Investigating Windsond Observations in Supercells

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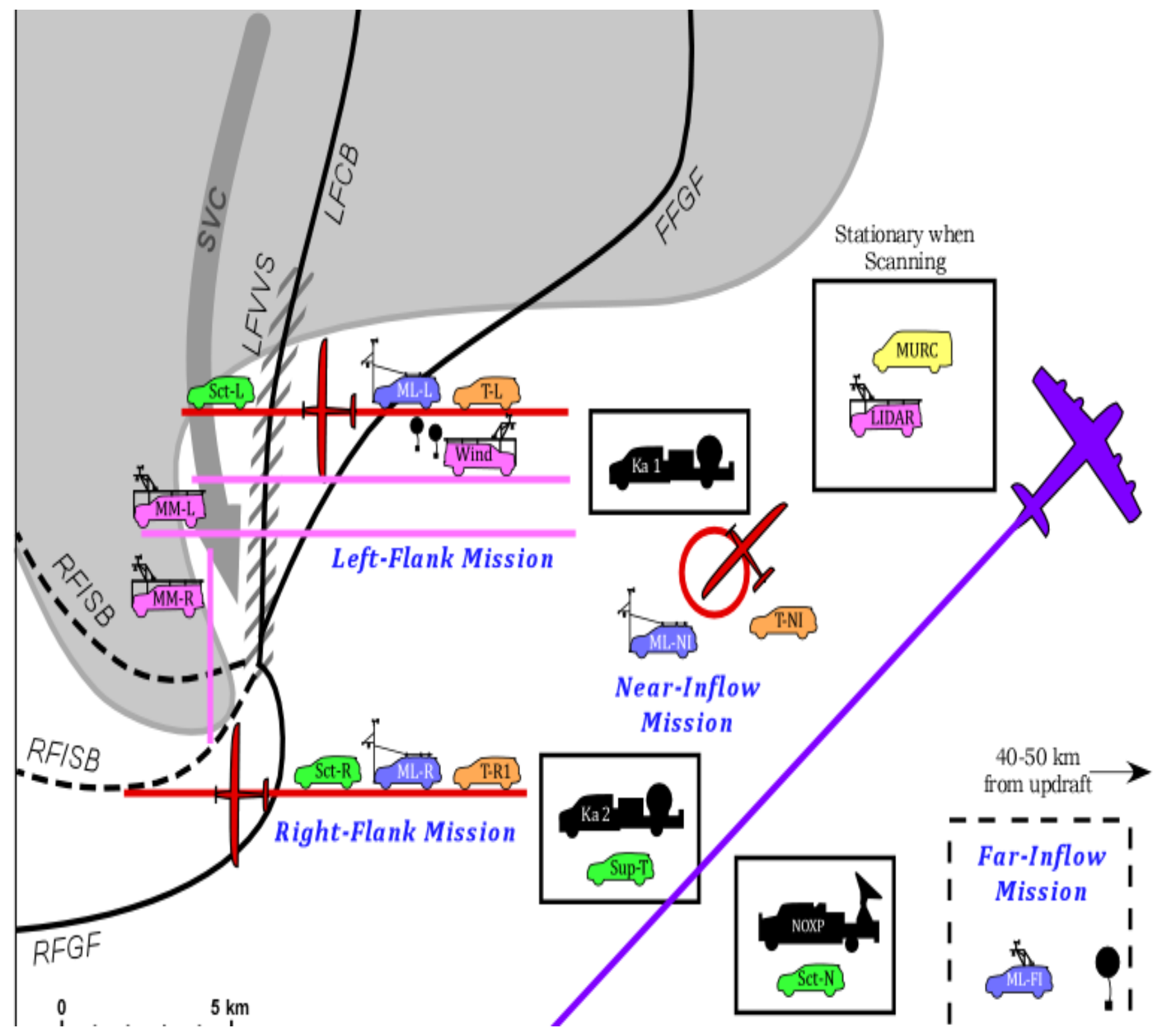
Introduction

Supercell thunderstorm data collection has long been restricted to ground observations, radar scans, single aircraft flights, and sporadic weather balloon launches. The Targeted Observations by Radar and Unmanned aircraft systems (UAS) of Supercells (TORUS) 2019 field campaign introduced new data collection approaches to collect in-situ observations in supercell thunderstorm environments. This included multiple UAS missions and targeted deployments of small balloon-borne instruments known as windsondes. The windsondes can act as pseudo-Lagrangian drifters and provide rare wind and thermodynamic observations of air flowing into the low-level mesocyclone. In particular, one feature of the supercell thunderstorm, known as the streamwise vorticity current (SVC), has been identified through simulations to influence tornado formation, but has not been observed. This project examined the effectiveness of windsonde data collection in near-storm environments and whether SVCs were present in the dataset. Implementing windsonde deployments in future field campaigns will aide in understanding microscale and mesoscale storm features that are otherwise more difficult to observe with conventional data collection techniques.

