13 May 2010 Severe Bow Echo Event over Northeast Oklahoma

Part 2: Characteristics of the Reflectivity – Doppler velocity Patterns and Mesovortex Evolution

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During the early morning of 13 May 2010 a large bow echo with several embedded mesovortices rapidly moved across parts of central and northeast Oklahoma. The bowing system was responsible for producing 11 meso-mesovortices, 6 of which were tornadic. A total of 12 tornadoes occurred with damage intensity ranged from EF0 – EF2. Extensive damage assessment was conducted by the WCM and several staff members. from WFO Tulsa

A surface boundary from earlier convection extended from northeast Oklahoma through the north-central part of the bow. A solid line echo bowing pattern was present north of the intersection, while a fragmented reflectivity pattern existed of the intersection to near the bow apex. South of apex the leading convective line was nearly absent.

Several long-lived mesovortices formed between the bow-apex northward to the intersection of the convective line – surface boundary. Their path lengths ranged from 110 to 255 km. North of the surface boundary mesovortex path lengths were much shorter with ranges from 19 to 47 km.

Rotational Velocity (Vr) time-height traces were constructed for both KINX (Tulsa WSR-88D) and TTUL (Tulsa Terminal Doppler radar). Comparisons of Vr values throughout the vortex column were made to determine vortex characteristics preceding and during the time of tornado occurrence.

Objectives of this study include: 1) examine the ambient shear –system cold pool relationship, 2) why long-lived mesovortices occurred in this case, 3) why many of the EF2 tornadoes occurred near and south of the surface boundary, and 4) what if any relationship existed between mesovortex strengthening at low levels and vortex deepening compared to the time of tornado occurrence

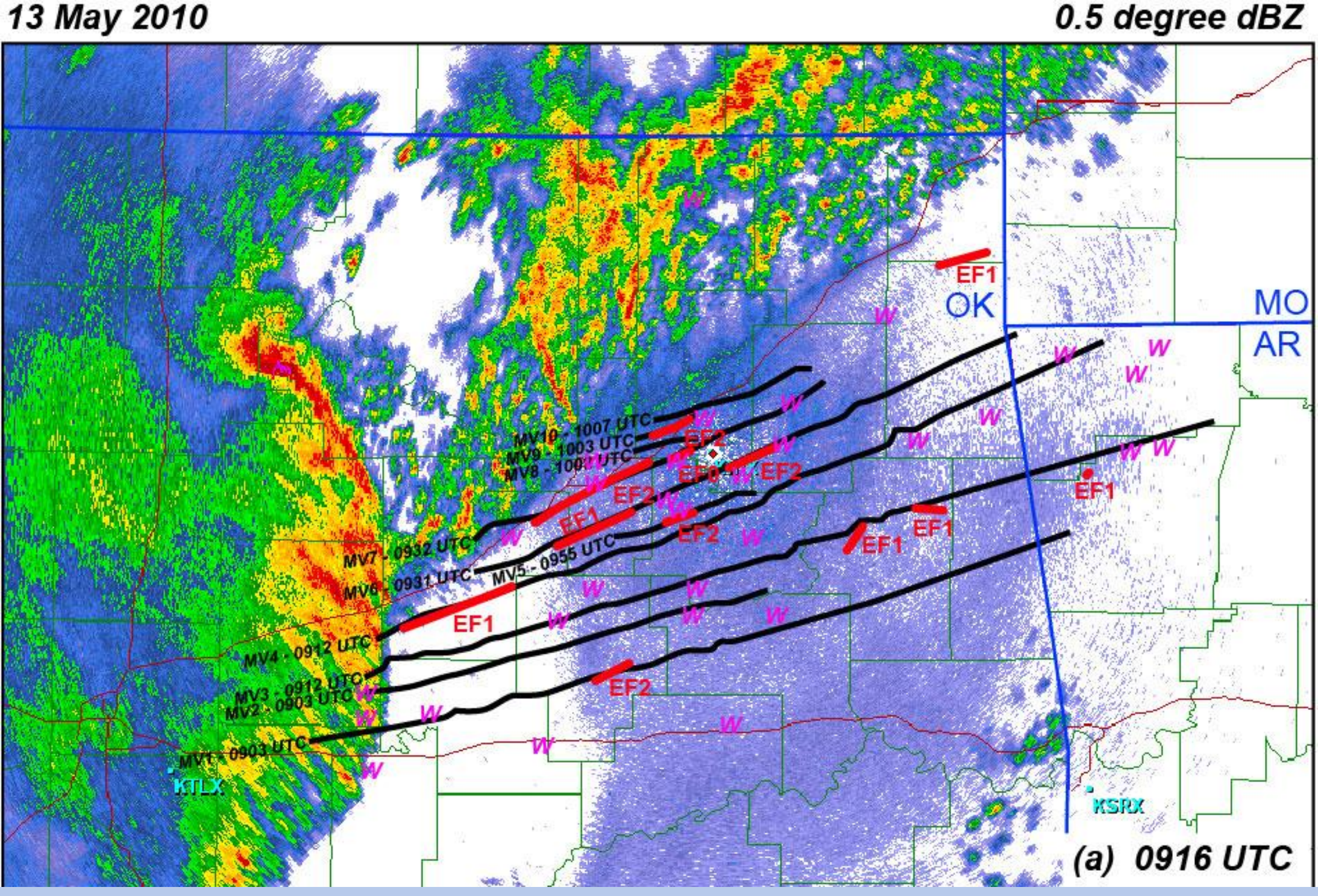

Fig. 1. Reflectivity image at 0.5 slice from KINX with mesovortices overlaid.

