CORRIGENDUM

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In all the lightning data assimilation (LDA) experiments of Fierro et al. (2016, hereafter F16), it is stated that, outside the observed lightning areas, the pseudo-observations for water vapor mass (q_v) were not created because these grid points are considered as non-updraft areas. This implied that pseudo-q_v outside the lightning areas were treated as missing values, which was the original intent. In the 3DVAR package, however, the missing pseudo-q_v outside the lightning areas were inadvertently assigned a zero innovation instead of a missing value. Because of this, all LDA-based experiments were assimilating zero innovations for q_v outside the lightning areas, forcing the analysis for q_v close to the background values there. Consequently, the information of pseudo-q_v inside the lightning areas (set to the saturation q_v with respect to liquid) cannot be spread out to the nonlightning areas, constraining the impact of the LDA. While setting the q_v innovations to zero in nonlightning areas could also be a valid approach to assimilate lightning, the fact that the radar data assimilation experiment (RAD) treated the radial winds as missing values outside reflectivity areas (i.e., no radial wind observations for dB$Z \leq$ 15–20) lead to inequitable comparisons between the original RAD and LDA experiments.

To illustrate this, an auxiliary experiment treating pseudo-q_v as missing values outside lightning areas and using the same horizontal decorrelation length scales R as in F16 (Table 1) was performed and shown in Fig. 3e. As can now be seen, when correctly assigning missing pseudo-q_v values in nonlightning areas, the 3DVAR analysis spreads the impact of the pseudo-q_v from inside the lightning areas (set to saturation q_v) to nonlightning areas (Fig. 6d). This has the main effect of producing an analysis and 1-h forecast that are arguably worse than the original RAD experiment (Figs. 3d,e). To produce results that are qualitatively comparable to the original LDA experiments (i.e., more targeted updraft cores), R must therefore be set to smaller values as illustrated by Figs. 3c and 3f and Figs. 6b and 6e for the OKLMA experiment (Table 1). Figures 3g and 6f show that when the same small R values are chosen in

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RAD, it is able to produce isolated convective cells in the analysis as well. Last, for these same smaller R values, Fig. 3h confirms that when the LDA is applied in tandem with RAD, the 1-h forecast is further improved relative to when only lightning (Fig. 3f) or radar data (Fig. 3g) are assimilated. While using $R \leq 10$ km may be optimal for the LDA, it can be arguably said that larger R values (>10 km) would benefit radial velocity assimilation (Figs. 3d,g). That is because radial velocity has a larger representative horizontal scale than the lightning data. Consequently, to effectively assimilate both types of observations, a multiscale approach, wherein different length scales are used for different types of observations, should be envisaged.

Despite this ambiguity, the additional experiments herein confirm that the general proof-of-concept of the 3DVAR LDA method in F16 remains valid. It is relevant to also clarify that the vertical decorrelation length scale used in all the experiments is 4 grid points, and not 12 km as incorrectly stated in F16.

REFERENCE

Fierro, A. O., J. Gao, C. L. Ziegler, K. M. Calhoun, E. R. Mansell, and D. R. MacGorman, 2016: Assimilation of flash extent data in the variational framework at convection-allowing scales: Proof-of-concept and evaluation for the short-term forecast of the 24 May 2011 tornado outbreak. *Mon. Wea. Rev.*, **144**, 4373–4393, doi:10.1175/MWR-D-16-0053.1.

TABLE 1. The left column lists the nomenclature/abbreviations used for the simulations/experiments described herein. The second column from the left briefly describes the type of experiments. The second column from the right indicates the type of data that were assimilated, with "dBZ" standing for radar reflectivity and "Vr" for radial velocity. The right column shows which model variable(s) is (are) impacted by the respective assimilation experiments with the symbols used to identify those variables bearing their usual meaning. For convenience, the first three rows list the original control run (CTRL), original lightning data assimilation experiment using the Oklahoma Lightning Mapping Array (OK-LMA) data, and the original radar data assimilation experiment (RAD). The first (second) value of R corresponds to the horizontal decorrelation length scale used during the first (second) 10-iteration pass of the 3DVAR analysis.