Background

A windsond is a weather instrument package developed by Sparv Embedded that records pressure, temperature, relative, humidity, and wind speed roughly every 3 seconds. In this project, windsondes were deployed in groups of 8 to attempt to observe streamwise vorticity currents (SVC) in the forward flank of the supercell. SVCs are narrow ribbons of horizontal vorticity that extend from the forward flank to the mesocyclone. At the surface SVCs can be identified by a marked wind shift and changes in the thermodynamic profile (Coffer and Parker, 2017).



TORUS Instrument Deployment Diagram

Methods

Data was collected in an eleven day period from 17 May 2019 to 27 May 2019 as a part of the TORUS field campaign. The windsondes were launched in deployments of at least three sondes up to eight sondes. The windsonde data was then quality controlled by determining flight time, correcting the starting altitude and accounting for periods of lost data. One windsond was launched in tandem to a radiosonde to compare the data from the two flights as shown in figures 1 and 2. Finally the trajectories and thermodynamic profile of each deployment were plotted and analyzed.

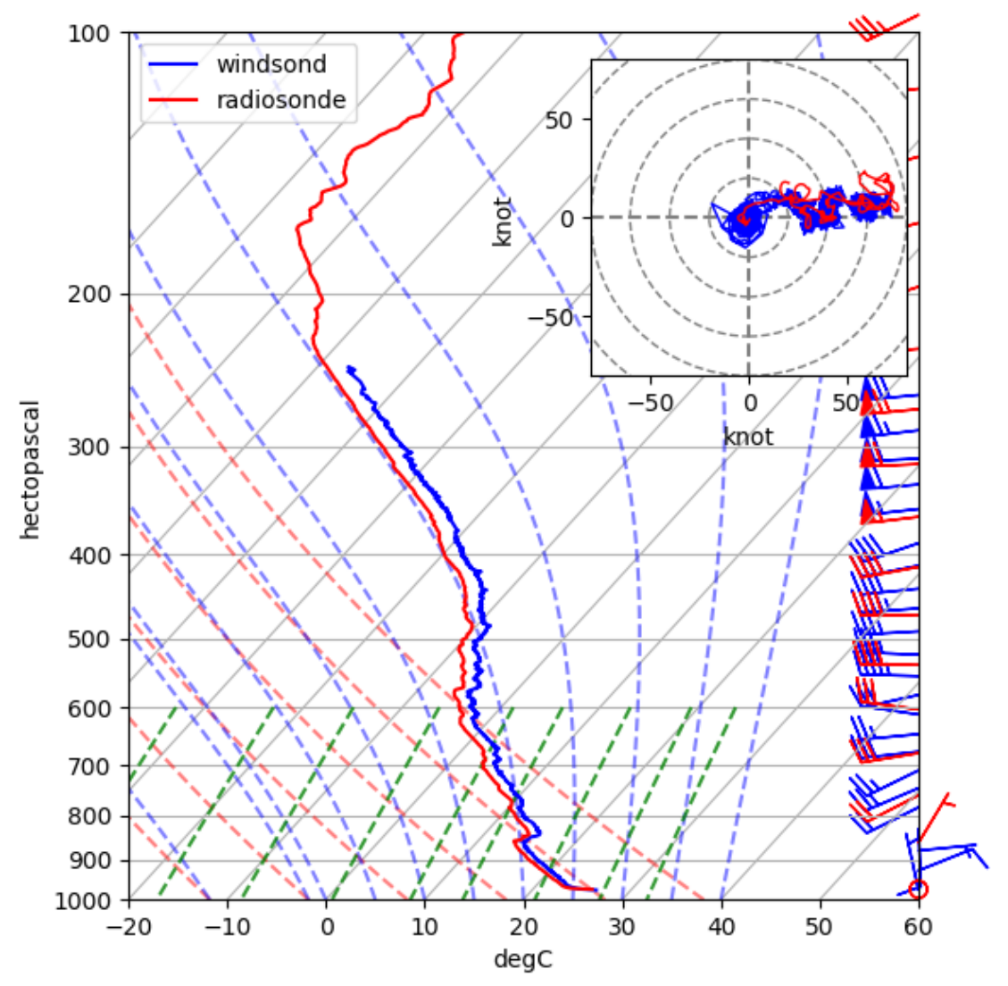


Figure1: Radiosonde and windsond sounding comparison, radiosonde plotted in red and windsond in blue.

