Reply

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It is clear to the authors that Markowski and Dotzek (2010, hereafter MD) have misconstrued much of the intent and accomplishment provided in the Agee and Jones (AJ) taxonomy. For instance, MD's criticism of our Table 1 could be interpreted as ''perfection or nothing at all,'' because we are unable to ascertain the complete dynamics responsible for every tornado species. We feel that a substantial step has been taken to define a tornado taxonomy, with a reasonable explanation of many types (and species) of tornado formation, and our paper invites the community to participate in making improvements in the taxonomy. The ''perfection'' implied in MD's comments is further illustrated by their reference to the single tornado that was captured by the Second Verification of the Origins of Rotation in Tornadoes Experiment (VORTEX2) field program in southeast Wyoming [where MD states that one might quantitatively explain the formation of only a single tornado from the *O*(1000) that occurred in 2009]. The implication of MD's comments suggest that there could not possibly be a practical taxonomy for classifying tornadoes, when adequate information will nearly always be unavailable.

Next, it is true that MD has correctly read our paper, and we will state again ''there are no supercells in QLCS'' and supercells are viewed as discrete entities and thus these events (with their mesocyclones) are clearly distinct from the proposed type II and type III events.

Next we would like to point out that MD do not seem to have a basic knowledge of dust devils, since these vortices occur under clear-sky conditions and calm winds, and any vortex with dust inside is not the definition of dust devils. Furthermore, gustnadoes are not dust devils, and gustnadoes have been accurately presented by us [and are appropriately classified as tornadoes in the American Meteorological Society (AMS) glossary; Glickman (2000)].

We would also like to reply to MD's comments that pertain to their reference to Wegner's 1917 definition of tornadoes being better than the Glickman (2000) definition. It is rather naïve on the part of MD to suggest that Wegner's definition of tornadoes is more practical than that provided by the individuals that contributed to the updated definition in the AMS glossary.

Again, MD wants perfection or nothing at all when distinguishing the dynamics of formation for tornado events. Hypothetically assuming that all information (and explanation of formation) is known about every single tornado event, there would still be a strong common bond for all, because there is only one vorticity equation. The role of stretching in a supercell is important and so is the role of stretching in a landspout, thus a strong similarity exists but among different species. Similar processes at work is not a reason to argue that two tornado types are the same. The physical character of vortices as well needs to be considered (e.g., supercell versus minisupercell). We are also surprised by MD's lack of appreciation for the published literature on minisupercells. Minisupercells occur in association with tropical cyclones (e.g., McCaul and Weisman 1996; Suzuki et al. 2000; Eastin and Link 2008) and distinctively different midlatitude continental systems (e.g., Kennedy et al. 1993; Knupp et al. 1998; Markowski and Straka 2000; Davies 2006; indeed, we now reference a paper by Markowski on this subject, and readers are strongly encouraged to read that paper). The general definition of minisupercells is provided in numerous papers, but refers to storms that are much smaller than the supercell (low top and small diameter as seen in the above papers) but with similar features to the supercell. Minisupercells, and associated tornadoes often occur in spring or fall severe weather episodes when storm relative helicity is high, and marginal CAPE

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is available to produce tornadoes. Tropical storms, on the other hand, that produce minisupercells in their outer convective bands at landfall are typically characterized by large CAPE and limited low-level shear.

Furthermore, MD comments that we make a general distinction between tornadoes and waterspouts, based on the underlying surface. Apparently, MD misunderstood, because landfall simply determines whether the tornado is counted (or not) in the record. In fact, we noted that the waterspout species is defined by the convergence and stretching in cumuliform clouds (i.e., type III, as seen frequently over the Florida Keys), but convective storms can move onshore in type I and type II events as noted in our Fig. 5 (and these would be type I and type II tornadoes, not type III). Similarly, in the landspouts (also type III, as shown in our Fig. 4) it is sometimes confusing to observers when vortex tubes, which look like landspouts, form in high-based intense cells (even supercells) over the western high plains. Chasers may refer to these as landspouts, when they are actually type I and type II tornadoes.

Finally, we do agree with comments made by MD regarding the IIIf tornado (and thus it could be colisted or even relocated to the type I classification). This is a valid suggestion and the authors have received e-mails suggesting this change.

Hopefully, MD values this reply, because we were pleased to receive (and respond to) their comments. However, MD has seemingly missed a significant aspect of the intent of the AJ taxonomy. It was not intended to provide a taxonomy based on the complete dynamical explanation of all tornadoes. The AJ taxonomy is sufficient to distinguish tornado types and species, and can potentially provide a basis for issuing more appropriate tornado warnings. It is also an objective of our effort to encourage the community to contribute (and improve) the proposed taxonomy. Conceivably, *Storm Data* could be continued as currently published, but a new National Oceanic and Atmospheric Administration (NOAA) archive could be created that would serve to meet our recommendation. In a trial exercise, the author has (with the assistance of undergraduate student E. Cornett) attempted to classify the March 2009 tornadoes (based largely on radar analyses), using the AJ taxonomy. Preliminary results have yielded a classification for 93 of the 115 tornadoes archived for March. This clearly illustrates some of the concerns raised in the review process, but it does not imply that the community should view the concept of a valid tornado taxonomy as unachievable. One is needed, and should be in place for monitoring any climatological changes in tornado activity as twenty-first century global warming continues to unfold. Such a new and improved tornado climatology could help resolve trends that may evolve on the national and/or regional scale due to changes in CAPE, severe thunderstorm frequency, tropical cyclone activity, and jet stream patterns. Complacency should be unacceptable.

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