Lightning Flashes in Alabama Tornadic Supercells on 27 April 2011

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Introduction

April 27, 2011 was arguably the day of the largest tornado outbreak in history. Most of the numerous supercells contained mesocyclones, some with very strong horizontal wind shear. All were prolific lightning producers. Between 18 UTC and 00 UTC, Vaisala, Inc. recorded 75,937 flashes.

Since current theories of lightning generation depend on hydrometer collisions or near-collisions for charge exchange, that suggests the hypothesis that powerful horizontal wind shear could have assisted in charge separation. April 27, 2011 provided a case to test.

If the hypothesis had merit, it was expected that more lightning flashes would be observed near the maximum shear area than in other cases from the scientific literature (e.g., Seimon, 1993, MacGorman and Neilson, 1991, Steiger et al., 2007)

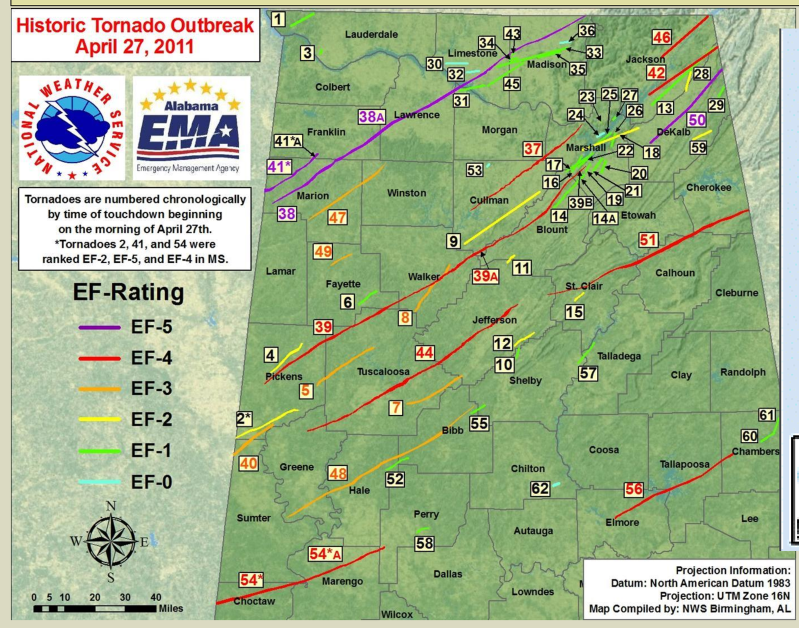


Figure 1. Tornado tracks as determined by NWS-Birmingham damage assessment teams.