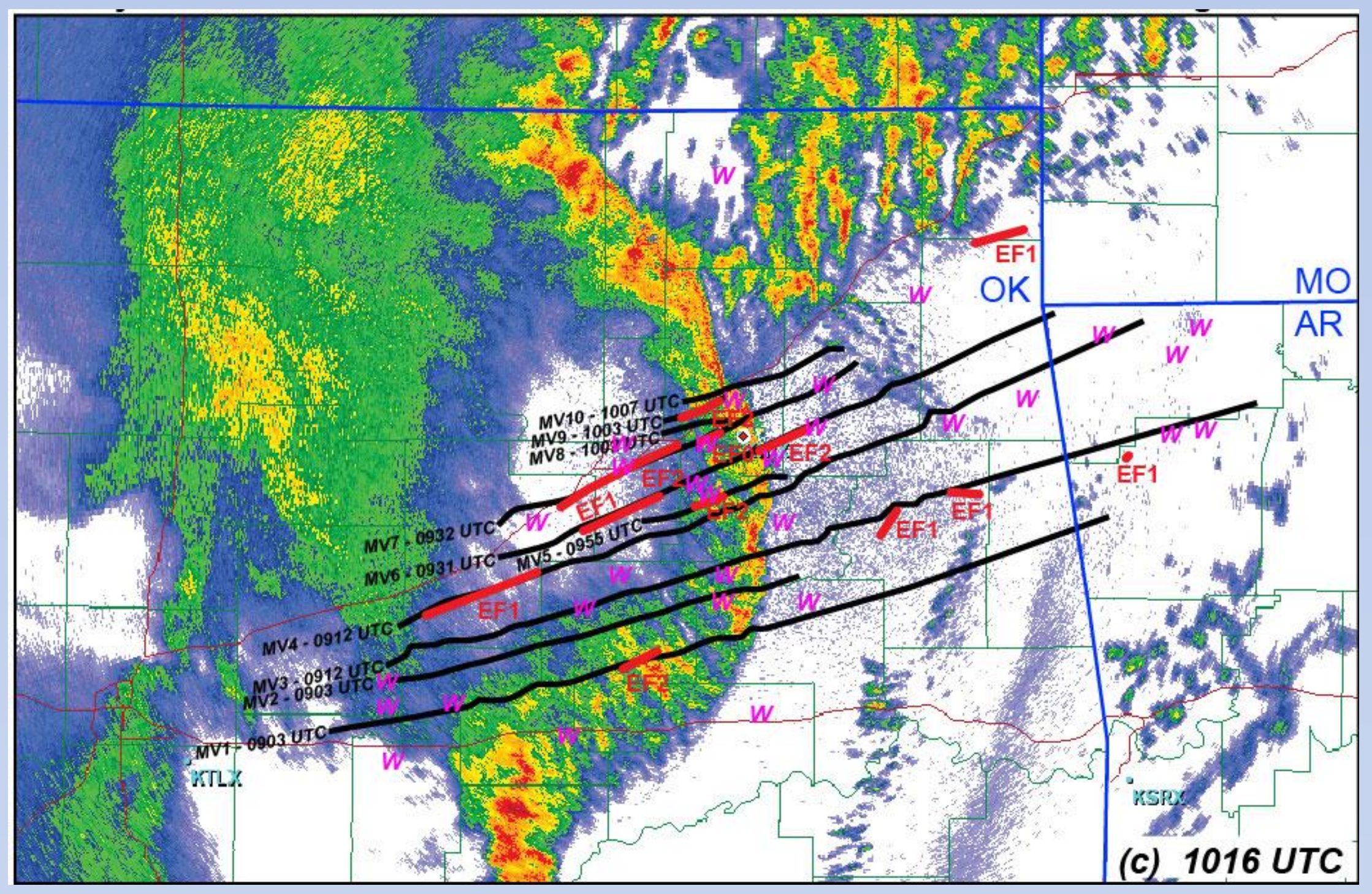

Fig.2. Same as Figure 1 except for 1016 UTC

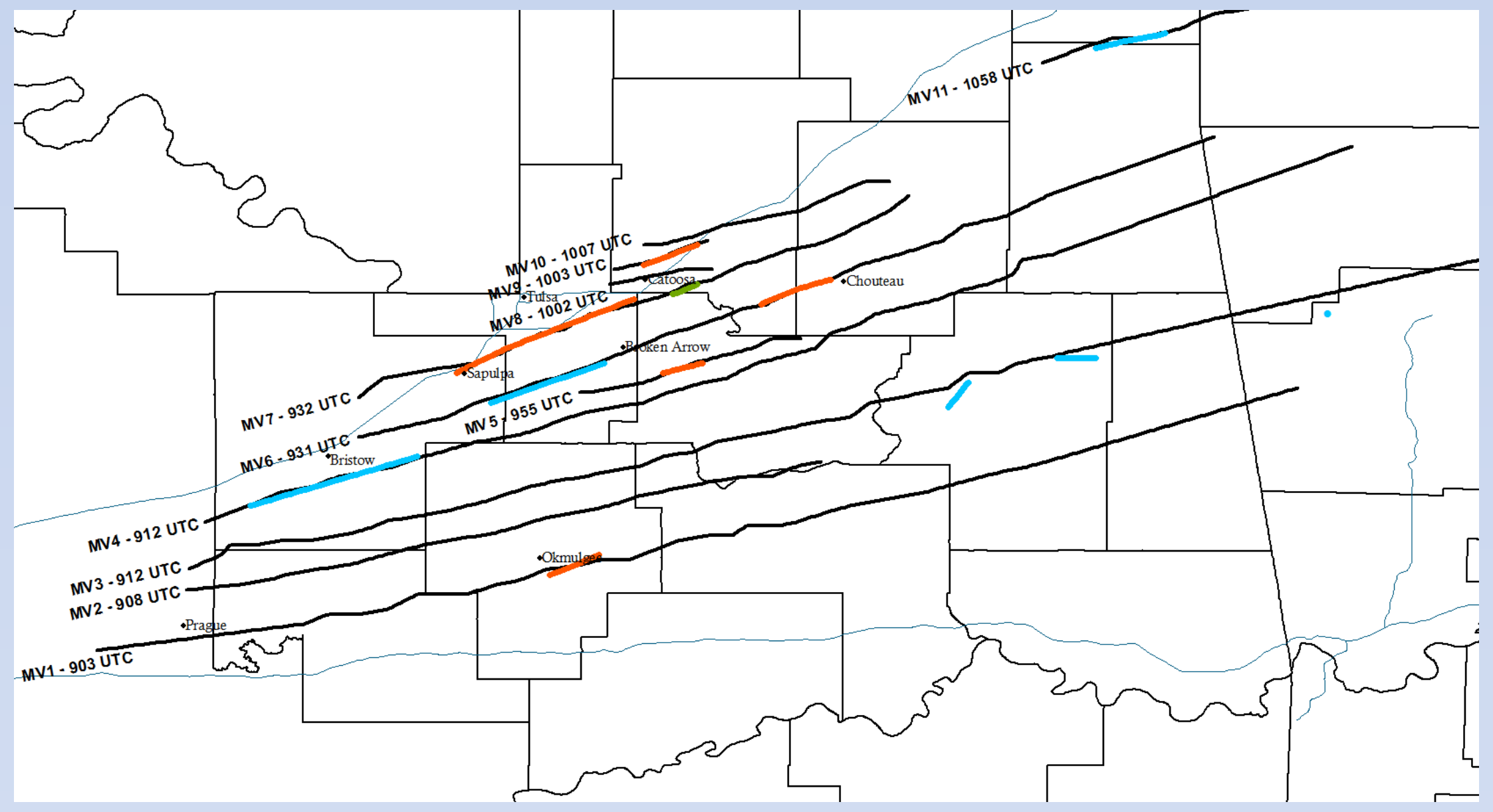

Fig .3. Mesovortex and tornado track overlaid. Red