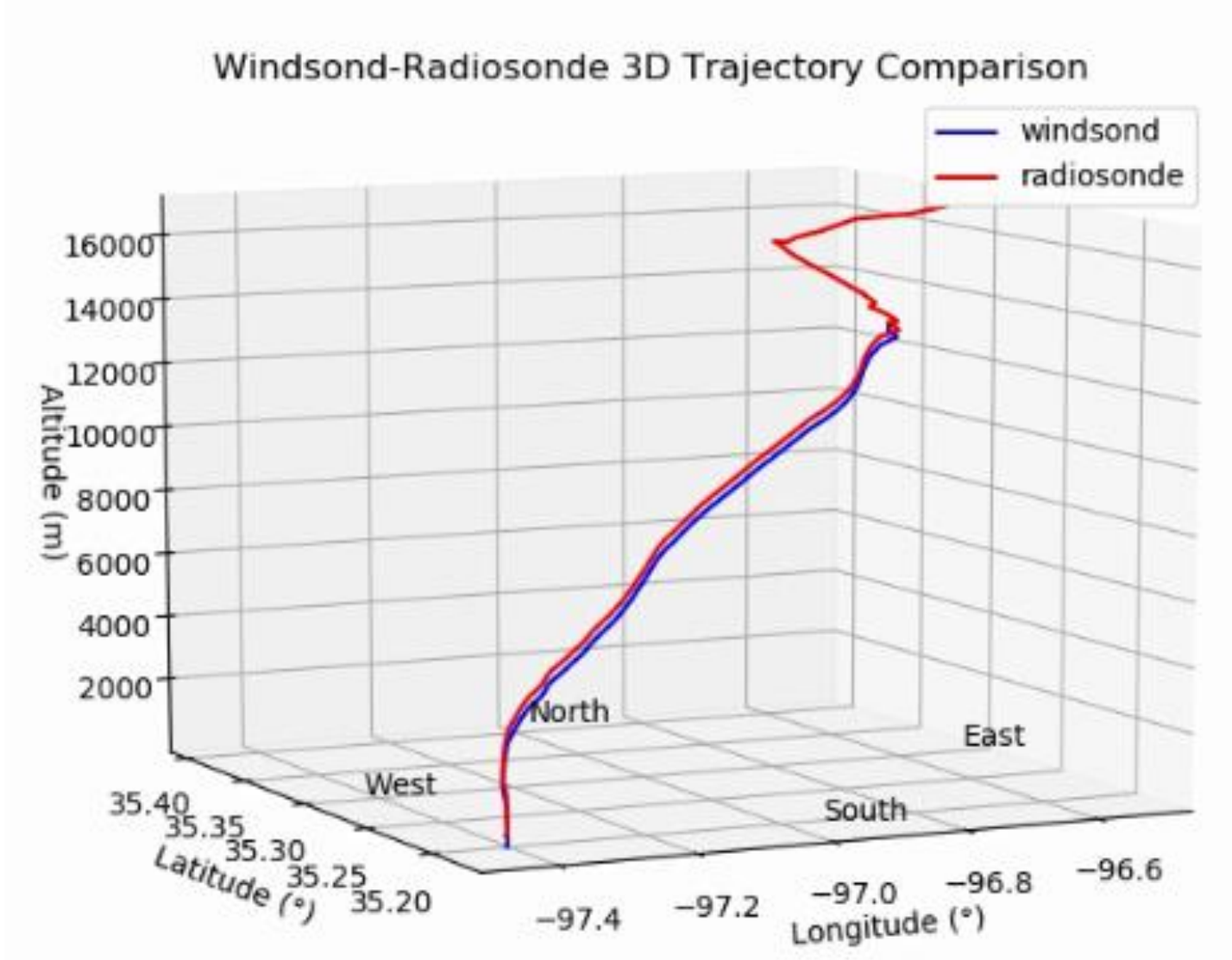


Figure2: Radiosonde and windsond 3D trajectory comparison, radiosonde plotted in red and windsond in blue.