Experiment	Description	Data assimilated	Model variables impacted
CTRL	Original control run	None	None
OKLMA	Original lightning assimilation run	OK-LMA flash extent density rates	q_v (LCL-15 km)
RAD	Original radar data assimilation run	Vr and dBZ	$q_r, q_g, q_i, q_s, q_h, u, v, w, \theta$
H24 OKLMA	Lightning assimilation run with $R = 24, 12$ km	OK-LMA flash extent density rates	q_v (LCL-15 km)
H6 OKLMA	Lightning assimilation run with $R = 6, 3$ km	OK-LMA flash extent density rates	q_v (LCL-15 km)
H6 RAD	Radar data assimilation run with $R = 6, 3$ km	Vr and dBZ	$q_r, q_g, q_i, q_s, q_h, u, v, w, \theta$
H6 RAD+OKLMA	Lightning + radar data assimilation run with $R = 6, 3$ km	Vr and dBZ, OK-LMA flash extent density rates.	q_v (LCL-15 km), $q_r, q_g, q_i, q_s, q_h, u, v, w, \theta$

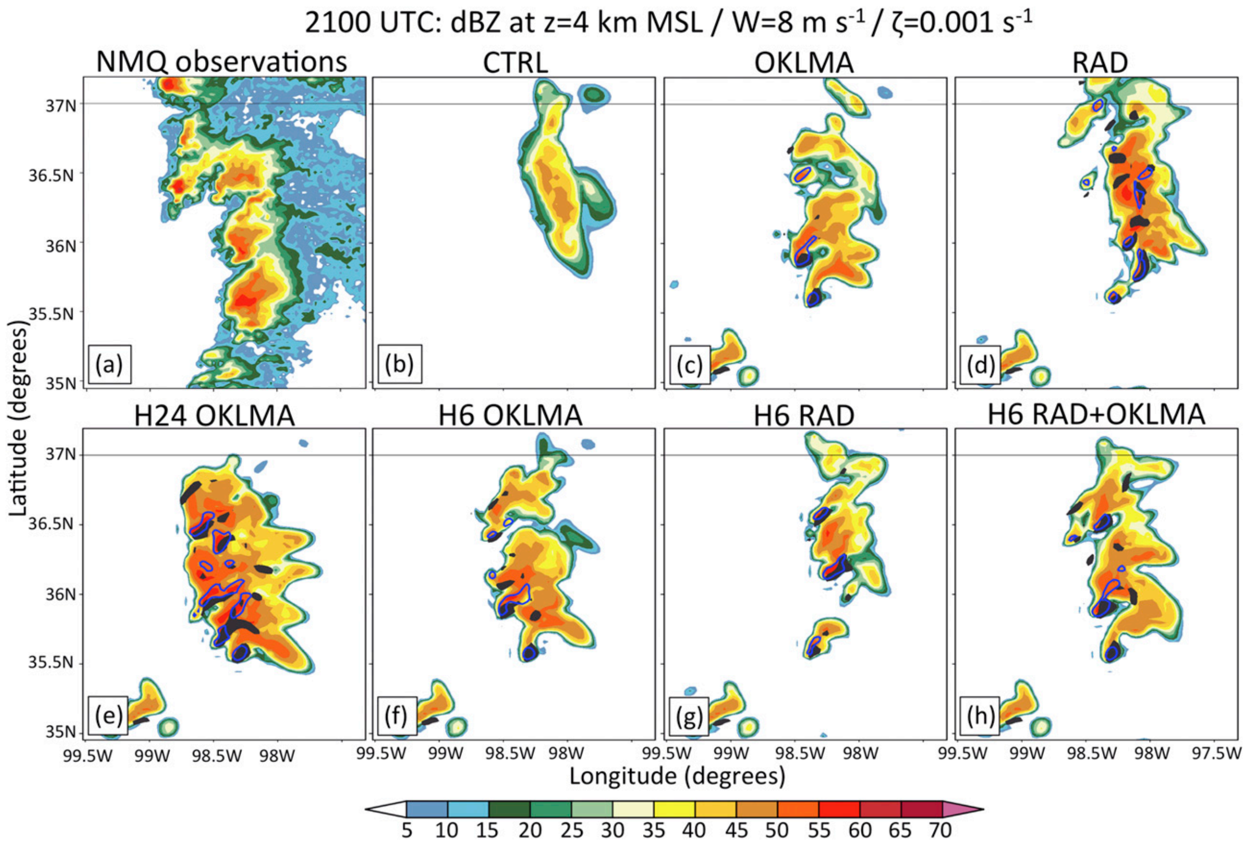

FIG. 3. Horizontal cross sections at 2100 UTC (1-h forecast) at $z = 4$ km MSL overlain with the 8 m s^{-1} vertical velocities (blue contour) and relative vertical vorticities of 10^{-3} s^{-1} (solid black) for (a) the NMQ observations, (b)–(d) selected original base experiments in F16, and (e)–(h) additional experiments described in Table 1.

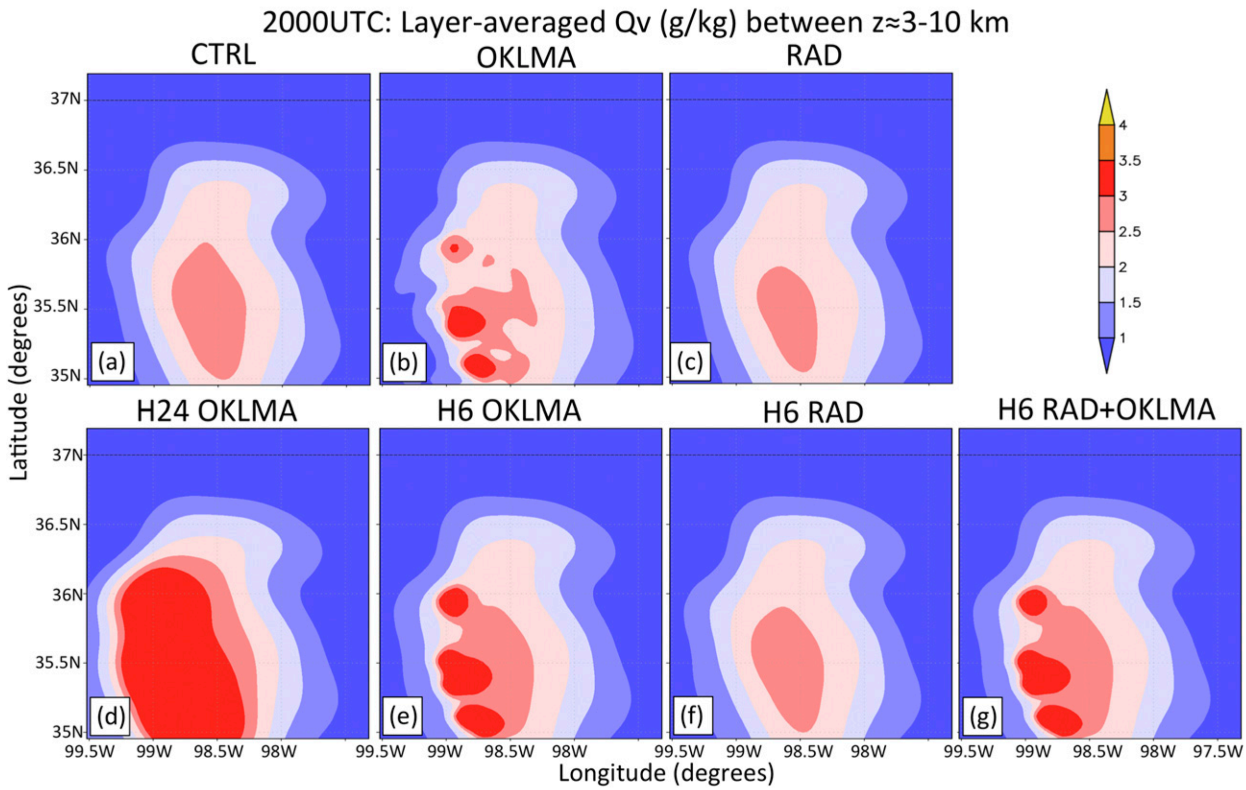

FIG. 6. Layer-averaged water vapor mass (q_v) between $z \approx 3$ and 10 km MSL at 2000 UTC. Results are shown from left to right for the original (a) CTRL, (b) OKLMA, and (c) RAD experiments followed by (d)–(g) the additional experiments described in Table 1.