signifies EF2 damage, Blue denotes EF1 damage.

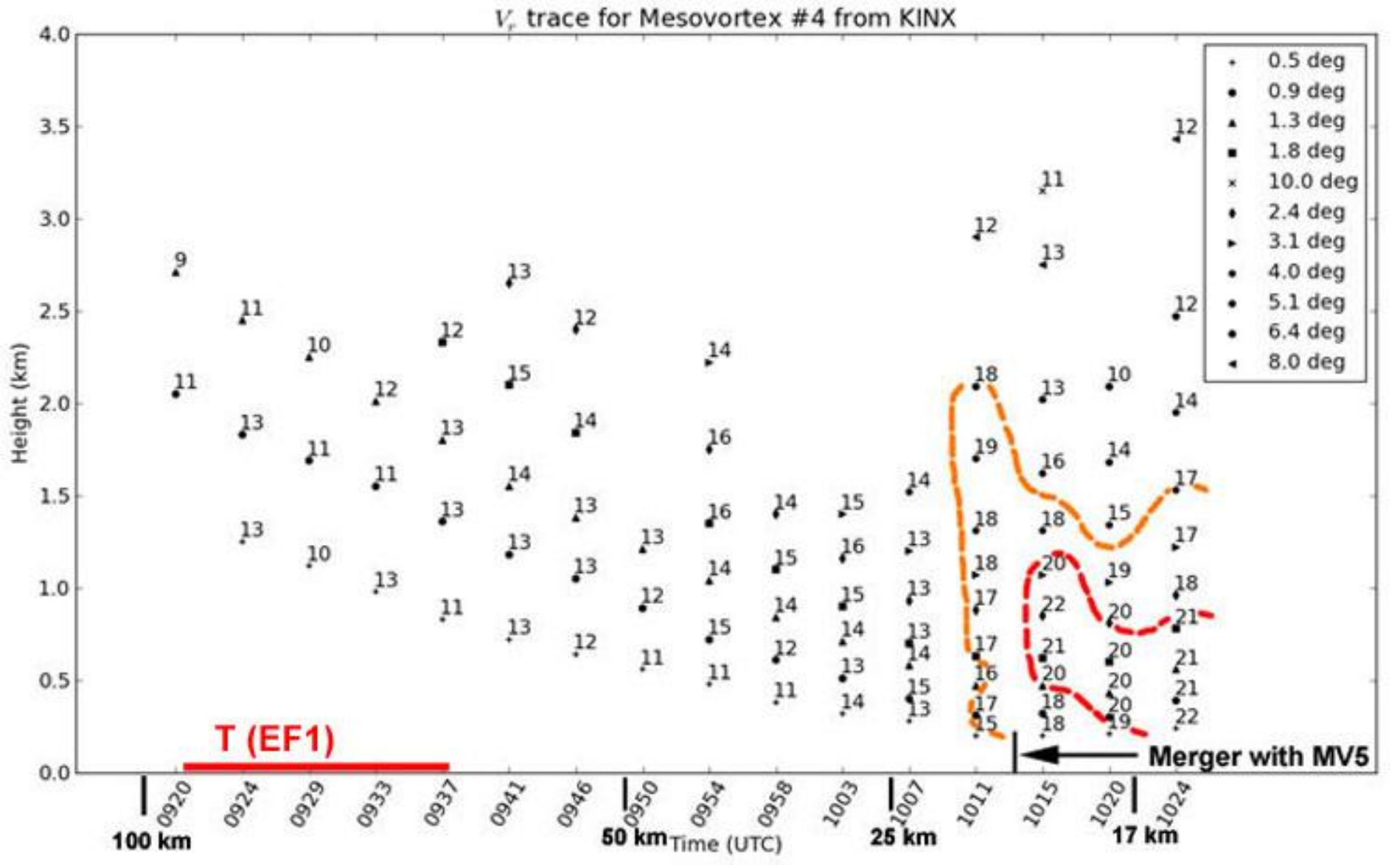

Fig. 5 Rotational Velocity (Vr) time-height trace for tornadic MV4. Magnitudes of Vr are in m s-1.