Results

Preliminary results from the data comparisons reveal that windsonde observations in the near-storm environment are valuable in identifying and analyzing storm-scale features of supercells. There is a slight warm bias to the windsond vertical temperature profile, but is not significant at the levels analyzed. The trajectories for the radiosonde and windsonde are identical when launched in tandem. Two supercell thunderstorm cases analyzed in an effort to identify SVC and thermodynamic boundaries of near inflow storm environments demonstrated two different results for each the deployment. The first, a high precipitation supercell targeted on 24 May 2019, showed a general shift of the surface and lower level from Northeast to Northwest as the storm progressed, but no substantial thermodynamic boundaries. A second supercell thunderstorm targeted on 27 May 2019 showed a thermodynamic boundary and marked wind shift from East to Northwest in the lowest 300 m as seen in figures 5 and 6. No distinct SVC was shown by the trajectories in either case.

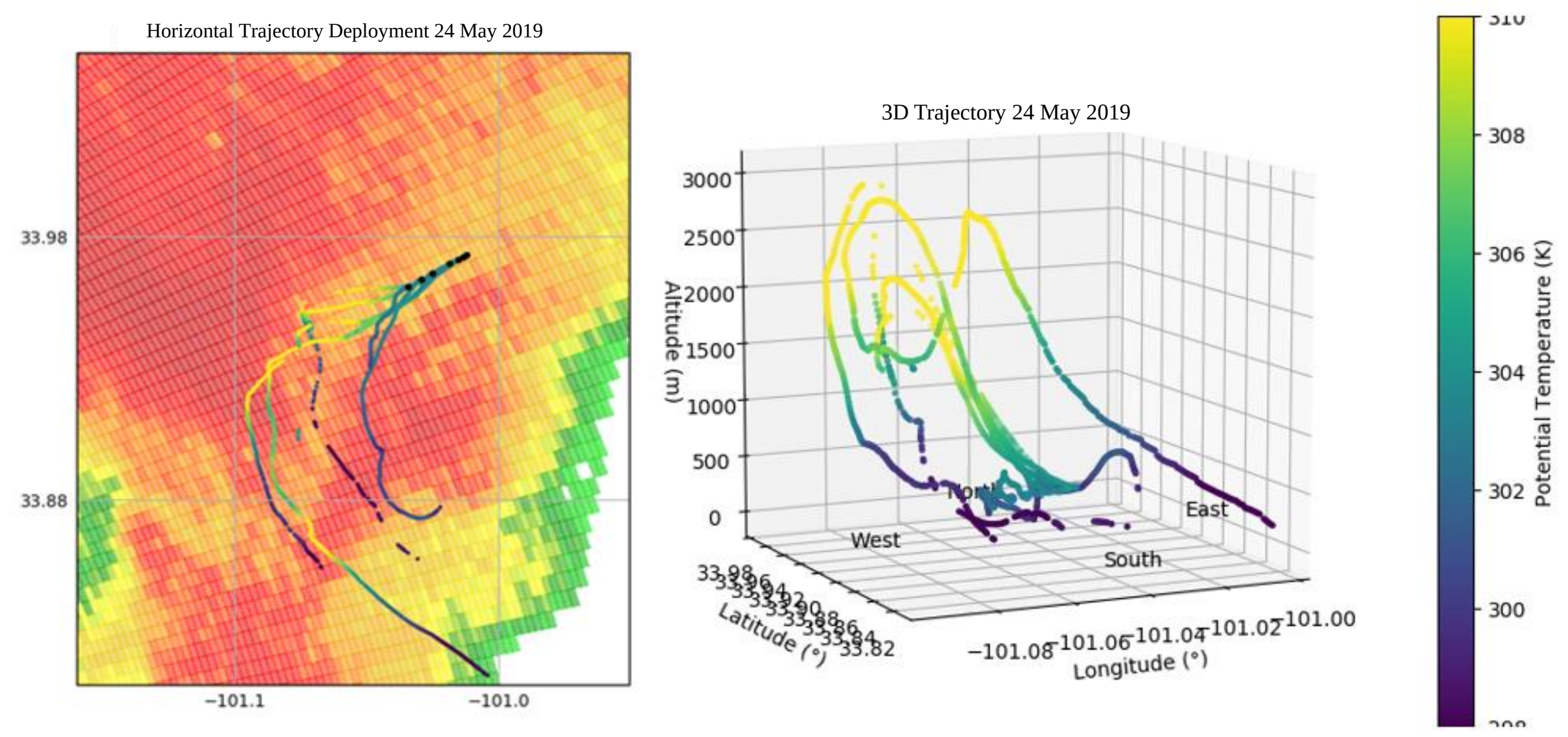


Figure 3: Thermodynamic trajectories for the 24 May 2019 deployment, potential temperature (K) is traced over the KLBB NEXRAD reflectivity in 2D and potential temperature (K) is traced in 3D

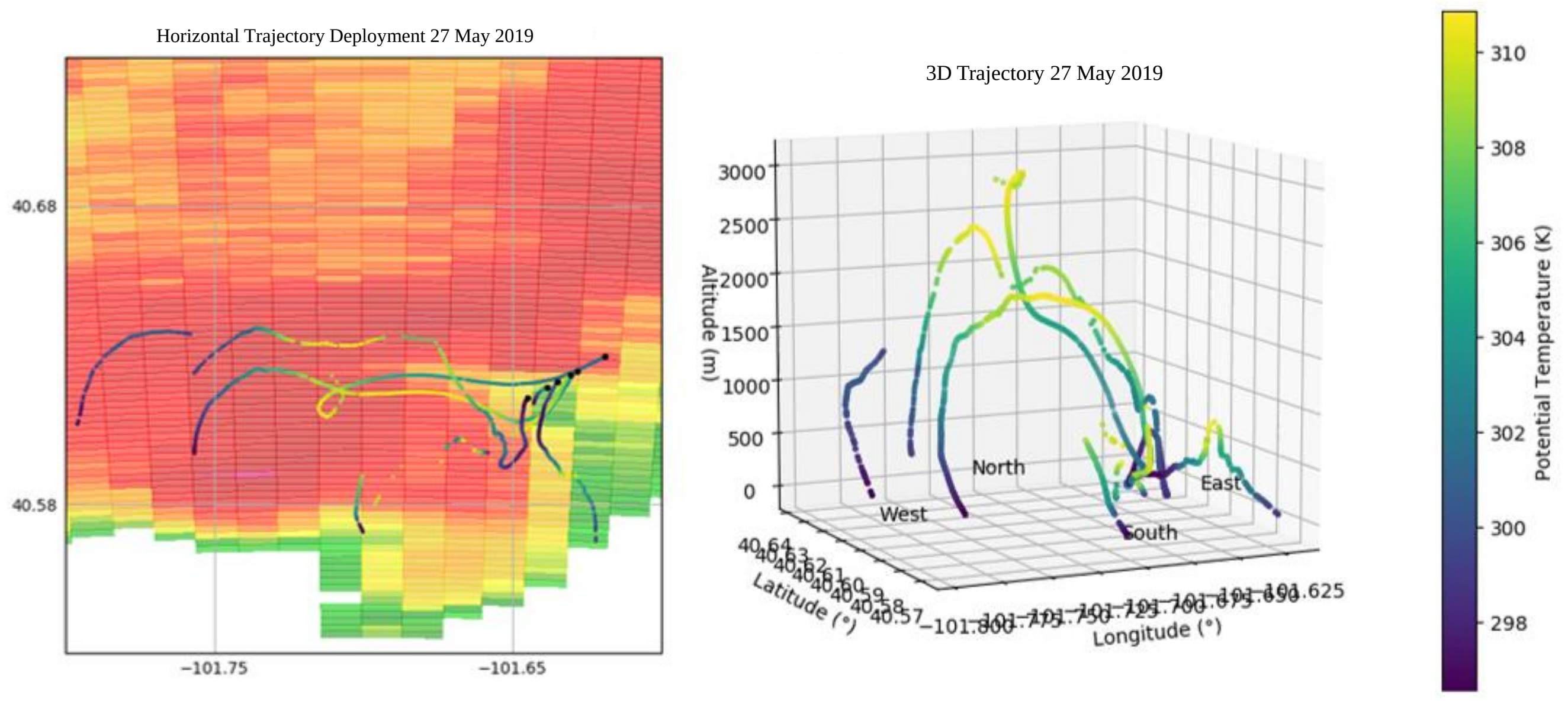


Figure 5: Thermodynamic trajectories for the 27 May 2019 deployment, potential temperature (K) is traced over the KGLD NEXRAD reflectivity in 2D and potential temperature (K) is traced in 3D

