Evaluation of the 3DRTMA Through Independent Radar and Lidar Wind Profiles from the PERiLS Field Campaign (2022-2023)

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Introduction

The PERiLS (Propagation, Evolution, and Rotation in Linear Storms) field campaign, conducted across the Southeastern United States during 2022 and 2023, aims to enhance our understanding of tornadoes and their interactions with the environment in the southeast US. The suite of instrumentation for PERiLS provides an unprecedented data set of independent observations including radar and lidar wind profiles, crucial for evaluating analysis systems such as the 3-dimensional Real Time Mesoscale Analysis (3DRTMA) system developed at the NOAA Global Systems Laboratory.

For this evaluation, we focused on the case from March 22 to 23, 2022. The Rapid Refresh Forecasting System (RRFS) retrospective experiment was run to provide hourly background for 3DRTMA. Then a separate 3DRTMA experiment was conducted to assimilate all conventional observations, but monitors independent radar and lidar wind from the PERiLS field campaign to examine the impact of conventional observations in the 3DRTMA. From those independent wind profiles, we can understand how and to what extent the aircraft and radar radial wind observations impact the analysis.

Experimental Configuration in RRFS

- Based on the FV3 dynamical core Limited Area Model (LAM) capability
- CONUS 3-km Convection-allowing grid
- 65 vertical layers
- Non variational cloud analysis
- GSI hybrid 3DEnVar analysis with 80 GDAS ensemble members
- Assimilated conventional observation
- Hourly cycle to provide background for RTMA

Data Assimilation in RRFS RTMA

- GSI hybrid 3DEnVar analysis with 80 GDAS ensemble members
- Assimilated all conventional observations but monitor independent radar and lidar wind profiles
- Smaller observation error comparing with RRFS

Table: Common data sources assimilated in RRFS

Observation Platform	Variables
METAR, Mesonet, Buoy, Ships	T, Q, W, PS, ceiling, visibility
Rawinsonde	T, Q, W
NEXRAD Radar	dBZ, rw, VAD W
Aircraft	T, Q, W
GOES-16/18	ABI, AMVs, Cloud top pressure, T
Polar orbiters	Radiances (AMSUA, MHS, ATMS, CrIS, IASI, SSMIS)

Monitor Radar and Lidar Wind Profiles to Verify RRFS RTMA during Mar. 22-23 2022

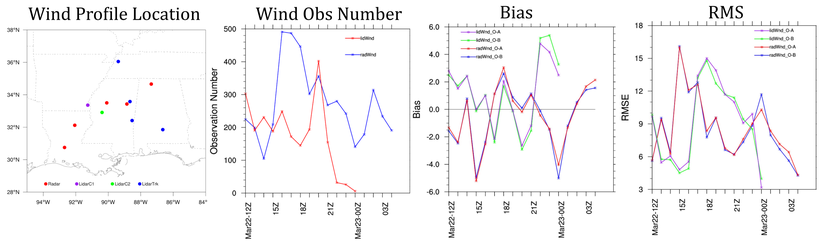


Figure 1: PERiLS Radar and lidar wind profile location, number, bias and RMS when these profiles were used to verify analysis from all conventional observation during 12Z March 22 to 04Z March 23, 2022.
lidWnd: lidar wind, radWnd: radar wind, O-B: observation-background, O-A: observation-analysis

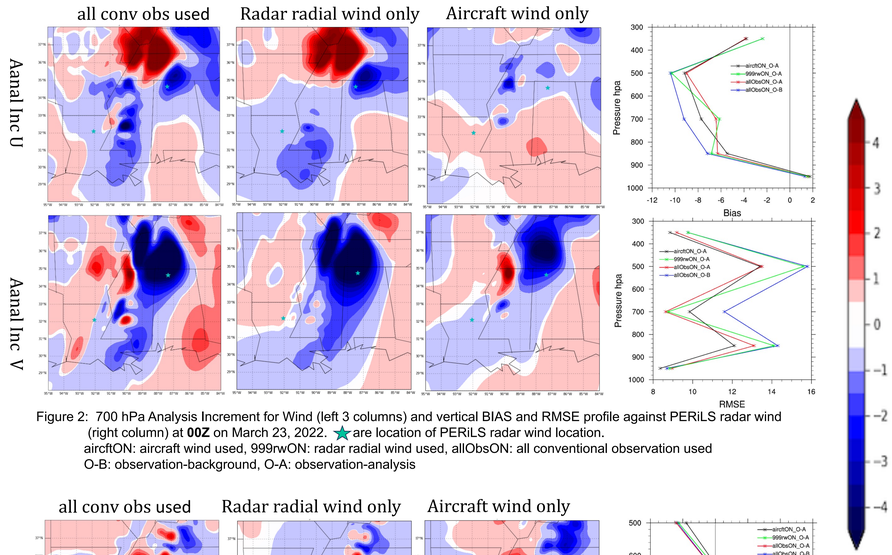


Figure 2: 700 hPa Analysis Increment for Wind (left 3 columns) and vertical BIAS and RMSE profile against PERiLS radar wind (right column) at **00Z** on March 23, 2022. ★ are location of PERiLS radar wind location.
aircftON: aircraft wind used, 999rwON: radar radial wind used, allObsON: all conventional observation used
O-B: observation-background, O-A: observation-analysis