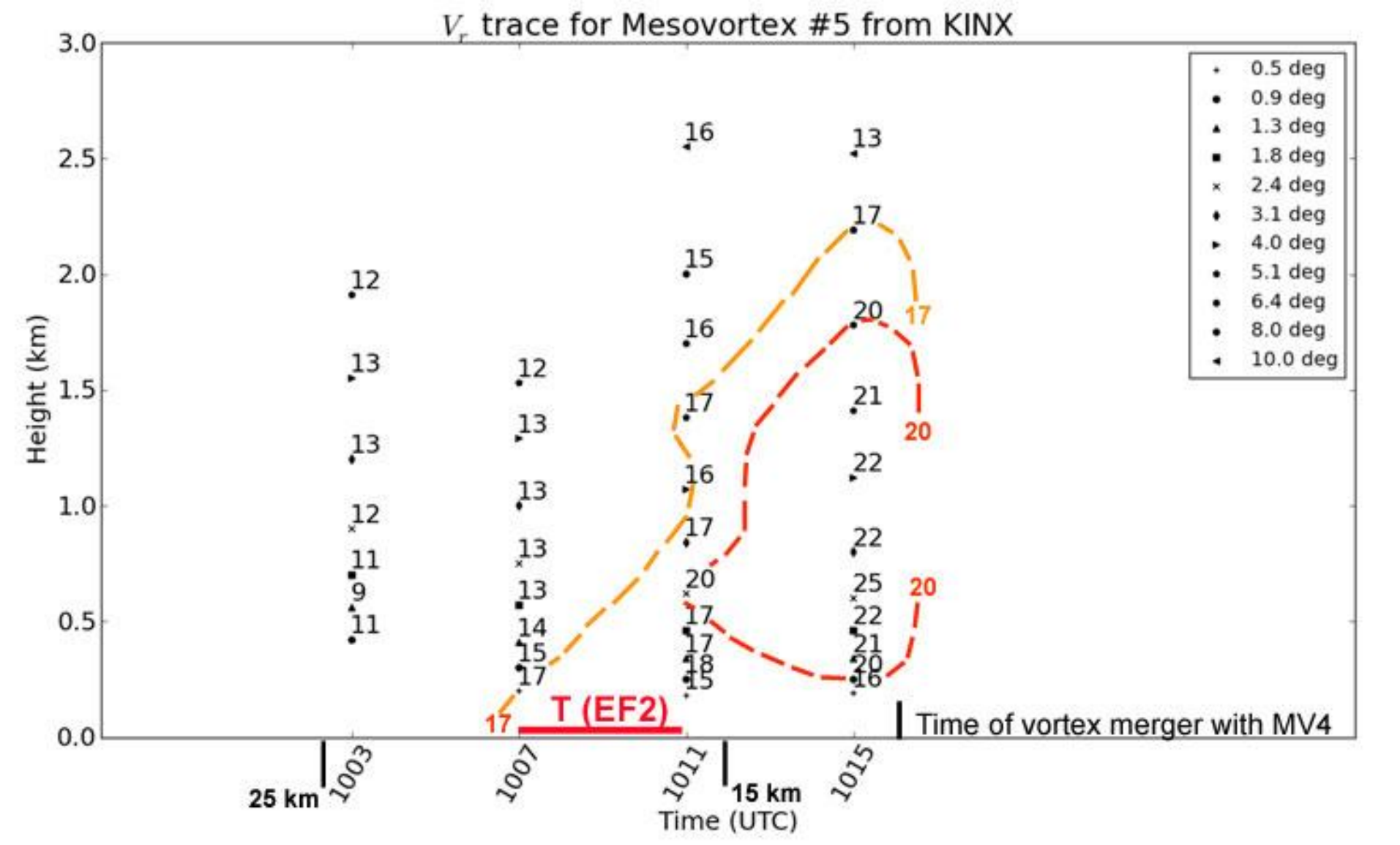

Fig. 6. Same as Fig 5 except for MV5. Note that MV5 merges with MV4

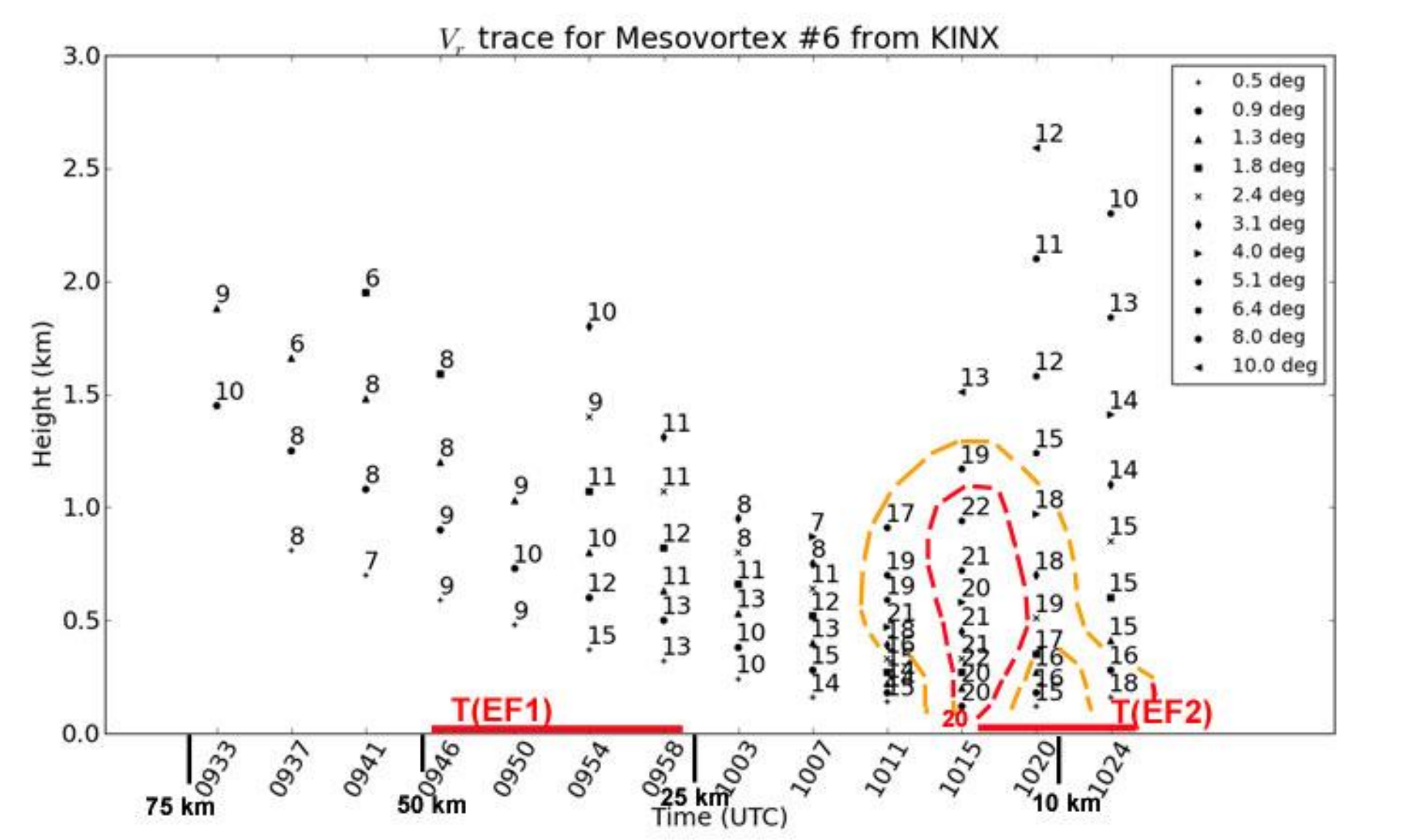

