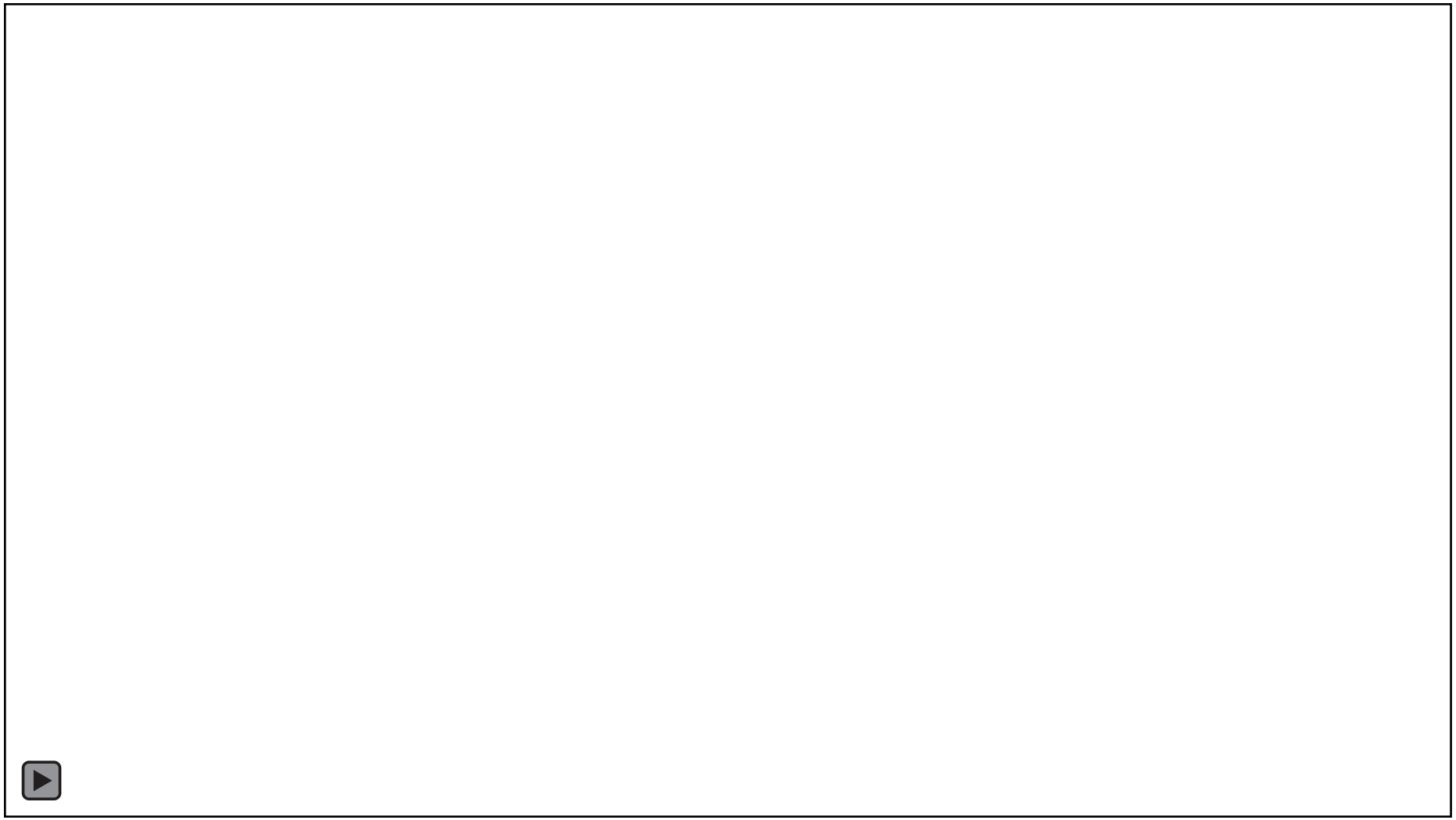
Houze et. al., Science, 2007



Hubbert et al., BAMS 2018

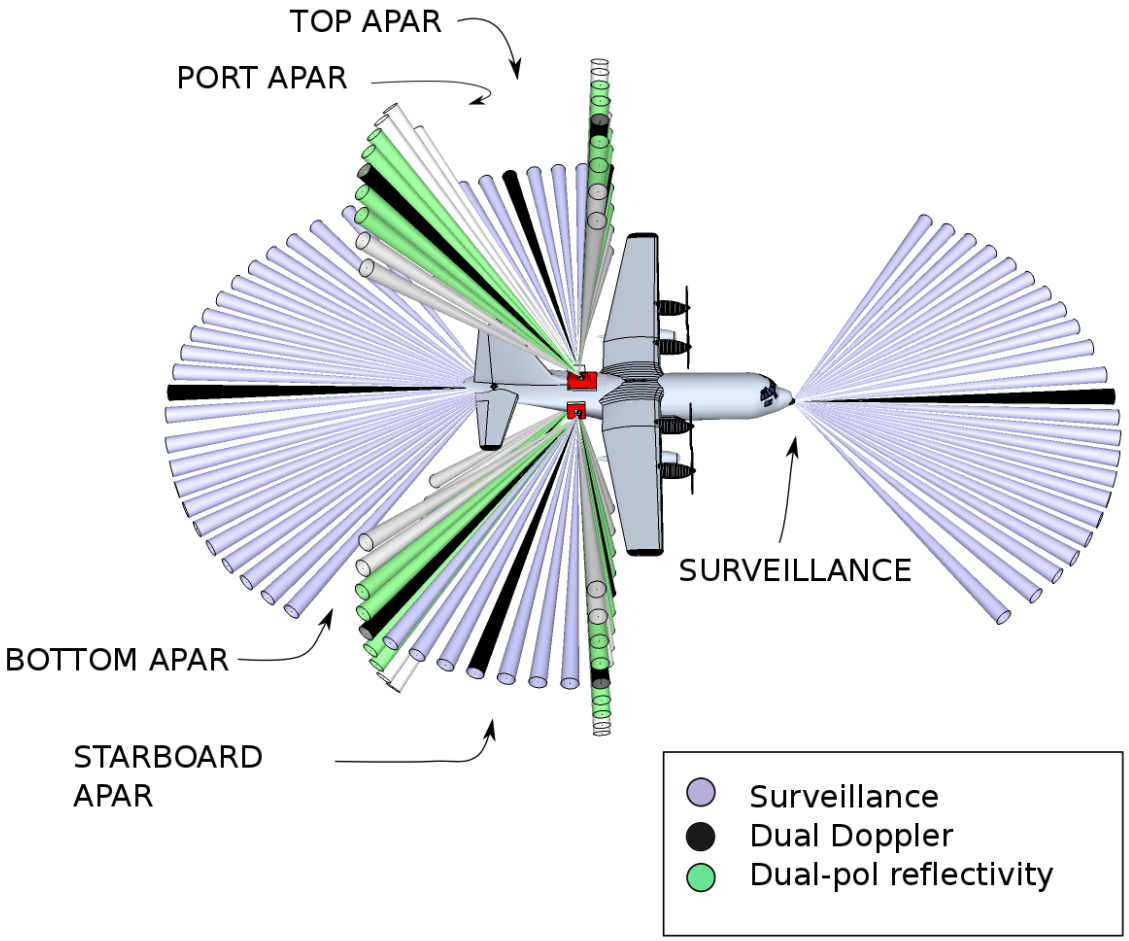


Airborne Phased Array Radar (APAR) Concept



NCAR is sponsored by the National Science Foundation.
This work sponsored by NOAA award NA18OAR4590431.

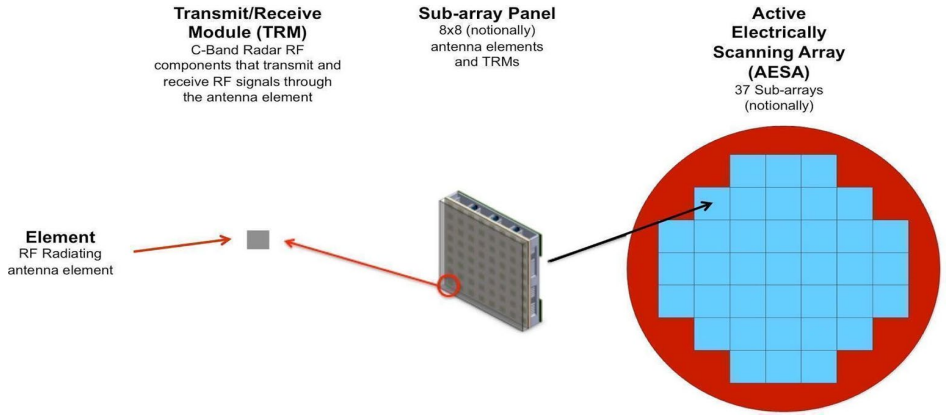
Beam Positions of the four PAR and Weather Avoidance Radar on C -130



Technical Advancement

1. Radar design adaptable to multiple platforms.
2. Flexibility to target and follow kinematic and microphysical structures over land and oceans.
3. C-band radar signal propagates deeper into storms.
4. Sensitivity: -11dBZ @ 10 km

   Dual-Pol and dual-Doppler



The choice of a C-band radar system may limit the usefulness of APAR when studying cloud micro-physical properties due to attenuation, resulting in incomplete penetration of the cloud mass, thus missing important features.

Summary

1. Concurrent 3-D winds and microphysical information to provide interrelationship between dynamics and microphysics: *diabatically driven circulations.*

2. APAR represents a generational leap in atmospheric remote sensing by adapting PAR technology.

3. PAR: agile beam, adaptive scanning, pulse compression and imaging.