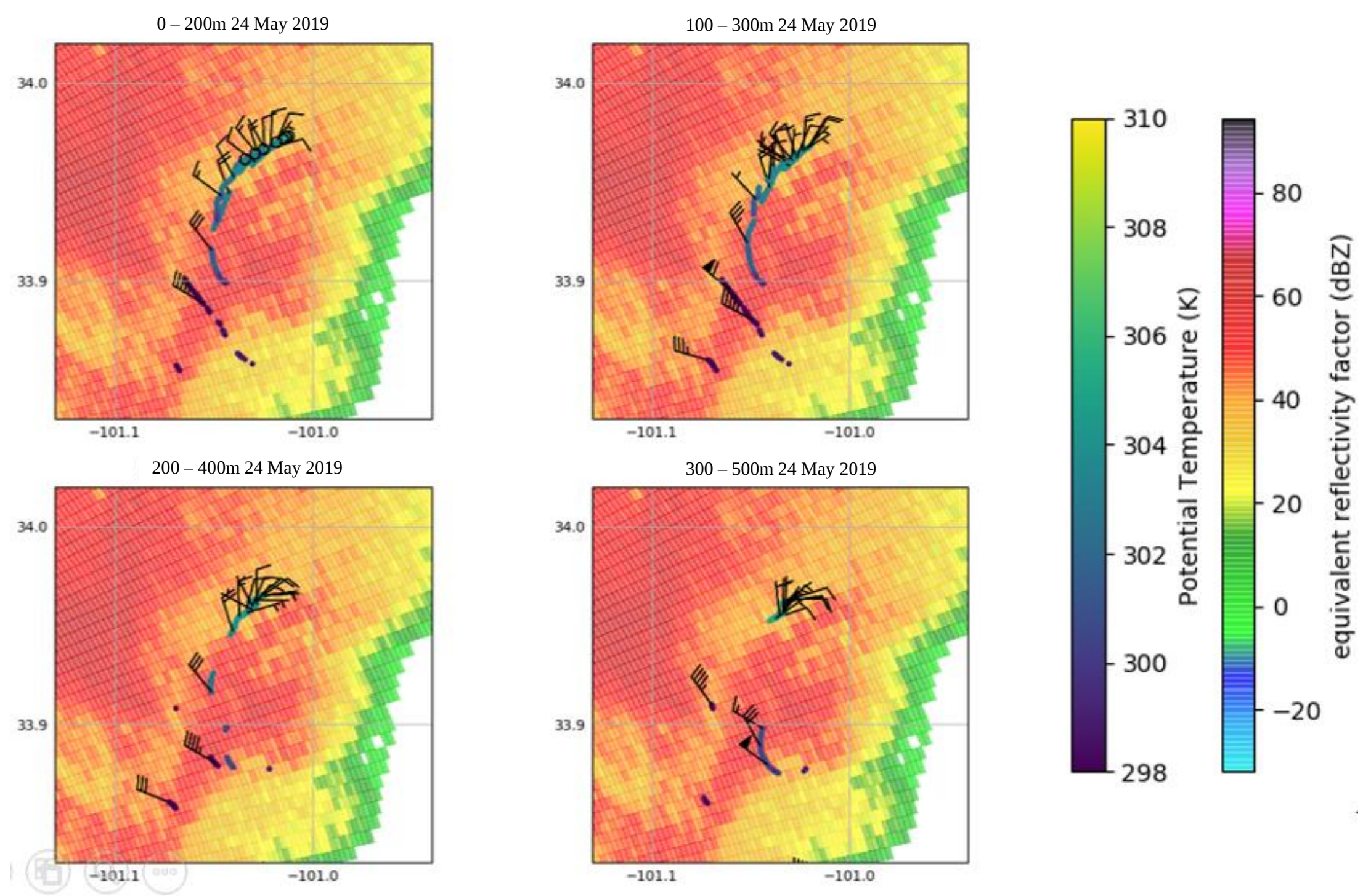


Figure 4: Potential temperature (K) and wind observations (kts) for the 24 May 2019 deployment traced over KLBB NEXRAD reflectivity at quasi horizontal levels