Fig. 7. Same as Fig. 5 ecept for MV6. Vortex mergers were absent

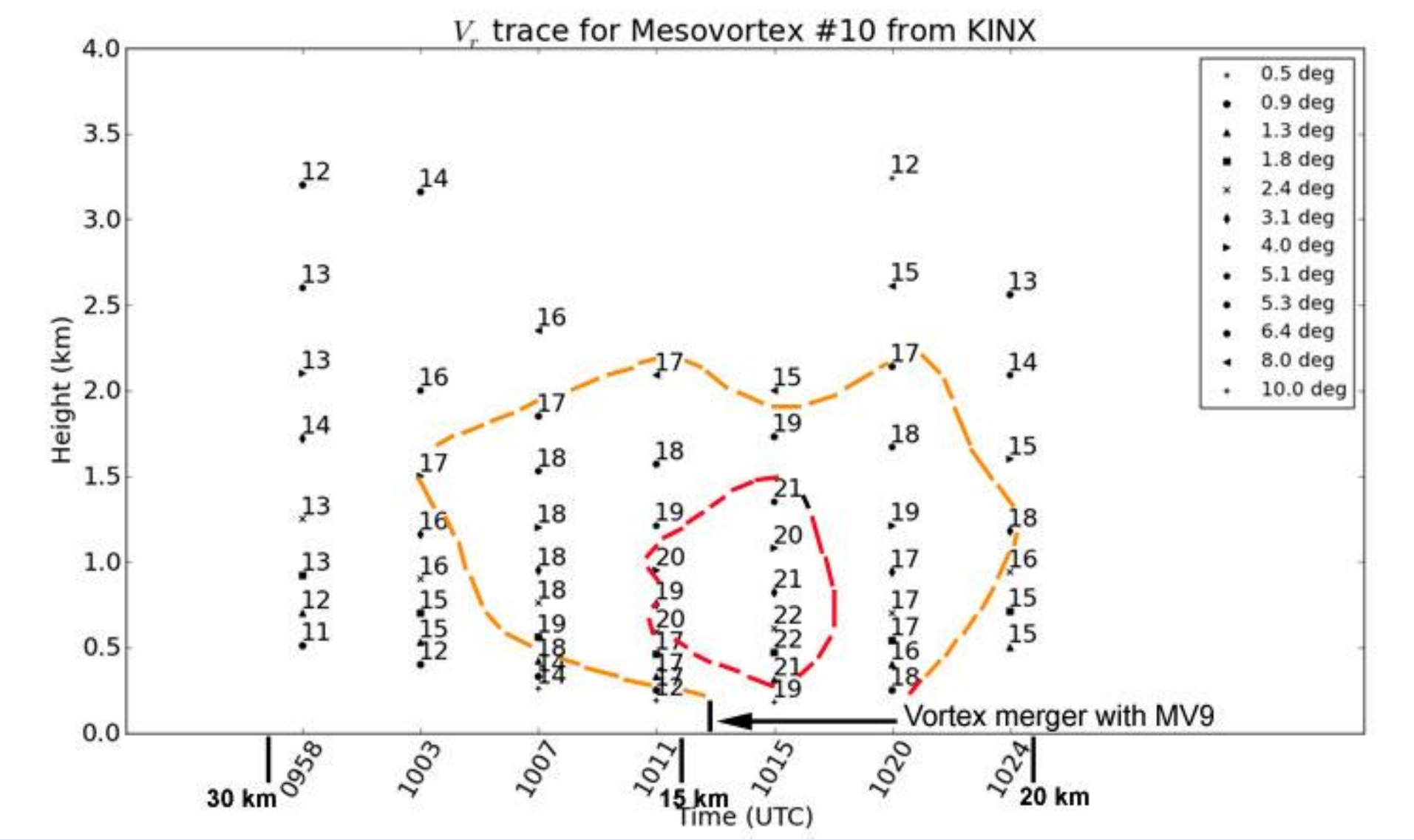

Fig 8. Same as Fig.5 except for MV10. MV9 mergers with MV10.

