What are supercells for?

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Some wild speculation …

On the Role of Deep Columnar Convective Vortices within the Atmosphere

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NOTICE: This manuscript is an informal one that approaches, but doesn't attain, the status of a formal publication. It hasn't successfully negotiated the path to formal journal publication. It's being offered here simply as the expression of my ideas regarding this topic. My readers can contact me at cdoswell_& earthlink.net if they wish to discuss any of this (use the email hyperlink, or cut and paste after replacing '_&_' with '@'). If you're not willing to have your comments (and my responses) included here, don't waste my time (or yours).

NOTE: footnotes are at the end of the manuscript.

Herein, I'm exploring some ideas I've had and some of them are simply too different or too speculative for some reviewers of journal manuscripts to swallow. Since I'm not yet prepared to offer an "airtight" presentation -- one with considerable direct supporting evidence, at least -- I'm putting it out here for others to mull over. Be prepared to encounter some new perspectives ...

This manuscript was withdrawn from consideration for publication in EJSSM after I received the second round of reviews from referees. I have no wish to sully the scientific integrity of EJSSM with mere speculation ... my readers might find it interesting to compare this paper with Lemon and Doswell (1979) with respect to the level of evidence provided.

ABSTRACT

Although considerable research over the past several decades has led to extensive knowledge of environments in which supercells and tornadoes occur -- the primary examples of deep columnar convective vortices -- there has been little progress in understanding what role these rotating systems play in the atmosphere. Any comprehensive understanding of deep columnar convective vortices should include: knowledge of the energy source that powers the process, what instability mechanism is involved, and how the resulting system alters the atmosphere to mitigate the need for the process to continue. Two conceptual models have been developed that satisfy these requirements: (1) The energy source for supercells includes the storm-relative helicity of the air ascending in the updraft, in combination with the buoyancy associated with the deep convection. (2) The energy source for tornadoes is dominated by storm-relative helicity within the low-level inflow to the tornado. The instability mechanism in both is the basic exponential growth process associated with the so-called stretching term in the vertical vorticity equation -- the energy tapped from the source of helicity is used to drive the amplification of the kinetic energy of the vortex, which ultimately is dissipated by viscosity. It is suggested that the tornado model is comprehensive; it applies to *all* tornadoes, including mesocyclonic and nonmesocyclonic tornadoes. Although the models cannot be evaluated conclusively at this time, a plan for testing the validity of the proposed conceptual models is offered.

1. Introduction

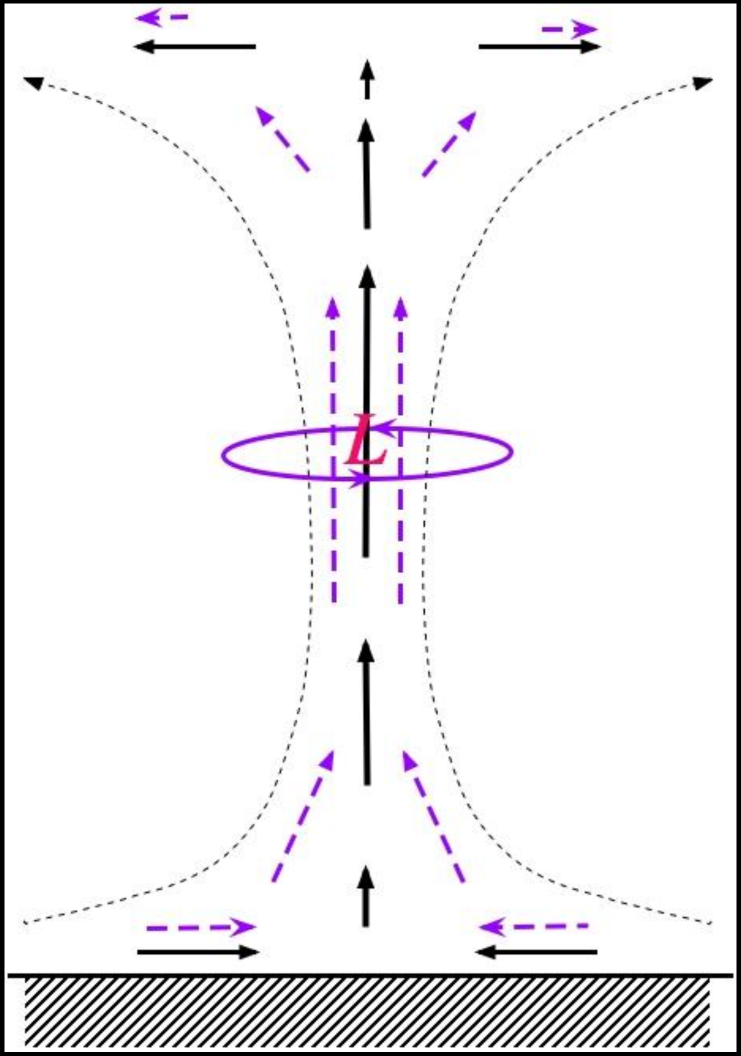
Supercells and tornadoes are deep columnar convective vortices (hereafter DCCVs), a modification of a similar term proposed by Snow (1987) for vortices that are "columnar" (their depth is greater than or equal to their width). The word "deep" here implies a depth on the order of the depth of troposphere. Tropical cyclone eyewalls might be another example. In the case of a supercell, this vortex is called a *mesocyclone*. The term mesocyclone is something of a misnomer, as it is not within the time and space scales usually associated with the term "mesoscale" (see Orlanski 1975; Emanuel 1980; Fujita 1981; Doswell 1987; Markowski and Richardson 2010, Ch. 1) -- although technically Orlanski would consider the scale of a mesocyclone "meso-γ". Markowski and Richardson view a mesocyclone as a mesoscale system, but I choose not to see it that way -- it is *my* understanding that the so-called "convective scale" (associated with convective clouds) is just below that of most mesoscale processes. In any case, the term "meoscyclone" has been in widespread use for decades and will be retained herein. The definition of a tornado has been problematic (as discussed at some length here) but the basic notion is that it is an intense columnar vortex, with winds near the surface capable of doing damage and is associated with a deep, moist convective cloud.

I take it as axiomatic that dynamic[1] processes that can be characterized as motion systems (i.e., having kinetic energy) in the atmosphere, such as supercells and tornadoes, are not random "accidents". For most such atmospheric motion systems, some sort of known instability mechanism is involved that converts potential energy into the disturbance kinetic energy of the process in question. For example, extratropical cyclones (ETCs), are associated with *baroclinic* instability that taps the available potential energy (APE) associated with the thermal wind. For ordinary deep moist convection (DMC), the *buoyant* instability of parcel theory associated with high lapse rates in the presence of moisture converts convective available potential energy (CAPE) into the kinetic energy of the convection. Once an instability mechanism and its energy source have been identified, then the role of the process producing the weather event is usually known. Thus, ETCs redistribute heat and momentum to mitigate the meridional thermal and momentum gradients. DMC redistributes sensible and latent heat in the vertical. Analogous statements can be made for numerous other atmospheric processes.

Why does the atmosphere need supercells?

- Can’t just be to do the same thing that ordinary deep convection does – erase CAPE
- Supercells have an additional source of vertical motion – that due to the dynamic part of the vertical perturbation pressure gradient
- “Helicity Instability”

Supercell updraft schematic



What I would like to have …

For both supercells and non-supercells