P928

# Tornadic Mesocyclone Wind Retrievals From Radar Observations

Qin Xu, *NOAA/National Severe Storms Laboratory, Norman, Oklahoma*

Li Wei and Kang Nai, *Cooperative Institute for Mesoscale Meteorological Studies, University of Oklahoma*

## 1. Introduction

A varational method is developed to retrieve 3D vortex winds of tornadic mesocyclones from radar observations. This method has the following features: (i) The vortex center is estimated as a continuous function of ($z$, $t$) in the 4D space from radar observations. (ii) The retrieval domain is co-centered and moving with the slantwise vortex core at each vertical level. (iii) Vortex-flow-dependent background error covariance functions are formulated with the mass continuity equation and boundary conditions satisfied automatically. The method has been applied to observations from the operational KTLX and TOKC radars as well as NSSL phased-array radar for the tornadic mesocyclone that struck Moore in Oklahoma on 20 May 2013. The results are presented below.

## 2. Estimation of vortex center location as a function of ($z$, $t$)

When a mesocyclone is detected as a by-product of the velocity dealiasing (Xu et al. 2013, *Advances in Meteorology*), its vortex center location is estimated on each tilt of radar scan. The vortex center location and movement are then estimated as functions of ($z$, $t$) in four-dimensional space (Xu et al. 2015, *37th Conference on Radar Meteorology*, 14A.2). As revealed by the estimated vortex center in Fig. 1 for the 20 May 2013 Oklahoma Moore tornadic mesocyclone, the vortex core became increasingly vertical as the vortex moved toward Moore.

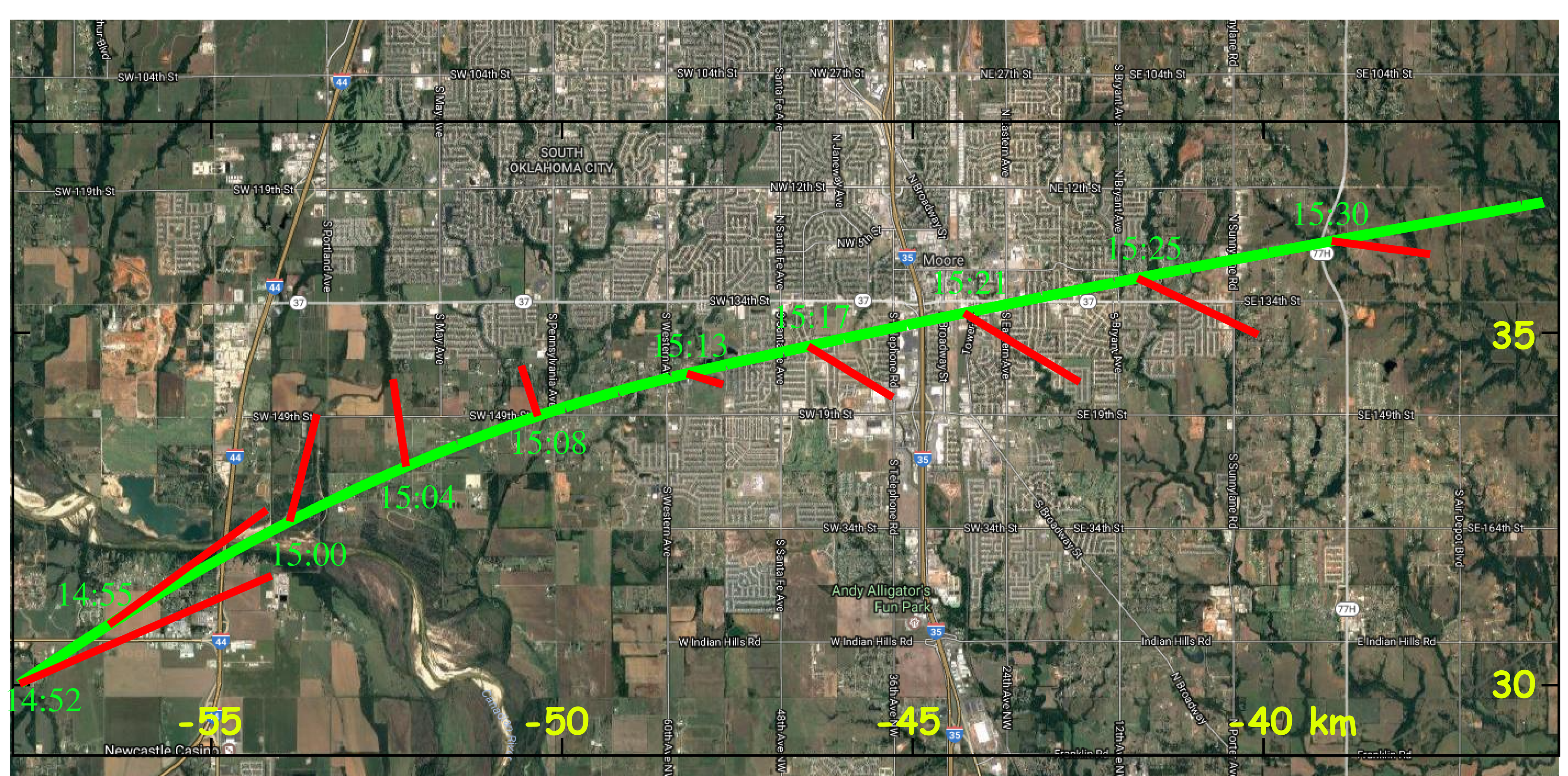


Fig. 1. Vortex center track at surface level ($z$ = 0) plotted by green curve with local times marked in green. The red line at each marked local time shows the shift of vortex center with height from $z$ = 0 to 5 km. The ($x$, $y$) coordinates (labeled in yellow) are centered at the KTLX radar site.