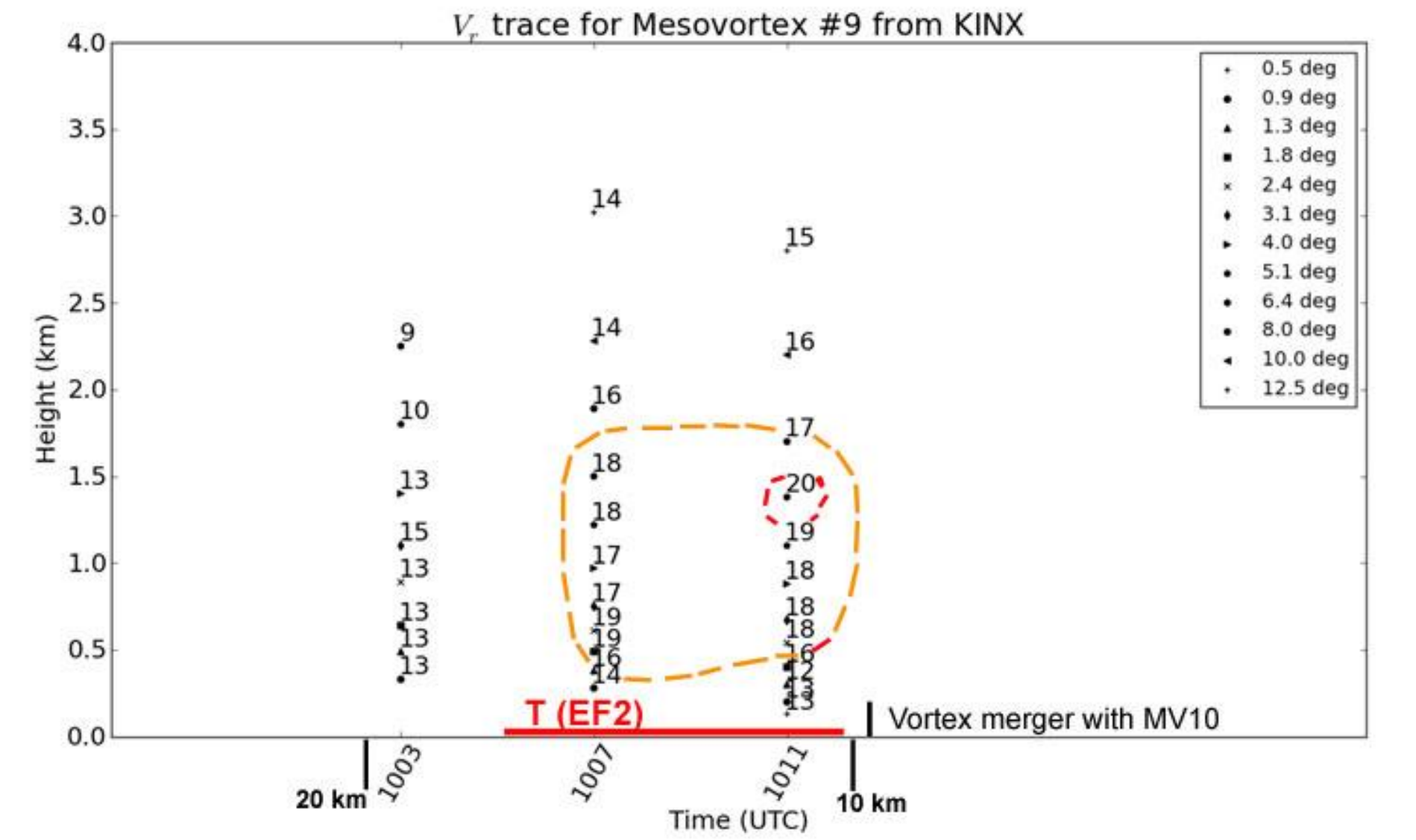

Fig. 9. Same as Fig 5a except for MV9. MV9 merges with MV10.

Preliminary findings include:

● The long-lived mesovorticies which formed from near the apex of the bow to the intersection of the surface boundary – convective line appeared to be the result of a **near balance between the ambient shear** (downshear of the convective line) and **system cold pool**. Strong low-level reflectivity gradients were present along the leading edge over this part of the line. The 0-3 km shear vectors were nearly line normal near the intersection with bulk shear magnitudes exceeded 15 m s-1. North of the apex of the bow the 0-3 km shear vectors were oriented 45 degrees from the convective line. Since shear vector magnitudes were exceeded 15 m s-1 (e.g. 20 m s-1) the contribution from the ambient shear was sufficient for mesovortex development.

● South and southwest of the apex of the bow – reflectivity towers trailed the leading gust front suggesting that the **system cold pool overwhelmed the environmental shear**. The 0-3 km shear vectors were nearly parallel to the convective line. Mesovortices were not identified over this part of the line.

● Near and just south of the surface boundary, both tornadic and non-tornadic mesovortices had significantly shorter lifetimes compared to their counterparts further south to the apex of the bow. The shallow -stable layer in the vicinity and north of the boundary may have played a role.

● There were **three mesovortex merg**ers (MV4-MV5); (MV7-MV8); and (MV9-MV10). In two of the three merger tornadogenesis preceded the merger of the two mesovortices. There was no evidence of tornadogenesis **after mesovortex merger**. Atkins et al (2005) showed similar results with the St. Louis Bow Echo event during the BAMEX. project

Nine of the ten mesovorticies formed within the 0.5 to 2.5 km layer. The exception was MV10 in which the initial vortex depth was 2.7 km deep. During the early stages, the **strongest rotation** was identified within the **1.0 – 2.0 km layer.** This suggest that sampling of the strength of tornadic mesovortices will be difficult to identify at distant ranges from the radar (greater than 120 km). Tornadoes formed 3 to 12 minutes after mesovortex identification suggesting very short lead times. The second tornado (EF2 damage) with MV6 occurred eight minutes after low-level vortex intensification.

● The 13 May 2010 tornadic bow echo event was very challenging for warning forecasters. The mesoscale environment and reflectivity – Doppler velocity patterns must be closely monitored for the rapid development of severe bow echo systems.

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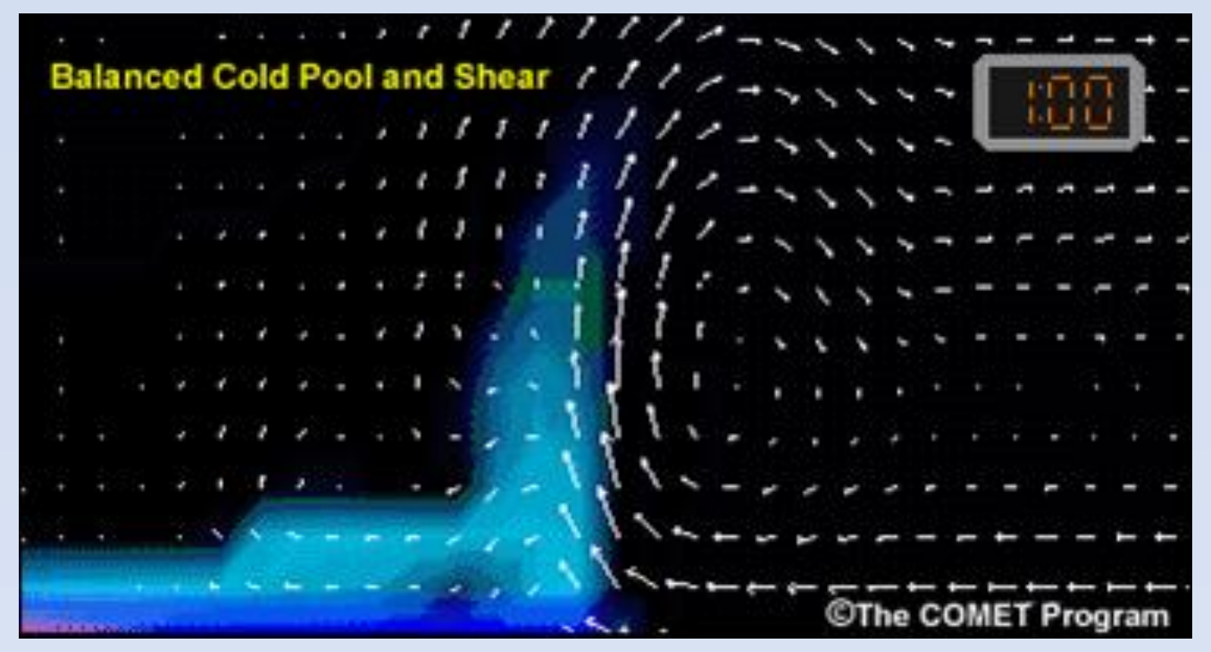

Fig. 4a. Stage 2 of Shear-Cold pool relationship. (Vertically upright convection. (After Weisman 1993).