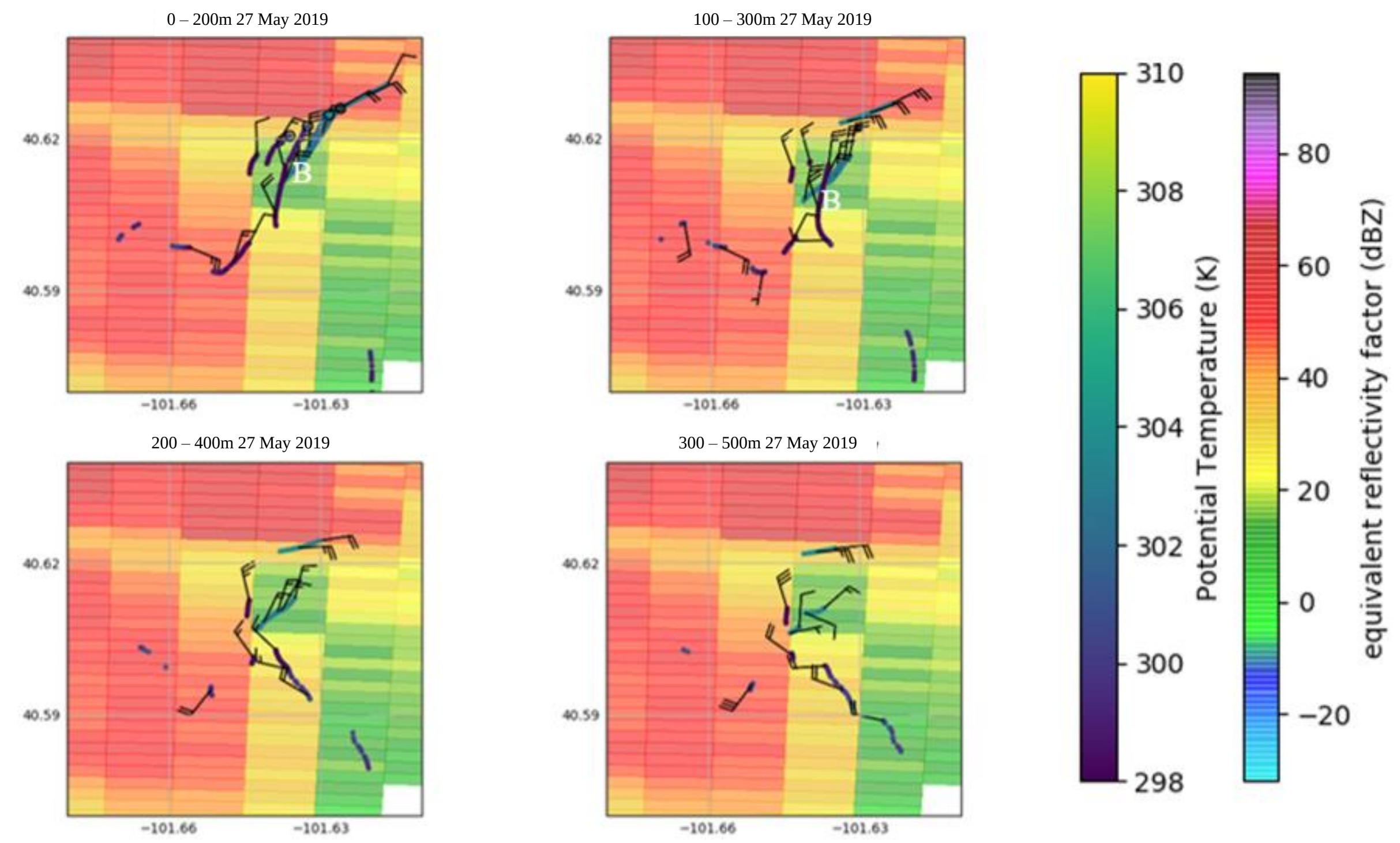


Figure 6: Potential temperature (K) and wind observations (kts) for the 27 May 2019 deployment traced over KGLD NEXRAD reflectivity at quasi horizontal levels. The white "B" denotes a thermodynamic boundary identified by the data.

Conclusions

- Windsondes are comparable to radiosondes and better in some aspects including data frequency, cost, and portability
- There are still a few issues to be resolved regarding connectivity between the windsondes and receivers
- Deployments of Windsondes are effective in analyzing near storm environments, especially in the lowest 1,000 – 2,000 m
- Storm-scale thermodynamic boundaries are visible from windsond observations

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