## 3. Varational method for vortex wind retrieval

The method is a 3D extension of the 2D method of (Xu et al. 2015, *Wea. Forecasting*). By using the tangential velocity $v_t$ and vertical-circulation streamfunction $\psi_v$ (or horizontal streamfunction $\psi_h$ and vertically integrated velocity potential $\int_0^z \chi dz'$) as the control variables for the axisymmetric (or asymmetric) part of the vortex flow, the analysis satisfies the mass continuity equation automatically. The 2D vortex-flow-dependent background error covariance functions are extended into 3D with the vertical correlation functions formulated for $\psi_v$ (or $\int_0^z \chi dz'$) to satisfy the surface boundary condition automatically.

## 4. Results

For the case in Fig. 1, the 3D vortex winds retrieved for three time periods in Fig. 2 reveal highly curved areas of strong updraft and downdraft around the slantwise vortex core. As the vortex core became increasingly vertical, the vortex became increasingly intense with the surface wind speed exceeded 65 m/s (not shown) in the 1 km vicinity southeast of vortex center.

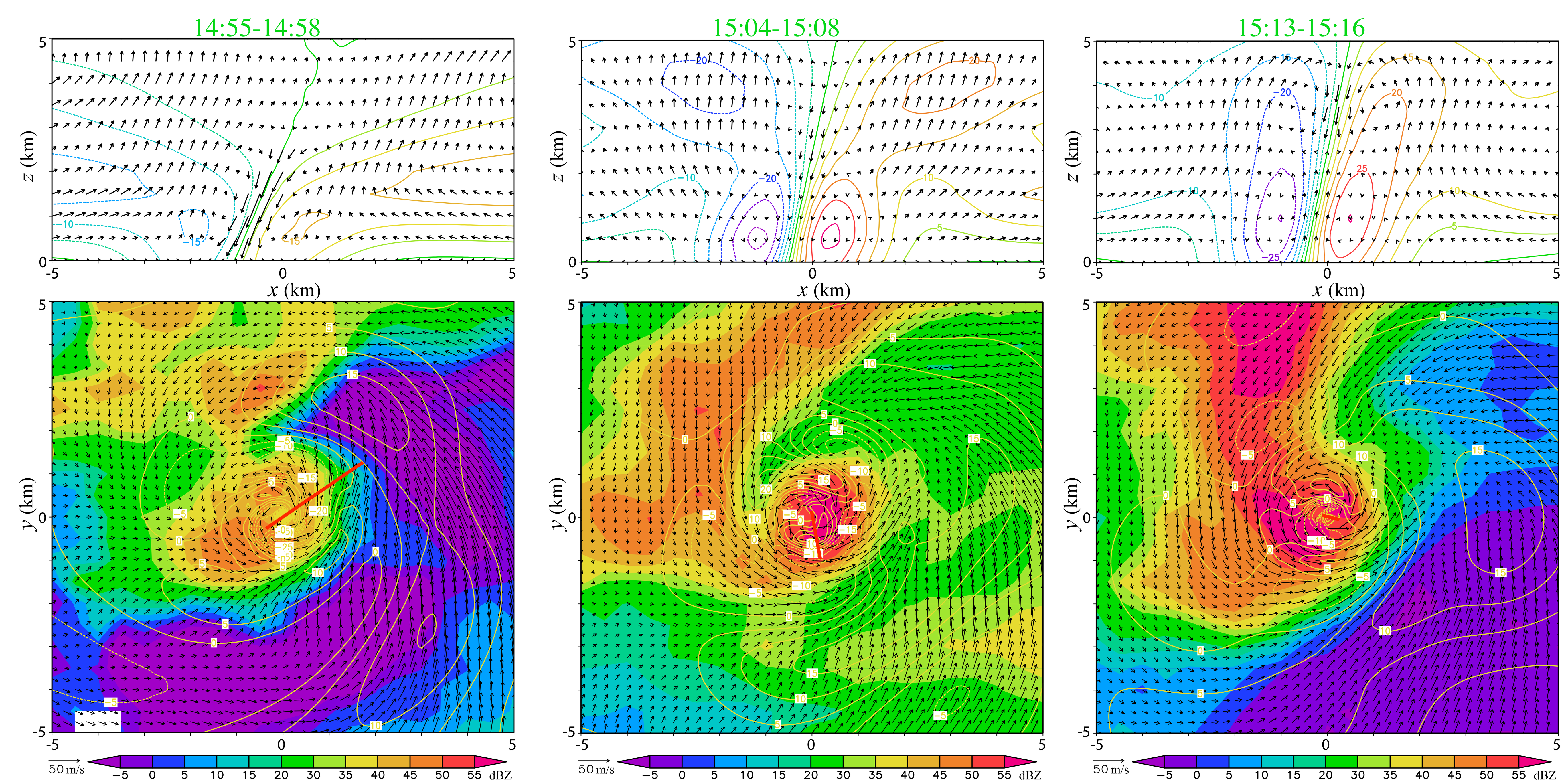


Fig. 2. Retrieved vortex winds for local time periods of 14:55-14:58, 15:04-15:08, and 15:13-15:16 plotted in the left, central and right column, respectively. In each column, the upper panel shows the vertical cross-section (along the slantwise vortex core shown by red line in the lower panel also in Fig. 1) for the axisymmetric part of vortex wind with vertical circulation plotted by arrows and tangential velocity plotted by contours of every 5 m/s, while the lower panel shows the horizontal cross-section at $z$ = 1 km for the total vortex wind with horizontal velocity plotted by arrows and vertical velocity plotted by contours of every 5 m/s superimposed on color shaded reflectivity.