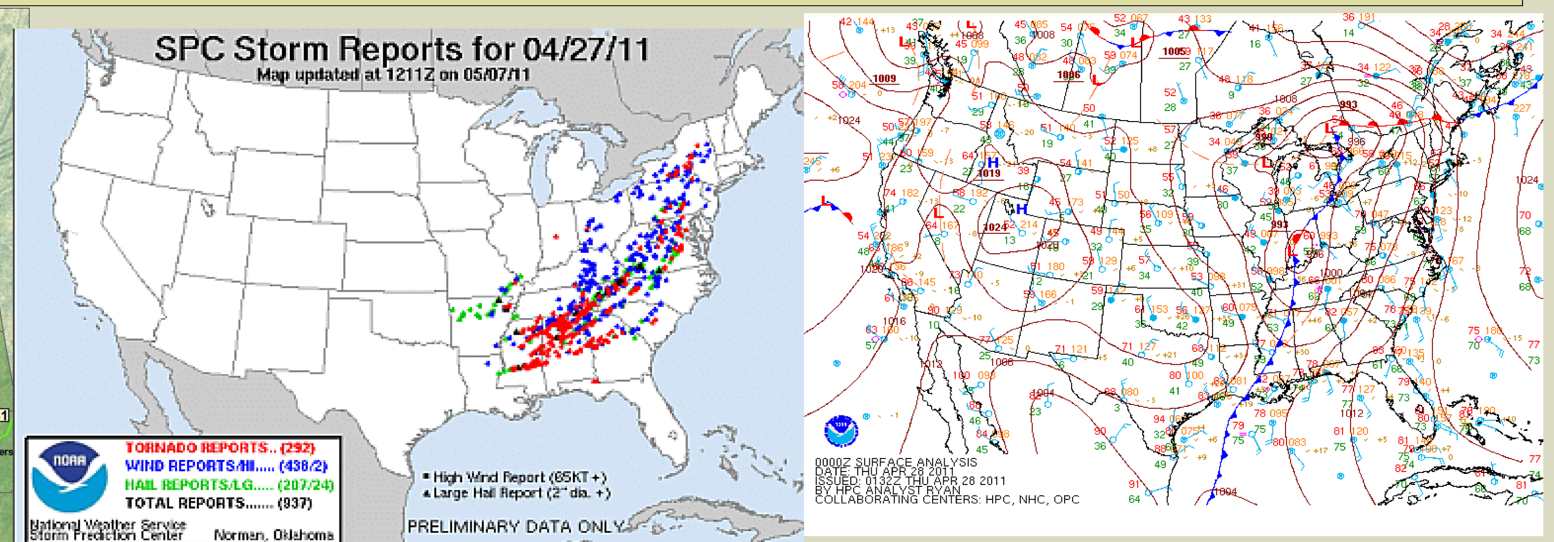


Figure 2. Preliminary severe weather reports 12 UTC April 27 to 12 UTC April 28, 2011 and MSLP map for 0000 UTC April 28, 2011.

(NOAA 2011, http://www.srh.noaa.gov/bmx/?n=event_04272011)

The goal was to study relationships between lightning flashes, reflectivity, and mesocyclone locations in this multiple supercell situation and to test the hypothesis that horizontal shear could cause lightning by increasing cloud charging.

Methods and Analysis

WSR-88D radar data of composite reflectivity and storm-relative radial velocity from the site at Birmingham, AL (KBMX) were downloaded from the National Climatic Data Center (http://www.ncdc.noaa.gov/nexradinv/). Lightning flash data from the National Lightning Detection Network, were provided by Vaisala, Inc. Unidata's Integrated Data Viewer was used to find locations of maximum reflectivity and centers of maximum radial velocity shear. Separately, the number of flashes within 10, 5, and 2 km were counted.