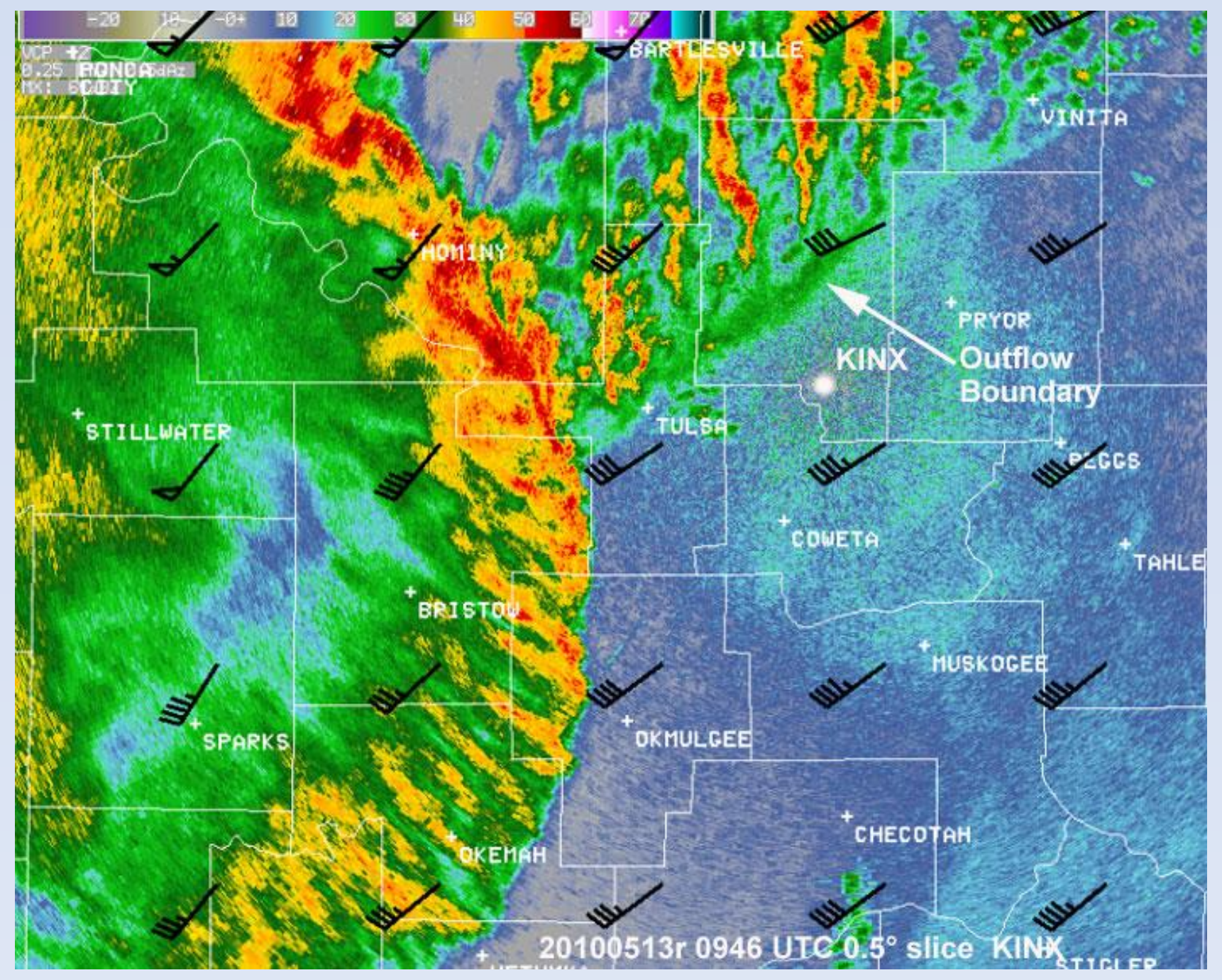

Fig.4b. Base Reflectivity image at 0946 UTC from KINX. 0-3 km Shear Vectors are overland on image.