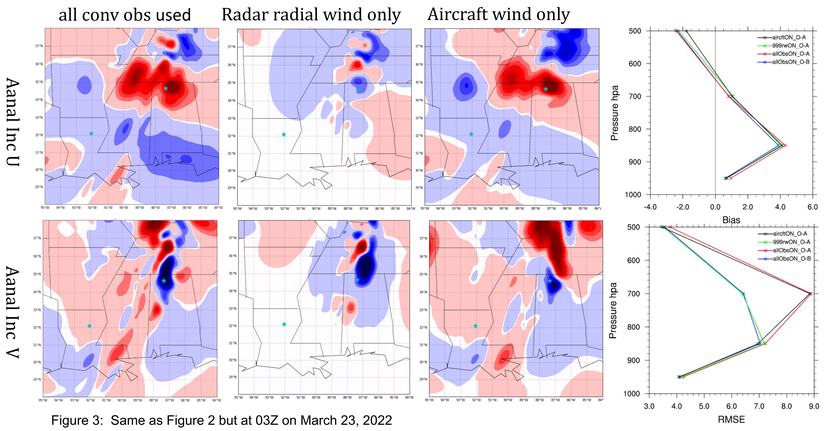


Figure 3: Same as Figure 2 but at 03Z on March 23, 2022

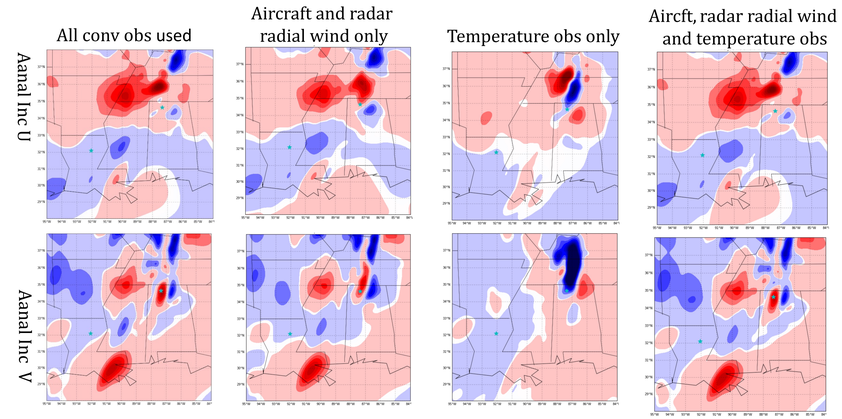


Figure 4: 700 hPa Analysis Increment for wind at 02Z on March 23, 2022 from analysis that use different set of conventional observations. ★ are location of PERiLS radar wind location.

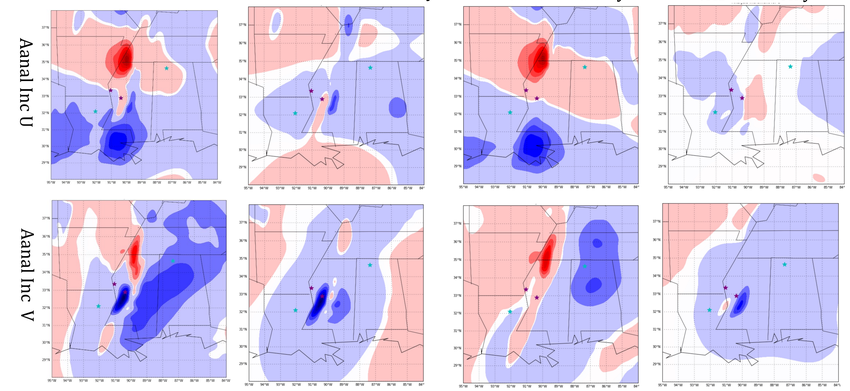


Figure5. 950 hPa Analysis Increment for Lidar Wind at 23Z on March 22, 2022. ★ are location of PERiLS Lidar wind location.

Summary and Future Work

Summary: The independent PERiLS radar/Lidar wind observations are used to evaluate 3DRTMA wind analysis. The aircraft and radar radial wind observations play key role in wind analysis. The aircraft shows positive impacts from 950-350 hPa while radial winds shows positive impacts at 700 hPa for 00Z. Both observations have mixed impacts for some cycles.

Future Work:
- Utilize the high-resolution VORTEX-USA data to advance and evaluate MPAS 3DRTMA Analysis