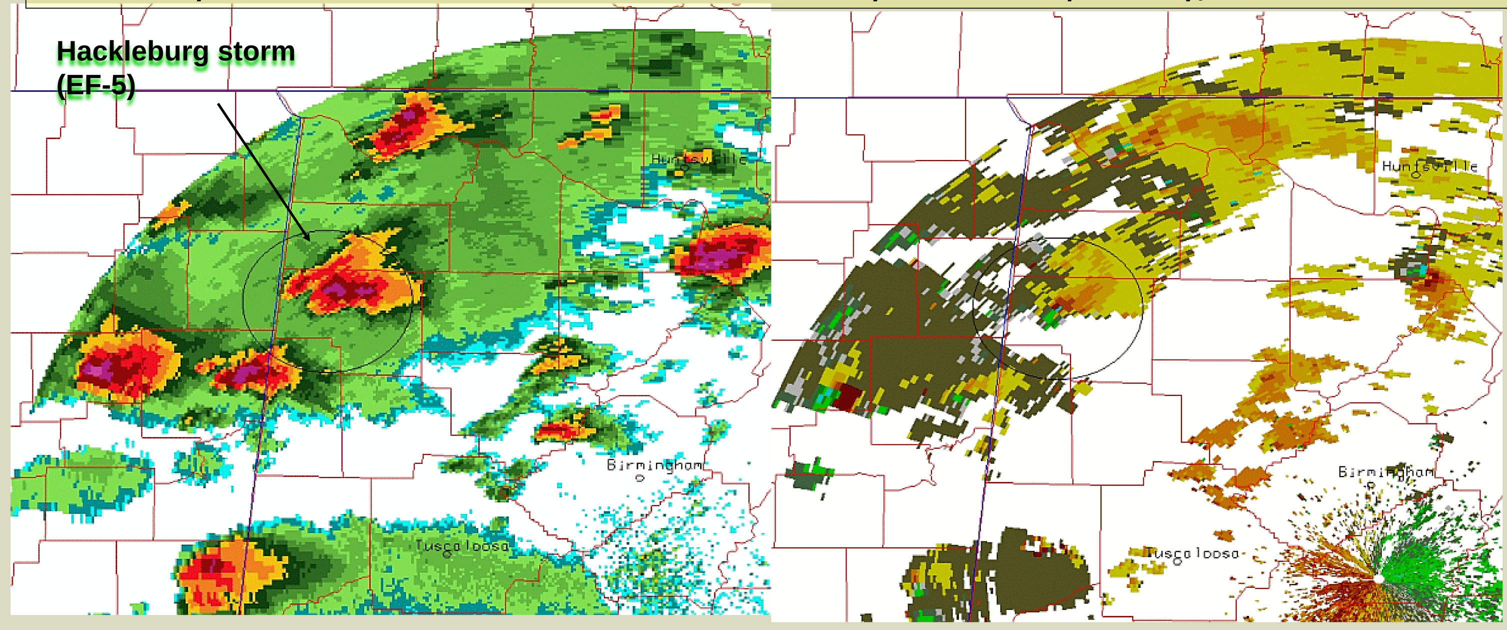


Figure 3. Examples of reflectivity and storm-relative radial velocity from KBMX, April 27, 2011 20:14:54 UTC as displayed by the Integrated Data Viewer. There are six supercells in this view, each with a mesocyclone.

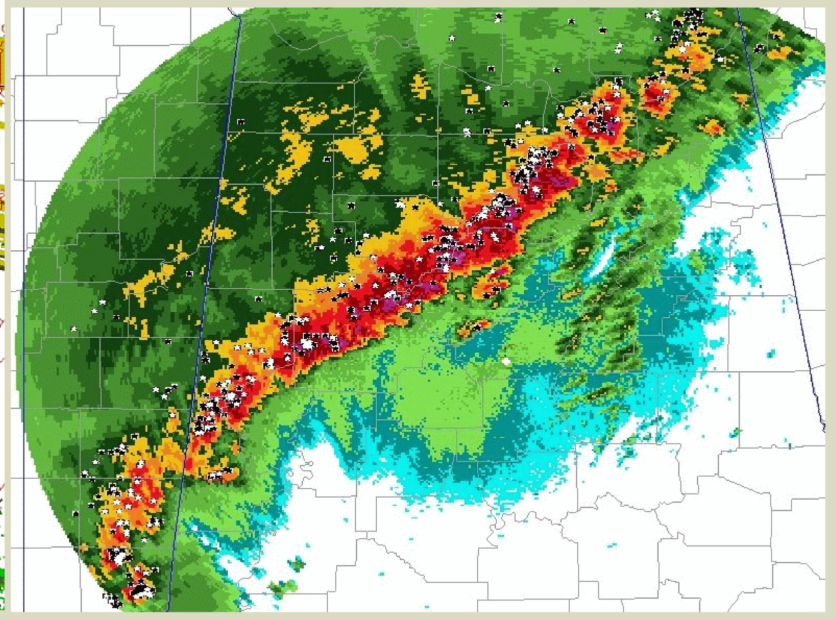


Figure 4. Comparison with an Alabama squall line case, April 04, 2011 23:56:27 UTC when Vaisala, Inc. recorded 33950 flashes.

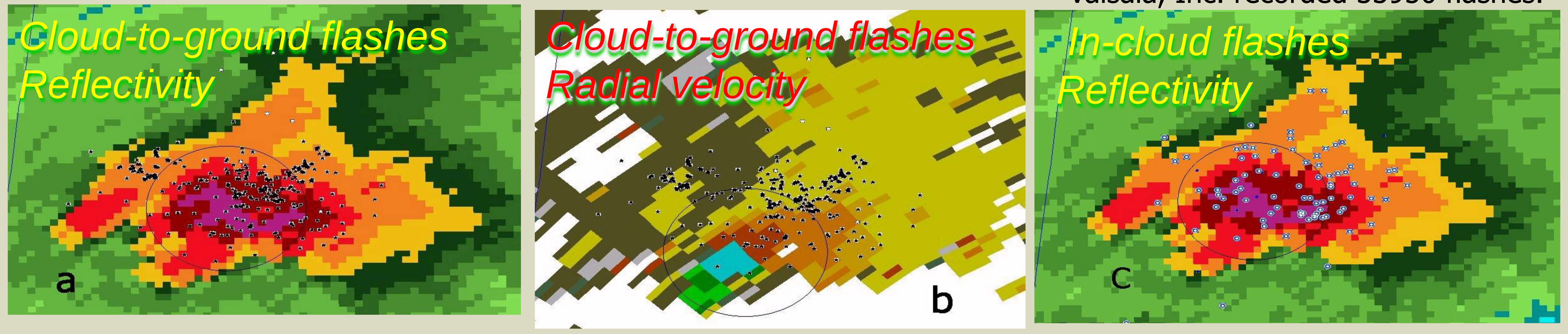


Figure 5. Hackleberg EF-5 tornado cell at 20:19:29 UTC. CG flash locations shown as black stars (-) and white stars (+). a) CG flashes over composite reflectivity with a 10 km radius circle centered on the maximum. b) CG flashes over storm-relative radial velocity with a 10 km radius circle centered on the maximum horizontal wind shear. c) IC (in-cloud) flashes over composite reflectivity