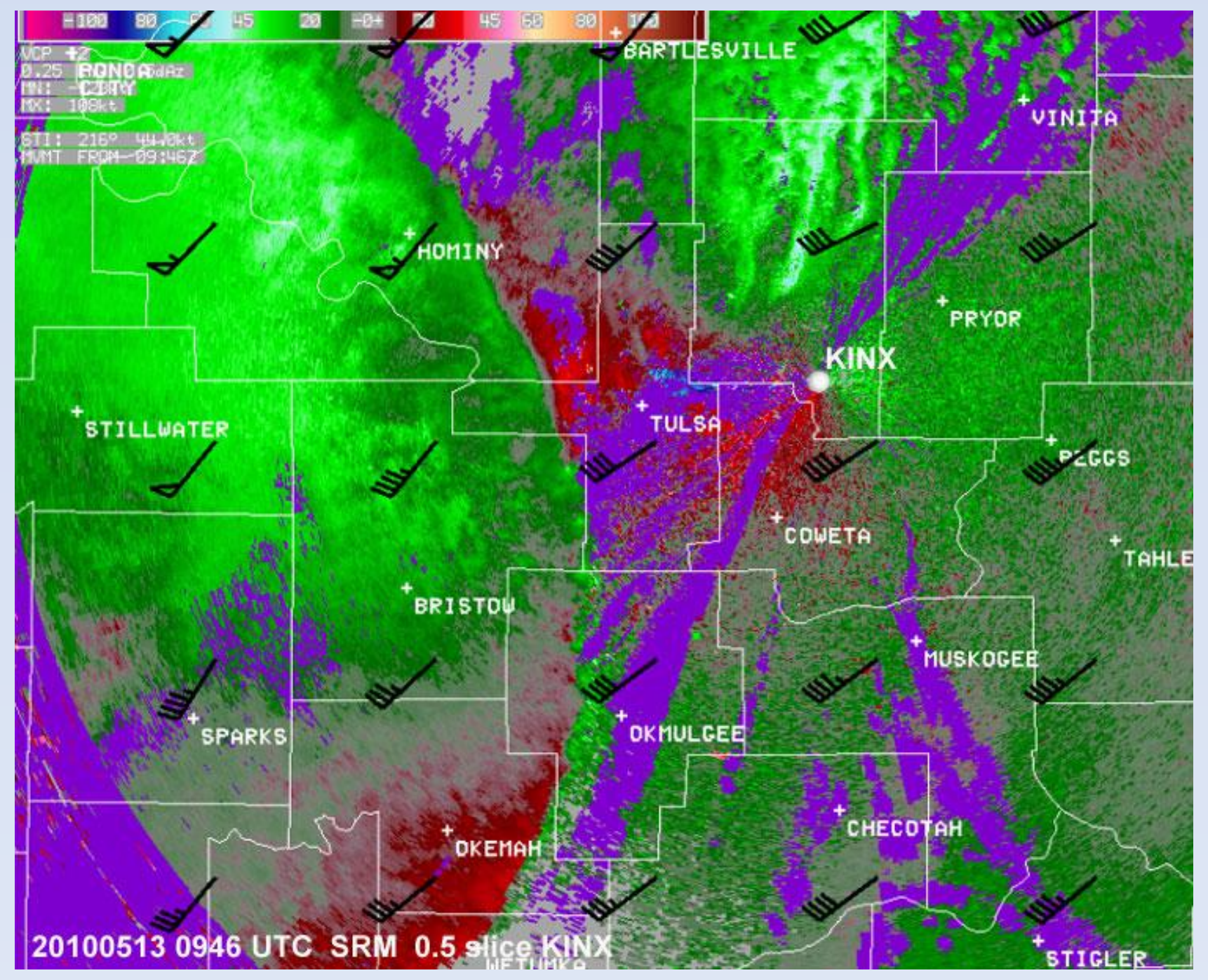

Fig 4c. Same as Figure 4a except for Storm-relative velocity data.

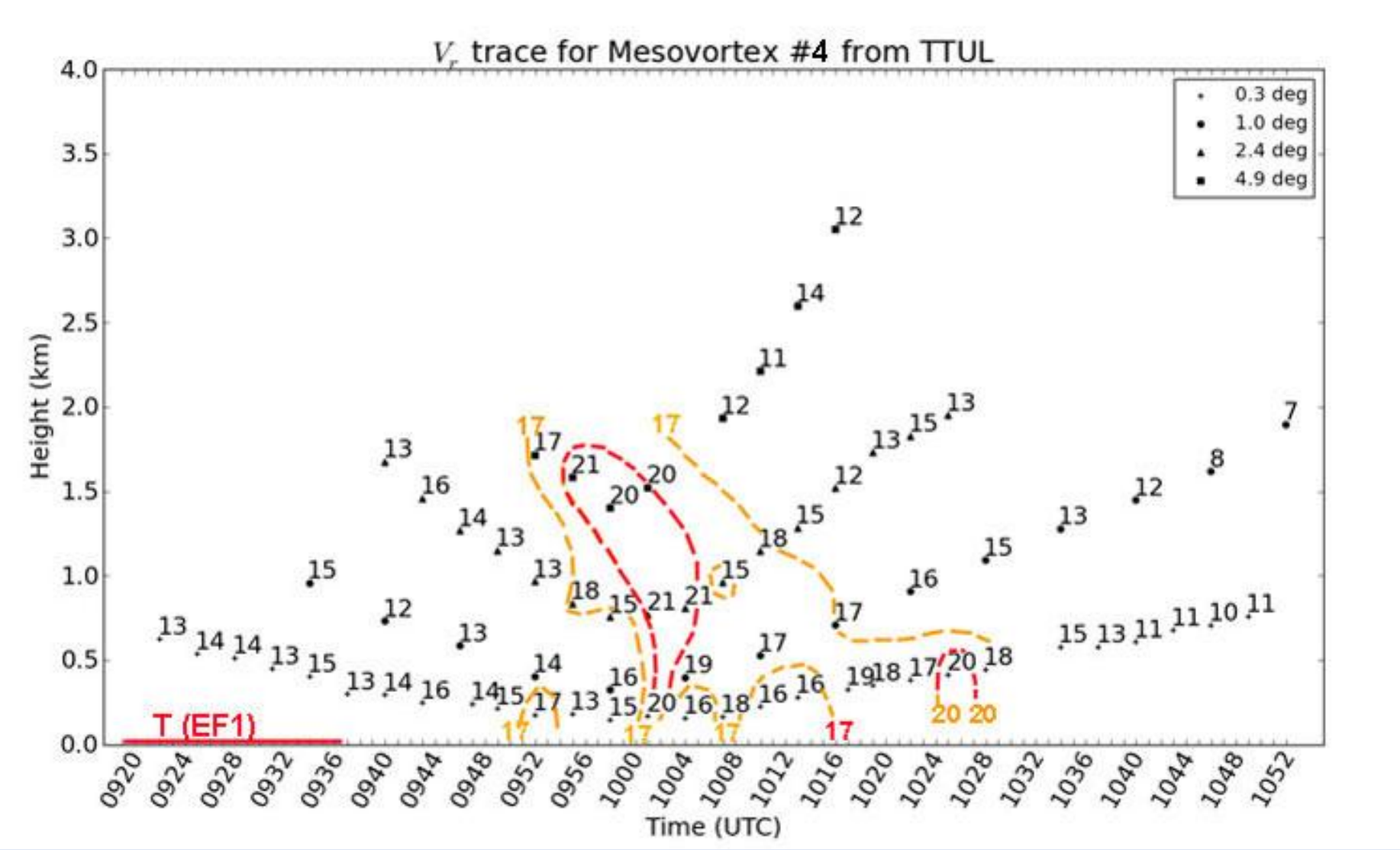

Fig. 10. Vr time – height trace of MV4 from TTUL Terminal Doppler radar.