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Interactive comment on "Reinterpreting aircraft measurements in anisotropic scaling turbulence" *by* S. Lovejoy et al.

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The present contribution (Lovejoy et al., 2009) happens to coincident with my own recent contribution to ACPD (Yano 2009). The present comments are directed to the former, overall, from the latter point of view.

Lovejoy et al. (2009) reveal the scaling behavior in atmospheric turbulence much wider scale range than hitherto identified. They especially show that, by both correcting previous neglected errors in airplane data due to a fractal trajectory of the plane as well as taking account of the anisotropy of atmospheric turbulence, the scale breakdowns previously pointed out are spirituous.

On the other hand, Yano (2009) reviews a classical picture on tropical atmospheric convection, a type of turbulence for the present discussion, proposed by Riehl and Malkus (1958). Those authors proposed that the tropical atmospheric circulations mainly consist of the two scales: a large-scale represented by the Hadley-Walker circulation and a small scale represented by deep moist convection ("hot" towers).

Yano (2009) emphasizes that this two-scale hypothesis, or the scale separation principle, is providing a strong theoretical basis for the current major trend of convective parameterizations using the mass fluxes.

After half a century of their original work, we do know now that the tropical atmospheric system is far more complex than originally envisaged by Riehl and Malkus. The tropical system not only consists of these two scales, but consists of many other scales in a hierarchical manner.

Deep convection is organized into a mesoscale of 100 km scale, associated notably with a stratiform precipitating system. The meso-scale systems are furthermore organized into larger-scale associated with various convectively-coupled equatorial waves (Wheeler and Kiladis 1999). Nakazawa (1988) notably categorized the two upper hierarchical structures as super-clusters and the Madden-Julian oscillations for the convective variability along the equator.

A universal fractality of the atmospheric turbulence argued by Lovejoy et al. (2009) is, unfortunately, in odd with a conventional view for tropical convection just summarized here. The latter view consists of many scales, but these scales are distinguishably separated each other.

A distinction between deep convection ("hot" towers) and mesoscale stratiform clouds would be the clearest example to make the point. In most of the tropical meteorologists' mind, these are two entities well separated by scales. Not only separated by scales, but these two entities are qualitatively different: deep convection is literally deep associated by deep ascents, whereas stratiform clouds are much wide spread horizontally with a downward motion (mesoscale downdraft) typically found immediately below. Intuitively,

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it is hard to accept a view that these two entities are just a part of spectrum continuum.

Thus, the main question to be posed to Lovejoy et al.'s claim of universal scaling law of the atmosphere is: how does this claim reconcile with the convectional view for the tropical atmosphere?

In my own opinion, a key to reconcile this virtual contradiction is to accept dominance of coherent structures in turbulence flows in a more explicit manner. Coherent vortices in two-dimensional turbulence is a textbook example, but it has long been accepted in atmospheric community that plumes constitute coherent basic elements for atmospheric convection both dry and moist.

Geometrical structure of convective clouds probably makes the point better. These clouds are not simple monofractal such as Koch curves, but they consist of many discrete elements, traditionally coined as "thermals" and "bubbles" (e.g., Ludlam and Scorer, 1953). In my very personal view, the fact that these natural fractals constitute multifractal clearly reflect their association with the coherent structures.

This point of view stems from our own investigation on the atmospheric 1/f-noise time series (Yano et al., 2004). 1/f-noise is dominated by pulse-like structures: for short-time scales of surface time series, they are identified as sudden cooling and drying associated with convective downdrafts. In longer time scales, they are identified as tropical westerly wind bursts, for example.

In this study, rather out of curiosity, we have extracted these pulse-like structures by a wavelet-based extraction method. To our surprise, these individual pluses themselves are shown to represent 1/f-spectrum. In other words, each pulse represents a scaling behavior by itself.

A direct inspection of time series shows that these pulses do not represent fractal-like structure in any convectional sense. It appears that the only reason that they represent the scaling behavior is due to their long tails away from a pulse peak. A

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Fourier transform of an algebraic tail would produce a power-law spectrum. With an appropriate exponent for the tail, thus a 1/f spectrum is obtained.

My personal feeling is that the so-called universal scaling law and fractality of the atmospheric turbulence is explained by these long tails associated with individual turbulence coherencies, such as bubbles, thermals, plumes, etc.

I believe, the present contributing authors are in the best position of demonstrating this point emphatically. As a result, a clearer link between a convectional view and their fractal view can be established.

Finally, what will be a fate of the standard mass-flux parameterizations under the evidences of universal scaling law? Should they be ultimately replaced by fractal-based parameterizations? It may turn out that it is just a matter of introducing a long-tail effect into existing mass-flux parameterizations, rather than any radical changes, if the above speculation turns out to be the case.

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