Results and Conclusions

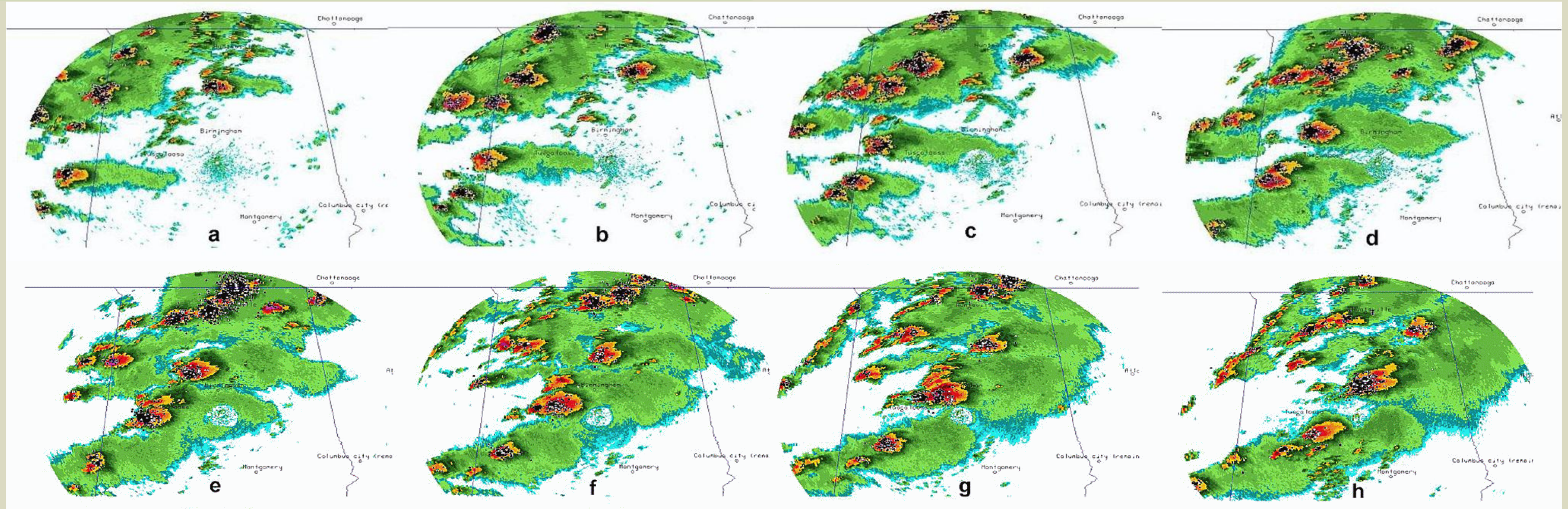
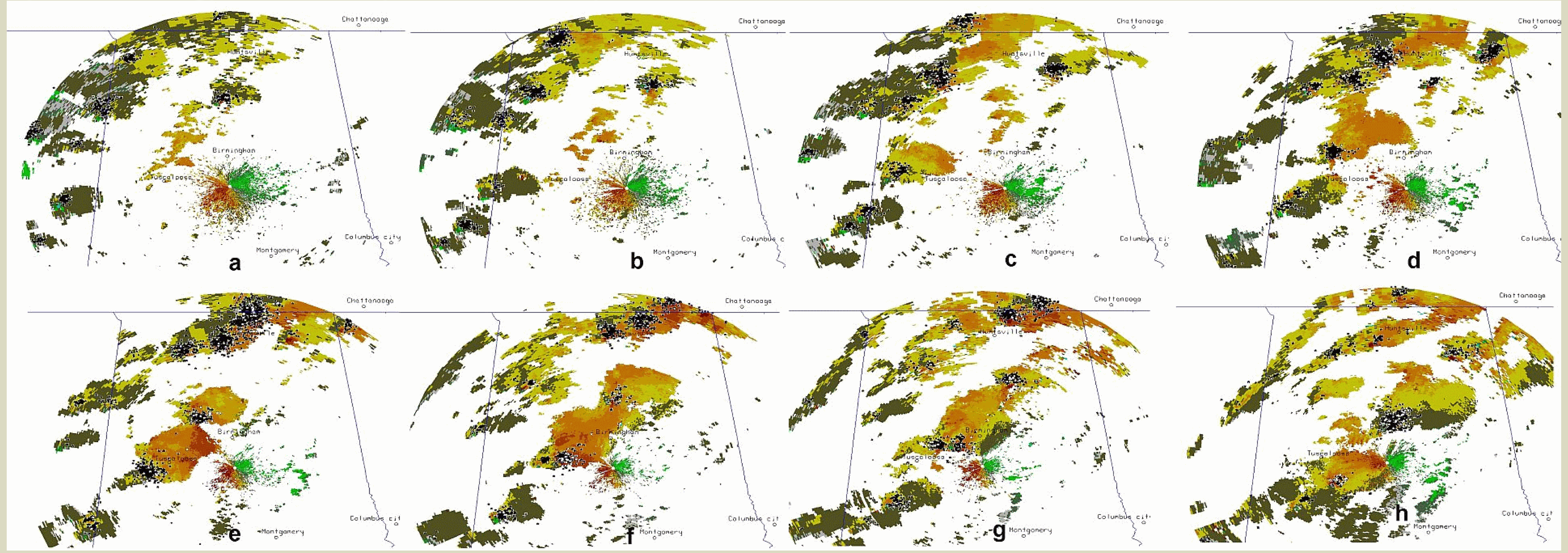


Figure 6. Composite reflectivity (above) and storm-relative radial velocity (below) with CG flashes (negative polarity as black stars, positive polarity as white stars). a) 19:52:00 (all times in UTC) b) 20:19:29 c) 20:42:51 d) 21:15:32 e) 21:47:38 f) 22:19:45 g) 22:42:40 h) 23:18:35. Many other times from 18 UTC to 00 UTC not shown.



Overall Summary

	Strokes within Radius of Maximum		
Radius:	10 km	5 km	2 km
CG Flashes Within Radius of Maximum in Composite Reflectivity	21162	8018	1430
CG Flashes Within Radius of Maximum in Storm-relative Radial Velocity Shear	12210	2834	411
IC Flashes Within Radius of Maximum in Composite Reflectivity	11023	4377	820
IC Flashes Within Radius of Maximum in Storm-relative Radial Velocity Shear	6852	1846	315

More flashes occurred around the reflectivity maxima than the mesocyclones. Strong horizontal shear did not appear to enhance charge separation or lead to more cloud-to-ground (CG) or in-cloud (IC) flashes near the maxima in horizontal wind shear.

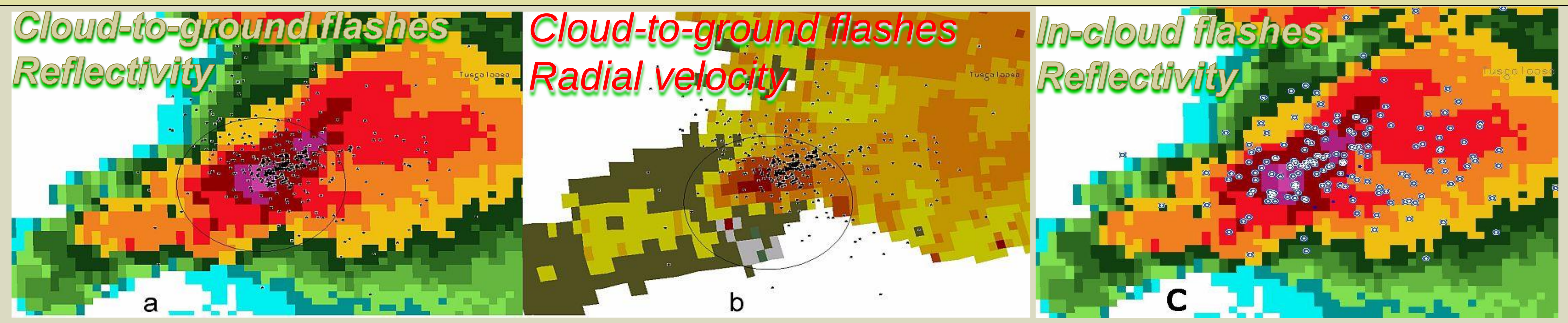


Figure 7. Close-up view of thunderstorm known as the Tuscaloosa-Birmingham cell at 21:47:38 UTC on 27 April 2011. a) CG flashes over composite reflectivity with a 10 km radius circle centered on the maximum. b) CG flashes over storm-relative radial velocity with a 10 km radius circle centered on the maximum horizontal wind shear. c) IC (in-cloud) flashes over composite reflectivity